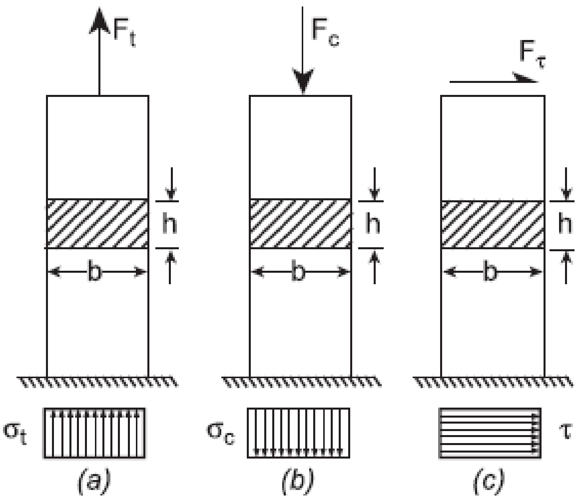
SIMPLE STRESS AND STRAIN

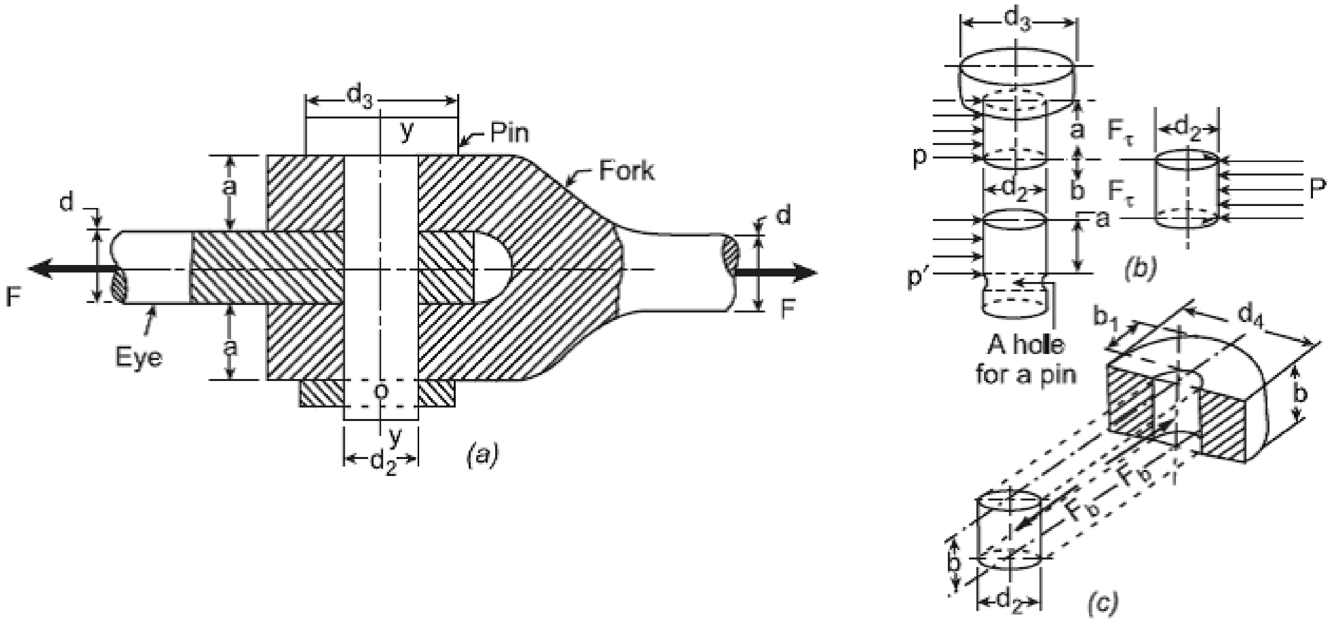
The stress in simple tension or compression $$\sigma_t = \frac{F_t}{A}; \quad \sigma_c = \frac{F_c}{A}$$

