CLASS TEST

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REINFORCED CEMENT CONCRETE

CIVIL ENGINEERING

Date of Test : 20/08/2023

ANSWER KEY

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

Detailed Explanations

1. (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.

2. (d)

3. (b)

As per yield line theory, (Inelastic analysis)

$$BM_{max} = \frac{w_u R^2}{6}$$

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

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

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

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

4. (c)

5. (d)

Side face reinforcement is provided when depth ≥ 750 mm (Without torsion)

or Depth = 450 mm (with torsion)

6. (b)

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

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

7. (c)

The straight length of the lap shall not be less than 15ϕ or 200 mm. (Refer Cl. 2.6.2.5.1 of **IS 456 : 2000**)

8. (a)

Bearing strength for base plate using WSM = 0.25 × f_{ck} (Cl. 34.4 of **IS 456 : 2000**)

= 0.25 × 25

= 6.25 N/mm^2

9. (c)

The anchorage value of bend shall be taken as 4 times the diameter of the bar for each 45° bend but in any case must, it must not exceed 16 times the bar diameter.

Thus, for L-shaped bend, it will be 8 times the diameter of bar.

10. (d)

11. (a)

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

Factored load = 1.5 × 20 = 30 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,

$$M_{cr} = 0.138\, f_{ck} B d^2$$
$$= 0.138 \times 25 \times 200 \times 500^2$$
$$= 172.5 \times 10^6 \text{ N-m} = 172.5 \text{ kN-m}$$
$$(\text{BM})_{max} < M_{cr}$$

∴ URS is provided

12. (b)

Loss of stress due shrinkage of concrete in post-tensioned PSC beam

$$= \frac{(2 \times 10^{-4}) E_s}{\log(T+2)} = \frac{(2 \times 10^{-4}) \times (2 \times 10^5)}{\log(6+2)} = 44.29 \text{ N/mm}^2$$

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

13. (d)

At initial stage, no losses are considered and only DL are considered.

At mid span, moment due to dead load:

$$M_d = \frac{wl^2}{8} = \frac{10 \times 6^2}{8} = 45 \text{ kNm}$$

STress at bottom of mid span $= \dfrac{P}{A} + \dfrac{Pe}{Z} - \dfrac{M_d}{Z}$

$$= \frac{500 \times 10^3}{300 \times 500} + \frac{500 \times 10^3 \times 100}{\frac{300 \times 500^2}{6}} - \frac{45 \times 10^6}{\frac{300 \times 500^2}{6}}$$

$$= 3.33 + 4 - 3.6 = 3.73 \text{ N/mm}^2$$

14. (a)

Given: B = 250 mm

Factored Moment, M_u = 1.5 × 45 = 67.5 kNm

and we know,

$$M_u \lim = 0.148\, f_{ck}\, Bd^2 \qquad \text{[Fe 250 is used]}$$

$\Rightarrow$ $67.5 \times 10^6 = 0.148 \times 20 \times 250 \times d^2$

$\Rightarrow$ d = 302 mm

15. (c)

$$\text{Equivalent shear, } V_e = V_u + \frac{1.6T_u}{b}$$

Here, $V_u = 0$

$$\therefore \quad V_e = 1.6 \times \frac{50 \times 10^3}{300} = 266.67 \simeq 267 \text{ kN}$$

16. (b)

Load on the column = 1250 kN

Weight of foundation@ 10% of column load = 125 kN

∴ Total load on the soil = 1250 + 125 = 1375 kN

$$\therefore \quad \text{Area of foundation} = \frac{1375}{100} = 13.75 \text{ m}^2$$

$$\text{Depth of foundation} = \frac{q}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

$$= \frac{100}{18}\left(\frac{1-\sin 30°}{1+\sin 30°}\right)^2$$

$$= 0.6173 \text{ m}$$

$$\simeq 0.62 \text{ m}$$

17. (a)

Total vertical load, W = 300 kN

Distance of point of application of the resultant force from the heel end = 2 m

$$\text{So, eccentricity, } e = 2 - \frac{b}{2} = 2 - \frac{3.5}{2} = 0.25 \text{ m}$$

$$\frac{b}{6} = \frac{3.5}{6} = 0.583 \text{ m}$$

$$\therefore \quad e < \frac{b}{6}$$

Extreme pressure intensity at the base,

$$= \frac{W}{b}\left[1 \pm \frac{6e}{b}\right]$$

$$= \frac{300}{3.5}\left[1 \pm \frac{6 \times 0.25}{3.5}\right]$$

$$= 122.449 \text{ kN/m}^2 \text{ and } 48.98 \text{ kN/m}^2$$

or, $\simeq 122 \text{ kN/m}^2$ and 49 kN/m^2

18. (a)

Critical section for shear shall be taken at a distance of $d/2$ from periphery of column/drop panel.

