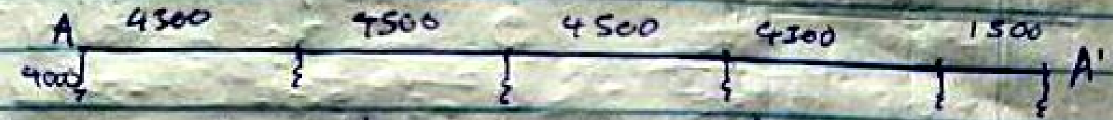
Assignment II

Designing for beam AA'



- Assuming slab thickness : 150mm , $f_{cu} = 25 N/mm^2$, $f_y = 410 N/mm^2$

Slab

- Slab loading

wt of slab = $0.15 \times 24 = 3.6 kN/m^2$

Partition = $1.0 kN/m^2$

Finishes = $1.2 kN/m^2$

(Gk) DL = $5.8 kN/m^2$

Design load DL = $1.4Gk + 1.6Qk = (1.4 \times 5.8) + (1.6 \times 3.0)$

$= 12.92 \simeq 13 kN/m^2$

Beam load

- Self wt of beam = $0.225 \times 0.6 \times 24 = 3.24 kN/m^2$

Finishes = $1.2 kN/m^2$

Wall load = $3 \times 3.47 = 10.41 kN/m^2$

Dead load (Gk) = $14.85 kN/m^2$

DL = $14.85 \times 1.4 = 20.79 kN/m^2$

~~slab load on beam = $\frac{1}{3} w l x^{l} = \frac{1}{3} \times 20.79 \times 4.3 \times$~~

~~$= \frac{1}{3} \times 13 \times 4.3 \times 1 = 18.63 kN/m$~~

~~$= \frac{1}{3} \times 13 \times 4.5 \times = 19.5 kN/m$~~

~~$= \frac{1}{3} \times 13 \times 1.5 \times = 6.5 kN/m$~~

~~Total load on beam = 1~~

Slab load on beam in longer direction

$= \frac{1}{3} w l_x (1 - \frac{1}{3 k^2})$

$= \frac{1}{3} \times 13 \times 4.3 (1 - \frac{1}{20.79^2}) = 18.08 kN/m$

$= \frac{1}{3} \times 13 \times 4.5 (1 - \frac{1}{5.8^2}) = 18.92 kN/m$

In shorter direction $= \frac{1}{3} w l_x$

$= \frac{1}{3} \times 13 \times 1.5 = 6.5 kN/m$

Total load on beam $= 20.79 + 18.08 = 38.87 kN/m$

$= 20.79 + 18.92 = 39.71 kN/m$

$= 20.79 + 6.5 = 27.29 kN/m$

Solving using hardy cross method

Distribution factor DF

$$k_{BA} = \frac{\frac{1}{L_{AB}}}{\frac{1}{L_{AB}} + \frac{1}{L_{BC}}} = \frac{\frac{1}{4.3}}{\frac{1}{4.3} + \frac{1}{4.5}} = 0.51$$

$$K_{BC} = 1 - K_{BA} = 1 - 0.51 = 0.49$$

$$k_{CB} = \frac{\frac{1}{4.5}}{\frac{1}{4.5} + \frac{1}{4.5}} = 0.5, \quad k_{CD} = 0.5$$

$$k_{DC} = \frac{\frac{1}{4.5}}{\frac{1}{4.5} + \frac{1}{4.3}} = 0.49, \quad k_{DE} = 0.51$$

$$k_{ED} = \frac{\frac{1}{4.3}}{\frac{1}{4.3} + \frac{1}{1.5}} = 0.26, \quad k_{EF} = 0.74$$

