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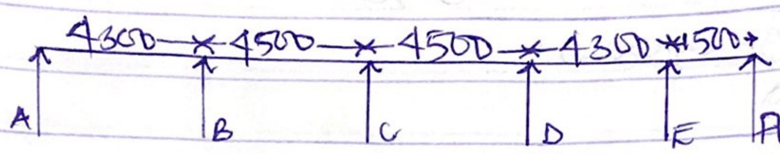
Civil Engineering 17/ENG03/038



Assumed specifications
thickness, t = 150mm
grade-stress = 25-410 N/mm²

Slab loading
Slab weight = 0.15 × 24 = 3.6 kN/m²
Partition = 1.0 kN/m²
finishes = 1.2 kN/m²
G_k = 5.8 kN/m²

$D.L = 1.4G_k + 1.6Q_k$ (Q_k = Library)
$= 1.4(5.8) + 1.6(4.0)$
$= 14.52$ kN/m

Beam loading
Self weight = 0.225 × 0.6 × 24 = 3.24 kN/m²
finishes/screeding = 1.2 kN/m²
wall = 3.47 × 3 = 10.41 kN/m²
G_k = 14.85 kN/m²

$D.L = 1.4G_k$
$= 1.4(14.85) = 20.79 \simeq 21$ kN/m²

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

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

$\frac{4300}{4000} = 1.075$ $\frac{4500}{4000} = 1.125$

$\frac{1}{2} \times 14.52 \times 4.3 \left(1 - \frac{1}{3(1.075^2)}\right) = 23.00 \ kN/m^2$

$\frac{1}{2} \times 14.52 \times 4.5 \left(1 - \frac{1}{3(1.125^2)}\right) = 24.07 \ kN/m^2$

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

$= \frac{1}{3} \times 14.52 \times 1.5 = 10.89 \ kN/m^2$

Total load $= 23 + 20.79 = 43.79 \ kN/m$

$= 24.07 + 20.79 = 44.86 \ kN/m$

$= 10.89 + 20.79 = 31.68 \ kN/m$

Distribution factor, $K = K/\Sigma K$

$K_A = \frac{1/L_A}{1/L_A + 1/L_{AB}} = \frac{0}{0 + 4.3} = 0$

$K_{AB} = 1$

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

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

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

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

$K_{DC} = K_{BC} = 0.49$

$K_{DE} = K_{BA} = 0.51$

$K_{ED} = \dfrac{1/L_{ED}}{1/L_{ED} + 1/L_{EA'}} = \dfrac{1/4.3}{1/4.3 + 1/1.5} = 0.26$

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

$K_{A'E} = 1$

$K_{A'} = 0$

$FEM = wl^2/12$

1) $\dfrac{43.79 \times 4.3^2}{12} = 67.47\ kN/m$

2) $\dfrac{44.86 \times 4.5^2}{12} = 75.70\ kN/m$

3) $\dfrac{31.68 \times 1.5^2}{12} = 5.94\ kN/m$

	A		B		C		D		E		A'	
		AB	BA	BC	CB	CD	DC	DE	ED	EA'	A'E	A'
DF	0	1	0.51	0.49	0.5	0.5	0.49	0.51	0.26	0.74	1	0
FEM		-67.47	67.47	-75.70	75.70	-75.70	75.70	-67.47	67.47	-5.94	5.94	
OBM	-67.47		-7.96		0		7.96		61.8		5.94	
BM	67.47		7.96		0		-7.96		-61.8		-5.94	
DM	0	67.47	4.06	3.9	0	0	-3.9	-4.06	-16.07	-45.73	-5.94	0
TM		2.03	33.74	0	1.95	-1.95	0	-8.04	-2.03	-2.97	-22.87	
OBM	2.03		33.74		0		-8.04		-5		-22.87	
BM	-2.03		-33.74		0		8.04		5		22.87	
DM	0	-2.03	-17.21	-16.53	0	0	3.94	4.10	1.3	3.7	22.87	0
TM		-8.61	-1.02	0	-8.27	1.97	0	0.65	2.05	11.44	1.85	
OBM	-8.61		-1.02		-6.3		0.65		13.49		1.85	
BM	8.61		1.02		6.3		-0.65		-13.49		-1.85	
DM	0	8.61	0.52	0.5	0	0	0.32	0.33	-3.51	-9.98	-1.85	0
TM		0.26	4.31	0	0.25	0.16	0	1.76	0.17	-0.93	-5	
OBM	0.26		4.31		0.41		-1.76		-0.76		-5	
BM	-0.26		-4.31		-0.41		1.76		0.76		5	
DM	0	0.26	-2.2	-2.11	0	0	0.86	0.9	0.2	0.56	5	0
Σ =	0	0	89.67	-89.94	69.63	-69.63	76.92	-75.35	49.58	-49.85	0	0

