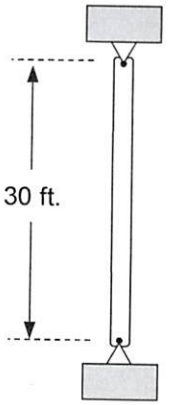
Classroom Problem 4.6-4: Select a **W14** shape with F_y = 70 *ksi* that can resist a service dead load of 125 *k* and a service live load of 250 *k*. The effective length, L_c = 30 *ft*.



* USE TRIAL & ERROR APPROACH

$$P_u = 1.2D + 1.6L = 1.2(125^k) + 1.6(250^k) = 550^k$$

$$\text{REQUIRED } A_g = \frac{P_u}{\phi_c F_n} \qquad * \text{ TRY } F_n = \tfrac{2}{3} F_y = \tfrac{2}{3}(70\,ksi) = 47\,ksi$$

$$= \frac{550^k}{0.9(47\,ksi)} = 13.00\,in^2$$

- TRY A W14 X48 $\quad A_g = 14.1\,in^2 > \text{REQ. A}$ o.k.

$$\frac{L_c}{r_{min}} = \frac{30\,ft(12\,in/ft)}{1.91\,in} = 187.5 \qquad 4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29{,}000\,ksi}{70\,ksi}} = 95.87$$

$$\frac{L_c}{r} > 4.71\sqrt{\frac{E}{F_y}} \Rightarrow \text{EQ. E3-3} \qquad F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000\,ksi)}{(187.5)^2} = 8.14\,ksi$$

$$F_n = 0.877(F_e) = 0.877(8.14\,ksi) = 7.14\,ksi \Leftarrow \text{WAY OFF GUESS } 47\,ksi$$

$$\phi P_n = \phi_c F_n A_g = 0.90(7.14\,ksi)\,14.1\,in^2 = 90.6^k < 550^k \quad \text{N. G.}$$

REVISED F_n ESTIMATE: $F_n = 7.14\,ksi + \frac{1}{3}(47\,ksi - 7.14\,ksi) = 20.43\,ksi$

$$\text{REQUIRED } A_g = \frac{P_u}{\phi_c F_n} = \frac{550^k}{0.90(20.43\,ksi)} = 29.92\,in^2$$

- TRY A W14 x 99.

$A_g = 29.1\,in < \text{REQ. } A_g$ o.k. (CLOSE ENOUGH)

$$\frac{L_c}{r_{min}} = \frac{30ft(12in/ft)}{3.71} = 97.04 > 4.71\sqrt{\frac{E}{F_y}}$$ USE AISC EQ. E3-3

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29000\,ksi)}{(97.04)^2} = 30.40\,ksi$$

$$F_n = 0.877 F_e = 0.877(30.40\,ksi) = 26.66\,ksi$$

$$\phi_c P_n = \phi_c F_n A_g = 0.90(26.66\,ksi)29.1\,in^2 = 698.2^k > 550^k$$ o.k.

CLASSROOM EXAMPLE 4.6-4

- CHECK NEXT LIGHTEST SECTION W14x90 $A_g = 26.5 in^2$

$$\frac{L_c}{r_{min}} = \frac{360\,in}{3.70\,in} = 97.30 > 4.71\sqrt{\frac{E}{F_y}} = 95.87$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000\,ksi)}{(97.30)^2} = 30.23\,ksi$$

$$F_n = 0.877 F_e = 0.877(30.23\,ksi) = 26.51\,ksi$$

$$\phi_c P_n = \phi_c F_n A_g = 0.90(26.51\,ksi)(26.5\,in^2) = 632.4^k > 550^k \quad \underline{\text{O.K.}}$$

USE W14x90 NOT SLENDER NO "c" FOOTNOTE