RTH 323-80

SUGGESTED METHOD FOR DETERMINING THE STRENGTH OF A ROCK BOLT ANCHOR (PULL TEST)

(International Society for Rock Mechanics)

1. Scope

1.1 This test is intended to measure the short-term strength of a rock bolt anchor installed under field conditions (Note 1). Strength is measured by a pull test in which bolt head displacement is measured as a function of the applied bolt load to give a load-displacement curve. The test is usually employed for selection of bolts and also for control on the quality of materials and installation methods (Note 2).

NOTE 1—It is essential to test anchors under realistic field conditions. It is, however, permissible to select safe and convenient test locations provided that the rock and the installation methods are identical with those encountered in full-scale utilization of the bolts. If the rock is schistose for example, test holes should be drilled at the same angle to the schistosity as anticipated for bolt utilization. If rock conditions are variable, the rock should be classified and tests conducted in rock of each class.

NOTE 2—The test is intended to measure anchor performance and this is possible only if the bolt, threads, nuts, and other components are stronger than the anchor. In some circumstances it may be desirable to reinforce the bolt or thread for purposes of anchor evaluation. Otherwise, if the bolt is consistently weaker than the anchor, it may be preferable to replace the field test with quality control of bolts and other components in a testing laboratory. Laboratory control testing may also be required as a supplement to field testing for evaluation of components, e.g. for their corrosion resistance, quality of materials, and consistency of dimensions.

1.2 At least five tests are required to evaluate an anchor in a given set of rock and installation conditions. The tests are destructive and should not in general be made on bolts that form part of the actual rock support system.

2. Apparatus

2.1 Equipment for installing the test anchors, including:

(a) Equipment for drilling and cleaning the drillhole, conforming to the manufacturers' specifications for optimum performance of the anchor provided that these are compatible with field conditions (Note 3).

NOTE 3--Manufacturers' specifications for hole dimensions and method of installation should be checked for compatibility with site operational limitations before testing and if compatible should be closely followed in the tests.

(b) Equipment for inspection and measurement of the drillhole, anchors, and bolts, e.g., a lamp, steel tape, internal and external calipers, and equipment for measuring the quantity of grout if used.

(c) Standard rock bolt assemblies as supplied by manufacturers of the bolts including anchors to be tested, grout and materials for grout injection if required, and equipment for installing the bolts in the manner recommended by the manufacturers (Note 3).

2.2 Equipment for applying the bolt load, e.g. as in Fig. 1, including:

(a) A hydraulic jack with hand pump and pressure hose capable of applying a load greater than the strength of both the anchor and the bolt to be tested and with travel of at least 50 mm.

(b) Equipment for transferring the load from the jack to the bolt (Note 4). A spherical seating, bevelled washers, and/or wedges under the jack are required to ensure that the applied load is coaxial with the bolt.

NOTE 4--Some types of anchors must essentially be tensioned during their installation, and these must be tested using a suitable coupling unit and bridging framework to carry load from the jack to the bolt (Fig. 1a). Whenever possible, however, anchors should be tested without pretensioning of the bolt, in which case a center-hole jack installed over the bolt may be used (Fig. 1b). The arrangement shown in Fig. 1a may also be used to test selected anchors in an operational support system at some time after their installation, provided this does not endanger the support as a whole. The percentage of initially applied bolt tension remaining at the time of test may be estimated from the load required to just loosen the faceplate and washers.

