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ADVANCED STRESS ANALYSIS & FEA M6200420

RYAN JAMES 0751093 11.5.20 1PM

1 a) carry out simple
split discretises

Interpolate Shape of problem and forces

material

physical properties

Loading

Evaluate

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ADVANCED STRESS ANALYSIS & FEA M620042

RYAN JAMES 0751043 11.5.20 12m

1b)

- Computing power available
- physical properties
- 1d 2d or 3d
- density of mesh

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ADVANCED STRESS ANALYSIS & FEA M6JK00420

RYAN JAMES 0751093 11.5.20 1pm

Q1
(1)

- Consider original Geometry

- is it 1d 2d 3d

- Time and computing power available

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ADVANCED STRESS ANALYSIS & FEA M0200420

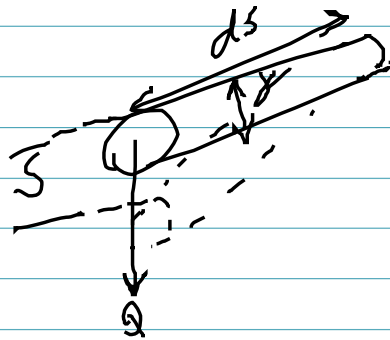
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Q 1)
a)

H adaptive physically adjusts the size of mesh cell in areas where a smaller mesh is needed

P adaptive adjusts the polynomial order of the mesh to improve accuracy

Q2)
 a) i)



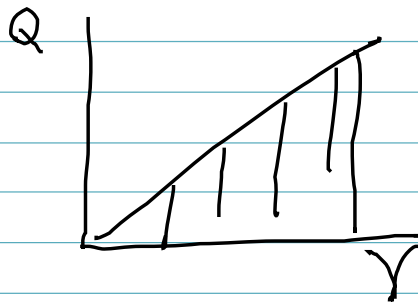
Shear modulus $G = \frac{\text{Shear Stress}}{\text{Shear Strain}}$

$$= \frac{\tau}{\gamma}$$

$$= \frac{Q}{\gamma A} \quad (\text{Since } \tau = \frac{Q}{A})$$

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

a) ii)



Strain energy in small element = $\frac{1}{2} Q \gamma$

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

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

$$\therefore \text{Strain energy} = \frac{1}{2} Q \frac{Q}{AG}$$

$$= \frac{1}{2} \frac{Q^2}{AG}$$

$$\therefore \text{Total Strain} = \int_0^L \frac{Q^2}{2AG} ds$$

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

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Q2b)
i)

$$A_{\text{net}} = (30 \times 20) - ((30 - (2 \times 2.5)) \times (20 - (2 \times 2.5)))$$

$$A_{\text{net}} = 2.5 \times 10^2 \text{ mm}^2$$

$$F = \sigma \times A = 480 \times 10^6 \times 2.5 \times 10^{-4}$$

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

$$U = \frac{\sigma^2 AL}{2E} = \frac{(480 \times 10^6)^2 \times 2.5 \times 10^{-4}}{2 \times 190 \times 10^9}$$

$$U = 3.64 \times 10^2 \text{ J}$$

bii)

$$P_G = mgh = mg(h + \delta L)$$

$$\epsilon = \frac{\sigma}{E} = \sigma = \frac{\delta L}{L} = \frac{\sigma L}{E} \therefore \delta L = \frac{\sigma L}{E}$$

$$P_G = mg(h + \frac{\sigma L}{E})$$

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

$$\frac{\sigma^2 V}{2E} = mg(h + \frac{\sigma L}{E})$$

$$\frac{\sigma^2 V}{2Emg}$$

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

$$mg = U \therefore h = \frac{\sigma^2 V}{2Emg}$$

$$- \frac{\sigma L}{E}$$

no extension

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ADVANCED STRESS ANALYSIS AND FEA M620042

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b
iii)

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

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

$$V = 2.5 \times 10^{-4} \times 2.4$$

$$\sigma = \sqrt{\left(\frac{h 2EW}{V} \right)}$$

$$V =$$

$$\sigma = \sqrt{\left(\frac{0.45 \times 2 \times 190 \times 10^9 \times (20 \times 9.81)}{(2.5 \times 10^{-4} \times 2.4)} \right)}$$

$$\sigma = 2.36 \times 10^8 \text{ N}$$

$$\sigma = 236 \text{ MN}$$

biv)

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

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

$$\frac{h 2EW}{\sigma^2 L} = \frac{\pi D_2^2}{4} - \frac{\pi D_1^2}{4} = \frac{\pi}{4} (D_2^2 - D_1^2)$$

~~$$\sqrt{\frac{h 2EW}{\sigma^2 L \pi}} = D_1$$~~
$$\sqrt{\frac{h 2EW}{\sigma^2 L \pi}} = D_1$$

~~$$\left(\sqrt{\frac{h 2EW}{\sigma^2 L \pi}} \right) = D_1 = 0.0178$$~~
$$\left(\sqrt{\frac{h 2EW}{\sigma^2 L \pi}} \right) = D_1 = 0.0178$$

$$t = 2.2 \text{ mm}$$

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ADVANCED Stress ANALYSIS & FEA M62 00420

