S.No. : 01 SK1_CE_B_190619
Structure Analysis

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 19/06/2019

ANSWER KEY ➤ Structure Analysis

1.	(b)	7.	(c)	13.	(b)	19.	(b)	25.	(b)
2.	(b)	8.	(b)	14.	(d)	20.	(b)	26.	(d)
3.	(a)	9.	(a)	15.	(c)	21.	(a)	27.	(c)
4.	(b)	10.	(d)	16.	(c)	22.	(d)	28.	(a)
5.	(c)	11.	(c)	17.	(d)	23.	(d)	29.	(d)
6.	(a)	12.	(c)	18.	(a)	24.	(c)	30.	(a)

DETAILED EXPLANATIONS

1. (b)

$$D_s = 3C - R' \quad \text{(where } R' = \text{no. of released reactions)}$$

Here $C = 3$

$R' = 7 \quad (2 + 2 + 2 + 1)$

$\therefore \quad D_s = 2$

2. (b)

$$D_s = 3C - R'$$
$$= 3 \times 1 - 4 = -1$$

$D_s < 0 \therefore$ unstable.

3. (a)

$$D_k = 3j - R_e$$
$$= 3 \times 5 - 6 = 9$$

5. (c)

$$\delta_B = 0$$

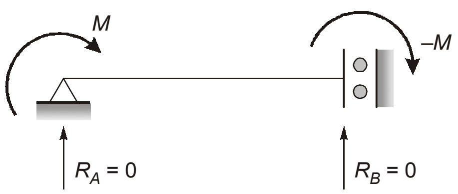
$$\frac{-Ml^2}{2EI} + \frac{R_B l^3}{3EI} = 0$$

$\therefore \quad R_B = \frac{3}{2}\frac{M}{l}$

Now $R_A + R_B = 0$

$\therefore \quad R_A = -R_B = -\frac{3}{2}\frac{M}{l}$ (downward)

6. (a)



$\therefore \quad$ COF $= -1$

7. (c)

$$k_A = \frac{4(3EI)}{l} + \frac{4(2EI)}{2l} + \frac{3EI}{l}$$

$$k_A = \frac{12EI}{l} + \frac{4EI}{l} + \frac{3EI}{l} = \frac{19EI}{l}$$

8. (b)

$$F_{BD}\cos\theta = 80$$

$$F_{BD} \times \frac{8}{10} = 80$$

$$F_{BD} = 100 \text{ kN (compressive)}$$

10. (d)

Degree of static indeterminacy

$$D_s = m + r_e - 2j$$

Here, $m = 12$, $j = 9$ and $r_e = 6$

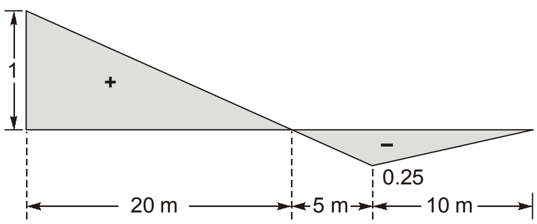
$\therefore$ $$D_s = 12 + 6 - 2 \times 9 = 0$$

Degree of kinematic indeterminacy

$$D_k = 2j - r_e - m$$
$$= 2 \times 9 - 6 - 0 = 12$$

$\therefore$ Thus truss is statically determinate and kinematically indeterminate.

11. (c)



$$\text{Shear force at } A = 2 \times \left[\frac{1}{2} \times 20 \times 1 - \frac{1}{2} \times 15 \times 0.25\right]$$

$$= 16.25 \text{ tonne}$$

12. (c)

The moment at crown being zero. Consider AC

$$H_A.2R = V_A.2R \Rightarrow H_A = V_A$$

For BC $$H_B R = V_B R \Rightarrow H_B = V_B$$

As $$H_A = H_B \Rightarrow V_A = V_B$$

Now $$V_A + V_B = W \Rightarrow V_A = V_B = W/2$$

$$\text{Inclination of RA with horizontal} = \frac{V_A}{H_A} = 1$$

$\therefore$ $$\text{Inclination} = 45°$$

13. (b)

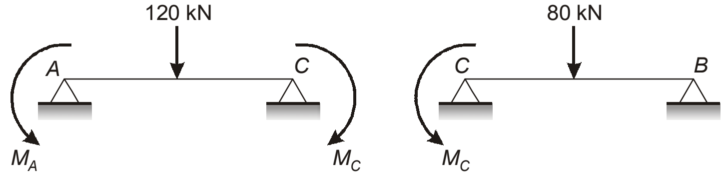
$$D_k = 3_i - R_e - m$$
$$= 3 \times 5 - 6 - 4 = 5$$

14. (d)

$$D_k = 3i + r - R_e$$
$$= 3 \times 9 + 3 - 9$$
$$D_k = 21$$

16. (c)

