Designation: D7705/D7705M – 12 (Reapproved 2019)

Standard Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars used in Concrete Construction[1]

This standard is issued under the fixed designation D7705/D7705M; 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 procedure for evaluating the alkali resistance of FRP bars used as reinforcing bars in concrete. Alkali resistance is measured by subjecting the FRP bars to an aqueous alkali environment, with or without sustained tensile stress, and then testing them to failure in tension according to Test Method D7205/D7205M. This standard presents three procedures conducted at a moderately elevated temperature of 60 ºC (140 ºF), each defining different loading conditions. The test method is also appropriate for use with linear segments of FRP reinforcements cut from two- or three-dimensional reinforcing grid.

1.2 The values stated in either inch-pound units or SI units shall be regarded separately as the standard. The inch-pound units are shown in the parentheses. The values stated in each system are not exact equivalents; therefore each system shall be used independently of each other. Combining values from the two systems may result in non-conformance.

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

1.4 *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]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C496/C496M Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
C1293 Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D3878 Terminology for Composite Materials
D7205/D7205M Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E70 Test Method for pH of Aqueous Solutions With the Glass Electrode
E456 Terminology Relating to Quality and Statistics

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 defines 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 *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 *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.

[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.

3.2.3 *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).

3.2.4 *standard cross-sectional area, n*—the cross-sectional area of a standard numbered steel concrete reinforcing bar as given in Specification A615/A615M, Table 1.

3.2.5 *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.

3.2.6 *traveler, n*—a short bar segment, subject to the same environmental conditions as the tension specimens, used for mass change measurements in Procedure A.

3.3 *Symbols:*

3.3.1 F_{tu0}—tensile capacity before conditioning (but after pre-conditioning), a baseline established according to Test Method D7205/D7205M.

3.3.2 F_{tu1}—tensile capacity after conditioning and post-conditioning, established according to Test Method D7205/D7205M.

3.3.3 R_{et}—tensile capacity retention, compared to the baseline measurement measured according to Test Method D7205/D7205M, expressed as a percentage.

3.3.4 W_0—mass of traveler specimen before conditioning.

3.3.5 W_{1A}—mass of traveler specimen after post-conditioning.

3.3.6 W_{1B}—mass of traveler specimen before post-conditioning.

4. Summary of Test Method

4.1 This test method provides standardized requirement for determining the alkali resistance of FRP bars under laboratory conditions. The principal variables used in the laboratory tests are the nature and concentration of the alkaline solution, and the sustained force level. Three procedures are available depending on the goals of the test.

4.1.1 Procedure A is designed to test the alkali resistance of FRP specimens with no tensile force applied. Four sets of specimens are immersed in an alkaline solution without tensile force. Each set of specimens is immersed for a different period of time: 1, 2, 3, or 6 months. After each of the required conditioning times, one set of specimens is removed from the alkaline solution and tested in tension. The test control parameters are the pH value and temperature of the alkaline solution and the immersion time. Procedure A also determines the mass uptake (or loss) of the specimens using travellers.

4.1.2 Procedure B is designed to test the alkali resistance of FRP specimens with sustained tensile force. Four sets of specimens are immersed in an alkaline solution under a sustained tensile force. Each set of specimens is conditioned for a different period of time: 1, 2, 3, or 6 months. After each of the required conditioning times, one set of specimens is removed from the alkaline solution and tested in tension. The test parameters are the sustained force level, the pH value, and the immersion time.

4.1.3 Procedure C is designed to test the alkali resistance of FRP specimens embedded in moist concrete under sustained tensile force. Four sets of specimens are embedded in moist concrete and held under a sustained tensile force. Each set of specimens is conditioned for a different period of time: 1, 2, 3, or 6 months. After each of the required conditioning times, one set of specimens are removed from the conditioning environment and tested in tension. The test parameters are the sustained force level, the pH value, and the embedment time.

4.2 The level of sustained loading (for Procedures B and C) is not specified as part of the test method. If service load conditions are not known, the sustained tensile stress in glass-fiber FRP bars shall be set to induce an initial tensile strain equal to 2000 microstrain. The level of sustained stress shall be reported.

5. Significance and Use

5.1 This test method is intended to determine alkaline resistance data for material specifications, research and development, quality assurance, and structural design and analysis. Depending on the procedure and test matrix, the primary test results are the mass change and tensile capacity retention of the test specimen, which are important factors to be considered in the use of FRP reinforcing bars. Procedures A and B are accelerated tests, substituting an alkaline aqueous environment for the presence of concrete porewater. Procedure C can be used to establish the accelerating effect of Procedure B.

5.1.1 Procedure A is appropriate for rapid screening of FRP bars for alkali resistance.

5.1.2 Procedure B is appropriate for characterizing the alkali resistance of FRP bars under sustained mechanical loading in a standard aqueous alkaline environment intended to represent the concrete porewater.

5.1.3 Procedure C is appropriate for characterizing the alkali resistance of FRP bars under sustained mechanical loading in Portland cement concrete.

6. Interferences

6.1 *Test Conditions*—Hygro-thermal degradation of FRP composite materials is highly dependent upon environmental conditions such as, for example, temperature, humidity, and chemical agents. The FRP bars shall be conditioned under tightly controlled and monitored conditions. For bars conditioned in aqueous solutions, the conditioning solutions may change over time due to evaporation. The quantity and pH of the solution shall be maintained by the addition of hydroxides and tap water as necessary to maintain the required pH level.

6.2 Additional interferences associated with execution of the tension testing can be found in Test Method D7205/D7205M.

7. Apparatus

7.1 *Balance*—For Procedure A, an analytical balance with an accuracy of 0.1 mg for traveler specimens weighing 50 g or