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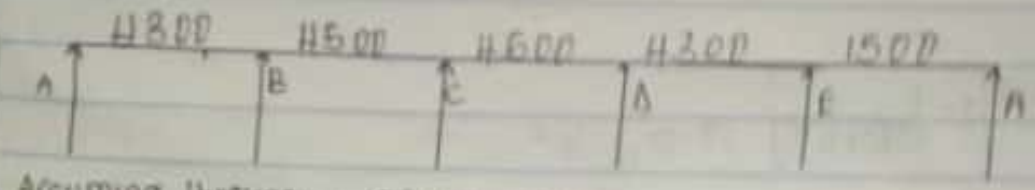
17/ENG03/032
CIVIL ENGINEERING
STRUCTURAL DESIGN
ASSIGNMENT 2

QUESTION ONE



Assuming thickness = 150mm = 0.15m
f_{cu} = 25N/mm²
f_y = 410N/mm²

Slab loading
Slab weight = 0.15 x 24 = 3.6KN/m²
partition = 1.0KN/m²
finishes = 1.2KN/m²
total G.k = 5.8KN/m²

D.L = ~~1.4(5.8)~~ + 1.4Gk + 1.6Qk
DL = 1.4(5.8) + 1.6(3.0)
= 8.12 + 4.8 = 12.92 ≈ 13KN/m²

Beam loading
self weight of Beam = 0.225 x 0.6 x 24 = 3.24KN/m²
finishes = 1.2KN/m²
Wall load = 3 x 3.47 = 10.41KN/m²
total G.k = 14.85KN/m²
D.L = 1.4(Gk)
= 1.4(14.85)
= 20.79KN/m²

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

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

$\frac{4300}{4000} = 1.075$

$\frac{4500}{4000} = 1.125$

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

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

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

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

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

$K_{AB} = 1$

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

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

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

$K_{CD} = 1 - 0.5$

$= 0.5$

$K_{DC} = 0.49$

$K_{DE} = 0.51$

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

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

$K_{AE} = 1$

F.E.M

UDL: $\dfrac{wl^2}{12}$

1) $\dfrac{40.68 \times 4.3^2}{12}$

$= 62.68 \text{ KN/m}$

2) $\dfrac{42.34 \times 4.5^2}{12}$

$= 71.45 \text{ KN/m}$

3) $\dfrac{27.29 \times 1.5^2}{12}$

$= 5.12 \text{ KN/m}$

	A		B		BC		D		E		A
	A	AB	BA	BC	CB	CD	DC	DE	ED	EA	AE	A
DF	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	
CBM		-62·68	-8·77	0		8·77		57·58		-5·1		
BM		62·68	8·77	0		-8·77		-57·58		5·1		
ΔM	0	62·68	4·47	4·30	0	0	-4·3	4·47	-1·47	-42·61	-5·1	0
TM		-2·235	-3·44	0	2·15	-2·15	0	-7·49	-2·24	-2·55	-21·305	
CBM		-2·235	-3·44	0		-3·44		-4·79		-21·305		
BM		2·235	3·44	0		3·44		4·79		21·305		
ΔM	0	-2·235	-1·58	-1·36	0	0	-3·67	-3·82	-1·25	-3·54	-21·30	0
		-7·99	-1·12	0	-1·69	1·84	0	0·63	1·91	10·66	1·77	
CBM		-7·99	-1·12	0		-5·15		0·63		12·57	1·77	
BM		~~7·99~~	~~1·12~~	0		5·15		-0·63		-12·57	-1·77	
ΔM	0	7·99	0·57	0·55	2·93	2·93	-0·31	-0·31	-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	
CBM		0·29	4·87	0	0·12		-0·17		-1·05		-4·65	
BM		-0·29	-4·87	0	-0·12		0·17		1·05		4·65	
ΔM	0	-0·29	-2·48	-2·39	-0·06	0·06	-0·08	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	

