VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

MEMORANDUM

GENERAL SUBJECT: **HYDRAULIC CEMENT CONCRETE REPAIR MATERIALS**	**NUMBER:** **MD 396-16**
SPECIFIC SUBJECT: **Requirements for Materials Divisions Approved List No. 31 and VTM 132 defining the tests required for approving hydraulic cement concrete repair materials.**	**DATE:** **March 31, 2016** **SUPERSEDES:**
APPROVED:	**Charles A. Babish, PE** **State Materials Engineer** **Approved:_____**

EFFECTIVE DATE

This memorandum is effective upon being published.

PURPOSE

This Memorandum notifies the users of the VDOT's Materials Division's List of Approved products, that Approved List No.31, Hydraulic Cement Concrete Repair Materials, has been revised. This revision has broadened the scope of materials to be used in the repair of concrete items. List 31 will now have three tables each with different requirements to better align it for the class of concrete being patched. Also included is VTM 132 to describe the types of tests needed and how to perform each test for product approval on list 31.

Changes are Shaded

PROCEDURES

Replace present Approved List No. 31 with the updated version.
Add link to VTM 132 to Approved List No. 31 for easy access.

NOTES

No products on the current Approved List No. 31 will be taken off the list during the update. Some of the materials on the current Approved List No. 31 do not have the entire range of test data needed for the new requirements. VDOT will work with these manufacturers to get the needed data.

REFERENCES

See attached Approved List No. 31 and VTM 132.

COPY DISTRIBUTION:

Deputy Chief Engineer
Division Administrators
District Administrators
District Location & Design Engineers
District Construction Engineers
District Maintenance Engineers
District Bridge Engineers
District Traffic Engineers
VDOT Resident Engineers
Federal Highway Administration
Virginia Ready Mix Association
Precast Concrete Association of Virginia
Virginia Transportation Construction Alliance
Virginia Asphalt Association
American Concrete Paving Association Mid-Atlantic Chapter
Old Dominion Highway Contractors Association

(31) HYDRAULIC CEMENT CONCRETE REPAIR MATERIALS – (Physical Lab)

The following lists of products are approved for use in repair of hydraulic cement concrete. These concrete repair materials meet the requirements of VTM 132 for repair of class A3, A4 or A5 concrete.
Table I repair materials are for repair of A3 Concrete Items
Table II repair materials are for repair of A4 Concrete Items.
Table III repair materials are for repair of A5 Concrete Items.
Products in Table III can also be used to repair A5, A4 and A3 concrete items. Products in Table II can be used to repair A4 and A3 concrete items. Product listed in Table I can only be used to repair A3 concrete items.
Products will be assigned to the highest table in which all the specifications are met.

All packaged, dry, rapid hardening repair materials shall meet the requirements of ASTM C 928, Section 4-**Chemical Composition.**

Table I (A3)

Approved concrete repair materials for A3 Concrete and miscellaneous concrete Items

Product	**Manufacturer**	**Description**	**Test Results**
All Approved concrete repair materials for A4 and A5 concrete items listed in Table II and Table III.			

(31) HYDRAULIC CEMENT CONCRETE REPAIR MATERIALS – (continued)

Table II (A4)

Approved concrete repair materials for A4 Concrete Items

Product	Manufacturer	Description	Test Results
All Approved concrete repair materials for A5 concrete items listed in Table III.			
Commercial Grade FastSet DOT Mix	The Quikrete Companies	A fiber reinforced, rapid-setting repair material specifically designed for a high-performance repair material. 55 lb. bag can be extended.	Setting Time – Initial Final Compressive Strength – 1.5 hrs. 5020 28 days 8490
Commercial Grade FastSet DOT Mix Extended	The Quikrete Companies	A fiber reinforced, rapid-setting repair material specifically designed for a high-performance repair material. 80 lb. bag already extended.	Setting Time – Initial Final Compressive Strength – 1.5 hrs. 2780 28 days 6160
Duracrete II FT	Kaufman Products Inc.	Very rapid setting, non-staining, and non-metallic cementitious repair mortar.	Setting Time – Initial 11 min. Final 14 min. Compressive Strength – 2 hrs. 4480 28 days 8980
Euco Repair V100	The Euclid Chemical Company	A single-component, quick-setting, low shrinkage repair mortar for trowel applied vertical and overhead repairs requiring.	Setting Time – Initial 11 min. Final 14 min. Compressive Strength – 6 hrs. 3080 28 days 5070
High Power D.O.T. Grade Repair Mortar	US Concrete Products	A single component, high early strength concrete repair product designed for the rapid repair of roadways, decks and slabs. The material is easily mixed and placed, and is fully cured in less than two hours.	Setting Time: Initial 11 min. Final 17 min. Compressive Strength – 2 hrs. 3540 28 days 6110
Planitop 18 ES	MAPEI	A one component, cementitious repair mortar with a corrosion inhibitor. It is suited for horizontal concrete repairs.	Setting Time – Initial 55 min. Final 60 min. Compressive Strength – 6 hrs. 5,870 28 days 9,410

