



Designation: A 944 – 99

Standard Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens¹

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1. Scope

1.1 This test method describes procedures to establish the relative bond strength of steel reinforcing bars in concrete.

1.2 This test method is intended to determine the effects of surface preparation or condition (such as bar coatings) on the bond strength of deformed steel reinforcing bars (of sizes ranging from No. 10 to No. 36 [No. 3 to No. 11]) to concrete.

1.3 The values stated in SI units are to be regarded as the standard. The values given in brackets are for information only.

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

2. Referenced Documents

2.1 ASTM Standards:

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory²

E 4 Practices for Force Verification of Testing Machines³

E 575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bond strength, n* —maximum measured load in a tensile bond test of a steel reinforcing bar.

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

3.1.3 *concrete cover, n* —minimum distance between the surface of the test bar and the top or bottom of the test specimen.

3.1.4 *embedment length, n* —the distance from the surface of the concrete test specimen to the installed end of the steel reinforcing bar. This equals the sum of the lead length and the bonded length.

3.1.5 *lead length, n* —the length of the test bar that is not in contact with concrete but is between the surface of the concrete test specimen and the bonded length.

3.1.6 *relative rib area, n* —ratio of the projected rib area normal to bar axis to the product of the nominal bar perimeter and the center-to-center rib spacing.

3.2 Symbols:

C_b = Concrete cover, mm [in.].

d_b = Nominal diameter of reinforcing bar, mm [in.].

l_e = Embedment length, mm [in.].

4. Apparatus

4.1 *Equipment*—A schematic of a suitable testing system is shown in Fig. 1. The loading system shall be capable of measuring the forces to an accuracy within $\pm 2\%$ of the applied load, when calibrated in accordance with Practices E 4. The test system shall have sufficient capacity to prevent yielding of its various components and shall ensure that the applied tensile load remains parallel to the axis of the steel reinforcing bar during testing.

4.2 *Compression Reaction Plate*—The compression reaction plate shall be placed a minimum clear distance equal to $0.9 l_e$ measured from the center of the test bar to the edge of the reaction plate.

4.3 *Bar Displacement Measurements*—Displacements of the loaded and free ends of the steel reinforcing bar shall be measured with respect to the loaded and free surfaces, respectively, of the concrete using suitable measurement devices. Dial gages having the smallest division of not more than $25 \mu\text{m}$ [0.001 in.] or linear variable differential transformers (LVDTs) with equal or superior accuracy are examples of satisfactory devices.

5. Test Specimen

5.1 *Beam-End Specimen*—The test specimen shall consist of the test bar cast in a block of reinforced concrete 600 ± 25 mm [24 ± 1 in.] long by $d_b + 200 \pm 13$ mm [$d_b + 8 \pm \frac{1}{2}$ in.] wide by a minimum of $d_b + C_b + l_e + 60$ mm [$d_b + C_b + l_e + 2\frac{1}{2}$

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² *Annual Book of ASTM Standards*, Vol 04.02.

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 04.07.

