Designation: E1190 – 11

Standard Test Methods for Strength of Power-Actuated Fasteners Installed in Structural Members[1]

This standard is issued under the fixed designation E1190; 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 These test methods describe procedures for determining the static axial tensile and shear strengths of power-actuated fasteners installed in structural members made of concrete, concrete masonry, and steel.

1.2 These test methods are intended for use with fasteners that are installed perpendicular to a plane surface of the structural member.

1.3 Tests for combined tension and shear, fatigue, dynamic, and torsional load resistance are not covered.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E4 Practices for Force Verification of Testing Machines

E575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies

E631 Terminology of Building Constructions

2.2 *ANSI Standards:*[3]

ANSI A10.3 Safety Requirements for Powder-Actuated Fastening Systems

3. Terminology

3.1 Definitions of general terms may be found in Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *displacement*—movement of a fastener relative to the structural member. In tensile tests, displacement is measured along the axis of the fastener; in shear tests it is measured in the direction of the applied load perpendicular to the axis of the fastener.

3.2.2 *drive pin*—a nail-like metal fastener designed to attach one material to another.

3.2.3 *edge distance, c*—the distance from the longitudinal axis (center) of a fastener to the nearest edge of the structural member in which it is installed.

3.2.4 *embedment depth, h_{ef}*—the distance from the surface of the structural member to the installed end of the fastener including its point, if any.

3.2.5 *fastener spacing, s*—the distance between the longitudinal axes of two fasteners in the same plane. Also, distance between longitudinal axis of fastener and nearest edge of test-system supports (see *s* in Fig. 1).

3.2.6 *powder-actuated fastening system*—a system that uses explosive powder to embed the fastener in structural elements.

3.2.7 *power-actuated fastening system*—a system that uses explosive powder, gas combustion, or compressed air or other gas to embed the fastener in structural elements.

3.2.8 *shear test*—a test in which a force is applied perpendicularly to the axis of the fastener and parallel to the surface of the structural member.

3.2.9 *static load*—a load or series of loads that are supported by or are applied to a structure so gradually that forces caused by change in momentum of the load and structural elements are negligible and all parts of the system at any instant are essentially in equilibrium.

3.2.10 *structural member*—an element of a structural system such as a beam, column, or truss.

3.2.11 *tensile test*—a test in which a fastener is loaded axially in tension at a specified rate.

[1] These test methods are under the jurisdiction of ASTM Committee E06 on Performance of Buildings and are the direct responsibility of Subcommittee E06.13 on Structural Performance of Connections in Building Construction.

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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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