(31) HYDRAULIC CEMENT CONCRETE REPAIR MATERIALS – (continued)

Table III (A5)
Approved concrete repair materials for A5 Concrete Items

Product	Manufacturer	Description	Test Results
ChemPatch Fast VO	ChemMasters	A one component, polymer modified shrinkage compensated, very fast setting, non-shrink repair mortar with fiber and corrosion inhibitor.	Setting Time – Initial 17 min. Final 19 min. Compressive Strength – 1 day 6,500 28 days 9,060
Planitop 11 SCC	MAPEI	A one component cementitious, self-consolidating polymer modified concrete mix pre extended with coarse aggregate.	Setting Time – Initial 7 hrs. 30 min. Final 9 hrs. 50 min. Compressive Strength – 28 days 12,250
Planitop 12 SR	MAPEI	A sulfate resistant one component, shrinkage compensated cementitious repair mortar. Fiber reinforced, contains both silica fume and a corrosion inhibitor and is intended for the repair of vertical, overhead and horizontal concrete surfaces.	Setting Time – Initial 225 min. Final 400 min. Compressive Strength – 28 days 9,100
Planitop 15	MAPEI	A one component, shrinkage compensated cementitious, fiber reinforced fluid mortar. Contains a corrosion inhibitor and silica fume and is well suited where followability is required.	Setting Time – Initial 185 min. Final 370 min. Compressive Strength – 6 hrs. 3,370 28 days 12,290
Planitop X	MAPEI	A one component, fiber reinforced, shrinkage compensated, high early strength, fast setting polymer modified high build cementitious repair mortar with corrosion inhibitor.	Setting Time – Initial 13 min. Final 22 min. Compressive Strength – 2 hrs. 2390 28 days 7400
Planitop XS	MAPEI	An extended working time variation of Planitop X. Shrinkage compensated, fiber reinforced, polymer modified and containing a proprietary corrosion inhibitor.	Setting Time – Initial 34 min. Final 49 min. Compressive Strength – 6 hrs. 2090 28 days 7040

RepCon 928	SpecChem, LLC	A single component concrete repair mortar with integral corrosion inhibitor for use on concrete floors, highway pavements, bridge decks.	Setting Time – Initial 23 min. Final 35 min. Compressive Strength – 3 hrs. 5210 28 days 11940
SikaQuick 2500	Sika Corporation	A 1-component, very rapid hardening, early strength gaining, cementitious, patching material for concrete	Setting Time – Initial 20 min. Final Compressive Strength – 3 hrs. 3650 28 days 7915
Tamms Form and Pour	The Euclid Chemical Co. Cleveland, OH	A flow able, one component, polymer modified, cementitious repair mortar containing silica fume and a migratory corrosion inhibitor.	Setting Time – Initial 55 min. Final 60 min. Compressive Strength – 1 day 7364 28 days 11,968

To have a product included on this Approved List, the manufacturer shall submit a signed and notarized letter to Materials Division's Physical Laboratory Assistant Concrete Program Manager stating that the material meets the requirements listed in VTM 132 for A3, A4 and/or A5 concrete repair material. Accompanying this letter must be independent laboratory data demonstrating compliance to the specification, a Safety Data Sheet (SDS) and Technical Data Sheets. Upon approval the Manufacturer will be required to submit a letter each December for the upcoming year, the notarized letter must state that the concrete repair material meets the requirements of VTM 132 for A3, A4 and/or A5 and that the product has not changed in formulation since initial approval showing it will meet the following requirements. VDOT Material's Division reserves the right to check any product on this list.

VTM 132 can be found at the following link;
http://www.virginiadot.org/business/resources/Materials/bu-mat-VTMs.pdf

Virginia Test Method - 132

TEST METHODS AND PHYSICAL REQUIREMENTS FOR PACKAGED MATERIALS TO BE USED IN CONCRETE REPAIRS

1. SCOPE

This document establishes the physical requirements and test methods to determine conformance to criteria for repair to hydraulic cement concrete class A3, A4 and A5 used in precast, pavement, sidewalks, concrete bridge decks, super- and sub- structures and miscellaneous concrete. Test results will be used to populate list 31.

1.1 Packaged, dry mortar materials are defined as containing aggregate of which less than 5% by weight of the total mixture is retained on the 3/8 inch sieve.

