ADEPOJU MARY ABIMBOLA

17/ENG03/004

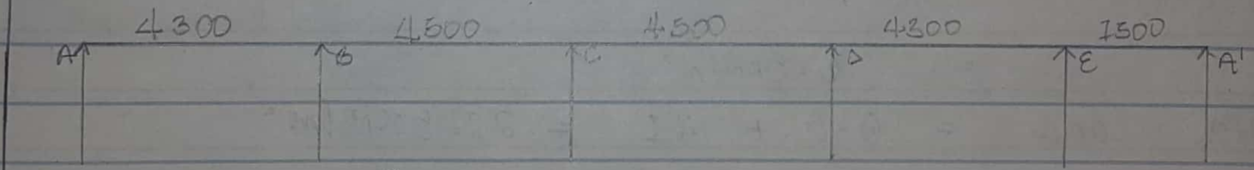
CIVIL ENGINEERING

CVE 308

STRUCTURAL DESIGN

ASSIGNMENT TWO

QUESTION ONE



Assume that: Thickness = 150mm = 0.15m

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

Assume that Q_k = 3.0

D.L = $1.4G_k + 1.6Q_k$

= 1.4(5.8) + 1.6(3.0)

= 12.92kN/m² ≃ 13kN/m²

Beam Loading

Self Weight of Beam = $0.225 \times 0.6 \times 24 = 3.24 kN/m^2$

Screeding / Finishes = $1.2 kN/m^2$

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

Total G.K = $14.85 kN/m^2$

D.L = 1.4 GK

= 1.4 (14.85)

= $20.79 kN/m^2 \simeq 21 kN/m^2$

Slab loading on beam along shorter span

= $\frac{1}{3} w l x$

= $\frac{1}{3} \times 13 \times 1.5$

= $6.5 kN/m^2$

Total Load = 6.5 + 21 = $27.5 kN/m^2$

Slab Loading on beam along longer span

= $\frac{1}{2} w l x \left(1 - \frac{1}{3k^2}\right)$

$k = \frac{ly}{lx}$

$k_1 = \frac{4300}{4000}$

= 1.075

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

= $19.89 kN/m^2$

Total Load = 19.89 + 21 = $40.89 kN/m^2$

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$k_2 = \frac{4500}{4000}$

$= 1.125$

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

$= 21.53\ kN/m^2$

Total Load $= 21.53 + 21 = 42.53\ kN/m^2$

Distribution Factor

$k_{AB} = 1$

$k_{BA} = \frac{1/L_{BA}}{1/L_{BA} + 1/L_{BC}} = \frac{1/4.3}{1/4.3 + 1/4.6}$

$= 0.51$

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

$k_{BC} = \frac{1/4.5}{1/4.5 + 1/4.3} = 0.49$

$k_{CB} = \frac{1/L_{CB}}{1/L_{CB} + 1/L_{CD}} = \frac{1/4.5}{1/4.5 + 1/4.6}$

$= 0.5$

$k_{CD} = \frac{1/L_{CD}}{1/L_{CD} + 1/L_{CB}} = \frac{1/4.5}{1/4.6 + 1/4.5}$

$= 0.5$

$k_{DC} = \frac{1/L_{DC}}{1/L_{DC} + 1/L_{DE}} = \frac{1/4.5}{1/4.5 + 1/4.3}$

$= 0.49$

$k_{DE} = \frac{1/L_{DE}}{1/L_{DE} + 1/L_{DC}} = \frac{1/4.3}{1/4.3 + 1/4.5}$

$= 0.51$

$$K_{EA} = \frac{1/L_{EA}}{1/L_{EA} + 1/L_{EA'}} = \frac{1/4.3}{1/4.3 + 1/1.5}$$

$$= 0.26$$

$$K_{EA'} = \frac{1/L_{EA'}}{1/L_{EA} + 1/L_{EA'}} = \frac{1/1.5}{1/4.3 + 1/1.6}$$

