Designation: C 586 – 05

Standard Test Method for
Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)[1]

This standard is issued under the fixed designation C 586; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of the expansion of a specimen of carbonate rock while immersed in a solution of sodium hydroxide (NaOH) at room temperature. The length changes occurring during such immersion indicate the general level of reactivity of the rock and whether tests should be made to determine the effect of aggregate prepared from the rock upon the volume change in concrete.

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 units in parentheses are provided for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [2]
C 294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C 295 Guide for Petrographic Examination of Aggregates for Concrete
C 1105 Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction
D 75 Practice for Sampling Aggregates
D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

3. Terminology

3.1 For definitions of terms relating to aggregates used in this test method, refer to Descriptive Nomenclature C 294.

4. Summary of Test Method

4.1 Small rock cylinders are immersed in a solution of NaOH except when removed for determination of length change. The length change of each specimen is periodically determined.

5. Significance and Use

5.1 This test method is intended to give a relatively rapid indication of the potential expansive reactivity of certain carbonate rocks that may be used as concrete aggregates. The test method has been successfully used in (*1*) research and (*2*) preliminary screening of aggregate sources to indicate the presence of material with a potential for deleterious expansion when used in concrete.

5.2 The test method is intended as a research and screening method rather than as the basis of a specification requirement. It is intended to supplement data from field service records, petrographic examinations according to Guide C 295, and tests of aggregate in concrete according to Test Method C 1105.

5.3 Alkalies participating in the expansive reactions with aggregate constituents in concrete usually are derived from the hydraulic cement; under certain circumstances they may be derived from other constituents of concrete or from external sources. Two types of alkali reactivity of aggregates are recognized: (*1*) alkali-silica reaction involving certain siliceous rocks, minerals, and artificial glasses, and (*2*) alkali carbonate reaction involving dolomite in certain calcitic dolomites, dolomitic limestones, and dolostones. This test method is not suitable as a means to detect alkali-silica reaction.

6. Apparatus and Reagents

6.1 *1 N Sodium Hydroxide Solution*—Dissolve 40 ± 1 g of reagent-grade sodium hydroxide (NaOH) in distilled water, dilute to 1 L and store in a polyethylene bottle.

6.2 *Sawing, Drilling, and Grinding Equipment*, suitable for preparing test specimens of the dimensions given in Section 8. This will require one or more rock saws, depending upon the size of the original sample, a drill press equipped with a small diamond core barrel for removing the cylindrical core, and a lap, grinder, or suitable modified lathe for shaping the ends of the specimens.

6.3 *Storage Bottles*, approximately 50 to 100-mL capacity with caps and openings of sufficient size to facilitate removal of specimens. The polyethylene bottle shall be selected to ensure that the solution will not be modified by reaction with the material composing the container, including pigments or other additives or by transpiration of phases through the walls of the container. Bottles with wall thickness not less than 0.50 mm (0.020 in.) and composed of high density polyethylene meeting the requirements of Specification D 1248 for materials of Type III, Class A, are suitable.

6.4 *Length Comparator*, for convenient and rapid measurement of lengths of specimens, the comparator shall be of such design as to provide, permit, or include the following characteristics. One type of comparator which has been found satisfactory is shown in Fig. 1.

6.4.1 A positive means of contact with the conical ends of the specimen to ensure reproducible measurement of length. A
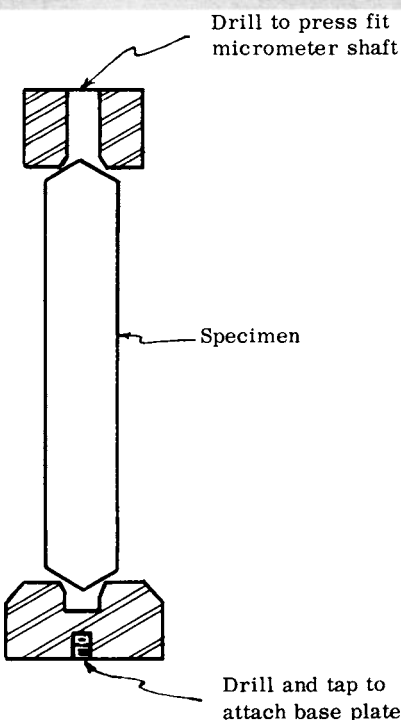

FIG. 1 A Typical Length Comparator

variety of contact points have been used successfully. Care should be exercised to ensure that when using specimens with conical ends as described in 8.3, contact is made on the end along a circle which is concentric about the long axis of the specimen. If the measuring device is a barrel micrometer, it shall have a ratchet stop to produce a constant pressure on the specimen,

6.4.2 A high-grade barrel or dial micrometer graduated to read in 0.001 or 0.002–mm (0.0001–in.) units, and accurate within 0.002 mm (0.0001 in.) in any 0.020–mm (0.0010–in.) range, and within 0.004 mm (0.0002 in.) in any 0.200–mm (0.0100–in.) range. The measuring device should be calibrated throughout its range to determine both periodic and cumulative errors for proper correction of observed data.

