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## Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs<sup>1</sup>

This standard is issued under the fixed designation C 928; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers packaged, dry, cementitious mortar or concrete materials for rapid repairs to hardened hydraulic-cement concrete pavements and structures. Materials that contain organic compounds, such as bitumens, epoxy resins, and polyesters, as the principal binder are not included.

1.1.1 Packaged, dry, concrete material contains aggregate of which at least 5 % by mass of the total mixture is retained on a 9.5-mm ( $\frac{3}{8}$ -in.) sieve.

1.1.2 Packaged, dry, mortar material contains aggregate of which less than 5 % by mass of the total mixture is retained on a 9.5-mm ( $\frac{3}{8}$ -in.) sieve.

1.2 Aqueous solutions, aqueous emulsions or dispersions may be included as components of the packaged materials. The manufacturer may specify that these liquids are to replace some or all of the mixing water.

1.3 Aggregates must be included as a component of the packaged materials. The manufacturer may recommend job site addition of specific amounts and types of additional aggregates to his product for some uses. However, such reformulated products are not within the scope of this specification.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound units given in parentheses are for information only. Values in SI units shall be obtained by measurement in SI units or by appropriate conversion of measurements made in other units, using the Rules for Conversion and Rounding given in IEEE/ASTM SI-10.

1.5 The following safety hazards caveat pertains to the test methods portion of this specification: *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:*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee C-9, C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.43 on Packaged, Dry, Combined Concrete.

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- C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens<sup>2</sup>
- C 78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)<sup>2</sup>
- C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)<sup>3</sup>
- C 143 Test Method for Slump of Hydraulic Cement Concrete<sup>2</sup>
- C 157 Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete<sup>2</sup>
- C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory<sup>2</sup>
- C 403/C 403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistant<sup>2</sup>
- C 494 Specification for Chemical Admixtures for Concrete<sup>2</sup>
- C 666 Test Method for Resistance of Concrete to Rapid Freezing and Thawing<sup>2</sup>
- C 672/C 672M Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals<sup>2</sup>
- C 702 Practice for Reducing Field Samples of Aggregate to Testing Size<sup>2</sup>
- C 882 Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear<sup>2</sup>
- C 1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution<sup>3</sup>
- E 96 Test Methods for Water Vapor Transmission of Materials<sup>4</sup>
- IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System<sup>5</sup>

### 3. Materials and Manufacture

3.1 Three types of packaged, dry, rapid-hardening concrete and three types of packaged, dry, rapid-hardening mortar are identified in Table 1.

### 4. Chemical Composition

4.1 If the material contains soluble chlorides or other ingredients in sufficient quantity to cause corrosion to steel reinforcement, the package markings shall contain the following statement in letter size no smaller than the directions for use:

This material is not recommended for use in a moist environment in contact with steel reinforcement.

4.1.1 Consider a total chloride ion content (Berman, 1972)<sup>6,7</sup> in the packaged repair material greater than 600 g/m<sup>3</sup> (1 lb/yd<sup>3</sup>) of the hardened repair material indicative that the packaged material contains sufficient chlorides to cause corrosion to steel reinforcement when the concrete is exposed to weather, is on the ground, or is in an otherwise moist environment. A much lower chloride ion content is suggested for use in prestressed concrete. Guidance for such users is outside the scope of this specification.

4.2 If the material contains metallic iron in excess of 1 weight %, the package markings shall contain the following statement in letter size no smaller than the directions for use:

If small or scattered spots of iron-staining are considered objectionable, do not use this material where it will be exposed.

### 5. Performance Requirements

5.1 The materials shall comply with the performance requirements in Table 1 for the applicable type.

### 6. Sampling

6.1 A lot is the quantity of packaged repair material normally placed on a pallet. In general, this quantity will weigh from ~~2000 to 4000 lb (900 to 1800 kg)~~ 2000 to 4000 lb.

6.2 A unit sample is a single package of material randomly selected from the lot.

### 7. Specimen Preparation

7.1 *Concrete*—Mechanically mix the packaged dry concrete material with mixing liquid. Determine the properties of the unhardened mixture, and mold and cure the specimens in accordance with Practice C 192/C 192M or modifications as outlined herein.

7.1.1 The sample of packaged dry material shall be any combination of whole packages yielding not less than 20 L (~~0.02~~  $\frac{2}{3}$  ft<sup>3</sup>) of hardened material.

7.1.2 Base the quantity of water, other liquid component, or both added to the sample on the quantity per bag stated in the directions for use.

7.1.3 Place the sample in the mixing machine and add the required amount of liquid. Start mixing immediately. Continue mixing for the length of time indicated in the directions for use.

<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.06.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>6</sup> Berman, H. A. Determination of Chloride in Hardened Portland Cement Paste, Mortar, and Concrete, *ASTM Journal of Materials*, Vol. 7, No. 3, 1972, pp. 330–335.

<sup>7</sup> Clear, K. C., and Harrigan, E. T., "Sampling and Testing for Chloride Ion in Concrete," Report No. FHWA-RD77-85, Federal Highway Administration, Washington, DC, August 1977 (Available as PB 275-428/AS National Technical Information Services).

