

assuming $\phi 2, 3, 4$

date: 11/5/2020

time: 1:00

module title: advanced stress analysis and FEA

module code: M6100920

name: Harry Furnhill

student number: 148376

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Q2) $\gamma = \frac{\phi}{A\phi}$ $G = \frac{\text{shear stress}}{\text{shear strain}}$

$\gamma = \frac{\tau}{G} = \tau = \frac{\phi}{A} \quad \gamma = \frac{\phi}{A\phi} \quad \gamma = \frac{\phi}{A\phi}$

i) $\gamma = \frac{\phi}{A\phi} = \frac{1}{2} \phi$

$u = \frac{1}{2} \frac{\phi \phi}{A\phi}$

$u = \frac{1}{2} \frac{\phi^2 L}{A\phi}$

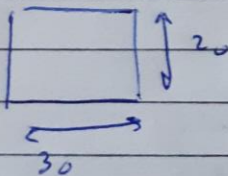
$u = \frac{\phi^2 L}{2A\phi}$

b) $u = \frac{\phi^2 L}{2A\phi}$

$F = \sigma A$

$F = 480 \times 10^6 \times 2.25 \times 10^{-4}$

$F = 108 \text{ kN}$



$u = \frac{(108 \times 10^3)^2}{2 \times 2.25 \times 10^4 \times 190 \times 10^9} = 327 \text{ J}$

$30 \times 10^{-3} = 0.03$

$0.03 - (0.0025 + 0.0025) = 0.025$

$20 \times 10^{-3} = 0.02$

$0.02 - (0.0025 + 0.0025) = 0.015$

Wall thickness = $2.5 \times 10^{-3} = 0.0025$

$\text{Area} = (0.03 \times 0.02) - (0.015 \times 0.025)$

$\text{Area} = 2.25 \times 10^{-4} \text{ m}^2$

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module code: M6800420

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$$i) \quad u = \frac{\sigma^2 AL}{2E} = \frac{\sigma^2 V}{2E} \quad \frac{\sigma^2 V}{2E} \omega (h+\delta) \quad \frac{\sigma^2 V}{2E} = h$$

$$ii) \quad h = \frac{\sigma^2 AL}{2EW} \quad \sqrt{\frac{2EW}{AL}} = \sigma = \sqrt{\frac{2 \times 190 \times 10^9 \times 20 \times 0.45}{2.25 \times 10^{-4} \times 2.4}}$$

$$h = 450 \text{ mm} = 0.45 \text{ m}$$

$$E = 190 \times 10^9$$

$$a = 2.25 \times 10^{-4} \text{ m}$$

$$L = 2.4 \text{ metres}$$

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

$$\sigma = \sqrt{\frac{3.42 \times 10^{12}}{5.4 \times 10^{-4}}}$$

$$\sigma = 79.58 \times 10^6 \text{ Pa}$$

$$\sigma = 79.6 \text{ MPa}$$

iv)

$$A = 11 \times 10^{-3} \text{ m}^2 = 314.16 \text{ mm}^2 = 20 - 15.26$$

$$\text{Length} = 2.4 \text{ metres}$$

$$\text{height} = 0.45$$

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

$$\sigma = 79.6 \text{ MPa}$$

$$d = 20 \text{ mm} = 20 \times 10^{-3}$$

$$h = \frac{\sigma^2 AL}{2EW} = 0.04 \text{ mm thickness}$$

$$\frac{h \times 2EW}{\sigma^2 L} = A$$

$$A = \pi R^2$$

$$\sqrt{\frac{A}{\pi}} = \sqrt{\frac{17.9}{\pi}} = 2.38 \text{ mm}$$

$$= \frac{0.45 \times 2 \times 190 \times 10^9 \times 20}{79.6 \times 10^6 \times 2.4} = 17.9 \text{ mm}^2$$

$$R \times 2 = 150.96 \text{ mm}$$

$$17900 \text{ mm}$$

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3)



