7.1.11

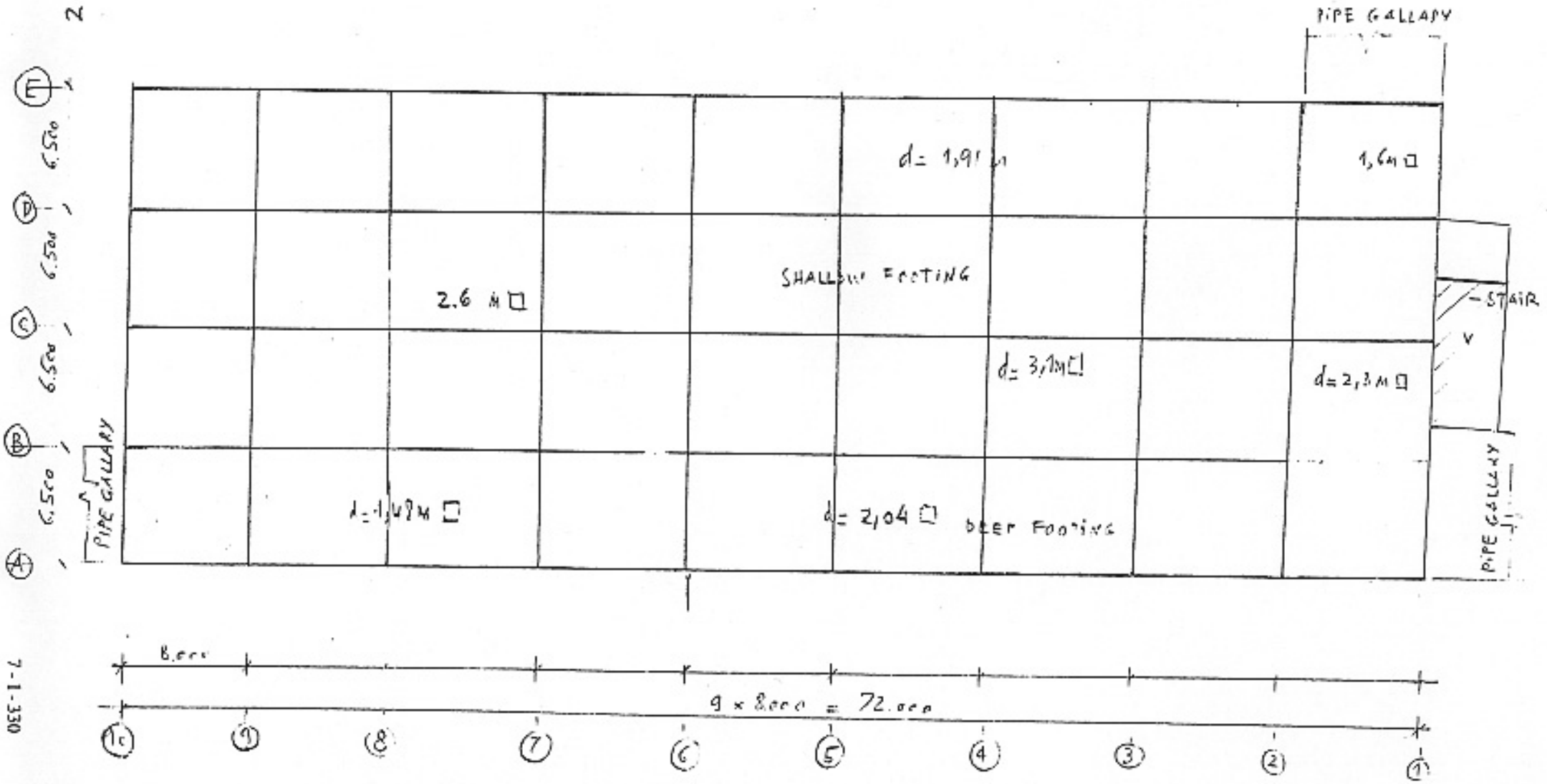
Dewatering Building

DEWATERING BUILDING CALCULATION SHEET

* DEEP FOOTING AREA $A_C B_C A_{10} B_{10}$:

- BOTTOM SLAB : $(0{,}10 + 1{,}00) \times 8{,}10 \times 33 \times 2500$
  $+ 6{,}50 \times 33 \times 500$ = 842.325 KG
- WALL : $33 \times 0{,}5 \times 4{,}3 \times 2 \times 2500$ = 354 750 KG
- BEAM (UNDER +2.50) :
  $0{,}8 \times 1{,}3 \times 2 \times 32 \times 2500$
  $+ 0{,}8 \times 1{,}3 \times 1 \times 6{,}5 \times 2500$
  $+ 8 \times 0{,}8 \times 1{,}00 \times 6{,}5 \times 2500$ = 267.300 KG
- COLUMNS :
  $9 \times 2 \times 0{,}5 \times 1 \times 4{,}3 \times 2500$ = 96.750 KG
- 1ST FLOOR SLAB :
  DL+LL : $0{,}4 \times 32 \times 6{,}5 \times 2500$
  $+ 0{,}75 \times 32 \times 6{,}5 \times 2000$
  $+ 4{,}05 \times 1000 \times 6{,}5 \times 32$
  $+ 32 \times 6{,}5 \times 0{,}15 \times 2500 + 1500 \times 4$ = 1.446.400 KG
- WALL :
  $0{,}2 \times (32 + 6{,}5) \times 2{,}5 \times 2000$
  $+ (5 \times 0{,}3 \times 4{,}85 \times 6.5 + 32 \times 2 \times 0.3 \times 4{,}85) \times 2500$ = 389.519 KG
- LOAD AT BOTTOM COLUMNS :
  $A_C; A_7; A_8; A_9; A_{10}$
  $B_6; B_7; B_8; B_9; B_{10}$:
  $4 \times 126.957 + 126.957/2$
  $+ 4 \times 68.183 + 68.183/4$ = 861.085 KG

$$\Rightarrow p_1 = \frac{4.278,129}{32 \times 6,5} = 20.568 \text{ KG/M}^2$$


PIPE GALLARY
d= 1,91 M
1,6M □
2.6 M □
SHALLOW FOOTING
STAIR
d= 3,1M □
d= 2,3M □
PIPE GALLARY
d= 2,04 □
DEEP FOOTING
PIPE GALLARY
8.000
9 × 8.000 = 72.000
6.500
6.500
6.500
6.500
(E)
(D)
(C)
(B)
(A)
(1c)
(9)
(8)
(7)
(6)
(5)
(4)
(3)
(2)
(1)

* DISTANCE OF PILES $= \sqrt{\frac{45.000}{20\,563}} = 1{,}48\ M$

$\Rightarrow n = 115$ piles

. Pressure of calculation:

$p_c = p_1 - (1{,}00 + 0{,}1) \times 1 \times 1 \times 2500 = 17.818\ KG/M^2$

$M^- = -\frac{p_c l^2}{12} = -17.818 \times 6{,}5^2/12 = -62.734\ KGM$

$M^+ = \frac{p_c l^2}{12} = 62.734\ KGM$

Taken $t = 100$ cm for bottom slab

* REINFORCEMENT: ($t = 100$ cm)

. $M = -62\,734\ KGM$

$\Rightarrow F_a = \frac{6273400}{1600 \times 0{,}92 \times 88} = 48{,}4\ cm^2$

$\Rightarrow 4\phi 36 + 4\phi 18 = 50{,}9\ cm^2$

. $M = 62734\ KGM$

$\Rightarrow F_a = \frac{6273400}{1600 \times 0{,}92 \times 93} = 45{,}8\ cm^2$

$\Rightarrow 4\phi 36 + 4\phi 18 = 50{,}9\ cm^2$

* DEEP FOOTING AT AREA $A_2A_cB_2B_c$:

- BOTTOM SLAB: $(0{,}1 + 0{,}8) \times 32 \times 8.1 \times 2500 + 500 \times 32 \times 6.5 = 687.200\ KG$

- WALL (UNDER +2,5):

$32 \times 2 \times 0{,}5 \times 4{,}3 \times 2500 = 344.000\ KG$

- BEAM (UNDER +2,5):

$8 \times 0{,}8 \times 0{,}6 \times 6{,}5 \times 2500 + 32 \times 2 \times 1{,}3 \times 0{,}8 \times 2500 = 228.800\ KG$

- 1ST FLOOR SLAB:

DL + LL: $0{,}5 \times 32 \times 6{,}5 \times 2500 + 500 \times 32 \times 6{,}5 + 24000 \times 6 = 508.000\ KG$

- WALL (UPPER +2.5m)

$32 \times 7{,}3 \times 0.2 \times 2000 = 93.440$ KG

- LOAD AT BOTTOM COLUMN

$A_2, A_3, A_4, A_5, A_6 ; B_2, B_3, B_4, B_5, B_6$:

$43.137 \times 4 + 43137/2$

$+ 43239 \times 4 \times 43.239/2 = 388.692$ KG

SUM = 2.248.332 KG

$p_1 = 2248332 / 32 \times 6.5 = 10.809 KG/M^2$

+ Distance of pile = $\sqrt{45000 / 10,809} = 2,04$ M

$\Rightarrow n = 64$ pile

- Pressure of calculation:

$p_c = p_1 - (0,8 + 0,1) \times 1 \times 1 \times 2500 = 8559 KG/M^2$

$M^- = -\frac{p_c l^2}{12} = -8559 \times 6.5^2/12 = -30.136$ KGM

$M^+ = \frac{p_c l^2}{12} = 30.136$ KGM

Take $t = 80$ cm

- REINFORCEMENT :

$M = -30.136$ KGM

$\Rightarrow Fa = \frac{30.13600}{1600 \times 0,95 \times 68} = 29,2 cm^2$

$\Rightarrow 4\phi 28 + 4\phi 16 = 32,67 cm^2$

$M = 30.136$ KGM

$\Rightarrow Fa = \frac{30.13600}{1600 \times 0,95 \times 73} = 27,10 cm^2$

$\Rightarrow 4\phi 25 + 4\phi 16 = 27,67 cm^2$

* DEEP FOOTING AREA $A_1 A_2 D_1 D_2$

- BOTTOM SLAB : $(0,8+0,1) \times 20,3 \times 8,8 \times 2500$
  $+ 19,5 \times 8 \times 500$ = 479 940 KG

- WALL (UNDER +2,50)
  $(8 + 13 +) \times 4,3 \times 0,5 \times 2500$ = 112 875 KG

- BEAM (UNDER +2.50) :
  $3 \times 0,8 \times 0.8 \times 8 \times 2500$
  $+ 1.3 \times (13 + 6,5) \times 0,8 \times 2500$
  $+ 1.9 \times 0,8 \times 13 \times 2500$ = 92,900 KG

- COLUMN (UNDER +2.50)
  $8 \times 0,3 \times 0,8 \times 2500 \times 4.3$ = 20.640 KG

- 1ST FLOOR SLAB :
  DL+LL : $0,5 \times 8 \times 19,5 \times 2500$
  $+ 500 \times 19,5 \times 8$
  $+ 2300$ = 275.300 KG

- WALL (UPPER +2.50)
  $(19,5 + 8) \times 0,2 \times 7,3 \times 2000$ = 50.300 KG

- LOAD AT BOTTOM COLUMN :
  $A_1, B_1, C_1, D_1, A_2, B_2, C_2, D_2$:

$\frac{1}{2}(43.137 + 43.239 + 83116) + 42463/4$
$+ 43.137 + 43.239 + 83116 + 42463/2$ = 286.656 KG

SUM = 1.348.040 KG

$\Rightarrow p_1 = 1348040 / 8 \times 19,5 = 8641 KG/M^2$

* Distance of piles = $\frac{45.000}{8641} = 2,3$ m $\Rightarrow n =$ 45 piles

. Pressure of calculation.

