CLASS TEST

S.No. : 03SK_CE_OPQ_27112024

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STRUCTURAL ANALYSIS

CIVIL ENGINEERING

Date of Test : 27/11/2024

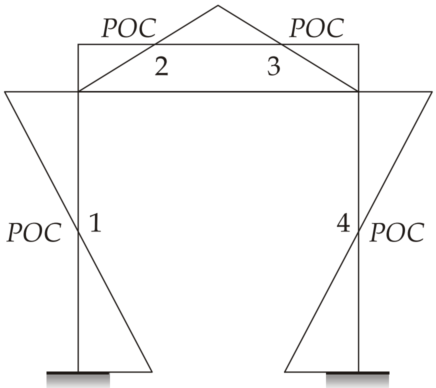
ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

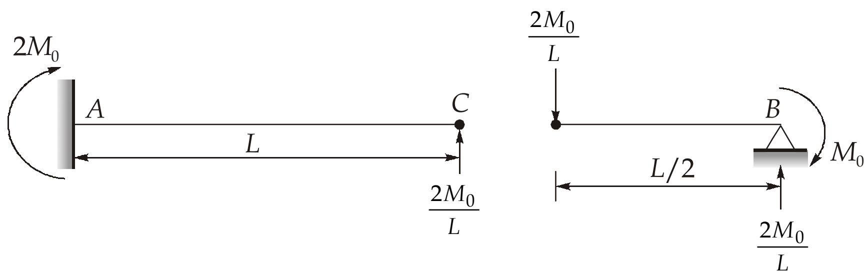
2. (c)



4 points of contra-flexure.

3. (c)

FBD:



So, $$\text{Carryover factor} = \frac{\text{Moment of } A}{\text{Applied moment at } B} = \frac{2M_0}{M_0} = 2$$

4. (c)

$$M_{FCB} = -\frac{12\times 4^2}{12} = -16 \text{ kNm}$$

$$M_{CB} + M_{CA} = 0$$

$$\Rightarrow \quad -16 + \frac{2EI}{4}\times(2\theta_C) + \frac{2EI}{4}\times(2\theta_C) = 0$$

$$\Rightarrow \quad \theta_C = \frac{8}{EI}$$

5. (d)

For static equilibrium in a space structure equations to be satisfied are,

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$

$$\Sigma M_x = 0, \Sigma M_y = 0, \Sigma M_z = 0$$

6. (c)

7. (d)

8. (b)

9. (d)

Stiffness of beam, $$k_b = \frac{48EI}{L^3}$$

$$k_b = \frac{48 \times 1}{2^3} = 6 \text{ unit}$$

Equivalent stiffness, k_{eq}

$$\frac{1}{k_{eq}} = \frac{1}{6} + \frac{1}{12} = \frac{3}{12}$$

(Because, beam and spring are in series as there deflection is different)

$$k_{eq} = 4 \text{ unit}$$

10. (b)

The maximum bending moment for any position of load occur under the load. So the equation for maximum bending moment is

$$M_{max} = \frac{x(L-x)}{L}$$

Thus the ILD for maximum bending moment is parabolic.
This is also called envelop of maximum bending moment.

11. (b)

Members of truss can be of different cross-section.

12. (c)

Let the vertical reaction at A and B be V_A and V_B respectively are horizontal thrust be H.

$$\Sigma M_A = 0$$

$$\Rightarrow \quad V_B \times 12 - 8 \times P = 0$$

$$\Rightarrow \quad V_B = \frac{2P}{3}$$

$$\Rightarrow \quad V_A = P - \frac{2}{3}P = \frac{P}{3}$$

$$\Sigma M_C = 0$$

$$\Rightarrow \quad 6 \times V_A - 4 \times H = 0$$

$$\Rightarrow \quad H = \frac{6V_A}{4}$$

$$\Rightarrow \quad H = \frac{6 \times P}{4 \times 3} = \frac{P}{2}$$

13. (b)

At joint B,

Joint	Members	Stiffness	Total Stiffness	Distribution factor
B	BA	$\frac{3EI}{L}$	$\frac{7EI}{L}$	$\frac{3}{7}$
	BC	$\frac{4EI}{L}$		$\frac{4}{7}$

