Class Test Solution (RCC) 25-08-2018

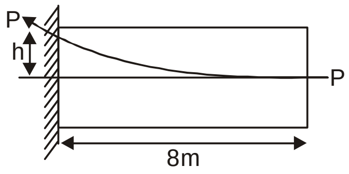
Answer key

1.	(d)	**16.**	(a)	**31.**	(a)	**46.**	(b)	**61.**	(a)
2.	(a)	**17.**	(d)	**32.**	(c)	**47.**	(a)	**62.**	(b)
3.	(c)	**18.**	(d)	**33.**	(d)	**48.**	(c)	**63.**	(c)
4.	(d)	**19.**	(b)	**34.**	(b)	**49.**	(d)	**64.**	(a)
5.	(a)	**20.**	(d)	**35.**	(b)	**50.**	(a)	**65.**	(d)
6.	(b)	**21.**	(a)	**36.**	(d)	**51.**	(b)	**66.**	(c)
7.	(a)	**22.**	(d)	**37.**	(c)	**52.**	(a)	**67.**	(a)
8.	(b)	**23.**	(b)	**38.**	(d)	**53.**	(b)	**68.**	(d)
9.	(c)	**24.**	(d)	**39.**	(a)	**54.**	(c)	**69.**	(a)
10.	(a)	**25.**	(c)	**40.**	(c)	**55.**	(a)	**70.**	(b)
11.	(c)	**26.**	(c)	**41.**	(c)	**56.**	(a)	**71.**	(d)
12.	(d)	**27.**	(c)	**42.**	(c)	**57.**	(a)	**72.**	(a)
13.	(c)	**28.**	(b)	**43.**	(b)	**58.**	(c)	**73.**	(d)
14.	(a)	**29.**	(c)	**44.**	(b)	**59.**	(c)	**74.**	(a)
15.	(a)	**30.**	(d)	**45.**	(d)	**60.**	(a)	**75.**	(b)

1. (d)

$$Ph = \frac{wl^2}{2}$$

$$2000 \times h \text{ kNmm} = \frac{20 \times 8 \times 8 \times 1000}{2} \text{ kNmm}$$



$$h = 320 \text{ mm.}$$

2. (a)

3. (c)

As per IS456 : 2000, minimum strain in tension reinforcement will be

$$\varepsilon_{max} = \frac{f_y}{1.15E_s} + 0.002$$

$$= \frac{415}{1.15 \times 2 \times 10^5} + 0.002$$

$$= 0.0038$$

4. (d)

$$\text{Stress} = 0.45 f_{ck}$$

$$= 0.45 \times 20$$

$$= 9 \text{ MPa}$$

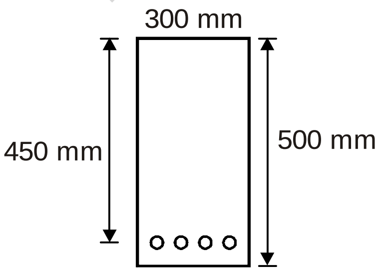
5. (a)

Case-I

Depth of critical neutral axis for Fe415 = 0.48d

$$\boxed{x_{u,lim} = 216 \text{ mm}}$$

Depth of actual neutral axis



$$C = T$$

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

$$x_u = \frac{0.87 \times 415 \times 1256}{0.36 \times 25 \times 300}$$

$$x_u = 168 \text{ mm}$$

$$\boxed{x_u < x_{u,lim}}$$

So actual depth of N.A. = 168 mm (from top).

Case-II

For Fe250

$$x_{u,lim} = 0.53d$$

$$\boxed{x_{u,lim} = 238 \text{ mm}}$$

Depth of actual neutral axis

$$C = T$$

$$0.36 f_{ck} x_u b = 0.87 f_y A'_{st} \qquad (A'_{st} = 2A_{st})$$

$$0.36 \times 25 \times x_u \times 300 = 0.87 \times 250 \times 2 \times 1256$$

$$\boxed{x_u = 202.35 \text{ mm}}$$

Difference in the depth of N.A. in both cases = 34.35 mm.

