

Steel Members Subject to Axial Tension and Biaxial Bending Moments

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According to Sect. 1.6.2 of the current edition (1978) of the AISC Specification, steel members subject to both axial tension and bending stresses shall be proportioned at all points along their length to satisfy the requirements of Formula (1.6-1b):

$$\frac{f_a}{0.60F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0 \quad (1.6-1b)$$

It is well known that Formula (1.6-1b) accounts for the cross-sectional strength of the members and that this form of the strength interaction equation is conservative for most sections and provides a factor of safety of at least 1.67 against the attainment of the ultimate moment capacity of the cross section. In Formula (1.6-1b), the term f_a represents the actual axial stress, and f_{bx} and f_{by} the actual bending stresses. The terms F_{bx} and F_{by} denote the allowable bending stresses, and $0.60F_y$ the allowable axial stress.

In the previous (1969) edition of the AISC Specification, the term $0.6F_y$ represented the allowable axial tensile stress on the net section. In the 1978 AISC Specification, however, $0.60F_y$ denotes the allowable axial tensile stress on the gross section, which constitutes one part of the requirements of the Sect. 1.5.1.1. For any tension member, except for pin-connected members, F_t shall not exceed $0.60F_y$ on the gross area nor $0.50F_u$ on the effective net area. The definitions of gross area, net area and effective net area are given in Sect. 1.14.

For cases where the bending stress and axial stress arise from independent load sources, the computed bending compressive stress, f_b , must not exceed the applicable value in Sect. 1.5.1.4. However, for those cases where the bending stress and axial stress are due to a single load source and are thus intimately coupled, it would seem rational that the allowable compressive and tensile stresses should be applied to the calculated *combined stress*.

To provide a more consistent specification, it is recommended that Sect. 1.6.2 be written in the following form:

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“1.6.2 Axial Tension and Bending

Members subject to both axial tension and bending stresses shall be proportioned at all points along their length to satisfy the following requirement

$$\frac{f_a}{F_t} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0 \quad (1.6-1c)$$

where f_b is the computed bending tensile stress, f_a the computed axial tensile stress, F_b is the allowable bending stress, and F_t is the allowable tensile stress given in Sect. 1.5.1.1.

However, the computed bending compressive stress arising from an independent load source relative to the axial tension, taken alone, shall not exceed the applicable value according to Sect. 1.5.1.4.”

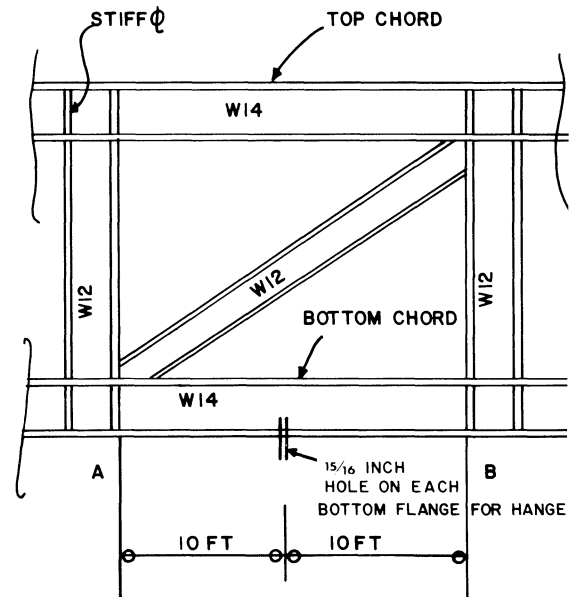


Fig. 1. Portion of the supported truss

DESIGN EXAMPLE

Given: Design member AB in Fig. 1, where:

P = hanger load on bottom chord
= 650 kips (tension)

M_x = 1440 kip-in.

M_y = 550 kip-in.

$L_x = L_y = 20$ ft (unsupported length)

$F_y = 50$ ksi; $F_u = 65$ ksi

Solution:

Try W14x145:

$A_{gross} = 42.7$ in.²

$A_{net} = 42.7 - 2(1\frac{5}{16} + 1\frac{1}{16})(1.090) = 40.52$ in.²

Since $L_u = 37.9$ ft $>$ $L_{bx} = 20$ ft $>$ $L_c = 13.9$ ft

and $b_f/2t_f = 7.1 < 65/\sqrt{50} = 9.19$,

use $F_{bx} = 0.60F_y$ and $F_{by} = 0.75F_y$.

From Formula (1.6-3):

$$\frac{650}{42.7(0.6)(50)} + \frac{1440}{232(0.6)(50)} + \frac{550}{87.3(0.75)(50)} \\ = 0.51 + 0.21 + 0.17 \\ = 0.89 < 1.0 \text{ o.k.}$$

or

$$\frac{650}{40.52(0.5)(65)} + \frac{1440}{232(0.6)(50)} + \frac{550}{87.3(0.75)(50)} \\ = 0.493 + 0.21 + 0.17 \\ = 0.873 < 1.0 \text{ o.k.}$$

For bending compressive stress alone, the requirement is clearly met.

Use: W14x145