Moments

Ma: 0kNm

Mb: -82·88kNm

Mc: 69·06kNm

Md: 72·06kNm

ME: 45·47kNm

Ma: 0kN

Free moment

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

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

(2) $\frac{42.84 \times 1.5^2}{8} = 107.17 KN/m^2$

(3) $\frac{27.29 \times 1.52}{8} = 8.24 KN/m^2$

Span moment

for UDL = $\frac{wl^2}{8}$ $M_{AB} = M^F - \left(\frac{M_A + M_B}{2}\right)$

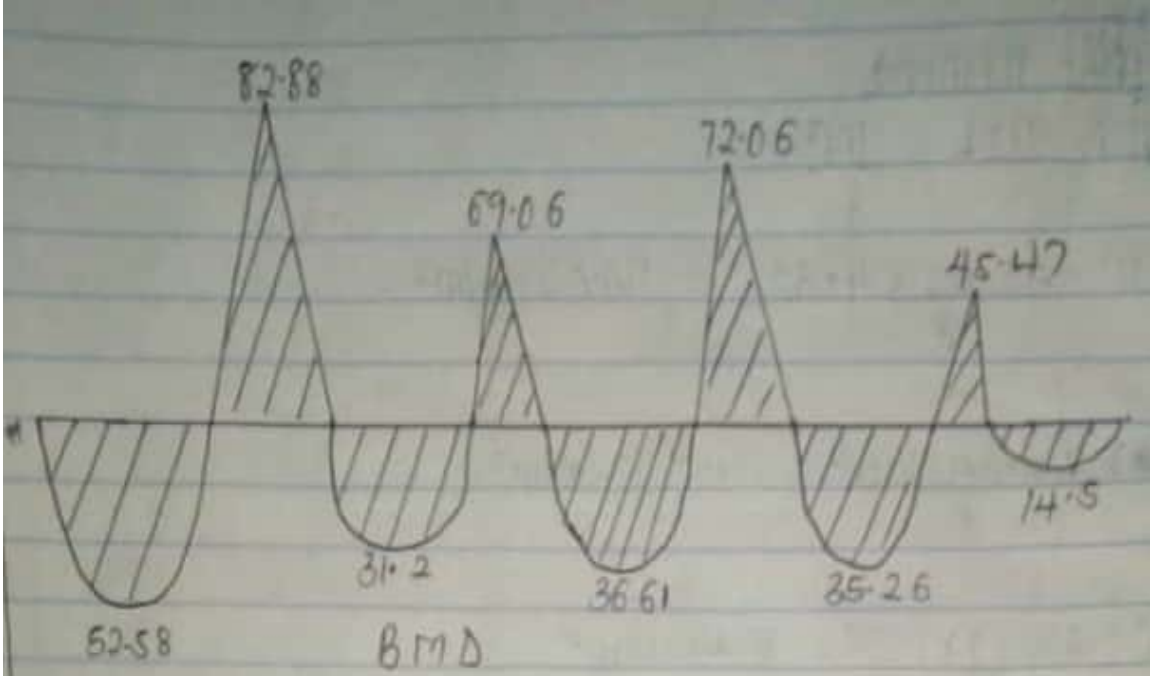
(1) 40.6 $= 94.02 - \left(\frac{0 + 82.88}{2}\right) = 52.58 KNm$

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

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

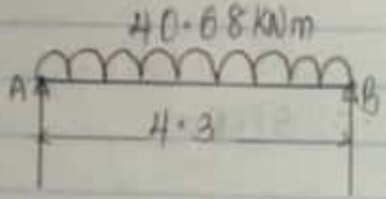
$M_{DE} = M^F - \left(\frac{M_D + M_E}{2}\right) = 94.02 - \left(\frac{72.06 + 45.47}{2}\right) = 35.26 KNm$

