The given I-beam is subjected to the loading shown. Determine the stress components (normal & shear) at points A and B and show the results on a differential element at each of these points. Use the shear formula \((VQ/d)\) to compute the shear stress.

\[ \Sigma M = 0 \]

\[ \Sigma M_{about \, D} = 0 \]

\[ \Rightarrow -4C_y + 2.5 \times 3.5 + 10 \times 1.5 = 0 \]

\[ \Rightarrow C_y = 5.94 \text{ kN} \]

\[ \Sigma F_x = 0 \Rightarrow F = 0 \]

\[ \Sigma F_y = 0 \Rightarrow 5.94 - 2.5 \times V = 0 \]

\[ \Rightarrow V = 3.44 \text{ kN} \]

\[ \Sigma M = 0 \]

\[ \Rightarrow -5.94 \times 1 + 2.5 \times 0.5 + M = 0 \]

\[ \Rightarrow M = 4.69 \text{ kN-m} \]

\[ \sigma_A = \frac{4.69 \times 10^6 \times 85}{1.619 \times 10^7} = 24.623 \text{ N/mm}^2 \text{ (Compressive)} \]

\[ \tau_A = 0 \]

\[ \sigma_B = \frac{4.69 \times 10^6 \times 25}{1.619 \times 10^7} = 7.242 \text{ N/mm}^2 \text{ (Tensile)} \]

\[ \tau_B = \frac{3.44 \times 10^3 \times 11 \times 10^4}{1.619 \times 10^7 \times 12} = 1.947 \text{ N/mm}^2 \]
Solve Prob. 8-45 for point B.

**Internal Forces and Moment:**

\[ \Sigma F = 0; \quad N_x = 0 \]
\[ \Sigma F_y = 0; \quad V_x + 300 = 0 \quad V_x = -300 \text{ N} \]
\[ \Sigma F_z = 0; \quad V_y - 500 = 0 \quad V_y = 500 \text{ N} \]
\[ \Sigma M_x = 0; \quad T_z = 0 \]
\[ \Sigma M_y = 0; \quad M_x - 500(0.15) = 0 \quad M_x = 75.0 \text{ N} \cdot \text{m} \]
\[ \Sigma M_z = 0; \quad M_y - 300(0.15) = 0 \quad M_y = 45.0 \text{ N} \cdot \text{m} \]

**Section Properties:**

\[ A = \pi (0.02)^2 = 0.400 \left(10^{-3}\right) \pi \text{ m}^2 \]
\[ I_x = I_y = \pi \left(0.02^2\right) = 40.0 \left(10^{-6}\right) \pi \text{ m}^4 \]
\[ J = \frac{\pi}{2} (0.02^4) = 80.0 \left(10^{-8}\right) \pi \text{ m}^4 \]
\[ (\Phi_1)_z = 0 \]
\[ (\Phi_2)_z = \frac{4(0.02)}{3\pi} \left(0.02^2\right) = 5.333 \left(10^{-4}\right) \text{ m}^3 \]

**Normal Stress:**

\[ \sigma = \frac{M_y}{A} = \frac{M_x}{I_x} + \frac{M_z}{I_y} \]
\[ \sigma_x = 0 = \frac{45(0.02)}{40.0 \left(10^{-6}\right) \pi} + \frac{75.0(0)}{40.0 \left(10^{-6}\right) \pi} \]
\[ = -7.16 \text{ MPa} = 7.16 \text{ MPa} \text{ (C)} \]

**Shear Stress:** The transverse shear stress in the \( z \) and \( y \) directions can be obtained using the shear formula, \( \tau_y = \frac{V_Q}{I_t} \).

\[ (\tau_y)_z = \frac{500(5.333 \left(10^{-4}\right))}{40.0 \left(10^{-6}\right) \pi (0.04)} = 0.531 \text{ MPa} \]

\[ (\tau_y)_y = \tau_y = 0 \]

\[ (\tau_x)_z = (\tau_x)_y = 0 \]
Solve problem # 8-60, let \( x = 0.5 \text{ m}\), \( y = 0.75 \text{ m}\) (page 461)

**Solution**

\[
A = 3(4.5) = 13.5 \text{ m}^2
\]

\[
I_x = \frac{1}{12} 3(4.5)^3 = 22.78125 \text{ m}^4
\]

\[
I_y = \frac{1}{12} * 3^3 * 4.5 = 10.125 \text{ m}^4
\]

\[
M_x = 800 * 0.75 = 600 \text{ kN.m}
\]

\[
M_y = 800 * 0.5 = 400 \text{ kN.m}
\]
\[
\sigma = \frac{P}{A} + \frac{M_x y}{I_x} + \frac{M_y y}{I_y}
\]

\[
\sigma_A = \frac{-800(10^3)}{13.5} + \frac{600(10^3)(2.25)}{22.78125} + \frac{400(10^3)(1.5)}{10.125} = 59.259 \text{kPa} (T)
\]

\[
\sigma_B = \frac{-800(10^3)}{13.5} + \frac{600(10^3)(2.25)}{22.78125} - \frac{400(10^3)(1.5)}{10.125} = -59.259 \text{kPa} (C)
\]

\[
\sigma_C = \frac{-800(10^3)}{13.5} - \frac{600(10^3)(2.25)}{22.78125} - \frac{400(10^3)(1.5)}{10.125} = -177.78 \text{kPa} (C)
\]

\[
\sigma_D = \frac{-800(10^3)}{13.5} - \frac{600(10^3)(2.25)}{22.78125} + \frac{400(10^3)(1.5)}{10.125} = -59.259 \text{ kPa} (C)
\]
8–25. The stepped support is subjected to the bearing load of 50 kN. Determine the maximum and minimum compressive stress in the material.

