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. If you have a question or problem that your fellow readers might help you to solve, please forward it to *Modern Steel Construction*. At the same time, feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

Answers and/or questions should be typewritten and double-spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

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Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 800/644-2400.

Treatment of Simple Shear Connections Subject to Combined Shear and Axial Forces

AS ITS NAME IMPLIES, A SIMPLE SHEAR CONNECTION IS INTENDED TO TRANSFER SHEAR LOAD OUT OF A BEAM while allowing the beam to act as a simply supported beam. The most common simple shear connection is the double angle connection with angles shop bolted or welded to the web of the carried beam and field bolted to the carrying beam or column. This note will deal with this connection.

Under shear load, the double angle connection is flexible regarding the simple beam end rotation, because of the angle leg thickness and the gage of the field bolts in the angle legs. The AISC Manuals (A.S.D. 9th Ed. p. 4-9, LRFD 2nd Ed. Vol. II, p. 9-12) recommend angle thicknesses not exceeding $^5/_8$ in. with the usual gages. Angle leg thicknesses of $^1/_4$ in. to $^1/_2$ in. are generally used, with $^1/_2$ in. angles usually being sufficient for the heaviest load. When this connection is subjected to axial load in addition to the shear, the important limit states are angle leg bending and prying action. These tend to require that the angle thickness increase or the gage decrease, or both, and these requirements compromise the connection's ability to remain flexible to simple beam end rotation. This lack of connection flexibility causes a tensile load on the upper field bolts which could lead to bolt fracture and a progressive failure of the connection and the resulting collapse of the beam. To the author's knowledge, there has never been a reported failure of this type, but it is perceived to be possible.

Even without the axial load, some shear connections are perceived to have this problem under shear alone. These are the single plate shear connections (shear tabs) and the Tee framing connections. Recent research on the Tee framing connections has led to a formula (AISC Manual LRFD 2nd Ed., Vol. II, p. 9-170) which can be used to assess the resistance to fracture (ductility) of double angle shear connections. The formula is

$$d_{b\,\min} = 0.163 t_f \sqrt{\frac{F_y}{b}\left(\frac{b^2}{L^2} + 2\right)}$$

where:

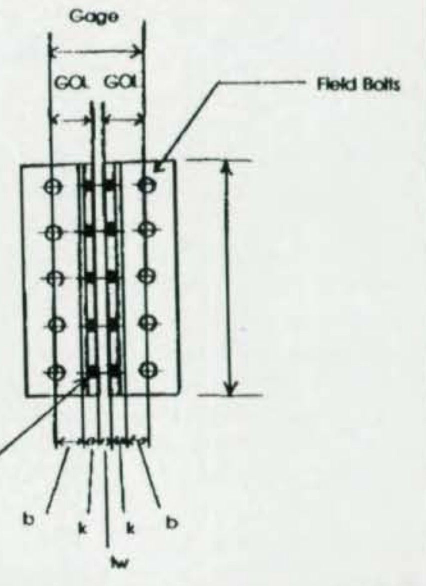
d_b is the minimum bolt diameter (A325 bolts) to preclude bolt fracture under a simple beam end rotation of 0.03 radian, and

t_f is the angle thickness

b is the distance from the bolt line to the k distance of the angle (see Fig. 1)

L is the length of the connection angles.

Figure 1



Note that this formula can be used for ASD and LRFD designs in the form given above. It can be used to develop a table (see Table 1) of angle thicknesses and gages for various bolt diameters which can be used as a guide for the design of double angle connections subjected to shear and axial tension. Note that Table 1 validates AISC's long-standing recommendation (noted above) of a maximum 5/8 inch angle thickness for the "usual" gages. The usual gages would be $4^1/_2$ to $6^1/_2$ in. Thus, for a carried beam web thickness of say $^1/_2$ in., GOL will range from 2 in. to 3 in. Table 1 gives a GOL of $2^1/_2$ in. for $^3/_4$ in. bolts (the most critical as well as the most common bolt size). Note also that Table 1 assumes a significant simple beam end rotation of 0.03 radian, which is approximately the end rotation that occurs when a plastic hinge forms at the center of the beam. For short beams, beams loaded near their ends, beams with bracing gussets at their end connections, and beams with light shear loads, the beam end rotation will be small and Table 1 does not apply.

Table 1
Estimated Minimum Angle Gages (GOL) for A36 Angles and A325 Bolts for Rotational Flexibility

ANGLE THICKNESS (in.)	MINIMUM GAGE OF ANGLE (GOL)*		
	$^3/_4$ in. dia. bolt (in.)	$^7/_8$ in. dia. bolt (in.)	1 in. dia. bolt (in.)
$^3/_8$	$1^3/_8$	$1^1/_4$	$1^1/_8$
$^1/_2$	$1^7/_8$	$1^5/_8$	$1^1/_2$
$^5/_8$	$2^1/_2$	$2^1/_8$	$1^7/_8$
$^3/_4$	$3^1/_4$	$2^{11}/_{16}$	$2^5/_{16}$
1	6	$4^7/_{16}$	$3^1/_2$

*Driving Clearance may control minimum GOL

The design of double angle connections subjected to shear and axial tension, can be accomplished as shown in the following AISC publications.

1. AISC Manual (ASD 9th Ed.), p. 4-94, Ex 34, where the beam web plays the same role as the gusset of this example.
2. AISC Manual (ASD 9th Ed./LRFD 1st Ed.) Vol. II, pp. 7-123 and 124, pp. 7-125 and 126, pp. 7-167 through 170.
3. AISC Manual (LRFD 2nd Ed.), Vol II, pp. 11-38 through 42.

While the design is being completed in the usual way as show in these publications, Table 1 can be consulted to guide the design, if appropriate.

W.A. Thornton
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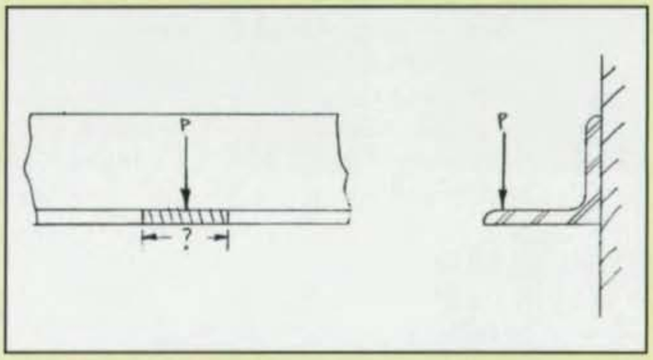
New Questions

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Co nstruction, One East Wacker Dr., Suite 3100, Chic ago, IL 60601-2001.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.



When considering a point load on the standing leg of an angle, what provisions are there for determining the effective allowable member width?

David Chida
Electric Power Door
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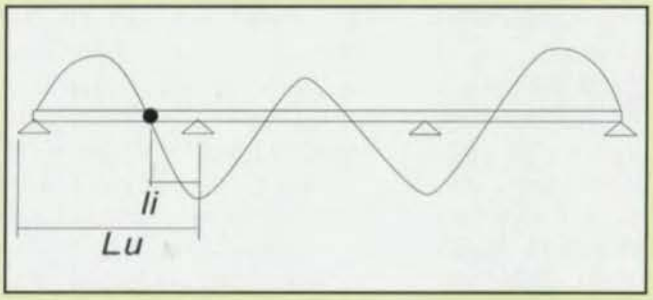

When is it conservative to select the beam shown assuming the unbraced length of l_i and C_b = 1.0?