

BRACE Yourself

BY LARRY S. MUIR, P.E., AND WILLIAM A. THORNTON, P.E., PH.D.

AISC Design Guide 29 provides a new resource for analyzing and designing vertical bracing connections.

A VERTICAL BRACE CONNECTION can often involve nearly every limit state related to connection design.

This fact should make the recently released AISC Design Guide 29: *Vertical Bracing Connections—Analysis and Design* useful not only to those involved in designing and checking vertical brace connections, but also to virtually anyone involved in designing steel structures.

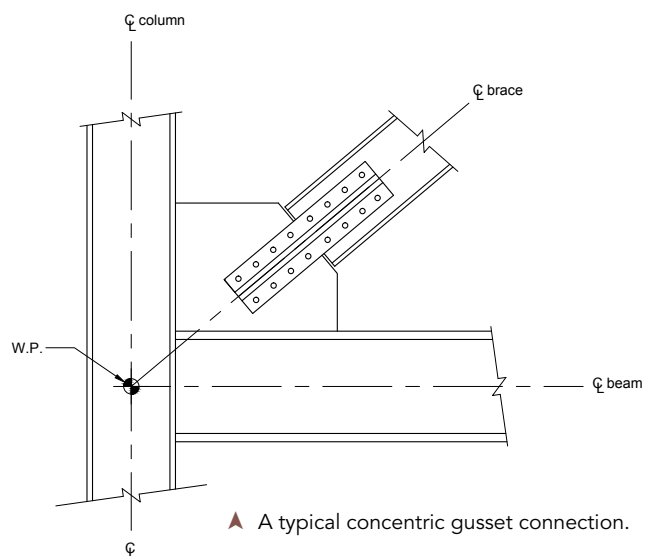
Nearly every applicable design equation in Chapter J of the AISC *Specification* is demonstrated in the context of connection designs—with an emphasis on real-world designs. The design examples presented are taken from actual projects, with only the names changed to protect the innocent. But unlike most textbook examples, in Design Guide 29 not every check passes

the first time. Plate thicknesses are increased, forces are redistributed, engineering judgments are made and choices between various options are presented and discussed.

And the guide doesn't just stop with the AISC *Specification*. Many other important aspects of connection design, even some perhaps viewed as esoteric, are also presented and put into context. The Lower Bound Theorem, the Uniform Force Method (UFM), the Whitmore section, yield-line analysis, frame distortion, alternative load paths and transfer forces all make appearances. There is something for everyone, from practical decisions (such as whether to mill a plate to bear or use a larger weld) to the mathematical acrobatics of derivations—and yes, even a Lagrange multiplier.



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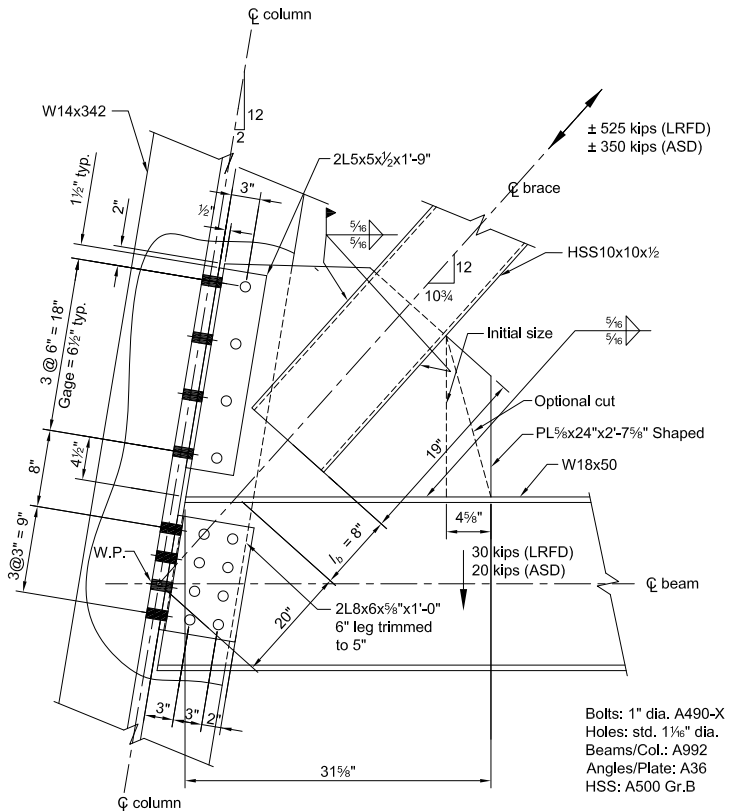
- A non-orthogonal bracing connection.

AISC Design Guide 29 contains six sections:

- Section 1 presents the scope and introduction. It includes a brief discussion of the Lower Bound Theorem of Limit Analysis, which forms the basis for much of the rest of the guide.
- Section 2 addresses common bracing systems and analysis considerations.
- Section 3 addresses connection configurations and brace member type.
- Section 4 addresses the determination of the distribution of forces. It provides an overview of the various methods that have historically been used, but focuses primarily on the application of the UFM. It addresses its application to connections where the brace force is applied concentrically, conditions with high beam-end shear demands, corner gussets that attach to the beam only and non-orthogonal corner connections, in addition to more typical conditions. This section also discusses the effects of frame distortion, connections to column bases and central, or Chevron, conditions.
- Section 5 presents design examples in both ASD and LRFD formats.
 - 5.1 - General Uniform Force Method – Strong-Axis Column Orientation
 - 5.2 - Uniform Force Method Special Case 1 – Strong-Axis Column Orientation
 - 5.3 - Uniform Force Method Special Case 2 – Strong-Axis Column Orientation
 - 5.4 - Uniform Force Method Special Case 3 – Strong-Axis Column Orientation
 - 5.5 - General Uniform Force Method – Weak-Axis Column Orientation
 - 5.6 - Uniform Force Method Special Case 1 – Weak-Axis Column Orientation
 - 5.7 - Uniform Force Method Special Case 2 – Weak-Axis Column Orientation
 - 5.8 - Uniform Force Method Special Case 3 – Weak-Axis Column Orientation
 - 5.9 - Chevron Brace Connection
 - 5.10 - Non-Orthogonal Bracing Connection
 - 5.11 - Truss Connection
 - 5.12 - Brace-to-Column Base Plate, in both strong- and weak-axis conditions
- Section 6 addresses the design of bracing connections for high-seismic demand.

The guide also contains four appendices that discuss the derivation and generalization of the UFM, the use of the directional strength increase for fillet welds, the stability of gusset plates and transfer forces.

- A yield line for a column web at a base plate.



A few highlights:

- If you have always wondered how to approach vertical brace-to-column base connections with the work point above or below the base plate, you will find the answer in Section 4.3.
- Does the Whitmore section extend beyond the gusset plate into the beam web? An example is shown on page 51.
- See how to convert the moment between the gusset and the beam to a normal force to check web crippling on page 95.
- Example 5.4 tackles braces with shallow bevels.
- Learn how to optimize extended single-plate connections with an alternative e_c location in Appendix A.

Design Guide 29 is free to AISC members at www.aisc.org/dg; nonmembers can purchase the guide for \$60. ■

