Question Number	DESIGN OF RC Structure Solution	Module - 1

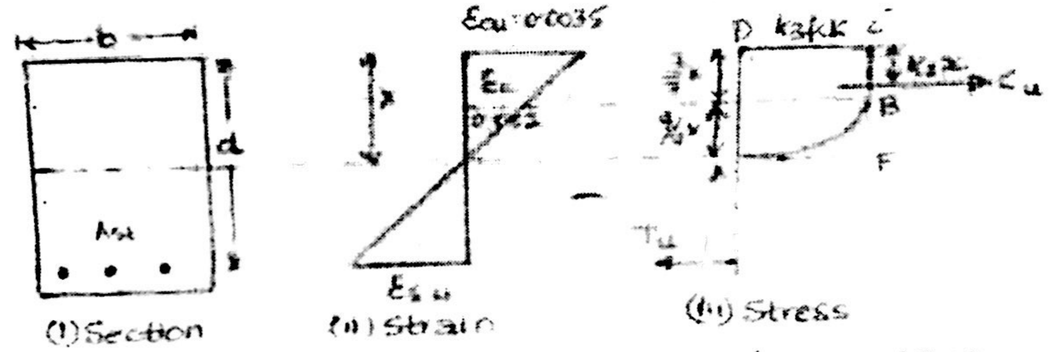
1.a) 1. characterstic load :- It means the value of load which has 95% probability of not being exceeded during the life time of the structure.

ii) Characterstic Strength :- The term characterstic strength means that value of strength of material below which not more than 5% of the test results are expected to fall.

iii) Partial Safety factor :- when assessing the strength of a structure for the limit state of collapse, the values of 1.5 for concrete and 1.15 for steel is adopted because there are greater chances of variation in strength.

Total = 2+2+2 = 6m

b)



K_1 = Shape factor = $\frac{\text{Area of ABCD}}{\text{Area of AFCD}} = \frac{\text{Area of ABCD}}{\text{Area}(x \times DC)}$

Ratio $\frac{AE}{AD} = \frac{0.002}{0.0035} = \frac{4}{7}$ Also, $\frac{ED}{AD} = \frac{0.0015}{0.0035} = \frac{3}{7}$

$AE = \frac{4}{7}AD = \frac{4}{7}x$ & $ED = \frac{3}{7}AD = \frac{3}{7}x$

Now Area ABCD = Area ABE + Area BCDE

$= \frac{8}{21}(AD \times CD) + \frac{9}{21}(AD \times CD)$

$\therefore K_1 = \frac{17}{21} = 0.81$

$K_2\, AD = \frac{(\text{Area ABE}) \times \bar{x}_1 + (\text{Area BCDE}) \times \bar{x}_2}{\text{Area ABCD}}$

$K_2 = 0.42$ & $K_3 = 0.67$

Total compressive force $C_u = b \times$ area of ABCD

$C_u = 0.36\, f_{ck}\, b\, x$

Total Tensile Force $T_u = 0.87\, f_y\, A_{st}$

total = 2+2+2+2+2 = 10m

Number

2 a) i) Developmental length:- is defined as the length of the bar required on either side of the section under consideration to develop the required stress in steel at the section through bond.

ii) Short term deflection:- are due to elastic deformations which occur immediately after the member is loaded.

iii) Long term deflection:- The deflections in the members go on increasing with the life due to creep & shrinkage.

total = 2+2+2 = 6m

2 b)

b = 300mm D = 650mm cover = 50 $f_{ck} = 20 N/mm^2$ $f_y = 415 N/mm^2$

L = 5m IL = 20KN/m

Total Service load W = 24.875 kN/m

$$\text{Max B.M} = \frac{wL^2}{8} = 77.734 \text{ kN.m}$$

$$M_r = \frac{f_{cr} \times I_{gr}}{y_t} = 66.132 \times 10^6 \text{ Nmm}, \quad E_c = 5000\sqrt{f_{ck}} = 22360.68$$

$$E_s = 2 \times 10^5 \text{ N/mm}^2$$

$$m = \frac{E_s}{E_c} = 8.944$$

$$\frac{bx^2}{2} = m A_{st} (d - x) \quad x = 157.66 \text{mm}$$

$$I_r = \frac{bx^3}{3} + m A_{st} (d - x)^2 = 2041.26 \times 10^6 \text{ mm}^4$$

$$I_{eff} = \frac{I_r}{1.2 - \frac{M_r}{M} \frac{z}{d} \left(1 - \frac{x}{d}\right) \frac{b_w}{b}} = 3297.80 \times 10^6 \text{ mm}^4$$

