An interview with the author of AISC's recently updated design guide on welded connections.

steelwise

INTERVIEW WITH THE WELDER

BY MARGARET MATTHEW, PE, AND DUANE MILLER, PE

WANT SOME WISDOM from a well-known welding wizard?

The second edition of Design Guide 21: *Welded Connections—A Primer for Engineers* was recently released. And what better way to learn about it than a chat with its author, Duane Miller.

The below conversation between AISC's Margaret Matthew and Miller provides a helpful overview as to why engineers, fabricators, erectors, detailers, inspectors, instructors and others will want to get their hands on a copy of the updated guide.

Margaret Matthew: The last time I interviewed you was for the Steel Profiles podcast. (Editor's note: You can find Margaret's interview of Duane and the rest of AISC's Steel Profiles podcasts at **www.aisc.org/podcasts**.) Today, I'd like to discuss the second edition of the design guide on welded connections. Let me start with a basic question: Why was it time to update Design Guide 21 to a second edition?

Duane Miller: Three issues drove the need for the updated edition. First, the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) and the AWS D1.1 *Structural Welding Code* (and other standards) had undergone multiple revisions since the first edition of Design Guide 21 was published. Given the multiple references within Design Guide 21 to these standards, it was appropriate to update the guide to reference the latest industry standards. Second, with the benefit of 12 years of use of the first edition, additional topics that were not addressed in that edition had been identified as desirable for coverage in a second edition. Finally, new developments in structural steel and welded connections needed to be incorporated into the document to maintain the value of the publication.

MM: What do you think are the most significant changes in welded connections since the first edition of Design Guide 21 was published in 2006?

DM: Most significant? Well, that's a good question. Unfortunately, my answer may be long!

Many engineers, fabricators and erectors will find the new chapter on problems and fixes (Chapter 15) to be very practical and helpful. The content of the chapter is not theoretical; the examples discussed were based upon actual inquiries to the AISC Steel Solutions Center. Practical solutions are offered to issues like repairs to base metal and cut edges, corrections for out-of-tolerance weld joints and many others. Fifteen different topics are addressed, and some topics may have multiple subsections. Some of these topics were discussed in the first edition, but additional subjects were added to the second edition.

Some of the topics included were based upon inquiries I received at Lincoln Electric. In particular, the discussion in Chapter 15 on repairing of lamellar tears was included based on a customer/fabricator inquiry where a significant number of lamellar indications and/or tears had to be repaired. The content of the draft on that portion was used to provide initial guidance to the contractor, and their experiences resulted in modification to the draft as it was being developed.

Margaret Matthew (**matthew@aisc.org**) is a senior engineer with AISC and oversees the development of all new design guides. **Duane Miller** (**duane_miller@lincolnelectric.com**) is manager of engineering services with Lincoln Electric and the author of Design Guide 21.

Design Guide 21 includes discussion of specialized situations such as welding on architecturally exposed structural steel (AESS), field welding and welding on existing structures.

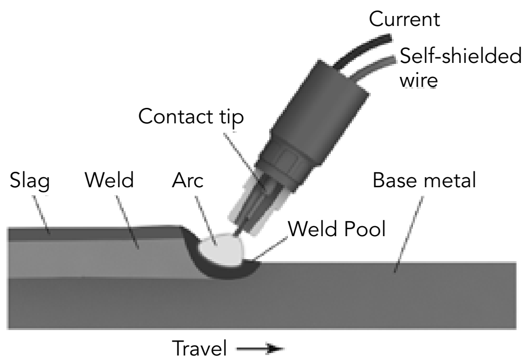
Finally, while it may not seem all that significant, the addition of an index will, I hope, prove to be user-friendly. When the reader needs to know about porosity, preheat or an RBS connection, the index will direct them to the portions of the guide that discuss that topic.

MM: You were right, that was a long answer—but a good one. Next question: This new edition includes an expanded chapter on seismic welding issues. Why are welded connections subjected to seismic loading expected to behave differently than either statically or cyclically loaded welded connections?

