Solution 1.2-1 Circular post in compression

$P_1 = 2500$ lb

$d_{AB} = 1.25$ in.

$d_{BC} = 2.25$ in.

(a) Normal stress in part AB

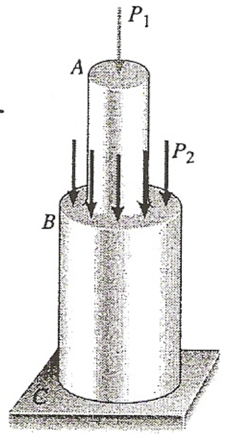
$$\sigma_{AB} = \frac{P_1}{A_{AB}} = \frac{2500 \text{ lb}}{\frac{\pi}{4}(1.25 \text{ in.})^2} = 2040 \text{ psi} \quad \longleftarrow$$

(b) Load P_2 for equal stresses

$$\sigma_{BC} = \frac{P_1 + P_2}{A_{BC}} = \frac{2500 \text{ lb} + P_2}{\frac{\pi}{4}(2.25 \text{ in.})^2}$$

$$= \sigma_{AB} = 2040 \text{ psi}$$

Solve for P_2: $P_2 = 5600$ lb $\longleftarrow$



Alternate Solution for Part (b)

$$\sigma_{BC} = \frac{P_1 + P_2}{A_{BC}} = \frac{P_1 + P_2}{\frac{\pi}{4} d_{BC}^2}$$

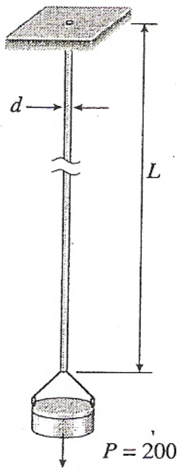
$$\sigma_{AB} = \frac{P_1}{A_{AB}} = \frac{P_1}{\frac{\pi}{4} d_{AB}^2} \qquad \sigma_{BC} = \sigma_{AB}$$

$$\frac{P_1 + P_2}{d_{BC}^2} = \frac{P_1}{d_{AB}^2} \text{ or } P_2 = P_1\left[\left(\frac{d_{BC}}{d_{AB}}\right)^2 - 1\right]$$

$$\frac{d_{BC}}{d_{AB}} = 1.8$$

$$\therefore P_2 = 2.24 P_1 = 5600 \text{ lb} \quad \longleftarrow$$

Solution 1.2-3 Long steel rod in tension



$P = 200$ lb

$L = 110$ ft

$d = ¼$ in.

Weight density: $\gamma = 490 \text{ lb/ft}^3$

W = Weight of rod

$= \gamma$(Volume)

$= \gamma AL$

$$\sigma_{max} = \frac{W + P}{A} = \gamma L + \frac{P}{A}$$

$$\gamma L = (490 \text{ lb/ft}^3)(110 \text{ ft})\left(\frac{1}{144} \frac{\text{ft}^2}{\text{in.}^2}\right)$$

$$= 374.3 \text{ psi}$$

$$\frac{P}{A} = \frac{200 \text{ lb}}{\frac{\pi}{4}(0.25 \text{ in.})^2} = 4074 \text{ psi}$$

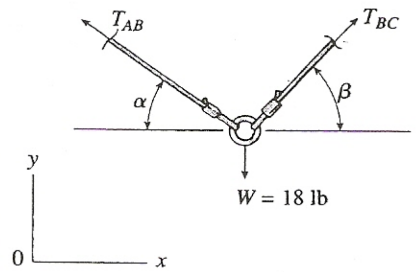
$$\sigma_{max} = 374 \text{ psi} + 4074 \text{ psi} = 4448 \text{ psi}$$

Rounding, we get

$$\sigma_{max} = 4450 \text{ psi} \quad \longleftarrow$$

Solution 1.2-7 Two steel wires supporting a lamp

Free-body diagram of point B



$\alpha = 34°$ $\quad \beta = 48°$

$d = 30$ mils $= 0.030$ in.

$$A = \frac{\pi d^2}{4} = 706.9 \times 10^{-6} \text{ in.}^2$$

Equations of Equilibrium

$\Sigma F_x = 0 \quad -T_{AB} \cos\alpha + T_{BC} \cos\beta = 0$

$\Sigma F_y = 0 \quad T_{AB} \sin\alpha + T_{BC} \sin\beta - W = 0$

Substitute numerical values:

$-T_{AB}(0.82904) + T_{BC}(0.66913) = 0$

$T_{AB}(0.55919) + T_{BC}(0.74314) - 18 = 0$

Solve the Equations:

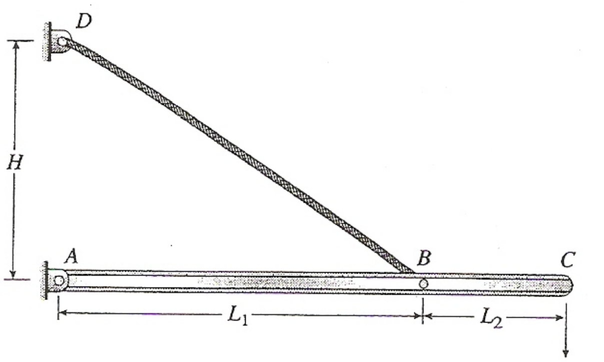
$T_{AB} = 12.163$ lb $\quad T_{BC} = 15.069$ lb

Tensile stresses in the wires

$$\sigma_{AB} = \frac{T_{AB}}{A} = 17{,}200 \text{ psi} \quad \longleftarrow$$

$$\sigma_{BC} = \frac{T_{BC}}{A} = 21{,}300 \text{ psi} \quad \longleftarrow$$

Solution 1.2-9 Loading crane with girder and cable



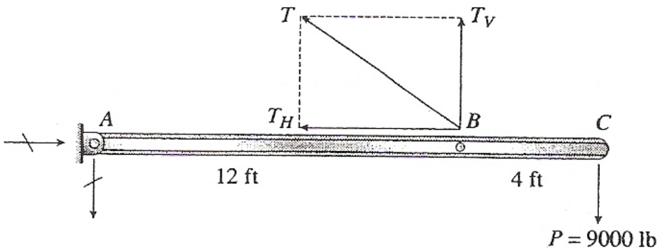
$H = 9$ ft $\quad L_1 = 12$ ft

$L_2 = 4$ ft $\quad A$ = effective area of cable

$A = 0.471$ in.^{2}

$P = 9000$ lb

FREE-BODY DIAGRAM OF GIRDER



T = tensile force in cable

$P = 9000$ lb

EQUILIBRIUM

$\Sigma M_A = 0$

$T_V(12 \text{ ft}) - (9000 \text{ lb})(16 \text{ ft}) = 0$

$T_V = 12{,}000$ lb

$$\frac{T_H}{T_V} = \frac{L_1}{H} = \frac{12 \text{ ft}}{9 \text{ ft}}$$

$$\therefore T_H = T_V\left(\frac{12}{9}\right)$$

$$T_H = (12{,}000 \text{ lb})\left(\frac{12}{9}\right)$$

$= 16{,}000$ lb

TENSILE FORCE IN CABLE

$$T = \sqrt{T_H^2 + T_V^2} = \sqrt{(16{,}000 \text{ lb})^2 + (12{,}000 \text{ lb})^2}$$

$= 20{,}000$ lb

(a) AVERAGE TENSILE STRESS IN CABLE

$$\sigma = \frac{T}{A} = \frac{20{,}000 \text{ lb}}{0.471 \text{ in.}^2} = 42{,}500 \text{ psi} \quad \longleftarrow$$

(b) AVERAGE STRAIN IN CABLE

L = length of cable $\quad L = \sqrt{H^2 + L_1^2} = 15$ ft

δ = stretch of cable $\quad \delta = 0.382$ in.

$$\varepsilon = \frac{\delta}{L} = \frac{0.382 \text{ in.}}{(15 \text{ ft})(12 \text{ in./ft})} = 2120 \times 10^{-6} \quad \longleftarrow$$

Solution 1.5-6 Brass specimen in tension

$d = 10$ mm $\quad$ Gage length $L = 50$ mm

$P = 20$ kN $\quad \delta = 0.122$ mm $\quad \Delta d = 0.00830$ mm

AXIAL STRESS

$$\sigma = \frac{P}{A} = \frac{20 \text{ kN}}{\frac{\pi}{4}(10 \text{ mm})^2} = 254.6 \text{ MPa}$$

Assume σ is below the proportional limit so that Hooke's law is valid.

