



Standard Test Methods for Laboratory Determination of Rock Anchor Capacities by Pull and Drop Tests¹

This standard is issued under the fixed designation D7401; 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 the quantitative determination of the working and ultimate static or dynamic capacities of full scale rock anchors. Dynamic capacities are determined to simulate rockburst and blasting conditions (1).² The rock anchors are installed in steel pipe to simulate standard boreholes sizes. Rock anchor capacities are determined as a function of resin to steel bolt bond strength and steel bolt yield strength. These tests are not intended to determine rock anchor to borehole rock surface shear strength.

1.2 These test methods are applicable to mechanical, resin, or other similar anchor systems.

1.3 Two methods are provided to determine the capacities of rock anchors, as follows:

1.3.1 *Method A*—Using a horizontal hydraulically loaded pull test system.

1.3.2 *Method B*—Using a vertical dynamically loaded drop test system.

1.4 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

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

1.6 *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.*

¹ These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

2. Referenced Documents

2.1 *ASTM Standards*:³

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

D4435 Test Method for Rock Bolt Anchor Pull Test

D4436 Test Method for Rock Bolt Long-Term Load Retention Test

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions*—Refer to Terminology D653 for specific definitions.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *linescan camera*—a camera with high optical linear resolution that captures two-dimensional images by moving the object perpendicularly to the scan line.

3.2.2 *maximum load*—represents the highest load value recorded during the test.

3.2.3 *rock anchor*—usually constructed of steel, which is inserted into pre-drilled holes in rock and secured with a fixing agent for the purpose of ground control.

3.2.4 *RPM*—acronym for revolutions per minute.

3.2.5 *transverse stiffness*—the ability of the borehole or steel tube wall to deform radially.

3.2.6 *yield load*—corresponds to the onset of plastic deformation.

4. Summary of Test Methods

4.1 A rock anchor is installed in a steel pipe instead of a borehole the same manner and in the same material as its

³ 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.

intended use (2). In the Pull test, the rock anchor is hydraulically pulled horizontally and the displacement of the bolt head is measured concurrently. The bolt is pulled until the anchor system fails (or to the ultimate stroke of the ram). The ultimate and working capacity of the rock anchor is calculated from the plot of load versus displacement. In the Drop test, a known mass is released vertically impacting on a plate at a preset distance that is in turn affixed to the end of a rock anchor. The maximum energy is expressed in kJ.

5. Significance and Use

5.1 For a support system to be fully effective, the support system must be able to contain the movement of rock material due to excavation stress release, slabbing, etc. Data from the load tests are used by engineers to design the appropriate support system to improve safety and stability of underground support systems. Test Methods D4435 and D4436 are used for in-situ load tests.

5.2 The local characteristics of the rock, such as roughness and induced fractures, are significant factors in the anchor strength. The material used to simulate the borehole surface should be sufficiently roughened so that failure occurs in the rock anchor and not at the simulated anchor-rock surface. In the case of steel pipe, internal threading using different spacing and depth is accomplished using a machinist's lathe to simulate roughness.

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/sampling/inspection/etc. Users of this standard 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 these factors.

6. Apparatus

6.1 Components Common to Both Test Methods:

6.1.1 The manufacturer provides the rock anchors, plates, nuts, domes, washers, bottom plate, resins, and steel tubes for the tests. The manufacturer specifies the borehole size, type of resin, penetration rate and rotation rate for the installation of the rock anchor and any other installation information.

6.1.2 Upon receipt, the rock anchor measurements include length, rod diameter, length and diameter of the threaded part, length and diameter of the mixing element and any specific characteristics.

6.1.3 Boreholes are simulated by 12 mm-thick cold rolled steel tubes of the required internal diameter. The steel tube preparation includes a slight roughening of the inside surface over approximately the last meter. This roughened section is referred to as the top of the tube. Two sets of 25.4 mm holes are drilled near the top of the tube. The top set supports the tube in the drop test apparatus and the lower holes allow access to the end of the rock anchor after installation. For each rock anchor, two holes are drilled through the top end of the rock anchor to allow the clevis to be attached during testing.

