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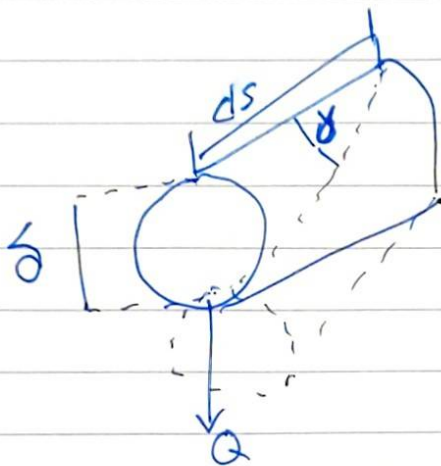
Name: Simon Ellis-Williams P150613

Date: 11/5/2020

Time: 1pm

Module: M6x00420 - Stress Analysis + FEA

2) a)



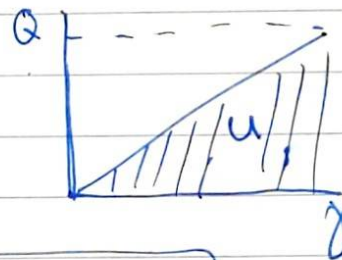
2)

Ai) Prove: $\gamma = \frac{Q}{AG}$: $G = \frac{\tau}{\gamma}$

$\therefore \tau = \frac{Q}{A}$

$\therefore G = \frac{Q}{\gamma A}$

$\therefore \gamma = \frac{Q}{GA}$



$U = \frac{1}{2} \gamma Q$

$\gamma = \frac{Q}{AG} \therefore U = \frac{1}{2} \frac{Q}{AG} Q$

$\therefore U = \frac{Q^2}{2AG}$

$\therefore U_{\text{tot}} = \int_0^L \frac{Q^2}{2AG} ds$

$U_{\text{tot}} = \frac{Q^2 L}{2AG}$

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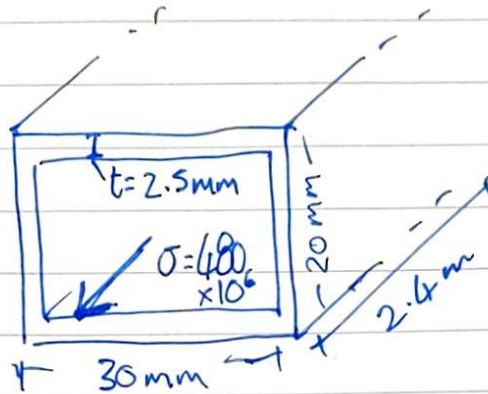
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2b1)

$$E = 190 \times 10^9 \text{ Pa}$$



$$U = \frac{P^2 L}{2AE} \rightarrow U = \frac{\sigma^2 A^2 L}{2AE}$$

$$\therefore U = \frac{\sigma^2 AL}{2E}$$

$$\begin{aligned} A &= \text{outer} - \text{inner} \\ &= (30 \times 20) - (15 \times 25) \\ &= 225 \text{ mm}^2 \\ &= 0.000225 \text{ m}^2 \end{aligned}$$

$$\therefore U = \frac{(480 \times 10^6)^2 \times (2.25 \times 10^{-4}) \times (2.4)}{2 \times (190 \times 10^9)}$$

$$U = 327.41 \text{ J}$$

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2bii) prove $h = \frac{\sigma^2 V}{2EW}$

Relationships

$L = \frac{V}{A}$

$E = \frac{\sigma}{\epsilon}$

$V = AL$ $A = \frac{V}{L}$

$P = \sigma A$

$PE = mgh = u$

$u = \frac{P^2 L}{2AE} = mgh$

$PE = mgh = u$

Find sigma: $P = \sigma A$

$u = \frac{\sigma^2 A^2 L}{2AE} \Rightarrow \frac{\sigma^2 AL}{2E} \Rightarrow \frac{\sigma^2 V}{2E} = mgh$

