DOUBLY REINFORCED SECTION

Q1. Design a RCB of rectangular section using the following data. Effective span = 5m, width of beam = 250mm, overall depth = 500mm, working load = 40 KN/m, effective cover = 50mm. M20grade concrete & Fe 415 grade steel is used.

Given Data:

L =5m, b =250mm, D = 500mm, d' = 50mm, d = D-d' = 500-50 = 450mm

fck = 20N/mm² fy = 415 N/mm²

W = 40 KN/m

Solution:

Step 1:- Cross-section dimension

b =250mm, D = 500mm, d' = 50mm, d = 450mm, L=5000mm

Step 2:- Load Calculation

Working load, W = 40 KN/m

Ultimate Load = Total load * partial safety factor

= 40 * 1.5 = 60 KN/m

Wu = 60 KN/m

Step 3:- Shear force & bending moment

$Mu = \frac{Wu*l^2}{8}$ [Ultimate moment]

$= 60 * 5^2 / 8 = 187.5$ KN.m

$Vu = \frac{Wu*l}{2}$ [Shear forces]

= 60 * 5 /2 = 150KN

Step 5:- Check for Mu, lim

Mu, lim = $0.138*fck*b*d^2$

$= 0.138*20*250*450^2$ = 139.73KNm say 140 KN.m

Mu >Mu, lim => Over reinforced section (i.e.) it is doubly reinforced section

Mu-Mulim = 187.5 – 140 [Pg No. 96]

= 47.5 KN.m

$$fsc = 0.0035\left\{\frac{[Xumax - d']}{Xumax}\right\} * Es$$

Xumax/d = 0.48 => Xumax = 0.48*d = 0.48*450

$$fsc = 0.0035\left\{\frac{[(0.48*450)-50]}{0.48*50}\right\} * 2 * 10^5$$

= 538 N/mm²

<u>Check:</u> fsc > 0.87 fy

538 > 361 (so adopt fsc as 361 N/mm²)

Mu, Mulim = fsc. Asc (d-d') [Pg No – 96]

187*10^6 – 140*10^6 = 361* Asc(450-50)

Asc = 328mm²

i. Use 16mm φ

n = Ast/ast = 328/(π*16²/4) = 1.63 ≈ 2 nos

therefore provide 2 nos of 16mm φ

$$Ast_2 = \frac{Asc.fsc}{0.87.fy}$$ [Pg No- 96]

=328*361 / (0.87*415)

= 328 mm²

$$Ast_1 = \left[\frac{0.36.fck.b\ Xumax}{0.87fy}\right]$$

{from Xumax/d = [0.87fy. Ast/(0.36. fck. b .d)] }

= 0.36*20*250*(0.48*450)/0.87*415

= 1077 mm²

Ast = Ast_1 + Ast_2

= 1077 + 328 = 1405 mm²

ii. Use 25mm φ

n = Ast/ast = 1405/(π*25²/4) = 3 nos

therefore provide 3 nos of 25mm φ

Step 5:- Check for shear stress

τ_v = Vu/bd = (150 * 10^3) / (250*450) [Pg No 72]

= 1.33 N/mm²

Percentage of tension reinforced, pt = 100Ast/bd = 100*1405/250*450 = 1.25

τc = 0.67 [refer table 19 Pg N0. 73]

$\tau v > \tau c$ => therefore shear reinforcement shall be provided.

Vus = Vu – τc bd [Pg No – 73]

Vus = 74625 N

Use 8mm φ 2 legged stirrups

Asv = $[\frac{\pi d^2}{4}]$ *2 = $[\frac{\pi * 8^2}{4}]$ *2 = 100.53 mm²

$$Vus = \frac{Asv\ (0.87\ fy)\ d}{Sv}$$

Therefore $Sv = \frac{Asv\ (0.87\ fy)\ d}{Vus}$

= 100.53(0.87*415)450/74625

Sv = 218.87 mm, say 200mm

Provide 2 legged 8mm φ stirrups @ 200mm c/c.

Step 6:- Check for deflection

(L/d)max = (L/d)basic. Kt. Kc. Kf [pg No. 37, clause 23.2.1]

= 20 * Kt. Kc. Kf

[Pg No 38, below fig 4]

$$* fs = 0.58\, fy \left[\frac{Area\ of\ crosssection\ of\ steel\ required}{Area\ of\ crosssection\ of\ steel\ provided}\right]$$

= 0.58. fy [1405/1472.62] Ast(provided) = 3*π*25² / 4 = 1472.62 mm²

= 230 N/mm².

Kt = 0.9 [from graph]

% of tension = 1.25

fs= 230 N/mm²

% of compression reinforcement = 100Ast/bd => 100*328 / 250*450 = 0.29

Kc = 1 [for doubly RCB]

⇨ (L/d)max = 20*0.9*1.09*1 = 19.62

⇨ (L/d) actual = 5000/450 = 11.1

(L/d) max > (L/d)actual

Therefore deflection is in control