

## AISC Design Guides

BY LEIGH ARBER

A concise rundown of what's covered in each of these 23 reference publications.

**TO DATE, AISC HAS PUBLISHED** a total of 23 design guides, and others currently are being written and reviewed. Each guide provides information on the theory, design, or construction practice of a different topic in the structural steel industry, ranging from the global design of low- and medium-rise buildings to the detailed design of partially restrained composite connections. Some guides are supported by extensive research while others are based on empirically proven methods. All design guides bring the collective experience and knowledge of the author and reviewers, including fabricators, engineers, professors, researchers, and practitioners in the engineering and construction industries.

Unlike the *Specification for Structural Steel Buildings* and *Seismic Provisions for Structural Steel Buildings*, AISC design guides are not code-adopted legal documents. Rather, they are concise, practical, and accessible tools to assist engineers with everyday design challenges.

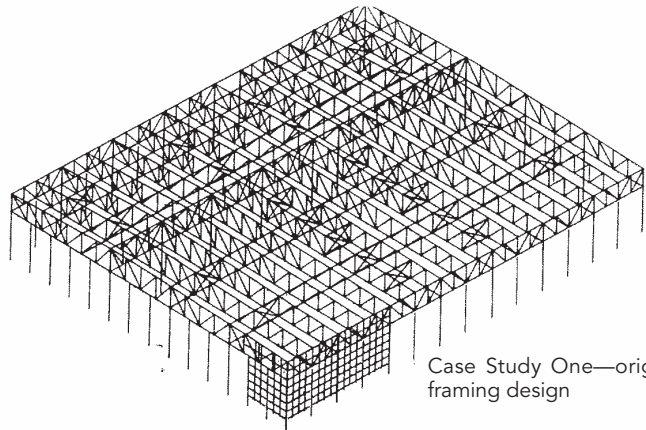
AISC design guides are freely downloadable for AISC members at [www.aisc.org/epubs](http://www.aisc.org/epubs), and bound paperback copies are also available through the AISC website at [www.aisc.org/store](http://www.aisc.org/store). The two most recently published design guides are described in detail below, followed by short summaries of the others.

### Steel Design Guide 23: Constructability of Structural Steel Buildings

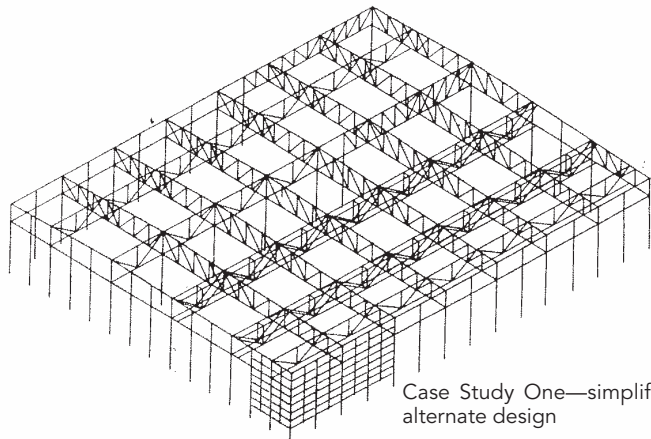
Author: David I. Ruby, P.E., S.E.

Constructability is an important, but often overlooked, part of a proposed building design and deserves attention from the design team, and especially the structural engineer, during the design phase. To illustrate this point, *Design Guide 23* shows the dramatic difference in complexity between a joint as it appears in line-drawing form on a structural drawing, and that same joint as it is actually detailed. The actual joint, designed by a specialty structural engineer retained by the fabricator, required complex connections with a large number of bolts—and communication with the Engineer of Record to ensure that the forces and load path were proper. Earlier consideration of constructability and communication with the fabricator may have resulted in a much simpler design solution.

The process of design, fabrication, and construction tends to be fragmented in the design-bid-build process, and thus constructability issues often are overlooked. One of the key points of this design guide is that constructability concerns should be discussed early enough in the project that revisions are still possible and economical. The rule of thumb is that errors cost 10 times less if they are caught in the design phase rather than the construction phase.



Case Study One—original framing design



Case Study One—simplified alternate design

These concept drawings are from a case study in *Design Guide 23*. They show how the original design compares to an alternate design that was 28% lighter, 15% stiffer, required 15,000 fewer field bolts, and saved both time and money.

