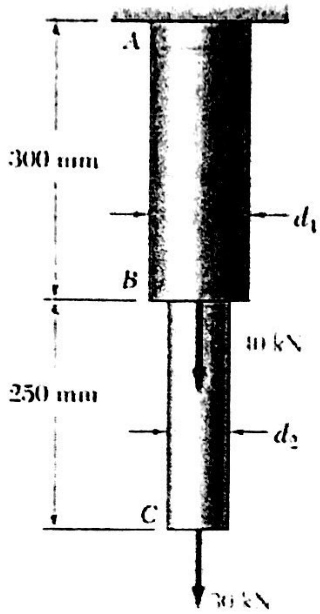
PROBLEM 1.2



Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that $d_1 = 50$ mm and $d_2 = 30$ mm, find the average normal stress at the midsection of (*a*) rod AB, (*b*) rod BC.

SOLUTION

(*a*) Rod *AB*

$$P = 40 + 30 = 70 \text{ kN} = 70 \times 10^3 \text{N}$$

$$A = \frac{\pi}{4}d_1^2 = \frac{\pi}{4}(50)^2 = 1.9635 \times 10^3 \text{mm}^2 = 1.9635 \times 10^{-3} \text{m}^2$$

$$\sigma_{AB} = \frac{P}{A} = \frac{70 \times 10^3}{1.9635 \times 10^{-3}} = 35.7 \times 10^6 \text{Pa}$$

$\sigma_{AB} = 35.7$ MPa ◀

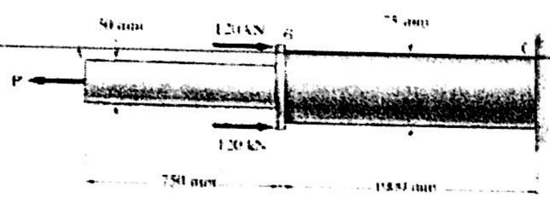
(*b*) Rod *BC*

$$P = 30 \text{ kN} = 30 \times 10^3 \text{N}$$

$$A = \frac{\pi}{4}d_2^2 = \frac{\pi}{4}(30)^2 = 706.86 \text{ mm}^2 = 706.86 \times 10^{-6} \text{m}^2$$

$$\sigma_{BC} = \frac{P}{A} = \frac{30 \times 10^3}{706.86 \times 10^{-6}} = 42.4 \times 10^6 \text{Pa}$$

$\sigma_{BC} = 42.4$ MPa ◀



PROBLEM 1.3

Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Determine the magnitude of the force $\mathbf{P}$ for which the tensile stress in rod AB is twice the magnitude of the compressive stress in rod BC.

SOLUTION

$$A_{AB} = \frac{\pi}{4}(50)^2 = 1963.5\ \text{mm}^2$$

$$\sigma_{AB} = \frac{P}{A_{AB}} = \frac{P}{1963.5}$$

$$A_{BC} = \frac{\pi}{4}(75)^2 = 4417.9\ \text{mm}^2$$

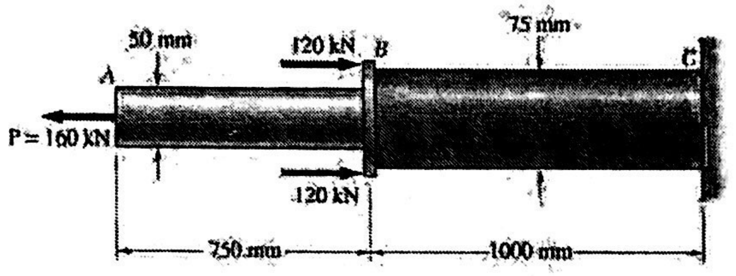
$$\sigma_{BC} = \frac{2(120) - P}{A_{BC}}$$

$$= \frac{240 - P}{4417.9}$$

Equating σ_{AB} to $2\sigma_{BC}$

$$\frac{P}{1963.5} = \frac{2(240 - P)}{4417.9}$$

$P = 112.9\ \text{kN}$ ◀



PROBLEM 1.4

In Prob. 1.3, knowing that $P = 160$ kN, determine the average normal stress at the midsection of (*a*) rod *AB*, (*b*) rod *BC*.