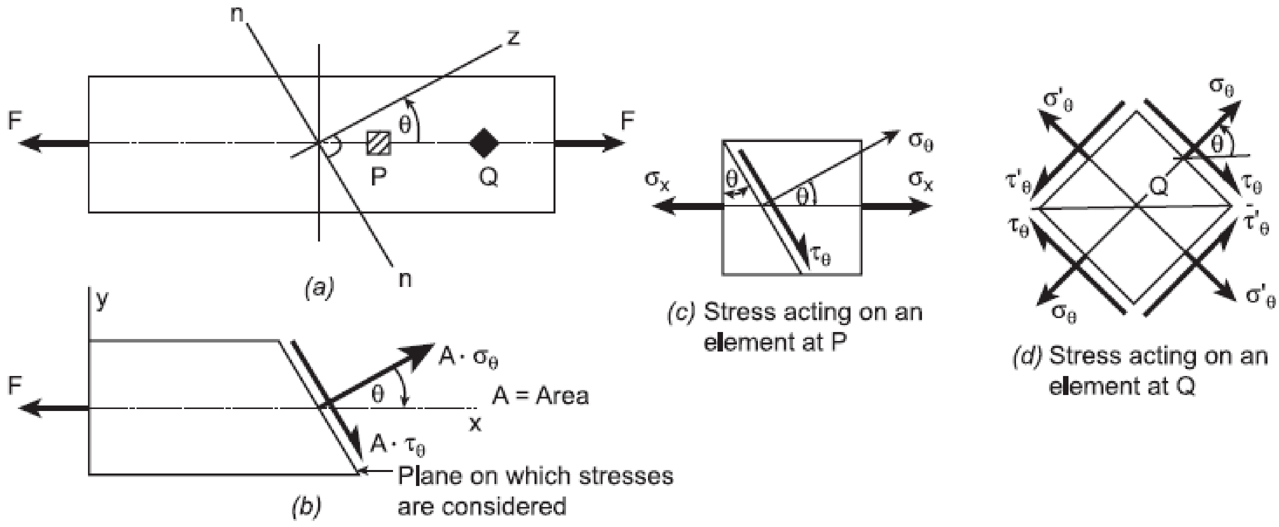
The total elongation of a member of length L $$\delta = \frac{Fl}{AE}$$

Strain, deformation per unit length $$\varepsilon = \frac{\delta}{l} = \frac{\sigma}{E}$$



The normal stress on the plane at any angle with x $\sigma_\theta = \sigma_x \cos^2 \theta$





The shear stress on the plane at any angle with x axis $$\tau_\theta = \frac{\sigma_x}{2}\sin 2\theta$$

Principal stresses $$\sigma_1 = \sigma_x \text{ and } \sigma_2 = 0$$

Angles at which principal stresses act $$\theta_1 = 0^\circ \text{ and } \theta_2 = 90^\circ$$

Maximum shear stress $$\tau_{\max} = \frac{\sigma_x}{2}$$

Angles at which maximum shear stresses act $$\theta_1 = 45^\circ \text{ and } \theta_2 = 135^\circ$$

The normal stress on the plane at an angle $$\sigma'_\theta = \sigma_x \cos^2\left(\theta + \frac{\pi}{2}\right) = \sigma_x \cos^2\theta$$

The shear stress on the plane at an angle $$\tau'_\theta = \sigma_x \sin\left(\theta + \frac{\pi}{2}\right)\cos\left(\theta + \frac{\pi}{2}\right) = \tfrac{1}{2}\sigma_x \sin 2\theta$$

$$\sigma_\theta = \sigma'_\theta \text{ and } \tau_\theta = -\tau'_\theta$$

PURE SHEAR

The normal stress on the plane at any angle $\sigma_\theta = \tau_{xy} \sin 2\theta$

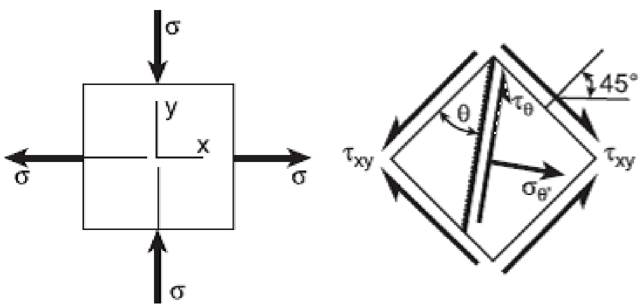
The shear stress on the plane at any angle $\tau_\theta = \tau_{xy} \cos 2\theta$

The principal stress $\sigma_1 = \tau_{xy}$ and $\sigma_2 = -\tau_{xy}$

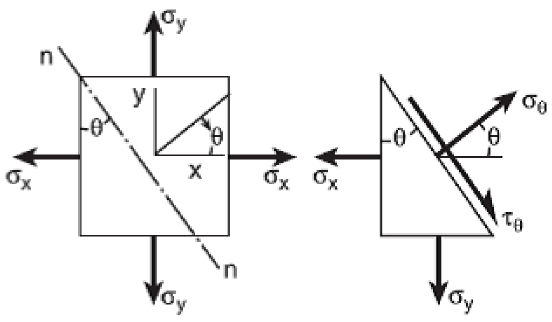
Angles at which principal stresses act $\theta_1 = 45^\circ$ and $\theta_2 = 135^\circ$