Let redundant be M_A and M_C



$$\theta_{CA} = \frac{M_A \times 6}{6EI} + \frac{M_C \times 6}{3EI} - \frac{120 \times 6^2}{16EI}$$

$$\theta_{CB} = \frac{80 \times 6^2}{16EI} - \frac{M_C \times 6}{3EI}$$

$$\theta_{CA} = \theta_{CB}$$

$\Rightarrow$ $$M_A + 4M_C = 450 \quad \text{...(i)}$$

$$\theta_A = 0$$

$\therefore$ $$\frac{-120 \times 6^2}{16EI} + \frac{6 \times M_A}{3EI} + \frac{M_C \times 6}{6EI} = 0$$

$\Rightarrow$ $$2M_A + M_C = 270 \quad \text{...(ii)}$$

Solving (i) and (ii),

$$M_A = M_C = 90 \text{ kNm}$$

17. (d)

$M_{FAB} = -80$, $M_{FBA} = 80$, solving by moment distribution method

A	B	
–80	80	
–	–60	
–30	–	
–	–	
–110	+20	–20

$\therefore$ $$M_A = -110 \text{ kNm}$$

18. (a)

Using the concept of symmetry

$$\text{Stiffness of } BC = \frac{2E(2I)}{8}$$

$$\text{Stiffness of } BA = \frac{2EI}{4}$$

$\therefore$ Distribution factor for BC = DF for $BA = 0.5$

$$M_{FBC} = -20 \text{ kNm}$$

$$M_{FBA} = +20 \text{ kNm}$$

Since the joint is balanced no. need to draw moment distribution table

$\therefore$ $$M_{BC} = M_{FBC} = -20 \text{ kNm}$$

19. (b)

Since clockwise moment is positive

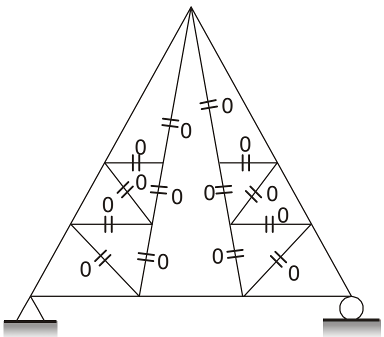
$$M_{FAB} = \frac{-Wl^2}{20} = -7.2 \text{ kNm}$$

$$M_{FAD} = \frac{+Wl^2}{12} = 13.33 \text{ kNm}$$

20. (b)

Joint	Member	Stiffness	D.F
B	*BA*	$\frac{4E(2I)}{4}$	0.47
	BE	$\frac{4E(2I)}{5}$	0.38
	BC	$\frac{4EI}{6}$	0.16

22. (d)



No. of zero force member = 14.

23. (d)

$$R_P = 50 \text{ kN}$$

$$R_Q = 40 \text{ kN}$$

At point *P*, $F_{PR} = -\frac{R_P}{\sin 45°} = -50\sqrt{2}$

At joint *T*, $F_{RT} = 60 \text{ kN}$ (tensile)

At joint *Q*, $-F_{SQ} \sin 45 = R_Q$

$$F_{SQ} = -40\sqrt{2}$$

At joint *S*, $F_{SU} = -F_{SQ} \sin 45$

$\therefore$ $F_{SU} = 40 \text{ kN}$ (tensile)

$$F_{RS} = F_{SQ} \cos 45$$

$$F_{RS} = -40 \text{ kN}$$

24. (c)

At joint D ($\Sigma F_v = 0$)

$$F_{OC} - 15\text{ T} = 0$$
$$F_{DC} = 15\text{ T.}$$

25. (b)

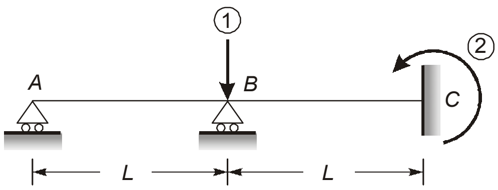
Stiffness of spring system,

$$K_{eq} = 0.5\,K + K + K = 2.5\,K$$

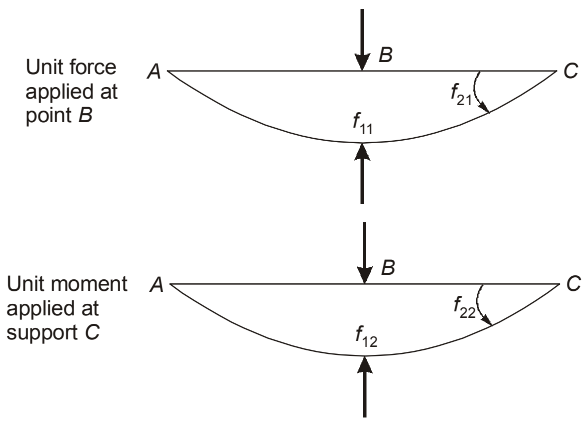
Stiffness of beam, $K_{Beam} = \dfrac{3EI}{l^3}$ $\left[\because \quad \text{Deflection, } \Delta = \dfrac{Pl^3}{3EI} \Rightarrow \dfrac{P}{\Delta} = \text{Stiffness} = \dfrac{3EI}{l^3}\right]$

$\therefore$ Total stiffness of system $= 2.5K + \dfrac{3EI}{l^3}$

26. (d)



The elements of the flexibility matrix are obtained by applying unit values of redundants at the coordinates one after the other as shown below.