$p_c = p_1 - (0,8+0,1) \times 1 \times 1 \times 2500 = 6391$ KG/M²

$M^- = -\frac{p_c l^2}{12} = -\frac{6391 \times 8^2}{12} = -34085$ KGM

$M^+ = \frac{p_c l^2}{12} = 34085$ KGM

. REINFORCEMENT: (Take $t = 80$ cm)

$M = -34085$ KGM

$\Rightarrow F_a = \frac{3408500}{1600 \times 0,94 \times 68} = 33,3$ CM²

$\Rightarrow 4\phi 28 + 4\phi 16 \# 33$ CM²

$M = 3408500$ KGM

$\Rightarrow F_a = \frac{3408500}{1600 \times 0,94 \times 73} = 31$ CM²

$\Rightarrow 4\phi 28 + 4\phi 16 = 32,67$ CM²

* DEEP FOOTING AREA $D_1E_1\ D_2E_2$

- BOTTOM SLAB : $(0,8+0,1) \times 9,6 \times 7,5 \times 2500 + 7,5 \times 8 \times 500 = 175.800$ KG

- WALL (UNDER +2.50)

$2 \times 7,5 \times 0,5 \times 4,3 \times 2500 = 80.625$ KG

- BEAM (UNDER +2.50)

$2 \times 0,8 \times 0,8 \times 8 \times 2500$
$+ 8 \times 1,3 \times 0,8 \times 2500$
$+ 7,5 \times 2 \times 1,3 \times 0,8 \times 2500 = 55.400$ KG

- COLUMN (UNDER +2.50)

$6 \times 0,3 \times 0,8 \times 4,3 \times 2500 = 15.480$ KG

- 1ST FLOOR SLAB :

DL + LL : $0,4 \times 7,5 \times 8 \times 2500$
$+ 0,75 \times 8 \times 6,5 \times 2000$
$+ 4.05 \times 100 \times 6,5 \times 8$
$+ 8 \times 6,5 \times 0,15 \times 2500 = 368.100$ KG

- WALL (UPPER + 2.50)

$0,2 \times (8 + 6.5) \times 2.5 \times 2000$

$+ \ 2(6.5+8) \times 2,5 \times 0,3 \times 2500 \quad = \quad 68.875 \text{ KG}$

- LOAD AT BOTTOM COLUMN

D_1, D_2, E_1, E_2 :

$42.462/4 + 42462 + 46181/2 + 46181 \quad = \quad 122.349 \text{ KG}$

SUM = 916.629 KG

$\Rightarrow p_1 = 916.629 / 6.5 \times 8 = 17.627 \text{ KG/M}^2$

* DISTANCE OF PILES $= \sqrt{\frac{45.000}{17.627}} = 1.6 \text{ M}$

$\Rightarrow n = 30 \text{ piles}$

. Pressure of calculation :

$p_c = p_1 - (0,8+0,1) \times 1 \times 1 \times 2500 = 15.377 \text{ KG/M}^2$

$M^- = - p_c l^2/12 = 15.377 \times 8^2/12 = -82.011 \text{ KGM}$

$M^+ = p_c l^2/12 = 82.011 \text{ KGM}$

. REINFORCEMENT ; ($e = 100$ CM)

. $M = -82.011 \text{ KGM}$

$\Rightarrow F_a = \frac{82.011\,00}{1600 \times 0,90 \times 88} = 64.72 \text{ CM}^2$

$\Rightarrow 8\phi 32 = 64,34 \text{ CM}^2$

. $M = 82.011 \text{ KGM}$

$\Rightarrow F_a = \frac{82.011\,00}{1600 \times 0,90 \times 93} = 61,3 \text{ CM}^2$

$\Rightarrow 8\phi 32 = 64,34 \text{ CM}^2$

$F_{a\,min} = 10 \text{ CM}^2 \Rightarrow 4\phi 18 = 10,18 \text{ CM}^2$

* STRIP A_2B_2 OF BOTTOM SLAB (DEEP FOOTING) ($b = 1,6$; $t = 80cm$)

$$M_t = 3,25 \times 8559 \times \frac{6.5^2}{12} + 3.25 \times 6391 \times \frac{6,5^2}{12} = 171.068 \text{ KGM}$$

$$= 106.918 \text{ KGM/M}$$

$$M_a = -0,8 \times M_t = -0,8 \times 106.918 = -85.534 \text{ KGM/M}$$

$$M_t = 85534 \text{ KGM/M}$$

* REINFORCEMENT :

. $M = -85534$ KGM

$$\Rightarrow F_a = \frac{8553400}{1600 \times 0.77 \times 63} = 110,2 \text{ CM}^2/\text{M}$$

$\Rightarrow$ 7Ø32 (2 LAYERS)/M
(11Ø32 FOR 1,6M) × 2 LAYERS

: $F_{a\min}$ ⇒ 7Ø14/M

. $M = 85534$ KGM

$$\Rightarrow F_a = \frac{8553400}{1600 \times 0,77 \times 68} = 102 \text{ CM}^2/\text{M}$$

$\Rightarrow$ 7Ø32 (2 LAYERS)/M
(11Ø32 FOR 1,6M × 2 LAYERS)

* SHALLOW FOOTING AREA $D_2D_6E_2E_6$: ($t = 80cm$)

1/ when the tanks are full sludge or water :

- BOTTOM SLAB : DL + LL
$0,8 \times 32 \times 7 \times 2500$
$+ 0,75 \times 32 \times 7 \times 2500$
$+ 4,05 \times 1000 \times 32 \times 6.5$
$+ 32 \times 6.5 \times 0,15 \times 2500$
$+ 1700 \times 4$ = 1.677.600 KG

- WALL : $4 \times 0,3 \times 4.05 \times 6,5 \times 2500$
$+ 32 \times 0,3 \times 4.05 \times 2 \times 2500$
$+ 32 \times 0,2 \times 2.5 \times 2000$ = 305.375 KG

- LOAD AT BOTTOM COLUMNS :

$D_2, D_3, D_4, D_5, D_6, E_2, E_3, E_4, E_5, E_6$:

$4 \times 42.463 \times \frac{1}{2} + 42463 \times \frac{1}{4} + 4 \times 46181 + 46181 \times \frac{1}{2}$ = 303 357 KG

SUM = 2.286.332 KG

$$\Rightarrow p_1 = 2286.332 / 32 \times 6.5 = 10.992 \text{ KG/M}^2$$

* Distance of piles = $\sqrt{\frac{40.000}{10\,992}} = 1,91\ M$

$\Rightarrow n = 85$ piles

2/ When the tanks are empty :

$P = 2.286\,332 - 842.400 = 1443.932\ KG$

$\Rightarrow p'c = 1.443.932 / 32 \times 6.5 = 6942\ KG/M^2$

$pc = 6942 - (0,8 \times 1 \times 1 \times 2500) = 4942\ KG/M^2$

* SLAB $D_2 D_6 E_2 E_6$:

$M_D = -0,7 M_0 = -0,7 \times 4942 \times 6,5^2/8 = -18.670\ KGM$

$M_{DE} = 0,7 M_0 = 18.670\ KGM$

* REINFORCEMENT : ($t = 80\ cm$)

. $M = -18.670\ KGM$

$\Rightarrow F_a = \frac{1867000}{1600 \times 0,96 \times 68} = 17,9\ cm^2$

$\Rightarrow 4\phi 18 + 4\phi 16 = 18,22\ cm^2$

* SHALLOW FOOTING AREA B_2D_2 B_CD_6 /

- 1ST FLOOR SLAB : DL + LL :

$(0,1+0,8)\times 32 \times 13 \times 2500$
$+ 500 \times 32 \times 13$
$+ 1.700 \times 6 + 1.100 \times 5$ $= 1.159.700$ KG /

- LOAD AT BOTTOM COLUMNS :

$\frac{1}{2} \times 4 \times 43239 + 43239 \times \frac{1}{4}$
$+ 83116 \times 4 + 83116 \times \frac{1}{2}$
$+ 4 \times 42463 \times \frac{1}{2} + 42463 \times \frac{1}{4}$ $= 566.852$ KG /

SUM $= 1.726.552$ KG

$\Rightarrow p_1 = 1.726.552 / 32 \times 13 = 4150$ KG/M^2

$\Rightarrow p_c = 4150 - (0,9 \times 1 \times 1 \times 2500) = 1900$ KG/M^2 /

* Distance of piles: $= \sqrt{\frac{40.000}{4150}} = 3,1\ M$
$\Rightarrow n = 3$ piles.

- SLAB SPAN 6.5 M x 3.2 M ($B_2 C_2 B_6 C_6$; $D_2 C_2 D_6 C_6$)

$$M_a^- = -0,5\ M_o = -0,5 \times \frac{P \times l}{4}$$

$$= -0,5 \times [40.000 - (3.5 \times 3,5 \times 0,8 \times 2500)] \times 6,5/4$$

$$= -12.594\ KGM$$

$$M_t = 12.594\ KGM$$

* REINFORCEMENT : . $M = -12.594$ KGM

$$\Rightarrow F_a = \frac{-12.59400}{1600 \times 0,97 \times 68} = 12\ cm^2$$

$\Rightarrow 4\phi 12 + 4\phi 16 = 12,56\ cm^2$

. $M = 12.594$ KGM

$$\Rightarrow F_a = \frac{12.59400}{1600 \times 0,97 \times 73} = 11\ cm^2$$

$\Rightarrow 4\phi 12 + 4\phi 16 = 12.56\ cm^2$

* REINF. FOR SPAN 3.2 M OF SLAB , USE $4\phi 16 = 8.04\ cm^2$

* SHALLOW FOOTING B6E6 B10E10

- 1ST FLOOR SLAB, DL + LL :

$(0{,}1+0{,}8) \times 32 \times 13 \times 2500$
$+ 500 \times 32 \times 13$
$+ 10.000 \times 3 + 840 \times 3$ = 1.236 520 KG

- WALL : $(32 + 19{,}5 + 24 + 13) \times 0{,}2 \times 7{,}4 \times 2000$ = 261.960 KG

- LOAD AT BOTTOM COLUMNS

$\frac{1}{2} \times 5 \times 68183 + 5 \times 236.188$
$+ 5 \times 67.604 + 4 \times 137.188$ = 2.238.170 KG

SUM = 3.736.650 KG

$\Rightarrow p_1 = 3736.650 / 32 \times 19{,}5 = 5988 \text{ KG/M}^2$

* Distance of piles = $\sqrt{\frac{40.000}{5988}} \approx 2{,}6$ M
$\Rightarrow n = 10$ piles

