Designation: D 4436 – 84 (Reapproved 1998)

Standard Test Method for Rock Bolt Long-Term Load Retention Test[1]

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 *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:*

D 4435 Method for Rock Bolt Anchor Pull Test[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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

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

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

3.1.4 *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 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.

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

Current edition approved Nov. 30, 1984. Published January 1985.

[2] *Annual Book of ASTM Standards,* Vol 04.08.

[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.

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.

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).

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. 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. 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 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 in position, torque the bolt to the manufacturer's recommendations to set the anchor. A pair of jam-nuts on the upper end of the rod may be used to apply torque without producing axial load in the bolt. If the manufacturer's torque cannot be achieved because of anchor slippage due to shear failure in the rock, note the maximum torque reading and install subsequent anchors to 80 % of this value. Do not test anchors where rotation occurs between rock bore hole surface and anchor. In all cases, record any slipping or other anomalous behavior as shown in Fig. 1.

7.4.2 Install grout or resin anchors according to the manufacturer's recommendations.

7.5 *Loading the Bolt*:

7.5.1 The torque wrench is recommended for tensioning the bolt. Alternatively, the hydraulic pulling system may be used to apply load. In this case, attach a pulling rod to the rock bolt above the nut. Apply the load hydraulically, then tighten the nut. As the nut is tightened, the hydraulic pressure decreases because the load is transferred from the ram to the nut.

7.5.2 Tension the bolt until the load cell indicates that the installation load has been achieved.

7.6 *Reading Intervals*—Monitor the load on the bolt at least twice daily for a period of 2 weeks after installation, and once daily thereafter. Bolts in rapidly yielding material may require more frequent readings.

7.7 *Data Recording*—As a minimum for this method, record all the data shown in Fig. 1.

8. Calculation

8.1 For each test, plot the load on the rock bolt as a function of time, as shown in Fig. 2. If either design load or stand time is specified, the other may be determined from the graph.

8.2 For each group of tests in a similar rock type, with the same anchor type and orientation (if applicable), calculate the mean and uncertainty of the loads at the 95 % confidence level[4].

9. Report

9.1 The report shall include the following:

9.1.1 Describe the rock materials in which the anchors were tested, including the composition, texture, and any structural features which could affect anchor behavior, such as joints, weathering, and the like,

9.1.2 Briefly describe the types of anchors tested,

9.1.3 Prepare a summary table of the test program, including test number, anchor type, orientation, and test depth,

[4] To calculate the mean and uncertainty of the results see, "Statistical Considerations," *Rock Testing Handbook*, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, 1980, Section 104-80.

Rock Bolt Long Term Load Retention Test
Test Data Sheet—Sample Form

Project ______ Anchor: Type ______
Feature ______ Depth ______
Test Location ______ Inst. Torque ______
Rock Type ______ Bolt: Type ______
Test Number ______ Length ______
Orientation ______ Diameter ______

Equipment Description	Serial No.	Date of Next Calibration

Borehole diameter ______ ______ ______ ______

Average ______

Date	Time	By	Displacement	Load

Date	Time	By	Displacement	Load

Remarks:

Test Supervisor ______ Date ______
Quality Assurance ______ Date ______
Project Engineer ______ Date ______

FIG. 1 Rock Bolt Long Term Load Retention Test Sample Form

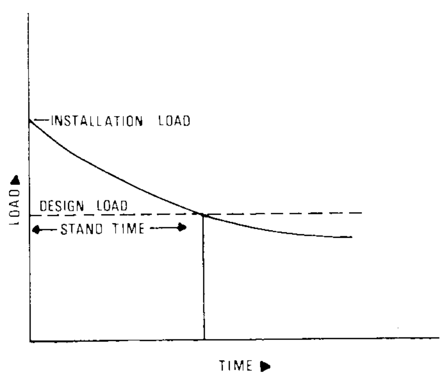

FIG. 2 Typical Load versus Time Curve for a Rock Bolt

9.1.4 List the equipment, other than anchors, with model numbers or dimensions as appropriate. Include the range, accuracy, and resolution of transducers,

9.1.5 Present the equations used to convert transducer output into engineering units.

9.1.6 Prepare a summary table of the results in each rock type, including anchor type, number of tests, mean stand time or design load, range, and uncertainty of the mean,

9.1.7 Include a plot of load versus time for each test, and

9.1.8 Append the data sheet for each test.

10. Precision and Bias

10.1 *Precision*—Due to the nature of rock materials tested by this test method, it is, at this time, either not feasible or too costly to produce multiple specimens which have uniform physical properties. Therefore, since specimens which would yield the same test results cannot be tested, Subcommittee D18.12 cannot determine the variation between tests since any variation observed is just as likely to be due to specimen variation as to operator or laboratory testing variation. Subcommittee D18.12 welcomes proposals to resolve this problem that would allow for development of a valid precision statement.

10.2 *Bias*—There is no accepted reference value for this test method; therefore, bias cannot be determined.

11. Keywords

11.1 anchors (rock); field testing; loading tests; mines; pull testing; rock