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

This standard is issued under the fixed designation C 1105; 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, the susceptibility of cement-aggregate combinations to expansive alkali-carbonate reaction involving hydroxide ions associated with alkalies (sodium and potassium) and certain calcitic dolomites and dolomitic limestones.

1.2 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard. When combined standards are cited, the selection of measurement system is at the user's discretion subject to the requirements of the referenced 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:*[2]

C 33 Specification for Concrete Aggregates
C 125 Terminology Relating to Concrete and Concrete Aggregates
C 150 Specification for Portland Cement
C 157/C 157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C 233 Test Method for Air-Entraining Admixtures for Concrete
C 294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C 295 Guide for Petrographic Examination of Aggregates for Concrete
C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
C 511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C 586 Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
C 595 Specification for Blended Hydraulic Cements
C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C 702 Practice for Reducing Samples of Aggregate to Testing Size
D 75 Practice for Sampling Aggregates

3. Terminology

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

4. Significance and Use

4.1 Two types of alkali reactivity of aggregates have been described in the literature: the alkali-silica reaction involving certain siliceous rocks, minerals, and artificial glasses (**1**),[3] and the alkali-carbonate reaction involving dolomite in certain calcitic dolomites and dolomitic limestones (**2**). This test method is not recommended as a means to detect combinations susceptible to expansion due to alkali-silica reaction since it was not evaluated for this use in the work reported by Buck (**2**). This test method is not applicable to aggregates that do not contain or consist of carbonate rock (see Descriptive Nomenclature C 294).

4.2 This test method is intended for evaluating the behavior of specific combinations of concrete-making materials to be used in the work. However, provisions are made for the use of substitute materials when required. This test method assesses the potential for expansion of concrete caused by alkali-carbonate rock reaction from tests performed under prescribed

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

[3] 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.**

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 (see Appendix X1).

4.3 Use of this test method is of particular value when samples of aggregate from a source have been determined to contain constituents that are regarded as capable of participation in a potentially deleterious alkali-carbonate rock reaction either by petrographic examination, Guide C 295, by the rock cylinder test, Test Method C 586, by service record; or by a combination of these.

4.4 Results of tests conducted as described herein should form a part of the basis for a decision as to whether precautions be taken against excessive expansion due to alkali-carbonate rock reaction. This decision should be made before a particular cement-aggregate combination is used in concrete construction (see Note 1).

NOTE 1—Other elements that may be included in the decision-making process for categorizing an aggregate or a cement-aggregate combination with respect to whether precautions are needed, and examples of precautions that may be taken, are described in Appendix X1.

4.5 While the basic intent of this test method is to develop information on a particular cement-aggregate combination, it will usually be very useful to conduct control tests in parallel using the aggregate of interest with other cements or the cement of interest with other aggregates.

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/C 157M and Practice C 490, and the molds shall have nominal 75-mm square cross sections.

6. Materials

6.1 *Maximum Size of Coarse Aggregate*—Coarse-aggregate fractions larger than the 19.0-mm sieve shall not be tested as such. When petrographic examination using Guide C 295 reveals that the material making up the size fractions larger than the 19.0-mm sieve is of such a composition and lithology that no differences should be expected compared with the smaller size material to be tested, or when tests, made in accordance with Test Method C 586, of material in such sizes reveal no significant differences from the sizes to be tested, then no further attention need be paid to the larger sizes. If results of petrographic examination or tests made in accordance with Test Method C 586 suggest that the larger size material should be studied for its effects in concrete, one or the other of two alternative procedures described herein may be used.

6.1.1 *Proportional Testing*—Material larger than the 19.0-mm sieve shall be crushed to pass the 19.0-mm sieve and material larger than the 4.75-mm sieve shall be proportioned to include the same proportion by mass of the crushed material originally retained on the 19.0-mm sieve and that originally passing this sieve, as may be expected to be used in the field concrete.

6.1.2 *Separated Size Testing*—Material larger than the 19.0-mm sieve shall be crushed to pass this sieve and shall be used in concrete as a second aggregate.

6.1.2.1 In the case of construction where several size ranges coarser than the 19.0-mm sieve are contemplated, each of these may, if desired, be separately crushed to pass this sieve and may be tested separately.

6.2 *Job Cement*—When it is desired to evaluate a particular cement-aggregate combination for use in particular work, the cement or cements used shall meet the requirements for the work and shall be from the source or sources and in the amounts expected to be used in the work. If several cements may be used in the work, it is desirable that tests be made using each cement separately.