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



Shear force

For A



$V_A = \frac{WL}{2} = V_a$

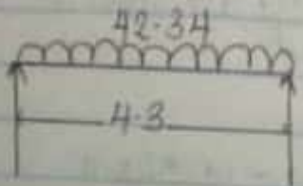
$= \frac{40.68 \times 4.3}{2} = 87.462 KN$

$V_{AB} = V_a + \left(\frac{M_B - M_A}{L}\right) = 87.462 + \left(\frac{0 - 82.88}{4.3}\right) = 68.19$

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

$= (40.68 \times 4.3) - 68.19 = 106.73 KN$

For B



$V_{BC} = \frac{WL}{2} = V_C$

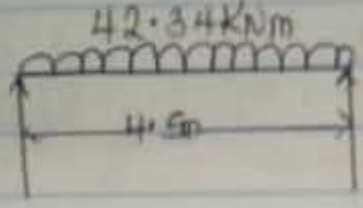
$= \frac{42.34 \times 4.5}{2} = 95.27$ ~~95.18 KN~~

$V_{BC} = V_B + \left(\frac{M_B + M_C}{L}\right) = 95.27 + \left(\frac{82.68 + 69.06}{4.5}\right) = 128.99 KN$

$V_{CB} = (42.34 \times 4.5) - 128.99$

$= 61.54 KN$

FOR C



$V_C = \frac{\omega L}{2} = V_B$

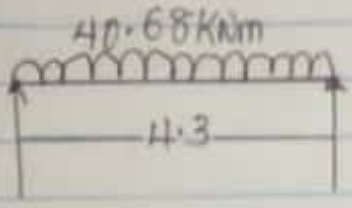
$= \frac{42.34 \times 4.5}{2} = 95.27$

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

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

$= 63.19\,KN$

FOR D



$V_C = \frac{\omega L}{2} = V_E$

$= \frac{42.34 \times 4.5}{2} \quad \frac{40.68 \times 4.3}{2} = 87.46\,KN$

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

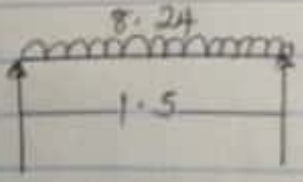
$= 87.46 - \left(\frac{72.06 + 45.47}{4.3}\right) = 60.13\,KN$