$u = \frac{\sigma^2 V}{2Emg} = h$

if $mg = W$

$u = \frac{\sigma^2 V}{2EW} = h$

2biii) $m = 20 \text{ kg}$ $\therefore \frac{\sigma^2 V}{2Emg} = h \Rightarrow \sqrt{\frac{h 2Emg}{V}} = \sigma$
 $h = 0.450 \text{ m}$

$\therefore \sqrt{\frac{(0.450) \times (2) \times (190 \times 10^9) \times (20) \times (9.81)}{(2.25 \times 10^{-4}) \times (2.4)}} = \sigma = 249.26 \times 10^6 \text{ N/m}^2$

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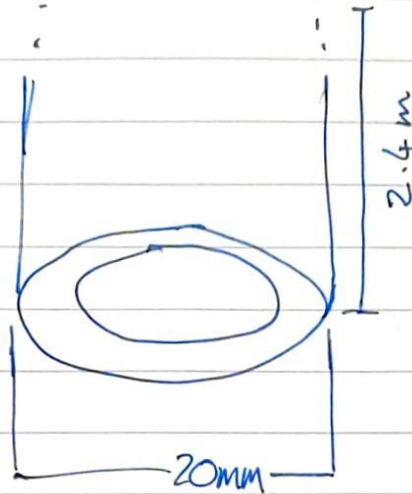
2bIV)

$$\sigma = 249 \times 10^6 \text{ N/m}^2$$

$$m = 20 \text{ kg}$$

$$h = 450 \text{ mm}$$

$$E = 190 \times 10^9 \text{ Pa}$$



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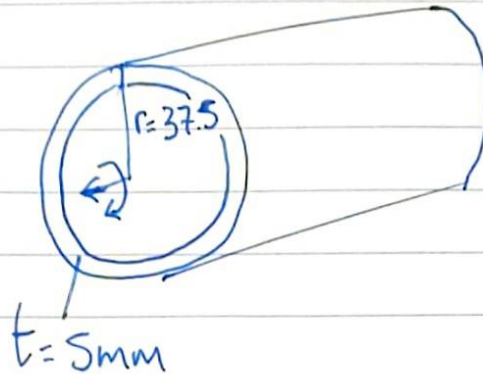
Name: Simon Ellis-Williams P150613 Date: 11/5/2020

Time: 7pm

module: M6x00420 - Stress analysis + FEA

3)A)

2D system



$$\sigma_{\max} = 325 \times 10^6 \text{ N/m}^2$$

$$\nu = 0.3$$

$$SF = 6$$

$$\therefore r_{in} = 32.5$$

A = outer - inner

$$= \pi r_o^2 - \pi r_i^2$$

$$= \pi 37.5^2 - \pi 32.5^2$$

$$A = \underline{1.0996 \times 10^3 \text{ m}^2}$$



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Time: 1pm

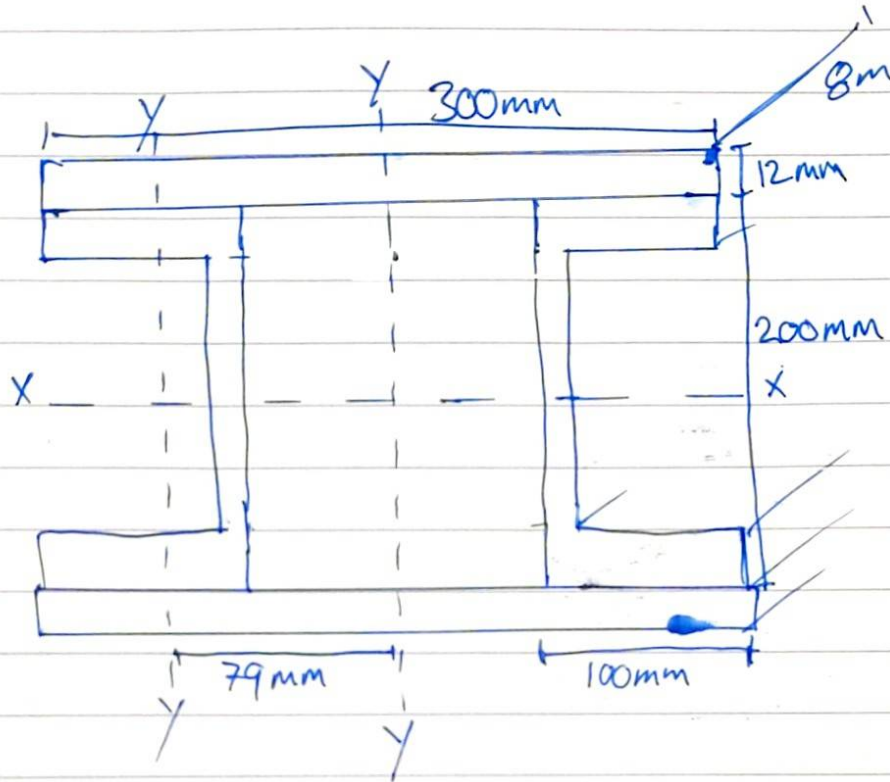
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4)

