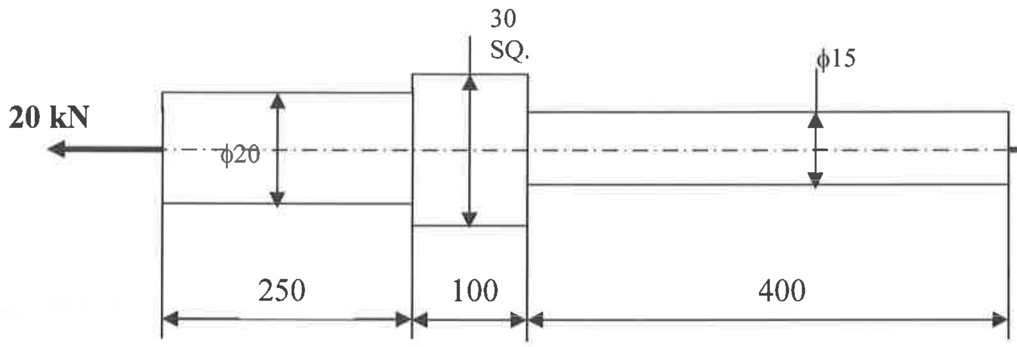
Direct Stress: Tension

Worked Example No.1

Determine the stress in each section of the steel bar shown in Figure Ex.1 when subjected to an axial tensile load of 20 kN. The central portion is of 30 mm square cross-section; the other portions are of circular cross-section, their diameters being as indicated.



Not to scale - all dimensions in mm

Figure Ex.1

Solution

$P = 20\times10^3 N$

$E = 210\times10^9 N/m^2$

$= 210\times10^3 N/mm^2$

$d_1 = 20mm$

$L_1 = 250mm$

$L_2 = 100mm$

$d_3 = 15mm$

$L_3 = 400mm$

$w_2 = 30mm$

$$\sigma_1 = \frac{P}{A_1} = \frac{4P}{\pi d_1^2} = \frac{4\times(20\times10^3)}{\pi\times20^2} = 63.7 N/mm^2$$

$$\sigma_2 = \frac{P}{A_2} = \frac{P}{w\times w} = \frac{20\times10^3}{30\times30} = 22.2 N/mm^2$$

$$\sigma_3 = \frac{P}{A_3} = \frac{4P}{\pi d_3^2} = \frac{4x20\times10^3}{\pi\times15^2} = 113.2 N/mm^2$$

$$E = \frac{\sigma}{\varepsilon} = \frac{\sigma.L}{\delta L} \therefore \delta L = \frac{\sigma.L}{E}$$

$$\delta L_1 = \frac{63.7\times250}{210\times10^3} = 0.0758 \ mm$$

$$\delta L_2 = \frac{22.2\times100}{210\times10^3} = 0.0106 \ mm$$

$$\delta L_3 = \frac{113.2\times400}{210\times10^3} = 0.2156 \ mm$$

Total Extension

$= \delta L_1 + \delta L_2 + \delta L_3$

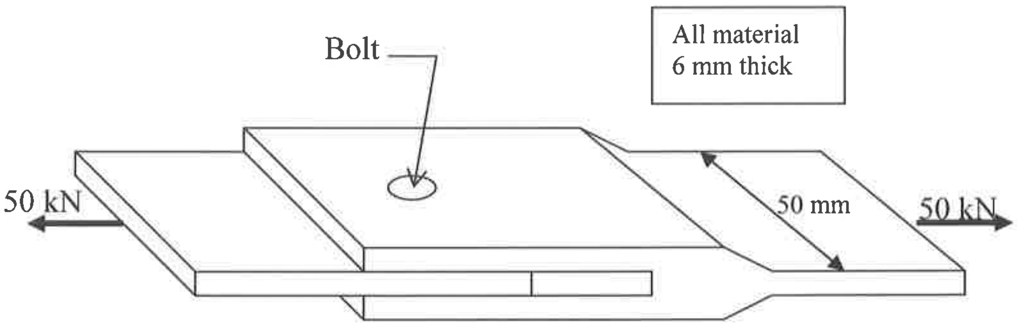
$= 0.302mm$

Indirect Stress: Shear

Worked Example No.2

The coupling shown in the Figure Ex.2 is constructed from steel of rectangular cross-section and is designed to transmit a tensile force of 50 kN. If the bolt is of 15 mm diameter, calculate:

(a) the shear stress in the bolt;
(b) the direct stress in the plate;
(c) the direct stress in the forked end of the coupling.



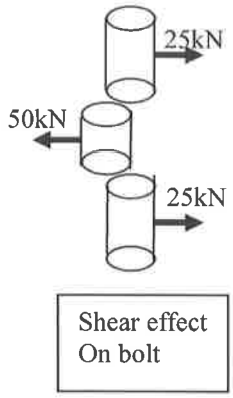


Figure Ex.2

Solution

(a) Bolt is subjected to double shear, tending to shear it as shown in Fig 3. Hence, there is twice the area of the bolt resisting the shear.

$P = 50 \times 10^3\,N$, $d_B = 15mm$, $\tau = ?$

$$\tau = \frac{P}{2A_B} \text{ (Double Shear) where } A_B = \frac{\pi d_B^2}{4}$$

$$= \frac{2P}{\pi d_B^2}$$

$$= \frac{2 \times 50 \times 10^3}{\pi \times 15^2}$$

ie. $\tau = 141.5N/mm^2$

(b) Plate is subjected to a direct tensile stress.

$P = 50 \times 10^3\,N$, $A_P = 50 \times 6 = 300mm^2$, $\sigma = ?$

$$\sigma = \frac{P}{A_P}$$

$$= \frac{50 \times 10^3}{300}$$

ie. $\sigma = 166.7N/mm^2$

(c) Force in coupling is shared by the forked end pieces, each subject to direct stress.

$P = \frac{50 \times 10^3}{2}$

$= 25 \times 10^3\,N$ *(per end piece)*

$A_P = 50 \times 6$

$= 300mm^2$

$\sigma = ?$

$$\sigma = \frac{P}{A_P}$$

$$= \frac{25 \times 10^3}{300}$$

ie. $\sigma = 83.3N/mm^2$