



Designation: D7205/D7205M – 21

Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars¹

This standard is issued under the fixed designation D7205/D7205M; 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 longitudinal tensile strength and elongation properties of fiber reinforced polymer matrix (FRP) composite bars commonly used as tensile elements in reinforced, prestressed, or post-tensioned concrete.

NOTE 1—Additional procedures for determining tensile properties of polymer matrix composites may be found in Test Methods [D3039](#)/[D3039M](#) and [D3916](#).

1.2 Linear elements used for reinforcing Portland cement concrete are referred to as bars, rebar, rods, or tendons, depending on the specific application. This test method is applicable to all such reinforcements within the limitations noted in the method. The test articles are referred to as bars in this test method. In general, bars have solid cross-sections and a regular pattern of surface undulations or a coating of bonded particles, or both, that promote mechanical interlock between the bar and concrete. The test method is also appropriate for use with linear segments cut from a grid. Specific details for preparing and testing of bars and grids are provided. In some cases, anchors may be necessary to prevent grip-induced damage to the ends of the bar or grid. Suggestions for a grouted type of anchor are provided in [Appendix X1](#).

1.3 The strength values provided by this method are short-term static strengths that do not account for sustained static or fatigue loading. Additional material characterization may be required, especially for bars that are to be used under high levels of sustained or repeated loading.

1.4 *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 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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1.4.1 Within the text, the inch-pound units are shown in brackets.

1.5 *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.*

1.6 *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

- [D792 Test Methods for Density and Specific Gravity \(Relative Density\) of Plastics by Displacement](#)
- [D883 Terminology Relating to Plastics](#)
- [D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials](#)
- [D3878 Terminology for Composite Materials](#)
- [D3916 Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rod](#)
- [D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials](#)
- [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](#)
- [E83 Practice for 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](#)
- [E456 Terminology Relating to Quality and Statistics](#)

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.



E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

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 of Terms Specific to This Standard:

3.2.1 *anchor, n*—a protective device placed on each 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, as opposed to flat strips where bonded tabs are more typical.

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 *effective bar 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 or the measured cross-sectional area of a bar, as appropriate.

3.2.4 *grid, n*—a two-dimensional (planar) or three-dimensional (spatial) rigid array of interconnected FRP bars that form a contiguous lattice that can be used to reinforce concrete. The lattice can be manufactured with integrally connected bars or constructed of mechanically connected individual bars. The grid bar elements have transverse dimensions typically greater than 3 mm [0.125 in.].

3.2.5 *measured cross-sectional area, n*—cross-sectional area of a bar, including any bond enhancing surface treatments such as deformations, lugs, and sand coating, determined over at least one representative length, measured according to **11.2.4.1**.

3.2.6 *nominal cross-sectional area, n*—the cross-sectional area of a standard FRP concrete reinforcing bar as originally developed for glass FRP bars in Specification **D7957/D7957M**.

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 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:

A	= cross-sectional area of a bar.
CV	= sample coefficient of variation, in percent.
d	= effective diameter of a bar.
E	= modulus of elasticity in the test direction.
F_u	= ultimate tensile strength.
K	= total number of stress-strain data points used in the modulus calculation.
L	= free length of specimen (length between anchors).
L_a	= anchor length.
L_g	= extensometer gage length.
n	= number of specimens.
P	= force carried by specimen.
P_{max}	= maximum force carried by a test coupon before failure.
r^2	= coefficient of determination.
s_{n-1}	= sample standard deviation.
x_i	= measured or derived property.
$\bar{x}$	= sample mean (average).
δ	= extensional displacement.
ε	= indicated normal strain from strain transducer.
σ	= normal stress.

4. Summary of Test Method

4.1 A fiber reinforced polymer (FRP) bar, preferably fitted with anchors, is mounted in a mechanical testing machine and monotonically loaded in tension to failure while recording force, longitudinal strain, and longitudinal displacement.

4.2 Anchors as described in **Appendix X1** are recommended but not required. Alternative methods for attaching the specimens to the testing machine are acceptable, but must allow for the full strength of the bar to be developed and for the failure of the specimens to occur away from the attachments.

5. Significance and Use

5.1 This test method is designed to produce longitudinal tensile strength and elongation data. From a tension test, a variety of data are acquired that are needed for design purposes. Test factors relevant to the measured tensile response of bars include specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, and speed of testing. Properties, in the test direction, that may be obtained from this test method include:

- 5.1.1 Maximum tensile force,
- 5.1.2 Ultimate tensile strength,
- 5.1.3 Ultimate tensile strain,
- 5.1.4 Tensile chord modulus of elasticity, and
- 5.1.5 Stress-strain curve.

6. Interferences

6.1 The results from the procedures presented are limited to the material and test factors listed in Section **5**.

6.2 *Gripping*—The method of gripping has been known to cause premature tensile failures in bars. Anchors, if used, should be designed in such a way that the full tensile capacity can be achieved without slip throughout the length of the anchor during the test.

6.3 *System Alignment*—Excessive bending may cause premature failure, as well as a highly inaccurate modulus of