max shear stress

diameter = 75mm = ~~0.75~~ 0.075 $D_1 = 75 = 0.075$

thickness = 5mm = 0.005 $D_2 = 70 = 0.07$

Elastic limit = 325×10^6

$$\sigma_1 = \tau$$

assuming $\sigma_2 = \sigma_3 = 0$

$$\sigma_3 = \tau$$

$$\sigma_\theta = \tau \cos 2\alpha$$

$$\frac{\tau}{r} = \frac{\tau}{R} = \left(\frac{60}{2}\right) \tau = \frac{\tau R}{J}$$

outside = 75mm = D

inner = 70mm = d

$$J_0 = \frac{\pi d^4}{32} (D^4 - d^4)$$

$$R = 75 = 37.5 \times 10^{-3} \text{m}$$

$$\tau = \frac{T R}{J}$$

$$J_0 = \frac{\pi}{32} ((75 \times 10^{-3})^4 - (70 \times 10^{-3})^4)$$

$$\tau = \frac{T R}{J}$$

$$= \frac{T}{32} (3.16 \times 10^{-5} - 2.4 \times 10^{-5})$$

$$\tau = \frac{75 \times 37.5 \times 10^{-3}}{2.87 \times 10^{-5}}$$

$$= 22.87 \times 10^{-5} \text{m}^4$$

$$\tau = 1306.62 \text{ T}$$

max shear stress

$$\tau + \tau/2 = 54.16 \times 10^6$$

$$\tau = 54.16 \times 10^6$$

$$\sigma_1 - \sigma_2 = \frac{\sigma_y}{n}$$

$$\tau \cdot \tau = \frac{325 \times 10^6}{6}$$

$$\tau = \frac{T}{1306} \frac{27.08 \times 10^6}{1308} = 27.08 \times 10^6 \text{ N/m}^2$$

$$1306 \quad 1308 = 20.73 \text{ kNm}$$

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b)

Von mises

$$\sigma_y^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)$$

$$\left(\frac{325 \times 10^6}{6}\right)^2 = T^2 + 0 + (-T)^2 - 2 \times 0.3(T \times -T)$$

$$2.64 \times 10^{16} = 2.6T^2$$

$$2.64 \times 10^{16} = 2.6 \times (1306.62)^2$$

$$\left(\sqrt{\frac{2.64 \times 10^{16}}{2.6}}\right) = T = 77.14 \text{ kN/m}$$

1306.2

c)

$$D = 50 \quad I_0 = \frac{\pi}{32} (150 \times 10^3)^4 - (47 \times 10^3)^4 \quad \gamma = \frac{TR}{J} = \frac{25 \times 10^3}{1.34 \times 10^7}$$

$$d = 47 \quad T_0 = \frac{\pi}{32} (6.25 \times 10^6 - 4.88 \times 10^6) \quad T = 186567 \text{ T}$$

$= 186 \times 10^3 \text{ T}$

$$I_0 = 1.34 \times 10^7 \text{ m}^4$$

Von mises

$$\sigma_y^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)$$

$$\left(\frac{1880}{2.75}\right)^2 = T^2 + 0 + (T)^2 - 2 \times 0.3(T \times -T)$$

$$1.024 \times 10^{17} = 2.6T^2$$

$$1.024 \times 10^{17} = 2.6 \times (186 \times 10^3)^2$$

$$T = \left(\sqrt{\frac{1.024 \times 10^{17}}{2.6}}\right) T = 1.05 \text{ kN/m}$$

186 \times 10^3

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Module code: M6100420

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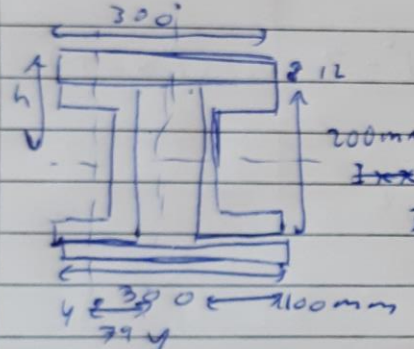
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50 mm diameter

d)
$$\frac{\text{Torque}}{\text{elastic limit}} = \frac{80 \times 1.05 \times 10^3}{880 \times 10^6} \times 100 = 1.1\% \quad \frac{20.73 \times 10^3}{325 \times 10^6} \times 100 = 6.3\%$$

