DEPARTMENT OF CIVIL ENGINEERING, IIT BOMBAY

CE 221 Solid Mechanics: QUIZ 1

Note: **Assume suitable data if not given.**

21/08/2014 Total Marks:10 Duration: 1 hr Instructors N.K.Chandiramani/S. Banerjee

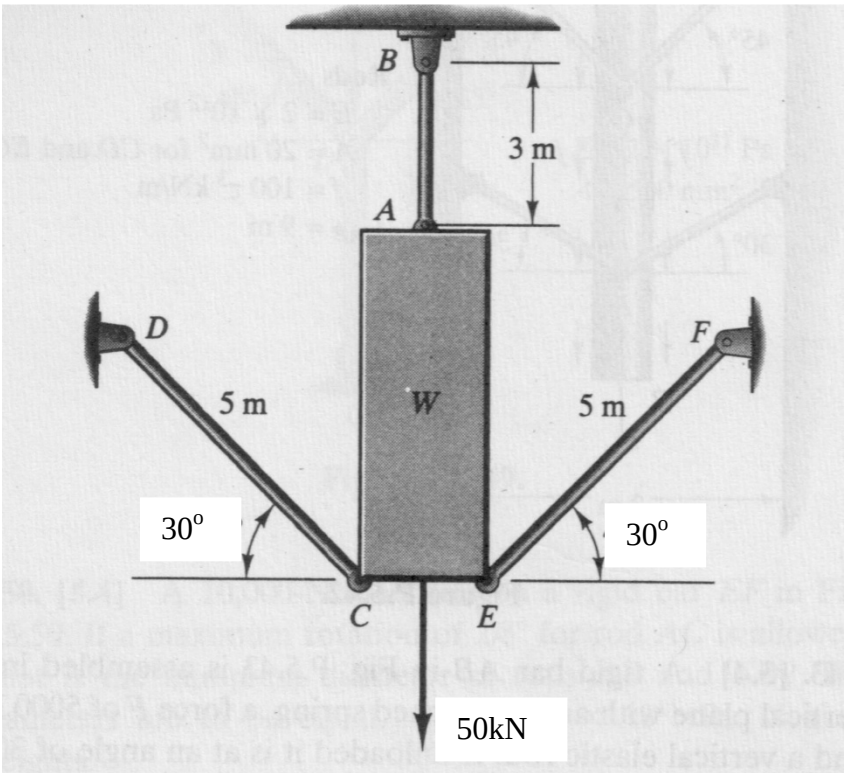
Problem 1 (5 marks):

A rigid block weighing 80kN is supported by rods *AB*, *CD*, and *EF*, each having diameter 100mm, Young's modulus E = 200GPa, and coefficient of thermal expansion α = 12.0 x 10^{-6}/°C. Considering a temperature decrease of 5° C in rod *AB* only, and the weight of the block, and the 50kN force applied as shown, find:

(i) stresses in the rods

(ii) vertical movement of the block.

Hint: Assuming small deformation, ignore the change in angles of rods *CD* and *EF* due to vertical movement of the rigid block.



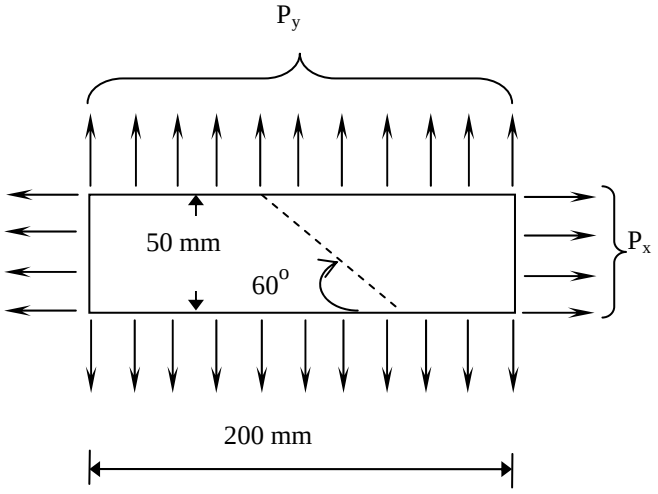
Problem 2 (5 marks):

A piece of 50 x 200 x 10 mm steel plate is subjected to uniformly distributed stresses along its edges as shown.Consider E=200 GPa and ν=0.25.