6.2 Method A—Pull Test System (Static):

6.2.1 A double acting hollow hydraulic ram, with a minimum load capacity of 325 kN and displacement of 150 mm is recommended for this test. Displacement positioning of the ram is accomplished using a hand operated pump. A hand pump is used during the controlled loading. Once the rock anchor or the resin starts to fail, an electric pump (Px) can be used until the specimen fails or the ram reaches its stroke capacity. Fig. 1 displays a typical pull test set-up.

6.2.2 The ram hydraulic pressure is monitored using an electronic pressure transducer. Two 25.4 mm stroke potentiometers with a resolution of 0.6 mm are recommended for displacement measurements. The potentiometers measure the plate and the end displacements during the test. All instruments are connected to a data acquisition system.

6.3 Method B—Drop Test System (Dynamic):

6.3.1 The drop or dynamic test system (Fig. 2) shall accommodate a height of drop of the mass of at least 2.0 m below the coupler pin. The mass capacity of 1 ton, (1T) shall not be less than 325 kN. As the energy input is controlled by the drop height and the mass, the maximum energy available and the maximum impact velocity that each drop can reach are 62 kJoules and 6.5 m/s, respectively.

6.3.2 Instrumentation used to measure the loads and the displacements are measured at the plate and at the end of the rock anchor. Displacements in some systems are measured using linescan cameras. The cameras are sampled at 10 000 lines per second to match the sampling of the analog signals. The lines are amalgamated to form an image of distance versus time. The location of black and white targets attached to the plate nut or to the bolt end, is detected within the image. This system measures loads using arrays of four piezoelectric force sensors, sandwiched between two platen rings.

