Recommendations for the Qualification of Structural Bolting Inspectors

AASHTO/NSBA Steel Bridge Collaboration
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It is intended that Owners adopt and implement Collaboration standards in their entirety to facilitate the achievement of standardization. It is understood, however, that local statutes or preferences may prevent full adoption of the document. In such cases Owners should adopt these documents with the exceptions they feel are necessary.

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Recommendations for the Qualification of Structural Bolting Inspectors

Introduction

These guidelines have been developed by the AASHTO/NSBA Steel Bridge Collaboration to define essential factors involved in structural bolting and the qualification of personnel inspecting and monitoring those operations.

This document should be a guide in developing individual training and qualification programs. The recommended elements listed in the Body of Knowledge in Section 5 should be modified to meet specific needs.
Recommendations for the Qualification of Structural Bolting Inspectors

Section 1
References

The following industry standards and specifications should be used in the development of a compliant qualification and certification program:

- AASHTO/NSBA Steel Bridge Collaboration S2.1, *Steel Bridge Fabrication Guide Specification*
- AISC *Manual of Steel Construction*
- Research Council on Structural Connection (RCSC) *Specification for Structural Joints – Using ASTM A 325 or A 490 Bolts*
- FHWA-SA-91-031, *High-Strength Bolts for Bridges*
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Section 2
Functions

2.1 Capabilities
A qualified Structural Bolting Inspector should be able to perform bolting inspections, supervise one or more inspectors, prepare inspection procedures, conduct audits of field bolting conditions and methods, and ensure that bolting operations conform to project requirements and applicable standards.

The Inspector should be able to identify deficiencies in structural bolting, verify rotational capacity testing and observe pre-installation testing.

2.2 Duties
Although the Inspector’s duties are defined by each organization, a Structural Bolting Inspector should be able perform at least the following duties:

2.2.1 Interpret drawings and other documents.
2.2.2 Interpret and accept rotational capacity (ROCAP) test reports, material test reports (MTRs) and manufacturers’ certificates of compliance.
2.2.3 Verify fastener assemblies for correct components, including bolt head markings and manufacturer and supplier marks, nut markings and structural washer markings, supported by proper documentation.
2.2.4 Verify proper storage conditions.
2.2.5 Verify proper lubrication and surface condition of structural bolts, nuts and washers.
2.2.6 Identify the requirements for washers and ensure adherence.
2.2.7 Verify snug-tight conditions prior to final pretensioning.
2.2.8 Witness performance of pre-installation verification and verify reference marks on components and material before final pretensioning.
2.2.9 Verify the suitability and calibration of equipment used to perform structural bolting activities.
2.2.10 Verify that the knowledge of personnel supervising or performing bolting applications is adequate.
2.2.11 Determine whether bolts may be reused (i.e. loosened and retightened).
2.2.12 Determine and verify required minimum fastener pretension.
2.2.13 Prepare clear, concise reports and verify that pertinent records are maintained.
Section 3
Training / Experience Requirements

3.1 Recommendations
The Structural Bolting Inspector should:
3.1.1 be a high school graduate, or hold a state approved high school equivalency diploma.
3.1.2 possess at least one year experience in structural steel bridge fabrication, erection and/or inspection and be directly involved with structural bolting operations.

3.2 Structured Training
Training and qualification required by this document may be considered satisfied if the candidate Inspector provides documentation for successfully completing a minimum of 8 hours of training offered by an organization or individual recognized by the Owner. Such documentation should include evidence of satisfying the requirements listed in Section 5.

3.3 Experience Credit
Structural Bolting Inspectors not meeting the above experience guidelines should work under the supervision of a qualified Structural Bolting Inspector until such time as the appropriate experience and training is gained.
4.1 Requirement

The requirements for qualifying a Structural Bolting Inspector under this Standard are as follows:

4.1.1 The Inspector should pass a written test of no less than 50 multiple choice and/or True/False questions with a minimum of 70% correct, proving a general understanding of the Body of Knowledge specified in Section 5 of this document.

4.1.2 The Inspector should demonstrate hands-on proficiency by completing or directing the completion of rotational capacity testing and pre-installation verification testing using a tension calibration device (e.g. Skidmore-Wilhelm) in the presence of an individual qualified in accordance with this standard.

4.1.3 The Inspector should remain qualified under this Standard provided he/she documents ongoing employment involving structural bolting operations, and performing inspection duties at least once every six months.