6. (b)

$$\frac{l}{d} = 26 \times 0.98 \times \frac{10}{12}$$

$$d = \frac{12000 \times 1.2}{26 \times .98}$$

$$= 565.14 \text{ mm.}$$

7. (a)

from equation $\frac{E_c}{E_{cl}} = 1 + \theta$

where θ = creep coefficient

$$2.35 = 1 + \theta$$

$$\theta = 1.35$$

8. (b)

$$\text{Design strength} = \frac{0.67}{1.5} f_{ck}$$

$= 0.446 \times 40$

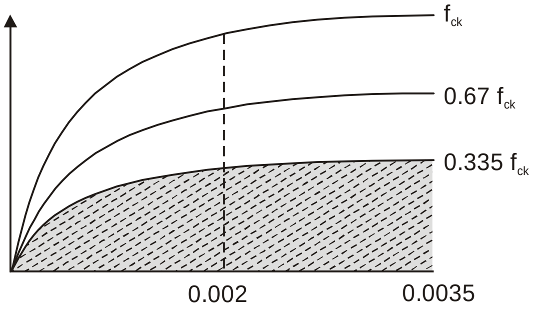
$= 17.85\,\text{MPa}$

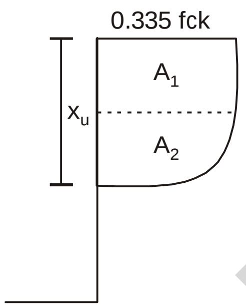
9. (c)

Design moment = 1.2 D.L. + 1.2 L.L. + 1.2 (E.L. or W.L.)

D.M. = 1.2 × 60 + 1.2 × 90 + 1.2 × 200 = 420 kN-m

10. (a)





total compressive strength

$= A_1 + A_2$

$$= \frac{2}{3}\times\frac{4}{7}x_u \times 0.335 f_{ck} \times b + \frac{3}{7}x_u \times 0.335 f_{ck} \times b$$

$= 0.1276\ f_{ck}\ x_u\ b + 0.1435\ f_{ck}\ x_u\ b$

$= 0.27\ f_{ck}\ x_u\ b$

11. (c)

12. (d)

13. (c)

14. (a)

Factored moment = 1.5 × 300 = 450 kNm

$$\frac{D_f}{d} = \frac{100}{500} = 0.02$$

and $x_u, \lim = 0.48 \times 500 = 240$ mm

$$\frac{7}{3}D_f = \frac{7}{3}\times 100 = 233.33 \text{ mm}$$

$$\because \quad x_u, \lim > \frac{7}{3}D_f$$

Hence, so neutral axis will be in web

$M_{ulim} = 0.138\ f_{ck}\ b_w d^2 + 0.446\ f_{ck}$ $(b_f - b_w)\ D_f\ (d - 0.5\ D_f)$

$M_{ulim} = 0.138 \times 20 \times 200 \times 500^2 + 0.446 \times 20 \times 550 \times 100 \times 450$

$= 358.77 \times 10^6$ Nmm

Additional moment

$450 - 358.77 = 91.23$ kNm

Compressive steel

$91.23 \times 10^6 = 353\ A_{sc}(500 - 50)$

$A_{sc} = 574.3\ \text{mm}^2$

15. (a)

$$b_f = \min\left[\begin{array}{l} \frac{l}{6} + b_w + 6D_f \\ \text{c/c distance of beams} \end{array}\right.$$

$$b_f = \frac{10}{6} + 0.2 + 6 \times 0.125$$

$= 2.61$ m

c/c distance of beam = 2.5 m

$b_f = 2.5$m.

16. (a)

anchorage slip = 3 mm

original length = 30 m

$$\text{strain} = \frac{3}{30 \times 10^3}$$

Loss of stress = strain × E

$= 21.0\ \text{N/mm}^2$

$$\% \text{ loss} = \frac{21}{1200} \times 100$$

$= 1.75\%$

17. (d)

loss of stress of mid span = P_0kx

$= P_0\ kx$

$= 1050 \times 0.003 \times 5$

$= 15.75\ N/m^2$

18. (d) As the Area of longitudinal and transverse reinforcement increases, stiffness of the RC section increases and hence the torsion resistance capacity of the section increases. To resist torsion section reinforcement must consist of closely spaced stirrups and longitudinal bars.

