CLASS TEST

S.No. : 01 IG_CE_B+D_140623

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REINFORCED CEMENT CONCRETE

CIVIL ENGINEERING

Date of Test : 14/06/2023

ANSWER KEY

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

2. (a)

Given: B = 200 mm, d = 500 mm, l_{eff} = 6 mm, Total load = 20 kN/m

$$\text{Factored load} = 1.5 \times 20 = 30 \text{ kN/m}$$

$$(\text{BM})_{max} = \frac{wl_{eff}^2}{8} = \frac{30\times 6^2}{8} = 135 \text{ kNm}$$

Maximum bending moment capacity of balanced beam (For Fe415)

$$M_{u,lim} = 0.138\, f_{ck}Bd^2$$
$$= 0.138 \times 25 \times 200 \times 500^2 \times 10^{-6}$$
$$= 172.5 \text{ kNm}$$
$$(\text{BM})_{max} < M_{u,lim}$$

$\therefore$ Under reinforced section is provided.

3. (b)

$$\text{Long term, } m_l = \frac{280}{3\sigma_{cbc}} = \frac{280}{3\times 8.5} \simeq 11$$

$$\text{Short term, } m_s = \frac{E_s}{E_c} = \frac{2\times 10^5}{5000\sqrt{25}} = 8$$

$$\frac{m_l}{m_s} = \frac{11}{8} = 1.375$$

$$m_l = 1.375\, m_s$$

4. (b)

As per IS-456:2000; Table - 3 and table -16, nominal cover $\ngtr$ 30 mm.

and according to clause 26.4.2.1 of IS-456 : 2000, nominal cover $\nless$ 40 mm for column any case.

So, here, answer will be 40 mm.

6. (b)

As per yield line theory, (Inelastic analysis)

$$\text{BM}_{max} = \frac{w_u R^2}{6}$$

$$12 = \frac{w_u \times 2^2}{6}$$

$$w_u = 18 \text{ kN/m}^2$$

$$\text{Working load} = \frac{18}{1.5} = 12 \text{ kN/m}^2$$

Note: As per elastic theory, $\text{BM}_{max} = \frac{3}{16} w_u R^2$

8. (b)

Maximum spacing for vertical stirrups, $k_1 = 0.75d$ and for inclined stirrups, $k_2 = d$

So, $$\frac{k_1}{k_2} = 0.75$$

9. (b)

$$r = \frac{l_y}{l_x} = \frac{4}{3}$$

Maximum shear force along larger edge,

$$F_L = \frac{w_u l_x \times r}{2+r} = \frac{12 \times 3 \times \frac{4}{3}}{2+\frac{4}{3}} = \frac{48 \times 3}{10} = 14.4\text{ kN/m}$$

Maximum shear force along shorter edge,

$$F_S = \frac{w_u l_x}{3} = \frac{12 \times 3}{3} = 12\text{ kN/m}$$

$$\frac{F_L}{F_S} = \frac{14.4}{12} = 1.2$$

10. (d)

- Lap length of reinforcement in tension shall not be less than 30ϕ.
- If three bars are bundled together, development length shall be increased by 20%.
- If 2 bars are bundled then 10% if 3 bars are bundled then 20% and if 4 bars are bundled then 33%.

11. (a)

For 50 m^3 of concrete volume, we need to consider 4 number of samples.

Above 50 m^3, one addition sample is required.

$\therefore$ For 206 m^3 concrete,

Number of samples required = 4 + 1 + 1 + 1 + 1 = 8

12. (a)

Effective bending moment due to torsion,

$$M_t = \frac{T_u}{1.7}\left(1+\frac{D}{b}\right) = \frac{140}{1.7}\left(1+\frac{750}{350}\right) = 258.82\text{ kNm} \simeq 259\text{ kNm}$$

Equivalent bending moment at bottom is,

$$M_e = M_t + M_u = 259 + 200 = 459\text{ kN-m}$$

13. (a)

Width of web, $b_w = 250$ mm

Effective depth, $d = 500 - 40 = 460$ mm

Nominal shear stress, $\tau_v = \frac{V_u}{b_w d} = \frac{200 \times 1000}{250 \times 460} = 1.74\text{ N/mm}^2$

Design shear stress, $\tau_{us} = \tau_v - \tau_c$

$= 1.74 - 0.62 = 1.12\text{ N/mm}^2$

14. (d)

The given value are as follows:

$D_f = 120$ mm, $b_f = 900$ mm, $b_w = 300$ mm, $d = 600$ mm

For Fe415, $(x_u)_{\lim} = 0.48d = 0.48 \times 600 = 288$ mm

Assuming neutral axis lies in the flange (i.e., $x_u < D_f$)

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f} = \frac{0.87 \times 415 \times 4 \times \frac{\pi}{4} \times 25^2}{0.36 \times 20 \times 900}$$

$$= 109.4 \text{ mm} < 120 \text{ mm } (= D_f)$$

∴ Our assumption is correct.

