CLASS TEST

S.No.:01_SKCE_ABCD_07082025

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REINFORCED CEMENT CONCRETE

CIVIL ENGINEERING

Date of Test : 07/08/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. **(c)**

As per IS 456:2000, the pH of water shall not be less than 6. Here water source having pH = 6 may also be used but pH = 7 is most suitable.

2. **(c)**

Case I : (D.L. + L.L) combination

$$P_1 = 1 \times 60 + 1 \times 90 = 150 \text{ kN}$$

Case II : (D.L. + W.L. or E.L.) combination

As E.L. is more so take E.L. directly no need to check for WL

$$P_2 = 1 \times 60 + 150 \times 1 = 210 \text{ kN}$$

Case III: (D.L. + 0.8 (L.L) + 0.8 (W.L. or E.Q.) combination

$$P_3 = 1 \times 60 + 0.8 \times 90 + 0.8 \times 150 = 252 \text{ kN}$$

So, design load for serviceability = 252 kN

3. **(b)**

$\because$
$$E_c = 5000\sqrt{f_{ck}} = 5000 \times \sqrt{25}$$
$$= 25000 \text{ N/mm}^2$$
$$= 25 \text{ kN/mm}^2$$

As per Cl. 6.2.3.1 of **IS 456 : 2000**, the actual measured value may differ by ±20% from the above value.

$$\text{So, range} = 0.8 \times 25 \text{ to } 1.2 \times 25$$
$$= 20 \text{ to } 30 \text{ kN/mm}^2$$

4. **(a)**

Bearing strength for WSM = $0.25 \times f_{ck}$ (Cl. 34.4 of **IS 456 : 2000**)

$$= 0.25 \times 25$$
$$= 6.25 \text{ N/mm}^2$$

5. **(b)**

B.M. at support next to the end support = $\frac{1}{10} w_d L^2 + \frac{1}{9} \times w_l l^2$ (Table 12 of **IS 456 : 2000**)

$$= \frac{1}{10} \times 6 \times 4.5^2 + \frac{1}{9} \times 3 \times 4.5^2$$
$$= 18.9 \text{ kN-m}$$

6. **(b)**

Development length for HYSD bars in compression

$$L_d = \frac{0.87 f_y \phi}{4\tau_{bd} \times (1.6 \times 1.25)}$$

$$= \frac{0.87 \times 415 \times 20}{4 \times 1.4 \times 1.6 \times 1.25}$$

$$= 644.73 \text{ mm}$$

7. **(c)**

In general, bond strength is enhanced when the following measures are adopted:

(i) Deformed bars are used instead of plain bars.
(ii) Smaller bar diameters are used.
(iii) Higher grade of concrete is used.
(iv) Increased cover is provided around each bar.
(v) Increased length of embedment, bends and hooks are provided.
(vi) Mechanical anchorages are employed.
(vii) Stirrups with increased area, reduced spacing and/or higher grade of steel is used.

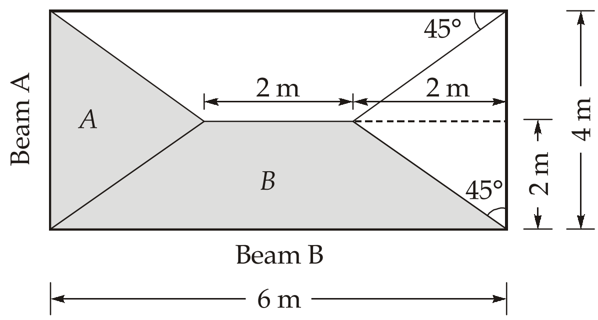
8. **(b)**

Creep increases when:

- Cement content is high
- Water cement ratio is high
- Aggregate content is low
- Air entrainment is high
- Relative humidity is low
- Temperature is high
- Loading occurs at an early age
- Loading sustained over a long period.

