

How to determine the
best connections for steel joists and metal deck.

MORE or Less

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CONNECTIONS INVOLVING open-web steel joist and steel deck aren't always intuitive.

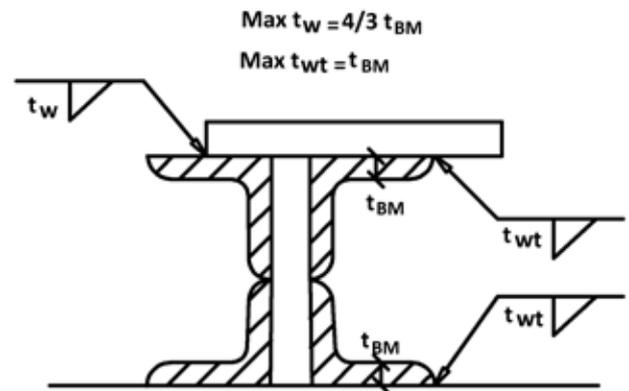
The key is knowing the difference between situations where more is not necessarily better and those where more is definitely better. Understanding this balance, as well as recognizing and strengthening weak points, knowing the options for standard fasteners and proprietary fasteners and learning how to enhance the connections for easier field installation, can go a long way in creating the best connection solution for the joists and deck in any given project. Here, we'll examine some of the more common connection options for joists and deck.

Welding

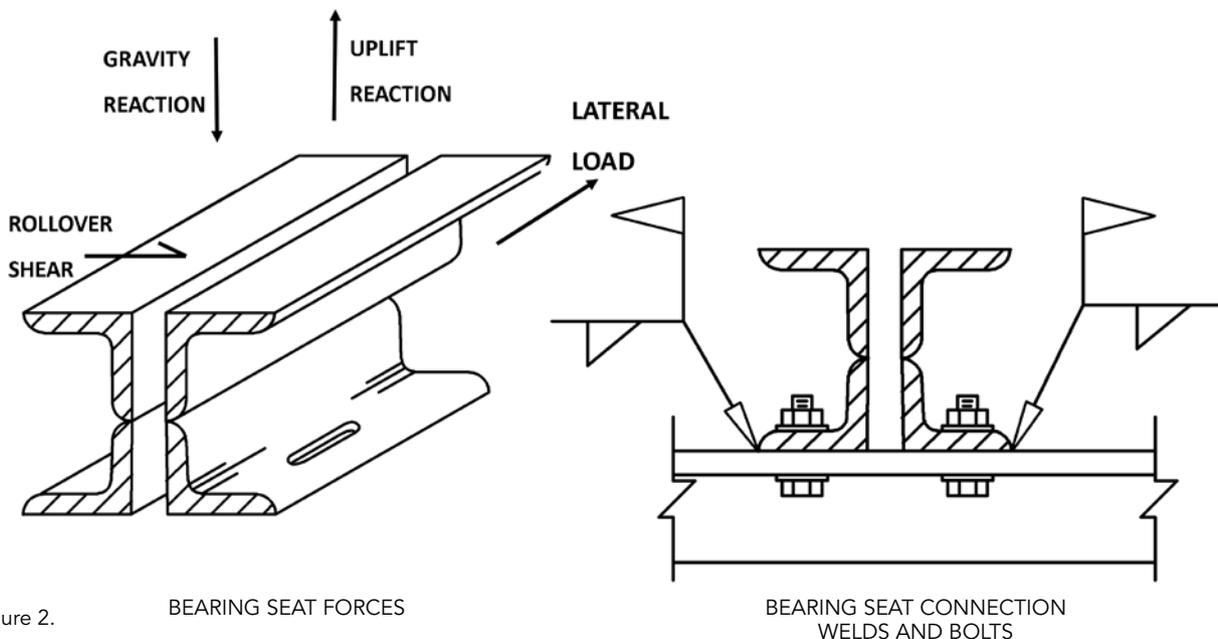
Let's start with welding, which is one of the "more is not always better" scenarios—especially with regard to fillet weld thickness when welding to steel joists. Steel joists have an excellent strength-to-weight ratio, and the individual components are relatively thin. A longer, thinner weld is best for joist economy, so as not to force joist components to be thicker simply to accept the weldment. For a weld placed at the toe of a chord angle, as shown in Figure 1, the fillet weld thickness cannot exceed the thickness of the chord angle. To avoid a potential

shear tear-out, a fillet weld placed on the joist chord leg should not exceed approximately $\frac{4}{3}$ of the chord angle thickness. Using fillet weld thicknesses of $\frac{1}{8}$ in. for K-Series joists, $\frac{3}{16}$ in. for LH-Series and smaller joist girders and $\frac{1}{4}$ in. for DLH-Series and larger joist girders will prevent the weld thickness from unnecessarily controlling joist component sizes.

