

EXAMPLE:

GIVEN STRUCTURAL STEEL WITH THE FOLLOWING PROPERTIES

$$\sigma_y = 30 \text{ ksi}$$

$$E = 30 \text{ Msi}$$

THE STEEL IS USED TO MAKE A HOLLOW CIRCULAR COLUMN 34 ft LONG THAT IS PINNED AT BOTH ENDS. FOR A CROSS-SECTION WITH THE PROPERTIES

$$A = 8.64 \text{ in}^2$$

$$I = 32.94 \text{ in}^4$$

IS EULER'S EQUATION APPLICABLE? WHAT IS THE CRITICAL LOAD? WHAT WOULD THE CONDITIONS BE IF THE END CONDITIONS WERE FIXED?

SOLUTION:

FOR THIS TYPE OF STEEL THE MINIMUM SLENDERNESS RATIO FOR WHICH EULER'S EQUATION IS APPROPRIATE IS

$$\left(\frac{P}{A}\right)_{cr} = \frac{\pi^2 E}{(L/r)^2} \Rightarrow \left(\frac{L}{r}\right) = \sqrt{\frac{\pi^2 E}{(P/A)_{cr}}}$$
$$\left(\frac{L}{r}\right) = \sqrt{\frac{\pi^2 \cdot (30)(10^6) \text{ lb/in}^2}{30(10^3) \text{ lb/in}^2}} = \underline{100}$$

FOR THIS SECTION THE SLENDERNESS RATIO IS CALCULATED TO BE

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{32.9 \text{ in}^4}{8.640 \text{ in}^2}} = 1.95 \text{ in}$$

$$\frac{L}{r} = \frac{34 \text{ ft} \cdot 12 \text{ in/ft}}{1.95 \text{ in}} = \underline{209}$$

EULER'S EQUATION IS APPLICABLE. THE CRITICAL LOAD IS

$$\left(\frac{P}{A}\right)_{cr} = \frac{\pi^2 E}{(L/r)^2} = \frac{\pi^2 \cdot 30(10^6) \text{ lb/in}^2}{(209)^2} = 6.778(10^3) \text{ lb/in}^2 = \boxed{6.78 \text{ ksi}}$$

$$P_{cr} = 6.778(10^3) \text{ lb/in}^2 \cdot 8.640 \text{ in}^2 = 58.5(10^3) \text{ lb} = \boxed{58.5 \text{ kips}}$$

FOR THE FIXED-FIXED CONDITION THE MINIMUM SLENDERNESS RATIO FOR WHICH EULER'S EQUATION IS APPLICABLE

$$\left(\frac{L}{r}\right) = 2 \cdot \sqrt{\frac{\pi^2 \cdot 30(10^6) \text{ psi}}{30(10^3) \text{ psi}}} = \underline{200}$$

EULER'S EQUATION IS STILL APPLICABLE

$$\left(\frac{P}{A}\right)_{cr} = \frac{\pi^2 E}{(\frac{1}{2} \cdot L/r)^2} = \frac{\pi^2 \cdot 30(10^6) \text{ lb/in}^2}{(\frac{1}{2} \cdot 209)^2} = \boxed{27.1 \text{ ksi}}$$

$$P_{cr} = (27.1 \cdot 10^3 \text{ lb/in}^2) \cdot (8.64 \text{ in}^2) = \boxed{234 \text{ kips}}$$