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**.

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Tolerances on Punched Holes

Regarding the tolerance for punched holes, RCSC *Specification* Table 3.1 footnote b simply states that holes are acceptable if properly matched dies are used. Is there a numerical tolerance on punched holes?

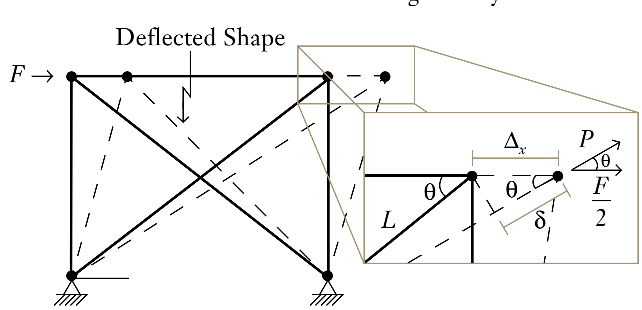
There is not a numerical tolerance for punched holes. The flare size will vary based upon the thickness that is punched because a properly matched die is dependent on that thickness to control the punch energy required to make the hole. The provision is based upon proper matching for that reason, and the matched die size defines the size that is permitted.

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

Braced Frame Stiffness

I've seen various sources showing that the lateral stiffness of a braced frame is a function of $\cos^2\theta$, where θ is the slope of the brace, but I have not been able to find the derivation of this formula. How is the lateral stiffness of an X-braced bay derived?

It's been said that if you give two engineers the same problem to solve, you will end up with at least two different answers. In this case, giving the problem to two engineers in AISC's Steel Solutions Center ended up with same answer, but two different paths were taken to get there. In both derivations that follow, the θ, *A*, *E* and *L* are assumed constant for both braces, and the braces are assumed to be the only source of deformation. The first derivation is based on the deformed geometry.



$$\cos\theta = \frac{\delta}{\Delta_x} \quad\rightarrow\quad \Delta_x = \frac{\delta}{\cos\theta}$$

$$\cos\theta = \frac{F/2}{P} \quad\rightarrow\quad F = 2P\cos\theta$$

$$K_x = \frac{F}{\Delta_x} = \frac{2P}{\delta}\cos\theta$$

$$\delta = \frac{PL}{AE} \quad\rightarrow\quad K_x = 2\frac{AE}{L}\cos^2\theta$$

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

This second approach uses the concept of virtual work, with a unit virtual load in the same position as *F*. In the real force system the force in each brace is:

$$P_r = \frac{F}{2\cos\theta}$$

In the virtual force system the force in each brace is:

$$p_v = \frac{1}{2\cos\theta}$$

For two braces (which adds the factor of 2 in the numerator), the deflection is:

$$\Delta_x = \frac{2P_r p_v L}{AE}$$

$$= 2\frac{F}{2\cos\theta}\frac{1}{2\cos\theta}\frac{L}{AE}$$

$$= \frac{F}{2\cos^2\theta}\frac{L}{AE}$$

The stiffness is:

$$K_x = \frac{F}{\Delta_x}$$

$$= 2\frac{AE}{L}\cos^2\theta$$

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

Alternative Materials

Section A3 of the AISC *Specification* lists the materials approved for use. Why are materials limited to those listed in this section? Can other materials be used?

You may find the Commentary to Section A3 of the AISC *Specification* to be useful; it is printed in the 14th Edition AISC *Steel Construction Manual* and can be found starting on page 16.1-247 (note also that the 2010 *Specification* is a free download at: **www.aisc.org/2010spec**).

The AISC *Specification* references only those materials that are most commonly useful to structural engineers working with buildings and building-like frames. These are the most commonly produced structural materials, and they are known to have a history of satisfactory performance.

The AISC *Specification* does not prohibit other materials from being used when they are considered and qualified by the engineer of record and acceptable to the building official. However, they are not listed because they were not contemplated by the AISC Committee on Specifications during development of the AISC *Specification*. When considering alternative materials, engineers and building officials may find the article that appeared in the August 2011 "Material Substitutions" SteelWise helpful since it outlines some of the more common considerations.

