**Prequalified Seismic Moment Connections**

Here’s a visual summary of the seismic requirements for two prequalified moment connections.

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Special Moment Frame (SMF) and Intermediate Moment Frame (IMF) structural steel systems designed in accordance with the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-05) are required to have beam-to-column connections that satisfy the requirements of Section 9.2 for SMF or 10.2 for IMF. These requirements include a minimum interstory drift angle each connection must be capable of sustaining, a minimum flexural resistance at that drift angle, and a minimum shear strength based on full yielding of the moment connection at each end of the beam. There are two ways to demonstrate that these criteria have been met:

- **Providing qualifying test results in accordance with Appendix S of the Seismic Provisions.**
- **Use of a connection prequalified in accordance with Appendix P of the Seismic Provisions, such as those in the prequalified connections standard.**

The first option requires that the engineer of record substantiate the ability of the connection to meet the requirements of section 9.2 or 10.2 and prove that the tests were performed according to Appendix S. Tests involve additional expense and the engineer must convince the authority having jurisdiction that all the requirements are met, but this may still be a viable option. Tests reported in literature performed in accordance with Appendix S can also be used, but demonstrating the applicability of those tests still rests on the engineer of record.

The second option requires that a prequalification panel is set up and approved by the authority having jurisdiction. This panel must then create guidelines and approve connections based on test data to be prequalified.

AISC’s Connection Prequalification Review Panel (CPRP) reviews connection test data and prequalifies connections in accordance with Appendix P. The result is the prequalified connections standard. This document is specifically permitted to be used in the Seismic Provisions. The CPRP continues to review connections and will release a new chapter for each new prequalified connection. Using this document is currently the easiest and most direct method of satisfying the conformance demonstration requirements for SMF and IMF connections in the Seismic Provisions.

The prequalified connections standard offers the following connections to choose from when designing IMF and SMF systems:

**Reduced Beam Section (RBS) Moment Connection (Chapter 5):** Portions of the beam flange are selectively trimmed in the region adjacent to the column-beam connection to ensure yielding and hinge formation within the reduced area. This connection type can be used for SMF and IMF systems.

**Bolted Unstiffened and Stiffened Extended End-Plate (EEP) Moment Connections (Chapter 6):** By welding the beam to an end-plate and bolting one of three end-plate configurations to the column, the connection ensures that inelastic deformation of the connection is achieved by beam yielding when designed in accordance with these provisions. This connection type can be used for SMF and IMF systems; however, it is not currently permitted to be used for SMF when a structural concrete slab is in contact with the beam, unless the slab is isolated from the beam.

The following details are a visual representation of the major requirements of the Seismic Provisions and the prequalified connections standard. These two documents contain the detailed design requirements and should be consulted on each design. The often-overlooked commentary on the Seismic Provisions and the prequalified connections standard can prove extremely helpful and offers guidance concerning the intent and application of the requirements. Make sure to visit [www.aisc.org/freePubs](http://www.aisc.org/freePubs) for free pdf files of the Seismic Provisions and the prequalified connections standard.

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**Notes**

1. Details shown are for hot-rolled wide-flange members. For built-up members see Sections 2.3.2, 2.4.4, 5.3.1(2), and 5.3.1(3) of the prequalified connections standard.

2. Although details are presented in LRFD format, corresponding to the format of ANSI/AISC 358-05, the connections can be designed with ASD provisions as well.
### Variables and Definitions

- **M^*_{pc}** = length of an RBS cut, in.
- **bbf** = length of an RBS cut, in.
- **b** = horizontal distance between a column flange and the start of an RBS cut, in.
- **a** = horizontal distance between a column flange and the start of an RBS cut, in.
- **TOS** = top of steel beam
- **SMF** = special moment frame
- **RBS** = reduced beam section connection
- **IMF** = intermediate moment frame
- **EEP** = extended end-plate connection
- **CJP** = complete joint penetration groove weld
- **360** refers to the AISC Seismic Provisions for Structural Steel Buildings
- **358** refers to AISC’s Special and Intermediate Steel Moment Frames for Seismic Applications
- **341** refers to the AISC Seismic Provisions for Structural Steel Buildings
- **Cf** = depth of an RBS cut at the center of the reduced beam section, in.
- **Cw** = width of beam flange, in.
- **Lst** = distance from the outside face of column flange to the end of the web clip in a continuity plate, in.
- **dc** = distance from outside face of column web to the end of the flange clip in a continuity plate, in.
- **db** = depth of the connecting beam, in.
- **k** = gage, the horizontal distance between bolts, in.
- **tsp** = thickness of shear plate, in.
- **k_{det}** = distance from web center line to flange toe of fillet, based on the largest fillet used in production, in.
- **k_{det}** = distance from outside face of flange to the web toe of fillet, on the largets fillet used in production, in.
- **L_h** = distance between brace points, in.
- **L_{ctbf}** = length of end-plate stiffener, in.
- **C_{pr}R_yF_yZ_x** = effective plastic section modulus of the beam cross section about the x-axis, in^3.
- **C_{pr}** = plastic section modulus of the full beam cross section, in^3.
- **F_y** = specified minimum yield stress of a column, ksi
- **F_yb** = specified minimum yield stress of a beam, ksi
- **F_{ub}** = specified minimum tensile strength of a beam, ksi
- **R_y** = ratio of the expected yield stress of the beam material to the specified minimum yield stress, per the AISC Seismic Provisions
- **K_y** = ratio of the expected yield stress of the column material to the specified minimum yield stress, per the AISC Seismic Provisions
- **t_{bf}** = thickness of end-plate stiffener, in.
- **V_{gravity}** = required beam shear force at beam end due to gravity loads
- **V_{RBS}** = shear force at center of RBS
- **V_{web}** = required shear force at beam web-to-column connection, kips
- **Z_e** = effective plastic section modulus of the beam connection, kips
- **Ze(RBS)** = shear force at center of RBS
- **F_{yc} – P_{uc} (358 Eq (2.4.3-1) also 5.8-5)**
- **C_{fr}b (358 Eq (5.8-7))**
- **M_{pr} = ∑(1.1R_yF_yZ_x)** (341-9.6)
- **M_{pr} = ∑(R_yF_yZ_x)** (358-5.4(2a))

