Determining Rock Bolt or Anchor Tension Using a Torque Wrench

This procedure is under the jurisdiction of the Materials Engineering and Research Laboratory, code 86-68180, Technical Service Center, Denver, Colorado. The procedure is issued under the fixed designation USBR 6584. The number immediately following the designation indicates the first year of acceptance or the year of last revision.

1. Scope

1.1 *Explanation.*-This designation establishes the guidelines, requirements, and procedure for determining rock bolt or anchor tension using a torque wrench. This procedure is described in the context of obtaining data for designing, constructing, or maintaining Reclamation structures.

1.2 *Objective.*-The objective of this test is to verify that a rock bolt or an anchor has a certain specified tension during or after its installation.

1.3 *Use.*-This method may be used to determine loss of tension or to verify if a previously installed rock bolt or its anchor has a strength that is equal to or greater than a designated value.

1.4 *Application.*-This method is applicable to mechanically anchored rock bolts, to cement, resin, epoxy, and polyester grouted anchor rock bolts, and to other types of anchored rock bolts.

1.5 *Units.*-The values stated in SI/metric units are to be regarded as standard.

1.6 *Caveats.*-This designation does not purport to address all the safety issues associated with its use and may involve hazardous materials, equipment, and operation. The user has the responsibility to establish and adopt appropriate safety and health practices. Also, the user must comply with prevalent regulatory codes while using this procedure.

1.7 *Sources.*-This designation reflects the information available from International Society of Rock Mechanics and Reclamation (see section 2).

2. Applicable Documents

2.1 *USBR Procedures:*

<u>USBR 1000 Standards for Linear Measurement Devices</u>

<u>USBR 1040 Calibrating Pressure Gauges</u>

USBR 1045 Calibrating Force Transducers (Load Cells)

USBR 1050 Calibrating Pressure Transducers

USBR 1430 Calibrating the Loading Device for Permeability Tests

USBR 3000 Using Significant Digits in Calculating and Reporting Laboratory Data

USBR 3910 Standard Terms and Symbols Relating to Rock Mechanics

USBR 9300 Checking, Rounding, and Reporting of Laboratory Data

2.2 *ISRM Documents*:

Suggested Methods for Rock Bolt Testing, "Part 2, Suggested Method of Determining Rock Bolt Tension Using a Torque Wrench," *Rock Characterization Testing and Monitoring, ISRM Suggested Methods*, Brown, E.T. (ed.), Pergamon Press, 1981, pp. 166-167.

3. Summary of Method

Apply enough torque (either a specified or a maximum value) with a torque wrench to cause the face nut on the rock bolt to rotate. Using the tension-to-torque ratio of the calibrated torque wrench, determine the tension in the rock bolt.

4. Significance and Use

4.1 *Performance*.-Rock bolts are used for support in a variety of engineering applications. This test provides a quantitative measure of the performance of a rock bolt or its anchor.

4.2 *Tension*.-At least 5 percent of the installed rock bolts or their anchors should be tested to verify if the rock bolts or their anchors have the specified tension.

5. Description of Terms Specific to This Designation

5.1 *Failure Torque*.-The torque at which the face nut of an anchored rock bolt starts rotating.

5.2 *Ultimate Capacity*.-The maximum torque which a rock bolt or its anchor can sustain without causing face nut rotation.

5.3 *Other Terms*.-See USBR 3910.

6. Apparatus

6.1 *Torque Wrench*.-A torque wrench of sufficient capacity, preferably with a maximum applied torque indicator. The readings must be repeatable throughout the range of torques to be measured. Appropriate sockets should be provided with the torque wrench for the nuts or bolt heads to be tested.

Note 1.-Torque wrenches may be manual or pneumatic. They come in capacities that range from 340 to 6120 N·m (250 to 4500 ft·lbf), with a resolution range of 15 to 40 N·m (10 to 25 ft·lbf). Torque wrench selection is based on the rock bolt diameter and its required tension.

6.2 *Special Equipment for Calibrating the Torque Wrench*.- This equipment includes a rigidly fixed bolt head, a weight pan and weights, and a measuring tape (figure 1).

