Steel Interchange

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine.

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principles to a particular structure.

If you have a question or problem that your fellow readers might help you to solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact *Steel Interchange* via AISC's Steel Solutions Center at:

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Slip-Critical Connections

Is there any situation where the design of a slip critical bolted connection would not be required to address bearing requirements? How about a connection using slotted holes?

Question sent to AISC's Steel Solutions Center

The following is a FAQ from AISC's website (www.aisc.org/faq.html). References to the RCSC Specification have been updated to the latest (2000) Specification available at www.boltcouncil.org.

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. 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 SER as slip-critical:

1. Connections with oversized holes.
2. 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.
3. Connections subject to fatigue or significant load reversal.
4. Connections in which welds and bolts share in transmitting shear loads at a common faying surface.
5. Other connections stipulated as such on the design plans. For example, 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 1999 AISC LRFD Specification Section E4.2, "the end connection shall be ... fully tensioned bolted with clean mill scale or blast-cleaned faying surfaces with Class A coatings." In other words, the end connection can be proportioned as a bearing connection as long as the faying surfaces offer at least a Class A slip coefficient.

Sergio Zoruba, Ph.D.
Steel Solutions Center

Welding on Loaded Structure

It is a general rule, that welding on an existing structural member is not permitted, unless provisions are made to unload the member first,(if the member is being reinforced) and that the weld not degrade the properties of the material. Is there a written reference that discusses this, both from a code perspective, and a practical approach?

Alan L. Blosser P.E.
Steel Interchange *question, October 2001*

The high temperature generated by welding can temporarily reduce the load-carrying capacity of

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the steel member being welded. For this reason, standard practice is to provide temporary shoring under the member. Also, it is often—but not always—desirable to relieve the existing stresses in the beam being reinforced, and the shoring can be used to pre-deflect the beam upward for this purpose. Once the shoring is in place, welding to existing structural members under load in many cases is possible, and such work has been done for years. Quite often, existing beams are reinforced with welded plates or WT sections. The main design difficulty in this operation is to establish the appropriate allowable stress levels in the existing loaded member and the reinforcing piece. There are various approaches to this issue. For ASD design, some sources recommend limiting the stress in the added piece to the difference between the allowable and the actual stress in the existing member. More commonly, the allowable stresses in the welded piece and the beam are limited by the maximum permitted by the code for new construction for the respective grades of steel. An in-depth discussion of this topic and a design example can be found in the new book "Structural Renovation of Buildings" by A. Newman (McGraw Hill, 2001).

Alexander Newman, P.E.
Foxborough, MA

There is no general rule requiring existing members to be unloaded prior to field welding. Despite the desirability of such a rule, in the real world it is rare that an existing beam can be shed of both of its live and dead load and rarer still for a column. However, there are proven procedures for field welding to existing load carrying members. One reference is "Field Welding to Existing Structures" in the *Engineering Journal*, First Quarter 1988. This reference also lists several other articles on the topic.

Dave Ricker, P.E.
Payson, AZ

Four papers from the AISC *Engineering Journal* that provide a quite a bit of guidance regarding welding and reinforcing existing steel structures are "Field Welding to Existing Steel Structures" (First Quarter 1988), "Reinforcing Loaded Steel Compression Members" (Fourth Quarter 1988), "The Reinforcement of Steel Columns" (First Quarter 1989) and "Reinforcing Steel Members and the Effects of Welding" (First Quarter 1990).

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Flexure in AISC ASD Specification

In the 1989 ASD Specification, Section F1.3 provides calculations for allowable stresses in members with unbraced lengths greater than L_c. Equation F1-8 seems to provide a very low allowable stress for these members, yet it can be applied to members for any value of l/r_t. Is there something that I am overlooking?

Question sent to AISC's Steel Solutions Center

Equation (F1-8) does indeed often result in a lower allowable stress compared to equations (F1-6) and (F1-7). Since equation (F1-8) uses d and A_f instead of r_t, it tends to be conservative compared to equations (F1-6) and (F1-7). Because equations (F1-6) and (F1-7) incorporate r_t, both capture the effect of weak-axis flexural resistance to lateral torsional buckling better, which usually rewards the practitioner with a larger value of allowable stress.

Sergio Zoruba, Ph.D.
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Bolt Projection Beyond Nut

One rule of thumb that our office uses for the minimum projection of bolts beyond the nut is 4.5 threads. Is there any written information documenting a minimum allowable projection?

Question sent to AISC's Steel Solutions Center

This is what is stated in the latest RCSC bolt specification, Section 2.3.2: "The bolt length used shall be such that the end of the bolt extends beyond or is at least flush with the outer face of the nut when properly installed."

The RCSC *Specification for Structural Joints Using ASTM A325 or A490 Bolts* is a free download available from www.boltcouncil.org.

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