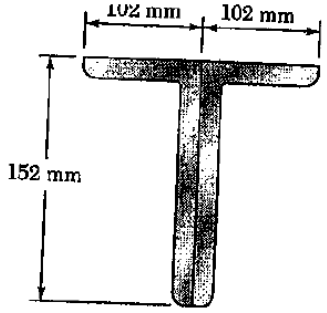
Column and Struts Buckling Examples

Example 1

A compression member of 7-m effective length is made by welding together two L152 × 102 × 12.7 angles as shown. Using E = 200 GPa, determine the allowable centric load for the member if a factor of safety of 2.2 is required.



SOLUTION

Angle L 152 × 102 × 12.7

$A = 3060\ mm^2$

$I_x = 7.20 \times 10^6\ mm^4$

$I_y = 2.64 \times 10^6\ mm^4$

$y = 50.3\ mm$

$x = 25.3\ mm$

Two angles: $I_x = (2)(7.20 \times 10^6) = 14.00 \times 10^6\ mm^4$

$I_y = 2\left[2.64 \times 10^6 + (3060)(25.3)^2\right] = 9.197 \times 10^6\ mm^4$

$I_{min} = I_y = 9.197 \times 10^6\ mm^4 = 9.197 \times 10^{-6}\ m^4$

$$P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (200 \times 10^9)(9.197 \times 10^{-6})}{(7.0)^2} = 370.5 \times 10^3\ N = 370.5\ kN$$

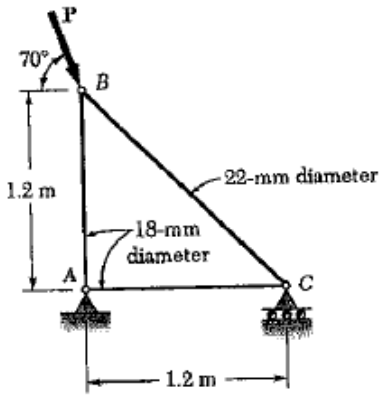
$$P_{all} = \frac{P_{cr}}{F.S.} = \frac{370.5}{2.2} = 168.4\ kN$$

(Note that L_e here referes to the effective length)

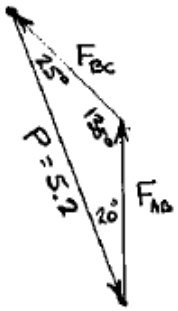
Example 2

Knowing that $P = 5.2$ kN, determine the factor of safety for the structure shown. Use $E = 200$ GPa and consider only buckling in the plane of the structure.

SOLUTION



Joint B: From force triangle



$$\frac{F_{AB}}{\sin 25^\circ} = \frac{F_{BC}}{\sin 20^\circ} = \frac{5.2}{\sin 135^\circ}$$

$F_{AB} = 3.1079$ kN (comp)

$F_{BC} = 2.5152$ kN (comp)

Member AB: $I_{AB} = \frac{\pi}{4}\left(\frac{d}{2}\right)^4 = \frac{\pi}{4}\left(\frac{18}{2}\right)^4 = 5.153\times10^{3}\ \text{mm}^4 = 5.153\times10^{-9}\ \text{m}^4$

$$F_{AB,cr} = \frac{\pi^2 E I_{AB}}{L_{AB}^2} = \frac{\pi^2(200\times10^9)(5.153\times10^{-9})}{(1.2)^2} = 7.0636\times10^3\ \text{N} = 7.0636\ \text{kN}$$

$$F.S. = \frac{F_{AB,cr}}{F_{AB}} = \frac{7.0636}{3.1079} = 2.27$$

Member BC: $I_{BC} = \frac{\pi}{4}\left(\frac{d}{2}\right)^4 = \frac{\pi}{4}\left(\frac{22}{2}\right)^4 = 11.499\times10^{3}\ \text{mm}^4 = 11.499\times10^{-9}\ \text{m}^4$

$L_{BC}^2 = 1.2^2 + 1.2^2 = 2.88\ \text{m}^2$

$$F_{BC,cr} = \frac{\pi^2 E I_{BC}}{L_{BC}^2} = \frac{\pi^2(200\times10^9)(11.499\times10^{-9})}{2.88} = 7.8813\times10^3\ \text{N} = 7.8813\ \text{kN}$$

$$F.S. = \frac{F_{BC,cr}}{F_{BC}} = \frac{7.8813}{2.5152} = 3.13$$

Smallest F.S. governs. F.S. = 2.27