* Pressure for calculation :

$p_c = 5988 \text{ Kg} - (0{,}866 \times 2500) \approx 3822 \text{ KG/M}^2$

* SLAB $B_7B_8E_7E_8$ (8M x 19,5M) - SHORT SPAN :

$M_a^- = -0{,}7 \times M_o = -0{,}7 \times \frac{3822 \times 8^2}{8} = -21.403 \text{ KGM}$

$M_t = 21.403 \text{ KGM}$ - * FOR LONG SPAN : $M_a^- = -10702 \text{ KGM}$
$M_t = 6421 \text{ KGM}$

× REINFORCEMENT (t = 80 cm)

. M = - 21 403 KG m

$$\Rightarrow Fa = \frac{2140300}{1600 \times 0,96 \times 68} = 20,5\ cm^2$$

$\Rightarrow 4\phi 20 + 4\phi 16 = 20,6\ cm^2$

. M = 21 403 KGm

$$\Rightarrow Fa = \frac{2140300}{1600 \times 0,96 \times 73} = 19,1\ cm^2$$

$\Rightarrow 4\phi 20 + 4\phi 16 = 20,6\ cm^2$

. M = - 10.702 KGm $\Rightarrow$ Fa = 10,3 cm^2

$\Rightarrow 4\phi 16 + 4\phi 12 = 12,56\ cm^2$

. M = 6421 KGm $\Rightarrow$ Fa min = $4\phi 16 = 8,05\ cm^2$

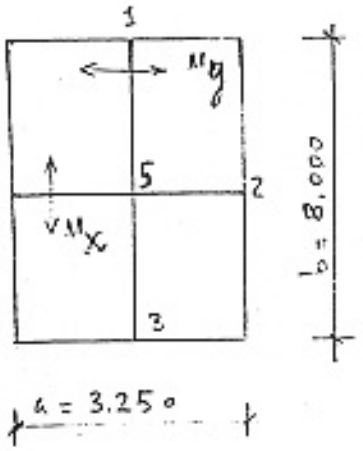
* RESUME QUANTITY CALCULATION OF PILE :

LOCATION AREA	DISTANCE OF PILE		NUMBER OF PILE	
	CALCULATED (M)	ACTUAL (M)	THIS TIME	PREPARE FOR FUTURE
$A_6 A_{10} B_6 B_{10}$	1,48 □	1,45 x 1,6	115	
$A_2 A_6 B_2 E_6$	2,04 □	1,9 x 2,17	64	
$A_1 A_2 D_1 D_2$	2,3 □	1,9 x 2,2	45	
$D_2 E_1 D_2 E_2$	1,6 □	1,56 x 1,6	30	
$D_2 D_6 E_2 E_6$	1,91 □	1,8 x 1,6	85	
$B_2 D_2 B_6 D_6$	3,10 □	3,1 x 3,27	30	
$B_6 E_6 B_{10} E_{10}$	2,6 □	2,67 x 2,45	103	
OTHERS			20	27
SUB TOTAL			492	27
TOTAL				519

* PIPE GALLERY – SECTION 5.00 M (UPPER SLAB $\ell = 40$ cm)

- $p = \begin{cases} 0,15 \times 1 \times 1 \times 2500 + 0,75 \times 1 \times 1 \times 2000 \\ +4,05 \times 1000 \\ +0,4 \times 1 \times 1 \times 2500 \end{cases} = 6925$ KG/M² /

(AT TREATED WATER TANK)



$a/b = 3,25/8 = 0,4$

$M_{y2} = -1/11 \times 6925 \times 3.25^2 = -6650$ KGM

$M_{y5} = 1/11 \times 6925 \times 3.25^2 = 6650$ KGM

$M_{x3} = 0,5 M_{y2} = 0,5 \times 6650 = -3325$ KGM

$M_{x5} = 0,3 M_{y5} = 0,3 \times 6650 = 1995$ KGM

. AT OTHER LOCATION

$p = 500 + 0,5 \times 1 \times 1 \times 2500 = 1750$ KG/M²

$M_{y2} = -0,060 \times 1750 \times 6,5^2 = 4436$ KGM

$M_{y5} = 0,023 \times 1750 \times 6,5^2 = 1702$ KGM

$M_{x3} = -0,054 \times 1750 \times 6.5^2 = 3992$ KGM

$M_{x5} = 0,017 \times 1750 \times 6.5^2 = 1258$ KGM

* PIPE GALLERY – SECTION 6,50M : (UPPER SLAB $\ell = 40$ cm)

- AT SLUDGE TANK : $0,15 \times 1 \times 1 \times 2500 + 0,75 \times 1 \times 1 \times 2000$

$p = \begin{cases} +4,05 \times 1000 \\ +0,4 \times 1 \times 1 \times 2500 \end{cases} = 6925$ KG/M² /

$b/a = 6.5/4 = 1,6$

$M_{y2} = -0,060 \times 6925 \times 4^2 = -6648$ KGM /

$M_{y5} = 0,023 \times 6925 \times 4^2 = 2549$ KGM /

$M_{x3} = -0,054 \times 6925 \times 4^2 = -5983$ KGM /

$M_{x5} = 0,017 \times 6.925 \times 4^2 = 1884$ KGM /

- AT POLYMER TANK :

$p_1 = 500 + 0,5 \times 1 \times 1 \times 2500) = 1750$ KG/M² /

$M_1 y_2 = -0,060 \times 1750 \times 4^2 = -1680$ KGM

$M_1 y_5 = 0,023 \times 1750 \times 4^2 = 644$ KGM

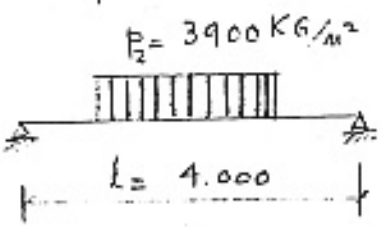
$M_1 x_3 = -0,054 \times 1750 \times 4^2 = -1512$ KGM

$M_1 x_5 = 0,017 \times 1750 \times 4^2 = 476$ KGM

• POLYMER TANK $p_2' = \frac{24.000}{3,14 \times 1,4^2} = 3900\ KG/M^2$

$\Rightarrow p_2 = 3900 - 500 = 3400\ KG/M$

a = 0.600 b = 2.800



$$M_{o2} = \frac{p_2 b (2l - b)}{8} = \frac{3400 \times 2,800 (2 \times 4 - 2,80)}{8} = 6.188\ KGM$$

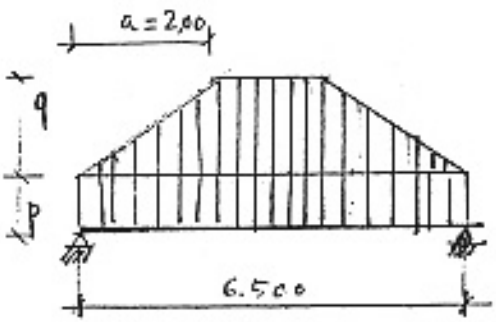
$$\Rightarrow M_{y2} = -(1680 + 6188) = -7868\ KGM$$

$$M_{15} = 644 + 6.188 = 6832\ KGM$$

$$M_{x3} = -(1512 + 6.188) = -7700\ KGM$$

$$M_{x5} = 476 + 6188 = 6664\ KGM$$

* BEAM SPAN 6,5 M AT SLUDGE TANK : 80 x 100



• uniform load :

$p = 0,8 \times 1,0 \times 1 \times 2500 + 4,4 \times 4,8 \times 1 \times 2500 = 6800\ KG/M$

$$M_{o1} = \frac{6800 \times 6,5^2}{8} = 35.913\ KGM$$

$$q = (0,75 \times 2000 + 0,4 \times 2500 + 0,15 \times 2500 + 4,05 \times 1000 + 500) \times \frac{4}{2} = 14.850\ KG$$

Triangular load

$$M_{o2} = \frac{q}{2}\left[\frac{l^2}{4} - \frac{a^2}{3}\right] = \frac{14.850}{2}\left[\frac{6,5^2}{4} - \frac{2^2}{3}\right] \times 2 = 137.103\ KGM$$

$$M_o = 35913 + 137.103 = 173016\ KGM$$

CASE 1 :

$$\Rightarrow M_t = 0,7 \times 173016 + 3500 = 124.611\ KGM$$

$$M_a = -0,7 \times 173016 - 3500 = -124.611\ KGM$$

CASE 2 :

$$M_t = 0,7 \times 173.016 - 48,600 = 74.311\ KGM$$

$$M_a = -0,7 \times 173.016 + 48.600 = -74.311\ KGM$$

$$N_{max} = 2912\ KG + 13870\ KG = 16.782\ KGM$$

* SHEAR :

$N_1 = 6800 \times \frac{6,5}{2} + 2\left(\frac{6.5+2.5}{2} \times \frac{1}{2} \times 7425\right) = 55513$ KG /

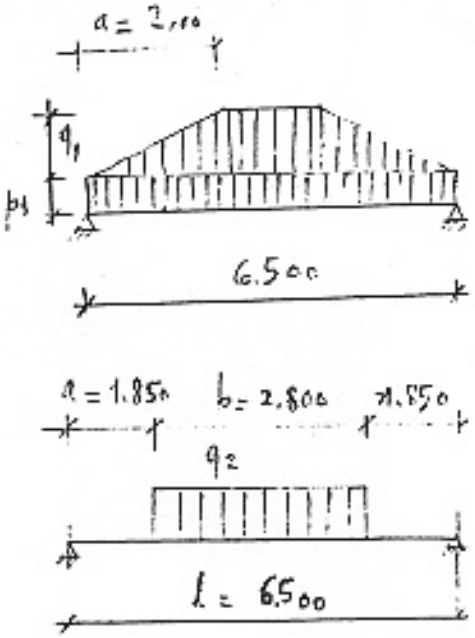
(AT THE WALL OF TANK)

(SECTION 800 x 1000)

$N_2 = 2\left(\frac{6.5+2.5}{2} \times \frac{1}{2} \times 7425\right) = 33413$ /

(AT MIDDLE THE TANK) $\tau = 33413 \times \frac{2.35}{3,25} / 80 \times 100 = 3 \text{ kg/cm}^2 < 3,6 \text{ KG/CM}$

+ BEAM SPAN 6.5 M AT POLYMER TANK (800 x 1000)



$p_1 = 98 \times 1 \times 1 \times 2500 = 2000$ KG/M /

$q_1 = [0,4 \times 1 \times 1 \times 2500 + 500] \times 2 = 3000$ KG

$M_{01} = \frac{2000 \times 6,5^3}{8} + \frac{q_1}{2}\left[\frac{l^2}{4} - \frac{a^2}{3}\right] \times 2$

$= 10.563 + \frac{3000}{2}\left[\frac{6.5^2}{4} - \frac{2^2}{3}\right] \times 2 = 38.261$ KGM