Leigh Arber is staff engineer at the American Institute of Steel Construction. She helps with the development of design guides, the *Seismic Provisions for Structural Steel Buildings*, and the *Seismic Design Manual*.



Building Information Modeling (BIM) is a recently developed tool that can greatly improve constructability and communication efforts. Professionals from different disciplines compile and store design information in a 3D model, for the purpose of ensuring compatibility and detecting conflicts well before construction begins. BIM can be a great visualization tool and help with project estimating and scheduling, but it does not solve potential constructability issues automatically. Experience and good judgment are necessary to interpret and understand the model: “Without experience, one does not know what one does not know,” the author writes on page 7. With the use of BIM, roles and responsibilities may become blurred and diffused, so it should not be viewed as a substitute for good communication and collaboration.

Some of the specific topics that should be considered for constructability are repetition of member sizes to reduce construction cost, spacing of column splices to strike a balance between economical size and cost of splice details, and the use of AISC standard connection details, which are familiar and easier to review and install. Bay spacing and aspect ratios are recommended for optimal constructability. Because the cost of detailing, fabricating, and erecting a small beam is about the same as for a large beam, it may be more economical to use a smaller number of members. Ultimately, these decisions depend on the skill sets, availability, and relative costs of all processes involved.

*Design Guide 23* also stresses the need for clarity in the design drawings. Statements in design drawings, such as “provide stiffeners and doublers as required” transfer too much responsibility to the fabricator and may have more than one valid interpretation. The ambiguity of such phrases can cause errors in bidding and construction, and foster adversarial relationships.

This design guide provides thorough checklists, general guidelines, and reference tables to help design professionals make wise decisions about constructability in everyday practice.

## Steel Design Guide 22: Façade Attachments to Steel-Framed Buildings

Author: James C. Parker, P.E.

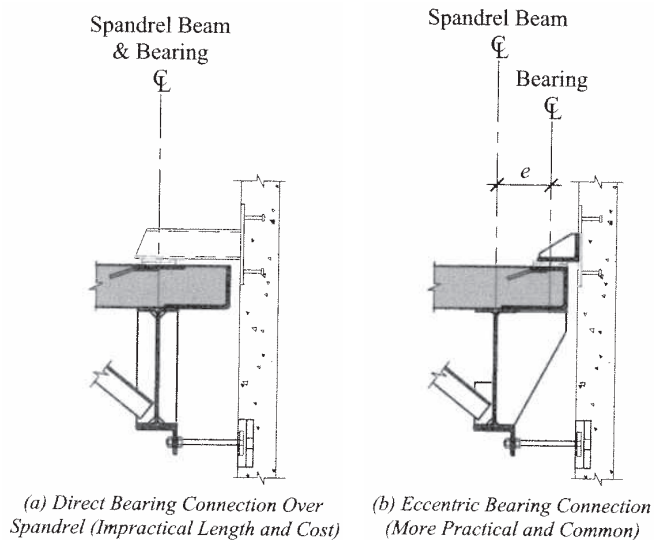
Façades, often the most visible part of a building, can be complex and often require inter-disciplinary knowledge and coordination; however, many structural engineers lack expertise on the topic. *Design Guide 22* comprehensively addresses the major issues in choosing, designing, and approving building façades, including strength, ductility, and deflection tolerances. In addition to these structural considerations, *Design Guide 22* also includes topics such as water and vapor barriers, aesthetics, constructability, and economy—all of which may influence structural decisions. Issues such as anchorage to the steel superstructure, slab edge details, and specific façade systems are discussed in depth.

To begin with, this design guide provides a table with the values for typical self-weights of various commonly used façade systems. The façade itself and the structural system must resist the façade self-weight, which can be a significant portion of the gravity load on perimeter framing. Values are given for aluminum curtain walls, brick veneer, precast concrete panels, and other systems.

