

A new prequalified connection
for seismic moment frames features an energy-dissipating fuse.

SPECIALIZED Seismic Solution

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A NEW TYPE of partial-strength steel moment resisting connection has been approved for inclusion in the upcoming ANSI/AISC 358-16 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*.

Developed by Simpson Strong-Tie specifically for seismic environments, it incorporates the company's patented Strong Frame Yield-Link structural fuse and is the first partial-strength steel moment frame connection to be qualified for use in special moment frame (SMF) systems. Merging a number of different technologies, the new field-bolted moment connection focuses seismic energy dissipation into bolt-on/bolt-off replaceable structural fuses facilitating resilience and rapid recovery after a seismic event. In doing so, the structural integrity of the beams and columns is maintained even in severe earthquakes.

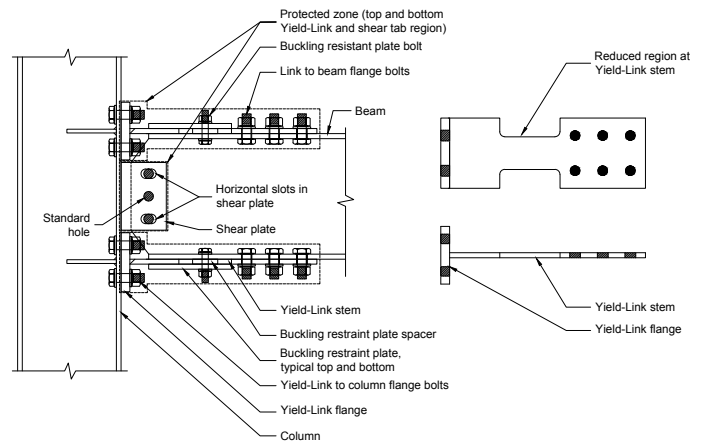
Based on Capacity

At its core, the connection relies on capacity-based design. Unlike current SMF connection designs, the beam-to-column connection is designed to be the yielding hinge as opposed to the beam itself. Once the necessary connection strength and stiffness is determined, the beam, column and column panel zone are all designed to develop the full inelastic strength of the connection, while themselves experiencing little, if any, inelastic demand. Given that the beam is stronger than the connection, the connection becomes classified as a partially restrained connection.

Under factored LRFD load combinations (not including load combinations that consider overstrength) the connection is required to remain elastic. Like any other SMF connection, code drift limits and base shear strength requirements still apply. This means that while the connection itself may be classified as partially restrained, a building using these connections will have the same minimum lateral strength and stiffness as required for other SMF connections. Full design and detailing requirements can be found in ANSI/AISC 358-16, Chapter 12.

The Yield-Link uses a T-section bolted to both the column flange and the beam flange at both beam flanges, and it acts in both tension and compression. The stem of the T contains a reduced section to control axial stiffness, yield strength and tensile strength. A buckling restraint plate is placed over the yielding