19. (b) Secondary stresses/warping stresses are generated in the R.C. member/beams and slabs which in turn results in the formation of the spiral cracks. So torsional reinforcement is provided in order to prevent these cracks.

In slabs,

Torsional reinforcement must be provided if both the edges are discontinuous or one edge is discontinuous. It is provided in the form of mesh (in four layers) having minimum area of steel 3/4 times of +ve reinforcement.

20. (d)

$P_{uz} = .446\ f_{ck}\ A_c + .75\ f_y\ A_{st}$

$= 0.446\ f_{ck}Ag + (.75\ f_y - .446\ f_{ck})A_{st}$

$= .446 \times 25 \times 400 \times 600 + (.75 \times 415 - .446 \times 25) \times 3694$

= 3784.57 kN.

21. (a)

As per IS Code 456 : 2000. The shear capacity of beam is increased by a factor ε due to axial compressive reaction where ε is

$$\varepsilon = \begin{cases} 1+\dfrac{3P_u}{A_g f_{ck}} \\ 1.5, \quad \text{whichever is less} \end{cases}$$

$$\varepsilon = 1+\frac{3\times(20\times1.5)\times1000}{200\times400\times25} = 1.045$$

22. (d) These are applicable to cases of uniformly loaded one-way continuous slabs and secondary continuous beams with atleast three spans which do not differ by more than 15% of the longest.

23. (b)

Ultimate load

$= 1.2 \times (\pi\times12)\times100/1000 = 4.52\,kN$

$\therefore$ Safe load = Ultimate load / load factor

= 4.52/1.5 = 3 kN.

24. (d)

IS 456 : 2000 recommends bond strength for M30 grade concrete to be 1.5 N/mm^2 for steel of grade Fe250 and M30 member subjected to tensile reaction. For Fe415 (HYSD bars) bond strength is increased by 60%].

Modified bond strength = $1.6\times\tau_{bd}$

$= 1.6 \times 1.5$

$t_{bd¢} = 2.4\ N/mm^2$

Development length

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

$$L_d = \frac{0.87\times415}{4\times2.4}\phi$$

$$\boxed{L_d \simeq 37.6\ mm}\times\phi$$

25. (c)

Local bond stress

$$\tau_{bd} = \frac{V}{\Sigma Ojd}$$

$$= \frac{75\times10^3}{4\times\pi\times16\times260}$$

$$= 1.4\ N/mm^2$$

26. (c)

27.(c)

reduction factor, C_r =

$$1.25 - \frac{l_{eff}}{48\times\text{least lateral dimension}}$$

$$C_r = 1.25 - \frac{6.0}{48 \times 0.20}$$

$$C_r = 0.625$$

28. (b)

upward point load = $2p\sin\theta$

$$= 2 \times 1000 \times \frac{1}{20}$$

$$= 100 \text{ kN}\uparrow$$

Net downward load = 160 – 100

$$= 60 \text{ kN}$$

$$\text{BM due to point load} = \frac{60 \times 6}{4} = 90 \text{ kNm}$$

$$\text{BM due to DL} = \frac{6 \times 6^2}{8} = 27 \text{ kNm}$$

$$Z = \frac{400 \times (600)^2}{6}$$

$$= 24 \times 10^6 \text{mm}^3$$

$$\text{BM due to prestressing} = +1000 \times \frac{50}{1000}$$

$$= 50$$

$$\text{total} = 90 + 27 + 100 = 167 \text{ kNm}$$

$$\text{stresses T/B} = \frac{1000 \times 10^3}{2.4 \times 10^5} \pm \frac{167 \times 10^6}{2.4 \times 10^7}$$

