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Reinforced Cement Concrete

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 22/09/2019

ANSWER KEY ➤ Reinforced Cement Concrete

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

DETAILED EXPLANATIONS

5. (a)

$$M_u = 0.36 f_{ck} x_u B(d - 0.42 x_u)$$
$$M_u = 1.5 M_w$$
$$M_u = 150 \text{ kNm.}$$
$$150 \times 10^6 = 0.36 \times 30 x_u \times 300 (450 - 0.42 x_u)$$
$$0.42x_u^2 - 450 x_u + 46296.3 = 0$$
$$\Rightarrow \quad x_u = 115.28 \text{ mm}$$

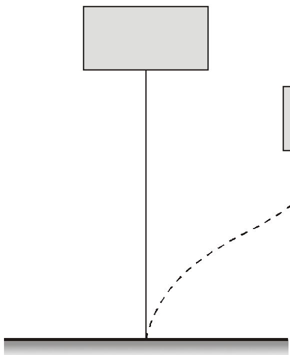
6. (b)

$$e_{min} = \left.\begin{matrix} \frac{L}{500} + \frac{D}{30} \\ 20 \text{ mm} \end{matrix}\right\} \text{Max}$$

$$e_{min} = \left.\begin{matrix} \frac{3500}{500} + \frac{350}{30} = 18.67 \text{ mm} \\ 20 \text{ mm} \end{matrix}\right\} \text{max}$$

$$e_{min} = 20 \text{ mm}$$

7. (a)

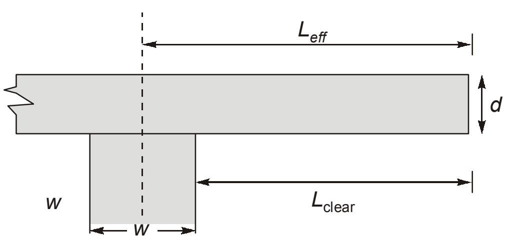


$$L_{eff} = 1.2 \text{ L}$$
$$L_{eff} = 1.2 \times 6 = 7.2 \text{ m}$$

9. (c)

As per IS 456

$$\text{left of continues beam} = l_{clear} + \frac{d}{2}$$



10. (b)

$$\frac{\text{Permissible shear stress in LSM}}{\text{Permissible shear stress in WSM}} = \frac{0.25\sqrt{f_{ck}}}{0.16\sqrt{f_{ck}}} = \frac{25}{16} = 25:16$$

11. (b)

Maximum spacing of shear reinforcement

(i) d for inclined shear reinforcement

0.75 d for vertical shear reinforcement

(ii) 300 mm.

So,
$$\text{spacing} = \min\begin{cases}375 \text{ mm}\\300 \text{ mm}\end{cases}$$
$$\text{spacing} = 300 \text{ mm}$$

12. (a)

$$\text{Design moment} = \max\begin{cases}1.5(DL+LL)\\1.5(\text{DL}+EQL)\\1.2(DL+LL+EQL)\end{cases}$$
$$= \max\begin{cases}1.5(50+40)=135 \text{ kNm}\\1.5(50+10)=90 \text{ kNm}\\1.2(50+40+10)=120 \text{ kNm}\end{cases} = 135 \text{ kNm}$$

15. (a)

For simply supported beam

$$L_{\text{eff}} = \text{Minimum}\begin{cases}L_{\text{clear}}+d\\L_{\text{clear}}+w\end{cases} = \text{Minimum of }\begin{cases}6+0.4\\6+0.25\end{cases}$$
$$L_{\text{eff}} = 6.25 \text{ m}$$
$$\text{Permissible deflection} = \frac{L_{eff}}{350} \text{ or } 20 \text{ mm}, \text{ whichever is less}$$
$$= \frac{6250}{350} = 17.857 \text{ mm}$$

16. (a)

Pressure line is the locus of resultant compressive force in the beam.

Cable line is the actual location of cable in the beam.

17. (a)

Permissible bearing stress in footing as per LSM is 0.45 f_{ck}.