**Internal Force and Moment:** As shown on FBD.

**Section Properties:** For the top portion of the stepped support.

\[ A = 0.06(0.1) = 0.00600 \text{ m}^2 \]

For the bottom portion of the stepped support.

\[ A = 0.1(0.1) = 0.0100 \text{ m}^2 \]
\[ I = \frac{1}{12}(0.1)(0.1^3) = 8.333 \times 10^{-5} \text{ m}^4 \]

**Normal Stress:** For the top portion of the stepped support.

\[ \sigma = \frac{N}{A} = \frac{-50.0(10^3)}{0.00600} = -8.33 \text{ MPa} = 8.33 \text{ MPa (C)} \]

For the bottom portion of the stepped support.

\[
\sigma = \frac{N}{A} \pm \frac{M c}{I} \\
= \frac{-50.0(10^3)}{0.0100} \pm \frac{1.00(10^3)(0.05)}{8.333(10^{-5})}
\]
\[ \sigma_A = -5.00 \times 10^6 - 6.00 \times 10^6 \]
\[ = -11.0 \text{ MPa} = 11.0 \text{ MPa (C)} \]
\[ \sigma_B = -5.00 \times 10^6 + 6.00 \times 10^6 \]
\[ = 1.00 \text{ MPa (T)} \]

Therefore, the maximum and minimum compressive stress is

\[(\sigma_C)_{\text{max}} = 11. \text{ MPa} \quad \text{Ans} \]
\[(\sigma_C)_{\text{min}} = 0 \quad \text{Ans} \]
Determine the state of stress at Point A, and at Point B. Show the results on an element located at each point separately.

Internal forces and moments

\[ \Sigma F_x = 0 \]
\[ -400 + N_x = 0 \]
\[ N_x = 400 \text{ N} \]

\[ \Sigma F_y = 0 \]
\[ y = 300 = 0, \quad V_y = 300 \text{ N} \]

\[ \Sigma F_z = 0 \]
\[ z = 500 = 0, \quad V_z = 500 \text{ N} \]

\[ \Sigma M_x = 0 \]
\[ T_x - 200 = 0, \quad T_x = 200 \text{ N.m} \]

\[ \Sigma M_y = 0 \]
\[ M_y + (500)(0.15) = 0, \quad M_y = -75 \text{ N.m} \]

\[ \Sigma M_z = 0 \]
\[ M_z - 300(0.15) = 0, \quad M_z = 45 \text{ N.m} \]
Point A

1. Normal Stress

\[ \sigma_N = \frac{N}{A} = 0.318 \text{ MPa (T)} \]

\[ \sigma = \frac{600}{1.256 \times 10^{-3}} = 476 \text{ MPa (T)} \]

\[ \sigma_{\text{tot}} \text{ at } A = 0.318 + 11.94 = 12.258 \text{ MPa (T)} \]

2. Shear Stress

\[ \tau_{xy} = \frac{(300)(5.33 \times 10^{-6})}{(1.257 \times 10^{-3})(0.04)} = 5.33 \times 10^{-6} \text{ m}^2 \]

\[ \tau_{xy} = 0.316 \text{ MPa} \]

\[ \tau_{xy} = \frac{(200)(0.02)}{2.512 \times 10^{-7}} = -15.92 \text{ MPa} \]

\[ \tau_{xy} = 0.316 - 15.92 = -15.6 \text{ MPa} \]

\[ \tau_{xy} = 0 \]
Normal Stress

\[ \sigma_N = \frac{400}{1.256 \times 10^{-3}} = 0.318 \text{ MPa} \ (T) \]

\[ \sigma_B = \frac{(45)(0.02)}{1.256 \times 10^{-7}} = 7.16 \text{ MPa} \ (C) \]

\[ (\sigma_{\text{tot}})_B = 0.318 - 7.16 = -6.85 \text{ MPa} \ (C) \]

Shear Stress

\[ (\tau)_B = 0 \]

\[ (\tau)_z = \frac{5.33 \times 10^{-6}}{1.257 \times 10^{-7} (-04)} = 0.53 \text{ MPa} \]

\[ 2 = \frac{V_B}{F} = \frac{(500)(5.33 \times 10^{-6})}{1.257 \times 10^{-7} (-04)} = 0.53 \text{ MPa} \]

\[ 2 = \frac{F_C}{J} = \frac{(200)(0.02)}{2 \times 5.12 \times 10^{-7}} = -15.92 \text{ MPa} \]

\[ 2 = -15.39 \text{ MPa} \]

\[ 2 \times y = 0. \]