### User Notes:
- **Demand Critical Welds** are welds that require increased ductility requirements. See 341-7.3b for specific requirements.
- all welds per 341 Appendix W, 341-7.3, and 358 Chapter 3.
- all bolts per 358 Chapter 4 (ASTM A325 and A490, or equivalent twist-off, high-strength bolts allowed).
- The effective beam flange width for compactness can be taken as \( b_{eff} = 2[c - R + \frac{(R^2 - b^2)^{1/2}}{R}] \) per 358-5.3.1(6).
- See 341 Commentary Figure C-I-7.2 and Section 9.5 for continuity plate details.
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- See 341 Commentary Figure C-I-7.2 and Section 9.5 for continuity plate details.
- See 341-9.7 for lateral bracing requirements for the beam-to-column connections.

### Other Important Sections

1. **341-6.3 Heavy Section CVN Requirements:** Special CVN requirements exist for hot-rolled shapes with flanges greater than or equal to 1.5 in. thick and for plates 2 in. thick and thicker.

2. **341-7.2 Bolted Joints:** All bolts shall be pretensioned and have Class A faying surfaces, even though they are designed for bearing shear values. Faying surfaces for end-plate connections are permitted to be painted with coatings without a Class A rating.

3. **341-7.2 Bolted Joints:** Bolts and welds shall not share a force in a joint or a force component in a connection.

4. **341-7.3b** contains the requirements for demand critical welds.

5. **341-7.4** contains the requirements for protected zones.

6. **341-8.4b** contains the requirements for columns splices for columns not part of the seismic load resisting system.

7. **341-8.5** contains the requirements for column bases.
Four-Bolt Unstiffened and Stiffened Extended End-Plate Moment Connections
(Eight-Bolt Stiffened and Unstiffened EEP Connections similar)

**Gage** (358-6.9.1)
\[ g \leq b_{pf} \]

**CJP** (358-2.4.4b)
Fillet welds allowed per the exception in 358-6.7.

**CJP** (358-6.9.7(5))

**Corner Clip: straight or curved**
\[ C_w \geq k_{det} + 1\frac{1}{2}'' \]
\[ k_1 \leq C_r \leq k_1 + 1\frac{1}{2}'' \]
radius if curved \( \geq \frac{1}{2}'' \)

**Column Splice**
Demand-critical CJP or Fillet per 341-9.9 (SMF) or 341-10.9 (IMF)
Locate fillet-welded splice per 341-8.4a: min. 4 ft above TOS (or \( \frac{1}{2}'' \) clear height above TOS if clear height < 8 ft.)

**Doubler Plate**
If required per 358-6.10 eqs. 6.9(16-18) SMF: detailed per 341-9.3c

**End Plate Width**
Width \( > b_{pf} \) (358-6.9.3)
Effective width \( \leq b_{pf} + 1'' \)

**Beam Flange to End Plate Weld**
per 358-6.9.7. Demand-critical CJP with root on inside face of flange and \( \frac{5}{16}'' \) fillet weld on inside flange. Weld access holes not allowed. See 358-6.9.7 (1), (3), and (4) for weld details.

**End Plate Bolts**
with required strength per 358-6.9.7(2)

**Beam Limitations** (358-6.4)
\[ d, t_y, b_r \] per 358 Table 6.1
Clear-span to depth ratio \( \geq 7 \) for SMF
\( \geq 5 \) for IMF
SMF: seismically compact per 341, Table I-8.1
IMF: compact per 360, Table B4.1
\[ F_y \leq 50 \text{ ksi} \]

**Lateral Bracing** per 341-9.8 (SMF) or 10.8 (IMF)
Max. spacing:
SMF: \[ L_b = 0.086 r_y E / F_y \]
IMF: \[ L_b = 0.17 r_y E / F_y \]
All braces must meet provisions of 360 Appendix 6 Eqs. A-6-7 and A-6-8 with \( M_r = R_y F_y Z_x \).

