Solid Answers

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The Engineering FAQs section of AISC's web site may just have the answers you've been looking for.

SINCE ITS INCEPTION IN 2001, THE AISC STEEL SOLUTIONS CENTER HAS ANSWERED MORE THAN 53,000 TECHNICAL INQUIRIES. As these questions are by no means all unique, we've organized the most-asked ones into 12 categories in the "Engineering FAQs" section of our web site, **www.aisc.org/faq**.

Originally based on the contents of AISC's out-of-print handbook *Engineering Quality Criteria*, the "Engineering FAQs" online have been expanded and updated based on the 2005 AISC specification (**www.aisc.org/2005spec**) as well as common industry practice.

To illustrate the depth and breadth of information that can be found in this section of our web site, we have provided a sampling of our FAQs and their answers:

2.2.4. Is it commonly necessary to mill bearing surfaces after sawing?

No. As stated in the 2005 AISC Specification, Section M2.6, "compression joints that depend on contact bearing ... shall have the bearing surfaces of individually fabricated pieces prepared by milling, sawing, or other suitable means." The 2005 AISC *Code of Standard Practice* Section 6.2.2 Commentary states that "Most cutting processes, including friction sawing and cold sawing, and milling processes meet a surface roughness limitation of 500 per AISI/ASME B46.1." Cold-sawing equipment produces cuts that are more than satisfactory.

2.2.8 To what profile must re-entrant corners, such as corners of beam copes, be shaped?

Re-entrant corners should provide a smooth transition between adjacent surfaces, but generally need not be cut exactly to a circular profile. The recommendation in the the 13th Edition AISC *Manual*, Part 9, is that an approximate minimum radius of ½ in. is acceptable. However, the primary emphasis should be that square-cut corners and corners with significantly smaller radii do not provide the smooth transition that is required. From the 2005 AISC Specification Section J1.6, it is acceptable to provide radius transitions by drilling (or hole sawing) with common-diameter drill sizes (not less than ¾ in.) as suggested in the 2005 Specification Commentary Figure C-J1.2.

When the corner of a cope has been square-cut, a common solution is to flame-cut additional material at the corner to provide a smooth transition as illustrated in Figure 2.2.8-1. Note that the sides of the cope need not meet the radius transition tangentially. Any notches that occur at re-entrant corners should be repaired as indicated in 2.2.7.

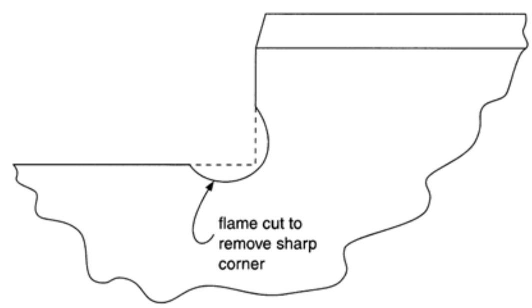

Figure 2.2.8-1

Editor's Note: *FAQ 2.2.7 (not reproduced here) is titled, "When surface roughness for thermally cut edges/surfaces does not meet the limitations in 2.2.6, how is the surface repaired?" FAQ 2.2.7 is available at* ***www.aisc.org/faq****.*

4.6.1. In a built-up I-shaped cross-section, how are welds connecting the plates designed?

Assuming that continuous fillet welds are used, the welds may be minimum size per the 2005 AISC Specification Table J2.4 (fillet welds) if the member is subjected only to axial compression or tension. If the member is subjected to flexure, the shear flow (kips/in.) can be calculated from the beam shear V_u as V_uQ/I and the weld sized to provide for this required strength; Q is the first moment about the neutral axis of the flange area and I is the moment of inertia of the entire cross-section.

4.6.3. What is tension-field action?

Tension-field action is the post-buckling development of diagonal tensile stresses in slender plate-girder web panels and compressive forces in the transverse stiffeners that border those panels. When tension-field action is considered in design, the 2005 AISC Specification G3 provisions apply; otherwise the AISC Specification Section G2 applies.

Editor's Note: Tension field action is most commonly utilized in plate girder design and for special plate shear walls. See AISC's Design Guide 20, Steel Plate Shear Walls *(www.aisc.org/epubs) for detailed information on the design and construction of steel plate shear walls.*

5.3.7. In many design examples in the 13th Edition *Steel Construction Manual*, yielding and buckling in a gusset plate or similar fitting are checked on a Whitmore section. What is a Whitmore section?

A Whitmore section identifies a theoretically effective cross-sectional area at

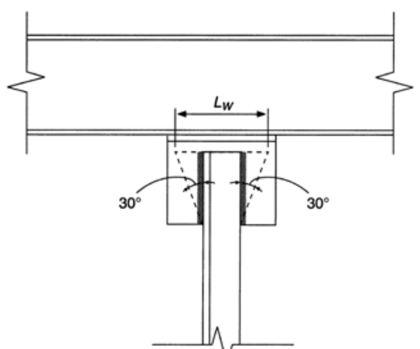

Figure 5.3.7-1

the end of a connection resisting tension or compression, such as that from a brace-to-gusset-plate connection or similar fitting. As illustrated in Figure 5.3.7-1 for a WT hanger connection, the effective length for the Whitmore section L_w is determined using a spread-out angle of 30° along both sides of the connection, beginning at the start of the connection. It is applicable to both welded and bolted connections.

