Designation: C928/C928M – 20a

Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs[1]

This standard is issued under the fixed designation C928/C928M; 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 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 polymers, 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 [⅜-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 [⅜-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 either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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, 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]

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)

C125 Terminology Relating to Concrete and Concrete Aggregates

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

C490/C490M Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete

C494/C494M Specification for Chemical Admixtures for Concrete

C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C672/C672M Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.43 on Packaged Dry Combined Materials.

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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

C702 Practice for Reducing Samples of Aggregate to Testing Size
C778 Specification for Standard Sand
C882 Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
C1012 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
E96/E96M Test Methods for Water Vapor Transmission of Materials

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification refer to Terminology C125.

4. Materials and Manufacture

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

5. Chemical Composition

5.1 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.

5.1.1 Consider a total chloride ion content (Berman, 1972)[3,4] in the packaged repair material greater than 600 g/m^3 [1 lb/yd^3] 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.

5.2 If the material contains metallic iron in excess of 1 % by 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.

6. Performance Requirements

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

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

[4] 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[A]

	3 h	1 day	7 days	28 days
Compressive Strength, min, MPa [psi]				
R1 concrete or mortar	3.5 [500]	14 [2000]	28 [4000]	[B]
R2 concrete or mortar	7.0 [1000]	21 [3000]	28 [4000]	[B]
R3 concrete or mortar	21 [3000]	35 [5000]	35 [5000]	[B]
Bond strength, min, MPa [psi]				
R1, R2, and R3 concrete or mortar	—	7 [1000]	10 [1500]	—
Length change, based on length at 3 h, max, %				
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

	concrete slump, min, mm [in.]	Flow of mortar, min, %
Consistency of concrete or mortar[C]		
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

Scaling resistance to deicing chemicals after 25 cycles of freezing and thawing	
Concrete, max visual rating	2.5
Mortar, max scaled material[D]	5 kg/m^2 [1 lb/ft^2]

[A] 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 C403/C403M
Flexural strength	Test Method C78
Freeze thaw	Test Method C666/C666M, Procedure A
Sulfate expansion	Test Method C1012

[B] The strength at 28 days shall be not less than the strength at 7 days.
[C] Slump or flow requirements are waived for materials intended for vertical or overhead applications.
[D] A 250-mm [10-in.] square spalled to an average depth of 3 mm [⅛ in.] for 100 % of its surface would have about 10 kg/m^2 [2.0 lb/ft^2] of scaled material.

7. Sampling

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

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

8. Specimen Preparation

8.1 *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 C192/C192M or modifications as outlined herein.

8.1.1 The sample of packaged dry material shall be any combination of whole packages yielding not less than 20 L [⅔ ft^3] of hardened material.

8.1.2 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.

8.1.3 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.

8.1.4 When making the slump test in accordance with Test Method C143/C143M, schedule work so the test will be completed in 5 ± ½ min after the mixing liquid is added to the R2 or R3 materials or 15 ± ½ min after mixing the liquid with the R1 materials.

8.1.5 Mold the required number of specimens using additional samples as may be necessary, mixed in accordance with 8.1.1 – 8.1.4. 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 25 mm [1 in.], the use of cylindrical molds 100 mm [4 in.] in diameter by 200 mm [8 in.] in length is suggested.

8.2 *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 C109/C109M or modifications as outlined herein.

8.2.1 The sample of packaged dry material shall weigh 3000 ± 3 g [6.6 ± 0.005 lb] and shall be representatively obtained from a whole package in accordance with Practice C702.

8.2.2 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.

8.2.3 When making the flow test in accordance with the section on consistency in Test Method C109/C109M, schedule work so the test will be completed in 5 ± ½ min after the start of mixing liquid with the R2 or R3 materials or 15 ± ½ min after mixing the liquid with the R1 materials.

8.2.4 Mold the required number of specimens using additional samples as necessary mixed in accordance with 8.2.1 – 8.2.3. Do not use the mixtures for molding test specimens when the flow is less than that specified in Table 1.

8.3 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 20 ± 8 °C [70 ± 15 °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 ±1 °C [±2 °F] of the extreme temperature(s) stated by the manufacturer in the package markings.

9. Test Methods

9.1 *Manifestly Faulty Specimens*—Treat manifestly faulty specimens in accordance with the corresponding section in Specification C494/C494M.

9.2 *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 C39/C39M for concrete and Test Method C109/C109M for mortar.

9.3 *Length Change*—Prepare and test three specimens (set) in accordance with Test Method C157/C157M, except as modified by this section and 8.3. The molds for casting test specimens and the length comparator shall comply with the requirements of Practice C490/C490M.