$$= 0.74$$

$$K_{A'E} = 1$$

$$(FEM)_{AB} = -\frac{wl^2}{12} = -\frac{(40.89 \times (4.3)^2)}{12}$$

$$= -63 kN/m$$

$$(FEM)_{BA} = \frac{wl^2}{12} = \frac{40.89 \times (4.3)^2}{12}$$

$$= 63 kN/m$$

$$(FEM)_{BC} = -\frac{wl^2}{12} = \frac{-42.53 \times (4.5)^2}{12}$$

$$= -71.8 kN/m$$

$$(FEM)_{CB} = \frac{wl^2}{12} = 71.8 kN/m$$

$$(FEM)_{CA} = -\frac{wl^2}{12} = -71.8 kN/m$$

$$(FEM)_{AC} = \frac{wl^2}{12} = 71.8 kN/m$$

$$(FEM)_{DE} = -\frac{wl^2}{12} = -63 kN/m$$

$$(FEM)_{AE} = \frac{wl^2}{12} = 63 kN/m$$

$(FEM)_{EA'} = \frac{-wl^2}{12} = \frac{-27.5 \times (1.5)^2}{12}$

$= -5.2 \, kN/m$

$(FEM)_{A'E} = \frac{wl^2}{12} = 5.2 \, kN/m$

Joint		A	B		C		D		E		A'	
Member		AB	BA	BC	CB	CD	DC	DE	ED	EA'	A'E	
DF	0	1	0.51	0.49	0.5	0.5	0.49	0.51	0.26	0.74	1	0
FEM		-63	63	-71.8	71.8	-71.8	71.8	-63	63	-5.2	5.2	
OBM			-8.8		0		8.8		57.8			
BM			8.8		0		-8.8		-57.8			
DM			4.48	4.3	0	0	-4.3	-4.48	-15	-42.7		
TM		2.24	0	0	2.15	-2.15	0	-7.5	-2.24	0	-21.35	
OBM			0		0		-7.5		-2.24			
BM			0		0		7.5		2.24			
DM			0	0	0	0	3.67	3.82	0.58	1.65		
TM		0	0	0	0	1.84	0	0.29	1.91	0	0.83	
OBM			0		1.84		0.29		1.19			
BM			0		-1.84		-0.29		-1.19			
DM			0	0	-0.92	-0.92	-0.14	-0.15	-0.31	-0.88		
TM		0	0	-0.46	0	-0.7	-0.46	0.15	-0.75	0	-0.44	
OBM			-0.46		-0.7		-0.61		-0.75			
BM			0.46		0.7		0.61		0.75			
DM			0.25	0.23	0.35	0.35	0.29	0.31	0.19	0.55		
TM		0.125		~~0.175~~	~~0.115~~	~~0.145~~	0.175	0.095	~~0.155~~		0.	
Σ		0	22.88	-82.88	69.05	-69.05	72.06	-72.06	45.41	-45.46	0	

Moments

$M_A = 0KNm$

$M_B - 82.88KNm$

$M_C = 69.06KNm$

$M_D = 72.06KNm$

$M_E = 45.47KNm$

$M_{A'} = 0KNm$

Free Moment $= \frac{wl^2}{8}$

1) $= \frac{40.89 \times (4.3)^2}{8}$

$= 94.51KN/m^2$

2) $\frac{42.53 \times (4.5)^2}{8}$

$= 107.65KN/m^2$

3) $\frac{27.5 \times (1.5)^2}{8}$

$= 7.73KN/m^2$

Span Moment

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

$= 52.58KNm$

$M_{BC} = M^F - \left(\frac{M_B + M_C}{2}\right) = 107.65\left(\frac{82.88 + 69.06}{2}\right)$

$= 31.2KNm$

$M_{CD} = M^F - \left(\frac{M_C + M_D}{2}\right) = 107.65 - \left(\frac{69.06 + 72.06}{2}\right)$