4.2 Documentation

The employer of the Inspector should maintain training records (including dates and curricula), completed examinations, evidence of initial demonstrated proficiency, qualification certificates issued, and documentation of inspections performed (dates, testing, types of assemblies).

Qualification certificates should contain the following information:

4.2.1 name of the Inspector

4.2.2 statement indicating satisfactory completion of training

4.2.3 statement indicating that the Inspector’s qualification is in accordance with this document or an acceptable industry standard

4.2.4 signature of party responsible for maintaining qualification

4.2.5 date of qualification
Section 5
Body of Knowledge

5.1 Bolted Connection Overview
This section delineates code requirements and proper methods for using bolted joints that the Inspector should understand and enforce. The Inspector should also understand the installation and inspection requirements for various types of high strength bolted joints.

5.1.1 Joint Types
The types of bolted joints commonly used in bridge and highway construction.

5.1.1.1 Slip-Critical
The definition, load transfer method, surface and bolt requirements, typical usage, installation and inspection of slip-critical joints.

5.1.1.2 Snug-Tightened
The definition, installation requirements and inspection of snug tightened joints.

5.1.1.3 Pretensioned
The definition, installation requirements and inspection of pre-tensioned joints.

5.1.2 Load Transfer
The difference between various load transfer mechanisms for high-strength bolted joints.

5.1.2.1 Shear/Bearing
Bolts subjected to direct shear at bearing connections in bolted splices.

5.1.2.2 Direct Tension
Effects of direct tension on connections for hangers, prying action, etc.

5.1.2.3 Friction
The types of surface conditions required to obtain proper slip coefficients.

5.1.3 Bolt Holes and Slots
The acceptance/rejection quality standards for standard bolt holes, oversized holes and short and long slotted holes including dimensions, reaming, multi-ply alignment, out-of-round, quality (tears, burrs, etc). The acceptance/rejection criteria for bolt spacing and edge distance (see RCSC Table 3.1).

5.1.4 Snug Tightening
The definitions of “snug tight”, for both rotational capacity testing and also for installation. Proper systematic tightening to bring an entire assembly to the snug tight condition.

5.1.5 Bolt Pretension
The principles and methods to tighten bolts in pretensioned and slip-critical joints (see RCSC Table 8.1, minimum bolt pretension values)
5.2 **Bolting Materials and Usage**

Be able to properly identify the bolting materials required for a project, ensure the materials’ quality upon receipt and after storage, and select the proper materials and methods for installation.

5.2.1 **Bolts**

5.2.1.1 **Bolt Types**
Understand the differences between various types of bolts (hex head, twist-off-type, lock-pin and collar, etc.).

5.2.1.2 **Material Grades**
The differences and common uses for each grade and type of structural bolt (A 325, A 354, A 490, A 449, F 1852, Type 1, Type 3, etc), including restricted uses and conditions.

5.2.1.3 **Markings, Dimensions, etc.**
The significance of head markings on structural bolts as well as common bolt dimensions and terminology (see RCSC Fig. C-2.1).

5.2.2 **Nuts**

5.2.2.1 **Materials, Markings, Dimensions, etc.**
The significance of markings on structural grade nuts as well as common nut dimensions and terminology (see RCSC Fig. C-2.1).

5.2.2.2 **Suitability with Bolts**
The acceptable combinations of nuts and bolts for structural bolting applications (see RCSC Table 2.1, see also A 563 Table X1.1), and the qualification of bolt-nut assemblies.

5.2.3 **Washers**

5.2.3.1 **Material, Dimensions, etc.**
The standard materials and sizes of hardened steel washers for structural applications (see F 436), and plate or beveled washers for slots or sloping surfaces.

5.2.3.2 **Connection Requirements**
The correct usage of hardened steel washers in applications with standard, slotted and oversized holes.

5.2.4 **Washer-Type Direct Tension Indicators (DTI)**

5.2.4.1 **Material, Dimensions, etc.**
The configuration, interpretation and sizes of washer-type direct tension indicators used with high-strength bolts (see F 959).

5.2.4.2 **Connection Requirements**
The correct installation and verification of washer-type direct tension indicators, including hardened washer requirements based on the turned element, and placement for standard, slotted, and oversized holes.
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5.2.5 Bolt Length/Grip
The correct bolt length for given applications, identify stripping, excessive stickout, and bottoming out of nuts.

5.2.6 Reuse of Bolts
The situations in which bolts that have been pretensioned may be reused (black vs. coated A 325; A 490) and know how to check for suitability for reuse.

