CONCRETE STRUCTURES TEST 2

Number of Questions: 30 **Time: 75 min.**

Directions for questions 1 to 30: Select the correct alternative from the given choices.

1. Minimum Grade of concrete for structural purpose
(A) M15 (B) M20
(C) M25 (D) M30

2. Balanced Neutral axis depth for a singly reinforced cross section depends on
(A) Grade of concrete
(B) Grade of steel
(C) Amount of steel reinforcement
(D) All the above

3. A rectangular concrete beam of width 230 mm and effective depth 300 mm is reinforced with 4 – 12 mm bars in tension zone. M20 Grade concrete and Fe 415 steel are used. Find the Moment of Resistance of the beam.
(A) 42.23 KNm (B) 35.26 KNm
(C) 64.13 KNm (D) 72.54 KNm

4. Minimum percentage of steel in both directions in a slab when HYSD bars are used is _____% of (bD)
(A) 0.1% (B) 0.15%
(C) 0.12% (D) 0.2%

5. In design for shear in Reinforced concrete structures, which of the following is considered explicitly.
(A) Dowel action
(B) Aggregate interlocking
(C) Concrete in compression zone
(D) All the above

6. As per IS: 456 – 2000, span/depth ratio of two way simply supported slabs is
(A) 40 (B) 30
(C) 20 (D) 35

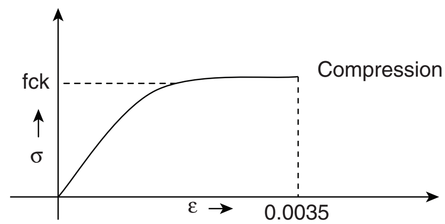
7. A hook of Fe 415 Grade is provided in Compression in M20 Grade Concrete with τ_{bd} = 1.2 MPa, Then the development length L_d = _______ ϕ
(A) 44.17 (B) 37.6
(C) 21.61 (D) Not allowed (hook)

8. In a plain concrete pedestal of M35 Grade, the maximum bearing pressure at the base is found to be 40 N/mm^2. Find the depth of footing if the projection beyond the column is 300 mm
(A) 3.1 m (B) 2.6 m
(C) 2.4 m (D) 1.9 m.

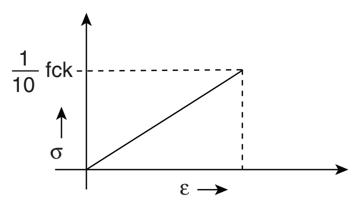
9. In the limit state design of serviceability the deflection after erection of partitions and erection of finishes is limited to
(A) span/250 (B) san/325
(C) span/350 (D) span/150

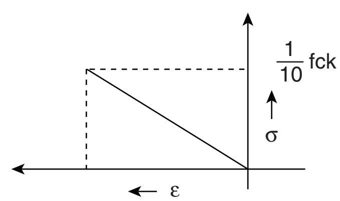
10. Calcium lignosulphate is an example of
(A) retarder (B) accelerator
(C) dispersal agent (D) hardness agent

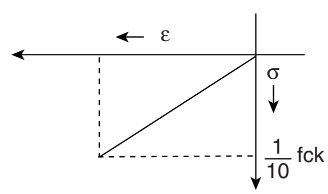
11. If the following figure represents the idealized $\sigma - \varepsilon$ curve of concrete in compression.

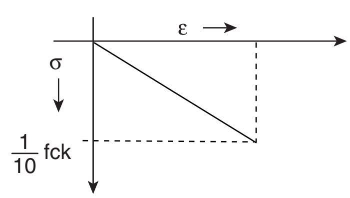


Then the $\sigma - \varepsilon$ curve of concrete in Tension is

(A)


(B)


(C)


(D)


Common Data for Questions 12 and 13:
A reinforced concrete beam, size 250 mm wide and 400 mm deep effective is simply supported over a span of 6 m. It is subjected to a point load of P at centre of the beam. The point load is increased gradually. Beam is reinforced with 5 HYSD bars of Fe 415 grade of 12 mm diameter placed at an effective cover of 40 mm on bottom face and nominal shear reinforcement. The characteristic compressive strength and bending tensile strength of concrete are 20MPa and 2.2MPa respectively.