$q_2 = \frac{24.000 + 3077}{2,8} = 7473$ KG/M

$M_{02} = \frac{7473 \times 2,8(2 \times 6.5 - 2.8)}{8} = 26.679$ KGM

$M_0 = 38.261 + 26.679 = 64.940$ KGM

* Calc 1

$\Rightarrow M_t = 0,7 \times 64.940 + 720 = 46.178$ KGM

$M_a = -0,7 \times 64.940 - 720 = -46.178$ KGM

* CALE 2 :

$M_t = 0,7 \times 64.940 - 6700 = 38758$ KGM

$M_a = -0,7 \times 64.940 + 6700 = -38758$ KGM

$N = 567 + 13870 = 14.437$ KG /

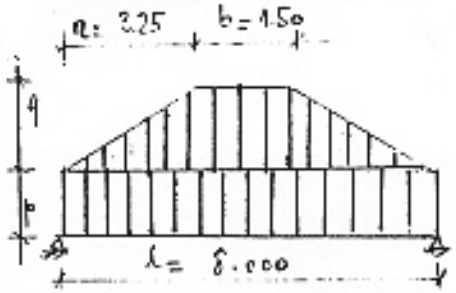
* SPEAR :

$N_{max} = 2000 \times 3,25 + 9 \times 1500) + \frac{29.000 \times 1,6}{2}$

$= 39.200 \text{ KG}$

$\tau = 39.200 \times \frac{2,35}{3,25} / (100 \times 80) \approx 3,5 \text{kg/cm}^2 < 3,6 \text{kg/cm}^2$

* BEAM SPAN 8,00 M (PIPE GALLERY) (80 x 130) (E) Axis



* Uniform load :

- Beam : $0,8 \times 1,3 \times 1 \times 2500 = 2600 \text{ KG/M}$
- Wall $2 \times 0,2 \times 1 \times 2000 = 800 \text{ KG/M}$
- Wall of Tank : $5 \times 0,4 \times 1 \times 2500 = 5000 \text{ KG/M}$

Sum = 8400 KG/M

$M_{o1} = \frac{8400 \times 8^2}{8} = 67200 \text{ KGM}$

$q = [0,4 \times 1 \times 1 \times 2500 + 4,7 \times 1000] \times \frac{3,25}{2} = 8288 \text{ KG}$

$M_{o2} = \frac{q}{2}\left[\frac{l^2}{4} - \frac{a^2}{3}\right] = \frac{8288}{2}\left[\frac{8^2}{4} - \frac{1,63^2}{3}\right] = 62.633 \text{ KGM}$

$M_o = M_{o1} + M_{o2} = 67200 + 62.633 = 129.834 \text{ KGM}$

$M_t = 0,7 \times 129.834 = 90.884 \text{ KGM}$

$M_a = -0,7 \times 129.834 = -90.884 \text{ KGM}$

$N = 13870 \text{ KG}$

* SHEAR :

$$N = 8400 \times 4 + \frac{1.63}{2 \times 2}(4{,}7+8) \times 5100 = 42.716 \text{ KG}$$

$$\tau = \left(42.716 \times \frac{3}{4}\right) / (80 \times 130) = 3{,}05 \text{ KG/CM}^2 < 3{,}6 \text{ kg/cm}^2$$

* BEAM SPAN 8M AT PIPE GALLERY - Ⓓ AXIS (800×1200) :

* Uniform load

- Beam : $0{,}8 \times 1{,}2 \times 1 \times 2500 = 2400$ KG/M
- Wall of tank : $5 \times 0{,}4 \times 1 \times 2500 = 5000$ KG/M

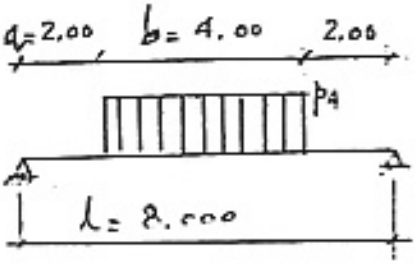
$$q_{UM} = 7400 \text{ KG/M}$$

$$M_{01} = -\frac{7400 \times 8^2}{8} = 59.200 \text{ KGM}$$

$$M_{02} = 62.633 \text{ KGM}$$

$$M_{03} = \frac{q_3}{2}\left(\frac{l^2}{4} - \frac{a^2}{3}\right) = \frac{1500 \times 1{,}63}{2}\left(\frac{8^2}{4} - \frac{1.63^2}{3}\right) = 18.477 \text{ KGM}$$

$$p_4 = 2300 / 4 = 575 \text{ kg/m}$$



$$M_{04} = \frac{p_4 b (2l - b)}{8} = \frac{575 \times 4 (2 \times 8 - 4)}{8} = 3450 \text{ KGM}$$

$$M_0 = 59.200 + 62633 + 18.477 + 3450 = 143.760 \text{ KG}$$

$$\Rightarrow M_t = 0{,}7 \times 143.760 = 100.632 \text{ KGM}$$

$$M_A = -0{,}7 \times 143.760 = -100.632 \text{ KGM}$$

$$N = 13.870 \text{ KG}$$

* SHEAR:

$$N = 7400\times4 + \frac{1.63}{2\times2}(7.4+8)\times6600 + \frac{2300}{2} = 72\,168\ KG$$

$$\tau = \left(72\,168\times\frac{3}{4}\right)/[120\times80+(40\times48)] = 1{,}87\ KG/CM^2 < 3.6\ KG/CM^2$$

* BEAM SPAN 8M AT PIPE GALLARY (OTHERS)

$$M_o = 2400\times\frac{8^2}{8} + 18.477\times2+3450 = 59\,604\ KGM$$

$$M_a = -0{,}7\times59.604 = -41.723\ KGM$$

$$M_t = 0{,}7\times59\,604 = 41723\ KGM$$

$$N = 13.870\ KG$$

- SHEAR

$$N = 2400\times4 + \frac{1.63}{2\times2}(7.4+8)\times(1500\times2) + \frac{2300}{2} = 29.577\ KG$$

$$\tau = 29.577/120\times80 = 3{,}1\ KG/CM^2 < 3.6\ KG/CM^2$$

* BEAM (A) AXIS, LEVEL +2.5 M (300x1300)

- SPAN 4M : (A & A10)

$$M_{oj} = p_1 l^2/8 = \left(2600 + 0{,}3\times48\times2500 + 0{,}2\times2{,}5\times2000\right)\frac{4^2}{8} = 14400\ KGM$$

$$M_{o2} = (0{,}4\times2500 + 0{,}25\times2000 + 4{,}01\times1000)\times2\times\frac{4^2}{12} = 17.600\ KGM$$

$$M_o = 14.400 + 17.600 = 32.000\ KGM$$

. EDGE SPAN : $M_a^- = -0{,}7\times M_o = -0{,}7\times32.000 = -22{,}400\ KGM$

$M_t = 22.400\ KGM$

. MIDSPAN : $M_a^- = -0.5\ M_o = -16.000\ KGM$

$M_t = 16.000\ KGM$

* SHEAR : $N = 2600\times2 + 7200 + 2000 + 6600\times4 = 40.800\ KG$

$$\tau = 40.800\times\frac{3}{4}/(130\times80) = 3\ KG/CM^2 < 3{,}6\ KG/CM^2$$

* BEAM A_1 A_C

- SPAN UM :

$M_{o1} = p_1 l^2/8 = \left(2600 + 0{,}2 \times 7{,}3 \times 2000\right)\frac{4^2}{8} = 11040$ KGM

$M_{o2} = \left(0{,}4 \times 2500 + 500\right) \times 2 \times \frac{4^2}{12} = 4000$ KGM

$M_{o3} = 24.000/2 \times \frac{4}{4} = 12.000$ KGM

$M_o = 11.040 + 4000 + 12.000 = 27.040$ KGM

. AT EDGE SPAN $M_a = -0{,}7 \times 27.040 = -18.928$ KGM

$M_t = 18928$ KGM

. AT MIDSPAN : $M_a = -0{,}5 \times 27.040 = -13.520$ KGM

$M_t = 13.520$ KGM

- SPAN SM :

$M_{o1} = p_1 l^2/8 = \left(2600 + 0{,}2 \cdot 7{,}3 \times 2000\right)\frac{8^2}{8} = 44.160$ KGM

$M_{o2} = \left(0{,}4 \times 2500 + 500\right) \times 4 \times \frac{8^2}{12} = 32.000$ KGM

$\Rightarrow M_o = 44.160 + 32.000 = 76.160$ KGM

$M_a = -0{,}7 \times 76.160 = -53.312$ KGM

$M_t = 53.312$ KGM

. SHEAR : $N = 2600 \times 4 + 2920 \times 4 + 1500 \times \frac{16}{2} = 34.080$ KG

$\tau = 34.080/130 \times 80 = 3{,}3$ KG/CM^2 $< 3{,}6$ KG/CM^2

* BEAM A_{10} B_{10} (130 × 80)

$M_{o1} = p_1 l^2/8 = \left(2600 + 0{,}4 \times 4{,}5 \times 2500 + 0{,}2 \times 2{,}5 \times 2000\right)\frac{6{,}5^2}{8}$

$= 44.363$ KGM

$M_{o2} = 68.552$ KGM

$M_o = 44.363 + 68.552 = 112.915$ KGM

$\Rightarrow M_t = 0{,}7 \times 112.915 + 4.950 = 83.991$ KGM

$M_a = -0{,}7 \times 112.915 - 4950 = -83.991$ KGM

$N = 2912 + 13.870 = 16782$ KG

* STRIP B_8E_8 , B_9E_9 , B_7E_7 ($b = 1{,}6M$, $t = 80\,cm$)

$M_o = 3{,}25 \times 3822 \times \frac{6.5^2}{12} \times 2 = 87.468$ KGM

. AT EDGE SPAN : $M_{a_D} = -\left(0{,}7 \times M_o + \frac{10.915}{2}\right) = -66.685$ KGM

$M_{t_{DE}} = 66.685$ KGM

$M_E = -118.499$ KGM , $N = 13\,211$ KG

. AT MIDSPAN : $M_{a_C} = -\left(0{,}5 \times M_o + \frac{117.119}{2}\right)$

$= -102.294$ KGM

$M_{t_{CD}} = 102\,294$ KGM , $N = 13.219$ KG

$M_B = -109.867$ KGM

$M_{BC} = 0{,}5 \times M_o + \frac{10.886}{2} = 49.177$ KGM

$N = 13.219$ KG

* STRIP $E_C E_{10}$ (1000 × 800)

- SPAN 8,00M : $M_o = 3822 \times 3{,}25/2 \left(\frac{8^2}{4} - \frac{3{,}25^2}{3}\right) = 77.505$ KGM

- EDGE SPAN : $M_a = -0{,}7 \times M_o = -54.254$ KGM

$M_t = 54.254$ KGM

- MIDSPAN : $M_a = -0{,}5 \times M_o = -38.753$ KGM

$M_t = 0{,}5 \times M_o = 38.753$ KGM

* STRIP C_2C_6 (1300 × 800) , D_2D_6

- SPAN 8,00M : $M_o = 1900 \times 3{,}25/2 \left(\frac{8^2}{4} - \frac{3{,}25^2}{3}\right) \times 2 = 77.052$ KGM

$M_a = -0{,}7 \times M_o = -53.941$ KGM

$M_t = 53.941$ KGM

* REINFORCEMENT : $t = 40$ CM

a AT SLUDGE TANK :

