Designation: C 1293 – 01

Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction[1]

This standard is issued under the fixed designation C 1293; 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, by measurement of length change of concrete prisms, of the susceptibility of an aggregate for participation in expansive alkali-silica reaction.

1.2 *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.*

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound values in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 125 Terminology Relating to Concrete and Concrete Aggregates[2]

C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]

C 143/C 143M Test Method for Slump of Hydraulic–Cement Concrete[2]

C 150 Specification for Portland Cement[3]

C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete[2]

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 227 Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)[2]

C 289 Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)[2]

C 294 Descriptive Nomenclature for Constituents of Concrete Aggregates[2]

C 295 Guide for Petrographic Examination of Aggregates for Concrete[2]

C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete[3]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks [3]

C 702 Practice for Reducing Samples of Aggregate to Testing Size[2]

C 856 Practice for Petrographic Examination of Hardened Concrete[2]

C 1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)[2]

D 75 Practice for Sampling Aggregates[3]

D 1193 Specification for Reagent Water[4]

2.2 *CSA Standards:*[5]

CSA A23.1-00 Concrete Materials and Methods of Concrete Construction, Appendix B

CSA A23.2-14A-00 Potential Expansivity of Aggregates (Procedure for Length Change due to Alkali-Aggregate Reaction in Concrete Prisms)

CSA A23.2-27A-00 Standard Practice to Identify Degree of Alkali-Reactivity of Aggregates and to Identify Measures to Avoid Deleterious Expansion in Concrete

3. Terminology

3.1 Terminology used in this standard is as given in Terminology C 125 or Descriptive Nomenclature C 294.

4. Significance and Use

4.1 Alkali-silica reaction is a chemical interaction between some siliceous constituents of concrete aggregates and hydroxyl ions **(1)**.[6] The concentration of hydroxyl ion within the concrete is predominantly controlled by the concentration of sodium and potassium **(2)**.

4.2 This test method is intended to evaluate the potential of an aggregate to expand deleteriously due to any form of alkali-silica reactivity **(3,4)**.

4.3 When selecting a sample or deciding on the number of samples for test, it is important to recognize the variability in lithology of material from a given source, whether a deposit of sand, gravel, or a rock formation of any origin. For specific

---

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

Current edition approved February 10, 2001. Published March, 2001. Originally published as C 1293 – 95. Last previous edition C 1293 – 95.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

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

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

[5] Canadian Standards Association Standards for Concrete Construction, 173 Rexdale Blvd., Rexdale, Ontario Canada, M9W1R3.

[6] The boldface numbers in parentheses refer to the list of references at the end of this test method.

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

advice, see Guide C 295.

4.4 This test method is intended for evaluating the behavior of aggregates in an alkaline environment. This test method assesses the potential for deleterious expansion of concrete caused by alkali-silica reaction, of either coarse or fine aggregates, from tests performed under prescribed laboratory curing conditions that will probably differ from field conditions. Thus, actual field performance will not be duplicated due to differences in wetting and drying, temperature, other factors, or combinations of these **(5)**.

4.5 Results of tests conducted as described herein should form a part of the basis for a decision as to whether precautions should be taken against excessive expansion due to alkali-silica reaction. This decision should be made before a particular aggregate is used in concrete construction. Criteria to determine the potential deleteriousness of expansions measured in this test are given in Appendix X1.

4.6 The basic intent of this test method is to develop information on a particular aggregate at a specific alkali level of 5.25 kg/m^3(8.85 lb/yd^3). It has been found that this high alkali level is required to detect the effects of certain deleteriously reactive aggregates **(3)**.

4.7 When the expansions in this test method are greater than the limit shown in X1.2, the aggregate is potentially alkali-reactive. Supplemental information should be developed to confirm that the expansion is actually due to alkali-silica reaction. Petrographic examination of the concrete prisms should be conducted after the test using Practice C 856 to confirm that known reactive constituents are present and to identify the products of alkali-silica reactivity. Confirmation of alkali-silica reaction is also derived from the results of the test methods this procedure supplements (see Appendix X1).

