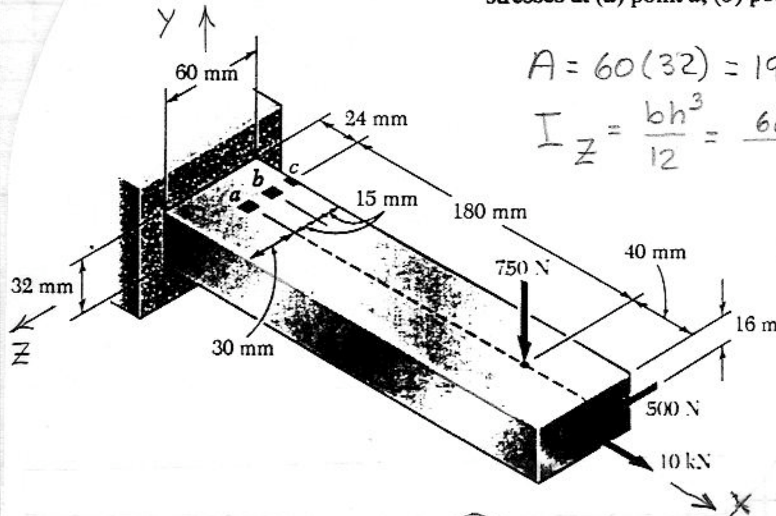
Problem 8.45

8.45 Three forces are applied to the bar shown. Determine the normal and shearing stresses at (*a*) point *a*, (*b*) point *b*, (*c*) point *c*.



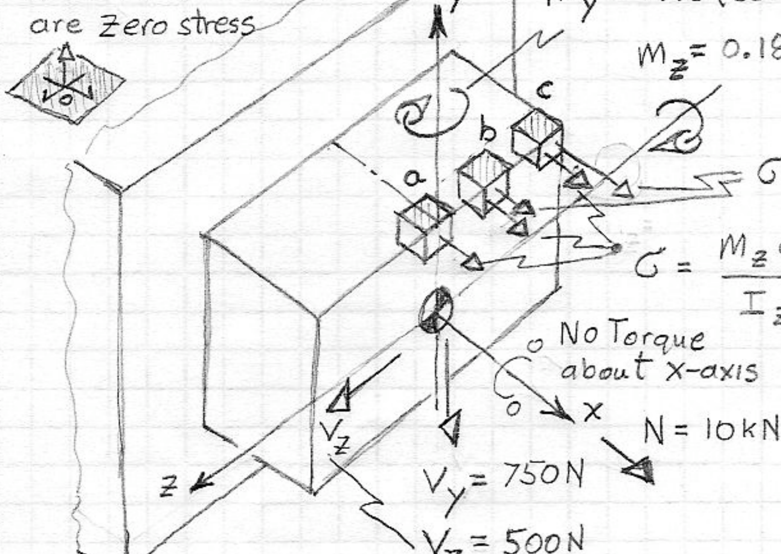
$$A = 60(32) = 1920\,mm^2 = 1920 \times 10^{-6}\,m^2$$

$$I_z = \frac{bh^3}{12} = \frac{60(32)^3}{12} = 163.84 \times 10^3\,mm^4 = 163.84 \times 10^{-9}\,m^4$$

$$I_y = \frac{32(60)^3}{12} = 576 \times 10^3\,mm^4 = 576 \times 10^{-9}\,m^4$$

Equivalent Loads @ a, b, c

Note: top surfaces at a, b, and c are zero stress



$M_y = 0.22\,(500) = 110\,N\cdot m$

$M_z = 0.18(750) = 135\,N\cdot m$

$\sigma = \frac{M_y y}{I_y}$ $\begin{cases} y_a = 0 \\ y_b = 15\,mm \\ y_c = 30\,mm \end{cases}$

$\sigma = \frac{M_z c}{I_z}$ $\quad c = 16\,mm$

No Torque about x-axis

$N = 10\,kN$

$V_y = 750\,N$

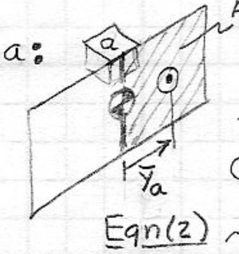
$V_z = 500\,N$

In general at a, b, and c

$$\sigma = +\frac{N}{A} + \frac{M_z c}{I_z} + \frac{M_y z}{I_y} \quad (1)$$

$$\tau = \frac{V_z Q}{I_y t}$$

a) Point a:



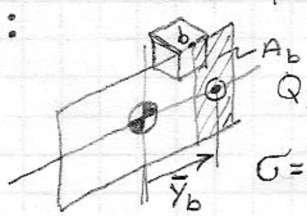
$Q_a = \bar{y}_a A_a = 15\left[(32)(30)\right] = 14.4 \times 10^3\,mm^3 = 14.4 \times 10^{-6}\,m^3 = Q_a$

Eqn.(1)

$\sigma = \frac{10{,}000}{1920 \times 10^{-6}} + \frac{135(0.016)}{163.84 \times 10^{-9}} + 0,\quad \boxed{\sigma = 18.39\,MPa}$

Eqn(2) $\tau = \frac{500\,(14.4 \times 10^{-6})}{576 \times 10^{-9}(0.032)}\quad \boxed{\tau = 0.391\,MPa}$

b) Point b:



$Q_b = \bar{y}_b A_b = 22.5\left[(32)(15)\right] = 10.3 \times 10^3\,mm^3 = 10.8 \times 10^{-6}\,m^3 = Q_b$

$\sigma = \frac{10{,}000}{1920 \times 10^{-6}} + \frac{135(0.016)}{163.84 \times 10^{-9}} + \frac{110\,(0.015)}{576 \times 10^{-9}},\quad \boxed{\sigma = 21.3\,MPa}$

$\tau = \frac{500\,(10.8 \times 10^{-6})}{576 \times 10^{-9}(0.032)}\quad \boxed{\tau = 0.293\,MPa}$

c) Point c: $Q_c = 0 \therefore \boxed{\tau = 0}$

$\sigma = \frac{10{,}000}{192 \times 10^{-6}} + \frac{135(0.016)}{163.84 \times 10^{-9}} + \frac{110(0.030)}{576 \times 10^{-9}}\quad \boxed{\sigma = 24.1\,MPa}$