12. Ignoring the pressure on tension reinforcement, find the value of load P in KN when the first flexural crack will develop on the beam

(A) 26.4 KN (B) 11.83 KN
(C) 16.4 KN (D) 35.5 KN

13. The theoretical failure load of the beam for attainment of limit sate of collapse in flexure is

(A) 33 KN (B) 48 KN
(C) 52 KN (D) 64 KN

14. A reinforced beam of size 230 mm width and 350 mm overall depth is subjected to a working moment of 65 KNm. If M20 grade concrete and Fe415 grade steel are used, it is to be designed as (effective cover = 50 mm)

(A) Balanced section
(B) Singly reinforced section
(C) Doubly reinforced section
(D) Over reinforced section

15. A hall of 10 m × 24 m consists of a number of beams 4 m centre to centre parallel to the shorter span of the hall. Width of web = 300 mm. Thickness of slab 120 mm, the beams are cast monolithic with the columns at their ends. The effective width of flange of an intermediate beam is

(A) 1.52m (B) 0.94m
(C) 2.01m (D) 2.19m

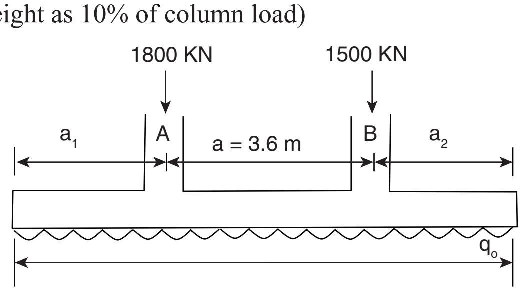
16. Match List – I with List – II and select the correct answer from the codes given below.

	List – I (Admixtures)		List – II (Example)
P.	Retarder	1.	Volcanic Tuff
Q.	Accelerator	2.	Natural wood resins
R.	Pozzolona	3.	Calcium sulphate
S.	Air entraining agent.	4.	Calcium chloride

Codes:

	P	Q	R	S
(A)	1	2	3	4
(B)	1	2	4	3
(C)	3	4	1	2
(D)	2	1	3	4

17. Two columns A and B carrying loads are shown in figure below with different notations. Soil bearing capacity of soil q_o = 200 KN/m². width of footing for both columns is 2.4 m. Find a_1 and a_2 shown in figure (assume footing weight as 10% of column load)



(A) a_1 = 1.82 m and a_2 = 2.14 m
(B) a_1 = 2.14 m and a_2 = 1.82 m
(C) a_1 = 1.24 m and a_2 = 2.72 m
(D) a_1 = 2.72 m and a_2 = 1.24 m

18. A reinforced concrete beam of 12m effective span and 1 m effective depth is simply supported. If the total *udl* of the beam is 10MN/m the design shear force for the beam is

(A) 20MN (B) 30MN
(C) 40MN (D) 50MN

19. A column is of 500 × 300 mm and unsupported length of 3 m. The design criteria of the column as per IS 456-2000 will be.

(A) short along long and short dimensions.
(B) long along short and short along long dimension
(C) long along long and short dimensions
(D) long along long and short along short dimensions

20. The factored load carrying capacity of a column of 300 mm × 500 mm size with minimum percentage of steel is (M20 and Fe415)

(A) 1234KN
(B) 1468KN
(C) 1524KN
(D) 1632KN

21. Match the following with reference to RCC.

	List – I		List – II
a.	Torsional Analysis	1.	Truss Analogy
b.	Shear stress Analysis	2.	Skew Bending Theory
c.	Limit state method	3.	Semi Probabilistic Approach
d.	Working stress method	4.	Deterministic

Codes:

	a	b	c	d
(A)	1	2	3	4
(B)	2	1	3	4
(C)	2	1	4	3
(D)	1	2	4	3

Common Data for Questions 22 and 23:

A post tensioned concrete beam 120mm wide and 300mm deep is prestressed by three cables each with a cross sectional area of 60 mm² and with an initial stress of 1100 MP_a. All the three cables are straight and located 100mm from the sofit of the beam. If the modular ratio is 6, the loss of stress due to elastic shortening in the beam

22. When simultaneous tensioning and anchoring of all the three cables is done will be.

(A) 24.51 MPa (B) 43.92 MPa
(C) 78.26 MPa (D) zero

23. When successive tensioning of the three cables are done (one at a time)

(A) 24.51MPa (B) 43.92MPa
(C) 78.26MPa (D) zero

24. Consider the following statements regarding the PORTLAND PUZZOLANA CEMENT

(1) It produces less heat of hydration
(2) Addition of Pozzolano does not contribute to the strength at early stages
(3) Strength of this cement at any time is always less than the strength of the Portland cement
(4) It is particularly useful in marine and hydraulic construction

(A) 1, 2, 3 are correct (B) 2, 3, 4 are correct
(C) 1, 3, 4 are correct (D) 1, 2, 4 are correct

25. A reinforced concrete beam of rectangular cross section of breadth 300 mm and effective depth 500 mm is subjected to maximum factored shear force of 400KN. The grades of concrete and steel are M25 and Fe415 respectively. Based on the area of main steel provided grade of concrete the design shear stress τ_c as per IS 456 : 2000 is 0.64N/mm^2. If 2 - 16ϕ bars are used as bent up bars α = 50°) Design shear reinforcement spacing of (8 mm ϕ) 2 legged vertical stirrups (τ_{cmax} = 3.1 N/mm^2)

(A) 90 mm (B) 110 mm
(C) 130 mm (D) 280 mm

26. A rectangular beam of 500 mm × 700 mm with effective cover of 40mm is subjected to a factored values of shear force 12KN, Bending Moment 150KNm and a torsional moment 15KNm. Find the design bending moment for the design in KN- m. Use share resistance of the cross section τ_c = 1.3MPa.

(A) 100 (B) 114
(C) 150 (D) 171

27. A T – beam roof section has the following particulars. Width of flange = 600 mm, Thickness of slab = 120 mm. Width of web = 250 mm depth of web = 300mm Effective cover = 50mm. If 3 - 20ϕ bars reinforcement is provided and M20 Grade concrete and Fe415 steel are used. Find the moment of Resistance of the beam.

(A) 92KNm (B) 106KNm
(C) 114KNm (D) 138KNm

28. A concrete column carries an axial load of 500 KN and a bending moment of 50 KN–m at its base. An isolated footing of 2 m × 3m, with 3m side along the plane of bending moment is provided under column. The *CG* of column and footing coincides. The net maximum and minimum pressures in KN/m^2 on the soil under the footing are respectively

(A) 100 and 66.67 (B) 95 and 55.32
(C) 72 and 46.18 (D) 120 and 75

29. Unfactored maximum bending moments at a section of a reinforced concrete beam resulting from a frame analysis are 330, 420 and 150KN-m under dead, live and wind loads respectively. The design moment(KN – m) as per IS 456 : 2000 for the limit state of collapse is

(A) 720KN – m (B) 840KN – m
(C) 1125KN – m (D) 1530KN – m

30. In under reinforced concrete beam, which of the following statements are correct?

1. Actual depth of neutral axis is less than the critical depth of neutral axis
2. Concrete reaches ultimate stress prior to steel reaching the ultimate stress.
3. Moment of resistance is less than that of balanced section
4. Lever arm of resisting couple is less than the balanced section.

