Designation: ~~C1105 – 23~~ C1105 – 23a

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

This standard is issued under the fixed designation C1105; 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~~ a coarse aggregate or cementitious materials 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 Results of tests conducted as described herein should form a part of the basis for a decision as to whether or not the coarse aggregate or specific combinations of concrete-making materials under test can be used in portland cement concrete construction. Interpretation of results can be found in Guide C1778.

1.3 The text of this standard refers to notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *Units*—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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C33/C33M Specification for Concrete Aggregates
C125 Terminology Relating to Concrete and Concrete Aggregates
C150/C150M Specification for Portland Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
~~C233/C233M Test Method for Air-Entraining Admixtures for Concrete~~

[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] 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**

C294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C295/C295M Guide for Petrographic Examination of Aggregates for Concrete
C490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
C494 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
C586 Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
C595/C595M Specification for Blended Hydraulic Cements
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C702/C702M Practice for Reducing Samples of Aggregate to Testing Size
C856/C856M Practice for Petrographic Examination of Hardened Concrete
C1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
C1778 Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete
D75/D75M Practice for Sampling Aggregates

3. Terminology

3.1 Terminology used in this standard is defined in Terminology C125 or Descriptive Nomenclature C294.

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 C294).

4.2 This test method ~~is intended for evaluating the~~ contains two methods. Method A is used to evaluate the susceptibility of a coarse aggregate to alkali-carbonate reaction. Method B is to evaluate the behavior of specific combinations of concrete-making materials to be used in ~~the work.~~concrete construction. 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 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~~ these.~~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 C295/C295M, by the rock cylinder test, Test Method C586, 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~~or not the aggregate under test can be used in portland cement concrete construction. Interpretation of results can be found in Guide C1778~~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 At the conclusion of the test it may be useful to conduct petrographic examination on the concrete following Practice C856/C856M and the aggregate following Guide C295/C295M to confirm that the aggregate causing expansive behaviour of the concrete, if any, is comparable to the petrography and chemistry of known deleteriously expansive alkali-carbonate reactive rocks. It is important to check the presence of potentially reactive silica that may not necessarily be visible at the scale of conventional transmitted light optical microscopy examination.

4.6 ~~While the basic intent of~~ The research, evaluation, and precision and bias statement for this test method ~~is to develop~~

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

~~information on a particular cement-aggregate combination, it~~were done on crushed quarried carbonate coarse aggregate ~~will~~(3). ~~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.~~Therefore, the results of evaluating alkali-carbonate reactive expansion of manufactured fine aggregate or natural sand containing crusher screenings derived from quarried carbonate rocks is unknown. Further, the applicability of this test to gravels containing carbonate rocks suspected of being alkali-carbonate reactive is unknown and as far as is known has not been evaluated.

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 C157/C157M and Practice C490, and the molds shall have nominal ~~75-mm square cross sections.~~75 mm square cross sections and nominal 285 mm length.

6. Materials for Method A – Aggregate Reactivity Determination

6.1 *Materials:*

6.1.1 To evaluate the potential alkali-carbonate reactivity of a coarse aggregate, use an alkali-silica nonreactive fine aggregate. An alkali-silica nonreactive fine aggregate is defined as an aggregate that develops an expansion in the accelerated mortar bar, (see Test Method C1260) of less than 0.10 % at 14 days (see Guide C1778 for interpretation of expansion data). Use a fine aggregate meeting Specification C33/C33M.

6.1.2 Sieve the coarse aggregate and recombine in accordance with the requirements in Table 1. Select the Table 1 grading based on the as-received grading of the sample. Coarse aggregate fractions larger than 19.0 mm sieve are not to be tested as such. When petrographic examination using Guide C295/C295M reveals that the material making up the size fraction larger than the 19.0 mm 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 have a different reactivity, the material should be studied for its effect in concrete according to one of the other alternative procedures described herein:

6.1.2.1 *Proportional Testing*—Crush material larger than the 19.0 mm sieve to pass the 19.0 mm sieve. The crushing operation shall be performed in a manner that minimizes production of material passing the 4.75 mm sieve. Grade this crushed material in accordance with the Table 1 grading and add to the original mass of graded aggregate produced in 6.1.2 such that the ratio of crushed, graded, oversize aggregate to total graded aggregate equals the ratio of material retained on the 19.0 mm sieve to the total material retained above the 4.75 mm sieve (see Note 1).

