MECH 360 Formula Sheet

Stress & Strain

Average normal stress:

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

Average shear stress:

$$\tau = \frac{V}{A}$$

Double shear:

$$\tau = \frac{P}{2A}$$

Bearing stress:

$$\sigma_b = \frac{P}{A} = \frac{P}{td}$$

Stresses on a 2-force member
(θ measured from vertical):

$$\sigma = \frac{P}{A_\perp}\cos^2\theta \qquad \tau = \frac{P}{A_\perp}\sin\theta\cos\theta$$

Factor of safety:

$$\text{Factor of safety} = \frac{\text{Ultimate Load}}{\text{Allowable Load}}$$

Normal strain:

$$\epsilon = \frac{\delta}{L} = \frac{d\delta}{dx}$$

Local shear strain (Change of $\pi/2$):

$$\gamma = \pi/2 - \theta$$

Axial Load

Hooke's Law and Modulus of Elasticity:

$$\sigma = E\epsilon$$

Elastic deformation under axial loading:

$$\delta = \frac{FL}{AE} = \sum_i \frac{F_i L_i}{A_i E_i}$$

Temperature change:

$$\delta_T = L_o \alpha \Delta T$$

Poisson's Ration:

$$\nu = -\frac{\epsilon_{\text{lat}}}{\epsilon_{\text{long}}}$$

Shear Stress-Strain Diagrams:

$$G = \frac{E}{2(1+\nu)}$$

$$\tau = G\gamma \qquad \text{(elastic region)}$$

Elastic Strain Energy:

$$u = \int_0^\sigma \sigma\, d\epsilon = \frac{1}{2}\frac{\sigma^2}{E}$$

Torsion

Polar Moment of Inertia:

$$J = \int r^2\, dA$$

$$J = \frac{\pi c^4}{2} \qquad \text{(full tube)}$$

$$J = \frac{\pi}{2}(c^4 - a^4) \qquad \text{(hollow tube)}$$

Shear Stress:

$$\tau = \frac{T\rho}{J} \qquad \tau_{\max} = \frac{Tc}{J}$$

Power:

$$P = T\omega$$

Angle of Twist:

$$\phi = \frac{TL}{JG} = \int_0^L \frac{T(x)}{J(x)G(x)}\, dx$$

Stress Concentrations:

$$\tau_{\max} = K\frac{Tc}{J}$$

Bending

Distributed Load Intensity at each point:

$$w = \frac{dV}{dx}$$

Shear at each point:

$$V = \frac{dM}{dx}$$

Normal Strain:

$$\epsilon_x = -\frac{y}{p} = -\frac{y}{c}\epsilon_{\max}$$

Normal Stress:

$$\sigma = -\frac{y}{c}\sigma_{\max}$$

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

$$\sigma_{\max} = \frac{Mc}{I}$$

Moment of Inertia:

$$I = \int y^2\, dA$$

Neutral Axis:

$$\int y\, dA = 0$$

Section Modulus:

$$S = I/c$$

Parallel Axis Theorem:

$$I_{\parallel} = I_G + Md^2$$

Stress Transformations

Principal Stresses:

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Maximum In-Plane Shear Stress:

$$\tau_{\max} = R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Angle of Principal In-Plane Stresses:

$$\tan 2\theta_p = \frac{2\tau_{xy}}{(\sigma_x - \sigma_y)}$$

Angle of Maximum In-Plane Stresses:

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)}{2\tau_{xy}}$$

Average Stress:

$$\frac{\sigma_x + \sigma_y}{2}$$

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https://github.com/DonneyF/formula-sheets