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End-loaded Bolted Joints

Chapter J in the AISC *Specification* covers reduction factors for long bolted joints and discusses an end-loaded configuration. What is an end-loaded joint and when do these reduction factors apply?

End-loaded connections are illustrated in AISC *Steel Design Guide 17*, Chapter 5; see Figures 5.2 and 5.3 and the supporting text. In the 2005 AISC *Specification*, there is a 20% reduction that covers the first 50 in. of length and an additional 20% reduction if the joint gets longer than that. The confusing part is that the first 0.8 reduction factor (for shorter connections, less than 50 in.) is already included in the bolt values in Table J3.2 of the 2005 *Specification*.

Of course, in a shear connection, the bolts are usually loaded uniformly unlike an end-loaded connection, so it is conservative to include this reduction factor, and that is what has been done traditionally to simplify bolt design by not having different values for different applications. For longer end-loaded connections, there is an additional 0.8 factor shown in Table J3.2 footnote f.

Note that the 2010 *Specification* will have some changes in this area, so watch for those when you start using it. Essentially, the initial reduction is reduced (a 0.9 factor replaces the 0.8 factor and the point at which a further reduction is required is reduced to 38 in.).

Brad Davis, S.E., Ph.D.

Sealing Fabrication Drawings

A contract we are considering states that we are to have our fabrication drawings sealed by an engineer other than the EOR. To do this, we would have to hire an engineer to review them. What does AISC think of this requirement?

In the general sense, it is inappropriate—illegal in some licensing jurisdictions—to place an engineer's stamp on drawings that were not prepared under that engineer's supervision. Shop and erection drawings are not instruments of design, but rather documents that are used in the shop and field to make the parts and assemble them. An engineer's stamp is placed on the work of the engineer—design drawings and design information—to show who is the engineer in responsible charge and signify that the engineer has released his or her work. Shop and erection drawings are prepared to show how a fabricator and erector have interpreted the requirements in design drawings and provide an opportunity for the EOR to review and approve or correct that interpretation. The requirement you question seems to run counter to these basic purposes.

In your specific case, I do not know what the local jurisdictional requirements are, but you should investigate what those are. I also suggest you look at the 2010 AISC *Code of Standard Practice*, Section 3.1.2. The information in the Commentary on Option 3, which covers the case of connection design work being delegated by the EOR to another engineer, is careful to avoid any suggestion that shop and erection drawings might be sealed because we believe this is an inappropriate practice. Rather, we call for a letter from the engineer performing the connection design, which can be sealed if required.

Charles J. Carter, S.E., P.E., Ph.D.

Accounting for Existing Web Openings

I am analyzing an existing structure for some new, increased floor loading. One of the impacted beams has two existing web openings with a clear distance between them less than recommended in AISC *Steel Design Guide No. 2*. How can I analyze this existing condition to account for any interaction that may occur between the two openings?

In Chapter 5 of AISC *Steel Design Guide No. 2*, it is explained that these spacing requirements are to ensure that the design equations presented are valid and potential problems of interaction are avoided. It also notes that this is based on observations of testing of single openings, and that testing was not performed on beams with multiple openings.

My first suggestion is to analyze the beam with one, large opening equal in size to the extents of the two openings. If the openings are large, this may not work, and then you would need to base your analysis on structural mechanics and engineering judgment. Perhaps you could consider the behavior of the beam in the region of the opening as similar to a Vierendeel truss and use the design guide as one source of guidance for limit states to consider. Chapter 5 lists several additional limit states to consider for closely-spaced openings.

Heath Mitchell, P.E.

Checking Combined Loads

For a built-up "C" section in compression and major-axis bending, what criteria from Table B4.1 in the AISC *Specification* need to be used to check the flanges and webs for width-thickness ratios?

The flanges and web will each be classified for local buckling (LB) twice: once for uniform compression (for use in the Chapter E calculations of compressive strength) and once for bending (for use in the Chapter F calculations of flexural strength). Note that the Chapter E calculations are performed as if the member has no bending, and the Chapter F calculations are performed as if there is no axial force. Axial force and bending are then combined later with these results in the Chapter H equations, after you have computed ϕP_n and ϕM_n.

In compression, you have two conditions: non-slender and slender. In bending, you have three conditions: compact, non-compact, and slender.

For the web, Cases 10 and 9 in Table B4.1 cover the slenderness conditions for compression and flexure, respectively. For the flanges, Case 3 and Case 1 cover compression and flexure, respectively.