6.3 *Special Equipment for Determining the Relationship Between Tension and Torque*.- Typically, this equipment is comprised of an installed rock bolt and a faceplate assembly identical with that to be used in practice, a hydraulic ram with a hollow piston (or a load cell), a hand pump, or a hollow load cell and a pressure gage (figure 2).

7. Auxiliary Items

- Hand tools
- Engineering scale
- Internal and external calipers
- Hand calculator
- Graph paper
- Flashlight
- Steel tape

8. Calibration and Standardization

8.1 *All Equipment.*-Use only calibrated equipment for conducting the test.

8.2 *Measurements.*-Engineering scales, steel tapes, and calipers should meet the standards of USBR 1000.

8.3 *Pressure Gages.*-Calibrate pressure gages using USBR 1040.

8.4 *Load Cell.*-Calibrate the load cell according to USBR 1045.

8.5 *Pressure Transducers.*- Calibrate pressure transducers using USBR 1050.

8.6 *Hydraulic Ram.*-Calibrate hydraulic ram using USBR 1430.

8.7 *Torque Wrench Calibration*.- With the torque wrench horizontal, position the torque wrench socket on a rigid bolt head (figure 1).

Determine and record the weight of the pan to the nearest 0.1 N (0.01 lbf).

Determine and record the distance L between the location of the pan and the center of the rigid bolt to the nearest 0.01 mm (0.01 in).

Suspend the pan from the center of the torque wrench handle.

Add known weights on the pan and calculate and record the total suspended weight, W_t, including the weight of the pan.

Determine and record the torque wrench reading.

Calculate the correct torque by multiplying W_t with L.

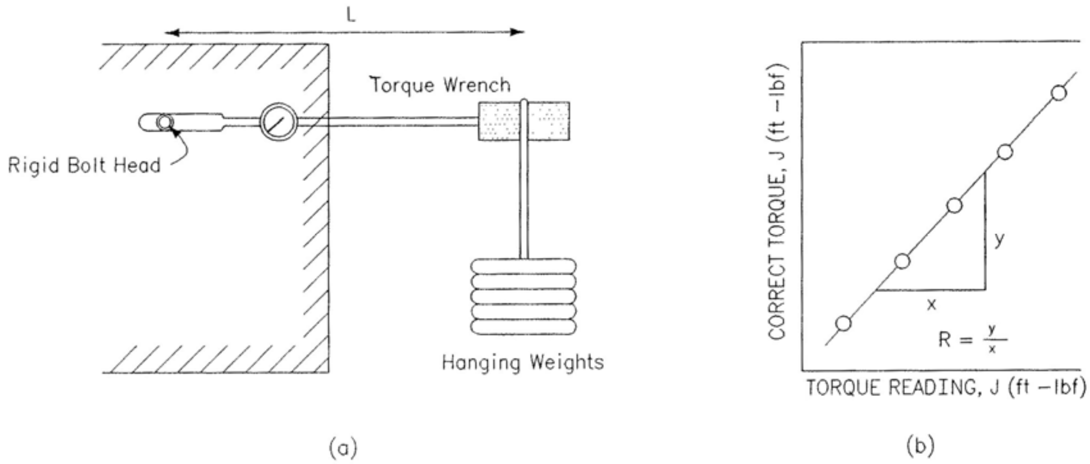

Figure 1.- Equipment for calibration of torque wrench.

