8–15. The screw of the clamp exerts a compressive force of 500 lb on the wood blocks. Determine the maximum normal stress developed along section a–a. The cross section there is rectangular, 0.75 in. by 0.50 in.

\[ A = 0.75(0.5) = 0.375 \text{ in}^2 \]

\[ I = \frac{1}{12}(0.5)(0.75^3) = 0.017578 \text{ in}^4 \]

\[ \sigma_{\text{max}} = \frac{P}{A} + \frac{Mc}{I} \]

\[ = \frac{500}{0.375} + \frac{2000(0.375)}{0.017578} = 44.0 \text{ ksi (T)} \]

Ans
8-20. The offset link supports the loading of \( P = 30 \, \text{kN} \). Determine its required width \( w \) if the allowable normal stress is \( \sigma_{\text{allow}} = 73 \, \text{MPa} \). The link has a thickness of 40 mm.

\[
\sigma_{a} = \frac{P}{A} = \frac{30 \times 10^3}{(w)(0.04)} = \frac{750 \times 10^3}{w}
\]

\[
\sigma_{\text{due to axial force}}
\]

\[
\sigma_{b} = \frac{Mc}{I} = \frac{30 \times 10^3(0.05 + \frac{w}{2})}{\left(\frac{1}{12}(0.04)^3w^3\right)} = \frac{4500 \times 10^3(0.05 + \frac{w}{2})}{w^2}
\]

\[
\sigma_{\text{due to bending}}
\]

\[
\sigma_{\text{max}} = \sigma_{\text{allow}} = \sigma_{a} + \sigma_{b}
\]

\[
73 \times 10^3 = \frac{750 \times 10^3}{w} + \frac{4500 \times 10^3(0.05 + \frac{w}{2})}{w^2}
\]

\[
73w^2 = 0.75w + 0.225 + 2.25w
\]

\[
73w^2 - 3w - 0.225 = 0
\]

\[
w = 0.0797 \, \text{m} = 79.7 \, \text{mm} \quad \text{Ans}
\]
8-21. The offset link has a width of \( w = 200 \text{ mm} \) and a thickness of \( t = 40 \text{ mm} \). If the allowable normal stress is \( \sigma_{\text{allow}} = 75 \text{ MPa} \), determine the maximum load \( P \) that can be applied to the cables.

\[
A = 0.2(0.04) = 0.008 \text{ m}^2
\]

\[
I = \frac{1}{12}(0.04)(0.2)^3 = 26.6667(10^{-6}) \text{ m}^4
\]

\[
\sigma = \frac{P}{A} + \frac{Mc}{I}
\]

\[
75(10^6) = \frac{P}{0.008} + \frac{0.150 P(0.1)}{26.6667(10^{-6})}
\]

\[ P = 109 \text{ kN} \quad \text{Ans} \]
8-22. The joint is subjected to a force of \( P = 80 \text{ lb} \) and \( F = 0 \). Sketch the normal-stress distribution acting over section e-e if the member has a rectangular cross-sectional area of width 2 in. and thickness 0.5 in.

\[
\sigma \text{ due to axial force:} \\
\sigma = \frac{P}{A} = \frac{80}{(0.5)(2)} = 80 \text{ psi}
\]

\[
\sigma \text{ due to bending:} \\
\sigma = \frac{Mc}{I} = \frac{100(0.25)}{\frac{1}{12}(2)(0.5)^3} = 1200 \text{ psi}
\]

\[
(\sigma_{\text{max},e}) = 80 + 1200 = 1280 \text{ psi} = 1.28 \text{ ksi} \quad \text{Ans}
\]

\[
(\sigma_{\text{max},c}) = 1200 - 80 = 1120 \text{ psi} = 1.12 \text{ ksi} \quad \text{Ans}
\]

\[
\gamma = \frac{(0.5 - \gamma)}{1.25} = 1.12
\]

\[
y = 0.264 \text{ in.}
\]
8-23. The joint is subjected to a force of \( P = 200 \) lb and
\( F = 150 \) lb. Determine the state of stress at points \( A \) and \( B \)
and sketch the results on differential elements located at
these points. The member has a rectangular cross-sectional
area of width 0.75 in. and thickness 0.5 in.

\[ A = 0.5(0.75) = 0.375 \text{ in}^2 \]

\[ Q_A = \gamma_k A' = 0.125(0.75)(0.25) = 0.0234375 \text{ in}^3; \quad Q_B = 0 \]

\[ I = \frac{1}{12}(0.75)(0.5^3) = 0.0078125 \text{ in}^4 \]

Normal Stress:

\[ \sigma = \frac{N}{A} + \frac{M_y}{I} \]

\[ \sigma_A = \frac{200}{0.375} + 0 = 533 \text{ psi} \quad \text{Ans} \]

\[ \sigma_B = \frac{200}{0.375} - \frac{50(0.25)}{0.0078125} = -1067 \text{ psi} = 1067 \text{ psi} \quad \text{Ans} \]

Shear Stress:

\[ \tau = \frac{VQ}{It} \]

\[ \tau_A = \frac{150(0.0234375)}{(0.0078125)(0.75)} = 600 \text{ psi} \quad \text{Ans} \]

\[ \tau_B = 0 \quad \text{Ans} \]
The gondola and passengers have a weight of 1500 lb and center of gravity at G. The suspender arm AE has a square cross-sectional area of 1.5 in. by 1.5 in., and is pin connected at its ends A and E. Determine the largest tensile stress developed in regions AB and DC of the arm.

