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Structural design exam

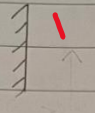
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Section A

a)

Fixed



Hinge



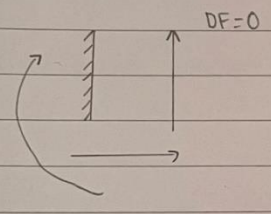
Roller



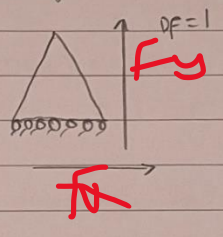
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b)

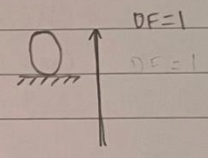
Fixed



Hinge



Roller



1

d)

Summation of horizontal forces is equal to 0

$$\sum H = 0$$

Summation of vertical forces are equal to 0

$$\sum V = 0$$

Summation of moments is equal to 0

$$\sum M = 0$$

6

f)

(F.1) = statically determinate.

(F.2) = statically determinate.

(F.3) = statically indeterminate to the second degree

(F.4) = statically indeterminate to the first degree.

4

c)

Determinate structures are analysed just by the use of basic equilibrium equations. By this analysis, the unknown reactions are found for the further determination of stresses. Whereas indeterminate structures are not capable of being analysed by mere use of basic equilibrium equations. Along with the basic equilibrium equations, some extra conditions are required. Special methods like strain energy method, slope deflection method, moment distribution method, column analogy method, virtual work method, matrix methods, etc are used for the analysis of redundant structures.

e)

- For statically determinate structures, $r = 3n$
- If $r > 3n$, structure is statically indeterminate

Where;

n = the total number of the parts of structure.

r = the total number of unknown reactive force and moment components

g)

Frame structures are the structures having the combination of beam, column and slab to resist the lateral and gravity loads. These structures are usually used to overcome the large moments developing due to the applied loading. Two basic classifications of frame structure would be rigid frame structure and braced frame structure.

h)

Over rigid meaning the truss has too many members. Under rigid meaning the truss has too little members.

i)

For a truss to be rigid, the following condition must exist

$$m = 2j - 3$$

where m = Number of members

j = Number of joints

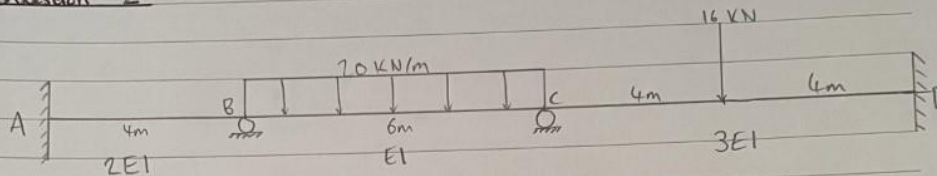
Non-rigid or imperfect truss does not obey this equation.

j)

(i) – Warren truss (ii) – Pratt truss (iii) – Howe truss (iv) – K-truss (v) – Fink truss

Q1 - 35

Question 2



Calculate the distribution factor for joint

Stiffness coefficient of member AB (K_{AB}) = $EI/L = 2/4$

Stiffness coefficient of member BC (K_{BC}) = $EI/L = 1/6$

Distribution factor BA (DF_{BA}) = $K_{AB} / (K_{AB} + K_{BC})$
 $= (2/4) / (2/4 + 1/6) = 0.75$

Distribution Factor BC (DF_{BC}) = $K_{BC} / (K_{AB} + K_{BC})$
 $= (1/6) / (2/4 + 1/6) = 0.25$

Stiffness coefficient of member BC (K_{BC}) = $EI/L = 1/6$

Stiffness coefficient of member CD (K_{CD}) = $EI/L = 3/8$

Distribution factor BA (DF_{CB}) = $K_{BC} / (K_{BC} + K_{CD})$
 $= 1/6 / (1/6 + 3/8) = 0.31$

