Concrete Structures Test I

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. The following two statements are made with reference to a simply supported Under Reinforced RCC beam.
   I. Steel reaches ultimate stress prior to concrete reaching ultimate stress.
   II. There is a shift in neutral axis upwards as the load is increased.
   (A) Both the statements are false
   (B) I is true but II is false
   (C) I is false but II is true
   (D) Both statements are true.

2. As per the provisions of IS 456-2000, the (short term) modulus of elasticity of M40 grade concrete (in N/mm^2) can be assumed to be
   (A) 31600 (B) 28500
   (C) 30000 (D) 36000

3. As per IS 456-2000, the effective length of column in a Reinforced concrete building frame is independent of
   (A) height of column
   (B) loads acting on frame
   (C) frame type
   (D) span of beam

4. Maximum strains in an extreme fiber in concrete and in the tension Reinforcement (Fe-250 grade and Es = 200 kN/mm^2) in a balanced section at limit state of flexure are respectively
   (A) 0.0035 and 0.0041
   (B) 0.002 and 0.0038
   (C) 0.0035 and 0.0030
   (D) 0.002 and 0.0018

5. An isolated foot bridge has a slab of 4 m width. The central supporting beam is of 8 m length, width of web-350 mm. The effective width of flange is,
   (A) 1.25 m (B) 1.68 m
   (C) 1.75 m (D) 2.0 m

6. The percentage of minimum shear Reinforcement as per IS456 using HYSD bars of Fe 415 grade is
   (A) 0.11% (B) 0.15%
   (C) 0.3% (D) 0.2%

7. Which of the following is the correct expression to estimate the development length of deformed reinforced bars used in compression as per IS456 in limit state of design?
   (A) $\frac{\phi\sigma_s}{8\tau_{bd}}$ (B) $\frac{\phi\sigma_s}{4\tau_{bd}}$
   (C) $\frac{\phi\sigma_s}{64\tau_{bd}}$ (D) $\frac{\phi\sigma_s}{5\tau_{bd}}$

8. What is the value of minimum percentage of reinforcement in case of Fe 250 steel in slabs?
   (A) 0.1% (B) 0.12%
   (C) 0.2% (D) 0.15%

9. Minimum grades of concrete to be used for pre tensioned and post tensioned structural elements are respectively [As per IS1343-1980]
   (A) M30 and M40
   (B) M40 and M30
   (C) M20 and M30
   (D) M30 and M30

10. Which of the following are subjected to primary torsion?
   (A) Isolated L-beam
   (B) Ringbeam of circular water tank
   (C) A and B
   (D) Grid system

11. A singly reinforced rectangular section of 300mm wide and 550 mm effective depth, reinforced with 3 bars of 16 mm diameter Fe415 steel bars. The concrete used is M20 grade. The ultimate moment of resistance of beam is _____ (in kN-m)
   (A) 110 (B) 150
   (C) 120 (D) 100

12. A reinforced beam of size 300 mm width and 700 mm overall depth is subjected to a service moment of 80 kN-m. If M25 and Fe 415 is used, it is be designed as (use effective cover = 50 mm)
   (A) doubley reinforced section
   (B) singly reinforced section
   (C) over reinforced section
   (D) None

13. The effective flange width of T-beams spaced at 4 m with web depth of 1.2 m, web width of 0.5 m spanning 10 m with a flange slab of 150 mm thickness is
   (A) 4 m (B) 2 m
   (C) 3 m (D) 5 m

14. An RC beam of 350 mm width and effective depth 550 mm is subjected to a factored shear force of 120 kN. M20 grade concrete is used for the beam. For shear reinforcement 6 mm diameter two legged mild steel stirrups are used. The spacing of shear reinforcement in beam is [take $\tau_{c,max}$ = 2.8 MPa and τ_c = 0.60 MPa]
   (A) 1500 mm (B) 410 mm
   (C) 90 mm (D) 300 mm

15. A bar of 12 mm diameter is embedded in concrete for a distance of 15 cm. Calculate the maximum load which the bar can take if bond stress is not to exceed 0.5 N/mm^2?

