CLASS TEST

S.No. : 02 IG_RCC_C+D_070722

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REINFORCED CEMENT CONCRETE

CIVIL ENGINEERING

Date of Test : 07/07/2022

ANSWER KEY

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

1. (a)

For Fe 415 grade steel

$$Q = 0.138\, f_{ck}$$
$$Q = 0.138 \times 30 = 4.14$$

2. (a)

Maximum pitch or maximum spacing of lateral ties shall be the minimum of:

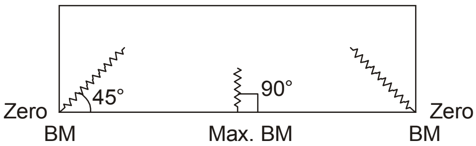
(i) Least lateral dimension = 400 mm

(ii) 16 times smallest dia. bar = 16 × 12 = 192 mm

(iii) 300 mm

Hence, maximum spacing will be 192 mm.

3. (b)



4. (b)

$$h = \frac{wl^2}{8P}$$

$$\Rightarrow \quad h = \frac{40\times 10^2}{8\times 2500} = 200 \text{ mm}$$

7. (a)

$$\text{Effective width of flange} = \frac{0.5 l_0}{\frac{l_0}{b}+4} + b_w$$

$$l_0 = 0.7 \times 15 \text{ (for fixed ends)} = 10.5 \text{ m}$$

$$\text{Effective width of flange} = \frac{0.5\times 10.5\times 1000}{\frac{10500}{650}+4} + 150 = 410.5 \text{ mm}$$

8. (c)

Bars in central, band,

$$\eta_c = \text{Total Bars}\left(\frac{2}{1+\frac{L}{B}}\right) = 20 \times \left(\frac{2}{1+\frac{3}{2}}\right) = 16$$

9. (c)

According to IS: 456-2000

$$\Rightarrow \text{Effective depth} \geq \frac{\text{Span}}{\text{(A) value} \times \frac{10}{\text{Span in metres}}} \qquad \text{(for span > 10 m)}$$

(A) value for simply supported beam is 20.

$\Rightarrow$ effective depth $>$ 1125 mm

10. (d)

For under Reinforced, steel yields first.

For ultimate failure, we check for maximum strain level upto fracture that can be sustained by concrete and steel.

Maximum strained upto fracture for concrete is 0.003 – 0.0045

Maximum strained upto fracture for steel is 0.12 – 0.20

For all type of section, strain variation is linear.

So, with increase in load, the extreme fibre of compressive concrete will reach its maximum strain level before steel will.

11. (d)

Assuming the neutral axis to lie within the flange and equating the compression and tension.

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

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} B} = \frac{0.87 \times 250 \times 1520.53}{0.36 \times 20 \times 1000} = 45.93 \text{ mm}$$

$$\left(A_{st} = 4 \times \frac{\pi}{4} \times 22^2 = 1520.53 \text{ mm}^2\right)$$

But, $D_f = 100$ mm, $x_u < D_f$

Hence our assumption about the position of the neutral axis is correct.

Also $x_{u,\max} = 0.53\, d = 0.53 \times 500 = 265$ mm

$\therefore$ $x_u < x_{u,\max}$

$\therefore$ The section is under reinforced.

Ultimate moment of resistance,

$$M_u = 0.36 f_{ck} B x_u (d - 0.42 x_u)$$

$$= 0.36 \times 20 \times 1000 \times 45.93\,(500 - 0.42 \times 45.93) \text{ Nmm}$$

$$= 158.96 \times 10^6 \text{ Nmm} = 158.96 \text{ kNm}$$

12. (d)

Factored shear force $= 1.5 \times 110 = 165$ kN

Effective depth $= 500 - 35 = 465$ mm

$$A_{st} = 2 \times \frac{\pi}{4} \times (20)^2 = 628.32 \text{ mm}^2$$

Characteristic strength of steel, $f_y = 415$ N/mm^2

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

Depth of neutral axis, $x_u = \dfrac{0.87\, f_y A_{st}}{0.36\, f_{ck} b} = \dfrac{0.87 \times 415 \times 628.32}{0.36 \times 20 \times 250}$

$= 126.03$ mm $< x_{u,\lim}$ ($x_{u,\lim} = 0.48$d $= 0.48 \times 465 = 223.2$ mm)

$$M_u = 0.87 \times 415 \times 2 \times \frac{\pi}{4} \times (20)^2 \times (465 - 0.42 \times 126.03)$$

$$= 93.48 \times 10^6 \text{ N-mm} = 93.48 \text{ kNm}$$

The anchorage value of a standard *U*-type hook is equal to 16 ϕ.

