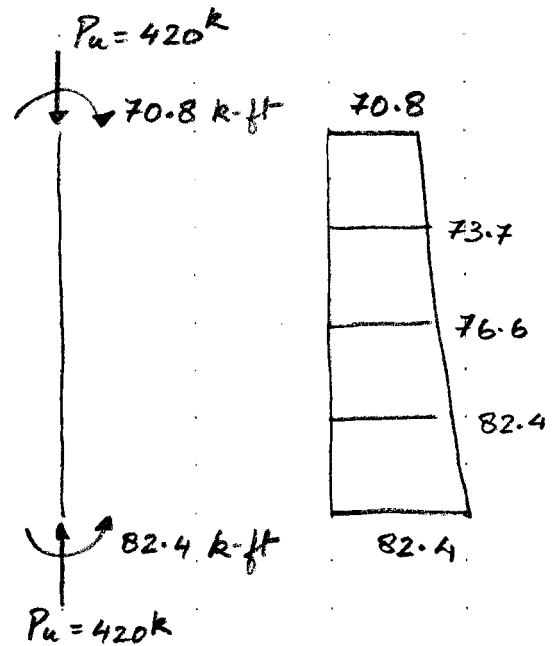
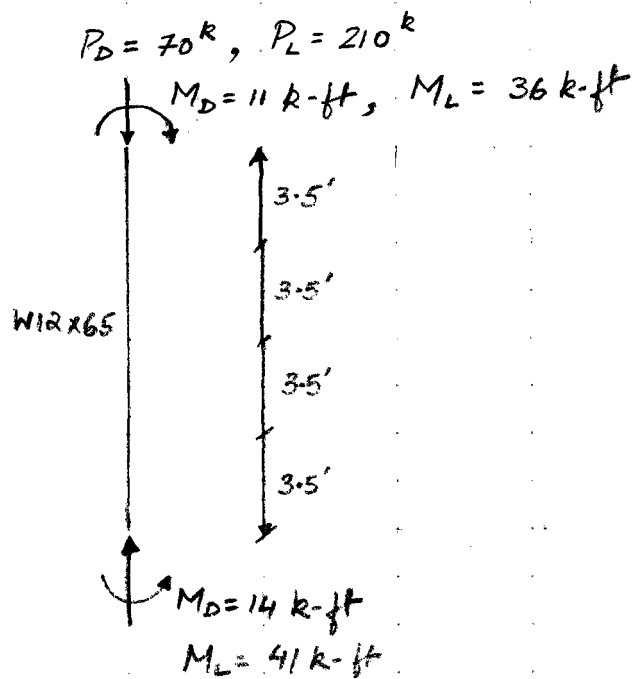


EXAMPLE

- MEMBER PART OF BRACED FRAME ; $K_x L = K_y L = 14 \text{ ft}$.



- For $KL = 14 \text{ ft}$; $W12 \times 65$; $\phi_c P_n = 685 \text{ kips}$

$$\therefore \frac{P_u}{\phi_c P_n} = \frac{420}{685} = 0.6131 > 0.2 \quad \therefore \text{Use AISC Equation H1-1a}$$

In the plane of bending $P_{e1} = \frac{\pi^2 E I_x}{(K_x L)^2} = \frac{\pi^2 \times 29000 \times 533}{(1.0 \times 14 \times 12)^2} = 5405 \text{ k}$

$$C_m = 0.6 - 0.4 \frac{M_1}{M_2} = 0.6 - 0.4 \times \left(\frac{-70.8}{80.4} \right) = 0.94$$

$$\therefore B_1 = \frac{C_m}{1 - \alpha P_r / P_{e1}} = \frac{0.94}{1 - 1.00 \times 420 / 5405} = 1.02$$

Assume $C_b = 1.0$, For $L_b = 14 \text{ ft}$; $\phi_b M_n = 345 \text{ k-ft}$

$$\text{Actual value of } C_b = \frac{12.5 (82.4)}{2.5 (82.4) + 3 (73.7) + 4 (76.6) + 3 (79.5)} = 1.06$$

$$\therefore \phi_b M_n = 1.06 * 345 = 366 \text{ k-ft}$$

$$\text{But } \phi_b M_p = 356 \text{ k-ft} < 366 \quad \therefore \text{use } \phi_b M_n = 356 \text{ k-ft}$$

$$M_{nt} = 82.4 \text{ k-ft} \quad M_{et} = 0$$

From AISC Equation C2-1a

$$M_r = M_u = B_1 M_{nt} + B_2 M_{et} = 1.02 (82.4) = 84.3 \text{ k-ft} = \underline{\underline{M_{ux}}}$$