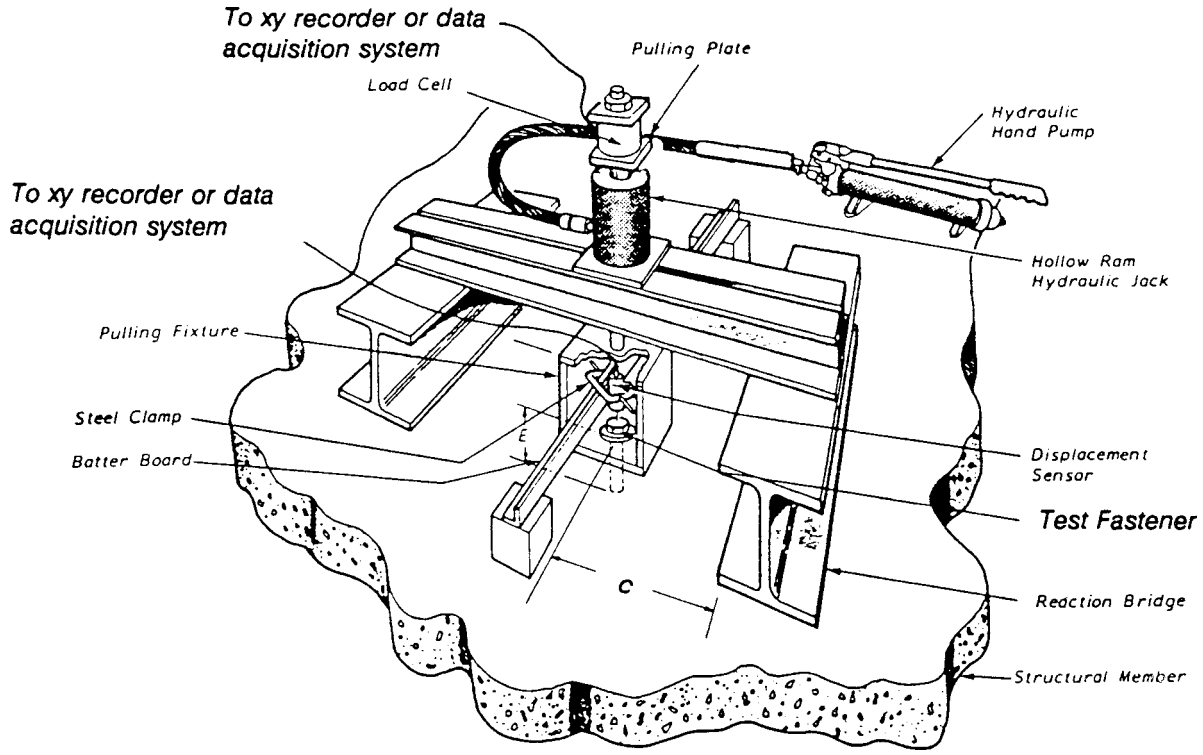

FIG. 1 Typical Static Tension Test Arrangement

3.2.12 *threaded stud*—a round metal-wire fastener, with a pointed shank at one end and threads along the other end, designed to be used as a removable fastening or in conjunction with a threaded coupler.

4. Significance and Use

4.1 These test methods are intended to measure the anchoring capability and shear resistance of power-actuated fasteners to provide information from which applicable design values are to be derived for use in structural applications, such as in members of concrete, concrete masonry, and steel.

5. Apparatus

5.1 *Equipment*—Any system suitable for applying tensile and shear forces shall be used, provided the requirements for rate of loading in 9.4 are met, and the instrumentation is capable of measuring the forces to an accuracy within ± 2 % of the applied force, when calibrated in accordance with Practices E4. The device shall be of sufficient capacity to prevent yielding of its various components and shall ensure that the applied tensile forces remain parallel to the axes of the fasteners and that the applied shear forces remain parallel to the surface of the structural member during testing. Load cells shall be used for laboratory testing. If pressure gages are used for field testing, they shall be calibrated immediately prior to use.

5.1.1 *Tensile Test*—A system suitable for applying tensile forces is shown in Fig. 1 for a single fastener specimen. The test system supports shall be of sufficient size to prevent failure of the surrounding structural member. The loading rod shall be of a size to develop the ultimate strength of the fastener hardware with minimal elongation and shall be attached to the fastener by means of a connector that will minimize the direct transfer of bending forces through the connection. When displacements are measured, dial gages or a linear variable differential transformer (LVDT) shall be mounted in a manner so as to ensure accurate displacement measurement.

5.1.2 *Shear Test:*

5.1.2.1 A system suitable for applying shear forces is shown in Fig. 2. for a single fastener specimen. The components of the test fixture shall be of sufficient size and strength to prevent yielding during application of the ultimate test load. The test system support shall be of sufficient size to prevent local failure of the structural member in the bearing contact area. When displacements are measured, dial gages or a linear variable differential transformer (LVDT) shall be mounted in a manner so as to ensure accurate displacement measurement.

