METHODS OF SAMPLING AND TESTING
MT 407-20
METHOD OF TEST FOR HIGH-STRENGTH BOLTS

1 Scope

1.1 The method covers rotational capacity testing of high strength bolts used in bridge construction. Two procedures are described in the document:

1.1.1 Procedure A – Long Bolts in Tension Calibrator

1.1.2 Procedure B – Bolts Too Short for Tension Calibrator

2 Reference Documents

ASTM

F3125 High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

STEEL STRUCTURES TECHNOLOGY CENTER, INC. (AASHTO/FHWA)

Structural Bolting Handbook

3 Terminology

Test – Three (3) bolt assemblies per grade, diameter, length, and lot

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PROCEDURE A – LONG BOLTS IN TENSION CALIBRATOR

4 Apparatus

4.1 *A Skidmore-Wilhelm calibrator* for measuring bolt tension, of sufficient capacity for the bolts to be tested

4.2 *Calibrated torque wrench*

4.3 *Spacers and/or washers* with a maximum hole size $^{1}/_{16}$ in. (2mm) larger than the bolt to be tested

4.4 *A steel section* on which to mount the bolt calibrator. The flange of a girder or a cross-frame accessible from the ground is acceptable

5 Procedure

5.1 Use black fasteners oily to the touch at testing. Ensure all galvanized nuts have a visible dye to verify the presence of the lubricant.

Note 1 – Weathered and rusty bolts should not be used.

5.2 Measure the bolt length, not including the head.

5.3 Install the bolt assembly into the tension measuring device by threading a nut onto the bolt with sufficient spacers to bring the bolt end to at least flush with the tightened nut to a maximum bolt stick-out of three threads. Provide 3 to 5 threads between the inside faces of the nut and the bolt head. Always use a hardened washer under the nut.

5.4 Tighten the nut with a wrench to produce the appropriate snug tension from Table 1, with an allowable error range from 0 kips to +2 kips (0 to + 9 kN). The snug condition should be the normal effort applied with a 12-inch wrench.

Table 1. Maximum Snug Tension

Bolt Dia. (in.)	Maximum Snug Tension (kips)	
	A325 Bolts	A490 Bolts
½	1	1
⅝	2	2
¾	3	4
⅞	4	5
1	5	6
1⅛	6	8
1¼	8	10
1⅜	10	12
1½	12	15

Source: ASTM F3125

5.5 Matchmark the bolt, nut and face plate of the calibrator with a straight line.

5.6 Using the torque wrench, tighten the nut to at least the pretension indicated in Table 2.

Table 2. Minimum Test Pretension

Bolt Dia. (in.)	Minimum Test Pretension (kips)	
	A325 Bolts	A490 Bolts
½	12	15
⅝	19	24
¾	28	35
⅞	39	49
1	51	64
1⅛	64	80
1¼	81	102
1⅜	97	121
1½	118	148

Source: ASTM F3125

Record the bolt tension and the torque that produced the tension. (Measure the torque with the nut in motion).

Calculate the value for maximum allowable torque:

T = 0.25 PD

where:
T = Maximum permitted torque(ft-lbs)
P = tension in lbs. (N)
D = diameter of bolt in feet (m).

If the recorded torque exceeds the value, T, as calculated above, then the fastener assembly fails the test.

5.7 Tighten the nut further by the number of turns shown in Table 3, using the mark on the calibrator faceplate made in Section 5.5 for reference. Record the bolt tension. If bolt and nut assemblies strip or fracture before achieving the full rotation, they have failed the test.

Table 3. Rotational Turns

Bolt Length (L) relative to Bolt Diameter (D)	L ≤ 4D	4D ≤ L ≤ 8D	8D ≤ L
Required Rotation (turns)	⅔	1	$1^{1}/_{6}$

Source: Structural Bolting Handbook

5.8 Compare the bolt tension recorded from Section 5.7 with the minimum test tension provided in Table 4. If fastener assemblies do not provide the minimum required tension in Table 4 at the rotation shown in Table 3, the assemblies have failed the test.

