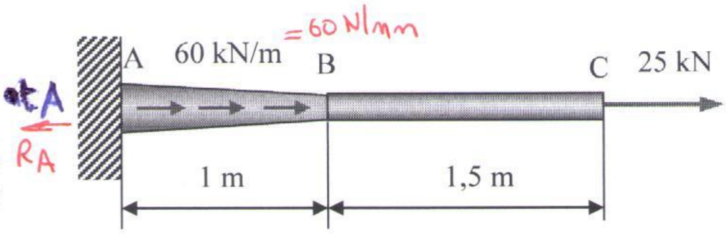
STRENGTH OF MATERIALS I

HOMEWORK 2, Deadline: 11th December 2013

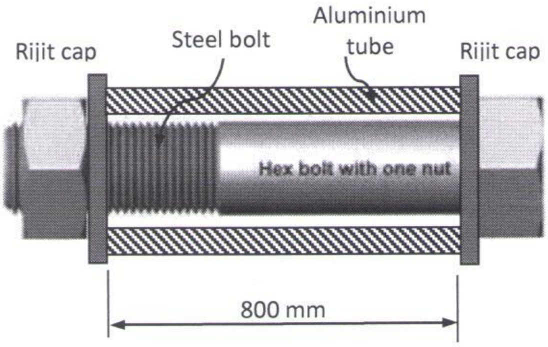
QUESTION 1. The bar shown in the figure has two segments, the bar AB is made of A-36 steel while the bar BC is made of 2024-T6 aluminium. Both of the segments have solid cross-sections. The diameter of AB is 40 mm and the diameter of BC is 20 mm. A distributed axial load of 60kN/m is applied on AB while a single force of 25 kN is applied at the free end, C.

(a) Determine the displacement of the point C.

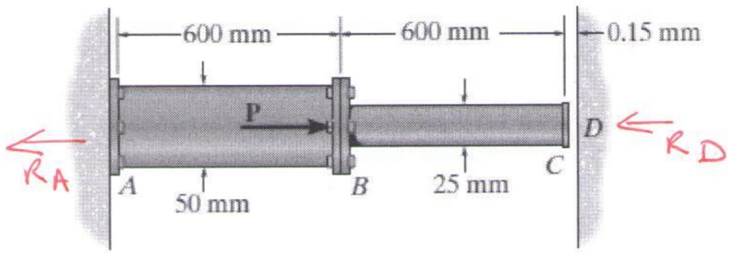
(b) Determine the maximum average normal stress in the bar.



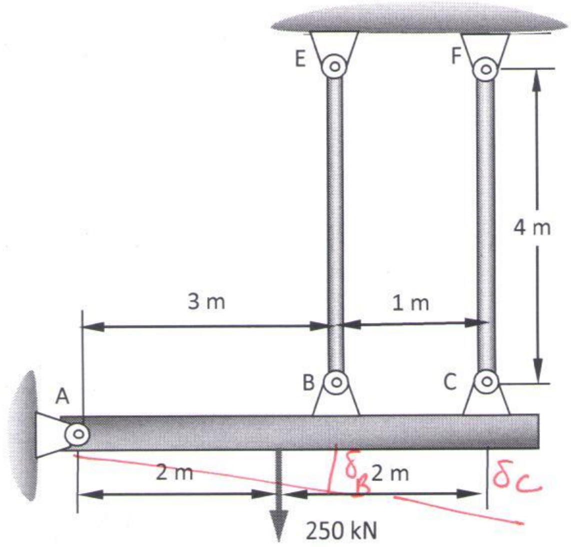
QUESTION 2. The assembly of a 6061-T6 aluminium tube and an A-36 steel bolt is shown in the figure. Each thread of the bolt is 0,8 mm. The cross sectional areas of the tube and the bolt are 900 mm^2 and 450 mm^2, respectively. The bolt has already been tightened such that a 30 MPa compressive stress is present on the tube. If the bolt is further tightened one more turn, determine the normal stress on the aluminium tube.



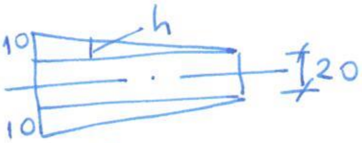
QUESTION 3. When the temperature is $T_1 = 20°C$, the gap between the end C and the rigid wall is 0,15 mm. If the temperature is raised to $T_2 = 50°C$ and an axial force of P = 200 kN is applied to the point B, determine the support reactions at A and D. The assembly is made of A-36 steel material (E_{st}=200 GPa).