. $M = 6648$ KGM

$\Rightarrow F_A = \dfrac{664800}{1600 \times 0{,}94 \times 33} = 13{,}4\ CM^2$

$\Rightarrow 4\phi 22 = 15{,}2\ CM^2$

. $M = -5983$ KGM

$\Rightarrow F_A = \dfrac{598300}{1600 \times 0{,}94 \times 33} = 12\ CM^2$

$\Rightarrow 4\phi 20$

. $M = 2549$ KGM

$\Rightarrow F_A = \dfrac{254900}{1600 \times 0{,}97 \times 33} = 4{,}97\ CM^2$

$\Rightarrow 4\phi 12 : 4{,}52\ CM^2$

. $M = 1884$ KGM $\Rightarrow$ USE $F_{A\,min} = 4\phi 12 = 4{,}52\ CM^2$

* AT TREATED WATER TANK : $t = 40$ CM

. $M = 6650$ KGM

$\Rightarrow F_A = \dfrac{665000}{1600 \times 0{,}94 \times 33} = 13{,}4\ CM^2$

$\Rightarrow 4\phi 22 = 15{,}2\ CM^2$

. $M = 3325$ KGM

$\Rightarrow F_A = \dfrac{332500}{1600 \times 0{,}98 \times 33} = 6{,}43\ CM^2$

$\Rightarrow 4\phi 16 = 8{,}04\ CM^2$

. $M = 1995$ KGM $\Rightarrow$ USE $F_{A\,min} = 4\phi 12 = 4{,}52\ CM^2$

* AT OTHER LOCATION FOR SLAB $t = 40$ CM

. $M = -4436$ KGM

$\Rightarrow F_A = \dfrac{443600}{1600 \times 0{,}97 \times 33} = 8{,}66\ CM^2$

$\Rightarrow 4\phi 18 = 10{,}18\ CM^2$

. $M = -3992$ KGM $\Rightarrow F_A = 7{,}7\ CM^2 \Rightarrow 4\phi 16 = 8{,}04\ CM^2$

. $M \leq 1702$ KGM $\Rightarrow$ USE $F_{A\,min} = 4\phi 12 = 4{,}52\ CM^2$

$\longrightarrow$

* AT POLYMER TANK :

. M = − 7868 KGM

$\Rightarrow Fa = \frac{786800}{1600 \times 0,93 \times 33} = 16,62 cm^2$

$\Rightarrow 4\phi 25 = 19,63 cm^2$

. M = − 7700 KGM $\Rightarrow$ $4\phi 25 : 19,63 cm^2$

. M = 6832 KGM

$\Rightarrow Fa = \frac{683200}{1600 \times 0,94 \times 33} = 13,8 cm^2$

$\Rightarrow 4\phi 22 = 15,2 cm^2$

. M = 6596 KGM $\Rightarrow$ $4\phi 22 = 15,2 cm^2$

* BEAM SPAN 6,5 M AT SLUDGE TANK : (800x1000)

. M = 124.611 KGM, N = 16.782 KG $\Rightarrow \ell = M/N = 743 cm$

$\Rightarrow Fa = \frac{16782 (743 + 100/2 - 12)}{1600 \times (81)} = 101,2 cm^2$

$\Rightarrow 17\phi 28 = 104,7 cm^2$

* BEAM SPAN 6,5M AT POLYMER TANK : (800x1000)

. M = 46.178 KGM . N = 14.437 KG

$\ell = M/N = 46178/14.437 = 320 cm$

$\Rightarrow Fa = \frac{14.437 (320 + 100/2 - 17)}{1600 (86)} = 38 cm^2$

$\Rightarrow 8\phi 25 = 39,3 cm^2$

* BEAM SPAN 8,00 M (PIPE GALLERY) (E) AXIS (80x130)

. M = 90.884 KGM, N = 13870 KG

$\ell = M/N = 655 cm$

$\Rightarrow Fa = \frac{13.870 (655 + 100/2 - 14)}{1600 (81)} = 73,95 cm^2$

$\Rightarrow 12\phi 28 = 73,9 cm^2$

* BEAM SPAN 8M AT Ⓓ AXIS : (80x120cm)

. M = 100.632 KGM ; N = 13.870 KG

$e = M/N = 726$ cm.

$\Rightarrow Fa = \frac{13.870\,(726 + 120/2 - 12)}{1600(10-1)} = 66,4\ cm^2$

$\Rightarrow 11\phi 28 = 67,7\ cm^2$

* BEAM SPAN 8M AT PIPE GALLARY (OTHERS)

M = 41.723 KGM ; N = 13870 KG

$e = M/N = 301$ cm

$\Rightarrow Fa = \frac{13.870\,(301 + 120/2 - 7)}{1600(116)} = 26,5\ cm^2$

$\Rightarrow 7\phi 22 = 26.6\ cm^2$

* BEAM $A_{10}A_6$, $B_{10}B_6$: (800x1300)

M = 22.400 KGM

$\Rightarrow Fa = \frac{2240000}{1600 \times 0,99 \times 123} = 11,5\ cm^2$ /

$\Rightarrow 4\phi 20 = 12,56\ cm^2$ /

M = 16.000 KGM

$\Rightarrow Fa = \frac{1600000}{1600 \times 0,99 \times 123} = 8,2\ cm^2$ /

$Fa_{min} = 10,4\ cm^2 \Rightarrow 4\phi 20 = 12,56\ cm^2$ /

* BEAM A_1A_6, B_2B_6 :

. M = 18.928 KGM

$\Rightarrow Fa = \frac{1892800}{1600 \times 0,99 \times 123} = 9,7\ cm^2$

$\Rightarrow 4\phi 20 = 12,56\ cm^2$ /

. M = 13.520 KGM

$\Rightarrow$ USE $Fa_{min} = 4\phi 20 = 12,56\ cm^2$ /

. M = 53.312 KGM

$\Rightarrow Fa = \frac{5331200}{1600 \times 0,97 \times 123} = 22\ cm^2$ /

$\Rightarrow 5\phi 28 = 30,8\ cm^2$

* BEAM $A_{10}B_{10}$ (1300 x 800 cm)

. M = 83.991 KGM

N = 16782 KG $\Rightarrow \ell = \frac{M}{N} = 500$ cm

$\Rightarrow Fa = \frac{16782\,(500 + 130/2 - 7)}{1600\,(116)} = 50{,}45\ CM^2$

$\Rightarrow 8\phi 28$

* STRIP B_8E_8 ; B_9E_9 ; B_7E_7 (b = 1,6 M, t = 80 cm)

* M = -102.294 KGM ; N = 13219 KG

$\Rightarrow M/N = 774$ cm

$\Rightarrow Fa = \frac{13.219\,(774 + 80/2 - 5)}{1600\,(61)\,(1,6)} = 68{,}5\ CM^2/M$

$\Rightarrow 7\phi 36 \# 71{,}3\ CM^2/M$

* M = - 66685 KGM , N = 13.219 KG

$\Rightarrow M/N = 504$ cm

$\Rightarrow Fa = \frac{13.219\,(504 + 80/2 - 12)}{1600\,(61)\,(1,6)} = 45\ CM^2$

$\Rightarrow 6\phi 32 = 48{,}25\ CM/M$

* M = 49.177 KGM ; N = 13219 KG

$\Rightarrow M/N = 372$ cm

$\Rightarrow Fa = \frac{13.219\,(372 + 80/2 - 7)}{1600\,(66)\,(1,6)} = 31{,}7\ CM^2$

$\Rightarrow 7\phi 25 = 34{,}4\ CM^2/M$

* M = -118.499 KGM , N = 13.219 KG

$\Rightarrow M/N = 896$ cm

$\Rightarrow Fa = \frac{13.219\,(896 + 80/2 - 7)}{1600 \times 66 \times 1,6} = 72{,}7\ CM^2$

$\Rightarrow 7\phi 36 /M$

* M = -109.867 KGM , N = 13219 KG $\Rightarrow M/N = 831$ cm

$\Rightarrow Fa = \frac{13\,219\,(831 + 80/2 - 12)}{1600 \times 61 \times 1,6} = 72.7\ CM^2$

$\Rightarrow 7\phi 36 /M$

* FERRAILLAGE :

* STRIP E_6E_{10} (1000x800)

. $M = -54\,254$ KGM

$\Rightarrow F_a = \frac{5425400}{1600 \times 0,89 \times 68} = 56\ cm^2$ $\Rightarrow 7\phi32 = 56,3\ cm^2$

. $M = -38753$ KGM

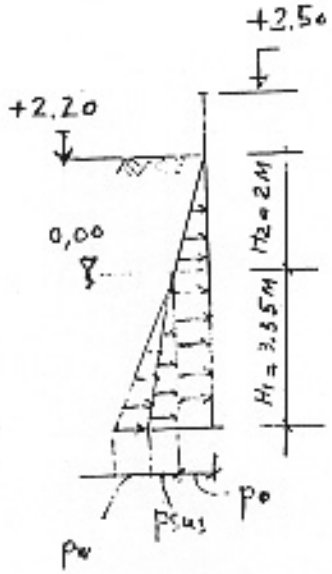
$\Rightarrow F_a = \frac{3875300}{1600 \times 0,92 \times 68} = 38,7\ cm^2$

$\Rightarrow 5\phi32 = 40,21\ cm^2$

* STRIP C_2C_6 (1300x800) ; D_2D_6 (1300x800)

. $M = -53.941$ KGM $\Rightarrow 7\phi32 = 56,3\ cm^2/1,3M$

* WALL (UNDER LEVEL +2.50)



a) Pressure of soil and water :

$p_{sus} = (\gamma' - \gamma_w) H_1 \times K_o$

$= (1800 - 1000) 3,35 \times 0,5 = 1340 \text{ KG/M}^2$

$p_o = \gamma' \times H_2 \times K_o$

$= 1800 \times 2,2 \times 0,5 \simeq 1980 \text{ KG/M}^2$

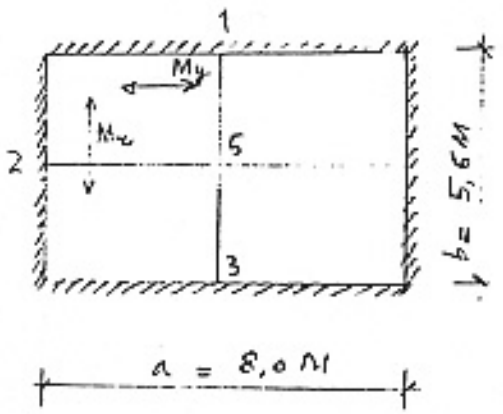
$p_w = \gamma_w \times H_1 = 1000 \times 335 = 3350 \text{ KG/M}^2$

$p = p_o + p_{sus} + p_w = 6670 \text{ KG/M}^2$

b) Vehicle load :

$p_v = 500 \text{ KG/M}^2$

* SLAB 8M x 5,6M : $a/b = 1,4$



a) Soil pressure load :

