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930 MATERIALS FOR CONCRETE REPAIR. (REV 1-9-08) (FA 4-9-08) (1-09)

SECTION 930 (Pages 807-812) is deleted and the following substituted:

SECTION 930 MATERIALS FOR CONCRETE REPAIR

930-1 Description.

This Section covers cementitious materials used to repair concrete including defects or purposely placed openings in concrete elements. Materials containing organic compounds, such as bitumens and epoxy resin as the principal binder are not included. The requirements for epoxy resin materials are covered in Section 926.

930-2 Product Acceptance on the Project.

930-2.1 Product Acceptance: Use only products listed on the Department's Qualified Products List (QPL). Manufacturers seeking evaluation of products must submit an application in accordance with Section 6 and include independently certified test reports that the material meets the requirements of this Section. The application must describe detailed quality control requirements for installation including, but not limited to: maximum water to cementitious material ratio, formulation for two or more component systems special materials and/or equipment, recommendations for cleaning/preparing substrate surfaces, and curing requirements.

Provide the Engineer certification conforming to the requirements of Section 6 from the manufacturer confirming that the material(s) used meets the requirements of this Section and is the appropriate product for the intended use.

When specified in the Contract Documents, furnish a report of test results from an independent laboratory on samples taken from material shipped. Ensure the test was performed within 45 days prior to the shipping date of the material.

930-2.2 Material Supply, Storage, and Marking: The material shall be pre-proportioned including aggregate. Deliver products in original, unopened containers with manufacturer's name, date of manufacture, expiration date, product identification label and batch numbers. Store the material in an elevated dry and weather protected enclosure in full compliance with the manufacturer's recommendations. Material must be used within manufacturer's recommended shelf life.

The material from which the containers are made shall have water vapor transmission not greater than 2,048 lb/ft² in 24 hours as determined in accordance with Procedure B of ASTM E 96.

All containers shall be marked with the following information:

- (a) LOT identification number and material expiration date
- (b) Directions for use shall include but are not limited to the following:
 - (1) The type and kind of adhesive recommended (if any) to bond fresh repair material to the concrete or mortar being repaired.
 - (2) The recommended amount of resin, other liquid component, or both, to be mixed with the package contents.
 - (3) The recommended length of mixing time or sequence of mixing and resting times in minutes.

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(c) Date the material was packaged.

(d) The yield in cubic feet or yield in ft²/in thickness when mixed with the recommended amount of liquid.

(e) The net mass in each container. (The contents of any container shall not vary by more than 2% from the mass stated in markings. The average mass of filled containers in a LOT shall be not less than the mass stated in the markings.)

(f) Instructions for the maximum and minimum water (or solutions) to cementitious material ratio.

(g) Define the approximate working time.

930-2.3 Sampling, Mixing, and Additional Testing: A LOT is the packaged repair material normally placed on a pallet. A unit sample is a single container or package of material randomly selected from the LOT. Mix and install the material(s) in accordance with the manufacturer's recommendations. Manufacturers will be required to provide field representation upon request by the Engineer. The Department reserves the right to conduct further field testing on any approved material.

930-2.4 Rejection: All broken containers will be rejected. Material that fails to meet any of the requirements of this Specification will be rejected. Report all materials failing to meet this specification and state the reason(s) for rejection in writing to the Engineer and the producer or supplier. Material in local storage in the hands of a vendor for more than six months after testing will be retested before use, except for the scaling resistance test and length change immersed in sulfate solution test for Magnesium Ammonium Phosphate Concrete. Retested material will be rejected if it fails to conform to any of the requirements of this Specification.

930-2.5 Chemical Requirements: The material shall not contain total chlorides or other corrosive ingredients in excess of 0.40 lb/yd³ of the hardened concrete when used in reinforced and prestressed structures. Chloride determination shall be made in accordance with FM 5-516.

930-2.6 Laboratory Specimen Preparation.

