ENGR 350 - Mechanics of Materials, Fall 2013

Homework #2

Due: Fri., Sept. 12

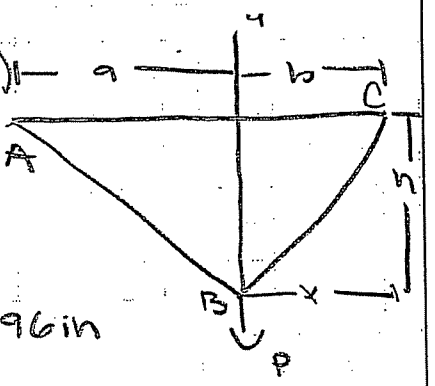
1. Problem P2.2, p. 38
2. Problem P2.4, p. 38
3. Problem P2.6, p. 39
4. Problem P2.10, p. 42
5. Problem P2.11, p. 42
6. Problem P2.13, p. 43

(all problems are from the textbook).

Problem 2.2

Given: B (0,0) B* (.35 in, -.6 in)

a = 11ft b = 6ft h = 8ft



Find: normal strain in each bar

Solution:

a = 132 in b = 72 in c = 96 in

$$L_{AB} = \sqrt{(132\text{ in})^2 + (96\text{ in})^2}$$

$$L_{AB} = 163.2176\text{ in}$$

$$L_{AB}' = \sqrt{(132.35\text{ in})^2 + (96.6\text{ in})^2}$$

$$L_{AB}' = 163.8538\text{ in}$$

$$\varepsilon_{AB} = \frac{163.85 - 163.2176\text{ in}}{163.2176}$$

$$\boxed{\varepsilon_{AB} = 3900\ \mu\varepsilon}$$

$$L_{BC} = \sqrt{(72)^2 + (96\text{in})^2}$$

$$= 120\text{ in}$$

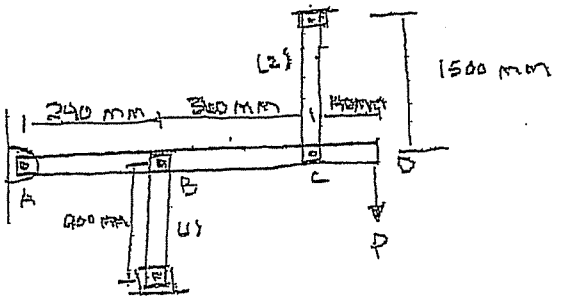
$$L_{BC}' = \sqrt{(71.65\text{ in})^2 + (96.6\text{ in})^2}$$

$$= 120.2717\text{ in}$$

$$\varepsilon_{BC} = \frac{120.2717\text{ in} - 120\text{ in}}{120\text{ in}}$$

$$\boxed{\varepsilon_{BC} = 2260\ \mu\varepsilon}$$

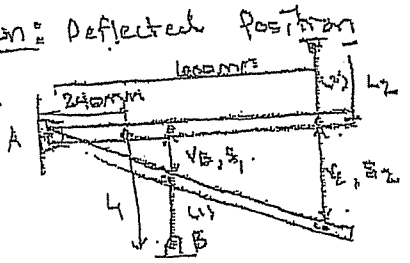
2.4



Given: Before the vertical bars before P. After load P is applied normal strain in rod (1) is $-570\ \mu\text{in/in}$

Find: a) normal strain in rod (2)
b) normal strain in rod (2) with a 1 mm gap in the connection at C before P is applied.
c) normal strain in rod (2) with a 1 mm gap in the connection at B before P is applied.

Solution: Deflected position



a) $\delta_1 = \varepsilon_1 L_1$

$= (-570 \times 10^{-6})(900\ \text{mm})$

$= -0.5130\ \text{mm}$

$v_B = 0.5130\ \text{mm}$ downward

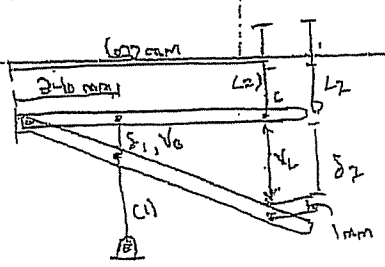
$\frac{v_B}{240\ \text{mm}} = \frac{v_C}{1500\ \text{mm}}$

$v_C = \left(\frac{1500\ \text{mm}}{240\ \text{mm}}\right)(0.5130\ \text{mm}) = 1.2825\ \text{mm}$ ↓

$\varepsilon_2 = \delta_2 / L_2 = \frac{1.2825\ \text{mm}}{1500\ \text{mm}} = \boxed{855\ \mu\varepsilon}$

2.4 continued

B)

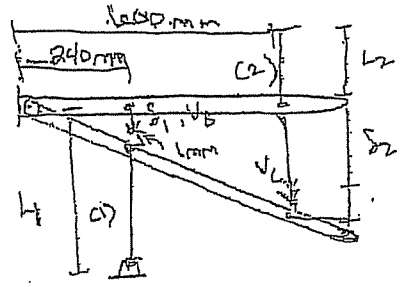


$\delta_2 = V_C - 1\,mm$

$= 1.2825\,mm - 1\,mm = 0.2825\,mm$

$\varepsilon_2 = \delta_2 / L_2 = \frac{0.2825\,mm}{1,500\,mm} = 188.3 \times 10^{-6} = \boxed{188.3\,\mu\varepsilon}$

