IF YOU'VE EVER ASKED YOURSELF "WHY?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to solutions@aisc.org.

Eccentrically Loaded Bolts

I am analyzing an eccentric bolt group and cannot use the eccentrically loaded bolt group tables in the AISC *Manual* due to a non-standard spacing. How can I calculate the coefficient *C*?

The Instantaneous Center of Rotation Method used to determine this value is described in Part 7 of the AISC *Manual*. It is an iterative process. Some engineers have written a program to do this, but you also can use a spreadsheet. Some structural engineering textbooks also present the calculations, which are readily adaptable to a spreadsheet.

Once you have built the spreadsheet or program, you can proceed in one of two ways. First, you can simply guess at a location of the instantaneous center until you satisfy equilibrium. This is not as bad as it may sound, if you are only doing this occasionally. Or second, you could use the spreadsheet goal seek function to find the location of the instantaneous center. For a symmetrical bolt group with a vertical load, the instantaneous center of rotation will be located along the line perpendicular to the load passing through the bolt group centroid. Knowing this makes the job easier.

There are a number of programs available online (many free) to do this work for you. Some will supply the location of instantaneous center of rotation. Once the center of rotation is known, the results can be easily verified.

If you would rather write a program, there is also an AISC *Engineering Journal* article by Brandt that presents a program in FORTRAN that can be used to find the coefficient *C* of the bolt group. This was published in the 2nd Quarter 1982 issue and is available as a free download for AISC members at **www.aisc.org/ej**.

Larry S. Muir, P.E.

Use of Lock Washers

A customer has asked that lock washers be provided at all pretensioned and slip-critical bolted connections. I cannot find lock washers mentioned in the AISC or RCSC specifications. Are lock washers permitted to be used in pretensioned or slip-critical connections?

I am assuming that your customer's request for the use of lock washers is the result of a concern for nuts backing off in service. Properly installed bolts will not experience this problem, and lock washers do not serve any purpose in a structural joint, especially if it is pretensioned.

Some further useful information is available in the last paragraph of the Commentary to ANSI/AISC 360 Section J3.1 for when an application such as a vibratory load might require more consideration. It states, "… it is advisable to deform the bolt threads or use a locking nut or jam nut to ensure that the nut does not back off further under service conditions. Thread deformation is commonly accomplished with a cold chisel and hammer applied at one location."

Keith Landwehr

Established Finish Line

In the AISC *Code of Standard Practice*, Section 7.13.1.3(b) on adjustable items refers to the "established finish line." What is the definition of an established finish line?

This term is not explicitly defined in the AISC *Code of Standard Practice*. The term describes a reference line parallel to (and perhaps coincident with) the building finish supported by the adjustable items.

Heath Mitchell, S.E., P.E.

Material Availability

I'm looking for a supplier of several structural shapes. How do I find information on availability and where to purchase structural steel?

Material availability is listed on the AISC website at **www.aisc.org/availability**. If you use the drop-down menus to see available sizes for the shapes you are seeking, this will list the names of producers. On this same page is a link to the contact information for producers.

Also, you can contact a steel service center (**www.aisc.org/servicecenter**), which has an inventory of material that it purchased from a steel mill. Today, most structural steel—around 70%—is supplied to fabricators by steel service centers. Many keep a full range of steel products in multiple lengths and also provide value-added services to fabricators, such as cutting beams to length, tee splitting, cambering, and plate burning. Steel service centers also assist with meeting staged delivery requirements by delivering shapes according to the project sequence.

Erin Criste, LEED GA

Fixed Connection to HSS Columns

Which AISC publications address the design of wide-flange beams moment connected to HSS columns? Will the connection design have an impact on the axial capacity of the column?

Connections to HSS columns are addressed in Chapter K of the AISC *Specification*. In addition, Chapter 4 of AISC *Steel Design Guide No. 24, Hollow Structural Section Connections*, provides a discussion of these moment connections and includes design examples.

