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Standard Test Methods for Polymer-Modified Mortar and Concrete[1]

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ε[1] NOTE—Editorial corrections were made throughout in October 1999.

1. Scope

1.1 Most sections of ASTM test methods and practices for hydraulic cement mortar and concrete apply to the preparation and testing of specimens made with polymer-modifiers. However, there are some exceptions, most notably curing, that need special procedures in order to develop the properties inherent with polymer-modification. These test methods cover these exceptions.

1.2 For testing polymer-modified mortar and concrete specimens, the procedures in this standard supersede those in the referenced ASTM test methods and practices. These test methods are not applicable to dry, packaged mortar and concrete.

1.3 The values stated in SI units are to be regarded as standard.

1.4 *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:*

C 33 Specification for Concrete Aggregates[2]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortar (using 2-inch or 50 mm Cube)[2]

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate[2]

C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]

C 143 Test Method for Slump of Portland Cement Concrete

C 150 Specification for Portland Cement[2]

C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]

C 185 Test Method for Air Content of Hydraulic Cement Mortar[3]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

C 260 Specification for Air-Entraining Admixtures for Concrete[2]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[3]

C 403 Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance[2]

C 494 Specification for Chemical Admixtures for Concrete[2]

C 778 Specification for Standard Sand[3]

C 1202 Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration[2]

C 1404 Test Method for Bond Strength of Adhesive Systems Used with Concretes Measured by Direction Tension[2]

C 1438 Specification for Latex and Powder Polymer Modifiers for Hydraulic Cement Concrete and Mortar[2]

3. Significance and Use

3.1 These test methods are used to develop data for comparison with the requirements of Specification C 1438. Standardized procedures are used to compare the properties of specimens made from test mixtures of polymer-modified concrete or mortar with the properties of specimens made from reference mixtures. These test methods are not intended to simulate job conditions.

4. Materials

4.1 *polymer modifier*—the polymer modifier of the required type as furnished by the supplier.

4.2 *antifoam agent*—antifoam agent of the type recommended by the manufacturer, if one is not incorporated in the polymer modifier.

4.3 *cement*—portland cement conforming to Specification C 150; if necessary, blend into a single lot prior to test. Use same lot for both test and reference mixtures.

4.4 *aggregates*—fine and coarse aggregates for concrete conforming to Specification C 33; if necessary, blend each into

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

a single lot prior to test. Use same lot for both test and reference mixtures.

4.5 *graded sand*—sand for mortar mixtures conforming to Specification C 778; if necessary, blend into a single lot prior to test. Use same lot for both test and reference mixtures.

5. Proportioning of Concrete and Mortar Mixtures

5.1 *Concrete Mixture Proportioning*—Make the test and reference concrete with proportions similar to those shown for a nominal cubic-meter batch.

5.1.1 *Test Concrete*—Make the test concrete conforming to the following requirements:

	Parts by Mass, kg
Portland cement	390 ± 3
Fine aggregate[A]	975 ± 6
Coarse aggregate #8[A]	780 ± 6
Polymer Modifier	[B]
Antifoam agent	[C]
Potable water	[D]

[A] Saturated-surface-dry basis as described in Test Methods C 127 and C 128.
[B] The level recommended by the manufacturer.
[C] If the polymer modifier does not contain an antifoam agent, add the type and dosage recommended by the manufacturer, to the polymer modifier prior to mixing the concrete.
[D] The amount of water to give a slump of 90 ± 15 mm.

5.1.2 *Reference Concrete*—Make the reference concrete conforming to the following requirements:

	Parts by Mass, kg
Portland cement	390 ± 3
Fine aggregate[A]	975 ± 6
Coarse aggregate #8[A]	780 ± 6
Air-entraining admixture	[B]
Potable water	[C]

[A] Saturated-surface-dry basis as described in Test Methods C 127 and C 128.
[B] The amount of air-entraining admixture, meeting Specification C 260, to give an air content within 2 % of the test concrete and not exceeding 7.0 %.
[C] The amount of water to give a slump of 90 ± 15 mm.