Ryan James 0751093 11.5.20 1pm

$$h_x = 106 \quad h_y = 79$$

Q4)

a) Plate Area = $300 \times 12 = 3.6 \times 10^3 \text{ mm}^2$

$$I_{xx} \text{ of plate} = \frac{bd^3}{12} = \frac{300 \times 12^3}{12} = 4.32 \times 10^4 \text{ mm}^4$$

$$I_{yy} \text{ of plate} = \frac{bd^3}{12} = \frac{12 \times 300^3}{12} = 2.7 \times 10^7 \text{ mm}^4$$

Parallel Theorem

$$I_{xx} = I + Ah^2 = (2 \times I_{xx \text{ plate}}) + (2 \times I_{xx \text{ (section)}}) + (\text{Plate Area} \times h_x^2)$$

$$\underline{I_{xx \text{ strut}} = 1.33 \times 10^{-4} \text{ m}^4}$$

$$I_{yy} = I + Ah^2 = (2 \times I_{yy \text{ plate}}) + (2 \times I_{yy \text{ (section)}}) + (\text{Area} \times h_y^2)$$

$$I_{yy \text{ strut}} = 1.12 \times 10^{-4} \text{ m}^4$$

$$\therefore I_{xx} > I_{yy} \quad \therefore \underline{\underline{\gamma \text{ Axis bending}}}$$

b) Strut Area = $(2 \times A_{\text{rect}}) + (2 \times P_{\text{rect}} A_{\text{rect}}) = 1.6 \times 10^4 \text{ mm}^2$

$$K = \sqrt{\frac{I}{A}} = \frac{1.12 \times 10^{-4}}{1.6 \times 10^4} = \underline{\underline{83.69 \text{ mm} \quad 83.7 \times 10^{-3} \text{ m}}}$$

c) S.R = $\frac{L}{K} = \frac{8}{83.7 \times 10^{-3}} = \underline{\underline{95.6 \text{ No unit ratio}}}$

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ADVANCED STRESS ANALYSIS & FEA M6X0420

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Q4) d) Euler pinned pinned

$$P_e = \frac{\pi^2 EI}{L^2} = \frac{200 \times 10^9 \times (\pi^2) \times 1.12 \times 10^{-4}}{8^2}$$

$$P_e = 3.46 \times 10^6 \text{ N} = 3.46 \text{ MN}$$

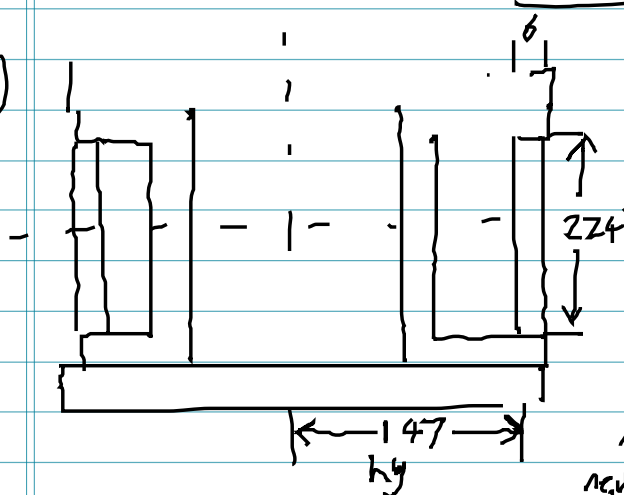
e)

$$P_r = \frac{\sigma_y A}{1 + \alpha (L/k)^2} = \frac{320 \times 10^6 \times (1.6 \times 10^4 / 1 \times 10^6)}{1 + \frac{1}{7500} \times (95.6^2)}$$

skin ratio

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

f)



Strut

$$I_{yy \text{ Shape}} = 1.12 \times 10^4 \text{ mm}^4$$

$$I_{yy \text{ plate}} = \frac{bd^3}{12} = \frac{6 \times (224^3)}{12}$$

$$= 4.03 \times 10^3 \text{ mm}^4$$

Area of new plate = $224 \times 6 = 1.34 \times 10^3 \text{ mm}^2$

$$I_{yy \text{ Strut}} = I + A h^2 = (2 \times I_{yy \text{ plate}}) + (I_{yy \text{ Shape}}) \times (h_y^2)$$

$$I_{yy} = 1.7 \times 10^{-4} \text{ m}^4$$

$$New_{area} = \text{Strut area old} + (2 \times \text{plate}_{new} \text{ area}) = 1.87 \times 10^4 \text{ mm}^2$$

$$k = \sqrt{\frac{I}{A}} = 95.403 \text{ mm}$$

$$P_r = \frac{\sigma_y A}{1 + \alpha \left(\frac{L}{k}\right)^2} = \frac{320 \times 10^6 \times (1.87 \times 10^4 / 1 \times 10^6)}{1 + \frac{1}{7500} \times \left(\frac{8}{95.4}\right)^2} = 3.09 \times 10^6 \text{ N}$$

$$3.09 \text{ MN}$$