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.

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BENDING : I & CHANNEL : X-AXIS

$l_b \le L_c$

Hybrid Girder or $F_y \ge 65ksi$

- $\frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}} \Rightarrow$ slender section (1)
- $\frac{b_f}{2*t_f} \le \frac{95}{\sqrt{F_y}} \Rightarrow F_b = 0.6*F_y$ (F1-5)

NOT Hybrid, and $F_y \le 65ksi$

- $\frac{b_f}{2*t_f} > \frac{95}{\sqrt{F_y}}$ $\Rightarrow$ slender section (1)
- $\frac{65}{\sqrt{F_y}} < \frac{b_f}{2*t_f} \le \frac{95}{\sqrt{F_y}}$
  - Built-Up $\Rightarrow F_b = F_y*[0.79 - 0.002*\frac{b_f}{2*t_f}*\sqrt{\frac{F_y}{k_c}}]$ (F1-4)
  - NOT Built-Up
    - $\frac{d}{t_w}$ satisfies Eqn(1) $\Rightarrow F_b = F_y*[0.79 - 0.002*\frac{b_f}{2*t_f}*\sqrt{F_y}]$ (F1-3)
    - $\frac{d}{t_w}$ NOT satisfies Eqn(1) $\Rightarrow F_b = 0.6*F_y$ *(NOTE) (F1-5)
- $\frac{b_f}{2*t_f} \le \frac{65}{\sqrt{F_y}}$
  - $\frac{d}{t_w}$ satisfies Eqn(1) $\Rightarrow F_b = 0.66*F_y$ (F1-1)
  - $\frac{d}{t_w}$ NOT satisfies Eqn(1) $\Rightarrow F_b = 0.6*F_y$ *(NOTE) (F1-5)

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

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

*(NOTE) : Slender section design is required only for compression elements. (B5.2)

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

$\frac{b_f}{2*t_f} \le \frac{95}{\sqrt{F_y}}$

- I sections $\Rightarrow$ tahe the maximum of (a) & (b)
- Channel $\Rightarrow$ use (b)

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

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

$$C_b = 1.75 + 1.05*\left(M_1/M_2\right) + 0.3*\left(M_1/M_2\right)^2 \le 2.3$$

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

(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.*

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

I SECTION :

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

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

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

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

SOLID ROUND & SOLID RECTANGULAR & SQUARE BAR :

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

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BENDING : BOX & RECTANGULAR TUBE & CIRCULAR TUBE

BOX AND RECTANGULAR TUBE

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

$\Rightarrow F_b = 0.66*F_y$ (F3-1)

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

$\Rightarrow$ slender section (2)

All Other Sections (non-compact) : (F3.2)

$\Rightarrow F_b = 0.6*F_y$ (F3-3)

CIRCULAR TUBE (???)

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

$\Rightarrow F_b = 0.66*F_y$

All Other Sections (non-compact) :

$\Rightarrow$ slender section (2)

$$L_C = (1950 + 1200\frac{M_1}{M_2})*\frac{b_f}{F_y} \qquad \text{(F3-2)}$$

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

$\Rightarrow F_b = 0.60*F_y$

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BENDING OF SLENDER SECTION

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

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

Slender Section (1) : (Unstiffened element)

$Q_a = 1$

$$\frac{95}{\sqrt{F_y/k_c}} < \frac{b_f}{2*t_f} \le \frac{195}{\sqrt{F_y/k_c}} \qquad \Rightarrow Q_S = 1.293 - 0.00309 * \frac{b_f}{2*t_f} * \sqrt{F_y/k_c} \qquad \text{(A-B5-3)}$$

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

Slender Section (2) : (Stiffened element)

$Q_S = 1$

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

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AXIAL COMPRESSION

For slender section

$\Rightarrow$ slender section (1) or (2) $\Rightarrow$ Find Q_S , Q_a $\Rightarrow$ $Q = Q_S * Q_a$ (see BENDING OF SLENDER SECTION)

$$S_e \le C_C \qquad \Rightarrow F_a = \frac{Q \cdot \left[1 - \frac{S_e^{\,2}}{2 \cdot C_C^{\,2}} \right] \cdot F_y}{\frac{5}{3} + \frac{3 \cdot S_e}{8 \cdot C_C} - \frac{S_e^{\,3}}{8 \cdot C_C^{\,3}}} \tag{E2-1}$$

$$S_e > C_C \qquad \Rightarrow F_a = \frac{12 \cdot \pi^2 \cdot E}{23 \cdot S_e^{\,2}} \tag{E2-2}$$

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

For compact and non-compact section

$$S_e \le C_C \qquad \Rightarrow F_a = \frac{\left[1 - \frac{S_e^{\,2}}{2 \cdot C_C^{\,2}} \right] \cdot F_y}{\frac{5}{3} + \frac{3 \cdot S_e}{8 \cdot C_C} - \frac{S_e^{\,3}}{8 \cdot C_C^{\,3}}} \tag{E2-1}$$

$$S_e > C_C \qquad \Rightarrow F_a = \frac{12 \cdot \pi^2 \cdot E}{23 \cdot S_e^{\,2}} \tag{E2-2}$$

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

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

AXIAL TENSION

$$F_t = \min(\ 0.6 \cdot F_y\ ,\ \ 0.5 \cdot F_u\ )$$

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