Fixed end moments, $$M_{FBC} = -\frac{WL}{8}$$

$$M_{FCB} = +\frac{WL}{8}$$

Distributing ($-M_{FBC}$) to M_{BA} and M_{BC}. Final moment will be,

$$M_{BA} = \frac{3}{7} \times \frac{WL}{8}$$

$$M_{BC} = -\frac{WL}{8} + \frac{4}{7} \times \frac{WL}{8} = -\frac{3WL}{56}$$

and carryover of distributed moment of member BC is

$$M_{CB} = \frac{1}{2}\left(\frac{4}{7} \times \frac{WL}{8}\right)$$

So, final moment, $$M_{CB} = \frac{WL}{8} + \frac{2WL}{56} = \frac{9WL}{56}$$

So, $$\frac{M_{BC}}{M_{CB}} = \frac{-\frac{3WL}{56}}{\frac{9WL}{56}} = -\frac{1}{3}$$

Magnitude $= \frac{1}{3}$

14. (b)

For two-hinged semi-circular arch with load W applied at any section, the radius vector corresponding to which makes an angle θ with the horizontal.

$$H = \frac{W}{\pi}\sin^2\theta$$

With load at crown, $$\theta = \frac{\pi}{2}$$

So, $$H = \frac{W}{\pi}$$

15. (c)

Circular frequency for damped condition is

$$\omega_D = \omega_n\sqrt{1-(\varepsilon)^2}$$

$$= \sqrt{\frac{k}{m}} \times \sqrt{1-\varepsilon^2}$$

$$\omega_D = \sqrt{\frac{21\times10^3}{32}} \times \sqrt{1-\left(\frac{3}{100}\right)^2}$$

$$\omega_D = 25.6 \text{ rad/sec}$$

Cyclic frequency, $$f_D = \frac{\omega_D}{2\pi} = \frac{25.6}{2\pi} = 4.075 \text{ Hz}$$

16. (a)

$$\text{Vertical reaction; } V = \frac{wl}{2} = \frac{15\times150}{2} = 1125 \text{ kN}$$

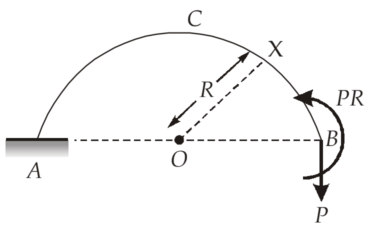
$$\text{Horizontal reaction; } H = \frac{wl^2}{8h} = \frac{15\times150^2}{8\times10} = 4218.75 \text{ kN}$$

$\therefore$ Maximum tension $= T_{max} = \sqrt{V^2+H^2} = \sqrt{1125^2+4218.75^2} = 4366.17$ kN

Minimum tension $= T_{min} = H = 4218.75$ kN

$\therefore$ $T_{max} - T_{min} = 147.42$ kN

17. (a)



For member ACB,

Moment at X, $M_x = PR - PR(1-\cos\theta) = PR\cos\theta$

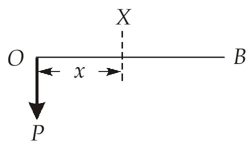
Strain energy stored, $$W_i = \int\frac{M_x^2 ds}{2EI} = \int_0^{\pi}\frac{(PR\cos\theta)^2 R d\theta}{2EI}$$

$$\Rightarrow \quad W_i = \frac{P^2R^3}{2EI}\times2\int_0^{\frac{\pi}{2}}\cos^2\theta\, d\theta = \frac{P^2R^3}{EI}\times\frac{\pi}{4}$$

$\therefore$ Vertical deflection at O due to member ACB,

$$\delta = \frac{\partial W_i}{\partial P} = \frac{\pi}{2}\frac{PR^3}{EI}$$

For member OB,



Strain energy stored, $W_i = \int \frac{M_x^2 ds}{2EI} = \int_0^R \frac{(Px)^2 dx}{2EI}$

$$W_i = \frac{P^2R^3}{6EI}$$

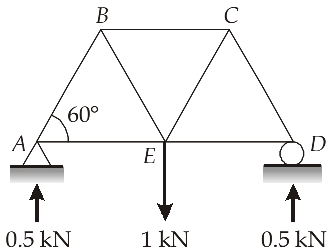
$\therefore$ Vertical deflection at O due to member OB,

$$\delta = \frac{\partial W_i}{\partial P} = \frac{1}{3}\frac{PR^3}{EI}$$

$$\text{Total deflection} = \left(\frac{\pi}{2} + \frac{1}{3}\right)\frac{PR^3}{EI} = 1.904\frac{PR^3}{EI}$$

18. (d)