PROBLEM 1.3 Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Determine the magnitude of the force **P** for which the tensile stress in rod *AB* is twice the magnitude of the compressive stress in rod *BC*.

SOLUTION

(*a*) Rod *AB*

$P = 160$ kN (tension)

$$A_{AB} = \frac{\pi d_{AB}^2}{4} = \frac{\pi}{4}(50)^2 = 1963.5 \text{ mm}^2$$

$$\sigma_{AB} = \frac{P}{A_{AB}} = \frac{160\times10^3 \text{ N}}{1963.5\times10^{-6} \text{ m}^2}$$

$\sigma_{AB} = 81.5$ MPa ◀

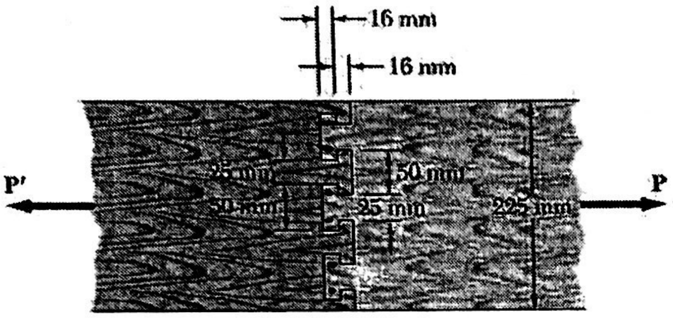
(*b*) Rod *BC*

$F = 160 - 2(120) = -80$ kN i.e., 80 kN compression.

$$A_{BC} = \frac{\pi d_{BC}^2}{4} = \frac{\pi}{4}(75)^2 = 4417.9 \text{ mm}^2$$

$$\sigma_{BC} = \frac{F}{A_{BC}} = \frac{-80\times10^3 \text{ N}}{4417.9\times10^{-6} \text{ m}^2}$$

$\sigma_{BC} = -18.11$ MPa ◀



PROBLEM 1.16

Two wooden planks, each 12 mm thick and 225 mm wide, are joined by the dry mortise joint shown. Knowing that the wood used shears off along its grain when the average shearing stress reaches 8 MPa, determine the magnitude P of the axial load which will cause the joint to fail.

SOLUTION

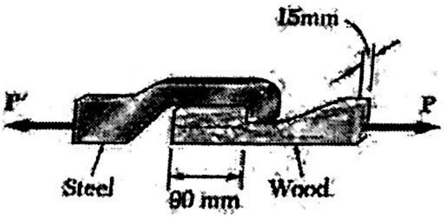
Six areas must be sheared off when the joint fails. Each of these areas has dimensions 16 mm × 12 mm, its area being

$$A = (16)(12) = 192 \text{ mm}^2 = 192 \times 10^{-6} \text{m}^2$$

At failure the force F carried by each of areas is

$$F = \tau A = (8 \times 10^6)(192 \times 10^{-6}) = 1536 \text{ N} = 1.536 \text{ kN}$$

Since there are six failure areas $\quad P = 6F = (6)(1.536) = 9.22 \text{ kN}$ ◀



PROBLEM 1.15

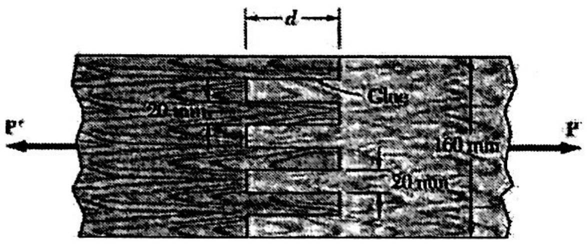
When the force **P** reached 8 kN, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure.

SOLUTION

Area being sheared: $A = 90 \text{ mm} \times 15 \text{ mm} = 1350 \text{ mm}^2 = 1350 \times 10^{-6} \text{m}^2$

Force: $P = 8 \times 10^3 \text{ N}$

Shearing stress: $\tau = \dfrac{P}{A} - \dfrac{8 \times 10^3}{1350 \times 10^{-6}} = 5.93 \times 10^6 \text{ Pa}$ $\qquad \tau = 5.93 \text{ MPa}$ ◀



PROBLEM 1.18

Two wooden planks, each 22 mm thick and 160 mm wide, are joined by the glued mortise joint shown. Knowing that the joint will fail when the average shearing stress in the glue reaches 820 kPa, determine the smallest allowable length d of the cuts if the joint is to withstand an axial load of magnitude $P = 7.6$ kN.

