Problem 1

The hoisting arrangement for lifting a large pipe is shown in Figure Q1. The spreader is a steel tubular section with outer diameter 70 mm and inner diameter 57 mm. Its length is 2.6 m and its modulus of elasticity is 200 GPa. Evaluate the maximum weight of the pipe that can be lifted, considering a safety factor of 2.25 with respect to Euler buckling. Assume pinned conditions at the ends of the spreader.
Hint: in the current arrangement, the spreader is under compression.

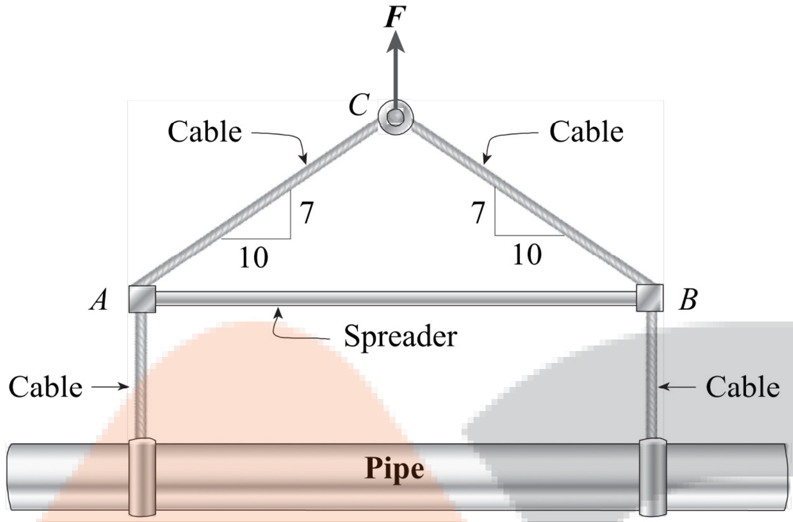


Figure Q1

Solution

$E = 200\ \text{GPa} \qquad d_2 = 70\ \text{mm}$

$d_1 = 57\ \text{mm} \qquad L = 2.6\ \text{m}$

$n = 2.25 \qquad \alpha = \arctan\left(\frac{7}{10}\right)$

$I = \frac{\pi}{64}\left(d_2^{\,4} - d_1^{\,4}\right) \qquad I = 660.4 \times 10^3\ \text{mm}^4$

$P_{cr} = \frac{\pi^2 EI}{L^2} \qquad P_{cr} = 199\ \text{kN}$

Allowable Load

$P_{allow} = \frac{P_{cr}}{n} \qquad P_{allow} = 88.6\ \text{kN}$

Equilibrium of joint *A*

$\Sigma F_{horiz} = 0 \quad -P + T\cos(\alpha) = 0$

$\Sigma F_{vert} = 0 \quad T\sin(\alpha) - \frac{W}{2} = 0$

Solve the equation

$W = 2P\tan(\alpha)$

Maximum weight of pipe

$W_{max} = 2P_{allow}\tan(\alpha) \qquad W_{max} = 124\ \text{kN}$

Problem 2

Figure Q2 shows truss ABC which supports a vertical load W at joint B. Members AB and BC are made of circular hollow steel pipes with outside diameter 100 mm and wall thickness of 6mm. Joint B is restrained against displacement perpendicular to the plane of the truss. Determine the critical buckling load, W_{cr}. Take Young's Modulus, E = 200 GPa.

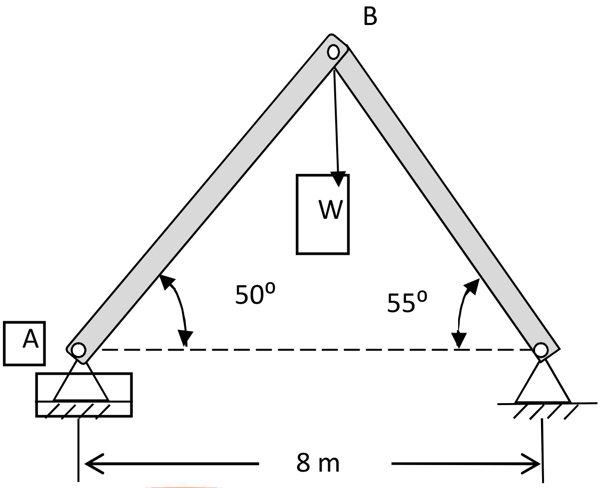
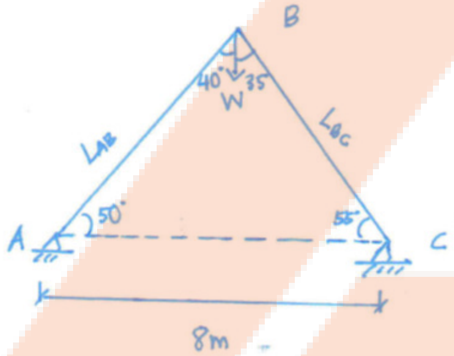


Figure Q2

Solution

Provided by Dr. Wong Jing Ying



$d_2 = 100mm$, $t = 6mm$

$d_1 = d_2 - 2t = 100 - 2(6) = 88mm$

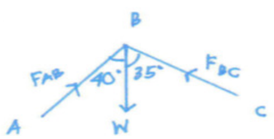
$\frac{L_{AB}}{\sin 55} = \frac{8}{\sin 75}$, $\frac{L_{BC}}{\sin 50} = \frac{8}{\sin 75}$

$L_{AB} = 6.784 m$ $\quad L_{BC} = 6.345m$

Buckling occurs when either member reaches its critical load.

$P_{cr}^{AB} = \frac{\pi^2 EI}{L_{AB}^2} = \frac{\pi^2 (200)(1.96\times10^6)}{6.784^2} = 84.06$ kN ✓

$P_{cr}^{BC} = \frac{\pi^2 EI}{L_{BC}^2} = \frac{\pi^2 (200)(1.96\times10^6)}{6.345^2} = 96.1$ kN



$\Sigma F_x = 0$, $F_{AB} \sin 40 - F_{BC} \sin 35° = 0$ — (1)

$\Sigma F_y = 0$, $F_{AB} \cos 40° + F_{BC} \cos 35° - W = 0$ — (2)

From (1), $F_{AB} = \frac{F_{BC} \sin 35}{\sin 40}$, $F_{BC} = \frac{F_{AB} \sin 40}{\sin 35}$

$\Rightarrow \left(\frac{F_{BC} \sin 35}{\sin 40} \right) \cos 40 + F_{BC} \cos 35^\circ - W = 0$

$W = 1.503 \, F_{BC}$

$\Rightarrow F_{AB} \cos 40^\circ + \left(\frac{F_{AB} \sin 40}{\sin 35} \right) \cos 35^\circ - W = 0$

$W = 1.684 \, F_{AB}$

$\therefore W_{CR}^{AB} = 1.684 \, P_{CR}^{AB} = 1.684 \, (84.06) = 141.56 \text{ kN}$

$W_{CR}^{BC} = 1.503 \, P_{CR}^{BC} = 1.503 \, (96.1) = 144.44 \text{ kN}$