▼ Figure 1: Weld sizes.



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▲ Figure 2. BEARING SEAT FORCES

BEARING SEAT CONNECTION
WELDS AND BOLTS

Bearing Seat Connections

Bearing seat connections provide a good example of where balance and simplicity are needed. Joist and joist girder bearing seat connections often carry forces in four different directions. Those connections may be resisting gravity loads, a net uplift end reaction or lateral loads both perpendicular and longitudinal to the seat, as illustrated in Figure 2. The bearing seat may be bolted *and* welded to the support.

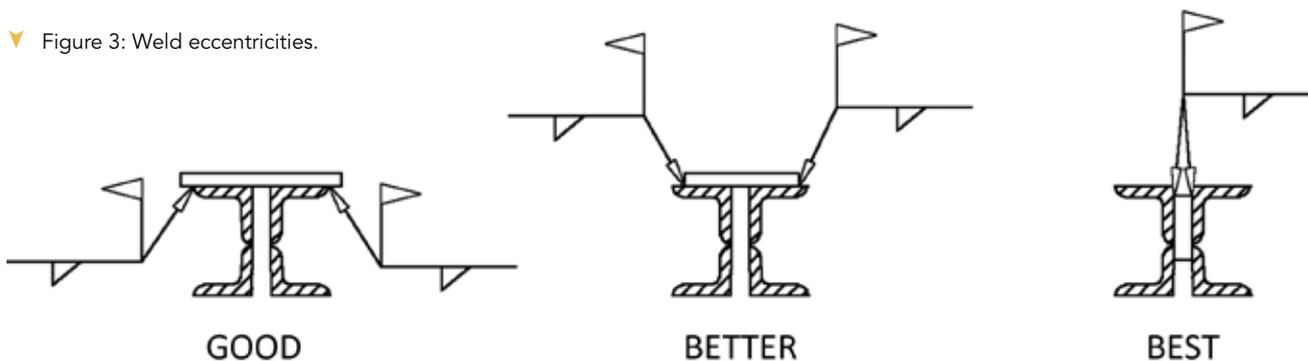
While bolts and welds may both be present, they should not be considered as acting together to resist all of the forces. Joist and joist girder bearing seats for bolted connections are made with slotted holes to allow fabrication and erection tolerance. Note that the slotted connection does not qualify as an AISC slip-critical connection. The weld at the seat prevents movement in the direction of the slot and serves the role of resisting the forces required to laterally brace the supporting structure and transfer forces in the lateral load resisting system. Separately, the net uplift end reaction force is acting in another direction, and the bolts are used to anchor the bearing seat, as shown in Figure 2. Particular attention is required for this connection and the bolts used at the bearing seats. The minimum of two 3/4-in. bolts, as required by Steel Joist Institute (SJI) specifications, may not be adequate for the uplift end reaction of a joist girder. SJI suggests a practical limit of 24 kips (ASD) for two 3/4-in. ASTM A325 bolts, with typical bearing seat construction (considering prying action of the seat angles). With a different seat construction, the full tensile capacity of the bolts may be achieved—39 kips for two 3/4-in. A325 bolts—but a large girder