4.8 If the supplemental tests show that a given aggregate is potentially deleteriously reactive, additional studies may be appropriate to evaluate preventive measures in order to allow safe use of the aggregate. Preventive measures are mentioned in the Appendix to Specification C 33.

5. Apparatus

5.1 The molds, the associated items for molding test specimens, and the length comparator for measuring length change shall conform to the applicable requirements of Test Method C 157 and Practice C 490, and shall have square cross sections of 75.0 ± 0.7 mm (3.00 ± 0.03 in.).

5.2 The storage container options required to maintain the prisms at a high relative humidity are described in 5.2.1.

5.2.1 *Recommended Container*—The recommended containers are 22-L (5.8-gal) polyethylene pails with airtight lids and approximate dimensions of 250- to 270-mm (9.8- to 10.6-in.) diameter at bottom, 290 to 310 mm (11.4 to 12.2 in.) at top, by 450 to 480 mm (17.7 to 18.9 in.) high.[7] Prevent significant loss of enclosed moisture due to evaporation with airtight lid seal. Place a perforated rack in the bottom of the storage container so that the prisms are 30 to 40 mm (1.2-1.6 in.) above the bottom. Fill the container with water to a depth of 20 ± 5 mm (0.8 ± 0.2 in.) above the bottom. A significant moisture loss is defined as a loss greater than 3 % of the original amount of water placed at the bottom of the pail. Place a wick of absorbent material consisting of polypropylene fibers around the inside wall of the container from the top so that the bottom of the wick extends into the reagent water.

5.2.2 *Alternative Containers*—Alternative storage containers may be used. Confirm the efficiency of the alternative storage container with an alkali-reactive aggregate of known expansion characteristics.[8] The expansion efficiency is confirmed when expansions at one year obtained using the alternative container are within 10 % of those obtained using the recommended container. Alternative storage containers must contain the required depth of reagent water. When reporting results, note the use of an alternative container, if one is used, together with documentation proving compliance with the above.

5.3 The storage environment necessary to maintain the 38.0°C (100.4°F) reaction accelerating storage temperature consistently and homogeneously is described in 5.3.1.

5.3.1 *Recommended Environment*—The recommended storage environment is a sealed space insulated so as to minimize heat loss. Provide a fan for air circulation so the maximum variation in temperature measured within 250 mm (9.8 in.) of the top and bottom of the space does not exceed 2.0°C (3.6°F). Provide an insulated entry door with adequate seals so as to minimize heat loss. Racks for storing containers within the space are not to be closer than 30 mm (1.2 in.) to the sides of the enclosure and are to be perforated so as to provide air flow. Provide an automatically controlled heat source to maintain the temperature at 38.0 ± 2.0°C (100.4 ± 3.6°F) (see Note 1). Record the ambient temperature and its variation within the space to ensure compliance.

NOTE 1—It has been found to be good practice to monitor the efficiency of the storage environment by placing thermocouples inside dummy concrete specimens inside a dummy container within the storage area. The storage room described in Test Method C 227 generally will be satisfactory.

5.3.2 *Alternative Storage Environment*—Use of an alternative storage environment is permitted. Confirm the efficiency of the alternative storage container with an alkali-reactive aggregate of known expansion characteristics.[8] The expansion efficiency is confirmed when expansions at one year obtained using the alternative storage environment are within 10 % of those obtained using the recommended environment. When reporting the results, note the use of an alternative storage environment, if one is utilized, together with documentation proving compliance with the above.

6. Reagents

6.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used. (**Precaution:** Before using NaOH, review: (*1*) the

---

[7] Polyethylene pails used in the food industry have been found to be suitable. Twenty two-L pails (Model Nos.: pail, 5251; lid, 63493), are available from IPL Products Ltd., 348 Park Street, Suite 201, East Building, North Reading, Mass. 01864.