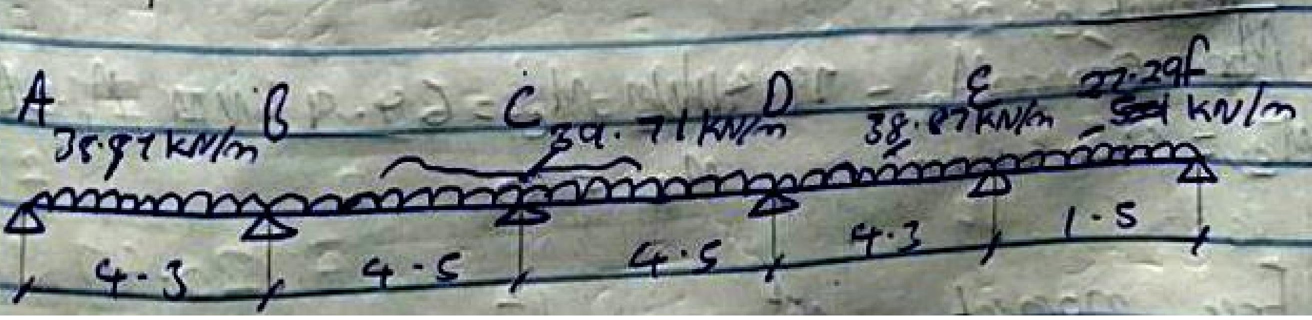
Fixed end moment (FEM)

for UDL $= \pm \frac{wL^2}{12}$

i) $\frac{38.87 \times 4.3^2}{12} = 59.89$ kN/m

ii) $\frac{39.71 \times 4.5^2}{12} = 67.01$ kN/m

iii) $\frac{27.29 \times 1.5^2}{12} = 5.1$ kN/m



	A		B		C		D		E		F	
	A	AB	BA	BC	CB	CD	DC	DE	ED	EF	FE	F
D.F	0	1	0.51	0.49	0.5	0.5	0.49	0.51	0.26	0.74	1	0
FEM		-59.89	59.89	-67.01	67.01	-67.01	67.01	-59.89	59.89	-5.1	5.1	
OBM	-59.89		-7.12		0		7.12		54.79		5.1	
BM	59.89		7.12		0		-7.12		-54.79		-5.1	
DM	0	59.89	3.63	3.49	0	0	-3.49	-3.63	-14.23	-40.55	-5.1	0
TM		1.82	29.95	0	1.75	-1.75	0	-7.13	-1.92	-2.55	-20.28	
OBM	1.82		29.95		0		-7.13		-4.37		-20.28	
BM	-1.82		-29.95		0		7.13		+4.37		20.28	
DM	0	-1.82	-15.27	-14.68	0	0	3.49	3.64	1.14	3.23	20.28	0
TM		-7.63	-0.91	0	-7.34	1.75	0	0.57	1.82	10.14	1.62	
OBM	-7.63		-0.91		-5.59		0.57		11.96		1.62	
BM	7.63		0.91		5.59		-0.57		-11.96		-1.62	
DM	0	7.63	0.46	0.45	2.8	2.8	-0.28	-0.29	-3.1	-8.9	-1.6	0
TM		0.22	3.8	1.4	0.23	-0.14	1.4	-1.6	-0.15	0.81	-4.5	0
OBM	0.23		5.2		0.09		-0.2		-0.96		-4.5	
BM	-0.23		-5.2		-0.09		+0.2		0.96		-4.5	
DM	0	-0.23	-2.65	-2.55	-0.05	-0.05	0.1	0.1	0.25	6.71	4.5	0
~~TM~~		~~[illegible]~~	~~[illegible]~~	~~-0.02~~	~~[illegible]~~	~~0.005~~	~~-0.03~~	~~0.15~~	0.05	2.3	0.30	
Σ	0		79.41	-78.41	64.9	-63.9	68.22	-67.12	44.04	-43.4	0	

Moments

$M_A = 0$, $M_B = 79.41 kNm$ $M_C = 64.9 kNM$, $M_D = 68.72 kNm$

$M_E = 44.04 kNm$, $M_F = 0$

Free moment, $M_A^f = \frac{wl^2}{8}$

$= \frac{39.87 \times 4.5^2}{8} = 89.84 kN/m^2$

$= \frac{39.71 \times 4.5^2}{8} = 100.52 kN/m^2$

$= \frac{27.29 \times 1.5^2}{8} = 8.24 kN/m^2$

Span moment

$M_{ab} = M^f_B - \left(\frac{M_a + M_B}{2}\right) = 89.84 - \left(\frac{0 + 79.41}{2}\right)$