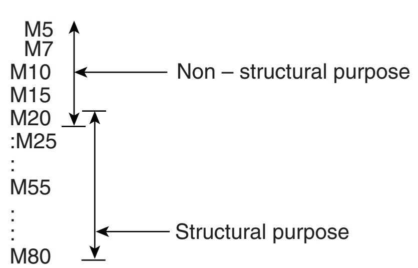
(A) 1 and 2 only (B) 1 and 3 only
(C) 2, 3 and 4 (D) 1, 2 and 4

Answer Keys

1. B	**2.** B	**3.** A	**4.** C	**5.** A	**6.** D	**7.** D	**8.** A	**9.** C	**10.** A
11. C	**12.** B	**13.** B	**14.** C	**15.** D	**16.** C	**17.** B	**18.** D	**19.** A	**20.** C
21. B	**22.** D	**23.** B	**24.** D	**25.** A	**26.** C	**27.** C	**28.** A	**29.** C	**30.** B

Hints and Explanations

1.



M 20 can be used for both structural and non structural purpose. Minimum Grade for structural purpose starts from M 20. Choice (B)

2. Neutral axis can be found from either σ diagram or ε diagram.

By considering σ diagram:

Compressive force = tensile force

$$0.36 fck\, bx = 0.87 f_y \text{ Ast}$$

$$X = \left[\frac{0.87 f_y Ast}{0.36 f_{ck}(bd)}.d\right] \quad \text{--------- (1)}$$

By considering ε diagram

$$\frac{\varepsilon_c}{x} = \frac{\varepsilon_s}{(d-x)}$$

$$\frac{0.0035}{x} = \frac{\frac{0.87fy}{E_s}+0.002}{d-x}$$

On simplifying

$$X = \left[\frac{0.0035}{0.005+\frac{0.87fy}{E_s}}\right]d \quad \text{-------- (2)}$$

From (1) and (2) equations
We can say that
N.A depends on only
(i) Grade of steel
(ii) Depth of cross section. Choice (B)

3. $X = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b} = \frac{0.87\times415\times4\times\frac{\pi}{4}\times12^2}{0.36\times20\times230} = 98.63$ mm

Balanced Neutral axis for Fe415 Grade
$X_b = 0.48 \times d = 0.48 \times (300) = 144$ mm
$X < x_b \Rightarrow$ under reinforced.
$\therefore$ $M = T.\ a = (0.87\ fy\ Ast)\ (d - 0.42x)$

$= 0.87 \times 415 \times \frac{\pi}{4} \times 4 \times 12^2$

$\times (300 - 0.42 \times 98.63)$
$= 42.23 \times 10^6$ N mm
$= 42.23$ KNm. Choice (A)

4. Minimum % of steel in slab
$= 0.15\%\ b\ D$ (for Mild steel)
$= 0.12\%\ b\ D$ (for HYSD bars). Choice (C)

5. Aggregate interlocking and concrete in compression Zone effect are considered implicitly
But dowel action is taken explicitly like in inclined bars

$V_{us} = 0.87\ fy\ As_v \frac{d}{Sv}(\sin\beta + \cos\beta)$. Choice (A)

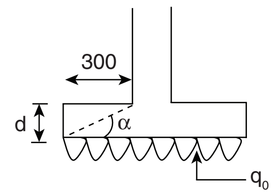
6. $$\frac{\text{span}}{\text{depth}} = \begin{cases} 20(\text{beams}) \\ \text{same as beam for one way slabs} \\ 35(\text{two way simply supported slabs}) \\ 40(2\text{way continuous slabs}) \end{cases}.$$

Choice (D)

7. In actual sense for every 45° bend, anchorage value $= 4\phi$
And for hook it is $180° = 4(45°)$
$\therefore$ $(L_d)_{req} = L_d - 4(4\phi)$
But maximum angle of bend in HYSD is only 135°
$\therefore$ Hook is not allowed with HYSD bars. Choice (D)

8. $\tan\alpha \ge 0.9\sqrt{\frac{100q_o}{f_{ck}}+1}$

$q_0 = 40\ \text{Mp}_a$
$f_{ck} = 35\ \text{Mp}_a$



$\tan\alpha \ge 0.9\sqrt{\frac{100\times40}{30}+1}$

$\tan\alpha = \frac{d}{300}$

$\frac{d}{300} \ge 0.9\sqrt{\frac{100\times40}{30}+1}$

$\frac{d}{300} \ge 10.43$

$d \ge 3129$ mm
≥ 3.13 m
$\therefore$ $d \simeq 3.1$ m. Choice (A)