∴ $$M_u = 0.36 f_{ck} b_f x_u (d - 0.42 x_u)$$

$$= 0.36 \times 20 \times 900 \times 109.4 (600 - 0.42 \times 109.4) \text{ Nmm} = 392.77 \text{ kN-m}$$

15. **(b)**

For solid slabs, to control deflection, span to overall depth ratios are given as:

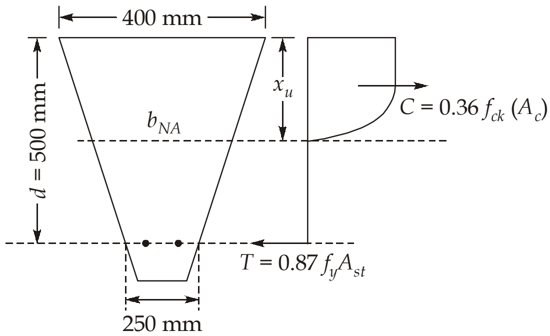
	Mild steel	HYSD
Simply supported slab	35	28
Continuous slab	40	32

16. **(c)**

Value of partial safety factor (γ_f) for loads under various load combinations:

Load combination	Limit state of collapse			Limit state of sericieability		
	DL	IL	WL/EL	DL	IL	WL/EL
DL + IL	1.5	1.5		1	1	
DL + WL/EL	1.5 or 0.90	-	1.50	1	-	1
DL + IL + WL/FL	1.2	1.2	1.2	1.0	0.8	0.8

17. **(a)**



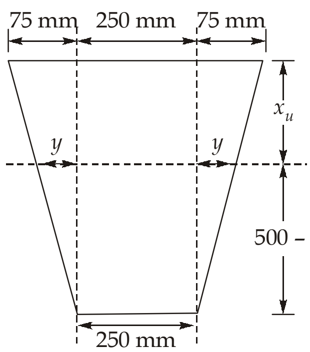
Let, A_c = Area of concrete

$$\frac{75}{500} = \frac{y}{500 - x_u}$$

⇒ $$y = 75\left(\frac{500 - x_u}{500}\right)$$

Width of section at neutral axis i.e., $b_{NA} = 250 + 2y$

$$b_{NA} = 250 + 150\left(\frac{500 - x_u}{500}\right)$$



Average width of beam section in compression

$$= \frac{1}{2}(400 + b_{NA})$$

$$= \frac{1}{2}\left[650 + 150\left(\frac{500 - x_u}{500}\right)\right]$$

$$= (400 - 0.15x_u)$$

$$C = T$$

⇒ $$0.36 f_{ck}\, b_{avg}\, x_u = 0.87\, f_y\, A_{st}$$

⇒ $0.36 \times 25 \times (400 - 0.15x_u)x_u = 0.87 \times 415 \times 1473$

⇒ $x_u^2 - 2666.7\, x_u + 393945.67 = 0$

∴ $$x_u = 157 \text{ mm} = 15.7 \text{ cm}$$

18. (d)

Given: h = 300 mm, L = 15 m, y = 130 mm,

Equation of parabolic cable is

$$y = \frac{4hx(l-x)}{l^2}$$

$$0.13 = \frac{4(0.3)(x)(15-x)}{15^2}$$

$$\Rightarrow \quad 29.25 = 18x - 1.2x^2$$

$$\Rightarrow \quad 1.2x^2 - 18x + 29.25 = 0$$

$$\therefore \quad x = 1.85 \text{ m}$$

19. (b)

Based on no tension at bottom

$$\frac{P}{A} - \frac{M}{Z} = 0 \quad \text{... (i)}$$

For top fiber $$\frac{P}{A} + \frac{M}{Z} = 40 \quad \text{... (ii)}$$

From equation (i) and equation (ii)

$$\frac{2M}{Z} = 40$$

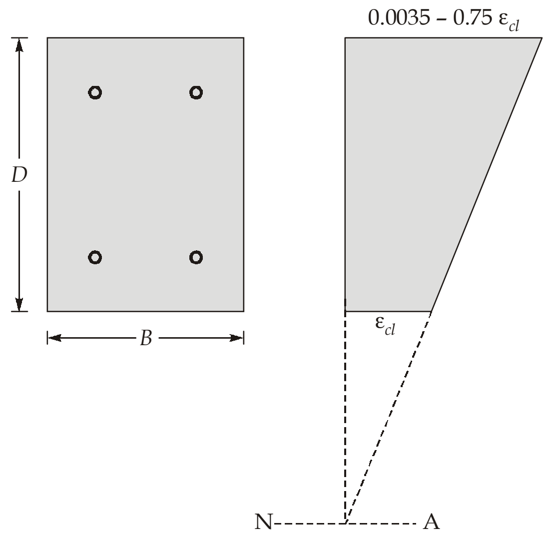
$$\Rightarrow \quad \frac{2M}{\left(\frac{BD^2}{6}\right)} = 40$$

$$\Rightarrow \quad M = \frac{40 \times 450 \times 650^2}{6} \times \frac{1}{2}$$

$$\Rightarrow \quad M = 633.75 \times 10^6 \text{ N-mm}$$

20. (c)

Maximum spacing between lateral ties is 300 mm.