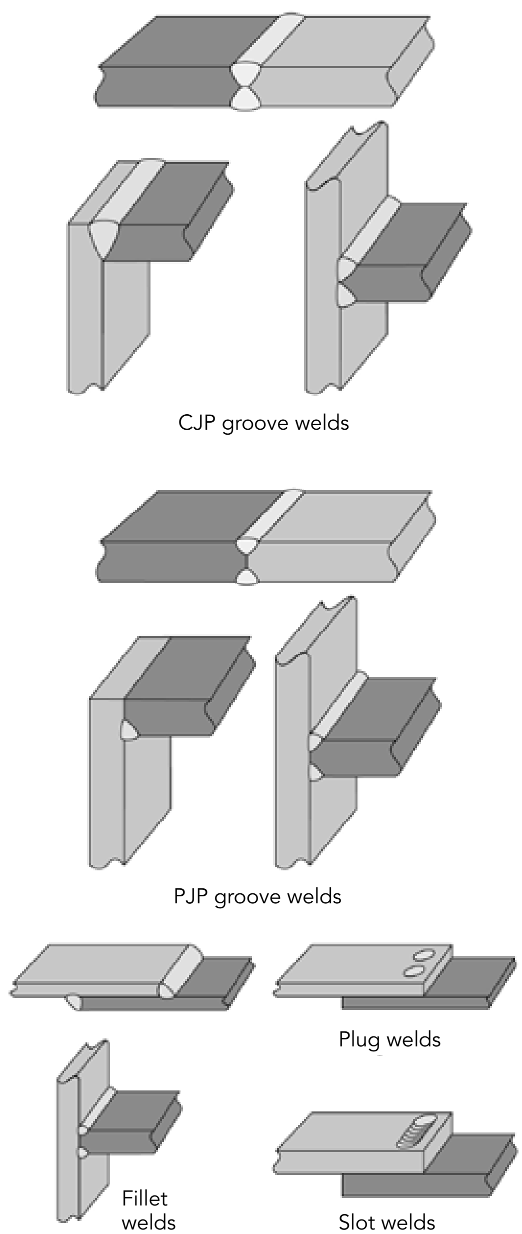
DM: For our reader's benefit, it was AISC's idea to expand the chapter on seismic welding issues (Chapter 11), as well as to include the new chapter on fracture-resistant welded connections (Chapter 13). Both chapters required a lot of additional work, but I hope the efforts will increase the usefulness of the guide.

I'll assume there is a base knowledge amongst the readers of *Modern Steel* as to what constitutes "static" loading. The "cyclic" loading conditions discussed in AISC *Specification* Appendix 3 (and discussed in Chapter 12 of the updated guide) deal with low-stress-range, high-cycle-loading situations. Appendix 3 deals with situations where the number of cycles of loading is expected to exceed 20,000. There is an implicit assumption that peak stresses are elastic when Appendix 3 is used. In contrast, seismic loading involves high-stress-range, low-cycle applications.

Self-shielded FCAW process.



Weld types.



The seismic design criteria contained in the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341) and AISC *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (ANSI/AISC 358) assumes inelastic deformations will be associated with a design-level earthquake. As a result, we have three basic loading conditions—static, cyclic and seismic—all with different design, detailing, fabrication, erection and inspection criterion.

MM: Why was the Northridge earthquake in 1994 one of the most significant earthquakes of the past century with regard to the wealth of engineering data obtained? And more specifically, the wealth of knowledge gained with regard to welded connections?