1.2 This specification does not include bitumens, epoxy resins and polyesters as the principle binder.

2 APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 31 Practices for Making and Curing Concrete Test Specimens in the Field
C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
C 187 Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste.
C 192 Practices for Making and Curing Concrete Test Specimens in the Laboratory
C 305 Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically
C 511 Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C 617 Practice for Capping Cylindrical Concrete Specimens
C 807 Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle
C 882 Bond strength of epoxy resin used with concrete by slant shear.

C 928 Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
C1231 Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

2.3 Virginia Test Method (VTM)

3. REQUIREMENTS

3.1 Requirements for class A3, A4 and A5 concrete repair materials are identified in the following Tables I, II and III.

3.2 The repair material will be placed on the approved list into the table in which all the requirements of the class of concrete are met.

3.3 Any repair material, in a higher class of concrete, can be used for repair in a lower class of concrete.

3.4 Specimens are moist cured unless specified otherwise by the manufacturer.

TABLE I

Physical Requirements for Repair of A3 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2000	3000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.15
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.15

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	3500

TABLE II

Physical Requirements for Repair of A4 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2500	4000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.08
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.08

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	2500

TABLE III

Physical Requirements for Repair of A5 Concrete Items

Test A Setting Time (minutes)

Initial Setting Time	reported for information
Finial Setting Time	reported for information

Test B Compressive Strength (min. psi)

2, 4, 6 hrs.	24 hrs.	28 days
Reported for information	2500	5000

Test C Bond Strength (min. psi)

7 days	1000

Test D Freeze-Thaw (max. %)

Loss after 25 cycles of freezing and thawing in 10% calcium chloride solution	8

Test E Length Change (max. %)

Maximum allowable change after 28 days in water, based on length at 3 hours.	± 0.08
Maximum allowable change after 28 days in air, based on length at 3 hours.	± 0.08

Test F Permeability (max. coulombs)

Rapid Chloride Ion Permeability at 28 days	1500

4. SPECIMEN PREPARATION

4.1 Bagged mortar: Mix the dry package material with all the mixing liquid in according to the manufacture recommendations. Follow the manufacturer's recommendations as to the order of addition and mixing times. Mold and cure the specimens in accordance with the individual physical test procedures for mortar.

4.1.1 The sample of package material used to prepare any individual test shall be of such size to yield 10 % excess after molding test specimens.

4.1.2 Use the maximum amount of liquid recommended by the manufacturer on the bag for each test. Base the quantity of water, or other liquid component, or both, added during mixing on the quantity per unit of weight stated, in the directions for use, supplied by the manufacturer.

4.2 Bagged concrete or bagged mortar extended: Mix the dry package material with all the mixing liquid in according to the manufacturer recommendations. Follow the manufacturer's recommendations as to mixing procedures. Mold and cure the specimens in accordance with the individual physical test procedures.

4.2.1 The sample of packaged, dry material used to prepare any individual test shall be at least one whole bag of material. If because of set time mixing a whole bag is impractical, mix partial bag showing mixed weight and amount of water used.

4.2.2 In cases where the material in the bag is mortar that can be extended, the size of stone recommended by the manufacturer will be used and the maximum amount of stone recommended by the manufacturer will be used.

4.2.3 Use the maximum amount of liquid recommended by the manufacturer on the bag for each test. Base the quantity of water, or other liquid component, or both, added during mixing on the quantity per unit of weight stated, in the directions for use, supplied by the manufacturer.

5. CURING

Follow the manufacturer recommendations as to the type of cure to be used.

5.1 Dry or Room Cure The test specimens are left in the molds uncovered in the mixing room in a place free from vibration. The set material in cube form is identified and removed from the mold as necessary. Removed samples shall be kept in the mixing room.

5.2 Damp Cure The test specimens are covered with a damp cloth or towel after the initial set. Plastic sheeting may be placed on the damp cloth to retard drying of the cloth. The set material is identified and removed from the mold as necessary. Curing is for the period specified.

5.3 Moist Cure Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all test specimens in the molds in the moist closet or moist room with their upper surfaces exposed to the moist air, but protected from dripping water. Keep them on the shelves of the moist closet or moist room for 24 hr. and then immerse the specimens in saturated lime water in storage tanks. Remove samples as required for testing.

6. TEST METHODS

6.1 Test methods for determining conformance to the physical requirements for class A3, A4 and A5 concrete repair materials in section 3 Tables I, II and III are listed below:

Test A <u>Setting Time:</u> Determine the initial and final setting time in accordance with the Test method for determining setting time of rapid hardening cementitious repair materials. If the mixture contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve.

