Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

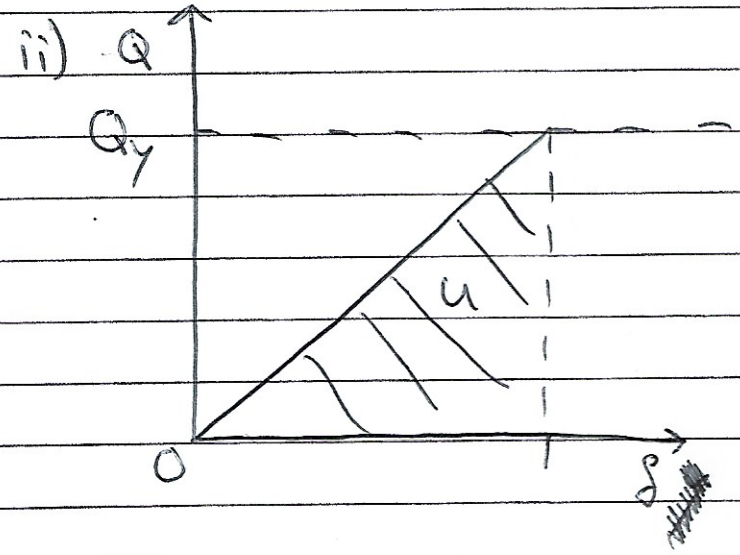
Sion Evans (P1506oo) 1/20

Two

a) i) $G = \frac{\tau}{\gamma}$ $\tau = \frac{Q}{A_y}$

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

ii)



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

$\gamma = \frac{\delta}{L}$

$\frac{1}{\gamma} = \frac{L}{\delta}$

$\delta = \frac{QL}{AG}$ $U = \frac{1}{2} Q \left[\frac{QL}{AG}\right]$

$= \frac{Q^2 L}{2AG}$

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(M6X00420)

Sion Evans (P150600) 2/20

Two

b i) $30\times10^{-3} \times 20\times10^{-3}$m Thickness 2.5×10^{-3}M

$L = 2.4$M $\sigma = 480\times10^{6}$pa $E = 190\times10^{9}$

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

$A = (25\times10^{-3})(15\times10^{-3})$

$= 3.75\times10^{-4}$ M^2

$A = (30\times10^{-3})(20\times10^{-3}) - 3.75\times10^{-4}$

$= \underline{2.25\times10^{-4}}$ M^2

$$U = \frac{(480\times10^{6})^2(2.25\times10^{-4})(2.4)}{(2)(190\times10^{9})}$$

$= \underline{327.41}$ J

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

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

$P = \sigma A$ $Mg = W$

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

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Sion Evans (P150600) 3/20

Two

b iii) $\sigma = \frac{h z w \epsilon}{v}$ $M = 20kg$ $h_{max} = 450 \times 10^{-3} M$

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

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

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

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

$$= 5.4 \times 10^{-4} (A)$$

$$5.4 \times 10^{-4} = \left(\frac{\pi d_e^2}{4} - \frac{\pi d_i^2}{4}\right) . L$$

$$\frac{5.4 \times 10^{-4}}{2.4} = \frac{(\pi)(20 \times 10^{-3})^2}{4} (B) - \frac{\pi d_i^2}{4}$$

$$\frac{\pi d_i^2}{4} = \frac{\pi (20 \times 10^{-3})^2}{4} - 2.25 \times 10^{-4}$$

$$= 3.14 \times 10^{-4} - 2.25 \times 10^{-4}$$

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

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Sion Evans (P150600) 4/20

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iv) Continued. . . .

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$$= 20\times10^{-3} - 10.65\times10^{-3}$$
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Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 45/20

Four

a) Plates 300 x 12 mm C-Channel 100 (wide) x 200 (tall) MM

C-channel @ $I_{xx} = 26.2 \times 10^6 MM^4$ $I_{yy} = 1.57 \times 10^6 MM^4$

$A = 4400 MM^2$

8M long

xx C-channel =

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

plate $= (2)(I + Ah^2)$

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

$= \underline{80.986 \times 10^6 MM^4}$

$I_{XX} = \underline{132.986 \times 10^6 MM^4}$ $132.986 \times 10^{-6} M^4$

yy Channel $= (2)(1.57 \times 10^6 + (4400)(79^2))$

$= \underline{58.06 \times 10^6 MM^4}$

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

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

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

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Sion Evans (P150600) 3/20

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Sion Evans (P150600) 4/20

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iv) Continued. . . .