9. **(d)**

As per IS 456 : 2000, load distribution for a two way slab is given as



Load carried by beam A = Shaded area A

$$= \frac{1}{2}\times 4\times 2\times 10 = 40 \text{ kN}$$

i.e., $\frac{40}{4} = 10 \text{ kN/m}$

Load carried by beam B = Shaded area B

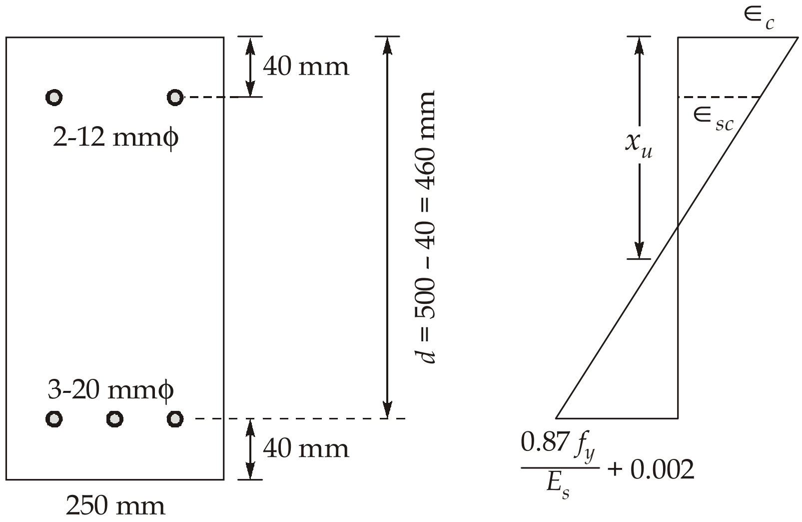
$$= \frac{1}{2}(6+2)\times 2\times 10 = 80 \text{ kN}$$

i.e., $\frac{80}{6} = 13.3 \text{ kN/m}$

10. **(d)**

As per Cl. 26.2.5 of IS 456 : 2000, splices in flexural members should not be provided where bending moment is more than 50 percent of the moment of resistance.

11. (a)



$$A_{sc} = 2\times\frac{\pi}{4}\times 12^2 = 226.19 \text{ mm}^2$$

$$A_{st} = 3\times\frac{\pi}{4}\times 20^2 = 942.48 \text{ mm}^2$$

For Fe415, $x_{u,\lim} = 0.48 \times d = 0.48 \times 460 = 220.8$ mm

Actual depth of neutral axis can be computed as,

$$C = T$$

$\Rightarrow \quad 0.36 f_{ck} B x_u + (f_{sc} - 0.45 f_{ck}) A_{sc} = 0.87 f_y A_{st}$ (Assuming tension steel as yielded)

$\Rightarrow \quad 0.36\times 20\times 250\times x_u + (345 - 0.45\times 20)\times 226.19 = 0.87\times 415\times 942.48$

$\Rightarrow \quad x_u = 146.82 \text{ mm} < x_{u,\lim}$ (220.8 mm ⇒ Under reinforced section)

∵ Section is under reinforced, maximum strain in extreme concrete fibre 0.0035 will be

From similar triangle concrete

$$\frac{\epsilon_{sc}}{x_u - d_c} = \frac{0.0035}{x_u}$$

$$\epsilon_{sc} = \frac{0.0035}{146.82}\times(146.82 - 40) = 2.54 \times 10^{-3} \simeq 0.00255$$

12. (c)

$|\delta|$ = Downward defection due to UDL
– Upward deflection due to pre-stressing force

Deflection due to UDL $(\delta_1) = \frac{5}{384}\cdot\frac{wl^4}{E_c I_c}$

$$E_c = 5000\sqrt{f_{ck}} = 5000\times\sqrt{35} \text{ N/mm}^2 = 29580.399 \text{ N/mm}^2$$

$$I_c = \frac{bd^3}{12} = \frac{500\times 750^3}{12} = 1.758\times 10^{10} \text{ mm}^4$$

$$\delta_1 = \frac{5}{384}\frac{wl^4}{E_c I_c} = \frac{5}{384}\times\frac{85(6000)^4}{(29580.399)(1.758\times 10^{10})} = 2.76 \text{ mm } (\downarrow)$$