Table 4 Minimum Test Tension

Bolt Dia. (in.)	Minimum Test Tension (kips)	
	A325 Bolts	A490 Bolts
½	14	17
⅝	22	28
¾	32	40
⅞	45	56
1	59	74
1⅛	74	92
1¼	94	117
1⅜	112	139
1½	136	170

Source: ASTM F3125

5.9 Remove the nut and bolt from the calibrator and examine them. If the fastener assembly threads show signs of stripping, shear or torsion failure or the nut fails to turn freely, by hand, on those threads occupied by the nut in the test position, then the assembly has failed the test.

Note 2 – The nut does not have to freely turn the entire length of the thread to pass this test.

5.10 Repeat Sections 5.1 to 5.9 until a minimum of two tests have been performed.

PROCEDURE B – BOLTS TOO SHORT FOR TENSION CALIBRATOR

6 Apparatus

6.1 Calibrated torque wrench and hand wrenches.

6.2 Spacers and/or washers with a maximum hole size $^{1}/_{16}$ in. (2mm) larger than the bolt.

6.3 A steel section with holes sized $^{1}/_{16}$ in. (2mm) larger than the bolt diameter, with a plate thickness that will accommodate section 7.3.

7 Procedure

7.1 Use black fasteners oily to the touch at testing. Ensure all galvanized nuts have a visible dye to verify the presence of the lubricant.

Note 3 – Weathered and rusty bolts should not be used.

7.2 Measure the bolt length, not including the head.

7.3 Install the fastener assembly in the steel plate with sufficient spacers to bring the bolt end out at least flush with the tightened nut, to a maximum bolt stick-out of three threads. Provide three to five threads in the length of bolt between the inside faces of the nut and bolt head. Always use a hardened washer under the nut.

7.4 Snug the bolt by applying no more than 20% of the torque allowed in Table 6 below, using a torque wrench. Measure and record the torque (with the nut in motion) on the bolt.

7.5 Matchmark the nut, bolt and plate with a straight line.

7.6 Tighten the nut with the torque wrench by the number of turns from Table 5. Use a hand wrench to ensure that the bolt does not turn. Measure and record the torque with the nut in motion.

Table 5. Rotational Turns

Bolt Length (L) relative to Bolt Diameter (D)	L ≤ 4D	4D ≤ L ≤ 8D	8D ≤ L
Required Rotation (turns)	⅓	½	2/3

Source: Structural Bolting Handbook

If the measured torque from Section 7.6 exceeds the corresponding value from Table 6, the fastener assembly has failed the test. Assemblies that fail prior to completing this rotation, by stripping or fracture, fail the test.

Table 6. Maximum Torque at First Rotation

	Maximum Torque at First Rotation (ft-lbs)	
Bolt Dia. (in.)	A325 Bolts	A490 Bolts
½	150	180
⅝	290	370
¾	500	630
⅞	820	1020
1	1230	1540
1⅛	1730	2160
1¼	2450	3050
1⅜	3210	3980
1½	4250	5310

Source: ASTM F3125

7.7 Further tighten the bolt by turning the nut until the rotation reaches the total rotation listed in Table 7 below, based off the initial reference mark from Section 7.5. Assemblies that fail prior to completing this rotation, by stripping or fracture, fail the test.

Table 7. Total Rotational Turns

Bolt Length (L) relative to Bolt Diameter (D)	L ≤ 4D	4D ≤ L ≤ 8D	8D ≤ L
Required Rotation (turns)	2/3	1	1-1/6

Source: Structural Bolting Handbook

7.8 Remove the nut and the bolt from the plate and examine them. If the fastener assembly threads show signs of stripping, shear or torsion failure or the nut fails to turn freely by hand, on those threads occupied by the nut in the test position, the assembly has failed the test.

Note 4 – The nut does not have to freely turn the entire length of the thread to pass this test.

7.9 Repeat Sections 7.1 to 7.8 until a minimum of two tests have been performed.

8 Report

8.1 Date tested

8.2 Name of tester

8.3 Procedure performed (A or B)

8.4 Assembly and component lot numbers

8.5 Testing equipment serial numbers

8.6 Testing equipment calibration dates

8.7 Bolt length

8.8 Bolt tension

8.9 Bolt torque at tension