



**INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS**

**TENSILE BOND PULL-OFF TEST
ITM No. 407-19**

1.0 SCOPE.

- 1.1 This test method covers the procedures for evaluating the tensile bond strength of a polymeric surface treatment applied to a prepared concrete substrate. The test determines the greatest perpendicular force (in tension) that a surface area may bear before a plug of material is detached.
- 1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ASTM STANDARDS.

- C881 Epoxy-Resin-Base Bonding Systems for Concrete
- C900 Pullout Strength of Hardened Concrete
- C1583 Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department Standard Specifications, Section 101, and as follows for this test method.

- 3.1 Adhesive. Material that bonds the bottom of the loading fixture to the top of Polymeric Concrete Surface Treatment
- 3.2 Loading Fixture. A metal structure that is flat on one end for bonding to the polymeric surface treatment, shaped on the other end for attachment to the tensile loading device, and used to determine the Tensile Bond Strength
- 3.3 Portable Tensile Loading Device. An instrument, with a load indicating system and nominal capacity of a maximum of 5000 lbf, that is capable of applying a concentric load and counter load to a single surface at a specific rate

4.0 SIGNIFICANCE AND USE.

- 4.1** This test method is used as a surface preparation test and a final cure test for a polymeric surface treatment. A circular loading fixture is attached to the surface of a test specimen prepared in the field. The test specimen is formed by drilling a shallow core into the concrete substrate that is perpendicular to the polymeric surface treatment. A force is applied to the loading fixture that extracts a disk or plug containing the concrete substrate and/or the applied surface treatment. The measured force is used to calculate an applied stress. This test method is suitable to determine the following:
- a) The tensile strength of concrete near the prepared surface, which may be used as an indicator of the adequacy of surface preparation before applying the final polymeric surface treatment. A test patch is prepared as described in the applicable specification.
 - b) The bond strength to the prepared concrete substrate or the tensile strength of either the surface treatment or concrete substrate, whichever is weaker, when the test is conducted as part of final acceptance for a newly placed polymeric surface treatment
- 4.2** The measured strength is controlled by the failure mechanism requiring the least stress. Failure will occur along a fractured surface exposing the weakest plane within the system comprising the test fixture, adhesive, polymeric surface treatment, and concrete substrate. The strength measured by the test is not possible to know beforehand. Therefore, the failure mode is reported for each individual test result and interpreted as stated in the applicable specification.

5.0 APPARATUS.

- 5.1** Core drill, with water capability to the core barrel
- 5.2** Core barrel, with diamond impregnated bits and a nominal 2 .0 in. inside diameter
- 5.3** Pull-Off Tensile Loading Device, portable, with a load-indicating system for determining the actual force applied to the test specimen. The loading device shall be capable of applying the load at the rate specified in Section 9.3. This system (Attachment A) consists of a base, load indicator, loading fixture and coupling device as follows:
- a) The base shall consist of a tripod or bearing ring for distributing the force to the supporting surface. A means of aligning the base is needed so that resultant force is normal to the surface.
 - b) The load indicator shall be verified to be within ± 2 % of the force measured by a calibrated testing machine or load cell. The load indicator shall be

calibrated annually and after repairs or adjustments according to the manufacturer's recommended procedure. A calibration log shall be maintained and kept with the equipment.

- c) The loading fixture, nominally 2.0 in. diameter and at least 1.0 in. thick, shall have a flat surface on one end that may be adhered to the tested surface and a means of attachment to the coupling device on the other end.
- d) The coupling device shall be used to connect the loading fixture to the tensile loading device. The 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 test specimen without imparting torsion or bending to the specimen.

5.4 Caliper, readable to 0.01 in., for measuring the diameter of the test specimen

5.5 Timer, readable to 1 s, to validate the load rate

5.6 Digital thermometer, graduated in 1°F increments, and having a range capable of measuring the required surface temperature

5.7 Marker, for outlining the location of the test specimen to be cored

5.8 Putty knife, for cleaning the testing loading fixture

5.9 Small propane torch, for use in applying heat to cool and/or dry the area surrounding the test specimen

5.10 Gloves, heat-resistant

5.11 Gloves, solvent-resistant

6.0 MATERIALS.

6.1 Rapid curing epoxy adhesive material, for bonding the loading fixture to the test specimen. The adhesive shall meet the requirements of ASTM C881, Type IV, Grade 3, except that a shorter gel time is permitted. The pot life, which is the time after mixing during which the epoxy retains sufficient workability for proper use, shall be 3 to 10 minutes.

