KATIHAR ENGINEERING COLLEGE, KATIHAR

(Department of Civil Engineering)

Class Test-02 Solution

Subject: Design of Concrete Structure-I
Instructor: RASHID MUSTAFA
Class : B.Tech, 6th Semester

Q-1. (c) A/c to IS: 456-2000, Cl 23.2

Cl 23.2.1, Deflection can be controlled by using appropriate span/depth ratio

Q-2 (b) Modular ratio = m

A/c to WSM, Let x_c be the depth of neutral axis of balanced section

$$x_c = \left(\frac{mc}{t+mc}\right)\cdot d = \left(\frac{m\sigma_{cbc}}{\sigma_{st}+m\sigma_{cbc}}\right)d$$

$$r = \frac{\sigma_{st}}{\sigma_{cbc}}$$

$$x_c = \left(\frac{m}{\frac{\sigma_{st}}{\sigma_{cbc}}+m}\right)d = \left(\frac{m}{r+m}\right)d$$

Q-3. (0.0038) A/c to Cl 38.1(f), (IS 456:2000)

$$\epsilon_s = \frac{f_y}{1.15E_s} + 0.002$$

$$\epsilon_s = \frac{415}{1.15\times2\times10^5} + 0.002 = 0.0038$$

Q-4 (644.73 mm) A/c to IS 456 : 2000, Cl 26.2.1 (Page 42 & 43)

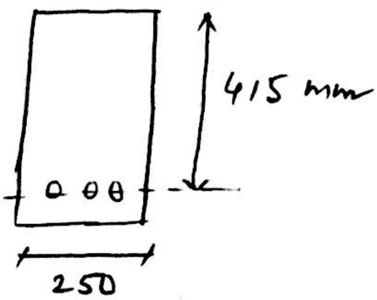
- For deformed bar conforming to IS 1786, τ_{bd} values shall be increased by 60%.
- For bars in compression, the value of bond stress for bars in tension shall be increased by 25%.

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

$$L_d = \frac{0.87 \times 415 \times 20}{4 \times 1.6 \times 1.25 \times 1.40} = 644.73 \text{ mm}$$

$$\boxed{L_d = 644.73 \text{ mm}}$$

Q-5. (a)



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

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

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

$$M_u = 0.87 f_y A_{st}\left(d - \frac{0.42 \times 0.87 f_y A_{st}}{0.36 f_{ck} B}\right)$$

$$M_u = 0.87 f_y A_{st}\left(d - 1.015 \frac{f_y}{f_{ck}} \cdot \frac{A_{st}}{B}\right)$$

$$70 \times 10^6 = 0.87 \times 415 \times A_{st}\left(415 - 1.015 \times \frac{415}{20} \cdot \frac{A_{st}}{250}\right)$$

$$70 \times 10^6 = 149835.75 A_{st} - 30.416 A_{st}^2$$

$$30.416\, A_{st}^2 - 149835.75\, A_{st} + 70\times10^6 = 0$$

$$A_{st}^2 - 4926.21\, A_{st} + 2301420.305 = 0$$

$$A_{st} = 4403.59 \text{ mm}^2 \text{ or } 522.62 \text{ mm}^2$$

Provide $A_{st} = 522.62 \text{ mm}^2$

Check :

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} B} = \frac{0.87\times415\times522.62}{0.36\times20\times250}$$

$$= 104.8 \text{ mm}$$

for $f_y = 415$ MPa

$$x_{u\,Lim} = 0.48\times415 = 199.2 > 104.6 \text{ mm}$$

With $A_{st} = 522.62 \text{ mm}^2$, the Section is Under reinforced

$$\boxed{A_{st} = 521.5 \text{ mm}^2}$$

Q-6 (c) For Under-reinforced Concrete beams

(i) $x_u < x_{u\,Lim}$

(ii) Tension steel reaches the max^m Permissible value prior to Concrete

(iii) Moment of resistance < (Moment of resistance)$_{Bal}$

(iv) Lever arm = $(d - 0.42\, x_u)$

Lever arm = $(d - 0.42\, x_{u\,Lim})$

(Lever arm) > (Lever arm)$_{\text{Balanced Section}}$

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Q-7 (225 mm) A/c to IS 456 : 2000, cl 26.5.1.5,