6.5.2. What is the definition of snug-tight bolt installation and when is it allowed?

The 2004 RCSC Specification defines a snug-tightened joint as a joint in which the bolts have been installed in accordance with Section 8.1. Note that no specific level of installed tension is required to achieve this condition, which is commonly attained after a few impacts of an impact wrench or the full effort of an ironworker with an ordinary spud wrench. The plies should be in firm contact, a condition that means the plies are solidly seated against each other, but not necessarily in continuous contact.

It is a simple analogy to say that a snug-tight bolt is installed in much the same manner as the lug nut on the wheel of a car; each nut is turned to refusal and the pattern is cycled and repeated so that all fasteners are snug. Essentially, snug-tight bolts utilize the higher shear/bearing strength of high-strength bolts with installation procedures similar to those used for ASTM A307 common bolts, which are never fully tensioned (see 6.6.2).

Editor's Note: FAQ 6.6.2, "Can an A307 Bolt be fully tensioned?", is not reproduced here. View it at www.aisc.org/faq.

6.5.4. When should bolted connections be specified as slip-critical?

Slip in bolted connections is not a structural concern for the majority of connections in steel building structures. The 2004 RCSC Specification Commentary Section 4.1 states that: "The maximum amount of slip that can occur in a joint is, theoretically, equal to twice the hole clearance. In practical terms, it is observed in laboratory and field experience to be much less—usually about one-half the hole clearance. Acceptable inaccuracies in the location of holes within a pattern of bolts usually cause one or more bolts to be in bearing in the initial, unloaded condition. Furthermore, even with perfectly positioned holes, the usual method of erection causes the weight of the connected elements to put some of the bolts into direct bearing at the time the member is supported on loose bolts and the lifting crane is unhooked. Additional loading in the same direction would not cause additional joint slip of any significance."

In some cases, slip resistance is required. The AISC and RCSC specifications list cases where connections must be designated by the Structural Engineer of Record as slip-critical:

- Connections with oversized holes
- Connections with slotted holes when the direction of the slot is not perpendicular to the direction of the load, unless slip is the intended function of the joint.
- Connections subject to fatigue or significant load reversal.
- Connections in which welds and bolts share in transmitting shear loads at a common faying surface.

Other connections stipulated as such on the design plans (e.g., from RCSC Specification Commentary Section 4, "(1) Those cases where slip movement could theoretically exceed an amount deemed by the Engineer of Record to affect the serviceability of the structure or through excessive distortion to cause a reduction in strength or stability, even though the resistance to fracture of the connection and yielding of the member may be adequate; and, (2) Those cases where slip of any magnitude must be prevented, such as in joints subject to significant load reversal and joints between elements of built-up compression members in which any slip could cause a reduction of the flexural stiffness required for the stability of the built-up member").

One special case also exists. A nominal amount of slip resistance is required at the end connections of bolted built-up compression members so that the individual component will act as a unit in column buckling. As specified in the 2005 AISC Specification Section E6.2, "The end connection shall be welded or pretensioned bolted with Class A or B faying surface."

6.6.1. What torque is required to fully tension a high-strength bolt?

Torque is an invalid measure for fully tensioned installation, unless it is calibrated. In1951, the first RCSC Specification incorporated a table of standard torque values for the installation of fully tensioned high-strength bolts. However, depending upon the condition of the threads, it was demonstrated that the resulting installed tension varied by as much as plus or minus 40%. It is now known that clean, well-lubricated threads result in tensions that are higher than required (and probably a few broken bolts), whereas rusted, dirty, or poorly lubricated threads result in tensions that are below the minimum required. Therefore, recognition of these standard torque values has long been withdrawn. Accepted procedures for fully tensioning high-strength bolts can be found in the 2004 RCSC Specification Section 8.2 (see also 6.6.3.). If torque is to be used as in the calibrated wrench method as described in the 2004 RCSC Specification Section 8.2.2, it must be calibrated on a daily basis for the lot, diameter, and condition of bolts being installed.

6.6.3. What are the accepted procedures for fully tensioning high-strength bolts?

Provisions in the 2004 RCSC Specification Section 8.2 include four methods for the installation of high-strength bolts in fully tensioned bearing and slip-critical connections: turn-of-nut method, calibrated wrench method, alternative design bolt method, and direct tension indicator method. When used properly, each method can produce properly tensioned high-strength bolts. The use of these methods is described in 6.6.4 (turn-of-nut), 6.6.5 (calibrated wrench), 6.6.6 (alternative design bolt), and 6.6.7 (direct tension indicator).

***Editor's Note:** Visit **www.aisc.org/faq** for FAQs 6.6.4, 6.6.5, 6.6.6, and 6.6.7*

6.9.1. The RCSC Specification discusses a "calibration device capable of indicating bolt tension." What is an example of such a bolt tension calibration device?

One such device is the Skidmore-Wilhelm Bolt Tension Calibrator, manufactured by the Skidmore-Wilhelm Manufacturing Company, Cleveland, OH, 216.481.4774, **www.skidmore-wilhelm.com**. When a sample bolt is installed in the "Skidmore," the tension is measured on a dial gauge. Thus, the appropriate torque for use in the calibrated wrench installation method may be determined, or the proper tension resulting from the turn-of-nut, alternative design bolt, or direct tension indicator methods may be verified. It is not intended that the use of other similar devices be excluded by this discussion. **MSC**

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