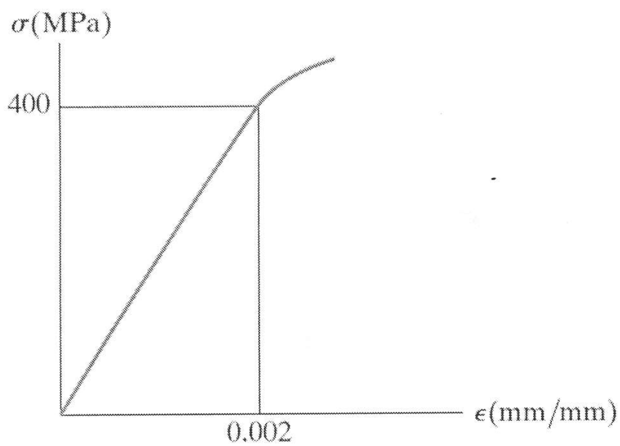
CME 260 – Mechanics of Materials
Exam #3 (02/14/2024)

StarID or TechID (no names) _Grading_

Do one of the two problems shown below (the second problem has two parts and is on the back). Show your work (you will not receive any credit if all you have is a final answer, right or wrong).

1. The elastic portion of the stress-strain diagram of a material is shown below. The specimen used in the testing has a diameter of 13 mm. When a load of 50 kN in tension is applied to the specimen, the diameter contracts to 12.99265 mm. What is the modulus of elasticity, E, and the Poisson's Ratio, v, of the material.



$$E = \frac{400\ MPa}{0.002\ \frac{mm}{mm}} = \boxed{200\ GPa} \quad (2)$$

$$\nu = -\frac{\epsilon_{lat}}{\epsilon_{long}}$$

with 50 kN applied in tension:

$$\sigma = \frac{50\ kN}{\frac{\pi}{4}(0.013\ m)^2} = 376.7\ MPa \quad (2)$$

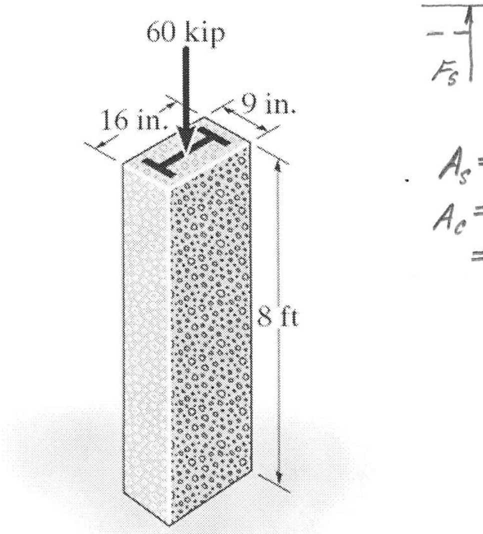
(within elastic portion of stress-strain diagram)

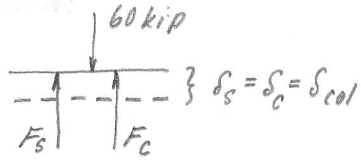
$$\epsilon_{long} = \frac{\sigma}{E} = \frac{376.7\ MPa}{200 \times 10^3\ MPa} = 0.0018835 \quad (2)$$

$$\epsilon_{lat} = \frac{12.99265\ mm - 13\ mm}{13\ mm} = -0.000565 \quad (2)$$

$$\nu = -\frac{(-0.000565)}{0.0018835} = \boxed{0.300} \quad (2)$$

2. Below is a steel column (in black) with an 18 in^2 cross-sectional area. The steel column is encased in concrete (in gray) to the dimensions shown. An axial force of 60 kip is applied to the column. What is the average compressive stress in the steel and the average compressive stress in the concrete? By how much does the 8 ft column shorten? The modulus of elasticity of the steel is 29 x 10^3 ksi and the concrete is 4.20 x 10^3 ksi.





$A_s = 18\ in^2$

$A_c = (16\ in)(9\ in) - 18\ in^2 = 126\ in^2$ (1)

equilibrium:

$\Sigma F_y = 0,\ F_s + F_c - 60\ kip = 0$

$F_s + F_c = 60\ kip$ (1)

compatibility:

$\delta_s = \delta_c$

$$\frac{F_s L}{A_s E_s} = \frac{F_c L}{A_c E_c}$$

$$\frac{F_s}{(18\ in^2)(29 \times 10^3\ \frac{kip}{in^2})} = \frac{F_c}{(126\ in^2)(4.20 \times 10^3\ \frac{kip}{in^2})}$$

$529.2\ F_s = 522\ F_c$

$F_c = \frac{529.2}{522} F_s = 1.0138\ F_s$ (2)

From equilibrium

$F_c = 1.0138\ (60\ kip - F_c)$

$2.0138\ F_c = 60.828\ kip$

$F_c = 30.21\ kip$ (1)

$F_s = 60\ kip - 30.21\ kip = 29.79\ kip$ (1)

$$\sigma_s = \frac{F_s}{A_s} = \frac{29.79\ kip}{18\ in^2} = \boxed{1.66\ ksi}$$ (1)

$$\sigma_c = \frac{F_c}{A_c} = \frac{30.21\ kip}{126\ in^2} = \boxed{0.240\ ksi}$$ (1)

$$\delta_{col} = \delta_s = \frac{F_s L}{A_s E_s} = \frac{(29.79\ kip)(96\ in)}{(18\ in^2)(29 \times 10^3\ \frac{kip}{in^2})} = \boxed{0.00548\ in}$$ (2)