

Exam 11/05/20 13:00 - 15:00
Advanced Stress Analysis + FEA
(M6X00420)

Sion Evans (P150600) 2/20

Two

b i) $30 \times 10^3 \times 20 \times 10^3 \text{ m}$ Thickness $2.5 \times 10^{-3} \text{ m}$
 $L = 2.4 \text{ m}$ $\sigma = 480 \times 10^6 \text{ Pa}$ $E = 190 \times 10^9$

$$U = \frac{P^2 L}{2AE} = \frac{\sigma^2 AL}{2E}$$

$$A = (25 \times 10^{-3})(15 \times 10^{-3})$$
$$= 3.75 \times 10^{-4} \text{ m}^2$$

$$A = (30 \times 10^{-3})(20 \times 10^{-3}) = 3.75 \times 10^{-4}$$

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

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

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

ii) $P.E = mgh$ $U = \frac{P^2 L}{2AE}$ $P.E = U$

$$Mgh = \frac{P^2 L}{2AE}$$

$$P = \sigma A$$

$$Mg = W$$

$$Wh = \frac{\sigma A^2 L}{2AE} = \frac{\sigma AL}{2E}$$

$$AL = V$$

$$h = \frac{\sigma V}{2WE}$$

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b iii) $\sigma = \frac{h z w E}{\sqrt{}}$ $M = 20 \text{ kg}$ $h = 450 \times 10^{-3} \text{ m}$

$$\sigma = \frac{(450 \times 10^{-3}) (2) (20) (9.81) (190 \times 10^9)}{(2.25 \times 10^{-4}) (2.4)}$$

$$\sigma = 6.21 \times 10^{16} \text{ Pa}$$

iv) $\sigma_{\max} = 6.21 \times 10^{16}$ $d = 20 \times 10^{-3}$ $L = 2.4$

$$V = \frac{h z w E}{\sigma} = \frac{(450 \times 10^{-3}) (2) (20) (9.81) (190 \times 10^9)}{6.21 \times 10^{16}}$$

$$5.4 \times 10^{-4} = \frac{\pi d e^2}{4} - \frac{\pi d i^2}{4} \cdot L = 5.4 \times 10^{-4} \text{ (A)}$$

$$\frac{5.4 \times 10^{-4}}{2.4} = \frac{\pi (20 \times 10^{-3})^2}{4} - \frac{\pi d i^2}{4} \quad 0.225 \times 10^{-4} =$$

$$\cancel{2.25 \times 10^{-4}} \quad \frac{\pi d i^2}{4} = \frac{\pi (20 \times 10^{-3})^2}{4} - 2.25 \times 10^{-4}$$

$$d i = \sqrt{\frac{(8.916 \times 10^{-5}) (4)}{\pi}} = 10.65 \times 10^{-3} \text{ m}$$

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$$\frac{4}{20}$$

iv) continued. . . .

$$\begin{aligned}\text{Wall thickness} &= D_e - D_i \\ &= 20 \times 10^{-3} - 10.65 \times 10^{-3} \\ &= \underline{9.35 \times 10^{-3} \text{ m}} \\ &= \underline{\underline{9.35 \text{ mm}}}\end{aligned}$$

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Four

a) Plates 300 x 12 mm C-channel ^{wide} 100 x ^{tall} 200 mm

C-channel $I_{xx} = 26.2 \times 10^6 \text{ mm}^4$ $I_{yy} = 1.57 \times 10^6 \text{ mm}^4$
 $A = 4400 \text{ mm}^2$

8m long

xx C-channel =

$$(2)(26.2 \times 10^6) = \underline{52.4 \times 10^6 \text{ mm}^4}$$

$$\text{plate} = (2)(1 + Ah^2)$$

$$= (2) \left(\frac{(300)(12)^3}{12} + (300)(12)(106)^2 \right)$$

$$= 80.986 \times 10^6 \text{ mm}^4$$

$$I_{xx} = \underline{132.986 \times 10^6 \text{ mm}^4} \quad 132.986 \times 10^6 \text{ mm}^4$$

yy channel = $(2)(1.57 \times 10^6 + (4400)(79)^2)$
 $= \underline{58.06 \times 10^6 \text{ mm}^4}$

$$\text{plate} = (2) \left[\frac{(12)(300)^3}{12} \right] = \underline{54 \times 10^6 \text{ mm}^4}$$

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

$I_{xx} > I_{yy}$, will buckle about yy

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$$\frac{5}{20}$$

Four b) $k = \sqrt{\frac{I}{A_T}}$

$$\begin{aligned} A_T &= (2)(4400) + (2)(300)(12) \\ &= 16,000 \text{ mm}^2 \\ &= \underline{\underline{16 \times 10^3 \text{ mm}^2}} \end{aligned}$$

$$K = \sqrt{\frac{112.06 \times 10^{-6}}{16 \times 10^{-3}}} \frac{\text{m}^4}{\text{m}^2}$$

$$I_{yy} = 112.06 \times 10^{-6} \text{ m}^4$$

$$= \underline{\underline{83.69 \times 10^{-3} \text{ m}^2}}$$

c) Slender ration = $\frac{L}{k} = \frac{8}{83.69 \times 10^{-3}} = \underline{\underline{95.59}}$

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

$$= 3.46$$

$$= \underline{\underline{\underline{112 \times 10^6 N}}}$$

$$e) P_R = \frac{\sigma_y A}{1 + a \left(\frac{L}{k} \right)^2} = \frac{(320 \times 10^6)(16 \times 10^3)}{1 + \left(\frac{1}{2500} \right) (95.54)^2} = 2.31 \times 10^6 \text{ N}$$

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Four F) 224 mm x 6 mm

$$I_{xx} = \frac{(6)(224^3)}{12} + \cancel{224(6)(2)} = 11.239 \times 10^6 \text{ mm}^4 \\ = 11.239 \times 10^6 \text{ mm}^4$$

$$I_{yy} = (2)(I + Ah^2) = (2) \left(\frac{(224)(6)^3}{12} + (224)(6)(153)^2 \right) \\ = 62.93 \times 10^6 \text{ mm}^4 \\ = \cancel{11.239 \times 10^6} \text{ mm}^4$$

$$I_{xx} = 132.99 \times 10^6 \text{ mm}^4 \quad I_{yy} = 174.99 \times 10^6 \text{ mm}^4$$

$I_{yy} > I_{xx}$, will buckle about I_{xx}

$$P_e = \frac{(\pi^2)(200 \times 10^9)(132.99 \times 10^{-6})}{8^2}$$

$$= 4.1 \times 10^6 \text{ N}$$

$$\text{increase of } 4.1 - 3.46 = \underline{\underline{0.64 \text{ MN}}}$$