6.2 Solvent or other means for cleaning the loading fixture surface

7.0 SAMPLING.

7.1 The method for selecting the location of the test specimen shall be in accordance with the applicable specification. Using the loading fixture as a template, a marker shall be used to trace a circle for the test specimen at each location.

8.0 PREPARATION OF TEST SPECIMEN.

- 8.1** Using the coring equipment with water being applied to the core barrel, drill a circular cut perpendicular to the surface. The depth of a circular cut shall be at least 0.5 in. below the surface treatment/concrete substrate interface. The test specimen shall be left intact attached to the substrate concrete.
- 8.2** Measure the diameter of the test specimen in two directions at right angles to each other. Record the average diameter, D, to the nearest 0.01 in.
- 8.3** Remove any standing water, clean the surface of any debris from the drilling operation, and allow the test site to dry. A small propane torch may be used to dry the area to be tested. Heating the surface to a temperature exceeding 120°F may damage the surface and result in a lower pull-off bond strength. Allow the surface to cool to ambient temperature. The ambient and surface temperature at the time of testing shall be 60 to 90°F.
- 8.4** Attach the loading fixture to the top of the test specimen using the epoxy adhesive. The adhesive shall be cured in accordance with the manufacturer's instructions and shall not run down the side of the test specimen into the annular cut. If this occurs, the specimen is not tested and another test site is prepared.

Ensure that the loading fixture is centered with the test specimen and that the axis of the fixture is parallel to the axis of the test specimen. When the ambient or surface temperature is below 70°F, the bonding face of the loading fixture may be gently heated to facilitate spreading of the adhesive and to accelerate curing. A small propane torch may be used for this purpose; however, the temperature of the loading fixture shall not exceed 120°F. The test specimen shall not be heated with a direct flame. When the ambient or surface temperature is above 90 °F, the test patch may be cooled by placing bagged ice on a waterproof blanket covering the patch to prevent the test patch from getting wet.

- 8.5** If the area immediately surrounding the loading fixture is subjected to moisture (e.g. rain) after the fixture has been attached to the test specimen, the area is required to be allowed to dry before conducting the test. Moisture may significantly reduce the tensile pull-off strength.

9.0 TEST PROCEDURE.

- 9.1** Attach the tensile loading device to the loading fixture using the coupling device
- 9.2** Apply the tensile load to the test specimen so that the force is parallel to and coincident with the axis of the specimen

- 9.3 Apply the tensile load at a constant rate so that the tensile stress increases at a rate of 5 ± 2 psi/s. If the load rate is not displayed, the load indicator and timer should be used to measure the load rate.
- 9.4 Record the load at the time of failure to the nearest 1 lb
- 9.5 Determine and record the mode of failure as described in the applicable specification
- 9.6 Record the ambient weather conditions and surface temperature during the testing

10.0 CALCULATIONS.

- 10.1 Calculate the tensile bond pull-off strength of the test specimen to the nearest 1 psi using the following formula:

$$T = \frac{L}{D^2} \times 1.273$$

where:

T = tensile bond pull-off strength, psi

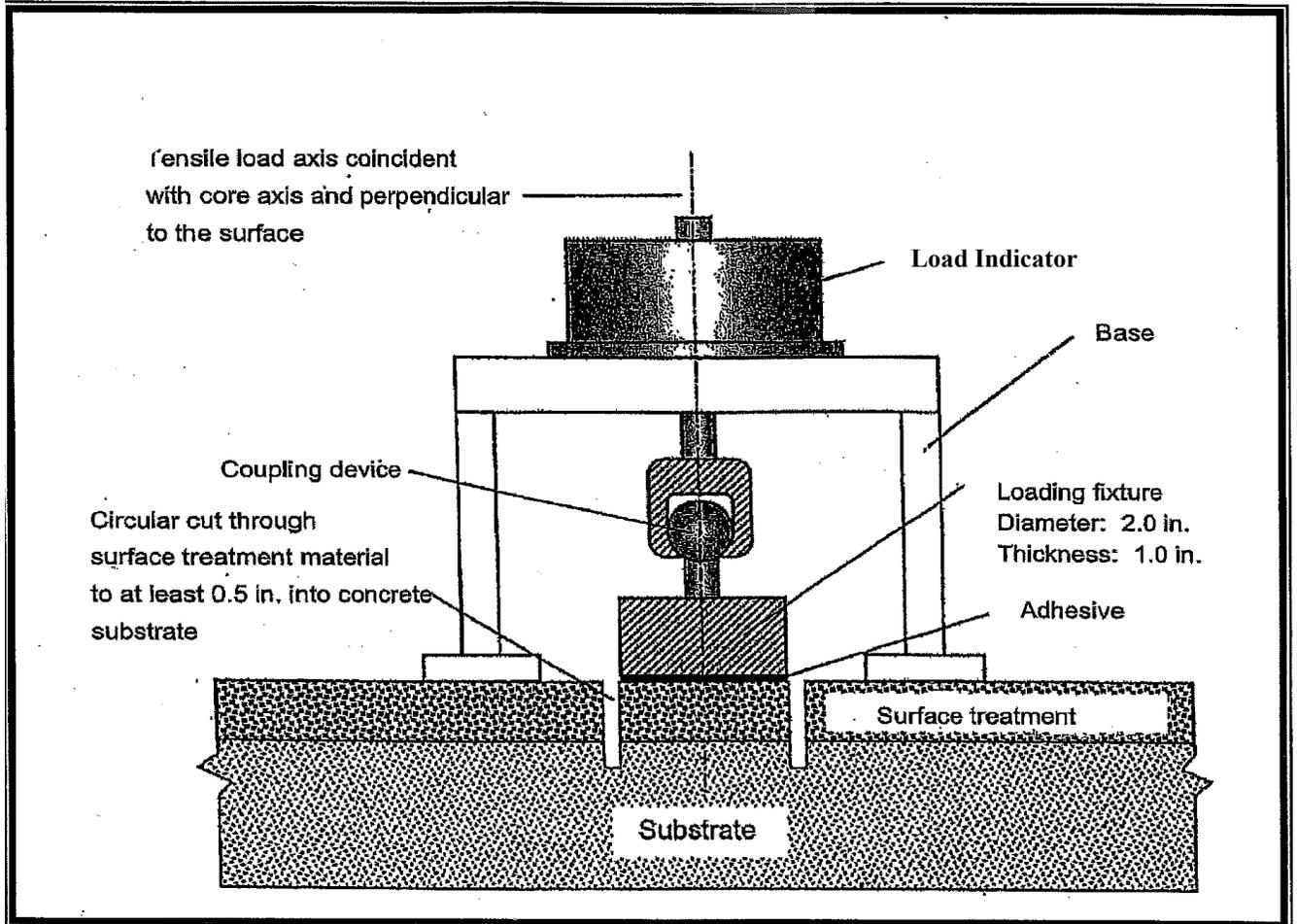
L = load at failure, lb

D = average diameter of specimen, in.

11.0 REPORT.

- 11.1 Report the following information for the Surface Preparation Test:
 - 11.1.1 Date of final cleaning of the concrete surface and date of pull-off testing
 - 11.1.2 Type of equipment used for final cleaning of the concrete surface
 - 11.1.3 Test patch number, station location, and offset as defined in the applicable specification
 - 11.1.4 Bridge span and area represented by the test patch number
 - 11.1.5 Each test result from the three test specimens. If the pull-off strength is less than 250 psi, report the mode of failure as defined in the applicable specification.
 - 11.1.6 The "Pass" or "Fail" test result as defined in the applicable specification
- 11.2 Report the following information for the Final Coat Test:

- 11.2.1** Date of final cleaning of the concrete surface and date of pull-off testing
- 11.2.2** Type of equipment used for the final cleaning of the concrete surface
- 11.2.3** Test specimen number, station location, and offset as defined in the applicable specification
- 11.2.4** Test result(s)
- 11.2.5** The "Pass", "Fail", or "Invalid" test result as defined in the applicable specification. If "Invalid", the test is continued until a passing or failing designation is obtained. If "Fail", the mode of failure, location(s) and the result(s) for additional testing are reported until a passing test is achieved as defined in the applicable specification.
- 11.2.6** The location and measured area for any surface treatment that is to be removed as defined in the applicable specification



Pull-Off Tensile Loading Device