$= 50.14 \text{ kNm}$

$M_{ab} = M_{DE} = 50.14 \text{ kNm}$

$M_{BC} = M^f - \left(\frac{M_b + M_c}{2}\right) = 89.84 - \left(\frac{79.41 + 64.9}{2}\right)$

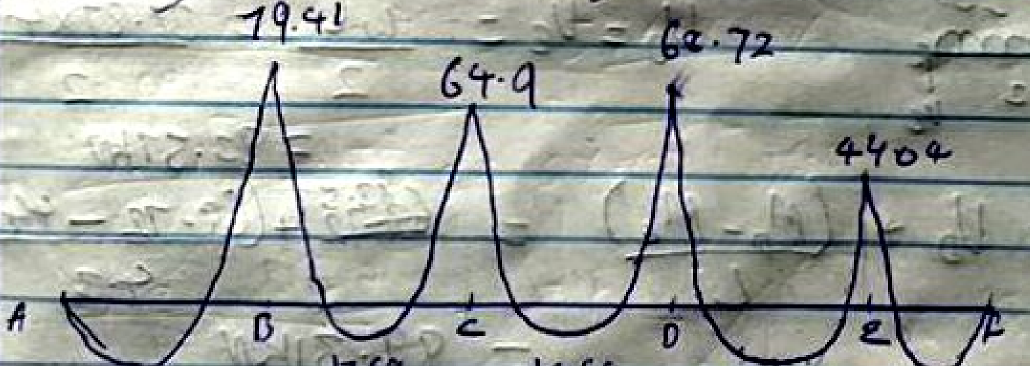
$= 17.69 \text{ kNm}$

$M_{BC} = M_{CD} = 17.69 \text{ kNm}$

$M_{EF} = M^f - \left(\frac{M_e + M_f}{2}\right) = 89.84 - \left(\frac{44.04 + 0}{2}\right)$

$= 67.82 \text{ kNm}$

Bending moment diagram



For SFD.

1. 38.87 kN/m, A — 4.3 — B, V_A, V_B

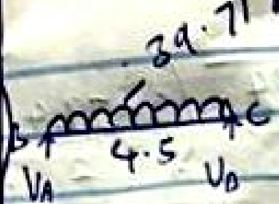
$V_A = V_b = \frac{wl}{2} = \frac{38.87 \times 4.3}{2} = 83.57 \text{ kN}$

$V_{AB} = V_A + \frac{(M_a + M_b)}{L} = 83.57 + \frac{(0 + 79.4)}{4.3}$

$= 102.12 \text{ kN}$

$V_{ba} = wl - V_{ab} = 38.87 \times 4.3 - 102.12 = 65.02 \text{ kN}$

ii

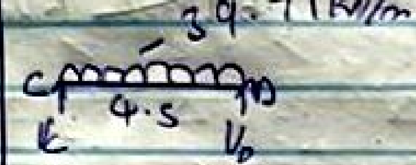


$$V_A = V_B = \frac{wL}{2} = \frac{39.71 \times 4.5}{2} = 89.35\,kN$$

$$V_{BC} = V_B + \frac{(M_B - M_C)}{L} = 89.35 + \frac{(79.41 - 64.9)}{4.5} = 92.57\,kN$$

$$V_{CB} = wL - V_{BC} = 39.71 \times 4.5 - 92.57 = 86.12\,kN$$

iii

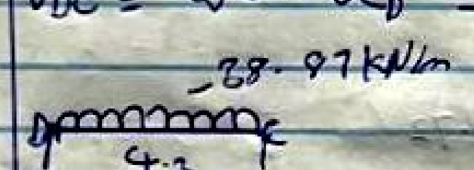


$$V_C = V_D = \frac{wL}{2} = \frac{39.71 \times 4.5}{2} = 89.35\,kN$$

$$V_{CD} = V_C + \frac{(M_C - M_D)}{L} = 89.35 + \frac{(64.9 - 68.72)}{4.5} = 88.5\,kN$$