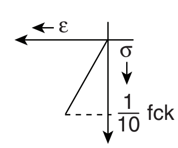
9. The final deflection of horizontal members should not exceed span/250.
The deflection after construction of partitions or application of finishes should not exceed span/350 or 20 mm whichever is less. Choice (C)

10. Calcium lignosulphate is an example of retarder. Choice (A)

11. If compressive stress is considered positive, Tensile stress is considered negative
If strain in compression is positive, strain in tension is negative

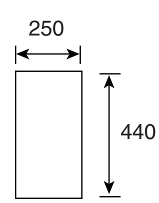
Tensile stress in concrete $= \frac{1}{10}$(compressive stress in concrete) $= \frac{1}{10}fck$

In compression $\delta\ell$ is reduction, In tension $\delta\ell$ is increasing.
$\therefore$ if $\sigma - \varepsilon$ of compression is in I quadrant
$\sigma - \varepsilon$ of tension is in III quadrant.

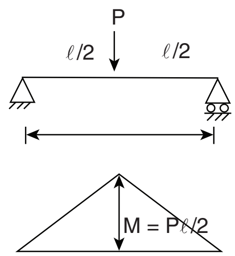


Choice (C)

12.



$d = 400$ mm
$D = 400 + 40 = 440$ mm
$b = 250$ mm
$\ell = 6$ m



From bending equation

$$\frac{M}{I} = \frac{f}{y}$$

$$f_{cr} = \frac{M}{Z}$$

$$2.2 = \frac{M}{\frac{250\times 440^2}{6}}$$

$M = 17.75$ KN – m

Bending Moment is maximum at centre.

Therefore flexural crack develops at centre

$$\frac{P\ell}{4} = 17.75$$

$\frac{P\times 6}{4} = 17.75 \Rightarrow P = 11.83$ KN. Choice (B)

13. $X = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$

$$= \frac{0.87\times 415\times 5\times \frac{\pi}{4}\times 12^2}{0.36\times 20\times 250}$$

$X = 113.43$ mm

Balanced Neutral axis

$X_b = 0.48\,d = 0.48 \times (400) = 192$ mm

$X < x_b \Rightarrow$ under reinforced beam

∴ Moment of Resistance

M = $T.a$

$= 0.87\, fy\, Ast(d - 0.42x)$

$= 0.87 \times 415 \times 5 \times \frac{\pi}{4} \times 12^2\,(400 - 0.42 \times 113.43)$

= 72 KNm

For simply supported with point load at centre M = $\frac{P\ell}{4}$

$72 = \frac{P\times 6}{4} \Rightarrow P = 48$ KN. Choice (B)

14. $b = 230$ mm

$D = 350$ mm

Effective cover $d^1 = 50$ mm

Effective depth d= 300 mm

$X_{u\,max} = 0.48\text{d} = 144$ mm

$M_{u\,limit} = 0.36\, fck\, bx_{umax}\,(d - 0.42\, x_{umax})$

$= 0.36 \times 20 \times 230 \times 144\,(300 - 0.42 \times 144)$

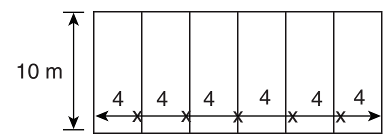
= 57.12 KNm

$M_u = 65\,k$ N m

$M_u > M_{u\,limit}$

∴ Design as doubly reinforced beam. Choice (C)

15.



