



Standard Test Method for Rock Bolt Anchor Pull Test¹

This standard is issued under the fixed designation D4435; 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.

^{ε1} NOTE—Editorial corrections were made throughout in February 2014.

1. Scope*

1.1 The objective of this test method is to measure the working and ultimate capacities of a rock bolt anchor. This method does not measure the entire roof support system. This method also does not include tests for pretensioned bolts or mine roof support system evaluation.

1.2 This test method is applicable to mechanical, cement grout, resin, (epoxy, polyester, and the like), or other similar anchor systems.

1.3 *Units*—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. Reporting of test results in units other than inch-pound shall not be regarded as nonconformance with this test method.

1.3.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.4.1 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analytical methods for engineering design.

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

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology D653.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *displacement*—the movement of the rock bolt head.

3.2.2 *failure*—in rock bolt testing, failure is defined as the inability of the anchor system or rock to sustain increased load without rapidly increasing deformation. In some instances, the peak load itself cannot be sustained.

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

3.2.4 *ultimate capacity*—the maximum load sustained by the anchor system.

3.2.5 *working capacity*—the load on the anchor system at which significantly increasing displacement begins.

4. Summary of Test Method

4.1 A rock bolt is installed in the same manner and in the same material as its intended construction use. The bolt is pulled hydraulically and the displacement of the bolt head is measured concurrently. The bolt is pulled until the anchor system or rock fails. The ultimate and working capacities of the bolt are calculated from the plot of load versus displacement.

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.

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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.

5. Significance and Use

5.1 Rock bolts are used for support in a variety of mining and civil engineering situations.³ The pull test may be used to provide a quantitative measure of the relative performance of different anchor systems in the same rock type. Anchor systems may be different mechanical anchors or different bond materials or lengths for grouted anchors. Such data can be used to choose an anchor type and determine bolt length, spacing, and size.

5.2 The objective of the method is to measure anchor performance, and not the performance of the rock bolt itself. Thus, to make sure the bolt response during the test is minimal and predictable, high strength, short-length (6 to 8 ft (1.8 to 2.5 m)) bolts have been specified. The bolt should be just long enough to make sure that failure occurs in the anchor system and not from the reaction pad bearing down on the rock mass.

5.3 Ideally, the rock bolt anchor should fail by shear at the anchor-rock interface or bond. Therefore, the local characteristics of the rock, such as roughness and induced fractures, are significant factors in the anchor strength. To obtain realistic strength values, the test holes should be drilled using the same methods as the construction rock bolt holes.

5.4 Rocks with significant time-dependent behavior, such as rock salt or shale, may respond to the anchor system itself and change the anchor strength. In these cases, consideration should be given to testing bolts over a period of time.

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

5.5.1 Anchor pull tests should be conducted in all rock types in which construction bolts will be installed. If the rock is anisotropic, for example, bedded or schistose, the tests should be conducted in various orientations relative to the anisotropy, including those at which the construction bolt may be installed.

5.5.2 In each rock type, at each orientation, and for each anchor system, a sufficient number of tests should be conducted to determine the average bolt capacities within a fixed uncertainty at the 95 % confidence level. The allowable uncertainty band depends on the project and involves such factors as the rock quality, expected project lifetime, and importance of the areas to be bolted. Its determination will require considerable engineering judgment. As a rough guideline, at least 10 to 12 pull tests for a single set of variables have been found necessary to satisfy the statistical requirements.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

³ For additional information see, "Suggested Method for Determining the Strength of a Rock Bolt Anchor (Pull Test)," *Suggested Methods for Rock Bolt Testing*, International Society for Rock Mechanics Commission on Standardization of Laboratory and Field Tests, 1974.

6. Apparatus

6.1 *Loading System*—The system for pulling the rock bolts shall consist of a hollow-center hydraulic ram and mounting/reaction frame. The hydraulic ram shall be of sufficient capacity to fail the anchor and shall have a travel range of at least 2 in. (50 mm). The mounting/reaction frame shall be usable against uneven rock surfaces. The loading system shall apply a force that deviates by no more than 5° from the long axis of the bolt during the test.

6.2 *Load Transducer*—An electronic load cell is recommended to measure the load on the rock bolt. The cell shall have an accuracy of at least ± 200 lbf (± 890 N), including errors introduced by the excitation and readout system, and a resolution of at least 100 lbf (445 N). Other types of load transducers may be used if their performance meets these specifications. Alternatively, a pressure gauge or electronic transducer may be used to measure the pressure applied to the ram, provided the load measurement requirements above are satisfied, including the effects of friction in the hydraulic ram, and the like.

6.3 *Displacement Transducer*—A dial gauge is recommended to measure the displacement of the rock bolt head. It shall have an accuracy of at least ± 0.001 in. (0.025 mm), a resolution of at least 0.0005 in. (0.013 mm), and a range of at least 2 in. (50 mm). It shall be mounted along the axis of the rock bolt within 5°. The end of the rock bolt, or pulling rod if used, shall be smooth with a counter-sink area approximately $\frac{1}{4}$ in. (6 mm) in diameter to accommodate the measuring tip of the dial gauge. Other types of displacement transducers may be used provided they satisfy the requirements of this section.

6.4 *Displacement Transducer Support*—The displacement transducer shall be supported from a point no closer than 3 ft (0.9 m) to the reaction frame, if attached to the same rock face. The support shall be sufficiently rigid such that no deflection or instability occurs during testing.

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

6.6 *Rock Bolt and Accessories*—The rock bolt shall be of sufficient diameter and strength that its elastic range is not exceeded during testing. Standard bearing plates, washers, and the like may be used as required.

6.7 *Drilling Equipment*—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 as much as practical to drill the test holes.