[8] Non-reactive aggregates and alkali-silica reactive aggregates of known expansion characteristics **(6)** are available from The Petrographer, Engineering Materials Office, Ministry of Transportation, 1201 Wilson Ave., Downsview, Ontario, Canada, M3M1J8.

safety precautions for using NaOH; (*2*) first aid for burns; and (*3*) the emergency response to spills as described in the manufacturers Material Safety Data Sheet or other reliable safety literature. NaOH can cause severe burns and injury to unprotected skin and eyes. Always use suitable personal protective equipment including: full-face shields, rubber aprons, and gloves impervious to NaOH (Check periodically for pinholes.).)

6.2 *Water*:

6.2.1 Unless otherwise indicated, references to water are understood to mean potable tap water.

6.2.2 The references to reagent grade water are understood to mean reagent water as defined by Type III or IV in Specification D 1193.

7. Materials

7.1 *Cement*—Use a cement meeting the requirements for a Type I Portland cement as specified in Specification C 150. The cement must have a total alkali content of 0.9 ± 0.1 % Na_2O equivalent (Na_2O equivalent is calculated as percent Na_2O + 0.658 × percent K_2O). Determine the total alkali content of the cement either by analysis or by obtaining a mill run certificate from the cement manufacturer. Add NaOH to the concrete mixing water so as to increase the alkali content of the mixture, expressed as Na_2O equivalent, to 1.25 % by mass of cement (see Note 2).

NOTE 2—The value of 1.25 % Na_2O equivalent by mass of cement has been chosen to accelerate the process of expansion rather than to reproduce field conditions. At the 420 kg/m^3 (708 lb/yd^3) cement content, this corresponds to an alkali level of 5.25 kg/m^3 (8.85 lb/yd^3).

7.2 *Aggregates*:

7.2.1 To evaluate the reactivity of a coarse aggregate, use a nonreactive fine aggregate. A nonreactive fine aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar, (see Test Method C 1260) of less than 0.10 % at 14 days (see X1.5 for interpretation of expansion data). Use a fine aggregate meeting Specification C 33 with a fineness modulus of 2.7 ± 0.2.

7.2.2 To evaluate the reactivity of a fine aggregate, use a nonreactive coarse aggregate. Prepare the nonreactive coarse aggregate according to 7.2.3.[8] A nonreactive coarse aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar (see Test Method C 1260) of less than 0.10 % at 14 days (see X1.5 for interpretation of expansion data). Use a coarse aggregate meeting Specification C 33. Test the fine aggregate using the grading as delivered to the laboratory.

7.2.3 Sieve all coarse aggregates to which this test method is applied and grade in accordance with the requirements in Table 1. Coarse aggregate fractions larger than 19.0-mm (¾-in.) sieve are not to be tested as such. When petrographic examination using Guide C 295 reveals that the material making up the size fraction larger than the 19.0-mm (¾-in.) sieve is of such a composition and lithology that no difference should be expected compared with the smaller size material, then no further attention need be paid to the larger sizes. If petrographic examination suggests the larger size material to be more reactive, the material should be studied for its effect in concrete according to one or the other alternative procedures described herein:

TABLE 1 Grading Requirement

Sieve Size		Mass (%)
Passing	Retained	
19.0-mm (¾-in.)	12.5-mm (½-in.)	33
12.5-mm (½-in.)	9.5-mm (⅜-in.)	33
9.5-mm (⅜-in.)	4.75-mm (No. 4)	33

7.2.3.1 *Proportional Testing*—Crush material larger than the 19.0-mm (¾-in.) sieve to pass the 19.0-mm (¾-in.) sieve. Grade the material passing the 19.0-mm (¾-in.) sieve as per the Table 1 grading, and proportionally add back to the original minus 19.0-mm (¾-in.) grading so as to include the oversized material in a mass proportion equal to its original grading percentage.

7.2.3.2 *Separated Size Testing*—Crush material larger than the 19.0-mm (¾-in.) sieve to pass the 19.0-mm (¾-in.) sieve, grade that material as per Table 1 and test in concrete as a separate aggregate.