**Protected Zone** (358-6.4(8))
Available shear strength per 360-J10.6
SMF: required shear strength per 341-9.3a; min. thickness per 341-9.3b
IMF: no additional requirements beyond 360

**Column Limitations** (358-6.5)
\[ d_c \leq d_b \]
End plate connected to flange
SMF: Seismically compact per 341 Table I-8-1
IMF: Compact per 360 Table B4.1
Column strength per 341-8.3
Lateral bracing per 341-9.7 (SMF) or 10.7 (IMF)

**Column-Beam Moment Ratio** (358-6.6)
SMF \[ \sum M_{pc} / \sum M_{pb} > 1.0 \]
per 341-9.6 \( \sum M_{pb} = \sum (1.1 R_y F_y Z_x + M_r) \)
IMF: no requirements beyond 360

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341 refers to ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings
358 refers to ANSI/AISC 358-05, Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications
360 refers to ANSI/AISC 360-05, Specification for Structural Steel Buildings
**Reduced Beam Section (RBS) Moment Connection**

**Groove or Fillet**

- Required strength per 358-2.4.4b

**Continuity Plates**

- May be required per 358-2.4.4
- If provided, design per 360-J10 and 358-2.4.4a

**Corner Clip:** straight or curved (341-7.5)

\[ C_w \geq k_{det} + 1\frac{1}{2}" \]

\[ k_1 \leq C_f \leq k_1 + 1\frac{1}{2}" \]

radius if curved ≥ 1/2"

**Parameter Limits**

- 358-5.8
  - 0.5b_{bf} ≤ a ≤ 0.75b_{bf}
  - 0.65d_b ≤ b ≤ 0.85d_b
  - 0.1b_{bf} ≤ c ≤ 0.25b_{bf}

**CJP (358-2.4.4b)**

\[ R = (4c^2 + b^2)/8c \]

\[ a \quad b \quad c \quad R \]

**Column Splice**

- Demand-critical CJP or fillet per 341-9.9 (SMF) or 341-10.9 (IMF)
- Locate fillet-welded splice per 341-8.4a: min. 4 ft above TOS (or 1/2 clear height above TOS if clear height < 8 ft.)

**Doubler Plate**

- If required per 360-J10
- SMF: detailed per 341-9.3c
- Weld to column flange is CJP or fillet weld to develop full strength of plate.

**Panel Zone (358-5.4(1))**

- Available shear strength per 360-J10.6
- SMF: required shear strength per 341-9.3a; min. thickness per 341-9.3b
- IMF: no additional requirements beyond 360

**Column Limitations (358-5.3.2)**

- \( d_c \leq W36 \)
- Beam connected to column flange
- SMF: Seismically compact per 341, Table I-8-1
- IMF: Compact per 360 Table B4.1
- Column strength per 341-8.3
- Lateral bracing per 341-9.7 (SMF) or 10.7 (IMF)

**Beam Web Connection Limitations**

- \( V_{web} = 2M_{pb}/L' + V_{gravity} \)
- CJP between access holes; plate ≥ 3/8" can be used as CJP backing

**Shear Plate (if provided)**

- Allowed for IMF or as CJP backing for SMF when \( t_{sp} \geq 3/8" \) (358-5.6)
- (use for temporary erection support bolt holes are allowed in beam web)

**Beam Limitations**

- \( F_y \leq 50 \text{ ksi (341-6.1)} \)
- \( d_b \leq W36 \)
- \( t_{bf} \leq 1\frac{3}{4}" \) (358-5.3.1)
- SMF: Seismically compact per 341, Table I-8-1
- IMF: compact per 360, Table B4.1
- weight ≤ 300 lb/ft
- clear-span to depth ratio ≥ 7 for SMF
- ≥ 5 for IMF

**Lateral Bracing per 341-9.8**

- (SMF) and 10.8 (IMF)
- Max. spacing:
  - SMF: \( L_b = 0.086 r_y E/F_y \)
  - IMF: \( L_b = 0.17 r_y E/F_y \)
- If the exception in 358-5.3.1(7) is not met, first brace must be ≤ \( d_b/2 \) from protected zone for SMF (358-5.3.1).
- All braces must meet provisions of 360 Appendix 6 Eqs. A-6-7 and A-6-8 with \( M_r = R/F_y Z_x \)

**Steel Backing (358-3.3.2)**

- When used, backing must be removed and the root pass must be backgouged and back-welded with a reinforcing fillet.

**Demand-critical CJP**

- (top and bottom, per 358-5.5) and Weld Access Hole (top and bottom per 360-J1.6)

**Protected Zone**

\[ a + b \]

358-5.3.1(8)

\[ d_b/2 \]

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