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DILIGENT DECK DESIGN

Tips to help your next steel deck project go smoothly.

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IT TAKES A LOT to keep steel deck in place.

Large steel deck roof and floor structures can consist of hundreds of steel deck panels and sheet metal accessories and thousands of powder-actuated fasteners, screws , arc spot puddle welds and shear stud connectors. The steel deck fasteners are installed at regular spacings on the panels and contribute strength and stiffness to the overall diaphragm system. Steel deck diaphragms resist lateral forces due to wind or seismic action, and their performance is directly related to the quality of the structural and sidelap connections. In other words, there is a lot of detail and effort that goes into properly designing and building steel deck systems, and there are some aspects that can go wrong or be overlooked. Following are some design and construction tips for structural engineers and installers that may facilitate an efficient and successful deck project.

Materials and Layout

It may seem elementary, but the installer should always ensure that the proper steel deck type is on-site and that it is placed in accordance with the project plans and specifications. This includes the correct deck profile (B, N, etc.), gauge thickness (22, 20, 18 or 16), surface finish and orientation. The installer should use care in measuring and marking the steel deck endlap conditions as specified, including the endlap dimensions or butted endlaps.

Fastening Locations and Patterns

One of the first steps in making a proper steel deck fastening is to make sure it's the right type in the right place. Installers should mark the steel deck fastening locations in the lower flutes of the deck over the steel supports and at endlap locations for structural connections. Fastener marks should be made with permanent marker or chalk prior to fastener installation. Sidelap fastening locations can similarly be marked on the deck panel edges where they nest or interlock with adjacent panels.

Frame fastener locations are typically represented in a pattern convention of "deck panel width/fasteners per sheet width," such as 36/7 for a 36-in.-wide steel deck panel with 7 contributing fasteners across that width. Sidelap fastener locations are represented in either a "center-to-center" spacing convention or "number of fasteners per span" convention. Either is acceptable, although regional preferences may exist, with West Coast designs typically using center-to-center spacing.

Fixing Mistakes

In cases where an improper or missing mechanical fastening or insufficient arc spot puddle weld occurs, the typical field procedure is to reinstall another mechanical fastener or re-weld the steel deck panel adjacent to the improper or missing connection in the same lower flute of the steel deck panel. Improper fastenings can include under or over-driven powder-actuated fasteners, under- or over-torqued screw fasteners and arc spot puddle welds that are too small or that have excessive weld burn-through. The structural engineer should be informed when these situations occur, as the steel deck design may be affected. The important point is to catch and correct improper or missing fastenings before concrete, insulation or roof coverings are installed, which would make repairs from the underside much more difficult later.

Connection Quality

Mechanical fasteners should be installed in accordance with manufacturer's instructions with tight clamping of the steel deck to the steel supports. Fastener washers or heads should not be cutting into the steel deck. This may occur during over-driving of fasteners if installation tools do not have power regulation or power adjustment features. Under-driven fasteners with excessive stand-off may also be inadequate, but the same fastener should not be re-driven. Instead, the power should be adjusted on the installation tool and a new fastener should be installed next to the under-driven fastener. Similarly, screws should be properly installed. Over-driven screws may have cracked or separated heads from the screw fastener shanks. Under-driven screws can also occur where the fastener head is not clamping the steel deck down to the base steel. Battery-operated or electric screwdrivers with adjustable torque settings, torque clutches or depth gauges should be used to facilitate proper and consistent setting of screws. A good recommendation is to conduct trial fastenings to set up the correct equipment prior to doing the work. (For optimized steel deck design with powder-actuated fasteners, screws and welded connection options, design assist software exists at www.us.hilti.com/decking.)

Ensure that arc spot puddle welds are of the proper size and made with the right electrode. The American Welding Society (AWS) D1.3 *Structural Welding Code—Sheet Steel* should be consulted for weld defect requirements such as cracks, porosity or visual discontinuities. Arc spot puddle weld diameters are viewed from the top surface of the steel deck and may be measured with gauges, rulers, calipers or other devices, but keep in mind that this represents only the visible weld diameter and not the effective diameter underneath the deck surface where the weld fusion occurs. AWS D1.3 provides some field testing measures for deck welds to verify connection quality. Welding machine settings and amperage should also be checked and properly set for the specific application.

Weld burn-through is damage to the steel deck panel that occurs when the welder strikes too long of an arc and burns a hole

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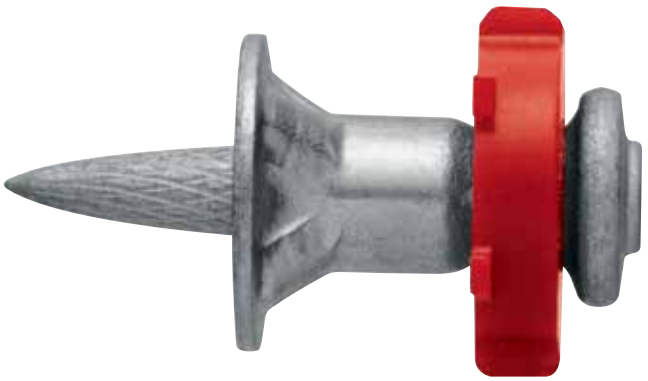
in the deck adjacent to the weld location. This may weaken the deck locally and require repair, depending on the location and size. Weld burn-through can also be a major aesthetic problem in big box retail stores and other applications with exposed ceilings. Large burn-through spots may need to be covered with sheet steel patches stitch screwed to the steel deck, and underside painting may also be required depending on the deck finish. Welding temperatures effectively burn off steel deck panel zinc coatings and paint. These should be repaired or touched up with zinc-rich compound or paint to ensure corrosion effects are inhibited when corrosion is an issue.

