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:**

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

\[
\lambda_c < 1.5 \therefore \text{use AISC Equation E2-2.}
\]

\[
F_{cr} = (0.658^{2.5})F_y = (0.658)(1.279)^2(50) = 25.21 \text{ ksi}
\]

\[
P_n = A_gF_{cr} = 21.8(25.21) = 549.6 \text{ kips}
\]

\[
\phi_P_n = 0.85(549.6) = 467 \text{ kips}
\]

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.

\[ F_y = 50 \text{ ksi} \quad A_y = 38.8 \text{ in}^2 \]
\[ F_u = 65 \text{ ksi} \quad r_x = 6.28 \text{ in.} \]
\[ r_y = 3.76 \text{ in.} \]

a) Assume the physical length \( L = 30 \text{ ft} \), 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.

b) Assume the physical length \( L = 30 \text{ ft} \), 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

\[ \lambda = \frac{b_y}{2t_f} = 7.15 \]

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

\[ \lambda_r = 0.56 \sqrt{\frac{E}{F_y}} = 0.56 \sqrt{\frac{29,000 \text{ ksi}}{50 \text{ ksi}}} = 13.5 \]

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

\[ \lambda_r = 1.49 \sqrt{\frac{E}{F_y}} \left( \frac{0.5 \times 0.7}{0.1} \right) = 35.9 \]

\[ \lambda_r = \frac{29,000 \text{ ksi}}{50 \text{ ksi}} \]
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,

\[
K = 1.0 \text{ for both the X-X axis and the Y-Y axis.}
\]

\[
\frac{KI_x}{r_x} = \frac{1.0(30 \text{ ft} \times 12 \text{ in./ft})}{6.28 \text{ in.}} = 57.3
\]

\[
\frac{KI_y}{r_y} = \frac{1.0(30 \text{ ft} \times 12 \text{ in./ft})}{3.76 \text{ in.}} = 95.7
\]

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

\[
\lambda_c = \frac{KI_y}{r_y} \sqrt{\frac{F_y}{E}}
\]

\[
= 95.7 \sqrt{\frac{50 \text{ ksi}}{29,000 \text{ ksi}}} = 1.26
\]

Since $\lambda_c < 1.5$,

\[
\phi_c P_n = \phi_c F_{ct} A_g = \phi_c \left(0.658d^2\right) F_y A_g = 0.85 \left(0.658 \left(\frac{12}{2}\right)^2\right) (50 \text{ ksi}) (38.8 \text{ in.}^2) = 844 \text{ kips}
\]

Per LRFD Specification Section B7,

\[
L_{max} = \frac{200r}{K} = \frac{200(3.76 \text{ in.})}{1.0(12 \text{ in./ft})} = 62.7 \text{ ft}
\]

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