Standard Test Methods for Strength of Anchors in Concrete Elements[1]

This standard is issued under the fixed designation E488/E488M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These test methods address the tensile and shear strengths of post-installed and cast-in-place anchors in test members made of cracked or uncracked concrete. Loadings include quasi-static, seismic, fatigue and shock. Environmental exposures include freezing and thawing, moisture, decreased and elevated temperatures and corrosion. These test methods provide basic testing procedures for use with product-specific evaluation and acceptance standards and are intended to be performed in a testing laboratory. Product-specific evaluation and acceptance standards may add specific details and appropriate parameters as needed to accomplish the testing. Only those tests required by the specifying authority need to be performed.

1.2 These test methods are intended for use with post-installed and cast-in-place anchors designed for installation perpendicular to a plane surface of a test member.

1.3 This standard prescribes separate procedures for static, seismic, fatigue and shock testing. Nothing in this standard, however, shall preclude combined tests incorporating two or more of these types of loading (such as seismic, fatigue and shock tests in series).

1.4 Both inch-pound and SI units are provided in this standard. The testing may be performed in either system and reported in that system and the results converted to the other. However, anchor diameters, threads, and related testing equipment shall be in accordance with either inch-pound or SI provisions.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
C33/C33M Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C150/C150M Specification for Portland Cement
C330/C330M Specification for Lightweight Aggregates for Structural Concrete
E4 Practices for Force Verification of Testing Machines
E8/E8M Test Methods for Tension Testing of Metallic Materials
E468 Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials
E575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies
E631 Terminology of Building Constructions
E2265 Terminology for Anchors and Fasteners in Concrete and Masonry
F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
F1624 Test Method for Measurement of Hydrogen Embrittlement Threshold in Steel by the Incremental Step Loading Technique
G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements

2.2 *ANSI Standards:*[3]

ANSI B212.15 American National Standard for Cutting Tools—Carbide-Tipped Masonry Drills and Blanks for Carbide-Tipped Masonry Drills

[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.

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms related to building construction used in this standard, refer to Terminology E631, and for definitions of terms related to anchoring, refer to Terminology E2265.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *load-controlled undercut anchor, n*—a post-installed anchor that derives its tensile holding strength by the mechanical interlock provided by installing the anchor by tensioning, which causes the sleeve to expand into the predrilled undercut.

3.2.2 *post-installed anchor, n*—an anchor that is installed after the placement and hardening of concrete.

3.2.3 *run-out, n*—a condition in which failure does not occur within the specified number of load cycles in a fatigue test.

3.2.4 *standard temperature, n*—73°F [23°C] ± 8°F [6°C].

3.2.5 *test member, n*—the base material in which the anchor is installed and which resists forces from the anchor.