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Sion Evans (P150600) 45/20

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

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Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 5/20

Four b) $k = \sqrt{\frac{I}{A_T}}$ $A_T = (2)(4400) + (2)(300)(12)$

$= 16{,}000\ MM^2$

$= 16 \times 10^{-3}\ M^2$

$k = \sqrt{\frac{112.06 \times 10^{-6}\ M^4}{16 \times 10^{-3}\ M^2}}$ $I_{yy} = 112.06 \times 10^{-6}\ M^4$

$= 83.69 \times 10^{-3}\ M^2$

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

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

$= 3.46 \times 10^6\ N$

e) $P_R = \frac{\sigma_y A}{1 + a\left(\frac{L}{k}\right)^2} = \frac{(320 \times 10^6)(16 \times 10^{-3})}{1 + \left(\frac{1}{7500}\right)(95.54)^2} = 2.31 \times 10^6\ N$

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b i) $30\times10^{-3} \times 20\times10^{-3}$m Thickness 2.5×10^{-3}M

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Sion Evans (P150600) 3/20

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$$= 5.4 \times 10^{-4} (A)$$

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Sion Evans (P1506oo) 6/7/20

Four F) 224MM x 6MM

$$XX = \frac{(6)(224^3)}{12}(2) = 11.239 \times 10^6 \text{ MM}^4$$

$$= 11.239 \times 10^6 \text{ M}^2$$

$$yy = (2)(1 + Ah^2) = (2)\left(\frac{(224)(6)^3}{12} + (224)(6)(153)^2\right)$$

$$62.93 \times 10^6$$

$$= \text{MM}^4$$

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

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

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

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

increase of $4.1 - 3.46 = 0.64$ MN

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b iii) $\sigma = \frac{h z w \epsilon}{v}$ $M = 20kg$ $h_{max} = 450 \times 10^{-3} M$

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

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

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

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

$$= 5.4 \times 10^{-4} (A)$$

$$5.4 \times 10^{-4} = \left(\frac{\pi d_e^2}{4} - \frac{\pi d_i^2}{4}\right) . L$$

$$\frac{5.4 \times 10^{-4}}{2.4} = \frac{(\pi)(20 \times 10^{-3})^2}{4} (B) - \frac{\pi d_i^2}{4}$$

$$\frac{\pi d_i^2}{4} = \frac{\pi (20 \times 10^{-3})^2}{4} - 2.25 \times 10^{-4}$$

$$= 3.14 \times 10^{-4} - 2.25 \times 10^{-4}$$

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

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 4/20

Two

iv) Continued. . . .

$$\text{Wall thickness} = D_e - D_i$$
$$= 20\times10^{-3} - 10.65\times10^{-3}$$
$$= 9.35\times10^{-3}\ M$$
$$\frac{}{2}$$
$$= 4.68\times10^{-3}\ M$$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 45/20

Four

a) Plates 300 x 12 mm C-Channel 100 (wide) x 200 (tall) MM

C-channel @ $I_{xx} = 26.2 \times 10^6 MM^4$ $I_{yy} = 1.57 \times 10^6 MM^4$

$A = 4400 MM^2$

8M long

xx C-channel =

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

plate $= (2)(I + Ah^2)$

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

$= \underline{80.986 \times 10^6 MM^4}$

$I_{XX} = \underline{132.986 \times 10^6 MM^4}$ $132.986 \times 10^{-6} M^4$

yy Channel $= (2)(1.57 \times 10^6 + (4400)(79^2))$

$= \underline{58.06 \times 10^6 MM^4}$

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

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

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

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 5/20

Four b) $k = \sqrt{\frac{I}{A_T}}$ $A_T = (2)(4400) + (2)(300)(12)$

$= 16{,}000\ MM^2$

$= 16 \times 10^{-3}\ M^2$

$k = \sqrt{\frac{112.06 \times 10^{-6}\ M^4}{16 \times 10^{-3}\ M^2}}$ $I_{yy} = 112.06 \times 10^{-6}\ M^4$

