Designation: D7913/D7913M – 26

Standard Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing[1]

This standard is issued under the fixed designation D7913/D7913M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the bond strength of fiber-reinforced polymer (FRP) composite bars used as reinforcing bars or pre-stressing tendons in concrete.

1.2 Two procedures for casting test specimens are provided. The first procedure aligns the bar with the concrete casting direction. The second procedure aligns the bar's transverse to the concrete casting direction.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A944 Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens

C33/C33M Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C143/C143M Test Method for Slump of Concrete

C150/C150M Specification for Portland Cement

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C293/C293M Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading) (Withdrawn 2025)[3]

C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

C617/C617M Practice for Capping Cylindrical Concrete Specimens

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D3878 Terminology for Composite Materials

D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials

D7205/D7205M Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

D7705 Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars used in Concrete Construction

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E83 Practice for Calibration, Verification, and Classification of Extensometer Systems

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.10 on Composites for Civil Structures.

Current edition approved March 15, 2026. Published April 2026. Originally approved in 2014. Last previous edition approved in 2025 as D7913/D7913M – 25. DOI: 10.1520/D7913_D7913M-26.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application
F2203 Test Method for Linear Measurement Using Precision Steel Rule

3. Terminology

3.1 Terminology in D3878 defines terms relating to high modulus fibers and their composites. Terminology in D883 defines terms relating to plastics. Terminology in E6 defines terms relating to mechanical testing. Terminology in E456 and in Practice E122 define terms relating to statistics and the selection of sample sizes. In the event of a conflict between terms, Terminology in D3878 shall have precedence over the other terminology standards.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anchor, n*—a protective device placed on one end of a bar, between the bar and the grips of the tensile testing machine, to prevent grip-induced damage. Usually used on bars with irregular surfaces. **D7205/D7205M**

3.2.2 *bar, n*—a linear element, often with surface undulations or a coating of particles that promote mechanical interlock with concrete.

3.2.3 *bonded length, n*—the length of the test bar that is in contact with concrete.

3.2.4 *effective circumference, n*—a geometric value representing the circumference of a circle which has an enclosed area equal to the nominal cross-sectional area of a bar.

3.2.5 *effective diameter, n*—a geometric value representing the diameter of a circle which has an enclosed area equal to the nominal cross-sectional area of a bar.

3.2.6 *nominal cross-sectional area, n*—a measure of cross-sectional area of a bar, determined over at least one representative length, used to calculate stress.

3.2.7 *nominal value, n*—a value, existing in name only, assigned to a measurable property for the purpose of convenient designation. Tolerances may be applied to a nominal value to define an acceptable range for the property.

3.2.8 *representative length, n*—the minimum length of a bar that contains a repeating geometric pattern that, placed end-to-end, reproduces the geometric pattern of a continuous bar (usually used in reference to bars having surface undulations for enhancing interlock with concrete).

3.2.9 *surface undulation, n*—variation in the area, orientation, or shape of the cross-section of a bar along its length, intended to enhance mechanical interlock between a bar and concrete, made by any of a number of processes such as, for example, indentation, addition of extra materials, and twisting.

3.3 *Symbols:*

3.3.1 A—nominal cross-sectional area of a bar

3.3.2 d_b—effective bar diameter per Test Method D7205/D7205M

3.3.3 C_b—effective circumference of FRP bar

3.3.4 CV—sample coefficient of variation

3.3.5 E_{CHORD}—tensile chord modulus of elasticity in the test direction per Test Method D7205/D7205M

3.3.6 F—tensile force in bar

3.3.7 f_c'—compressive strength of concrete

3.3.8 l—bonded length

3.3.9 L—free length of the loaded-end of the bar

3.3.10 L_c—length from the top of the embedded bar to the point of attachment of the slip measuring device

3.3.11 n—number of specimens

3.3.12 r—repeatability limit, the value below which the absolute difference between two individual test results obtained under repeatability conditions may be expected to occur with a probability of approximately 0.95 (95 %)

3.3.13 Sc—elastic elongation

3.3.14 s_{n-1}—sample standard deviation

3.3.15 $\bar{x}$—sample mean

3.3.16 x_i—measured or derived property

3.3.17 w/c—water to cement ratio

3.3.18 τ—average bond stress

4. Summary of Test Method

4.1 FRP bars are cast in concrete prisms in one of two orientations and the concrete is allowed to cure for 28 days. Cured specimens are placed in a test fixture consisting of a compression platen at one end. The loaded-end of the bar is gripped in a tension anchor and loaded in tension until failure. The average bond stress is calculated as the maximum force observed during the test divided by the surface area of the bar bonded to the concrete prism.

5. Significance and Use

5.1 The behavior of the bond between concrete and FRP reinforcing bars is an important performance aspect that has been used in material specifications and design standards. This test method serves as a means for uniformly preparing specimens and testing FRP bar-to-concrete bond, and for providing a standard method to calculate, evaluate and report bond strength.

5.2 This test method for measuring bond strength by pullout testing is intended for use in laboratory tests in which the principal variable is the size or type of FRP bars.

NOTE 1—This test method should not be used to establish design bond values and development lengths for FRP bars embedded in concrete, as it does not represent the state of bond stress observed in concrete flexural members reinforced with FRP bars. See Test Method A944 for a beam-end test configuration, used for determining bond stress in steel bars.

5.3 This test method is intended to determine the bond behavior for material specifications, research and development. The bond behavior will be specimen-configuration dependent, which may affect both analysis and design. The primary test result is the bond strength of the specimen to normal weight concrete.

5.4 This test method may also be used to determine the conformance of a product or a treatment to a requirement