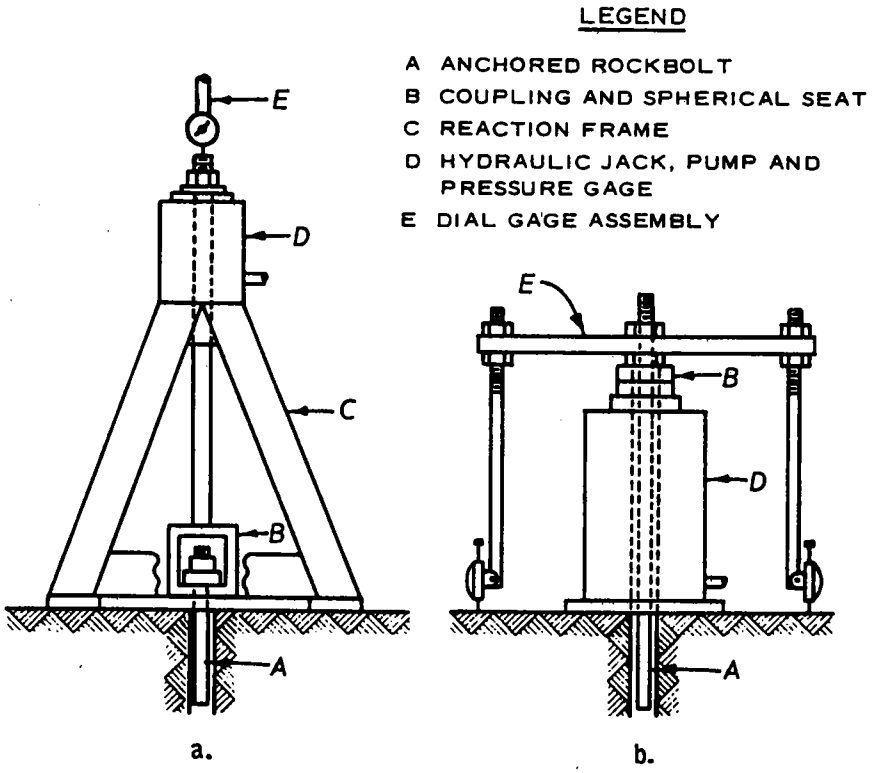

Fig. 1. Rock bolt testing equipment.

2.3 Equipment for measuring load and displacement, including:

(a) A load measuring device, e.g., a load cell or a hydraulic pressure gage connected to the pump and calibrated in load units. Measurement should be accurate to 2 percent of the maximum load reached in the test. The device should include a maximum load indicator.

(b) Equipment for measuring the axial displacement of the bolt head (travel at least 50 mm and accurate to 0.05 mm (Note 5)). For example, a single dial gage measuring directly onto the bolt head may be used; alternatively, the displacement may be obtained as an average from two or three gages spaced equidistant from the bolt as shown in Fig. 1b.

NOTE 5--When testing anchors that in operation are intended to provide a reaction for external loads (e.g. holding anchors for cranes, suspension cables), the test equipment should be designed so that no test reaction forces are applied closer than one bolt length from the anchor drillhole.

3. Procedure

3.1 Site Preparation:

(a) The test site or sites are selected to ensure that rock conditions are representative of those in which the bolts are to operate (see Note 1).

(b) Holes are drilled as specified and at locations convenient for testing (Notes 1 and 3). The rock face surrounding each hole should be firm and flat and the hole should be perpendicular to the face (±5 deg).

(c) Drillholes and anchor materials are inspected before installation to ensure that they conform to specifications. Preliminary data, e.g., the measured dimensions of the drillhole, bolt, and anchor and the type and condition of rock at the test location, are recorded on a data sheet (e.g. Fig. 2).

(d) Bolts are installed in the specified manner (Note 3), recording essential details such as the installation torque (if any) (Note 4) and the date and time of installation.

ROCK ANCHOR TEST RESULT SHEET TEST No.

Date of installation: _____ Date of test _____

PROJECT: _____ Location: _____

ANCHOR: Type _____ Length: _____ installation Torque: _____

ROCK: Classification _____ Fracture spacing: _____ Strength _____

BOLT: Diameter: _____ Strength: _____ Length: _____ Untensioned length: _____

HOLE: Diameter: _____ Length: _____ Orientation & roughness: _____

Pump Pressure	Bolt tension	Displacement readings					REMARKS
		Reading	Displacement	Reading	Displacement	Average	

TEST RESULTS: Maximum pull force: _____

Displacement at maximum pull force: _____ Max. displacement in test: _____

Nature of failure or yield: _____

Other remarks: _____

TESTED BY: _____ CHECKED BY: _____

Fig. 2. Rock bolt test data sheet.

3.2 Testing:

(a) The loading equipment is assembled, taking care to ensure that the direction of pull is axial to the bolt, that the equipment sits firmly on the rock, and that no part of the bolt or grout column will interfere with the application or measurement of load during the test (Note 5).

(b) An initial arbitrary load not greater than 5 kN (500 kgf) is applied to take up slack in the equipment. The displacement equipment is assembled and checked (Note 6).

NOTE 6--The displacement measuring system should be securely mounted and dial gages should be located on firm flat rock; glass or metal plates can, if necessary, be cemented to the rock to provide smooth measuring surfaces perpendicular to the bolt. All measuring equipment must be checked and calibrated at regular intervals to ensure that the standards of accuracy required by this "suggested method" are maintained.

