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.

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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 at:

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Question from September 2000:

The 2nd ed. LRFD *Manual of Steel Construction*, vol. II, Part 11, includes a discussion on holes for anchor rods and grouting in column base plates. Table 11-3 gives recommended base plate hole sizes to accommodate anchor rods. The discussion indicates that "An adequate washer should be provided for each anchor rod." Why are the recommended holes sizes so much larger than those in the ASD *Manual*, Part 4? What washer materials and thicknesses would be considered adequate?

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Hole sizes for steel-to-steel structural connections are not the same as hole sizes for steel-to-concrete anchorage applications. In the case of steel-to-steel connections, the parts are made in a shop under good quality control, so standard holes (bolt diameter plus 1/16"), oversized holes (bolt diameter plus 3/16"), and short and long-slotted holes can be used quite successfully. However, the field placement of anchorage devices has long been subject to more permissive tolerances (and often, inaccuracies that exceed those tolerances anyway and may require consideration by the structural Engineer of Record).

AISC published *Design Guide No. 1: Column Base Plates* back in the early 1990s. At that time, it was recognized that the quality of foundation work was getting worse and worse. To allow the erector (and designer) greater latitude when possible, the permissible hole sizes in base plates were increased. These same larger hole sizes were included in the 2nd ed. LRFD *Manual.* The values there are maximums, not a required size. Smaller holes can be used if desired. Plate washers are generally required with these holes because ASTM F436 washers can collapse into the larger-sized holes, even under erection loads.

The larger hole sizes are primarily intended for the majority of base plates that transfer only axial compression from the column into the foundation. The anchor rods don't usually do much after erection in that case.

For other applications, such as base plates with moment or uplift, the hole size is more of a concern for load transfer. It may be better in these cases to consider a detail that has been called a "boot," an anchor rod chair and a bolt box. Whatever its name, it's a detail with stiffeners that transfers tensile forces from the column flange to the anchor rods directly, not through the base plate. It is a more efficient and direct method to get the load out of the column. If you choose, anchor rods and thick washers over the base plate holes will work in many cases. You can find washer sizing guidance in AISC *Design Guide No. 10: Erection Bracing of Low-Rise Structural Steel Buildings.*

In applications involving shear at the column base, there are several ways to transfer the force. The frictional resistance due to the compressive load in the column is often adequate without further consideration. If not, the column base can be designed for shear using the shear-friction analogy. Alternatively, the anchor rods and plate washers can be detailed for shear transfer or a shear lug can be provide on the bottom of the base plate. When the shear to be resisted is significant, the shear-lug approach may be the most appropriate.

Column base design, erection and other considerations are also covered in a December 1993 *Steel Tips* article available in AISC's online resource library at www.aisc.org/library.html.

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The ASD method for determining the required section modulus for an eccentric connection plate differs in three separate examples in ASD Vol. II, *Connections*. In Example 7 (Page 3-62), the allowable bending stress (F_b) check uses $0.60F_y$ through the bolt holes, i.e., the critical section at net area, to determine the required

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connection plate thickness. In Example 4 (Page B-10), the F_b check uses $0.50F_u$, also through the net area to determine the required plate thickness. Additionally, in Example 2 (Page 1-17), the F_b check includes both $0.60F_y$ on the gross area and $0.50F_u$ on the net area.

The question is: shouldn't $0.60F_y$ be used at the gross section and $0.50F_u$ be used at the net section. That is, when designing the connection plate, shouldn't the plate thickness be based on the section modulus requirements utilizing the greater of $M/0.60F_y$ based on the gross section and $M/0.50F_u$ based on the net section? Is the upper limit for the allowable buckling stress (F_{bc}) $0.60F_y$ or $0.50F_u$?

If the value for F_{bc} is less than its limiting value, either $0.60F_y$ or $0.50F_u$, should this value be used for checks at both the gross and net sections?

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You've touched on three limit states that apply in the design of a bracket plate or similar connection element with a net section: flexural yielding on the gross section, flexural rupture on the net section and local buckling. A clear and complete example of bracket plate design can be found on page 12-7 of the 2nd ed. LRFD *Manual* (Example 12-1). In that example, the flexural yielding strength is determined as $0.9F_yS_x$ (the elastic section modulus is used conservatively, based upon historic practices and engineering judgement); the flexural rupture strength is determined as $0.75F_uS_{net}$; and the local buckling strength is assessed as recommended by Salmon and Johnson in *Steel Structures–Design and Behavior*, 3rd ed. In allowable stress design, the same basic limit states would be applicable, with $0.6F_y$ used for the flexural yielding check and $0.5F_u$ used for the flexural rupture check.

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What is the minimum recommended fillet weld size on a bridge girder? Also, what is the typical haunch dimension (distance between the top of steel flange and bottom of the concrete slab)?

Minimum fillet weld sizes can be found in Table 2.1 of AWS D1.5, the bridge welding code. The minimum size is typically 1/4" (6 mm) for plates less than or equal to 0.75" (20mm) and 5/16" (8 mm) for plates greater than 0.75" (20 mm). Fillet welds should be sized based upon applied forces, but minimums typically govern.

A typical haunch, the distance from the top of the web to the bottom of the slab, is the thickness of the thickest top flange plus 1.25".

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Is there an AISC Specification requirement that simple shear beam connections be a minimum depth? For example, what if a W21 has very little load and only two bolts are required by calculation? The AISC Manual shows a minimum of 4 bolts.

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There is no AISC Specification requirement that specifically relates to the minimum depth of connections. However, there is a good-practice recommendation in the AISC *Manual* that simple beam connections should have a minimum depth of $T/2$ so as to impart some degree of erection stability to the beam. That is, it's a good idea to provide connections that will keep the beams upright before the floor slab is in place. Connection design tables in the *Manual* are set up to incorporate this historically recommended minimum, which is de facto standard practice unless erection stability is provided by some other means.

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