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SEISMIC UPGRADE

A brief overview of what's new in the 2nd Edition AISC *Seismic Design Manual*.

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EARLIER THIS YEAR, AISC introduced the 2nd Edition of the *Seismic Design Manual*.

Built upon the 2010 AISC *Seismic Provisions for Structural Steel Buildings*, the new *Seismic Design Manual* provides additional discussion and design examples and demonstrates the application of that standard. It is organized as follows:

- Part 1: General Design Considerations
- Part 2: Analysis
- Part 3: Systems not Specifically Detailed for Seismic Resistance
- Part 4: Moment Frames
- Part 5: Braced Frames
- Part 6: Composite Moment Frames
- Part 7: Composite Braced Frames and Shear Walls
- Part 8: Diaphragms, Collectors and Chords
- Part 9: Provisions and Standards
- Part 10: Engineered Damping Systems

Part 9 includes the 2010 AISC *Seismic Provisions* and the 2010 AISC *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*. Some topics in the new edition are expanded from the 1st Edition while others, such as analysis and composite systems, are new.

There are several other changes as well. In addition to the burgundy cover, one of the obvious updates is the inclusion of both load and resistance factor design (LRFD) and allowable strength design (ASD) methods throughout the design examples. There was also a concerted effort by the committee responsible for the maintenance of the *Seismic Design Manual* to incorporate expanded discussion for each chapter, as well as expanded explanatory text and figures in the design examples themselves. As part of this effort the 2nd Edition *Seismic Design Manual* illustrates more of the seismic design and detailing concepts and also offers alternatives in design that readers can consider in their own projects.

For example, the special moment frame connection design example illustrates full design checks for doubler and continuity plates and their required welds, as shown in Figure 1. As an alternative, the example calculates the next largest column for which this extra panel zone detailing would not be required, so that readers can understand the options available and choose the best one for each application. In addition, by including step-by-step descriptions and citing the applicable sections and equations from the AISC *Specification for Structural Steel Buildings* and the AISC *Seismic Provisions* used in each example, the new *Seismic Design Manual* will prove to be an effective reference for designers.

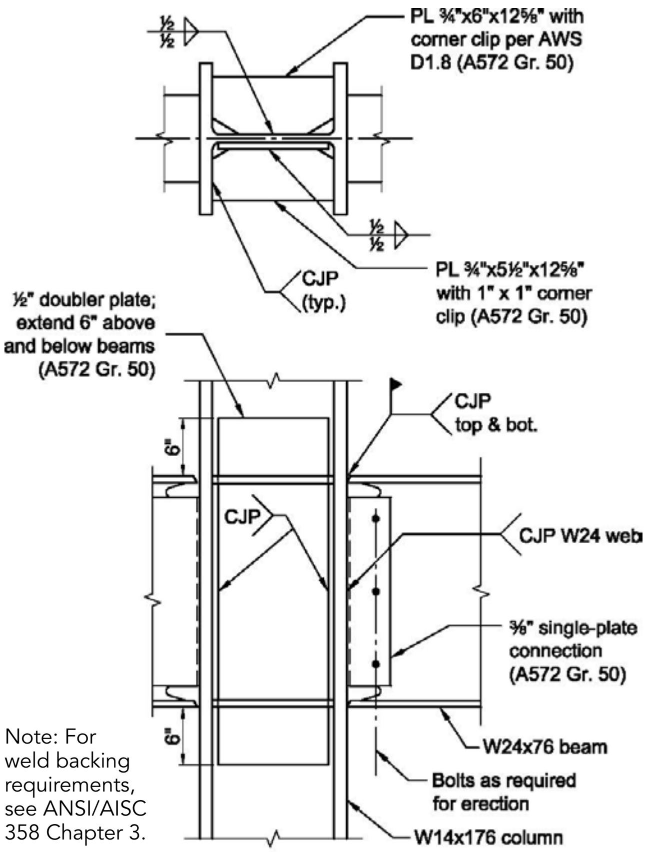

Figure 1: SMF panel zone detailing from *Seismic Design Manual* Example 4.3.4.