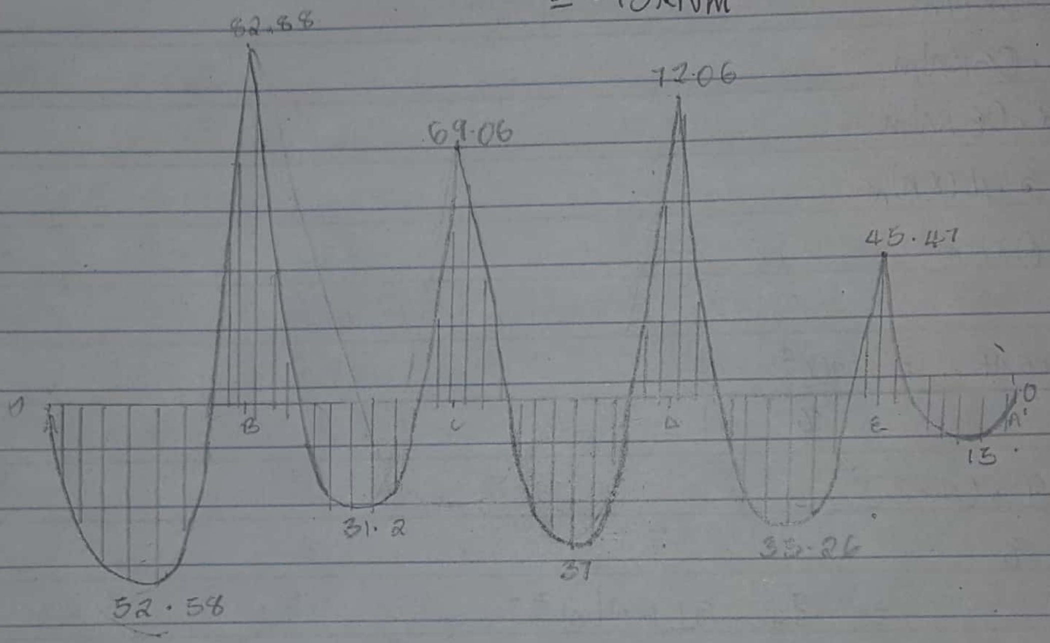
$= 37KNm$

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

$= 35.26KNm$

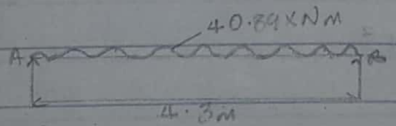
$M_{EA'} = M^F - \left(\frac{M_E + M_{A'}}{2}\right) = 7.73 - \left(\frac{45.47 + 0}{2}\right)$

$= -15 KNm$



Shear Force

For A

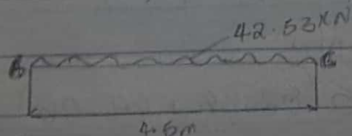


$V_A = {wL}/{2} = \frac{40.89 \times 4.3}{2} = 88KN = V_B$

$V_{AB} = V_a + \left(\frac{M_A - M_B}{L}\right) = 88 + \left(\frac{0 - 82.88}{4.3}\right) = 68.2$

$V_{BA} = wL - V_{AB} = (40.89 \times 4.3) - 68.2 = 107KN$

For B

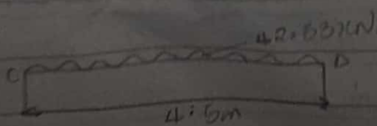


$V_B = {wL}/{2} = \frac{42.53 \times 4.5}{2} = 95.7KN = V_C$

$V_{BC} = V_B + \left(\frac{M_B + M_C}{L}\right) = 95.7 + \left(\frac{82.88 + 69.06}{4.5}\right) = 129.5KN$