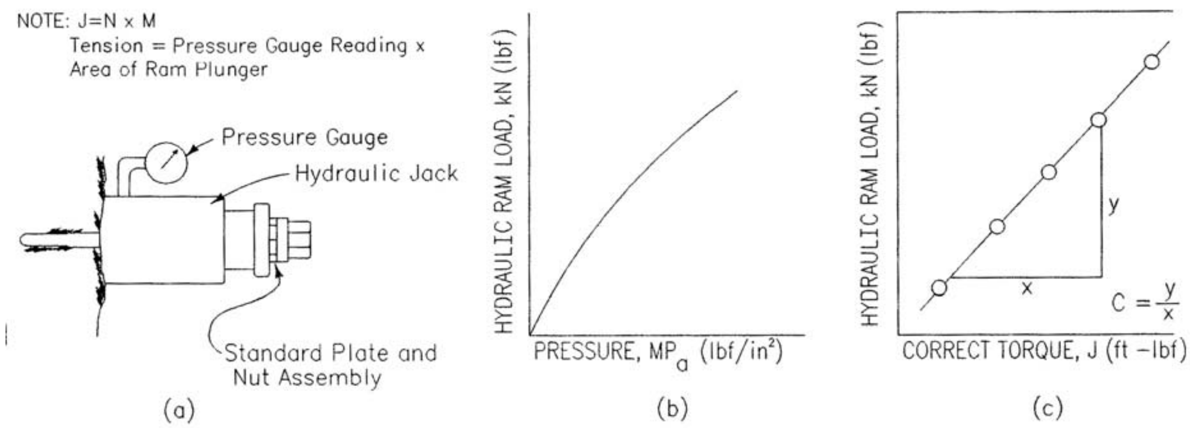

Figure 2.- Equipment for determining the relationship between tension and torque.

Plot the point corresponding to the correct torque and the torque wrench reading (figure 1b). Repeat the procedure with increasing weights to obtain at least five correct torque and five torque wrench readings, and fit a straight line through the plotted points. The gradient of this line, *R*, gives the ratio of the corrected torque to the indicated torque reading.

8.8 *Determination of C*.- Where C is the ratio of tension to correct torque.

8.8.1 With the piston of the hollow hydraulic ram extended to three-quarter travel (a hollow load cell can be substituted for the hollow hydraulic ram), position the ram concentrically and coaxially over the head of the rock bolt. Place the standard face plate on the rock bolt and thread the nut to the rock bolt. Tighten the nut to take up the slack in the ram-plate-nut assembly. Close the pump valve and increase the ram pressure slightly to seat the entire assembly.

8.8.2 Calculate the maximum designated load (area of the rock bolt times fifty percent of the ultimate tensile stress of the bolt) to be carried by the rock bolt.

8.8.3 Using the torque wrench, apply torque in at least five increments to the maximum designated load. Determine and record the corresponding torque wrench readings. Using the calibration curve of the hydraulic ram, determine and record the load (usually the hydraulic ram load equals hydraulic ram pressure gage reading times the area of the hydraulic piston) corresponding to hydraulic ram pressure gage readings.

8.8.4 Plot a graph, (figure 2c), of hydraulic ram load (i.e., tension in the rock bolt versus correct torque) and fit a straight line to the plotted points. Calculate the slope of this line as the ratio of tension in the rock bolt to correct torque, *C*.

8.8.5 Determine the ratio, *C*, separately for each change in bolt diameter, thread pitch, and any variations in the bolt/anchor/faceplate assembly.

9. Pretest Considerations

9.1 *Site Selection.*-Select a test site or sites to ensure that the rock mass conditions are very close to those in which rock bolts are to operate.

9.2 *Rock Face.*-The rock face surrounding the test locations should be flat and firm.

9.3 *Drill Sites.*-The drill holes for the rock bolt anchor should be perpendicular to the rock face within a tolerance of ±5 degrees.

9.4 *Specifications.*-For new installations, inspect the rock bolt, anchor, and the accessories to ensure that they conform to specifications.

10. Conditioning

10.1 *Rock Bolt Installation.*-Before conducting the test, ensure that the rock bolt is properly installed.

10.2 *Grout Readiness.*-Ensure that epoxy or cement grout that has been used during the installation of rock bolt is sufficiently hardened before performing the test.

11. Precautions

11.1 *Torque Wrench Use.*-Do not use the torque wrench for any purpose other than testing tension in the rock bolts or its anchors.

11.2 *Torque Wrench Storage.*-Always store the torque wrench in a dry place after each use.

11.3 *Rock Mass Failure.*-If the rock mass fails during testing, discard the test.

11.4 *Real World Validation.*-The rock bolt diameter, thread pitch, faceplate, and washers should be identical to those expected in actual rock bolt installation.