$$V_{DC} = wL - V_{CD} = 39.71 \times 4.5 - 88.5 = 90.2\,kN$$

iv

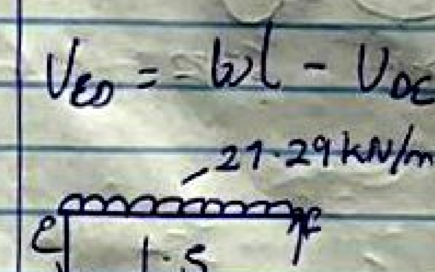


$$V_D = V_E = \frac{wL}{2} = \frac{38.87 \times 4.3}{2} = 83.57\,kN$$

$$V_{DE} = V_D + \frac{(M_D - M_E)}{L} = 83.57 + \frac{(68.72 - 44.04)}{4.3} = 89.31\,kN$$

$$V_{ED} = wL - V_{DE} = 38.87 \times 4.3 - 89.31 = 77.88\,kN$$

v

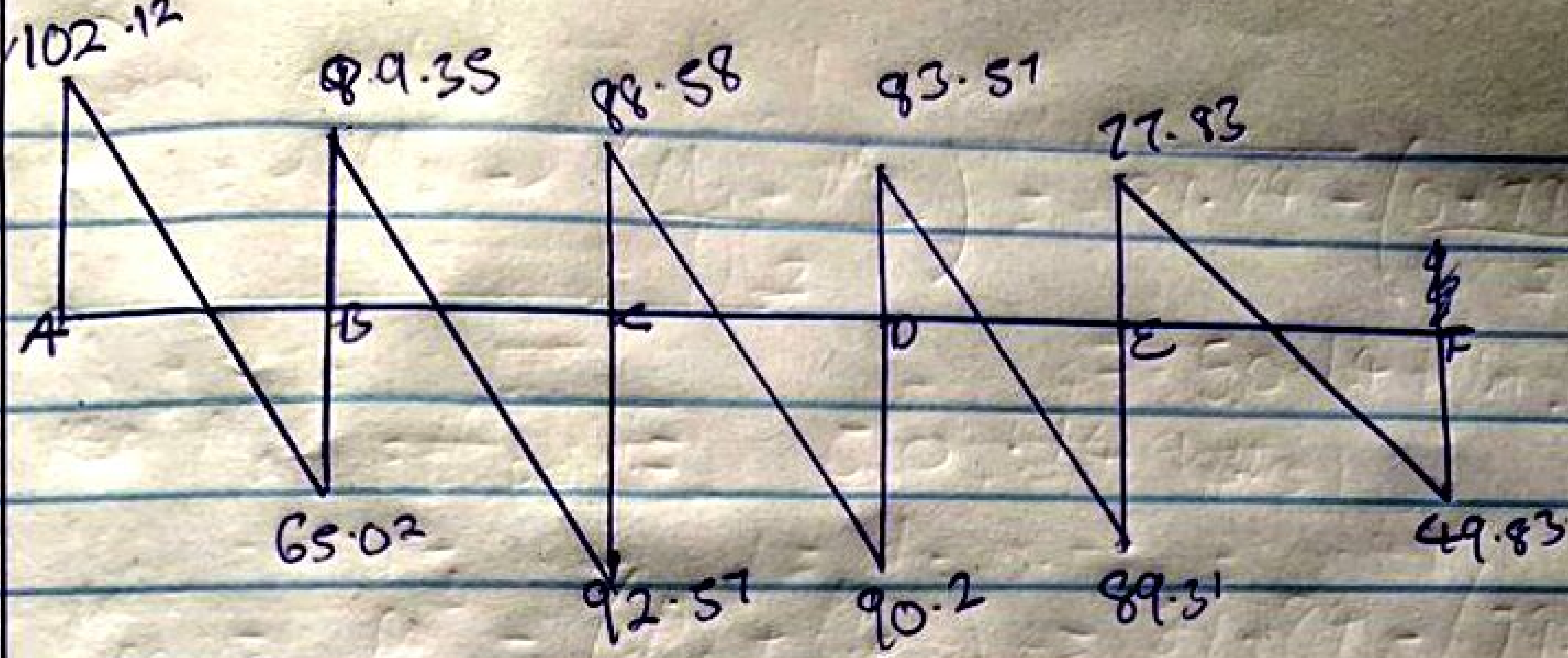


$$V_E = V_F = \frac{wL}{2} = \frac{27.29 \times 1.5}{2} = 20.47\,kN$$

$$V_{EF} = V_E + \frac{(M_E - M_F)}{L} = 20.47 + \frac{44.04}{1.5} = 49.83\,kN$$

$$V_{FE} = wL - V_{EF} = 27.29 \times 1.5 - 49.83 = -8.895\,kN$$

Shear force diagram



b **Base design**

$N = 1200 kN$, $f_b = 150$, $h = 660mm$

Area required $= \frac{N \times 1.1}{\lambda f_b}$ where $\lambda = 1.46$

$\frac{1200 \times 1.1}{1.46 \times 150} = 6.03 m^2$

Length of side for square base $= \sqrt{6.03} = 2.46$

Net pressure, $f_{nd} = \frac{N \times 1.1}{B} - 1.4 \times h \times \lambda_{conc}$

$= \frac{1200 \times 1.1}{2.46} - 1.4 \times 24 \times 0.66$

$= 514.41 kNm$

Moment, $M_1 = \frac{f_{nd} l^2}{2}$

$l = \frac{1}{2}(B - h)$, $h = 660$

$l = \frac{1}{2}(2.46 - 0.66) = 0.9$

$M = \frac{514.41 \times 0.9^2}{2} = 208.34 kNm$

$d = h - cover - \frac{1}{2}\phi$

$= 660 - 50 - \frac{1}{2}(25) = 597.5 mm$

