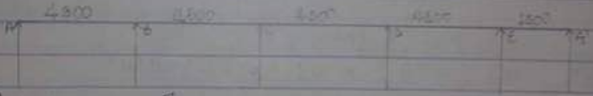
CIVIL ENGINEERING

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

$D.L = 1.4G_k + 1.6Q_k$

$= 1.4(5.8) + 1.6(3.0)$

$= 12.92kN/m^2 \simeq 13kN/m^2$

# 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 = $1.4 G_K$

$= 1.4(14.85)$

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

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 larger span

$= \frac{1}{2} w l_x \left(1 - \frac{1}{3K^2}\right)$

$K = \frac{L_y}{L_x}$

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

$= 1.075$

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

$= 19.89 kN/m^2$

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

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

$= 1.125$

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

$= 21.53 \, kN/m^2$

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

Distribution Factor

$K_{AB} = 1$

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

$= 0.51$

~~$K_{BC} = 1 - 0.51$~~ $K_{BC} = \frac{1/4.5}{1/4.5 + 1/4.3} = 0.49$

~~$= 0.49$~~

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

$= 0.5$

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

$= 0.5$

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

$= 0.49$

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

$= 0.51$

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

$= 0.26$

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

$= 0.74$

$K_{A'E} = 1$

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

$= -63 kN/m$

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

$= 63 kN/m$

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

$= -71.8 kN/m$

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

$(FEM)_{CD} = -\dfrac{wL^2}{12} = -71.8 kN/m$

$(FEM)_{DC} = \dfrac{wL^2}{12} = 71.8 kN/m$

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

$(FEM)_{ED} = \dfrac{wL^2}{12} = 63 kN/m$

$$(FEM)_{EA'} = \frac{-wl^2}{12} = \frac{-27.8 \times (1.5)^2}{12}$$

$$= -5.2 \, kN/m$$

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

| Joint | A | B | | C | | D | | E | | A' |
|---|---|---|---|---|---|---|---|---|---|---|
| Member | AB | BA | BC | CB | CD | DC | DE | ED | EA' | A'E |
| D.F | 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 | | 4.4 | 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 | 21.36 |
| 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 | -0.86 | |
| TM | 0 | 0 | -0.46 | 0 | -0.7 | -0.46 | 0.15 | -0.15 | 0 | -0.44 |
| OBM | | -0.46 | | -0.7 | | -0.51 | | -0.15 | | |
| BM | | 0.46 | | 0.7 | | 0.51 | | 0.15 | | |
| DM | | +0.25 | +0.23 | 0.35 | 0.35 | 0.29 | 0.31 | 0.29 | 0.55 | |
| TM | ~~-0.185~~ | | ~~0.115~~ | ~~0.115~~ | ~~0.115~~ | ~~0.115~~ | ~~0.095~~ | ~~0.155~~ | | 0 |
| Σ | 0 | 22.98 | -22.98 | 69.06 | -69.06 | 12.06 | -12.06 | 45.46 | -45.46 | 0 |

Moments

$M_A = 0 KNm$

$M_B = 92.55 KNm$

$M_C = 89.06 KNm$

$M_D = 72.06 KNm$

$M_E = 45.47 KNm$

$M_R = 0 KNm$

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

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

$= 94.51 KN/m^2$

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

$= 107.65 KN/m^2$

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

$= 7.73 KN/m^2$

Span Moment

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

$= 52.58 KNm$

$M_{BC} = M' - \left(\frac{M_B + M_C}{2}\right) = 107.65 \left(\frac{82.88 + 89.06}{2}\right)$

$= 32.2 KNm$

$M_{CD} = M' - \left(\frac{M_C + M_D}{2}\right) = 107.65 - \left(\frac{89.06 + 72.06}{2}\right)$

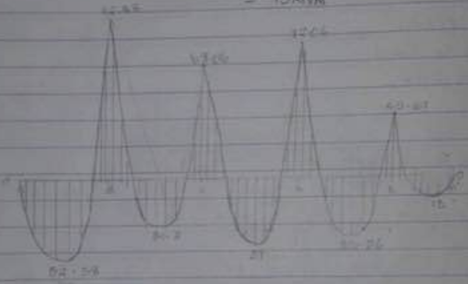
$= 37 KNm$

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

$= 35.26 KNm$

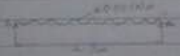
$M_{EA'} = M^F - \left(\frac{M_E + M_{A'}}{2}\right) = 7.73 - \left(\frac{45.47 + 0}{2}\right)$