930-2.6.1 Concrete: Packaged, dry concrete material shall contain aggregate of which more than 5% by mass of the total mixture is retained on a 3/8 inch sieve. The manufacturer shall indicate the maximum proportions of coarse aggregates used for extensions. This material can be used for repairing concrete with a depth up to six inches. Any depth larger than this shall be repaired with portland cement concrete meeting the requirements of Section 346.

Mechanically mix the packaged, dry concrete material with water and/or mixing liquid. Prepare and test three test specimens for each age of all of the hardened tests and each level of mixing temperature in accordance with ASTM C 31.

(a) The sample of packaged dry material shall be any combination of whole packages yielding not less than 0.667 ft³ of hardened material.

(b) Use only liquid components based on the manufacturer's recommendation. Measure the maximum amount of liquid needed based on the quantity per bag stated in the instructions for use.

(c) Place the sample in the mixing machine and add the required amount of liquid. Start mixing immediately and continue mixing for the length of time indicated in the directions for use.

(d) When performing the slump test, schedule work so the test will be completed in 15 ± 1/2 minutes after mixing the liquid with the rapidly hardening materials.

(e) Mold the required number of specimens using additional samples as may be necessary, mixing in accordance with (a) through (d).

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Use 4 in x 8 in test cylinders to mold concrete test specimens. The maximum nominal size of the aggregate in the concrete mix shall not exceed one inch.

930-2.6.2 Mortar: Packaged, dry mortar material may contain aggregate of which less than 5% by mass of the total mixture is retained on a 3/8 inch sieve. These materials may not be extended by the addition of aggregate in the field. This material can be used for repairing concrete with a depth up to six inches. Any depth larger than this shall be repaired with portland cement concrete meeting the requirements of Section 346.

Mechanically mix the packaged, dry mortar material with mixing liquid. Prepare and test three test specimens for each age of all of the hardened tests and each level of mixing temperature in accordance with ASTM C 109.

(a) The sample obtained from the packaged dry material shall weigh 6.6 ± 0.05 lbs and shall be representatively obtained from a whole package in accordance with FM 1-T 248.

(b) Base the quantity of liquid added during mixing on the quantity per unit of weight stated in the directions for use.

(c) When performing the flow test, schedule work so the test will be completed in $15 \pm 1/2$ minutes after mixing the liquid with the rapidly hardening materials.

(d) Mold the required number of specimens using additional samples as necessary mixing in accordance with (a) through (c).

930-2.6.3 Temperature: 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 55°F to 85°F, the product must be tested at the extreme of those temperatures. Specimens shall be mixed, molded and cured during the first three hours within $\pm 2^\circ\text{F}$ of the extreme temperature(s) stated by the manufacturer in the package markings.

930-2.6.4 Length Change: Make and cure the test specimens in accordance with ASTM C 157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period. The average length change of the test specimens for each preparation temperature and for each storage condition after 28 days shall meet the requirements as shown below.

930-2.6.5 Time of Setting: Initial time of set for concrete materials will be tested in accordance with ASTM C 403. Initial time of set for mortar materials will be tested in accordance with ASTM C 191.

930-2.6.6 Manifestly Faulty Specimens: Visually examine each group of specimens representing a given test or a given age of test, including tests of freshly mixed concrete, before or during the test, or both, whichever is appropriate. Discard any specimen found to be manifestly faulty by such examination without testing. Visually examine all specimens representing a given test at a given age after testing, and should any specimen be found to be manifestly faulty the test results thereof shall be disregarded. Should more than one specimen representing a given test at a given age be found manifestly faulty either before or after testing, the entire test shall be disregarded and repeated. The test result reported shall be the average of the individual test results of the specimens tested or, in the event that one specimen or one result has been discarded, it shall be the average of the test results of the remaining specimens.

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930-3 Materials for Repair of Predominately Horizontal Surfaces.

930-3.1 General: This material is intended to be used to repair concrete where the area to be treated will be on a horizontal surface. Examples of the type of locations for these materials are bridge decks, portland cement concrete pavements and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing, and curing the concrete unless otherwise directed in the Contract Documents.