Martin Anderson

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Definition of K-Area

Is the k-area the same as the k-dimension published for W-shapes in Table 1-1 of the AISC *Steel Construction Manual*?

No. The k-dimension and the k-area denote different parts of the cross-section. The "k-area" is located adjacent to the "k-dimension."

A discussion of this topic can be found in the Commentary to AISC *Specification* Section J10.8, including sketches (figures C-J10.6 and C-J10.7) that depict the difference between the k-dimension and the k-area. As shown in these figures, the k-dimension represents the distance from the outside face of the flange to the intersection of the web-to-flange fillet with the beam web. The k-area is the region of the web that extends approximately 1½ in. beyond this intersection.

Keith Landwehr

Slots in HSS

Is there guidance on how far beyond the edge of a gusset a HSS can be slotted?

I am not aware of any published guidance specific to slots in HSS. However, one approach is to determine how far apart stitch welds would need to be to make two channels (each ½ of the HSS) act as a built-up section. You will likely find that the slot can be quite large without adversely affecting the compression strength of the section.

Larry S. Muir, P.E.

Effective Length of X-Bracing

When X-bracing is connected at the center, what should be considered the unbraced length of the brace? Some engineers suggest using the full end-to-end length in determining the effective length, while others suggest using half the length.

In R=3 designs and those that are not expected to undergo large, cyclic inelastic deformations, the unbraced length is typically considered to be the distance from the corner connection to the intersection of the "X," or $L/2$ of the brace. Two AISC *Engineering Journal* articles—"Effective Length Factor for the Design of X-Bracing Systems" (Q1 1986) and "Practical Application of Energy Methods to Structural Stability Problems" (Q4 1997)—discuss this topic.

Note that this practice may not be advisable when considering bracing in a seismic force resisting system that is expected to undergo large, cyclic, inelastic deformations, such as those expected to occur in a special concentrically braced frame (SCBF). In this case, using the full length of the member is recommended.

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

Blast Cleaning and Slip-Critical Connections

In terms of SSPC designation, what level of blast cleaning is required to meet the requirements for "Class A" or "Class B" faying surfaces in the RCSC *Specification*? AISC *Steel Construction Manual* Table 2-8 lists several levels of blast cleaning ranging from "brush blasting" to "near white."

There are two separate considerations related to your question: uncoated surfaces and coated surfaces. Let's start with coated surfaces as they are the easier of the two to address. The required level of blast cleaning for a qualified coating (Class A or Class B) will depend on what was used in the coating manufacturer's qualification testing. In other words, the coating manufacturer should specify the required level of blast cleaning for their coating.

Blast cleaning is not required for uncoated Class A surfaces, so that is another easy one.

Finally, let's look at uncoated Class B surfaces. Neither the AISC *Specification* nor the RCSC *Specification* make a direct reference to a required SSPC surface preparation for uncoated Class B surfaces. The intent is to remove loose mill scale and any other foreign matter and produce a roughened faying surface. From Table 12.2 in the *Guide to Design Criteria for Bolted and Riveted Joints* (a free download at **www.boltcouncil.org**) that grit blasting to white metal produced a slip coefficient of 0.73 +/- 0.05. This is much higher than what's reported in Table 5.1 of the *Guide* for grit blasted surfaces (0.51 +-0.09) or sand blasted surfaces (0.52 +/- 0.09). So, SSPC SP10 (near white) would definitely get you the 0.5 slip coefficient, but you can satisfy the intent with a much lower level. In fact, any of the SSPC blast cleaning preparations listed in AISC *Manual* Table 2-8 will be acceptable. As a bottom line, SSPC-SP6 provides the minimum level of blast cleaning of those listed in the table. This goes hand-in-glove with our FAQ 10.3.4, which addresses blast cleaning in general.

Heath Mitchell, 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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