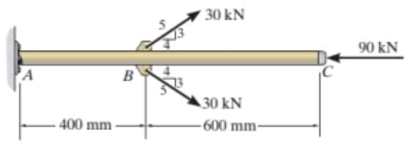
Homework 6

Tuesday, October 13, 2020 9:15 PM

"I pledge my honor I have abided by the Stevens Honor system."

\- Alex Daskins

F9–3. The 30-mm-diameter A992 steel rod is subjected to the loading shown. Determine the displacement of end C.



$$A = \pi\left(\frac{d}{2}\right)^2$$

$$= \pi\left(\frac{.03}{2}\right)^2$$

$$= .7068 \times 10^{-3}\ m^2$$

$$\delta_{BC} = \frac{F_{BC} L_{BC}}{AE}$$

$$= \frac{-90 \times 10^3 (.6)}{.7068 \times 10^{-3} (200 \times 10^9)}$$

$$= 3.82 \times 10^{-4}\ m.$$

$$F_x = 0$$

$$F_{AB} + 30\left(\frac{4}{5}\right)(2) - 90 = 0$$

$$F_{AB} = 42\ kN$$

$$\delta_{AB} = \frac{F_{AB} L_{AB}}{AE} = \frac{-42 \times 10^3 (.4)}{.7068 \times 10^{-3} (200 \times 10^9)} = 1.188 \times 10^{-4}\ m.$$

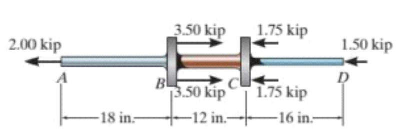
$$\delta_{AC} = \delta_{AB} + \delta_{BC}$$

$$= (-1.188 - 3.82)(10^{-4})$$

$$= -5.008 \times 10^{-4}\ m.$$

9–3. The composite shaft, consisting of aluminum, copper, and steel sections, is subjected to the loading shown. Determine the displacement of end A with respect to end D and the normal stress in each section. The cross-sectional area and modulus of elasticity for each section are shown in the figure. Neglect the size of the collars at B and C.

Aluminum	Copper	Steel
$E_{al} = 10(10^3)$ ksi	$E_{cu} = 18(10^3)$ ksi	$E_{st} = 29(10^3)$ ksi
$A_{AB} = 0.09$ in^2	$A_{BC} = 0.12$ in^2	$A_{CD} = 0.06$ in^2



$$\sigma_{AB} = \frac{F_{AB}}{A_{AB}} = \frac{2}{.09} = 22.2\ ksi$$

$$\sigma_{BC} = \frac{F_{BC}}{A_{BC}}; \quad F_{BC} = -3.5 - 3.5 + 2$$

$$F_{BC} = -5\ kip$$

$$= \frac{-5}{\ }$$

$.012$

$= -41.7 \text{ ksi}$

$\sigma_{CD} = \dfrac{F_{CD}}{A_{CD}}$; $\quad F_{CD} = 2 - 3.5 - 3.5 + 1.75(2)$

$F_{CD} = -1.5 \text{ kip}$

$= \dfrac{-1.5}{.06}$

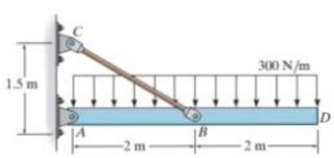
$= -25 \text{ ksi}$

$$\delta_{AD} = \frac{F_{AB} L_{AB}}{A_{AB} E_{Al}} + \left(\frac{F_{BC} L_{BC}}{A_{BC} E_{cu}}\right) + \left(\frac{F_{CD} L_{CD}}{A_{CD} E_{st}}\right)$$

$$= \frac{2(16)}{.09 \times 10 \times 10^3} + \left(\frac{-5(12)}{.12 \times 18 \times 10^3}\right) + \left(\frac{-1.5(16)}{.06 \times 29 \times 10^3}\right)$$

$= .00157 \text{ in.}$

9–13. The rigid bar is supported by the pin-connected rod *CB* that has a cross-sectional area of 14 mm² and is made from 6061-T6 aluminum. Determine the vertical deflection of the bar at *D* when the distributed load is applied.