QUESTION 4. Before the force P = 250 kN is applied, the ABC rigid bar is horizontal. The cross-sectional areas of the bars EB and FC are 800 mm^2 and 1200 mm^2, respectively. If EB and FC are made of aluminium, determine the stress values in each bar (E_{al}=70 GPa).



1) $R_A = 60000 + 25000 = 85000\,N$



$\frac{10}{1000} = \frac{h}{1000-x} \quad h = \frac{1000-x}{100}$

$$\delta_c = \int_0^{1000} \frac{(85000-60x)\,dx}{2\,10^5 \frac{\pi}{4}\left(20+\frac{1000-x}{50}\right)^2} + \underbrace{\int_0^{1500} \frac{25\,10^3\,dx}{73.1\,10^3 \frac{\pi}{4} 20^2}}_{1.633\,mm}$$

$$= \int_0^{1000} \frac{-3(2x-8500/3)}{2\pi(4\,10^6 - 4\,10^3 x + x^2)}\,dx = \int_0^{1000} \frac{-3}{2\pi}\left[\frac{2x - \frac{8500}{3} - \frac{3500}{3} + \frac{3500}{3}}{4\,10^6 - 4\,10^3 x + x^2}\right]dx$$

$2000 - x = t$

$-dx = dt$

$$= \underbrace{-\frac{3}{2\pi}\left[\ln(2000-x)^2\Big|_0^{1000} + \int_0^{1000} \frac{3500/3}{(2000-x)^2}\,dx\right]}_{0{,}383\,mm}$$

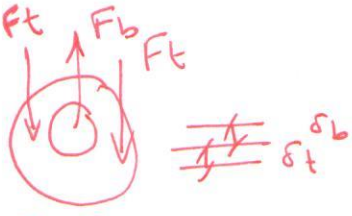
$= 2.016\,mm$

$$\sigma = \frac{P}{A} = \frac{85000-60x}{\frac{\pi}{4}\left(20+\frac{1000-x}{50}\right)^2} \qquad \frac{d\sigma}{dx} = 0 \qquad \frac{2500}{\frac{\pi}{4}} \frac{(85000-60x)}{(2000-x)^2}$$

$x = 2500/3$

$P = 35000\,N \qquad A = \frac{1225}{9}\pi\ mm^2 \qquad \sigma = 81.85\,MPa \qquad \sigma = \frac{25\,10^3}{\frac{\pi}{4}400} = 79.6\,MPa$

2)



$F_t = F_b$

$30 = \frac{P}{450} \qquad P = 13500\,N$

$\delta = \frac{13500 \cdot 800}{2\,10^5 \cdot 450} = 0{,}12\,mm$

$0{,}12 + 0.8 = 0.92\,mm$

$\frac{F_b \cdot 800}{2\,10^5\ 450} - \frac{F_t\,800}{68.9\,10^3\ 900} = 0{,}92 \qquad F_t = F_b = -407639.87\,N$

$\sigma_t = \frac{-407639.87}{900} = -452.93\,MPa$

$\sigma_b = 905.86\,MPa$

3) $\delta = \frac{2\,10^5\,600}{2\,10^5 \frac{\pi}{4} 50^2} + \alpha \Delta T L = 0{,}305 + 12\,10^{-6} \cdot 30 \cdot 1200 = 0.737\,mm$

$\frac{R_A\,600}{2\,10^5 \frac{\pi}{4} 2500} + \frac{(R_A - 2\,10^5)\,600}{2\,10^5 \frac{\pi}{4} 625} + 12\,10^{-6} \cdot 30 \cdot 1200 = 0.15$

$R_A = 123045\,N$

$R_D = 2\,10^5 - R_A = 76954\,N$

4) $\frac{\delta_B}{3} = \frac{\delta_c}{4} \qquad -250 \cdot 2\,10^3 + F_B 3 + F_c \cdot 4 = 0$

$\frac{F_B \cdot 4}{70 \cdot 800} = \frac{3}{4} \frac{F_c \cdot 4}{70 \cdot 1200} \qquad F_B = \frac{F_c}{2} \qquad F_c = 50000/6.5 \qquad F_c = 76923\,N$

$F_B = 38461.5\,N$

$\sigma_{EB} = \frac{38461.5}{800} = 48\,MPa \qquad \sigma_{FC} = \frac{76923}{1200} = 64\,MPa$