FLORIDA DEPARTMENT OF TRANSPORTATION
State Materials Office
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FLORIDA METHOD OF TEST FOR BOND STRENGTH OF ADHESIVES USED IN RETROFIT ADA WARNING SURFACE MATERIALS BY DIRECT TENSION (PULL-OFF)

Designation: FM 5-589

1. Scope

1.1. This test method is suitable for both field and laboratory use to determine bond strength of adhesives used in retrofit Detectable Warning Surface Systems in compliance with the Americans with Disabilities Act (ADA).

1.2 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.

1.3 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 1583 Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
C 125 Terminology Relating to Concrete and Aggregates
C 881/C 881 M Specification for Epoxy-Resin Base Bonding Systems for Concrete
C 900 Test Method for Pullout Strength of Hardened Concrete

2.2 ACI Standards:

ACI 503R Use of Epoxy Compounds with Concrete

3. Terminology

3.1 For definitions of terms used in this test method refer to Terminology ASTM C 125 and ACI 503R.

3.2 Mat Material – Any material used in the manufacture of Detectable Warning Surface System.

4. Summary of Test Method

4.1 This test is performed on the surface of a mat material after the mat has been bonded to a concrete surface.

4.2 A metal disk (dolly) is bonded to the top surface of the mat. The test specimen is formed by drilling a shallow core around the dolly, through the mat material, into and perpendicular to the surface of the concrete leaving the intact core attached.

4.3 A tensile load is applied to the steel disk (dolly) until failure occurs. The failure load and the failure mode are recorded and the nominal tensile stress at failure is calculated.

5. Significance and Use

5.1 This test method determines the tensile strength of adhesives used to bond mat materials to concrete surfaces.

5.2 When the test is performed on the surface of the mat material, it determines the mat materials tensile strength, mat to adhesive bond strength, adhesive to concrete bond strength or the tensile strength of the concrete, whichever is weaker.

5.3 When the test is performed on the surface of a material applied to the concrete, the measured strength is controlled by the failure mechanism requiring the least stress. Thus it is not possible to know beforehand which strength will be measured by the test. For this reason, the failure mode has to be reported for each individual test result, and test results are averaged only if the same failure mode occurs.

6. Apparatus

6.1 Core Drill Motor, of sufficient torque to drill through mat materials and adhesives for preparing test specimen.

6.2 Core Barrel/ Hole Saw, with either a diamond impregnated or tungsten carbide grit bit typically 30.0mm [1.18 in.] inside diameter for a 35 mm [1.38 in.] outside diameter.

Note 1: It is also advantageous to use a carbide tipped hole saw typically 32 mm [1.26 in.] inside diameter for a 35 mm [1.38 in.] outside diameter on soft mat materials.

6.3 Machined Metal Disks (Dollies), outside diameter 0.08 inches less than the diameter of the core barrel and thick enough to transfer the load without deformation. The dolly is configured to receive the coupling device of the tensile loading device.

6.4 Tensile Loading Device (Bond Tester), with a load-indicating system and nominal capacity of 22 k N (5,000 lbf) and capable of applying load at a constant rate. The loading device includes a tripod or bearing ring for distributing the force to the supporting surface.

6.4.1 Within the operating range, the indicated tensile force shall be within +/-2 % of the force measured by a calibrated testing machine or load cell. Verify the tensile loading device at least once a year and after repairs and adjustments.

Note 2: See ASTM C 900 for suitable verification schemes.

6.4.2 A coupling device shall be used to connect the dolly to the tensile loading device. The coupling device shall be designed to withstand the tensile load capacity without yielding, and to transmit the tensile force parallel to and in line with the axis of the cylindrical test specimen without imparting torsion or bending to the test specimen.

7. Materials

7.1 Epoxy adhesive material for bonding the dolly to the test specimen, shall be a fast-curing paste or gel meeting the requirements of ASTM C 881/C 881M for Type IV, Grade 3, except that a shorter gel time is permitted.