$V_{CB} = wL - V_{BC} = (42.53 \times 4.5) - 129.5 = 61.8KN$

For C



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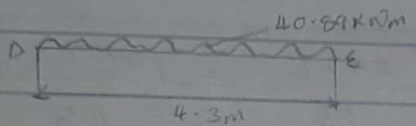
$$V_C = \frac{wl}{2} = \frac{42.53(4.5)}{2} = 95.7\,kN$$

$$V_{CD} = V_C + \left(\frac{M_C + M_D}{L}\right) = 95.7 + \left(\frac{69.06 + 72.06}{4.5}\right) = 127\,kN$$

$$V_{DC} = wL - V_{CD} = (42.53 \times 4.5) - 127 = 64.4\,kN$$

For D

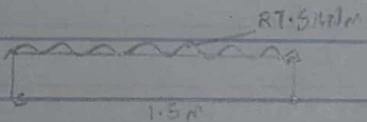


$$V_D = wl/2 = \frac{40.89 \times 4.3}{2} = 88\,kN$$

$$V_{DE} = V_D - \left(\frac{M_D + M_E}{L}\right) = 88 - \left(\frac{72.06 + 45.47}{4.3}\right) = 60.7\,kN$$

$$V_{ED} = wL - V_{DE} = (40.89 \times 4.3) - 60.7 = 115.73\,kN$$

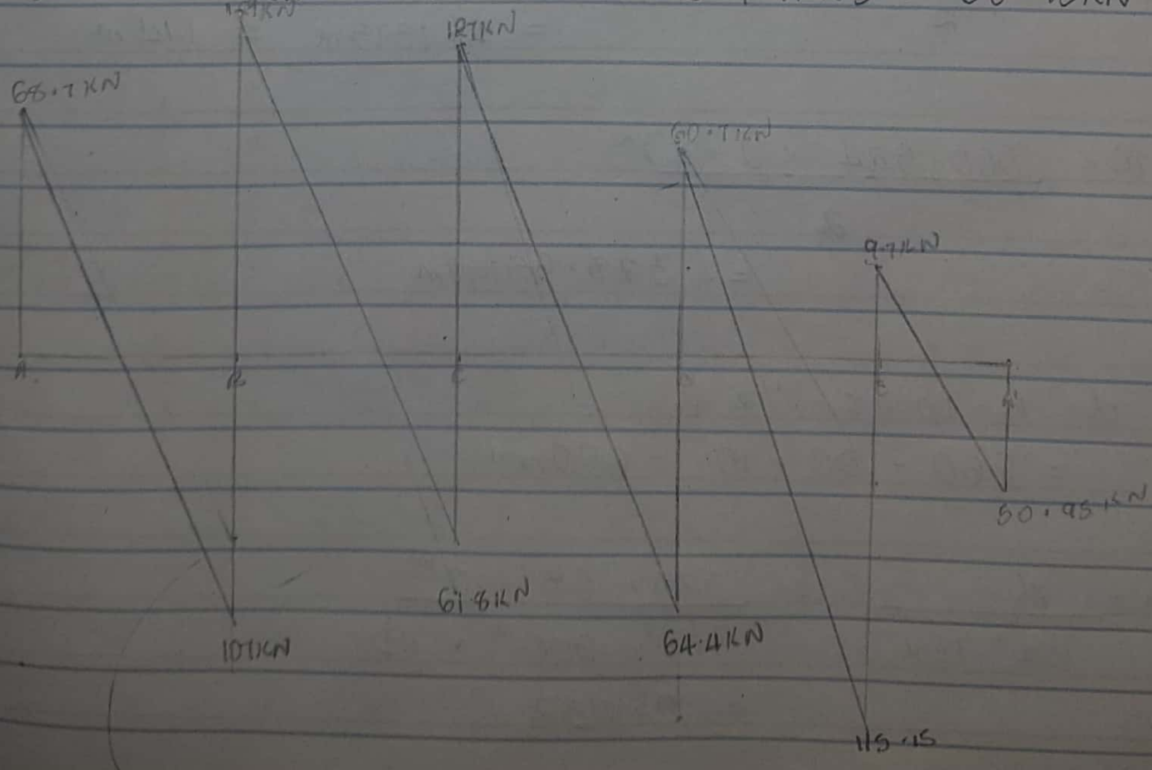
For E



$$V_E = wl/2 = \frac{27.5 \times 1.5}{2} = 20.63\,kN$$

$$V_{EA'} = V_E - \left(\frac{M_E + M_{A'}}{L}\right) = 20.63 - \left(\frac{45.47 + 0}{1.5}\right) = -9.7\,kN$$

$$V_{A'E} = wL - V_{EA'} = (27.5 \times 1.5) - (-9.7\,kN) = 50.95\,kN$$



QUESTION TWO

Base Design

N = 1,200KN

Strength = 25 - 410 N/mm^2

SBC = 150KN/m^2

n = 1.46

Area of Base Required = $\frac{N \times 1.1}{n \times SBC}$ = $\frac{1200 \times 1.1}{1.46 \times 150}$

= 6.027m^2

$\sqrt{6.027}$ = 2.45m ≃ 2.5m

Net Pressure, Fnet = $\frac{N \times 1.1}{B}$ - $\frac{1200 \times 1.1}{2.5}$

= 528 - (24 × 0.660 × 1.4)

= 505.824KNm

Moment, M = $\frac{Fnet \times L^2}{2}$

Where L = ½(B-h)

L = $\frac{1}{2}$(2.5 - 0.225)

= 1.1375m ≃ 1.14m