Maximum shear stresses $\tau_{max} = \tau_{xy} = \sigma$

Angles at which maximum shear stress act $\theta_1 = 0$ and $\theta_2 = 90^\circ$



(a) $-\sigma_y = \sigma_x = \sigma$ (b) $\tau_{max} = \tau_{xy} = \sigma$



(a) (b)

BIAXIAL STRESSES

The normal stress on the plane at any angle

$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta$$

The shear stress on the plane at any angle

$$\tau_\theta = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta$$

The shear stress τ_θ at $\theta = 0$

$$\tau_\theta = 0$$

The shear stress τ_θ at $\theta = 45^\circ$

$$\tau_{\max} = (\sigma_x - \sigma_y)/2$$

The normal stress on the plane at any angle

$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

The shear stress in the plane at any angle

$$\tau_\theta = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta - \tau_{xy}\cos 2\theta$$

The maximum principal stress

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \left[\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2\right]^{1/2}$$

The minimum principal stress

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \left[\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2\right]^{1/2}$$

Angles at which principal stresses act

$$\theta_{1,2} = \tfrac{1}{2}\arctan\frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

where θ_1 and θ_2 are 180° apart

Maximum shear stress

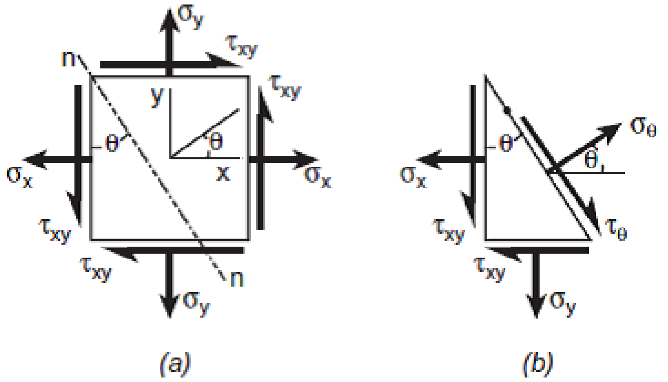
$$\tau_{\max} = \left[\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2\right]^{1/2} = \frac{\sigma_1 - \sigma_2}{2}$$

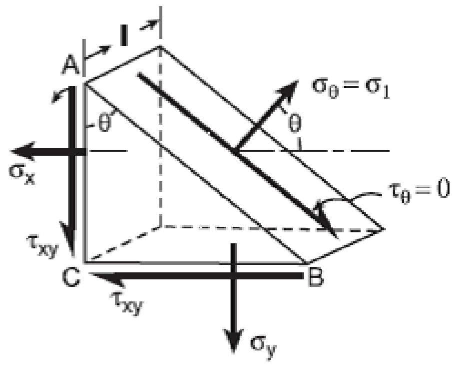
Angles at which maximum shear stress acts

$$\theta = \tfrac{1}{2}\arctan\frac{\sigma_x - \sigma_y}{2\tau_{xy}}$$

The equation for the inclination of the principal planes in terms of the principal stress

