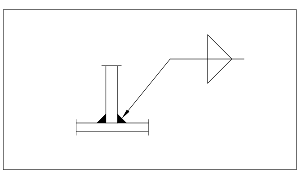
conference preview

BEST INTENTIONS

How to accurately convey your design intent with weld symbols.

BY ROBERT WHYTE, S.E., P.E.



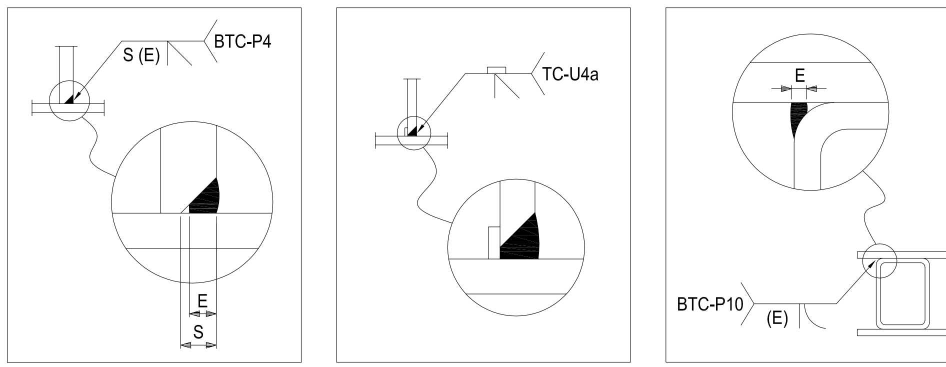


Figure 1. Fillet Weld, BTC-P4 (PJP), TC-U4a (CJP), BTC-P10 (PJP).

WE USE WELD SYMBOLS EVERYWHERE, from contract documents and fabrication level drawings to hand-drawn sketches for informal use in the office.

But more often than not weld symbols can be misused or overused. This not only can lead to excessive welding and unwarranted RFIs, but in some cases it can inhibit the proper behavior of the connected members.

It is important to understand and accurately show weld symbols since they tie the design intent with the actual fabrication and manufacturing process. Simply pointing at a joint with a fillet weld symbol only gets you halfway there. What is the weld leg size? What is the weld length? Did you maybe mean to stitch-weld the joint? Is that supposed to be a field weld?

Back to Basics

To make the connection between design intent and fabrication it is necessary to know the basics about weld types, weld processes and positions. The most frequently used weld types in the structural steel industry are fillet welds, partial joint penetration (PJP) welds, complete joint penetration (CJP) welds and flare-bevel groove welds, which are a special type of PJP. Among these, fillet welds are by far the most commonly used type (see Figure 1).

PJP and CJP welds require the base metals to be prepared with a groove (they will often be referred to as groove welds), which simply means that one or more of the edges of the base metals will get cut at an angle. There are a number of joint designations for PJP and CJP welds that are dependent on the geometry of the groove on the base metal(s), the joint separation and base metal orientation, among other things.

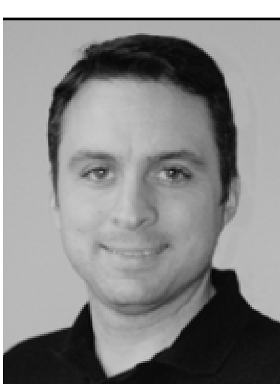
Frequently used joint designations for PJP welds are BTC-P4 and BTC-P10. The latter is a unique PJP joint designation that does not require a "cut-in" groove and is meant for welding the radiused corners of HSS members or bent plates. Common joint designations for CJP welds are TC-U4a,b and B-U4a,b; these are regularly used in moment connected beam flanges.

When it comes to arc welding processes, commonly used ones are shielded metal arc welding (SMAW), flux core arc welding (FCAW) and gas metal arc welding (GMAW). The joint type and weld position (flat, horizontal, vertical and overhead) are dependent on these processes. For example, SMAW (stick-electrode) can be used in every position, but for certain joint designations GMAW or FCAW are limited to the flat or horizontal positions.

Don't Overuse All-Around!