Moments

$M_a = 0 kNm$ $M_{a'} = 0 kNm$

$M_b = 89.67 kNm$

$M_c = 69.63 kNm$

$M_d = 76.92 kNm$

$M_e = 49.58 kNm$

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

1) $\frac{43.79 \times 4.3^2}{8} = 101.21 \ kN/m^2$

2) $\frac{44.86 \times 4.5^2}{8} = 113.55 \ kN/m^2$

3) $\frac{31.68 \times 1.5^2}{8} = 8.91 \ kN/m^2$

Span moment

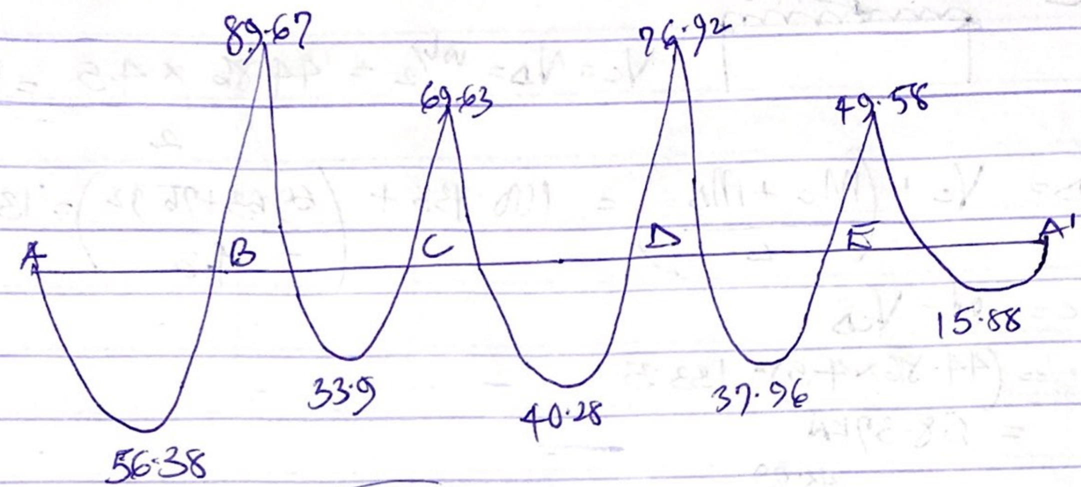
$M_{AB} = M^F - \left(\frac{M_A + M_B}{2}\right) = 101.21 - \left(\frac{0 + 89.67}{2}\right) = 56.38 \ kNm$

$M_{BC} = M^F - \left(\frac{M_B + M_C}{2}\right) = 113.55 - \left(\frac{89.67 + 69.63}{2}\right) = 33.9 \ kNm$

$M_{CD} = M^F - \left(\frac{M_C + M_D}{2}\right) = 113.55 - \left(\frac{69.63 + 76.92}{2}\right) = 40.28 \ kNm$

$M_{DE} = M^F - \left(\frac{M_D + M_E}{2}\right) = 101.21 - \left(\frac{76.92 + 49.58}{2}\right) = 37.96 \ kNm$

$M_{EA'} = M^F - \left(\frac{M_E + M_{A'}}{2}\right) = 8.91 - \left(\frac{49.58 + 0}{2}\right) = 15.88 \ kNm$



BMD

Shear force

For A

$w = 43.79\,kN/m$

$V_A = V_B = \frac{wl}{2} = \frac{43.79 \times 4.3}{2} = 94.15\,kN$

$V_{AB} = V_A + \left(\frac{M_A - M_B}{L}\right) = 94.15 + \left(\frac{0 - 89.67}{4.3}\right) = 73.30\,kN$

$V_{BA} = wl - V_{AB}$
$= (43.79 \times 4.3) - 73.30$
$= 114.997\,kN$

For B

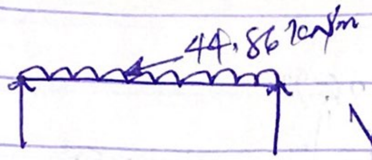
$w = 44.86\,kN/m$

$V_B = V_C = \frac{wl}{2} = \frac{44.86 \times 4.5}{2} = 100.94\,kN$

$V_{BC} = V_B + \left(\frac{M_B + M_C}{L}\right) = 100.94 + \left(\frac{89.67 + 69.63}{4.5}\right)$ ~~= 129.55 kN~~
$= 136.34\,kN$

$V_{CB} = wl - V_{BC}$
$= (44.86 \times 4.5) - 136.34$
$= 65.53\,kN$

For C

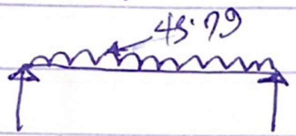


$V_C = V_D = wl/2 = \frac{44.86 \times 4.5}{2} = 100.935\text{kN}$

$V_{CD} = V_C + \left(\frac{M_C + M_D}{L}\right) = 100.935 + \left(\frac{69.63 + 76.92}{4.5}\right) = 133.5\text{kN}$

$V_{DC} = wl - V_{CD}$
$= (44.86 \times 4.5) - 133.5$
$= 68.37\text{kN}$

For D

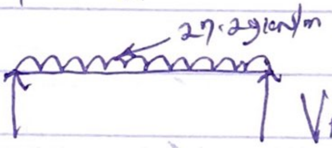


$V_D = V_E = wl/2 = \frac{43.79 \times 4.3}{2} = 94.15\text{ kN}$

$V_{DE} = V_D + \left(\frac{M_D + M_E}{L}\right) = 94.15 + \left(\frac{76.92 + 49.58}{4.3}\right) = 123.57\text{kN}$