6.4.3 A sufficient range to allow for small differences among gage lengths of various specimens. If care is taken in the fabrication of the specimens, a measuring device with a travel of not less than 7.5 mm (0.3 in.) provides ample range in the instrument, and

6.4.4 A standard or reference shall be used for checking the measuring device at regular intervals. The bar that serves as a reference for the length comparator shall have an over-all length of 35 ± 2 mm (1.38 ± 0.08 in.) The length of the bar shall be known to an accuracy of 0.002 mm (0.0001 in.). The bar shall be fused silica or a steel alloy having a coefficient of thermal expansion not greater than 1.0×10^{-6}°C. Each end shall be machined to the same shape as that of the rock specimens. If a steel alloy is used, it shall be polished (See Note 1). The reference bar shall be placed in the instrument in the same position each time a length measurement is made. The micrometer setting of the measuring device shall be checked by use of the reference bar at least at the beginning and end of the readings made within a half day when the apparatus is kept in a room maintained at constant temperature. It shall be checked more often when kept in a room where temperature is not constant.

NOTE 1—Steel alloys with low thermal expansion coefficient should not be heat treated because they lose their low coefficient of thermal expansion when so treated.

7. Sampling

7.1 Sample the rock in accordance with the applicable requirements of Practice D 75, except that the sample mass of each discernable stratum shall be at least 1 kg, and individual pieces shall be not less than 75 × 75 × 75 mm in size.

7.2 Sampling should be under the direction of an individual capable of distinguishing differences in lithology, and the sample of rock should be taken to represent only the particular lithology under consideration bearing in mind the limitations and significance of this method as stated in Section 5. Each sample of rock should be in one piece of sufficient size for preparing the necessary test specimens.

7.3 One test specimen will sufficiently represent the sample of rock unless shale seams or other discontinuities are present or the bedding is not discernible. In these cases, prepare and test 3 mutually perpendicular specimens. Of such three specimens that one showing the greatest length change after 28 days of immersion in alkali solution as determined in 9.7 shall be used. Discard the remaining two.

8. Test Specimens

8.1 Test specimens shall be in the form of right circular cylinders or square prisms with conical or plane parallel ends, unless otherwise specified.

8.2 The specimen shall have an over-all length of 35 ± 5 mm (1.38 ± 0.20 in.) and a diameter or sides of 9 ± 1 mm (0.35 ± 0.04 in.) for cylinders and prisms respectively. Care shall be exercised in the preparation of the specimens to avoid alteration of the cylindrical surface by polishing or with materials which will affect the rate of entry of alkali solution into the rock.

8.3 The included angle of the conical ends shall be approximately 120°.

8.4 Fabricate specimens having flat–end faces in such a manner as to ensure that the faces are parallel to each other and perpendicular to the major axis of the specimen (see Note 2).

NOTE 2—End faces parallel to each other and perpendicular to the major axis of the specimen can be made by turning the specimen in a small lathe and using tool steel to cut the ends.

9. Procedure

9.1 Place a position mark on the specimen to permit placing the specimen in the comparator in the same position during subsequent measurements.

9.2 Measure the length of the test specimen.

9.3 Immerse the specimen in distilled water at a room temperature in the range of 20 to 27.5 °C (68 to 81.5 °F).

9.4 At intervals, remove the specimen, blot to remove excess surface water and measure until the change in length during a 24-h water immersion period does not exceed 0.02 % as calculated in 10.1. The length when in this condition is taken as the reference length. The reference length is usually achieved after 1 to 4 days of immersion.

9.5 Immerse the water-saturated specimens in a bottle containing a minimum of 35 mL of 1N NaOH solution per specimen at room temperature and seal. Immerse no more than two specimens in a bottle.

9.6 Measure the length of the specimens after 7, 14, 21, and 28 days of immersion in NaOH solution and at 4-week intervals thereafter. If the tests continue beyond 1 year, make measurements at 12-week intervals.

9.7 When measurements are made, remove the specimen from the bottle, rinse with distilled water, blot to remove excess surface water and determine its length in the same position as during the initial measurement.