5.1.2.2 The thickness of the shear fixture in the immediate vicinity of the test fastener shall be approximately equal to the fastener shank diameter at the point of intersection of the fastener and the base material unless otherwise specified. The hole in the shear fixture designed to accommodate the fastener shall have a diameter that is 0.5 ± 0.1 mm (0.020 ± 0.004 in.) greater than that of the fastener shank diameter tested. Alternatively, a shear fixture using a slot to accommodate the fastener instead of a round hole shall be permitted. The loading end of the slot shall have a width that is 0.5 ± 0.1 mm (0.020 ± 0.004 in.) greater than that of the fastener shank diameter tested. The non-loading end of the slot is permitted to be larger than the fastener head or thread diameter. The initial shape of the hole or the loading end of the slot in the shear fixture shall correspond to that of the fastener shank cross section and shall be maintained throughout all tests. For shear fixtures using a slot to accommodate the fastener instead of a

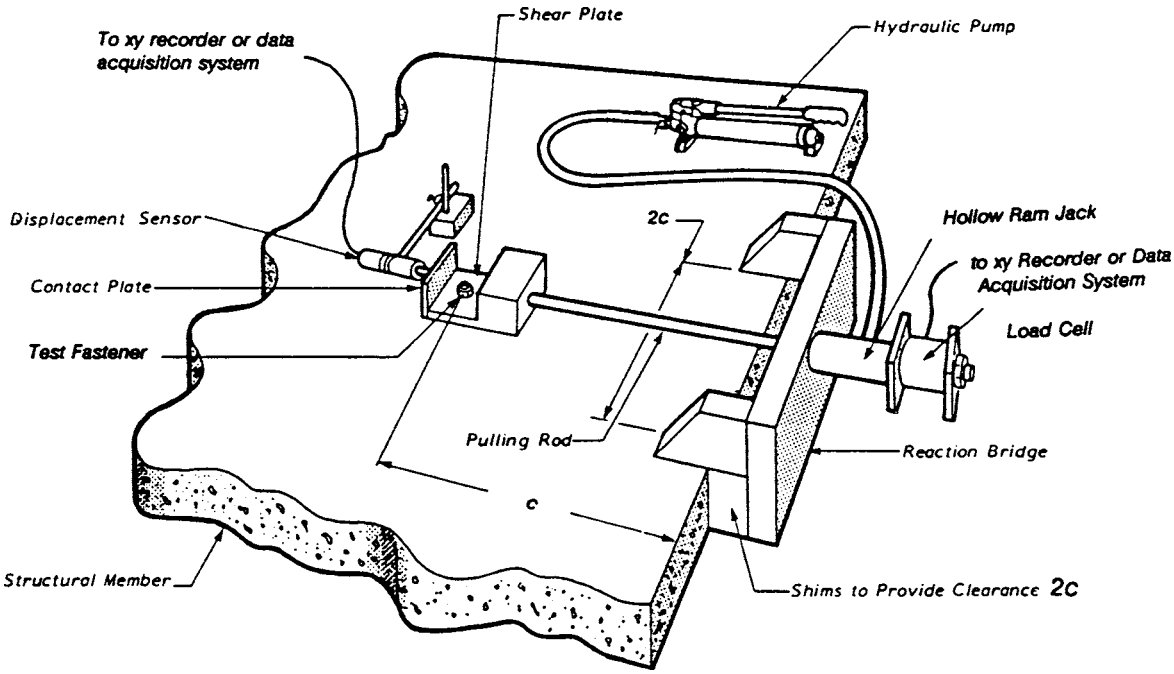

FIG. 2 Typical Static Shear Test Arrangement

hole, loading is to be applied parallel to the slot. Worn or deformed holes or slots shall be repaired. When required, insert sleeves shall be installed in the shear plate to meet these requirements, provided they do not increase deformation of the anchorage under load.

5.2 *Optional Displacement Measurements*— Displacement or deformation measurements are not required to derive design data for a given fastening system.

5.2.1 *Tension Test* (see Fig. 1)—Dial gages, having a smallest division of not more than 0.025 mm (0.001 in.), or any suitable measurement devices or calibrated sensors of at least comparable accuracy and sensitivity, such as an LVDT, shall be used to measure displacement of the fastening system relative to the structural member. The instruments shall be positioned to measure the vertical movement of the fastener with respect to points on the structural member, at a minimum distance of 40 mm (1.6 in.) from the center of the test fastener. The instruments shall be mounted on the fastener specimen or loading rod at a distance not more than 100 mm (4.0 in.) from the structural member surface, in order to minimize extraneous movements (hardware elongation) in the displacement measurements.