7.3 *Concrete Mixture Proportions*—Proportion the concrete mixture to the following requirements:

7.3.1 *Cement Content*—420 ± 10 kg/m^3(708 ± 17 lb/ yd^3).

7.3.2 *Volume of Coarse Aggregate Per Unit of Volume of Concrete*—Use a coarse aggregate oven-dry-rodded unit volume of 0.70 ± 0.2 % for all classes of aggregates (for example, low density, normal, and high density).

7.3.3 *Water-Cement Ratio (w/c)*—Maintain w/c in the range of 0.42 to 0.45 by mass. Adjust the w/c within this range to give sufficient workability to permit satisfactory compaction of the concrete in the molds. Report the w/c ratio used.

7.3.4 *Admixture (NaOH)*—Dissolve in the mixing water and add as required to bring the alkali content of the concrete mixture, expressed as Na_2O_e = % Na_2O + 0.658× % K_2O, up to 1.25 % by mass of cement (see Note 3). Use no other admixture in the concrete.

NOTE 3—A sample calculation for determining the amount of NaOH to be added to the mixing water to increase the alkali content of the cement from 0.90 % to 1.25 %:

Cement content of 1 m^3 concrete = 420 kg
Amount of alkali in the concrete = 420 kg × 0.90 %
= 3.78 kg
Specified amount of alkali in concrete = 420 kg × 1.25 %
= 5.25 kg
Amount of alkali to be added to concrete = 5.25 kg − 3.78 kg
= 1.47 kg

The difference (1.47 kg) is the amount of alkali, expressed as Na_2O equivalent, to be added to the mix water. Factor to convert Na_2O to NaOH:
since

$$(Na_2O + H_2O \rightarrow 2\ NaOH)$$

Compound	Molecular Weight
Na_2O	61.98
NaOH	39.997

Conversion factor:

$$2 \times 39.997/61.98 = 1.291; \tag{1}$$

Amount of NaOH required:

$$1.47 \times 1.291 = 1.898\ kg/m^3 \tag{2}$$

8. Sampling

8.1 Obtain the aggregate sample in accordance with Practice

D 75 and reduce it to test portion size in accordance with Practice C 702.

9. Specimen Preparation

9.1 *Mixing Concrete*:

9.1.1 *General*—Mix concrete in accordance with the standard practice for making and curing concrete test specimens in the laboratory as described in Practice C 192.

9.1.2 *Slump*—Measure the slump of each batch of concrete immediately after mixing in accordance with Test Method C 143.

9.1.3 *Yield, and Air Content*—Determine the yield, and air content of each batch of concrete in accordance with Test Method C 138. Concrete used for slump, yield, and air content tests may be returned to the mixing pan and remixed into the batch.

9.2 Prepare three specimens of the type required for concrete in Test Method C 157 from one batch of concrete (see Note 4).

NOTE 4—It has been found useful to cast an additional (4th) prism that can be removed from the test and used for petrographic examination at any time.

9.3 *Initial Conditioning*—Cure, store, and remove molds in accordance with Test Method C 157.

10. Procedure

10.1 *Initial Comparator Reading*—Follow the procedure of Test Method C 157, except do not place in saturated lime water. Make initial length reading at the time of removal from the mold at an age of 23.5 ± 0.5 h. Thereafter, keep the specimens at 38.0 ± 2°C (100.4 ± 3.6°F) in storage containers in accordance with 5.2.

10.2 *Subsequent Comparator Readings*—Stand the specimen on end. Specimens shall not be in contact with water in the reservoir within the storage container. Seal the container and place container in a 38.0 ± 2°C (100.4 ± 3.6°F) storage environment. At no time should the storage container be in contact with the walls or floor of the 38.0 ± 2°C (100.4 ± 3.6°F) storage environment and there shall be an adequate flow of air around the container.

