Designation: E1512 – 01 (Reapproved 2015)

Standard Test Methods for Testing Bond Performance of Bonded Anchors[1]

This standard is issued under the fixed designation E1512; 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 cover instructions for making a variety of tests for the strength of the adhesive bond developed between a steel anchor and the surface of a hole in concrete or masonry (including masonry units and mortar joints) and for assessing the effects on such bond of a variety of factors including elevated temperature, fire, moisture, and freezing and thawing action. The specifier or manufacturer shall select those tests that are appropriate for the given anchoring system and intended application.

1.2 The adhesive-bonded anchor system refers to a smooth or deformed steel bar or threaded rod, set in a predrilled hole containing chemical bonding compounds. Loads are transferred mainly by the bond of the adhesive both to the anchor and the surrounding elements along the sides of the hole. For anchoring systems made of significantly different materials, these test methods shall be taken as a guideline.

1.3 These test methods apply to all adhesives used to bond steel anchors or steel reinforcement bars (rebar) to concrete or masonry. These test methods apply to anchorages used in uncracked concrete or masonry. They do not apply to the use of the anchor in the concrete tension zone. The usual forces applied during the tests are in tension, shear, and under a combination of both tension and shear.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI 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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing

E119 Test Methods for Fire Tests of Building Construction and Materials

E488/E488M Test Methods for Strength of Anchors in Concrete Elements

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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *baseline test*—restrained test conducted on anchors installed in the same test member and under the same installation method as a required environmental test for comparison purposes.

3.1.2 *bonded anchor*—a fastener placed in hardened concrete or masonry that derives its holding strength from a chemical compound placed between the wall of the hole and the embedded portion of the anchor.

4. Significance and Use

4.1 These test methods are intended to provide information from which applicable design data and specifications are derived for a given anchorage device and for qualifying anchors or anchorage devices.

4.2 These test methods shall be followed to ensure reproducibility of the test data.

5. General Requirements

5.1 The adhesive bonded anchors to be tested shall be representative of the product made available for typical field installations. The manufacturer shall provide information on physical, mechanical, and chemical properties of the anchor system. If required by a customer or approval agency, the

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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.

testing laboratory shall verify, or have a specialized laboratory verify, the physical, mechanical, and chemical properties of the adhesive.

5.2 The installation equipment, instructions, and procedures shall be as specified by the manufacturer. If there are any deviations from the manufacturer's instructions when testing commercial anchors, they shall be described in the report.

5.3 The structural members shall be as described in Test Methods E488/E488M.

5.4 The test and measuring equipment for performing static tension and shear tests, as well as dynamic tests, are described in Test Methods E488/E488M. For performing long-term creep tests, equipment that will sustain the required loads without distress shall be used.

6. Materials and Manufacture

6.1 The adhesive-bonded anchors shall be installed for use in accordance with written instructions of the manufacturer. An inert filler that does not affect the performance of the components, if specified by the manufacturer, shall be uniformly incorporated in one or both bonding components.

7. Procedure

7.1 This section presents the specific tests that shall be performed as required to evaluate the bonded anchor system. When evaluating bonded anchors in concrete, the concrete strength shall be 3000 ± 500 psi (20 ± 3 MPa) compressive strength, unless otherwise specified, using aggregate of river gravel or crushed rock. Cure the concrete for a minimum of 28 days. Condition the test member to 75 ± 10°F (24 ± 5°C) prior to anchor installations, unless otherwise specified. Masonry shall be permitted to be used as the test member.

7.2 *Static Tests:*

7.2.1 Perform tension and shear tests in accordance with Test Methods E488/E488M. All sizes are to be tested at both minimum and maximum embedments expected. Shear tests at the maximum embedment shall be permitted to be excluded if shear tests at a shallower embedment result in a steel failure. If there is a difference greater than 9 anchor diameters between these embedments additional intermediate embedments shall be tested. Clean holes and install anchors as specified by the manufacturer. Measure and record hole diameters and/or drill bit diameters. Install and cure anchors at 75 ± 10°F (24 ± 5°C).

7.3 *Dynamic Tests:*

7.3.1 *Fatigue Tests*—Perform fatigue tests in accordance with Test Methods E488/E488M.

7.3.2 *Seismic Tests*—Perform seismic tests in accordance with Test Methods E488/E488M.

