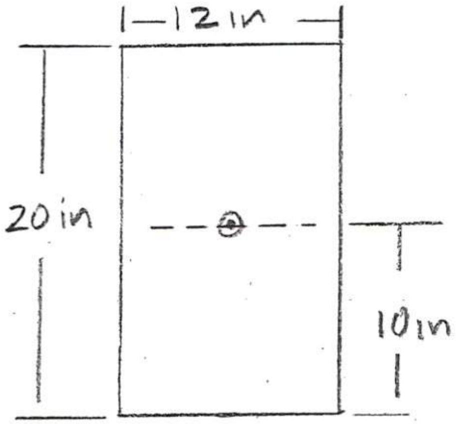
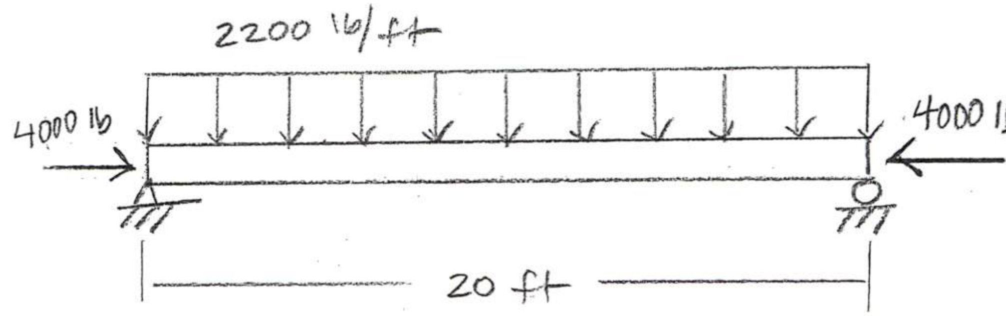
Show all work for full credit.

Name: Solution

Determine the minimum and maximum combined stress in the beam shown. The axial load is applied at the centroid of the section. Locate the point of zero stress within the cross section.





solution.

$A = 12\text{ in} \times 20\text{ in} = 240\text{ in}^2$

$P = -4000\text{ lb}$ (constant Compression throughout the beam)

$w = 2200\text{ lb/ft}$

$$I = \frac{bh^3}{12} = \frac{12\text{in}(20\text{in})^3}{12} = 8000\text{ in}^4$$

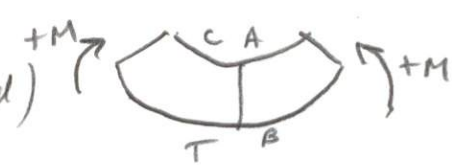
$L = 20\text{ ft} \times 12\text{ in} = 240\text{ in}$

$$S = \frac{bh^2}{6} = \frac{12\text{in}(20\text{in})^2}{6} = 800\text{ in}^3$$

Normal stress for axial load

$$\sigma_1 = \frac{-P}{A} = \frac{-4000\text{ lb}}{240\text{ in}^2} = -16.67\text{ psi (C)}$$

Normal stress for Bending (uniform Load)



From Table 13-1, case 4

$$M_{MAX} = \frac{wL^2}{8} = \frac{2200\text{ lb/ft}(20\text{ ft})^2}{8} = 110{,}000\text{ lb}\cdot\text{ft}$$

$$M_{MAX} = 110{,}000 \text{ lb}\cdot\text{ft} \left(\frac{\text{kip}}{1000 \text{ lb}}\right)\left(\frac{12 \text{ in}}{\text{ft}}\right) = 1320 \text{ kip}\cdot\text{in}$$

$$\sigma_2 = \frac{M}{S} = \frac{1320 \text{ kip}\cdot\text{in}}{800 \text{ in}^3} = 1.65 \text{ ksi} \left(\frac{1000 \text{ lb}}{\text{kip}}\right)$$

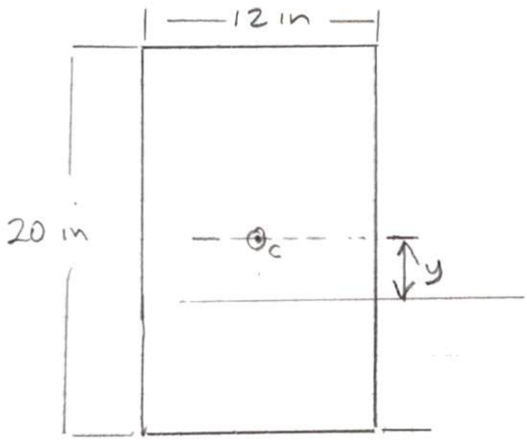
$$= 1650 \text{ psi}$$

<u>Combined Stresses</u>

Top of Beam $\sigma_A = -\sigma_1 - \sigma_2 = -16.67 \text{ psi} - 1650 \text{ psi} = -1667 \text{ psi (C}$

Bottom of Beam $\sigma_B = -\sigma_1 + \sigma_2 = -16.67 \text{ psi} + 1650 \text{ psi} = 1633 \text{ psi (T)}$

To locate the point of zero stress within the cross section



Set combined stress $= 0$

$$0 = -\frac{P}{A} + \frac{My}{I}$$

$$\frac{My}{I} = \frac{P}{A}$$

$$y = \frac{IP}{MA}$$

$$= \frac{8000 \text{ in}^4 (4000 \text{ lb})}{110{,}000 \text{ lb}\cdot\text{ft}\left(\frac{12 \text{ in}}{\text{ft}}\right)(240 \text{ in}^2)}$$

$$= \frac{32{,}000{,}000 \text{ in}^4\cdot\text{lb}}{316{,}800{,}000 \text{ lb}\cdot\text{in}^3}$$

$= 0.101$ in (From the centroidal axis)