AISC Equation H1-1a

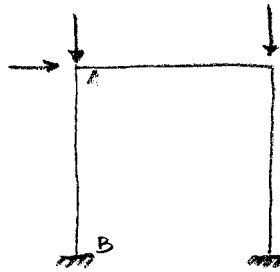
$$\frac{P_u}{\phi_c P_n} + \frac{8}{9} \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) = 0.6131 + \frac{8}{9} \left(\frac{84.30}{356} \right) = 0.824 < 1.0$$

OK!

$\therefore$ The member design works.

CE 470 - BEAM COLUMNS

$$B_2 = \frac{1}{1 - \alpha \frac{\sum P_{nt}}{\sum P_{e2}}}$$



+



=



$$M_{max} = M + P\Delta$$

$$\sum P_{e2} = \sum \frac{\pi^2 EI}{(K_2 L)^2}$$

EXAMPLE 6-6

W12 x 65 of A992 steel, 15 ft. long is a SWAY frame.

- (a) The axial loads and end moments obtained from 1st order analysis of the gravity loads. The frame and loading are symmetric
- (b) The wind load moments from 1st order analysis

strong axis bending.

$$K_x = 1.2 \left| \begin{array}{l} \text{sway} \end{array} \right|$$

$$K_x \left| \begin{array}{l} \text{braced} \end{array} \right| = 1.0$$

$$P_D = 85^R; P_L = 220^R$$

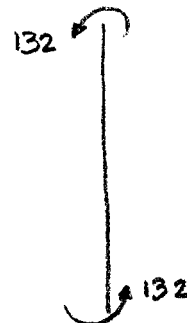
$$M_D = 15$$

$$M_L = 45$$

$$M_D = 18 \text{ k-ft}$$

$$M_L = 52 \text{ k-ft}$$

GRAVITY



WIND

$$1.4 D$$

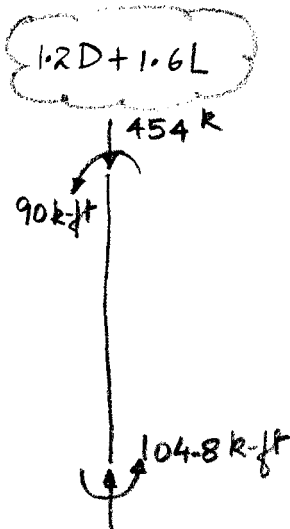
$$1.2 D + 1.6 L$$

$$1.2 D + (0.5 L \text{ or } 0.8 W)$$

$$1.2 D + 1.6 W + 0.5 L$$

$$1.2 D + 0.5 L$$

$$0.9 D \pm 1.6 W$$



$$K_y L = 15 \text{ ft}$$

$$\frac{K_x L}{r_x/r_y} = (K L)_{x\text{-eq}} = \frac{1.2 \times 15}{1.75}$$

$$(K L)_{x\text{-eq}} = 10.3 \text{ ft} < 15 \text{ ft}$$

$$\therefore (K_y L) = 15' \text{ governs}$$

$$W12 \times 65 \text{ tables; } \phi_c P_n = 662 \text{ k}$$

$$\text{Now, } P_u = 454 \text{ k}$$

$$M_{nt} = 104.8 \text{ k-ft}$$

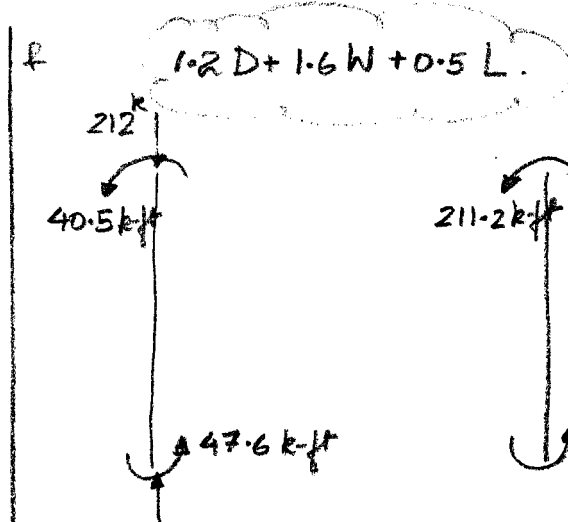
$$M_{et} = 0$$

