If you've ever asked yourself "Why?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to **solutions@aisc.org**.

steel interchange

Welding Steel Deck

Is it acceptable to make arc spot welds of metal deck to ASTM A992 steel beams using E60 electrodes? Are there conditions that require using higher-strength electrodes?

This topic was briefly discussed in the March 2010 SteelWise article "Attaching Metal Decking" (available via the "Back Issue Archives" at **www.modernsteel.com**).

It states: "The most common filler metal used for welding steel deck is an E6022 electrode. Most load tables for roof and non-composite (form) deck are based on a specified minimum yield strength of 33 ksi, although manufacturers may provide steels with higher yield strengths. Accordingly, an E60XX electrode is the "matching" electrode, and the diaphragm design tables found in SDI DDM03 (SDI *Diaphragm Design Manual*, 3rd Edition) are based on this matching E60XX electrode for composite deck, roof deck and non-composite floor deck with thicknesses of 22 gage or greater. Diaphragm design tables for non-composite floor deck with thicknesses of less than that are based on using a weld washer and E70XX electrodes, due to the higher strength material used for these thinner decks."

For more information on this topic you can refer to the 3rd Ed. *Diaphragm Design Manual* published by the Steel Deck Institute (**www.sdi.org**).

Heath Mitchell, S.E., P.E.

Vibration Design of Footbridges

Is there an AISC resource for the design of footbridges for vibration due to walking excitation?

Yes, AISC Steel Design Guide 11 Chapter 4 applies to the design of interior and exterior footbridges for vibration due to walking excitation.

The only difference between the evaluation of indoor and outdoor footbridges is the tolerance limit, which is 1.5%g for indoor and 5%g for outdoor footbridges. People will tolerate a lot higher acceleration when outdoors because of the higher level of ambient noise, wind, and longer distance between their eyes and reference stationary objects around them, among other factors.

The walking acceleration is predicted using Equation 4.1, which needs the reference force P_o from Table 4.1. P_o is not "the force that loads the floor," but is a combined parameter including the walker body weight, part of the dynamic coefficient (see Chapter 2), and the reduction factor R (see Chapter 2). R is 0.7 for footbridges, whereas it's 0.5 for floors, hence the different P_o used for footbridges and floors.

Brad Davis, S.E., Ph.D.

Fatigue Design

In AISC 360 Appendix 3, why are the allowable stress ranges used for fatigue design independent of the yield and tensile strength of the steel?

This is based on fracture mechanics principals and research that has been conducted to investigate fatigue issues. The Commentary to AISC 360 (a free download from **www.aisc.org/2010spec**) Appendix 3 states the following regarding the fatigue design requirements (#3 specifically addresses your question, while the others are indirectly applicable):

"Extensive test programs using full-size specimens, substantiated by theoretical stress analysis, have confirmed the following general conclusions (Fisher et al., 1970; Fisher et al., 1974):

1) Stress range and notch severity are the dominant stress variables for welded details and beams;
2) Other variables such as minimum stress, mean stress and maximum stress are not significant for design purposes; and
3) Structural steels with a specified minimum yield stress of 36 to 100 ksi (250 to 690 MPa) do not exhibit significantly different fatigue strengths for given welded details fabricated in the same manner."

The referenced documents are:

- "Fisher, J.W., Frank, K.H., Hirt, M.A. and McNamee, B.M. (1970), "Effect of Weldments on the Fatigue Strength of Beams," Report 102, National Cooperative Highway Research Program, Washington, DC."
- "Fisher, J.W., Albrecht, P.A., Yen, B.T., Klingerman, D.J. and McNamee, B.M. (1974), "Fatigue Strength of Steel Beams with Welded Stiffeners and Attachments," Report 147, National Cooperative Highway Research Program, Washington, DC."

Heath Mitchell, S.E., P.E.

Filler Metal Strength

Can 80 ksi or 90 ksi filler metal be used in a prequalified joint with ASTM A992 steel?

AISC 360 Table J2.5 contains the requirements for filler metal strengths. In general, matching weld metal is required, but one strength level over matching is allowed. There are also specific instances where one strength level below matching is allowed. Matching base metal/weld metal combinations for prequalified welds are found in AWS D1.1 Table 3.1.

ASTM A992 steel is included in Table 3.1 as a Group II material, and this table lists 70 ksi weld metal as matching for Group II materials. Therefore, AISC 360 Table J2.5 allows 70 ksi and 80 ksi weld metal to be used and in some cases, 60 ksi weld metal is allowed when welding A992 steel. However, 90 ksi filler metal is not allowed to be used in a prequalified joint with A992 steel.

