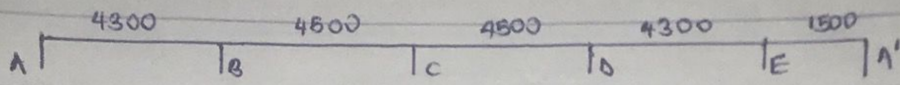
Assignment 2, Question 1

Designing beam AA'



Assuming thickness = 150mm

$f_{cu} = 25 N/mm^2$

$f_y = 410 N/mm^2$

Solution

Slab loading

Slab wt = 0.15 × 24 = 3.6 KN/m²

Partition = 1.0 KN/m²

Finishes = 1.2 KN/m²

Total G.K = 5.8 KN/m²

classroom

D.L = 1.4(5.8) + 1.6(3.0) = (1.4 × 5.8) + (1.6 × 3.0)

= 13 KN/m²

Beam loading

Self wt of beam = 0.225 × 0.6 × 24 = 3.24 KN/m²

finishes = 1.2 KN/m²

Wall load = 3 × 3.47 = 10.41 KN/m²;

Total G.K 14.85

D.L = 1.4(14.85) = 20.79 KN/m²

Slab load on beam in longer direction = $\frac{1}{2} w l_x \left(1 - \frac{1}{3k^2}\right)$

where $k = \frac{l_y}{l_x}$

$\frac{4300}{4000} = 1.075$ $\quad \frac{1}{2} \times 13 \times 4.3 \left(1 - \frac{1}{3 \times (1.075)^2}\right) = 19.89 KN/m^2$

$\frac{4500}{4000} = 1.125$ $\quad \frac{1}{2} \times 13 \times 4.5 \left(1 - \frac{1}{3 \times (1.125)^2}\right) = 21.55 KN/m^2$

Slab load on beam in shorter direction = $\frac{1}{3} w l_x$

$= \frac{1}{3} \times 13 \times 1.5 = 6.5 KN/m^2$

Total load = 19.89 + 20.79 = 40.68 KN/m

21.55 + 20.79 = 42.34 KN/m

6.5 + 20.79 = 27.29 KN/m

Distribution factor

$$K_{BA} = \frac{\frac{1}{L_{BA}}}{\frac{1}{L_{BA}} + \frac{1}{L_{BC}}} = \frac{\frac{1}{4.3}}{\frac{1}{4.2} + \frac{1}{4.5}} = 0.51$$

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

$$K_{CB} = \frac{\frac{1}{L_{CB}}}{\frac{1}{L_{CB}} + \frac{1}{L_{CD}}} = \frac{\frac{1}{4.5}}{\frac{1}{4.5} + \frac{1}{4.5}} = 0.5$$

$K_{CD} = 1 - 0.5 = 0.5$

$K_{DC} = 0.49$

$K_{DE} = 0.51$

$$K_{ED} = \frac{\frac{1}{4.3}}{\frac{1}{4.3} + \frac{1}{1.5}} = 0.26$$

$K_{EA'} = 1 - 0.26 = 0.74$

F.E.M

for U.D.L = $\frac{wL^2}{12}$

i) $\frac{40.68 \times 4.3^2}{12} = 62.68$

ii) $\frac{42.34 \times 4.5^2}{12} =$ ~~87.97~~ 71.45

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

	A	AB	BA	BC	CB	CD	DC	DE	ED	EA'	A'E	A'
D.F	0	1	0.51	0.49	0.5	0.5	0.49	0.51	0.26	0.74	1	0
FEM		-62.68	62.68	-71.45	71.45	-71.45	71.45	-62.68	62.68	-5.1	5.1	
OBM	-62.68		-8.77		0		8.77		57.58		5.1	
BM	62.68		8.77		0		-8.77		-57.58		-5.1	
DM	0	62.68	4.47	4.30	0	0	-4.30	-4.47	-14.97	-42.61	-5.1	0
TM		2.235	31.34	0	2.15	-2.15	0	-7.49	-2.24	-2.55	-21.305	
OBM	2.235		31.34		0		-7.49		-4.79		-21.305	
BM	-2.235		-31.34		0		7.49		4.79		21.305	
DM	0	-2.235	-15.98	-15.36	0	0	3.67	3.82	1.25	3.54	21.31	0
TM		-7.99	-1.12	0	-7.69	1.84	0	0.63	1.91	10.66	1.77	
OBM	-7.99		-1.12		-5.85		0.63		12.57		1.77	
BM	7.99		1.12		5.85		-0.63		-12.57		-1.77	
DM	0	7.99	0.57	0.55	2.93	2.93	-0.31	-0.32	-3.27	-9.29	-1.77	0
TM		0.29	3.40	1.47	0.28	-0.16	1.47	-1.64	-0.16	-0.89	-4.65	
OBM	0.29		4.87		0.12		-0.17		-1.05		-4.65	
BM	-0.29		-4.87		-0.12		0.17		1.05		4.65	
DM	0	-0.29	-2.48	-2.39	-0.06	-0.06	0.08	0.09	0.27	0.78	4.65	0
	Σ	0	82.88	-82.88	69.06	-69.05	72.06	-72.06	45.47	-45.46	0	

