

9-29 The bell crank is pinned at A and supported by a short link BC. If it is subjected to the force of 80 N, determine the principal stresses at (a) point D and (b) point E. The crank is constructed from an aluminum plate having a thickness of 20 mm.

Point D :

$$A = 0.04(0.02) = 0.8(10^{-3}) \text{ m}^2$$

$$I = \frac{1}{12}(0.02)(0.04^3) = 0.1067(10^{-6}) \text{ m}^4$$

$$Q_D = \bar{y}A' = 0.015(0.02)(0.01) = 3(10^{-6}) \text{ m}^3$$

Normal stress :

$$\sigma_D = \frac{P}{A} + \frac{My}{I} = \frac{64}{0.8(10^{-3})} - \frac{7.2(0.01)}{0.1067(10^{-6})} = -0.595 \text{ MPa}$$

Shear stress :

$$\tau_D = \frac{VQ}{It} = \frac{48(3)(10^{-6})}{0.1067(10^{-6})(0.02)} = 0.0675 \text{ MPa}$$

Principal stress :  $\sigma_x = -0.595 \text{ MPa}$   $\sigma_y = 0$   $\tau_{xy} = 0.0675 \text{ MPa}$

$$\begin{aligned} \sigma_{1,2} &= \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \\ &= \frac{-0.595 + 0}{2} \pm \sqrt{\left(\frac{-0.595 - 0}{2}\right)^2 + 0.0675^2} \end{aligned}$$

$$\sigma_1 = 7.56 \text{ kPa} \quad \text{Ans}$$

$$\sigma_2 = -603 \text{ kPa} \quad \text{Ans}$$

Point E :

$$I = \frac{1}{12}(0.02)(0.05^3) = 0.2083(10^{-6}) \text{ m}^4$$

$$Q_E = \bar{y}A' = 0.02(0.01)(0.02) = 4.0(10^{-6}) \text{ m}^3$$

Normal stress :

$$\sigma_E = \frac{My}{I} = \frac{5.2364(0.015)}{0.2083(10^{-6})} = 377.0 \text{ kPa}$$

Shear stress :

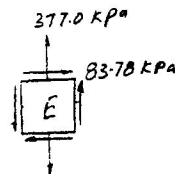
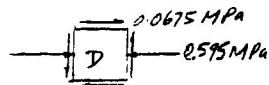
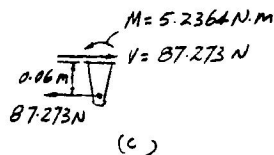
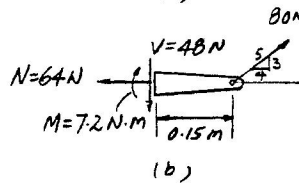
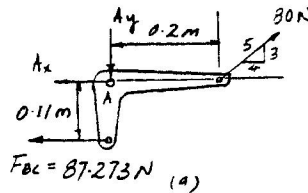
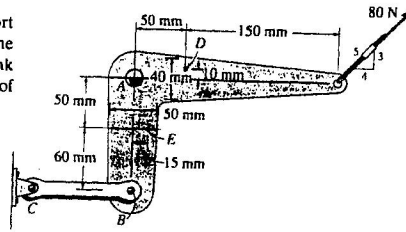
$$\tau_E = \frac{VQ}{It} = \frac{87.273(4.0)(10^{-6})}{0.2083(10^{-6})(0.02)} = 83.78 \text{ kPa}$$

Principal stress :  $\sigma_x = 0$   $\sigma_y = 377.0 \text{ kPa}$   $\tau_{xy} = 83.78 \text{ kPa}$

$$\begin{aligned} \sigma_{1,2} &= \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \\ &= \frac{0 + 377.0}{2} \pm \sqrt{\left(\frac{0 - 377.0}{2}\right)^2 + 83.78^2} \end{aligned}$$

$$\sigma_1 = 395 \text{ kPa} \quad \text{Ans}$$

$$\sigma_2 = -17.8 \text{ kPa} \quad \text{Ans}$$



From *Mechanics of Materials*, Sixth Edition by R. C. Hibbeler, ISBN 0-13-191345-X.

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