

Recommend Approval: _____ Assistant Division Chief Date _____ Division Chief Date	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
Approved: _____ Director Date	ACCELERATED DETECTION OF POTENTIALLY DELETERIOUS EXPANSION OF MORTAR BARS DUE TO ALKALI - SILICA REACTION AGGREGATE OR AGGREGATE/POZZOLAN COMBINATION	MSMT 212

SCOPE:

This procedure is used for detecting the potential for deleterious expansion of mortar bars due to the alkali-silica reaction.

This procedure may involve hazardous materials, operations, and equipment, however, it does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety practices and determine the applicability of regulatory limitations prior to use. A specific precautionary statement is provided in **Note 3**.

REFERENCE DOCUMENTS:

- C 227** Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
- C 1240** Specification for Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
- M 85** Portland Cement
- M 92** Wire-Cloth Sieves for Testing Purposes
- M 201** Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
- M 210** Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
- M 240** Blended Hydraulic Cement
- M 295** Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
- M 302** Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
- T 106** Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2 in. Cube Specimens)
- T 162** Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

SIGNIFICANCE AND USE:

This test procedure provides a means of detecting the potential of an aggregate or aggregate/pozzolan combination used in concrete for undergoing alkali-silica reaction and resulting potentially deleterious internal expansion in sixteen days. It is based on the national building research institute in South Africa Accelerated Test Method. It provides an alternative method to C 227 and may be especially useful for aggregates that react slowly or produce expansion late in the reaction.

MATERIALS AND EQUIPMENT:

1. Refer to M 210, except as follows:
2. Square hole, woven-wire cloth sieves conforming to M 92.
3. Mixer, paddle, and mixing bowl conforming to T 162, except that the clearance between the lower end of the paddle and the bottom of the bowl shall be 0.20 ± 0.01 in.
4. Tamper and trowel conforming to T 106.
5. Containers that will allow the bars to be totally immersed in the water or 1N NaOH solution and are made of materials that will withstand prolonged exposures to 176 F and are inert to the 1N NaOH solution. The containers shall be constructed so that the loss or gain of moisture is prevented by tight fitting covers, by sealing, or both when used for storing. The bars shall be placed and supported so that the solution has access to the entire bar; therefore, the specimens shall not come in contact with the sides of the container or each other. Upright standing specimens in the solution shall not be supported by the metal gauge stud.

NOTE 1: NaOH solutions corrode glass or metal containers. Rubbermaid container #7 or similar microwaveable food storage containers are acceptable for this test. Supports for the specimens to rest on during the test may be cut from small diameter PVC plumbing pipe.

6. Mechanical convection oven or water bath capable of maintaining 176 ± 3 F.
7. Moist closet or room conforming to M 201.

The relative humidity of the molding room shall be not less than 50 percent.

8. Reagents:

- (a) 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.
- (b) Sodium hydroxide solution - Each liter of solution shall contain 40.0 grams 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 to 1 volume of mortar bars.

NOTE 2: The volume of a mortar bar may be taken as 11.25 in^3 .

NOTE 3: PRECAUTION: Before using NaOH, review the following:

- (1) Safety precautions for using NaOH,
- (2) First aid for burns, and
- (3) Material Safety Data Sheet supplied by the manufacturer or other reliable safety literature.
- (4) Procedures for emergency response to spills.

NaOH can cause very severe burns and injury to unprotected skin and eyes. Suitable personal protective equipment should always be used. This equipment should include full face shields, rubber aprons, and gloves impervious to NaOH. Gloves should be checked periodically for pin holes.

CONDITIONING

The molding room and dry materials shall be maintained between 68 and 81 F.

SAMPLING AND PREPARATION OF TEST SPECIMENS

1. Selection of Aggregate. Materials proposed for use as fine aggregate in concrete shall be processed as described in Step 2 of this section with a minimum of crushing. Materials proposed for use as coarse aggregate in concrete shall be processed by crushing to produce as nearly as practical a graded product which can be obtained. The sample shall have the grading as described in Step 2 and be representative of the composition of the coarse aggregate proposed for use.

When a given quarried material is proposed for use both as coarse and as fine aggregate, it will be tested only by selection of an appropriate sample crushed to the fine aggregate sizes, unless there is reason to expect that the coarse size fractions have a different composition than the finer sizes and that these differences might significantly affect expansion due to reaction with the alkalis in the cement. In this case the coarser size fractions shall be tested in a manner similar to that employed in testing the fine aggregate sizes.

2. Preparation of Aggregate. Aggregates to which this test method is applied shall be graded as specified in TABLE 1. Aggregates containing insufficient quantities of the sizes specified in TABLE 1 shall be crushed until the required materials have been produced. When aggregates containing insufficient amounts of one or more of the larger sizes listed in TABLE 1 shall be

used because 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. The test report shall document the use for such procedures. After the aggregate has been separated into the various sieve sizes, each size shall be washed with a water spray over the sieve to remove adhering dust and fine particles from the aggregate. The portions retained on the various sieves shall then be dried and each portion not used immediately shall be stored individually in a clean container with a tight fitting cover.

