EQUATIONS

Small angle ($\theta \approx 0$) approximations

$$\sin(\theta) \approx \theta \qquad \cos(\theta) \approx 1 \qquad \tan(\theta) \approx \theta$$

Average stress

$$(\sigma)_{ave} = \frac{P}{A} \qquad (\tau)_{ave} = \frac{V}{A}$$

Generalized Hooke's Law

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

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

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

$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_x + \nu(\epsilon_y + \epsilon_z) - (1+\nu)\alpha\Delta T]$$

$$\sigma_y = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_y + \nu(\epsilon_x + \epsilon_z) - (1+\nu)\alpha\Delta T]$$

$$\sigma_z = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_z + \nu(\epsilon_x + \epsilon_y) - (1+\nu)\alpha\Delta T]$$

$$\gamma_{xy} = \frac{1}{G}\tau_{xy}$$

$$\gamma_{yz} = \frac{1}{G}\tau_{yz}$$

$$\gamma_{xz} = \frac{1}{G}\tau_{xz}$$

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

Axial deformations

$$e_{AB} = u_B - u_A$$

$$e = \int_0^L \frac{F}{AE}\,dx + \int_0^L \alpha\Delta T\,dx$$

$$e = \frac{FL}{AE} + \alpha\Delta T L$$

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

Torsional deformations

$$\phi_{AB} = \phi_B - \phi_A$$

$$\phi = \int_0^L \frac{T(x)}{G(x)I_p(x)}dx$$

$$\phi = \frac{TL}{GI_p}$$

$$\gamma = \rho\frac{d\phi}{dx}$$

$$\gamma = \frac{\rho T}{GI_p}$$

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

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

$$I_p = \frac{\pi}{2}r^4 \text{ (solid)} \qquad I_p = \frac{\pi}{2}(r_o^4 - r_i^4) \text{ (hollow)}$$