$$C_m = 0.6 - 0.4 \frac{M_1}{M_2} = 0.6 - 0.4 \frac{90}{104.8}$$

$$\therefore C_m = 0.25$$

$$P_{e1} = \frac{\pi^2 EI}{(K L)^2} = \frac{\pi^2 EI_x}{(K_x L)^2} = \frac{\pi^2 \times 29000 \times 533}{(10 \times 15 \times 12)^2}$$

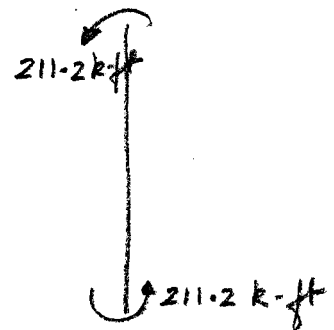
$$P_{e1} = 4708 \text{ k}$$



nt (gravity)

$$P_{nt} = 212 \text{ k}$$

$$M_{nt} = 47.6 \text{ k-ft}$$



et (WIND)

$$P_{et} = 0$$

$$M_{et} = 211.2 \text{ k-ft}$$

$$C_m = 0.6 - 0.4 \frac{M_1}{M_2} = 0.6 - 0.4 \frac{40.5}{47.6} = 0.26$$

$$\therefore C_m = 0.26$$

$$P_{e1} = 4708 \text{ k}$$

$$\therefore B_1 = \frac{C_m}{1 - \alpha_r \frac{P_r}{P_{e1}}} = \frac{0.26}{1 - \frac{212}{4708}} = 0.27$$

$$B_1 = 1.0$$

Assume applied axial load and buckling load is similar for all columns.

$$B_2 = \frac{1}{1 - \alpha \frac{\sum P_{nt}}{\sum P_{e2}}}$$

$$B_2 \approx \frac{1}{1 - P_{nt}/P_{e2}}$$

$$B_1 = \frac{C_m}{1 - \alpha \frac{P_r}{P_{e1}}} = \frac{0.2565}{1 - \frac{454}{4708}}$$

$$B_1 = 0.284 \geq 1.0$$

$$\therefore B_1 = 1.0$$

$$M_r = B_1 M_{nt} + B_2 M_{lt} = 1.0(104.8) + 0$$

$$M_r = 104.8 \text{ k-ft}$$

$$\text{For } L_b = 15 \text{ ft}$$

from beam design charts

$$\phi_b M_n = 340 \text{ k-ft} \quad (C_b = 1.0)$$

$$\phi_b M_p = 356 \text{ k-ft}$$

$$\text{Actual } C_b = \frac{12.5 M_{\max}}{2.5 M_{\max} + 3M_A + 4M_B + 3M_C}$$

$$\therefore C_b = 2.24$$

$$\therefore \phi_b M_n = 2.24(340) \leq 356 \text{ k-ft}$$

$$\therefore \phi_b M_n = 356 \text{ k-ft}$$

$$\frac{P_u}{\phi_c P_n} = \frac{454}{662} = 0.6 > 0.2$$

$$\therefore \frac{P_u}{\phi_c P_n} + \frac{M_u}{\phi_b M_n} = 0.69 + \frac{8}{9} \left(\frac{104.8}{356} \right) = 0.95 < 1.0$$

OK!

