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steel interchange

Steel Headed Stud Anchors Welded to Bent Plate

We have conditions where ¾-in.-diameter steel headed stud anchors cannot be placed directly on the beam flange and instead must be attached to bent edge plate that is in turn welded to the beam. I have two questions: 1.) If we weld the ¼-in. bent edge plate adequately to the transfer the shear force from the stud to the top flange of the beam, can the shear studs be attached to the edge plate rather than the beam flange? 2.) What is the required shear force that needs to be transferred from the plate to the beam flange?

This does not seem like an optimal condition. Generally, the bent plate should be held back from the centerline so that the steel headed stud anchors can be attached directly to the beam flange. However, I will provide some guidance related to the condition you have described.

I think a rational argument could be made that the flow of internal forces for the approach you are proposing—welding the headed studs to the bent plate—is not significantly different than what occurs with a built-up steel shape that is used for composite construction.

So, to answer your first question, I believe conceptually that it should be acceptable to attach a steel headed stud anchor to a plate that is then attached to the beam. However, there are restrictions in the Specification (Section I8.1) on the relationship between the stud diameter and thickness of connected element and a ¾-in.-diameter stud on a ¼-in.-thick plate would not adhere to these provisions. I8.1 states that the headed stud diameter shall not be greater than 2.5 times the thickness of the base metal the stud is attached to, which would limit you to a stud diameter of no more than ⅝ in. in your case.

Your second question about the shear force that needs to be transferred is going to depend on your specific member forces and beam design. Essentially, you would need to transfer the same amount of force that is being transferred from your studs to the concrete. You should be able to extract this information from your design/analysis and, in addition to using it for sizing your plate welds, use it to determine the size and spacing of a smaller diameter stud that doesn't violate the provision noted above.

Susan Burmeister, PE

Eccentricity in Combined Axial and Shear Beam End Reaction

When both axial and vertical beam end reactions coexist at single-plate connections configured similar to the single-plate shear connections shown in Part 10 of the AISC *Steel Construction Manual*, must the out-of-plane eccentricity between the center of the single-plate connection and the center of the beam web be considered in the design of the single-plate connection?

I know little about your particular conditions, so you must use your own judgment to determine what is appropriate for your situation. However, I will provide some thoughts.

Even though your condition may not be designed to satisfy the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341), the AISC *Seismic Design Manual* has several examples which provide some guidance, including Examples 5.2.4, 5.3.12 and 8.4.2, for single-plate connections subjected to axial loads (both publications are available at **www.aisc.org/publications**). The example calculations do not consider the eccentricity between the plate and the beam web. I'm not aware of any other practical design-oriented publications on this topic, but I provided further information below to help with your decision.

Based on my research on bracing connections, for connections subjected to compression I believe the continuity at the plate-to-beam connection is the primary variable affecting the eccentric moment in the plate. The eccentricity between the plate and the beam web causes a moment that must be resisted somewhere within the connection. In many situations, the beam will be much stronger and stiffer than the connection plate. In these cases, the moment in the plate can be neglected, but the local strength of the beam web must be adequate to properly transfer the moment into the beam flanges. You may also want to review the research by Thomas (2014), who tested extended single plate connections in compression.

For connections subjected to tension, self-alignment decreases the eccentricity. I recall some older tests have shown this. It is also discussed in the commentary to Section D3 of the *Specification*. The magnitude of the eccentricity reduction is probably dependent on the connection geometry, the boundary conditions, the ductility of the welds and the level of continuity at the plate-to-beam connection. An estimate of the elastic eccentricity reduction is $1/(1 + P_r/P_e)$, where P_r is the axial tension load and P_e is the Euler elastic flexural buckling load of an equivalent plate in compression. This estimate would likely be very conservative to use in design because it does not account for inelastic deformations.

Reference:

Thomas, K. (2014), *Design and Behavior of Extended Shear Tabs under Combined Loads*, Master's Thesis, University of Alberta.