9.3.1 *Preparation of Specimen Molds and Material Conditioning*—The temperature of the mixing water and the materials used to prepare the test specimens shall be 23 ± 2.0 °C [73.5 ± 3.5 °F] except as modified by 8.3. The air temperature of the mixing room, molds and base plates shall be maintained at 23 ± 2.0 °C [73.5 ± 3.5 °F] and at a relative humidity of not less than 50 % except if modified by 8.3. Prepare the specimen molds in accordance with the requirements of Practice C490/C490M. Mold dimensions shall be at least three times the nominal aggregate size. The test specimen for mortar shall be a prism of 25-mm [1-in.] square cross-section and approximately 285-mm [11¼-in.] in length. The test specimen for concrete, which all the aggregate passes a 50-mm [2-in.] sieve, shall be a prism of 100-mm [4-in.] square cross-section and approximately 285-mm [11¼-in.] long. However, a prism of 75-mm [3-in.] square cross-section shall be used if all the aggregate passes a 25-mm [1-in.] sieve and a 50-mm [2-in.] square cross-section shall be used if all aggregates passes a 13-mm [½-in.] sieve.

9.3.2 *Initial Curing and Demolding of Test Specimens*—Cure the test specimens in the molds at 23 ± 2.0 °C [73.5 ± 3.5 °F] and not less than 50 % relative humidity except if modified by 8.3. Remove specimens from the molds at an age of 2¾ to 3 h after the addition of mixing liquid to the dry cementitious mixture during the mixing operation.

9.3.3 Make the initial comparator measurement reading of length at 3 to 3¼ h after the addition of mixing liquid to the dry cementitious mixture during the mixing operation. If specimens are cured at temperatures other than 23 ± 2.0 °C [73.5 ± 3.5 °F], then both initial and final length measurements shall be made with the bars conditioned to ±2.0 °C [±3.5 °F] of initial temperatures.

9.3.4 *Curing of Test Specimens*—After making the initial comparator reading, immediately store one set of specimens as for "Air Storage" and one set as for "Water Storage" within 10 min of reading.

9.3.4.1 *Air Storage*—Store the specimens in a dry room so that the specimens have a clearance of at least 25 mm [1 in.] on all sides and the room is maintained at a relative humidity of 50 ± 4 % and a temperature of 23 ± 2.0 °C [73.5 ± 3.5 °F] except if modified by 8.3.

9.3.4.2 *Water Storage*—Water-stored specimens shall be completely submerged in untreated tap water with no more than one set of specimens per container at a temperature of 23 ± 2.0 °C [73.5 ± 3.5 °F] except if modified by 8.3.

9.3.5 *Final Comparator Reading*—Measure the length at an age of 28 days ± 20 h. For specimens stored in water, remove the specimens from water storage one at a time, remove surface moisture and take the comparator reading within 15 s of removing from water. Determine the average percent change in length of specimens.

9.4 *Scaling Resistance*—Make and cure the test specimens in accordance with Test Method C672/C672M, 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 110 ± 5 °C [230 ± 9 °F] mass per unit area of exposed test area.

9.5 *Slant Shear Bond Strength*—Prepare six complete test specimens in accordance with Test Method C882 for Type II and V systems except as modified by this section.

9.5.1 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.

9.5.2 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.

10. Report

10.1 Report the following:

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

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

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

10.1.4 Bond strength at 1 day and 7 days,

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

10.1.6 Percent flow in mortar at 5 or 15 min,

10.1.7 Slump in concrete at 5 or 15 min, and

10.1.8 Scaling resistance after 25 cycles.

11. Precision and Bias

11.1 *Length Change:*

11.1.1 *Precision*—The precision of the length change test method described in section 9.3 is based on an interlaboratory study that was conducted in 2007.[5] Seven laboratories tested one rapid-hardening material that consisted of commercially available rapid hardening cement blended with three parts standard graded sand complying with Specification C778. The precision values were calculated for both "water storage" and "air storage" of test specimens. A test result is defined in this specification as the average of three separate measurements (triplicate lengthchange specimens).

11.1.2 The single-operator standard deviation for water storage of test specimens has been found to be 0.0031 %.[6] Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ by more than 0.009 %.[6] The single-operator standard deviation for air storage of test specimens has been found to be 0.0067 %.[6] Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ by more than 0.019 %.[6]

11.1.3 The multi-laboratory standard deviation for water storage of test specimens has been found to be 0.0078 %.[6] Therefore, results of two properly conducted tests from two different laboratories on the same material are not expected to differ by more than 0.022 %.[6] The multilaboratory standard deviation for air storage of test specimens has been found to be 0.015 %.[6] Therefore, results of two properly conducted tests from two different laboratories on the same material are not expected to differ by more than 0.041 %.[6]

11.1.4 *Bias*—Since there is no accepted reference material suitable for determining any bias that might be associated with this test method, no statement on bias is being made.

12. Rejection

12.1 The purchaser has the right to reject material that fails to conform to the requirements of this specification. Rejection shall be reported to the producer or supplier in writing.

13. Certification

13.1 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.

14. Product Marking

14.1 Mark all packages to contain the following information:

14.1.1 Specification designation.

14.1.2 R1 or R2 or R3 type.

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

14.1.3.1 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.

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

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1035. Contact ASTM Customer Service at service@astm.org.

[6] These measurements represent, respectively, the (1s) and (d2s) limits in accordance with Practice C670.