Note 3 – PermaPoxy 5 minute Epoxy (3400 psi) as manufactured by Permatex or Super Glue as manufactured by Loctite, both have been found to be sufficient bonding agents.

7.2 Concrete test specimen blocks for mounting mat material test sections shall be at least 12 in. x 12 in. x 2 in. (3048 mm x 3048 mm x 51 mm). Testing blocks for this procedure may be obtained from typical Home Improvement

Stores (i.e., Lowe's, Home Depot) or from Concrete Precast Supply Companies, and are sold as patio blocks. Randomly select three test blocks to perform tensile tests. Perform three pull off tests per block, then average the test results. The resulting average of all tests shall be a minimum of 250 psi with no one test result below 200 psi.

8. Sampling

8.1 Select three qualified concrete blocks (per 7.2) to apply mat materials

8.2 Five individual test results shall be obtained from each of three prepared test specimen blocks with no one result falling below the specified minimum. If a result falls below the specified minimum in mode (a), (c), or (d) as described in section 11.4, retest.

8.3 Locate test sites in the flat areas between the truncated domes such that the domes do not interfere with the test site or leveling device of the bond tester.

Note 4: Pre-positioning of the bond tester leveling device, prior to marking the test sites will aid in determining the test sites.

8.4 The center-to-center distance of adjacent test sites shall be at least two disk diameters. The distance from the center of a test site and a free edge of the test block shall be at least one disk diameter. A test site may not be placed near a manufactured edge such that it would incorporate a beveled edge.

9. Preparation of Test Surfaces

9.1 Preparation of Concrete Test Specimen Block

9.1.1 Remove all surface contaminants including loose materials and dust to obtain a clean dry surface on the concrete specimen test block.

9.2 Preparation of Test Dolly

9.2.1 The testing surface of the dolly must be cleaned of all foreign debris and lightly sanded using 100 grit sand paper in a cross-hatch pattern to enhance bonding characteristic. Immediately before use, the dolly should be wiped clean with alcohol using a soft cloth.

9.3 Preparation of Mat Material Test Specimen

9.3.1 Any texture in the test area must be removed to provide a flat surface for bonding of the dollies. Before bonding the dollies, the test area must be cleaned of any contaminants that would interfere with bonding.

10. Preparation of Test Specimen

10.1 Attach mat material to the concrete block following manufacturer's suggested application procedures. Allow curing of the adhesive as directed by the manufacturer's instructions.

10.2 Attach the dolly to the top of the mat using the epoxy adhesive. Ensure that the dolly is positioned in a flat area of the mat between the truncated domes in such a way that the domes do not interfere with the leveling device. Cure the epoxy adhesive following manufacturer's instructions.

Note 5: ACI 503R provides guidance on applying and curing epoxy.

10.3 Using the coring equipment, drill through the test mat material into and perpendicular to the concrete surface to ensure isolation of the mat material adhesive from the surrounding concrete. It is important to maintain perpendicularity while drilling over the dolly in order to not affect any adhesive bonds.

Note 6: Fig. 1 Schematic of the test for determining bond strength of mat material adhesive. This schematic is not intended to indicate a specific equipment design.