3.3 *Symbols:*

c_a = distance from the center of an anchor shaft to the edge of test member, in. [mm].
c_{min} = minimum distance from the center of an anchor shaft to the edge of test member, determined from tests, in. [mm].
d = nominal diameter of anchor to be tested, in. [mm].
d_{fix} = diameter of hole in shear sleeve, ≥d, in. [mm].
d_{hole} = diameter of drilled borehole in test specimen, in. [mm].
d_m = diameter of carbide-tipped drill bit with diameter on low end of tolerance range for new bit, representing moderately used bit, in. [mm].
d_{max} = diameter of carbide-tipped drill bit with diameter on high end of tolerance range for new bit, representing bit as large as would be expected in use, in. [mm].
d_{min} = diameter of carbide-tipped drill bit with diameter below low end of tolerance range for new bit representing a well-used bit, in. [mm].
d_o = outside diameter of post-installed anchor, in. [mm].
$d_{opening}$ = diameter of hole in confining plate for confined tension tests, in. [mm].
F_{cr} = crack-inducing force, applied to reinforcing bars, lb [N].
f'_c = specified concrete compressive strength, psi [MPa].
$f'_{c,ref}$ = specified compressive strength of reference concrete test member, psi [MPa].
$f'_{c,test}$ = specified compressive strength of concrete test member, psi [MPa].
h_{ef} = effective embedment depth, measured from the concrete surface to the deepest point at which the anchor tension load is transferred to the concrete, in. [mm].
h_{min} = minimum member thickness, in. [mm].
h_{nom} = distance between embedded end of concrete screw and concrete surface, in. [mm].
n_{ct} = number of test cycles.
n_{pt} = number of permitted pretest crack cycles.
$N_{p,cr}$ = characteristic pullout resistance in cracked concrete for the minimum specified concrete strength of 2500 psi [17 MPa], as determined from tests in cracked concrete, lb [N].
$N_{st,mean}$ = mean ultimate steel capacity determined from tensile tests on full-sized anchor specimens, lb [N].
$N_{sust,l}$ = sustained load, lb [N].
$N_{sust,con}$ = sustained load used for confined reference tests, lb [N].
$N_{sust,ft}$ = specified constant tension load, lb [N].
$N_{u,con,mean}$ = mean ultimate load determined from confined reference tests, lb [N].
$N_{u,mean}$ = mean ultimate load determined from tests, lb [N].
N_w = tensile load in tests of anchors located in cracks whose opening width is cycled, lb [N].
s_{min} = minimum anchor spacing, determined from test, in. [mm].
t_{fix} = effective thickness of shear sleeves (see d), in. [mm].
t_{pl} = thickness of confining plate for tension tests, ≥d, in. [mm].
T_{inst} = specified or maximum setting torque for expansion or prestressing of an anchor, ft·lb [N·m].
T_{screw} = specified maximum setting torque to prevent anchor failure during installation, ft-lb [N-m].
W_1 = largest crack width during test, in. [mm].
W_2 = smallest crack width during test, in. [mm].
W_3 = largest crack width at beginning of test, in. [mm].
ℓ_{side} = side length of test cube, in. [mm].

4. Significance and Use

4.1 These test methods are intended to provide reproducible data from which acceptance criteria, design data, and specifications can be developed for anchors intended to be installed in concrete.

5. Apparatus

5.1 *Testing Equipment:*

5.1.1 *General*—Use calibrated electronic load and displacement measuring devices meeting the specified sampling rate. Use load-measuring equipment with an accuracy of ±1 % of the anticipated ultimate load and calibrated in accordance with Practices E4. Use displacement measuring devices with an accuracy of ±0.001 in. [±0.025 mm] and crack-width measuring devices with an accuracy of ±0.0005 in. [±0.013 mm]. For recording load and displacement measurements, use a data-acquisition system capable of recording at least 120 data points per instrument for each individual test, prior to reaching peak load. The testing equipment shall have sufficient capacity to prevent yielding of its components under the anticipated ultimate load, and shall have sufficient stiffness to ensure that the applied tension loads remain parallel to the axes of the anchors and that the applied shear loads remain parallel to the surface of the test member during testing.

5.1.2 *Tension Test Equipment*—The support for the tension test equipment shall be of sufficient size to prevent failure of the surrounding test member. The loading rod shall be of sufficient diameter to develop the anticipated ultimate strength of the anchorage hardware with an elastic elongation not exceeding 10 % of the anticipated elastic elongation of the anchor, and shall be attached to the anchorage system by a connector that will minimize the direct transfer of bending stress to the anchor. The displacement measuring device(s) shall be positioned to measure the movement of the anchors with respect to points on the test member so that the device is not influenced during the test by deflection or failure of the anchor or test member. See Fig. 1 and Fig. 2 for examples of typical test setups.

NOTE 1—Other support geometries are acceptable.

Table 1 gives the minimum required clear distance from the test support to the anchor for tension and shear loading.

5.1.3 *Shear Test Equipment*—Position the displacement-measuring device(s) to measure displacement in the direction of the applied load only. Place the device on the test member so that the sensing element bears perpendicularly on the anchor or on a contact plate located on the loading plate, or use another method that restricts deflections other than those in the direction of the applied load. See Fig. 4 for a typical example of a shear test setup. For tests on anchor groups, the axis of the displacement-measuring device shall coincide with the centroid of the group. Table 1 gives the minimum required clear distance from the test support to the anchor shear loading toward a free edge.

