



Standard Test Methods for Testing Bond Performance of Adhesive-Bonded Anchors¹

This standard is issued under the fixed designation E 1512; 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 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 the standard. The SI units given in parentheses are for information only.

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:

C 666 Test Method for Resistance of Concrete to Rapid Freezing and Thawing²

E 119 Test Methods for Fire Tests of Building Construction and Materials³

E 488 Test Method for Strength of Anchors in Concrete and Masonry Elements⁴

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 *control anchor*—the anchor tested to provide a reference value that shall be used to compare with the value obtained by the test anchor. The control anchor shall be tested in concrete of the same strength and age as that of the test anchor.

3.1.2 *epoxy resin*—a viscous liquid or brittle solid containing epoxide groups that cross-link into final form by means of a chemical reaction with a variety of setting agents used with or without heat.

3.1.3 *polyester resin*—a condensation product resulting from a chemical reaction between a dicarboxylic acid and a dihydroxy alcohol or by the polymerization of a hydroxy carboxylic acid.

3.1.4 *test anchor*—the anchor being tested to criteria to determine its load-carrying capacity.

3.1.5 *vinylester resin*—vinylesters are the reaction products of epoxy resins with ethylenically unsaturated carboxylic acids. These materials react to give crosslinking either by polymerization of the vinylester resin with itself or by copolymerization with unsaturated monomers such as styrene.

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 *Annual Book of ASTM Standards*, Vol 04.02.

³ *Annual Book of ASTM Standards*, Vol 04.07.

⁴ *Annual Book of ASTM Standards*, Vol 04.11.

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 Method E 488.

5.4 The test and measuring equipment for performing static tension and shear tests, as well as dynamic tests, are described in Test Method E 488. 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 chemical anchor system.

7.1.1 The tests given in 7.2-7.4 are designed to determine load capacity for the chemical anchoring system. Perform these tests in accordance with Test Method E 488 with the test reaction-force distance from the test anchor complying with the requirements of Table 2 of that test method.

7.1.2 The tests given in 7.5-7.10 are designed to determine the influence of loading and environmental influences on the bond strength of the adhesive. To ensure evaluation of the adhesive bond strength, use steel of sufficiently high strength to prevent steel failure for the anchor. The reaction force shall be close to the anchor to preclude concrete or masonry failure, but allow bond failure. To provide comparative standardized data,

anchors shall have a diameter of 1/2 in. (12 mm). Test anchors of other diameters where specified by the purchaser.

7.1.3 Perform all tests in accordance with Test Method E 488 under continuous load application, with continuous measurement of both load and displacement (deformation). The load application rate shall cause failure between 2 and 5 min. Concrete compressive strength shall be between 2500 psi (17 MPa) and 3500 psi (24 MPa), unless otherwise specified, at the time of testing with a minimum concrete age of 28 days. In addition, for smooth bars, the surface finish shall be typical for the standard anchor and, for threaded or deformed bars, the deformation pattern shall be typical for the standard anchor to ensure a true bond strength. Unless otherwise specified, install anchors at a room temperature between 65 and 75°F (18 and 24°C). Install and cure anchors according to the manufacturer's instructions unless otherwise specified.

7.2 *Static Tests*—Perform static shear and tension tests in accordance with Test Method E 488.

7.3 *Fatigue Tests*—Perform fatigue tests in accordance with Test Method E 488.

7.4 *Seismic Tests*—Perform seismic tests in accordance with Test Method E 488.

7.5 *Long-Term Load (Creep) Tests:*

7.5.1 Test a minimum of three 1/2 in. (12 mm) diameter anchors in tension.

7.5.2 The test duration shall be a minimum of 120 days. Maintain the temperature of the test specimens between 65 and 75°F (18 and 24°C).

7.5.3 Load each anchor to a minimum constant static tensile force of 0.4 times the manufacturer's published ultimate load for the full test duration. Typical test setups are shown in Figs. 1 and 2.

7.5.4 Load-displacement response for each specimen shall be monitored at sufficient intervals to develop a representative curve for the system. Since a large portion of the movement occurs in the very early stages of the test, readings small be