$M_{y_2} = -0,025 \times 6670 \times 5,6^2 = -5229 \text{ KGM}$

$M_{y5} = 0,009 \times 6670 \times 5,6^2 = 1883 \text{ KGM}$

$M_{1x_1} = -0,033 \times 6670 \times 5,6^2 = -6902 \text{ KGM}$

$M_{1x_3} = -0,050 \times 6670 \times 5,6^2 = -10458 \text{ KGM}$

$M_{1x_5} = 0,025 \times 6670\ 5,6^2 = 5229 \text{ KGM}$

b) Vehicle load :

$M_{2y_2} = -0,051 \times 500 \times 5,6^2 = -800 \text{ KGM}$

$M_{2y5} = 0,018 \times 500 \times 5,6^2 = 282 \text{ KGM}$

$M_{2x_1} = -0,083 \times 500 \times 5,6^2 = -1301 \text{ KGM}$

$M_{2x_3} = -0,083 \times 500 \times 5,6^2 = -1301 \text{ KGM}$

$M_{1x_5} = 0,041 \times 500 \times 5,6^2 = 643 \text{ KGM}$

$\Rightarrow M_{y2} = M_{1y2} + M_{2y2} = 6029 KGM$

$M_{y5} = M_{1y5} + M_{2y5} = 2165 KGM$

$M_{x1} = M_{1x1} + M_{2x2} = -8203 KGM$

$M_{x3} = M_{1x3} + M_{2x3} = -11759 KGM$

$M_{x5} = M_{1x5} + M_{2x5} = 5872 KGM$

* Pressure of water inside : $p = \gamma h = 1000 \times 5,35 = 5350 KG.$

$M_{y2} = -0,025 \times 5350 \times 5,6^2 = -4194 KGM$ /

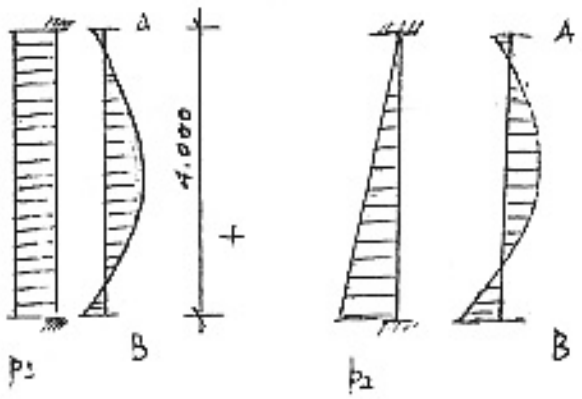
$M_{y5} = 0,009 \times 5350 \times 5,6^2 = 1510 KGM$ /

$M_{x1} = -0,033 \times 5350 \times 5,6^2 = -5537 KGM$ /

$M_{x3} = -0,050 \times 5350 \times 5,6^2 = -8389 KGM$ /

$M_{x5} = 0,025 \times 5350 \times 5,6^2 = 4194 KGM$ /

* TEMPORARY WALL (AT THE WAY TO FUTURE GRAVITY THICKENERS)



$p_1 = p_v + \gamma h_A \times K_o$

$= 500 + 1800 \times 1,4 \times 0,5$

$= 1760 KG/M^2$ /

$p_2 = 6670 - 1760 = 4910 KG$

$\Rightarrow M_A = -\left(\frac{1760 \times 4^2}{12} + \frac{4910 \times 4^2}{30}\right) = -4965 KGM$ /

$M_B = -\left(\frac{1760 \times 4^2}{12} + \frac{4910 \times 4^2}{20}\right) = -6275 KGM$ /

$M_t = \left(\frac{1760 \times 4^2}{24} + \frac{4910 \times 4^2}{40}\right) = 3137 KGM$ /

* WALL BESIDE STAIR S_1 : $h = 5,6 M$, $t = 50 cm$

$M_A = -6670 \times 5,6^2/30 = -6972 KGM$ /

$M_B = -6670 \times 5,6^2/20 = -10.459 KGM$ /

$M_t = 6670 \times 5,6^2/40 = 5230 KGM$ /

* REINFORCEMENT : (t = 50 cm)

. M1 = - 11759 KGM * (Vertical – outer layer)

$\Rightarrow$ $Fa = \frac{1175900}{1600 \times 0,94 \times 43} = 18,1\ cm^2$

$\Rightarrow$ 4Ø20 + 4Ø14 = 18,72 cm^2

. M = - 8203 KGM

$\Rightarrow$ $Fa = \frac{820300}{1600 \times 0.96 \times 43} = 12,48\ cm^2$

$\Rightarrow$ 8Ø14 = 12,34 cm^2

. M1 = 4194 KGM

$\Rightarrow$ $Fa = \frac{419400}{1600 \times 0,98 \times 43} = 6,2\ cm^2$ /

$\Rightarrow$ 4Ø14 = 6,16 cm^2 /

* Horizontal Reinf – Outer layer :

. M = - 6029 KGM

$\Rightarrow$ $Fa = \frac{602900}{1600 \times 0,97 \times 43} = 9,03\ cm^2$

$\Rightarrow$ 4Ø18 = 10,18 cm^2

. M = 1510 KGM

$\Rightarrow$ $Fa = \frac{151000}{1600 \times 0,99 \times 43} = 2,2\ cm^2$ /

use Fa min = 5 cm^2

$\Rightarrow$ 4Ø12

* Vertical Reinf – Inner layer :

. M = - 8389 KGM

$\Rightarrow$ $Fa = \frac{838900}{1600 \times 0,96 \times 43} = 12.7\ cm^2$ /

$\Rightarrow$ 4Ø18 + 4Ø10 = 13,32 cm^2

. M = - 5537 KGM

$\Rightarrow$ $Fa = \frac{553700}{1600 \times 0.97 \times 43} = 8.3\ cm^2$

$\Rightarrow$ 4Ø18 = 10,18 cm^2

. M = 5872 KGM

$\Rightarrow$ $Fa = \frac{587206}{1600 \times 0,97 \times 43} = 8,8\ cm^2$ /

$\Rightarrow$ 4Ø18 = 10,18 cm^2

* Horizontal Reinf – Inner layer :

. M = – 4194 KGM

$\Rightarrow F_a = \frac{419400}{1600 \times 0{,}98 \times 43} = 6{,}2\ CM^2$ ✓

$\Rightarrow 4\phi 14 = 6{,}16\ CM^2$

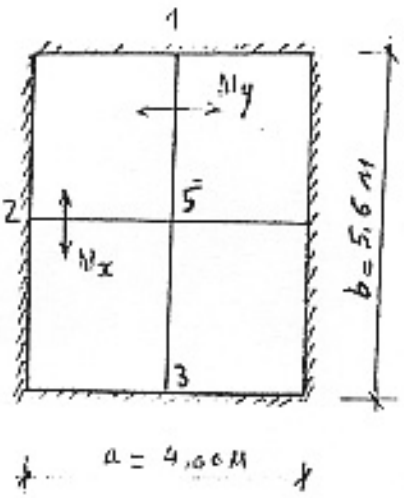
. M = 2165 KGM

$\Rightarrow F_a = \frac{216500}{1600 \times 0{,}99 \times 43} = 3{,}2\ CM^2$

$\Rightarrow$ use $F_{a\,min} = 5\ CM^2 \Rightarrow 4\phi 14 = 6{,}16\ CM^2$

* WALL SLAB 4M X 5,6M :

$a/b = 0{,}7$



a) Soil pressure load :

$M_1 y_2 = -0{,}039 \times 6670 \times 4^2 = -4162\ KGM$

$M_1 y_5 = 0{,}018 \times 6670 \times 4^2 = 1921\ KGM$

$M_1 x_3 = -0{,}093 \times 6670 \times 4^2 = -4589\ KGM$

$M_1 x_2 = -0{,}014 \times 6670 \times 4^2 = -1494\ KGM$

$M_1 x_5 = 0{,}004 \times 6670 \times 4^2 = 427\ KGM$

b) Vehicle load :

$M_2 y_2 = -0{,}051 \times 500 \times 4^2 = -408\ KGM$ ✓

$M_2 y_5 = 0{,}018 \times 500 \times 4^2 = 144\ KGM$ ✓

$M_2 x_1 = -0{,}051 \times 500 \times 4^2 = -408\ KGM$ ✓

$M_2 x_3 = -0{,}051 \times 500 \times 4^2 = -408\ KGM$ ✓

$M_2 x_5 = 0{,}018 \times 500 \times 4^2 = 144\ KGM$ ✓

$\Rightarrow$ $M_{y2} = -(4162 + 408) = -4570$ KGM

$M_{y5} = 1921 + 144 = 2065$ KGM

$M_{x1} = -(1494 + 408) = -1902$ KGM

$M_{x3} = -(4589 + 408) = -4997$ KGM

$M_{x5} = 427 + 144 = 571$ KGM

- Pressure of water inside : $p = \gamma h = 1000 \times 5{,}35 = 5350$ KG/M

$M_{y1} = -0{,}039 \times 5350 \times 4^2 = -3338$ KGM

$M_{y5} = 0{,}018 \times 5350 \times 4^2 = 1541$ KGM

$M_{x3} = -0{,}043 \times 5350 \times 4^2 = -3681$ KGM

$M_{x4} = -0{,}014 \times 5350 \times 4^2 = -1198$ KGM

$M_{x5} = 0{,}004 \times 5350 \times 4^2 = 343$ KGM

* REINFORCEMENT : ($t = 50$ CM)

. Vertical - outer layer :

. $M = -4997$ KGM

$\Rightarrow F_a = \dfrac{499700}{1600 \times 0{,}98 \times 43} = 7{,}4$ CM^2

$\Rightarrow 8\phi 12 = 9{,}04$ CM^2

. $M = -1902$ KGM $\Rightarrow F_{a\,min} = 5$ CM^2 $\Rightarrow 4\phi 12$

. $M = 343$ KGM $\Rightarrow F_{a\,min} = 4\phi 12$

* Horizontal Reinf - Outer layer :

. $M = -4570$ KGM

$\Rightarrow F_a = \dfrac{457000}{1600 \times 0{,}98 \times 43} = 6{,}76$ CM^2

$\Rightarrow 4\phi 16 = 8{,}04$ CM^2

* Vertical Reinf - Inner layer

. M = - 3631 KGM ⇒ Fa = 5,4 cm² ⇒ 4 ϕ14 = 6,16 cm²

* Horizontal Reinf - Inner layer :

. M = - 3338 KGM ⇒ Fa = 4.9 cm² ⇒ 4 ϕ14 = 6,16 cm²

. ALL VALUE OF MOMENT ≤ 3338 KGM USE Famin = 5 cm²

TEMPORARY WALL , t = 50 cm

* . M = - 4965 KGM

⇒ Fa = 496500 / 1600 × 0.97 × 43 = 7,4 cm² /

⇒ 4 ϕ16 = 8.04 cm²

. M = - 6275 KGM

⇒ Fa = 627500 / 1600 × 0,96 × 43 = 9.5 cm² /

⇒ 4 ϕ16 + 4 ϕ12

. M = 3137 KGM

⇒ Fa = 313700 / 1600 × 0,98 × 43 = 4,7 cm² /

⇒ 4 ϕ12

* HORIZONTAL REINF : ϕ12 a 250

* WALL BESIDE STAIR S1 :