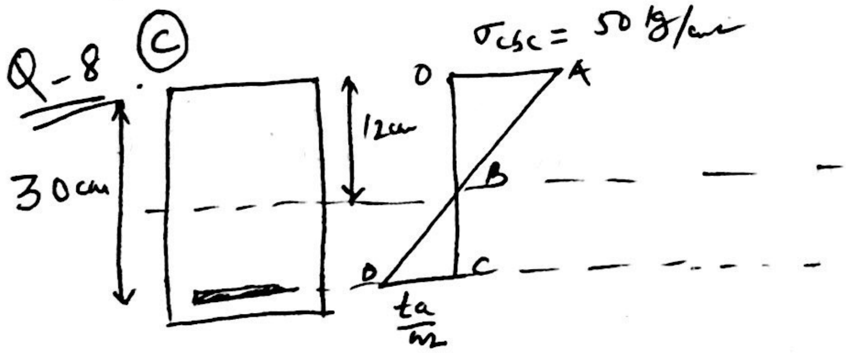
~~Maxm~~ maxm spacing of shear reinforcement measured along the axis of the member shall not exceed 0.75d for vertical stirrups & d for inclined stirrups at 45°, where d is the effective depth of the section under consideration. In no case shall the spacing exceed 300 mm

Maxm spacing = 0.75d / 300 mm } whichever is less

= 0.75 × 300 or 300 } whichever is less

= 225 mm or 300 mm } whichever is less

Q-8 (c)



For over reinforced section

$C_a = \sigma_{cbc}$

$\frac{t_a}{m} < \frac{\sigma_{st}}{m}$, $x_a > x_c$

In similar ΔOAB & ΔBCD

$$\frac{50}{12} = \frac{t_a}{m \times 18}$$

$$t_a = \frac{50 \times 18 \times 18}{12} = 1350 \text{ kg/cm}^2$$

Q-9 (d)

$$(\%)\,P_{t\,Lim} = \frac{100\,A_{st\,Lim}}{B \cdot d}$$

$$0.87\,f_y\,A_{st\,Lim} = 0.36\,f_{ck}\,B\,X_{u\,Lim}$$

$$A_{st\,Lim} = \frac{0.36\,f_{ck}\,B\,X_{u\,Lim}}{0.87\,f_y}$$

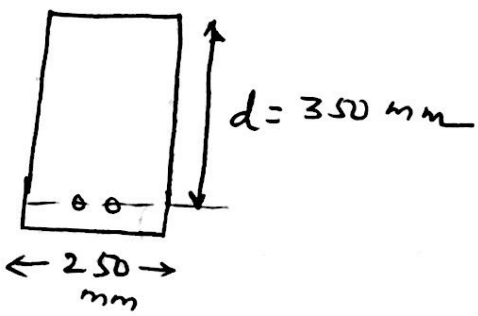
$$A_{st\,Lim} = \left(\frac{0.36}{0.87}\right)\left(\frac{f_{ck}}{f_y}\right) \cdot B \cdot X_{u\,Lim}$$

$$P_{t\,Lim} = \frac{100 \times \frac{0.36}{0.87} \cdot \left(\frac{f_{ck}}{f_y}\right) \cdot B \cdot X_{u\,Lim}}{B \cdot d}$$

$$= 41.38\left(\frac{f_{ck}}{f_y}\right) \cdot K$$

Q-10 (8.2 cm)

$V_U = 200$ kN



$$A_{sv} = 2 \times \frac{\pi}{4} \times 100$$

$$= 157.08\ mm^2$$

$$S_v = \frac{0.87\,f_y\,A_{sv} \cdot d}{V_U - \tau_c \cdot B d}$$

$$= \frac{0.87 \times 250 \times 157.08 \times 350}{200 \times 10^3 - 0.62 \times 250 \times 350}$$

$$= 82\ mm$$

Q-11 (b) Shear capacity $= 0.87 f_y A_{sv} \cdot \frac{d}{S_v}$

$= 0.87 f_y A_{sv} \times \frac{d}{0.75d}$

$= 1.16 (f_y \cdot A_{sv})$

Q-12 (5300 mm) $L_c = 5m$

$W = 300$ mm

$B = 250$ mm

$d = 400$ mm

$L_{eff} = \left.\begin{matrix} L_c + d \\ L_c + W \end{matrix}\right\}$ Whichever is less.