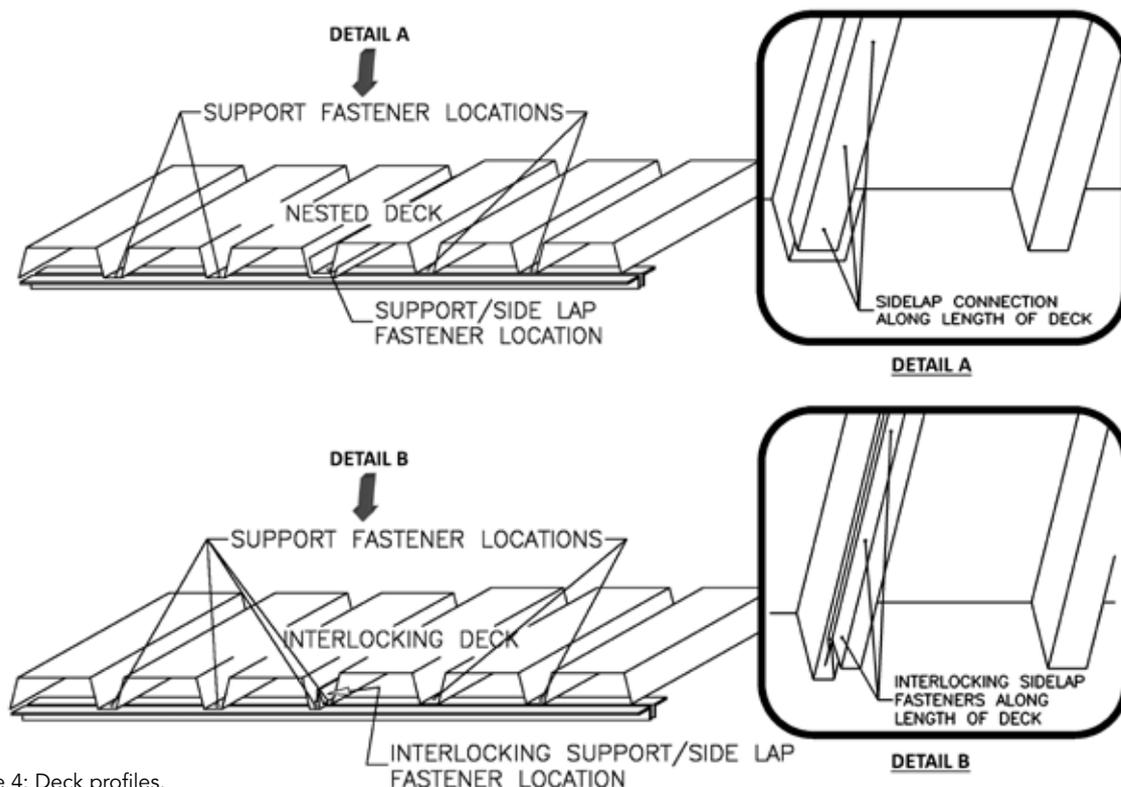
in a moderate to heavy wind area could have an uplift end reaction in excess of that bolt capacity.

The joist girder uplift end reaction used to determine the connection is typically conservative if the summation of the joist components is used. A reduced joist girder uplift end reaction can be obtained from the main wind resisting system (MWRS) analysis. When the loads are greater than what a standard connection can resist, larger-bolt diameters, higher-strength bolts or even a four-bolt pattern may need to be considered.

The eccentricity induced in a bearing seat connection can be significant. Ensuring that a joist bearing seat has an adequate bearing length and proper bearing depth, in order to allow the end web to intercept with the top chord over the support point, is essential in reducing eccentricities. Also, the placement of the connection welds or fasteners needs to be considered for eccentricity. For example, when a joist or joist girder is carrying a lateral load from wind or seismic, reducing eccentricities should be considered when specifying a connection. If the load path to transfer a lateral load from top chord is through the bearing seat, significant forces due to the induced eccentricities need to be considered and resisted. When transferring forces from joist to joist, an additional plate (see Figure 3) virtually eliminates eccentricities. In addition, this type of lateral load transfer detail can be classified as “good, better and best.” Figure 3 illustrates this for joist girder seats when the loads can be very large. “Better” is preferred over “good” because it replaces a difficult overhead weld with a common fillet weld. “Best” is preferred over “better” because it moves the welds closer to the center of the joist girder.

▼ Figure 3: Weld eccentricities.





▲ Figure 4: Deck profiles.

Deck Connections

A key aspect of designing connections for deck is recognizing that one solution is not best for all situations. A review of the typical design process illustrates how the attachment decisions are made.

The deck design typically includes the selection of a deck profile and gage that meets the stress and deflection requirements for the out-of-plane (gravity and wind) loads. While not usually governing, bearing should also be checked.

Deck attachments that meet in-plane seismic or wind lateral loads—and if applicable, combined lateral and uplift loads—are then selected. Some of the considerations to evaluate when specifying an attachment system are:

- ▶ Ensure selected fasteners are appropriate for the support member thickness. Coordinate the fastener substrate thickness requirements with the joist top chord thickness specifications.
- ▶ Recognize that interlocking deck sidelaps use different types of connections (proprietary clinched connections, top-seam welds, or button-punches) than nested sidelaps (screws, fillet welds or arc-seam welds). See Figure 4.
- ▶ Properly consider the effect of connection shear and tension interaction due to combined shear and uplift on the diaphragm system capacity.
- ▶ Zone fastening patterns (and deck gages) to match changing demand across the diaphragm.
- ▶ Reduce costs through use of nontraditional support fastener patterns (such as 36/7 at end laps and 36/4 at interior supports), which may meet required strength and stiffness with significantly fewer fasteners.
- ▶ Select fasteners that are easy to reliably inspect, such as proprietary clinched sidelap connections comparable to top-seam welds on interlocking sidelaps.
- ▶ Understand the aesthetics of installed fasteners relative to the end use of the structure—are burn marks or protruding fastener tips acceptable?
- ▶ Minimize labor for trades that follow the deck installation—for example by eliminating the need for interior touch-up painting

through the use of mechanical fasteners in lieu of welding.