19. (a)

For main reinforcing bars

Maximum spacing = $3d$ or 300 mm whichever is less

= 3 × 90 or 300 mm = 270 mm

For distribution bars :

Maximum spacing = $5d$ or 450 mm = 5 × 90 or 450 mm whichever is less
= 450 mm

20. (c)

For simply supported, $\left(\frac{l}{d}\right)_{\text{basic}} = 20$

For span > 10 m

$$\left(\frac{l}{d}\right)_{\text{basic}} = 20\times\frac{10}{24} = \frac{200}{24}$$

Now, $\left(\frac{l}{d}\right)_{\text{max}} = \left(\frac{l}{d}\right)_{\text{basic}} k_t\, k_c$

$\therefore$ $$d_{min} = \frac{24000}{\frac{200}{24}\times1.6\times1.2} = 1500 \text{ mm}$$

21. (b)

Long term modulus of elasticity,

$$E_\theta = \frac{5000\sqrt{f_{ck}}}{1+\theta}$$ (Clause C-4.1 of **IS 456 : 2000**)

$\because$ $f_{ck} = f_m - 1.65\sigma = 36 - 1.65 \times 4 = 29.4$ MPa

$$E_\theta = \frac{5000\times\sqrt{29.4}}{1+1.5} = 10844.35 \text{ MPa}$$

22. (d)

Given ϕ = 18 mm

τ_{bd} = 1.5 N/mm^2 and Fe415 grade steel

Development length,

$$L_d = \frac{0.87 f_y \phi}{4\tau_{bd}}$$

$\because$ Bars are in compression and HYSD bars are used. So, increase bond stress by 25% and 60% respectively.

$$L_d = \frac{0.87\times415\times18}{4\times1.6\times1.25\times1.5} = 541.575 \text{ mm} \simeq 541.6 \text{ mm}$$

23. (c)

The maximum compressive strain = 0.0035 – 0.75 × strain in least compressed extreme fibre

$\Rightarrow$ $0.0028 = 0.0035 - 0.75\in_l$

$\Rightarrow$ $\in_l = 9.33 \times 10^{-4}$

24. (b)

$$\because \quad \frac{\text{Reinforcement in central band width}}{\text{Total reinforcement in short direction}} = \frac{2}{\beta+1}$$

where $$\beta = \frac{\text{Long side}}{\text{Short side}} = \frac{4.5}{3} = 1.5$$

$$\therefore \quad \text{Reinforcement in central band width} = \frac{2}{1.5+1} \times 825 = 660 \text{ mm}^2$$

25. (d)

$$A_{st} = 4 \times \frac{\pi}{4} \times 18^2 = 1018 \text{ mm}^2$$

b = 250 mm, d = 500 mm, f_{ck} = 20 MPa

Equating compressive and tensile forces

$$C = T$$

$$0.36 f_{ck}\, x_u b = 0.87\, A_{st} f_y$$

$$x_u = \frac{0.87 \times 1018 \times 250}{0.36 \times 20 \times 250} = 122.99 \text{ mm} \simeq 123 \text{ mm}$$

Also, $x_{u,\lim} = 0.53d = 0.53 \times 500$

$= 265 \text{ mm} > 123 \text{ mm}$ ($x_u < x_{ulim}$ so under reinforced section)

$x_u = 123 \text{ mm} = 12.3 \text{ cm}$

26. (d)

Effective width of flange,

$$b_f = \frac{l_0}{\frac{l_0}{b} + 4} + b_w$$

$$= \frac{8000}{\frac{8000}{1000} + 4} + 300 = 966.67 \text{ mm}$$

27. (b)

Given : l = 3200 mm, D = 400

$$\Rightarrow \quad \text{Slenderness ratio} = \frac{l}{D} \le \frac{3200}{400} = 8.0 \ (\text{as column is braced})$$

As $\frac{l}{D} \le 12$, the column may be designed as a short column

Minimum eccentricity

$$e_{\min} = \frac{l}{500} + \frac{D}{30}$$

$$e_{\min} = \frac{3200}{500} + \frac{400}{30} = 19.73 \text{ mm } (< 20.0 \text{ mm})$$

Factored load,

$$P_u = 1500 \text{ kN (given)}$$

$$\text{For spiral column, } P_u = 1.05\left[0.4 f_{ck} A_g + \left(0.67 f_y - 0.4 f_{ck}\right) A_{sc}\right]$$

Design of longitudinal reinforcement

$$\frac{1500 \times 10^3}{1.05} = 0.4 \times 25 \times \frac{\pi \times 400^2}{4} + (0.67 \times 415 - 0.4 \times 25) A_{sc}$$

$$\Rightarrow \quad 1428.6 \times 10^3 = 1256.6 \times 10^3 + 268.05 A_{sc}$$

$$\Rightarrow \quad A_{sc} = (1428.6 - 1256.6) \times \frac{10^3}{268.05}$$

$$= 642 \text{ mm}^2$$

$$\text{Percentage reinforcement} = \frac{642}{\frac{\pi}{4} \times (400)^2} \times 100 = 0.51\% < 0.8\%$$

$$\text{So,} \quad A_{sc,\min} \text{ @ } 0.8\% \text{ of } A_g = \frac{0.8}{100} \times \frac{\pi \times 400^2}{4} = 1005 \text{ mm}^2$$

28. (a)

$$L_d \leq \frac{1.3 M_1}{V} + L_0$$

$$\frac{0.87 \times 415 \times 20}{4\tau_{bd} \times 1.6} \leq \frac{1.3 \times 93.45 \times 10^6}{110 \times 1.5 \times 10^3} + L_0$$

$$940.23 \leq 736.27 + L_0$$

$$L_0 \geq 203.96 \text{ mm} \simeq 204 \text{ mm}$$

29. (b)

30. (d)

Since column face governs the bearing resistance,

$$\text{So, } f_{br} = 0.45 f_{ck} = 0.45 \times 25 = 11.25 \text{ MPa}$$

So, Limiting bearing resistance = $11.25 \times 450^2 \times 10^{-3}$ kN = 2278.125 kN

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