9.8 After measurement, immediately return the specimen to the bottle and reseal.

9.9 Replace the solution every 6 months during the testing period.

10. Calculation

10.1 Calculate the length change to the nearest 0.01 % of the reference length as follows:

$$\Delta l = [(l_1 - l_0)/l_0] \times 100 \qquad (1)$$

where:
Δl = % length change at test age,
l_1 = length in mm (in.) at test age, and

l_0 = reference length after equilibrium in water, as outlined in 9.4.

11. Report

11.1 Report the following:

11.1.1 Identification number,

11.1.2 Type and source of rock,

11.1.3 Specimen shape and dimensions if other than right circular cylinder,

11.1.4 Length change in percent to the nearest 0.01 % at each time of measurement. Where no times of measurement are specifically requested, data should be presented for at least the following ages: 1, 4, 8, and 16 weeks and the age at the final measurement.

11.1.5 Significant features revealed by examination of specimen during and after storage in alkali solution, such as cracking, warping, splitting, etc., and

11.1.6 Other significant information as deemed necessary, such as petrographic and chemical analyses.

12. Precision and Bias

12.1 *Precision*:

12.1.1 If the results of replicate specimens measured by the same operator and which presumably represent the same material, differ by more than 0.10 percentage point for expansions less than 1.0 %, it is highly probable that the specimens represent rocks that are significantly different in chemical composition, texture, or both.

12.1.2 The single-operator, single-comparator, single-specimen precision has been found to be ±0.02 percentage point (3S) as defined in Practice E 177.

12.1.3 The multi-operator, single-comparator, single-specimen precision has been found to be ±0.03 percentage point (3S) as defined in Practice E 177.

12.1.4 The multi-operator, multi-comparator, single-specimen precision has been found to be ±0.05 percentage point (3S) as defined in Practice E 177.

12.1.5 In a single laboratory, single operator study of the range of expansion of pairs of rock cylinders from 29 samples of rock from a single quarry (each pair of cylinders cut from a different sample block approximately 75 × 75 × 50 mm in size), the following data were found:

12.1.5.1 For pairs of specimens giving average expansion of less than 0.50 %, the average standard deviation was found to be 0.0255 %[3]; therefore, the difference in expansion between pairs of cylinders cut from a single block should only exceed 0.072 %[3] one time in twenty when the average expansion is less than 0.50 %.

12.1.5.2 For pairs of specimens giving average expansion of more than 0.50 %, the average standard deviation was found to be 0.095 %[3]; therefore, the difference in expansion between pairs of cylinders cut from a single block should only exceed 0.269 %[3] one time in twenty when the average expansion is more than 0.50 %.

12.2 *Bias*—The procedure in this test method for measuring expansion has no bias because the expansion can be defined only in terms of this test method.

13. Keywords

13.1 aggregate; alkali reactivity; carbonate rocks; concrete; deleterious expansion

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

APPENDIX

(Nonmandatory Information)

X1. Interpretation of Results

X1.1 Since the expansion caused by reactions between cement alkalies and carbonate aggregates is sensitive to subtle changes in aggregate lithology, the results of measurements should be interpreted with full recognition of the variables which would affect the results obtained. The acceptance or rejection of aggregate sources based solely on the results of this test is not recommended since, in commercial production, expansive and nonexpansive materials may occur in close proximity and the securing of samples adequately representative of the variability of the production of the source is a difficult task and requires the efforts of an individual trained to distinguish differences in lithology.

X1.2 The relationship of the test results to the behavior of large quantities of rock from a given source will depend upon the degree to which the petrographic and chemical properties of the rock vary within the source.

X1.3 Research results have indicated that the expansive behavior of aggregate in concrete is qualitatively predicted by the results of the rock cylinder test. Quantitative prediction of the expansion of concrete containing reactive aggregate depends upon (*1*) the degree of aggregate reactivity, (*2*) the amount of reactive constituent, (*3*) the alkali content of the cement, and (*4*) the environment. Appreciable expansion should indicate the need for further testing. In the light of current knowledge, it appears that expansions in excess of 0.10 % are indicative of chemical reaction and should warrant additional testing preferably in concrete using Test Method C 1105. Usually expansive tendencies are evident after 28 days of immersion in alkali, however, exceptions to this have been noted. Deleterious expansion of concrete appears to depend

upon the magnitude and rate of aggregate expansion and the time at which it begins; however, quantitative predictions of concrete expansion in service solely from results of this test method are not possible.