Beam monolithic with columns means beam are fixed to columns

$L_0 = 0.7\ell = 0.7 \times 10 = 7$m

$$b_f = \frac{\ell_0}{6} + b_w + 6D_f.$$

$$= \frac{7}{6} + 0.3 + (6 \times 0.12)$$

$\left.\begin{aligned} &b_f = 2.19 \text{ m} \\ &b_f \not> C = 4\text{m} \end{aligned}\right\}$ use minimum

∴ $b_f = 2.19$ m. Choice (D)

16. Retarder – calcium sulphate

Accelerator – calcium chloride

Pozzolone – volcanic Tuff

Air entraining agent – Natural word resins. Choice (C)

17. $a = 3.6$ m

$B = 2.4$ m

$SBC = q_0 = 200$ KN/m²

$$\frac{P_1\times 1.1}{q_0} = 9.9 = A_1;\ \frac{P_2\times 1.1}{q_0} = 8.25 = A_2$$

$$L_1 = \frac{A_1}{B} = 4.125\ L_2 = \frac{A_2}{B} = 3.44$$

$$\frac{L_1 + L_2}{2} = 3.78 > 3.6 = a$$

∴ combined footting is provided

$$A = \frac{(P_1 + P_2)\times 1.1}{q_0} = 18.15 \text{ m}^2$$

$$L = \frac{A}{B} = 7.56 \text{ m}$$

Distance of centroid from column A

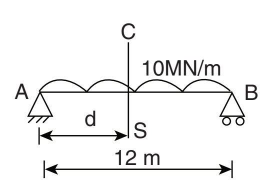
$$\bar{x} = \frac{P_2 a}{P_1 + P_2} = 1.64 \text{ m}$$

$$a_1 + \bar{x} = \frac{L}{2}$$

$a_1 = 2.14$ m

$a_2 = 1.82$ m Choice (B)

18.



Design shear force at critical section. i.e., at $d = 1$ m from one end

$V_u = R_A - 10d$

$= \dfrac{10 \times 12}{2} - 10 \times 1 = 50$ MN. Choice (D)

19. $\dfrac{\ell}{b} = \dfrac{3000}{300} = 10 < 12$

$\dfrac{\ell}{D} = \dfrac{3000}{500} = 6 < 12$

$\therefore$ short columns along both directions. Choice (A)

20. Minimum % of steel = 0.8% (Ag)

$A_{SC} = \dfrac{0.8}{100} \times (300 \times 500) = 1200 \text{ mm}^2$

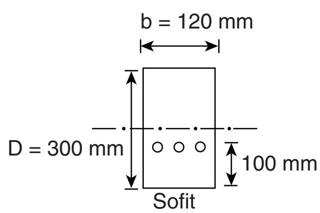
$A_c = Ag - A_{SC} = 148.8 \times 10^3 \text{ mm}^2$

$P_u = 0.4\, fck\, A_c + 0.67\, fy\, A_{SC}$

$= 0.4 \times 20 \times (148.8 \times 10^3) + (0.67 \times 415 \times 1200)$

$= 1524 \times 10^3\text{N} = 1524$ KN. Choice (C)

22.



In simultaneous tensioning and anchoring, there will be no losses

$\therefore$ losses = 0. Choice (D)

23. prestressing force in each cable

$P = \sigma_s . A_S = 1100 \times 60 = 66$KN

$f_c = \dfrac{P}{A_C} + \dfrac{Pe}{I}(e)$

$= \dfrac{66 \times 10^3}{120 \times 300} + \dfrac{66 \times 10^3 \times 50}{\dfrac{120 \times 300^3}{12}} \times 50$

$f_c = 2.44$ MPa

$\text{Loss} = \dfrac{n(n-1)}{2}[mf_c]$

Given m = 6 = $\dfrac{3(3-1)}{2}[\,6 \times 2.44]$

$= 43.92$ MP$_a$. Choice (B)

24. Portland puzzolana cement produces less heat of hydration and so less cracks and used in hydraulic construction.

Less strength at early ages, but more strength at later ages. Choice (D)