$V_{ED} = wl - V_{DE}$
$= (43.79 \times 4.3) - 123.57$
$= 64.727\text{kN}$

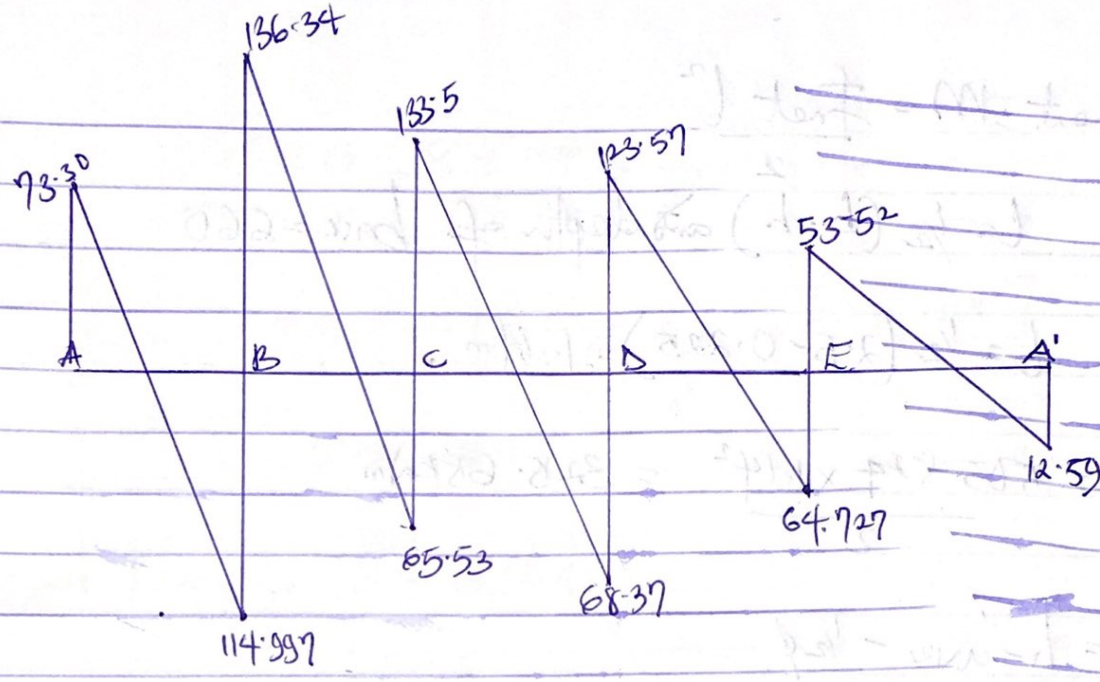
For E



$V_E = V_{A'} = \frac{wl}{2} = \frac{27.29 \times 1.5}{2} = 20.47\text{kN}$

$V_{EA'} = V_E + \left(\frac{M_E + M_{A'}}{L}\right) = 20.47 + \left(\frac{49.58 + 0}{1.5}\right) = 53.52\text{kN}$

$V_{A'E} = wl - V_{EA'}$
$= (27.29 \times 1.5) - 53.52$
$= 12.59\text{kN}$



SFD

2) Base design

N = 1200 kN

strength = 25-410 N/mm²

$f_b = 150\ kN/m^2$

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

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

$\sqrt{6.027} = 2.5 m$

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

$= \frac{1200 \times 1.1}{2.5} = 505.82\ kN/m$

Moment, $M = \frac{F_{net}\, l^2}{2}$

$l = \frac{1}{2}(b - h)$ and depth of base = 660

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

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

$d = h - cover - \frac{1}{2}\phi$
$= 660 - 50 - 10$
$= 600mm$

$K = 0.032$
$l_a = 0.95$
$Z = 0.95 \times 600 = 570 mm$
$A_s = \frac{328.68 \times 10^6}{0.95 \times 410 \times 570} = 1480.44 mm^2$

Provide Y25 @ 300 c/c (1640)

Punching shear
Column size = 225 × 450 mm
grade stress = 25-410 N/mm
Area footing = 6.027 m²
footing size = 2500 × 2500
d = 600
critical section, $\frac{d}{2} = 300$

$300 + 300 + 225 = 825\, mm$

$300 + 300 + 450 = 1050\, mm$

Shear force $= 505.824 \left[2.5 \times 2.5 - (0.3 + 0.6)^2 \right]$

$V_A = 2751.68\, kN$

Normal shear stress $\tau_v = V_A / bd$

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

$\tau_v = 1.223\, N/mm^2$

Permissible shear stress

~~$k_s \times \tau_c$~~

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

$\tau_v = 1.223\, N/mm^2$

$\tau_v \leq \tau_v'$

Depth assumed is OK

$q = (1200 \times 2.5 \times 2.5) + (24 \times 0.660)$

$= 214.94\, kN/m^2$