High Seismic Detailing and Fabricating

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Projects designated as "high seismic" require special attention. Here's an introduction to some of the complexities of detailing and fabricating high seismic projects.

THE 2005 AISC SEISMIC PROVISIONS FOR STRUCTURAL STEEL BUILDINGS govern the design, fabrication, and erection of structural steel members and connections in the seismic load resisting systems (SLRS) and splices in columns that are not part of the SLRS, in buildings and other structures—where other structures are defined as those structures designed, fabricated, and erected in a manner similar to buildings—with building-like vertical and lateral load-resisting-elements.

The seismic provisions apply when the seismic response modification coefficient *R*, as specified in the applicable building code, is taken greater than 3, regardless of the seismic design category. When *R* is taken as 3 or less, the structure is not required to satisfy the provisions unless specifically required by the applicable building code. Members and connections of the SLRS must satisfy the requirements of the applicable building code, the AISC specification, and the seismic provisions.

The AISC seismic provisions give specific information to the structural engineer as to what to include on the structural design drawings and in the structural specifications. This information, provided by the structural engineer, is essential for the detailer, fabricator, and erector to ensure proper understanding and execution of the contract requirements. Although the structural engineer's responsibilities are beyond the scope of this presentation, the following information is necessary as a background to what a detailer and fabricator should expect to find on the structural design drawings and in the structural specification:

- Designation of the SLRS.
- Designation of the member and connections that are part of the SLRS.
- Configuration of the connections.
- Connection material specifications and sizes.
- Locations of demand-critical welds.
- Lowest anticipated service temperature of the steel structure, if the structure is not enclosed and maintained at a temperature of 50 °F or higher.
- Locations and dimensions of protected zones.
- Locations where gusset plates are to be detailed to accommodate inelastic rotation.
- Welding requirements as specified in Appendix W, Section W2.1.

The detailer, fabricator, and erector must have a knowledge and understanding of the following terms from the seismic provisions when detailing and fabricating a project designated as "high seismic":

Seismic design category is a classification assigned to a building by the applicable building code based upon its seismic use group and the design spectral response acceleration coefficients.

Seismic response modification coefficient (*R*) is a factor that reduces seismic load effects to a strength level specified by the applicable building code.

Seismic load resisting system (SLRS) is an assembly of structural elements in the building that resist seismic loads, including struts, collectors, chords, diaphragms, and trusses.

Special Moment Frames (SMF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the design earthquake.

Intermediate Moment Frames (IMF) are expected to withstand limited inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the design earthquake.

Ordinary Moment Frames (OMF) are expected to withstand minimal inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the design earthquake.

Special Truss Moment Frames (STMF) are expected to withstand significant inelastic deformation within a specially

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designed segment of the truss when subjected to the forces from the motions of the design earthquake.

Special Concentrically Braced Frames (SCBF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the design earthquake.

Ordinary Concentrically Braced Frames (OCBF) are expected to withstand limited inelastic deformations in their members and connections when subjected to the forces resulting from the motions of the design earthquake.

Eccentrically Braced Frames (EBF) are expected to withstand significant inelastic deformations in the links when subjected to the forces resulting from the motions of the design earthquake.

Buckling-Restrained Braced Frames (BRBF) are expected to withstand significant inelastic deformations when subjected to the forces resulting from the motions of the design earthquake.

Special Plate Shear Walls (SPSW) are expected to withstand significant inelastic deformations in the webs when subjected to the forces resulting from the motions of the design earthquake.

Protected zones are areas of members in which limitations apply to fabrication and attachments.

Demand-critical welds are welds that are part of the SLRS that are deemed to be critical, since they transfer important earthquake loads.

Prequalified connections are connections that comply with the requirements of Appendix P of the Provisions (ANSI/AISC 358)

Continuity plates are column stiffeners at the top and bottom of the panel zone; they are also known as transverse stiffeners.

The k-area is the region of the web that extends from the tangent point of the web and the flange-web fillet (AISC's *k* dimension), a distance of 1½ in. (38 mm) into the web beyond the *k* dimension.

Detailing High Seismic

Shop Drawings: AISC *Seismic Provisions* Part 5.2 and Appendix W, Section W2.2.