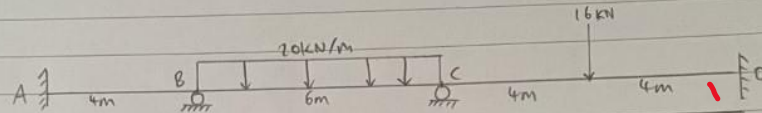
Distribution factor BC (DF_{CD}) = $K_{CD} / (K_{BC} + K_{CD})$
 $= 3/8 / (1/6 + 3/8) = 0.69$

Calculate the fixed-end moment

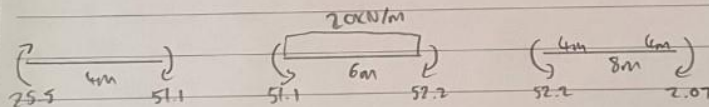
Fixed-end moment member AB (FEM_{AB}) = $WL^2/12 = 20 \times 6 \times 6 / 12 = 60 \text{ kNm}$

Fixed-end moment member BC (FEM_{BC}) = $PL/8 = 16 \times 4 / 8 = 8 \text{ kNm}$

Balance moment at joints



Distribution Factor	<u>1</u>	0.75	0.25	0.31	0.69	0
Fixed-end moment	0	0	60	-60	16	-16
Balance		-45	-15	13.64	30.36	
Carry	-22.5		6.92	-7.5		15.18
Balance		-5.12	-1.71	2.33	5.18	
Carry	-2.56		1.17	-0.86		2.59
Balance		-0.98	-0.3	0.27	0.6	
Carry	-0.49		0.14	-0.15		0.3
Balance		-0.11	-0.04	0.05	0.1	
Final Moment	-25.5	-51.1	51.1	-52.2	52.2	2.07



