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Standard Test Method for Evaluating Bond of Individual Steel Wire, Indented or Plain, for Concrete Reinforcement[1]

This standard is issued under the fixed designation A1096/A1096M; 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~~ Scope*

1.1 This test method describes procedures for evaluating bond of individual steel wire, indented or plain, for concrete reinforcement. The bond determined by this test method is stated as the tensile force needed to pull the wire through the cured mortar in a cylindrical steel casing.

1.2 The result of the test is the maximum tensile force measured on the loaded end of the wire recorded at a free-end slip less than or equal to 0.10 in. [2.5 mm].

1.3 *Units*—The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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]

A421/A421M Specification for Stress-Relieved Steel Wire for Prestressed Concrete
A881/A881M Specification for Steel Wire, Indented, Low-Relaxation for Prestressed Concrete
C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)
C150/C150M Specification for Portland Cement
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C778 Specification for Standard Sand

[1] This test method is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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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.

***A Summary of Changes section appears at the end of this standard**

3. Terminology

3.1 *Definitions:*

3.1.1 *bond, n*—longitudinal components of adhesion, friction, and mechanical interlock between wire and mortar or concrete.

3.1.2 *bond breaker, n*—product wrapped around wire to prevent wire-to-mortar bond over a certain length.

3.1.2.1 *Discussion*—

Duct tape is commonly used for this purpose.

3.1.3 *mortar, n*—mixture of cement, fine aggregate, and water.

3.1.4 *test specimen, n*—assembly consisting of one steel casing, one sample of wire, and mortar.

4. Summary of Test Method

4.1 Six samples of 0.2 – 0.3 in. [5 – 8 mm] diameter (see Note 1) steel wire are selected from a single continuous length for testing. Each wire sample is cast into a steel casing with a bonded length of 6 in. [150 mm].

4.2 A mortar mixture, including the fine aggregate source, is prescribed, but the cement source is not.

4.3 Testing of the six specimens begins shortly after the mortar-cube compressive strength reaches 4500 psi [31.0 MPa] and ends before the strength reaches 5000 psi [34.5 MPa]. A specified, force-controlled loading rate is applied at the bottom of the wire while the applied load and free-end slip at the opposite (top) end is continuously monitored and recorded. The maximum pullout force occurring at an end slip less than or equal to 0.10 in. [2.5 mm] is recorded as the "test result." One complete test is comprised of the average of these six specimens.

NOTE 1—This test method was developed specifically to correlate pullout values with transfer lengths for 0.208 in. [5.28 mm] diameter steel wire conforming to Specification A881/A881M for prestressed concrete railroad ties but may be modified or adapted to accommodate smaller or larger wire sizes and in prestressing or other non-prestressed concrete reinforcement applications.

5. Significance and Use

5.1 Steel wire for concrete reinforcement is used in various applications wherein the wire is expected to transfer passive or prestressing forces to the structural member via the bond of the exposed wire surfaces to the surrounding concrete.

5.2 Wire manufacturing processes, subsequent handling, and storage conditions can influence the wire bond.

5.3 Steel wire for concrete reinforcement is used in construction applications with a variety of concrete mixtures. Developing test methods and threshold values for the performance of the wire in each of these unique mixtures is impractical.

6. Apparatus

6.1 A position transducer having a minimum precision of 0.001 in. [0.025 mm] is used.

6.2 A tensile testing machine is used with the following functionality:

6.2.1 Force-controlled loading rate;

6.2.2 *Gripping Device without Torsional Restraint*—This may be accomplished by providing a thrust bearing to allow rotation; other similar methods may be used (see Note 2).

6.2.3 *Rigid Testing Frame*—An example of the frame used for conducting the test is shown in Fig. 1. Other similar test frame setups may be used.

NOTE 2—This test method was developed without torsional restraint. In the case of some particular wire geometries (for instance, helical-deformed wire),

FIG. 1 Photo of Pullout Test Frame and Specimen as the Test is Being Conducted

wire behavior during test method development indicated a tendency for the frame to rotate.

7. Wire Sampling

7.1 The wire shall conform to Specifications A421/A421M or A881/A881M.

7.2 Samples of wire approximately 20 in. [500 mm] long shall be taken from the same coil or reelless pack of wire. The wire shall be cut to have flat ends. A minimum of six wire samples are required.