Test B <u>Compressive Strength:</u> Prepare and test three mortar cubes for each age of test using maximum water recommended and cured according to the Test Method for Determining Compressive Strength. If the bagged material has coarse aggregate or can be extended, test three (4” x 8”) cylinders at maximum water and maximum stone. Compressive strength test should be performed at 2, 4, 6 and 24 hours as well as at 28 days. The 24 hour and 28 day strength shall meet the requirement for the appropriate class of concrete repair material.

Test C <u>Bond Strength:</u> Prepare and test three neat test specimens using the maximum amount of water recommended. If the mixture contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve. Test in accordance with the Method for Determining Bond Strength. The average bond strength of the three (3) (3” x 6”) test specimens shall not be less than 1000 psi.

Test D <u>Resistance to Freezing and Thawing:</u> Prepare and test three cubes in accordance with the Test Method for Measuring Freeze-Thaw. If the mix contains coarse aggregate, then wet sieve the mixture over a ¼ inch sieve. The average percent loss by weight of the specimens shall not be more than 8%.

Test E <u>Length Change:</u> Prepare and test four beams, two for Air and two for water, using maximum water recommended. Test in accordance with the Test Method for Measuring Length Change. The two air cured bars are averaged together and the two water cured bars are averaged together. The average length change shall be not more than ± 0.08% for class A4 and A5 concrete repair material or ± 0.15 for class A3 concrete repair material. Beams will have a ten inch gauge length using molds 1” x 1” x 11 ¼”.

Test F <u>Resistance to the Penetration of Chloride Ions:</u> Prepare and test two - four inch by eight inch cylinders in accordance with VTM-112, Method A. The maximum coulomb value shall not exceed a value of 1500 coulombs for class

A5 concrete repair material, 2500 coulombs for class A4 concrete repair material or 3500 coulombs for class A5 concrete repair material when tested at 28 days.

Test G — Total Chloride Content: The total percent chloride content shall contain no more than 0.10 percent chlorides when tested in accordance with AASHTO T 260. The sample shall be taken from one random bag of material and screened over a No. 4 sieve before the analysis is performed. Test G applies to all categories of concrete repair materials if the material is cementitious.

Note: Test Methods A, E, F and G are not applicable for non-cementitious materials.

7. REJECTION

7.1 All broken packages shall be rejected.

7.2 Material failing to meet all of the requirements of a given Table shall be rejected.

8. MARKING

8.1 Directions on Product Data sheet must match the directions on the package. All packages shall be clearly marked and contain the following information:

8.1.1 Average time to reach final set.

8.1.2 Directions for use shall include but are not limited to:

8.1.2.1 The maximum amount of water, other liquid component, or both, to be mixed with the package contents.

8.1.2.2 The recommended length of mixing time or sequence of mixing and resting times in minutes.

8.2 Date the material was packaged.

8.3 The yield in cubic feet (or cubic meters) when mixed with the recommended amount of liquid.

8.4 The net weight of each package. The contents of any package shall not vary by more than 2% from the weight stated in the markings.

Test A

TEST METHOD FOR DETERMINING SETTING TIME OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This test method covers the determination of time of setting of a mortar prepared from prepackaged cementitious repair materials by a modified vicat needle.

1.2 The zero or start time for the purpose of establishing initial and final setting time will be the time of initial contact of mixing liquid with the prepackaged material.

2. APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens)
C 187 Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste.
C 807 Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle
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3. APPARTUS

3.1 Tamper and trowel, conforming to the requirements of ASTM C 109.

3.2 Vicat apparatus, conforming to the requirements of ASTM C 187 as modified by ASTM C 807 section 6.2.2.

3.3 Mold conforming to the requirements of ASTM C 187

4. PREPARATION OF TEST SAMPLE

4.1 The cement paste used for the determination of the time of setting is obtained from one of the two following methods:

4.1.1 Paste is used from mortar mix of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer.

4.1.2 For material that is packaged already extended, record how the material was mixed. Either it was wet sieved or dry sieved. If dry sieved, record how much material and the amount of water was used.

4.2 Paste is placed into mold in a way to ensure good consolidation.

5. TIME OF SETTING DETERMINATION

5.1 Immediately after molding the test sample, bring the 2 ± 0.05 mm needle of the apparatus in contact with the surface of the sample and tighten the setscrew. Set the movable indicator to the upper zero mark on the scale. Release the rod quickly by releasing the setscrew and allow the needle to settle for 30 seconds. If the sample is obviously quite fluid on early readings, the fall of the rod should be retarded to avoid possible damage to the needle. Take penetration tests as often as necessary until the needle reads 25 mm. (Note 1) No penetration test shall be closer than ¼ inch from any previous penetration test or from the inside edge of the mold. Record the results of all penetration tests and by interpolation, determine the time when a penetration of 25 mm is obtained. Record all penetration test results and by interpolation determine the time when a penetration of 25 mm is obtained.