$M_A = 0$

$$-1200(2) + F_{BC}\left(\frac{1.5}{\sqrt{1.5^2 + 2^2}}\right)(2) = 0$$

$F_{BC} = 2000 \text{ N.}$

$BC = \sqrt{AB^2 + AC^2}$

$= \sqrt{2^2 + 1.5^2}$

$= 2.5 \text{ m.}$

$$\delta_{BC} = \frac{F_{BC} L_{BC}}{AE}$$

$$= \frac{2000(2.5)}{14 \times 10^{-6}(68.9 \times 10^9)}$$

$= 5.183 \times 10^{-3} \text{ m.}$

$B'C = 2.5 + (5.183 \times 10^{-3}) = 2.505\ m.$

$B'C^2 = AC^2 + AB^2 - 2(AC)(AB)\cos(90+\alpha)$

$(2.505)^2 = (2)^2 + (1.5)^2 - (2(2)(1.5)\cos(90+\alpha))$

$\cos(90+\alpha) = -4.32 \times 10^{-3}$

$\alpha = .247°$

$.247\left(\frac{\pi}{180}\right)$

$\alpha = .0043\ rad$

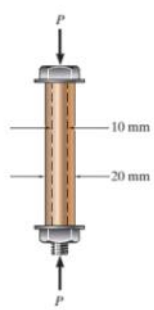
$\tan(\alpha) = \frac{\delta_D}{AD}$; $\delta_D = AD(\alpha)$

$\delta_D = 4(.0043)$

$\delta_D = .01729\ m.$

$\delta_D = 17.24\ mm.$

9–41. The 10-mm-diameter steel bolt is surrounded by a bronze sleeve. The outer diameter of this sleeve is 20 mm, and its inner diameter is 10 mm. If the yield stress for the steel is $(\sigma_Y)_{st} = 640$ MPa, and for the bronze $(\sigma_Y)_{br} = 520$ MPa, determine the magnitude of the largest elastic load P that can be applied to the assembly. $E_{st} = 200$ GPa, $E_{br} = 100$ GPa.



$F_y = 0$

$P_{st} + P_{br} - P = 0$

$A = \frac{\pi}{4}(10)^2 = 78.54\ mm.^2$

$P_{st} = (\sigma_{Y_{st}})A_{st}$

$= 640\left(\frac{1\ N/mm^2}{1\ MPa}\right)(78.54)$

$= 50265.6\ N.$

$A_{br} = \frac{\pi}{4}(d_o^2 - d_i^2)$

$$A_{br} = \frac{\pi}{4}(d_o^2 - d_i^2)$$

$$= \frac{\pi}{4}(20^2 - 10^2)$$

$$= 235.62 mm^2$$

$$\frac{P_{st}}{A_{st}E_{st}} = \frac{P_{br}}{A_{br}E_{br}}$$

$$\frac{P_{st}}{78.54(200\times10^9)} = \frac{P_{br}}{235.62(100\times10^9)}$$

$$P_{br} = \frac{P_{st}}{.66} = \frac{50265.6}{.66}$$

$$P_{br} = 75360.72 N$$

$$P_{st} + P_{br} - P = 0$$

$$50265.6 + 75360.72 - P = 0$$

$$P = 126 kN$$

$$P_{br} = (\sigma_{y\,br}) A_{br} = 520(235.62)$$

$$P_{br} = 122.5 kN$$

$$P_{st} = .66(P_{br}) = .66(122522.4)$$

$$P_{st} = 81722.44 N.$$

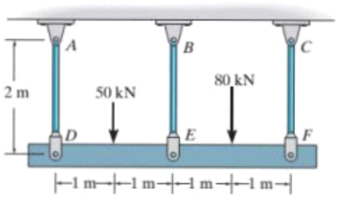
$$P_{st} + P_{br} - P = 0$$

$$81722.44 + 122522.4 - P = 0$$

$$P = 204.24 kN$$

Greatest elastic load must be 126 kN

9–55. The three suspender bars are made of A992 steel and have equal cross-sectional areas of 450 mm². Determine the average normal stress in each bar if the rigid beam is subjected to the loading shown.



$F_y = 0$

$F_{AD} + F_{BE} + F_{CF} = 130$

$M_D = 0$

$F_{BE}(2) + F_{CF}(4) = 290$

$\delta_{BE} = \delta_{AD} + \left(\frac{\delta_{CF} - \delta_{AD}}{4}\right)(2)$

$\delta_{BE} = \frac{1}{2}(\delta_{AD} + \delta_{CF})$

$2F_{BE} = F_{AD} + F_{CF}$

$F_{AD} + F_{CF} - F_{BE}(2) = 0$

$F_{AD} = 35.83\ kN.$

$F_{BE} = 43.33\ kN.$

$F_{CF} = 50.83\ kN.$

$\sigma_{AD} = \frac{F_{AD}}{A}$

$\frac{35.83\times10^3}{450\ mm^2} = 79.6\ MPa$

$\sigma_{BE} = \frac{F_{BE}}{A}$

$\frac{43.33\times10^3}{450\ mm^2} = 96.3\ MPa$

$\sigma_{CF} = \frac{F_{CF}}{A}$

$\frac{50.83\times10^3}{450\ mm^2} = 112.9\ MPa$