SPECIAL TREATMENT

When it comes to fabrication, design, and welding of steel shapes, working with HSS is a whole other ball of wax.

BY THOMAS J. SCHLAFLY

AS HOLLOW STRUCTURAL SHAPES (HSS) are inherently different than more common W-shapes, it's no surprise that their design and fabrication are different as well. And because HSS are closed sections and cannot be reinforced or even accessed on the back side, they are also subject to unique welding requirements.

The differences between HSS and other shapes are significant enough that AISC at one time published a separate HSS manual. However, AISC moved the specification provisions for HSS connection design into Chapter K of the 2005 AISC specification to ensure that they were readily available to engineers.

The American Welding Society (AWS) also originally dedicated a chapter of AWS D1.1, *Structural Welding Code—Steel* specifically to HSS provisions, but following a reorganization in 1996, distributed those provisions to the various chapters of the code (these provisions include design, fabrication, and qualification requirements for welders and welding procedures). But besides these written provisions, there are also real-life lessons to be learned about welding HSS connections.

Overlapping Connections

Many HSS connections come in the form of overlapped K connections, where one branch overlaps the other (see Figure 1). This creates an area where two pieces of HSS meet, one that cannot be seen after fabrication. This is known as a "hidden joint," and this situation raises a question: Does a symbol showing a weld on the *visible* branch-to-chord joint indicate a weld on the *hidden* branch-to-chord-joint? A welder with little experience with tubular joints would think it unreasonable to *not* weld the hidden joint. But welders that routinely work with HSS are aware that the overlapping diagonals frequently do not have clearance for fit-up after the overlapped branches have been welded. This is particularly true for round HSS. If there is a sequence that works, it may demand repeated repositioning of a truss to do it.

While positioning a beam takes a lot of time, positioning a truss takes even more time. So the welding of the hidden joint can get pretty expensive, much more so than simply adding arc time for the additional inches of welding. As such, there are "rules" as to when the hidden joint needs to be welded—and quite often it does not (see p. 378 of the 2005 AISC specification Commentary K2). Therefore, it is reasonable to interpret a symbol indicating a weld only on the visible joint to mean that no weld is necessary on the hidden joint. Bottom line, welding symbols indicating a weld in a hidden joint must be clear and specific.

Gapped Connections

Of course, another way to eliminate issues with the hidden weld in an overlapped connection is to use a gapped connection instead (see Figure 2). While it is true that this may cause an eccentricity on the chord, and may also cause increased deformation of the connecting chord face, the research on gapped connections is thorough and the design methods are clear in Chapter K of the AISC specifica-

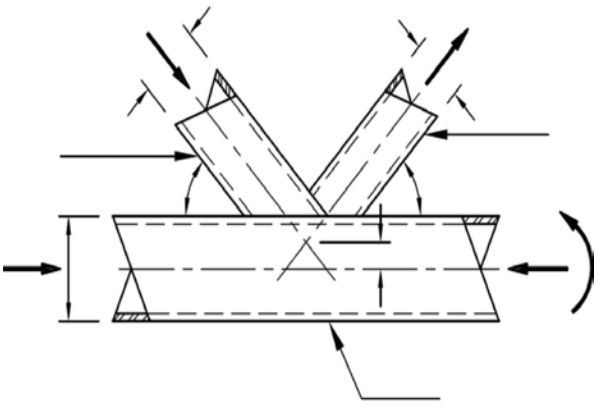

Figure 1. Overlapped connection.

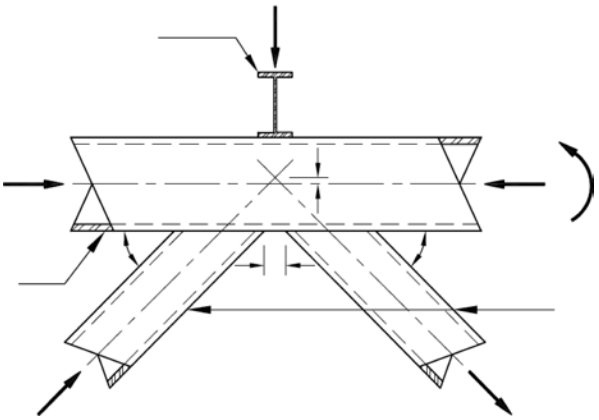

Figure 2. Gapped connection.

tion. With gapped connections, the chord and weld sizes often do not have to be increased from those used with overlapped connections, and the cutting, fitting, and welding are significantly simplified.

Gusset Plates

Another way to reduce problems with HSS truss-type connections is to use gusset plates. They can be cut and finished to suit architectural requirements, and used to eliminate the unusual geometry in cutting, tolerance issues with fitting, and one-sided welding associated with direct-welded truss connections. And on the design side, they can eliminate problems with punching shear and ovalization.

PJPs and Fillets

Partial joint penetration (PJP) welds or fillets make the cutting and qualification easier, and on round HSS can often be designed to develop the strength of the branch or the capacity of the connection. Fillets work particularly well in "stepped" square/rectangular HSS connections where the branch members are about 80% of the width of the chord. That width ratio gives the welder a place to put the fillet, and the designer still obtains a high connection capacity, unlike with smaller branch members. When PJP welds and fillets are used, the designer must be wary of uneven loading (hot spots) along the weld. (Provisions for this are included in AISC and AWS design specifications.) The designer also must check side wall crippling and face plastification, which occur differently than with open-section connections.

Where the HSS members to be connected are rectangular and have the same width, the corner radius of the chord member leaves a gap between the chord and the branch that must be filled. There are a number of conventional ways to deal with that gap, but they all involve expenses that are avoided if stepped connections are used.

Lessons Learned

There are many lessons to be learned in the design and construction of HSS truss-type connections. But the lesson that encompasses them all is this: Connection and welding issues play an even larger role when choosing HSS member sizes than when choosing open-section member sizes. MSC

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