Heath Mitchell, S.E., P.E.

steel interchange

Non-Fusable Weld Backing

Does the use of non-fusable weld backing require a welding procedure specification (WPS)? If so, is a procedure qualification record (PQR) also required?

Yes to both. Section 3.3.1 of AISC Steel Design Guide 21 states, "While AWS D1.1 specifically permits the use of copper backing, none of the prequalified joint details use it, so WPSs that call for copper backing must be qualified by test."

Section 7.5 of AISC Steel Design Guide 21 states, "To qualify a WPS, the contractor must first weld a test plate that will be subject to a variety of nondestructive and mechanical tests. The welding variables and parameters used during the test, as well as the results from the various tests, are recorded on a Procedure Qualification Record, or PQR. If the testing demonstrates that all the AWS D1.1 requirements and job specifications have been met, then the contractor can develop a specific WPS based on these results. At a minimum, the parameters used in making the test weld will constitute a valid WPS. The values recorded on the PQR are simply transcribed to a separate form, now known as a WPS rather than a PQR."

Larry S. Muir, P.E.

Historic Cast Iron

We would like to use some welded details for the renovation of an existing building but have concerns that some existing columns are cast iron and thus not weldable. What field tests would determine if they are cast iron or steel and what test can be performed to determine if the material is weldable?

Numerous sources indicate that wrought iron, cast iron and steel can be differentiated with spark tests, where a grinding wheel is applied to piece and differences in the type and color of spark indicate different compositions.

AISC Steel Design Guide 21 states, "…it may be desirable to repair broken cast iron parts or to weld cast iron members to structural steel. While cast iron can be welded, it is difficult to weld, and the results are inconsistent. Cast iron should not be welded if the weld is intended to serve a structural function. Of course, cast iron members were nearly always used to resist compression, and cosmetic cracks or portions that have broken off may be repaired by welding using the proper procedures and materials."

One approach might be to have a knowledgeable contractor conduct a spark test. If the results indicate cast iron, you should probably forego welding. If steel, Steel Design Guide 21 provides information concerning the welding of historical steels. It suggests testing to determine chemistry and also provides details about a bend tab test, which is typically done in the field.

Larry S. Muir, P.E.

Design of Cribbing Beams

Steel I-beams are commonly used for cribbing or shoring. In many of these applications they are not rotationally restrained at their supports. I am concerned that this lack of rotational restraint precludes me from using AISC 360 Chapter F in their design. Is that correct? Are there any resources that discuss the design of steel I-beams uses as cribbing?

You are correct to be concerned. AISC 360 Section F1 requires that beams be rotationally restrained at their supports, so you are also correct that the AISC *Specification* cannot be directly applied to the flexural design of these members.

This topic was addressed at the 2012 NASCC: The Steel Conference. The presentation was "Erection Engineering: The Science Behind The Art," which can be viewed at:
www.aisc.org/uploadedcontent/2012NASCCSessions/N3/

The discussion of cribbing beams begins at about the 14:00 minute mark and describes an approach that uses an adjusted length for lateral-torsional buckling.

Heath Mitchell, S.E., P.E.

AISC Search Utility

Has the AISC Search Utility been updated for the 14th Edition *Manual*?

No. The AISC Search Utility was written for us by a company that no longer exists, and it has not been updated. However, all subsequent versions of the shape data has been made available in simplified spreadsheet form and can be downloaded at:
www.aisc.org/shapesdatabase

Note that the shape data has been divided into two main files; the one named "Current" contains the data on current shapes, while "Historic" contains the data for older shapes (the version with "DLL" in the name is intended for use by software). Although the spreadsheets were created using Excel, they do not use any Microsoft-specific features, and thus should be usable with essentially any modern spreadsheet-type program.

You may find the "Readme" file to be useful, as it explains the various column headings, and note that the "Current" data contains U.S. Customary and Metric/SI entries.

Martin Anderson

The complete collection of Steel Interchange questions and answers is available online. Find questions and answers related to just about any topic by using our full-text search capability. Visit Steel Interchange online at **www.modernsteel.com**.

Heath Mitchell is director of technical assistance and Martin Anderson is Solutions Center specialist at AISC. Brad Davis and Larry Muir are consultants to AISC.

Steel Interchange is a forum to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine.

If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

Steel SolutionsCenter

1 E Wacker Dr., Ste. 700, Chicago, IL 60601
tel: 866.ASK.AISC • fax: 312.803.4709
solutions@aisc.org