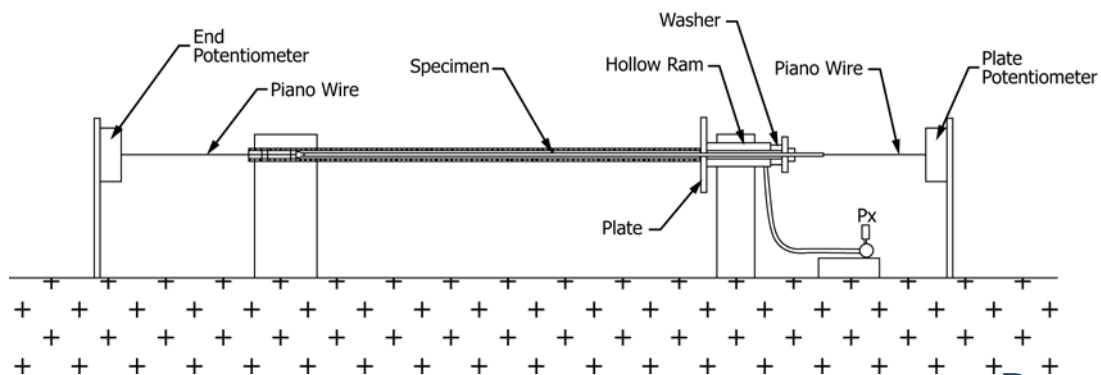


FIG. 1 Schematic of Pull Test System

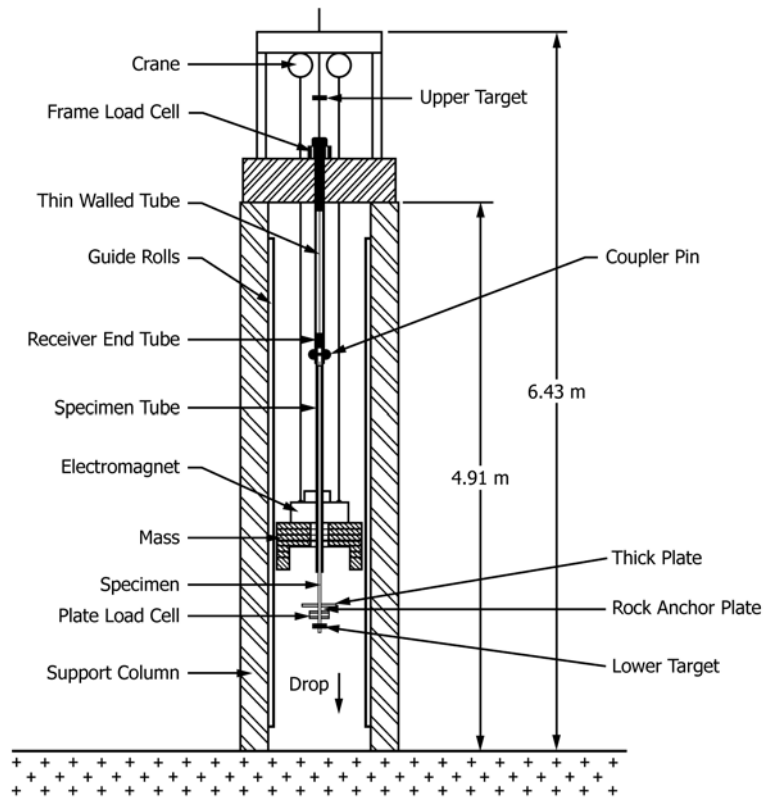


FIG. 2 Schematic of Drop Test System

6.3.3 All instruments are connected to a data acquisition system. The impact duration is typically 60 ms, but data are recorded for about 1.5 s before and up to 5 s after the impact to ensure that all instruments have stabilized.

7. Procedure

7.1 Encapsulated Resin Anchor Bolt Specimen Installation:

7.1.1 Insert into the tube (see Fig. 3), a plug, which extends from the top of the specimen tube to below the second set of 25.4 mm holes. This prevents the end of the rock anchor and the resin from being installed past this point.

7.1.2 Insert additional plugs into the bottom set of holes to prevent resin from escaping during installation.

7.1.3 Place the specimen tube in a jig to align it with the drill.

7.1.4 Prior to installation, slide the rock anchor specimen completely into the tube.

7.1.5 Mark the collar position and orientation of the mixing element on the rock anchor specimen. These lines are used during installation to ensure that the rock anchor is fully inserted and to identify the paddle orientation.

7.1.6 Thread the two nuts completely onto the rock anchor and tighten them in order to seat the drill chuck.

7.1.7 Remove the rock anchor and slide the resin cartridges into the end of the tube.

7.1.8 Insert the rock anchor into the chuck, which is attached to a drill mounted on a sliding rail with an independent advance drive system.

7.1.9 Spin the rock anchor into the tube at a steady advancement and constant RPM rate.

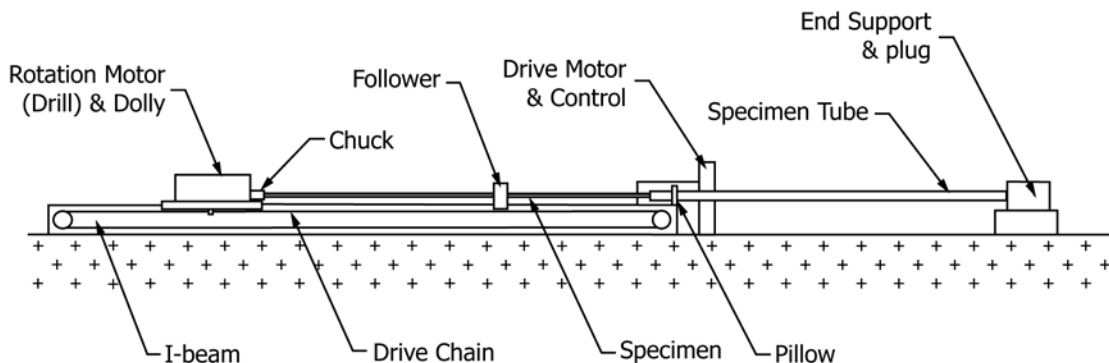


FIG. 3 Schematic of Installation System