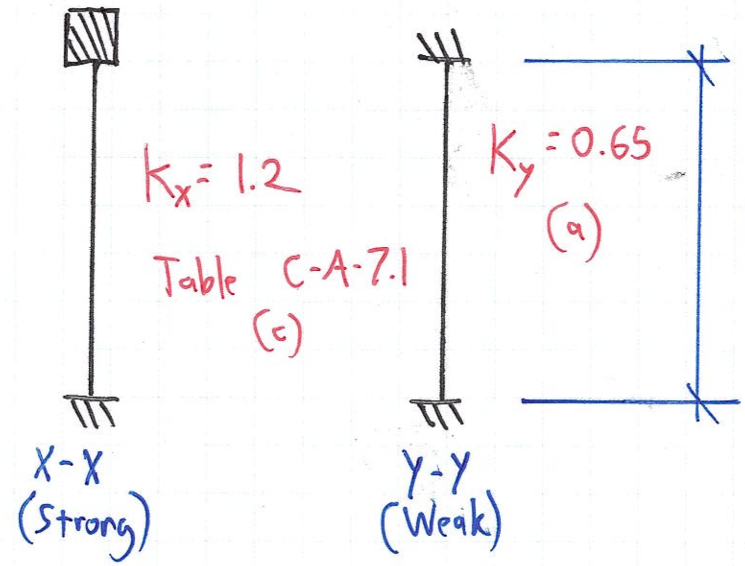
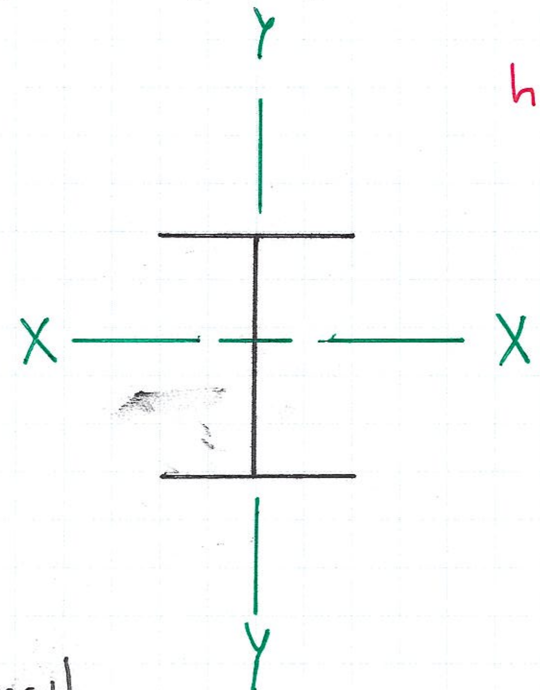
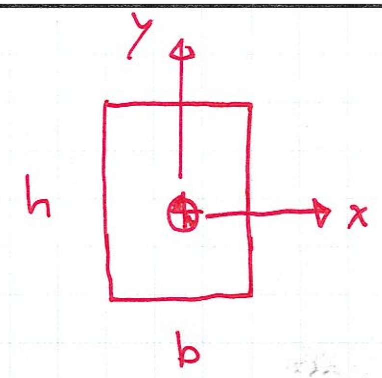
EXAMPLE

GIVEN: A W14X90, A992 Steel, Supported as shown







$$I_x = \frac{1}{12} b h^3$$

$$I_y = \frac{1}{12} h b^3$$

REQ'D: Compute the design compressive strength

SOLN: W14X90: $A_g = 26.5 \text{ in}^2$

$\frac{b_f}{2t_f} = 10.2$; $\frac{h}{t_w} = 25.9$

$r_x = 6.14$ in ; $r_y = 3.7$ in

A992: $f_y = 50$ ksi

$f_u = 65$ ksi

LOCAL BUCKLING

EXPLICIT METHOD

$$\frac{b_f}{2t_f} = 10.2 \le \frac{95}{\sqrt{F_y}} = \frac{95}{\sqrt{50\text{ ksi}}} = 13.4 \checkmark$$

$$\frac{h}{t_w} = 25.9 \le \frac{254}{\sqrt{F_y}} = \frac{254}{\sqrt{50\text{ ksi}}} = 35.9 \checkmark$$