Moments:

$M_A = 0$ KNm $M_B = 82.88$ KNm $M_C = 69.06$ KNm $M_D = 72.06$ KNm $M_E = 45.47$ KNm $M_{A'} = 0$ KNm

Freemoment,

for UDL $= \frac{wL^2}{8}$

i) $\frac{40.68 \times 4.3^2}{8} = 94.02 \, KN/m^2$

ii) $\frac{42.34 \times 4.5^2}{8} = 107.17 \, KN/m^2$

iii) $\frac{27.29 \times 1.5^2}{8} = 8.24 \, KN/m^2$

Span Moment;

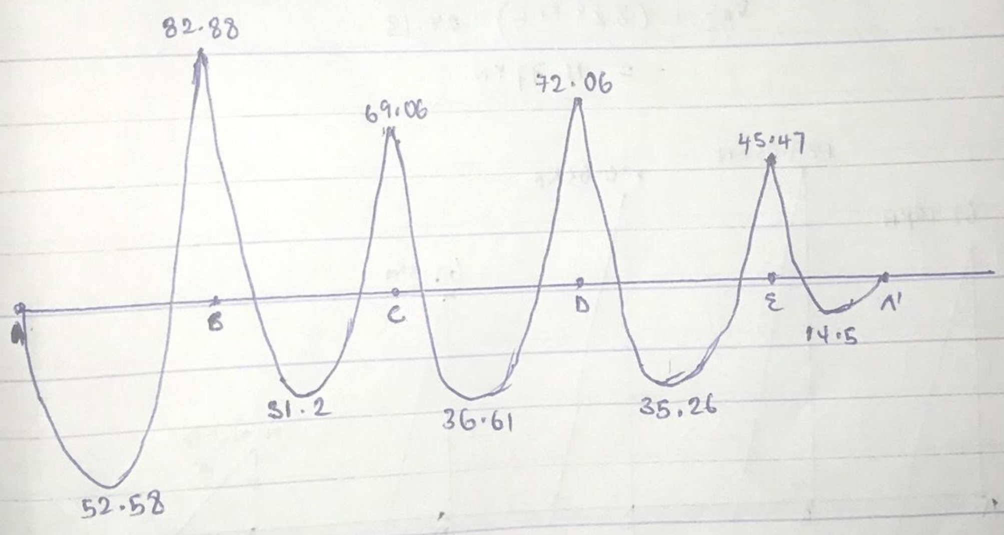
$M_{AB} = M^f - \left(\frac{M_A + M_B}{2}\right) = 94.02 - \left(\frac{0 + 82.88}{2}\right) = 52.58\ KNm$

$M_{BC} = M^f - \left(\frac{M_B + M_C}{2}\right) = 107.17 - \left(\frac{82.88 + 69.06}{2}\right) = 31.2\ KNm$

$M_{CD} = M^f - \left(\frac{M_C + M_D}{2}\right) = 107.17 - \left(\frac{69.06 + 72.06}{2}\right) = 36.61\ KNm$

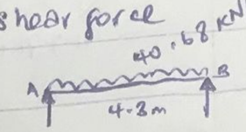
$M_{DE} = M^f - \left(\frac{M_D + M_E}{2}\right) = 94.02 - \left(\frac{72.06 + 45.47}{2}\right) = 35.26\ KNm$

$M_{EA'} = M^f - \left(\frac{M_E + M_{A'}}{2}\right) = 8.24 - \left(\frac{45.47 + 0}{2}\right) = -14.5\ KNm$



shear force

A;



$V_A = \frac{wL}{2} = V_B$

$= \frac{40.68 \times 4.3}{2} = 87.462\ KN$

$V_{AB} = V_a + \frac{(M_a - M_B)}{L}$

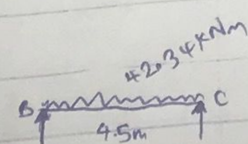
$= 87.462 + \left(\frac{0 - 82.88}{4.3}\right) = 68.19$

