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 Wordperfect file or in ASCII format).

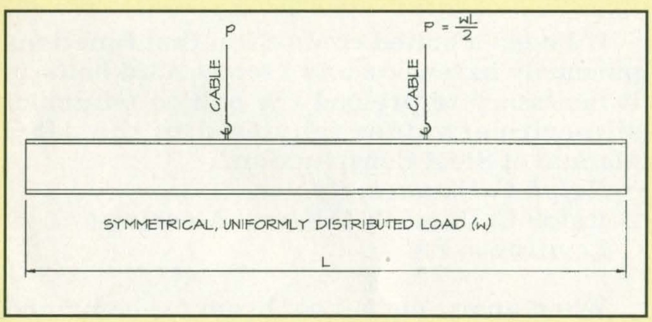
The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, 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:

What is acceptable practice for determining the load capacity for a lifting beam, similar to that shown in the accompanying sketch, for which there is no lateral support? Is it appropriate to use the full beam length to determine the bending strength of the member? Is doing so overly conservative? Are there design considerations other than strong axis bending capacity?



An excellent reference on this subject is *Distortional Buckling of Steel Beams*, Structural Engineering Report No. 185, Department of Civil Engineering, University of Alberta, Edmonton, Alberta, by Essa, H.S. and D. J. L. Kennedy. This report provides the following formulas for calculating the critical load for suspended beams buckling under self weight.

$$w_{cr} = \frac{\gamma}{L^3}\sqrt{EI_yGJ}$$

where
w_{cr} is the weight per unit length of the beam that will initiate buckling and L is the total length of the beam. E, I_y, G, and J are beam properties as defined by AISC. For the case where the cable attachment positions are located between the midspan and the quarter points, (can be approximated by the following formula.

$$\gamma = \frac{1000X}{9.91 - 5.47\left(\frac{Z}{L}\right) - 325\left(\frac{Z}{L}\right)^2 + 794\left(\frac{Z}{L}\right)^3}$$

Where Z is the distance from the center of the beam to the cable, measured along the length of the beam. X is the beam torsional parameter, defined by the following formula.

$$X = \frac{\pi}{L}\sqrt{\frac{EC_w}{GJ}}$$

Where C_w is defined by AISC.

The reference provides a chart to find (when the cables are attached within the range of $0.3 < Z/L < 0.5$. The reference also indicated that the buckling resistance is greatest when the cables are placed near the quarter points.

Bo Doswell
Structural Design Solutions
Birmingham, AL

Does an unbraced trolley beam that is loaded on the bottom flange have the same buckling characteristics as an unbraced beam loaded on the top flange?

Recommended approximate solutions to estimate a beam's critical capacity under concentrated loads have been presented in a July 1971 issue of the Structural Engineer in Nethhercot and Rockey's *A Unified Approach to the Elastic Lateral Buckling of Beams*. The content of this article was later referenced in the text of Chen and Lui's *Structural Stability, Theory and Implementation*, 1987, Elsevier with comparison to theoretical solutions of Timoshenko and Gere. The approximate solutions for centrally loaded simple beams with tip flange, shear center and bottom flange loading shows close agreement using suggested C_b values.

The C_b values are determined for the three loading conditions by a straightforward application of the beam's span, unsupported length, cross sectional and material properties and has proven useful for design applications.

The C_b value = $A*B$ for load at bottom (or compression) flange
A for load at shear center
A/B for load at top (or tension) flange

where $A = 1.35$ and $B = 1 + 0.649W - 0.180W^2$

$$W = \frac{\pi}{L}\sqrt{\frac{EC_w}{GJ}}$$

Barry P. Gahagan, P.E.
Forte and Tablada, Inc.
Baton Rouge, LA

Does an unbraced trolley that is loaded on the bottom flange have the same buckling characteristics as an unbraced beam that is loaded on the top flange?

A beam with a concentrated load applied at its bottom flange will support a larger load before buckling laterally than the same beam where the load is applied at the top flange. The reason for this is that the top load will tend to increase any torsion that occurs due to displacement of the tip flange relative to the bottom flange, while the bottom load will tend to decrease such torsion. AISC Equations (F1-6), (F1-7), and (F1-8) should be used for determining the allowable bending stress for tip loaded beams. However, when the beam is bottom loaded these allowable stresses should be increased by a factor, which is equal to the critical buckling load of the bottom loaded beam divided by the critical buckling load of the tip loaded beam. The factors applicable to a simple span beam with a concentrated load at mid-span are shown in the table below which was developed from information contained in *Theory of Elastic Stability* by Timoshenko and Gere.

L^2C/C_1	0.4	4	8	16	24	32	48
Factor	2.85	2.49	2.26	1.97	1.81	1.70	1.59
L^2C/C_1	64	80	96	160	240	320	400
Factor	1.49	1.45	1.40	1.31	1.25	1.22	1.18

where: L = span; $C = GJ$, torsional rigidity; $C_1 = EC_w$, warping rigidity; E, C_w, G, and J are as defined by AISC.

In no case should the allowable bending stress used exceed $0.60F_y$.

W. Scott Gleason, P.E.
Tulsa, OK

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.

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?
Sam Babatunde, P.E.
Orbital Engineering Inc.
Pittsburgh, PA

If I need a bolted connection that functions primarily in tension and I select A325 bolts, is it necessary to preload the bolt to minimum slip-critical values tabulated in the AISC Manual of Steel Construction?
Ralph C. Dumack, P.E.
Ralph C. Dumack, P.E. and Associates
Levittown, PA

When analyzing a steel beam for combined strong and weak axis bending, axial load and torsional load, to what allowable stress should warping torsion stresses in the flanges be compared in using AISC Eq. H1-1, H1-2 and H1-3?
Warren S. Foy, P.E.
Mason & Hanger Engineering, Inc.
Lexington, KY

Should a bearing type connection be used in connection resisting seismic loads (reversible loading at low cycles) or should only slip-critical connections be designed?
Rodney Hartunian
Rinne & Peterson
Palo Alto, CA