$= -15 KN_m$



Shear Force

For A



$V_A = {}^{wl}/_2 = \frac{40.89 \times 4.3}{2} = 88 KN = V_B$

$V_{AB} = V_A + \left(\frac{M_A - M_B}{L}\right) = 88 + \left(\frac{0 - 88.58}{4.3}\right) = 68.2$

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

For B

$V_B = {}^{wL}/_2 = \frac{42.53 \times 4.5}{2} = 95.7 KN = V_C$

$V_{BC} = V_B + \left(\frac{M_B + M_C}{L}\right) = 95.7 + \left(\frac{88.88 + 69.06}{4.5}\right) = 129.5 KN$

$V_{CB} = wL - V_{BC} = (42.53 \times 4.5) - 129.5 = 61.9 KN$

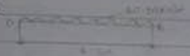
For C

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

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

$V_{DC} = wl - V_{CD} = (42.53 \times 4.5) - 127 = 64.4KN$

For D

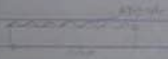


$V_D = wl/2 = \frac{40.89 \times 4.3}{2} = 88KN$

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

$V_{ED} = wL - V_{DE} = (40.89 \times 4.3) - 60.7 = 115.13KN$

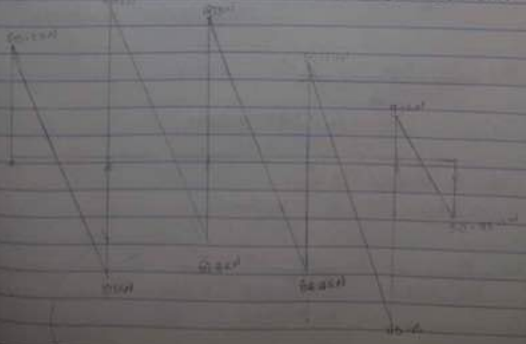
For E



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

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

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



## QUESTION TWO

Base Design

$N = 1{,}200kN$

Strength $= 25 - 410N/mm^2$

SBC $= 150kN/m^2$

$\lambda = 1.46$

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

$= 6.027m^2$

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

Net Pressure, $I_{net} = \frac{N \times 1.1}{B} = \frac{1800 \times 1.1}{2.5}$

$= 529 - (24 \times 0.660 \times 1.4)$

$= 505.824kNm$

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

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

$L = \frac{1}{8}(2.5 - 0.225)$

$= 1.1375m \simeq 1.14m$

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

$= 328.68kNm$

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

$= 660 - 50 - 10 = 600mm$

$k = \frac{M}{bd^2 f_{cu}} = \frac{328.68 \times 10^6}{1000 \times 600^2 \times 25}$

$= 0.032$

$J_a = 0.5 + \sqrt{0.25 + \frac{...}{0.9}}$

$= 0.96 (\geq 0.95)$

$Z = J_a d = 0.95 \times 600$

$= 570 mm$

$A_{st} = \frac{M}{0.95 f_y Z} = \frac{825.65 \times 10^6}{0.95 \times 410 \times 570}$

$= 1480.44 mm^2$

Provide 4Ø5 @ 300 c/c (A = 1640 mm²)

Punching Shear

Column size = 225 × 450 mm

$f_{ck}/f_y$ = 20-410 mm

Area footing = 6.027 m²

Size of footing = 2000 × 2000

$q_u$ Net Pressure = 505.824 kN/m

Depth = 600

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

= 300

300 + 300 + 225 = 825 mm

300 + 300 + 450 = 1050 mm

Shear force $V_u = q_u \times$ (Area footing − $(0.3 + d)^2$)

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

$V_u = 2751.68$

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

$\tau_v = 1.223 N/mm^2$

Scanned by CamScanner

Permissible Shear Stress

$\tau_c' = k_s \times \tau_c$

$k_s = (0.5 + \beta_c)$

$\beta_c$ = Ratio of longer column sides

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

$k_s = 1$

$\tau_c' = 0.25\sqrt{25}$

$= 1.25 N/mm^2$

$\tau_v < \tau_v'$

∴ Depth assumed is Okay

Check for IB with actual footing size

Unit weight of concrete = 24 kN/m³

" " " Soil = $1.091 \times 10^{-6}$ kN/mm³

Actual footing $q = [1700 \times 2.5 \times 2.50 + (2.4 \times 0.6 \ldots$

$(1.091 \times 10^{6} \times 0.8)$

$= 214.92 kN/m^2$