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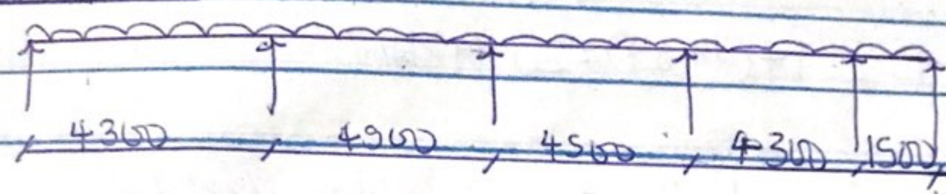
17/ENG03/024
Civil Engineering
CVE 308 (Structural Design) assignment 2.

Question 1



Assumptions
Thickness: 150mm
Designing for a Classroom
f_{cu}: $25 N/mm^2$
f_y : $410 N/mm^2$

Slab Loading
Slab weight = $0.15 \times 24 = 3.6 kN/m^2$
Partition = $1.0 kN/m^2$
finishes = $1.2 kN/m^2$
$\Sigma G_k = 5.8 kN/m^2$

$D.L = 1.4(5.8) + 1.6(3.0)$
$= 12.92 \simeq 13 kN$

Beam load

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

finishes $= 1.2 kN/m^2$

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

$\Sigma G_k = 14.85 kN/m^2$

$\therefore D.L = 1.4(14.85) = 20.79 kN/m^2$

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

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

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

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

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

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

Total load $= 19.89 + 20.79 = 40.68 kN/m$

$= 21.55 + 20.79 = 42.34 kN/m$

$21.55 + 20.79 = 42.34 kN/m$

$19.89 + 20.79 = 40.68 kN/m$

$6.5 + 20.79 = 27.29 kN/m$

Distribution factor (D.F)

$K_{AB} = 1$

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

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

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

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

$K_{DC} = 0.49$

$K_{DE} = 0.51$

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

$K_{EA'} = 1 - 0.26 = 0.79$

$K_{A'E} = 1$

Fixed End Moment (F.EM)

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

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

	A		B		C		D		E		A'	
		AB	BA	BC	CB	CD	DC	DE	ED	EA'	A'B	
D.F	0	1	0.51	0.49	0.5	0.5	0.44	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
		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	2.43	2.43	-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	0.06	0.09	0.27	0.78	4.65	0
Σ =		0	22.88	-82.88	69.06	-69.05	72.06	-72.06	45.47	-45.46	0	

$M_A = 0 kNm$

$M_B = 82.88 kNm$

$M_C = 69.06 kNm$

$M_D = 72.06 kNm$

$M_E = 45.47 kNm$

$M_{A'} = 0 kNm$

Free moment

For U.D.L $= \frac{wl^2}{8}$

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.) $\frac{27.29 \times 1.5^2}{8} = ~~8.24 kN/m^2~~ \ 7.68 kN/m^2$

Span moment

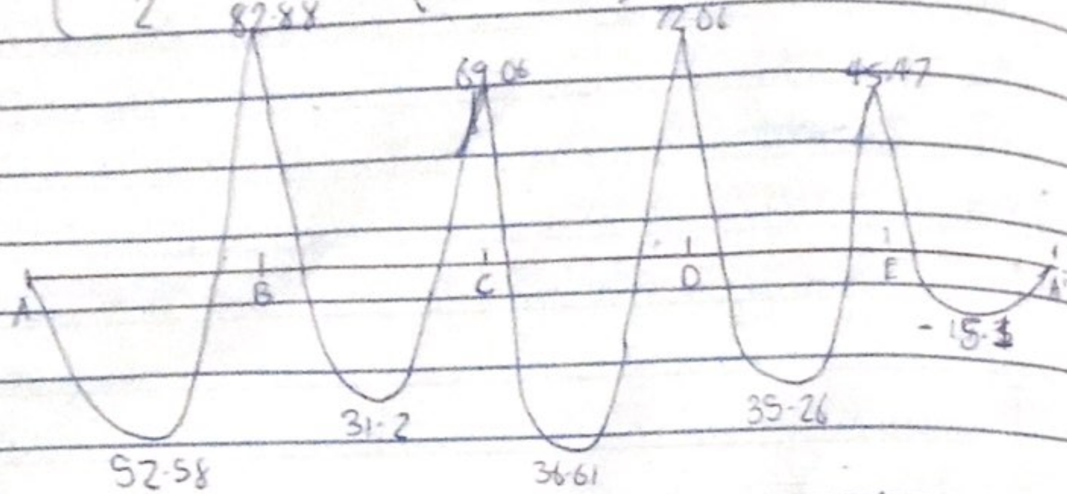
$M_{AB} = M^F - \left(\frac{M_A + M_B}{2}\right) = 94.02 - \left(\frac{0 + 82.88}{2}\right) = 52.58 kNm$