10.2.1 When the specimens are 7 days old, take a comparator reading after removal of the container and contents from the storage environment according to 10.2.2. Subsequent readings are required at the ages of 28 and 56 days, as well as 3, 6, 9, and 12 months. Additional readings, if required, are suggested at 6-month intervals.

10.2.2 Remove the containers holding the prisms from the 38.0 ± 2.0°C (100.4 ± 3.6°F) temperature environment and place in a moist cabinet or moist room that is in compliance with Specification C 511 for a period 16 ± 4 h before reading.

10.3 Fabricate all specimens placed in a given storage container at the same time so that all specimens in that container are due for comparator reading at the same time.

10.4 Identify the specimens so as to place the specimens in the comparator with the same end up. After the comparator reading of the prism, replace the specimen in the storage container but invert the upper end as compared with the previous storage period. In this way the prisms are not stored through two consecutive storage periods with the same ends up.

11. Calculation

11.1 Calculate the change in length between the initial comparator reading of the specimen and the comparator reading at each time interval to the nearest 0.001 % of the effective gage length and record as the length change of the prism for that period. Calculate the average length change in percentage for the group of prisms at the age.

11.2 Data from at least three bars must be available at any age to constitute a valid test at that age.

12. Report

12.1 Report the following information:

12.1.1 Type and source of coarse and fine aggregates,

12.1.2 Type and source of portland cement,

12.1.3 The alkali content of the cement as percent potassium oxide (K_2O), sodium oxide (Na_2O), and calculated percent NA_2O_e,

12.1.4 Concrete mixture proportions based on SSD aggregates, and corrected for yield,

12.1.5 The amount of sodium hydroxide (NaOH) added to the mixing water, expressed as percent sodium oxide (Na_2O) equivalent by mass of the cement,

12.1.6 The w/c based on saturated, surface dry (SSD) aggregates,

12.1.7 The slump, with mass yield and air content of the concrete batched,

12.1.8 The average length change in percent at each reading of the prisms along with the individual length change in percentage for each prism,

12.1.9 Any significant features revealed by examination of the concrete prisms either during the test or at the end of the test (for example, cracks, gel formation, or peripheral reaction rims on aggregate particles), and

12.1.10 Type of storage container and 38.0 ± 2.0°C (100.4 ± 3.6°F) storage environment used to store the concrete prisms if they differ from those specified in 5.2.1 and 5.3.1.

13. Precision and Bias

13.1 *Multi-Laboratory Precision*:

13.1.1 *Average Expansion Less Than 0.014 %*—The multi-laboratory standard deviation of a single test result (mean of measurements of three prisms) for average expansion less than 0.014 % has been found to be 0.0032 % (CSA A23.2-14A-00).[5] Therefore, results of two properly conducted tests in different laboratories on the same aggregate should not differ by more than 0.009 %, nineteen times out of twenty.

13.1.2 *Average Expansion Greater Than 0.014 %*—The multi-laboratory coefficient of variation of a single test result (mean of measurements of three prisms) for average expansion greater than 0.014 % has been found to be 23 % (CSA A23.2-14A-00).[5] Therefore, results of two properly conducted tests in different laboratories on the same aggregate should not differ from each other by more than 65 % of their average, nineteen times out of twenty.

13.2 *Within-Laboratory Precision*:

13.2.1 *Average Expansion Less Than 0.02 %*—For average expansions of less than 0.02 %, the multi-specimen, within-laboratory standard deviation has been found to be 0.0025 % (CSA A23.2-14A-00). Therefore, the range (difference between highest and lowest) of the three individual prism measurements used in calculating an average test result should not exceed 0.008 %, nineteen times out of twenty.

13.2.2 *Average Expansion Greater Than 0.02 %*—For average expansions of more than 0.02 %, the multi-specimen, within-laboratory coefficient of variation has been found to be 12 % (CSA A23.2-14A-00). Therefore, the range (difference between highest and lowest) of the three individual prism measurements used in calculating an average test result should not exceed 40 % of the average, nineteen times out of twenty.

