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ADVANCED STRESS ANALYSIS AND FEA M6X00420

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Q1

① There are three different element types to choose from 1D, 2D and 3D.

A one dimensional model would most suit 1D element types and would require the section and section orientation to be defined. A 2D model would most suit 2D element types (where one axis dimension is significantly smaller than the other two). The element thickness will need to be defined for a 2D Element. 3D element types most suit complex 3D models.

All the physical properties are already defined in a 3D model.

A 3D model can however be modelled as ~~a~~ with 1D Elements if so required (such as a steel frame made up of beams.)

② Element size plays an important role in an FEA model for a multitude of reasons, and it is important to consider these following factors. Element size directly influences processing times thus if the deadline is near or computational processing power is limited a larger mesh is suggested. The modelled geometry must be considered, holes and complex features will require a smaller mesh to retain accuracy; holes also benefit a brick mesh over 'tets', while 'tets' can largely be automatically meshed through software compared to brick mesh. This will directly influence pre-processing times. The user may decide to use biasing to specify a coarse mesh at sections of simple geometry and a finer mesh at more complex features. If no specific mesh size is preferred the user may choose to run tests on the accuracy and time figures of various mesh sizes.

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(c) First order elements only feature nodes at the corners of each element while second order elements also feature nodes at the mid-points at each element. See diagram below. The quad element below has 8 ^{nodes for} first order elements while if it was second order it would have 20 nodes. The greater the number of nodes the longer time it would take to solve. However as each calculation is done at a node, more nodes produce a greater degree of accuracy.

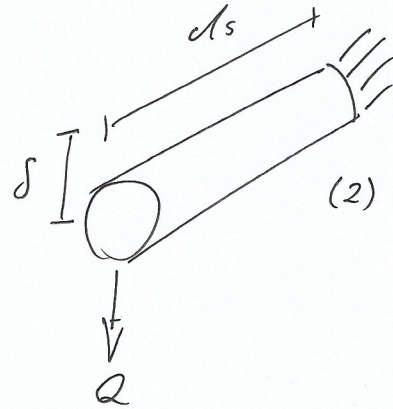
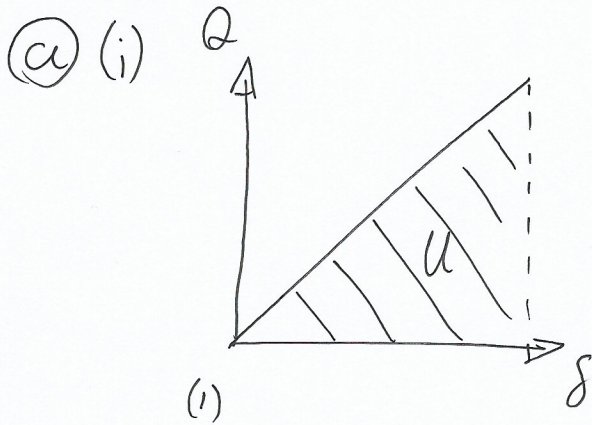
(d) An h-adaptive meshing adjusts the mesh automatically around features which require a finer mesh while p-adaptive meshing adjusts the polynomial order of the mesh. Both add a level of automation to the meshing process but may cause mis-interpretations when geometry is very complex.

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Q2



$$G = \frac{\text{shear stress}}{\text{shear strain}} = \frac{\tau}{\gamma}$$

$$\text{shear stress} = \frac{Q}{A}$$

shear strain γ

$$G = \frac{\frac{Q}{A}}{\gamma}$$

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

(ii) See diagram (i) above.