7.4 *Environmental Tests:*

7.4.1 The tests given in 7.4.3 – 7.4.8 are designed to determine the effect of loading and environmental influences on the bond strength of the adhesive. To ensure bond failure, use steel of sufficiently high strength to prevent steel failure of the anchor. To provide comparative standardized data, anchors shall be ½ in.–13 UNC Threaded Rod, unless otherwise specified (12 mm), and be embedded 4.5 ± 0.1 in. (115 ± 2.5 mm). Test anchors of other diameters when specified by the purchaser or manufacturer. Install and cure all anchors at 75 ± 10 (24 ± 5°C), unless specified otherwise. Install and cure anchors according to the manufacturers instructions, unless directed otherwise.

7.4.2 The tests given in 7.4.3 – 7.4.8 shall be conducted as restrained tests or unrestrained tests, unless the section in question requires a specific test. A restrained test is defined as a test conducted in accordance with Test Methods E488/E488M except that the test equipment support clearance requirements of Test Methods E488/E488M do not apply. The reaction base shall be approximately equal to the drilled hole diameter for the anchor to preclude concrete or masonry failure, but allow bond failure. An unrestrained test is defined as a test conducted in accordance with Test Methods E488/E488M. If the environmental tests are conducted as restrained tests, baseline tests are required for comparison purposes. Baseline tests are defined as restrained tests conducted on three ½-in. (12-mm) anchors embedded 4.5 ± 0.1 in. (115 ± 2.5 mm) in the same base material using the same installation method as the required environmental test. If the environmental tests are conducted as unrestrained test, baseline tests are not required.

7.4.3 *Test on Short-term Effect of Fire*—The purpose of this test is to determine anchor performance when subjected to the temperatures and times given in the fire-temperature curve in Test Methods E119. This test shall be conducted in the unrestrained mode. Install and test a minimum of three anchors. Use a test member that is sufficiently large (36 in.^{2} (1 m^2)) to give realistic concrete or masonry response to the fire temperature exposure in the vicinity of the test anchor. Condition the test member in accordance with Test Methods E119 under the "Protection and Conditioning of Test Specimen" section. A typical set-up is shown in Fig. 1. During testing, subject the anchors to a constant tension load. This load shall be the allowable load for the anchor as determined in 7.2, or other load as specified by the manufacturer. Maintain the load as the fire temperature is increased in accordance with the Test Methods E119 time-temperature curve. Record temperature and displacement readings at 1-min increments until failure occurs.

7.4.4 *Radiation Test*—Perform these tests where the radiation resistance of the adhesive is required. The tests shall be conducted as restrained tests, or unrestrained tests. If testing is conducted in the restrained mode, baseline tests are required. Install and test a minimum of three anchors. Expose the test specimens to a minimum gamma radiation level of 2×10^7 rads. Conduct tension tests and compare the irradiated anchor results to the baseline test results if the radiation tests were conducted in the restrained mode. Compare the irradiated anchor results to the results determined in 7.2 for the same size anchor if the radiation tests were conducted in the unrestrained mode. Upon completion of the tests, the testing agency shall be responsible for safely disposing of the test samples in accordance with applicable regulations.