$$E = 200 \times 10^9$$

$$\alpha = \frac{1}{7500}$$

$$\sigma_y = 320 \times 10^6$$



1 Channel

$$I_{xx} = 26.2 \times 10^6 \text{ mm}^4$$

$$I_{yy} = 1.57 \times 10^6 \text{ mm}^4$$

$$A = 4400 \text{ mm}^2$$

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A)

$$I_{xx} = 2 \text{ plates} + 2 \text{ channels}$$

$$= 2(I + Ah^2) + 2(26.2 \times 10^6)$$

$$= 2 \times \left(\frac{bd^3}{12} + Ah^2 \right) + 2(26.2 \times 10^6)$$

$$= 2 \times \left(\left(\frac{300 \times 12^3}{12} \right) + (300 \times 12) \times (100)^2 \right) + 2(26.2 \times 10^6)$$

$$= 80.99 \times 10^6 + 2 \times (26.2 \times 10^6)$$

$$= 133.39 \times 10^6 \text{ mm}^4$$

$$\times 10^{-12} = 133.39 \times 10^{-6}$$

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Time:

Module:

$$\begin{aligned} I_{yy} &= 2 \times (I_{yy}) + 2 \times (I_{yy} \text{ plate}) \\ &= 2 \times ((1.57 \times 10^6) + Ah^2) + 2 \left(\frac{bd^3}{12} \right) \\ &= 2 \times (1.57 \times 10^6) + (4400) \times (79^2) + 2 \left(\frac{12 \times 300^3}{12} \right) \\ &= 2 \times (58.06 \times 10^6) + 2 \times (27 \times 10^6) \end{aligned}$$

$$I_{yy} = \underline{112.06 \times 10^6 \text{ mm}^4} \times 10^{-12} = 112.06 \times 10^{-6}$$

buckles about I_{yy}

$$\text{b) rad of gyration } K = \sqrt{\frac{I}{A}} = \sqrt{\frac{112.06 \times 10^6}{16000 \times 10^{-6}}} = \underline{\underline{0.08369 \text{ m}}}$$

$$\begin{aligned} A &= 2(4400) + 2(300 \times 12) \\ &= \underline{16000 \text{ mm}^2 \times 10^{-6}} \end{aligned}$$

$$\text{c) slender ratio} = \frac{L}{K} = \frac{8}{0.08369} = \underline{\underline{95.59}}$$

$$\text{d) euler } P_e = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 \times (200 \times 10^9) \times (112.06 \times 10^{-6})}{8^2}$$

$$P_e = 3.456 \times 10^6 \text{ N}$$

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e) rankine $P_r = \frac{\sigma_y A}{1 + a \left(\frac{L}{k}\right)^2} = \frac{(320 \times 10^6) (16000 \times 10^{-6})}{1 + \left(\frac{1}{7500}\right) \times (95.59)^2}$

$$P_r = \underline{\underline{2.31 \times 10^6 \text{ N}}}$$

f)