$u = \text{work done}$

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

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Q2

(b)(i)

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

$$\sigma = \frac{P}{A}$$

$$P = \sigma A$$



$$P = (480 \times 10^6) (\{0.030 \times 0.020\} - \{0.025 \times 0.015\})$$

$$P = (480 \times 10^6) (6 \times 10^{-4} - 3.75 \times 10^{-4})$$

$$P = (480 \times 10^6) (2.25 \times 10^{-4})$$

$$P = 108 \text{ kN}$$

$$\therefore U = \frac{(108 \times 10^3)^2 (2.4)}{2(2.25 \times 10^{-4})(190 \times 10^9)}$$

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

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Q2
(b) (ii)

$$\begin{aligned} P.E. &= mgh \\ &= mg(h + \delta L) \end{aligned} \quad (1)$$

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

$$\text{Now, } \epsilon = \frac{\sigma}{E} = \sigma \div \frac{\delta L}{L} = \frac{\sigma L}{\delta L}$$

$$\sigma = \frac{P}{A}$$

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

↓
①

$$P.E. = mg\left(h + \frac{\sigma L}{E}\right) \quad (2)$$

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

$$AL = \text{Area} \times \text{length} = \text{Volume} = V$$

$$\therefore U = \frac{\sigma^2 V}{2E} \quad (3)$$

② into ③

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

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

Extension of box section
is not significant in the
energy transfer therefore,

$$h = \frac{\sigma^2 V}{2Emg} \quad W = mg$$

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

Energy transfer is not significant

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Q2 (b) (iii)

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

$$\begin{aligned} 2EW h &= \sigma^2 V \\ \sqrt{\frac{2EW h}{V}} &= \sqrt{\sigma^2} \\ \sqrt{\frac{2EW h}{V}} &= \sigma \end{aligned}$$

$$\therefore \sigma = \frac{\sqrt{2(190 \times 10^9)(20 \times 9.81)(0.450)}}{2.25 \times 10^{-4}}$$

$$\sigma = \underline{\underline{386.15 \text{ MPa}}}$$

Q2 (b) (iv)

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24

(a) $I_{yy} = 2I_{yy}(\text{channel}) + 2I_{yy}(\text{plate})$

$$= 2(I_{yy} + Ah^2) + 2\left(\frac{bd^3}{12}\right) \quad 0.012 \times 0.300^3$$

$$= 2(1.57 \times 10^{-6} + (0.0044)(0.079)^2) + 2\left(\frac{12 \times 100^3}{12}\right)$$

$$= 58.06 \times 10^{-6} + 54 \times 10^{-6}$$

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

$$I_{xx} = 2(I_{xx}(\text{channel})) + 2(I + Ah^2)$$

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

$$= 52.4 \times 10^{-6} + 2\left(\frac{0.300 \times 0.012^3}{12} + (0.300 \times 0.012)(0.144)^2\right)$$

$$= 52.4 \times 10^{-6} + 2(4.32 \times 10^{-8} + 74.6496 \times 10^{-6})$$

$$= 52.4 \times 10^{-6} + 2(74.69 \times 10^{-6})$$

$$= 52.4 \times 10^{-6} + 149.3856 \times 10^{-6}$$

$$= 201.78 \times 10^{-6} \text{ mm}^4$$

$I_{xx} > I_{yy}$ therefore it would buckle about YY.

24 (b) $k = \sqrt{\frac{I}{A}} = 0.084 \text{ m}$

$$= \sqrt{\frac{112.06 \times 10^{-6}}{2(0.0044) + 2(0.3 \times 0.012)}}$$

$$= \sqrt{\frac{112.06 \times 10^{-6}}{0.016}}$$

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(c)

Slenderness Ratio = $\frac{L}{k}$

$$= \frac{8}{0.084} = \underline{\underline{95.59}}$$

 $24(a)$

$$P_e = \frac{\pi^2 EI}{L^2}$$

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

= 365.2422367 days

~~$= \frac{1}{6} [2 + 2 + 2 + 2 + 2 + 2] = 2$~~

$$= \underline{3.46 \text{ MN}}$$

24 (e)

$$R = \frac{\sigma_y A}{1 + a(L/k)^2}$$

$$= \frac{(320 \times 10^6)(0.016)}{1 + \left(\frac{1}{7500}\right)\left(\frac{8}{0.084}\right)^2}$$

$$= \underline{\underline{2.32 \text{ MN}}}$$

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Q4
(P)

$$P_e = \frac{\pi^2 EI}{L^2}$$