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

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

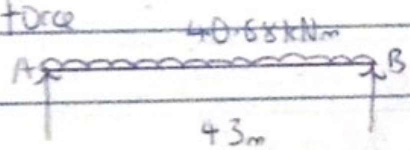
$M_{DE} = M^F - \left(\frac{M_D + M_E}{2}\right) = 94.02 - \left(\frac{72.06 + 45.47}{2}\right) = 35.26 kNm$

$$M_{EA} = M^F - \left(\frac{M_E + M_{A'}}{2}\right) = 8.68 - \left(\frac{45.47 + 0}{2}\right) = -15.1\,kNm$$



Bending Moment Diagram

Shear force



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

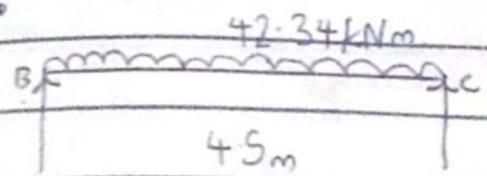
$$= \frac{40.68 \times 4.3}{2} = 87.462\,kN$$

$$V_{AB} = V_a + \left(\frac{M_A - M_B}{L}\right) = 87.462 + \left(\frac{0 - 82.88}{4.3}\right)$$

$$= 68.19\,kN$$

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

$$= (40.68 \times 4.3) - 68.19 = 106.73\,kN$$



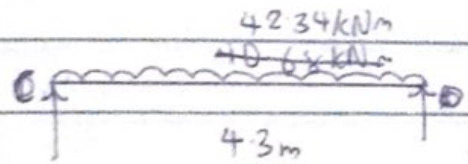
$V_{B'} = \frac{wl}{2} = V_C$

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

$V_{BC} = V_B + \left(\frac{M_B + M_C}{L}\right) = 95.27 + \left(\frac{82.68 + 69.06}{4.5}\right) = 129.03kN$

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

$= 61.5kN$



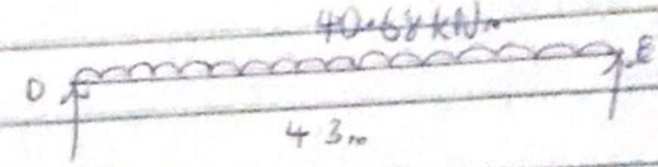
$V_{C'} = \frac{wl}{2} = V_D$

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

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

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

$= 63.19kN$



$V_{D'} = \frac{wl}{2} = V_E$

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

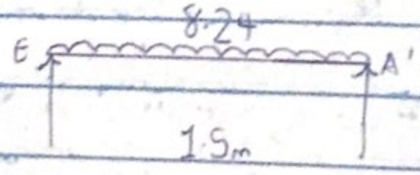
$V_{DE} = V_D - \left(\frac{M_D + M_E}{L}\right)$