$V_{BA} = WL - V_{AB}$

$= (40.68 \times 4.3) - 68.19$

$= 106.73\ KN$

B,



$V_B' = \frac{wL}{2} = V_C$

$= \frac{42.34 \times 4.5}{2} = 95.27\ KN$

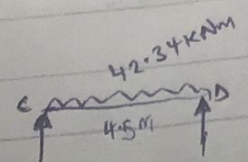
$V_{BC} = V_B + \frac{(M_B + M_C)}{L}$

$= 95.27 + \left(\frac{82.88 + 69.06}{4.5}\right) = 129.03$

$V_{CB} = (42.34 \times 4.5) - 129.03$

$= 61.5$

C;



$V_C' = \frac{wL}{2} = V_D$

$= \frac{42.34 \times 4.5}{2} = 95.27\ KN$

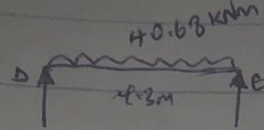
$V_{CD} = 95.27 + \left(\frac{69.06 + 72.06}{4.5}\right)$

$= 126.63$

$V_{DC} = (42.34 \times 4.5) - 126.63$

$= 63.9\ KN$

D;



$V_D' = \frac{wl}{2} = V_E$

$= \frac{40.68 \times 4.3}{2} = 87.46\ \text{kN}$

$V_{DE} = V_D - \left(\frac{M_D + M_E}{L}\right)$

$= 87.46 - \left(\frac{72.06 + 45.47}{4.3}\right)$

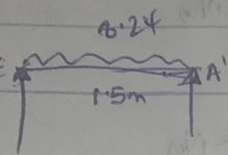
$= 60.13\ \text{kN}$

$V_{ED} = wL - V_{DE}$

$= (40.68 \times 4.3) - 60.13$

$= 114.79\ \text{kN}$

E;



$V_E' = \frac{wl}{2} = V_A'$

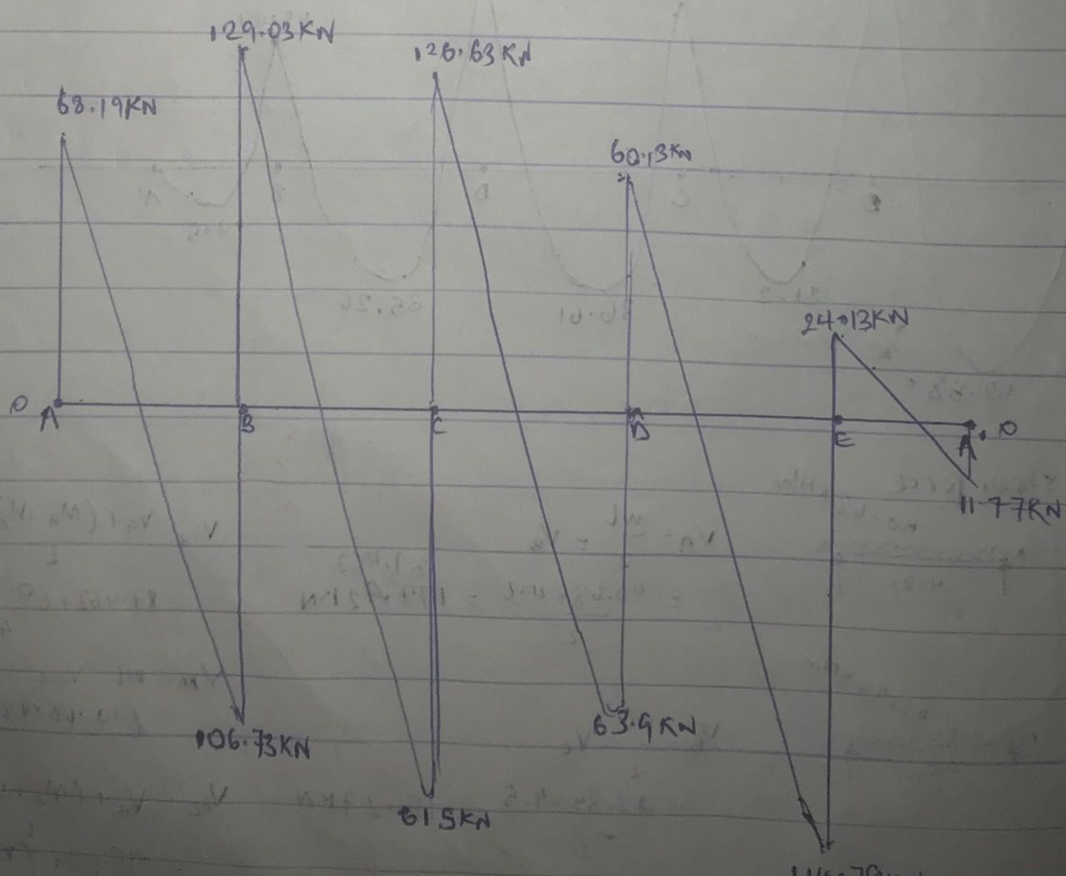
$= \frac{8.24 \times 1.5}{2} = 6.18\ \text{kN}$