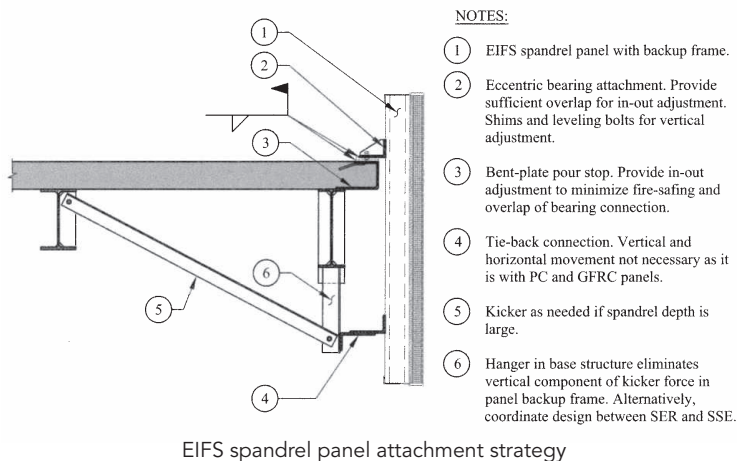
Façade systems are often complex, and the entire system work must work in an integrated way to ensure proper performance. For example, greater corrosion protection of the façade is required when a reliable waterproof membrane is not used. Steel “roll beams” (beams that frame to and torsionally stiffen a spandrel beam) or kickers should be used if the façade attachment is particularly heavy or if the slab cantilevers well beyond the spandrel beam.

One of the important details for façade attachments is the slab edge. The most basic design decision is whether to rely on the slab to carry façade loads to the steel structure or to provide a steel assembly for this purpose. Reference tables give the flexural strength of the cantilevered slab as a function of reinforcement, slab depth, and compressive strength. Options such as light-gage pour stops and steel bent plates are also discussed.

The structural effect of façade attachments on the spandrel beams also must be considered. Unlike typical beam design, the maximum permitted deflection of the spandrel beam may be an absolute value irrespective of the beam length. Additionally, the façade attachment often induces torsion in the spandrel beam. If the spandrel beam is



Direct vs. eccentric bearing connections at spandrels.



This annotated EIFS support detail from *Design Guide 22* includes notes addressing various components and considerations.

*Design Guide 22* provides numerous conceptual details comparing the practicality of different supports, such as these for precast concrete panels.

a girder, the beams that frame into it may provide adequate restraint against torsion. If the spandrel beam is parallel to the typical floor beam, roll beams or kickers between the spandrel beam and the first interior beam may be needed. HSS shapes sometimes are used as perimeter beams for this purpose as well.

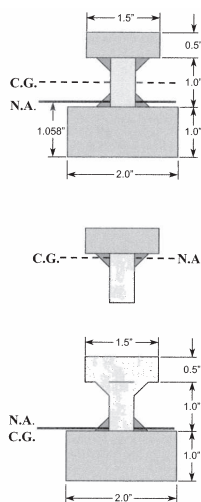
Several commonly used façade systems, including masonry cavity wall systems, precast concrete wall panels, aluminum curtain walls, and glass-fiber-reinforced concrete panels, are discussed. For each, the design guide provides general descriptions, strategies for structural support, and other features and requirements such as movement, durability, tolerances, and fire protection. Design examples are included. It also gives important guidelines for façade attachments from other standards organizations, such as tolerances for precast panels given by the Precast/Prestressed Concrete Institute. For more information, refer to the SteelWise article “Pushing the Envelope.” (December 2007 *MSC*, p. 41.)

### Steel Design Guide 21: Welded Connections—A Primer for Engineers

Author: Duane K. Miller, Sc.D., P.E.

This design guide provides an outline of the welding considerations and requirements in the AISC *Specification* and the AWS *Structural Welding Code for Steel*. It covers different types of welding processes, weld preparation, and connection types.

**Right:** This illustration from *Design Guide 21* accompanies a discussion of how weld sequencing can affect a connection.



### Steel Design Guide 20: Steel Plate Shear Walls

Authors: Rafael Sabelli, S.E. and Michel Bruneau, Ph.D.

Steel plate shear walls offer advantages over concrete shear walls by allowing for reduced thickness, reduced mass, and faster construction time. A survey of existing steel plate shear wall buildings, research on system behavior, methods of analysis, and design examples in areas of low and high seismicity are presented.

For more information, reference the SteelWise article titled “A Closer Look at Steel Plate Shear Walls.” (January 2008 *MSC*, p. 63.)

### Steel Design Guide 19: Fire Resistance of Structural Steel Framing

Authors: John L. Ruddy, S.E., Joseph P. Marlo, Socrates A. Ioannides, Ph.D., S.E., and Farid Alfawakhiri, P.Eng., Ph.D.