5.2 *Group Test Equipment*—Measure the simultaneous displacement of all anchors or groups of anchors tested. Only one set of displacement-measuring devices is required for a group of anchors. Displacement measurements as described in 5.1.1 include components of deformation not directly associated with displacement of the anchor relative to the test member, such as elastic elongation of the loading rod, deformation of the loading plate, sleeves, shims, attachment hardware, and local test member material. Using supplementary measuring devices or calibration test data for the installed test set-up with a rigid anchor replacing the anchor to be tested, identify such deformation components and subtract them from the total measured displacement. To evaluate the findings, use the average displacement indicated by the instruments in each group.

5.3 *Loading Plates:*

5.3.1 For tension loading the plate thickness t_{fix} in the immediate vicinity of the test anchor shall be equal to or greater than the nominal anchor diameter to be tested.

5.3.2 For shear testing the plate thickness t_{fix} in the immediate vicinity of the test anchor shall be equal to the nominal anchor diameter to be tested, –1⁄16 +1⁄8 in. [–1.5 +3.0 mm]. The hole in the loading plate shall have a diameter of 0.06 ± 0.03 in. [3.0 ± 1.5 mm] greater than the specified diameter of the test anchor unless another diameter is specified. The shape of the hole in the loading plate shall correspond to that of the anchor cross section. When sleeve inserts of the required diameter are used they shall be periodically inspected and replaced to meet these requirements and prevent eccentric loading of sleeve. See Fig. 5 for a representative shear plate with sleeves. The contact area between the loading plate through which the anchor is installed and the test member shall be as given in Table 2, unless otherwise specified. Chamfer or smooth the edges of the loading plate so that it does not dig into the concrete. Place a sheet of polytetrafluoroethylene (PTFE) or other friction-limiting materials with a minimum thickness of 0.020 in. [0.5 mm] between the loading plate and base

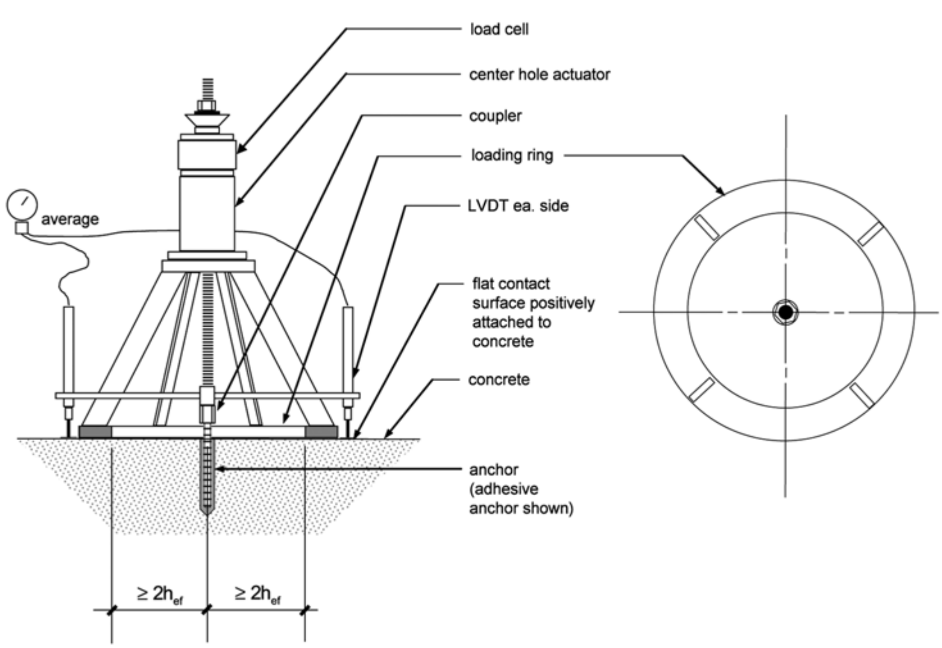

FIG. 1 Example of Unconfined Tension Test Setup – Displacement Measurement with Dual LVDTs