18. (a)

$$\text{Equivalent area} = BD + (m-1)A_s = 400\times600+(6-1)\times6\times\frac{\pi}{4}\times6^2$$
$$= 240848.23 \text{ mm}^2$$
$$\text{Applied prestressing force} = 6\times\frac{\pi}{4}\times6^2\times1500 = 254.47 \text{ kN}$$
$$\text{Eccentricity, } e = \frac{600}{2}-100 = 200 \text{ mm}$$

$$\text{Stress at soffit} = \frac{P}{A} + \frac{Pl}{Z}$$

$$= \frac{254.47 \times 10^3}{240848.23} + \frac{254.47 \times 10^3 \times 200}{400 \times \frac{600^2}{6}}$$

$$= 1.056 + 2.12 = 3.176 \text{ N/mm}^2$$

19. (d)

$$M_{eq} = M_u + M_{Tu}$$

if, $M_{Tu} > M_u$

$$M_{eu_2} = M_{Tu} - M_u$$

$$M_{Tu} = \frac{T_u}{1.7}\left[1 + \frac{D}{B}\right] = \frac{35}{17}\left[1 + \frac{450}{250}\right]$$

$$M_{Tu} = 57.647 \text{ kNm} > M_u$$

$$M_{eu_2} = M_{Tu} - M_u = 57.647 - 50 = 7.647 \text{ kNm}$$

20. (c)

As per IS 456 : 2000

$$\text{spacing} = \min\begin{cases}\text{Least lateral dimension} \\ 16\phi_{main}(\text{min}) \\ 300 \text{ mm}\end{cases}$$

$$\text{Diameter} = \min\begin{cases}400 \\ 16 \times 16 = 256 \\ 300 \text{ mm}\end{cases}$$

So provide, $S = 250$ mm.

23. (d)

$$\text{Long term, } E = \frac{5000\sqrt{f_{ck}}}{1 + \theta}$$

$$\theta(\text{for 28 days loading}) = 1.6$$

$$E = \frac{500\sqrt{25}}{1 + 1.6} = 9615.4 \text{ N/mm}^2$$

25. (c)

For simply supported beam, $l_{eff} = \left.\begin{matrix} L_{clear} + d \\ L_{clear} + w \end{matrix}\right\}\text{min.}$

$$6000 = \left.\begin{matrix} L_{clear} + 450 \\ L_{clear} + 200 \end{matrix}\right\}\text{min.}$$

$\Rightarrow$ $L_{clear} = 5800$ mm

$w = 4$ kN/m

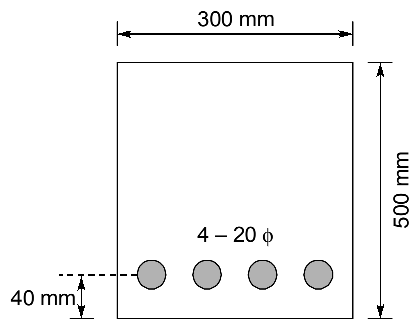
$\Rightarrow$ $w_u = 1.5\,w = 1.5 \times 4 = 6$ kN/m

$$V_u = \frac{w_u L_{clear}}{2} = \frac{6 \times 5.8}{2} = 17.4 \text{ kN}$$

$$w = \frac{V_u}{Bd} = \frac{17.4 \times 10^3}{250 \times 450} = 0.154 \text{ N/mm}^2$$

26. (b)

For M30 concrete, Fe 500 steel



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

$$0.36 \times 30 \times x_u \times 300 = 0.87 \times 500 \times 4 \times \frac{\pi}{4} \times 20^2$$

$$x_u = 168.715 \text{ mm} < x_{u,\,\lim}\ (x_{u,\,\lim} = 0.46 \times 460 = 211.6 \text{ mm})$$

$$M_R = 0.36\, f_{ck}\, x_u\, B(d - 0.42\, x_u)$$

$$M_R = 0.36 \times 30 \times 168.715 \times 300 \times (460 - 0.42 \times 168.715)$$

$$M_R = 212.718 \text{ kNm}$$

The maximum applied moment is equal to moment of resistance of beam.