[A/c to IS 456:2000 cl. 22.2 (a)]

$= \left.\begin{matrix} 5000 + 400 \\ \text{OR} \\ 5000 + 300 \end{matrix}\right\}$ Whichever is less

$L_{eff} = 5300$ mm

Q-13 (6.4) $L_d = \frac{\phi \cdot \sigma_s}{4 \tau_{bd}}$

A/c to IS 456 : 2000 cl. 26.2.1

For deformed bar, τ_{bd} value increased by 60%.

$L_d = \frac{\phi \cdot \sigma_s}{4 \times 1.6 \times \tau_{bd}} = \left(\frac{1}{6.4}\right) \cdot \left(\frac{\phi \cdot \sigma_s}{\tau_{bd}}\right)$

$K = 6.4$

Q-14 . (9615.38 MPa)

long term static modulus (E_{CL}) = $\frac{\text{Short term static modulus } (E_{CS})}{1+\theta}$

A/c to IS 456:2000, CL 6.2.3.1

$E_{cs} = 5000\sqrt{f_{ck}}$

A/c to IS 456:2000, CL 6.2.5.1, Creep Coefficient (θ) depends on Age at loading

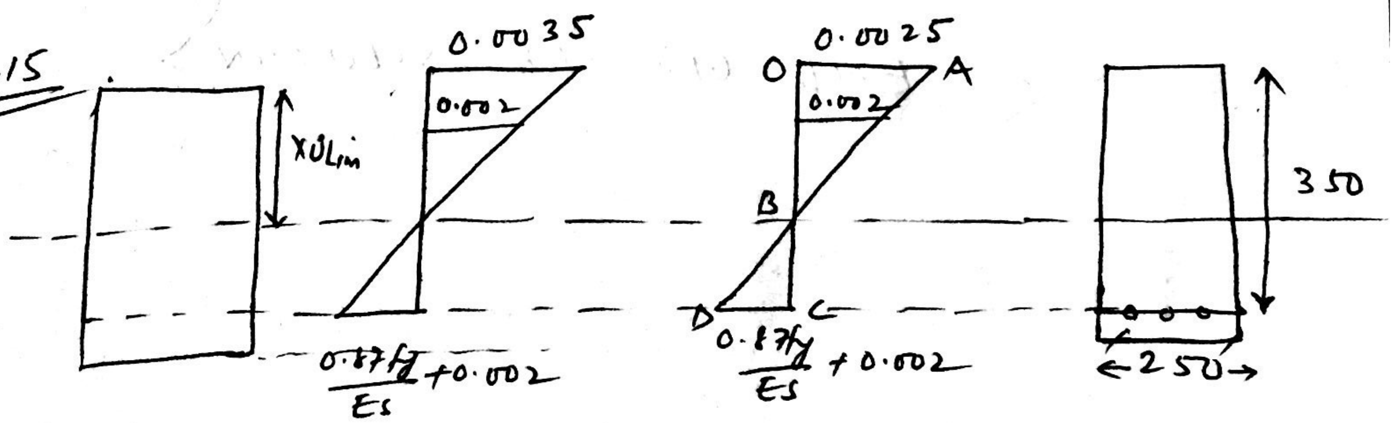
Age at loading	θ
7 days	2.2
28 days	1.6
1 Year	1.1

$$E_{CL} = \frac{5000\sqrt{f_{ck}}}{1+\theta} = \frac{5000\sqrt{25}}{1+1.6}$$

$$= \frac{25,000}{2.6} = 9615.38 \text{ N/mm}^2$$

E_{CL} = 9615.38 MPa

Q-15



A/c to IS 456:2000 CL 38.1 (b) Page-69

A/c to Question Paper

Strain diagram

In similar Δ OAB & Δ BCD

$$\frac{0.0025}{x_{ulim}} = \frac{\frac{0.87 f_y}{E_s} + 0.002}{d - x_{ulim}}$$

$$\frac{d - x_{ulim}}{x_{ulim}} = \frac{\frac{0.87 f_y}{E_s} + 0.002}{0.0025}$$

$$\frac{d}{x_{ulim}} - 1 = \frac{\frac{0.87 \times 250}{2 \times 10^5} + 0.002}{0.0025}$$

$$\frac{d}{x_{ulim}} - 1 = \frac{3.0875 \times 10^{-3}}{0.0025} \doteq 1.235$$

$$\frac{d}{x_{ulim}} = 2.235$$

$$\frac{x_{ulim}}{d} = 0.447$$

$$x_{ulim} = (0.447 \times 350)$$

$$\boxed{x_{ulim} = 156.45 \text{ mm}}$$

< END OF THE SOLUTION >