1 Not Slender ∴ Section E3 applies
2 No local buckling issues

NOTATION METHOD: No Notation "C" ∴ Not Slender in Compression

GLOBAL BUCKLING ⇒ SECT E3

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2_{max}} = \frac{\pi^2 (29{,}000\text{ ksi})}{(42.2)^2} = 160.7^{ksi} \geq 0.44 F_y = 22^{ksi} \therefore$$

Inelastic LTB Buckling

largest $\left(\frac{KL}{r}\right)$ controls

$$\left(\frac{KL}{r}\right)_x = \frac{1.2(18')(12)}{6.14\text{ in}} = 42.2 \le 200 \checkmark$$

$$\left(\frac{KL}{r}\right)_y = \frac{0.65(18')(12)}{3.7\text{ in}} = 37.95 \le 200 \checkmark$$

Serviceability Check

(E3-2) $$f_{cr} = \left[0.658^{F_y/F_e}\right] F_y = \left[0.658^{50\,ksi/160.7\,ksi}\right](50\,ksi) = 43.9\,ksi$$

$$\phi_c P_n = \phi_c f_{cr} A_g = \overbrace{0.9(43.9\,ksi)}^{\phi_c F_{cr}}\underbrace{(43.9\,ksi)(26.5\,in^2)}_{\text{Nominal Strength}} = \underline{\underline{1047^k}}$$

design comp Strength

ALTERNATE METHODS TO COMPUTE $\phi_c P_n$

1) Critical Stress Table p4-229, Table 4-14

$$\left(\frac{KL}{r}\right)_{max} = 42.2 = \left(\frac{L_c}{r}\right)$$

$\frac{L_c}{r}$	$\phi_c F_{cr}$
42	39.5 ksi
42.2	39.46 ksi
43	39.3 ksi

$$y = y_0 + (y_1 - y_0)\frac{x - x_0}{x_1 - x}$$

$$\phi_c P_n = \phi_c f_{cr} A_g = (39.46^{ksi})(26.5\ in^2) = \underline{\underline{1046^k}}$$

2) COLUMN DESIGN TABLE p4-12, Table 4-1a

$$(KL)_y = (L_c)_y = 0.65(18^{ft}) = 11.7^{ft}$$

$$\cancel{r_y}\left(\frac{(KL)_y}{\cancel{r_y}}\right) = \left(\frac{(KL)_x}{r_x}\right) r_y \Rightarrow (KL)_{equiv} = \frac{(KL)_x}{(r_x/r_y)}$$

$$(KL)_{equiv} = \frac{1.2(18^{ft})}{6.14/3.7} = 13.02^{ft}$$ ← largest controls

$$\phi_c P_n = \underline{\underline{1050^k}} \ @ \ 13^{ft}$$ (p4-16, Table 4-1a)

* All these answers are acceptible for $\phi_c P_n$

COLUMN DESIGN

- AISC Colm. Design Tables p4-12 to 227
- Tables for W, HP, HSS, WT, ⅃L, L
- W-Shapes: W8, W10, W12, & W14
- Assume Y-Axis Buckling controls for a W-Shape
- Section Listed satisfy local buckling requirements

$$\frac{b_f}{2t_f} \leq \frac{95}{\sqrt{F_y}}$$

$$\frac{h}{t_w} \leq \frac{254}{\sqrt{F_y}}$$

~~Unles~~ ~~all~~ unless otherwise noted, W14X43

PROCEDURE FOR DESIGN

1) Compute P_u from Load Combinations

2) Compute $(KL)_x$ & $(KL)_y$

3) Enter Column Tables w/ Larger

$$\left.\begin{array}{c} (KL)_y \\ \text{-or-} \\ \dfrac{(KL)_x}{r_x/r_y} \end{array}\right\} \text{Select member ST } \phi_c P_n \geq P_u$$