(a) If P_X = 100 kN and P_Y = 200 kN,what change in thickness occurs due to the application of these forces?

(b) If $P_X$acts alone, what should its magnitude be so as to cause the same change in thickness as in part (a)?

(c) Determine the stresses on the inclined plane shown as dotted line when $P_X$of part (b) acts alone.



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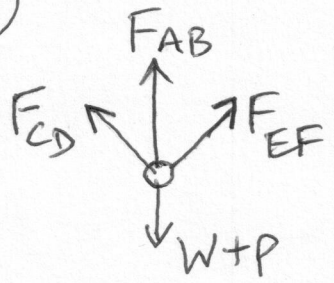
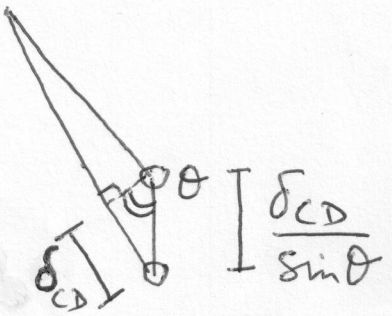
①



Symmetry → $F_{CD} = F_{EF}$

Equilibrium ($\Sigma F_y = 0$) → $2F_{CD}\sin\theta + F_{AB} = W + P$ → ①



Compatibility → $\frac{\delta_{CD}}{\sin\theta} = \delta_{AB}$

Displacements in compat → $\frac{F_{CD}L_{CD}}{AE\sin\theta} = \frac{F_{AB}L_{AB}}{AE} + \alpha\Delta T L_{AB}$ → ②

① , ② → $F_{CD}\left(\frac{L_{CD}}{AE\sin\theta} + \frac{2\sin\theta\, L_{AB}}{AE}\right) = \alpha\Delta T L_{AB} + \frac{(W+P)L_{AB}}{AE}$

Put $\theta = 30°$, $L_{CD} = 5m$, $L_{AB} = 3m$, $\alpha = 12E{-}6$, $\Delta T = -5$, $W = 80000$, $P = 50000$, $A = \frac{\pi}{4}(100E{-}3)^2$, $E = 200E9$

$F_{CD} = 8250.51\,N$, $F_{AB} = 121749.49\,N$.

(i) $\sigma_{AB} = \frac{F_{AB}}{A_{AB}} = 15.50\ MPA$, $\sigma_{CD} = 1.05\ MPA$ ◀

(ii) $\delta_{CE} = \frac{F_{CD}L_{CD}}{AE\sin\theta} = 0.0525\ mm$ ◀

(2) (a) $\sigma_x = \frac{100E3}{(50)(10)}$ MPa $= 200$ MPa , $\sigma_y = \frac{200E3}{(200)(10)} = 100$MPa.

all other stresses zero

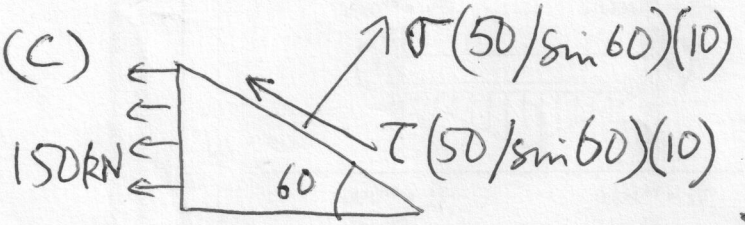
$$\varepsilon_z = -\frac{\nu}{E}(\sigma_x + \sigma_y) = -\frac{0.25}{200E3}(200+100) = -3.75E{-}4$$

$$\Delta t = 10\,\varepsilon_z = -3.75 * 10^{-3} \text{ mm} \blacktriangleleft$$

(b) Need $\sigma_x = 200 + 100 = 300 \Rightarrow P_x = (300)(50)(10)$

$= 15E4\,N = 150$ kN. ▶

(c)



$$\Sigma F_\sigma = 0 \rightarrow \sigma\left(\frac{50}{\sin 60}\right)(10) = 150\cos 30$$

$$\Sigma F_\tau = 0 \rightarrow \tau\left(\frac{50}{\sin 60}\right)(10) + 150\sin 30 = 0$$

$$\sigma = 0.225\,\frac{kN}{mm^2} = 225\,MPa \blacktriangleleft$$

$$\tau = -0.1299\,\frac{kN}{mm^2} = -129.9\,MPa \blacktriangleleft$$