6.3 *Reference Cements*—When it is desired to evaluate aggregates for general use or to compare aggregates for investigational purposes, the cement used shall be of the highest alkali content representative of the general use intended, or available to the laboratory making the tests. The cement or cements selected should comply with Specification C 150 or Specification C 595. Additional information of value may be obtained by conducting parallel tests with cements of different alkali content, of different sodium oxide to potassium oxide ratio, or blended with pozzolan or ground blast-furnace slag, or both.

6.4 *Substitute Fine Aggregate*—If the test aggregate is to be used only as coarse aggregate and the fine aggregate that it will be used with is not available, a fine aggregate that is not expected to participate in an expansive reaction with alkalies (see Note 2) shall be used.

NOTE 2—Advice on judging the expansive reactivity of aggregate is given in Appendix XI of Specification C 33.

7. Sampling

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

8. Test Specimens

8.1 Prepare six specimens, of the type required for concrete Test Method C 157/C 157M, from one batch of concrete. The concrete mixture shall be the mixture in which the aggregates are proposed for use. In the event that no specific concrete mixture is being considered, that described in Test Method C 233 shall be used.

8.2 If control or comparison mixtures are made, specimens shall be made from those mixtures as described in 8.1.

9. Conditioning

9.1 Cure, store, and remove molds in accordance with Test Method C 157/C 157M. Thereafter, keep the specimens in moist storage in accordance with Specification C 511 but do not immerse in water.

10. Procedure

10.1 Follow the procedure of Test Method C 157/C 157M, except that the specimens shall be stored in a moist room or moist cabinet meeting the requirements of Specification C 511 and length measurements shall be made at ages 7, 28, and 56 days, and 3, 6, 9, and 12 months.

11. Calculation

11.1 Calculate the change in length of each of the prisms at each of the ages at which determinations are made and express as a percentage change based on the length at the time of removal from the mold at an age of 23½ ± ½ h. Calculate the average length change in percentage for the group of prisms.

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 Pertinent details about materials and mixtures used,

12.1.2 The length change in percentage for each specimen and for the group of prisms at each test age, and

12.1.3 Description of the circumstances under which results on any one of the specimens are not included in the average.

13. Precision and Bias [4]

13.1 *Precision*:

13.1.1 *Single-Operator Precision*—The precision statement is based on calculations made using data reported by Buck (**2**). The particular within-laboratory variability for which precision is reported was obtained by a single operator, using the same materials and equipment over a short period of time. The single-operator standard deviation (1s[A]) does not vary appreciably with age over the range of 90 through 365 days. Standard deviation varies with the magnitude of the expansion described as follows:

	Average % Expansion	
	<0.040 %	≥0.040 %
Single-operator standard deviation (1s) among individual bars	0.003 %	0.005 %
Maximum difference (d2s[A]) between extreme values within a set of bars in a properly conducted test should not exceed:		
number of bars in set		
6	0.013 %	0.021 %
5	0.012 %	0.020 %
4	0.012 %	0.019 %
3	0.011 %	0.017 %
Calculated expected 1S associated with a mean of 3 bars	0.002 %	0.003 %
Maximum permissible difference between two such means in properly conducted tests should not exceed	0.005 %	0.008 %

[A] As described in Practice C 670.

13.1.2 *Multilaboratory Precision*—In studies involving 12 and 20 laboratories (**8**,9), testing three specimens rather than the six specified in this test method, and testing nominal 19 mm maximum size coarse aggregates known to be susceptible to alkalicarbonate rock reaction, in concrete mixtures with a cement content of 310 kg/m^3 , the multilaboratory precision was found to be as follows:

13.1.2.1 For concrete with an average expansion less than 0.014 % the multilaboratory standard deviation of a single test result (mean of measurements on three prisms) for average expansion less than 0.014 % has been found to be 0.0032 %. Therefore, results of two properly conducted tests in different laboratories using the same aggregate should not differ by more than 0.009 %.[5]

13.1.2.2 For concrete with an average expansion greater than 0.014 % the multilaboratory coefficient of variation of a single test result (mean of measurements on three prisms) for average expansion greater than 0.014 % has been found to be 23 %. Therefore, results of two properly conducted tests in different laboratories using the same aggregate should not differ from each other by more than 65 % of their average.[5]

13.2 *Bias*—A statement on bias has not been developed since no reference materials are available.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: C09-1002.