$= 83.69 \times 10^{-3}\ M^2$

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

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

$= 3.46 \times 10^6\ N$

e) $P_R = \frac{\sigma_y A}{1 + a\left(\frac{L}{k}\right)^2} = \frac{(320 \times 10^6)(16 \times 10^{-3})}{1 + \left(\frac{1}{7500}\right)(95.54)^2} = 2.31 \times 10^6\ N$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 6/7/20

Four F) 224MM x 6MM

$$XX = \frac{(6)(224^3)}{12}(2) = 11.239 \times 10^6 \text{ MM}^4$$

$$= 11.239 \times 10^6 \text{ M}^2$$

$$yy = (2)(1 + Ah^2) = (2)\left(\frac{(224)(6)^3}{12} + (224)(6)(153)^2\right)$$

$$62.93 \times 10^6$$

$$= \text{MM}^4$$

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

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

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

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

increase of $4.1 - 3.46 = 0.64$ MN

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 8/20

Three a) $d_o = 75 \times 10^{-3} M$ thickness $= 5 \times 10^{-3}$ Torsion

no axial loading $\sigma_y = 325 \times 10^6$

$\nu = 0.3$ $n = 6$

$$\frac{T}{J} = \frac{\tau}{R} \quad \text{or} \quad \tau = \frac{TR}{J} \qquad J = \frac{\pi d^4}{32}$$

$d_i = 65 \times 10^{-3}$

$$J = \frac{\pi (75)^4}{32} - \frac{\pi (65 \times 10^{-3})^4}{32} = 1.35 \times 10^{-6} \, M^4$$

$$\tau = \frac{T(@37.5 \times 10^{-3})}{1.35 \times 10^{-6}} = T\,27,777$$

~~Hoop stress~~ $= \frac{Pd}{4t} = \sigma_1$ ~~Radial = 0 = σ_3~~

~~Longitudinal~~ $= \frac{Pd}{4t} = \sigma_2$

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

$$\sigma_3 = (\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 2/20

Two

b i) $30\times10^{-3} \times 20\times10^{-3}$m Thickness 2.5×10^{-3}M

$L = 2.4$M $\sigma = 480\times10^{6}$pa $E = 190\times10^{9}$

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

$A = (25\times10^{-3})(15\times10^{-3})$

$= 3.75\times10^{-4}$ M^2

$A = (30\times10^{-3})(20\times10^{-3}) - 3.75\times10^{-4}$

$= \underline{2.25\times10^{-4}}$ M^2

$$U = \frac{(480\times10^{6})^2(2.25\times10^{-4})(2.4)}{(2)(190\times10^{9})}$$

$= \underline{327.41}$ J

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

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

$P = \sigma A$ $Mg = W$

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

$AL = V$

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

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 3/20

Two

b iii) $\sigma = \frac{h z w \epsilon}{v}$ $M = 20kg$ $h_{max} = 450 \times 10^{-3} M$

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

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

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

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

$$= 5.4 \times 10^{-4} (A)$$

$$5.4 \times 10^{-4} = \left(\frac{\pi d_e^2}{4} - \frac{\pi d_i^2}{4}\right) . L$$

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$$= 3.14 \times 10^{-4} - 2.25 \times 10^{-4}$$

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

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 4/20

Two

iv) Continued. . . .

$$\text{Wall thickness} = D_e - D_i$$
$$= 20\times10^{-3} - 10.65\times10^{-3}$$
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$$= 4.68\times10^{-3}\ M$$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 45/20

Four

a) Plates 300 x 12 mm C-Channel 100 (wide) x 200 (tall) MM

C-channel @ $I_{xx} = 26.2 \times 10^6 MM^4$ $I_{yy} = 1.57 \times 10^6 MM^4$

$A = 4400 MM^2$

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xx C-channel =

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

$= \underline{80.986 \times 10^6 MM^4}$

$I_{XX} = \underline{132.986 \times 10^6 MM^4}$ $132.986 \times 10^{-6} M^4$

yy Channel $= (2)(1.57 \times 10^6 + (4400)(79^2))$

$= \underline{58.06 \times 10^6 MM^4}$

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

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

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

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 5/20

Four b) $k = \sqrt{\frac{I}{A_T}}$ $A_T = (2)(4400) + (2)(300)(12)$

$= 16{,}000\ MM^2$

$= 16 \times 10^{-3}\ M^2$

$k = \sqrt{\frac{112.06 \times 10^{-6}\ M^4}{16 \times 10^{-3}\ M^2}}$ $I_{yy} = 112.06 \times 10^{-6}\ M^4$