Apply a unit load at joint E

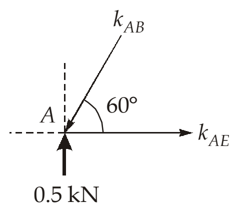


$$\delta_E = \Sigma K(L\alpha\Delta T) \quad ...(1)$$

At joint A; $\Sigma F_y = 0$

$\Rightarrow$ $0.5 - K_{AB}\sin 60° = 0$

$\therefore$ $K_{AB} = \frac{1}{\sqrt{3}}$ (compressive)

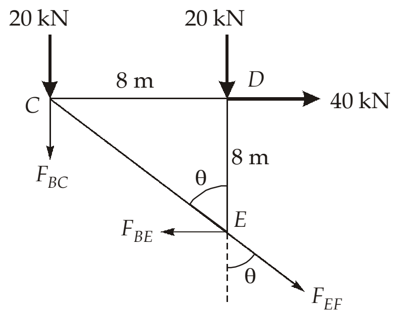


Also; $K_{AB} = K_{CD}$ (Due to symmetry)

From (1)

$\therefore$ $\delta_E = \left(\frac{1}{\sqrt{3}} \times 2 \times 12 \times 10^{-6} \times 20\right) \times 2 \text{ m} = 0.55 \text{ mm}$

19. (d)



Cut a section through BC, BE and EF

$\Sigma F_y = 0; \Rightarrow 20 + 20 + F_{EF}\cos\theta + F_{BC} = 0 \quad ...(1)$

$\Sigma M_E = 0; \Rightarrow F_{BC} \times 8 + 20 \times 8 = 40 \times 8$

$\Rightarrow$ $F_{BC} = 20 \text{ kN}; \ (\sin\theta = \cos\theta = \frac{1}{\sqrt{2}})$ $(\because \theta = 45°)$

From (1); $F_{EF} = -60\sqrt{2}$ kN (–ve i.e. compression)

∴ Magnitude of $F_{EF} = 60\sqrt{2}$ kN

20. **(b)**

Since, more moment will get transferred to the fixed ends due to decrease in stiffness of middle half.

21. **(c)**

As per Muller Breslau principle, release the reaction at A and a unit displacement is given to primary structure at A.

22. **(b)**

Since beam is symmetric

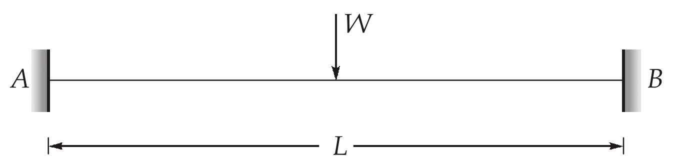
∴ Vertical reaction at A and B is i.e. $V_A = V_B = 50$ kN

∴ Taking moments about C

$$M_A = V_A \times 4 = 50 \times 4 = 200 \text{ kNm}$$

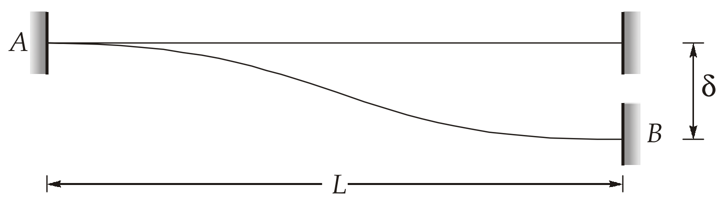
23. **(c)**

- Due to load



$$M_{FBA} = \frac{WL}{8} \text{ (clockwise)}$$

- Due to sinking of support



$$M_{FBA} = \frac{6EI\delta}{L^2} = \frac{6EI \times WL^3}{L^2 \times 48EI} \text{ (anticlockwise)}$$