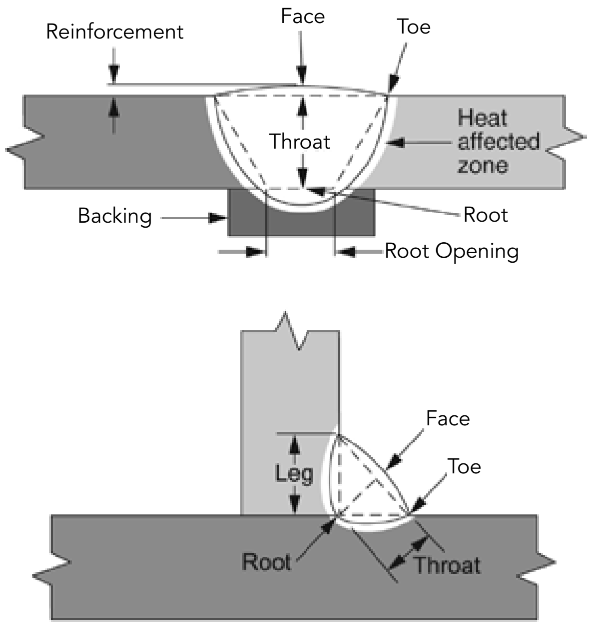
DM: You're quoting from the design guide, but I'm not the author of those words; that is a quotation from Ron Hamburger. And obviously, I agree with those comments. One person on the peer review panel for the design guide took major exception to the inclusion of a discussion of the Northridge Earthquake, an event that took place over 20 years ago. The section was retained, however, for the reasons Ron stated.

Seismic design has always relied on analysis, laboratory experimentation and actual post-earthquake field observations. In the case of the Northridge earthquake, the unexpected damage to the welded connections in moment frames resulted in millions of dollars of research on the focused topic of welded connections. The complexity of the behavior of the moment connections, and the myriad contributing factors to the observed behavior, required systematic research that was in some ways unprecedented. A unique aspect of the findings from Northridge was that they were quickly incorporated into consensus documents such as the *Seismic Provisions*.

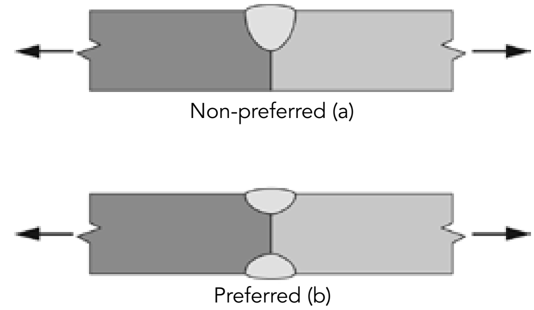
MM: There is also the new chapter on fracture-resistant welded connections (Chapter 13). For most building structures, the *Specification* indicates that the probability of fracture is low. Under what conditions does a design engineer need to worry about fracture as a limit state in welded connections?

DM: For most building applications, the limit state of fracture is not a principal concern because it is not typically the controlling limit state. There are many reasons why this is the case: The steel in most buildings in service is relatively warm; service loads create strain rates that are essentially static; the number of full design stress cycles is typically low; codes limit the severity of stress raisers; buildings normally have significant redundancy; and the typical fracture toughness of steels used in building construction is adequate even when fracture toughness levels are not specified. Thus far, I have not responded to your question but have reinforced the premise behind your question—that the risk of fracture in buildings is relatively low.

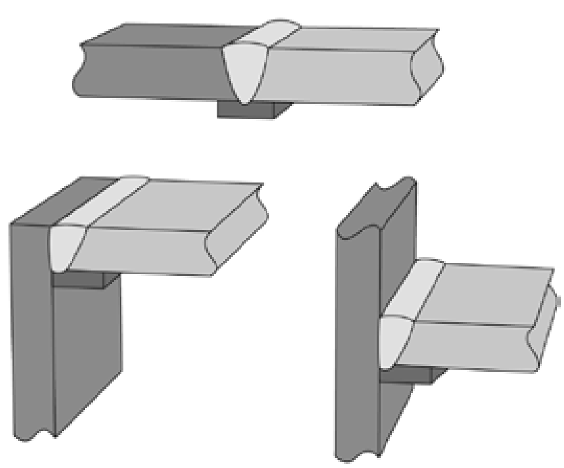
When does the design engineer need to be concerned about fracture? When the listed conditions are not true: when the service temperature of the steel may be cold; when dynamic loads are anticipated to be applied to structures (e.g., seismic or blast); or when the structure will be cyclically loaded (e.g., crane rail supports). Under such conditions, the possibility of fracture increases. For structures with less redundancy, the consequences of fracture become more pronounced. Finally, there are a few notable examples where the fracture toughness



