

Question 1

$$\epsilon_x = 22 \times 10^{-6}$$

$$\epsilon_y = -12 \times 10^{-6}$$

$$\nu = 0,28$$

$$E = 170 \cdot 10^9 \text{ Pa}$$

(i) $\sigma_x = ?$

$\sigma_y = ?$

compressive or tensile

(ii) $\sigma_y = 42 \cdot 10^6 \text{ Pa}$

$\epsilon_x = ?$

$\sigma_x = 82 \cdot 10^6 \text{ Pa}$

$\epsilon_y = ?$

(i) $\sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \cdot \epsilon_y)$

check?

$$\sigma_x = \frac{170 \cdot 10^9}{1-0,28^2} \cdot (22 \cdot 10^{-6} - 0,28 \cdot 12 \cdot 10^{-6})$$

$$\sigma_y = \frac{E}{1-\nu^2} (\epsilon_y + \nu \cdot \epsilon_x)$$

$$\sigma_x = 1,84 \cdot 10^{11} \cdot 1,864 \cdot 10^{-5}$$

$$\sigma_y = \frac{170 \cdot 10^9}{1-0,28^2} (-12 \cdot 10^{-6} + 0,28 \cdot 22 \cdot 10^{-6})$$

$$\sigma_x = 34,3 \cdot 10^5 \text{ Pa (N/m}^2\text{)}$$

↳ tensile (positive)

$$\sigma_y = 1,84 \cdot 10^{11} \cdot (-5,84 \cdot 10^{-6})$$

$$\sigma_y = -10,8 \cdot 10^5 \text{ Pa (N/m}^2\text{)}$$

↳ compressive (negative)

(ii) $\sigma_x = 82 \cdot 10^6 \text{ Pa}$ $\sigma_y = 42 \cdot 10^6 \text{ Pa}$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \cdot \sigma_y)$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \cdot \sigma_x)$$

$$\epsilon_x = \frac{1}{170 \cdot 10^9} \cdot (82 \cdot 10^6 - 0,28 \cdot 42 \cdot 10^6)$$

$$\epsilon_y = \frac{1}{170 \cdot 10^9} (42 \cdot 10^6 - 0,28 \cdot 82 \cdot 10^6)$$

$$\epsilon_x = 5,88 \cdot 10^{-12} \cdot (70,2 \cdot 10^6)$$

$$\epsilon_y = 5,88 \cdot 10^{-12} (14 \cdot 10^6)$$

$$\epsilon_x = 4,13 \cdot 10^{-4}$$

$$\epsilon_y = 1,12 \cdot 10^{-4}$$

Question 2

given

$$\sigma_x = 103 \cdot 10^6 \text{ Pa}$$

$$\sigma_y = 202 \cdot 10^6 \text{ Pa}$$

$$\tau_{xy} = 125 \cdot 10^6 \text{ Pa}$$

$$(i) \sigma_1 = ? \quad \sigma_2 = ? \quad \checkmark \text{ Asked}$$

$$(ii) \tau_{max} = ? \quad \tau_{min} = ?$$

(iii) Mohr's circle

$$(i) \sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$\sigma_1 = \frac{103 \cdot 10^6 + 202 \cdot 10^6}{2} + \frac{\sqrt{(103 \cdot 10^6 - 202 \cdot 10^6)^2 + 4 \cdot (125 \cdot 10^6)^2}}{2}$$

$$\sigma_1 = 155,5 \cdot 10^6 + 133,3 \cdot 10^6 = 288,9 \cdot 10^6 \text{ Pa}$$

$$\sigma_1 = 288,9 \cdot 10^6 \text{ Pa}$$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$\sigma_2 = 155,5 \cdot 10^6 - 133,3 \cdot 10^6 = 22,1 \cdot 10^6 \text{ Pa}$$

$$\sigma_2 = 22,1 \cdot 10^6 \text{ Pa}$$

$$(ii) \tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{288,9 \cdot 10^6 - 22,1 \cdot 10^6}{2} = 133,3 \cdot 10^6 \text{ Pa}$$

$$\tau_{max} = 133,3 \cdot 10^6 \text{ Pa}$$

$$\tau_{min} = -\left[\frac{\sigma_1 - \sigma_2}{2}\right] = -133,3 \cdot 10^6 \text{ Pa}$$