M = - 10.459 KGM ⇒ Fa = 1045900 / 1600 × 0,95 × 43 : 16 cm² /

⇒ ϕ18 + ϕ14 a 125

M = - 6972 KGM ⇒ Fa = 697200 / 1600 × 0,97 × 43 = 10,5 cm² /

⇒ ϕ18 a 250

. M = 5230 KGM ⇒ Fa = 523000 / 1600 × 0,98 × 43 = 7,8 cm² /

⇒ ϕ16 a 250

* Horizontal Reinf. ϕ16 a 250 (inside + outside layer)

Vert. Reinf (inner layer) : ϕ16 a 250

* STAIR. (AT $B_9 - B_{10}$)

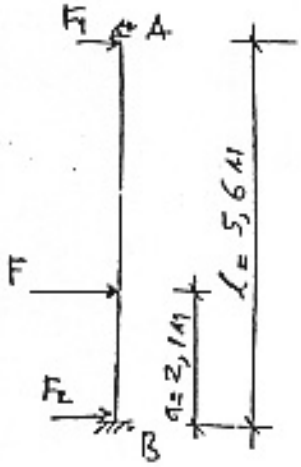
- Stair's width $\approx$ 1200 M

$p(DL + LL) = 1{,}2 \times 1 \times 0{,}3 \times 2500 + 500 = 1400\ KG/M^2$

$M = \frac{pl^2}{8} = 1400 \times \frac{1{,}2^2}{8} = 252\ KGM$

$\Rightarrow$ USE $F_{a\,min}$ = $\phi 12 \text{ a } 250$ for stair's slab

* SOIL PRESSURE EFFECTING AT COLUMN :



$F = 45.860$ KG

$a = d = 2{,}1$ M

$l = 5{,}6$ M

$$F_2 = V_B = \frac{F(l-a)^2(l+2a)}{l^3}$$

$$= \frac{45\,860\,(5.6-2.1)^2\,(5.6+2\times 2{,}1)}{5.6^3}$$

$$= 31.990 \text{ KG}$$

$$F_1 = V_A = 45.860 - 31.990 = 13.870 \text{ KG}$$

$$M_A = -\frac{Fa^2(l-a)}{l^2} = \frac{-45.860\times 2{,}1^2\,(5.6-2{,}1)}{5.6^2}$$

$$= -22572 \text{ KGM}$$

$$M_B = \frac{-Fxa\,(l-a)^2}{l^2} = \frac{-45.860\times 2{,}1\times(5{,}6-2{,}1)^2}{5.6^2}$$

$$= -37.620 \text{ KGM}$$

* COLUMN C_1 : $A_6, A_7, A_8, A_9, A_{10}$ (1000×1000)

- $M_{max} = 0{,}55\times 108000 + 37620 = 70.290$ KGM
- Weight at bottom column :

$1{,}0\times 1{,}0\times 5{,}6\times 2500 + (0{,}4\times 2500 + 0{,}75\times 2000 + 0{,}15\times 2500 + 4050)\times 4\times 3.25 + 0{,}3\times 0\times 4{,}8\times 2500 + 0{,}2\times 2{,}5\times 4\times 2000 + 0{,}3\times 3{,}25\times 4{,}8\times 2500 + 0{,}8\times 1{,}3\times 4\times 2500 + 0{,}8\times 1\times 3.25\times 2500 + 1500/4 + 126.957 = 278.357$ KG

* REINFORCEMENT :

$$e = M/N = 70.290/278.357 = 25 \text{ cm}$$

$$\Rightarrow F_a = \frac{278357\,(25+100/2-12)}{1600\,(100-24)} = 144{,}2 \text{ cm}^2$$

$\Rightarrow 18\phi 32 = 144{,}8 \text{ cm}^2$

* COLUMN C_2 : (800 x 800)

. $M_{max} = 0{,}2 \times 10.886 + 37620 = 39.797$ KGM

. Weight at bottom column # 220 000 KG

$M/N = 39.797 / 220.000 = 18$ CM

$\Rightarrow \quad Fa = \dfrac{220.000\left(18 + \frac{80}{2} - 12\right)}{1650\,(80-24)} = 113\ CM^2$

$\Rightarrow$ 14 ϕ 32

* COLUMN C_3 : (800 x 800) : at the corner : 14 ϕ 32, 2 WAYS

7.1.12

Gravity Thickener

GRAVITY THICKENER CALCULATION SHEET

* PRESSURE OF WATER (SLUDGE)

$p_o = p_w = 1300 \times 3,75 = 4875 \text{ KG/M}^2$

$T_w = p_w \times R = 4875 \times 7 = 34125 \text{ KG}$

Taken $t = 40 \text{ CM}$

$\beta'' = \frac{3(1-0,15^2)}{7 \cdot 7 \times 0,4 \times 0,4} = 0,3740$

$\beta = 0,7820$; $\beta h = 0,7820 \times 4,00 = 3,128$

$1/\beta h = 0,3197$

$1 - 1/\beta h = 1 - 0,3197 = 0,6803$

$M = \frac{p_o}{2\beta^2}\left[-\left(1 - \frac{1}{\beta h}\right) e^{-\beta x} \cos\beta x + e^{-\beta x} \sin\beta x \right]$

$M_o = \frac{-p_o}{2\beta^2}\left(1 - 1/\beta h\right) = \frac{-4875}{2 \times 0,7820^2} \times 0,6803 = \underline{-2712 \text{ KGM}}$

$T_o = \frac{p_o}{2\beta}\left(2 - 1/\beta h\right) = \frac{4875}{2 \times 0,782}\left(2 - 0,3197\right) = 5238 \text{ KG}$

$T = \frac{p_o}{2\beta}\left[e^{-\beta x}\left(\cos\beta x - \sin\beta x\right) + \left(1 - \frac{1}{\beta h}\right) \times e^{-\beta x}\left(\cos\beta x + \sin\beta x\right) \right]$

$T = 0 \Rightarrow e^{-\beta x}\left(\cos\beta x - \sin\beta x\right) + 0,6803 \times e^{-\beta x}\left(\cos\beta x + \sin\beta x\right) = 0$

$\Rightarrow 1,6803\, e^{-\beta x} \cos\beta x - 0,3197 \sin\beta x = 0$

$\Rightarrow \tg\beta x = \frac{1,6803}{0,3197} = 5,26$

$\Rightarrow \beta x = 1,38 \Rightarrow x = \frac{1,38}{0,7820} = 1,764 \text{ M}$

$\cos\beta x = 0,191$

$\sin\beta x = 0,982$

$M^+_{max} = \frac{4875}{2 \times 0,7820^2}\left[-0,6803 \times 0,191 e^{-\beta x} + 0,982\, e^{-\beta x} \right]$

$= 3396\, e^{-\beta x} = 3396\, e^{-1,38} \approx 700 \text{ KGM}$

$M = 0 \Rightarrow \frac{\sin\beta x}{\cos\beta x} = 0,6803 = tg\,\beta x$

* $tg\,\beta x = 0,6803 \Rightarrow \beta x = 0,593$

$\Rightarrow x_1 = 0,76M$

* $tg(\pi + \beta x) = 0,6803 \Rightarrow \pi + \beta x = 0,593$

$\Rightarrow x_2 = 3,26M$

* BOTTOM SLAB :

- WEIGHT OF WALL :

$3,14 \times 14,4 \times 4 \times 0,4 \times 2500 = 180.864$ KG

- GUTTER :

$1 \times 0,15 \times 1,3 \times 3,14 \times 12 \times 2500 = 18.369$ KG

SUM = 199.233 KG (1)

- MAINTENANCE BRIDGE :

. BEAM + FLOOR : $3100 \times 2 = 6.200$ KG

. LL ; $500 \times (16,2 \times 1,2 \times 3,9 \times 0,7 \times 2) = 12.450$ KG

. EQUIPMENT : $= 12.500$ KG

SUM = 31 150 KG (2)

TOTAL (1) + (2) = 230.383 KG

* DESIGN LOAD :

$q = \frac{230.383}{3,14 \times 7,4 \times 7,4} = 1340$ KG/M²

* SOIL PRESSURE AT BOTTOM :

$q_s = 1340 + (1300 \times 3,75) + 0,5 \times 2500 = 7165$ KG/M²

≠ 0,75 KG/CM²

⇒ Distance of pile : $= \sqrt{\frac{40}{7,5}} = 2,3M$

⇒ n = 35 piles

* WALL :

- TENSION TOTAL IN THE WALL :

$$T = P \times R = 1300 \times h \times \frac{h}{2} \times \frac{D}{2} = 325 h^2 D$$

$h_1 = 1M$ (FROM WATER LEVEL) $\Rightarrow T_1 = 325 \times 1^2 \times 14 = 4550\ KG$

$h_2 = 2M$ (") $\Rightarrow T_2 = 325 \times 2^2 \times 14 = 18200\ KG$

$h_3 = 3M$ (") $\Rightarrow T_3 = 325 \times 3^2 \times 14 = 40.950\ KG$

$h_4 = 3.75M$ (") $\Rightarrow T_4 = 325 \times 3,75^2 \times 14 = 63.985\ KG$

* PRESSURE OF SOIL AND GROUND WATER OUTSIDE THE TANK :

$P_{WATER} = 1000 \times 3,75 = 3750\ KG/M^2$

$P_{SNS} = (\gamma' - \gamma_w) \times H \times K_o$

$= (1800 - 1000) \times 3,75 \times 0,50$

$= 1500\ KG/M^2$

$P_V = 1000 \times K_o = 1000 \times 0,50 = 500\ KG/M^2$

$P = P_w + P_{sns} + P_V = 3750 + 1500 + 500 = \underline{5750\ KG/M^2}$

Moment at bottom of wall (approx.)

$$M = p \frac{s^2}{2} \left[1 - \frac{s}{l} \right]$$

$$= p \times \frac{0,76^2 \times \pi \times L}{2} \left[1 - \frac{0,76\sqrt{\pi c}}{l} \right]$$

$$= 5750 \times \frac{0,76^2 \times 7 \times 0,4}{2} \left[1 - \frac{0,76 \times \sqrt{7 \times 0,4}}{4} \right]$$

$$= 3170\ KGM$$

* BOTTOM SLAB :

- TEMPORARY CASE 1 : INSIDE EMPTY, NO GROUND WATER OUTSIDE (FOR EXECUTION)

• DESIGN LOAD : $q = 1340 \text{ KG}/\text{M}^2$

• EDGE CONDITION : CLAMPED

* RESULTS OF CALCULATION :

r (M)	RADIAL MOMENT M_r (KGM)	CIRCUM. MOMENT M_t (KGM)	SHEAR (KG/M)
0	4720	4720	0
1	4456	4599	670
2	3664	4234	1340
3	2345	3626	2010
4	498	2777	2680
4,2	0	2567	2814
5	-1876	1684	3350
6	-4478	348	4020
6,2	-5422	0	4154
7	-8208	-1231	4690

