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HSS

ARTICLE

CONNECTING TO STRUCTURAL CASTINGS

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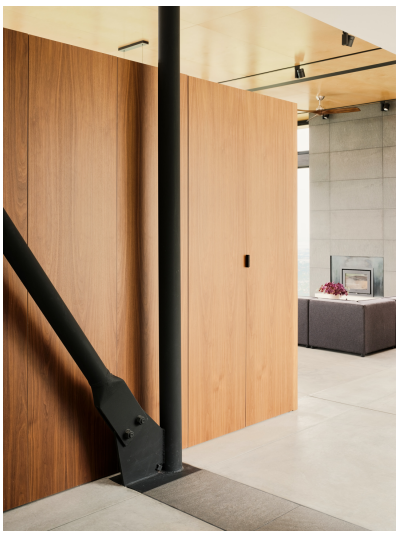
Steel castings are not just for the highly visible and complex showcase structures you see highlighted in magazines. While no one can argue their architectural splendor, we are finding them increasingly applicable in “standard” construction. For example, a round hollow structural section (HSS) brace is often slotted and welded to a gusset in a braced frame. Detailing the connection as an off-the-shelf casting not only provides a visual advantage to our architectural clients but it also negates shear lag considerations, and for higher seismic designs, there is no need to reinforce the slot in the section.

Castings also solve problems. Castings can be used for nodes in tubular structures with many intersecting members, complex geometry, and/or tight angles that wouldn’t allow for adequate welding and inspection access in conventional fabrication. The welded seams between the casting and the HSS can be placed away from the node in a less-stressed location, resulting in more efficient weld design. The lack of sharp edges and the ability to maintain the member cross-section through the joint also make castings an especially attractive solution for fatigue or heavily loaded joints.

Steel castings are formed by pouring molten steel into a mold that is typically made from sand. In structures, castings are often used as member end connections or nodes where multiple members intersect. The connected members are typically conventional steel shapes such as HSS. The connection of a casting to a structural member can be achieved a number of ways, including bolting, pinning and welding to name a few. The connection between castings and HSS is typically achieved by a shop or field weld.

As is typical of conventional steel construction, a shop weld is preferred and is typically used to connect castings at the ends of members such as braces or columns. In joints where multiple members intersect, shop welding all joints may not be possible due to size and transportation constraints. In this case, performing as many of the welds as possible in the shop is preferred, leaving minimal work to be done and inspected in the field.

Castings can be as cast or machined at their interface with the structural member to provide the proper preparation needed for the weld specified. Whether a partial joint penetration weld or a complete penetration weld is specified, a prequalified weld can be executed without additional backing or fabrication. As is always the case, preheating may be required for welds between very thick rolled and/or cast steels.



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Before a weld can be specified, a material for the casting should be considered. AISC 360-16, Section A3.2 indicates castings “shall conform to an ASTM standard intended for structural applications…” but the design and fabrication of castings is not covered by this specification. AISC Steel Construction Manual, 15th Edition, indicates castings are specified as ASTM A27 Grade 65-35 or ASTM A216 Grade 80-35. The Steel Founders’ Society of America indicates ASTM A27 and A148 are material specifications adequate for structural applications (Steel Founders’ Society of America, 2020). Additional grades for structural applications are defined in AISC Design Guide 21 (Miller, 2017) as ASTM A216 Grades WCA, WCB or WCC; ASTM A352 Grades LCA, LCB or LCC; and ASTM A958 Grade SC8620 Class 80/50. ASTM A216, A352 or A958 grades are preferred as those standards dictate more specifically the chemical requirements than do A27 or A148.

Steel castings can have chemical compositions similar to the member to which they are connected. This is the case with the ASTM Specifications listed above, and therefore the weldability of the casting would be similar to the member. Among the specifications listed above, castings produced to the ASTM A216 Specification have the highest weldability but also limited strength. Yield strengths range from 30 to 40 ksi depending on the material grade specified. Supplement S50 allows for a maximum carbon equivalency of 0.50, which improves the weldability of ASTM A216 material (Miller, 2017). ASTM A352 lists 10 grades, three of which are commonly used for structural applications. A352 corresponds similarly to A216 except that A352 requires a specified Charpy V-notch toughness test. It also carries a supplement allowing for a specification of a maximum carbon equivalency. The benefit of specifying ASTM A958 Grade SC8620 Class 80/50 is the higher minimum yield strength requirement of 50 ksi.

Cast steels have yet to be included as approved base metals in Table 5.3 of AWS D1.1:2020. Therefore, a Weld Procedure Specification must be qualified by testing when castings are to be welded. Ideally, testing should be performed on material with similar chemistry, thickness and shape. Test plates of cast material can be obtained from the casting manufacturer, and HSS can be manipulated to create the required test plate. Because of their similar chemical and mechanical properties to the members they are often welded to, it has been suggested that the ASTM specifications used for castings and identified above be added to AWS D1.1:2020, Table 5.3. The case for this addition is presented in a Welding Journal article (David et al., 2015), but the committee has not yet approved this.

Project specifications should include nondestructive examination requirements to verify the integrity and soundness of not just the global casting, but especially the material in the vicinity of the welded joints. This will identify any discontinuities in the casting at the critical interface with the connecting member.

Castings used in an architecturally exposed structure can be connected to HSS members seamlessly. As with all architecturally exposed structural steel, the welds may need to be ground smooth and flush between the casting and the connected structural member and filled if necessary. Proper attention should be paid to the surface preparation after these post-welding activities to ensure the application of the coatings (primer and paint) provides the desired seamless result.

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