



Designation: D 4436 – 04

Standard Test Method for Rock Bolt Long-Term Load Retention Test¹

This standard is issued under the fixed designation D 4436; 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 The objective of this test method is to determine the time over which rock bolt tension decreases from the installed value to a designated minimum value.

1.2 This test method is applicable to any anchor system which is not fully encapsulated immediately upon installation, including mechanical, cement grout, resin (epoxy, polyester, and the like) or other similar systems.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.4.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

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

D 653 Terminology Relating to Soil, Rock and Contained Fluids

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4435 Method for Rock Bolt Anchor Pull Test

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6167 Guide for Conducting Borehole Geophysical Log-

ging: Mechanical Caliper

3. Terminology

3.1 See Terminology D 653 for general definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *load*—the total axial force on the rock bolt.

3.2.2 *design load*—the load specified for the rock bolt during the life of the project.

3.2.3 *installation load*—the load on the bolt immediately after installation.

3.2.4 *stand time*—the time required for the bolt load to decrease from the installation load to the design load.

4. Summary of Test Method

4.1 A rock bolt is installed in the same manner and in the same material as its intended support use. The load on the bolt is monitored over a period of time, usually several weeks.

5. Significance and Use

5.1 Rock bolts are used for support in a variety of mining and civil engineering situations.³ After a bolt is installed, the load generally decreases over time due to deterioration of the borehole wall, creep, and other factors. This process may be arrested by fully encapsulating the bolt shortly after installation. This is generally done by pumping the bolt hole full of cement grout, though synthetic resins may also be used. The rate of load loss determines the interval during which the bolt must be encapsulated during construction.

5.2 The local characteristics of the rock, such as roughness of the borehole and induced fractures, are significant factors in the load loss characteristics of the bolt. To obtain realistic values, the test holes should be drilled using the same methods as those used for the construction boreholes.

5.3 In establishing a testing program, the following factors should be considered:

5.3.1 Load retention tests should be conducted in all rock types where construction bolts will be installed. If the rock is anisotropic, for example, bedded or schistose, the tests should

¹ This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics. Current edition approved July 1, 2004. Published July 2004. Originally approved in 1984. Last previous edition approved in 1998 as D 4436 – 84 (1998).

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 For additional information see, "Suggested Method for Monitoring Rock Bolt Tension Using Load Cells," *Suggested Methods for Rock Bolt Testing*, International Society for Rock Mechanics Commission on Standardization of Laboratory and Field Tests, 1974.

*A Summary of Changes section appears at the end of this standard.

be conducted in the same orientations relative to the anisotropy as the construction bolts will be installed.

5.3.2 In each rock type, at each orientation, and for each anchor system, a sufficient number of tests should be conducted to determine the average and minimum long-term capacities within a fixed uncertainty band at the 95 % confidence level. The allowable uncertainty band depends on the project and involves such factors as rock quality, expected project lifetime, and importance of the areas to be bolted. The uncertainty band determination will require considerable engineering judgment. As a rough guideline, at least six long-term tests for a single set of variables have been found necessary to satisfy the statistical requirements.

5.3.3 The design load and installation load on the rock bolt system should be predetermined. The installation load is less than the anchor capacity, as determined by Method D 4435. The design load is less than the installation load; the amount depends on rock properties and the minimum time required to encapsulate the bolts. Alternatively, this method can be run for a predetermined time interval based on construction requirements, and a realistic design load can be determined from the data.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Load Cell*—A load cell shall be used to measure the tension in the rock bolt. The cell may be of the mechanical, photoelastic, hydraulic, rubber compression pad, or electronic type. The electronic type is recommended. The cell shall have an accuracy of at least ± 200 lbf (± 890 N), including errors introduced by the excitation and read-out system, and a resolution of least 100 lbf (445 N).

6.2 *Anchor Systems*—The anchors used for testing shall be from the manufacturer's standard production stock. Mechanical anchors shall be inspected to ensure that no defective anchors are tested. Grout or resin shall be fresh (within the shelf life) and obtained from unopened containers. If grouted anchors are to be tested, ensure resin cartridge sizes are compatible with hole diameter, rock bolt bar diameter and length of anchorage required. For anchorages utilizing injected grout, ensure mixing and injection equipment and systems are compatible with manufacturer's recommendations.

6.3 *Rock Bolt and Accessories*—The rock bolt shall be of sufficient diameter and strength so that its elastic range is not exceeded during the tests. Standard bearing plates, washers, and the like may be used as required to align the load cell. A spherical bearing is desirable on very uneven surfaces. Rock bolts used with grout or resin anchors shall have identical ungrouted bolt lengths.

6.4 *Drilling Equipment*—As far as possible, the same type of drilling equipment and drill bits that will be used for installing rock bolts during the construction phase of the project shall be used to drill the test holes.

6.5 *Torque Wrench*—If expandable shell mechanical anchors are used, a torque wrench shall be used to set them. The torque wrench shall also be used to load the bolts. It shall have a capacity at least 20 % greater than the manufacturer's recommended anchor-setting torque. The torque wrench shall have an accuracy of at least ± 2 % of the full-scale reading and a resolution of at least 1 % of the full-scale reading.

6.6 *Hydraulic Pulling System*—As an alternative to the torque wrench, a hydraulic ram and reaction frame may be used to tension the bolts.

6.7 *Borehole Diameter Measuring Gage*—A gage shall be used to measure the diameter of the borehole at the anchor location. It shall have an accuracy of at least ± 0.02 in. (0.5 mm) and resolution of at least 0.01 in. (0.25 mm).

6.8 *Thermometer*—A thermometer shall be used to measure temperature in the borehole, within the anchor zone if resin or cement grout anchorages are being tested. The temperature of the resin or grout shall also be measured at the time of injection. The thermometer should have an accuracy of at least $+ 0.5^\circ\text{F}$ (0.28°C) and a resolution of at least 1°F (0.56°C).

7. Procedure

7.1 *Location*—Do not locate the test area in a zone that will be affected by future excavations, as rock response to stress changes can produce load changes in the bolt.

7.2 *Drilling the Test Hole*:

7.2.1 Drill the test hole using the same procedure that will be used during construction. Wash or blow the borehole clean of all cuttings.

7.2.2 The hole need not be as deep as the proposed length of the construction rock bolts. It shall, however, be deep enough to set the anchor past the zone of disturbance caused by the excavation and conform to the manufacturer's specifications for optimum performance, considering also compatibility with actual field conditions. For mechanical shell anchors, drill the hole 1 ft (300 mm) past the end of the anchor. A hole approximately 6 ft (1.8 m) in length has generally been found to be adequate.

7.2.3 Inspect the test hole visually using a flashlight, or mirror to reflect sunlight down the hole. If more than one-half of the bottom of the hole cannot be seen, the hole is not sufficiently straight for the test and shall not be used.

7.2.4 Measure the test hole diameter in two perpendicular directions at the top and bottom of the anchor location, using the borehole diameter measuring gage, for a total of four measurements.

7.3 *Preparation of Anchors*—If any anchor preparations, such as degreasing or rust removal, will be done during construction, prepare the test anchors in the same way. If no special preparation is done during construction, do not prepare the anchors.

7.4 *Setting the Anchor*:

7.4.1 If mechanical anchors are used, lightly lubricate the downhole end of the rock bolt and screw on the anchor. When