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

14. Keywords

14.1 aggregate; alkali-silica reactivity; concrete; length change

APPENDIX

(Nonmandatory Information)

X1. Interpretation of Results

X1.1 The question of whether or not criteria based on the results obtained using this test method should be used for acceptance of materials for use as concrete aggregate will be dealt with, if deemed appropriate, in Specification C 33.

X1.2 Work has been reported from which it may be inferred that an aggregate might reasonably be classified as potentially deleteriously reactive if the average expansion of three concrete specimens is equal to or greater than 0.04 % at one year **(7)** (CSA A23.2-27A-00 Table 1).

X1.3 A history of satisfactory field performance in concrete is the best method of evaluating the potential for an aggregate to cause premature deterioration of concrete due to alkali-silica reaction. When field performance of an aggregate in concrete is to be accepted, the following conditions should be met **(8)**:

X1.3.1 The cement content and alkali content of the cement should be the same or higher in the field concrete than is proposed in the new structure.

X1.3.2 The concrete examined should be at least 10 years old.

X1.3.3 The exposure conditions of the field concrete should be at least as severe as those in the proposed structure.

X1.4 This test method supplements the results of other test methods. The results of the other test methods are usually reported before the results of this test method are available. Standards that this test method supplements include: Test Method C 227, Guide C 295, Test Method C 289, and Test Method C 1260. It is recommended that the relevant procedure(s) be performed concurrently with this test method and any discrepancies between the results explained. Care should be exercised in the interpretation of these other test method results **(9-14)**.

X1.5 The use of this test method should especially be considered when other test methods may be inadequate. Some examples of such problems are as follows: The potential reactivity of various varieties of quartz may not be accurately determined by Test Method C 227 since the test method may produce a false-negative result **(3)**. False-negative results are possible with a number of aggregates such as slow-late expanding argillaceous greywackes, strained quartz and microcrystalline quartz associated with strained quartz **(3,4,13)**. False-negative results are also possible due to storage conditions **(9)**, reactive aggregate levels far above or below pessimum **(3)** or insufficient alkali to accelerate the test **(3)**. The potential reactivity of various varieties of quartz may not be accurately determined by Test Method C 1260 since the test method may produce a false-positive result with a number of marginally reactive aggregates **(13)**. Test Method C 1260 may also give a false-negative result with aggregates suspected of containing deleterious strained quartz **(14)**.

X1.6 If the data generated with other test methods and supplemented with information from this test method judge an aggregate to be "not potentially deleteriously alkali-silica reactive," no restrictions are usually required with the use of that aggregate in order to protect against expansion due to alkali-silica reaction **(7)** (see Note X1.1).

X1.7 Additional interlaboratory testing data is provided in Ref **(15)**.

NOTE X1.1—In critical structures such as those used for nuclear containment or large dams, where slight expansions cannot be tolerated, a lower expansion limit may be required.

REFERENCES

(**1**) Diamond, S., "Alkali Reactions in Concrete-Pore Solution Effects," *Proceedings*, 6th International Conference on Alkali-Aggregate Reaction in Concrete, Copenhagen, Denmark, 1983, pp. 155–166.

(**2**) Diamond, S., "ASR—Another Look at Mechanisms," *Proceedings*, 8th International Conference on Alkali-Aggregate Reaction, Kyoto, Japan, 1989, pp. 83–94.

(**3**) Grattan-Bellew, P. E., "Test Methods and Criteria for Evaluating the Potential Reactivity of Aggregates," *Proceedings*, 8th International Conference on Alkali-Aggregate Reaction, Kyoto, Japan, 1989, pp. 279–294.

(**4**) Grattan-Bellew, P. E., "Microcrystalline Quartz, Undulatory Extinction and Alkali-Silica Reaction," *Proceedings*, 9th International Conference on Alkali-Aggregate Reaction in Concrete, Concrete Society, Slough, U.K., 1992, pp. 383–394.