$$P_{e2} = \frac{\pi^2 EI_x}{(K_2 L)^2} = \frac{\pi^2 \times 29000 \times 533}{(1.2 \times 15 \times 12)^2}$$

$$\therefore P_{e2} = 3270 \text{ kips}$$

$$\therefore B_2 = \frac{1}{1 - \alpha \frac{P_{nt}}{P_{e2}}} = \frac{1}{1 - \frac{1.00(212)}{3270}}$$

$$\therefore B_2 = 1.07$$

$$\therefore M_u = B_1 M_{nt} + B_2 M_{lt}$$

$$= 1.0(47.6) + 1.07(211.2)$$

$$M_u = 273.4 \text{ k-ft}$$

$C_b > 1.0$; but no need to recalculate since M_{nt} & M_{lt} are both double curvature

$$\therefore \phi_b M_n = \phi_b M_p = 356 \text{ k-ft}$$

$$\frac{P_u}{\phi_c P_n} = \frac{212}{662} = 0.32 > 0.2$$

$$\therefore \frac{P_u}{\phi_c P_n} + \frac{8}{9} \frac{M_u}{\phi_b M_n} = 0.32 + \frac{8}{9} \left(\frac{273.4}{356} \right) = 1.00$$

OK! barely

DESIGN OF BEAM COLUMNS

- Because of too many variables, trial-and-error process
- Procedure as follows:
 - Assume H1-1a governs

$$\therefore \frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0$$

$$\therefore \frac{1}{P_c} (P_r) + \left(\frac{8}{9 M_{cx}} \right) M_{rx} + \left(\frac{8}{9 M_{cy}} \right) M_{ry} \leq 1.0$$

$$\text{or } \phi P_r + b_x M_{rx} + b_y M_{ry} \leq 1.0$$

$$\text{where } \phi = \frac{1}{P_c} ; b_x = \frac{8}{9 M_{cx}} ; b_y = \frac{8}{9 M_{cy}}$$

$$\text{If } \phi P_r < 0.2 ; \text{ then } 0.5 \phi P_r + \frac{9}{8} (b_x M_{rx} + b_y M_{ry}) \leq 1.0$$

$$\text{If } \phi P_r > 0.2 ; \text{ then } \phi P_r + b_x M_{rx} + b_y M_{ry} \leq 1.0$$

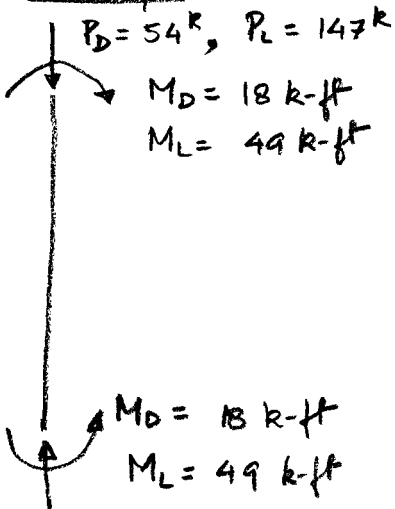
Table 6-1 give values of ϕ , b_x , & b_y for all W shapes

The values of C_b , B_1 , & B_2 must be calculated independently

1. Select a trial shape from Table 6-1
2. Use $(KL)_{\text{eff}}$ to select ϕ , use (L_b) to select b_x , b_y is independent of length
 - Assume weak axis buckling, & $C_b = 1.0$
3. Calculate ϕP_r & use applicable interaction equation
4. Evaluate interaction equation

- 5.) If result is not close to 1.0, try another shape. By examining terms in the equation, you will know
- 6.) Continue until interaction gives 0.9 - 1.0
-

Example:



$$P_u = 300^k$$

$$\text{Assume } B_1 = 1.0$$

$$\therefore M_u = 100 \text{ k-ft}$$

$$KL = L_b = 16 \text{ ft} ; C_b = 1.0$$

Try a W10 shape: For W10x60; $p = 1.89 \times 10^{-3}$ & $b_x = 3.51 \times 10^{-3}$

$$\phi P_r = 1.89 \times 10^{-3} \times 300 = 0.57 > 0.2$$

$$\therefore \phi P_r + b_x M_{rx} + b_y M_{ry} = (1.89 \times 10^{-3}) \times 300 + (3.51 \times 10^{-3}) \times 100 = 0.92 < 1.0$$

Is this the best section? Hmm... Try lighter

W10x54 $\phi = 2.12 \times 10^{-3}$ & $b_x = 3.97 \times 10^{-3}$

$$\phi P_r + b_x M_{rx} = 1.03 > 1.0$$

N.G.