5.2 The difference (in minutes) between the zero or start time (the zero or start time begins when the dry material comes into contact with the liquid) and the 25 mm penetration is the initial setting time. The final setting time is that time when the needle does not visibly sink into the test sample.

5.3 Report the initial setting time and the final setting time to the nearest whole minute.

Note 1: The manufacturer's data should provide some guidance as to what an approximate interval should be.

Test B

TEST METHOD FOR DETERMINING COMPRESSIVE STRENGTH OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This method of test covers the compressive strength of rapid hardening cementitious material.

2. APPLICABLE DOCUMENTS

2.1 **ASTM**

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens)
C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory
C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically

3. SPECIMEN PREPARATION

3.1 Specimens will be made in accordance with ASTM C 109 or ASTM C 192 and cured in air at 73 ± 5°F for up to 24 hours in molds. Cubes for 28 day strength shall be stripped at 24 hours and stored in lime water at 73 ± 5°F for the remaining time. Cylinders for 2, 4, 6 and 24 hour are to remain in molds with tops until stripped to be broken. Cylinders for 28 day strength shall be stripped at 24 hours and stored in a moist environment at 73 ± 5°F for the remaining time.

3.2 Cubes: If mortar mixture is used, use whole bag or select a representative sample from the bag. Mix a batch of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer. If mix has coarse aggregate, or is extended, wet sieve material over a ¼ sieve if making cubes.

3.2.1 Use 2 inch cube molds meeting the requirements for *Specimen Molds,* in ASTM C 109 when making cubes.

3.2.2 Break a set of three cubes for each strength determination at each given time (2, 4, 6 and 24 hours and at 28 days).

3.3 Cylinders: Use bagged product containing coarse aggregate premixed in bag or extend bagged product according to manufacturer's directions with recommended coarse aggregate.

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3.3.1 Use 4 inch by 8 inch cylinder molds meeting the requirements for molds, in ASTM C 470 when making cylinders.

3.3.2 Break a set of three cylinders for each strength determination at each given time (2, 4, 6 and 24 hours and at 28 days).

4. SPECIMEN TESTING

4.1 Cubes shall be tested according to ASTM C 109.

4.2 Cylinders shall be tested according to ASTM C 39.

4.3 All test specimens shall be broken within the permissible tolerance prescribed as follows:

Test Age	Tolerance
2 and 4 hrs.	± 5 min
6 hr.	± 10 min
24 hr.	± 1/2 hr.
28 day	± 12 hr.

5. REPORT

5.1 Report cube strengths as the average of three 2 inch cubes broken at each given time.

5.2 Report cylinder strengths as the average of three 4x8 cylinders broken at each given time.

6. ACCEPTANCE

6.1 To be included on the Approved List, the average strength of three test specimens must comply with the strength requirement for the determined use.

Test C

TEST METHOD FOR DETERMINING BOND STRENGTH OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIAL

1. SCOPE

1.1 This method covers the determination of the bond strength of prepackaged cementitious repair materials to be used in repairing hydraulic cement concrete.

2. APPLICABLE DOCUMENTS

2.1 ASTM Standards

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens C 305 Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C 470 Molds for Forming Concrete Test Cylinders Vertically
C 617 Practice for Capping Cylindrical Concrete Specimens
C 511 Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks used in the Testing of Hydraulic Cements and Concretes
C 882 Bond strength of epoxy resin used with concrete by slant shear.

3. SUMMARY OF METHODS

3.1 A portion of the freshly mixed prepackage product is placed into a 3 by 6 inch cylindrical mold which contains a cured cementitious half cylinder of the dimensions shown in Figure 1. After specified curing of the prepackaged product, the bond strength is performed by determining the compressive strength of the composite cylinder.

4. APPARATUS

4.1 Apparatus to mix portland cement mortar shall be as described in ASTM C 305.

4.2 Specimen Molds: The molds shall be waxed single use molds meeting the requirements of ASTM C 470 for paper molds.

4.3 Dummy Section: A dummy section (Figure 1) shall be machined of a hard material that is not attacked by portland cement mortar. It shall fit the mold and be equal to half the volume of the cylinder, but at an angle of 30 degrees from the vertical.

4.4 Tamping Rod: The tamping rod shall be a round rod of brass, steel or plastic, 3/8 inch in diameter and approximately 12 inches long, having both ends rounded to hemispherical tips.

