Solutions for MBD Midterm II (2009)

Problem I. (20 points)

(a) (5 points)

$S_u = (0.5)\ H_B \Rightarrow H_B = 2\ S_u = 2(66) = 132\ (BH_n)$

$R_f = 1 - \frac{A_f}{A_o} = 1 - \frac{1}{2.5} = 60\%$

(or $\varepsilon = R - 1 = 2.5 - 1 = 150\%$)

(b) (5 points)

at point K, $\sigma = 65$ ksi, $\varepsilon = 0.20$

$\sigma_T = \sigma \cdot R = 65(1.2) = 78$ ksi

$\varepsilon_T = \ln(1+\varepsilon) = 0.18$

(c) (5 points)

$S_u' = 66\ (1.2) = 79.2$ ksi

$S_y' = 65\ (1.2) = 78.0$ ksi

Ductility

$R' = \frac{R}{1.2} = \frac{2.5}{1.2} = 2.1 = \frac{A_o}{A_f}$

$R_f = 1 - \frac{A_f}{A_o} = 1 - \frac{1}{2.1} = 52\%$

(or $\varepsilon = R - 1 = 2.1 - 1 = 110\%$.)

(d) (5 points) at point F, $\sigma_T = 45(2.5) = 112.5$ ksi

$\varepsilon_T = \ln(1+\varepsilon) = 0.92$

at point k, $\sigma_T = 78$ ksi

$\varepsilon_T = 0.18$

solve for $\sigma_T = \sigma_o\ \varepsilon_T^{\ m}$ or $\ln \sigma_T = \ln \sigma_o + m\ \varepsilon_T$

$\Rightarrow m = 0.22$ and $\sigma_o = 114$ (ksi)

Problem 2 (20 points)

(a) (15 points)

$F = 800\left(\frac{\pi}{4}\right)(3^2) = 5655$ lbf, $S_y = 39$ ksi

$P_{cr} = n_d \cdot F = 17{,}000$ lbf, $E = 30\times10^6$ psi

assume Euler with $C=1$ (rounded – rounded)

$$I = \frac{\pi}{64} d^4 = \frac{P_{cr} l^2}{C\pi^2 E} \Rightarrow d = \left[\frac{64 P_{cr} l^2}{\pi^3 CE}\right]^{1/4}$$

$$\Rightarrow d = \left[\frac{64(17000)(60^2)}{\pi^3(1)(30\times10^6)}\right]^{1/4} = 1.433 \text{ in}$$

Use $d = 1.5$, $k = \frac{d}{4} = 0.375$

$$\frac{l}{k} = \frac{60}{0.375} = 160$$

$$\left(\frac{l}{k}\right)_1 = \left(\frac{2\pi^2 E\cdot C}{S_y}\right)^{1/2} = \left(\frac{2\pi^2 \times 30\times10^6\times 1}{39\times10^3}\right)^{1/2} = 123$$

since $\frac{l}{k} = 160 > \left(\frac{l}{k}\right)_1 = 123$, Euler is ok!

∴ choose $d = 1.5$ in

(b) (5 points)

since $\frac{l(=80)}{k} = \frac{80}{0.375} = 213 > \left(\frac{l}{k}\right)_1$

Euler is applicable!

$$\Rightarrow P_{cr} = \frac{C\pi^2 EI}{l^2} = \frac{\pi^2(30\times10^6)\left(\frac{\pi}{64}\right)(1.5^4)}{80^2} = 11479$$

$$n_d = \frac{P_{cr}}{F} = \frac{11479}{5655} \approx 2.03$$

Problem 3 (20 points)

(a) (10 points)

close runnig fit $\Rightarrow$ H8/f7

For bushing: H8 $\Rightarrow$ $\Delta D = 0.015$

$D = D_{min} = 2$ in

$D_{max} = D + \Delta D = 2.015$ in

For shaft: IT 7 $\Rightarrow$ $\Delta d = 0.0010$ in

f $\Rightarrow$ $\delta_F = -0.0010$ in

$d_{max} = d + \delta_F = 1.9990$ in

$d_{min} = d_{max} - \Delta d = 1.9980$ in

(b) (10 points)

Locational interference fit $\Rightarrow$ H7/p6

For bushing: H7 $\Rightarrow$ $\Delta D = 0.0010$ in

$D = D_{min} = 2$ in

$D_{max} = D_{min} + \Delta D = 2.0010$ in

For shaft IT6 $\Rightarrow$ $\Delta d = 0.0006$ in

p $\Rightarrow$ $\delta_F = 0.0010$

$d_{min} = d + \delta_F = 2.0010$ in

$d_{max} = d_{min} + \Delta d = 2.0016$ in