**TABLE 1 Performance Requirements<sup>A</sup>**

Compressive strength min, MPa (psi)	3 hours	1 day	7 days	28 days	
<u>Compressive Strength,</u> min, MPa (psi)					
R1 concrete or mortar	3.5 (500)	14 (2000)	28 (4000)	<sup>B</sup>	
R2 concrete or mortar	7.0 (1000)	21 (3000)	28 (4000)	<sup>B</sup>	
R3 concrete or mortar	21 (3000)	35 (5000)	35 (5000)	<sup>B</sup>	
<u>Bond strength, min, MPa (psi)</u>					
R1, R2 and R3 concrete or mortar	—	7 (1000)	10 (1500)	—	
<u>Length change, based on length at 3 h, max, %</u>					
R1, R2, and R3 concrete or mortar	allowable increase after 28 days in water			+0.15	
	R1, R2, and R3 concrete or mortar	allowable increase after 28 days in water		+0.15	
		allowable decrease after 28 days in air			-0.15
<u>Consistency of concrete or mortar</u>					
		concrete slump, min, mm (in.)	Flow of mortar, min, %		
<u>Consistency of concrete or mortar</u>					
		concrete slump, min, mm (in.)	Flow of mortar, min, %		
R1 consistency after 15 min after addition of mixing liquid		75 (3)	100		
R2 and R3 consistency at 5 min after addition of mixing liquid			75 (3)	100	
<u>Scaling resistance to deicing chemicals after 25 cycles of freezing and thawing</u>					
Concrete, max visual rating			2.5		
Mortar, max scaled material <sup>C</sup>			5 kg/m <sup>2</sup> (1 lb/ft <sup>2</sup> )		

<sup>A</sup> It is recognized that other characteristics of rapid-hardening concrete repair materials might need consideration. Such characteristics might be necessary in some environments and applications; however, to impose specification limits on all products is considered beyond the scope of this specification. Optional considerations with suggested methods of test may include tests for the following:

Time of setting      Test Method C 403/C 403M  
 Flexural strength    Test Method C 78  
 Freeze thaw          Test Method C 666, Procedure A  
 Sulfate expansion    Test Method C 1012

<sup>B</sup> The strength at 28 days shall be not less than the strength at 7 days.

<sup>C</sup> A 10-in. (254-mm) square spalled to an average depth of 1/8 in. (3.17 mm) for 100 % of its surface would have about 2.10 lb/kg/ft<sup>2</sup> (42.0 kg lb /m<sup>2</sup>) of scaled material.

7.1.4 When making the slump test in accordance with Test Method C 143, schedule work so the test will be completed in 5 ± 1/2 min after the mixing liquid is added to the R2 or R3 materials or 15 ± 1/2 min after mixing the liquid with the R1 materials.

7.1.5 Mold the required number of specimens using additional samples as may be necessary, mixed in accordance with 7.1.1-7.1.4. Do not use the mixtures for molding test specimens when the slump is less than that specified in Table 1.

NOTE 1—Where the nominal maximum particle size is not greater than 1 in. (25 mm), 25 mm (1 in.), the use of cylindrical molds 4 in. (102 mm) 100 mm (4 in.) in diameter by 8 in. (203 mm) 200 mm (8 in.) in length is suggested.

7.2 *Mortar*—Mechanically mix packaged dry mortar material with mixing liquid. Determine the properties of the unhardened mixture, and mold and cure the specimens in accordance with Test Method C 109/C 109M or modifications as outlined herein.

7.2.1 The sample of packaged dry material shall weigh 7.6 3000 ± 0.006 lb (3000 ± 3 g (7.6 ± 0.006 lb) and shall be representatively obtained from a whole package in accordance with Practice C 702.

7.2.2 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.

7.2.3 When making the flow test in accordance with the section on consistency in Test Method C 109/C 109M, schedule work so the test will be completed in 5 ± 1/2 min after the start of mixing liquid with the R2 or R3 materials or 15 ± 1/2 min after mixing the liquid with the R1 materials.

7.2.4 Mold the required number of specimens using additional samples as necessary mixed in accordance with 7.2.1-7.2.3. Do

not use the mixtures for molding test specimens when the flow is less than that specified in Table 1.

7.3 In those cases where the manufacturer has indicated in the package markings, or elsewhere, that the packaged repair material can be mixed and applied at temperatures that lie beyond the range of  $70 \pm 20 \pm 15^{\circ}\text{F}$  ( $20 \pm 8^{\circ}\text{C}$  ( $70 \pm 8^{\circ}\text{C}$ ),  $15^{\circ}\text{F}$ ), the product must meet the requirements of Table 1. Specimens must be made and cured in accordance with the procedures of this section. The mixing, molding and curing temperatures during the first 3 h after molding shall be within  $\pm 2^{\circ}\text{F}$  ( $\pm 1^{\circ}\text{C}$ )  $\pm 1^{\circ}\text{C}$  ( $\pm 2^{\circ}\text{F}$ ) of the extreme temperature(s) stated by the manufacturer in the package markings.