The connection to the HSS column can lead to a reduction in HSS column strength, but our approach to this eliminates any impact. This is addressed in Chapter K of the AISC *Specification* through the use of the Q_f factor, which appears in the calculation of a number of the limit states applied to HSS connections. The Q_f factor limits the available strength of the connection to a level that will not decrease the axial capacity of the column.

Larry S. Muir, P.E.

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NDT per AISC 360 Chapter N

The 2010 AISC *Specification* requires UT inspection for some CJP groove welds with a transversely applied tension load (Section N5.5b). This would seem to apply to most bolted end-plate moment connections. In light of the very good results seen historically with this type of connection and the recent push to tout the advantages of visual weld inspection and the weak points of relying on NDT as the sole arbiter of weld quality, how are we justifying this seeming discrepancy?

The amount of NDT to be required during construction historically has been left to the discretion of the EOR. During the development of Chapter N, the Task Committee was asked to provide a baseline for engineers with regard to NDT requirements. Chapter N, Section 5, is the result of the committee's deliberations. Please note the following:

1. The 100% requirement in Section N5.5b is limited to transversely applied tension loading for structures in Risk Category III or IV.
2. The requirement only applies to materials that are 5⁄16-in. thick or greater.
3. Section N5.5e permits reduction in UT frequency based on satisfactory welder performance.
4. The User Note in Section N1 Scope highlights that modifications to the QA/QC Plan are allowed, when approved.

Keith Landwehr

OMF Connection Design

AISC *Seismic Design Manual* Example 4.4 calculates the required shear strength, V_u, of an OMF connection equal to $3(1.1R_yM_p)/(2L)$. However, AISC 341-05 Equation 11-1 specifies V_u equal to $2(1.1R_yM_p)/L_b$. Which is correct?

Section 11.2a of the *Seismic Provisions* assumes that the plastic hinges form in the beam. From an equilibrium diagram with $1.1R_yM_p$ at each end of the beam and shear in opposite directions at each end of the beam, a summation of moments about one end of the beam yields:

$$2\,[1.1R_yM_p(\text{beam})] - V_uL_b = 0$$

Solving for V_u,

$$V_u = 2\,[1.1R_yM_p(\text{beam})]/L_b$$

Example 4.4 is based on a different assumption. As noted at the top of page 4-17, it is showing the case where the plastic hinges occur in the column tops of a two-bay frame (see Figure 4-2). The equation in Section 11.2a must be adapted to this case, and moment equilibrium about the top of the center column yields:

$$3\,[1.1R_yM_{p(col)}] - 2V_uL = 0$$

Solving for V_u,

$$V_u = 3\,[1.1R_yM_{p(col)}]/(2L)$$

Heath Mitchell, S.E., P.E.

Monorail Runway Design

I am designing a monorail crane runway with loads on the bottom flange of the runway beam. What resources are available to aid me in this design?

The AISC *Specification* is used, and applies in general, but there is nothing specific about monorail crane runways in it. Crane loads are specified in the building code and other standards that specifically address the design of cranes (i.e., ASCE 7, CMAA, AIST Technical Report No.13). ASCE 7-10 Section 4.9 "Crane Loads" specifically addresses impact loads. Also, information on the design of industrial cranes and crane runways (including the preceding information) is contained in AISC *Steel Design Guide No. 7*, *Industrial Buildings—Roofs to Anchor Rods*, 2nd Edition.

The following are some additional resources that may be useful for monorail design:

1. American National Standards Institute, 1996, *Specifications for Patented Underhung Cranes and Monorail Systems*, MH27.1, ANSI, New York, NY. MH 27.1-2003.
2. Tanner, N.S., 1985, "Allowable Bending Stress for Overhanging Monorails," *Engineering Journal*, Vol. 22, No. 3, pp. 133–138, AISC, Chicago, IL.
3. Galambos, T.V., 1998, *Guide to Stability Design Criteria for Metal Structures*, 5th Edition, John Wiley & Sons, New York, NY.
4. ASME B30.11, "Monorails and Underhung Cranes," 1993 Edition including through addenda "c".
5. AISC *Steel Design Guide No. 9*, *Torsional Analysis of Structural Steel Members*.

Erin Criste, LEED GA

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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.

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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:

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