Material Properties

Material	Young's Modulus E, ksi	Shear Modulus G, ksi	Coefficient of Thermal Expansion α, /°F	Density lb/in^3	Tensile Yield Strength σ_Y, ksi
Aluminum	10x10^3	3.7x10^3	13.1x10^{-6}	0.10	37
Steel	30x10^3	11x10^3	6.6x10^{-6}	0.30	36
Brass	14.6x10^3	5.4x10^3	9.8x10^{-6}	0.32	10
Titanium	17.4x10^3	6.4x10^3	5.2x10^{-6}	0.16	134

Centroid of area

$$\bar{x} = \frac{\int_A x\,dA}{A} \qquad \bar{y} = \frac{\int_A y\,dA}{A}$$

Relations between load, shear and bending moment

$$\frac{dV}{dx} = h(x) \qquad V_2 - V_1 = \int_1^2 h(x)dx$$

$$\frac{dM}{dx} = V(x) \qquad M_2 - M_1 = \int_1^2 V(x)dx$$

Linear Elastic Materials

$$\sigma = E\varepsilon \qquad \tau = G\gamma$$

Axial Loading

$$\sigma = \frac{P}{A} \qquad \Delta L = \frac{PL}{AE} + \alpha\Delta T L$$

Torsion

$$\tau = \frac{Tr}{J} \qquad \Delta\phi = \frac{TL}{JG}$$

$$J = \frac{\pi}{2}\left(c^4 - c_i^4\right)$$

Bending

$$\sigma = -\frac{My}{I_x}$$

Shear

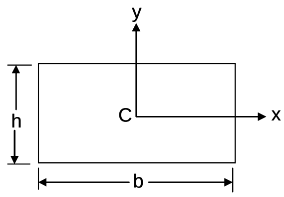
$$\tau = \frac{VQ}{I_x t}$$

For rectangular section: $\tau_{\max} = \frac{3}{2}\frac{V}{A}$

For wide-flange section: $\tau_{\max} \cong \frac{V}{A_{web}}$

Geometric Properties of Areas

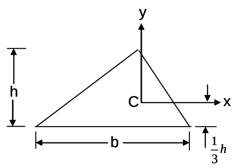
C: Centroid



$A = bh$

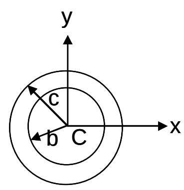
$I_x = \frac{1}{12}bh^3$

$I_y = \frac{1}{12}hb^3$



$A = \frac{1}{2}bh$

$I_x = \frac{1}{36}bh^3$

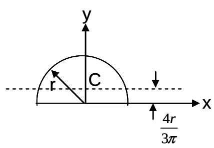


$A = \pi\left(c^2 - b^2\right)$

$I_x = \frac{1}{4}\pi\left(c^4 - b^4\right)$

$I_y = \frac{1}{4}\pi\left(c^4 - b^4\right)$

$J = \frac{1}{2}\pi\left(c^4 - b^4\right)$



$A = \frac{1}{2}\pi r^2$

$I_x = \frac{1}{8}\pi r^4$

$I_y = \frac{1}{8}\pi r^4$

Parallel axis theorem: $I_x = I_{xc} + Ad^2$