5.2.2 *Tests of a Group of Fasteners*— Only one set of instruments is required for a group of fasteners tested as a closely spaced cluster. The displacement to be used for the evaluation of the findings is the average deformation indicated by all instruments mounted symmetrically equidistant from the center of the cluster.

5.2.3 *Shear Test* (see Fig. 2)—A single dial gage, having a smallest division of not more than 0.025 mm (0.001 in.) or any suitable measurement device, such as an LVDT, or calibrated sensor of at least comparable accuracy and sensitivity shall be used to measure the displacement of the fastening system relative to the structural member. The instrument shall be positioned to measure displacement in the direction of the applied force. The displacement sensor shall be placed on the structural member to allow the sensing element to be in direct contact with the fastener or be attached directly to the fastener. For tests on clusters of fasteners, the instrument shall lie in a plane through the axis of the shear loading rod or plate. An extension of the axis of the shear fixture shall pass through the centroid of the cluster of fasteners.

6. Hazards

6.1 Take precaution to ensure that people are not injured and that test equipment, instrumentation, and the building, its components, and its finish are not damaged prior to, during, or after load application, by any unexpected release of potential strain energy accumulated during testing.

6.2 All operators of powder-actuated tools used for the installation of test specimens shall be licensed by the manufacturer. Operators shall comply with ANSI A10.3 requirements and local safety requirements.

7. Test Specimens

7.1 *Fastening System*—The fastening system shall be representative of the type and lot to be used in field construction and shall include all accessory hardware normally required.

7.2 *Fastener Installation*—The fasteners shall be installed using the manufacturer's installation instructions and tools or, where specific deviation is justified, in accordance with accepted field methods or to meet the requirements of the tests.

7.3 *Fastener Placement*—All fasteners (types, sizes, embedment depths) to be used in a given installation shall either be tested individually or in groups of two or more at the intended spacing. Fasteners shall be installed at distances equal to or greater than those specified in Table 1 to preclude influences

TABLE 1 Fastener Spacing, *s*, and Edge Distance, *c*, to Preclude Influences on Fastener Performance

Shank Diameter, mm (in.)	Minimum Fastener Spacing, mm (in.)		Minimum Edge Distance, mm (in.)	
	Steel	Concrete	Steel	Concrete
2.5 to 4.0 (0.100 to 0.156)	25 (1.0)	100 (4.0)	12 (0.5)	80 (3.2)†
4.1 to 5.0 (0.157 to 0.199)	25 (1.0)	130 (5.1)	12 (0.5)	90 (3.5)
5.1 to 6.5 (0.200 to 0.250)	40 (1.6)	150 (5.9)	25 (1.0)	100 (4.0)

† The value in parenthesis was corrected editorially

from adjacent fasteners or edges during testing. These distances are not to be considered minimum distances. Tests shall be performed to determine minimum spacing and edge distances.

7.4 *Structural Member*—The structural member in which the fastener is to be installed shall be representative of the materials and configuration intended for field use. Concrete or masonry structural members do not have to be reinforced with steel (Note 1).

NOTE 1—The location and orientation of reinforcement embedded in concrete and masonry members may influence fastener capacity. Their influence shall be evaluated if reinforcement is used.

7.5 The concrete or masonry structural member thickness, T, shall be sufficient to ensure that the installation and testing of the fastener will not crack or cause any other failure of the base material.

7.6 The length, *L*, and width, *W*, of concrete structural members shall ensure that no shear breakout or tension failure spall intersects either the outside edges of the structural member or the bearing contact points of the test frame.

7.7 The edge distance, *c*, shall be as in Table 1 where the reaction bridge in the shear test set-up shown in Fig. 2 provides a minimum 150-mm (5.9-in.) clearance along the edge of the concrete structural member and a minimum 50-mm (2.0-in.) clearance along the edge of a steel structural member (not shown). A shear reaction bridge is not required when concrete edge distances exceed 150 mm or steel edge distances exceed 50 mm.