930-3.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-3.2.1 Rapid Hardening: Moderate compressive strength for repairing concrete with an in-place compressive strength less than or equal to 4,000 psi.

930-3.2.2 Very Rapid Hardening: High compressive strength for repairing concrete with an in-place compressive strength greater than 4,000 psi.

930-3.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 1 as determined by the specified test methods.

Table 1 - Physical Properties of Repair Materials for Horizontal Surfaces			
Requirement	Test Method	Rapid Hardening	Very Rapid Hardening
Minimum Compressive Strength, psi			
3 hours	ASTM C 39* or ASTM C 109*	500	2,000
24 hours		2,000	4,000
7 days		4,000	6,000
28 days		Greater than or equal to strength at 7 days.	
Maximum Length Change (at 28 days), %			
Allowable expansion in water cured compared to length at one day	ASTM C 157	0.12	0.12
Allowable shrinkage in air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.2	0.2
Minimum Slump (Concrete), inches	ASTM C 143	3	3
Minimum Flow (Mortar), %	ASTM C 1437	100	80
Time of Setting (Initial), minutes	ASTM C 191* or ASTM C 403*	30 to 60	10 to 29
Coefficient of Thermal Expansion, in/in/°F	ASTM C 531	5.0 x 10 ⁻⁶ to 9.0 x 10 ⁻⁶	5.0 x 10 ⁻⁶ to 9.0 x 10 ⁻⁶
Minimum Bond Strength by Slant Shear, psi			
24 hours	ASTM C 882	400	400
7 days		Greater than or equal to strength at 24 hours.	

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* as applicable

930-3.4 Specimen Preparation:

930-3.4.1 Concrete: Samples shall be prepared in accordance with 930-2.6.1 except that work shall be scheduled so the test for flow will be completed in $5 \pm 1/2$ minutes after the start of mixing liquid with the very rapid hardening materials or $15 \pm 1/2$ minutes after mixing the liquid with the rapid hardening materials. The tests for temperature, length change, and time of set shall be performed in accordance with 930-2.6.3 through 930-2.6.5.

930-3.4.2 Mortar: Samples shall be prepared in accordance with 930-2.6.2 except that work shall be scheduled so the test for flow will be completed in $5 \pm 1/2$ minutes after the start of mixing liquid with the very rapid hardening materials or $15 \pm 1/2$ minutes after mixing the liquid with the rapid hardening materials. The tests for temperature, length change, and time of set shall be performed in accordance with 930-2.6.3 through 930-2.6.5.

930-4 Materials for Repair of Predominately Vertical Surfaces.

930-4.1 General: This material is intended to be used to repair concrete where the area exposed in the field to be treated will be on a vertical surface. If an element has both horizontal and vertical surfaces, then the repair used will be for vertical surfaces. If it is not apparent which material is to be used, the vertical application will prevail. Examples of the type of locations for these materials are columns, caps, beams, piles, incidental concrete products, drainage structures and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the concrete.

930-4.2 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 2 as determined by the specified test methods.

Table 2 - Physical Properties of Repair Materials for Vertical Surfaces*		
Requirement	Test Method	Test Value
Minimum Compressive Strength, psi		
24 hours	ASTM C 39** or ASTM C 109**	2,000
7 days		5,000
28 days		Greater than or equal to strength at 7 days
Maximum Length Change (at 28 days), %		
Allowable expansion in water cured compared to length at one day	ASTM C 157	0.12
Allowable shrinkage in air cured compared to length at one day		-0.08
Allowable difference between increase in water and decrease in air		0.2
Maximum Slump (Concrete), inches	ASTM C 143	3 ***
Maximum Flow (Mortar), %	ASTM C 1437	100
Time of Setting (Initial), minutes	ASTM C 191** or ASTM C 403**	10 to 60