($\because$ For every 45° bend, anchorage value is 4ϕ)

$$L_0 = 16\,\phi = 16 \times 20 = 320 \text{ mm}$$

According to IS 456,

$$L_d \leq \frac{1.3 M_1}{V} + L_0$$

$$\leq \frac{1.3 \times 93.48 \times 10^6}{165 \times 1000} + 320$$

$$L_d \leq 1056.51 \text{ mm}$$

16. (d)

As per the **IS 456:2000**

17. (c)

18. (a)

For deformed bars value of bond stress is increased by 60%.

For bars in compression the value of bond stress is increased by 25%

$$\text{Development length} = \frac{\phi(0.87 f_y)}{4 \times 1.25 \times 1.6 \tau_{bd}} = \frac{25(0.87 \times 415)}{4 \times 1.25 \times 1.6 \times 1.4} = 805.9 \approx 806 \text{ mm}$$

19. (a)

Depth of neutral axis

$$B.x_a.\frac{x_a}{2} = m.A_{st}(d - x_a)$$

$$160 \times x_a \times \frac{x_a}{2} = 18 \times 4 \times \frac{\pi}{4} \times 16^2 (300 - x_a)$$

$$80\, x_a^2 + 14476.46\, x_a - 4342937.7 = 0$$

$$x_a = 159.46 \simeq 159.5$$

20. (d)

$$V_{ueq} = 1.5 \times 150 + \frac{1.6 \times (1.5 \times 50)}{0.3} = 625 \text{ kN}$$

$$\Rightarrow \quad \tau_{Veq} = \frac{625 \times 10^3}{300 \times 700} = 2.98 \text{ N/mm}^2$$

$$\tau_{Veq} > \tau_{cmax} \Rightarrow \text{section must be redesigned}$$

21. (c)

Maximum tensile stress due to load will be at the bottom fibre of Mid span.

$$\text{Bending load at Mid span} = \frac{3 \times 8^2}{8} = 24 \text{ kN-m}$$

distance of bottom fibre from centroid is 244 mm

$$\sigma_{min} = \frac{P}{A} + \frac{P.e.y}{I} - \frac{M}{I}.y = 0$$

$$\Rightarrow \quad \frac{P}{46400} + \frac{P.(194).244}{75.8 \times 10^7} - \frac{24 \times 10^6 \times 244}{75.8 \times 10^7} = 0$$

$$\Rightarrow \quad 8.4 \times 10^{-5} (P) = 7.73$$

$$\Rightarrow \quad P = 92.02 \text{ kN} \approx (92 \text{ kN})$$

22. (a)

$$\tau_{us} = \tau_v - \tau_c$$

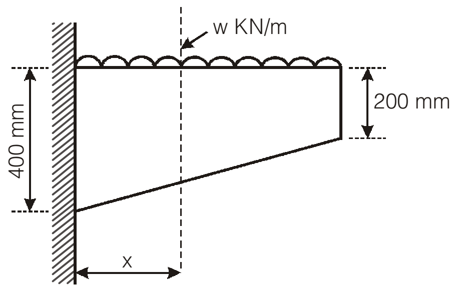
$$\tau_v = 0.6 \text{ N/mm}^2 + 0.74 \text{ N/mm}^2 = 1.34 \text{ N/mm}^2$$

at x = 1m from support

$$\text{depth} = 400 - \left(\frac{400-200}{3}\times 1\right) = 333.33 \text{ mm}$$

$$\text{effective depth} = 333.33 - 40 = 293.33 \text{ mm}$$

$$\tau_v = \frac{V_u \pm (M_u/d)\tan\beta}{bd} \quad \text{...(i)}$$



$$\tan\beta = \frac{400-200}{3000} = 0.067$$

$$V_u = 1.5 \times [w(L - x)] \qquad [\text{put } x = 1 \text{ m}]$$

$$= 3w \text{ kN}$$

$$M_u = 1.5\frac{w(l-x)^2}{2} = \frac{1.5w}{2}\times 4 = 3w \text{ kN-m}$$

putting value of M_u, V_u and τ_v in equation (i)

$$1.34 = \frac{3000w - \dfrac{(3\times 10^6)w}{293.33}\times 0.067}{250\times 293.33}$$