C)



$V_B = \delta_1 + 1\,mm$

$= 0.5130\,mm + 1\,mm = 1.5130\,mm$

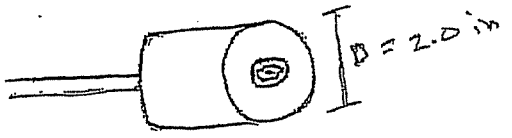
$\frac{V_B}{240\,mm} = \frac{V_L}{(240 + 360)\,mm}$

$V_L = \frac{1500\,mm}{240\,mm}(1.5130\,mm) = 3.7825\,mm$

$\varepsilon_2 = \delta_2 / L_2 = \frac{3.7825\,mm}{1,500\,mm} = 2.521 \times 10^{-6}\,mm/mm$

$= \boxed{2,520\,\mu\varepsilon}$

2.16

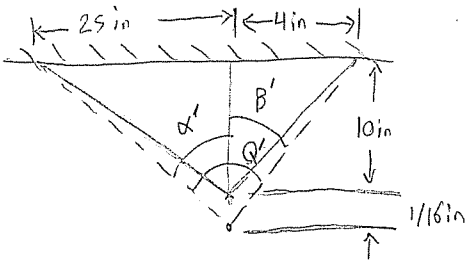


$\Delta D = 2.15\,in - 2.0\,in$
$= 0.15\,in$

a) $\varepsilon_D = \frac{\Delta D}{D} = \frac{(2.15 - 2.0)\,in}{2.0\,in} = 0.075\ \frac{in}{in}$

b) $\varepsilon_C = \frac{\Delta C}{C} = \frac{\pi(2.15)\,in - \pi(2.0\,in)}{\pi \cdot (2.0\,in)} = 0.075\ \frac{in}{in}$

2.10)



Find the difference between Q (before deformation) and Q' (after deformation)

if $Q = 90^\circ = \pi/2$ rads

$$\alpha' = \tan^{-1}\left[\frac{25\,in}{10\,in + \frac{1}{16}\,in}\right]$$

$$= 68.1^\circ$$

$$\beta' = \tan^{-1}\left[\frac{4\,in}{10\,in + 1/16\,in}\right]$$

$$= 21.7^\circ$$

$$Q' = \alpha' + \beta'$$

$$= 68.1^\circ + 21.7^\circ$$

$$= 89.8^\circ \left[\frac{\pi\ rad}{180\ deg}\right]$$

$$= 1.567\ rad$$

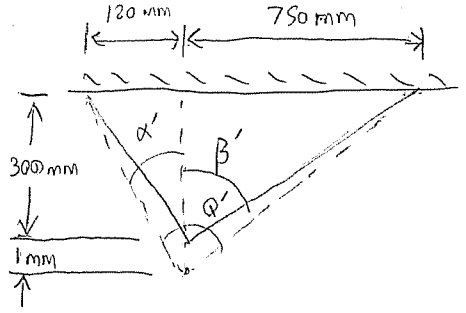
$$\gamma = Q - Q'$$

$$= \pi/2 - 1.567\ rad$$

$$= 0.004296\ rad$$

$$\boxed{\gamma = 4{,}300\ \mu rad}$$

2.11)



Find the change in Q caused by the deformation (shear strain, Q')

$$\alpha' = \tan^{-1}\left[\frac{120\text{ mm}}{300\text{ mm} + 1\text{ mm}}\right]$$

$$= 21.7^\circ$$

$$\beta' = \tan^{-1}\left[\frac{750\text{ mm}}{300\text{ mm} + 1\text{ mm}}\right]$$

$$= 68.1^\circ$$

$$Q' = \alpha' + \beta'$$

$$= 21.7^\circ + 68.1^\circ$$

$$= 89.8^\circ \left[\frac{\pi\text{ rad}}{180\text{ deg}}\right]$$

$$= 1.569\text{ rad}$$

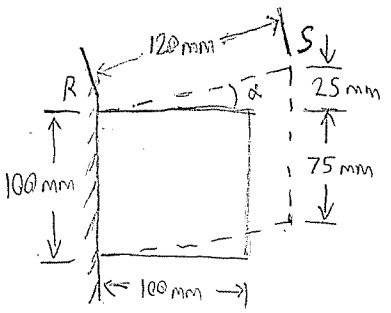
$$\gamma = Q - Q'$$

$$= \pi/2 - 1.569\text{ rad}$$

$$= 0.002394\text{ rad}$$

$$\boxed{\gamma = 2{,}300\ \mu\text{rad}}$$

2.13)



Determine shear strain

(a) at corner R

(b) at corner S

(a) $\alpha = \sin^{-1}\left[\frac{25\text{ mm}}{120\text{ mm}}\right]$

$= 0.210$ rad

$R = \pi/2$; $S = \pi/2$

$R' = R + \alpha$

$= \pi/2 + 0.210\text{ rad} = \pi/2 - \gamma_R$

$\boxed{\gamma_R = -0.210\text{ rad}}$

(b) 'S is deformed inversely to R

$S' = S - \gamma_S$

$= \pi/2 - \gamma_S = \pi/2 - 0.210\text{ rad}$

$\boxed{\gamma_S = 0.210\text{ rad}}$