Chapter One: Concept of stress

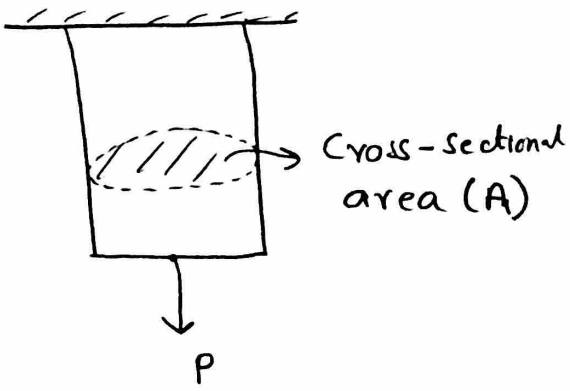
$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

الاجهاد

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

Sigma

stress (σ)



Units of stress

$$\sigma = \frac{P}{A} = \frac{N}{m} \text{ or Pascal (Pa)}$$

(10^3) 1,000 Pa ⟶ 1 Kilo pascal (1 kPa)

(10^6) 1,000,000 Pa ⟶ 1 Mega Pascal (1 MPa)

(10^9) 1,000,000,000 Pa ⟶ 1 Giga Pascal (1 GPa)

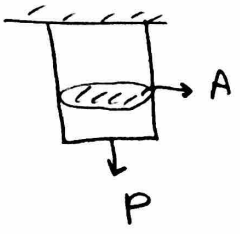
Types of stress

الاجهاد العمودي ① Normal stress (σ) $P \perp A$ $\sigma = \frac{P}{A}$

الاجهاد القصي ② Shear stress (τ) ⟵ tau $P \parallel A$ $\tau = \frac{P}{A}$

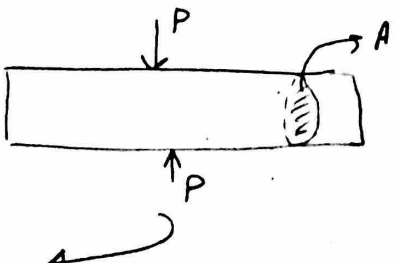
Parallel

Normal stress (σ)



$P \perp A$ $\sigma = \frac{P}{A}$

Shear stress (τ)



$P \parallel A$ $\tau = \frac{P}{A}$

Q = Why is it important to study stress ?

A = Because each material has an allowable stress (σ_{all}) and (τ_{all})

If $\sigma > \sigma_{all}$ or $\tau > \tau_{all}$

$\Rightarrow$ Failure

If $\sigma \leq \sigma_{all}$ or $\tau \leq \tau_{all}$

$\Rightarrow$ Safe design

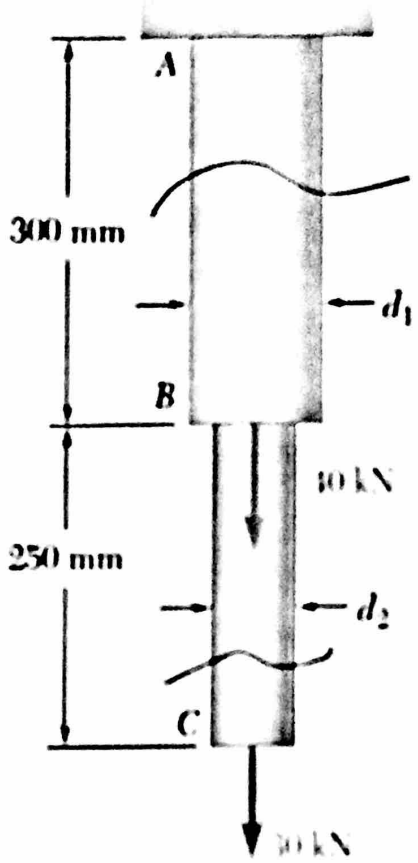
Important notes

Normal stress and Shear stress are computed from reaction (or internal) forces not from applied Forces.

