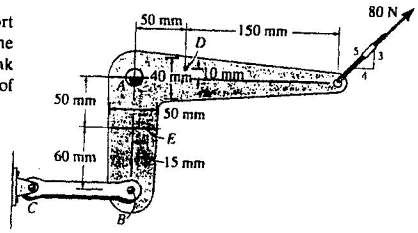
9–29 The bell crank is pinned at A and supported by a short link BC. If it is subjected to the force of 80 N, determine the principal stresses at (a) point D and (b) point E. The crank is constructed from an aluminum plate having a thickness of 20 mm.

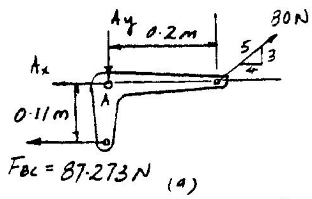


Point D :

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

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

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

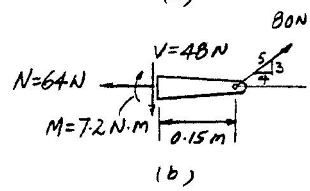


Normal stress :

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

Shear stress :

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



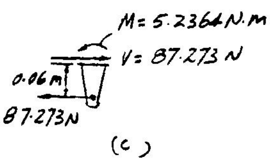
Principal stress : $\sigma_x = -0.595\ \text{MPa}$ $\sigma_y = 0$ $\tau_{xy} = 0.0675\ \text{MPa}$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{-0.595 + 0}{2} \pm \sqrt{\left(\frac{-0.595 - 0}{2}\right)^2 + 0.0675^2}$$

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

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



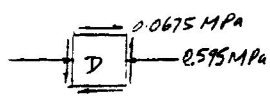
Point E :

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

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

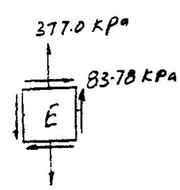
Normal stress :

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



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

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{0 + 377.0}{2} \pm \sqrt{\left(\frac{0 - 377.0}{2}\right)^2 + 83.78^2}$$

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

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