$V_{CD} = \omega L - V_{DC}$

$= (40.68 \times 4.3) - 60.13$

$= 114.79\,KN$

FOR E

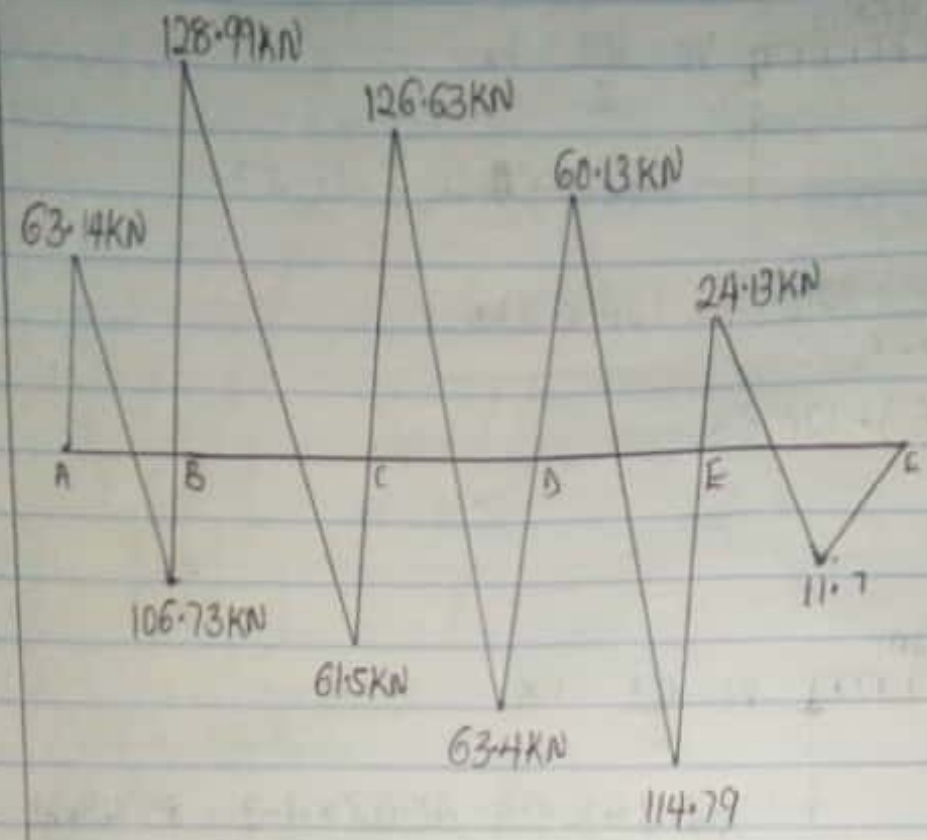


$V_E = \frac{\omega L}{2} = V_A$

$= \frac{8.24 \times 4.3}{2} = 6.18\,KN$

$V_{EA} = V_A - \left(\frac{M_E + M_A}{L}\right) = 6.18 - \left(\frac{45.47 + 0}{1.5}\right) = 24.13\,KN$

$V_{AE} = (8.24 \times 1.5) - 24.13$



QUESTION 2

N = 1200 KN

length = 25 - 410 N/mm²

fb = 150 KN/m²

Area of base req = $\frac{N \times 1.1}{1 \times Fb}$ 1 = 1.46

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

$\sqrt{6.027} = 2.45m \simeq 2.5$

Net pressure, Fnet = $\frac{N \times 1.4}{B}$

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

$= 505.824 KNm$

moment, m = $\frac{fnet\ l^2}{2}$

where l = 1/2 (B - h) : depth of base = 660

$L = \frac{1}{2}(2.5 - 0.225) = 1.1375 \approx 1.14\,m$

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

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

$660 - 50 - 10 = 600mm$

$K = \frac{m}{bdf_{cu}} = \frac{328.68 \times 10^6}{1000 \times 600^2 \times 25} = 0.037$

$R_a = 0.5 + \sqrt{0.25 + \frac{0.037}{0.9}} = 0.96 > 0.85$

$Z = R_{ad} = 0.95 \times 600 = 570\,mm$

$A_s = \frac{m}{0.95 f_y z} = \frac{328.68 \times 10^6}{0.95 \times 410 \times 510} = 1480.44mm^2$

Provide Y25 @ 300 c/c (1640)

Punching Shear

Column Size = 225 x 450mm

f_{cu} f_y = 25 - 410mm

Area footing = $6.027m^2$

Size of footing = 2500 x 2500

q = net pressure = 508.824 KN/m

depth = 600

Critical Section; $\frac{d}{2} = \frac{600}{2} = 300$

300 + 300 + 225 = 825mm

300 + 300 + 450 = 1050mm

Shear force $V_a = q_0 \times [\text{Area of footing} - (0.3+d)^2]$

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

~~$V_a = 505.824(6.25 - 0.81) = 2751.68$~~

NUMBA

Shear stress $\tau_v = V_a/bd$

b = parameter of critical section

d = effective span depth

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

$\tau_v = 1.223 \text{ N/mm}^2$

Permisible 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 larger side of columns

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

$K_s = 1$

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

$\tau_v = 1.223 \text{ N/mm}^2$

$\tau_v < \tau_v'$

Hence depth assumed is OK

Checking for f_b with actual size of footing

Unit weight of concrete = 24 KN/mm^3

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

Actual pressure footing below

$q = (1200 \times 2.5 \times 2.5) + (24 \times 0.660) + (1.091 \times 10^6 \times 0.64)$

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