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).

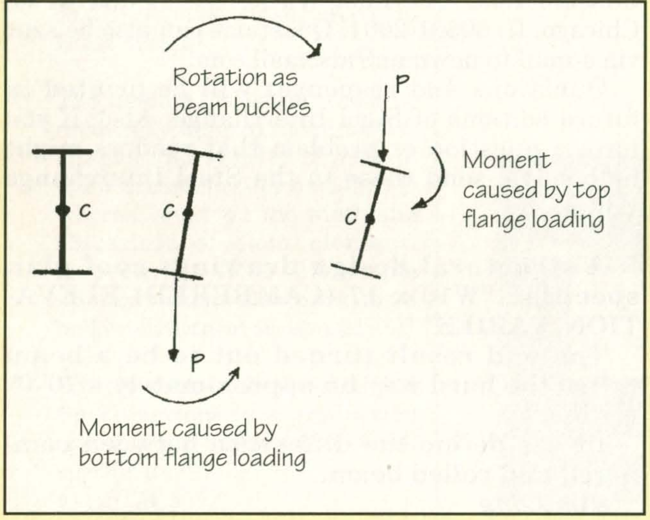
The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer,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

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?



An unbraced trolley beam that is loaded on the bottom flange has increased resistance to buckling compared to a similar beam loaded on the top flange. When a load on the bottom flange moves with the beam during buckling, it causes an additional moment about the shear center of the beam. This moment is opposite to the twist rotations of the beam, and therefore, resists the tendency of the beam to buckle. By the same reasoning, top flange loading causes an additional moment about the shear center which is additive to the twist rotations of the beam. Buckling resistance is therefore decreased.

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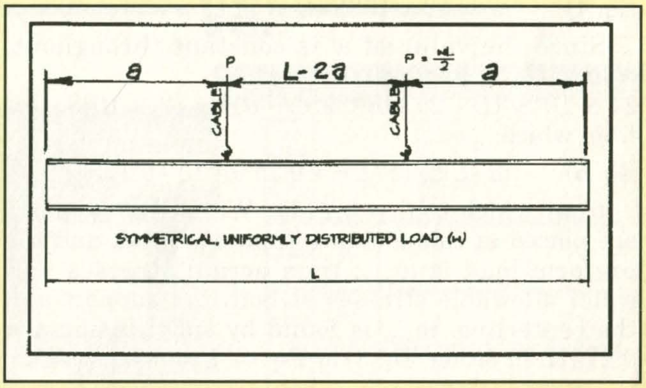
What is acceptable practice for determining the load capacity for a lifting beam, similar to that shown in the accompanying sketch, for which there is no lateral support? Is it appropriate to use the full beam length to determine the bending strength of the member? Is doing so overly conservative? Are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



The answers to the questions are given by ANSI (American National Standards Institute) in their publication *American National Standard Specifications for Underhung Cranes & Monorail Systems*, MH27.1, pages 7 and 8. ANSI refers to AISC formula F1-8, with $C_b = 1$. (Specification for Structural Steel Buildings - Allowable Stress Design). To determine the capacity between supports, use (L-2a) in place of L.

Between Supports:

Eq. 1) $F_{b1} = 12 \times 10^3 / ((L-2a)d/A_f)$,
$\max F_{b1} = 0.6F_y$

To determine the capacity at the cantilever end, use twice the length of the cantilever. Use 2a in place of L in F1-8. (stresses in kips/in.^{2})

For the cantilever:

Eq. 2) $F_{b2} = 12 \times 10^3 / (2ad/A_f)$,
$\max F_{b2} = 0.6F_y$

Some other design considerations given by ANSI are Brinell hardness, deflections, ratio of span to top flange widths, allowable tensile stress in the load carrying flange, etc.

A beam carrying load on the bottom flange has a greater capacity than the same beam with the load on the top flange.

It is of interest to ask what should be the value of a to obtain the maximum allowable uniform load for a given lifting beam. The problem is to find a so that for the same uniform load, w, the stress at the support will be at its allowable value while the stress at the centerline will be at its allowable value. These two allowables are not necessarily equal.

At the center line: Equate F_{b1} to the centerline moment divided by the elastic section modulus, S. For simplicity, let $Q = d/A_f$.

$12 \times 10^3/((L - 2a)Q) = 0.5wL(0.25L - a)/S$. Solving for w yields:

Eq. 3) $w = 24 \times 10^3S/((L - 2a)QL(0.25L - a))$

At the support: $12 \times 10^3/(2aQ) = wa^2/2S$ Solving for w yields:

Eq. 4) $w = 12 \times 103S/Qa^3$

Since the value of w is constant throughout, equate Eq. 3) and Equation 4):
$24 \times 10^3S/((L - 2a)QL(0.25L - a)) = 12 \times 10^3S/Qa^3$ from which:

Eq. 5) $(a/L)^3 - (a/L)^2 + 0.75(a/L) - 0.125 = 0$

from which $a/L = 0.2151$. When the supports are placed at this distance from each end, and the uniform load is w_{max}, then actual stresses will equal allowable stresses at both the support and the centerline. w_{max} is found by substituting a = $0.2151L$ in either Eq. 3) or Eq. 4). From Eq. 4):

Eq. 6) $w_{max} = 1{,}206 \times 10^3S/(QL^3)Q = d/A_f$

w_{max} includes the deadload of the beam, which must be subtracted from wmax to find the usable load. Units: wmax, kips/in.; L, d and a, inches; A_f, square inches; F_{b1}, F_{b2}, and F_y, kips/in^2.

EXAMPLE: Find the maximum allowable uniform load for a W24 x 55 A36 lifting beam, 40' long. Section modulus = 114, $Q = d/A_f = 6.66$. Place pickup points at 0.2151 x 40 = 8.604' = 8' - 7¼" from each end. Eq. 6) gives the maximum allowable uniform load, including dead load. w_{max} = 1,260 x 103 x 114 x 12/(6.66 x 4803) = 2.24 kips/ft. The usable capacity is 2.24 - 0.055 = 2.18 kips/ft.

Computations not presented here show that actual stresses at the supports and centerline are equal to the allowables found from Eq. 1) and Eq. 2).

Peter Kocis
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How does one design a stepped column?

AISE (Association of Iron and Steel Engineers) design standard Guide for the Design and Construction of Mill Buildings, AISE Technical Report No. 13 contains a section on designing "stepped columns. A copy of the Guide can be obtained from AISE.

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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.

A structural design drawings roof plan specified "W10 x 17 (CAMBERED) ELEVATION. VARIES"

The end result turned out to be a beam rolled the hard way on approximately a 10'-0" radius.

Please define the difference between cambered and rolled beam.

Jim Long
Via email

CORRECTION:

May 1997

First Column, Second line from bottom should read:

midspan and the quarter points, γ, can be approxi-

Second Column, eighth line should read:

The reference provides a chart to find γ when the