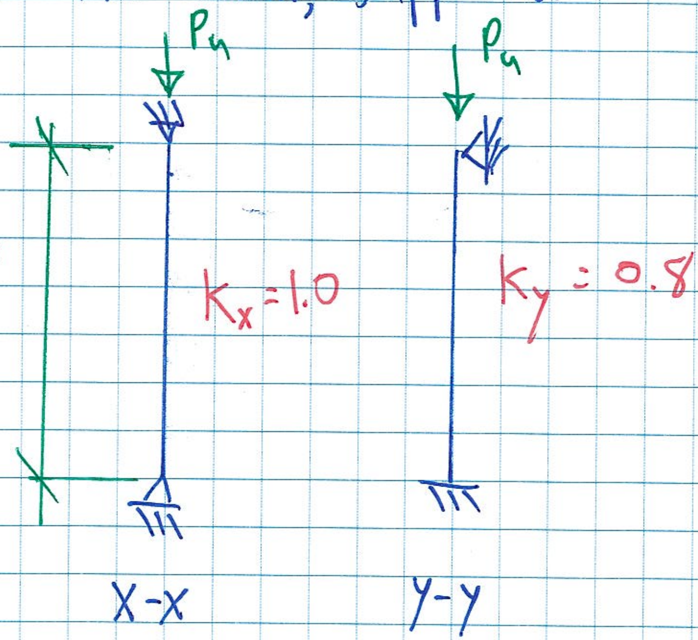
4) Verify Column Capacity using eqn. E3

5) Verify local buckling

6) Check Serviceability Criteria

EXAMPLE

GIVEN: A column, supported as shown, must carry: $D_L = 250^k$, $L_L = 500^k$



$P_u = 1.2 D_L + 1.6 L_L = \underline{\underline{1100^k}}$

REQ'D: Use A992 Steel, Select the lightest
1) W12 X ___
2) W18 X ___

SOLN:

EFF. LENGTH: $(KL)_x = 1.0(16^{ft}) = 16^{ft}$
$(KL)_y = 0.8(16^{ft}) = 12.8^{ft}$

$\Big\}$ W12 X ___ ST $\phi_c P_n \geq P_u = 1100^k$

Try W12X106: $\phi_c P_n = 1170^k > P_u = 1100^k$ @ 13 ft (Table 4-1a, p4-19)

$(KL)_y = 12.8^{ft}$ ← largest controls

$$(KL)_{Eqv.} = \frac{(KL)_x}{r_x/r_y} = \frac{16^{ft}}{1.76} = 9.1\ ft$$

↖ estimate r_x/r_y, p4-19

Verify Capacity: W12X106: $A_g = 31.2\ in^2$

$r_y = 3.11\ in$

$r_x = r_y\left(\frac{r_x}{r_y}\right) = 5.47\ in$"

$$\left(\frac{KL}{r}\right)_x = \frac{1.0(16')(12)}{5.47''} = 35.1$$

$$\left(\frac{KL}{r}\right)_y = \frac{0.8(16')(12)}{3.11} = 49.4$$ ← controls ≤ 200 ✓ Serviceability

* No notation in table ("c") ∴ no local buckling issues

E3:

$$f_e = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2_{max}} = \frac{\pi^2(29000 \text{ ksi})}{49.4} = 117.3 \text{ ksi} \geq 0.44 f_y = 22^{ksi}$$

($f_y = 50^{ksi}$)

$\therefore$ Inelastic Buckling

$$f_{cr} = \left[0.658^{f_e/f_y}\right] f_y = \left[0.658^{117.3/50}\right](50 \text{ ksi}) = 41.8 \text{ ksi}$$

$$\phi_c P_n = \phi_c f_{cr} A_s = 0.9(41.8 \text{ ksi})(31.2 \text{ in}^2) = \underline{\underline{1175^k}} \geq P_u = 1100^k \checkmark$$

NOTE: W12X96 $\left(\frac{KL}{r}\right)_{max} = 49.71$; $f_e = 115.8^{ksi}$; $f_{cr} = 41.74^{ksi}$

$\phi_c P_n = 1060^k \leq 1100^k$ X

$$\boxed{\text{USE W12X106, } 16^{ft}\text{, A992 STEEL}}$$

PART 2 - NO DESIGN TABLE FOR W18X___

We Can Estimate Critical Stress using part 1

Assume $f_{cr} \approx 40$ ksi ← We calculated 41.8 ksi, rounded

$$\therefore (A_g)_{req'd} = \frac{P_u}{\phi_c f_{cr}} = \frac{1100^k}{0.9(40\text{ ksi})} = 30.6 \text{ in}^2$$

