

ALLOWABLE STRESS DESIGN FLOWCHART
FOR
AISC MANUAL OF STEEL CONSTRUCTION, NINTH EDITION
APPENDIX A
ALLOWABLE NORMAL STRESS CALCULATION

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S-Y. Chen, December 1997, *Using Genetic Algorithms for the Optimal Design of Structural Systems*, Dissertation for Doctor of Philosophy, Department of Civil Engineering, Arizona State University.

BENDING : I & CHANNEL : X-AXIS

$$l_b \leq L_c \quad \text{Hybrid Girder or } F_y \geq 65\text{ksi} \quad \left\{ \begin{array}{l} \frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}} \Rightarrow \text{slender section (1)} \\ \frac{b_f}{2*t_f} \leq \frac{95}{\sqrt{F_y}} \Rightarrow F_b = 0.6*F_y \end{array} \right. \quad (\text{F1-5})$$

NOT Hybrid, and $F_y \leq 65\text{ksi}$

$$\left. \begin{array}{l} \frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}} \Rightarrow \text{slender section (1)} \\ \frac{65}{\sqrt{F_y}} < \frac{b_f}{2*t_f} \leq \frac{95}{\sqrt{F_y}} \end{array} \right\} \begin{array}{l} \text{Built-Up} \Rightarrow F_b = F_y * [0.79 - 0.002 * \frac{b_f}{2*t_f} * \sqrt{\frac{F_y}{k_c}}] \\ \text{NOT Built-Up} \end{array} \quad (\text{F1-4})$$

$$\left. \begin{array}{l} \text{NOT Built-Up} \\ \frac{d}{t_w} \text{ satisfies Eqn(1)} \end{array} \right\} \Rightarrow F_b = F_y * [0.79 - 0.002 * \frac{b_f}{2*t_f} * \sqrt{F_y}] \quad (\text{F1-3})$$

$$\left. \begin{array}{l} \text{NOT Built-Up} \\ \frac{d}{t_w} \text{ NOT satisfies Eqn(1)} \end{array} \right\} \Rightarrow F_b = 0.6*F_y^{*(\text{NOTE})} \quad (\text{F1-5})$$

$$\left. \begin{array}{l} \frac{b_f}{2*t_f} \leq \frac{65}{\sqrt{F_y}} \\ \frac{d}{t_w} \text{ satisfies Eqn(1)} \end{array} \right\} \Rightarrow F_b = 0.66*F_y \quad (\text{F1-1})$$

$$\left. \begin{array}{l} \frac{b_f}{2*t_f} \leq \frac{65}{\sqrt{F_y}} \\ \frac{d}{t_w} \text{ NOT satisfies Eqn(1)} \end{array} \right\} \Rightarrow F_b = 0.6*F_y^{*(\text{NOTE})} \quad (\text{F1-5})$$

$$k_c : \left(\begin{array}{l} \text{IF: } \frac{h}{t_w} > 70 \Rightarrow k_c = \frac{4.05}{\left(\frac{h}{t_w}\right)^{0.46}} \\ \text{ELSE: } \Rightarrow k_c = 1.0 \end{array} \right) \quad (\text{F1-4})$$

$$\text{Eqn(1) : } \left(\begin{array}{l} \text{for } \left| \frac{f_a}{F_y} \right| \leq 0.16 : \frac{d}{t_w} \leq \frac{640}{\sqrt{F_y}} * \left(1.0 - 3.74 * \frac{f_a}{F_y} \right) \\ \text{for } \left| \frac{f_a}{F_y} \right| > 0.16 : \frac{d}{t_w} \leq \frac{257}{\sqrt{F_y}} \\ \frac{f_a}{F_y} = 0, \text{ if member is in tension} \end{array} \right) \quad (\text{TBL B5.1})$$

*(NOTE): Slender section design is required only for compression elements.

