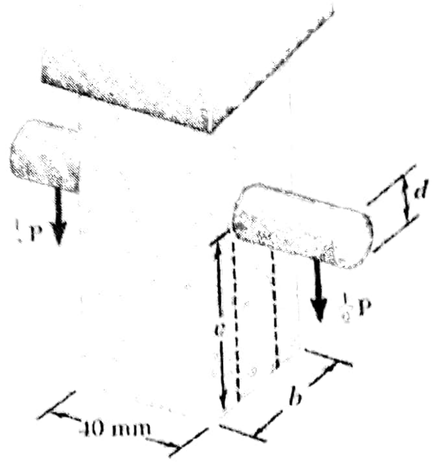
| Mansoura University | | level 100 |
|---|---|---|
| Faculty of Engineering | | Strength of Materials |
| BME | Time Allowed:1 Hours | Mid-Term Exam - 2017/2018 |

Name: Department/ Sec.:

## *PROBLEM 1:*

A load P is supported as shown by a steel pin that has been inserted in a short wooden member hanging from the ceiling. The ultimate strength of the wood used is 60 MPa in tension and 7.5 MPa in shear, while the ultimate strength of the steel is 145 MPa in shear.
Knowing that, b = 40 mm, c = 55 mm, and d = 12 mm.
Determine:
The load P if an overall factor of safety of 3.2 is desired.




$\boxed{8}$

**SOLUTION**

Based on double shear in pin: 2

$\tau_{pin} = \frac{145}{3.2} = 45.3$ MPa

$P_1 = 2A\tau = 10.25$ kN

$$P_U = 2A\tau_U = 2\frac{\pi}{4}d^2\tau_U$$
$$= \frac{\pi}{4}(2)(0.012)^2(145\times10^6) = 32.80\times10^3\text{N}$$

Based on tension in wood: 2

$\sigma_w = \frac{60}{3.2} = 18.75$ MPa

$P_2 = A\sigma = 21$ kN

$$P_U = A\sigma_U = w(b-d)\sigma_U$$
$$= (0.040)(0.040-0.012)(60\times10^6)$$
$$= 67.2\times10^3\text{N}$$

Based on double shear in the wood: 2

$\tau_w = \frac{7.5}{3.2} = 2.34$ MPa

$$P_U = 2A\tau_U = 2wc\tau_U = (2)(0.040)(0.055)(7.5\times10^6)$$
$$= 33.0\times10^3\text{N}$$

$P_3 = 2A\tau = 10.25$ kN

Use smallest $\quad P_U = 32.8\times10^3\text{N}$

Allowable: $\quad P = \frac{P_U}{F.S.} = \frac{32.8\times10^3}{3.2} = 10.25\times10^3\text{N}$ 2 $\quad$ 10.25 kN ◄

smallest value is safe

BME

Scanned by CamScanner

$\boxed{12}$

## PROBLEM 2:

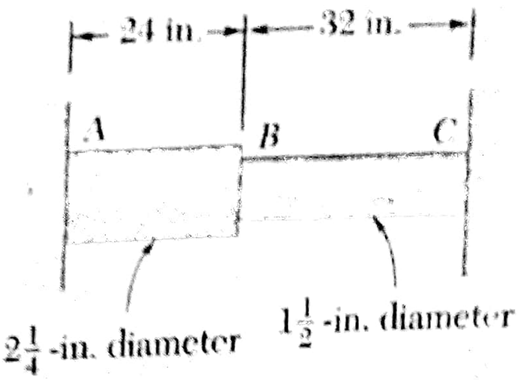
rod consisting of two cylindrical portions $AB$ and $BC$ is restrained at h ends. Portion $AB$ is made of steel ($Es = 29 \times 10^6$ psi, $\alpha = 6.5 \times 10^{-6}$ ) s and portion $BC$ is made of Aluminum ($Ea = 10.4 \times 10^6$ psi, $\alpha$ 3.3 $\times 10^{-6}$ /°F).

owing that the rod is initially unstressed.

termine:

the normal stresses induced in portions $AB$ and $BC$ by a temperature e of 70°F.

the corresponding deflection of point $B$.




**SOLUTION**

$$A_{AB} = \frac{\pi}{4}(2.25)^2 = 3.9761 \text{ in}^2 \quad A_{BC} = \frac{\pi}{4}(1.5)^2 = 1.76715 \text{ in}^2$$


Free thermal expansion. $\Delta T = 70°F$

$$(\delta_T)_{AB} = L_{AB}\alpha_s(\Delta T) = (24)(6.5\times10^{-6})(70) = 10.92\times10^{-3}\text{ in}$$ 2

$$(\delta_T)_{BC} = L_{BC}\alpha_a(\Delta T) = (32)(13.3\times10^{-6})(70) = 29.792\times10^{-3}\text{ in}$$ 2

Total. $\delta_T = (\delta_T)_{AB} + (\delta_T)_{BC} = 40.712\times10^{-3}$ in

Shortening due to induced compressive force $P$

$$(\delta_P)_{AB} = \frac{PL_{AB}}{E_sA_{AB}} = \frac{24P}{(29\times10^6)(3.9761)} = 208.14\times10^{-9}P$$ 2

$$(\delta_P)_{BC} = \frac{PL_{BC}}{E_aA_{BC}} = \frac{32P}{(10.4\times10^6)(1.76715)} = 1741.18\times10^{-9}P$$ 2

Total: $\delta_P = (\delta_P)_{AB} + (\delta_P)_{BC} = 1949.32\times10^{-9}P$

Compression

For zero net deflection, $\delta_P = \delta_T$ $\quad 1949.32\times10^{-9}P = 40.712\times10^{-3}$ $\quad P = 20.885\times10^3$ lb 1

(a) $\sigma_{AB} = -\frac{P}{A_{AB}} = -\frac{20.885\times10^3}{3.9761} = -5.25\times10^3$ psi $\quad \sigma_{AB} = -5.25$ ksi ◄ 1

$\sigma_{BC} = -\frac{P}{A_{BC}} = -\frac{20.885\times10^3}{1.76715} = -11.82\times10^3$ psi $\quad \sigma_{BC} = -11.82$ ksi ◄ 1

(b) $(\delta_P)_{AB} = (208.14\times10^{-9})(20.885\times10^3) = 4.3470\times10^{-3}$ in.

$\delta_B = (\delta_T)_{AB} \rightarrow + (\delta_P)_{AB} \leftarrow = 10.92\times10^{-3} \rightarrow + 4.3470\times10^{-3} \leftarrow$ $\quad \delta_B = 6.57\times10^{-3}$ in. $\rightarrow$ ◄ 1

or

$(\delta_P)_{BC} = (1741.18\times10^{-9})(20.885\times10^3) = 36.365\times10^{-3}$ in.

$\delta_B = (\delta_T)_{BC} \leftarrow + (\delta_P)_{BC} \rightarrow = 29.792\times10^{-3} \leftarrow + 36.365\times10^{-3} \rightarrow = 6.57\times10^{-3}$ in. $\rightarrow$ (checks)

$\delta = \text{zero}$

$\delta_{th} = \alpha \Delta T L$

$\sigma = \frac{F}{A}$

$\delta = \delta_{th} + \delta_{mech}$

$\delta_{mech} = L\frac{F}{AE}$

Best Wishes

Ass.Prof.Dr. Noha Fouda