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Coefficient of Thermal Expansion, in/in/°F	ASTM C 531	5.0 x 10 ⁻⁶ to 9.0 x 10 ⁻⁶
Minimum Bond Strength by Slant Shear, psi,		
24 hours	ASTM C 882	750
7 days		Greater than or equal to strength at 24 hours.
Minimum Flexural Strength, psi	ASTM C 580	750
Maximum Absorption (Mortar at 7 days), %	ASTM C 413	4
Minimum Surface Resistivity (Concrete at 28 days), KOhm-cm	FM 5-578	22
* use cement based materials modified with polymers and silica fume for extremely aggressive environments ** as applicable *** for pump and pour applications, the slump can be adjusted according to the contract documents		

930-4.3 Specimen Requirements:

930-4.3.1 Concrete: Samples shall be prepared in accordance with 930-2.6.1, 930-2.6.3 through 930-2.6.5.

930-4.3.2 Mortar: Samples shall be prepared in accordance with 930-2.6.2 through 930-2.6.5.

930-5 Material for Repair of Concrete in High Stress Concentration Areas.

930-5.1 General: This material is intended to be used to repair block-outs and holes in post-tensioned elements, load bearing area of a beam, and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the concrete. This material shall be a magnesium ammonium phosphate based concrete (MAPC).

930-5.2 Physical Properties: The MAPC material shall meet or exceed physical properties stated in Table 3 as determined by the specified standard test methods.

Table 3 - Physical Properties of Repair Material in High Load Areas		
Requirement	Test Method	Test Value
Minimum Compressive Strength (at 28 days), psi	ASTM C 109	8,500
Minimum Flexural Strength (at 28 days), psi	ASTM C 348	600
Minimum Slant Shear Bond (at 14 days), psi	ASTM C 882	2,500
Time of Setting (Initial), minutes	ASTM C 191	15 to 60
Maximum Scaling Resistance	ASTM C 672	No scaling
Maximum Length Change (at 28 days), % Allowable expansion in water cured compared to length at one day	ASTM C 157	0.03

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Allowable shrinkage in air cured compared to length at one day		-0.03
Maximum Expansion due to Sulfate Resistance (after 52 week of immersion), %	ASTM C 1012	0.1
Maximum Chloride Absorption at 21 days, %	NCHRP 12-19A*	1.5
* Use cube specimens meeting the requirements of ASTM C 109.		

930-5.3 Specimen Requirements:

930-5.3.1 Mortar: Samples shall be prepared in accordance with 930-2.6.2 and 930-2.6.4.

930-5.3.2 Curing of Compressive Strength, Flexural Strength and Slant Shear Bond Specimens: The test methods for compressive strength (ASTM C 109), flexural strength (ASTM C 348), and Slant Shear Bond (ASTM C 882) shall be modified so that the specimens are air cured instead of moist cured. All of these samples shall be air cured until the time of testing.

930-5.3.3 Time of Setting: Initial time of set for MAPC will be tested in accordance with ASTM C 191. The initial time of set shall be tested at a minimum of 95°F.

930-6 Packaged, Thermosetting Polymer Material For Concrete Repair.

930-6.1 General: This material covers packaged, thermosetting, polymer modified hydraulic cement for rapid repairs to hardened portland cement concrete pavement and structures. Only low odor materials, such as styrene diluted polyester resin, will be permitted.

If the area is being used for vehicular traffic, the repair material shall have a minimum compressive strength of 2,200 psi prior to opening to traffic or as noted in the plans.

930-6.2 Classification: The materials to be permitted as alternates shall meet the following requirements:

930-6.2.1 Type 1 Polymer: Moderate compressive strength for repairing concrete with an original compressive strength less than 4,500 psi.

930-6.2.2 Type 2 Polymer: Low modulus with a compressive strength less than 2,500 psi for repairing low quality and or moving concrete (across working cracks).

930-6.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 4 as determined by the specified standard test methods.