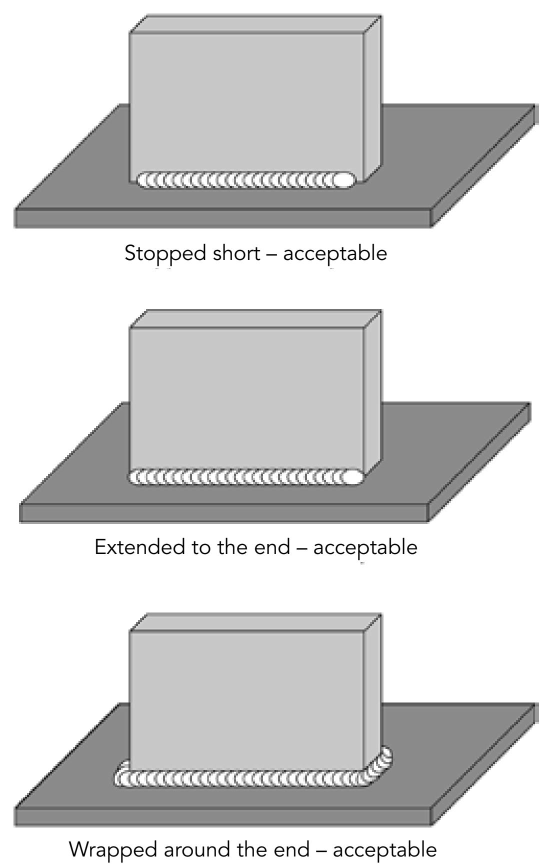
Weld terminology.



Eliminate bending about the root by using a double-sided PJP.



Examples of weld backing.



Fillet weld termination options.

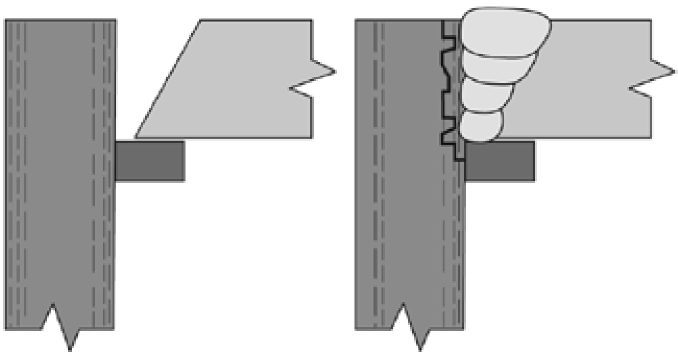
of commonly used steels is lower than normal. When such situations are encountered, considering the limit state of fracture is more important.

MM: Is it okay to goober a mislocated hole full of weld metal? If not, why not?

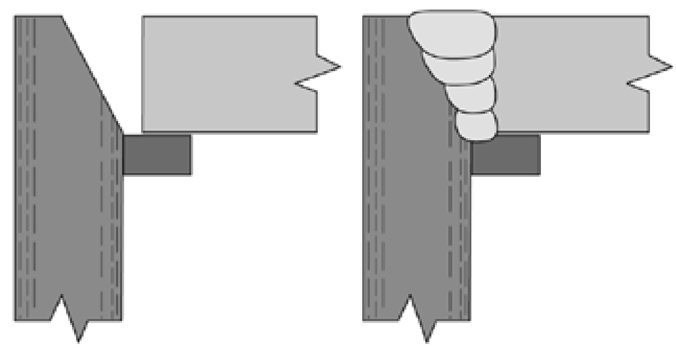
DM: Ah! You're using one of my favorite terms: goober! It is never okay to use goober welds. Why not? Because they're not prequalified!