$$\tan\theta = \frac{\sigma_1 - \sigma_x}{\tau_{xy}}$$

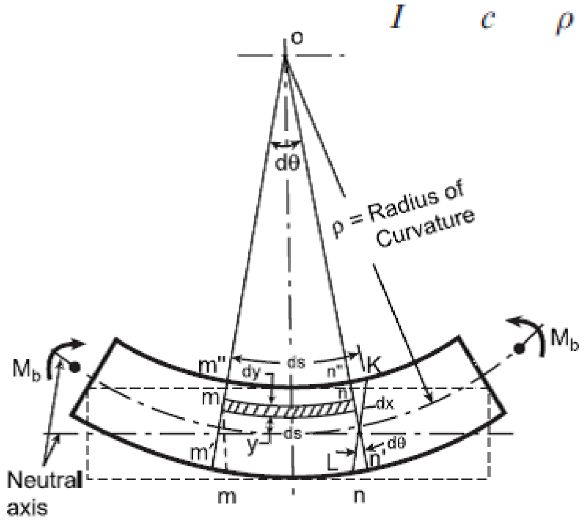




BENDING

The general formula for bending

$$\frac{M_b}{I} = \frac{\sigma_b}{c} = \frac{E}{\rho}$$



The maximum values of tensile and compressive bending stresses

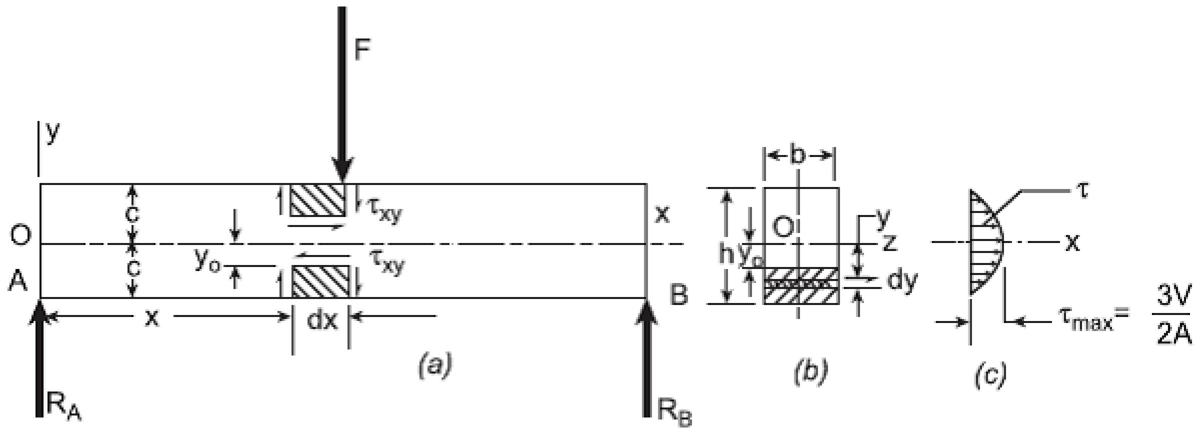
$$\sigma_b = \frac{M_b c}{I}$$

The shear stresses developed in bending of a beam

$$\tau = \frac{V}{Ib}\int_{y_0}^{c} y\,dA$$

The shear flow

$$q = \frac{VQ}{I}$$

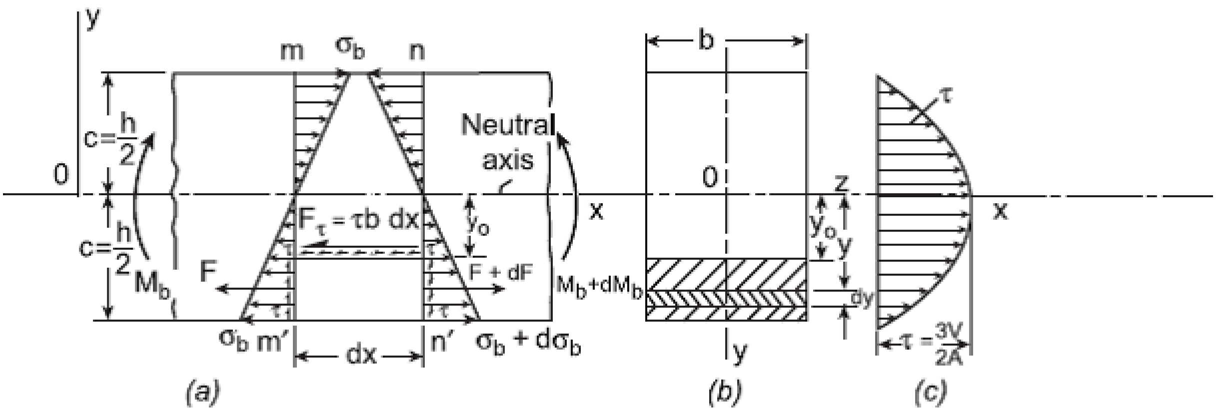


The first moment of the cross-sectional area outside the section at which the shear flow is required

$$Q = \int_{y_0}^{c} y\,dA$$

The maximum shear stress for a rectangular section

$$\tau_{max} = \frac{3V}{2A}$$



For a solid circular section beam, the maximum shear stress

$$\tau_{max} = \frac{4V}{3A}$$

For a hollow circular section beam, the expression for maximum shear stress

$$\tau_{max} = \frac{2V}{A}$$

An appropriate expression for τ for structural beams, columns and joists used in structural industries

$$\tau_{max} = \frac{V}{A_w}$$

where A_w is the area of the web

$$\sigma_{max} = \frac{F}{A} + \frac{M_b}{Z} \text{ and } \sigma_{min} = \frac{F}{A} - \frac{M_b}{Z}$$

$$\sigma_z = \pm\frac{F}{A} \pm \frac{M_{bx}e_y}{I_{xx}} \pm \frac{M_{by}e_x}{I_{yy}}$$

$$F_{cr} = \frac{n\pi^2 EA}{(l/k)^2} = \frac{n\pi^2 EI}{l^2}$$