8. Mortar Requirements

8.1 *Materials:*

8.1.1 *Sand*—The sand shall be silica sand from the Ottawa, Illinois region and shall be Graded Sand conforming to Specification C778.

8.1.2 *Cement*—The cement shall conform to Specification C150/C150M requirements for Type III cement.

8.1.3 *Water*—The water shall be potable.

8.1.4 *Admixtures*—Admixtures shall not be used.

8.1.5 *Aggregates*—No aggregates other than sand as specified in 8.1.1 shall be used.

8.2 *Mixing Procedure*—The mixing procedure shall conform to Practice C192/C192M except no coarse aggregates or admixtures are allowed.

8.3 *Strength*—Mortar strength shall be evaluated according to Test Method C109/C109M using 2 in. [50 mm] mortar cubes. Brass molds shall be used. Testing of the pullout specimens should begin as soon as practical after the 2 in. [50 mm] mortar cube compressive strength reaches 4500 psi [31.0 MPa]. This mortar strength is defined as the average compressive strength of at least two individual 2 in. [50 mm] mortar cubes. If the mortar strength exceeds 5000 psi [34.5 MPa] before the end of the test, then the test shall be considered invalid and shall be repeated.

NOTE 3—Practice C192/C192M is described as a standard practice to be used for concrete test specimens. As outlined in 8.1, only fine aggregates (that is, sand) are included in the mixture along with cement and water. Because coarse aggregates are not included, this mixture is defined as "mortar" and not "concrete." Aside from this difference and a few other exceptions noted in Section 8, the practices documented in Practice C192/C192M are to be applied when making the mortar used in this test method.

8.4 *Mixture Proportions:*

8.4.1 The mixture proportions and batch weights listed in Table 1 shall be used (Note 4).

NOTE 4—In Table 1, a mortar with a water-to-cement ratio (w/c) of 0.425 and an oven-dry sand-to-cement (s/c) ratio of 2.0 is shown.

9. Preparation of Test Specimens

9.1 *Materials:*

9.1.1 *Wire Samples*—Requirements as defined in Section 7.

9.1.2 *Mortar*—Requirements as defined in Section 8.

9.1.3 *Bottom Bond Breaker*—A 1.0-in. [25-mm] wide ± 0.125-in. [3.0-mm] strip of woven cloth adhesive tape (duct tape) shall be used as a bottom bond breaker. The length of bond breaker should not be less than 5 in. [130 mm] before application. Wrap the bond breaker around the wire snugly.