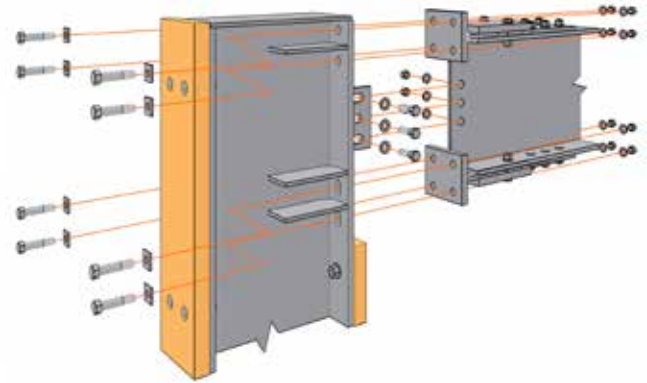
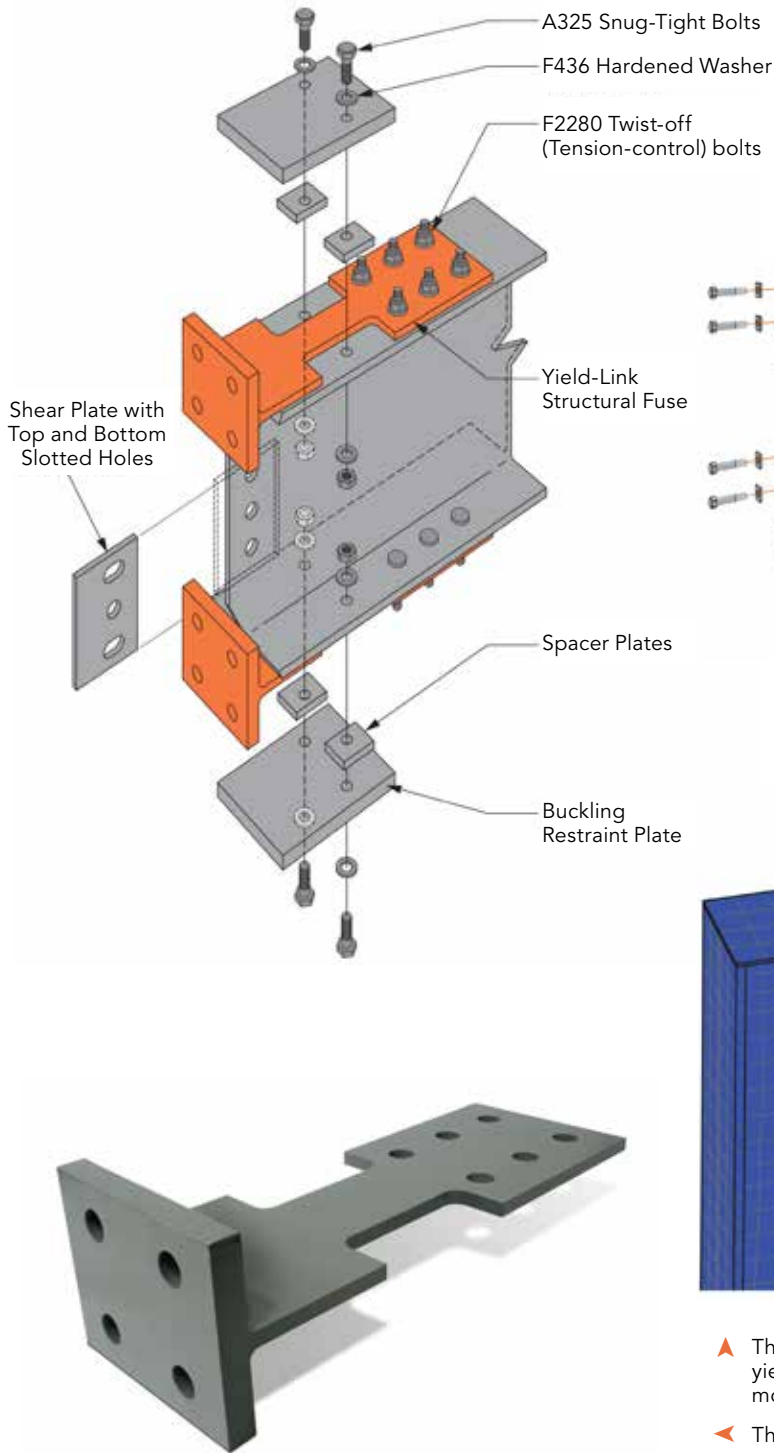
section to prevent buckling when in compression. The buckling restraint plate is bolted to the beam flange on either side of the reduced area, with the bolts passing through a spacer plate with the same thickness as the stem of the T-section. Beam shear is transferred to the column via a single-plate shear connection, which uses a combination of holes and slots to avoid moment transfer through the shear plate.



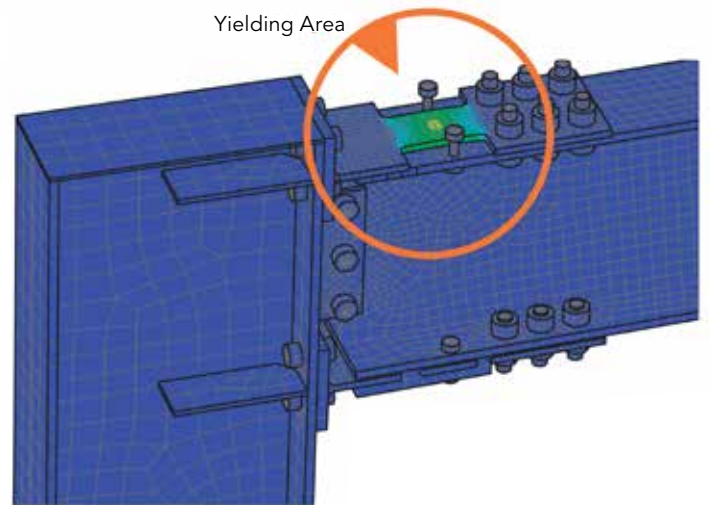
▲ Figure 12.1 of 358-16. Simpson Strong-Tie Strong Frame moment connection.

Beam Bracing

A primary reason for developing this new technology was to provide an SMF solution in situations where the surrounding structure (such as a wood structure) prevents the development of the required strength and stiffness in the beam bracing system required to prevent lateral-torsional buckling of the beam during seismic events. Because seismic inelastic demand is concentrated in the connection elements rather than the beam cross section, the beam remains essentially elastic and can be designed according to the AISC *Specification*. If one chooses, the beam can be selected so that for the span and loads under consideration it is adequate even without flange bracing. Addition-



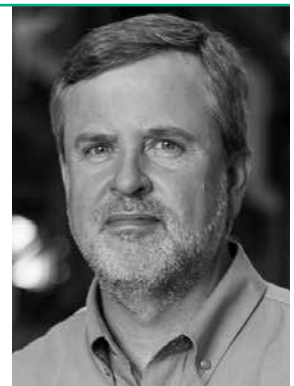
- ▲ A 3D connection detail.
- ◀ An installation diagram.