## 8. Test Methods

8.1 *Manifestly Faulty Specimens*—Treat manifestly faulty specimens in accordance with the corresponding section in Specification C 494.

8.2 *Compressive Strength*—Prepare and test three test specimens for each age of test and each level of mixing temperature. Test in accordance with Test Method C 39 for concrete and Test Method C 109/C 109M for mortar.

8.3 *Length Change*—Prepare and test specimens in accordance with Test Method C 157, except as modified by this section and 7.3. Use 25 mm (1-in.) prism for mortar material and 75 mm (3-in.) prism for concrete material.

8.3.1 Remove specimens from the molds at an age of 2½ to 2¾ h after the addition of mixing liquid to the dry cementitious mixture during the mixing operation.

8.3.2 Make the initial observation of length at 3 to 3¼ h after the addition of mixing liquid to the dry cementitious mixture during the mixing operation. When specimens are cured at temperatures other than  $73.4 \pm 3^{\circ}\text{F}$  ( $23 \pm 2^{\circ}\text{C}$  ( $73.4 \pm 1.7^{\circ}\text{C}$ ),  $3^{\circ}\text{F}$ ), then both initial and final length observations must be made with the bars conditioned to  $\pm 3^{\circ}\text{F}$  ( $\pm 1.7^{\circ}\text{C}$ )  $\pm 2^{\circ}\text{C}$  ( $\pm 3^{\circ}\text{F}$ ) of initial temperatures.

8.3.3 Immediately store one set of specimens as for “Air Storage” and one set as for “Water Storage” except that the water-stored specimens shall be stored in untreated tap water with no more than one set of specimens per container.

8.3.4 Take observations of length at age 28 days  $\pm$  20 h. Determine the average percent change in length when stored in water, and the average change in length of specimens stored in air.

8.4 *Scaling Resistance*—Make and cure the test specimens in accordance with Test Method C 672/C 672M, except as provided herein. For specimens of mortar omit the visual rating procedure after every 5 cycles and after 25 cycles determine the amount of scaling as the oven dry ( $230 \pm 9^{\circ}\text{F}$ ,  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ) mass per unit area of exposed test area.

8.5 *Slant Shear Bond Strength*—Prepare six complete test specimens in accordance with Test Method C 882 for Type II and V systems except as modified by this section.

8.5.1 Do not apply a bonding system to prepared surface unless a bonding system is required by the manufacturer of the rapid-hardening cementitious material. Fill the top half of the cylinder with the rapid-hardening cementitious material instead of the portland cement mortar specified.

8.5.2 Test three specimens in compression at 1 day and three at 7 days. Calculate the bond strength on the elliptical area and report the failure type.

## 9. Report

9.1 Report the following:

9.1.1 Source and identification, including type, of material tested,

9.1.2 Details of any variations and options practiced by the tester that are recommended or allowed by the manufacturer or others,

9.1.3 Compressive strength of material at 3 h, 1 day, 7 days and 28 days,

9.1.4 Bond strength at 1 day and 7 days,

9.1.5 Percent length change at 28 days in water and in air,

9.1.6 Percent flow in mortar at 5 or 15 min,

9.1.7 Slump in concrete at 5 or 15 min, and

9.1.8 Scaling resistance after 25 cycles.

## 10. Rejection

~~10.1 All broken packages may be rejected.~~

~~10.2 Material~~

10.1 The purchaser has the right to reject material that fails to meet any of conform to the requirements of this specification. Rejection shall be rejected.

~~10.3 Rejection and reason(s) for rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with reason(s) stated or of the test results reported, the producer or supplier may make claim for a hearing. writing.~~

## 11. Certification

11.1 When specified in the purchase order or contract, a producer, supplier, or an independent testing laboratory shall furnish certification to the purchaser that the material has been tested in accordance with this specification and found to meet the requirements. When specified in the purchase order or contract, a report of test results on samples taken from material shipped shall be furnished.

## 12. Product Marking

12.1 Mark all packages to contain the following information:

12.1.1 Specification designation.

12.1.2 R1 or R2 or R3 ~~classification~~ type.

12.1.3 Directions for use that shall include but are not limited to:

12.1.3.1 When a bonding agent is used in the test of bond strength, the type and kind of adhesive recommended to bond fresh repair material to the concrete or mortar being repaired.

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

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

12.1.4 Date the material was packaged.

12.1.5 The yield in ~~cubic feet (or cubic metres)~~ litres (cubic feet) or yield in ~~square feet per inch (or square metres per centimetre (square feet per inch))~~ thickness when mixed with the recommended amount of liquid.

12.1.6 The net weight in each container. The contents of any container shall not vary by more than 2 % from the weight stated in the markings. The average weight of filled containers in a lot shall be not less than the weight stated in the markings.

## 13. Packaging

13.1 The material from which the containers are made shall have water vapor transmission not greater than 100 g/m<sup>2</sup> in 24 h as determined in accordance with Procedure B of Test Methods E 96.

## 14. Keywords

14.1 cementitious mortar or concrete materials for repair; concrete; packaged; mortar; packaged; packaged dry materials for concrete repair; rapid hardening materials; repair materials

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