Requirement	Test Method	Type 1 Polymer	Type 2 Polymer
Minimum Compressive Strength, psi			
3 hours	ASTM C 579	1,500	800
24 hours		3,500	1,500
7 days		4,500	2,000
28 days		Greater than or equal to 7 days	
Time of Setting (Initial), minutes	ASTM C 191	12 to 20 minutes	12 to 20 minutes
Minimum Slant Shear Bond (at 7 days), psi	ASTM C 882	3,500	2,000

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Minimum Flexural Strength (at 7 days), psi	ASTM C 580	1,800	800
Minimum Tensile Strength (at 7 days), psi	ASTM C 307	900	400
Maximum Shrinkage, %	ASTM C 531	0.03	0.03
Maximum Expansion, per °F	ASTM C 531	0.000012	0.000012
Maximum Absorption (Mortar at 7 days), %	ASTM C 413	4	4
Minimum Surface Resistivity (Concrete at 28 days), KOhm-cm	FM 5-578	22	22

930-6.4 Specimen Requirements:

930-6.4.1 Mortar: Samples shall be prepared in accordance with 930-2.6.2, 930-2.6.3 and 930-2.6.5.

930-6.4.2 Mixing: The catalyst, resin and aggregate blend shall be provided by the manufacturer and approved by the Department.

930-6.5 Constructability: Furnish to the Engineer for approval shop drawing as may be required to complete repairs in compliance with the design shown in the plans and the manufacturer's recommended repair system.

930-7 Special Fillers.

930-7.1 General: This material is intended to be used as filler material and for rapid repairs to pile jacket structures and other locations specified in the Plans when no design mix concrete is available or a special filler is specified in the Contract Documents. Follow the requirements of Section 457 for preparing the surfaces, placing, testing and curing the concrete. Mix the material in accordance with the manufacturer's recommendations.

930-7.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-7.2.1 Cathodic Protection (CP) Filler: Provide cementitious based materials with a minimum cement content of 900 pounds of cement per cubic yard of mix. Material formulation must not contain fly ash, slag, silica fume or other mineral admixtures which may produce increased electrical resistance. The material shall not contain any chlorides or substances corrosive to metals.

930-7.2.2 Non-Cathodic Protection (Non-CP) Filler: Provide cementitious based materials with a minimum cement content of 900 pounds of cement per cubic yard of mix. The material shall not contain any chlorides or substances corrosive to metals.

930-7.2.3 Extended Materials: Where concrete filler materials are specified, approved mortar materials may be extended using 89 gradation aggregates from a certified FDOT approved source.

930-7.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 5 as determined by the specified standard test methods. Extended and non-extended materials shall meet the minimum requirements.

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Table 5 - Physical Properties of Special Fillers			
Requirement	Test Method	Cathodic Protection	Non-Cathodic Protection
Minimum Compressive Strength, psi			
24 hours	ASTM C 39* or ASTM C 109*	1,500	1,500
7 days		4,000	4,000
28 days		5,000	5,000
Maximum Length Change (at 28 days), %			
Allowable expansion in water cured compared to length at one day	ASTM C 157	0.12	0.12
Allowable shrinkage in air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.2	0.2
Slump (Concrete), inches	ASTM C 191* or ASTM C 403*	8	8
Time of Setting (Initial), minutes	ASTM C 191* or ASTM C 403*	30 to 90	30 to 90
Minimum Bond Strength by Slant Shear (at 7 days), psi	ASTM C 882	750	750
Minimum Flexural Strength (at 7 days), psi	ASTM C 580	750	750
Minimum Tensile Strength (at 7 days), psi	ASTM C 307	200	200
Surface Resistivity (at 28 days), KOhm-cm	FM 5-578	15 or less	22 or greater
*as applicable			

930-7.4 Specimen Requirements:

930-7.4.1 Concrete: Samples shall be prepared in accordance with 930-2.6.1, 930-2.6.3 through 930-2.6.5.

930-7.4.2 Mortar: Samples shall be prepared in accordance with 930-2.6.2 through 930-2.6.5.

930-7.5 Constructability: Furnish to the Engineer for approval shop drawing as may be required to complete repairs in compliance with the design shown in the plans and the manufacturer's recommended repair system.