(c) The anchor is tested by increasing the load until a total displacement greater than 40 mm has been recorded, or until the bolt yields or fractures if this occurs first.

(d) Readings of load and displacement are taken at increments of approximately 5-kN (500-kgf) load or 5-mm displacement, whichever occurs first. The rate of load application should be in the range 5-10 kN/min. Readings are taken only after both load and displacement have stabilized. The times required for stabilization should be recorded.

4. Calculations

4.1 Total displacement values are computed as the test progresses by subtracting initial readings from the incremental readings, taking averages if more than one gage is used.

4.2 The test data are plotted graphically as shown in Fig. 3. Anchor strength, defined as the maximum load reached in the test provided that the bolt itself does not yield or fail, is recorded on this graph. If the bolt yields or fails, the load 'X' at which this occurs is recorded, and the anchor strength is specified as "unknown but greater than 'X'".

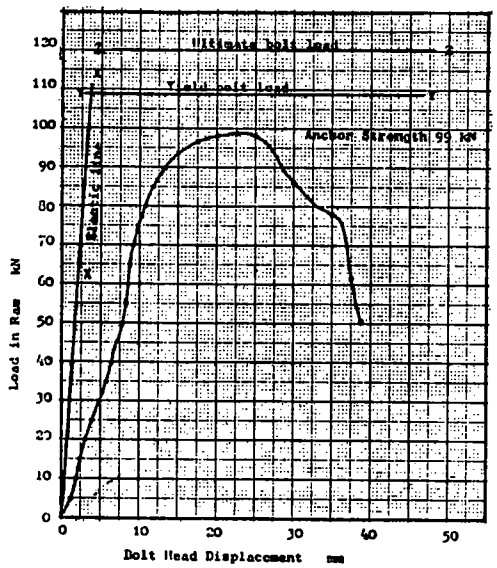

Fig. 3. Example of anchor test results graph.

4.3 The elastic elongation of the bolt at a given applied load may be calculated as

$$\text{Elongation at load P is equal to } \frac{P \cdot L}{A \cdot E}$$

where L is the tensioned ungrouted length of bolt + 1/3 the grouted length + length of extension bar used; A is the cross-sectional area of the bolt; and E is the modulus of elasticity of the bolt steel.

A straight line X-X is constructed to pass through this point and the origin of the load-displacement graph (Fig. 3). Straight lines Y-Y and Z-Z are constructed at the specified yield and ultimate loads of the bolt. Comparison of the actual test curve with these three lines allows independent assessment of anchor and bolt behavior.

4.4 For the evaluation of grouted anchors, the results of several tests should be abstracted and presented graphically to show the influence of grout cure time and bonded length on anchor strength (e.g. Fig. 4).

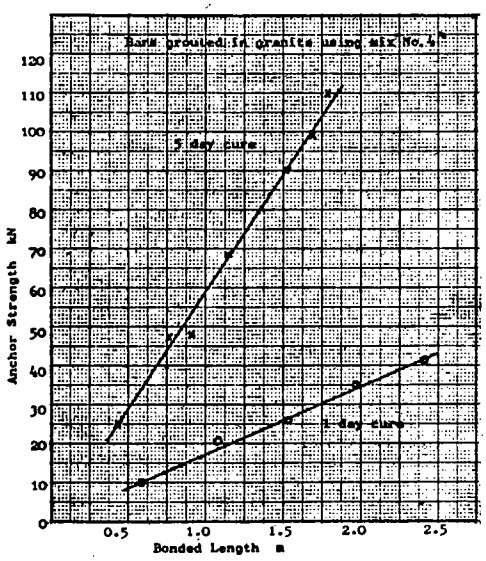

Fig. 4. Graph showing influence of bond length and cure time on the strength of anchors.

5. Reporting of Results

5.1 The report should include the data sheets and graphs illustrated in Figs. 2-4 together with full details of:

(a) Rock in which the anchors were tested.

(b) The anchors and associated equipment.

(c) The drillholes, including length, diameter, method of drilling, straightness, cleanness and dryness, and orientation.

(d) The method and time of installation.

(e) The method and time of testing.

(f) The nature of failure and other observations pertinent to the test results.

5.2 If required, the report may also compare performance of the anchors tested with an arbitrary acceptable performance established by previous extensive testing. Anchor strength, total displacements, and displacement per increment of load should be considered when making this comparison.