(A) 1.4 KN (B) 3.5 KN
(C) 2.0 KN (D) 2.8 KN

16. The minimum extension of steel bars of 12 mm diameter bar of Fe250 grade steel in M25 grade concrete with a design bond strength of 1.6 MPa and 135° standard bend at the end is
(A) 410 mm (B) 265 mm
(C) 150 mm (D) None

17. A reinforced concrete beam of 12 m effective span and 1.5 m effective depth is simply supported. If the total udl on the beam is 5 kN/m, the design shear force for the beam is
(A) 22.5 KN (B) 50 KN
(C) 30 KN (D) 40 KN

18. At the limit state of collapse, an RCC beam is subjected to total flexural moment of 300 kN-m, shear force of 30 kN, torque of 18 kN-m, the beam is of 350 mm wide and 450 mm gross depth with an effective cover of 30 mm. The equivalent nominal shear stress (τ_{ve}) as calculated using the code turns out to be lesser than the design shear strength (τ_c) of concrete. The equivalent shear force is
(A) 30 KN
(B) 115 KN
(C) 80 KN
(D) 200 KN

19. Based on the above data, the equivalent bending moment (Me_1) for designing the longitudinal tension steel is
(A) 400 KN-m
(B) 300 KN-m
(C) 325 KN-m
(D) 18 KN-m

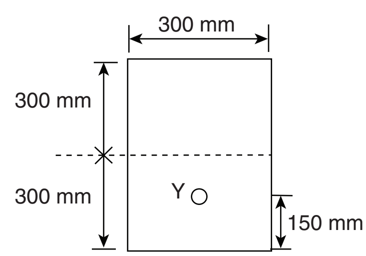
20. A rectangular column of 350 mm × 650 mm is reinforced with 0.8% reinforcement based on gross area. Fe500 steel and M25 grade concrete is used. The ultimate load carrying capacity of column is
(A) 4.8 MN
(B) 2.8 MN
(C) 3.2 MN
(D) 5.6 MN

21. The composition of an air entrained concrete is given below:
Water : 180 kg/m^3
Ordinary Portland cement: 360 kg/m^3
Sand : 600 kg/m^3
Coarse aggregate : 1200 kg/m^3
Assume the specific gravity of OPC, sand and coarse aggregate to be 3.0, 2.68 and 2.70 respectively. The air content in liters/m^3 is _______
(A) 30 (B) 40
(C) 50 (D) None

22. A column of size 300 × 550 mm has unsupported length of 4.0 m and is braced against side sway in both directions. According to IS456-2000, the minimum eccentricities (in mm) with respect to major and minor principle axes are
(A) 18 mm, 26.33 mm
(B) 26.33 mm, 18 mm
(C) 20 mm, 18 mm
(D) 26.33 mm, 20 mm

23. A simply supported reinforced concrete beam of length 12 m sags while undergoing shrinkage. Assuming a uniform curvature of 0.006 m^{-1} along the span, the maximum deflection at mid span is
(A) 0.20 m
(B) 0.11 m
(C) 0.30 m
(D) 0.25 m

24. In a pre stressed concrete beam section shown in figure. The net loss is 15% and the final prestressing force applied at y is 700 KN. The initial fiber stresses (in N/mm^2) at the top and bottom of beam were:



(A) + 49 and 58
(B) – 58 and – 49
(C) – 49 and 58
(D) – 58 and 49

25. A concrete column carries an axial load of 350 KN and a bending moment of 45 KN-m at its base. An isolated footing of 3 m × 5m with 5m side along the plane of bending moment, is provided under column. The C.G. of column and footing coincides, the net maximum and minimum pressures in KN/m^2 on the soil under the footing are respectively?
(A) 150, 98 (B) 100, 75
(C) 150, 120 (D) 134, 98

Answer Keys

1. D	**2.** A	**3.** B	**4.** C	**5.** B	**6.** A	**7.** A	**8.** D	**9.** B	
10. C	**11.** A	**12.** B	**13.** C	**14.** C	**15.** D	**16.** B	**17.** A	**18.** B	**19.** B
20. B	**21.** A	**22.** D	**23.** B	**24.** C	**25.** D				

Hints and Explanations

2. $E_c = 5000\sqrt{fck} = 5000\sqrt{40}$

$= 31622$ N/mm^2 Choice (A)

4. Maximum strain in steel at extreme tension fiber

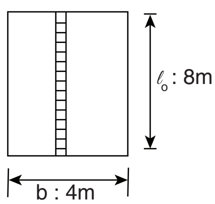
$\leq 0.002 + \dfrac{0.87\,fy}{Es}$

$= 0.002 + \dfrac{0.87 \times 250}{2 \times 10^5}$

$= 0.0030.$

Miximum strain in concrete = 0.0035 Choice (C)

5. $b_f = \dfrac{\ell_o}{\dfrac{\ell_o}{b} + 4} + bw \leq b$



Isolated T-beam : so use the above formula

$b_f = \dfrac{8}{\dfrac{8}{4} + 4} + 0.35 = \dfrac{8}{6} + 0.35$

$b_f = 1.68$ m Choice (B)

6. $\dfrac{A_{sv}}{b \times s_v} = \dfrac{0.4}{0.87\,fy}$

% minimum shear Reinforcement $= \dfrac{0.4}{0.87 \times 415} \times 100$

$= 0.110\%$

Choice (A)