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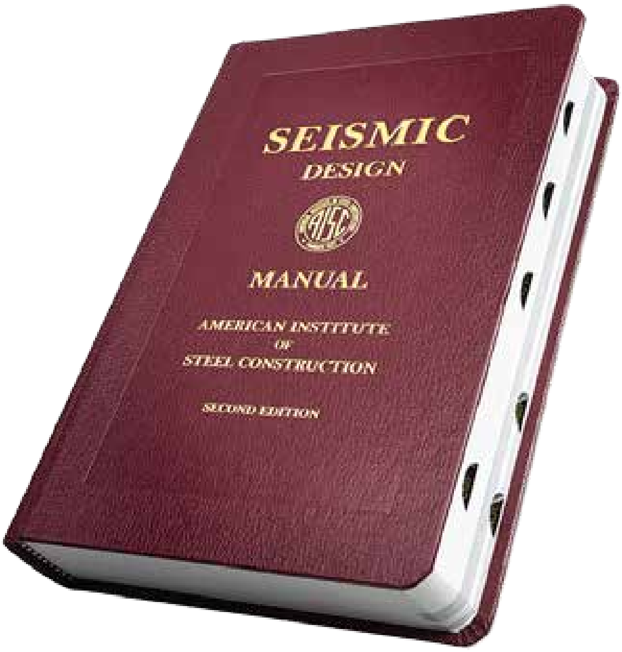
To provide clarity as to when the AISC *Seismic Provisions* are to be applied, the 2nd Edition includes a Scope statement following the Preface clarifying whether systems are required to be designed according to the additional seismic detailing requirements of the AISC *Seismic Provisions* or the basic requirements of the AISC *Specification*. This distinction is dependent on the system classification in ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*. For convenience, Part 1, General Design Considerations, expands on this by providing tables that are condensed versions of ASCE/SEI 7-10 Table 12.2-1, Design Coefficients and Factors for Steel and Steel and Concrete Composite Seismic Force Resisting Systems, and ASCE/SEI 7-10 Table 15.4-1, Design Coefficients and Factors for Nonbuilding Structures Similar to Buildings. These tables incorporate a listing of the applicable sections where detailing requirements are specified—either in the AISC *Seismic Provisions*, AISC *Specification* or ASCE/SEI 7—for each system type listed.



Summary of Parts

Part 1 begins with a listing of the applicable specifications, codes and standards that are to be used with the 2nd Edition. This is followed by a discussion of several subjects that relate to seismic design in general, including: performance goals; application of ASCE/SEI 7, in conjunction with AISC standards; maximum force delivered by the system; building joints; building drift; quality control and quality assurance; and design drawing requirements. There is considerable discussion of the applicable ASCE/SEI 7 parameters, such as seismic performance factors (R, C_d, Ω_o and ρ) and how they relate to the *Seismic Provisions*. The use of the term *amplified seismic load* in the *Seismic Provisions* is also explained, as it can have two different meanings: use of the ASCE/SEI 7 load combinations that include the overstrength factor, Ω_o, or a term defined to meet a capacity design requirement. Part 1 also introduces composite systems, including their integration into the main body of the *Seismic Provisions* and their presentation for the first time in the 2nd Edition.

Part 2 (Analysis—again, a new addition in the 2nd Edition) provides an overview of analysis provisions and stability design methods and how they apply to seismic design in the *Specification*, *Seismic Provisions* and ASCE/SEI 7. The relationship between ASCE/SEI 7 methods of analysis (equivalent lateral force analysis and modal response spectrum analysis) and the direct analysis method of the *Specification* is also discussed, including what criteria must be met in the ASCE/SEI 7 methods to maintain consistency with the direct analysis method. A general discussion on modeling the strength and stiffness of structural elements, as well as diaphragms and gravity loads, is also incorporated.

Until the 2010 *Specification* was introduced, an ASCE/SEI 7 specified seismic response modification coefficient, R, equal to 3 was the dividing line between low seismic and high seismic applications. That is, only systems with R greater than 3 were required to satisfy the *Seismic Provisions*. Because ASCE/SEI 7 now includes systems with $R \leq 3$, which *do* require seismic detailing requirements, the scopes of the *Specification* and the *Seismic Provisions* were modified to simply refer to the applicable building code to determine whether the system is exempt from the requirements of the *Seismic Provisions*. A summary is provided, however, to make clear where special seismic detailing is and is not required.

Part 3 of the *Seismic Design Manual* (Systems Not Specifically Detailed for Seismic Resistance) addresses systems that do not require special seismic detailing. This section is included because even when the *Seismic Provisions* and seismic detailing are not required, there are other seismic design considerations stipulated in ASCE/SEI 7, such as horizontal and vertical structural irregularities, seismic load combinations, duration of loading and amplification of accidental torsional moment. Design examples demonstrate that most of the design of the moment frame and braced frame systems presented is based on the requirements of the *Specification*; however, the applicable load combinations including seismic effects are stated in the problem solution to indicate that these have been included in the analysis.

