

Example 1 (LRFD Steel Design, Third Edition by William T. Segui, page 95.)

Compute the design compressive strength of a W14 × 74 with a length of 20 feet and pinned ends. A992 steel is used.

Slenderness ratio:

$$\text{Maximum } \frac{KL}{r} = \frac{KL}{r_y} = \frac{1.0(20 \times 12)}{2.48} = 96.77 < 200 \quad (\text{OK})$$

$$\lambda_c = \frac{KL}{r\pi} \sqrt{\frac{F_y}{E}} = \frac{96.77}{\pi} \sqrt{\frac{50}{29,000}} = 1.279$$

$$\lambda_c < 1.5 \quad \therefore \text{ use AISC Equation E2-2.}$$

$$F_{cr} = (0.658^{\lambda_c^2}) F_y = (0.658)^{(1.279)^2} (50) = 25.21 \text{ ksi}$$

$$P_n = A_g F_{cr} = 21.8(25.21) = 549.6 \text{ kips}$$

$$\phi_c P_n = 0.85(549.6) = 467 \text{ kips}$$

Design compressive strength = 467 kips. ■

Example 2 (LRFD Manual, page 4-7, 4-8.)**W-shape compression member design (braced frame).**

Determine the design strength of an ASTM A992 W14×132 that is part of a braced frame.

$$\begin{aligned} F_y &= 50 \text{ ksi} & A_g &= 38.8 \text{ in.}^2 \\ F_u &= 65 \text{ ksi} & r_x &= 6.28 \text{ in.} \\ & & r_y &= 3.76 \text{ in.} \end{aligned}$$

- Assume the physical length $L = 30$ ft, the ends are pinned and the column is braced at the ends only for both the X-X and Y-Y axes. Also, calculate at what length this compression member would cease to satisfy the slenderness limitation in LRFD Specification Section B7.
- Assume the physical length $L = 30$ ft, the ends are pinned, and the column is braced at the ends only for the X-X axis and braced at the ends and mid-height for the Y-Y axis.

From Table 1-1, the width-thickness ratio for the flanges is

$$\lambda = \frac{b_f}{2t_f} = 7.15$$

and the width-thickness ratio for the web is

$$\lambda = \frac{h}{t_w} = 17.7$$

From LRFD Specification Section B5.1, for flange compactness

$$\begin{aligned} \lambda_r &= 0.56 \sqrt{\frac{E}{F_y}} \\ &= 0.56 \sqrt{\frac{29,000 \text{ ksi}}{50 \text{ ksi}}} \\ &= 13.5 \end{aligned}$$

Since $\lambda < \lambda_r$, the flanges are not slender. From LRFD Specification Section B5.1, for web compactness

$$\begin{aligned} \lambda_r &= 1.49 \sqrt{\frac{E}{F_y}} \\ &= 1.49 \sqrt{\frac{29,000 \text{ ksi}}{50 \text{ ksi}}} \\ &= 35.9 \end{aligned}$$

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Since $\lambda < \lambda_r$, the web is not slender. Since neither the flanges nor the web are slender, the W14×132 can be designed per LRFD Specification Section E2.

From LRFD Specification Section C2.1 and Commentary Table C-C2.1, $K = 1.0$ for both the X-X axis and the Y-Y axis.

$$\frac{Kl_x}{r_x} = \frac{1.0(30 \text{ ft} \times 12 \text{ in./ft})}{6.28 \text{ in.}} = 57.3$$

$$\frac{Kl_y}{r_y} = \frac{1.0(30 \text{ ft} \times 12 \text{ in./ft})}{3.76 \text{ in.}} = 95.7$$

Since $Kl_y/r_y > Kl_x/r_x$, buckling about the Y-Y axis controls. From LRFD Specification Section E2,

$$\begin{aligned}\lambda_c &= \frac{Kl}{r\pi} \sqrt{\frac{F_y}{E}} \\ &= \frac{95.7}{\pi} \sqrt{\frac{50 \text{ ksi}}{29,000 \text{ ksi}}} \\ &= 1.26\end{aligned}$$

Since $\lambda_c < 1.5$,

$$\begin{aligned}\phi_c P_n &= \phi_c F_{cr} A_g \\ &= \phi_c (0.658^{\lambda_c^2}) F_y A_g \\ &= 0.85 (0.658^{(1.26)^2}) (50 \text{ ksi}) (38.8 \text{ in.}^2) \\ &= 844 \text{ kips}\end{aligned}$$

Per LRFD Specification Section B7,

$$\begin{aligned}L_{\max} &= \frac{200r}{K} \\ &= \frac{200(3.76 \text{ in.})}{1.0(12 \text{ in./ft})} \\ &= 62.7 \text{ ft}\end{aligned}$$

Thus, the W14×132 compression member satisfies the slenderness requirements up to a 62.7-ft length.