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.

Extended Single-Plate Shear Connections

The last paragraph on 10-103 of the 13th edition AISC *Manual* states that this design procedure permits the column to be designed for an axial force without eccentricity. Does this also apply to girders used as the supporting member? In other words, if this design procedure is followed for a beam-to-girder connection, does the girder need to be designed for an eccentric load from the extended single-plate beam connection?

The design procedure for the extended single-plate connection included in the *Manual* was developed so that the supporting member is not required to resist any additional moment from the shear connection. This applies to beams/girders as well as columns.

The point of this discussion was to highlight the possibility of designing connections in which the column is required to resist additional moment so that the demand on the plate and/or bolt group might be reduced. Supporting beams/girders are not mentioned in this discussion because they would have to resist any additional moment through torsion, which generally makes this option impractical.

Larry S. Muir, P.E.

Compactness Criteria for Angles

Could you help me understand the connotation of the "Compactness Criteria for Angles Table" shown on page 1-47 of the 13th edition *Manual*?

The Table on page 1-47 of the 13th edition *Manual* is merely an aide in determining the width/thickness ratios for legs of angles to meet the compactness criteria of the *Specification*. The first column relates to the requirement for compression members and the other two columns relate to the requirements for flexural members. These are based on angle material with $F_y = 36$ ksi.

As an example, if you are looking at the angle subject to compression, the table shows that an 8-in. angle leg is non-slender when the thickness is ⅝ in. or greater.

Kurt Gustafson, S.E., P.E.

IMF and OMF Connections

Is an IMF connection required to be stronger than an OMF connection?

The requirements for IMF connections are generally more stringent than those for OMF connections because greater deformation capability is required for the IMF system. IMF connections are also subjected to requirements for conformance demonstration, whereas OMF connections are more prescriptive. You can find the requirements for IMF beam-to-column connections in Section 10 of the AISC 341 (the AISC S*eismic Provisions*); OMF beam-to-column connections are covered in Section 11.

Kurt Gustafson, S.E., P.E.

k_c Factor?

Table B5.1 in the 9th edition *Manual* incorporates a k_c factor for defining the Compact/Non-Compact behavior of flanges for I-shape welded beams in flexure. Why is this factor used and is there any update to this provision?

k_c is a coefficient for slender unstiffened elements, which accounts for the interaction of flange and local web buckling.

The 2005 AISC *Specification* (a free download at **www.aisc.org/2005spec**) is the current version of the *Specification*. Table B4.1 in the 2005 *Specification* also employs the k_c factor, which is discussed on page 224 of the *Commentary*.

Kurt Gustafson, S.E., P.E.

Bending Bolts?

Is it okay to heat and bend a structural bolt that was placed in concrete in the wrong place? The contractor placed the bolts anywhere from 1½ in. to 3½ in. out of alignment, then heated the bolts and bent them like a snake and told me that they would be okay. I do not feel comfortable with this assurance. I did find one article that says to look in the 9th edition of the AISC *Manual* on page 4-4, but I do not understand what this means. Could you explain this in more detail?

I do not know of any authority that condones the practice of bending of structural bolts, whether heated or not. Do you mean that there is now a longitudinal offset, which might affect the strength and performance of the as-built elements? If so, I think there is more to it that must be considered.

Page 4-4 in the 9th edition *Manual* contained a statement recommending against the heating and welding of anchor rod material that is quenched and tempered. Many types of anchor rods are mild carbon steel that are suitable for heating and welding. However, this statement does not address the subject of bending of bolts or anchor rods.

Since you are describing the fastener as being embedded in concrete, I am assuming that you are talking about anchor rods rather than structural bolts. Mistakenly bent anchor rods of mild carbon steel are often straightened back to vertical alignment, sometimes with and sometimes without heat application. However, the engineer of record will often place limitations on the amount of bend that can be straightened and usually if the rod is bent in the threaded area, straightening is not allowed.

From your description, it sounds like the rods are purposely being bent to remedy a misplaced location. This is an entirely different matter than straightening of bent rods. This involves the structural performance of the base anchorage. Assuming that the rods serve a required function in the final structure, it would appear that any tension in the rod would have a tendency to straighten that rod as the load is applied. This is a condition that could detrimentally affect the performance of the base connection and should be evaluated by the responsible design professional.

Kurt Gustafson, S.E., P.E.

steel interchange

Restrained or Unrestrained Rating?

My understanding is that we are able to consider all beams in a building as restrained for fire protection requirements, regardless of whether they are part of an interior bay or an end bay. Can you provide me with insight into the accuracy of this statement?

Much effort has been spent disseminating the research sponsored by the American Iron and Steel Institute (AISI) that confirmed the performance of steel framing and the use of restrained ratings in the selection of fire protection. The conclusion of that research remains valid: steel-framed structures can be considered thermally restrained.

The test data supporting this conclusion are documented in "Restrained Fire Resistance Ratings in Structural Steel Buildings," which was published by Gewain and Troup in the 2nd Quarter 2001 AISC *Engineering Journal*. Furthermore, AISC Design Guide No. 19, *Fire Resistance of Structural Steel Framing*, correctly reports that with few exceptions, steel structures should be considered thermally restrained.

The issue of restrained vs. unrestrained construction is unique to the United States. It has been a source of confusion since the concept's introduction in 1970. To assist the design professional in determining this parameter, AISC has collected information demonstrating that steel-framed construction qualifies for a restrained classification and makes it available so that the provisions of section 703.2.3 of the International Building Code can be satisfied.

John Ruddy, P.E.

Editor's note: John Ruddy was the lead author of AISC Design Guide No. 19 and was widely considered an expert in the fire resistance of structures. Sadly, John passed away only several days before this inquiry was received. As John had answered a similar question before, we were able to share his thoughts with the inquirer, which are reprinted here as a tribute to the service John has provided for the design community and steel industry both as an engineer and as an expert in fire-resistant design.

Camber Measurement

Section 6.4.4 of the AISC Code of Standard Practice includes the following sentence:

"For the purpose of inspection, camber shall be measured in the Fabricator's shop in the unstressed condition."

What does the term "unstressed" imply? Does the "unstressed condition" include or exclude the dead weight of the beam?

The term "unstressed condition" is generally taken to mean that for measuring the vertical camber in a beam, it is laid down on the side in the shop such that the self weight of the member does not affect the camber measurement.

Kurt Gustafson, S.E., P.E.

I_{yc} of Compression Flange

Section H1.1 of the AISC *Specification* states, "...I_{yc} is the moment of inertia about the y-axis referred to the compression flange." Could you please expand on the definition of I_{yc}?

I_{yc} is the moment of inertia of the compression flange around its major axis. Of course, the major axis of the flange corresponds to the y-axis of the entire shape. For a rectangular compression flange, I_{yc} is equal to $t_f b_f^3/12$.

Amanuel Gebremeskel, P.E.

What is r_{ts} ?

What does the r_{ts} listed in Table 1-1 of the AISC *Steel Construction Manual* represent? How is this function calculated?

The r_{ts} listed in Part 1 of the *Manual* is an effective radius of gyration. This parameter is defined in the Symbols section of the AISC *Specification* as the "effective radius of gyration used in the determination of L_r, for the lateral-torsional buckling limit state for major axis bending of doubly symmetric compact I-shaped members and channels."

The method of calculating r_{ts}^2 is defined in Equation (F2-7) of the *Specification*, which is the basis of the values listed in the *Manual* tables. The user note in that section of the *Specification* also provides a method to determine a conservative approximation of r_{ts}.

Kurt Gustafson, S.E., P.E.

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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.

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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