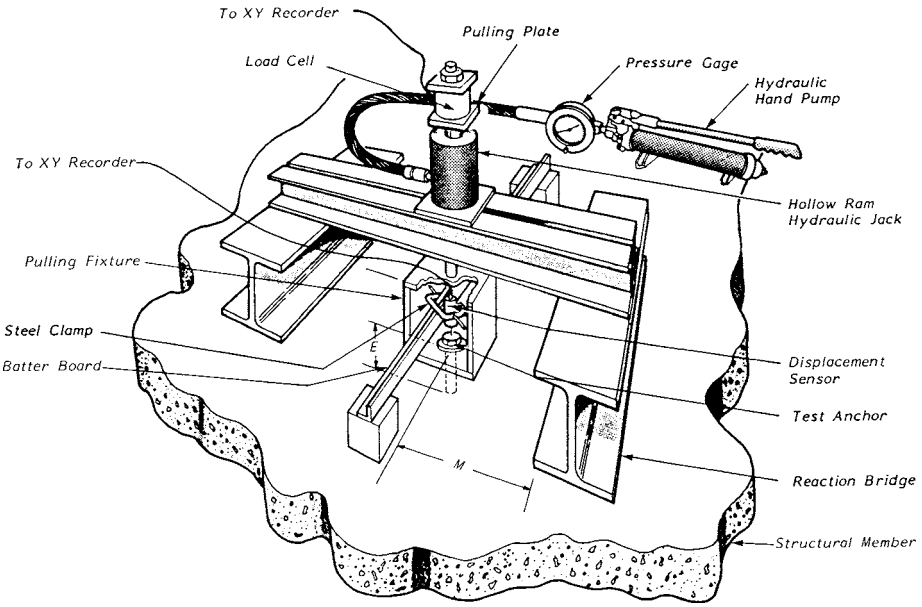

FIG. 1 Tension Creep Test Arrangement

7.4.5 *Tests on Effect of Freezing and Thawing Conditions*—The tests shall be conducted as restrained tests, or unrestrained tests. If testing is conducted in the restrained mode, baseline tests are required. Install and test a minimum of three anchors. Freezing-and-thawing resistant concrete shall be used as an option. Cover the surface of the test member, within a minimum 3-in. (76-mm) radius from the center of the test anchor, with tap water, maintaining a minimum of ½-in. (12-mm) depth throughout the test. Load each anchor with a constant tension load equal to at least 40 % of the ultimate load capacity of the baseline tests for restrained tests, or 40 % of the ultimate load capacity for the same size anchor determined in 7.2 for an unrestrained test. This load is to be maintained during the freezing and thawing cycles. The nominal freezing and thawing cycles shall consist of alternately lowering the temperature of the chamber to −10°F (−23°C) and holding this temperature for 3 h, then raising the temperature to 104°F (40°C) and holding this temperature for 3 h. Measure the temperature at the surface of the concrete at a location outside the standing water. At the completion of fifty complete cycles, conduct tension tests and compare the results to the baseline test results or to the results determined in 7.2 for the same size anchor as applicable.

7.4.6 *Tests on Effects of Damp Environment*—The tests shall be conducted as restrained tests, or unrestrained tests. If testing is conducted in the restrained mode, baseline tests are required. Install and test a minimum of three anchors. Prior to anchor installations, fill the test holes with tap water and maintain the water level filled for a minimum of seven days. Immediately prior to installing the anchors, all freestanding water shall be removed so that the walls of the test holes are surface moist. After the appropriate cure time has elapsed, conduct tension tests to failure and compare the results to the baseline test results or to the results determined in 7.2 for the same size anchor as applicable. If the application requires installation in water-filled holes, conduct the test as described above except that the freestanding water is not removed. Install the anchors in the water-filled holes.

7.4.7 *Tests on Effect of Service Temperature:*

7.4.7.1 *Tests on Effect of Elevated Temperature on Cured Samples*—The tests shall be conducted as restrained tests, or unrestrained tests. Install and test a minimum of three anchors for each temperature data point. Test a sufficient number of temperature data points to develop a load-temperature response curve of the adhesive anchor. Test, as a minimum 70°F (21°C) and at least four higher temperatures, one of which shall be at least 180°F (82°C). All anchors are to be installed and cured at 75 ± 10°F (24 ± 5°C). Following the recommended cure period, heat and maintain the specimens at the desired temperature for a minimum of 24 h. Remove the test specimens from the heating chamber and tension test the anchors immediately in order to assure the test specimens remain at the conditioned temperature. A thermocouple inserted into the test member may be used to confirm the temperature at the time of testing. Plot a chart depicting the performance trend showing the percentage change, compare to the strength at 70°F (21°C), attributed to the change in temperature.

7.4.7.2 *Tests on Effect of Reduced Temperature on Curing*—The tests shall be conducted as restrained tests, or unrestrained tests. Install and test a minimum of three anchors. Prior to installation, condition the anchor rod and test member to the desired temperature and maintain that temperature for a minimum of 24 h. Install the anchors and allow them to cure at the stabilized temperature for the manufacturers recommended cure time. Remove the test specimens from the cooling chamber and tension test the anchors immediately in order to assure the test specimens remain at the conditioned temperature. A thermocouple inserted into the test member may be used to confirm the temperature at the time of testing. Compare the results to the load obtained in 7.4.7.1 at 70°F (21°C). When specific adhesives are recommended for use below 50°F (10°C), perform the following additional test:

(a) Install and test a minimum of three anchors. Prior to installation, condition the anchor rod and test member to the desired temperature and maintain that temperature for a minimum of 24 h. Install the anchors and allow them to cure at the stabilized temperature for the manufacturer's recommended cure time. Apply a constant tension load equal to 25 % of the ultimate load obtained in 7.4.7.1 at 70°F (21°C), then remove the test specimens from the cooling chamber. Raise the temperature of the test member uniformly to 75 ± 10°F (24 ± 5°C) over a period of 72 to 96 h while monitoring the displacement response for each anchor. A thermocouple inserted into the test member may be used to confirm the temperature of the specimen during the test. Once the test member attains the desired temperature, conduct tension tests to failure.