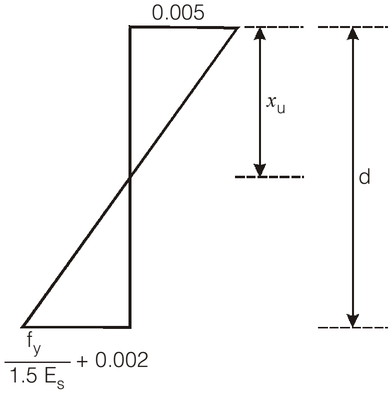
[Since BM and depth rae increasing in same direction negative sign will be used]

$$w = 42.45 \text{ N/mm}$$

23. (b)

According to IS 456 : 2013,

Linear strain diagram



$$\frac{0.005}{x_u} = \frac{\frac{f_y}{1.5\times2\times10^5}+0.002}{d-x_u} \text{ m}$$

$$\frac{x_u}{d} = 0.596$$

Limiting depth of neutral axis using Fe415 according to IS 456:2000 = 0.48 d

∴ Difference in the limiting depth of neutral axis = 0.596 d – 0.48 d = 0.116 d ≈ 0.12 d

24. (a)

Equivalent bending moment (M_{eq}) = M + M_T

$$M_T = \frac{T\left(1+\frac{D}{b}\right)}{1.7} = \frac{20\times10^6\left(1+\frac{400}{400}\right)}{1.7}$$

$$= 23.53 \times 10^6 \text{ N-mm}$$

$$M_{eq} = 60 \times 10^6 + 23.53 \times 10^6$$

$$= 83.53 \times 10^6 \text{ N-mm}$$

Equivalent shear

$$V_{eq} = V + \frac{1.6\,T}{B}$$

$$= 30000 + \frac{1.6\times20\times10^6}{400} = 110000 \text{ N}$$

$$\frac{M_{eq}}{V_{eq}} = \frac{83.53\times10^6}{0.11\times10^6} = 759.36$$

25. (c)

Clause 40.2.2 specifies that the design shear strength in presence of axial compression should be taken as $\delta \times \tau_c$

Where δ is coefficient of increase in shear strength

$$\delta = \left\{\begin{matrix} 1+\dfrac{3P_u}{A_g f_{ck}} \\ 1.5 \end{matrix}\right\} \text{which ever is less}$$

$$P_u = 1100 \text{ kN}$$
$$A_g = 500 \times 500 \text{ mm}^2$$
$$f_{ck} = 25 \text{ MPa}$$

$$\delta = 1+\frac{3P_u}{A_g f_{ck}} = 1+\frac{3\times 1100\times 10^3}{(500\times 500)\times 25}$$
$$= 1 + .528$$
$$= 1.528$$

δ is lesser of 1.528 and 1.5

So, $\delta = 1.5$

The enhanced permissible shear strength of concrete is

$$\tau'_c = \delta\tau_c$$
$$= 1.5 \times 0.75 = 1.125 \text{ MPa}$$

26. (d)

Average initial stress in concrete

$$f_c = \left(\frac{300\times 10^3}{250\times 250}\right)$$
$$= 4.8 \text{ N/mm}^2$$

Modular ratio $= m = \dfrac{E_s}{E_c} = 6.56$

Loss due to elastic deformation

$$= \frac{E_s}{E_c}\times f_c = 6.58 \times 4.8$$
$$= 31.58 \text{ N/mm}^2$$

Loss due to creep of concrete

$$\theta m f_c = 1.6 \times 6.56 \times 4.8 = 50.381 \text{ N/mm}^2$$

Loss due to shrinkage of concrete

$$= (200 \times 10^{-6}) \times E_s$$
$$= 42 \text{ N/mm}^2$$

Therefore, all options (i), (ii) and (iii) are correct.

