CLASS TEST

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REINFORCED CEMENT CONCRETE

CIVIL ENGINEERING

Date of Test : 14/08/2022

ANSWER KEY

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

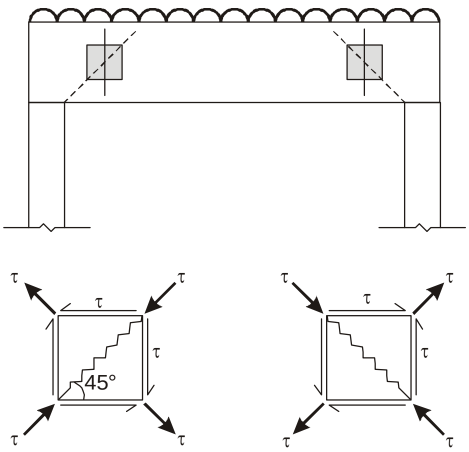
1. (d)

The IS code specifies minimum spacing of reinforcing bars to ensure that concrete can be placed easily in between and around the bars. Also maximum limits are specified for tension reinforcement for controlling crack widths and improving bond.

2. (a)

Diagonal tension failure occurs due to large shear force and lesser bending moment.

It can be seen in the case of pure shear {flexure tensile stress = 0} that maximum tension occurs along the diagonal.



Pure shear case

3. (b)

In the conventional prestressing, the diagonal tension reduces as whole section is under compression generally in prestressing.

4. (c)

The limiting principal tensile stress in an uncracked prestressed concrete member is given by

$$f_t = 0.24\sqrt{f_{ck}} = 0.24\sqrt{35} = 1.42 \text{ MPa}$$

6. (b)

At the time of initial tensioning, the maximum tensile stress immediately behind the anchorages should not exceed 80% of the ultimate tensile strength of the wire.

8. (a)

In partially prestressed members, tensile stresses are permitted in concrete under service loads with control on the maximum width of crack. The additional reinforcement is required in the cross–section for various reasons such as to resist differential shrinkage, temperature effects and handling stresses.

9. (c)

For deep beam,

$$\frac{L}{D} < 2.5 \text{ for continuous beam}$$

and $$\frac{L}{D} < 2.0 \text{ for simply supported beam}$$

So, $$L < 2.5 \times D$$

So, maximum effective length < 2.5 × (550 + 50)

< 1500 mm

So, most favourable option is (c)

10. (a)

Concrete i.e. allowed to dry out quickly undergoes considerable early age shrinkage which can cause shrinkage cracks. Besides curing also ensures the cement hydration reaction to progress steadily producing calcium silicate hydrate gel making the concrete denser thereby decreases the porosity and enhances the physical and the mechanical properties of concrete.

11. (d)

(Source IS : 1343)

12. (a)

For an isolated *T*-beam

Effective width of flange, $b_f = \dfrac{l_0}{\dfrac{l_0}{b}+4}+b_w$

$$b_f = \frac{8000}{\dfrac{8000}{1300}+4}+250 = 1037.9 \text{ mm} < 1300 \text{ mm} \quad \text{(OK)}$$

13. (b)

Load on the column = 1250 kN

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

$\therefore$ Total load on the soil = 1250 + 125 = 1375 kN

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

$$\text{Depth of foundation} = \frac{q}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2 = \frac{100}{18}\left(\frac{1-\sin 30}{1+\sin 30}\right)^2 = 0.6173 \text{ m} \simeq 0.62 \text{ m}$$

14. (c)

$$E_{\text{long}} = \frac{E}{1+\theta} = \frac{5000\sqrt{f_{ck}}}{1+\theta}$$

$$= \frac{5000\sqrt{30}}{1+1.1} = \frac{5000\sqrt{30}}{2.1} \quad \text{[Creep coefficient, } \theta = 1.1 \text{ for 1 year]}$$

$$= 13041.01 \text{ MPa}$$

16. (b)

$$M_{eq.} = M_U + \frac{T_U}{1.7}\left(1+\frac{D}{b}\right) = 60 + \frac{20}{1.7}\left(1+\frac{400}{400}\right) = 83.53 \text{ kNm}$$

$$V_{eq.} = V_U + \frac{1.6T_U}{b} = 30 + \frac{1.6\times 20}{0.4} = 110 \text{ kN}$$

$$\therefore \quad \frac{M_{eq.}}{V_{eq.}} = \frac{85.53}{110} = 0.76 \text{ m}$$

$$= 760 \text{ mm}$$

17. (a)

Marcus correction factor = $1 - \frac{5}{6}\left(\frac{r^2}{1+r^4}\right)$ where r is the ratio of long span to short span.