Bo Dowswell, PE, PhD

Specifying Welds to Develop the Strength of the Base Metal

I am an engineer who has to specify weld requirements on design documents. I have a number of questions about complete joint penetration (CJP) groove weld symbols.

1. If the contract documents provide a weld symbol with no throat specified, should a CJP groove weld be provided by default?
2. Where the strength of the connected parts must be developed, should the engineer always indicate CJP in the tail?
3. AWS D1.1 Clause 2.2.5.3 states: "Contract documents do not need to show groove type or groove dimensions... The welding symbol without dimension and without CJP in the tail designates a weld that will develop the adjacent base metal in tension and shear..." Is it true that only a CJP groove weld will "develop the adjacent base metal in tension and shear?"
4. Must the engineer specify welds using the symbols shown for prequalified welds table 8-2 of the *Manual*, including backer bars, etc.?
5. My understanding is that it is the contractor's responsibility to determine the best type of groove weld even if I specify the use of backing and a particular joint preparation. Is this correct?

I have addressed your questions below:

1. No. Clause 2.3.5.3 of AWS D1.1:2015 states that: A weld symbol without dimension and without CJP in the tail designates a weld that will develop the adjacent base metal strength in tension and shear; a weld symbol without dimension and with CJP in the tail designates a CJP groove weld; and a partial joint penetration (PJP) groove weld must specify the required effective throat.
2. No. If your goal is to simply develop the adjacent base metal strength in tension and shear, then it may be better not to put CJP in the tail. It is often possible and more economical to develop the strength of the base metal using a fillet weld or a PJP groove weld with fillet weld reinforcement. There may be some conditions (most likely related to fatigue or seismic) where it is important to have a CJP groove weld as opposed to the other alternatives. For optimal economy, a CJP groove weld should only be designated when a CJP groove weld is required for the performance of the structure.
3. No. As stated above, it is often possible and more economical to develop the strength of the base metal using a fillet weld or a PJP groove weld with fillet weld reinforcement.
4. No. AWS D1.1 recognizes that structural engineers often have limited experience related to welding. It also recognizes that fabrication practices vary based on fabricator preference and equipment. Clause 2.2.5.3 is written so that the engineer would not have to specify details that are not critical to the performance of the structure. Allowing the contractor to make these decisions will likely lead to a more economical structure.
5. No. Weld symbols must conform to the AWS requirements. Providing unnecessary information can cause as much confusion as not providing necessary information.

It is interesting that your expectation is that the welder will disregard some portion of your instructions. This is not consistent with the intent of AWS and illustrates the sorts of problems that can be caused by improperly specifying welds. The fabricator is left asking, "Which parts of your instructions did you want to be followed and which did you not?"

For more on groove welds from a guru of the welding world (Duane Miller) visit **www.aisc.org/2017nascconline** and view the recording of the 2017 NASCC: The Steel Conference presentation "More Welding Questions Answered."

Larry S. Muir, PE

Using Rubber Mats for Vibration and Sound

Can rubber mats be used in corridors to reduce the effects of vibrations and sound due to walking?

Rubber mats may be effective in reducing sounds but not structural vibrations.

The newly updated AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity*, 2nd Edition (available at **www.aisc.org/dg**), states: "Carpeting, rubber mats and the like do not reduce the footfall forces transmitted to the structural floor appreciably and thus are not useful for reduction of walking-induced vibrations. According to Galbraith and Barton (1970), who studied the effect of shoe and surface hardness, the variation from test-to-test using the same footwear and surface was as great as the variability between tests with different footwear and surface."

However, Design Guide 30: *Sound Isolation and Noise Control in Steel Buildings* (**www.aisc.org/dg**) states: "Resilient floor underlayments are very effective for improving footfall noise isolation of floating floor assemblies such as engineered wood, laminate and vinyl floor products. This improvement extends to lower frequencies for thicker underlayments." It also states: "Resilient underlayment products include recycled rubber mats, entangled wire mesh products typically used under gypsum concrete, foam, felt, fiberglass and cork. For naildown wood flooring, resilient floor systems with built-in wood nailers are available."

Larry S. Muir, PE

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If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

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