Brad Davis, S.E., Ph.D.

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Bolted Joints in Seismic Applications

According to AISC 341-05, Part I, Section 7.2, all bolts shall be pretensioned high-strength bolts and shall meet the requirements for slip-critical faying surfaces in accordance with AISC 360-05 *Specification* Section J3.8. The last sentence of the first paragraph in Section 7.2 says that "the available shear strength of bolted joints using standard holes shall be calculated as that for bearing-type joints in accordance with *Specification* Sections J3.7 and J3.10..." Must we design the bolted connections to be slip-critical or is using J3.7 and J3.10 the appropriate design?

I refer to this as designed as bearing, detailed as slip-critical. The bolts should be designed relative to the design loads as they would be in a bearing connection. However, they must be pretensioned and the surfaces must be qualified slip-critical surfaces.

The idea is that the joints are expected to slip even if designed as slip-critical. Slip is thought to be inevitable during a major earthquake. Therefore, it does not make sense to design the connections as slip-critical. It also can become much more costly. However, during smaller events the slip resistance provided will absorb energy and prevent damage to the connection.

Some exceptions to all this are worth noting:

1) Section 7.2 of the AISC *Seismic Provisions* states, "For brace diagonals, oversized holes shall be permitted when the connection is designed as a slip-critical joint, and the oversized hole is in one ply only."
2) Section 7.2 also states, "Alternative hole types are permitted if designated in the *Prequalified Connections for Special and Intermediate Moment Frames for Seismic Applications* (ANSI/AISC 358), or if otherwise determined in a connection prequalification in accordance with Appendix P, or if determined in a program of qualification testing in accordance with Appendix S or T."
3) Section 7.2 states, "The faying surfaces for end-plate moment connections are permitted to be coated with coatings not tested for slip resistance, or with coatings with a slip coefficient less than that of a Class A faying surface."

Finally, in the 2010 version of the AISC *Seismic Provisions*, the last exception regarding the faying surface will be stated to apply more generally to all connections that have tension in the bolts and not shear at the shear planes, since in these cases the slip resistance never comes into play.

Larry S. Muir, P.E.

Drilling Through a Weld

We are fabricating members for steel buildings as per AWS D1.1. Please advise if drilling holes through a CJP butt weld is allowable.

I am not aware of restrictions against such drilling. Weld metal will be higher strength and therefore harder than the base metal—this could hurt the drills. Such drilling is a frequent requirement but would be best to avoid when possible.

Tom Schlafly

SteelFacts

Someone showed me a copy of a document called *Facts for Steel Buildings, Earthquakes and Seismic Design*. Is this an AISC publication? How can I get it?

Yes, this is an AISC publication. AISC's Facts for Steel Buildings series includes three primers so far, all in a convenient question-and-answer format:

Facts for Steel Buildings #1: Fire, by Richard G. Gewain, Nestor R. Iwankiw and Farid Alfawakhiri, serves as an objective general reference and introductory primer on fire considerations for the benefit of engineers, architects, building code officials, owners, developers, construction managers, general contractors and the general public and others with interest in the subject.

Facts for Steel Buildings #2: Blast and Progressive Collapse, by Kirk A. Marchand and Farid Alfawakhiri, presents background and definitions for explosive loads and progressive collapse, general principles of blast loads and response prediction, recommendations for structures designed to resist blast and mitigate progressive collapse, recent guidelines and federal and DoD requirements, some observations from historical events, and some information on ongoing research.

Facts for Steel Buildings #3: Earthquakes and Seismic Design, by Ronald O. Hamburger, presents an overview of the causes of earthquakes, the earthquake effects that damage structures, the structural properties that are effective in minimizing damage, and the organization and intent of seismic design requirements for steel structures in the U.S. today.

They are available at **www.aisc.org/freepubs**.

Charles J. Carter, S.E., P.E., Ph.D.

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Charlie Carter is vice president and chief structural engineer, Tom Schlafly is director of research, and Heath Mitchell is director of technical assistance at AISC. Brad Davis and Larry Muir are consultants to AISC.

Steel Interchange is a forum 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.

If you have a question or problem that your fellow readers might help you 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:

Steel SolutionsCenter
One East Wacker Dr., Suite 700
Chicago, IL 60601
tel: 866.ASK.AISC • fax: 312.803.4709
solutions@aisc.org