$k = \frac{M}{bd^2 f_{cu}} = \frac{208.34 \times 10^6}{1000 \times 597.5^2 \times 25} = 0.023$

$l_a = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.023}{0.9}}$

$= 0.97 > 0.95$

$Z = l_a d = 0.95 \times 597.5 = 567.6 mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{208.34 \times 10^6}{0.95 \times 410 \times 567.6} = 942.37 mm^2$

Provide Y_{25} @ 300 c/c ($A_s = 1640 mm^2$)

b For punching shear

Column dimension = 225 x 450 mm

Area of footing = $6.03 m^2$, footing size = 2500x2500

Net pressure = 514.41 kN/m

Depth = 597.5 mm

Critical section = $d/2$ = 298.75 mm

298.75 + 298.75 + 225 ≈ 823 mm

298.75 + 298.75 + 450 ≈ 1048 mm

Shear force, $V_u = q_u \times$ [area of footing $- (0.3 + d)^2$]

$= 514.41 [2.5 \times 2.5 - (0.3 + 0.597)^2]$

$V_u = 2800.7 kN$

Nominal shear stress $\tau_v = \frac{V_u}{bd}$

b = perimeter of critical section

d = effective depth

$\tau_v = \frac{2800.7 \times 10^3}{[(2 \times 823) + (2 \times 1048) \times 597.5]}$

$\tau_v = 2.28 N/mm^2$

Permissible shear stress

$\tau_c' = k_s \times \tau_c$

$k_s = (0.5 + \beta_c)$, must be < 1

β_c = Ratio of shorts to longer side of column

$\tau_c = 0.25\sqrt{f_{cu}}$

$k_s = 0.5 + 2 = 2.5 \simeq 1$

$\tau_c' = 0.25\sqrt{25} = 1.25 N/mm^2$

$\tau_v = 2.23 N/mm^2$

$\tau_v > \tau_c'$, hence the depth needs to be increased