$I_r \le I_{eff} \le I_{gr}$ Hence ok

$$\text{Maxm Deflection} = \frac{5}{384} \frac{wL^4}{EI} = 2.70 \text{mm}$$

total = 2+2+2+2+2 = 10m

MODULE - 2

3 a) i) Under Reinforced Section:- In this, the percentage of steel provided is less than that provided in balanced section

ii) Over Reinforced Section:- In this section stresses in concrete reaches its permissible value while steel is not fully stressed.

Balanced Section:- A balanced section is that in which stress in concrete & steel reach their permissible value at the same time

total = 2+2+2 = 6m

3 b) b = 300mm, D = 500mm, cover = 50mm, d = 450mm, $f_{ck} = 20 N/mm^2$

$f_y = 500 N/mm^2$

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b} = 161.92 \text{mm}$$

$x_{ulim} = 0.46d = 207mm$ ∴ $x_u < x_{ulim}$ under reinforced Secti

$M_u = 133.60$ KNm →

$M_u = \frac{W_u l^2}{8}$ $W_u = 42.752$ KN/m
  $W = 28.501$ kN/m

Super imposed load = 28.501 − 3.75 = 24.751 kN/m →

total = 3+3+4 = 10m

4 a) $b = 250mm$, $D = 450mm$, $d = 400mm$, $f_{ck} = 20N/mm^2$, $f_y = 415N/$

$V_c = \tau_c \cdot bd = 0.61 \times 250 \times 400 = 61000N = 61KN$ —

Strength due to shear reinforcement

$V_{us} = \frac{0.87 f_y A_{sv} d}{S_v} = 90.74KN$ —

$V_u = V_c + V_{us} = 61 + 90.74 = 151.74KN$ —

total = 3m + 3m + 1m = 7m

4 b) $D_f = 120mm$, $b_w = 300mm$, $d = 580mm$, $A_{st} = 2513mm^2$

$b_f = \frac{l_0}{6} + b_w + 6D_f \not> 0.5(L_1 + L_2) b_w$

1620mm $\not>$ 3000mm

hence $b_f = 1620mm$ is OK —

Assuming $x_u < D_f$

$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f} = 77.79mm < D_f$

Assumption is correct —

$x_{ulim} = 278.4mm$

therefore under reinforced Section

$M_u = 496.62$ KNm —

total = 3m + 3m + 3m = 9m

Module - 3

5) over all dimension of beam :- b = 300mm $d = \frac{1}{12}$th to $\frac{1}{15}$th span

$d = 400mm$ $D = 450mm$

$W_u = 23.06$ kN/m $M_u = \frac{W_u L^2}{8} = 114.88$ kN-m —

$x_{ulim} = 0.48d = 192mm$

$M_{ulim} = 132.45$ KN-m $M_{ulim} > M_u$ design as —

$M_u = 0.87 f_y A_{st} d\left(1 - \frac{A_{st} f_y}{b d f_{ck}}\right)$

$A_{st} = 917.12 mm^2$

Provide 3 bars of 20mm dia.

Design for Shear:- Provide 2L - 6mmϕ Stirrups @ 300 mm c/c throughout

check for deflection:- $\left(\frac{L}{d}\right)_{max} > \left(\frac{L}{d}\right)_{provided}$

Sketch the details

total = 3m + 3m + 3m + 4m + 3m = 16m

6) b = 230 D = 600, d = 550, d' = 50, fck = 20, fy = 415

Mu = 293.29 kN-m

Mulim = 191.976 kN-m

Mu > Mulim ∴ Doubly reinforced Section

$A_{st1} = \frac{0.36 f_{ck}\, b\, x_{ulim}}{0.87 f_y} = 1210.9 mm^2$

$A_{st2} = \frac{M_u - M_{ulim}}{0.87 f_y (d - d')} = 561.2 mm^2$

$A_{st} = A_{st1} + A_{st2} = 1772.1 mm^2$

$A_{sc} = 575.6 mm^2$ Ast 6# 20mm & Asc 2# 20mm

Design for Shear:- 2L - 8mmϕ @ 190mm c/c

Sketch the details.