$= 83.69 \times 10^{-3}\ M^2$

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

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

$= 3.46 \times 10^6\ N$

e) $P_R = \frac{\sigma_y A}{1 + a\left(\frac{L}{k}\right)^2} = \frac{(320 \times 10^6)(16 \times 10^{-3})}{1 + \left(\frac{1}{7500}\right)(95.54)^2} = 2.31 \times 10^6\ N$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

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

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

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

increase of $4.1 - 3.46 = 0.64$ MN

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 8/20

Three a) $d_o = 75 \times 10^{-3} M$ thickness $= 5 \times 10^{-3}$ Torsion

no axial loading $\sigma_y = 325 \times 10^6$

$\nu = 0.3$ $n = 6$

$$\frac{T}{J} = \frac{\tau}{R} \quad \text{or} \quad \tau = \frac{TR}{J} \qquad J = \frac{\pi d^4}{32}$$

$d_i = 65 \times 10^{-3}$

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P1506oo) 8⁹/20

Three a) $\sigma_y = 0 \quad \sigma_x = 0$

$$\text{Tresca} = \sigma_1 - \sigma_3 = \frac{\sigma_{yield}}{n}$$

if $a = \sigma_x + \sigma_y \qquad b = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$

$$\frac{\sigma_{yield}}{n} = \left(\frac{1}{2}a + \frac{1}{2}b\right) - \left(\frac{1}{2}a - \frac{1}{2}b\right)$$

$$54.17 \times 10^6 = b = \sqrt{\sigma_x^2 + 4\tau_{xy}^2}$$

$$\frac{\sigma_{yield}^2}{n} = \sigma_x^2 + 4\tau_{xy}^2$$

$$\tau_{xy} = \sqrt{\frac{\sigma_{yield}^2 - \sigma_x^2}{4n^2}} = \sqrt{\frac{(54.17 \times 10^6)^2 - }{(4)(6^2)}}$$

$$= 4.514 \times 10^6 \text{ pa}$$

$$T = \frac{4.514 \times 10^6}{27,777} = 162.5 \text{ Nm}$$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 2/20

Two

b i) $30\times10^{-3} \times 20\times10^{-3}$m Thickness 2.5×10^{-3}M

$L = 2.4$M $\sigma = 480\times10^{6}$pa $E = 190\times10^{9}$

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

$A = (25\times10^{-3})(15\times10^{-3})$

$= 3.75\times10^{-4}$ M^2

$A = (30\times10^{-3})(20\times10^{-3}) - 3.75\times10^{-4}$

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 4/20

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iv) Continued. . . .

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

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Advanced Stress Analysis + FEA

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Exam 11/05/20 13:00 - 15:00

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

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Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

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$$= 4.514 \times 10^6 \text{ pa}$$

$$T = \frac{4.514 \times 10^6}{27,777} = 162.5 \text{ Nm}$$

Clean

10/20

Three

Von-Mises

$$\sigma_1^2 - (-\sigma_3^2) + (\sigma_3 - \sigma_1)^2 = \frac{\sigma_y^2}{n}$$

$$\left(\frac{1}{2}a + \frac{1}{2}b\right)^2 + \left(\frac{1}{2}a - \frac{1}{2}b\right)^2 + \left(\frac{1}{2}a - \frac{1}{2}b - \frac{1}{2}a + \frac{1}{2}b\right)^2$$

$$= \left(\frac{1}{4}a^2 + \frac{1}{4}ab + \frac{1}{4}ab + \frac{1}{2}b^2\right) + \left(\frac{1}{4}a - \frac{1}{2}ab - \frac{1}{2}ab + \frac{1}{4}b^2\right) + b^2$$

$$= \frac{2\sigma_y^2}{n}$$

$$2\sigma_3^2 = \frac{\sigma_y^2}{n}$$

$$(2)\sqrt{4\tau_{xy}^2} = \frac{\sigma_y^2}{n}$$

$$\tau_{xy}^2 = \frac{2\sigma_y^2}{n^2}$$

$$\tau_{xy} = \sqrt{\frac{(2)(325\times10^6)^2}{(6)^2}}$$

$$= 76.6 \times 10^6 \text{ Pa}$$

$$T = 2757.79 \text{ Nm}$$

Exam 11/05/20 13:00 - 15:00

Advanced Stress Analysis + FEA

(M6X00420)