$V_{EA'} = V_E - \left(\frac{M_E + M_{A'}}{L}\right) = 6.18 - \left(\frac{45.47}{1.5}\right)$

$= 24.13\ \text{kN}$

$V_{A'E} = (8.24 \times 1.5) - 24.13$

$= 11.77\ \text{kN}$



BASE DESIGN

N = 1200 KN

Strength = 25-410 N/mm²

F_b = 150 KN/m²

Area of base req = $\frac{N \times 1.1}{\lambda \times F_b}$ λ = 1.46

$\frac{1200 \times 1.1}{1.46 \times 150}$ = 6.027 m²

$\sqrt{6.027}$ = 2.45m ≈ 2.5m

Net pressure, F_{net} = $\frac{N \times 1.1}{B}$

$\frac{1200 \times 1.1}{2.5}$ − 24 × 0.660 × 1.4

= ~~520.44 KNm~~ = 505.824 KNm

Moment, M = $\frac{F_{net} L^2}{2}$ where L = ½ (B − h)   & h = depth of base = 660

L = ½ (2.5 − 0.225) = 1.138 ≈ 1.14m

M = $\frac{505.824 \times 1.14^2}{2}$ = ~~338.22 KNm~~ 328.68 KNm

d = h − cover − ½φ

= 660 − 50 − 10 = ~~165 mm~~ 600mm

K = $\frac{M}{bd^2 f_{cu}}$ = $\frac{328.68 \times 10^6}{1000 \times 600^2 \times 25}$ = ~~0.5~~ 0.037

I_a = 0.5 + $\sqrt{0.25 - \frac{0.037}{0.9}}$ = ~~0.78~~ 0.96 > 0.95

Z = $I_a d$ = 0.95 × 600 = 570 mM

A_s = $\frac{M}{0.95 f_y Z}$ = $\frac{328.68 \times 10^6}{0.95 \times 410 \times 570}$ = 1480.44 mm²

Provide Y25 @ 300 c/c (1640)

Punching Shear

Column size = (225 × 450) mm

25 - 410 N/mm²

Area footing = 6.027 m²

Size of footing = 2500 × 2500

q_u, Net Pressure = 505.824 KNm

depth = 600 mm

Critical section; $d/2$ = 300 mm

300 + 300 + 225 = 825 mm

300 + 300 + 450 = 1050 mm

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

= 505.824 [~~6.027~~ 2.5 × 2.5 - (0.3 + 0.6)^2]

V_u = 2751.68 KN

Nominal Shear Stress $\tau_v = V_u / bd$

b = perimeter of critical section

d = effective depth

$$\tau_v = \frac{2751.68 \times 10^3}{(2 \times (825) + 2(1050)) \times 600)}$$

τ_v = 1.223 N/mm²

Permissible Shear Stress

$\tau_c' = k_s \times \tau_c$

$k_s = (0.5 + \beta_c)$ but not greater than 1

β_c = Ratio of shorter to longer side of column

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

$k_s = 1$

$\tau_c' = 0.25\sqrt{25}$ = 1.25 N/mm²

τ_v = 1.223 N/mm²

$\tau_v \leq \tau_c'$, Hence the assumed depth is ok.

Check for ~~[illegible]~~ wt Fb with actual size of footing

Unit weight of concrete = $24 KN/mm^3$

Unit weight of soil = $1.091 \times 10^{-6} KN/mm^3$

The actual Pressure below footing

$q = (1200/2.5 \times 2.45) + (24 \times 0.660) + ([illegible] \times 0.660)$

~~$q = 2214.78$~~

$q = 214.94 KN/m^2 > 150 KN/m^2$ (SBC of soil given)

size of footing Not O.K.