High-Strength Bolting Made Easy

This month's SteelWise takes a closer look at some common and not-so-common questions on high-strength bolted joint design and construction.

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CONFUSION BETWEEN ENGINEERS AND CONTRACTORS CAN ARISE ON JOB SITES WHEN ONE PARTY IS UNCERTAIN OF CORRECT INSTALLATION AND INSPECTION PROCEDURES FOR HIGH-STRENGTH BOLTED JOINTS. To properly address high-strength bolting issues, the Research Council on Structural Connections (RCSC) developed the 2004 edition of the *Specification for Structural Joints Using ASTM A325 or A490 Bolts* (a free download from **www.boltcouncil.org**). This specification examines the design, inspection, and material requirements for high-strength bolted joints. In addition, Chapter J of the 2005 AISC *Specification for Structural Steel Buildings* (free at **www.aisc.org/2005spec**) addresses bolting design requirements, in conjunction with the RCSC specification.

This article will briefly address fastener problems that have been observed in the field, as well as common questions associated with high-strength bolted joint design.

Common Field-Related Questions

How tight is "snug-tight"?

The term "snug-tight" is defined in the RCSC specification as "…the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the plies into firm contact." Snug-tightened joints do not have a prescribed installed pretension requirement. This is because the amount of pretension required to achieve a snug-tight joint depends on many factors, including the base material thickness, force applied, and the slope between the bolt and plies. With most applications, snug-tightened joints have the pretension necessary to close gaps between plies in areas adjacent to the bolt or bolt group in bringing the joint into firm contact.

What happens if full contact cannot be achieved between faying surfaces of slip-critical joints?

Slip-critical joints rely on a clamping force (between the faying surfaces) that results from installed pretension in the fasteners. However, in some cases, full or continuous contact between thick faying surfaces may not be possible. Assuming the requirements for the slip-critical joint are met and the fastener group has the required pretension in total, the load will be transferred through the portions of the faying surfaces that are in firm contact. Refer to the commentary found in Section 8.2 of the RCSC specification.

Are bolts considered "overstressed" if they exceed the rotation values in Table 8.2 of the RCSC specification for turn-of-nut pretensioning? If so, is this cause for rejection?

The term "overstress" is often misused when discussing bolt installation. Section 9.2.1 of the RCSC specification states "a pretension that is greater than the value specified in Table 8.2

The RCSC specification requires bolt pretensions to be at least 70% of the specified minimum tensile strength, as shown in Table 8.1. To simplify field installation procedures using the turn-of-the-nut pretensioning method, Table 8.2 of the RCSC specification indicates the amount of bolt rotation required to achieve this minimum pretension. However, field conditions can often make it difficult to achieve the exact amount of prescribed bolt rotation. Upper and lower rotation tolerances are located in the footnotes of Table 8.2 to account for this. While it is obvious that the lower tolerance ensures that fasteners receive the minimum required tension, many engineers misinterpret the upper tolerance.

The upper tolerance is a practical limit to prevent bolts from being broken during the turn-of-the-nut installation process. Laboratory tests confirm that the actual bolt pretension achieved by the turn-of-the-nut method can be substantially greater than the $0.70F_u$ specified minimum installed pretension. The installation process becomes uneconomical if the bolts break during pretensioning. Rotating the nut subjects the fastener to a combination of tension and torsion force during installation. Once the installation process is complete, the

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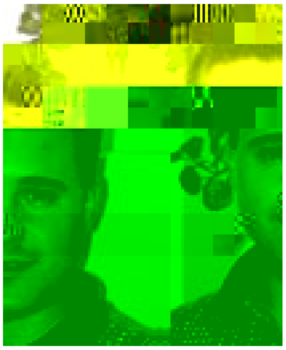

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stress in the bolt decreases due to removal of the torsional force. Therefore, bolts that do not fail during installation are adequate for service from an installation perspective. Rotations greater than those prescribed in Table 8.2 need not be cause for rejection of the bolted joint.

Should light surface corrosion or oxidation be removed from faying surfaces prior to installing high-strength bolts?

After fabrication, steel members often sit idle before they are erected. During this period, light surface corrosion or oxidation often forms on the surfaces of uncoated blast-cleaned steel. This surface corrosion can actually be beneficial to the connection by increasing the slip resistance of the joint. In fact, tests have shown that a Class B slip resistance, which represents the largest mean slip coefficient of all classes, can be preserved after one-year of exposure to normal atmospheric conditions. Refer to the commentary in Section 3.2.2 in the 2004 RCSC specification.

Can galvanized faying surfaces be roughened mechanically?

Galvanized faying surfaces must be hand-roughened rather than mechanically roughened. The purpose of roughening the faying surface is to increase the slip coefficient between surface plies. Mechanical roughening can polish the surface (and sometimes remove the galvanized coating), thereby reducing the slip resistance. Refer to Section 3.2.2 (c) of the RCSC specification.

Bolted joints with long-slotted holes require a 5⁄16" thick washer or continuous bar. Can multiple washers be used if their total thickness is at least 5⁄16"?

The use of multiple washers is unacceptable, as the washer must provide for a non-galling surface. For pretensioned and slip-critical joints, the washer must be capable of transferring bolt pretension over the slotted holes. As such, the washer must have adequate stiffness to properly develop the clamping force. The stacking of washers does not provide the same stiffness as a single 5⁄