The all-around weld symbol is commonly used in places where it simply doesn't apply. In some cases it is a way of saying "weld anywhere you can." This may be acceptable for secondary steel where end connection forces aren't of great consideration—at the ends of joist stability kickers, for example. But in other cases overuse of this symbol can quickly get you in trouble in various ways:

1. It can translate into unnecessary, and thus time-consuming, welding since the person doing the welding is not there to interpret the design intent. They are going to weld *everywhere* you've told them to.



Robert Whyte is an assistant project manager and the connections division manager in the Birmingham, Ala., office of LBYD, Inc. You can reach him at rwhyte@lbyd.com.

2. In the case where clip angles are used to connect a beam to an existing member, if the top edges of the outstanding legs of the clip angles are welded, it will prevent the angles from "flexing" and consequently inhibit the desired simply supported behavior of the beam. Oh, and it will also load the supporting member with an unwanted moment.
3. Stress concentrations can occur at the end of slotted HSS connections (near the rounded end of the slot) and at the tips (toes) of column flanges at base plate connections.

Misplaced or Erroneous Symbols

Always point at the joint with the weld arrow as though you are the one that will be doing the welding. Don't point through a member! (See Figure 2.)

When mirroring from an existing detail make sure to always keep the fillet or groove symbol pointed to the right, with the weld size on the left of it and the weld length to the right (see Figure 3).

About Fillet Welds

Fillet welds are idealized as triangles with the weakest segment assumed through the effective throat, E, which is 0.7071 times the weld size (or weld leg, D). Strength calculations are therefore based on an area equal to E times the effective length of the fillet weld, L.

The most common electrode used is an E70XX, for which the tensile strength of the weld deposit material is 70 ksi. The XX symbols are reserved for position and type of coating and electrical current.

In ASD, the strength of a fillet weld in shear is 21 ksi, which represents a 70% hit from the electrode's strength of 70 ksi. In LRFD the shear strength is 31.5 ksi.

Gaps between the base materials in fillet welded connections are permitted up to 3⁄16 in.; however, the strength must be reduced proportionally to the amount of gap.

In lapped plate connections fillet weld sizes are permitted to equal the thickness of the lapped plate up to ¼ in. thick. After that the plate must be at least 1⁄16 in. thicker than the required weld size—i.e., a ¼-in. weld on ¼-in. thick plate is fine, but for a 5⁄16-in.-thick plate, the maximum fillet weld allowed is ¼ in.

Single fillet welds in tension are *not* allowed. A fillet weld must never be loaded with a moment about its longitudinal axis.

On Economy

Fillet weld sizes up to and including 5⁄16 in. can be made by a "one-pass" weld. Welds of 3⁄8 in. and greater are "multi-pass" welds.

In most cases fillet welds are more economical than PJPs, and PJPs are more economical than CJPs. What is the leg size of a fillet weld before considering going to a PJP? Some fabricators say 5⁄8 in., others say ¾ in.

For PJPs, it is often said that "two welds are better than one." An effective throat, E, of ¾ in. will have the same strength as 2⅜ in.; however the latter will require one-third less weld deposit than the former.

For CJPs the weld strength will equal the strength of the lesser material grade joined. Increasing the thickness of the lesser-grade material will not increase the strength of the welded joint. MSC

This article serves as a preview of Session N72 at NASCC: The Steel Conference, taking place April 17–19 in St. Louis. Learn more about the conference at www.aisc.org/nascc.

Figure 2. Don't weld "through" a member.

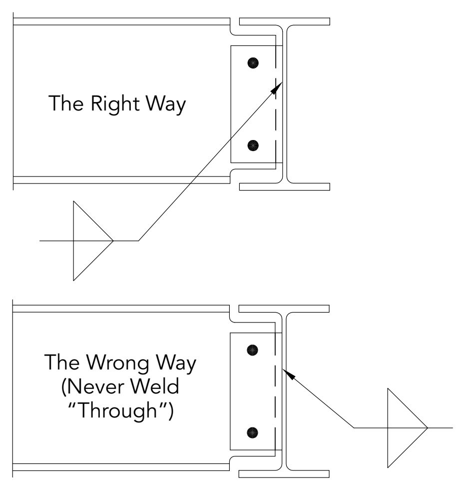


Figure 3. Mirrored fillet weld symbol. Notice not all parts of the symbol have been mirrored.