Strain diagram

21. (b)

$\because$ D > 400 mm and column is helically reinforced, so

As per IS 456 : 2000,

$\therefore$ $P_u = [0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{sc}] \times 1.05$

where A_c = Area of concrete

$= A_g - A_{sc}$

A_{sc} = Area of steel in compression

A_g = Gross cross-sectional area of compression member

5% increment in load carrying capacity as it is helically reinforced.

$$\therefore \quad P_u = 1.05\left[0.4 \times 25 \times \left(\frac{\pi}{4} \times 500^2 - 8 \times \frac{\pi}{4} \times 20^2\right) + 0.67 \times 500 \times \frac{\pi}{4} \times 8 \times 20^2\right] \times 10^{-3}$$

$\Rightarrow$ $P_u = 1.05\,[1938362.667 + 841946.83] \times 10^{-3}$

$\Rightarrow$ $P_u = 2919.32 \text{ kN} \simeq 2920 \text{ kN (say)}$

22. **(d)**

For axially loaded column,

$$e_{min} = \max\begin{cases} \dfrac{L}{500} + \dfrac{B \text{ or } D}{30} < 0.05\,(B \text{ or } D) \\ 20 \text{ mm} \end{cases}$$

$$= \max\begin{cases} \dfrac{3000}{500} + \dfrac{400}{30} = 19.33 < 0.05(B \text{ or } D) = 20 \text{ mm} \\ 20 \text{ mm} \end{cases}$$

$\therefore$ $P_u = 0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{sc}$

$P_u = 0.4\, f_{ck}\, [A_g - A_{sc}] + 0.67\, f_y\, A_{sc}$

where A_c = Area of concrete

A_g = Gross area of column

A_{sc} = Area of compression steel

$1650 \times 10^3 = 0.4 \times 20\,[400^2 - A_{sc}] + 0.67\,(500)\,A_{sc}$

$1650 \times 10^3 = 1280000 - 8\,A_{sc} + 335\,A_{sc}$

$A_{sc} = 1131.498 \text{ mm}^2 \simeq 1131.50 \text{ mm}^2$

But as per IS 456, $(A_{sc})_{min}$ = 0.8% of cross-sectional area

$$= \frac{0.8}{100} \times 400^2 = 1280 \text{ mm}^2$$

$\therefore$ $A_{sc} = 1280 \text{ mm}^2$

23. **(c)**

Stress in concrete at the level of tendon

$$f_c = \frac{P}{A} + \frac{Pe^2}{I}$$

$$= \frac{200 \times 10^3}{150 \times 250} + \frac{200 \times 20^2 \times 10^3}{\dfrac{150 \times 250^3}{12}}$$

$= 5.743$ MPa

Loss of prestress due to elastic deformation

$$\Delta f_s = \frac{E_s}{E_c} \times f_c = \frac{2.1 \times 10^5}{3.0 \times 10^4} \times 5.743 = 40.20 \text{ MPa}$$

24. (a)

$$\text{Required footing area} = \frac{1.1P}{q_u}$$

where P = Column load

Self-weight of footing and backfill soil considered is 10% of column load.

$$\therefore \quad A = \frac{1.1 \times 2000}{210} = 10.48 \text{ m}^2$$

$$\frac{L}{B} = \frac{600}{400} = \frac{3}{2}$$

$$\therefore \quad L \times B = 10.48$$

$$\Rightarrow \quad \frac{3}{2}B \times B = 10.48$$

$$\therefore \quad B = 2.64 \text{ m}$$

and L = 3.96 m

Hence, nearest answer is option (a).

25. (b)

We know, maximum diameter of steel = $\dfrac{\text{Slab thickness}}{8}$

For minimum thickness of slab, we have to use minimum size of reinforcement.

So, Minimum thickness = 8 × (min. dia of r/f) = 8 × 12 = 96 mm

26. (b)

Loss of shrinkage of concrete in post-tensioned PSC beam

$$= \frac{(2 \times 10^{-4})E_s}{\log(T+2)} = \frac{(2 \times 10^{-4}) \times (2 \times 10^5)}{\log(8)} = 44.29 \text{ N/mm}^2$$

$$\%\text{loss} = \frac{44.29}{1000} \times 100 = 4.429\% \simeq 4.43\%$$

27. (d)

- Critical section for one-way shear is at distance 'd' from the face of the column.
- Critical section for maximum bending moment under masonary wall is located at mid-way between the face and middle of wall.

28. (a)

$$\delta = \left(1 + \frac{3P_u}{f_{ck}BD}\right) \leq 1.5 = \left(1 + \frac{3 \times 1.5 \times 500 \times 10^3}{25 \times 300 \times 500}\right) \leq 1.5$$

$$\delta = 1.6 \not\leq 1.5$$

So, $\delta = 1.5$

30. (c)

1. Here the concrete in the test specimen is subjected to a state of compression (and not tension).
2. Factors such as cracking and dowel forces, which lower the bond resistance of a flexural member, are not present in a concentric pull out test.
3. Friction at the bearing on the concrete offers some restraint against splitting.

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