This design guide presents an overview, with design examples, of the parameters that determine fire resistance requirements, including occupancy, area, height, and location. It also discusses standard tests and fire-resistant assemblies and materials, such as gypsum and intumescent coatings.

### Steel Design Guide 18: Steel-Framed Open-Deck Parking Structures

Authors: Charles H. Churches, Emile W. J. Troup, and Carl Angeloff

Steel-framed parking structures offer several advantages including lower life-cycle costs and rapid construction. Deck selection is an important design consideration for steel-framed parking structures,

and this design guide discusses five types: cast-in-place reinforced concrete, cast-in-place post-tensioned slabs, precast double tees, filigree systems, and hollow-core plank. Recent developments in fire resistance and corrosion protection make the use of steel-framed parking structures more viable.

For more information, refer to the SteelWise article “Are You Next?” (September 2006 *MSC*, p. 35.)

### Steel Design Guide 17: High Strength Bolts—A Primer for Structural Engineers

Author: Geoffrey Kulak

Beginning with a comparison of bolts and rivets and the history of their use, this design guide discusses the design of bolts in tension, shear, and under combined loads. It also explains different types of joints, block shear, shear lag, and slip resistance. Finally, special topics such as galvanized bolts, oversized and slotted holes, and surface coatings are addressed.

### Steel Design Guide 16: Flush and Extended Multiple-Row Moment End-Plate Connections

Authors: Thomas M. Murray, P.E., Ph.D. and W. Lee Shoemaker, P.E., Ph.D.

This design guide discusses four flush and five extended end-plate connections. It outlines connection design procedures for determining end-plate thickness by yield-line theory, bolt forces, and prying forces. Recommendations for suitable construction methods also are provided.

### Steel Design Guide 15: AISC Rehabilitation and Retrofit Guide—A Reference for Historic Shapes and Specifications

Author: Roger L. Brockenbrough, P.E.

This design guide gives a historical overview of ASTM standards and AISC specifications, and explains evaluation methods for gravity, wind, and seismic loads in existing structures. Tables provide properties of sections produced over the last century and allowable stress values for welds, bolts, and rivets over the past several decades.

For more information, refer to the SteelWise article “Evaluation of Existing Structures.” (February 2007 *MSC*, p. 41.)

### Steel Design Guide 14: Staggered Truss Framing Systems

Authors: Neil Wexler, P.E. and Feng-Bao Lin, Ph.D., P.E.

The staggered truss system usually consists of one-story deep trusses prefabricated in the shop and bolted to columns in the field. The system, as explained in this guide, can provide benefits such as column-free space, low cost, high resistance to lateral load, and shorter construction schedules.

For more information, see the SteelWise article “Anatomy of a Staggered Truss.” (September 2002 *MSC*, p. 35)

### Steel Design Guide 13: Stiffening of Wide-Flange Columns at Moment Connections: Wind and Seismic Applications

Author: Charles J. Carter, P.E.

Although stiffeners are often required for columns in moment connections, there may be a more cost-effective solution: a heavier column that is sufficient without the use of stiffeners or doubler plates. With the goal of making designers more aware of this important consideration, this design guide addresses stiffness considerations, force transfer, and the economical selection of columns. When required, it also provides extensive guidance for the design and selection of stiffeners and doublers.

### Steel Design Guide 12: Modification of Existing Welded Steel Moment Frame Connections for Seismic Resistance

Authors: John L. Gross, Michael D. Engelhardt, Chia-Ming Uang, Kazuhiko Kasai, and Nestor R. Iwankiw

Upgrades to pre-Northridge moment connections in high-seismic applications are discussed, including retrofit with welded haunches, bolted brackets, or reduced beam sections.

### Steel Design Guide 11: Floor Vibrations Due to Human Activity

Authors: Thomas M. Murray, Ph.D., P.E., David E. Allen, Ph.D., Eric E. Ungar, Sc.D., P.E.

Vibration may be important for human comfort or for sensitive equipment. This design guide discusses basic principles of vibration, serviceability criteria, estimation of natural floor frequency, and remedial measures.