7.8 When testing fasteners installed in horizontal mortar joints, the masonry wall shall be treated as a complete structural member. The minimum edge distances and spacing listed in Table 1 for concrete structural members do not apply to masonry walls. Fasteners shall be installed in masonry walls using the manufacturer's installation instructions or in accordance with accepted field methods.

8. Number of Tests

8.1 *Tensile or Shear Resistance*—For determining the average tensile or shear resistance, perform at least the minimum number of tests per condition specified in Table 2. Depending on the purpose of the test, the number of tests shall be increased. These tests shall be repeated for each variation in fastener type, size, embedment depth, location, and for each variation in the type or strength of structural member.

TABLE 2 Number of Tests Required For Statistical Data

Coefficient of Variation, %	Minimum Number of Tests Required
Up to 15	10
15 and greater	30

Alternatively, if the sample size is ten and the coefficient of variation is 15 % or greater, the fastener capacity shall be based on the lowest test value for the original ten tests instead of increasing the sample size.

8.2 All installed fasteners shall be tested regardless of fastener embedment, angle of installation, damage to the structural member, or damage to the fastener. Fasteners that cannot be tested, because they did not set at all, that is were not installed properly, shall be reported as invalid data points. Invalid data points shall not be included when determining the average ultimate test values.

8.3 For developing minimum edge distances and fastener spacings, the number of fasteners for each condition shall be at least ten.

9. Procedure

9.1 *Positioning of Loading System:*

9.1.1 *Tension Test*—Position the loading system over the fastener, such as shown in Fig. 1, in such a way that the test system supports are equidistant from the test fastener and spaced sufficiently apart as not to influence the test findings. The failure plane of the fastening system shall not interact with the test system supports. Provide uniform contact between the surface of the structural member and the test system supports. Position and attach the loading rod so that the load is applied through the center of a single fastener, as shown in Fig. 1, or through the centroid of a cluster of fasteners. Whenever a loading plate is required in the testing of a cluster of fasteners, make every effort to provide uniform loading of the individual fasteners of the cluster.

9.1.2 *Shear Test*—Position and fasten the structural member as shown in Fig. 2 in such a way that the test surface of the structural member is parallel to the shear plate and the long axis of the shear rod. Place the shear fixture onto the structural member and secure it in place with the appropriate nut or other locking device used for the particular fastener to be tested. The amount of force exerted on the shear plate by the nut or locking device has a significant effect on the shear capacity of the fastening system and shall be uniform for each series of tests performed. The amount of force applied shall be in accordance with that specified by the fastener manufacturer or, where specific deviation is justified, in accordance with accepted field methods.

9.2 *Mounting of Instruments* (see 5.2):

9.2.1 *Tension Test*—Use dial gages, measurement devices, or suitable sensors, as specified in 5.2.1, for each individual fastener or cluster of fasteners. Mount the instruments on the fastener or loading rod in accordance with the requirements of 5.2.1. Place the sensing elements of the instruments normal to and in contact with a special bearing plate on the surface of the structural member in such a way as to measure displacement in the direction of the applied load. For clusters, use at least two

instruments in any convenient arrangement consistent with the requirements of 5.2.2.

9.2.2 *Shear Test*—Use a single instrument to measure shear slip of either individual or clustered fasteners. Mount the instrument on the structural member to allow the sensing element to be attached directly to the fastener as previously described, in such a way as to measure displacement in the direction of the applied load.

9.3 *Load Application for a Given Period*—If application of a given load is required for a certain period, such as 24 h, deformation readings shall be taken at the beginning, at intervals during this period, and at the end of this period, to allow the satisfactory plotting of a time-deformation curve for the complete period.

9.4 *Rate of Loading*—Apply the rate of increment loading at a constant rate of motion of the movable crosshead of the testing machine or at a uniform rate of loading. Run the test with the force being applied at a uniform rate so that the ultimate strength of the fastener is reached in no less than 30 s.