18. (b)

$$A_{st} = 4 \times \frac{\pi}{4} \times 18^2 = 1017.9 \text{ mm}^2$$

Now, $C = T$

$\Rightarrow$ $0.36\, f_{ck}\, bx_u = 0.87\, f_y A_{st}$

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

$= \dfrac{0.87 \times 415 \times 1017.9}{0.36 \times 20 \times 250} = 204.17 \text{ mm}$

$x_{u,\text{lim}} = 0.48d = 0.48 \times 520$

$= 249.6 \text{ mm} > x_u \quad (= 204.17 \text{ mm})$

$\therefore$ Under reinforced section.

$\therefore$ Lever arm, $z = d - 0.42x_u$

$= 520 - 0.42 \times 204.17$

$= 434.25 \text{ mm}$

19. (c)

$$L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{20 \times (0.87 \times 415)}{4 \times 1.4 \times (1.6 \times 1.25)} = 644.73 \text{ mm}$$

According to **IS 456:2000**, clause 26.2.1.2, the development length should be increased by 33% for four bars in contact.

$L_d = 1.33 \times 644.73$

$= 857.5 \text{ mm}$

20. (a)

Effective depth $= 400 - 40 = 360 \text{ mm}$

Equilibrium of forces, $C = T$

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

$\Rightarrow$ $x_u = \dfrac{0.87 \times 415 \times 4 \times \frac{\pi}{4} \times 20^2}{0.36 \times 20 \times 200}$

$= 315.08 \text{ mm}$

For Fe415, $x_{u,\text{lim}} = 0.48d$

$= 0.48 \times 360$

$= 172.8 \text{ mm} < x_u$

$\therefore$ Section is over-reinforced.

Allowable moment resisting capacity,

$$M_{u,\,\text{lim}} = 0.36\, f_{ck} x_{\text{lim}} (d - 0.42 x_{\text{max}}) \times b$$

$= 0.36 \times 20 \times 172.8 \times (360 - 0.42 \times 172.8) \times 200 = 71.52 \text{ kNm}$

Alternatively,

For Fe415 steel,

$$M_{u,\ \text{lim}} = 0.138\, f_{ck} bd^2$$
$$= 0.138 \times 20 \times 200 \times 360^2$$
$$= 71.54 \text{ kNm}$$

Another check for over-reinforced section

$$A_{st} = 4 \times \frac{\pi}{4} \times 20^2 = 1256.64 \text{ mm}^2$$

$$\therefore \quad p_t = \frac{A_{st}}{bd} \times 100 = \frac{1256.64}{200 \times 360} \times 100 = 1.75\%$$

$$p_{t\ \text{lim}} = 41.61\left(\frac{f_{ck}}{f_y}\right)\frac{x_{u\text{lim}}}{d} = 41.61\left(\frac{20}{415}\right)0.48$$
$$= 0.96\% < p_t$$

$\therefore$ Over-reinforced section.

21. (b)

$$\text{Gross area, } A_g = 400 \times 400 = 16 \times 10^4 \text{ mm}^2$$

$$\text{Area of steel, } A_{sc} = 4 \times \frac{\pi}{4} \times (25)^2 = 1963.5 \text{ mm}^2$$

$$\therefore \quad \text{Area of concrete, } A_c = A_g - A_{sc}$$
$$= 16 \times 10^4 - 1963.5$$
$$= 158036.5 \text{ mm}^2$$

Let p_s be stress in steel and p_c be stress in concrete.

From equilibrium,

$$P_s + P_c = P$$
$$p_s A_s + p_c A_c = 1500 \times 10^3 \quad \text{...(i)}$$

From compatibility condition,

$$\in_s = \in_c$$
$$\Rightarrow \quad \frac{p_s}{E_s} = \frac{p_c}{E_c}$$
$$\Rightarrow \quad p_c = \frac{E_c}{E_s} p_s$$
$$= \frac{13.6}{200} p_s = 0.068 p_s \quad \text{...(ii)}$$

So, from equation (i)

$p_s \times 1963.5 + 0.068\, p_s \times 158036.5 = 1500 \times 10^3$

$$\Rightarrow \quad p_s = 118.02 \text{ N/mm}^2$$
$$\simeq 118 \text{ MPa}$$

22. (b)

First crack in concrete occurs when,

$$\text{Stress in concrete} = 0.7\sqrt{f_{ck}}$$

$$\text{Strain at this time in concrete} = \frac{0.7\sqrt{f_{ck}}}{5000\sqrt{f_{ck}}} = 1.4 \times 10^{-4}$$

$\therefore$ Strain in reinforcement $= 1.4 \times 10^{-4}$

$\therefore$ Stress in reinforcement $= 1.4 \times 10^{-4} \times 2 \times 10^{5}$

$= 28 \text{ N/mm}^2$

23. (d)