5.2 *Mortar Mixture Proportioning*:

5.2.1 *Test Mortar*—Make the test mortar conforming to the following proportions:

	Parts by Mass, kg
Portland cement	100 ± 2
Graded sand[A]	275 ± 10
Polymer modifier	[B]
Antifoam agent	[C]
Potable water	[D]

[A] Saturated-surface-dry basis as described in Test Methods C 128.
[B] The level recommended by the manufacturer.
[C] If the polymer modifier does not contain an antifoam agent, add the type and dosage recommended by the manufacturer, to the polymer modifier prior to mixing the mortar.
[D] The amount of water that produces a flow of 105 to 115 % when tested according to Test Method C 109.

5.2.2 *Reference Mortar*—Make the reference mortar conforming to the following proportions:

	Parts by Mass, kg
Portland cement	100 ± 2
Graded sand[A]	275 ± 10
Air-entraining admixture	[B]
Potable water	[C]

[A] Saturated-surface-dry basis as described in Test Methods C 128.
[B] The amount of air-entraining admixture, meeting Specification C 260, to give an air content that is within 2 % of the test mortar and not exceeding 12.0 %.
[C] Amount of water that produces a flow of 105 to 115 % when tested according to Test Method C 109.

6. Procedure

6.1 *General*—Mix concretes and mortars in mechanical mixers in batches of such size as to leave about 10 % excess after molding test specimens and testing the unhardened mixtures.

6.2 *Temperature*—Before mixing the concrete or mortar, bring the materials to a uniform temperature, as described in Practice C 192 for concrete and Test Method C 109 for mortar.

6.3 *Polymer Modifier*—Store the polymer modifier in a dry place, in moisture-proof containers. Mix the polymer modifier thoroughly before use to ensure uniformity.

6.4 *Reference Concrete and Mortar*—Prepare reference concrete or mortar in compliance with Practice C 192 or Test Method C 109, respectively.

NOTE 1—For trial batches to establish the amounts of water and air-entraining admixture to achieve the specified fresh properties, it is permissible to add these ingredients in increments and remix the batches. With the first increment of water and air-entraining admixture, if applicable, follow the mixing procedures specified in the previous section. If the slump, or flow, or air content is less than required, add additional water or air-entraining admixture and remix the batch. For mortar mixtures, remix at slow speed for 30 s. For concrete, remix the batch for 1 min. Remixing is permitted as often as necessary, provided the elapsed time from the start of initial mixing to the completion of mixing does not exceed 30 min. Cover the mixer to minimize evaporation when tests of fresh properties are being performed. These are trial batches only and are not to be used for testing.

6.5 *Test Mortar*—For mixing test mortar, follow Practice C 305, with the following changes:

6.5.1 *For Latex Polymer Modifiers*:

6.5.1.1 Place all the polymer modifier (with antifoam agent, as required) and mixing water in the bowl.

6.5.1.2 Add the cement to the bowl; start the mixer and mix at the slow speed (140 ± 5 r/min) for 30 s.

6.5.2 *For Powder Polymer Modifiers*:

6.5.2.1 Blend all the polymer modifier (with antifoam agent, as required) and cement, within 1 h of mixing the mortar.

6.5.2.2 Place the water in the bowl.

6.5.2.3 Add the cement/polymer modifier blend to the water; start the mixer and mix at the slow speed (140 ± 5 r/min) for 30 s

6.6 *Test Concrete*—For mixing test concrete, follow Practice C 192, with the following changes:

6.6.1 *For Latex Polymer Modifiers*—Prior to starting rotation of the mixer, add the coarse aggregate, polymer modifier, and approximately half of the water. Rotate the mixer a few revolutions, then add the fine aggregate, cement and remaining water. Mix the concrete for 3 min, followed by a 1 minute rest, followed by 1 min final mixing. Cover the open end of the mixer during the rest period to prevent evaporation. Take precautions to compensate for mortar retained by the mixer so that the discharged batch, as used, will be correctly proportioned (see Note 2).

6.6.2 *For Powder Polymer Modifiers*—Blend all the polymer modifier (with antifoam agent, as required) and cement, within 1 h of mixing the concrete. Prior to starting rotation of the mixer, add the coarse aggregate and approximately half of the water. Rotate the mixer a few revolutions, then add the fine aggregate, cement/polymer modifier blend, and remaining water. Mix the concrete for 3 min, followed by a 1 min rest, followed by 1 min final mixing. Cover the open end of the mixer during the rest period to prevent evaporation. Take

precautions to compensate for mortar retained by the mixer so that the discharged batch, as used, will be correctly proportioned (see Note 2).