7.4.8 *Creep Test*—The tests shall be conducted as a restrained test, or as an unrestrained test, but in either case all test series shall be of the same type. A test series shall consist of a minimum of three anchors. Concrete used in all test series shall have the same mix design, and the compressive strength shall be between 2500 psi and 3500 psi (17 MPa and 24 MPa) at the time of static load tests and at initiation of creep tests, with a minimum concrete age of 28 days. Anchors shall be cured for 7 ± 5 days prior to test commencement.

7.4.8.1 *Static Tension Test Series at 75 ± 10°F (24 ± 5°C)*—A static tension load test series shall be performed at 75 ± 10°F (24 ± 5°C) to determine the average ultimate tension load. Results that are less than 85 % of the average value shall be excluded from the determination of the average ultimate tension load, with the average value re-calculated using the remaining results.

7.4.8.2 *Static Tension Test Series at Elevated Temperature*—A static tension load test series shall be performed at a minimum specified concrete temperature of 110°F (43°C) to determine the average displacement at ultimate tension load. The concrete temperature is established as noted in 7.4.8.3 to follow. Displacement results that are greater than 115 % of the average value shall be excluded from the determination of the average displacement, with the average value re-calculated using the remaining results.

7.4.8.3 *Creep Test Series at Elevated Temperature*—Thermocouples shall be embedded a minimum of 4 ½ in. (114 mm) from the surface of the concrete into which the anchors are to be installed. The thermocouples must be cast in place or installed into maximum ½-in. diameter (12-mm) holes drilled into concrete, with the holes sealed in a manner so as to ensure that temperature readings reflect the concrete temperature. After the anchor curing period, the temperature of the specimens shall be increased until the temperature, as determined from the thermocouples, is stabilized for at least 24 h at the minimum elevated temperature of 110°F (43°C). A preload not exceeding 5 % of the sustained creep load shall be applied before zeroing displacement readings. Sustained creep load is defined as 40 % of the average ultimate determined by 7.4.8.1. The remainder of the sustained creep load shall then be applied. The initial elastic displacement (additional displacement after the preload) shall be measured within 3 min of applying the sustained creep load. The concrete specimen temperature shall be recorded at maximum 1-h intervals. As an alternative, the concrete specimen temperature can be recorded at maximum 24-h intervals, provided the heat chamber temperature necessary to maintain the required concrete temperature is maintained and is recorded at maximum 1-h intervals. For a smooth displacement-versus-time curve, displacements shall be measured at least hourly for the first 6 h, and daily for the duration of the test. If the concrete test temperature falls below the minimum specified temperature (including tolerances) for over 24 h, the creep test duration shall be extended to account for the total period below the minimum specified temperature. Creep tests shall continue for a minimum of 42 days. The total displacement at 600 days, which includes the initial elastic displacement plus the creep displacement, is