$$l_b > L_c \quad \frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}} \Rightarrow \text{slender section (1)}$$

$$\frac{b_f}{2*t_f} \leq \frac{95}{\sqrt{F_y}} \begin{cases} \text{I sections} & \Rightarrow \text{take the maximum of (a) \& (b)} \\ \text{Channel} & \Rightarrow \text{use (b)} \end{cases}$$

$$\left(\begin{array}{l} \text{(a) for } \sqrt{\frac{120*10^3*C_b}{F_y}} \leq \frac{l_b}{r_T} \leq \sqrt{\frac{510*10^3*C_b}{F_y}} \Rightarrow F_b = \left[\frac{2}{3} - \frac{F_y*(\frac{l_b}{r_T})^2}{1530*10^3*C_b} \right] * F_y \leq 0.6*F_y \\ \text{for } \frac{l_b}{r_T} > \sqrt{\frac{510*10^3*C_b}{F_y}} \Rightarrow F_b = \frac{170*10^3*C_b}{(\frac{l_b}{r_T})^2} \leq 0.6*F_y \\ \text{(b) for any } \frac{l_b}{r_T} \Rightarrow F_b = \frac{12*10^3*C_b}{l_b*d/A_f} \leq 0.6*F_y \end{array} \right) \quad \text{(F1-6) \& (F1-7) \& (F1-8)}$$

$$r_T = \sqrt{\frac{I_y/2 - \frac{h*t_w^3}{36}}{A_f + A_w/6}} \cong \sqrt{\frac{I_y/2}{A_f + A_w/6}} \quad L_c = \min\left(\frac{76*b_f}{\sqrt{F_y}}, \frac{20000}{(d/A_f)*F_y}\right)$$

$$C_b = 1.75 + 1.05*\left(\frac{M_1}{M_2}\right) + 0.3*\left(\frac{M_1}{M_2}\right)^2 \leq 2.3$$

$$\left| \frac{M_1}{M_2} \right| \leq 1; \left(\frac{M_1}{M_2}\right) > 0, \text{ if } M_1 \& M_2 \text{ cause reverse curvature; otherwise, } \left(\frac{M_1}{M_2}\right) < 0$$

(1) C_b can be conservatively taken as 1.0

(2) when there is moment greater than M_1 or $M_2 \Rightarrow C_b = 1.0$

(3) C_b should be taken as 1.0, for frame BRACED AGAINST sidesway.

BENDING : I & SOLID ROUND & SOLID RECTANGULAR & SQUARE BAR : Y-AXIS

I SECTION :

$$F_y > 65ksi \quad \Rightarrow F_b = 0.6 * F_y \quad (F2-2)$$

$$F_y \leq 65ksi \quad \frac{b_f}{2 * t_f} > \frac{95}{\sqrt{F_y}} \quad \Rightarrow \text{slender section (1)}$$

$$\frac{65}{\sqrt{F_y}} < \frac{b_f}{2 * t_f} \leq \frac{95}{\sqrt{F_y}} \quad \Rightarrow F_b = F_y * [1.075 - 0.005 * \frac{b_f}{2 * t_f} * \sqrt{F_y}] \quad (F2-3)$$

$$\frac{b_f}{2 * t_f} \leq \frac{65}{\sqrt{F_y}} \quad \Rightarrow F_b = 0.75 * F_y \quad (F2-1)$$

SOLID ROUND & SOLID RECTANGULAR & SQUARE BAR :

$$\Rightarrow F_b = 0.75 * F_y \quad (F2-1)$$

BENDING : BOX & RECTANGULAR TUBE & CIRCULAR TUBE

BOX AND RECTANGULAR TUBE

$$\text{For Compact Section : } \frac{b_f}{2*t_f} \leq \frac{95}{\sqrt{F_y}} \quad \& \quad l_b \leq L_c \quad \& \quad \frac{d}{t_w} \text{ satisfies eqn1} \quad \& \quad \begin{matrix} d < 6*b_f \\ t_f < 2*t_w \end{matrix} \quad (\text{F3.1})$$

$$\Rightarrow F_b = 0.66*F_y \quad (\text{F3-1})$$

$$\text{For Slender Section : } \frac{b_f}{2*t_f} > \frac{119}{\sqrt{F_y}} \quad \text{or} \quad \left(\frac{d}{t_w} \text{ does NOT satisfy eqn1} \quad \& \quad \frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}} \right) \quad \text{or} \quad d > 6*b_f$$

$$\Rightarrow \text{slender section (2)}$$

All Other Sections (non-compact) :

$$\Rightarrow F_b = 0.6*F_y$$

(F3.2)