NOTE 2—It is difficult to recover all of the mortar from mixers. To compensate for this difficulty one of the following procedures may be used to ensure the correct final proportions in the batch:

(1) "Buttering the Mixer"—Just prior to mixing the test batch, the mixer is "buttered" by mixing a batch proportioned to simulate closely the test batch. The mortar adhering to the mixer after discharging is intended to compensate for loss of mortar from the test batch.

(2) "Over-Mortaring" the Mixture—The test mixture is proportioned by the use of an excess mortar, the amount established in advance, to compensate for that which, on the average, adheres to the mixer. In this case the mixer is cleaned before mixing the test batch.

7. Tests of Freshly Mixed Concrete and Mortar

7.1 *Concretes*—Test samples of the freshly mixed concrete in accordance with the following methods:

7.1.1 *Slump*—Test Method C 143.

7.1.2 *Air Content*—Test Method C 173 or C 231.

7.1.3 *Unit Weight*—Test Method C 138.

7.1.4 *Time of Setting*—Test Method C 403.

7.2 *Mortars*—Test samples of the freshly mixed mortar in accordance with the following methods:

7.2.1 *Flow*—Test Method C 109.

7.2.2 *Unit Weight*—Test Method C 185.

7.2.3 *Time of Setting*—Test Method C 403.

7.2.4 *Air Content*.

7.2.5 *Test Mortar*:

7.2.5.1 *Mass per 400 mL of Test Mortar*—When the quantity of mixing water has been found that produces a flow of 105 to 115 %, immediately determine the mass per 400 mL of mortar, following the procedures in Test Method C 185.

7.2.5.2 *Air Content Calculation*—Calculate the air content of the test mortar using the following formulas, which are based on the assumption that the specific gravities of the portland cement and sand are 3.15 and 2.65, respectively:

$$\text{air content, volume \%} = 100\,(1 - W_a / W_c) \tag{1}$$

where

W_a = measured density of test mortar, g/mL,
= W_t/400, where W_t is the mass in grams of 400 mL of the test mortar,

W_c = theoretical mass per unit volume, calculated on an air-free basis as follows:

$$= \frac{100 + 275 + L + A + D}{\frac{100}{3.15} + \frac{275}{2.65} + \frac{L}{S_L} + \frac{A}{S_A} + \frac{D}{1.0}} \tag{2}$$

where:

L = mass of polymer modifier (includes water), g/100 g cement,
S_L = specific gravity of polymer modifier,
A = mass of antifoam agent, g/100 g cement,
S_A = specific gravity of antifoam agent, and
D = mass of water added, g/100 g cement.

7.2.6 *Reference Mortar*:

7.2.6.1 *Mass per 400 mL of Reference Mortar*—When the quantity of mixing water has been found that produces a flow of 105 to 115 %, immediately determine the mass per 400 mL of mortar, following the procedures in Test Method C 185.

7.2.6.2 *Air Content Calculation*—Calculate the air content of the reference mortar using the following formulas, which are based on the assumption that the specific gravities of the portland cement and sand are 3.15 and 2.65, respectively:

$$\text{Air content, volume \%} = 100\,(1 - W_a / W_c) \tag{3}$$

where:

W_a = measured density of reference mortar, g/mL,
= W_r/400, where W_r is the mass in grams of 400 mL of the reference mortar,

W_c = theoretical mass per unit volume, calculated on an air-free basis as follows:

$$\frac{100 + 275 + AE + D}{\frac{100}{3.15} + \frac{275}{2.65} + \frac{AE}{S_{AE}} + \frac{D}{1.0}} \tag{4}$$

where:

AE = mass of air-entraining admixture, g/100 g cement,
S_{AE} = specific gravity of air-entraining admixture, and
D = mass of water added, g/100 g cement.

8. Preparation of Test Specimens

8.1 Prepare test specimens, from at least three separate batches of the mixtures being tested, according to the procedures in the test methods prescribed in Section 9. Three replicates shall be required for each test, except for Test Method C 1202, for which two replicates are acceptable. Complete the preparation of all specimens within three days.

8.2 *Manifestly Faulty Specimens*—Visually examine each specimen before testing. Do not test any specimen found to be manifestly faulty by such examination. Visually examine all specimens after testing, and discard the test result of any specimen found to be manifestly faulty. Should more than one specimen for a given test at a given age be found manifestly faulty either before or after testing, disregard the entire test and repeat. The test results reported shall be the average of the individual test results of the three specimens tested or, in the event that one specimen or one result has been disregarded, the average of the test results of the two remaining specimens.