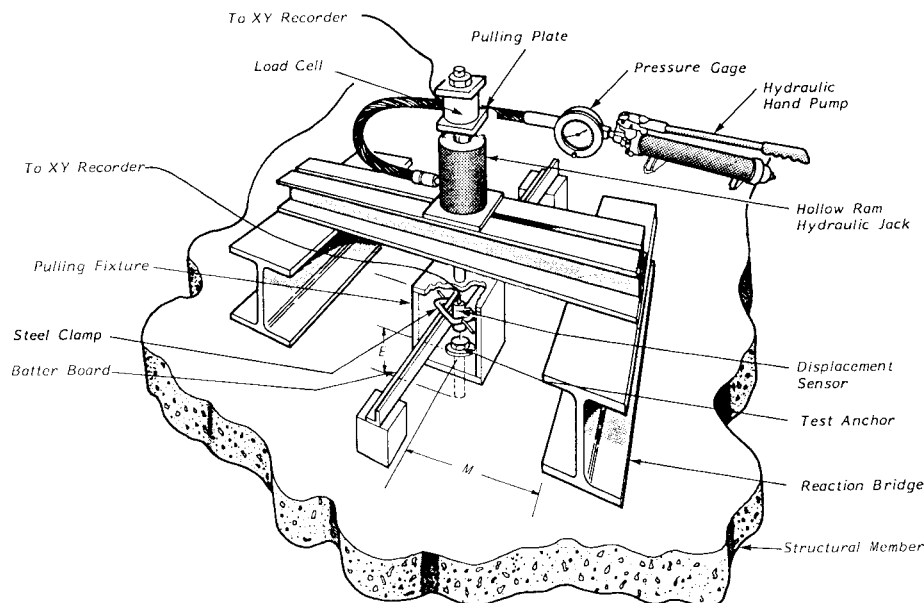


FIG. 1 Tension Creep Test Arrangement

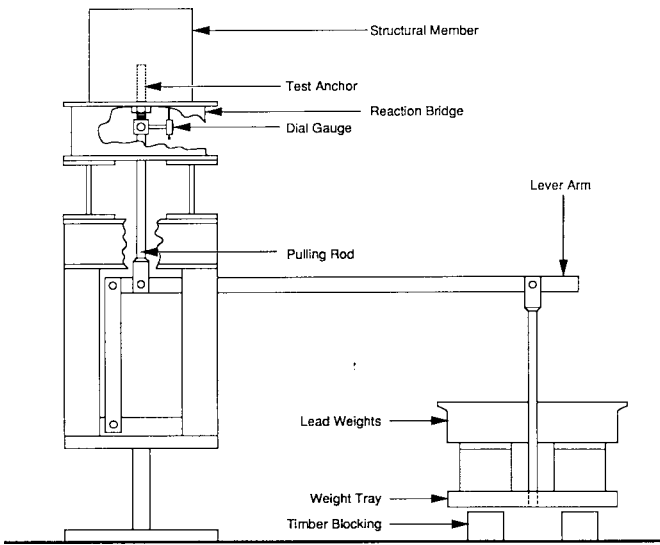


FIG. 2 Tension Creep Test Arrangement Using a Dead Weight

made immediately after the load is applied, every ten minutes for the first hour, every hour for the next seven hours, once a day for the next ten days, and then every five to ten days for the duration of the test.

7.5.5 After the 120-day period, the anchors shall be tension tested to failure and a continuous load-displacement curve plotted.

7.6 Tests on Effect of Service Temperature on Cured Samples:

7.6.1 Tension test a sufficient number of temperature data points to develop a load-temperature response curve of the adhesive anchor system. Test, as a minimum, 32°F (0°C) 70°F (21°C), and at least four higher temperatures, one of which shall be at least 180°F (82°C). Test a minimum sample size of three anchors of nominal 1/2 in. (12 mm) diameter for each temperature. Install test anchors in concrete blocks, masonry, or cylinders with sides or diameter not to exceed 12 in. (300 mm).

7.6.2 Store the test specimens for a minimum of 24 h at the desired test temperature prior to testing.

7.6.3 Remove the test specimen, wrap in an insulating material covering all exposed sides except the side containing the test anchor. Tension test the anchor without undue delay after removal from the conditioned storage area.

7.6.4 Plot a chart depicting the performance trend showing the percentage change, compared to the strength at 70°F (21°C), attributed to the change in temperature.

7.6.5 When specific adhesives are supplied for low temperature use, perform the following tests to determine the effect of setting temperatures on cured samples.

7.6.5.1 Test a minimum of three anchors for the specified minimum installation temperature. Cool the structural member sufficiently long to ensure that the entire sample is at the specified installation temperature. Install the chemical anchor system and maintain the test system at the installation temperature for the time specified by the manufacturer as a minimum time for loading the anchor at that temperature. Tension test the anchors to failure at the minimum specified installation temperature.

7.6.5.2 Install additional anchors at the minimum temperature in structural members cooled at the specified temperature sufficiently long to ensure that the entire sample is at the specified temperature. Test the anchors in accordance with 7.6.1-7.6.4. Compare the ultimate loads, load displacement curves, and the load-temperature charts to those of 7.6.4.

7.7 Tests on Effect of Damp Environment:

7.7.1 Test a minimum of five anchors. The anchors shall be of 1/2 in. (12 mm) diameter.

7.7.2 Install the control anchors in concrete or masonry conditioned as required for concrete test specimens in Test Methods E 119 and tested in tension. Test the test anchors in damp concrete or masonry, that is, after the test holes have been filled with water at room temperature of 68°F (20°C) for a minimum of seven days. Immediately prior to installing the test anchors, all freestanding water shall be removed so that the hole walls are surface moist.