total = 4m + 4m + 2m + 4m + 2m = 16m

Module - 4

7) d = 120mm D = 150mm b = 230mm Leff = 3390mm

Mu = 13.93 kN-m

Mulim = 39.733×10^6 N-mm

∴ Mu < Mulim, design as Singly reinforced Section.

$M_u = 0.87 f_y A_{st} d\left(1 - \frac{A_{st} f_y}{b d f_{ck}}\right)$ $A_{st} = 341.7 mm^2$

Provide 10mm dia bars at 225mm c/c

Check for shear:- $P_t = 0.291$

$\tau_c = 0.38 = 1.3 \times 0.38 = 0.494 N$

$\tau_v = \frac{V_u}{bd} = 0.197 N/mm^2$

$\tau_{cmax} = 0.5 \times 2.8 = 1.4 N/mm^2$

∴ $\tau_v < \tau_c$ & $< \tau_{cmax}$

Shear reinforcement is not required.

check for deflection :- $\left(\frac{l}{d}\right)_{max} = 40.3$ $\left(\frac{l}{d}\right)_{prov} = 28.25$

∴ Safe

Sketch the details Total = 4+2+4+4+2 = 16m

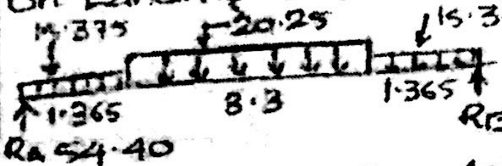
3. Number of Risers = 12, Tread = 11, Eff span = 6.03m

Dead load = 9.7 kN/m , DL + Finishing load in going = 10.5k

DL Landing portion = 6.25 kN/m + Finishing load = 7.25 kN/m

L.L = 3 kN/m², factored load on going = 20.25 kN/m

on Landing slab = 15.375 kN/m



Mu = 87.5 kN-m

Mulim = 172.5×10⁶ N-mm

∴ designed as Singly reinforced section

$Mu = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$

$A_{st} = 1063 mm^2$ Provide 16mm dia bars @ 180mm c/c

Dist. Steel :- provide 10mm bars @ 230mm c/c

Sketch the details total = 6+6+4 = 16m

Module-5

7. $\frac{P_u}{f_{ck} b D} = 0.325$ Mu trial = 252.5 kN-m $\frac{Mu}{f_{ck} b D^2} = 0.158$

$\frac{d'}{D} = 0.15$, Refer Chart 45, SP-16 $\frac{P}{f_{ck}} = 0.145$

P = 3.625 Asc = 5800 mm²

Provide 12 bars of 25mm dia ∴ $P_{act} = 3.68$

$\frac{P}{f_{ck}} = 0.147$

to find Mu_{x1}

$Mu_{x1} = 0.16 \times 25 \times 400 \times 400^2 = 256$ kN-m

to find Mu_{y1} = 256 kN-m $P_{uz} = 3567$ kN

$\alpha_n = 1.273$

Check $\left[\frac{Mux}{Mux_1}\right]^{\alpha_n} + \left[\frac{Muy}{Muy_1}\right]^{\alpha_n} = 1.025 > 1$ slightly greater than 1 hence ok.

sketch details total = 4+4+4+2+2 = 16m

size of footing 2m×2m

$q_u = 225 kN/m^2$, Depth of footing d = 360mm

Check for bending Mulim = 715.39×10⁶ N-mm

$Mu = q_u \frac{B(B-b)^2}{8} = 162.563 \times 10^6$ N-mm < Mulim ∴ Depth Provided is OK.

Check for two way shear :-

$A_{st} = 1299 mm^2$ Provide 12mm bars @ 170mm c/c

Sketch the details. Total = 4+4+4+2+2 = 16m

—x—x—x—x—