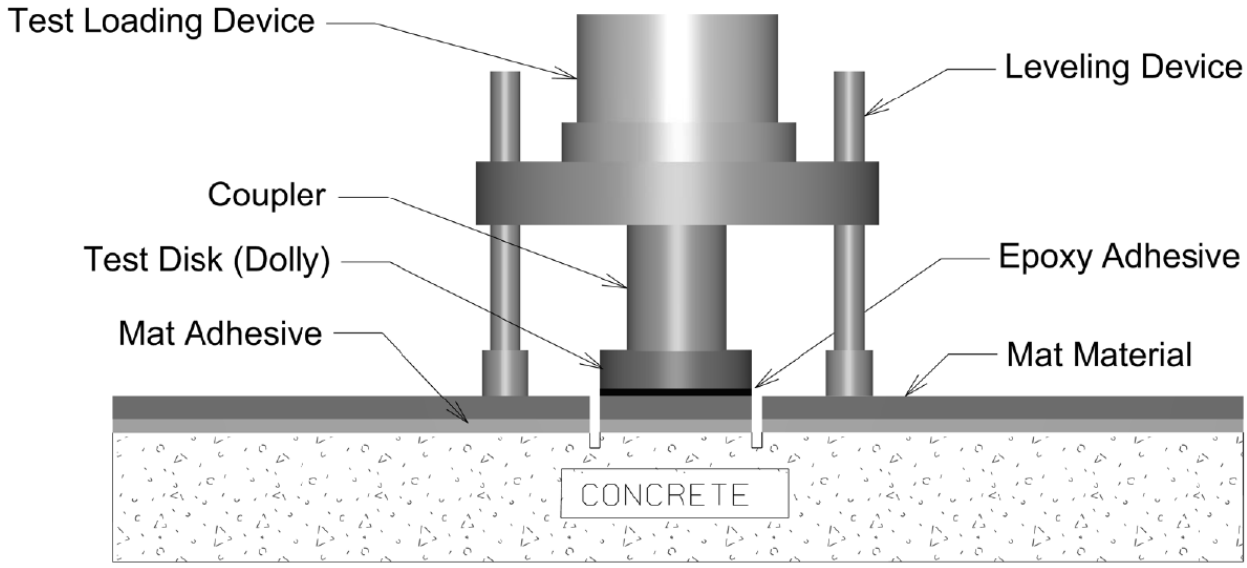

Fig. 1 Schematic of Setup to Test Material Applied to Concrete

11. Test Procedure

11.1 Attach the tensile loading device to the dolly using the coupling device.

11.2 Apply the tensile load to the test specimen so that the force is parallel to and coincident with the axis of the specimen.

11.3 Apply and maintain the tensile load at a constant rate throughout the test.

11.4 Record the failure load and the failure mode.
Record the failure mode (see Fig. 2) as:
- (a) in the concrete
- (b) at the interface between the concrete and the mat material
  - i) concrete and mat adhesive
  - ii) within the mat adhesive
  - iii) mat adhesive and mat material
- (c) in the mat material
- (d) at the bond between the mat material and the dolly.

11.5 Calculate the tensile strength by dividing the tensile load at failure by the area of the test dolly:

$$\text{Tensile Strength (psi [MPa])} = \frac{\text{Tensile load (lbf [N])}}{\text{Area of test dolly (in}^2\text{ [mm}^2\text{])}}$$

11.6 Record the individual strengths to the nearest 1 psi [0.01 MPa].

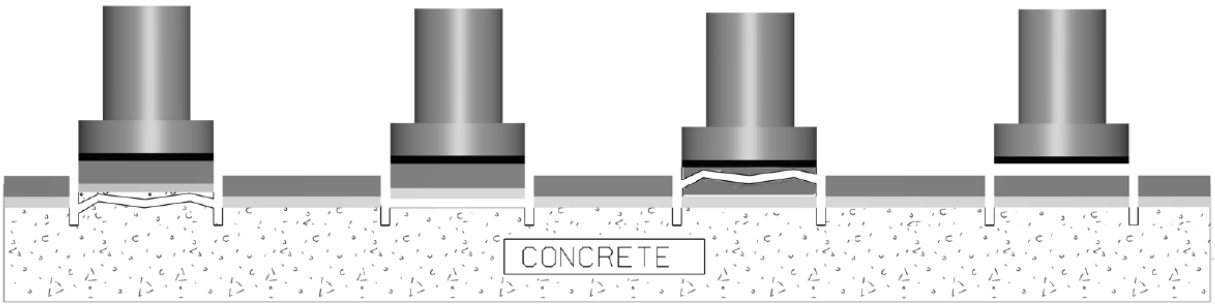

Fig. 2 Schematic of Failure Modes

12. Report

12.1 The test report shall contain the following:

12.2 Identification of all materials used.

12.3 The failure mode for each test.

12.4 The strength for each test.