7. $L_d = \dfrac{\phi\sigma_s}{4 \times \tau_{bd}}$

For HYSD bars increase τ_{bd} by 60% and for compression increase τ_{bd} by 25%

$L_d = \dfrac{\phi\sigma_s}{4 \times 1.6 \times 1.25\tau_{bd}} = \dfrac{\phi\sigma_s}{8\tau_{bd}}$ Choice (A)

11. Given

Singly Reinforced section

$b = 300$ mm

$d = 550$ mm

$A_{st} = 3 \times \dfrac{\pi}{4} \times (16)^2$

$f_y = 415$ N/mm^2

$f_{ck} = 20$ N/mm^2

$M_u = ?$

$X_{umax} = (0.48)\,(d) = 0.48 \times 550 = 264$ mm

Calculation of x_u:

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

$X_u = \dfrac{0.87 \times 415 \times 3 \times \dfrac{\pi}{4} \times 16^2}{0.36 \times 20 \times 300}$

$X_u = 100.82$ mm

$X_u < x_{umax} \Rightarrow$ under reinforced section

$\therefore\quad M = T \times$ lever arm

$M_u = 0.87 f_y A_{st}\,(d - 0.42\,x_u)$

$M_u = 0.87 \times 415 \times 3 \times \dfrac{\pi}{4} \times 16^2\,(550 - 0.42 \times 100.82)$

$M_u = 110.55$ KN-m Choice (A)

12. $b = 300$ mm;

$D = 700$ mm; $d = 650$ mm

Design moment, $M_u = 80 \times 1.5 = 120$ KN-m

$f_{ck} = 25$ MPa

$fy = 415$ MPa

$d^1 = 50$ mm

M_u, limit $= 0.138\,fck\,bd^2 = 0.138 \times 25 \times 300 \times 650^2$

$= 437.28$ KN-m

$M_u \leq M_u$, lim $\Rightarrow$ singly Reinforced section. Choice (B)

13. $C = 4$ m

$b_w = 0.5$ m

$D_f = 150$ mm

$\ell_o = 10$ m

$b_f = \dfrac{\ell_o}{6} + b_w + 6D_f \leq c = 4\text{ m} = \dfrac{10}{6} + 0.5 + 6\,(0.15)$

$b_f = 3.06$ m Choice (C)

14. $b = 350$ mm

$d = 550$ mm

$V_u = 120$ KN

$f_{ck} = 20$ MPa

$\tau_{cmax} = 2.8$ MPa

$\tau_c = 0.60$ MPa

$\tau_v = ?$

Nominal (average) shear stress due to external load is

$\tau_v = \dfrac{V_u}{bd} = \dfrac{120 \times 10^3}{350 \times 550}$

$\tau_v = 0.623$ N/mm^2

$\tau_v < \tau_{cmax} \Rightarrow$ No. diagonal compression failure.

$\tau_v > \tau_c$ $\therefore$ not safe in shear

Shear reinforcement is required for

$V_{us} = v_u - \tau_c\,(bd)$

$= 120 \times 10^3 - 0.60\,(350 \times 550) = 4500$ N

$V_{us} = 4.5$ KN

$V_{us} = \dfrac{0.87\,fy\,A_{sv} d}{s_v}$

$$4500\text{ N} = \frac{0.87\times 250\times 2\times\frac{\pi}{4}\times 6^2\times 550}{s_v}$$

$S_v = 1503$ mm

S_v based on minimum shear RFM

$$\frac{A_{sv}}{bs_v} = \frac{0.4}{0.87\,fy}$$

$$S_v = \frac{(A_{sv})(0.87\,fy)}{(0.4)(b)}$$

$$S_v = \frac{\left(2\times\frac{\pi}{4}\times 6^2\right)(0.87\times 250)}{0.4\times 350}$$

$S_v = 87.85$ mm

$S_v = 0.75 \times 550 = 412.5$ mm

S_v should be minimum of

(1) s_v calculated based on vertical stirrups

(2) s_v based on minimum shear reinforcement

(3) $\leq 0.75\,d$

(4) 300 mm

$\therefore\ s_v = 87.85$ mm Choice (C)

15. $\tau_{bd} = 0.5\text{ N/mm}^2$

$L_d = 15$ cm

$\phi = 12$ mm

$P = ?$

$P = (\tau_{bd})\,(\prod\phi L_d)$

$= (0.5)\,(\pi \times 12 \times 150)$

$P = 2827.43$ N

$P = 2.82$ kN Choice (D)

16. $\phi = 12$ mm

$fy = 250$ MPa

$fck = 25$ MPa

$\tau_{bd} = 1.6$ MPa

135° bend

$(L_d)_{\text{required}} = (L_d)_{\text{straight bar}}$ – anchorage value

$$(L_d)_{\text{straight bar}} = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{12\times 0.87\times 250}{4\times 1.6}$$