11.5 *Torque Application.*-Ensure that the torque application is smooth and that the force causing the torque is applied through the center of the torque wrench handle.

12. Procedure

12.1 *Test.*-Determine the tension in a rock bolt or its anchor.

12.1.1 Fit the socket of the torque wrench to the rock bolt head or nut to be tested.

12.1.2 Apply a preset torque to the rock bolt or its anchor, increasing the torque in small increments until just sufficient to cause the face nut to rotate. Record the torque wrench reading, the date of test, and the rock bolt identifications.

12.1.3 If a torque wrench with a maximum applied torque indicator is used, the torque may be applied steadily rather than in increments as stated in section 12.1.2. Apply the torque until the face nut starts to rotate. Record the maximum torque applied, the date of test, and the rock bolt identifications.

12.1.4 Calculate and record the rock bolt tension or its anchor tension (see section 13).

12.2 *Record.*- Record the test data as shown on table 1, and perform calculations.

12.3 *Clean.*-Clean the test site.

13. Calculations

13.1 *Torque.*-Calculate R, the ratio of correct torque to torque wrench reading (see section 8.7).

13.2 *Tension.*-Calculate C, the ratio of tension in the rock bolt to correct torque (see section 8.8).

13.3 *Anchor*.-Calculate the tension in the rock bolt or its anchor, P, as follows:

$$P = R \times C \times T$$

where:

R =ratio of correct torque to torque wrench reading

C =ratio of tension in rock bolt to correct torque, kN/N·m (lbf/ft·lbf)

T =reading on torque wrench, N·m (ft·lbf)

P =tension in the rock bolt or its anchor, whichever was being tested, kN (lbf)

14. Report

14.1 *Results.*-Report the results using USBR 3000 and USBR 9300.

14.2 *Main Report.*-The report shall include:

14.2.1 General description of the project, test location, and types of rock bolts or anchors tested.

14.2.2 The model number of the torque wrench and its date of calibration.

14.2.3 The torque wrench calibration graph and the value of coefficient *R*.

14.2.4 The graph to determine *C*, the ratio of tension to applied torque (see section 12.1), and its value.

14.2.5 The equation used to calculate the tension in the tested rock bolts or anchor.

14.2.6 The data sheet (see table 1).

15. Precision and Bias

The precision and bias for this designation have not been determined. Any variation observed in these data is just as likely to be caused by test site variations as to operator or testing variations. Because of the variability of rock, this test procedure has no reference value.

Table 1. B Data sheet - tension test for a rock bolt or its anchor using a torque wrench.

1.General

Project ________________
Feature ________________
Test Location ________________
Date ________________
Tested by ________________
Test No. ________________
Rock Type ________________

Test Hole:
Orientation ____________
Depth ____________
Average Diameter ____________

Anchor:
Type _____________
Length_____________

Rock bolt:
Type _____________
Depth _____________
Diameter _____________
Torque _____________

2.Calibration

Torque Wrench	ID No. or Serial No.	Date of Calibration
__________	______	_______

___

3.Calculations for coefficient *R* (see section 8.7)

	Total Weight, W_t kN (lbf)	L ft (m)	Correct Torque W_t x L, N·m (ft·lbf)	Torque Wrench Reading N·m (ft·lbf)
1.				
2.				
3.				
4.				
5.				

R (see section 8.7) = _______________

____

4. Calculations for coefficient *C* (see section 8.8)

Hydraulic Ram Data Tension Rockbolt
Torque
(A) Piston Area (B) Pressure Gage Reading Product (A) x (B)
wrench
$mm^2 (in^2)$ kPa (lbf/in^2) kN (lbf)
reading
N·m (lbf·ft)

1.
2.
3.
4.
5.

C (see section 8.8) = ________________________

5. Test Data

Date	Time	Anchor or rock bolt ID No.	Torque Wrench Reading (*T*)	Calculated Tension *P = R.C.T.*

6. Remarks

7. Signoff

Test Person ______________ Date ______
Test Supervisor ______________ Date ______
Quality Assurance ______________ Date ______
Responsible Engineer ______________ Date ______