(**5**) Rogers, C. A., and Hooton, R. D., "Comparison Between Laboratory and Field Expansion of Alkali-Carbonate Reactive Concrete," *Proceedings*, 9th International Conference on Alkali-Aggregate Reaction in Concrete, Concrete Society, Slough, U.K., 1992, pp. 877–884.

(**6**) Rogers, C. A., "General Information on Standard Alkali-Reactive Aggregates from Ontario, Canada," Ontario Ministry of Transportation, Engineering Materials Office, 1988, p. 59.

(**7**) Grattan-Bellew, P. E., "Reevaluation of Standard Mortar Bar and Concrete Prism Tests," *Materiaux et Constructions*, Vol 16, No. 94, 1983, pp. 243–250.

(**8**) British Cement Association, "The Diagnosis of Alkali-silica Reaction," British Cement Association, Crowthorne, Berks, RG1 6YS, United Kingdom, Second edition, 1992.

(**9**) Rogers, C. A., and Hooton, R. D., "Reduction in Mortar and Concrete Expansion with Reactive Aggregates Due to Leaching," *Cement, Concrete and Aggregates*, CCAGDP, Vol 13, 1991, pp. 42–49.

(**10**) Bérubé, M. A., and Fournier, B., "Accelerated Test Methods for Alkali-Aggregate Reactivity," *Advances in Concrete Technology*, Malhotra, V. M., ed., Canada Communication Group, Ottawa, 1992, pp. 583–627.

(**11**) Sorrentino, D., Clément, J. Y., and Goldberg, J. M., "A New Approach to Characterize the Chemical Reactivity of the Aggregates," *Proceedings*, 9th International Conference on Alkali-Aggregate Reaction in Concrete, Concrete Society, Slough, U.K., 1992, pp. 1009–1016.

(**12**) Fournier, B., and Bérubé, M. A., "Application of the NBRI Accelerated Mortar Bar Test to Siliceous Carbonate Aggregates Produced in the St. Lawrence Lowlands (Quebec, Canada), Part 1: Influence of Various Parameters on the Test Results, *Cement and Concrete Research*, Vol 21, 1991, pp. 853–862.

(**13**) Hooton, R. D., "New Aggregate Alkali-Reactivity Test Methods," Ontario Ministry of Transportation, Research and Development Branch Report MAT-91-14, November, 1991.

(**14**) Kerrick, D. M., and Hooton, R. D., "ASR of Concrete Aggregate Quarried from a Fault Zone: Results and Petrographic Interpretation of Accelerated Mortar Bar Test," *Cement and Concrete Research*, Vol 22, 1992, pp. 949–960.

(**15**) Fournier, B. and Malhotra, V.M., "Interlaboratory Study on the CSA A 23.2-14A Concrete Prism Test for Alkali-Silica Reactivity in Concrete", *Proceedings*, 10th International Conference on Alkali-Aggregate Reaction in Concrete", CSIRO, Melbourne, Australia, 1996, pp. 302-309.

SUMMARY OF CHANGES

This section identifies the location of changes to this test method that have been incorporated since the last issue.

(*1*) Paragraph 1.1 was revised.
(*2*) Section 2 was updated.
(*3*) Paragraphs 4.1, 4.3, 4.6 and 4.8 were revised.
(*4*) Paragraphs 5.1, 5.2.1 and 5.2.2 were revised.
(*5*) Notes 2-4 were revised.
(*6*) Paragraphs 7.2.1, 7.2.2, 7.3.2, 7.3.3 and 7.3.4 were revised.
(*7*) Paragraphs 10.2, 10.2.2 and 10.4 were revised.
(*8*) Paragraphs 12.1.3, 12.1.6 and 12.1.9 were revised.
(*9*) Paragraphs 13.1.1, 13.1.2, 13.2, 13.2.1, 13.2.2 and 13.3 were revised.
(*10*) Paragraph X1.2 was revised, and X1.7 was added.
(*11*) Reference 15 was added.
(*12*) Summary of Changes was added.