divide the torque by the elastic limit to show the difference

a) 
$$I_{xx} = 2 \times I_{xxc} + 2 \left(\frac{b d^3}{12} + A h^2 \right)$$
$$I_{xx} = 2 \times 26.2 \times 10^4 + 2 \left(\frac{300 \times 12^3}{12} + (300 \times 12) \times 100^2 \right)$$
$$I_{xx} = 52.4 \times 10^6 + 72.08 \times 10^6$$
$$I_{xx} = 124.48 \times 10^6 \text{ mm}^4$$

$$I_{yy} = 2 \times I_{yyc} + 2 \times I_{yyc}$$
$$I_{yy} = 2 \left(1.57 \times 10^6 + 4400 \times 74^2 \right) + 2 \left(\frac{12 \times 300^3}{12} \right)$$
$$I_{yy} = 58.06 \times 10^6 + 54 \times 10^6$$
$$I_{yy} = 112.16 \times 10^6 \text{ mm}^4$$

b)
$$I_{yy} = 112.16 \times 10^6 \text{ mm}^4$$
 handle cross this axis

length = 8 metres

$$a = \frac{1}{7800}$$

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

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

pinned both ends

$$h = \sqrt{\frac{F_y I_{yy}}{a}} = \sqrt{\frac{112.16 \times 10^6}{16000}} = 83.73 \text{ mm}$$

$$a = \frac{2(12 \times 300 + 4400)}{0.083 \text{ m}}$$

$$a =$$

c)
$$\frac{L}{h} = \frac{8}{0.083} = 96.4 \quad \frac{8}{83.73 \times 10^{-3}} = 95.59$$

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module code: M6X0042.0

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d) pinned both ends

$$\frac{\pi^2 EI}{L^2} = P_c = \frac{\pi^2 \times 200 \times 10^9 \times (112.16 \times 10^6 \times 10^{-12})}{8^2}$$

$$P_c = \cancel{3.4 \times 10^6} \quad 3.5 \times 10^6 \text{ N}$$

e) combined Gordon theory

$$P_R = \frac{\sigma_y A}{1 + a \left(\frac{L}{h} \right)^2}$$

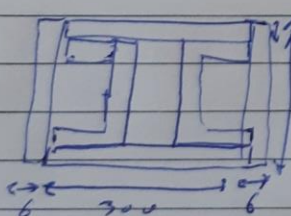
$$P_R = \frac{320 \times 10^6 \times 0.016}{1 + \frac{1}{7500} \times \left(\frac{8}{0.083} \right)^2}$$

$$A_{\text{req}} = 2(12 \times 300 + 4400)$$

$$A_{\text{req}} = 16000 \times 10^{-6} = 0.016$$

$$P_R = 2.29 \times 10^6 \text{ N}$$

f)



$$I_{xx} = 2 \times \frac{26.2 \times 10^6}{12} + 2 \times \frac{(312 \times 12^3)}{12} + (312 \times 12) \times 100^2$$

$$I_{xx} = 52.4 \times 10^6 + 74.97 \times 10^6$$

$$I_{xx} = 127.37 \times 10^6$$

$$b = 312$$

$$d = 12$$

$$h =$$

$$I_{yy} = 2(1.57 \times 10^6 + 4400 \times 79^2) + 2 \left(\frac{12 \times 312^3}{12} \right)$$

$$I_{yy} = 58.06 \times 10^6 +$$

$$I_{yy} = 118.9 \times 10^6 \text{ mm}^4$$

$$60.74 \times 10^6$$

$$I_{yy} =$$

likely to buckle

radius of gyration

$$h = \sqrt{\frac{118.9 \times 10^6}{2(312 + 2 + 4400)}}$$

$$= 108.78 \text{ mm}$$

$$= 0.108 \text{ m}$$

$$P_c = \frac{\pi^2 \times 200 \times 10^9 \times (118.9 \times 10^6 \times 10^{-12})}{8^2}$$

$$P_c = 3.67 \times 10^6 \text{ N}$$

$$\text{increase of } 0.17 \times 10^6 \quad P_c = 3.67 \times 10^6 > 3.5 \times 10^6$$