NOTE 1—For example, if the material retained on the 19 mm sieve formed 25 % of the total material retained above the 4.75 mm sieve, then the mass of crushed and returned oversize material shall form 25 % of the total graded aggregate.

6.1.2.2 *Separated Size Testing*—Crush material larger than the 19.0 mm sieve to pass the 19.0 mm sieve, grade that material as in accordance with Table 1 and test in concrete as a separate aggregate. In the event that the required aggregate gradation is not available or supplied, include that in the reporting section according to 13.1.5.

6.1.3 *Cement*—An ASTM C150 Type I cement shall be used.

6.2 *Reagents:*

6.2.1 *Sodium Hydroxide (NaOH)*—USP or technical grade may be used. (**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 manufacturers

TABLE 1 Gradation Requirement for Coarse Aggregate in Procedure A

Sieve Size		Mass Fraction	
Passing	Retained	Coarse	Intermediate
19.0 mm	12.5 mm	⅓	...
12.5 mm	9.5 mm	⅓	½
9.5 mm	4.75 mm	⅓	½

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.)

6.2.2 *Water*—Use potable tap water for mixing and storage.

6.3 *Mixture Proportions:*

6.3.1 *Aggregate Content*—The aggregate shall be proportioned in a coarse to fine aggregate ratio of 60:40 by mass.

6.3.2 *Cement Content*—The total cement content in the concrete mixture shall be 310 kg/m^3 ± 10 kg/m^3.

6.3.3 *Concrete Alkali Loading*—The cement used shall produce an alkali loading in the final concrete not less than 1.80 kg/m^3 and not greater than 3.10 kg/m^3. (See Note 2.)

NOTE 2—This range of alkali loadings is known to identify alkali-carbonate reactive rocks. Some very highly reactive alkali-silica reactive rocks may react at a test temperature of 23 °C. (**4**)

Determine the total alkali content of the cement either by analysis or by obtaining a mill certificate from the cement manufacturer. If needed add NaOH to the concrete mixing water to produce the alkali loading required in this section (see Note 3).

6.3.4 *Example A:*
(Cement Only)

Cement content of concrete	= 310.0 kg/m^3
Amount of alkali in the concrete	= 310.0 kg/m^3 × 0.52 %
	= 1.61 kg/m^3
Required amount of alkali in concrete (1.80 to 3.10 kg/m^3)	
Target 2.50 kg/m^3	
Amount of alkali to be added to concrete	= 2.50 kg/m^3 – 1.61 kg/m^3
	= 0.89 kg/m^3

The difference (0.89 kg/m^3) is the amount of alkali, expressed as Na_2O_{eq}, to be added to the mix water. The factor to convert Na_2O to NaOH since:

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

Compound	Molecular Weight
Na_2O	61.980
NaOH	39.997

Conversion factor:

$$2 \times 39.997 / 61.980 = 1.291 \quad (1)$$

Amount of NaOH required in Example A:

$$0.89 kg/m^3 \times 1.291 = 1.15 kg/m^3 \quad (2)$$

NOTE 3—Example calculations for determining the amount of NaOH to be added to the mixing water to increase the alkali content of the cement from 1.61 kg/m^3 to 2.50 kg/m^3 assuming a cement alkali content of 0.52% Na_2O_{eq}. This would produce a cement alkali content between 1.80 kg/m^3 and 3.10 kg/m^3 per the test method.

6.3.5 *Water to Cement Materials 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. If necessary to obtain sufficient workability within the required w/c range, use of a high-range water reducer (HRWR), meeting the requirements of Specification C494 Type F is permitted. If, within the required w/c range, specimens representative of the concrete mixture cannot be fabricated due to excessive bleeding or segregation, the use of a viscosity modifying admixture (VMA) is permitted. Report the w/c ratio used and the amount, if any, of HRWR or VMA.

7. Materials for Method B – Cementitious Material-Aggregate Combination Reactivity Determination

7.1 *Maximum Size of Coarse Aggregate*—Coarse-aggregate fractions larger than the 19.0-mm19.0 mm sieve shall not be tested as such. When petrographic examination using Guide C295/C295M reveals that the material making up the size fractions larger than the 19.0-mm19.0 mm sieve is of such a composition and lithology that no differences should be expected compared with the