Upward deflection due to prestressing force

$$\delta_2 = \frac{5}{48} \times \frac{Pel^2}{E_c I_c}$$

$$= \frac{5}{48} \times \frac{(1620 \times 10^3)(145)(6000)^2}{(29580.399)(1.758 \times 10^{10})} = 1.69 \text{ mm } (\uparrow)$$

$\therefore$ $$\delta = \delta_1 - \delta_2 = 2.76 - 1.69 = 1.07 \text{ mm } (\downarrow)$$

13. (b)

Column is fixed at one end and pinned at other end.

$$e_{min} = \frac{L_0}{500} + \frac{D}{30}$$

$$= \frac{3200}{500} + \frac{400}{30}$$

$$= 19.73 \text{ mm} < 0.050D = 20 \text{ mm} \quad \text{(OK)}$$

$\therefore$ $$l_{eff} = 0.8 \times 3.2 = 2.56 \text{ m}$$

$$\lambda = \frac{256}{40} = 6.4 < 12$$

$\therefore$ It is a short column

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

$$\Rightarrow \quad 1200 \times 10^3 = 0.4 \times 20 \times \left[\frac{\pi}{4} \times 400^2 - A_{sc}\right] + 0.67 \times 415 \times A_{sc}$$

$$\Rightarrow \quad 1200 \times 10^3 = 1005309.65 - 8A_{sc} + 278.05 A_{sc}$$

$$\Rightarrow \quad A_{sc} = 720.94 \text{ mm}^2$$

Check: Minimum steel = 0.8% of gross area

$$= \frac{0.8}{100} \times \frac{\pi}{4} \times 400^2 = 1005.31 \text{ mm}^2 > A_{sc}$$

So provide $A_{sc} = 1005.31 \text{ mm}^2$

14. (a)

Given: $b = 200$ mm, $d = 350$ mm

Pre-stressing force $= 3 \times 60 \times 1100 \times 10^{-3}$ kN

$= 198$ kN

Eccentricity, $$e = \frac{350}{2} - 90 = 85 \text{ mm}$$

$$m = 6$$

Stress at the level of tendons $= \dfrac{P}{A} + \dfrac{Pe^2}{I}$

$$= \frac{198 \times 10^3}{200 \times 350} + \frac{198 \times 10^3 \times 85^2}{\frac{200 \times 350^3}{12}} = 2.83 + 2.00 = 4.83 \text{ N/mm}^2$$

Loss of stress due to elastic deformation = $m.f_c$

$= 6 \times 4.83 = 28.98 \text{ N/mm}^2$

Loss of prestressing force $= \dfrac{28.98 \times 3 \times 60}{1000} \text{kN} = 5.22 \text{ kN} \simeq 5.2 \text{ kN}$

15. **(d)**

For axially loaded column,

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

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

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

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

where A_c = Area of concrete

A_g = Gross area of column

A_{sc} = Area of compression steel

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

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

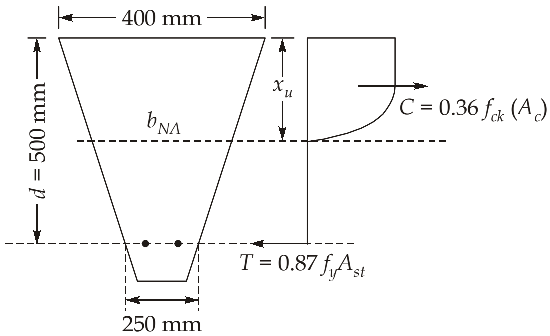
$A_{sc} = 1131.498 \text{ mm}^2 \simeq 1131.50 \text{ mm}^2$

