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CALM, COOL AND CONNECTED

Cracking the challenges of designing HSS connections.

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WHEN ASKING DESIGNERS and fabricators to share their biggest challenge in using hollow structural sections (HSS), the answer is almost always the design of connections.

Connections involving HSS are often said to be too hard and too expensive to design and fabricate. Some designers complain that there are not enough resources or information on the subject.

The Tempe Town Lake pedestrian bridge in Tempe, Ariz., has four 225-ft tied arch spans made from 16-in.-diameter HSS.

While it's true they can be a challenging subject, information does exist to guide the design of all typical HSS connections. Furthermore, the truth is that many connections for HSS are not so different from connections that join wide-flange and similar structural steel members. In fact, when HSS are used as braces or columns, the connections are often identical or at least very similar.

HSS truss connections are covered in the literature discussed below, but it is important to understand the difference in applicable limit states and behavior of HSS—and also that the size of HSS members has a greater influence on the connection and joint capacity. The local strength and limit states of HSS have a direct impact on the connection design.

This article will help point you to the available references; it can also serve as the starting point for a discussion with a fabricator to make your HSS connections as cost-effective as possible.

Think Thickness

One of the first things to consider is wall thickness. Choosing an HSS with a wall that's too thin may make it difficult to attain the required connection capacity. For example, when selecting the lightest HSS for a column application, you may find that a shear plate connection does not have the required capacity to carry the applied beam reaction due to the limit state of plastification of the face of the HSS. Save yourself some grief later on and make sure the wall is not slender. Otherwise, you may be stuck paying a lot more for through-plates. There are other similar examples, including the wall thickness at truss joints.

Tension and compression connections. Tension and compression connections include connections for bracing members and splices between two members. Braces usually have slotted gusset plate connections, but other details exist.

HSS-to-HSS truss connections. Trusses are generally analyzed as pin-connected, so these connections are usually designed for the primary tension and compression loads. However, it is important to pay attention to the eccentricities that can arise from the truss geometry and joint configuration. These eccentricities can lead to secondary moments in the members and joints that should be accounted for. And as mentioned before, the wall thickness can control the strength of the truss at the connection, so it pays to make sure the joints will work before selecting the final member size.

Shear. Shear connections to HSS columns do not differ greatly from connections with other steel shapes. In fact, a lot of the typical shear connections such as single-plate, single- and double-angle, single-WT and seated connections are applicable whether the supporting column or beam is a wide-

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Bolted tee end connections are simple and effective for tension and compression loads.

flange section or an HSS. The dimension of the workable flat dimension of the HSS column face and the connection material must be compatible—easy for a single-plate but perhaps a challenge for double-angles with smaller column sizes.

Moment connections. Moment connections are likely to be some of the more challenging connections for HSS, and both wide-flange and HSS beams rigidly connected to HSS columns can present a few challenges to both the designer and the fabricator.

When it comes to moment connections in high-seismic applications, these need to be prequalified—otherwise connection testing is required. There is currently only one prequalified moment connection that uses an HSS column: the proprietary ConXTech XL connection.

For R=3 applications, there are more options available. The simplest form of moment connection involves running the beam continuous over the top of the HSS column. This is a good way to develop continuity, and it works well for single-story construction and roof framing in multi-story construction.

Generally, HSS moment connections require diaphragm plates. These plates can either be attached to the outside of the column, acting as a collar, or pass directly through the HSS column. The former detail is as strong as the latter but costs less, and the column is not cut and reconnected during fabrication. These moment connections can provide the full moment capacity of the beams when used with an HSS column that has adequate capacity.

What about directly welded details? While this kind of detail can be built, it cannot develop much of the full moment capacity of the beam, due to the flexibility of the HSS column face. To maximize the strength of this connection, it is important to use the widest beam possible to spread the load out across the column.

Yes, HSS-to-HSS moment connections are used, but generally only in applications that do not require the development of significant moments, such as highway signage structures and Vierendeel trusses.

Resources

Guidance is available on all of these and other HSS connections. In fact, there are several good resources on HSS connections. The AISC *Specification* (ANSI/AISC 360-10) includes Chapter K, which covers the design of HSS connections (this document is a free download at **www.aisc.org/epubs**). The AISC *Steel Construction Manual* also includes design information as does AISC Steel Design Guide 24 (a free download for AISC members at **www.aisc.org/epubs**).

The design provisions included in AISC *Specification* Chapter K are based on the same criteria used to develop the CIDECT design guides. CIDECT (the International Committee for Research and Technical Support for Hollow Section Structures) is an international association of leading pipe and tube manufacturers whose mission is to expand the knowledge of HSS and its applications through research and study. There are nine CIDECT design guides (these also are available, along with a lot of other HSS-related information, for free download at **www.aisc.org/hss**). They cover several subjects on HSS and connections, including both static and seismic loading, joints subjected to fatigue, composite HSS, HSS exposed to fire and column connections. While these design guides reference related Eurocode clauses, they are still an excellent resource for subjects that are not typically covered by the AISC *Specification* and Design Guides. MSC