Shop drawings shall include items required by the AISC specification and the following, as applicable:

1. Designation of the members and connections that are part of the SLRS.
2. Connection material specifications.
3. Locations of demand-critical shop welds.
4. Locations and dimensions of protected zones.
5. Gusset plates drawn to scale when they are detailed to accommodate inelastic rotation.
6. Welding requirements as specified in Appendix W, Section W2.2 Shop drawings shall include, as a minimum, the following information:
   a. Access hole dimensions, surface profile, and finish requirements.
   b. Locations where backing bars are to be removed.
   c. Locations where weld tabs are to be removed.
   d. NDT to be performed by the fabricator, if any.

Erection Drawings: AISC *Seismic Provisions* Part 5.3 and Appendix W, Section W2.3.

Erection drawings shall include items required by the AISC specification and the following, as applicable:

1. Designation of the members and connections that are part of the SLRS.
2. Field connection material specifications and sizes.
3. Locations of demand-critical field welds.
4. Locations and dimensions of protected zones.
5. Locations of pretensioned bolts.
6. Field welding requirements as specified in Appendix W, Section W2.3 Erection drawings shall include, as a minimum, the following information:
   a. Locations where backing bars are to be removed.
   b. Locations where supplemental fillets are required when backing is permitted to remain.
   c. Locations where weld tabs are to be removed.
   d. Those joints or groups of joints in which a specific assembly order, welding sequence, or welding technique—or other special precautions—are required.

Fabricating High Seismic

Personnel Requirements

1. Welders shall pass the Supplemental Welder Qualification for restricted access welding; see AWS D1.8 Annex C. Tack welders are not required to perform the SWQRA.
2. Each welder shall be assigned an identification symbol or mark.
3. QC welding inspectors shall be associate welding inspectors (AWI) or higher.
4. QA welding inspectors shall be welding inspectors (WI) or senior welding inspectors (SWI).
5. Nondestructive testing (NDT) technicians shall meet special qualification requirements.
6. These requirements are in addition to normal AWS D1.1 qualifications.

Structural Steel Material Requirements

1. Charpy V-Notch (CVN)
2. Hot-rolled shapes with flanges ≤ 1½ in. thick
3. Plates 2 in. and thicker
4. 20 ft-lb at 70 °F

Weld Requirements

1. Welding Procedure Specifications (WPS) shall meet AWS D1.1 and requirements for demand-critical welds.
2. WPS shall list electrode manufacturer and trade names.
3. WPS shall list one or more combinations of welding variables that produce heat inputs within acceptable established AWS ranges.
4. Must use approved processes for demand-critical welds (SMAW, GMAW, FCAW, and SAW). Other processes are allowed, provided certain criteria are met.
5. Gas-shielded process is allowed when air velocity does not exceed 3 mph.
6. Filler Metal Diffusible Hydrogen: maximum of 16 ml per 100 grams deposited weld metal. Certain variances and exemptions may be applicable.
7. Intermix of FCAW-S filler metal.
8. Weld tabs.
9. Bottom flange welding sequence.
10. Notch-toughness characteristics.
11. Storage and exposure of FCAW electrodes.
12. Maximum interpass temperature.

Fabrication

1. Demand-critical welds.
2. Forbidden items within the protected zone:
   a. Tack welds, erection aids, arc-air gouging, thermal cutting, etc. Repair when required.
   b. Welded shear studs and penetrating decking attachments. Decking arc spot welds to secure the deck are permitted.
   c. Welded, bolted, screwed, or shot-in attachments for perimeter edge angles, exterior facades, partitions, duct work, piping, or other construction.

Continuity Plates and Stiffeners

1. Inside corner clips (curved or straight).
2. CJP or heavy fillets.
3. Hold fillets back ¼ in. from edge.
4. Where specified backing bars are to be removed, back gouged, and re-welded.
5. Where specified supplemental fillet welds may be used where backing bars are permitted to remain.
6. Joints or groups of joints may specify a specific assembly order, welding sequence, welding technique, or other special precautions.
7. Access hole dimensions, surface profile, and finish requirements.

Tack Welds

All bolted faying surfaces shall meet requirements for Class A surfaces or better. MSC

References

AISC *Seismic Provisions for Structural Steel Buildings*, including Supplement No. 1, 2005; Appendices P, Q, and W.

AISC *Seismic Design Manual*, 2006.

AWS D1.8