Try W18X106: $A_g = 31.1 \text{ in}^2 \geq (A_g)_{req'd} = 30.6 \text{ in}^2$

$r_x = 7.84$ in ; $r_y = 2.66$ in

$$\left(\frac{KL}{r}\right)_x = \frac{1.0(16')(12)}{7.84} = 24.5$$

$$\left(\frac{KL}{r}\right)_y = \frac{0.8(16)(12)}{2.66 \text{ in}} = 57.74$$ ← Controls ≤ 200 ✓

$$f_e = \frac{\pi^2(29000\text{ ksi})}{57.74} = 85.8^{ksi} \geq 0.44F_y = 22^{ksi}$$ ∴ Inelastic Buckling

$$f_{cr} = \left(0.658^{f_e/f_y}\right) f_y = \left(0.658^{85.8/50}\right)(50\ ksi) = 39.2\ ksi$$

$$\phi_c P_n = 0.9\,(39.2\ ksi)(31.1\ in^2) = \cancel{1096}\ \underline{1097}^{k} \approx P_u = 1100^k$$

* This prob. would work b/c we don't know the loads (actual) that accurately

Try W18X119:

$A_g = 35.1\ in^2$

$\left(\frac{kL}{r}\right)_x = 24.3$; $\left(\frac{kL}{r}\right)_y = 57.1 \le 200$ ✓

controls

$f_e = 87.8\ ksi$; $f_{cr} = 39.4\ ksi$

$\phi_c P_n = 1245^k \geq P_u = 1100^k$ ✓

LOCAL BUCKLING

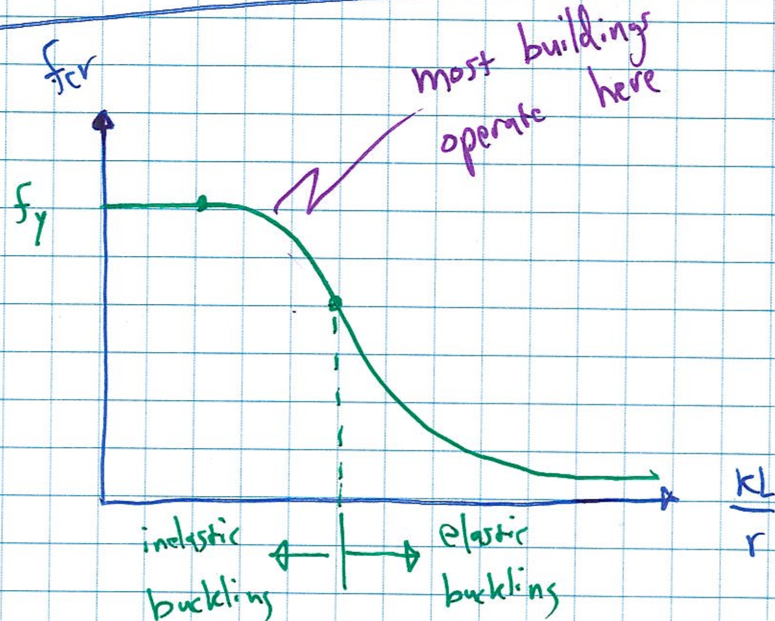
No notation in Sect. prop.

(Notation Method)

(Explicit Method) Table B4.1a

$$\frac{h}{t_w} = 24.5 \le \frac{254}{\sqrt{f_y}} = 35.9 \quad \checkmark$$

$$\frac{b_f}{2t_f} = 5.3 \le \frac{95}{\sqrt{f_y}} = 13.9 \quad \checkmark$$



$0 < f_{cr} < f_y$

Segui $\Rightarrow$ $\frac{2}{3} f_y \approx 33^{ksi}$

Sometimes $\frac{1}{2} f_y \approx 25^{ksi}$

* Estimate $f_{cr} \approx 0.8 f_y \approx 40^{ksi}$