SOLUTION

Seven surfaces carry the total load $P = 7.6 \text{ kN} = 7.6 \times 10^3$.

Let $t = 22$ mm.

Each glue area is $A = dt$

$$\tau = \frac{P}{7A} \qquad A = \frac{P}{7\tau} = \frac{7.6 \times 10^3}{(7)(820 \times 10^3)} = 1.32404 \times 10^{-3} \text{m}^2$$

$$= 1.32404 \times 10^3 \text{mm}^2$$

$$d = \frac{A}{t} = \frac{1.32404 \times 10^3}{22} = 60.2$$

$d = 60.2$ mm ◀

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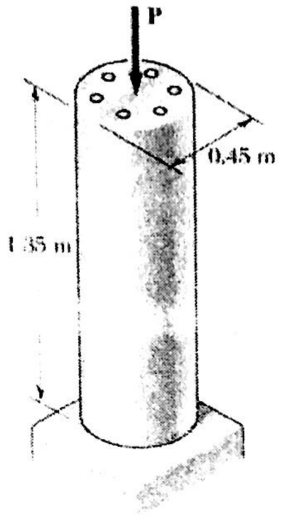


PROBLEM 2.35

The 1.35 m concrete post is reinforced with six steel bars, each with a 28 mm diameter. Knowing that $E_s = 200$ GPa and $E_s = 29$ GPa, determine the normal stresses in the steel and in the concrete when a 1560 kN axial centric force **P** is applied to the post.

SOLUTION

Let P_c = portion of axial force carried by concrete

P_s = portion carried by the six steel rods

$$\delta = \frac{P_c L}{E_c A_c}, \quad P_c = \frac{E_c A_c \delta}{L}$$

$$\delta = \frac{P_s L}{E_s A_s}, \quad P_s = \frac{E_s A_s \delta}{L}$$

$$P = P_c + P_s = (E_c A_c + E_s A_s)\frac{\delta}{L}$$

$$\varepsilon = \frac{\delta}{L} = \frac{P}{E_c A_c + E_s A_s}$$

$$A_s = 6\frac{\pi}{4}d_s^2 = \frac{6\pi}{4}(28)^2 = 3694.5 \text{ mm}^2$$

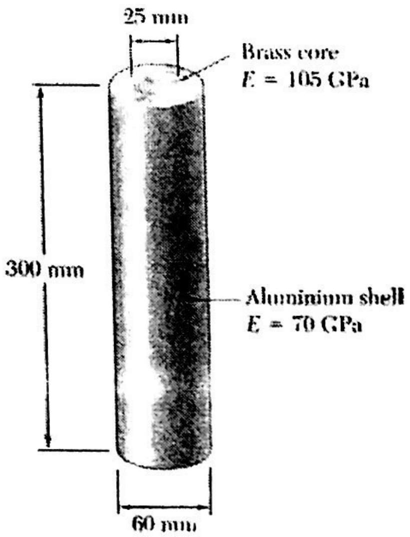
$$A_c = \frac{\pi}{4}d_c^2 - A_s = \frac{\pi}{4}(450)^2 - 3694.5 = 155348.6 \text{ mm}^2$$

$$L = 1.35 \text{ m} = 1350 \text{ mm}$$

$$\varepsilon = \frac{-1560\times 10^3}{\left(\frac{29\times 10^9}{10^6}\right)(155348.6)\left(\frac{200\times 10^9}{10^6}\right)(3694.5)} = -297.48\times 10^{-6}$$

$$\sigma_s = E_s\varepsilon = \left(\frac{200\times 10^9}{10^6}\right)(-297.48\times 10^{-6}) = -59.5 \text{ N/mm}^2 = -59.5 \text{ MPa} \quad ◀$$

$$\sigma_c = E_c\varepsilon = \left(29\times\frac{10^9}{10^6}\right)(-297.48\times 10^{-6}) = -8.627 \text{ N/mm}^2 = -8.627 \text{ MPa} \quad ◀$$



PROBLEM 2.33

An axial force of 200 kN is applied to the assembly shown by means of rigid end plates. Determine (*a*) the normal stress in the aluminum shell, (*b*) the corresponding deformation of the assembly.