$$= (4.17 \pm 6.958) \text{ N/mm}^2$$

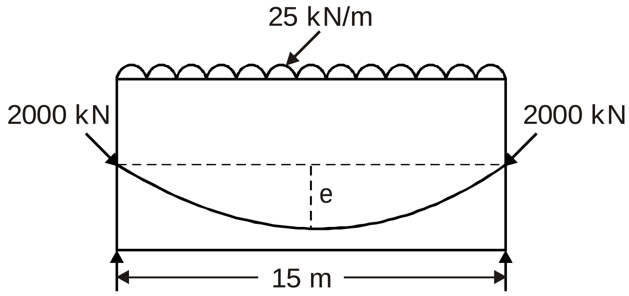
$$\sigma_t = 11.13 \text{ N/mm}^2$$

$$\sigma_b = -2.788 \text{ N/mm}^2$$

29. (c) Providing high steel will reduce the cross section requirement considering flexure criteria and hence the stiffness (flexural rigidity) of the cross section will decrease and hence higher stress, higher creep and higher long term deflection so in order to control it we need to increase depth.

30. (d)

31. (a)



$$\text{Bending moment at mid span, } M = \frac{wl^2}{8}$$

$$M = \frac{25 \times 1000 \times (15 \times 1000)^2}{1000 \times 8}$$

$$M = 7.03125 \times 10^8 \text{ N-mm}$$

Maximum compressive stress

$$\frac{P}{A} - \frac{P \cdot e}{z} + \frac{M}{z} = 30$$

$$\frac{2000 \times 1000}{300 \times 600} - \frac{2000 \times 10^3 \times e}{\frac{300 \times 600^2}{6}} + \frac{7.031 \times 10^8}{\frac{300 \times 600^2}{6}} = 30$$

$$11.11 + 39.06 - 0.11e = 30$$

$$e = 183.36 \text{ mm}$$

32. (c)

In the design of combined footing, C.O.G. of columns loads and C.O.G. of footing slab is matched.

Centroid of footing slab from face AB

$$\bar{y} = \frac{h}{3}\left[\frac{a+2b}{a+b}\right]$$

$$\bar{y} = \frac{4}{3}\left[\frac{3+2\times 2}{3+2}\right]$$

$$\bar{y} = \frac{4}{3} \times \frac{7}{5} = \frac{28}{15} = 1.86\text{m}$$

C.O.G. of loads from the face AB

$$\frac{P_1 \times 1 + P_2 \times 3.5}{P_1 + P_2} = 1.86$$

$$\frac{500 + P_2 \times 3.5}{500 + P_2} = 1.86$$

$$1.86P_2 + 933.3 = 500 + 3.5P_2$$

$$1.64P = 433.33$$
$$P = 264.2 \text{ kN}$$

33. (d)

Pitch

$$= \min \begin{cases} \text{least lateral dimension} \\ 16 \text{ times smallest diameter of main bars} \\ 300\text{mm} \end{cases}$$

$$= \min \begin{cases} 350 = 350 \\ 16 \times 20 = 320 \\ 300 \end{cases}$$
$$= 300\text{mm}$$

34. (b)

35. (b)

$$\tau \not> K_s \tau_C$$
$$K_S = 0.5 + \beta_C$$
$$= 0.5 + \frac{400}{900} = 0.944$$
$$\tau_C = 0.25\sqrt{f_{ck}} = 1.118$$
$$\tau_V \not> 1.055$$

36. (d)

37. (c)

1. $X_{u,\ max} = 0.53d$ – Fe-250
   $= 0.48d$ – Fe-415
   $= 0.46d$ – Fe-500

2. $$\frac{Ast, min}{bd} = \frac{0.85}{fy}$$

38. (d)

39. (a)

$$Mu = 0.36\,fck.b.x_u(d - 0.42x_u)$$
$$= 0.36\,fck.b.\left(\frac{x_u}{d}\right)\left[1 - 0.42\frac{x_u}{d}\right]d^2$$
$$= 0.36\,fck \times \left(\frac{x_u}{d}\right)\left[1 - 0.42\frac{x_u}{d}\right]bd^2$$
$$Mu = 0.36 \times 30 \times 0.46 \times [1 - 0.42 \times 0.46] \times bd^2$$
$$Mu = 4.00\,bd^2$$
$$\therefore \quad R = 4.0$$

40. (c)