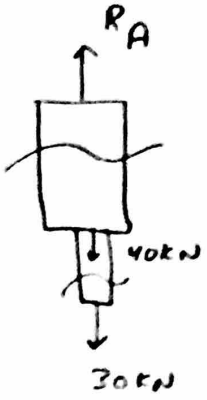
Example: For system shown,

Find Stress in rod AB and BC $\quad d_1 = 25$ mm

$\quad d_2 = 10$ mm



① F.B.D

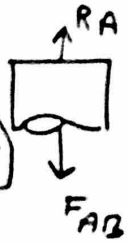


Please note

$R_{Ax} = 0$, $M_A = 0$

$+\uparrow \Sigma F_y = 0 \Rightarrow R_A = 70$ kN

- To Find Stress in AB we need find internal forces in AB



$\Sigma F_y = 0$

$\Rightarrow \boxed{F_{AB} = R_A = 70 \text{ kN}}$

$$\sigma_{AB} = \frac{F_{AB}}{A_{AB}} = \frac{70 \times 10^3}{\pi (12.5 \times 10^{-3})^2} = 142.603 \times 10^6 \text{ Pa}$$

$$= 142.603 \text{ MPa}$$

- For stress in BC $\Rightarrow$ Find internal force in BC

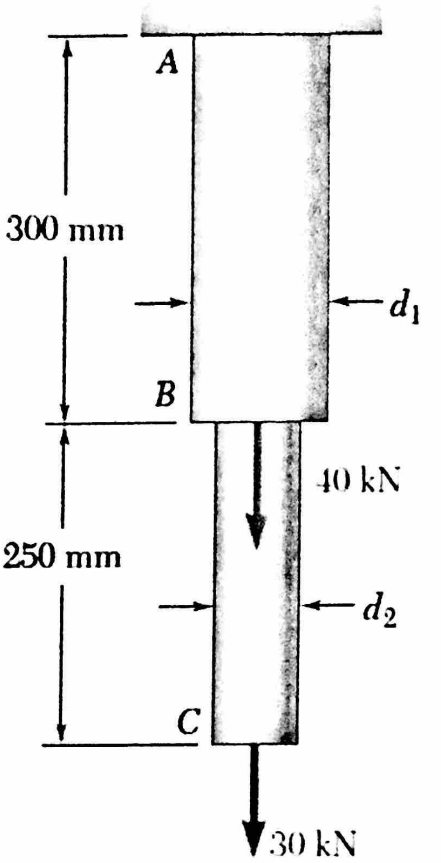
$\Sigma F_y = 0 \Rightarrow F_{BC} = 30$ kN

$$\sigma_{BC} = \frac{F_{BC}}{A_{BC}}$$

$$= \frac{30 \times 10^3}{\pi (5 \times 10^{-3})^2} = 381.972 \text{ MPa}$$

Example: If σ_{all} in rod AB = 175 MPa
and σ_{all} in rod BC is 150 MPa

Find diameters d_1 and d_2



Solution

From previous example,
internal forces $F_{AB} = 70$ kN
and $F_{BC} = 30$ kN

So,
For rod AB

$$\sigma_{all} = \frac{F_{AB}}{A_{all}} = \frac{F_{AB}}{\frac{\pi}{4} d_1^2}$$

$$\Rightarrow d_1^2 = \frac{4 F_{AB}}{\sigma_{all} \pi}$$

For circle radius r and diameter
$d = 2r$ $\quad A = \pi r^2$
$A = \frac{\pi}{4} d^2$

$$\Rightarrow d_1 = \sqrt{\frac{4 F_{AB}}{\pi \sigma_{all,AB}}} = \sqrt{\frac{(4)(70\times10^3)}{(\pi)(175\times10^6)}}$$

$$\Rightarrow \boxed{d_1 = 22.56 \text{ mm}}$$

Similarly, rod BC

$$d_2 = \sqrt{\frac{4 F_{BC}}{\pi \sigma_{all,BC}}} = \sqrt{\frac{(4)(30\times10^3)}{(\pi)(150\times10^6)}}$$

$$\boxed{d_2 = 15.95 \text{ mm}}$$