4.5 Spatula: To be used for rodding pointed section.

4.6 Testing Machine: The testing machine shall be as described in ASTM C39.

4.7 Moist Room: The moist room shall conform to the requirements of ASTM C 511.

5. MATERIALS

5.1 Laboratory made half cylinders shall have a minimum compressive strength of 2500 psi at 28 days.

5.1.1 To make half cylinders, lightly oil the dummy section. Position the dummy section in the mold with the slant side up. Place the molds in their normal vertical position and place a layer of freshly mixed material into the molds to a depth of approximately one inch. Rod this thin layer with the spatula sufficiently to insure that all voids are filled. Place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 20 strokes using the tamping rod. Distribute the strokes over the cross-section, and make them deep enough to penetrate into the underlying layer. Strike off the surface of the top layer with the trowel, and cover the specimen. A laboratory external vibrator may be used in lieu of rodding to consolidate the mortar. Remove the half cylinder specimens from the molds after one day and cure them for at least 13 additional days in the moisture room.

5.2 Fill a 3 by 6 inch mold without dummy section to check strength of mix. Mortar cylinder shall be a compressive strength calculated on the basis of the normal cross-sectional area of the cylinder (7.07 $inch^2$). Make as many mortar cylinders as needed to determine when mortar has reached desired strength.

6. TEST SPECIMENS

6.1 Remove three standard mortar half-cylinders from the curing room, sandblast or wire brush the elliptical surfaces and then carefully remove the loose surface material. For each prepackaged cementitious material tested, mix ample material to cast three composite bond strength specimens. The prepackaged material should be mixed according to the manufacturer's mixing instructions using maximum water allowed. Place the mortar sections into three cylinder molds and slightly dampen the elliptical surfaces. Place the molds in their normal vertical position and place a layer of freshly mixed material into the molds to a depth of approximately one inch. Rod this thin layer with the spatula sufficiently to insure that all voids are filled. Place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 20 strokes of the tamping rod. Distribute the strokes over the cross-section, and make them deep enough to penetrate into the underlying layer. A laboratory external

vibrator may be used in lieu of rodding to consolidate the mortar. Strike off the surface of the top layer with the trowel, and cover the mold.

6.2 Curing: Demold the testing specimens after 24 hours and cure them 6 additional days in a moist environment at 73 ± 5°F.

7. PROCEDURE

7.1 Capping: Cap all specimens after removal from curing in accordance with ASTM C617.

7.2 Strength Testing: Test the specimens in compression, after capping, in accordance with ASTM C39

8.1 Calculate the bond strength of the bonding system by dividing the load carried by the specimen at failure by the elliptical area of the cylinder (approximately 14.13 $inch^2$).

8. ACCEPTANCE

9.1 To be included on the Approved List, the average strength of three test specimens must comply with the strength requirement for the determined use.