- ▶ Verify that fastener requirements as determined for diaphragm resistance are sufficient to comply with any applicable Factory Mutual or UL provisions, which often include attachment type and spacing requirements.

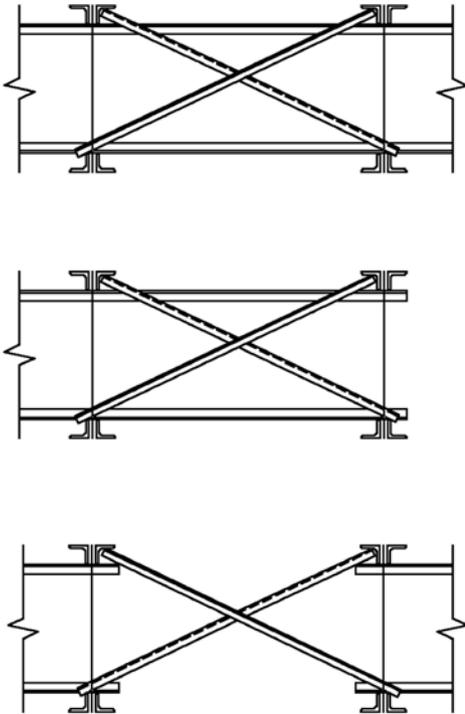
The final step in the diaphragm design is to ensure that the number of support attachments at diaphragm chords, struts, ties or other collector elements that are parallel to the deck flutes is adequate to develop the full capacity of the diaphragm. The number of required support attachments is determined based on the nominal diaphragm shear required and the nominal shear strength of the support fastener. Nominal values are used for this calculation because the safety and resistance factors typically published for individual fastener strengths are different than those used for diaphragm system strengths.

Connection and/or diaphragm system strength and stiffness values are available from manufacturer's literature and design aids. Performance of powder actuated fasteners (PAFs) and the proprietary clinched side-lap connections not quantified by recognized design standards must be determined by testing, using appropriate statistical analysis of the safety and resistance factors. Most manufacturers obtain product evaluation reports to provide an independent review of the published fastener and/or system performance.

Selecting the “best” deck fastening system is dictated by considering all of the design requirements (structural and nonstructural) in conjunction with the installer's preferences and capabilities. There is usually more than one combination of connection type and pattern or spacing that will achieve a specific design objective. Sometimes the use of a larger number of connections with lower individual strength, such as PAFs, is more economical to install than fewer stronger connections, such as welds. In other situations, a larger number of connections with a lighter deck is the most economical solution. Providing the design requirements in the design documents facilitates evaluation of alternate systems. Willingness to consider solutions can lead to the most cost-effective installation for the owner.

Bridging Connections

While they are not large or cumbersome, connections to maintain the continuity of, or to terminate, horizontal bridging lines are essential. Horizontal bridging is considered a two-way system that needs to extend in both directions from each joist to a point of anchorage at a wall, beam or other primary structural element. The bridging can be terminated with diagonal bridging that resolves the forces between the top and bottom chords where anchorage points are not available, or in order to resolve accumulated forces in a long bay. If for any reason a horizontal bridging line must be cut or the continuity is lost, then a termination needs to be added in the form of diagonal bridging, as shown in Figure 5.



▲ Figure 5: Horizontal bridging termination.
▼ Figure 6: Deck shear force transfer.

Shear Connections

If and when shear forces need to be transferred from the deck to the structural load resisting member, such as a joist girder, these connections become part of the lateral load resisting system. There are two common methods to transfer shear forces from the deck to the structural member: roll-over, in which forces act perpendicular to the joist seat, or through a shear collector, which is connected directly from the deck to the structural member. When roll-over forces are specified, the bearing seats need to be stiffened to resist the forces. In some cases, a stiffened seat can only resist 2.0 kips. These types of connections can be very costly both in the joist seat and the deck connection to the joist, and should only be used when the magnitude of the loads and deck connections is a good fit. A shear collector can resist heavier loads and distribute the loads uniformly. With shear transfers of this type, more frequent connections of lesser capacity are better than fewer connections with greater capacity.

Care must be taken to correctly detail and place shear collection elements that run parallel to the metal decking. As shown in Figure 6, if the shear collector is not properly placed and is narrow, it may fall entirely below a top deck flute, leaving no contact for attachment. An HSS member, for example, is a good option that allows more contact surface than, say, a channel section.

With joist and deck connections there are situations where more is not necessarily better and then there are those where more is definitely better. Different scenarios may require different solutions, and often there is more than one option. It's a matter of reviewing each situation and determining the best one, with an emphasis on keeping it simple and practical while meeting the needs of the project. ■