SOLUTION

Let P_a = Portion of axial force carried by shell

P_b = Portion of axial force carried by core.

$$\delta = \frac{P_a L}{E_a A_a}, \quad \text{or} \quad P_a = \frac{E_a A_a}{L}\delta$$

$$\delta = \frac{P_b L}{E_b A_b}, \quad \text{or} \quad P_b = \frac{E_b A_b}{L}\delta$$

Thus, $$P = P_a + P_b = (E_a A_a + E_b A_b)\frac{\delta}{L}$$

with $$A_a = \frac{\pi}{4}[(0.060)^2 - (0.025)^2] = 2.3366 \times 10^{-3}\ \text{m}^2$$

$$A_b = \frac{\pi}{4}(0.025)^2 = 0.49087 \times 10^{-3}\ \text{m}^2$$

$$P = [(70\times10^9)(2.3366\times10^{-3}) + (105\times10^9)(0.49087\times10^{-3})]\frac{\delta}{L}$$

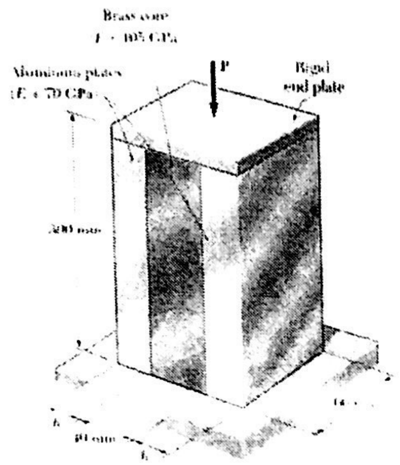
$$P = 215.10\times10^6\,\frac{\delta}{L}$$

Strain: $$\varepsilon = \frac{\delta}{L} = \frac{P}{215.10\times10^6} = \frac{200\times10^3}{215.10\times10^6} = 0.92980\times10^{-3}$$

(*a*) $\sigma_a = E_a\varepsilon = (70\times10^9)(0.92980\times10^{-3}) = 65.1\times10^6\,\text{Pa}$ $\qquad \sigma_a = 65.1$ MPa ◀

(*b*) $\delta = \varepsilon L = (0.92980\times10^{-3})(300\ \text{mm})$ $\qquad \delta = 0.279$ mm ◀

MEJ



PROBLEM 2.37

For the composite block shown in Prob. 2.36, determine (*a*) the value of h if the portion of the load carried by the aluminum plates is half the portion of the load carried by the brass core, (*b*) the total load if the stress in the brass is 80 MPa.

SOLUTION

Let P_b = portion of axial force carried by brass core

P_a = portion carried by the two aluminum plates

$$\delta = \frac{P_b L}{E_b A_b}, \quad P_b = \frac{E_b A_b \delta}{L}$$

$$\delta = \frac{P_a L}{E_a A_a}, \quad P_a = \frac{E_a A_a \delta}{L}$$

(*a*) Given $P_a = \frac{1}{2} P_b$

$$\frac{E_a A_a \delta}{L} = \frac{1}{2} \frac{E_b A_b \delta}{L}$$

$$A_a = \frac{1}{2} \frac{E_b}{E_a} A_b$$

$$A_b = (40)(60) = 2400 \text{ mm}^2 = 2400 \times 10^{-6} \text{m}^2$$

$$A_a = \frac{1}{2} \frac{105 \times 10^9}{70 \times 10^9} 2400 = 1800 \text{ mm}^2 = (2)(60)h$$

$$h = \frac{1800}{(2)(60)} = 15 \text{ mm}$$

(*b*) $\sigma_b = \frac{P_b}{A_b}$

$$P_b = A_b \sigma_b = (2400 \times 10^{-6})(80 \times 10^6) = 192 \times 10^3 \text{ N}$$

$$P_a = \frac{1}{2} P_b = 96 \times 10^3 \text{ N}$$

$$P = P_b + P_a = 288 \times 10^3 \text{ N} = 288 \text{ kN}$$