After the steel deck is installed, loose construction material and consumables including screws, fasteners, welding electrodes and other metal debris should also be removed from the work surface in order to prevent rust spotting. Policing the steel deck job site after installation is just good workmanship.

Deck Endlaps

Ensure that steel deck endlaps are tightly nested and in contact with one another and the steel supports. Steel deck endlaps are critical locations on steel deck diaphragms and represent areas where shear forces in the panels transfer to the adjacent panels for diaphragm continuity and load path. The endlap can be a double- or four-layer connection of steel deck. These can be particularly challenging to mechanically fasten or weld properly in 18- and 16-gauge thicknesses. Care must be taken to make sure these connections are secure. Double-layer endlaps exist for both nestable and interlocking deck profiles and four-layer corner connections exist at the panel edges for nestable deck profiles where the deck panels sheets overlay both laterally and longitudinally.

Keep in mind that AWS D1.3 provides a total sheet steel thickness limitation for welds of 0.15 in. Arc spot puddle welding through multiple steel deck sheets in the thicker gauges can be impossible or impractical due to reduced shear capacities. In cases where the heavier deck gauges can't be brought into bearing and the gaps can't be removed, structural engineers may want to consider designing the steel deck with butted ends, with the understanding that this requires an additional row of fasteners or welds per steel deck panel end. Butted ends of steel decks bearing on open-web steel joists also entails connections on both sides of the joist top chord for a balanced connection. Although this may not be the most preferable solution from the installer's standpoint, a single steel deck layer will produce a more reliable connection regardless of the fastening method.



A powder-actuated fastener for steel deck attachment.

Another option is to specify a mechanical fastener rated for multiple sheet connections. Short mechanical fasteners without sufficient shank length and fasteners with smooth tips and no washers should be avoided. Powder-actuated fasteners with longer shank lengths and fully knurled tips can increase the ability of the fastener to resist combined pull-out and shear forces generated during prying action of the endlap connection. Similarly, screws should have the proper diameter, sufficient shank length and right drill tip for the combined thickness of steel deck and steel supports.

Bearing Conditions

Ensure that the steel deck is in direct bearing in-plane with steel supports, with no gaps between the steel deck panels and the steel supports. No knife-edge bearing conditions should exist, otherwise the connection may not perform as intended. If knife edge bearing conditions exist, bent plates are generally used to ensure in-plane bearing of the steel deck panel on the base steel surface. These conditions can occur due to excessive construction tolerances and roof slopes.

Gaps in the connection surfaces as small as ⅛ in. may inadvertently introduce additional shear and bending forces on fasteners or welds that might lead to overstress and ultimately causing premature connection failure. Gaps in the connection may also prevent welds from fully penetrating through the steel deck panels and connecting to the steel supports. In certain cases with thinner deck, the driving energy of powder-actuated fastening systems may be sufficient to pull loose steel deck panels down into contact with the steel supports, but that should not be relied upon with thicker deck gauges. The best solution is to have the steel deck panels in direct bearing on steel supports prior to fastening of any type.

Verified Test Data

There has been extensive historical use of analytical design procedures for calculating the shear strength and stiffness of steel deck diaphragms. These analytical models are well-proven but in order to meet the performance demands of modern steel structures, many manufacturers also test their steel deck systems. Tests should follow the AISI S907 *Test Standard for Cantilever Test Method for Cold-Formed Steel Diaphragms*, AISI S905 *Test Methods for Mechanically Fastened Cold-Formed Steel Connections* and ICC-ES AC43 *Acceptance Criteria for Steel Deck Roof and Floor Systems*. Both large-scale and small-scale test conditions should match the project application as closely as possible, including the number, type and fastening patterns of connections and their application limits, weld times, quality control and repeatability of other proprietary connection methods, number of deck spans and endlap conditions. Structural engineers and installers should read evaluation reports and approvals closely, paying attention to any diaphragm shear table footnotes, conditions of use and limitations.

Better Deck Projects

Checking items such as the steel deck materials, fastener types, connection quality, deck endlaps and bearing conditions during the construction process can help improve the quality of installed steel deck roof and floor systems. Structural engineers should also use diaphragm test data carefully and verify that tested conditions are appropriate for their project designs. There are many other design and construction aspects involving steel deck that need to be addressed, but these are just a few tips that may help avoid problems on future projects. MSC