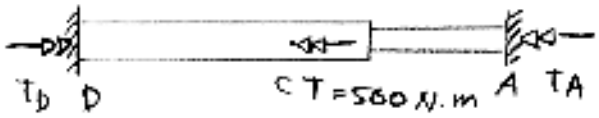
5-80



Equilibrium: $T_A + T_D - 500 = 0$

Compatibility: $\phi_{C/D} = \phi_{C/A}$

$$\frac{T_D(1)}{\frac{\pi}{2}(0.025^4)(37.0)(10^9)} = \frac{T_A(0.5)}{\frac{\pi}{2}(0.025^4)(37)(10^9)} + \frac{T_A(0.15)}{\frac{\pi}{2}(0.015^4)(75)(10^9)}$$

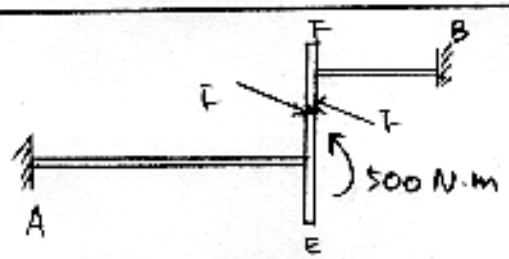
$$T_A = 0.29807\, T_D$$

$\therefore T_A = 385.19$ N·m, $T_D = 114.81$ N·m

$$\tau_{CD} = \frac{T_D c}{J} = \frac{385.19 \times 0.025}{\frac{\pi}{2}(0.025^4)} = 15.7 \text{ MPa}$$

$$\tau_{AB} = \frac{T_A c}{J} = \frac{114.81(0.015)}{\frac{\pi}{2}(0.015^4)} = 21.7 \text{ MPa} = \tau_{max}$$

5-85



Equilibrium; $T_A + F(0.1) - 500 = 0$

$T_B - F(0.05) = 0$

$\rightarrow T_A + 2T_B - 500 = 0$ ... ①

Compatibility: $0.1\phi_E = 0.05\phi_F$

$\phi_E = 0.5\phi_F$

$$\frac{T_A(1.5)}{GJ} = (0.5)\frac{T_B(0.15)}{GJ}$$

$T_A = 0.25 T_B$ ... ②

By ① & ②

$T_A = 55.6$ N·m $\quad T_B = 222$ N·m

5-88

Equilibrium:

$T_A + T_B + (200)(0.5) - 500 = 0$

$T_A + T_B = 400$ ... ①

Compatibility; $\phi_{C/A} = \phi_{C/B}$

$$\phi_{C/A} = \int \frac{T(x)\,dx}{GJ} = \int_0^{0.5} \frac{(T_A + 200x)\,dx}{GJ}$$

$$= \frac{0.5T_A + 25.0}{GJ}$$

$$\phi_{C/B} = \frac{T_B(0.5)}{GJ}$$

$$\frac{0.5T_A + 25.0}{GJ} = \frac{T_B(0.5)}{GJ}$$

$T_B - T_A = 50$ ... ②

By ① & ②

$T_A = 175.0$ N·m, $T_B = 225.0$ N·m

Allowable shear stress:

The maximum torque occurs at $x = 0.5$ m in segment AC

$T_{max} = 175 + 200(0.5) = 275.0$ N·m

$$\tau_{allow} = \frac{T_{max} \cdot c}{J} \rightarrow 135(10^6) = \frac{275(\frac{d}{2})}{\frac{\pi}{2}(\frac{d}{2})^4}$$

$\therefore d = 0.02181$ (m) $= 21.8$ (mm)