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

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

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

16. **(c)**



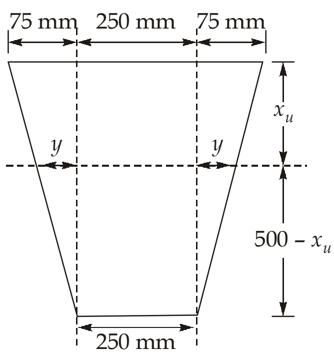
Let, A_c = Area of concrete

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

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

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 is compression

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

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

$= (400 - 0.15x_u)$

$$C = T$$

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

$$\Rightarrow 0.36 \times 25 \times (400 - 0.15 x_u) x_u = 531826.65$$

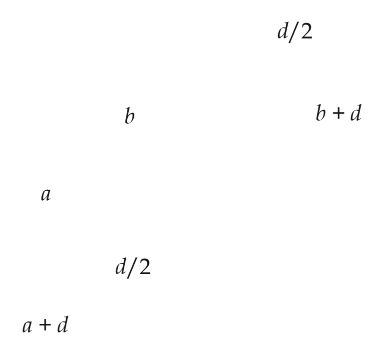
$$\Rightarrow x_u^2 - 2666.7\, x_u + 393945.67 = 0$$

$$\therefore \quad x_u = 157 \text{ mm} = 15.7 \text{ cm}$$

17. (a)

$$(\tau_{ve})_{developed} = \frac{P_o - w_o[(a+b)(b+d)]}{2(a+d+b+d)\times d}$$

$\because$ Critical section for two way shear will be at $\frac{d}{2}$ distance from column face



$$(\tau_{ve})_{developed} = \frac{1300 - 205[(0.4+0.75)(0.5+0.75)]}{2[0.75\times(0.4+0.75+0.5+0.75)]} \text{ kN/m}^2$$

$$= 0.279 \text{ N/mm}^2 \simeq 0.28 \text{ N/mm}^2$$

18. (d)

$$P_L = P_0[kx + \mu\alpha]$$

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

$$\tan\alpha = \frac{4\times 250}{12000} = 0.0833 \; (\therefore \; \alpha = 4.76° = 0.0831 \text{ radian})$$

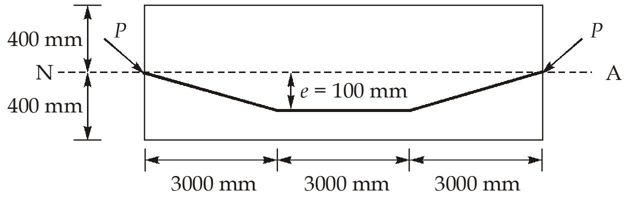
Given, $k = 0.15$ per 1000 m $= \frac{0.15}{1000}$ per m

$x = 6.0$ m {as loss is asked at mid-span of beam}

$$\therefore \quad P_L = 1200\left[\frac{0.15}{1000}\times 6.0 + 0.35\times 0.0831\right]$$

$$\Rightarrow \quad P_L = 35.982 \text{ kN} \simeq 36 \text{ kN}$$

19. (a)



The given trapezoidal cable profile of prestressing wire reflects the bending moment diagram due to the two point loads.

Given: $Q = 40$ kN, $e = 100$ mm

$L = 9$ m

P = Prestressing force

For balancing the bending effect,

$$P \times e = \frac{QL}{3}$$

$$\Rightarrow \quad P \times 100 = \frac{40 \times 10^3 \times 9000}{3}$$

$$\Rightarrow \quad P = 1200 \text{ kN}$$

20. (a)

Loss of stress due to creep $= \in_{cc} f_c E_s$

where, $$f_c = f_{c_1} + \frac{2}{3}\left(f_{c_2} - f_{c_1}\right)$$

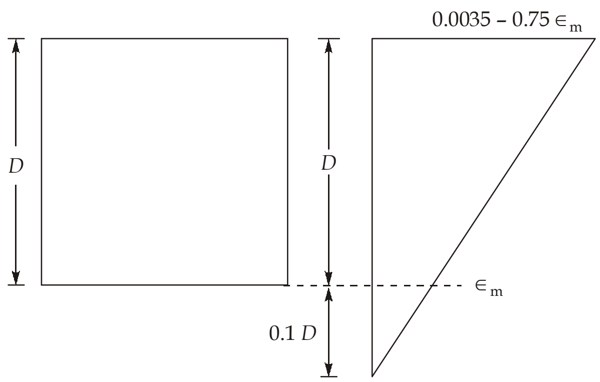
$f_{c1} = 8$ MPa

$f_{c2} = 14$ MPa

$$\therefore \quad f_c = 8 + \frac{2}{3}(14-8) = 8 + \frac{2}{3} \times 6 = 12 \text{ MPa}$$

$$\therefore \quad \text{Loss of stress} = 30 \times 10^{-6} \times 12 \times 210 \times 10^3 = 75.6 \text{ MPa}$$

