

Useful Equations

$$\sigma_{avg} = \frac{F_N}{A} \qquad FS = \frac{\sigma_{fail}}{\sigma_{allow,member}}$$

$$\tau_{avg} = \frac{V}{A} \qquad FS = \frac{\tau_{fail}}{\tau_{allow,member}}$$

Generalized Hooke's law:

$$\epsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)] + \alpha \Delta T$$

$$\epsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_x + \sigma_z)] + \alpha \Delta T$$

$$\epsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)] + \alpha \Delta T$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy} \quad \gamma_{xz} = \frac{1}{G} \tau_{xz} \quad \gamma_{yz} = \frac{1}{G} \tau_{yz}$$

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

Axial deformation:

$$e_{AB} = u_B - u_A \qquad e = \int_0^L \frac{F}{AE} dx + \int_0^L \alpha \Delta T dx, \qquad e = \frac{FL}{AE} + \alpha \Delta T L$$

$$e = u \cos(\theta) + v \sin(\theta)$$

Torsional deformation:

$$\phi_{AB} = \phi_B - \phi_A \qquad \phi_{AB} = \int_0^L \frac{T_{AB}(x)}{G(x) I_p(x)} dx \qquad \phi_{AB} = \frac{T_{AB} L}{G I_p}$$

$$\gamma = \rho \frac{d\phi}{dx} \qquad \tau = G \rho \frac{d\phi}{dx}$$

$$\gamma = \frac{\rho T}{G I_p} \qquad \tau = \frac{\rho T}{I_p}$$

$$\text{with} \quad I_p = \int_A \rho^2 dA, \quad I_p = \frac{\pi r^4}{2} \text{ (solid),} \quad I_p = \frac{\pi}{2} (r_o^4 - r_i^4) \text{ (hollow)}$$