AXIAL STRAIN

$$\varepsilon = \frac{\delta}{L} = \frac{0.122 \text{ mm}}{50 \text{ mm}} = 0.002440$$

(a) MODULUS OF ELASTICITY

$$E = \frac{\sigma}{\varepsilon} = \frac{254.6 \text{ MPa}}{0.002440} = 104 \text{ GPa} \quad \longleftarrow$$

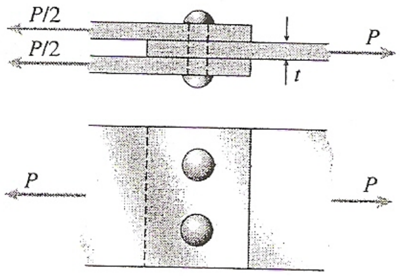
(b) POISSON'S RATIO

$\varepsilon' = \nu\varepsilon$

$\Delta d = \varepsilon' d = \nu \varepsilon d$

$$\nu = \frac{\Delta d}{\varepsilon d} = \frac{0.00830 \text{ mm}}{(0.002440)(10 \text{ mm})} = 0.34 \quad \longleftarrow$$

Solution 1.6-2 Three plates joined by two rivets



t = thickness of plates = 16 mm

d = diameter of rivets = 20 mm

P = 50 kN

τ_{ULT} = 180 MPa (for shear in the rivets)

(a) MAXIMUM BEARING STRESS ON THE RIVETS

Maximum stress occurs at the middle plate.

A_b = bearing area for one rivet

$= dt$

$$\sigma_b = \frac{P}{2A_b} = \frac{P}{2dt} = \frac{50\text{ kN}}{2(20\text{ mm})(16\text{ mm})}$$

$$= 78.1\text{ MPa} \quad \longleftarrow$$

(b) ULTIMATE LOAD IN SHEAR

Shear force on two rivets $= \dfrac{P}{2}$

Shear force on one rivet $= \dfrac{P}{4}$

Let A = cross-sectional area of one rivet

Shear stress $\tau = \dfrac{P/4}{A} = \dfrac{P}{4\left(\frac{\pi d^2}{4}\right)} = \dfrac{P}{\pi d^2}$

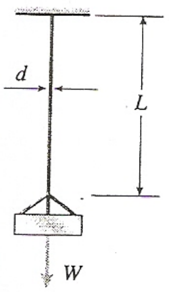
or, $P = \pi d^2 \tau$

At the ultimate load:

$$P_{ULT} = \pi d^2 \tau_{ULT} = \pi (20\text{ mm})^2 (180\text{ MPa})$$

$$= 226\text{ kN} \quad \longleftarrow$$

Solution 1.7-6 Wire hanging from a balloon



d = 4.0 mm

L = 25 m

σ_Y = 350 MPa

Margin of safety = 1.5

Factor of safety = n = 2.5

$$\sigma_{allow} = \frac{\sigma_Y}{n} = 140\text{ MPa}$$

Weight density of steel: $\gamma = 77.0\text{ kN/m}^3$

Weight of wire:

$$W_0 = \gamma A L = \gamma \left(\frac{\pi d^2}{4}\right)(L)$$

$$W_0 = (77.0\text{ kN/m}^3)\left(\frac{\pi}{4}\right)(4.0\text{ mm})^2(25\text{ m})$$

$$= 24.19\text{ N}$$

Total load $P = W_{max} + W_0 = \sigma_{allow} A$

$$W_{max} = \sigma_{allow} A - W_0$$

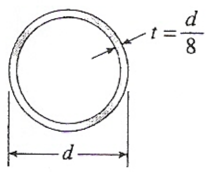
$$= (140\text{ MPa})\left(\frac{\pi d^2}{4}\right) - 24.19\text{ N}$$

$$= (140\text{ MPa})\left(\frac{\pi}{4}\right)(4.0\text{ mm})^2 - 24.19\text{ N}$$

$$= 1759.3\text{ N} - 24.2\text{ N} = 1735.1\text{ N}$$

$$W_{max} = 1740\text{ N} \quad \longleftarrow$$

Solution 1.8-2 Steel pipe in compression



P = 1200 kN

σ_Y = 270 MPa

n = 1.8

σ_{allow} = 150 MPa

$$A = \frac{\pi}{4}\left[d^2 - \left(d - \frac{d}{4}\right)^2\right] = \frac{7\pi d^2}{64}$$

$$P = \sigma_{allow} A = \frac{7\pi d^2}{64}\sigma_{allow}$$

SOLVE FOR d:

$$d^2 = \frac{64\,P}{7\pi\sigma_{allow}} \qquad d = 8\sqrt{\frac{P}{7\pi\sigma_{allow}}}$$

SUBSTITUTE NUMERICAL VALUES:

$$d_{min} = 8\sqrt{\frac{1200\text{ kN}}{7\pi(150\text{ MPa})}} = 153\text{ mm} \quad \longleftarrow$$