Parts 4 through 7 address most of the system types that are included in the *Seismic Provisions*. Each sub-section of each part contains one seismic force resisting system (SFRS) outlined in the *Seismic Provisions*. For example, Part 4.2 addresses ordinary moment frame systems (OMF), which corresponds to *Seismic Provisions* Section E1. Each of these sub-sections contains a discussion section, a description of the relevant seismic parameters and a few key plans and elevations for a typical building. The examples that follow present designs of some of the members and connections in that building. This allows the *Seismic Design Manual* to demonstrate that a key element of seismic design is the proper proportioning of members within the frame (e.g., strong column-weak beam) and the principles of capacity design (e.g., the required strength of a bracing connection is based on the expected strength of the brace).

Part 4, Moment Frame Systems, begins with a discussion of OMFs, intermediate moment frames (IMFs) and special moment frames (SMFs), followed by design examples. IMF requirements are very similar to those of SMFs. (For this reason, IMF design examples aren't included.) Table 4-1 provides a comparison of the requirements for the two systems. The following design examples are included for both OMFs and SMFs: story drift and stability checks based on ASCE/SEI 7, beam and column design and connection designs (eight-bolt stiffened end plate for OMF and prequalified reduced beam section—RBS—moment connection for SMF). The eight-bolt stiffened end plate connection was used in the 2nd Edition as an alternative to the prescriptive connection described in *Seismic Provisions* Section E1.6b(c). The prequalified reduced beam section moment connection is just one of the types of connections available for use in IMFs or SMFs according to the *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*. Part 4 concludes with two examples on column splice design, including a column that is part of an SMF and two types of fixed column base designs—one with a base plate and one with the column base embedded in concrete.

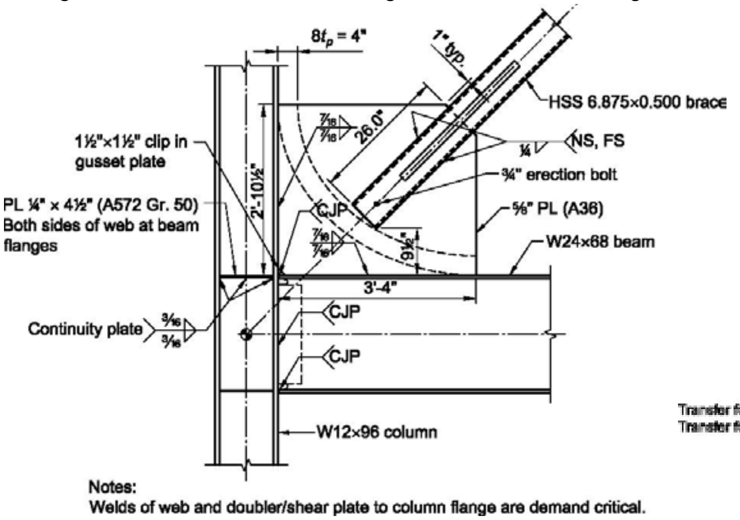
Part 5, Braced Frame Systems, includes discussion and design examples for ordinary concentrically braced frames (OCBFs), special concentrically braced frames (SCBFs), eccentrically braced frames (EBFs) and buckling restrained braced frames (BRBFs), along with a brief discussion of nonbuilding structures. The OCBF examples show partial design of a one-story building with X-bracing and an all-bolted brace-to-gusset connection using claw angles. The SCBF examples highlight refined analysis requirements of the *Seismic Provisions* Section F2. In addition, the SCBF connection examples provide multiple options for accommodating brace rotation both in and out of the plane of the frame and for both simple and moment beam-to-column connections, as shown in Figure 2. In the EBF section, capacity design principles are illustrated through design examples of the non-yielding members based on the adjusted shear strength of the link. The BRBF section, which is new in the 2nd Edition, provides useful discussion and design examples, including coordination with the manufacturer and application of manufacturer-provided parameters for design.

Parts 6 and 7 incorporate composite framing systems into the *Seismic Design Manual* for the first time. Prior to 2010, these systems were relegated to "Part II" of the *Seismic Provisions*. In the 2010 *Seismic Provisions*, they have been moved into the main body of the standard to be included with the steel systems. With that move, composite system requirements were expanded to provide more comprehensive design provisions by incorporating topics that align with those provided for the steel seismic systems, such as basis of design, system requirements, demand critical welds and protected zones. Part 6, Composite Moment Frames, and Part 7, Composite Braced Frames and Shear Walls, begin with a discussion and overview of the applicable design provisions for each of the systems included.