[5] These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C 670.

APPENDIX

(Nonmandatory Information)

X1. GENERAL INFORMATION

X1.1 The question of whether or not criterion 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 a cement-aggregate combination might reasonably be classified as potentially deleteriously reactive if the average expansion of six concrete specimens is equal to or greater than: 0.015 % at 3 months; 0.025 % at 6 months; or 0.030 % at 1 year (**1**,**2**). Data for later ages are preferred but the 3-month or 6-month average may be used if necessary.

X1.3 If this test method has been performed on a cement-aggregate combination involving an aggregate that has not been examined petrographically using Practice C 295, or that has not been measured by the rock prism expansion in Test Method C 586, it is recommended that one or both of those procedures be performed.

X1.4 When it has been concluded from the results of tests performed using this test method and supplementary information from petrographic examination, rock-prism testing, service records, or combinations of these, that a given cement-aggregate combination is potentially deleteriously expansive, additional studies may be appropriate to develop information on the potential expansion of other combinations containing the same cement with other aggregates, the same aggregate with other cements, or the same cement-aggregate combination with a pozzolan or slag.

X1.5 If a cement-aggregate combination tested using this test method is judged by the results to be "non-reactive," no restrictions on the use of the aggregate with the cement used in the test are necessary in order to protect against probable alkali-carbonate rock reaction. If the combination is judged to be "reactive," measures to control the effects of the reaction (**3**,**4**) include:

X1.5.1 The use of the smallest nominal maximum size coarse aggregate that is practical.

X1.5.2 A maximum of 20 % reactive rock in the coarse aggregate, 20 % reactive rock in the fine aggregate, or a total of 15 % reactive rock if the coarse and fine aggregate both contain reactive rock.

X1.5.3 Use of a cement having no greater an alkali content than a cement tested using test method for which the results are judged to be "non-reactive."

X1.5.4 Additional useful information about this chemical reaction is included in (**5-7**).

REFERENCES

(**1**) Newlon, H. H., and Sherwood, W. C.," A Study of Remedial Methods for Reducing Alkali-Carbonate Reaction,'' *Progress Report No. 4—Potentially Reactive Carbonate Rocks*, Virginia Council of Highways Investigation and Research, May 1963.

(**2**) Buck, A. D., "Control of Reactive Carbonate Rocks in Concrete,'' *Technical Report C-75-3*, U.S. Army Engineer Waterways Experiment Station, CE, September 1975.

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(**4**) Mather, Bryant, "Developments in Specifications and Control,'' *Cement-Aggregate Reaction, Transportation Research Record 525*, National Research Council, 1974, pp. 38–42.

(**5**) Hadley, D. W., "Alkali Reactivity of Dolomitic Carbonate Rocks,'' Highway Research Record 45, Highway Research Board, 1964, pp. 1–19.

(**6**) Walker, H. N., "Chemical Reactions of Carbonate Aggregates in Cement Paste," *Significance of Tests and Properties of Concrete and Concrete-Making Materials, ASTM STP169B*, ASTM, 1978, pp. 722–743.

(**7**) Rogers, C. A., "Evaluation of the Potential for Expansion and Cracking of Concrete Caused by the Alkali-Carbonate Reaction,'' *Cement, Concrete, and Aggregates*, Vol. 8, No. 1, Summer 1986, pp. 13–23.

(**8**) Rogers, C. A.," Interlaboratory Study of the Concrete Prism Expansion Test for the Alkali-Carbonate Reaction," Proceedings of the 7th International Conference on Concrete Alkali-Aggregate Reactions, Ottawa, Published by Noyes Publications, Park Ridge, N.J., 1987, pp. 270–274.

(**9**) Rogers, C. A.," Interlaboratory Study of the Concrete Prism Expansion Test for the Alkali-Carbonate Reaction," *Canadian Developments in Testing Concrete Aggregates for Alkali-Aggregate Reactivity*, Ontario Ministry of Tranportation, Engineering Materials Report EM-92, March 1990, pp. 136–149.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C 1105 – 08, that may impact the use of this test method. (Approved December 1, 2008)

(*1*) Revised 1.2.

Committee C09 has identified the location of selected changes to this test method since the last issue, C 1105 – 05, that may impact the use of this test method. (Approved February 1, 2008)

(*1*) Revised 1.2, 5.1, and 8.1.

(*2*) Removed all informational inch-pound units throughout to conform to ASTM Form and Style.