

Recommend Approval: <u>Victor R. Street</u> 10-4-12 Assistant Division Chief Date <u>J. H. Kelly</u> 10/4/12 Division Chief Date	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
Approved: <u>Tom Smith</u> 10-18-12 Director Date	CONCRETE MODIFIED WITH STYRENE – BUTADIENE LATEX EMULSION	MSMT 721

SCOPE:

These procedures are used to determine the physical properties of portland cement concrete containing a styrene-butadiene latex emulsion.

REFERENCED DOCUMENTS:

- T 22 Compressive Strength of Cylindrical Concrete Specimens
- T 97 Flexural Strength of Concrete (using Simple Beam with Third-Point Loading)
- T 119 Slump of Hydraulic Cement Concrete
- T 127 Sampling and Amount of Testing of Hydraulic Cement
- T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
- T 160 Length Change of Hardened Hydraulic Cement Mortar and Concrete
- T 259 Resistance of Concrete to Chloride Ion Penetration
- T 260 Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials
- 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 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory
- C 672 Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals
- C 882 Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear

COMPRESSIVE AND FLEXURE TESTS

MATERIALS AND EQUIPMENT:

1. Making and Curing Concrete test specimens in the Laboratory; refer to T 126.
2. Slump of Hydraulic cement concrete; refer to T 119.
3. Air content of freshly mixed concrete by the pressure method; refer to T 152.
4. Compressive strength of cylindrical concrete specimens; refer to T 22.
5. Flexural strength of concrete (Using simple beam with third point loading); refer to T 97.
6. Drying room for air storage, as specified in T 160.

7. Container, having sufficient dimensions to completely immerse three compressive strength specimens in water.

TEST PROCEDURES:

1. Prepare nine compressive strength cylinders measuring 3 x 6 in. and six flexure test beams measuring 3 x 4 x 16 in. to be used in prequalifying a latex emulsion. Mix the specimens as specified in T 126 with the following exceptions:
 - a. The coarse aggregate and latex shall be combined and mixed for 30 seconds.
 - b. The fine aggregate and cement shall be added and mixed for one minute.
 - c. Add the water to the batched material and mix for two minutes.
2. The slump test shall be determined as specified in T 119 four minutes after completion of mixing.
3. Air content test shall be measured as specified in T 152.
4. Cure compressive strength cylinders and flexure test beams by the following method:
 - a. Cure the specimens in the molds covered with wet burlap until 24 hr have elapsed since adding the water to the cement.
 - b. Remove the specimens from the molds and place them in air storage conforming to the requirements of T 160.
 - c. Test three of each compressive and flexure specimens at 7 and 28 days.
 - d. Remove the three 42 day compressive strength specimens from air storage at 28 days and immerse in water maintained at a temperature of 73 ± 3 F and a minimum of 2 g of lime per liter solution.
5. Determine the compressive and flexure strength as specified in T 22 and T 97, respectively.

DURABILITY FACTOR

MATERIALS AND EQUIPMENT:

1. Resistance of Concrete to Rapid Freezing and Thawing; refer to T 161.
2. Drying room for air storage as specified in T 160.

3. Container having sufficient dimensions to completely immerse the specimen beams in water.

TEST PROCEDURES:

1. Prepare a minimum of two beams measuring 3 x 4 x 16 in. representing the specified latex mixture in conformance with the "Compressive and Flexure Tests" section of these procedures.
2. Determine the durability factor as specified in T 161, Procedure B, except that the curing shall be as follows:
 - a. Specimens shall be cured in the molds and covered with wet burlap until 24 hr have elapsed since adding the water to the cement.
 - b. Remove the specimens from the molds and cure in air storage as specified in T 160.
 - c. When the specimens have cured 14 days, immerse them for 14 days in 73 ±3 F water having a minimum of 2 g of lime per liter of solution.

CHLORIDE PERMEABILITY

MATERIALS AND EQUIPMENT:

1. Resistance of Concrete to Chloride Ion Penetration; refer to T 259.
2. Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials; refer to T 260.
3. Drying room for air storage as specified in T 160.