Span AB

$$V_{AB} \times 4 + 25.5 + 51.1 = 0$$

$$4V_{AB} + 76.6 = 0$$

$$V_{AB} = \frac{-76.6}{4} = -19.15 \text{ kN} \downarrow$$

BA

$$(-V_{BA} \times 4) + 25.5 + 51.1 = 0$$

$$-V_{BA} \times 4 = -76.6$$

$$V_{BA} = \frac{76.6}{4} = 19.15 \text{ kN} \uparrow$$

Span BC

$$V_{BC} \times 6 - 51.1 - (20 \times 6 \times 3) + 52.2 = 0$$

$$6V_{BC} = 358.6$$

$$V_{BC} = \frac{358.6}{6} = 59.76 \text{ kN}$$

CB

$$(-V_{CB} \times 6) + 52.2 + (20 \times 6 \times 3) - 51.1 = 0$$

$$6V_{CB} = 361.1$$

$$V_{CB} = \frac{361.1}{6} = 60.2 \text{ kN}$$

CD

$$V_{CD} \times 8 - 52.2 - (16.72) + 2.07$$

$$8V_{CD} = -177.93$$

$$V_{CD} = \frac{-177.93}{8}$$

$$= -22.24 \text{ kN}$$

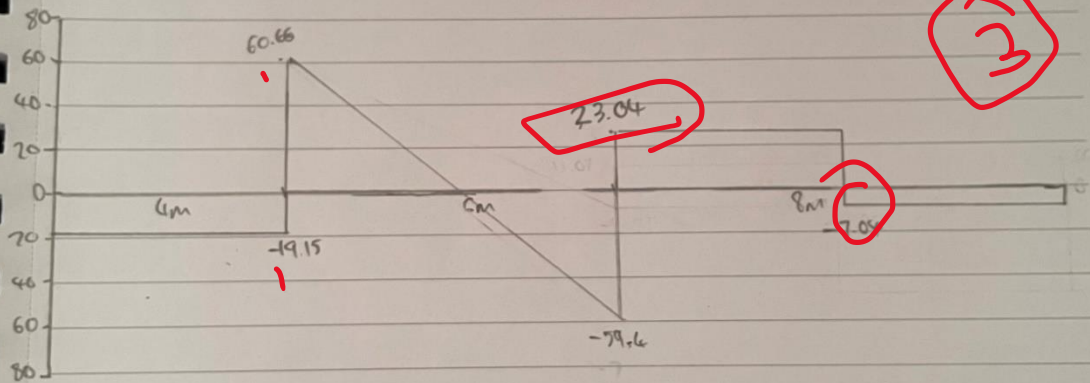
DC

$$-V_{DC} \times 8 + 7.07 + (16.72) - 52.2$$

$$8V_{DC} = 77.97$$

$$V_{DC} = \frac{77.97}{8} = 9.7$$

Shear force diagram



$$V_A = 19.15 \text{ kN} \downarrow$$

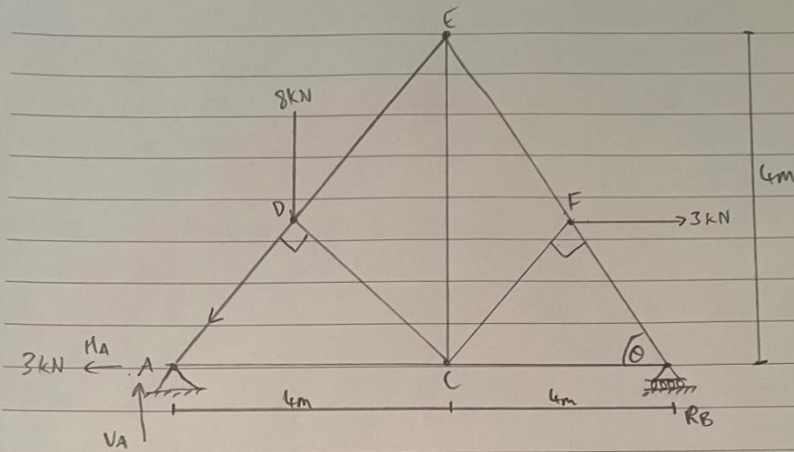
$$V_B = 19.15 + 59.76 = 78.91$$

$$V_C = 60.2 + 22.24 = 82.44$$

$$V_D = 9.7$$

Q2 - 21

Question 4



$$\tan \theta = \frac{4}{4} = 1 \quad \theta = 45^\circ$$

Support reactions at A and B

$$R_B \times (4+4) - 3 \times 2 - 8 \times 2 = -14$$

$$R_B = -14 \text{ kN (C)} +$$

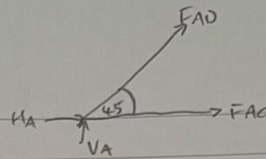
$$\begin{aligned} V_A &= 8 - R_B \\ &= 8 - (-14) \\ &= 22 \text{ kN} \end{aligned}$$

$$H_A = 3 \text{ kN} \leftarrow$$

$$\begin{aligned} R_A &= \sqrt{V_A^2 + H_A^2} \\ &= \sqrt{(22)^2 + (3)^2} \\ &= 22.2 \text{ kN} \end{aligned}$$

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Members AD and AC



Using $\sum F = 0$

$$F_{AD} = \sin 45 + V_A$$

$$0.707 F_{AD} + 22$$

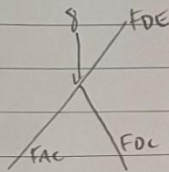
$$F_{AD} = 22.707 \text{ (C)}$$

$$F_{AC} + F_{AD} \cos 45 - H_A = 0$$

$$F_{AC} - 22.7 \times 0.707 - 3$$

$$F_{AC} = 19.04 \text{ kN (T)}$$

Forces in members DE and DC



$$8 - F_{DE} \sin 45 + F_{DC} \sin 45 - F_{AD} \sin 45 = 0$$

$$8 - 0.707 F_{DE} + 0.707 F_{DC} - 22.7 \times 0.707 = 0$$

$$7.3 + 0.707 F_{DC} + 0.707 F_{DE} = 0$$

$\sum F = 0$

$$F_{AD} \cos 45 + F_{DC} \cos 45 + F_{DE} \cos 45 = 0$$

$$22.7 \times 0.707 + 0.707 F_{DC} + 0.707 F_{DE} = 0$$

$$16.05 + 0.707 F_{DC} + 0.707 F_{DE} = 0$$

$F_{DC} =$

Q4-8

4