EQUATIONS

Principal stresses for plane stress state

$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Extreme-value shear stresses for plane stress state

$$\tau_1, \tau_2 = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Plane-stress transformation equations

$$\sigma = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\phi + \tau_{xy} \sin 2\phi$$

$$\tau = -\frac{\sigma_x - \sigma_y}{2} \sin 2\phi + \tau_{xy} \cos 2\phi$$

Axial stress

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

Normal stress for beam in bending

$$\sigma = \frac{Mc}{I}$$

Second-area moment

- for rectangular cross-section

  $$I = \frac{bh^3}{12}$$

- for circular cross-section

  $$I = \frac{\pi r^4}{4} = \frac{\pi d^4}{64}$$

- for hollow round cross-section

  $$I = \frac{\pi}{4}\left(r_o^4 - r_i^4\right) = \frac{\pi}{64}\left(d_o^4 - d_i^4\right)$$

Maximum transverse shear stress

- for rectangular cross-section

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

- for circular cross-section

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

- for hollow, thin-walled round cross-section

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

- for thin-walled I-beam

  $$\tau_{\text{max}} \approx \frac{V}{A_{\text{web}}}$$

EQUATIONS (continued)

Shear stress due to torsion

$$\tau = \frac{T\rho}{J}$$

$$\tau_{\max} = \frac{Tr}{J}$$

Polar second moment of area

- for circular cross-section

$$J = \frac{\pi r^4}{2} = \frac{\pi d^4}{32}$$

- for hollow round cross-section

$$J = \frac{\pi}{2}(r_o^4 - r_i^4) = \frac{\pi}{32}(d_o^4 - d_i^4)$$

Ductile Coulomb-Mohr (DCM) theory

$$\frac{1}{n} = \frac{\sigma_1}{S_{yt}} - \frac{\sigma_3}{S_{yc}}$$

Maximum shear stress (MSS) theory for ductile materials

$$n = \frac{S_y}{2\tau_{\max}} = \frac{S_y}{\sigma_1 - \sigma_3}$$

Distortion energy (DE) theory for ductile materials

$$n = \frac{S_y}{\sigma'}$$

$$\sigma' = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}{2}}$$

$$\sigma' = \sqrt{\frac{\left(\sigma_x - \sigma_y\right)^2 + \left(\sigma_y - \sigma_z\right)^2 + (\sigma_x - \sigma_z)^2 + 6\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{xz}^2\right)}{2}}$$

Brittle Coulomb-Mohr (BCM) theory

$$\frac{1}{n} = \frac{\sigma_1}{S_{ut}} - \frac{\sigma_3}{S_{uc}}$$

Modified Mohr (MM) theory for brittle materials (plane stress)

$n = \frac{S_{ut}}{\sigma_A}$ for $\sigma_A \geq \sigma_B \geq 0$ and for $\sigma_A \geq 0 \geq \sigma_B$ where $\left|\frac{\sigma_B}{\sigma_A}\right| \leq 1$

$\frac{1}{n} = \frac{(S_{uc} - S_{ut})\sigma_A}{S_{uc}S_{ut}} - \frac{\sigma_B}{S_{uc}}$ for $\sigma_A \geq 0 \geq \sigma_B$ where $\left|\frac{\sigma_B}{\sigma_A}\right| > 1$

$n = -\frac{S_{uc}}{\sigma_B}$ for $0 \geq \sigma_A \geq \sigma_B$

Stress intensity factor

$$K_I = \beta\sigma\sqrt{\pi a}$$

Factor of safety against sudden fracture

$$n = \frac{K_{Ic}}{K_I}$$

Approximations for steels

$S_u \approx 0.5\, H_B$ ksi

$S_u \approx 3.4\, H_B$ MPa