(F3-3)

CIRCULAR TUBE (???)

$$\text{For Compact Section : } \frac{D}{t} \leq \frac{3300}{\sqrt{F_y}} \quad \& \quad l_b \leq L_c \quad \& \quad \frac{d}{t_w} \text{ satisfies eqn1}$$

$$\Rightarrow F_b = 0.66*F_y$$

All Other Sections (non-compact) :

$$\Rightarrow \text{slender section (2)}$$

$$L_c = (1950 + 1200 \frac{M_1}{M_2}) * \frac{b_f}{F_y}$$

(F3-2)

BENDING : ALL OTHER SECTIONS : Y-AXIS (1978) (???)

$$\Rightarrow F_b = 0.60*F_y$$

BENDING OF SLENDER SECTION

$$\Rightarrow F_b = 0.6 * F_y * Q_s * Q_a$$

$$k_c : \begin{cases} IF: \frac{h}{t_w} > 70 \Rightarrow k_c = \frac{4.05}{\left(\frac{h}{t_w}\right)^{0.46}} \\ ELSE: \Rightarrow k_c = 1.0 \end{cases}$$

Slender Section (1) : (Unstiffened element)

$$Q_a = 1$$

$$\frac{95}{\sqrt{F_y/k_c}} < \frac{b_f}{2 * t_f} \leq \frac{195}{\sqrt{F_y/k_c}} \Rightarrow Q_s = 1.293 - 0.00309 * \frac{b_f}{2 * t_f} * \sqrt{F_y/k_c} \quad (A-B5-3)$$

$$\frac{195}{\sqrt{F_y/k_c}} < \frac{b_f}{2 * t_f} \Rightarrow Q_s = \frac{26200}{F_y/k_c * \left(\frac{b_f}{2 * t_f}\right)^2} \quad (A-B5-4)$$

Slender Section (2) : (Stiffened element)

$$Q_s = 1$$

$$\text{With uniform thickness : } \Rightarrow Q_a = \frac{253 * t_f}{\sqrt{f_a + f_b}} \left[1 - \frac{50.3}{\left(\frac{b_f}{t_f}\right) * \sqrt{f_a + f_b}} \right] \leq 1.0 \quad (A-B5-7)$$

AXIAL COMPRESSION

For slender section

⇒ slender section (1) or (2) ⇒ Find Q_s, Q_a ⇒ $Q = Q_s * Q_a$ (see BENDING OF SLENDER SECTION)

$$S_e \leq C_C \quad \Rightarrow F_a = \frac{Q \cdot \left[1 - \frac{S_e^2}{2 \cdot C_C^2} \right] \cdot F_y}{\frac{5}{3} + \frac{3 \cdot S_e}{8 \cdot C_C} - \frac{S_e^3}{8 \cdot C_C^3}} \quad (\text{E2-1})$$

$$S_e > C_C \quad \Rightarrow F_a = \frac{12 \cdot \pi^2 \cdot E}{23 \cdot S_e^2} \quad (\text{E2-2})$$

where $C_C = \sqrt{\frac{2 \cdot \pi^2 \cdot E}{Q \cdot F_y}} \quad S_e = \frac{K \cdot l}{r}$

For compact and non-compact section

$$S_e \leq C_C \quad \Rightarrow F_a = \frac{\left[1 - \frac{S_e^2}{2 \cdot C_C^2} \right] \cdot F_y}{\frac{5}{3} + \frac{3 \cdot S_e}{8 \cdot C_C} - \frac{S_e^3}{8 \cdot C_C^3}} \quad (\text{E2-1})$$

$$S_e > C_C \quad \Rightarrow F_a = \frac{12 \cdot \pi^2 \cdot E}{23 \cdot S_e^2} \quad (\text{E2-2})$$

where $C_C = \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_y}} \quad S_e = \frac{K \cdot l}{r}$

*(NOTE) : Both x (major) and y (minor) buckling mode should be check, and pick the smaller one

AXIAL TENSION