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:

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*** 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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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).

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

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) \[ F_{b1} = 12 \times 10^3 / ((L-2a)d/Ay) \]
\[ \text{max} F_{b1} = 0.6F_y \]

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) \[ F_{b2} = 12 \times 10^3 / (2ad/Ay) \]
\[ \text{max} F_{b2} = 0.6F_y \]

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 \( F_{bl} \) to the centerline
moment divided by the elastic section modulus, \( S \).
For simplicity, let \( Q = d/A_r \).

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

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

**At the support:**

\[
12 \times 10^3/Q = w/2S.
\]
Solving for \( w \) yields:

Eq. 4) \( w = 12 \times 10^3S/Qa^3 \)

Since the value of \( w \) is constant throughout,
equate Eq. 3) and Equation 4):

\[
24 \times 10^3S/(L - 2a)QL(0.25L - a) = 12 \times 10^3/Qa^3
\]
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 \( w_{\text{max}} \), then actual stresses will
equal allowable stresses at both the support and
the centerline. \( w_{\text{max}} \) is found by substituting \( a =
0.2151L \) in either Eq. 3) or Eq. 4). From Eq. 4):

Eq. 6) \( w_{\text{max}} = 1.206 \times 10^3S/(QL^2)Q = d/A_r \)

\( w_{\text{max}} \) includes the deadload of the beam, which
must be subtracted from \( w_{\text{max}} \) to find the usable
load. Units: \( w_{\text{max}} \), kips/in.; \( L \), \( d \) and \( a \), inches; \( A_r 
\text{square inches}; F_{bl}, F_{bd}, \) and \( F_y \), kips/in².

**EXAMPLE:** Find the maximum allowable uni-
form load for a W24 x 55 A36 lifting beam, 40' long.
Section modulus = 114, \( Q = d/A_r = 6.66 \). Place pick-
up points at 0.2151 x 40 = 8.604' = 8' - 7 1/2" from
each end. Eq. 6) gives the maximum allowable uni-
form load, including dead load. \( w_{\text{max}} = 1.260 \times 103 \times
114 x 12/(6.66 x 4803) = 2.24 \) 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).

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