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

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

$= (40.68 \times 4.3) - 60.13$

$= 114.79kN$



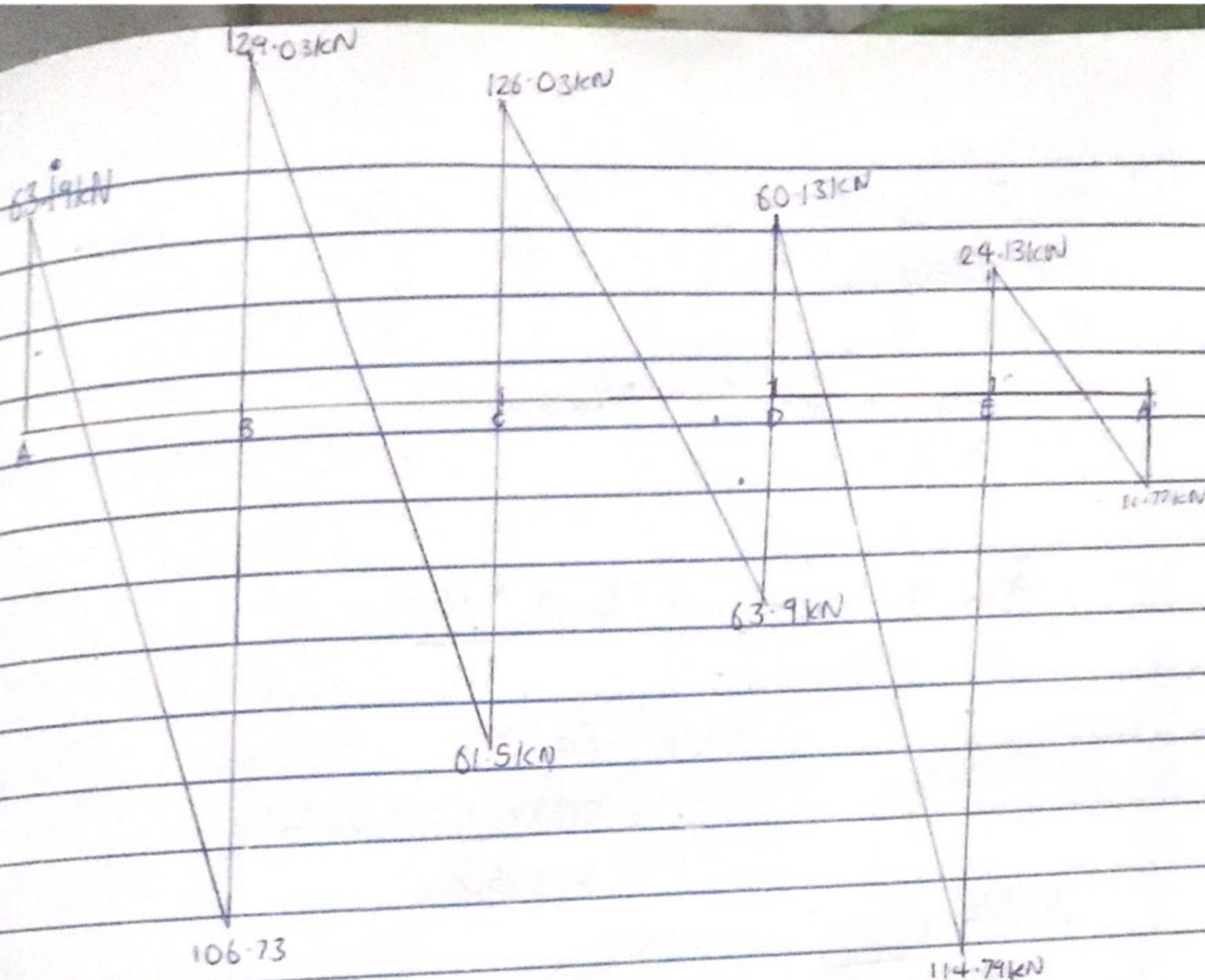
$V_{E'} = \frac{wl}{2} = V_{A'}$

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

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

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

$= 11.77kN$



Shear force diagram

Question 2

Base design

$N = 1200kN$

f_b = grade strength $= 25-40N/mm^2$

$S.B.C = 150kN/m^2$

Area of base required $(A_{req}) = \frac{N \times 1.1}{\lambda f_b}$

$\lambda = 1.46$

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

$A = l \times b = l^2$

$l = B = \sqrt{6.027} = 2.45m$ (Assume a square base) $A = 2.45 \times 2.45 = 6.0$

$f_{net} = \frac{N \times 1.1}{B} - 1.4 \times \rho_{conc} \times d$

$= \frac{1200 \times 1.1}{2.45} - 1.4 \times 24 \times 0.660$

$= 516.6kNm$

$M = \frac{f_{net}\ l^2}{2}$

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

$= \frac{1}{2}(2.45 - 0.660) = 0.9m$

$$M = \frac{516.6 \times 0.9^2}{2} = 209.223 kNm$$

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

$= 660 - 50 - 10 = 600mm$

$$k = \frac{M}{bd^2 f_{cu}} = \frac{209.223 \times 10^6}{1000 \times 600^2 \times 25} = 0.023$$

$$I_a = 0.5 + \sqrt{0.25 - \frac{0.023}{0.9}} = 0.97 > 0.95$$

$Z = I_a d = 0.95 \times 600 = 570mm$

$$A_s = \frac{M}{0.95 f_y z} = \frac{209.223 \times 10^6}{0.95 \times 410 \times 570} = 942.4mm^2$$

Provide Y_{12} @ 100 c/c (1130)

Punching shear

Column size = (225 x 450) mm

25 - 410 N/mm^2

Area footing = 6.027m^2

Size of footing = 2500 x 2500

qu Net pressure = 516.6 kNm

depth = 600mm

critical section; $d/2 = 300mm$

$300 + 300 + 225 = 825mm$

$300 + 300 + 450 = 1050mm$

Shear force $V_u = q_u \times [\text{Area of footing} - (0.3 + d)^2]$

$= 516.6 \times [2.5 \times 2.5 - (0.3 + 0.6)^2]$

$V_u = 2810.304 kN$

Nominal shear stress $\tau_v = V_u / bd$

b = Perimeter of critical section

d = effective depth

$\tau_v = \dfrac{2810.304 \times 10^3}{[(2 \times (825) + 2(1050)) \times 600]}$

$\tau_v = 1.25 N/mm^2$

Permissible Shear Stress

$\tau_c' = k_s \times \tau_c$

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

β_c = Ratio of shorter to longer side of column

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

$k_s = 1$

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

$\tau_v = 1.25 N/mm^2$

$\tau_v = \tau_c'$ ∴ depth is ok.

Check for f_b with actual size of footing

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

Unit weight of soil = $1.09 \times 10^{-6} kN/mm^3$

$q = (1200/2.5 \times 2.5) + (24 \times 0.660) + (1.09 \times 10^{-6} \times 0.660)$

$q = 214.94 kN/m^2 > 150 kN/m^2$

$\therefore$ size of footing is not ok.