$$\Rightarrow \quad w_u \frac{l^2}{8} = M_R$$

$$w_u = \frac{212.718 \times 8}{6^2} = 47.27 \text{ kN/m}$$

$$\text{Service load} = \frac{47.27}{1.5} = 31.513 \text{ kN/m}$$

$$\text{Self weight of beam} = 0.3 \times 0.5 \times 25 = 3.75 \text{ kN/m}$$

$$\text{Permissible imposed service load} = 31.513 - 3.75 = 27.763 \text{ kN/m}$$

27. (c)

$$\text{Effective depth, } d = 400 - 35 = 365 \text{ mm}$$

$$\text{Percentage tension steel, } p_t = \frac{100\, A_{st}}{bd} = \frac{100 \times 5 \times \frac{\pi}{4} \times 25^2}{300 \times 365}$$

$$= 2.24\% > p_{t\lim} \left(= 41.61 \frac{f_{ck}}{f_y} \cdot \frac{x_{u\lim}}{d} = 41.61 \times \frac{20}{415}(0.48) = 0.96\% \right)$$

∴ Doubly reinforced section is required.

Design shear strength of concrete,

$$\tau_c = 0.8092 \text{ N/mm}^2 \qquad \text{[From table for } p_t = 2.24\%\text{]}$$

$$\text{Nominal shear stress, } \tau_v = \frac{V_u}{bd} = \frac{240 \times 10^3}{300 \times 365} = 2.19 \text{ N/mm}^2$$

$$\text{Area of shear stirrups, } A_{sv} = 2 \times \frac{\pi}{4} \times 12^2 = 226.19 \text{ mm}^2$$

∴ Spacing of vertical shear stirrups,

$$S_v = \frac{0.87 f_y A_{sv} d}{(\tau_v - \tau_c) bd}$$

$$= \frac{0.87 \times 415 \times 226.19}{(2.19 - 0.8092) \times 300} \simeq 197 \text{ mm} \quad (< 0.75d = 273.75 \text{ mm})$$

28. (b)

When jacking is done from both ends

$$\text{Maximum loss at } x = \frac{l}{2}$$

and $$\alpha = \frac{4h}{l}$$

$$\alpha = \frac{4 \times 200}{8000} = \frac{1}{10}$$

$$p_x = p_0(kx + \mu\alpha) = 1500\left(0.0015 \times 4 + 0.4 \times \frac{1}{10}\right)$$

$$P_x = 69 \text{ N/mm}^2$$

$$\text{Percentage loss} = \frac{69}{1500} \times 100 = 4.6\%$$

29. (b)

Dead load = 0.5 × 0.7 × 25 = 8.75 kN/m

$$I = \frac{500 \times 700^3}{12} = 1.43 \times 10^{10} \text{mm}^4$$

$$\delta = \frac{5P(e_1 + e_2)L^2}{48E_cI_c} - \frac{P_{e_1}L^2}{8E_cI_C} + \frac{5wl^4}{384E_cI_c}$$

$$\delta = \frac{5 \times 1500 \times 10^3 \times (50 + 200) \times 10000^2}{48 \times 35000 \times 1.43 \times 10^{10}} - \frac{1500 \times 10^3 \times 50 \times 10000^2}{8 \times 35000 \times 1.43 \times 10^{10}} + \frac{5 \times 8.75 \times 10000^4}{384 \times 35000 \times 1.43 \times 10^4}$$

$$\delta = 7.8047 - 1.873 + 2.2763 = 8.208 \text{ mm}$$

$$\delta = 8.208 \text{ mm}$$

30. (d)

$$l_{eff} = 0.65 \times 3.6 \text{ m} = 2.34 \text{ m}$$

$$\frac{l_{eff}}{D} = \frac{2340}{500} = 4.68 < 12$$ [short column]

$$e_{min} = \frac{3600}{500} + \frac{500}{30} = 23.8667 \text{ mm} < 0.05\, D\, (= 25 \text{ mm})$$

$$k_u = 1.05[0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_s]$$

$$1.5 \times 2500 \times 10^3 = 1.05\left[0.4 \times 30 \times \left(\frac{\pi}{4} \times 500^2 - A_s\right) + 0.67 \times 415 \times A_s\right]$$

⇒ $$A_s = 4567.7 \text{ mm}^2$$

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