Segment AB:

\[
(\sigma_{\text{max}})_{\text{AB}} = \frac{P_{AB}}{A} = \frac{1500}{(1.5)(1.5)} = 667 \text{ psi} \quad \text{Ans}
\]

Segment CD:

\[
\sigma_a = \frac{P_{CD}}{A} = \frac{1500}{(1.5)(1.5)} = 666.67 \text{ psi}
\]

\[
\sigma_b = \frac{M_c}{I} = \frac{1875(12)(0.75)}{\frac{1}{12}(1.5)(1.5^3)} = 40000 \text{ psi}
\]

\[
(\sigma_{\text{max}})_{\text{CD}} = \sigma_a + \sigma_b = 666.67 + 40000 = 40666.67 \text{ psi} = 40.7 \text{ ksi} \quad \text{Ans}
\]
5-25 The vertical force $P$ acts on the bottom of the plate having a negligible weight. Determine the shortest distance $d$ to the edge of the plate at which it can be applied so that it produces no compressive stresses on the plate at section $a-a$. The plate has a thickness of 10 mm and $P$ acts along the center line of this thickness.

\[
\sigma_a = 0 = \sigma_a - \sigma_b \\
0 = \frac{P}{A} - \frac{Mc}{I} \\
0 = \frac{P}{(0.2)(0.01)} - \frac{P(0.1 - d)(0.1)}{12(0.01)(0.2^2)} \\
P\left(1000 + \frac{15000d}{0.0667m = 66.7 \text{ mm}}\right) = 0
\]

Ans

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8-26. The bar has a diameter of 40 mm. If it is subjected to a force of 800 N as shown, determine the stress components that act at point A and show the results on a volume element located at this point.

\[ I = \frac{1}{4} \pi r^4 = \frac{1}{4} \pi (0.02)^4 = 0.1256637 \times 10^{-6} \text{ m}^4 \]

\[ A = \pi r^2 = \pi (0.02)^2 = 1.256637 \times 10^{-3} \text{ m}^2 \]

\[ Q_A = y' A' = \frac{4 (0.02) \pi (0.02)^2}{3 \pi} = 5.3333 \times 10^{-4} \text{ m}^3 \]

\[ \sigma_A = \frac{P}{A} + \frac{M z}{I} = \frac{400}{1.256637 \times 10^{-3}} + 0 = 0.318 \text{ MPa} \quad \text{Ans} \]

\[ \tau_A = \frac{V Q_A}{I t} = \frac{692.82 \times 5.3333 \times 10^{-4}}{0.1256637 \times 10^{-4} \times 0.04} = 0.735 \text{ MPa} \quad \text{Ans} \]
8-27. Solve Prob. 8–26 for point $B$.

\[ I = \frac{1}{4} \pi r^4 = \frac{1}{4} (\pi)(0.02)^4 = 0.1256637 \times 10^{-4} \, \text{m}^4 \]

\[ A = \pi r^2 = \pi (0.02)^2 = 1.256637 \times 10^{-3} \, \text{m}^2 \]

\[ Q_B = 0 \]

\[ \sigma_z = \frac{P}{A} \frac{M}{I} = \frac{400}{1.256637 \times 10^{-3}} - \frac{138.56 \times (0.02)}{0.1256637 \times 10^{-6}} = -21.7 \, \text{MPa} \quad \text{Ans} \]

\[ \tau_B = 0 \quad \text{Ans} \]

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The cylindrical post, having a diameter of 40 mm, is being pulled from the ground using a sling of negligible thickness. If the rope is subjected to a vertical force of \( P = 500 \) N, determine the stress at points \( A \) and \( B \). Show the results on a volume element located at each of these points.

\[
I = \frac{1}{4} \pi r^4 = \frac{1}{4} \pi (0.02^2) = 0.1256637 \times 10^{-6} \text{ m}^4
\]

\[
A = \pi r^2 = \pi (0.02^2) = 1.256637 \times 10^{-3} \text{ m}^2
\]

\[
\sigma_A = \frac{P}{A} + \frac{Mx}{I} = \frac{500}{1.256637 \times 10^{-3}} + 0 = 0.398 \text{ MPa} \quad \text{Ans}
\]

\[
\sigma_B = \frac{P}{A} - \frac{Mc}{I} = \frac{10 \times (0.02)}{1.256637 \times 10^{-3}} = -1.19 \text{ MPa} \quad \text{Ans}
\]
8-38. Determine the maximum load P that can be applied to the pin having a negligible thickness so that the normal stress in the pin does not exceed \( \sigma_{\text{allow}} = 30 \text{ MPa} \). The pin has a diameter of 50 mm.

