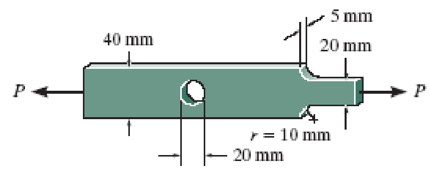
HW# 5 Key Solutions

***4–88.** If the allowable normal stress for the bar is $\sigma_{allow} = 120$ MPa, determine the maximum axial force P that can be applied to the bar.



Assume failure of the fillet.

$$\frac{w}{h} = \frac{40}{20} = 2; \qquad \frac{r}{h} = \frac{10}{20} = 0.5$$

From Fig. 4-24. $K = 1.4$

$$\sigma_{allow} = \sigma_{max} = K\sigma_{avg}$$

$$120(10^6) = 1.4\left(\frac{P}{0.02\,(0.005)}\right)$$

$$P = 8.57 \text{ kN}$$

Assume failure of the hole.

$$\frac{r}{w} = \frac{10}{20} = 0.25$$

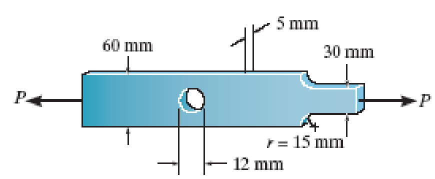
From Fig. 4-25. $K = 2.375$

$$\sigma_{allow} = \sigma_{max} = K\sigma_{avg}$$

$$120(10^4) = 2.375\left(\frac{P}{(0.04 - 0.02)\,(0.005)}\right)$$

$$P = 5.05 \text{ kN (controls)}$$ **Ans.**

•4–93. Determine the maximum normal stress developed in the bar when it is subjected to a tension of $P = 8$ kN.



Maximum Normal Stress at fillet:

$$\frac{r}{h} = \frac{15}{30} = 0.5 \quad \text{and} \quad \frac{w}{h} = \frac{60}{30} = 2$$

From the text, $K = 1.4$

$$\sigma_{max} = K\sigma_{avg} = K\frac{P}{h\,t}$$

$$= 1.4\left[\frac{8(10^3)}{(0.03)(0.005)}\right] = 74.7 \text{ MPa}$$

Maximum Normal Stress at the hole:

$$\frac{r}{w} = \frac{6}{60} = 0.1$$

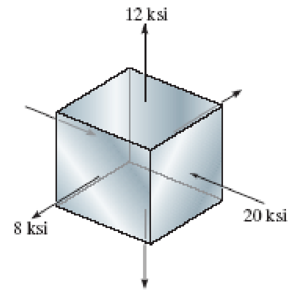
From the text, $K = 2.65$

$$\sigma_{max} = K\sigma_{avg} = K\frac{P}{(w - 2r)\,t}$$

$$= 2.65\left[\frac{8(10^3)}{(0.06 - 0.012)(0.005)}\right]$$

$$= 88.3 \text{ MPa} \quad (\textit{Controls})$$ **Ans.**

10–38. The principal stresses at a point are shown in the figure. If the material is A-36 steel, determine the principal strains.



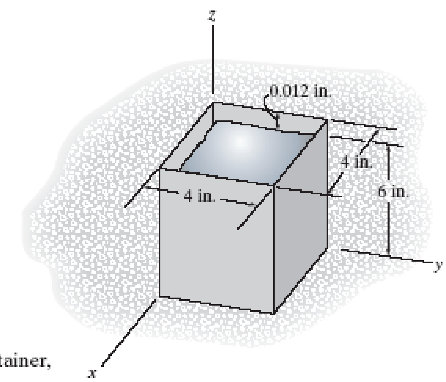
$$\varepsilon_1 = \frac{1}{E}\left[\sigma_1 - \nu(\sigma_2 + \sigma_3)\right] = \frac{1}{29.0(10^3)}\left\{12 - 0.32\left[8 + (-20)\right]\right\} = 546\,(10^{-6})$$

$$\varepsilon_2 = \frac{1}{E}\left[\sigma_2 - \nu(\sigma_1 + \sigma_3)\right] = \frac{1}{29.0(10^3)}\left\{8 - 0.32\left[12 + (-20)\right]\right\} = 364\,(10^{-6})$$

$$\varepsilon_3 = \frac{1}{E}\left[\sigma_3 - \nu(\sigma_1 + \sigma_2)\right] = \frac{1}{29.0(10^3)}\left[-20 - 0.32(12 + 8)\right] = -910\,(10^{-6})$$

$\varepsilon_{max} = 546\,(10^{-6})$ $\quad \varepsilon_{int} = 346\,(10^{-6})$ $\quad \varepsilon_{min} = -910\,(10^{-6})$ **Ans.**

10–54. The smooth rigid-body cavity is filled with liquid 6061-T6 aluminum. When cooled it is 0.012 in. from the top of the cavity. If the top of the cavity is not covered and the temperature is increased by 200°F, determine the strain components ϵ_x, ϵ_y, and ϵ_z in the aluminum. *Hint:* Use Eqs. 10–18 with an additional strain term of $\alpha \Delta T$ (Eq. 4–4).



Normal Strains: Since the aluminum is confined at its sides by a rigid container, then

$$\varepsilon_x = \varepsilon_y = 0 \qquad \textbf{Ans.}$$

and since it is not restrained in *z direction*, $\sigma_z = 0$. Applying the generalized Hooke's Law with the additional thermal strain,

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu\left(\sigma_y + \sigma_z\right)\right] + \alpha \Delta T$$

$$0 = \frac{1}{10.0(10^3)}\left[\sigma_x - 0.35\left(\sigma_y + 0\right)\right] + 13.1\left(10^{-6}\right)(200)$$

$$0 = \sigma_x - 0.35\sigma_y + 26.2 \qquad [1]$$

$$\varepsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right] + \alpha \Delta T$$

$$0 = \frac{1}{10.0(10^3)}\left[\sigma_y - 0.35(\sigma_x + 0)\right] + 13.1\left(10^{-6}\right)(200)$$

$$0 = \sigma_y - 0.35\sigma_x + 26.2 \qquad [2]$$

Solving Eqs. [1] and [2] yields:

$$\sigma_x = \sigma_y = -40.31 \text{ ksi}$$

$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - \nu\left(\sigma_x + \sigma_y\right)\right] + \alpha \Delta T$$

$$= \frac{1}{10.0(10^3)}\{0 - 0.35[-40.31 + (-40.31)]\} + 13.1\left(10^{-6}\right)(200)$$

$$= 5.44\left(10^{-3}\right) \qquad \textbf{Ans.}$$