One Engineer's Opinion

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In Sect. 1.8 of the Addenda to the AISC Commentary (Effective June 12, 1974), there are provisions wherein the effective column length factor, K, may be equal to 1.0 for certain unbraced frames. Having met these provisions, interaction stresses must by checked by Formulas (1.6-1a) and (1.6-1b), or by Formula (1.6-2), depending on the value of f_a/F_a. However, upon investigation of these specific provisions and the interaction formula, it can be shown that Formula (1.6-1a), the most complicated formula of the three, *need never be checked*. This can be proven as follows:

AISC Formulas (1.6-1a) and (1.6-1b), respectively, are:

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} \leq 1.0^* \qquad (1)$$

$$\frac{f_a}{0.6F_y} + \frac{f_{bx}}{F_{bx}} \leq 1.0^* \qquad (2)$$

Both of these formulas must be satisfied. If Eq. (2) can be shown to always govern, then Eq. (1) may be disregarded. To do this it must be shown that Eq. (2) always yields higher answers than does Eq. (1).

Assume that Eq. (2) governs:

$$\frac{f_a}{0.6F_y} + \frac{f_{bx}}{F_{bx}} > \frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} \qquad (3)$$

Solving this inequality for f_{bx} gives:

$$f_{bx} > \frac{f_a F_{bx}}{0.6 F_a F_y} (0.6F_y - F_a) \left(\frac{F'_{ex} - f_a}{F'_{ex} - C_{mx} F'_{ex} - f_a}\right) \qquad (4)$$

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* *For this paper, y-axis bending is assumed to be negligible or non-existent.*

In the above, C_{mx} is to be determined the same as if it were for a braced frame. Recalling that there are 10 to 30 stories above these columns (the Addenda limits criteria to lower columns of 10 to 40 story structures), it is apparent that the moment ratios, M_1/M_2, will be near +1.0. Thus, solving for C_{mx} at, say $M_1/M_2 = 0.8$:

$$C_{mx} = 0.6 - 0.4(+0.8) = 0.28 \leq 0.4 \qquad (5)$$

Thus, $C_{mx} = 0.4$, and Eq. (4) can be rewritten:

$$f_{bx} > \frac{f_a F_{bx}}{0.6 F_a F_y} (0.6F_y - F_a) \left(\frac{F'_{ex} - f_a}{0.6F'_{ex} - f_a}\right) \qquad (6)$$

Equation (2) can be rewritten as:

$$f_{bx} < \left(1 - \frac{f_a}{0.6F_y}\right) F_{bx} \qquad (7)$$

Equation (6) is the situation where Eq. (2) governs and Eq. (7) is where Eq. (2) will give an answer less than 1.0. Combine these two inequalities and drop out f_b. Thus:

$$\frac{f_a F_{bx}}{0.6 F_a F_y} (0.6F_y - F_a) \left(\frac{F'_{ex} - f_a}{0.6F'_{ex} - f_a}\right) < \left(1 - \frac{f_a}{0.6F_y}\right) F_{bx} \qquad (8)$$

Putting all terms on the left of the inequality and equating to y:

$$y = \frac{f_a}{F_a} \left(\frac{0.6F_y - F_a}{0.6F_y - f_a}\right) \left(\frac{F'_{ex} - f_a}{0.6F'_{ex} - f_a}\right) < 1 \qquad (9)$$

The next step is to show that when y is a maximum value according to the criteria of the Addenda, it never exceeds unity. It is obvious that y will be a maximum for $f_a/F_a = 0.75$. Thus, substituting:

$$y = 0.75 \left(\frac{0.6F_y - F_a}{0.6F_y - 0.75F_a}\right) \left(\frac{F'_{ex} - 0.75F_a}{0.6F'_{ex} - 0.75F_a}\right) \qquad (10)$$

Equation (10) can then be plotted for any grade of steel (F_y = 36 to 65) as a function of l/r_x. See Fig. 1.

Thus, it is apparent that for $F_y \leq 65$ ksi, y will always be less than unity for $l/r_x \leq 35$; therefore, AISC Formula (1.6-1a) need not be checked. The interaction analysis is as shown below:

$$0.15 < f_a/F_a \leq 0.75$$

$$\frac{f_a}{0.6F_y} + \frac{f_{bx}}{F_{bx}} \leq 1.0 \qquad (1.6\text{-}1b)$$

$$f_a/F_a \leq 0.15$$

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} \leq 1.0 \qquad (1.6\text{-}2)$$

The limits on the above are:

(a) $C_{mx} = 0.4$
(b) $F_y \leq 65$ ksi
(c) $l/r_x \leq 35$
(d) y-axis bending can be ignored

Under no other conditions can the above analysis be considered valid.

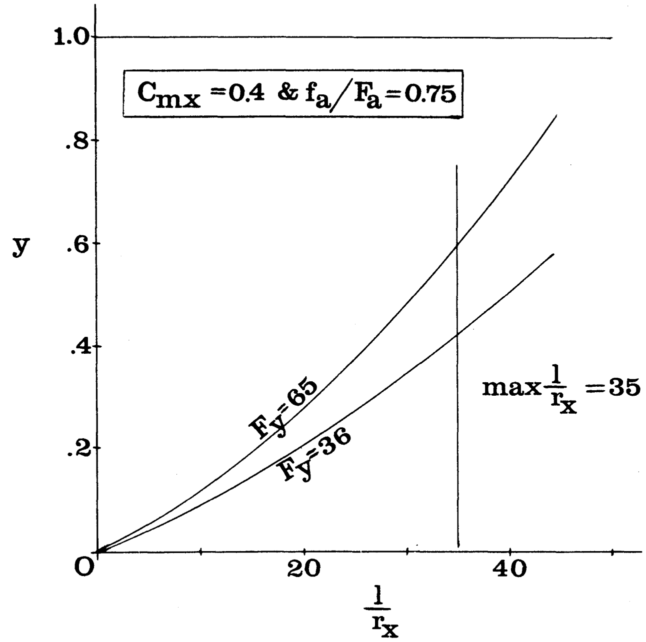

Figure 1