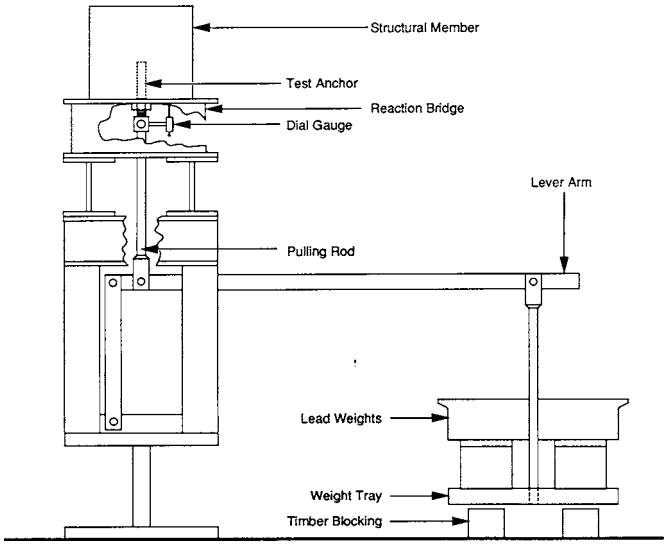

FIG. 2 Tension Creep Test Arrangement Using a Dead Weight

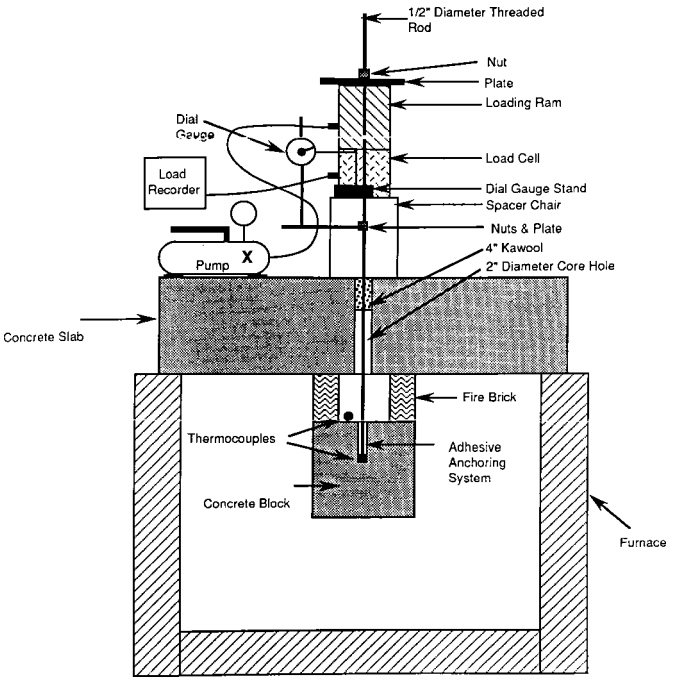

FIG. 3 Typical Fire Test Setup

determined for each specimen by projecting a logarithmic trend line (determined by calculating a least-squares fit through the data points, using the equation y = c ln(x) + b), constructed from data from not less than the last 20 days (minimum of 20 data points) of the creep test, forward to 600 days. Compare the average total displacement at 600 days to the average displacement determined in 7.4.8.2.

8. Report

8.1 Report the applicable information pertinent to the type of test performed (static, fatigue, seismic, shock, etc.) and specifically include the following:

8.1.1 Date of test and date of report,

8.1.2 Test sponsor and test agency,

8.1.3 Identification of anchors tested: manufacturer, model, type, material, finish, shape, dimensions, and other pertinent information,

8.1.4 Description of the anchoring system tested and description of the structural member, including dimensions and installed reinforcing,

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

8.1.6 Physical strength properties of the structural member into which the anchor or anchors are embedded, including mix design of the concrete, compressive strength at the time of test, and age of the structural member at the time of test,

8.1.7 Description of the procedure, tools, and materials used to install the anchorage system and any deviations from the recommended procedures and reason for such deviation,

8.1.8 Age, in hours or days, of the anchorage system since installation,

8.1.9 Temperature conditions at time of installation and at time of testing; and any other temperature experience that affects anchor performance. For fire testing, record the time-temperature curve, average furnace temperature at failure, and average time to which the test assemblies were exposed prior to failure,

8.1.10 Embedment depth of installed anchors,

8.1.11 Amount of torque applied to anchor prior to test, if applicable,

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

8.1.13 Number of replicate samples tested,

8.1.14 Individual and average ultimate load values per embedded anchor, standard deviation or coefficients of variation, where applicable,

8.1.15 Individual and average displacement values at ultimate loads, and load displacement curves,

8.1.16 Description of failure modes,

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

8.1.18 Equipment calibration certification for load cells issued within one year prior to test dates and pressure gages calibrated within 30 days of testing,

8.1.19 Summary of findings, and

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

9. Precision and Bias

9.1 No statement is made on the precision or bias of the procedures given in these test methods, since the test results indicate only whether there is conformance to given criteria, and since no generally accepted method for determining precision and bias of these tests is currently available. General guidelines provided herein on the specimens, instrumentation, and procedures make the results intractable to calculation of meaningful values by statistical analysis for precision and bias at this time.

10. Keywords

10.1 adhesive anchors; anchors; chemical anchoring systems; concrete; masonry elements; methods of testing