STEEL INTERCHANGE

Steel Interchange is an open forum for *Modern Steel Construction* readers 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 to solve, please forward it to *Modern Steel Construction*. At the same time, feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

Answers and/or questions should be typewritten and double-spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Word file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principals to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 800/644-2400.

****** Questions and answers can now be e-mailed to: newman@aiscmail.com ******

The following responses from previous Steel Interchange columns have been received:

Are there any recommendations or reference materials on the design and or analysis of details (e.g. loads and connection designs) for square bins and hoppers, towable trailers, supports, and stands.

Tubular Steel Structures - Theory and Design by M. S. Troitsky,(published by the James F. Lincoln Arc Welding Foundation) Chapter 7 "Bins and Bunkers provides information for analysis and design of square and rectangular as well as circular bins, bunkers and hoppers, and supports for bins and bunkers. Appendix "A" - Example number 1 shows design of rectangular bin. Appendix "B" - Example number 2 shows design of rectangular bunker.

Mike Ginsburg, P.E.
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Torsional stability in curved bridges is achieved through the interaction of girders and diaphragms. How do you design a single curved monorail beam to resist St. Venant and warping torsion? Also which standard governs the allowable stresses of monorails and lift beams, AISC or ANSI?

This answer assumes that the reference to a "curved monorail beam" implies the use of a single I-section beam, as opposed to a box beam. It must be noted that single I-sections do not typically make good curved beams. Their St. Venant torsional stiffness is very low. Their warping torsional stiffness may be relatively high, but it takes reliable warping restraint to develop it. In general, box sections make much better single curved girders than I-sections do.

However, assuming that an I-section is required for other than structural reasons, there are some issues which are important to address. At the very least, there must be some kind of torsional restraint provided at every vertical support. Warping restraint (which is very different from torsional restraint) can be furnished at end supports of simple spans by rigidly attaching the beam to a rigid "abutment." At intermediate supports of continuous spans there is a "natural": warping restraint that results from the tendency of cross-sections on opposite sides of the vertical support to warp in opposite directions, effectively canceling or at least partially relieving the warping deformations and providing warping restraint. Of course, going hand in hand with warping restraint are warping normal stresses which must be directly superimposed on the longitudinal bending stresses.

The following general approach would be applicable to this type of problem:

1. Research the literature for applicable theory, with special consideration given to the boundary conditions which can be provided for the beam.
2. Devise an approach which would likely be some combination of rigorous theory and ordinary rational design.
3. Rationally apply appropriate AASHTO and/or AISC specification provisions.

The following sources are recommended as a starting point for further research:

- *AASHTO's Guide Specifications for Horizontally Curved Bridges,* 1993. This document contains many guidelines for the design of curved steel I girders.
- Gaylord, E.H., C.N. Gaylord, and J.E. Stallmeyer, editors, *Structural Engineering Handbook*, 4th Edition. This textbook contains an entire section on curved I-girders.
- Nakai, H. and C. Yoo, *Analysis and Design of Curved Steel Bridges*, 1988. This text is entirely devoted to curved structures and includes much information taken from Japanese curved beam research.
- Seaburg, P. and C. Carter, *Torsional Analysis of Structural Steel Members*, AISC Steel Design Guide Series No. 9, 1997. This book contains an excellent presentation on basic theory and practice of design for torsion and warping stresses.

• Zureick, A., R. Naqib, and J.M. Yadlosky, Curved Steel Bridge Research Project, Interim Report I, "Synthesis," Report No. FHWA-RD-93-129, December, 1993. This report presents a very through survey of the excellent summary of currently proposed design theory and experimental results and an extensive bibliography of curved beam literature.

William N. Poellot, Jr., P.E.
HDR Engineering, Inc.
Pittsburgh, PA
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Dallas, TX

If a connection combines high-strength bolts and welds, which is installed first? Are the bolts tightened before welding or is welding performed before the bolts are fully tightened? Will slipping of the bolts or cracking of the welds occur if it is not done in the proper manner?

Load and Resistance Factor Design Specification for Structural Steel Buildings Section J1.9 and its *Commentary* have been referenced in previous answers to this question. Section J1.9 pertains to the use of bolts and welds in combination when used in the same plane, that is, which share the same faying surface. This qualification is not made clear in the text of Section J1.9.

There are, however, connections involving bolts and welds in combination but with more than one connection plane, where welding should be done first. One which comes to mind is the moment joint of a wide-flange beam to a column, where the flanges are complete penetration welded to the column face and the beam web is connected by means of a shear plate (or angle) shop welded to the column and field bolted to the beam web. In this case, the bolts are placed first and snug tightened, and serve as erection bolts. (The shear plate should have short horizontal slots.) The welds are made subsequently and allowed to shrink. Finally, the bolts are tightened as required. If the bolts were tightened first and the welds made subsequently, the weld shrinkage would cause an indeterminate but significant amount of pre-load in both the bolts and welds.

The sequence of connecting suggested in *Commentary* J1.9 applies to each connecting plane but may not necessarily apply to a joint involving multiple connection planes.

David T. Ricker, P.E.
Payson, AZ

New Questions

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001. Questions can also be sent via e-mail to newman@aiscmail.com.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.

AISC LRFD load factors and combinations address conditions encountered in buildings and bridges. What load factors and combinations should be used for steel structures supporting pre-packaged equipment (such as skid-mounted and modular units) and subject to temporary ground and sea transportation motion forces?

John C. Clarkin
UOP Equitec Services, Inc.

Are there any references on allowable compressive stress (buckling stress) for large diameter (120 ft.) steel tank wall when it is empty and subjected to external soil pressure?

Anant Gokhale, P.E.
Gem Engineering, Inc.
Pocatello, ID

Corrections:

July 1997

Page 10: Equation 4 should read:
$w = 12 \times 10^3 S /Qa^3$

Page 10: The second and third lines following Equation 6 should read:
must be subtracted from w_{max} to find the usable load. Units: w_{max}, kips/in.;...

Page 10: The definition of w_{max} in the sixth line of the example should read:
$w_{max} = 1{,}206 \times 10^3 \times 114 \times 12/(6.66 \times (480)^3) = 2.24$ kips/ft.

This answer was prepared by **Peter Kocsis, S.E., P.E.**