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Two

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$L = 2.4$M $\sigma = 480\times10^{6}$pa $E = 190\times10^{9}$

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

$A = (25\times10^{-3})(15\times10^{-3})$

$= 3.75\times10^{-4}$ M^2

$A = (30\times10^{-3})(20\times10^{-3}) - 3.75\times10^{-4}$

$= \underline{2.25\times10^{-4}}$ M^2

$$U = \frac{(480\times10^{6})^2(2.25\times10^{-4})(2.4)}{(2)(190\times10^{9})}$$

$= \underline{327.41}$ J

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

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

$P = \sigma A$ $Mg = W$

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

$AL = V$

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

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Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 3/20

Two

b iii) $\sigma = \frac{h z w \epsilon}{v}$ $M = 20kg$ $h_{max} = 450 \times 10^{-3} M$

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

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

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

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

$$= 5.4 \times 10^{-4} (A)$$

$$5.4 \times 10^{-4} = \left(\frac{\pi d_e^2}{4} - \frac{\pi d_i^2}{4}\right) . L$$

$$\frac{5.4 \times 10^{-4}}{2.4} = \frac{(\pi)(20 \times 10^{-3})^2}{4} (B) - \frac{\pi d_i^2}{4}$$

$$\frac{\pi d_i^2}{4} = \frac{\pi (20 \times 10^{-3})^2}{4} - 2.25 \times 10^{-4}$$

$$= 3.14 \times 10^{-4} - 2.25 \times 10^{-4}$$

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

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Two

iv) Continued. . . .

$$\text{Wall thickness} = D_e - D_i$$
$$= 20\times10^{-3} - 10.65\times10^{-3}$$
$$= 9.35\times10^{-3}\ M$$
$$\frac{}{2}$$
$$= 4.68\times10^{-3}\ M$$

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Four

a) Plates 300 x 12 mm C-Channel 100 (wide) x 200 (tall) MM

C-channel @ $I_{xx} = 26.2 \times 10^6 MM^4$ $I_{yy} = 1.57 \times 10^6 MM^4$

$A = 4400 MM^2$

8M long

xx C-channel =

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

plate $= (2)(I + Ah^2)$

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

$= \underline{80.986 \times 10^6 MM^4}$

$I_{XX} = \underline{132.986 \times 10^6 MM^4}$ $132.986 \times 10^{-6} M^4$

yy Channel $= (2)(1.57 \times 10^6 + (4400)(79^2))$

$= \underline{58.06 \times 10^6 MM^4}$

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

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

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

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Four b) $k = \sqrt{\frac{I}{A_T}}$ $A_T = (2)(4400) + (2)(300)(12)$

$= 16{,}000\ MM^2$

$= 16 \times 10^{-3}\ M^2$

$k = \sqrt{\frac{112.06 \times 10^{-6}\ M^4}{16 \times 10^{-3}\ M^2}}$ $I_{yy} = 112.06 \times 10^{-6}\ M^4$

$= 83.69 \times 10^{-3}\ M^2$

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

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

$= 3.46 \times 10^6\ N$

e) $P_R = \frac{\sigma_y A}{1 + a\left(\frac{L}{k}\right)^2} = \frac{(320 \times 10^6)(16 \times 10^{-3})}{1 + \left(\frac{1}{7500}\right)(95.54)^2} = 2.31 \times 10^6\ N$

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Four F) 224MM x 6MM

$$XX = \frac{(6)(224^3)}{12}(2) = 11.239 \times 10^6 \text{ MM}^4$$

$$= 11.239 \times 10^6 \text{ M}^2$$

$$yy = (2)(1 + Ah^2) = (2)\left(\frac{(224)(6)^3}{12} + (224)(6)(153)^2\right)$$

$$62.93 \times 10^6$$

$$= \text{MM}^4$$

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

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

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

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

increase of $4.1 - 3.46 = 0.64$ MN

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Three a) $d_o = 75 \times 10^{-3} M$ thickness $= 5 \times 10^{-3}$ Torsion

no axial loading $\sigma_y = 325 \times 10^6$

$\nu = 0.3$ $n = 6$

$$\frac{T}{J} = \frac{\tau}{R} \quad \text{or} \quad \tau = \frac{TR}{J} \qquad J = \frac{\pi d^4}{32}$$