21. (c)



$$\frac{0.0035 - 0.75 \in_m}{1.1D} = \frac{\in_m}{0.1D}$$

$$\Rightarrow \quad 11.75 \in_m = 0.0035$$

$$\Rightarrow \qquad \in_m = \frac{0.0035}{11.75}$$

∴ Strain in extreme compression fibre,

$$\in = 0.0035 - 0.75 \in_m$$

$$\Rightarrow \qquad \in = 0.0035 - 0.75 \times \frac{0.0035}{11.75}$$

$$\Rightarrow \qquad \in = 0.003276596$$

$$\Rightarrow \qquad \in = 3276.596\ \mu$$

22. **(b)**

$$V_u = 80 \times 10^3 \text{ kN}$$

$$P_t = \frac{100 \times 4 \times \frac{\pi}{4} \times 12^2}{250 \times 400} = 0.452\%$$

Using the table to get τ_c corresponding to

$$P_t = 0.452\%$$

$$\frac{0.48 - 0.36}{0.5 - 0.25} = \frac{0.48 - x}{0.5 - 0.452}$$

$$\Rightarrow \qquad x = \tau_c = 0.457 \text{ MPa}$$

$$\tau_v = \frac{80 \times 10^3}{250 \times 400} = 0.8 \text{ MPa}$$

We see that $\tau_c < \tau_v$

$$\therefore \qquad V_{us} = V_u - \tau_c bd$$

$$= 80 \times 10^3 - 0.457 \times 250 \times 400 = 34300 \text{ N}$$

Since vertical stirrups,

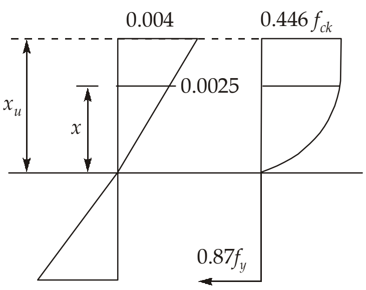
$$S_v = \frac{0.87 f_y A_{sv}\, d}{V_{us}}$$

$$\therefore \qquad 280 = \frac{0.87 \times 250 \times 2 \times \frac{\pi}{4}\phi^2 \times 400}{34300}$$

$$\Rightarrow \qquad \phi = 8.38$$

Let us provide 10 mm dia. stirrups.

23. **(d)**



From strain diagram,

$$\frac{0.004}{x_u} = \frac{0.0025}{x}$$

$$\Rightarrow \quad x = \frac{0.0025}{0.004} x_u$$

$$\Rightarrow \quad x = \frac{5}{8} x_u$$

∴ Total compressive force,

$$C = C_{\text{linear}} + C_{\text{parabolic}}$$

$$\Rightarrow \quad C = 0.446 f_{ck} \times (x_u - x) \times b + \frac{2}{3} \times 0.446 f_{ck} \times x \times b$$

$$\Rightarrow \quad C = 0.446 f_{ck} \left(x_u - \frac{5}{8} x_u \right) \times b + 0.185 f_{ck} b \left(\frac{5}{8} x_u \right)$$

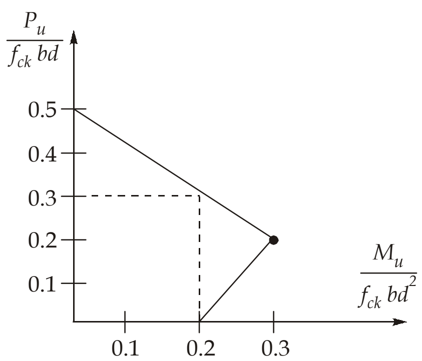
$$\Rightarrow \quad C = 0.167 f_{ck}\, bx_u + 0.185 f_{ck}\, bx_u$$

$$\Rightarrow \quad C = 0.352 f_{ck} bx_u = 0.352 \times 25 \times bx_u$$

$$\Rightarrow \quad C = 8.8\, bx_u$$

24. (d)

$$\frac{P_u}{f_{ck}bd} = \frac{540 \times 10^3 \text{ N}}{20 \times 300 \times 300} = 0.3$$