### Steel Design Guide 10: Erection Bracing of Low-Rise Structural Steel Buildings

Authors: James M. Fisher, Ph.D., P.E. and Michael A. West, P.E.

Temporary support systems, such as braced frames, rigid frames, diaphragms, or cantilevered construction, may be required for incomplete assemblies that are unable to support imposed loads. This design guide also addresses columns and column bases, tie members, and beam-to-column connections.

### Steel Design Guide 9: Torsional Analysis of Structural Steel Members

Authors: Paul A. Seaburg, Ph.D., P.E. and Charles J. Carter, P.E.

This design guide includes an overview of the theory of torsional loading, torsional stresses in combination with other stresses, AISC *Specification* requirements, and serviceability concerns. Design examples, torsional properties, and case charts are provided as design aids.

### Steel Design Guide 8: Partially Restrained Composite Connections

Authors: Roberto T. Leon, Jerod J. Hoffman, Tony Staeger, P.E.

A partially restrained composite connection (PR-CC) is a connection type that engages the reinforcing bars in the concrete slab. The advantages, limitations, assumptions, and design recommendations for this type of connection are examined.

### Steel Design Guide 7: Industrial Buildings—Roofs to Anchor Rods, Second Edition

Author: James M. Fisher

Industrial buildings generally act as enclosures for production or storage. Part I discusses design criteria, roof systems, roof trusses, and wall systems. Part II covers industrial buildings with cranes.

### Steel Design Guide 6: Load and Resistance Factor Design of W-Shapes Encased in Concrete

Author: Lawrence G. Griffis

The design of composite beams and columns, including rebar arrangement, ties, bar splices, connections, base plates, and fire resistance, is the focus of this design guide.

### Steel Design Guide 5: Low- and Medium-Rise Steel Buildings

Author: Horatio Allison, P.E.

This design guide takes a global look at the design of build-

ings. Structural engineers make important decisions in building design such as bay size, grade of steel, and floor load capacity. This guide also explains the limitations of several common engineering assumptions.

### Steel Design Guide 4: Extended End Plate Moment Connections—Seismic and Wind Applications, Second Edition

Authors: Thomas M. Murray, Ph.D., P.E. and Emmett A. Sumner, Ph.D., P.E.

Clear design procedures and examples help explain three connections that are appropriate for seismic applications. The design approach is discussed in terms of connection limit states.

### Steel Design Guide 3: Serviceability Design Considerations for Steel Buildings, Second Edition

Authors: Michael A. West, James M. Fisher, Ph.D., P.E., and Lawrence G. Griffis

The AISC *Specification* defines serviceability as “a state in which the function of a building, its appearance, maintainability, durability, and comfort of its occupants are preserved under normal usage.” This design guide discusses five topics related to serviceability: camber, expansion, deflections and vibration, connection slip, and corrosion.

For more information, refer to the SteelWise article “Serviceability: Updated Design Guide 3 Offers Guidance.” (November 2004 *MSC*, p. 33.)

### Steel Design Guide 2: Steel and Composite Beams with Web Openings

Author: David Darwin

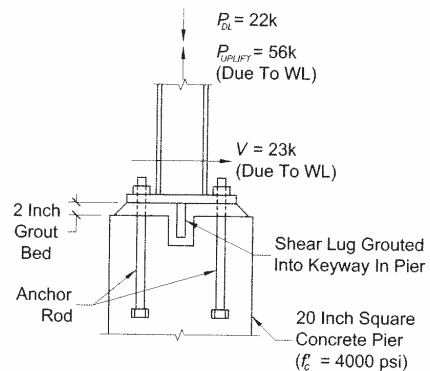
Openings in the webs of steel beams allow for utilities to pass through, thereby minimizing the space between floors. This design guide addresses stiffener plates, composite action, and optimal location and geometry of the openings.

### Steel Design Guide 1: Base Plate and Anchor Rod Design, Second Edition

Authors: James M. Fisher, Ph.D., P.E. and Lawrence A. Kloiber, P.E.

Column base plates and anchor rods often need to be designed for uplift, shear, or flexure in addition to axial compression in the column. This design guide discusses material selection, welding, and anchor rod size and spacing. An updated version of this design guide is being published in 2010.

**MSC**



*Design Guide 1* provides numerous illustrated examples explaining the process for specific applications, such as for shear lug design. An updated version of this guide is being published in 2010.