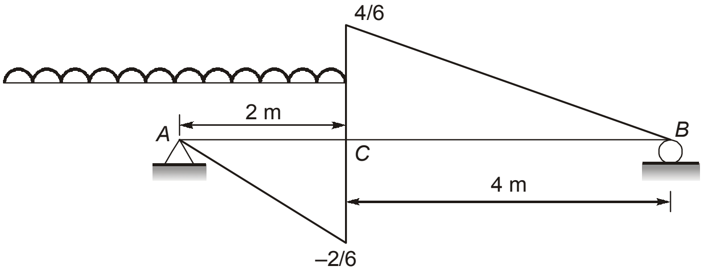
$$f_{11} = \frac{(2L)^3}{48EI} = \frac{L^3}{6EI}$$

$$f_{21} = f_{12} = \frac{1(2L)^2}{16EI} = \frac{L^2}{4EI}$$

$$f_{22} = \frac{2L}{3EI}$$

$\therefore$
$$[F] = \frac{L}{12EI}\begin{bmatrix} 2L^2 & 3L \\ 3L & 8 \end{bmatrix}$$

28. (a)

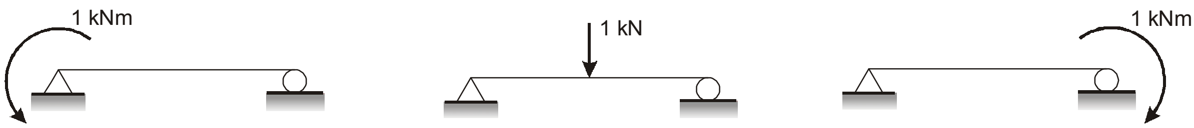


$$\text{Maximum negative shear force at } C = \frac{1}{2}\times 2\times \frac{-2}{6}\times 10$$

$$= \frac{-20}{6} = -3.33 \text{ kN}$$

29. (d)

For development of flexibility matrix, a unit load is applied at the co-ordinate direction and the deformation produced in other co-ordinate direction is measured.



$$f_{11} = \frac{l}{3EI} \qquad f_{13} = \frac{-l^2}{16EI} = f_{31} \qquad f_{22} = \frac{l}{3EI}$$

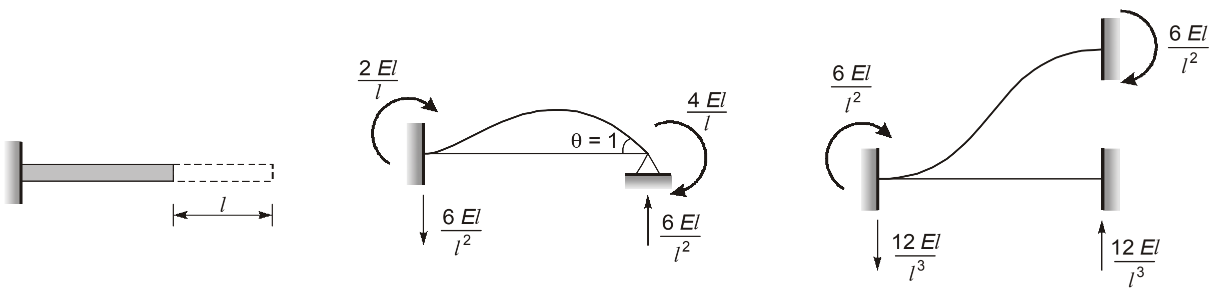
$$f_{21} = \frac{l}{6EI} = f_{12} \qquad f_{23} = \frac{-l^2}{16EI} = f_{32}$$

$$f_{33} = \frac{l^3}{48EI}$$

$$f = \begin{bmatrix} f_{11} & f_{21} & f_{31} \\ f_{12} & f_{22} & f_{32} \\ f_{13} & f_{23} & f_{33} \end{bmatrix}$$

30. (a)

For development of stiffness matrix, unit deformation is provided in one coordinate direction by restraining deformation in other co-ordinate direction. The force developed in the respective co-ordinate direction is the measure of stiffness matrix co-efficient.



$$k_{11} = \frac{AE}{l} \qquad k_{13} = 0 \qquad k_{12} = 0$$

$$k_{21} = 0 \qquad k_{23} = \frac{6EI}{l^2} \qquad k_{22} = \frac{12EI}{l^3}$$

$$k_{31} = 0 \qquad k_{33} = \frac{4EI}{l} \qquad k_{32} = \frac{6EI}{l^2}$$

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