TEST PROCEDURES:

1. Prepare and test specimens as specified in T 259, except cure the specimens as follows:
 - a. Initially cure the specimens under wet burlap until 24 hours have elapsed since water was added to the cement.
 - b. Place the specimens in air storage conforming to the requirements of T 160 for 27 days.
2. Determine total chlorides as specified in T 260.

SCALING RESISTANCE

MATERIALS AND EQUIPMENT:

1. Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals; refer to C 672.
2. A solution of sodium chloride and water having a concentration such that each 100 mL of solution contains 3 g of sodium chloride.

TEST PROCEDURES:

1. Prepare specimens as specified in C 672, except perform curing as specified in the "Durability Factor" above.
2. Determine scaling resistance after 50 cycles as specified in C 67; using a three percent solution of sodium chloride.

SHEAR BOND

MATERIALS AND EQUIPMENT:

1. Standard Test Method for Compressive Strength of Hydraulic Cement Mortars; refer to C 109. **Note:** This applies only to the mixing of the mortar.
2. Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory; refer to C 192.
3. Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear; refer to C 882.
4. Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; refer to C 39.
5. Trowel.
6. Glass or metal plates each with an area sufficient to cover molded cylindrical specimens.
7. Apparatus for mixing epoxy-resin bonding system, including 1000 mL tri-pour plastic beakers, and wooden stirring sticks or spatula.
8. Specimen molds shall be right cylindrical, 3 1/16 in. inside diameter and 6 1/16 in. high; machined to 1/64 in. tolerance in each dimension. The molds shall be metal, resistant to

attack by the mortar; with rigid sides to prevent spreading or warping.

9. Dummy sections machined from hard wood, not attached by the mortar. The section shall fit the mold and be equal to half the volume of the cylinder. The shear face shall be at a 30 degree angle from the vertical.
10. Tamping rod shall be round, of brass or plastic 3/8 in. diameter and approximately 12 in. long having two hemispheric round tips.

TEST PROCEDURES:

1. Mix the mortar as specified in C 109.
 - a. Lightly oil the dummy section and the mold with commercial form release oil.
 - b. Ensure the mold is tightly secured to the base plate.
 - c. Position the dummy section in the mold with the slant shear face up.
 - d. Place the mortar in the mold in three layers of equal volume.
 - e. Rod each layer with 25 strokes, gently tapping the side of the mold with a mallet between layers.
 - f. Distribute the strokes uniformly over the section and rod deeply enough to penetrate any underlying layer.
 - g. Strike off the top layer with a trowel and cover with a glass or metal plate.
 - h. Cure the specimen as specified in C 192 for at least 28 days. Allow the specimen to dry under laboratory conditions for least 7 days.
2. 3 x 6 in. cylinder of the mortar shall have a compressive strength of at least 4500 psi at 7 days when tested as specified in C 882, calculated on the basis of the normal cross-sectional area of the cylinder (7.07 in^2).

PREPARATION OF SHEAR TEST SPECIMENS

1. A test consists of three bonded 3 in. diameter by 6 in. tall specimens made by applying a bonding latex or latex slurry to the diagonal faces of the hardened half cylinders placed in the molds. Fill the molds with mortar using the latex modified mortar as follows:
 - a. Hold the mold at an angle so that the shear face is horizontal and place a layer of

latex concrete mortar about ½ in. thick on the shear face.

- b. Rod the layer using the tamping rod, while gently tamping against the shear surface.
 - c. Place the mold in a vertical position on the work bench and fill with mortar in two layers of approximate equal volume.
 - d. Rod each layer 25 strikes with the rod, gently tapping the side of the mold with a mallet between layers.
 - e. Strike off excess with a trowel then cover with a glass or metal plate.
2. Place the freshly made specimens in the moisture room to cure.
 3. Cure and remove the specimens from the molds as specified in C 192.
 4. Determine the compressive strength of the specimens at 42 days as specified in C 39; except the total load will be divided by the area of the elliptical shear surface instead of the area of the top of the cylinder as shown in CALCULATIONS.

CALCULATIONS:

The bond strength shall be calculated as follows:

$$B = \frac{T}{14.13 \text{ in}^2}$$

where:

B = bond strength

T = total load to failure

14.13 in² = area of the elliptical bonding surface of the test cylinder

REPORT:

Report the average bond strength to the nearest 10 psi and the type of shear occurring, if any.