8.3 *Curing*:

8.3.1 *Reference Concrete and Mortar*—Cure reference concrete and mortar specimens in conformance with Practice C 192 and Test Method C 109, respectively.

8.3.2 *Test Concrete and Mortar*—Unless otherwise specified, immediately cover the polymer-modified concrete and mortar specimens with polyethylene film (0.1 mm minimum thickness) and store at 23 ± 2°C for 24 ± 1 h. Remove the polyethylene cover and store the specimens at 23 ± 2°C and 50 ± 10 % R. H. until time of test.

9. Tests on Hardened Concretes and Mortars

9.1 *Concretes*—Test specimens of hardened concrete in accordance with the following methods:

9.1.1 *Compressive Strength*—Test Method C 39.

9.1.2 *Bond Strength*—Use the procedure in Test Method C 1404 to prepare the base assembly. After the top nipple has been taped to the bottom nipple, use the following procedure to complete the composite specimen.

9.1.2.1 Dampen the cut surface with water. A properly

prepared surface will be damp but have no water sheen.

NOTE 3—Paper and cloth towels have been used to remove standing water.

9.1.2.2 Place approximately 50 mL of the test mixture onto the damp, cut surface and, using the brush, apply a uniform coating of paste to the concrete surface and the inside surface of the nipple.

9.1.2.3 Fill the top nipple in two equal layers, and rod each layer using 25 strokes. Strike off the surface with a trowel and cover with polyethylene film.

9.1.2.4 At the specified age, test the composite specimen, calculate the tensile strength at failure, and estimate the percentage of each mode of failure (base, bond line, or overlay), in accordance with Test Method C 1404.

9.1.3 *Indication of Chloride Ion Penetration*—Test Method C 1202. Use cylinders.

9.2 *Mortars*—test specimens of hardened mortar in accordance with the following methods:

9.2.1 *Compressive Strength*—Test Method C 109.

9.2.2 *Bond Strength*—Test Method C 1404. Use the same procedure as described above for concrete.

9.2.3 *Indication of Chloride Ion Penetration*—Test Method C 1202.

10. Calculation

10.1 Calculate the water content, exclusive of water absorbed by the aggregates, of the test mixtures and the reference mixtures. Include the water in the polymer modifier, if applicable.

10.2 Calculate the water content of test concrete as a percentage of the reference concrete, and the test mortar as a percentage of the reference mortar, as follows:

$$WC_P = WC_t / WC_r \times 100 \quad (5)$$

where:

WC_P = water content of test concrete or mortar as a percentage of the reference concrete or mortar,

WC_t = water content of test concrete or mortar corrected to saturated-surface-dry condition of the aggregates, kg, and

WC_r = water content of reference concrete or mortar corrected to saturated-surface-dry condition of the aggregates, kg.

WC_t is calculated as follows:

$$WC_t = (WL + AW) \quad (6)$$

where:

WL = mass of water contributed by latex, and

AW = mass of water added to the mixer corrected to saturated-surface-dry condition of the aggregates.

WL is calculated as follows:

$$WL = [(100-P)/100]\,(ML) \quad (7)$$

where:

P = polymer content of latex (percent), measured by oven drying in accordance with Specification C 494, and

ML = mass of latex added to batch.

11. Report

11.1 Report the following information:

11.1.1 Brand name, manufacturer's name, lot number, chemical composition, polymer content, type and dosage of polymer-modifier; brand name and dosage of any post-added antifoam agent.

11.1.2 Type of portland cement used.

11.1.3 Water content of the test mixture as a percent of the reference mixture.

11.1.4 Curing conditions and age of each specimen tested.

11.1.5 *For the Test Concretes*—Slump, air content, unit weight, time of setting, compressive strength, size of compressive strength cylinders, bond strength, indication of chloride penetration; as actual values, and percent of reference concrete.

11.1.6 *For the Test Mortars*—Flow, air content, unit weight, time of setting, compressive strength, bond strength, indication of chloride penetration; as actual values, and percent of reference mortar.

12. Precision and Bias

12.1 *Precision*—The precision of each of the procedures in this test method is being determined.

12.2 *Bias*—The procedures in this test method have no bias because the values are defined only in terms of this test method.

13. Keywords

13.1 latex; latex polymer; polymer-modified concrete; polymer-modified mortar; powder polymer