On a serious note, some individuals making welded repairs to mislocated holes have viewed the activity as one of "filling up a hole" instead of recognizing that the resultant weld will be part of the completed structure. And, particularly when placed into cyclic service, improperly made repairs to mislocated holes have resulted in fracture problems.

In the chapter on problems and fixes (Chapter 15), the issue of repairing mislocated holes is addressed. The first recommendation is: Whenever it is possible, leave the mislocated hole where it is, unwelded and unrepaired. The design guide provides several possible corrective actions that can be taken that do not require any welding. When welding is required, the guide provides some detailed recommendations that are largely based upon advice in the commentary to AWS D1.1. The welding advice, however, does not encourage any goober welds!



Sensitive to lamellar tearing



Preferred detail.

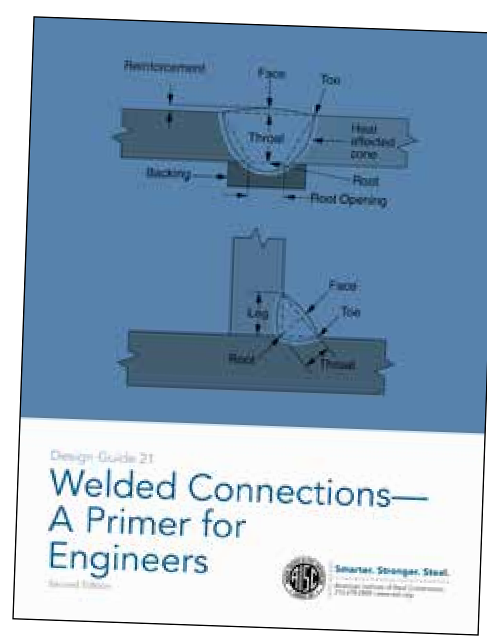
MM: What is included in the updated chapter on special welding applications (now Chapter 14)?

DM: This chapter deals with unusual welding-related applications. While Chapter 15 deals with problems, Chapter 14 is intended to provide information that will help avoid problems when dealing with special welding applications. The first edition of DG 21 included guidance on welding on unusual materials such as anchor rods, painted and galvanized steels, heavy rolled sections and hollow structural sections (HSS). Also discussed were specialized situations such as welding on architecturally exposed structural steel (AESS), field welding and welding on an existing structure.

The expanded coverage in the second edition includes guidance on welding on headed stud anchors, welding of members to be galvanized, deck welding and welding on embed plates. Cold weather is discussed, including welding in cold weather as well as the performance of welds at low temperatures. Chapter 14 ends with a detailed discussion of "buttering," a weld overlay technique that is a useful tool for resolving various construction challenges, including mitigating lamellar tearing issues and resolving some poor fit-up situations. Also, given the expanded coverage of AESS in the latest edition of the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303), the coverage of welding on AESS has been significantly modified in the second edition.

MM: Chapter 16, which covers the engineer's role in welded construction, has a revised focus in the second edition. What type of guidance in provided in this revised chapter?

DM: Chapter 16 was totally rewritten in the second edition, with a focus on providing the engineer practical ways to address welding-related issues. To the best of my knowledge, for every situation where AWS D1.1 requires the engineer's involvement, practical advice has been offered to enable them to make a more informed decision. The various topics in Chapter 16 include the following: selection of applicable codes, production of contract documents, consideration of joint detail suitability, specification of options, requests for documentation, approval of standard items, specification of engineer-initiated alternatives, evaluation of contractor-initiated alternatives, handling unexpected construction difficulties and development of specifications for work on existing structures. My hope is that this chapter will be helpful to both engineers and contractors and will help all involved to achieve the goal of dependable, economical and safely constructed welded connections in steel structures.



MM: Thanks Duane. I think this gives the readers a great overview of all the new and updated information they can expect to find in the second edition of Design Guide 21.

AISC members can download the guide for free and nonmembers can purchase it at **www.aisc.org/dg**. All other AISC standards and codes mentioned in this article can be found at **www.aisc.org/specifications**. ■