10. Failure Analysis

10.1 *Load at Failure*—Determine the maximum test load for each assembly tested to failure.

10.2 *Concrete or Masonry Failure Modes*— Failure occurs by one or a combination of the following modes:

10.2.1 Brittle failure of the structural member in the form of a shear cone.

10.2.2 Failure of the structural member by cracking that radiates outward from the location of the fastening device, resulting in pull-out of the fastener.

10.2.3 Failure of the bond between a fastener and the structural member.

10.3 *Fastener Failure Modes*—Failure occurs by one or a combination of the following modes:

10.3.1 Failure of the bond between a fastener and the structural member (tension).

10.3.2 Ductile failure of the fastener (tension).

10.3.3 Shear failure of the fastener.

10.3.4 Bending failure of the fastener (shear).

10.4 The yielding or fracture of any component of the fastening device including hardware accessories shall constitute failure.

11. Calculation

11.1 *Maximum Load Data:*

11.1.1 Determine the average of the maximum loads per fastener as the arithmetic mean of all maximum loads for a given test series where P_t = average ultimate load in a tension test series, and P_s = average ultimate load in a shear test series.

11.1.2 In tests of clusters of fasteners, the average of the maximum loads per test series is divided by the number of fasteners per cluster in order to obtain the average of the maximum loads per fastener.

11.1.3 Determine the standard deviation.

12. Report

12.1 The report on static tests shall include the applicable information listed in Practice E575 and specifically the following:

12.1.1 Date of test and date of report,

12.1.2 Test sponsor and test agency,

12.1.3 Identification of fasteners tested: manufacturer, model, type, material, finish, shape, dimensions, and other pertinent information, such as power level of cartridges used to install test specimens, cracks, and other defects,

12.1.4 Description of the fastening system tested and physical description of the structural members, including dimensions of the test section, and pretest curing, if any,

12.1.5 Detailed drawings or photographs of test specimens before and after testing if not fully described otherwise,

12.1.6 Description of test equipment used and calibration records,

12.1.7 Physical strength properties of the structural member in which the fastener(s) is embedded, based on test data for concrete cylinders, masonry units, or grout, obtained at time of fastener tests,

12.1.8 Concrete mixture(s), including a complete description of the type and size of aggregate used in the concrete and water-cement ratio, if applicable,

12.1.9 Mill certificates for structural steel members,

12.1.10 Description of the procedure and materials used to install the fastening system,

12.1.11 Age, in days, of the structural member at time of test,

12.1.12 Age, in hours or days, of fastening system since installation, where applicable,

12.1.13 Moisture condition, at the time of test, of the structural member in percent of oven-dry weight (Note 2), where applicable,

12.1.14 Average depth, in millimetres (inches), of fastener embedment,

12.1.15 Description of test method and loading procedure used and actual rate of loading,

12.1.16 Number of replicate specimens tested,

12.1.17 Number of, and reason(s) for, test specimens not tested,

12.1.18 Individual and mean maximum load values, in newtons (or pounds-force), per embedded fastener (P_t or P_s, or both) and standard deviations, where applicable,

12.1.19 Individual and mean slip values (optional) at ultimate and intermediate load values, in millimetres (inches), and load versus displacement graphs (optional),

12.1.20 Photographs, sketches, or word descriptions of the failure modes observed,

12.1.21 Summary of findings,

12.1.22 Relevant test limitations and recommendations, and

12.1.23 Listing of observers of tests and signatures of responsible persons.

NOTE 2—The moisture content of the structural member at time of test may be determined by several methods including drying of small samples to constant mass or use of moisture meters.

13. Precision and Bias

13.1 *Precision*—No data are available on precision of these test methods.

13.2 *Bias*—Data cannot be obtained on bias of these test methods since no standard reference materials exist.

14. Keywords

14.1 concrete; drive pin; edge distance; failure modes; fastener; masonry; powder-actuated; power-actuated; shear test; spacing; structural member; tension test; threaded stud