$= 407.81$ mm

Anchorage value for a 135° bend

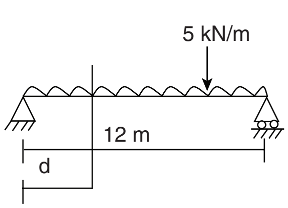
$= 12\phi = 12 \times 12 = 144$ mm

$(L_d)_{\text{required}} = 407.81 - 144$

$= 263.81$ mm Choice (B)

17. $L = 12$ m

$d = 1.5$ m



Critical section for shear is at a distance 'd' from support

$\therefore$ Design shear force $= \frac{wl}{2} - wd = \frac{5\times 12}{2} - 5(1.5)$

$F = 22.5$ kN Choice (A)

18. $M_u = 300$ kN-m

$V_u = 30$ kN

$T_u = 18$ kN-m

$b = 350$ mm

$D = 450$ mm

$d^1 = 30$ mm

$d = 420$ mm

$\tau_{ve} < \tau_c$

Equivalent shear force;

$$V_e = V_u + V_T = V_u + \frac{1.6T_u}{b} = 30 + \frac{1.6\times 18}{0.35}$$

$V_u = 112.28$ KN Choice (B)

19. Longitudinal tension steel is based on M_u only.

[ignoring the effect of torsion] If $\tau_{ve} < \tau_c$

$\therefore\ M_{e1} = M_u = 300$ KN-m Choice (B)

20. $b = 350$ mm

$D = 650$ mm

$A_{sc} = 0.8\%\,(A_g)$

$= \frac{0.8}{100}(350\times 650)$

$A_{sc} = 1820\text{ mm}^2$

$A_c = A_g - A_{sc}$

$= (350 \times 650) - (1820)$

$A_c = 225680\text{ mm}^2$

$P_u = (0.4\,fckA_c) + (0.67\,fyA_{sc})$

$= (0.4 \times 25 \times 225680) + (0.67 \times 500 \times 1820)$

$P_u = 2866$ KN

$P_u = 2.8$ MN Choice (B)

21. $$\frac{Mc}{\rho_c} + \frac{M_s}{\rho_s} + \frac{M_a}{\rho_a} + v_w + v_a = 1$$

$$\frac{360}{3\times 1000} + \frac{600}{2.68\times 1000} + \frac{1200}{2.7\times 1000} + \frac{180}{1000} + v_a = 1$$

$V_a = 0.0316$

$= 0.0316 \times 1000$

$= 31.67$ Choice (A)

22. $e_{\min} = \frac{L}{500} + \frac{b}{30}$ or 20 mm which ever is more

$$e_{xx} = \frac{4000}{500} + \frac{550}{30} = 26.33\text{ mm}$$

$$e_{yy} = \frac{4000}{500} + \frac{300}{30} = 18.0\text{ mm}$$

Subject to a minimum of 20 mm,so, take 20 mm.

Choice (D)

23. $EI\dfrac{d^2y}{dx^2} = M_x$

$$\frac{d^2y}{dx^2} = \frac{M_x}{EI}$$

$$\frac{d^2y}{dx^2} = \rho$$

$$\frac{dy}{dx} = \rho x$$

$$y = \frac{\rho x^2}{2}$$

$$y_{at\,x=\frac{L}{2}} = \frac{(0.006)\left(\frac{L}{2}\right)^2}{2}$$

$$= \frac{(0.006)(6)^2}{2} = 0.108 \text{ m}$$

Choice (B)

24. $P_i = 1.15 \times 700 = 805$ KN

$$\sigma_i = \frac{P}{A} \pm \frac{M}{I} \times y$$

$$= \frac{1.15 \times 700 \times 10^3}{300 \times 600} \pm \frac{1.15 \times 700 \times 10^3 \times 150}{300 \times \frac{300^3}{12}} \times 300$$

$= 4.47 \pm 53.66$

$= -49.18$ and 58.13 (in N/mm^2)

Choice (C)

25. $P = 350$ KN

$M = 45$ KN-m

$$e = \frac{M}{P} = \frac{45}{350} = 0.128 \text{ m}$$

$$\left.\begin{matrix}\sigma_{max}\\ \sigma_{min}\end{matrix}\right\} = \frac{P}{A} \pm \frac{P.e}{z}$$

$$= \frac{P}{A} \pm \frac{P.e(6)}{bd^2}$$

$$= \frac{P}{bd}\left[1 \pm \frac{6.e}{d}\right]$$

$$= \frac{350}{3 \times 5}\left[1 \pm \frac{6 \times 0.128}{5}\right]$$

$\sigma_{max} = 134.58$ kN/m^2

$\sigma_{min} = 98.74$ kN/m^2

Choice (D)