$d_i = 65 \times 10^{-3}$

$$J = \frac{\pi (75)^4}{32} - \frac{\pi (65 \times 10^{-3})^4}{32} = 1.35 \times 10^{-6} \, M^4$$

$$\tau = \frac{T(@37.5 \times 10^{-3})}{1.35 \times 10^{-6}} = T\,27,777$$

~~Hoop stress~~ $= \frac{Pd}{4t} = \sigma_1$ ~~Radial = 0 = σ_3~~

~~Longitudinal~~ $= \frac{Pd}{4t} = \sigma_2$

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

$$\sigma_3 = (\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

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Three a) $\sigma_y = 0 \quad \sigma_x = 0$

$$\text{Tresca} = \sigma_1 - \sigma_3 = \frac{\sigma_{yield}}{n}$$

if $a = \sigma_x + \sigma_y \qquad b = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$

$$\frac{\sigma_{yield}}{n} = \left(\frac{1}{2}a + \frac{1}{2}b\right) - \left(\frac{1}{2}a - \frac{1}{2}b\right)$$

$$54.17 \times 10^6 = b = \sqrt{\sigma_x^2 + 4\tau_{xy}^2}$$

$$\frac{\sigma_{yield}^2}{n} = \sigma_x^2 + 4\tau_{xy}^2$$

$$\tau_{xy} = \sqrt{\frac{\sigma_{yield}^2 - \sigma_x^2}{4n^2}} = \sqrt{\frac{(54.17 \times 10^6)^2 - }{(4)(6^2)}}$$

$$= 4.514 \times 10^6 \text{ pa}$$

$$T = \frac{4.514 \times 10^6}{27,777} = 162.5 \text{ Nm}$$

Clean

10/20

Three

Von-Mises

$$\sigma_1^2 - (-\sigma_3^2) + (\sigma_3 - \sigma_1)^2 = \frac{\sigma_y^2}{n}$$

$$\left(\frac{1}{2}a + \frac{1}{2}b\right)^2 + \left(\frac{1}{2}a - \frac{1}{2}b\right)^2 + \left(\frac{1}{2}a - \frac{1}{2}b - \frac{1}{2}a + \frac{1}{2}b\right)^2$$

$$= \left(\frac{1}{4}a^2 + \frac{1}{4}ab + \frac{1}{4}ab + \frac{1}{2}b^2\right) + \left(\frac{1}{4}a - \frac{1}{2}ab - \frac{1}{2}ab + \frac{1}{4}b^2\right) + b^2$$

$$= \frac{2\sigma_y^2}{n}$$

$$2\sigma_3^2 = \frac{\sigma_y^2}{n}$$

$$(2)\sqrt{4\tau_{xy}^2} = \frac{\sigma_y^2}{n}$$

$$\tau_{xy}^2 = \frac{2\sigma_y^2}{n^2}$$

$$\tau_{xy} = \sqrt{\frac{(2)(325\times10^6)^2}{(6)^2}}$$

$$= 76.6 \times 10^6 \text{ Pa}$$

$$T = 2757.79 \text{ Nm}$$

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Advanced Stress Analysis + FEA

(M6X00420)

Sion Evans (P150600) 11/20

Three c)

~~Von-Mises~~

$$\tau = \frac{T(25\times10^{-3})}{3.62\times10^{-7}} \qquad J = \frac{\pi(50\times10^{-3})^4}{32} - \frac{\pi(40\times10^{-3})^4}{32}$$

$$= 3.62\times10^{-7}\ m^4$$

$$\tau = T\,69,060.77$$

$$\tau = \sqrt{\frac{(2)(880\times10^6)^2}{2.75^2}} = 452.54\times10^6\ Pa$$

$$T = 6552.9\ Nm$$

d) $$\frac{6552.9 - 2757.74}{\frac{6552 + 2757}{2}} \times 100 = 81\%$$