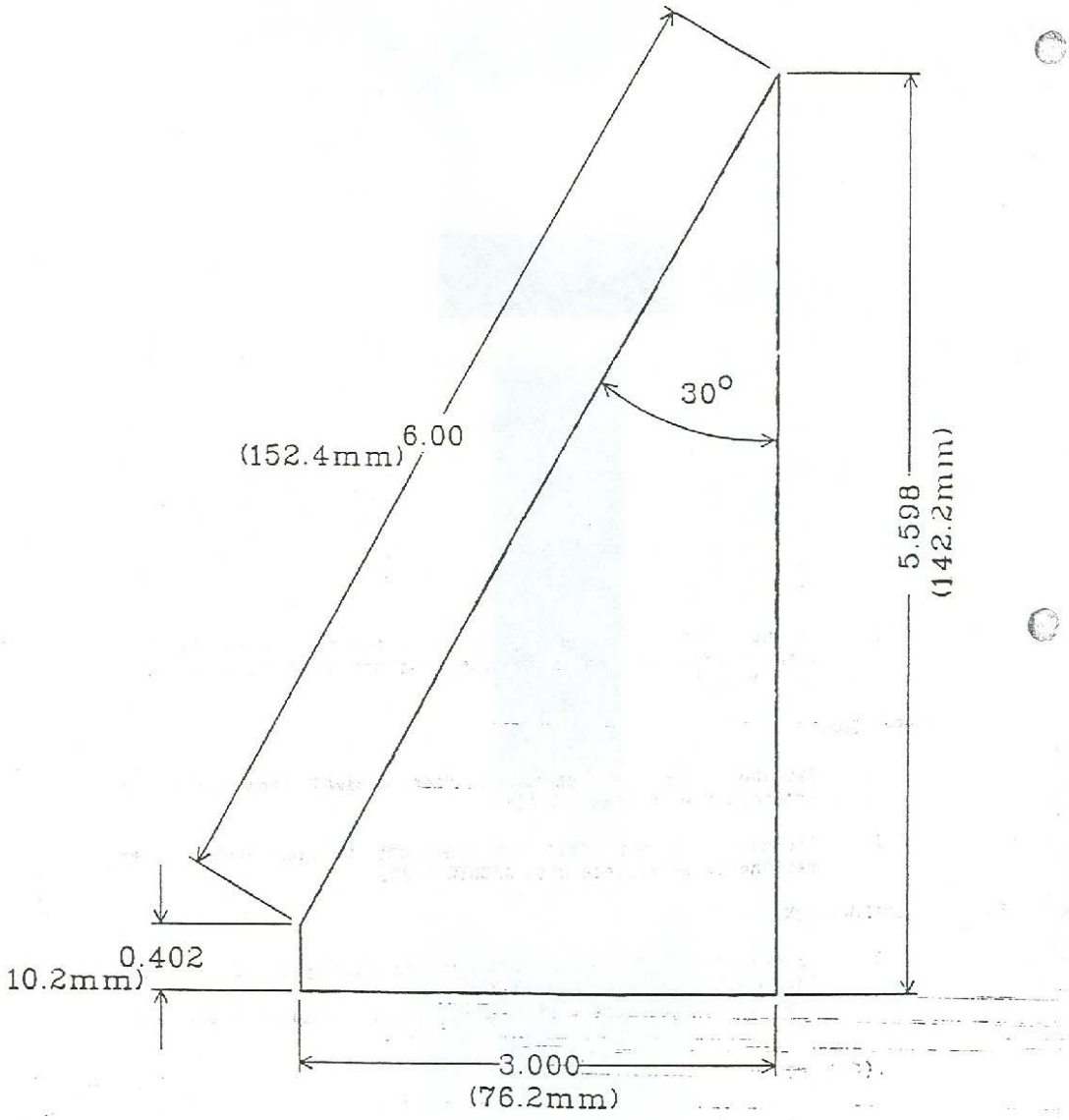

FIG. 1 DUMMY SECTION
FOR 3"X6" (76.2X152.4mm)CYLINDER

Test D

TEST METHOD FOR MEASURING FREEZE – THAW RESISTANCE OF RAPID HARDENING CEMENTITIOUS REPAIR MATERIALS

1. SCOPE

1.1 This test method covers the procedure for determining the resistance of 2 inch cube specimens of mortar, to alternate freezing and thawing cycles while immersed in a brine of 10% by weight of calcium chloride (USP or better) in water.

2. APPLICABLE DOCUMENTS

2.1 None

3. APPARATUS

3.1 Container – a suitable container (Note 1) of sufficient size to permit at least 6 specimens to be surrounded on 5 sides by not less than ½ inch of the salt solution at all times during freezing and thawing cycles.

Note 1: A plastic dish pan may be found suitable.

3.2 Freezing Apparatus: The freezing apparatus shall consist of a suitable chamber in which the specified container, (as described above), salt solution and specimens may be subjected to the specified freezing temperature of -10°F. or lower and shall contain the necessary refrigerating equipment for maintaining this temperature range.

3.3 Thawing Area: The thawing area shall be relatively dust-free and shall have a temperature range of 75 ± 15°F. in order to complete the thawing of the test specimens and salt solution within a 7 ± 1 hour period (Note 2 below).

Note 2: Ordinary room temperature usually is sufficient for this purpose, but a 15 watt infra-red lamp may be used to accelerate the thawing. When one of these lamps is used, it shall be placed at a distance of at least 7 inches from the test specimens and salt solution.

3.4 Solution: 10% by mass calcium chloride (USP or better) in water.

4. TEST SPECIMENS

4.1 The specimens are 2 inch cubes made in accordance with Test B of this VTM.

4.2 Specimens shall be cured in air at 73 ± 5°F for 22 ± 2 hours in molds. After the initial 22 ± 2 hour, remove the specimens from the molds and individually identify. Immerse in lime water at 73 ± 5°F for the remainder of the 14-day curing period.

5. PROCEDURE

5.1 At the end of the 14-day curing period (as described in Section 4.2), the specimen shall be removed from the storage tanks, surface dried with the damp cloth or towel, weighed and the weight recorded to the nearest 0.1 g. The specimens shall be protected from loss of moisture at all times by completely covering with a damp cloth or towel.

5.2 Place the specimens at random locations within the container (as described in Section 3 above) and cover with the specified salt solution so that all specimens are surrounded on 5 sides by not less than ½ inch of the solution. (Note 4 below)

Note 4: At no time during the test shall the cubes be covered by less than ½ inch of salt solution.

