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steel interchange

Grinding Between Weld Passes

We are welding using metal-cored electrodes and have been told that the AISC *Specification* requires that each completed weld pass must be ground before the next pass can be deposited. Is this correct?

No. Section J2 of the AISC *Specification* states that, with a few exceptions, all provisions of AWS D1.1 apply under the *Specification*. Section 5.15 of AWS D1.1 requires that the surface to be welded shall be free of slag or other items that would be detrimental to the welds. It does not require grinding between passes.

One of the benefits of metal-cored electrodes is that they produce little slag and therefore minimize activities such as grinding, chipping the slag or removing spatter. This is alluded to in AISC Design Guide 21 (free for members at **www.aisc.org/dg**), which states: "GMAW uses a solid- or metal-cored electrode and leaves no appreciable amount of residual slag."

Carlo Lini

Reuse of Fasteners Not Addressed in RCSC *Specification*

The RCSC *Specification* prohibits the reuse of A490 bolts. We have a situation where we need to repeatedly pre-tension and loosen bolts. Due to the loads we need to use bolts with a tensile strength of 150 ksi. Since we cannot reuse A490 bolts, the use of A354 Grade BD has been proposed. Is there a prohibition against reusing A354 Grade BD bolts?

The RCSC *Specification* does not address the use of A354 Grade BD fasteners, and ASTM A354 does not address reuse. Therefore, there is no explicit prohibition against reusing A354 Grade BD bolts. Since it is not addressed, you will have to use your own judgment.

The Commentary to the RCSC *Specification* states: "Pre-tensioned installation involves the inelastic elongation of the portion of the threaded length between the nut and the thread run-out. ASTM A490 bolts and galvanized ASTM A325 bolts possess sufficient ductility to undergo one pre-tensioned installation, but are not consistently ductile enough to undergo a second pre-tensioned installation. Black ASTM A325 bolts, however, possess sufficient ductility to undergo more than one pre-tensioned installation as suggested in the Guide (Kulak et al., 1987). As a simple rule of thumb, a black ASTM A325 bolt is suitable for reuse if the nut can be run up the threads by hand."

The point of the foregoing is that A490 bolts have less ductility than the A325 bolts because they are of higher strength. Section J3.1 of the AISC *Specification* indicates that in order to ensure proper pre-tension the A354 Grade BD would have to have "bolt geometry including the thread pitch, thread length, head and nut(s)… equal to or (if larger in diameter) proportional to that required by the RCSC *Specification*." In other words, the A354 grade BD fastener you are proposing in place of the A490 bolt will be nearly identical to an A490 bolt. Therefore, it seems likely that the same reuse prohibition would be applicable.

Note also that your repeated pre-tensioning and loosening means A325 bolts likely would not be suitable for your intended use either. The *Guide to Design Criteria for Bolted and Riveted Joints* (a free download from **www.boltcouncil.org**) states: "A325 bolts can be reused once or twice, providing that proper control on the number of reuses can be established."

Carlo Lini

Economical Weld Details

In my experience a CJP groove weld is generally used when the strength of the base metal must be developed. However, a fillet weld can also be designed to develop the strength of the base metal. It seems that a fillet weld would always be the more economical choice, since a fillet weld usually will require less weld metal than a CJP groove weld. Therefore, it would seem that fillet welds should always be specified.

Are there instances where the AISC *Specification* requires the use of a CJP groove weld? If there are no such requirements then why are CJP groove welds so commonly specified?

The AISC *Specification* never requires the use of CJP groove welds. There are some instances in the AISC *Seismic Provisions* when CJP groove welds must be used. CJP groove welds often are specified because it is easy to write and there are no calculations associated with them—not the most economical of reasons in the shop and field, of course.

You are correct that a fillet weld is often the more economical choice. However, when a fillet weld becomes very large, a CJP groove weld can become the more economical choice. The advantages of the options available must be weighed. The cost of providing the prepped edge (for the CJP) must be weighed against additional weld volume and passes (for the fillet). There may also be additional inspection requirements for a CJP groove weld to consider as well. There are also other options such as a PJP groove weld, with or without reinforcing fillets.

Note also that a fillet weld may or may not require less weld metal than a CJP weld.

Let's compare a 1-in. plate welded with a ¾-in. fillet weld on both sides to the same plate with a CJP groove weld. The theoretical volume of the fillets is one-half the base times the height, or $2(0.5)(0.75)^2 = 0.563$ in.^{2}/in. for both welds. The volume of the CJP groove weld depends on the configuration. If we assume a B-U4a with a 45° bevel, the volume will be $0.5(1)^2 + 0.25 = 0.75$ in.^{2}/in. However, you may still have fewer passes and therefore less labor and less cost. Some configurations will actually result in less weld volume and fewer passes.

If you look at Table 8-12 in the *Manual*, you will see that a ¾-in. fillet requires about 8 passes (16 passes for both welds). A CJP groove weld with a 45° single bevel requires 11 passes. This can actually drop to as few as five passes when a 30° double bevel is used and the volume of weld metal is decreased. Of course, there will be some additional cost associated with providing two bevels instead of one. It should also be noted that the table provides only approximate values but even these approximate values can help evaluate alternatives.

There are a lot of variables to consider. What is the cost of beveling the edge versus the cost of the additional passes? Will the CJP groove weld have to be evaluated with ultrasonic inspection (UT), adding an additional step to the process? Will the member have to be flipped to complete the double bevel and the welding? Can the flipping be accomplished with a single crane or will it tie up multiple cranes and operators? Unless you know the answers to these questions it will be difficult, if not impossible, to choose the optimal weld. That is why it is often best to allow the fabricator to choose the best option.

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Curved Beam References

What are some publications related to the design of curved or arched beams?

Unfortunately, the information available for vertically curved members (arches) is in many scattered publications. Both the in-plane and the out-of-plane stability of arches are discussed in the SSRC *Guide* (Ziemian, 2010). A designer-friendly reference is *Design of Curved Steel* (King and Brown, 2001), which discusses the design of both horizontally and vertically curved members. Blake (1966) and Young and Budynas (2002) have some general information on both horizontally and vertically curved members. There is a local flange bending effect for vertically curved I-beams, which is discussed by Vandepitte (1982). Vacharajittiphan and Trahair (1975) and Papangelis and Trahair (1987) have more information on the out-of-plane stability of vertically curved members.

References

- Blake, A. (1966), *Design of Curved Members for Machines*, Industrial Press.
- King, C. and Brown, D. (2001), *Design of Curved Steel*, SCI Publication P281, The Steel Construction Institute.
- Papangelis, J.P. and Trahair, N.S. (1987), "Flexural-Torsional Buckling of Arches," *Journal of the Structural Division*, American Society of Civil Engineers, Vol. 113, No. 4, April, pp. 889-1906.
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- Vandepitte, D. (1982), "Ultimate Strength of Curved Flanges of I-Beams," *Journal of Constructional Steel Research*, Vol. 2, No. 3, September, pp. 22-28.
- Young, W.C. and Budynas, R.G. (2002), *Roark's Formula's for Stress and Strain*, Seventh Edition, McGraw-Hill.
- Ziemian, R.D. (2010), *Guide to Stability Design Criteria for Metal Structures*, Sixth Edition, John Wiley & Sons.

There are also several articles and publications available from AISC via the "curved steel channel" at **www.aisc.org**.

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