25. $\tau_{cmin} = 0.64$ MP$_a$ < $\tau_{cmax} = 3.1$ MP$_a$

$V_c = (\tau_{cmin})\, bd$

$= (0.64) \times (300 \times 500) = 96$ KN

$v_{us} = V_u - V_c = 400 - 96 = 304$ KN

$304\text{KN} = V_{bentup} + V_{stirrups}$

$V_{bentup} = 0.87\, fy\, A_{sb} \times \sin \alpha$

$= 0.87 \times 415 \times 2 \times \dfrac{\pi}{4} \times 16^2 \times \sin(50°)$

$V_{bentup} = 111$KN

$V_{stirrrups} = 304 - 111 = 193$ KN

$V_{bentup} \not> 50\% \,(V_{us}) = \dfrac{304}{2} = 152$KN

Satisfied

$V_{stirrups} = \dfrac{0.87\, fyA_{sv}d}{S_v}$

$193 \times 10^3 = \dfrac{0.87 \times 415 \times 2 \times \dfrac{\pi}{4} \times 8^2 \times 500}{S_v}$

$S_v \not> 94$ mm

$\not> 0.75\, d = 375$ mm

$\not> 300$ mm

$\therefore$ 2 legged 8ϕ @ $S_v = 90$ mm. Choice (A)

26. $V_e = V_u + V_T = V_u + \dfrac{1.6T_u}{b}$

$= 12 + \dfrac{1.6 \times 15 \times 1000}{500} = 60$KN

$\tau_{vc} = \dfrac{V_e}{bd} = \dfrac{60 \times 10^3}{500 \times (700 - 40)}$

$= 0.182$ MPa

$\tau_{ve} < \tau_c$

$\Rightarrow$ Ignore Torsion effect

$\therefore$ $M_u = 150$ KN – m. Choice (C)

27. $x_b = 0.48d = 0.48 \times (420 - 50) = 177.6$ mm

Let NA lies in flange

$0.36\, fck\, b_f x = 0.87\, fy\, Ast$

$0.36 \times 20 \times 600 \times x = 0.87 \times 415 \times 3 \times \dfrac{\pi}{4} \times 20^2$

$X = 78.77$ mm

$X < D_f = 120$ mm $\therefore$ NA is with in flange

$X < x_b \Rightarrow$ under reinforced

$M = T.a$

$= 0.87 \times fy \times A_{st}(d - 0.42x)$

$= 0.87 \times 415 \times 3 \times \dfrac{\pi}{4} \times 20^2 \times (370 - 0.42 \times 78.77)$

$= 114.65$ KNm. Choice (C)

28. $\left.\begin{matrix}\tau_{max} \\ \tau_{min}\end{matrix}\right\} = \sigma \pm f = \dfrac{P}{A} \pm \dfrac{M}{Z} = \dfrac{500}{2 \times 3} \pm \dfrac{50}{\dfrac{2 \times 3^2}{6}}$

$\sigma_{max} = 100 \text{ KN/m}^2$

$\sigma_{min} = 66.67 \text{ KN/m}^2$. Choice (A)

29. Design load for collapse

(i) $1.5\,DL + 1.5\,LL$
$= 1.5\,(330 + 420)$
$= 1125$ KN – m

(ii) $1.5\,DL + 1.5\,WL$
$= 1.5\,(330 + 150)$
$= 720$ KN – m

(iii) $1.2\,DL + 1.2\,LL + 1.2\,WL$
$= 1.2\,(330 + 420 + 150)$
$= 1080$ KN – m

Design moment = maximum of above combinations
$= 1125$ KN – m.

Choice (C)

30. For under reinforced beam

(i) $x < x_b$(balanced)
X = depth of neutral axis

(ii) Steel yields prior to concrete

(iii) $M_{UR} = 0.87\,fy\,A_{st}\,(d - 0.42x)$
Which is also $= 0.36\,fck\,bx(d - 0.42x)$ -------- (1)
As x was found by
$0.36\,fck\,bx = 0.87\,fy\,A_{st}$
$M_B = 0.36\,fck\,bx_b\,(d - 0.42\,x_b)$ -------- (2)
From (1) and (2)
$\Rightarrow \quad M_{UR} < M_B\,(as\ x < x_b)$

(iv) Lever arm $= (d - 0.42x)$
$(d - 0.42x) > (d - 0.42\,x_b)$ [$\because\ x < xb$] Choice (B)