**TABLE 1
GRADING REQUIREMENTS**

SIEVE SIZE		PERCENT, BY WEIGHT
PASSING	RETAINED	
No. 4	No. 8	10
No. 8	No. 16	25
No. 16	No. 30	25
No. 30	No. 50	25
No. 50	No. 100	15

SELECTION AND PREPARATION OF CEMENT

1. Portland Cement shall conform to M 85.

NOTE 4: Since the specimens are exposed to a NaOH solution, the alkali content of the cement is not a significant factor in affecting expansions.

2. Preparation of Cement. Cement for use in this test shall be passed through a No. 20 sieve to remove lumps before use.

3. Blended Hydraulic Cement. The blended hydraulic cement shall conform to M 240 Type IP, or Type I (PM) except that the pozzolan content shall be between 15 to 25 percent of the weight of the portland-pozzolan cement.

4. Selection of Pozzolans:

- (a) Fly Ash shall conform to M 295, Class F.
- (b) Ground Iron Blast-Furnace Slag shall conform to M 302, Grade 100 or 120.
- (c) Microsilica shall conform to C 1240, and the oversize requirement is waived.

NOTE 5: For this test method, a pozzolan is considered to be a fly ash, a ground iron blast-furnace slag, or a micro-silica.

5. Preparation of Test Specimens.

- (a) **Number of Specimens.** At least three test specimens for each cement-aggregate or cement-aggregate-pozzolan combination.
- (b) **Preparation of Molds.** As specified in M 210 except, that the interior surfaces of the mold shall be covered with a release agent. A release agent is acceptable if it does not affect the setting of the cement or leave a residue that inhibits the penetration of water into the specimen.

NOTE 6: 3M's TFE-fluorocarbon tape #63 has been found to perform satisfactorily.

6. Proportioning of Mortar. Proportion the dry materials for the test mortar by using the specified materials in one of the following combinations:

- (a) 1 part portland cement to 2.25 parts aggregate by weight conforming to TABLE 1.
- (b) 1 part blended cement to 2.25 parts aggregate by weight conforming to TABLE 1.
- (c) 1 part portland cement, replacing 15 to 25 percent of its weight with fly ash to 2.25 parts aggregate by weight conforming to TABLE 1.
- (d) 1 part portland cement, replacing 25 to 50 percent of its weight with ground iron blast-furnace slag to 2.25 parts aggregate by weight conforming to TABLE 1.
- (e) 1 part portland cement, replacing 5 to 7 percent of its weight with microsilica to 2.25 parts aggregate by weight conforming to TABLE 1.

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 cement or cement/pozzolan 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 to cement ratio equal to 0.47 by weight. Quantity of replacement cement used by the Contractor shall be noted, if applicable.

7. Mixing of Mortar - As specified in T 162.

8. Molding of Test Specimens - Mold test specimens with a total elapsed time of not more than 2 minutes and 15 seconds 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.

TEST PROCEDURE:

- 1. Initial Storage and Measurement** - Place each mold in the moist cabinet or room immediately after molds have been filled. Remove the specimens from the molds after 24 ± 2 hours and, while still protected from loss of moisture, promptly identify and measure the initial length. Make and record the initial and all subsequent measurements to the nearest 0.0001 in. Place the specimens of each aggregate sample in a storage container with enough tap water to totally immerse them. Seal and place the containers in an oven maintained at 176 ± 3 F for a period of 24 hr.
- 2. Zero Measurements** - 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. Remove the bars one at a time from the water and dry the surface and the two metal gage measuring studs with a towel. Read the zero measurement of each prism as soon as the bar is in position after drying. Complete the process of drying and measuring the specimen within 15 ± 5 seconds of removal from the water. After measurement, leave the specimen on a towel until the remainder of the bars have been measured. Place all specimens in separate containers with sufficient 1N NaOH at 176 ± 3 F for the samples to be totally immersed. Seal the containers and return them to the test environment.

NOTE 7: The comparator bar should be measured prior to each set of specimens since the heat from the mortar bars may cause the length of the comparator to change.

- 3. Subsequent Storage and Measurement** - Measure the specimens periodically at approximately the same time each day for 14 days after the zero reading, taking at least three intermediate readings. The measuring procedure is identical to that described in **TEST PROCEDURE 2 (Zero Measurements)**, except that each specimen is returned to its original container after measurement.

CALCULATIONS:

1. Calculate the difference between the zero length of the specimen and the length at each measurement to the nearest 0.001 percent 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 cement-aggregate or cement-aggregate-pozzolan combination to the nearest 0.01 percent as the expansion for the combination for a given period.

2. When the mean expansion of the test specimens exceeds 0.10 percent at 16 days from casting (14 days from zero reading), it is indicative of potentially deleterious expansion.
3. When the mean expansion of the test specimens is 0.10 percent or less at 16 days after casting, it is indicative of innocuous results.

REPORT:

1. Report the average expansion of the three specimens to the nearest 0.01 percent.