

Digging Through the Rubble, Part Two

BY MONICA STOCKMANN AND THOMAS J. SCHLAFLY

The discussion on welding for seismic applications continues...

LAST MONTH WE PROVIDED a glimpse of what seismic welding is all about, discussing the historical perspective of seismic welding requirements and the resulting references; the three weld categories (non-seismic, seismic, and demand-critical); the protected zone; and filler metal requirements for seismic and demand-critical welds. This month we build on the previous article (read it online at www.modern-steel.com) and continue to highlight seismic weld requirements. Please refer to the following references for more detailed information: AISC *Seismic Provisions for Structural Steel Buildings* (AISC 341-05), AWS D1.8 *Structural Welding Code—Seismic Supplement* (AWS D1.8), AISC *Prequalified Connections for Special and Intermediate Moment Frames for Seismic Applications* (AISC 358-05), and AISC *Design Guide 21 Welded Connections—A Primer for Engineers*.

Steel Backing

Welds joining beam flanges to columns in seismic framing systems specifically detailed for seismic resistance have been the subject of several of the additional seismic provisions by AISC and AWS. In non-seismic applications (buildings designed with $R = 3$ that are not specifically detailed for seismic resistance), steel backing is typically permitted to remain in the finished connection. However, backing bar removal is often required in seismic structures. When steel backing is used in tee joints, typical of beam-to-column connections in special moment frames (SMF), the lateral forces will cause bending moments, which impose tensile stresses on these connections, particularly on the bottom beam flange connection in this case. The notch-like condition created by backing left in place in tee joints can serve as a stress concentrator and crack initiator. To eliminate this condition, for the bottom beam flange to column flange connection, the steel backing is removed and the root pass is gouged to sound weld metal. The welder must then re-weld the gouge and add a contouring fillet weld under the bottom flange. Any remaining gouges must be repaired. Figure 1, located on page 50, illustrates the steel backing removal process, which is typically performed overhead.

For top beam flange to column flange welds, the backing

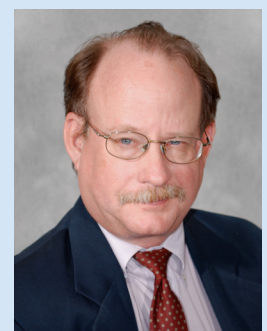
can be left in place with the addition of a reinforcing fillet weld between the backing and column. As illustrated in Figure 2 (page 50), the backing that is to remain under the top flange must be fillet welded to the column; fillet welds to the beam are not permitted. This procedure will minimize the tension force delivered from the beam into the backing, and also will convert an external “crack-like” interface between the column and backing into an internal interface that won’t open up. The overhead fillet weld does add some labor and cost to the connection when compared to standard non-seismic applications, but the top flange requirements are certainly less expensive than the bottom flange requirements.

Don't be afraid to pick up the phone and contact a steel fabricator for advice on economical connection design, shop vs. field welding questions, and other constructability issues.

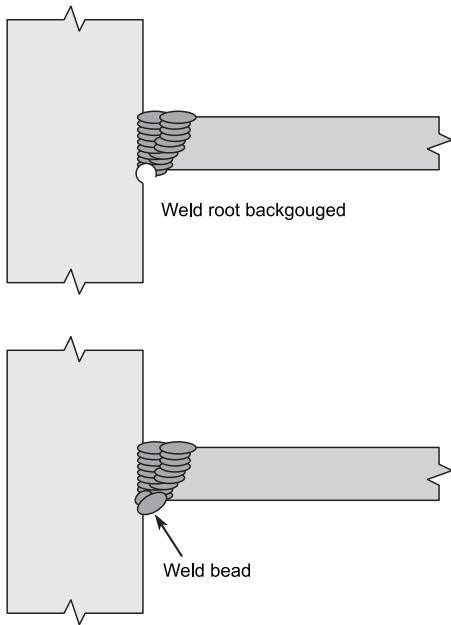
Weld Access Holes

Weld access holes are not used at all with moment end-plate connections. Additionally, special seismic access holes are not typically required with reduced beam section (RBS) connections; rather, AISC 358-05 refers to the requirements of AISC *Specification for Structural Steel*

Buildings (AISC 360-05), Section J1.6 for weld access hole geometry requirements. AISC 341-05 does, however, include special requirements for weld access hole geometries for fully restrained (FR) moment connections in ordinary moment frames (OMF). According to the Federal Emergency Management Agency (FEMA) research, FR moment connections with special weld access hole geometries may possibly be qualified as SMF and IMF connections as well. When weld access holes are required, they must

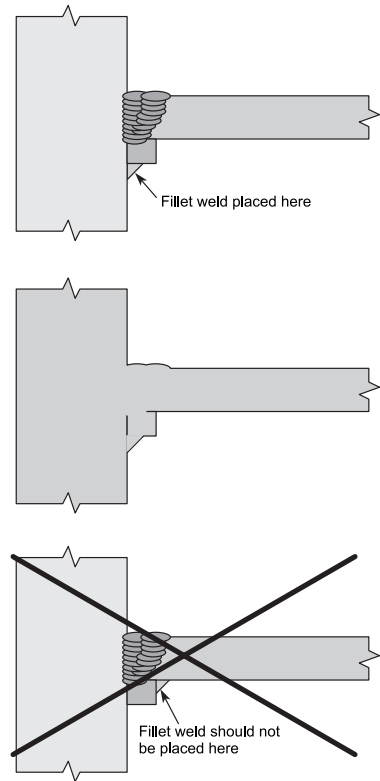


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Left: Figure 1. Steel Backing Removal (Figure 10-2, page 109 of AISC DG 21)

Right: Figure 2. Backing Treatment for Top Flanges (Figure 10-3, page 109 of AISC DG 21)



be fabricated free of unacceptable notches and gouges that may serve as stress concentrators, in accordance with the fabrication requirements specified in AWS D1.8.