- ▲ The highlighted green section illustrates the yield-link area on the Strong Frame special moment frame connection.
- ◀ The yield-link itself.

ally, with the exception of a minimum flange thickness of 0.40 in. (10 mm) and the requirement that the flange width-to-thickness ratio not exceed λ_p , beam and flange width-to-thickness requirements are required to comply with the AISC *Specification* rather than the AISC *Seismic Provisions*. This is proving to be very useful for seismic retrofits in wood structures that want to use a high-performance SMF solution but otherwise cannot meet the requirements for both strength and stiffness in the flange bracing system, while the field-bolted nature of the construction avoids the potential fire hazards associated with field welding in an existing wood structure. Another area of potential use would be frame systems that would otherwise have to be designed as ordinary moment frames, such as those used in the metal building industry.

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➤ The Strong Frame system.

Like other connections, there are limits to what has been prequalified:

- Yield-Link stem thickness of 0.50 in. (12.5 mm)
- Maximum width of the reduced yielding portion of the stem of 3.50 in. (89 mm)
- Buckling restraint plate thickness of 0.875 in. (22 mm)
- Snug-tight bolts are permitted at the Yield-Link-to-column and shear plate connection, and are required at the buckling restraint plate connection
- Fully pretensioned bolts are required at the Yield-Link-to-beam connection (no paint in the faying surface, but no special surface preparation)
- Maximum beam depth consistent with W16 profiles
- Maximum column depth consistent with W18 profiles
- Strong-axis connections only

Cyclic testing has been performed, which has successfully demonstrated that the connection meets or exceeds the requirements for SMF connections as required by the AISC *Seismic Provisions*. Additionally, full-scale shake table testing beyond the requirements of the *Seismic Provisions* has also demonstrated the outstanding performance of frames using the connection in conjunction with beams lacking flange bracing.



The connection is well suited to both new and retrofit applications, and with the ever-increasing awareness of the role that structural resiliency plays in our communities, the connection is ready to do its part in a new and unique way. ■

AISC 358-16 will be available to the public later this year. You can find out more about the Simpson Strong-Tie special moment frame at www.strongtie.com/smf.

Prequalified Connections

Below are some FAQs about how prequalified connections are addressed in AISC 358.

What is a prequalified moment connection?

Prequalified moment connections are structural steel moment connection configurations and details that have been reviewed by AISC's Connection Prequalification Review Panel (CPRP) and incorporated into the AISC 358 standard. The criteria for prequalification are spelled out in AISC's seismic provisions, AISC 341. In short, AISC 341 contains performance and testing requirements that have been shown to produce robust moment connections, and AISC 358 details connections that meet those criteria. Both standards are free downloads at www.aisc.org/specifications.

What's involved in prequalification?

Chapter K of AISC 341 describes parameters for test specimens as well as the testing requirements that all connections must satisfy. Test specimens must essentially be full scale and cover a range of shapes and sizes for which the connection is proposed. The test results as well as proposed design provisions are provided to the Connection Prequalification Review Panel for review and approval. The CPRP does not charge any fees for reviewing connections.

Full-scale testing is expensive, as you can imagine, and CPRP does not fund or perform testing itself. Various industry initiatives have funded tests for several non-proprietary (not patented) moment connections, and the developers of several proprietary (patented) moment connections have funded and performed their own tests for their respective connections.

Why does prequalification exist?

Before the 1994 Northridge (California) earthquake, most seismic moment connections were prescriptively designed welded flange connections with bolted single-plate web connections. After the quake, more damaged connections were observed than what was expected, which led to a program of moment connection testing funded by federal agencies, state associations and various trade groups, including AISC. The result of those tests was a series of seismic moment connection guidelines published by FEMA (the Federal Emergency Management Agency).

To integrate all of this knowledge into contemporary structural steel design—and to create a logical path for extending the industry's knowledge going forward—AISC adopted (and adapted) the FEMA guidelines into the AISC 358 standard in 2005. Over the past 10 years, AISC 358 has expanded as more structural steel moment connections for seismic applications have been studied and codified.

What if a moment connection configuration doesn't fit the parameters of a prequalified connection?

Each prequalified connection in AISC 358 contains the parameters for which the connection is considered prequalified. Connections that don't fall within the criteria for an existing prequalified connection would have to be tested according to the requirements of Section K2 in AISC 341. In practical terms, this means that some common sloped and skewed configurations (for example, sloping roof girders) do not fit the prequalification criteria, and engineering judgment is required.