

Slotted Web Steel Beam-to-Column Connection Designs

This connection design is shown schematically in the attached Innovation Illustration. It is similar to the popular and economical field welded–field bolted beam-to-column moment frame connection, shown in the current American Institute of Steel Construction's LRFD and ASD steel design manuals, which has become known as the “pre-Northridge” connection because of its numerous fractures during the 1994 Northridge, CA earthquake. The Structural Engineers Association of California concluded in 1994 that the pre-Northridge connection is fundamentally flawed and should not be used in the construction of new seismic moment frames. However, by (1) separating the beam flanges from the beam web in the region of the connection by using beam web slots and (2) welding the beam web to the column flange, the force, stress and strain distributions in this economical field welded-field bolted connection are changed dramatically in the following ways:

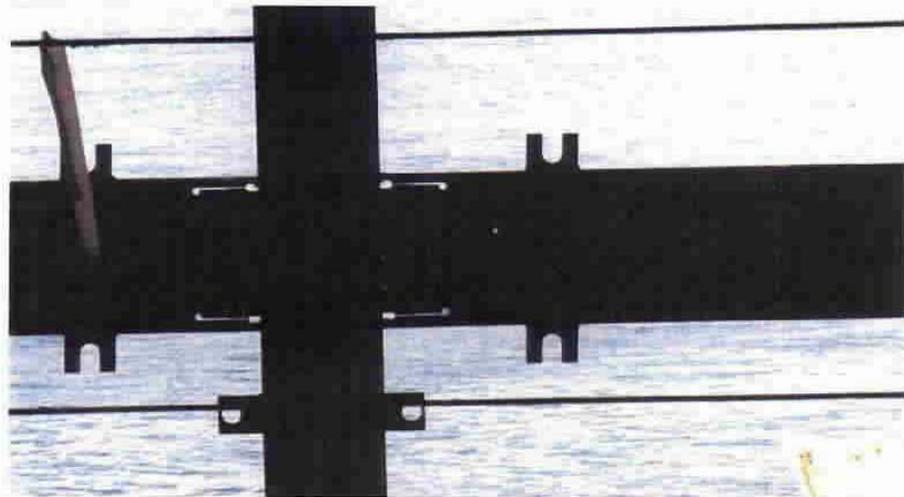
- The Slotted Web connection is kinematic so that the connection force distributions are statically determinate and are independent of interstory drift. The beam web resists the entire beam vertical shear and its share of the beam moment whereas the flanges resist only moment. Full scale low cycle fatigue tests have shown that this kinematic attribute more than triples the fatigue life over the non-slotted connections that subject the beam flange/welds to a large portion of the beam seismic vertical shear.
- The lateral-torsional mode of beam buckling that is characteristic of non-slotted beams is eliminated. The separation of the beam flanges and beam web allow the flanges and web to buckle independently and concurrently, which eliminates the twisting mode of buckling and its associated torsional beam flange/weld stresses. Elimination of this buckling mode is important for perimeter seismic moment frames that support the exterior cladding of the building. Even a small amount of twisting of these perimeter beams will be reflected as significant visible distortion of the exterior cladding.
- The beam web slots eliminate the seismic shear in the beam flanges, which reduces the large stress and strain gradients across and through the beam flanges and at the weld access hole by permitting the flanges to flex out of plane. Typically, the elastic stress and strain concentration factors (SCFs) of the pre-Northridge connection, caused by the large beam flange shear that result in severe local beam flange and/or column flange distortions, are reduced from 4.0 to 5.0 down to 1.2 to 1.4.
- The separation of the beam web and the flange results in biaxial rather than triaxial stress and strain states in the region of the connection, which increases its fatigue life. Moreover, residual weldment stresses are significantly reduced because the slots also provide a long structural separation between the vertical web and horizontal flange weldments.

The Slotted Web connection design rationale that sizes the beam slot length, shear plate, and connection weldments, is based upon successful FEMA/AISC ATC-24 protocol test results and extensive inelastic finite element analyses of the beam and column stress and strain distributions and buckling modes. Incorporated in this rationale, which has been accepted by numerous departments of building and safety, are the UBC and AISC Load and Resistance Factor Design (LRFD) Specifications and the 1997 AISC Seismic Design Provisions for Steel Buildings and its supplements.

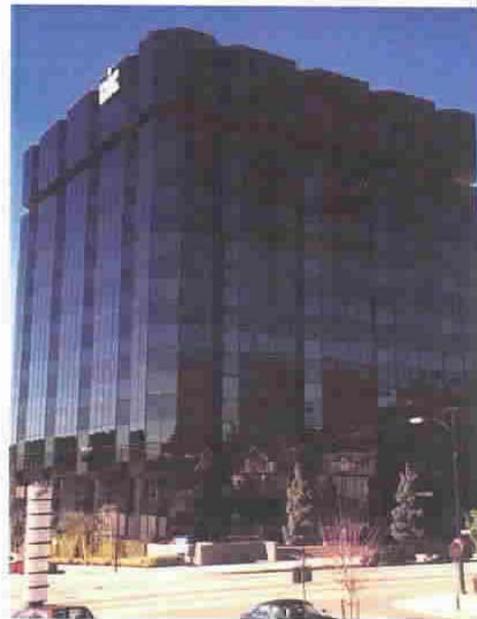
Seismic Structural Design Associates, Inc. (SSDA), owners of the proprietary Slotted Web Connection Designs, have successfully completed numerous ATC-24 protocol tests for both new and retrofit construction with beams ranging from W27x94 to W36x300 with columns ranging from W14x176 to W14x550. Additionally, successful tests have been completed using W24x94 and W36x170 beams with deep W30 columns. None of these assemblies experienced the lateral-torsional mode of buckling of the beams or columns that is typical of non-slotted beam and column assemblies.

The SSDA Slotted Web seismic connection is very cost effective for both new construction and for retrofitting existing steel moment frames. Currently SSDA has completed or contracted for the design of their connections in over 150 new buildings in California, Utah, Arizona and Nevada. Included in these are a 40 story building in San Francisco, a 32 story building in San Diego, and a 20 story building in Salt Lake City. Additionally, six buildings have been retrofitted including a 10-story office building in Burbank and a three story medical office building in Granada Hills. The California Office of Statewide Health Planning and Development (OSHPD) has approved the Slotted Web connection designs for use in three hospitals.

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SSDA Slotted Web™



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