Designation: D7914/D7914M – 21

Standard Test Method for Strength of Fiber Reinforced Polymer (FRP) Bent Bars in Bend Locations[1]

This standard is issued under the fixed designation D7914/D7914M; 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 determines the quasi-static ultimate strength of fiber reinforced polymer (FRP) composite bent bars commonly used as anchorages for stirrups in reinforced, prestressed, or post-tensioned concrete structures. This test method only applies to bars with a solid cross section.

1.2 FRP bent bars are often used in reinforced concrete applications to shorten the development length of the bar or to act as a tie or a stirrup to resist shear forces. Bent bars can be produced with varying angles of bend in order to fit their intended purpose.

1.3 For this test method, the FRP bars are bent at a 90 degree angle. In general, bars have a regular pattern of surface undulations, a coating of bonded particles, or both, that promote mechanical interlock between the bar and concrete.

1.4 This test method may be completed on standardized bars, produced according to Specification D7957/D7957M. In this case, the nominal cross-sectional areas and effective diameters are taken from D7957/D7957M. This test method may also be used for bars that are not standardized. In this case, the cross-sectional areas and effective diameters should be measured and calculated as described in Test Method D7205/D7205M.

1.5 The strength values provided by this method are short-term, quasi-static tensile strengths that do not account for sustained static or cyclic loading. If bars are to be used under high levels of sustained or repeated loading, additional material characterization may be required.

1.6 The characteristic values obtained from this test method are intended to represent the quasi-static ultimate strength of FRP bent bars with a tail length of twelve bar diameters.

1.7 *Units*—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.

1.7.1 Within the text, the inch-pound units are shown in brackets.

1.8 *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.*

1.9 *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]

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

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

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

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

D7957/D7957M Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement

E4 Practices for Force Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E122 Practice for Calculating Sample Size to Estimate, With

[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.

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

Specified Precision, the Average for a Characteristic of a Lot or Process
E456 Terminology Relating to Quality and Statistics

3. Terminology

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

3.2 *Definitions:*

3.2.1 *bar, n*—a linear element, with a substantially round cross-section, often with surface undulations or a coating of particles that promote mechanical interlock with concrete.

3.2.2 *bend diameter, n*—inside diameter of a bent bar as shown in Fig. 1.

3.2.2.1 *Discussion*—For standardized bars, the bend diameters should be as described in Table 4 of Specification D7957/D7957M.

3.2.3 *bend strength, n*—ultimate tensile stress that can be carried by the FRP bent bar provided that failure occurs in the bend.

3.2.4 *bent bar, n*—a bar with a section formed in such a manner as to deviate from its primary axis.

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

3.2.6 *measured cross-sectional area, n*—the average cross-sectional area of a bar, including deformations, lugs, sand coating, or any bond-enhancing surface treatment, measured according to Test Method D7205/D7205M.

3.2.7 *nominal cross-sectional area, n*—a standard cross-sectional area of a bar, as described in Table 3 of Specification D7957/D7957M.

3.2.8 *quasi-static, adj*—loading where inertial effects (time and inertial mass) are irrelevant.

3.2.9 *standardized bar, n*—a bar produced according to Specification D7957/D7957M.

3.2.10 *stirrup, n*—a bar shape comprised of one or more bent bars used to resist shear forces in reinforced concrete.

3.2.11 *tail length, n*—the length provided beyond the bend portion of a bent bar.

3.2.12 *tensile strength, n*—ultimate tensile strength of FRP bars in the direction parallel to the fibers.

3.3 *Symbols:*

3.3.1 A—nominal or measured cross-sectional area of a single leg of the FRP bent bar, as appropriate, mm^2 [$in.^2$]

3.3.2 CV—sample coefficient of variation, in percent

3.3.3 D—inside diameter of the bent portion of an FRP bent bar as shown in Fig. 1, mm [in.]

3.3.4 d_b—effective bar diameter determined based on nominal or measured cross-sectional area, as appropriate, mm [in.]

3.3.5 F_{fb}—ultimate bend strength of the FRP bent bar, MPa [psi]

3.3.6 L_t—tail length of the FRP bent bar occurring after the bent portion of the bar, mm [in.]

3.3.7 n—number of specimens

3.3.8 P_{fb}—ultimate force capacity of the FRP bent bar, N [lb]

3.3.9 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 %)

3.3.10 S_{n-1}—sample standard deviation

3.3.11 x_i—measured or derived property

3.3.12 $\bar{x}$—sample mean (average)

4. Summary of Test Method

4.1 One or more FRP bent bars, cast into two blocks of concrete, are loaded in tension until failure occurs at the bent

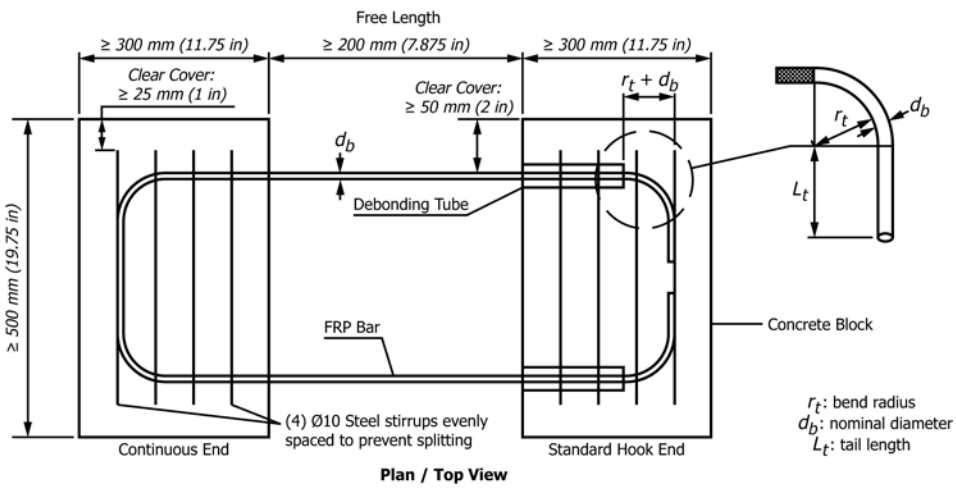

FIG. 1 Specimen Configuration