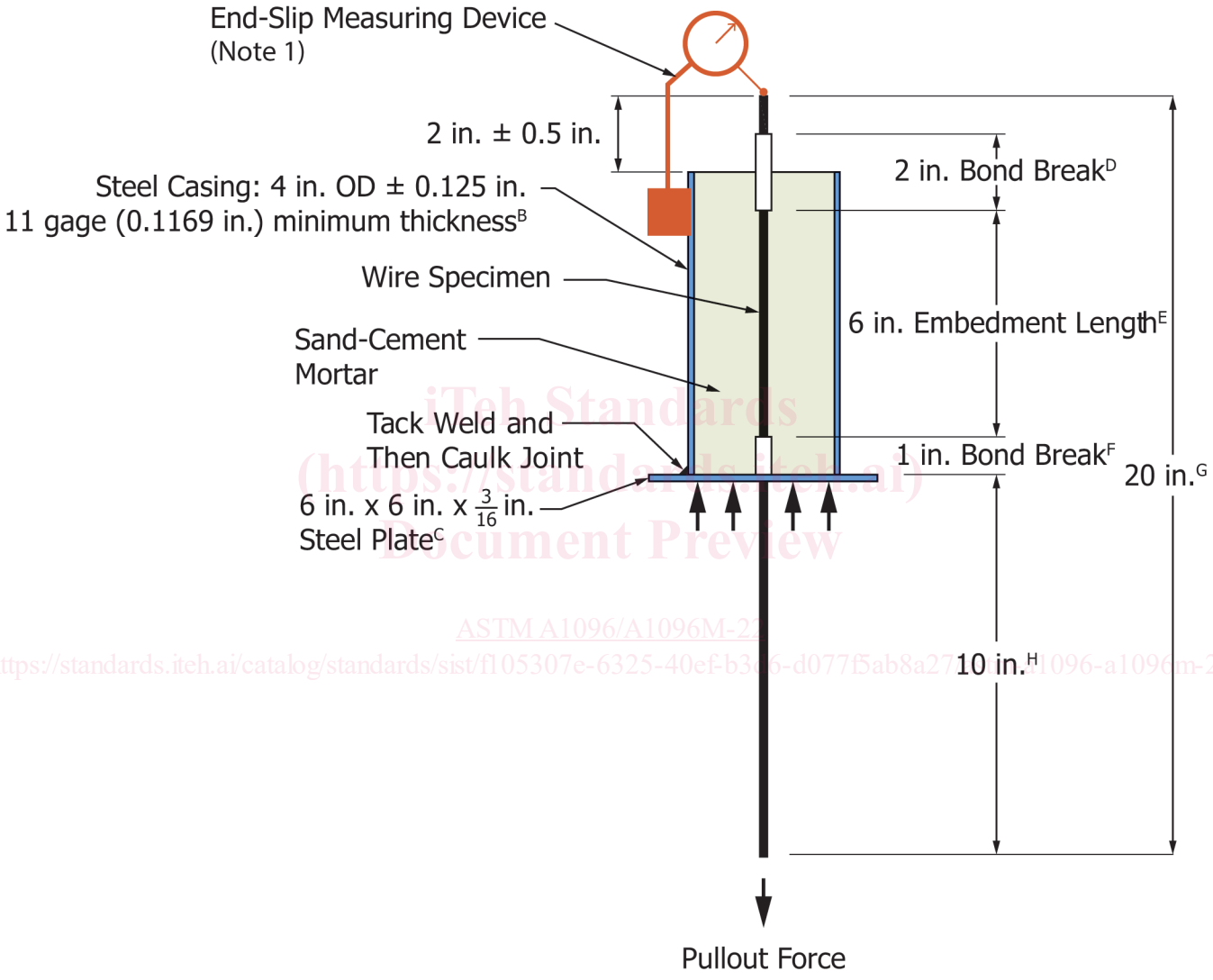
9.1.4 *Top Bond Breaker*—Use a 2.0-in. [50-mm] wide ± 0.125-in. [3.0-mm] strip of woven adhesive cloth (duct tape) as a top bond breaker. The length of bond breaker should not be less than 3.0 in. [75 mm] before application. Wrap the bond breaker around the wire snugly. The top bond breaker extends below the top mortar surface approximately 1.0 in. [25 mm] to ensure the actual bond length desired in case of settlement. The distance between the top and bottom bond breaker (embedment length) is maintained at 6.0 ± 0.0625 in. [150 ± 1.6 mm].

TABLE 1 Recommended Batch Weight

Material	Proportional Weight
C150/C150M Type III Cement	1.0
C778 Ottawa Sand (Oven-Dry)	2.0
Water	0.425

9.1.5 *Steel Casing*—Each individual wire sample shall be cast in a 4 in. [100 mm] outer diameter steel tube, approximately ⅛ in. [3 mm] wall thickness (11 gauge), and a total length of 8 in. [200 mm]. A 6.0 in. × 6.0 in. × 3⁄16 in. [150 mm × 150 mm × 5 mm] thick steel plate is tack welded to the bottom of the tube. The remaining contact surface between the tube and plate shall be caulked to prevent any leakage of mortar during filling and curing. A schematic of the wire pullout specimen is shown in Fig. 2. The bottom plate shall have a center-drilled hole using the smallest standard 1⁄32-in. [0.8-mm] drill bit to allow the wire to freely pass through the hole.

9.2 *Specimen Assembly*—Each wire sample shall be cast into a steel casing in the vertical position. The wires shall be held centered



NOTE 1—The 'End Slip Measurement' apparatus shown here is an example of one type of measurement set-up. Other configurations and devices may be used.

A SI equivalent: 51 mm ± 13 mm
B SI equivalent: 102 mm ± 3 mm (OD) × 3 mm min (wall thickness)
C SI equivalent: 152 mm × 152 mm × 4.8 mm
D ± 0.25 in.
SI equivalent: 51 mm ± 6.4 mm
E ± 0.063 in.
SI equivalent: 152.4 mm ± 1.6 mm
F ± 0.036 in.
SI equivalent: 25.4 mm ± 1.6 mm
G + 10 in. / – 0 in.
SI equivalent: 508 mm + 254 mm / – 0mm
H SI equivalent: 203 mm ± 3.2 mm

FIG. 2 Schematic of Wire Pullout Test Specimen