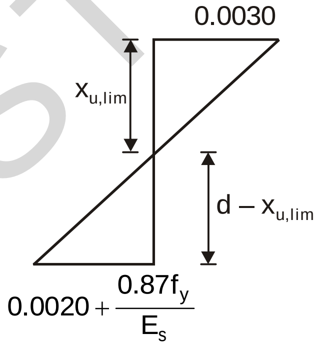
41. (c)

Critical section is the section in which permissible strain reaches both in concrete and steel simultaneously

From principle of similar triangle

$$\frac{0.0030}{x_{u,lim}} = \frac{0.002 + \frac{0.87f_y}{E_s}}{d - x_{u,lim}}$$

$$\frac{d - x_{u,lim}}{x_{u,lim}} = \frac{0.002 + \frac{0.87f_y}{E_s}}{0.0030}$$



$$\frac{d}{x_{u,lim}} - 1 = \frac{0.002 + \frac{0.87 \times 415}{2.01 \times 10^5}}{0.0030}$$

$$\frac{d}{x_{u,lim}} - 1 = 1.265$$

$$x_{u,lim} = 220.70 \text{ mm}$$

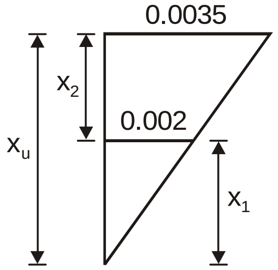
42. (c)

Similar triangle principle :

$$\frac{0.0035}{x_u} = \frac{0.0020}{x_1}$$

$$x_1 = \frac{4}{7}x_u \qquad x_2 = \frac{3}{7}x_u$$

Centroid of stress block :



$$\bar{x} = \frac{A_1\bar{x}_1 + A_2\bar{x}_2}{A_1 + A_2}$$

$$\bar{x} = \frac{0.45f_{ck} \times \frac{3}{7}x_u \times \frac{3}{14}x_u + \frac{1}{2}\times 0.45f_{ck} \times \frac{4}{7}x_u \times \left(\frac{3}{7}+\frac{1}{3}\times\frac{4}{7}\right)x_u}{0.45f_{ck}\cdot\frac{3}{7}x_u + \frac{1}{2}\times 0.45f_{ck}\times\frac{4}{7}x_u}$$

$$\bar{x} = 0.376\, x_u$$

Lever arm $= d - 0.376\, x_u$

$= d - 0.38\, x_u$

43. (b)

44. (b)

Shear resistance of a single group of 2 parallel bars bent up at the same cross-section is given by

$$V_{ui} = .87 f_y \text{ Ast } \sin\alpha$$

$$= 0.87 \times 415 \times \frac{\pi}{4} \times 25^2 \times \sin 45° \times 2$$

$$= 25064 \text{ N}$$

$$\tau_v = \frac{25064}{350 \times 500}$$

$= \mathbf{1.43\ N/mm^2}$.

45. (d)

The serviceability limit state refers to parameters such as deflection, corrosion, vibration, etc.

46. (b) Flexural tensile strength

$$= 0.7\sqrt{f_{ck}}$$

$$= 0.7 \times \sqrt{20}$$

$$= 3.13 \text{ MPa}$$

$$E_c = 5000\sqrt{f_{ck}}$$

$$= 5000\sqrt{20}$$

$$I = \frac{bd^3}{12} = \frac{300 \times 600^3}{12}$$

$$= 5.4 \times 10^9 \text{ mm}^4$$

Cracking moment

$$M_u = \frac{f_{cr} I}{y_t} = \frac{3.13 \times 5.4 \times 10^9}{300}$$

$$= 56.34 \text{ kNm}$$

$$M = \frac{Wl^2}{2} = \frac{25 \times 4^2}{2}$$

$$= 200 \text{ kNm}$$

$$\text{ratio} = \frac{56.34}{200} = 0.2817 \approx 0.30$$

47. (a)

48. (c)

49. (d)

