

MOOC – “Mechanics of Materials I”
Week Five Quiz

Problem 1) At a point on the surface of a plane stressed object, the strains are measured to be:

$$\varepsilon_x = 800 \mu \frac{\text{mm}}{\text{mm}} \quad \varepsilon_y = -150 \mu \frac{\text{mm}}{\text{mm}} \quad \gamma_{xy} = 500 \mu \text{rad}$$

The object's material properties are:

$$E = 200 \text{ GPa} \quad \nu = 0.25$$

Determine σ_x , σ_y , and τ_{xy} at the point.

$$\sigma_x = \frac{E}{1-\nu^2} (\varepsilon_x + \nu \varepsilon_y) = \frac{200 \text{ GPa}}{1-(0.25)^2} (800 + (0.25)(-150)) \mu$$

$$\underline{\underline{\sigma_x = 0.163 \text{ GPa}}} \text{ANS}$$

$$\sigma_y = \frac{E}{1-\nu^2} (\varepsilon_y + \nu \varepsilon_x) = \frac{200 \text{ GPa}}{1-(0.25)^2} (-150 + (0.25) 800) \mu$$

$$\underline{\underline{\sigma_y = 0.0107 \text{ GPa}}} \text{ANS}$$

$$G = \frac{E}{2(1+\nu)} = \frac{200 \text{ GPa}}{2(1+0.25)} = 80$$

$$\tau_{xy} = G \gamma_{xy} = 80 \text{ GPa} (500 \mu)$$

$$\underline{\underline{\tau_{xy} = 0.0400 \text{ GPa}}} \text{ANS.}$$

Problem 2) A mechanical part is made of structural steel and subject to an uniaxial tensile force of 150 kN. The member has a cross-sectional area of 1300 mm². The yield stress of the steel is 250 MPa. The ultimate strength of the steel is 450 MPa. Find the Factor of Safety with respect to yield and the Factor of Safety with respect to fracture.

$$FOS_{YIELD} = \frac{YIELD\ STRESS}{ACTUAL\ STRESS}$$

$$\sigma_{ACTUAL} = \frac{N}{A} = \frac{150}{1300}$$

$$\sigma_{ACTUAL} = 0.115\ GPa = 115\ MPa$$

$$FOS_{YIELD} = \frac{250\ MPa}{115\ MPa} = \underline{\underline{2.17}}\ ANS$$

$$FOS_{FRACTURE} = \frac{ULTIMATE\ STRENGTH}{ACTUAL\ STRESS}$$

$$FOS_{FRACTURE} = \frac{450\ MPa}{115\ MPa} = \underline{\underline{3.9}}\ ANS$$

Problem 3) Bar DE is steel and has a cross sectional area of 0.25 in^2 and a modulus of elasticity of 29,000 ksi. $\sigma_{\text{steel yield}} = 36 \text{ ksi}$.

Bar BC is brass and has a cross sectional area of 0.3 in^2 and a modulus of elasticity of 15,000 ksi. $\sigma_{\text{brass yield}} = 30 \text{ ksi}$.

Bar ABDF can be considered rigid. Both the steel and brass bars are deformable. The weight of the bars can be assumed negligible in comparison to the forces they are supporting.

Find the axial stress in the steel and brass bars, and the deflection at point A

Not to Scale

DEFORMATION EQUATION

$$\frac{\delta_D}{2} = \frac{\delta_B}{6}$$

$$\delta_B = 3\delta_D$$

ASSUME LINEAR ELASTIC

$$\delta = \frac{PL}{AE}$$

$$\frac{B_x(16)}{(0.3)(15 \times 10^3)} = 3 \frac{D_x(8)}{(0.25)(29 \times 10^3)}$$

$$B_x = 0.931 D_x$$

EQUILIBRIUM EQUATION

$$\sum M_F = 0$$

$$5.4(10) - B_x(6) - D_x(2) = 0$$

$$3B_x + D_x = 27$$

SOLVE SIMULTANEOUSLY

$$D_x = 7.12 \text{ kips}$$

$$B_x = 6.63 \text{ kips}$$

STRESSES

$$\sigma_{DE} = \frac{D_x}{A_{DE}} = \frac{7.12 \text{ kips}}{0.25 \text{ in}^2} = 28.5 \text{ ksi} < \sigma_{\text{STEEL YIELD}} = 36 \text{ ksi}$$

$$\sigma_{BC} = \frac{B_x}{A_{BC}} = \frac{6.63 \text{ kips}}{0.3 \text{ in}^2} = 22.1 \text{ ksi} < \sigma_{\text{BRASS YIELD}} = 30 \text{ ksi}$$

NEITHER BAR HAS YIELDED
= LINEAR ELASTIC ASSUMPTION HOLDS

DEFLECTIONS

$$\delta_D = \sigma_{DE} \frac{L_{DE}}{E_{DE}} = 28.5 \left(\frac{8}{29000} \right) = 0.007862 \text{ in}$$

$$\frac{\delta_D}{2} = \frac{\delta_A}{10} \Rightarrow \delta_A = 5\delta_D = 0.0393 \text{ in}$$