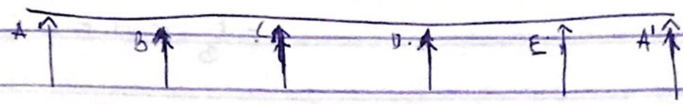
Oriha Robert Agbonrighale
17/ENG03/046
Civil Engineering

1)



Assuming thickness = 150mm
f_{cu} = 25N/mm²
f_y = 410N/mm²

Slab loading
Slab weight = 0.15×24 = 3.6kN/m²
Partition = 1.0kN/m²
Finishes = 1.2kN/m²
Total (G.K) = 5.8kN/m²
DL = 1.4(5.8) + 1.6(3.0) = 13kN/m²

Beam loading
Self wt of beam = 0.225×0.6×24 = 5.24kN/m²
finishes = 1.2kN/m²
Wall load = 3×3.47 = 10.41kN/m²
Total (G.k) = 14.45
DL = 1.4(14.45) = 20.79kN/m²

Slab loads on beam in longer direction = $\frac{1}{2}wl_x(1-\frac{1}{3k^2})$

$k = \frac{l_y}{l_x} = \frac{4300}{4000} = 1.075$

$\frac{4500}{400} = 1.125$

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

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

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

$k_{AB} = 1$

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

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

$k_{CB} = \frac{\frac{1}{4.5}}{1/4.5 + 1/4.5} = 0.5$

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

$k_{DC} = 0.49$

$k_{DE} = 0.51$

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

$k_{EF} = 1 - 0.26 = 0.74$

$k_{FE} = 1$

FEM

$M_{DL} = \frac{wL^2}{12}$

1) $\frac{40.64 \times 4.3^2}{12} = 62.68\ kN/m$

2) $\frac{42.34 \times 4.5^2}{12} = 71.45\ kN/m$

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

①	A	AB	BA	BC	CB	CD	DE	EF	FD	FA'	A'E	
	A		B		C		D		E		A'	
DF	0	1	0.51	0.44	0.5	0.5	0.49	0.51	0.26	0.74		
FEM		-62.68	62.68	-71.45	71.45	-71.55	71.45	-62.68	62.68	-5.1	5.1	
OBM		-62.64		-4.77		0		4.77		52.58		-5.1
BM		62.86		4.77		0		-4.77		-52.58		5.1
DM	0	62.68	4.47	4.30	0	0	-4.30	-4.47	-1.49	42.61	-5.1	0
TM		2.235	31.34	0	2.15	2.15	0	-7.49	-2.24	-2.55	-21.305	
②												
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	213	0
TM		-7.99	-1.12	0	-7.69	1.44	0	0.60	1.91	10.66	1.77	
③												
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	
TM		0.29	3.40	1.47	0.28	-0.16	1.47	1.64	-0.16	-0.89	-4.65	
④												
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	0.04	0.07	0.27	0.78	4.65	0
ΣM		0	22.88	-82.88 ~~-69.05~~	69.06 ~~72.21~~	-69.05 ~~72.06~~	72.06 ~~45.45~~	-72.06 ~~45.46~~	45.46	-45.46	0	

Moments

M_A = ~~0kNm~~ 0kNm

M_B = 82.88 kNm

M_C = 69.06 kNm

M_D = 72.06 kNm

M_E = 45.47 kNm

M_F = 0kNm

Fixed moment

For UDL, $= \frac{wl^2}{8}$

① $\frac{40.68 \times 4.3^2}{8} = 94.02 kN/m^2$

② $\frac{42.34 \times 4.5^2}{8} = 107.17 kN/m^2$

③ $\frac{27.29 \times 1.5^2}{8} = 8.24 kN/m^2$

Open moment:

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

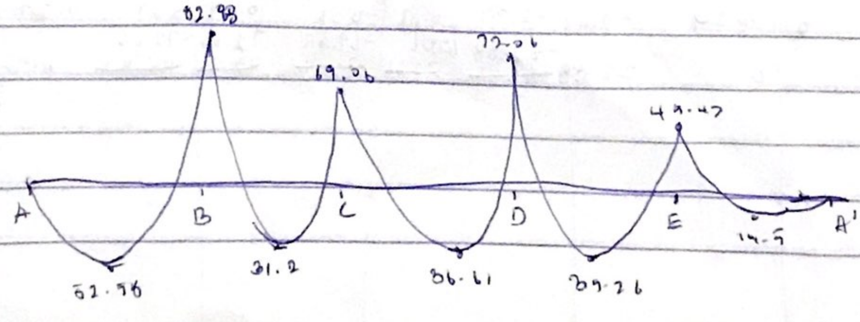
$M_{BC} = M^F - \left(\frac{M_B + M_C}{2}\right) = 107.17 - \left(\frac{82.88 + 69.06}{2}\right) = 31.2 kNm$

$M_{CD} = M^F - \left(\frac{M_C + M_D}{2}\right) = 107.17 - \left(\frac{69.06 + 72.01}{2}\right) = 36.6 kNm$

$M_{DE} = 94.02 - \left(\frac{72.06 + 45.47}{2}\right) = 35.26 kNm$

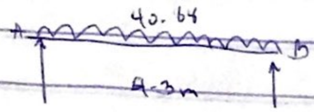
$M_{EA'} = 8.24 - \left(\frac{45.47 + 0}{2}\right) = -14.5 kNm$

BMD



Shear Force

A;



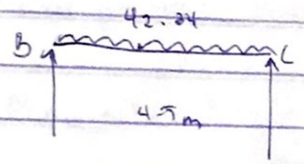
$V_A = \frac{wL}{2} = \frac{40.64 \times 4.3}{2} = 87.462$ kN/m

$V_{AB} = V_A + \left(\frac{M_A - M_B}{L}\right) = 87.462 + \left(\frac{0 - 82.38}{4.3}\right) = 68.19$

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

$= (40.64 \times 4.3) - 68.19 = 106.73$ kN

B;



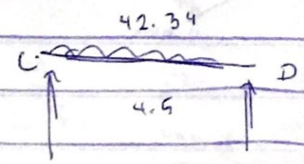
$V_C = \frac{42.34 \times 4.5}{2} = 95.27$ kN/m

$V_{BC} = 95.27 + \left(\frac{82.38 + 69.06}{4.5}\right) = 127.03$ kN

$V_{CB} = (42.34 \times 4.5) - 127.03$

$= 61.5$ kN

C;



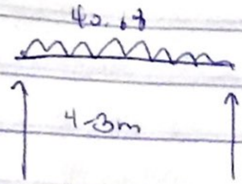
$V_C = V_B = 95.27$ kN/m

$V_{CD} = 95.27 + \left(\frac{69.06 + 72.06}{4.5}\right) = 126.63$ kN

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

$= 63.19$ kN

D.

