

Over Landon Load

P150216

1.00pm

Advanced Stress Analysis

M6200420

and FEA

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Q1 a)

1D Elements:

- A simple optimization study

- Basic scenarios

- Rods, Bars, Beams, Pipes etc

- Needs length and width measurements only

2D Elements:

- Sheet components

- Requires Length, width and "thickness"

3D Elements

- Complex geometries

- Requires full cartesian geometries in x, y and z

Use 1D for simple cases

Use 2D for "Sheet or Surface" Studies

Use 3D for full geometries complex studies

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Q₁

B)

1. Use the rule-of-thumb "Three elements in the Smallest Geometries."

2. In Complex geometries the overall ~~element~~ global element size can be small at the cost of Solvetime. If there are simple geometries the elements can be larger to aid Solvetime.

3. Element Shape can determine size.

4. Local mesh refinement.

C) Element order is based off the balance between Solve time and quality of results. If you want a Fast Solve use a 1st order set of elements to reduce the number of calculations. If you want a High quality result then use a higher order element to increase the nodes and number of calculations.

d) H mesh = Automatically reduce the mesh size based on the error norm

P mesh = Increase the order of elements used.

Q2

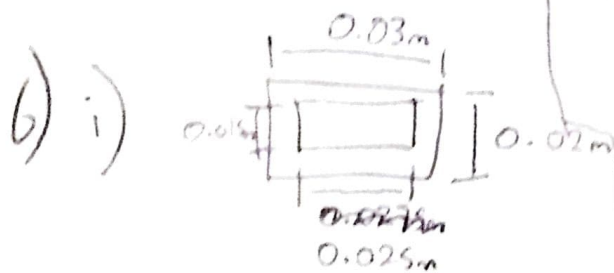
a) i) $\delta = \frac{Q}{AG}$ $G = \frac{\tau}{\gamma}$

$= \frac{Q}{\delta A}$

dueto. $\gamma = \frac{Q}{A}$

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

ii)  Strain Energy = $\frac{1}{2} Q \delta$



$L = 2.4m$

$\sigma = 480 MPa$

$E = 170 GPa$

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

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

$= \int_0^L \frac{Q^2}{2AG} ds$

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

$A = (0.03 \times 0.02) - (0.025 \times 0.015)$
 $= 2.25 \times 10^{-4} m^2$

$P = \sigma A = 480 \times 10^6 \times 2.25 \times 10^{-4} = 108000 N$

$U_1 = \frac{P^2 L}{2AE} = \frac{108000^2 \times 2.4}{2 \times 2.25 \times 10^{-4} \times 170 \times 10^9}$ 108kN

$\therefore U_1 = 327.41 J$

Q2

b) ii)

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

$$V = m_s$$

$$\therefore \frac{\sigma^2 V}{2Em_s} = h$$

$$\text{So, } PE = m_s h$$

$$= m_s (h + \Delta L)$$

$$E = \frac{\sigma}{\epsilon} = \sigma \div \frac{\Delta L}{L} = \frac{\sigma L}{\Delta L} \therefore \Delta L = \frac{\sigma L}{E}$$

$$m_s (h + \Delta L) = \frac{P^2 L}{2AE}$$

$$m_s \left(h + \frac{\sigma L}{E} \right) = \frac{\sigma^2 L}{2AE}$$

$$m_s \left(h + \frac{\sigma L}{E} \right) = \frac{\sigma^2 AL}{2E}$$

$$AL = V$$

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

$$\frac{\sigma^2 V}{2Em_s} = h + \frac{\sigma L}{E}$$

$$\text{So, } h = \frac{\sigma^2 V}{2Em_s}$$

due to extension being
"Not Significant"

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Q4

$$a) I_{xx} = 2 I_{xx} 'C' + 2 I_{xx} 'Plate'$$

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

$$= 52.4 \times 10^6 + \cancel{0.9728 \times 10^6}$$

$$= \cancel{53.2928 \times 10^6} \text{ mm}^4$$

$$I_{yy} = 2 I_{yy} 'C' + 2 I_{yy} 'Plate'$$

$$= 2 \times (1.57 \times 10^6 + Ah^2) + 2 \left(\frac{12 \times 300^3}{12} \right)$$

$$= \cancel{3.14 \times 10^6} + 0.18 \times 10^6$$

$$= \underline{58.2408 \times 10^6 \text{ mm}^4}$$

∴ The strut will buckle about

$$\underline{I_{xx}} \text{ as } \underline{I_{yy} > I_{xx}}$$

$$b) K = \sqrt{\frac{I}{A}}$$

$$= \sqrt{\frac{53.2928 \times 10^6}{2 \times 4400 \times (12 \times 12)}}$$

$$= \underline{57.71 \text{ mm}}$$

$$c) \text{Slenderness Ratio} = \frac{L}{K} = \frac{8000}{57.71} = 138.65$$

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Q4

d)

Pinned Both

$$\begin{aligned} P_c &= \frac{\pi^2 EI}{L^2} \\ &= \frac{\pi^2 \times 200 \times 10^9 \times 53.2928 \times 10^{-6}}{8^2} \\ &= 1643683.917 \text{ N} \\ &= \underline{\underline{1643.68 \text{ kN}}} \end{aligned}$$

e)

$$\begin{aligned} P_{Re} &= \frac{\sigma_y A}{1 + \alpha \left(\frac{L}{k}\right)^2} \\ &= \frac{320 \times 10^6 \times 16000 \times 10^{-3}}{1 + \frac{1}{7500} \times 138.65^2} \\ &= 1436920.186 \text{ N} \\ &= \underline{\underline{1436.92 \text{ kN}}} \end{aligned}$$

f)

$$\begin{aligned} I_{xx} &= I_{xx} \text{ original} + 2 I_{xx} \text{ New Plates} \\ &= 53.2928 \times 10^6 + 2 \left(\frac{6 \times 224^3}{12} \right) \\ &= 53.2928 \times 10^6 + 11.239424 \times 10^6 \end{aligned}$$

$$\text{New } I_{xx} = 64.53224 \times 10^6 \text{ mm}^4$$

$$\begin{aligned} P_c &= \frac{\pi^2 EI}{L^2} = \frac{\pi^2 \times 200 \times 10^9 \times 64.53224 \times 10^6}{8^2} \\ &= 1980336.5 \text{ N} \\ &= 1980.34 \text{ kN} \end{aligned}$$

Euler load for xx would increase to 346.66 kN