The complete joint penetration (CJP) groove welds between the beam bottom flange and the column flange using weld access holes are sequenced according to Section 6.14 of AWS D1.8. The provision includes that each layer of weld must be completed across the full length of the flange before beginning the next layer.

Weld Tabs

Weld tabs are normally permitted to be left in place for building construction, but for high-seismic applications, weld tab removal is typically required, including for the prequalified connections in AISC 358-05. This eliminates potential harmful effects that discontinuities on the weld tab may cause. AWS D1.8 explains the methods and surface roughness requirements for weld tab removal.

The removal of steel backing is not treated the same as the removal of weld tabs in AWS D1.1; if you direct removal of one, you have not directed removal of both. This is as expected because the removal of backing is a much more costly process.

Making the Grade

Additional testing requirements are placed upon those welders that are required

to make demand-critical welds that join the bottom beam flange to column flange by welding through a weld access hole in the beam web. Not only do they need to meet AWS D1.1 testing requirements, the welders performing this task on seismic jobs must also pass the Supplemental Welder Qualification for Restricted Access Welding as prescribed in Annex C in AWS D1.8. This test limits the welders to deposition rates in the shop and field not higher than that for which they qualified in their qualification testing. Requiring welders to demonstrate their skills on the connection mock-up tests, at certain deposition rates, helps to ensure that workmanship on the final structure will meet the special demands of welding on structures subject to high-seismic loading.

Nondestructive Examination

The building codes typically assign the responsibility for developing a Quality Assurance Plan (QAP) to the engineer of record. Nondestructive Examination (NDE) is commonly specified in the QAP. Testing process, extent, techniques, and standards of acceptance should be clearly defined in the QAP. To ease compliance with this responsibility, AISC 341 includes a reference QAP in Appendix Q.

The NDE methods and acceptance criteria for seismic structures are generally the same as those for non-seismic appli-

cations defined in AWS D1.1. AWS D1.8 includes supplemental requirements for NDE technician qualifications, inspection techniques, and acceptance criteria. AWS D1.8 also includes provisions for flaw sizing if needed to resolve problems.

What to Include

The resources referenced throughout this article provide lists of information and specifications that the engineer must include in the contract documents. AISC 341-05 Appendix W, Section W2 specifies the necessary information that the engineer must include on the structural design drawings and specifications. This section also lists the items that must be included on the shop drawings and the erection drawings. AWS D1.8, Section 1.2.1 lists 14 items that the engineer must provide in the contract documents.

The Bottom Line

Designers and contractors need to be familiar with the added costs associated with high-seismic applications. Keep in mind that each of the requirements described above has a price tag associated with it. Some of the more costly seismic weld items include column splice CJP groove weld requirements and backing bar requirements. For example, a typical special moment connection beam flange to column flange weld can take a welder an

entire day to complete, due to the backing bar removal, back gouging, and re-welding requirements. In addition, applying AISC 341-05 to a structure typically results in thicker stiffener plates, which in turn typically results in larger welds, and often CJP groove welds.

If it's possible to design the building with $R = 3$, then do so. It is true that the use of $R > 3$ may result in a lower base shear. However, the seismic detailing requirements associated with such a design, in particular the seismic welding requirements, will result in higher steel fabrication and erection costs.

Another helpful hint: Don't be afraid to pick up the phone and contact a steel fabricator for advice on economical connection design, shop vs. field welding questions, and other constructability issues. Steel fabricators are an invaluable, often untapped, resource to the design community.

It is important to keep in mind that no matter what building material you choose, a project located in a high-seismic zone will almost always have a higher structural frame cost than the exact same project located in a low-seismic zone. This is the nature of the world in which engineers are designing today. But hopefully we've given you a better idea of the added welding requirements in high-seismic applications and some adequate references for more detailed information. MSC

CPRP Supplement Preview

Currently, there are three prequalified connections: Reduced Beam Section (RBS), Bolted Unstiffened Extended End Plate (BUEEP), and Bolted Stiffened Extended End Plate (BSEEP). The BUEEP and BSEEP connections currently are not prequalified for SMFs if a concrete structural slab is in direct contact with the steel. However, AISC's Connection Prequalification Review Panel (CPRP) will be releasing a supplement to AISC 358-05 in the near future. The supplement will include additional prequalified connections and enhanced criteria to the existing prequalified connections. In particular, for BUEEP and BSEEP connections, it is expected that the "no concrete slab in contact with steel" limitation will be eliminated if the slab is isolated from the column with a compressible material, such as rigid insulation. A new prequalified connection will be included in the supplement as well: Bolted Flange Plate (BFP).