\[ \sum F = 0; \quad N - P = 0; \quad N = P \]

\[ \sum M = 0; \quad M - P(0.025) = 0; \quad M = 0.025P \]

\[ A = \frac{\pi}{4} d^2 = \pi (0.025^2) = 0.625 \times 10^{-3} \pi \text{ m}^2 \]

\[ I = \frac{\pi}{4} r^4 = \frac{\pi}{4} (0.025^4) = 97.65625 \times 10^{-7} \pi \text{ m}^4 \]

\[ \sigma = \frac{N}{A} + \frac{My}{I} \]

\[ \sigma = 30(10^6) = \frac{P}{0.625 \times 10^{-3} \pi} + \frac{P(0.025)(0.025)}{97.65625 \times 10^{-7} \pi} \]

\[ P = 11.8 \text{ kN} \quad \text{Ans} \]
The 1\text{-in.}-diameter bolt hook is subjected to the load of $F = 150$ lb. Determine the stress components at point $A$ on the shank. Show the results on a volume element located at this point.

\[ \sum F = 0; \quad N_A - 150 \cos 30^\circ = 0 \]

\[ N_A = 129.9038 \text{ lb} \]

\[ \sum F_y = 0; \quad V_A - 150 \sin 30^\circ = 0 \]

\[ V_A = 75 \text{ lb} \]

\[ \sum M_A = 0; \quad 150 \cos 30^\circ (1.5) + 150 \sin 30^\circ (2) - M_A = 0 \]

\[ M_A = 344.8557 \text{ lb} \cdot \text{in.} \]

\[ \sigma_A = \frac{P}{A} + \frac{Mc}{I} = \frac{129.9038}{\pi \left(\frac{1}{2}\right)^2} + \frac{344.8557 \left(\frac{1}{2}\right)}{\left(\frac{1}{2}\right)^4} = 28.8 \text{ ksi} \quad \text{Ans} \]

\[ \tau_A = 0 \quad (\text{since } Q_A = 0) \quad \text{Ans} \]
8-31 The 1-in.-diameter bolt hook is subjected to the load of \( F = 150 \text{ lb} \). Determine the stress component at point \( B \) on the shank. Show the results on a volume element located at this point.

\[ \sum F = 0; \quad N_B - 150 \cos 30^\circ = 0; \quad N_B = 129.9038 \]

\[ \sum F = 0; \quad V_B - 150 \sin 30^\circ = 0; \quad V_B = 75 \text{ lb} \]

\[ \sum M = 0; \quad 150 \cos 30^\circ (1.5) + 150 \sin 30^\circ (4) - M_B = 0 \]

\[ M_B = 494.8557 \text{ lb} \cdot \text{in.} \]

\[ \sigma_B = \frac{P}{A} - \frac{Mc}{I} - \frac{129.9038}{\frac{3}{4}(1.5)^2} - \frac{494.8557(1)}{\frac{3}{4}(1.5)^4} = -39.7 \text{ ksi} \quad \text{Ans} \]

\[ \text{Ans} \]

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8.32. The pin support is made from a steel rod and has a diameter of 20 mm. Determine the stress components at points A and B and represent the results on a volume element located at each of these points.

\[ I = \frac{1}{4} \pi (0.01)^4 = 7.85398 \times 10^{-6} \text{ m}^4 \]

\[ Q_A = \frac{4}{3\pi} \frac{1}{2} \pi (0.01)^2 = 0.66667 \times 10^{-6} \text{ m}^3 \]

\[ Q_A = 0 \]

\[ \sigma_A = \frac{V_Q}{I} = \frac{150 \times 0.6667 \times 10^{-6}}{7.85398 \times 10^{-6}} = 15.3 \text{ MPa} \quad \text{Ans} \]

\[ \tau_A = 0 \quad \text{Ans} \]

\[ \sigma_B = 0 \quad \text{Ans} \]

\[ \tau_B = \frac{V_Q}{I} = \frac{150 \times 0.6667 \times 10^{-6}}{7.85398 \times 10^{-6}} = 0.637 \text{ MPa} \quad \text{Ans} \]

\[ \sigma_A = 15.3 \text{ MPa} \quad \tau_A = 0.637 \text{ MPa} \]
8-33 Solve Prob. 8-32 for points C and D.

\[ I = \frac{1}{4} \pi (0.01^4) = 7.85398 \times 10^{-6} \text{ m}^4 \]

\[ Q_C = 0 \]

\[ \sigma_C = \frac{M_C}{I} = \frac{12(0.01)}{7.85398(10^{-6})} = 15.3 \text{ MPa} \quad \text{Ans} \]

\[ \tau_C = 0 \quad \text{Ans} \]

\[ \sigma_D = 0 \quad \text{Ans} \]

\[ \tau_D = \frac{VQ_D}{I} = \frac{150(0.6667)(10^{-6})}{7.85398(10^{-6})(0.02)} = 0.637 \text{ MPa} \quad \text{Ans} \]

\[ \epsilon_C = 15.3 \text{ MPa} \]

\[ \tau_D = 0.637 \text{ MPa} \]