27. (a)

Shear resistance of shear reinforcement,

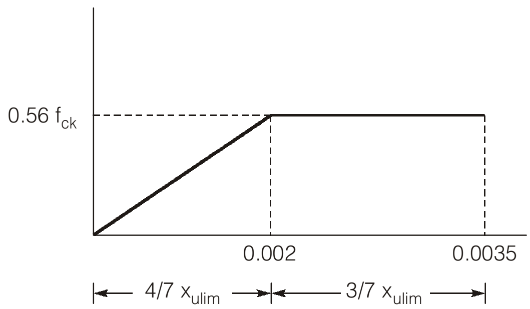
$$V_{us} = \frac{0.87 f_y A_{sv} d}{S_v}$$

$$\Rightarrow \qquad V_{us} = \frac{0.87 \times 415 \times 2 \times \frac{\pi}{4} \times 10^2 \times 450}{250} = 102.08\text{kN}$$

Shear resistance of concrete, $V_{uc} = \tau_c\, bd = 0.6 \times 250 \times 450 = 67.5$ kN

$\therefore$ Total shear capacity $= V_{us} + V_{uc} = 169.58$ kN

28. (b)



Stress-strain curve

According to IS - 456, the partial safety of factor for stress in concrete is 1.5 and maximum stress according to this factor is 0.45 f_{ck} but for new assigned factor (= 1.2) this value changes to 0.558 f_{ck},

for balanced section $\frac{x_{u\,lim}}{d} = 0.48$ (for Fe 415)

$\Rightarrow$ $x_{u\,lim} = 192$ mm (d = 400 mm)

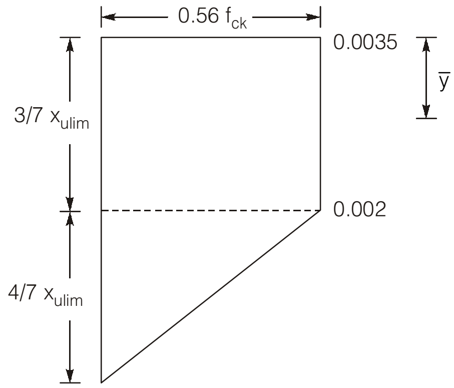
Compressive force = b [Area of the triangle + Area of Rectangle]

$$= b\left[\frac{1}{2} \times \frac{4}{7} x_{ulim} \times 0.56 f_{ck} + \frac{3}{4} x_u \times 0.56 f_{ck}\right]$$

$$= b\left[0.16\, x_{ulim}\, f_{ck} + 0.24 x_{ulim}\, f_{ck}\right]$$

$$= 0.4\, f_{ck}\, b\, x_{u\,lim} = 460.8 \text{ kN}$$

29. (d)



To calculate limiting moment, we need to calculate the lever arm

Centroid of compressive force,

$$\bar{y} = \frac{\left(\frac{3}{7}x_{u\,lim}\right)(0.56 f_{ck})b\left(\frac{3}{14}x_{u\,lim}\right)+\frac{1}{2}\left(\frac{4}{7}x_{u\,lim}\right)(0.56 f_{ck})b\left(\frac{3}{7}x_{u\,lim}+\frac{4}{21}x_{u\,lim}\right)}{460.8\times10^3}$$

$$\bar{y} = \frac{11375.2\times10^3+21907.8\times10^3}{460.8\times10^3} = 72.23\,\text{mm}$$

$\therefore$ $M_{u\,lim} = 460.8 \times 10^3 \times (400 - 72.33)$

$= 151.04$ kN-m

30. (a)

Given $b = 250$ mm; $d = 450$ mm;

$f_{ck} = 20$ N/mm^2; $f_y = 415$ N/mm^2

Limiting moment of resistance,

$M_{u,\,lim} = 0.138\, f_{ck} b d^2$ (For Fe415)

$= 0.138 \times 20 \times 250 \times 450^2$ Nmm

$= 139.725$ kNm

$$p_{t,\,lim} = 41.4\frac{f_{ck}}{f_y}\cdot\frac{x_{u\,max}}{d} = 41.4\times\frac{20}{415}\times0.48$$ (For Fe415)

$= 0.957\%$

$$A_{st,\,lim} = \frac{0.957}{100}\times250\times450 \simeq 1077\,\text{mm}^2$$

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