5.3 Place the container inside the freezing chamber for a period of 16 ± 2 hours. Maintain the temperature of the freezing chamber at -10°F or lower for the freezing period.

5.4 After the 16 ± 2 hour freezing period, remove the container and permit the contents to thaw at a temperature of 75 ± 15°F for a period of 7 ± 1 hour.

5.5 Alternately cycle between freezing and thawing as specified in the two previous paragraphs. At the end of each fifth cycle, during the thawing phase, remove the specimens (one at a time) rinse with clean water to remove all traces of brine, surface dry with a damp cloth or towel and weigh. Record the weight to the nearest 0.1 g and return the specimens to the container. Care shall be taken to prevent loss of moisture during the weighing operation by covering the specimens completely with a damp cloth or towel. When weighting, if a loss greater than the maximum is encountered, testing can be terminated.

5.6 When the sequence of freezing and thawing cycles must be interrupted, store the specimens in a frozen condition.

5.7 The test specimens shall be subjected to 25 cycles of alternate freezing and thawing.

6 CALCULATIONS

6.1 Calculations shall be made upon the completion of each 5 cycles to determine the percent loss during those cycles. Determine the total percent loss at the end of the testing period.

a. Calculate the percent of loss by using the following formula:

$$L = \frac{W - X}{W} * 100$$

Where:

L = Percent Loss
W = Weight of specimen at 0 cycles
X = Weight of same specimen after completion of each testing period (5 cycles, then at 10 cycles, etc., up to and including final cycle).

7 ACCEPTANCE

7.1 To be included on the Approved List, the average percent loss by weight of the specimens shall not be more than indicated for the determined use.-

Test E

TEST METHOD FOR MEASURING LENGTH CHANGE OF HARDENED HYDRAULIC CEMENT MORTAR AND CONCRETE.

1. SCOPE

1.1 This test method covers the determination of the length changes that are produced by causes other than externally applied forces and temperature changes in hardened hydraulic cement mortar and concrete specimens made in the laboratory and exposed to controlled conditions of temperature and moisture.

2. APPLICABLE DOCUMENTS

2.1 ASTM

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

C 490 Use of Apparatus for the Determination of length change of hardened cement paste, mortar, and concrete.

3. APPARATUS

3.1 Molds and Length Comparator: The molds for casting test specimens and the length comparator for measuring length change shall conform to the requirements ASTM C490. Beams will have a ten inch gauge length using molds that are 1” x 1” x 11 ¼”.

3.2 Tamper: The tamper shall be made of a material such as medium-hard rubber and shall have a cross section of 0.5 in. by 1.0 in. and a convenient length of about 6 in. The tamping face of the tamper shall be flat and at right angles to the length of the tamper.

4. Procedure for Mixing and Preparing Test Specimens

4.1 For material containing no aggregate: Mix a batch of such size to yield 10 % excess after molding test specimens of dry-packaged material using the maximum amount of water stated in the directions supplied by the manufacturer. The test specimen shall be a prism of 1-in. square cross-section and approximately 11¼ in. in length. Two specimens shall be prepared for air curing and two specimens for water curing.

4.2 For material that is packaged already extended, record how the material was mixed. Either it was wet sieved or dry sieved. If dry sieved, record how much material and the amount of water was used.

5. Procedure for Molding Specimens

5.1 Place the mortar in the mold in two approximately equal layers. Compact each layer 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, strike off the mortar flush with the top of the mold and smooth the surface with a few strokes of a trowel.

6. Procedure for Curing of Specimens

6.1 Remove specimens from molds soon after final set.

6.2 Measure bars immediately after removal from the molds and record the length.

6.3 Water Storage—Immerse two specimens in lime saturated water storage at 73 ± 5°F.

6.4 *Air Storage*—Store the specimens in the drying room, (Temperature 73 + 3 °F and relative humidity of 50%), so that the specimens have a clearance of at least 1 inch.

6.5 At 28 days measure the specimens as before and record the length.

7. Procedure for Calculating Length Change

7.1 Length Change—Calculate the length change of each specimen at 28 days after the initial comparator reading as follows:

$$\triangle \mathbf{Lx} = \frac{\text{CRD- initial CRD}}{G} * 100$$

where:

$\triangle$Lx = length change of specimen, %,
Initial CRD = Length of the specimen bar when removed from mold
CRD = Length of the specimen bar at 28 days
G = the gage length (10 in.).

7.2 The two air-cured and water-cured bars are measured individually. The average of the two readings for each condition is the reported length change.

8. ACCEPTANCE

8.1 To be included on the Approved List, the average length change of either shall be not outside the limits for the determined use.