where

The y-axis is the principal axis in the plane of bending

I_y = moment of inertia about the y-axis

S_x = section modulus about the x-axis

d = depth of the beam

Alternately, for channels and I-shaped sections symmetric about the bending axis r_{ye} shall be taken as $r_y d/(2r_x)$ or $1.2r_y$.

F.4.2.2 Singly Symmetric Open Shapes Unsymmetric About the Bending Axis

For singly symmetric open shapes unsymmetric about the bending axis and with $I_{yc} \le I_{yt}$, determine the slenderness using Section F.4.2.1 where r_{ye} is calculated with I_y, S_x and J determined as though both flanges were the same as the compression flange with the overall depth d remaining the same.

F.4.2.3 Closed Shapes

For closed shapes, the slenderness is

$$\lambda = 2.3\sqrt{\frac{L_b S_{xc}}{C_b\sqrt{I_y J}}} \qquad \text{(F.4-6)}$$

F.4.2.4 Rectangular Bars

For rectangular bars, the slenderness is

$$\lambda = \frac{2.3}{t}\sqrt{\frac{dL_b}{C_b}} \qquad \text{(F.4-7)}$$

where

d = dimension of the bar in the plane of flexure

t = dimension of the bar perpendicular to the plane of flexure

F.4.2.5 Any Shape

For any shape symmetric or unsymmetric about the bending axis the slenderness is:

$$\lambda = \pi\sqrt{\frac{ES_{xc}}{C_b M_e}} \qquad \text{(F.4-8)}$$

where M_e is the elastic lateral-torsional buckling moment determined by analysis or as:

$$M_e = \frac{\pi^2 EI_y}{L_b^2}\left[U + \sqrt{U^2 + \frac{0.038JL_b^2}{I_y} + \frac{C_w}{I_y}}\right] \qquad \text{(F.4-9)}$$

where

The y-axis is the centroidal symmetry or principal axis such that the tension flange has a positive y coordinate and bending is about the x-axis. The origin of the coordinate system is the intersection of the principal axes.

$$U = C_1 g_o + C_2\beta_x/2 \qquad \text{(F.4-10)}$$

C_1 and C_2:

a) If no transverse loads are applied between the ends of the unbraced segment $C_1 = 0$ and $C_2 = 1$.

b) If transverse loads are applied between the ends of the unbraced segment C_1 and C_2 shall be taken as 0.5 or determined by rational analysis.

g_0 = distance from the shear center to the point of application of the load; g_0 is positive when the load acts away from the shear center and negative when the load acts towards the shear center. If there is no transverse load (pure moment cases) $g_0 = 0$.

$$\beta_x = \frac{1}{I_x}\left(\int_A y^3\,dA + \int_A yx^2\,dA\right) - 2y_o \qquad \text{(F.4-11)}$$

For singly symmetric I shapes, as an alternative to Equation F.4-11,

$$\beta_x = 0.9d_f\left(\frac{2I_{yc}}{I_y} - 1\right)\left[1 - \left(\frac{I_y}{I_x}\right)^2\right] \qquad \text{(F.4-12)}$$

where

I_{yc} = moment of inertia of the compression flange about the y-axis

d_f = the distance between the flange centroids; for tees d_f is the distance between the flange centroid and the tip of the stem.

Alternately, for singly symmetric I shapes where the smaller flange area is not less than 80% of the larger flange area, β_x shall be taken as $-2y_o$.

y_o = the shear center's y-coordinate

F.4.3 Interaction Between Local Buckling and Lateral-Torsional Buckling

For open shapes:

a) whose flanges are flat elements in uniform compression supported on one edge and

b) for which the flange's elastic buckling stress F_e given in Section B.5.6 is less than the lateral-torsional buckling stress of the beam F_b determined in accordance with Section F.4, the lateral-torsional buckling strength shall not exceed

$$M_{nmb} = \left[\frac{\pi^2 E}{\left(\frac{L_b}{r_{ye}\sqrt{C_b}}\right)^2}\right]^{1/3} F_e^{2/3} S_{xc} \qquad \text{(F.4-13)}$$

F.5 SINGLE ANGLES

For single angles, the nominal flexural strength M_n shall be determined as follows.

a) For the limit state of local buckling:

(1) If a leg tip is a point of maximum compression (Figure F.5.1):