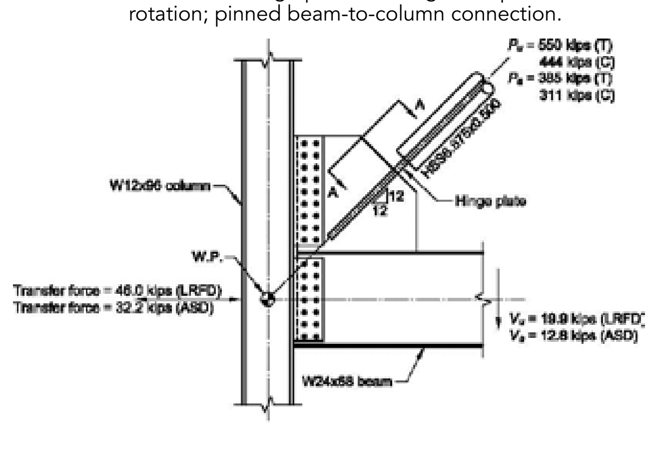
Part 6 includes a discussion of the following systems: composite ordinary moment frames, composite intermediate moment frames, composite special moment frames and composite partially restrained moment frames; a section on connection design for these types of systems is also included. Because there are no prequalified connections available for use in composite moment frames, the discussion provides references and a summary of available test results and evaluation of some applicable connection types, such as reinforced concrete column-to-steel beam connections, round filled composite column-to-steel beam connections and rectangular filled composite column-to-steel beam connections.

Part 7 addresses the following systems: composite braced frames and shear walls, composite ordinary braced frames, composite special concentrically braced frames, composite eccentrically braced frames and composite shear walls. The examples discuss the design of steel and composite coupling beams in composite shear wall systems (ordinary and special). Coupling beams provide the transfer of vertical forces between adjacent walls to create a frame-like coupling action that resists a part of the total overturning moment induced by the seismic action. The efficiency of coupled wall systems and details of the embedded coupling beam are discussed in Part 7. Unlike the other parts, the design examples in Part 7 are implemented using only LRFD. As is stated in the *Seismic Provisions*, systems with reinforced concrete elements that must be designed according to ACI 318 should be designed only by the LRFD method because ACI 318 does not

Figure 2: Two SCBF connection designs from the *Seismic Design Manual*.



(a) SCBF connection from Seismic Design Example 5.3.11, with elliptical offset allowing for out-of-plane brace rotation; fixed beam-to-column connection.



(b) SCBF connection from Seismic Design Example 5.3.12, with hinge plate allowing for in-plane brace rotation; pinned beam-to-column connection.

address ASD. This is consistent with the recommendation that ASD and LRFD methods not be combined within a structure.

The design of diaphragms, collectors and chords is not specifically addressed in Parts 4 through 7; therefore, Part 8 applies to these elements and their connections that are also required to be detailed for seismic resistance. A general discussion is included on diaphragms explaining that diaphragms and collectors are required to distribute lateral forces to vertical frames that may not be uniformly spaced and continuous throughout the building. Part 8 also defines collector elements as tension and compression members that deliver the diaphragm forces to the lateral force resisting frames. New discussion has been added on determining the compressive strength of a collector due to flexural-torsional buckling when the section is constrained to twist about its top flange rather than its centroid. This condition occurs when the top flange is continuously braced by a steel deck with ribs perpendicular to the beam (see Figure 3). A design example demonstrates the application of this limit state for collector design.

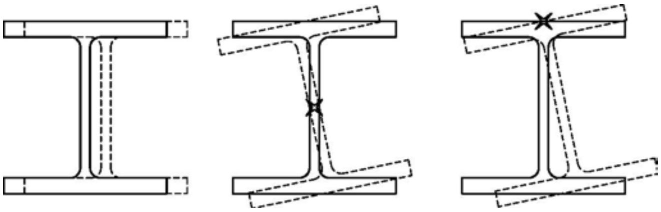


Figure 3: Types of collector buckling.

Expanded Coverage

Both new and experienced seismic designers of structural steel buildings will find the 2nd Edition *Seismic Design Manual* an important reference. This new edition includes discussion of most of the seismic force resisting systems currently addressed in the *Seismic Provisions*, in addition to handling other seismic elements such as diaphragms, collectors and chords. The expanded coverage on these topics and the detailed design examples are intended to make seismic design more transparent. For additional instruction on the new *Seismic Design Manual*, be sure to check out the AISC Louis F. Geschwindner Seminar Series on the 2nd Edition *Seismic Design Manual*, which will visit several cities beginning this fall. Additional publications relevant to seismic design, such as design guides, Steel Facts and background references, can be found at **www.aisc.org/seismic**.

AISC is always interested in receiving feedback. If you have any questions or comments on this new AISC publication or any steel-related topic, please contact the AISC Steel Solutions Center at **www.solutions@aisc.org**. MSC