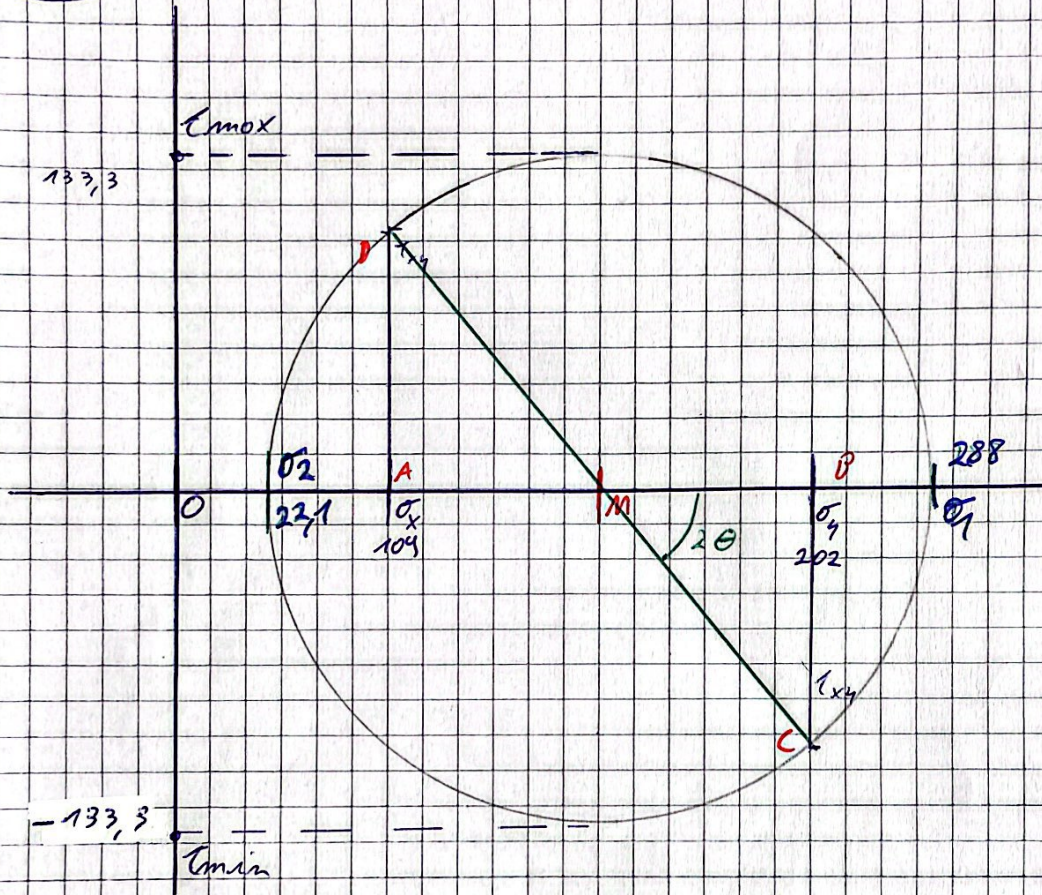
$$\tau_{min} = 133,3 \cdot 10^6 \text{ Pa}$$

ACHA 5015

Question 2

iii

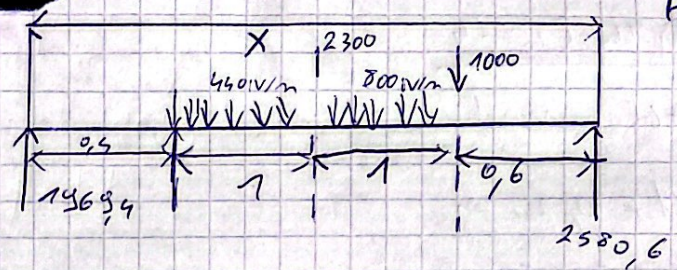
All numbers displayed are $\times 10^6$ PoC