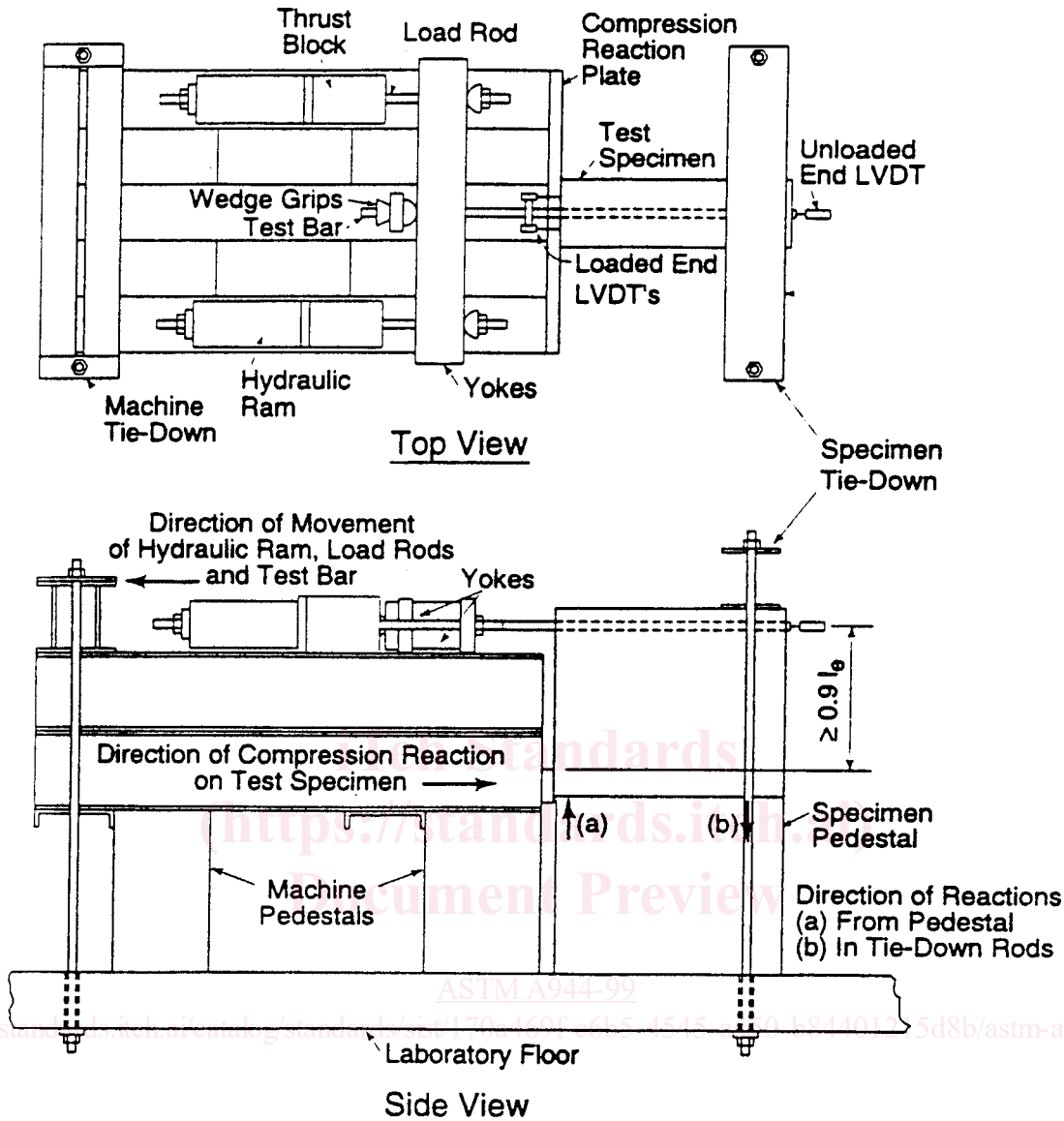


FIG. 1 Schematic of Test Apparatus

in.] high. A typical test specimen is illustrated in Fig. 2. The specimen shall be reinforced by four closed stirrups oriented parallel to the sides of the specimen and two flexural steel reinforcing bars parallel to the test bar, as shown in Fig. 2. Transverse steel reinforcing bars similar to those illustrated in Fig. 2 may be used to aid in fabrication and testing. The test bar shall extend from the front surface a distance that is compatible with the test system. Two polyvinyl chloride (PVC) pipes shall be used as bond breakers to control the bonded length of the bar and to avoid a localized cone-type failure of the concrete at the loaded end of the specimen. The free end of the test bar shall butt against a hollow steel conduit or other device to provide access to the free end for measuring slip during the test. The closed stirrups shall be fabricated from Grade 420 [Grade 60] No. 10 [No. 3] bars for test bars up to and including No. 25 [No. 8] and No. 13 [No. 4] bars for test bars larger than No. 25 [No. 8]. The two flexural steel reinforcing bars shall be selected so as to provide a total area not less than that of the test bar.

NOTE 1—The lead length, shown in Fig. 2, is typically between 13 and 100 mm [0.5 and 4 in.]. This unbonded region is used to prevent a cone-type pullout failure at the surface of the concrete. Increases in lead length generally result in an increase in bond strength.

5.2 *Fabrication*—The concrete block shall be fabricated using concrete designed to produce a strength at the time of test between 31 and 38 MPa [4500 and 5500 psi]. The specimen shall be cast in approximately equal layers not exceeding 250 mm [9 in.] in depth. Each layer shall be adequately consolidated with an internal vibrator to ensure removal of entrapped air.

NOTE 2—The nominal maximum size course aggregate should be less than or equal to $\frac{3}{4}$ of the minimum clear space between reinforcement or between reinforcement and the concrete surface of the beam-end specimen.

6. Conditioning

6.1 *Specimen Conditioning and Curing*—The test specimen shall be cured in the forms using a curing compound or a