5.2.7 Storage
Proper jobsite storage and protection
5.2.7.1 Jobsite/Shop Storage
Proper lot segregation and storage procedures and identify and isolate defective items.
5.2.7.2 Lubrication
Proper lubrication of nuts and bolts (black as well as galvanized) and the proper methods and materials are used for re-lubrication.
5.2.7.3 Bolted Splices
The requirements for the use of alignment (drift) pins for splice alignment prior to snug tightening and pretensioning.

5.3 Inspection
Know and understand the specific inspection requirements as they apply to the following below listed installation methods.

5.3.1 Prior to Installation
How to identify the fasteners (i.e. grade, etc.), proper storage and lubrication, and know and perform proper pre-installation verification.

5.3.2 Rotational Capacity (ROCAP) Testing
Witness the performance of rotational capacity testing for each bolt-nut-washer assembly lot, verifying the effectiveness of nut lubrication and the ability of bolts to resist stripping.

5.3.3 Snug Tight
Know and understand the definition of snug tight and systematic tightening, know how to identify a snug tightened condition and know to verify this condition prior to pretensioning.

5.3.4 After Snuggling
The Inspector should know proper snug-tightening procedures and results, know how to apply systematic tightening and know bolt and nut match marking.

5.3.5 During Pretensioning
The Inspector should know correct observation techniques for witnessing turning of bolts both with and without match-marking and know how to address loose bolts.
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5.3.6 After Pretensioning
The Inspector should be able to inspect and verify match marking and that proper torque has been applied (proper use of torque wrench) and should know the parameters for reuse of previously pretensioned bolts.

5.4 Installation Methods
Verify and inspect for various common fastener installation techniques.

5.4.1 Turn-of-Nut Installation
Be familiar with all critical aspects of the turn-of-nut installation technique.

5.4.1.1 Pre-Installation Verification
Observe pre-installation verification and demonstrate the proper use of a tension calibration device (e.g. Skidmore-Wilhelm) for long bolts as well as the procedure for short bolt testing. Determine the check torque for installed bolts.

5.4.1.2 Joint Pretensioning
Verify snug-tight condition, know the match mark system used on nuts and bolts and know the required pretension for the bolts used.

5.4.2 Twist-Off-Type Tension-Control Bolts
Understand all aspects of the installation technique for twist-off-type tension-control bolts (torsion actually governs twist-off, but it’s related to fastener tension by test results.).

5.4.2.1 Pre-Installation Verification
Verify proper tension at twist-off using a tension calibration device (e.g. Skidmore-Wilhelm) for long bolts or for short-bolt testing.

5.4.2.2 Joint Pretensioning
Verify the snug tight condition is achieved before any twist-offs occur and understand the need for systematic tightening.

5.4.2.3 Specific Inspection Aspects
5.4.2.3.1 After Snugging
Verify the snug tight condition, with the twist-off spline intact, and verify the bolt grip is correct.

5.4.2.3.2 During Pretensioning
Observe and verify the correct operation of the wrench and determine that all bolts remain tight as pretensioning continues.

5.4.2.3.3 After Pretensioning
Observe and verify that all twist-off splines are sheared and apply check-torque to random bolts.
5.4.3 Washer-Type Direct Tension Indicators (DTI)
Understand the installation of high-strength bolts using washer-type direct tension indicators.
5.4.3.1 Pre-Installation Verification
Using a tension calibration device (e.g. Skidmore-Wilhelm), verify DTIs properly indicate pretension by closing gaps or other methods.
5.4.3.2 Joint Pretensioning
Verify proper bolt pretension by visual verification or by the use of a feeler gauge.

5.4.4 Calibrated Wrench Installation
Understand the installation of high-strength bolts using a calibrated torque wrench.
5.4.4.1 Pre-Installation Verification
Using a tension calibration device (e.g. Skidmore-Wilhelm) for long bolts or direct tension indicators for short bolt testing, ascertain the torque required to fully pretension a bolt/nut from a snug condition. Know how to set the calibrated wrench to indicate when the correct torque is applied for both installation and also for post-installation check-torques.
5.4.4.2 Joint Pretensioning
Verify snug tight condition, know systematic tightening pattern used on nuts and bolts and be able to set the wrench properly for both installation and check torque values.

5.5 Time Management
It is not possible to closely monitor multiple bolting crews. Be aware of crew schedules and tell-tale indications of good or bad crew technique to determine how often to check each operation for efficient inspection.

5.6 Arbitration of Disputes
Be familiar with the correct procedures for arbitrating disputes (see RCSC Section 10).