M = $\frac{505.824 \times (1.14)^2}{2}$

= 328.68KNm

d = h - cover - ½ ϕ

= 660 - 50 - 10 = 600mm

K = $\frac{M}{bd^2 fcu}$ = $\frac{328.68 \times 10^6}{1000 \times 600^2 \times 25}$

= 0.032

$I_a = 0.5 + \sqrt{0.25 + \frac{0.032}{0.9}}$

$= 0.96 \ (\geq 0.95)$

$z = I_a d = 0.95 \times 600$

$= 570 mm$

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

$= 1480.44 mm^2$

Provide Y25 @ 300 c/c $(A = 7640 mm^2)$

Punching Shear

Column size = 225 x 450 mm

f_{cu} / f_y = 25 - 410 mm

Area footing = $6.027 m^2$

Size of footing = 2500 x 2500

q_s, Net Pressure = 505.824 x N/m

Depth = 600

Critical section $= \frac{d}{2} = \frac{600}{2}$

= 300

300 + 300 + 225 = 825 mm

300 + 300 + 450 = 1050 mm

Shear force $V_a = q_s \times (\text{Area Footing} - (0.3 + d)^2)$

$= 505.824 \times (2.5 \times 2.5 - (0.3 + 0.6)^2)$

$V_a = 2751.68 kN$

Normal Shear Stress $\tau_v = \frac{V_a}{bd} = \frac{2751.68}{((2 \times (825 + 2(1050)) \times 600)}$

$\tau_v = 1.223 N/mm^2$

Permissible Shear Stress

$T_c' = ks \times T_c$

$ks = (0.5 + \beta_c)$

β_c = Ratio to larger column sides

$T_c' = 0.25\sqrt{f_{ck}}$

$ks = 1$

$T_c' = 0.25\sqrt{25}$

$= 1.25 N/mm^2$

$T_v \leq T_v'$

∴ Depth assumed is Okay

Check for FB with actual footing size

Unit weight of concrete $= 24 kN/mm^2$

" " " soil $= 1.091 \times 10^{-6} kN/mm^2$

Actual footing $q = (1200 \times 2.5 \times 2.5) + (2.4 \times 0.660) +$

$(1.091 \times 10^{6} \times 0.6)$

$= 214.94 kN/m^2$