For $\frac{P_u}{f_{ck}bd} = 0.3, \quad \frac{M_u}{f_{ck}bd^2} = 0.2$ from interaction curve diagram

Hence, $M_u = 0.2 \times 20 \times 300 \times 300^2$ Nmm

$= 108$ kNm

25. (c)

Determining the depth of N.A.

Let N.A. lies in the flange i.e.

$$x_u \le D_f$$

$$\therefore \quad C = T$$

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

$$\Rightarrow \quad x_u = \frac{0.87 \times 415 \times 4 \times \frac{\pi}{4} \times 20^2}{0.36 \times 20 \times 800}$$

$= 78.77$ mm $\le D_f$ (= 80 mm)

Hence, N.A. lies in flange

For Fe415, $x_{u,\lim} = 0.48 \times 400 = 192 \text{ mm} > x_u$ (= 78.77 mm) OK

So, section is underreinforced

$\therefore$ MOR $= 0.87 f_y A_{st} (d - 0.42 x_u)$

$$= 0.87 \times 415 \times 4 \times \frac{\pi}{4} \times 20^2 \times (400 - 0.42 \times 78.77) \text{ Nmm}$$

$$= 166.47 \text{ kNm}$$

26. (d)

Initial stress in wires $= \dfrac{300 \times 10^3 \text{ N}}{200 \text{ mm}^2} = 1500 \text{ N/mm}^2$

For post tensioned beam, total residual shrinkage strain $= \dfrac{2 \times 10^{-4}}{log(t+2)} = \dfrac{2 \times 10^{-4}}{log(18+2)} = 1.537 \times 10^{-4}$

Loss of stress $= 210 \times 10^3 \times 1.537 \times 10^{-4} = 32.277$ MPa

Percentage loss of stress $= \dfrac{32.277}{1500} \times 100 = 2.15\%$

27. (d)

28. (a)

Fundamental time period of vibration as per Cl. 7.6.2 (c) of IS 1893 : 2016 (part-I) is.

$$T = \frac{0.09H}{\sqrt{D}} \qquad \text{(Here, } H = 70 \text{ m, } D = 16 \text{ m in short direction)}$$

$$\Rightarrow \quad T = \frac{0.09 \times 70}{\sqrt{16}} = 1.575 \text{ sec} \simeq 1.6 \text{ sec}$$

29. (a)

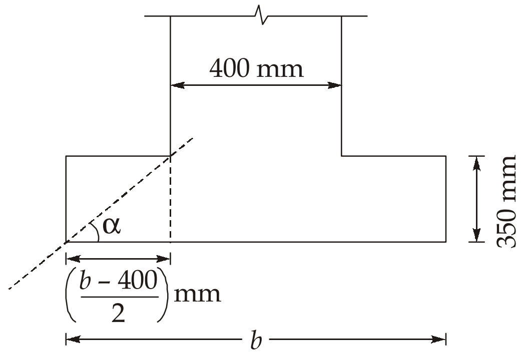
$$\tan \alpha \nleq 0.9\sqrt{\frac{100 \times q_0}{f_{ck}} + 1}$$

$$\Rightarrow \quad \frac{350}{\frac{b-400}{2}} \nleq 0.9\sqrt{\frac{100 \times 6}{25} + 1}$$

$$\Rightarrow \quad \frac{700}{b-400} \nleq 4.5$$

$$\Rightarrow \quad 155.56 \nleq b - 400$$

$$\Rightarrow \quad b \ngtr 555.56 \text{ mm}$$



30. (b)

The maximum strain in concrete at outermost compression fibre is flexural compression is 0.0035.

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