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Question 3

i) Around R_D

$$EI \cdot \frac{d^2 y}{dx^2} = M = (1969.4 \cdot x) - \frac{450(x-0.5)^2}{2} + \frac{450 \cdot (x-1.5)^2}{2} - 2300 \cdot (x-1.5) - \frac{800 \cdot (x-1.5)^2}{2} + \frac{800 \cdot (x-2.5)^2}{2} - 1000 \cdot (x-2.5) \quad (1)$$

ii) integrating (1):

$$EI \cdot \frac{dy}{dx} = \frac{(1969.4 \cdot x)^2}{2} - \frac{450(x-0.5)^3}{6} + \frac{450(x-1.5)^3}{6} - \frac{2300 \cdot (x-1.5)^2}{2} - \frac{800 \cdot (x-1.5)^3}{6} + \frac{800 \cdot (x-2.5)^3}{6} - \frac{1000 \cdot (x-2.5)^2}{2} + A \quad (2)$$

integrating (2):

$$EI \cdot y = \frac{1969.4 x^3}{6} - \frac{450 \cdot (x-0.5)^4}{24} + \frac{450 \cdot (x-1.5)^4}{24} - \frac{2300 \cdot (x-1.5)^3}{6} - \frac{800 \cdot (x-1.5)^4}{24} + \frac{800 \cdot (x-2.5)^4}{24} - \frac{1000 \cdot (x-2.5)^3}{6} + Ax + B \quad (3)$$

$$\left. \begin{array}{l} \text{At } x=0 \quad y=0 \\ \text{or } x=3.1 \quad y=0 \end{array} \right\} \text{ in to (3)}$$

$$EI(0) = 0 - 0 + \frac{450(-1.5)^4}{24} - 0 - 0 + \frac{800(-2.5)^4}{24} - 0 + 0 + B$$

$$0 = 99.92 + 1302.1 + B \quad \Rightarrow \boxed{B = -1397}$$

$$EI(0.7) = \frac{1969.4 \cdot 0.7^3}{6} - \frac{450 \cdot (0.7-0.5)^4}{24}$$

Question 3

ii) continued

A Part (iv) is already in this

$$y=0 \quad x=3,1$$

$$\begin{aligned} 0 = & \frac{1469 \cdot 3,1^3}{6} - \frac{450 \cdot (3,1-0,5)^4}{24} + \frac{450 \cdot (3,1-0,5)^4}{24} \\ & - \frac{2300 \cdot (3,1-1,5)^3}{6} - \frac{800 \cdot (3,1-1,5)^4}{24} + \frac{800 \cdot (3,1-2,5)^4}{24} \\ & - \frac{1000 \cdot (3,1-2,5)^3}{6} + A \cdot 3,1 - 1397 \end{aligned}$$

$$\begin{aligned} -A \cdot 3,1 = & 9776,41 - 856,83 + 122,88 - 1570,13 - 218,45 \\ & + 4,32 - 36 - 1397 \end{aligned}$$

$$-3,1A = 5825,12$$

$$A = -1879,07$$

slope:

A in to (2)

$$\begin{aligned} \frac{dy}{dx} = & \left(\frac{1469 \cdot x^2}{2} - \frac{450 \cdot (x-0,5)^3}{6} + \frac{450 \cdot (x-1,5)^3}{6} - \frac{2300 \cdot (x-1,5)^2}{2} \right. \\ & \left. - \frac{800 \cdot (x-1,5)^3}{6} + \frac{800 \cdot (x-2,5)^3}{6} - \frac{1000 \cdot (x-2,5)^2}{2} - 1879 \right)_{E \circ I} \end{aligned}$$

$$\frac{dy}{dx} = \text{full equation}_{E \circ I}$$

Question 3

iii

Reflection

$$\begin{aligned}
 E.I.g = & \frac{1464 \cdot x^3}{6} - \frac{450 \cdot (x-0,5)^4}{24} + \frac{450 \cdot (x-1,5)^4}{24} \\
 & - \frac{2300 \cdot (x-1,5)^3}{6} - \frac{800 \cdot (x-1,5)^4}{24} + \frac{800 \cdot (x-2,5)^4}{24} \\
 & - \frac{1000 \cdot (x-2,5)^3}{6} - 1879,07x - 1397
 \end{aligned}$$

iv

can be found in (ii)

$$A = -1879,07$$

$$B = -1397$$

Question 4

ACHASO-14

P6

thin wall

1.1.18 calculation

03/05/22

$$d = 0,28 \text{ m}$$

$$L = 0,600 \text{ m}$$

$$\eta_L = 52\% = 0,54$$

$$\eta_C = 62\% = 0,62$$

$$P = 14,9 \text{ bar} = 14,9 \cdot 10^5 \text{ N/m}^2$$

$$\sigma_{\text{max}} = 150 \cdot 10^6 \text{ N/m}^2$$

i

$$\sigma_C = \frac{P \cdot D}{2 \cdot t \cdot \eta_L} \quad \Rightarrow \quad t \cdot \sigma_C = \frac{P \cdot D}{2 \cdot \eta_L} \quad \Rightarrow \quad t = \frac{P \cdot D}{2 \cdot \sigma_C \cdot \eta_L}$$

$$t_C = \frac{14,9 \cdot 10^5 \cdot 0,28}{2 \cdot 150 \cdot 10^6 \cdot 0,54} = 0,00257 \text{ m} = t_C$$

ii

$$\sigma_L = \frac{P \cdot D}{4 \cdot t \cdot \eta_C} \quad \Rightarrow \quad t = \frac{P \cdot D}{2 \cdot \sigma_L \cdot \eta_C}$$

$$t_L = \frac{14,9 \cdot 10^5 \cdot 0,28}{4 \cdot 150 \cdot 10^6 \cdot 0,64} = 0,00108 \text{ m} = t_L$$

iii

$t_{\text{min}} = \text{largest}$
~~smallest~~
from t_C and t_L

$$= 2,57 \text{ mm}$$

iii minimum thickness = $0,00257 \text{ m} = 2,57 \text{ mm}$

ii minimum thickness longitudinal stress = $0,00108 \text{ m}$
 $= 1,08 \text{ mm}$

i min. thickness circumferential stress = $0,00257 \text{ m}$
 $= 2,57 \text{ mm}$

Question 5

ACHASO15

$$L = 1,32 \text{ m}$$

$$D = 0,01305 \text{ m}$$

$$t = 0,0012 \text{ m}$$

$$E = 200 \cdot 10^9 \text{ Pa}$$

PAG

$$(i) \quad I_{xx} = \frac{\pi}{64} (0,01305^4 - 0,01665^4) = 2,69 \cdot 10^{-9} \text{ m}^4$$

(ii) bottom fully restrained, top unrestrained.

$$m = 0,25$$

$$(iii) \quad F_{CR} = \frac{m \cdot \pi \cdot E \cdot I}{L^2} = \frac{0,25 \cdot \pi \cdot 200 \cdot 10^9 \cdot 2,69 \cdot 10^{-9}}{1,32^2}$$

$$F_{CR} = 242,5 \text{ N}$$

$$(iv) \quad SR = \frac{L}{k} = \frac{1,32}{0,00632} = 208,8$$

$$k = \sqrt{\frac{EI}{A}} = \sqrt{\frac{2,69 \cdot 10^{-9}}{6,72 \cdot 10^{-5}}} = 0,00632$$

$SR > 120$, so in
"strut"