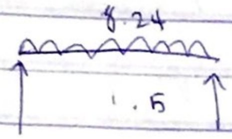


$V_D = \frac{40.67 \times 4.3}{2} = 87.46kN$

$V_{DE} = 87.46 - \left(\frac{72.06 + 45.47}{4.3}\right) = 60.13kN$

$V_{ED} = (40.6 \times 4.3) - 60.13 = 114.79kN$

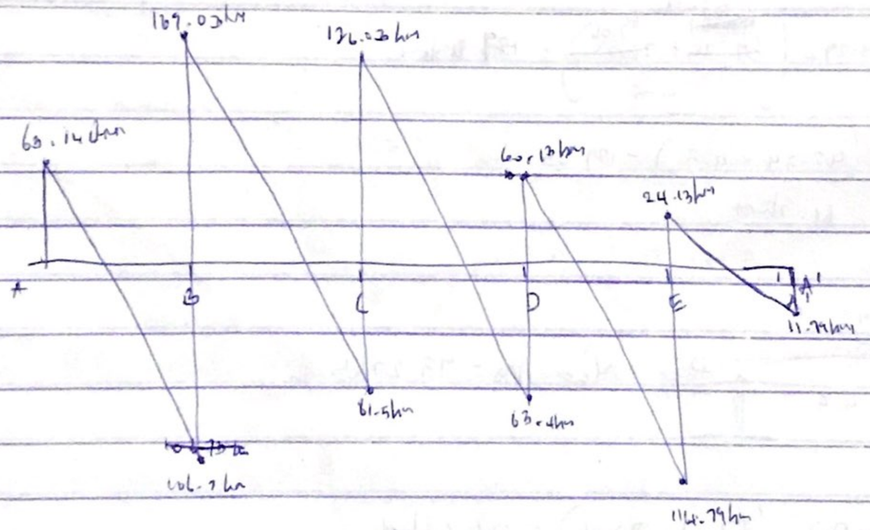
E.



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

$V_{EA'} = 6.18 - \left(\frac{45.47 + 0}{1.5}\right) = 24.13kN$

$V_{A'E} = (8.24 \times 1.5) - 24.13 = 11.77kN$



Base Design

$N = 1200kN$

Strength = 25 - 410N/mm²

$f_b = 150kN/m^2$

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

$= \frac{1200 \times 1.1}{1.46 \times 150} = 6.027m^2$

$B = \sqrt{6.027} = 2.45m \approx 2.5$

Net pressure, $F_{net} = \frac{N \times 1.1}{B} = \frac{1200 \times 1.1}{2.5} = 505.824 kN/m$

Moment, $m = \frac{F_{net} l^2}{2}$; $l = \frac{1}{2}(B - h)$; depth of base = 660 = h

$l = \frac{1}{2}(2.5 - 0.225) = 1.638 \approx 1.14m$

$m = \frac{505.824 \times 1.14^2}{2} = 328.68kNm$

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

$d = 660 - 50 - 10 = 600mm$

$k = \frac{M}{bd^2 f_{cu}} = \frac{324.68 \times 10^6}{1000 \times 600^2 \times 25} = 0.037$

$l_a = 0.5 + \sqrt{0.25 + \frac{0.037}{0.9}} = 0.96$; $0.96 > 0.95$

$z = l_a d = 0.95 \times 600 = 570mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{328.68 \times 10^6}{0.95 \times 410 \times 570} = 1480.44mm^2$

Provide T20 @ 300 c/c (1640)

÷

Punching shear

Column size = 225 x 450 mm

f_{ck} - f_y = 25 - 410

Area footing = 6.02 m^2

Size of footing = 2500 x 2500

q_u = Net pressure = 305.424 kN/m

depth = 600

critical section = $\frac{d}{2}$ = 300

300 + 300 + 225 = 825 mm

300 + 300 + 450 = 1050 mm

Shear force, V_u = q_u x (Area of footing - $(0.3 + 1)^2$)

= 305.424 x (2.5 x 2.5 - $(0.3 + 0.6)^2$)

= 2791.68

Normal shear stress, $\tau_v = V_u / bd$

b = perimeter of critical section

d = effective span / depth

$\tau_v = \frac{2751.61 \times 10^3}{(2 \times (825) + 2(1050)) \times 600}$

= 1.223 N/mm²

Permissable shear stress

$\tau_c' = k_s \times \tau_c$

$k_s = (0.5 + \beta_c) \leq 1$

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

$\tau_v < \tau_c'$

∴ Assumed depth is ok

Checking for f_b with actual size of footing

Unit weight of concrete = 24 kN/mm²

Unit weight of soil = 1.091×10^{-6} kN/mm

Actual pressure footing below

$$q = (1200/2.5 \times 2.5) + (24 \times 0.660) + (16.91 \times 10^{-6} \times 0.60)$$

$$= 214.94 \text{ kN/m}^2$$