Diameter of core = 390 – 40 – 40

= 310 mm

Diameter of helix = 390 – 40 – 40 – 6

= 304 mm

$$\frac{V_{sp}}{V_c} = \frac{\frac{\pi}{4}\times 6^2 \times \pi \times \frac{304}{S_v}}{\pi \times \frac{310^2}{4}} = \frac{.3578}{S_v}$$

$$\frac{V_{sp}}{V_c} \geq .36\left(\frac{f_{ck}}{f_y}\right)\left(\frac{A_g}{A_c} - 1\right)$$

$$\frac{.3578}{S_v} \geq .36 \times \frac{25}{415} \times \left(\frac{\pi \times \frac{390^2}{4}}{\pi \times \frac{310^2}{4}} - 1\right)$$

$$S_v \leq 28.31 \text{ mm}$$

$$S_v > \begin{Bmatrix} 25 \text{ mm} \\ 3 \times 6 = 18\text{mm} \end{Bmatrix}$$

$$S_v < \begin{Bmatrix} 75 \text{ mm} \\ \frac{310}{6} = 51.67\text{mm} \end{Bmatrix}.$$

50. (a)

Region I, in the interaction diagram represents minimum eccentricity region for which load carrying capacity of column would be

$P_u = 0.4\, f_{ck}A_c + 0.67 f_y A_s$

$= 0.4 \times 20 \times (400 \times 500 - 3000)$

$+ 0.67 \times 415 \times 3000$

$= 2410.15$ kN

51. (b)

Transverse Reinforcement is greater of

(i) $\frac{1}{4}$ of max. dia (ii) 6 mm

(i) $\frac{1}{4} \times 16 = 4$ (ii) 6 mm

Use 6 mm dia and spacing is minimum of

(i) 400 mm (ii) $16 \times 12 = 192$ mm (iii) 300 mm

Use 6 mm dia @ 190 mm c/c

52. (a)

$$h = \frac{q_0}{w_c}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

$$= \frac{150}{20}\left(\frac{1-\sin 30}{1+\sin 30}\right)^2$$

$$= .833 \text{ m.}$$

53. (b)

54. (c)

55. (a)

56. (a)

$$fm = 1.2 \text{ MPa}$$

$$\sigma = 0.26$$

$$f_{ck} = fm - 1.65 \times \sigma$$

$$f_{ck} = 1.2 - 1.65 \times 0.26$$

$$f_{ck} = 0.77$$

57. (a) Since no additional reinforcement for torsion will be provided so

$$\tau_{ve} = \tau_c = .5 \text{ N/mm}^2$$

$$V_e = (.5 \times 300 \times 600) \text{ N}$$

$$= 90 \text{ kN}$$

$$T_u = (V_c - V_u)\frac{b}{1.6}$$

$$= (90-70)\times\frac{.3}{1.6}$$

$$= 3.75 \text{ kNm.}$$

58. (c)

$$M_w = M_u + \frac{T_u}{1.7}\left(1+\frac{D}{B}\right)$$

$$= 300 + \frac{72}{1.7}\left(1+\frac{500}{400}\right)$$

$$= 395.29 \text{ kN-m}$$

59. (c)

60. (a)

61. (a) Lower values of p_t and f_{st} are indicative of lower design loads and lower stains distributed across the cross-section and hence lower curvatures and lesser deflections.

62. (b) In strain compatibility, the strain at any point in the steel is equal to that in the adjoining concrete.

63. (c)

The stress distribution below the combined footing must be uniform.

64. (a)

The maximum limits are specified for bars in tension for the purpose of controlling crack-width and improving bond.

65. (d)

66. (c) The surface is generated as the envelope of a number of design interaction curves for different axes of bending.

67. (a) If the eccentricity, $e = \frac{M_u}{P_u}$ is relatively small, the axial compression behaviour predominates and the consequent failure is termed compression failure. On the other hand, if the eccentricity is relatively large the flexural behaviour predominates and the consequent failure is termed as tension failure.

68. (d)

Minimum grade of concrete in RCC is Restricted to M20 as per IS 456:2000

69. (a)

70. (b) This is so, because regardless of whether the beam is under-reinforced or over-reinforced, collapse invariably occurs by the crushing of concrete.

71. (d)

72. (a) In addition to increased ductility, spiral columns exhibit increasaed toughness (resistance to impact loading) and are particularly effective under dynamic loading conditions.

73. (d)

74. (a)

75. (b)