$$= \frac{WL}{8}$$

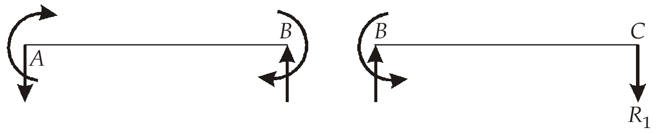
So fixing moment at B,

$$M_{FBA} = \frac{WL}{8}(\text{ACW}) + \frac{WL}{8}(\text{CW})$$

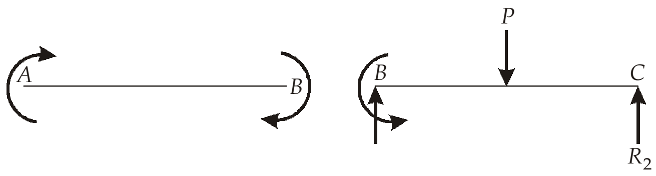
$$= 0$$

24. **(b)**

Due to sinking of support A,



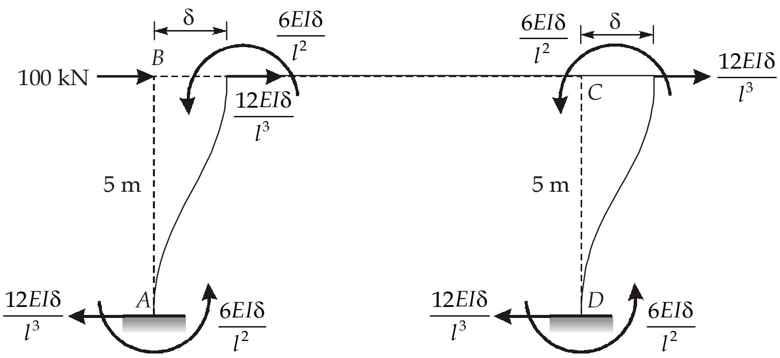
Due to load P



$\therefore$ $$R_C = R_1(\downarrow) + R_2(\uparrow) = R_2 - R_1 < R_2$$

Hence, reaction at C decreases.

25. **(b)**



$$\frac{12EI\delta}{l^3} + \frac{12EI\delta}{l^3} = 100$$

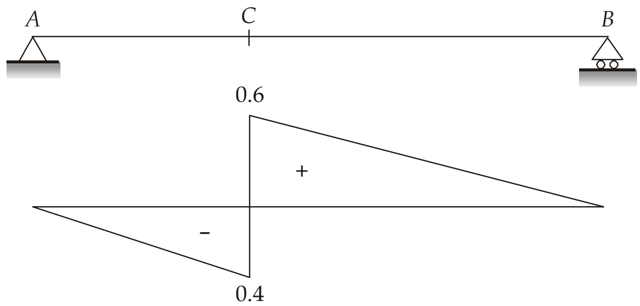
$\Rightarrow$ $$\frac{24EI\delta}{l^3} = 100$$

$$M_A = \frac{6EI\delta}{l^2}$$

$$= \frac{100 \times l}{4} = \frac{100 \times 5}{4} = 125 \text{ kNm}$$

26. **(a)**

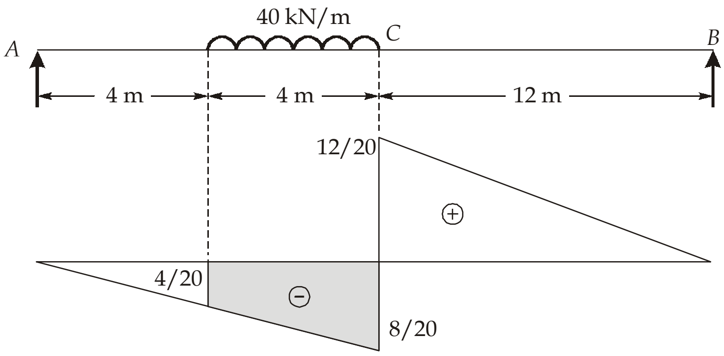
ILD for SF at C is shown below



ILD for S.F. at C

$$\therefore \quad \text{Maximum S.F.} = \frac{1}{2} \times 0.6 \times 6 \times 15$$
$$= 27 \text{ kN}$$

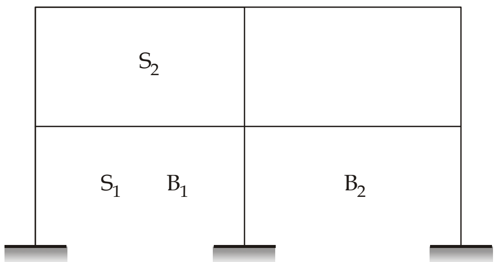
27. (b)



When head of UDL is at 8 m from A,

$$SF = 40\left[\frac{4}{20} + \frac{8}{20}\right] \times \frac{1}{2} \times 4 = 48 \text{ kN}$$

28. (b)



$$j = (S + 1)(B + 1) = \text{Number of joints}$$
$$m = S(B + 1) + BS = \text{Number of members}$$
$$r_e = 3(B + 1)$$
$$D_k = 3j - r_e - m$$
$$\therefore \quad D_k = 3(S + 1)(B + 1) - 3(B + 1) - S(B + 1) - BS$$
$$= S(B + 2)$$

29. (b)

30. (d)

■■■■