For M25 concrete, $\sigma_{cbc} = 8.5$ MPa

For Fe415, $\sigma_{st} = 230$ MPa

Moment of resistance, MOR:

$$\text{MOR} = \sigma_{st} A_{st} jd$$

$$\Rightarrow \quad A_{st} = \frac{MOR}{\sigma_{st} j}$$

$$\Rightarrow \quad p_t = \frac{A_{st}}{bd} \times 100 = \frac{100 \times \text{MOR}}{\sigma_{st} jbd^2} = \frac{100 \times \frac{1}{2} \times \sigma_{cbc} \cdot k_b j\left(bd^2\right)}{\sigma_{st} jbd^2}$$

$$= \frac{50\sigma_{cbc} k_b}{\sigma_{st}}$$

Neutral axis coefficient, k_b

$$k_b = \frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}}$$

$$= \frac{1}{1 + \dfrac{\sigma_{st}}{m\sigma_{cbc}}} = \frac{1}{1 + \dfrac{3\sigma_{st}}{280}} = \frac{1}{1 + \dfrac{3 \times 230}{280}} = 0.2887$$

$$\therefore \quad p_t = \frac{50\sigma_{cbc} k_b}{\sigma_{st}}$$

$$= \frac{50 \times 8.5 \times 0.2887}{230} = 0.533\% \simeq 0.53\%$$

25. (b)

Check for cracking due to bending in compression members are required if design load < $0.2 f_{ck} A_g$

Where A_g = Area of gross section of concrete.

Maximum spacing requirement is based on the criterion to control cracking.

26. (c)

Live load, $w_L = 20$ kN/m

$$\text{Moment due to live load } (M) = \frac{wl^2}{8} = \frac{20 \times 15^2}{8} = 562.5 \text{ kNm}$$

$$\text{Section modulus required, } Z = \frac{M}{f_c} = \frac{562.5 \times 10^6}{15} = 37.5 \times 10^6 \text{ mm}^3$$

But, $$Z = \frac{bd^2}{6}$$

$$\therefore \quad d = \sqrt{\frac{6 \times 37.5 \times 10^6}{400}} = 750 \text{ mm}$$

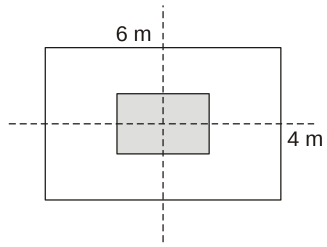
$$\therefore \quad \text{Area} = b \times d = 400 \times 750$$

$$= 3 \times 10^5 \text{ mm}^2$$

$$\text{Prestressing force} = \frac{1}{2}Af_c = \frac{1}{2} \times 3 \times 10^5 \times \frac{15}{1000} \text{ kN}$$

$$\simeq 2250 \text{ kN}$$

27. (a)



$$\text{Area of footing} = 4 \times 6 = 24 \text{ m}^2$$

$$\text{Critical section modulus, } Z = 6 \times \frac{4^2}{6} = 16 \text{ m}^3$$

$$\sigma = \frac{P}{A} \pm \frac{M}{Z}$$

$$= \frac{1000}{24} \pm \frac{80}{16} = 41.67 \pm 5$$

$$\sigma_{max} = 46.67 \text{ kN/m}^2$$

$$\sigma_{min} = 36.67 \text{ kN/m}^2$$

$$\Rightarrow \quad \frac{\sigma_{max}}{\sigma_{min}} = \frac{46.67}{36.67} = 1.273$$

28. (b)

Bending moment at the mid span,

$$M = \frac{wl^2}{8} = \frac{15 \times 14^2}{8} = 367.5 \text{ kNm}$$

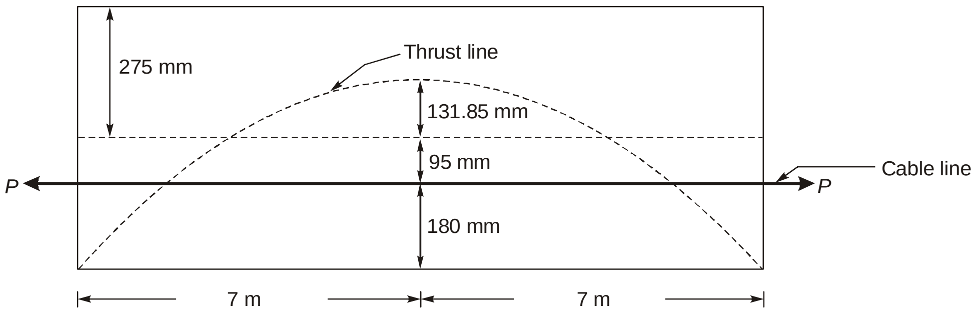
$$\text{Prestressing force, } P = A_{st} f_s$$

$$= \frac{1800 \times 900}{1000} = 1620 \text{ kN}$$

$$\text{Shift of thrust line, } a = \frac{M}{P} = \frac{367.5 \times 10^6}{1620 \times 10^3} = 226.85 \text{ mm}$$

$$\text{Eccentricity} = 275 - 180 = 95 \text{ mm}$$

$$\therefore \text{Eccentricity of thrust line} = 226.85 - 95 = 131.85 \text{ mm}$$



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