7.7.3 After the appropriate curing time has elapsed, test the test anchors in tension.

7.7.4 If the application requires installation in water-filled holes, conduct this test in accordance with 7.7.1-7.7.3 except install the anchors in water-filled holes.

7.8 Tests on Short-Term Effect of Fire:

7.8.1 The purpose of this test is to determine anchor performance when subjected to the temperatures and times given in the fire time-temperature curve in Test Methods E 119.

7.8.2 Tension test a minimum of three anchors of 1/2 in. (12 mm) diameter nominal size.

7.8.3 Use a test slab that is sufficiently large (36 in.² (1 m²)) to give a realistic concrete or masonry response to the fire temperature exposure in the vicinity of the test anchor. Condition the test slab according to Test Methods E 119 under the "Protection and Conditioning of Test Specimen" section. A typical setup is shown in Fig. 3.

7.8.4 During testing, subject the anchor to a constant tension

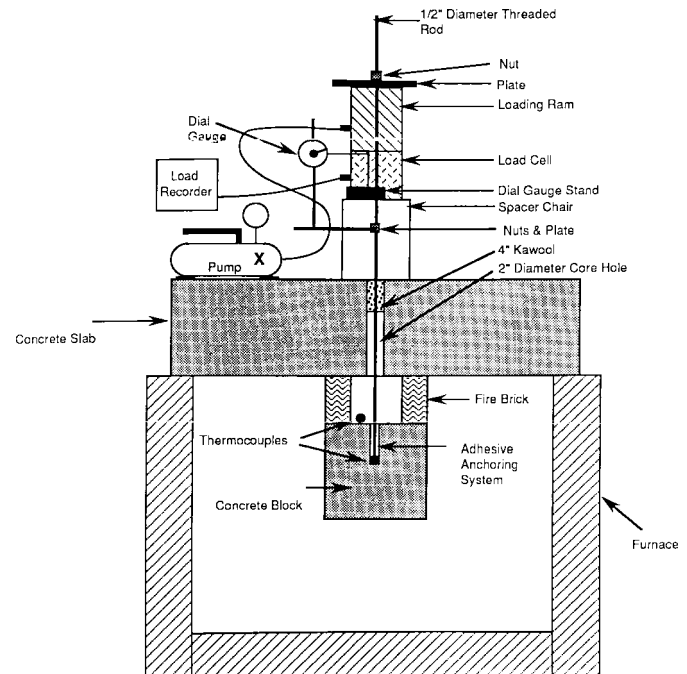


FIG. 3 Typical Fire Test Setup

load. This load shall be the allowable working load as published by the manufacturer or other load as specified. Maintain the load as the fire temperature is increased in accordance with the Test Methods E 119 time-temperature curve.

7.8.5 Record temperature and displacement readings at one-minute increments until failure.

7.9 *Tests on Effect of Freezing and Thawing Conditions:*

7.9.1 Install the anchors in freezing-and-thawing resistant concrete or masonry. Freezing-and-thawing resistant concrete is defined as concrete that, when tested by Procedure A of Test Method C 666, gives a durability factor greater than 80 after 330 cycles of freezing and thawing. Install the anchor in concrete, masonry, or concrete block having a 28-day compressive strength between 3500 and 5500 psi (24 and 38 MPa). The minimum dimension of the concrete, masonry, or block specimen shall be no less than 6 in. (150 mm) and the maximum dimension shall not exceed 12 in. (300 mm). Test a minimum of five anchors.

7.9.2 Cover only the top portion of the block or masonry surrounding the adhesive and anchor with tap water, maintaining at least ½ in. (12 mm) depth.

7.9.3 The nominal freezing and thawing cycles shall consist of alternately lowering the temperature of the chamber within 1 h to -10°F (-23°C), holding the temperature for 3 h, raising the temperature to 104°F (40°C) within 1 h, and holding the temperature for 3 h. The temperature is measured at the surface of the concrete or masonry at the location of the anchor and adhesive.

7.9.4 After completion of fifty complete cycles, conduct static tension tests.

7.10 *Radiation Tests:*

7.10.1 These tests shall be performed where the radiation resistance of the adhesive is required.

7.10.2 Install a minimum of two control and two test anchors in 6 in. (152 mm) or larger cubes or cylinders. Expose the test specimens to a minimum gamma radiation level of 2×10^7 rads.

7.10.3 Conduct tension tests on the anchors and compare the irradiated anchor results to those of the control anchors.

7.10.4 The testing agency shall be responsible for safely disposing of the test samples in accordance with applicable regulations.

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

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