. Formula for calculation :

$$M_r = \frac{q}{16}\left[R^2(1+\nu) - r^2(3+\nu)\right]$$

$$M_t = \frac{q}{16}\left[R^2(1+\nu) - r^2(1+3\nu)\right]$$

With : ν is coefficient of Poisson equal 0,15

$R = 14/2 = 7,00 \text{ M}$

• TEMPORARY CASE 2 :

* SHEAR AND MOMENT CAUSING BY UPLIFT FORCE

- WEIGHT OF WALL : $3,14 \times 14,4 \times 0,4 \times 4 \times 2500 = 180.864$ KG
- BOTTOM SLAB : $3,14 \times 7,7 \times 7,7 \times 0,5 \times 2500 = 232.714$ KG

SUM = 413.578 KG

- UPLIFT : $3,14 \times 7,4 \times 7,4 \times 4 \times 1000$

$- 413.578 = 274208$ KG

- LOAD AGAINST UPLIFT : $q' = \frac{274208}{3,14 \times 7,4 \times 7,4} = 1595$ KG/M2

(USE PILE UNDER BOTTOM FOR AGAINST UPLIFT)

- EDGE CONDITION : CLAMPED

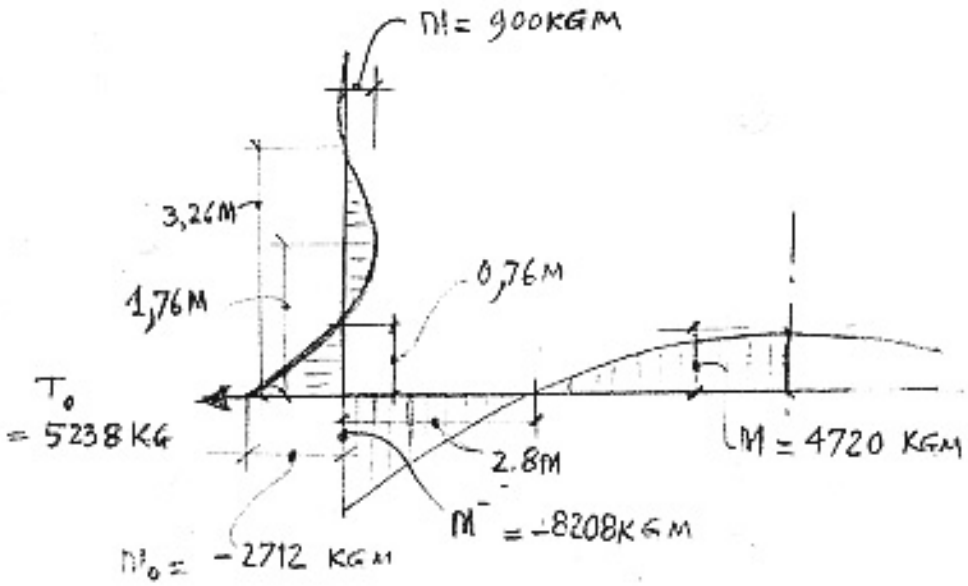
* RESULTS OF CALCULATION :

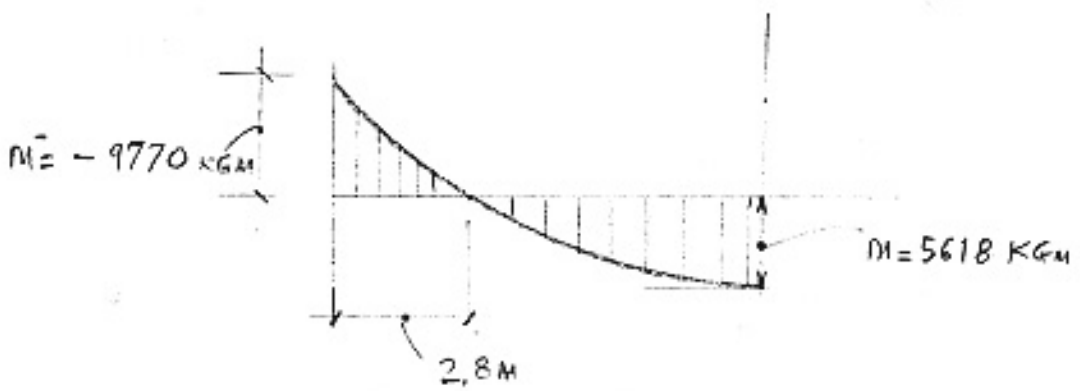
r (M)	RADIAL MOMENT M_r (KGM)	CIRCUM. MOMENT M_t (KGM)	SHEAR (KG/M)
0	5618	5618	0
1	5303	5473	798
2	4362	5039	1596
3	2792	4317	2394
4	593	3305	3192
4,2	0	3068	3352
5	-1641	2004	3990
6	-5444	414	4788
6,2	-6454	0	4948
7	-9770	-1466	5586

★ TEMPRARY CASE : MOMENT DIAGRAGM -

. WALL : Subtainning pressure of water inside, outside emty.

. BOTTOM : inside emty.





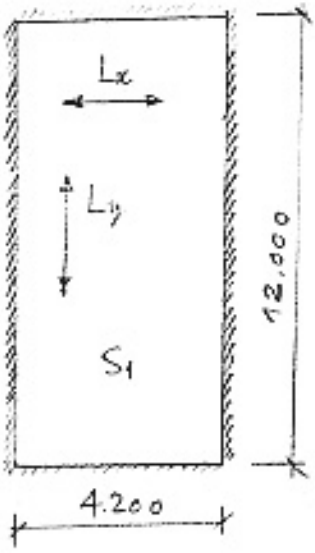
BOTTOM SLAB : MOMENT DIAGRAGM IN CASE OF SUBTAINING UPLIFT FORCE

* COVER SLAB OF PIPE GALLARY :

SLAB S_1 : 12M x 4,2 M

$L_x/L_y = \frac{4,2}{12} = 0,35$

(ONE WAY SLAB)



Taken t = 400 MM

DL : $0,4 \times 2500$ = 1000 KG/M²

BACKFILL : 1800×1 = 1800 KG/M²

L.L or P_v 500 KG/M²

SUM = 3300 KG/M²

* L_x direction :

$M_t = \frac{pl^2}{11} = \frac{3300 \times 4,2^2}{11} = 5292$ KGM

$M_a = -\frac{pl^2}{14} = -\frac{3300 \times 4,2^2}{14} = -4158$ KGM

* L_y direction :

$M_t = 0,3 \times 5292 = 1588$ KGM

$M_a = -0,5 \times 4385 = -2079$ KGM

(14)

COVER SLAB OF PIPE GALLERY :

* REINFORCEMENT :

• M = 5292 kgm

$\Rightarrow Fa = \frac{529200}{1600 \times 0.97 \times 33} = 10,33\ cm^2$

$\Rightarrow 6\phi 16 = 12,06\ cm^2$

• M = − 4158 KGM

$\Rightarrow Fa = \frac{415800}{1600 \times 0,98 \times 33} = 8,04\ cm^2$

$\Rightarrow 7\phi 14 = 10,77\ cm^2$

$Fa\ min = 0,2\% \times 20 \times 100 = 4\ cm^2 \Rightarrow 5\phi 12 = 4,52 cm^2$

• M = 1675 KGM
• M = −2193 KGM
$\Rightarrow$ use $Fa\ min = 4\ cm^2 \Rightarrow 5\phi 12 = 4,52\ cm^2$

* SLAB S_2, S_3: Taken e = 20 MM

Consider 1 strip 1 M wide and 2,2 M Long

DL : $0,2 \times 2500 = 500$ KG/M²

LL : = 500 KG/M²

SUM = 1000 KG

$M = \frac{pl^2}{12} = \frac{1000 \times 2,2^2}{12} = 403$ KGM

✓ REINFORCEMENT use $Fa\ min = 20 \times 100 \times 0,2\% = 4,\ cm^2$

$\Rightarrow 5\phi 12 = 4\ cm^2$ (TWO LAYERS)

* WALL H = 1,5 M − 2 M , e = 300MM

$p = 1,800 \times 1 \times 0.50 = 900$ KG/M²

$M = \frac{1}{2} \times 900 \times \frac{1}{3} = 150$ KGM

use $Fa\ min = 5\phi 12 = 4,5\ cm^2$

* BOTTOM SLAB :

. RADIAL REINFORCEMENT :

- UNDER LAYER : . M = 5208 KGM

$\Rightarrow F_a = \frac{520800}{1600 \times 0,95 \times 38} = 14,21\ CM^2$

$\Rightarrow 6\phi 18 = 15,27 CM^2$
or $\phi 14 + \phi 16$ a 125

. M = 5618 KGM

$\Rightarrow F_a = \frac{561800}{1600 \times 0,97 \times 38} = 9,53\ CM^2$

$\Rightarrow 7\phi 14 = 10,77\ CM^2$

- UPPER LAYER : . M = 9770 KGM

$\Rightarrow F_a = \frac{977000}{1600 \times 0,96 \times 43} = 14,79\ CM^2$

$\Rightarrow 6\phi 18 = 15,27\ CM^2$
or $\phi 14 + \phi 18$ a 125

. M = 4720 KGM

$\Rightarrow F_a = \frac{472000}{1600 \times 0,98 \times 43} = 7\ CM^2$

$\Rightarrow 7\phi 12 = 7,92\ CM^2$

. CIRCUM. REINFORCEMENT :

- UNDER LAYER : M = 5618 KGM

$\Rightarrow F_a = \frac{561800}{1600 \times 0,97 \times 38} = 9,52\ CM^2$

$\Rightarrow 7\phi 14 = 10,77\ CM^2$

M = 2004 KGM

$\Rightarrow F_a = \frac{200400}{1600 \times 0,99 \times 38} = 3,3\ CM^2 < F_{a\,min} = 5 CM^2$

USE $F_{a\,min} : 5\ CM^2 \Rightarrow 5\phi 12 = 5,65\ CM^2$

- UPPER LAYER : M = 4720 KGM

$\Rightarrow F_a = \frac{472000}{1600 \times 0,98 \times 43} = 7\ CM^2$

$\Rightarrow 7\phi 12 = 7,92\ CM^2$

. M = 1684 KGM

$\Rightarrow F_a = \frac{168400}{1600 \times 0,99 \times 43} = 2,47 CM^2$

use $F_{a\,min} = 5\ CM^2 \Rightarrow 5\phi 12 = 5,65\ CM^2$

* REINFORCEMENT : WALL : HORIZONTAL REINF. ($L = 4.00$ MM)

TAKEN $\sigma_a = 1600$ KG/CM²

$F_{a1} = \frac{T_1}{\sigma_a} = \frac{4550}{1600} = 2,84$ CM²

$F_{a2} = \frac{T_2}{\sigma_a} = \frac{18200}{1600} = 11,38$ CM² } 8.54 CM² ⇒ Φ 10 a 150 × 2 LAYERS

$F_{a3} = \frac{T_3}{\sigma_a} = \frac{40950}{1600} = 25,59$ CM² } 14.21 CM² ⇒ Φ 12 a 150 × 2 LAYERS

$F_{a4} = \frac{T_4}{\sigma_a} = \frac{63.985}{1600} = 40$ CM² } 14,41 CM² ⇒ Φ 14 a 150 × 2 LAYERS

* VERTICAL REINFORCEMENT :

- INNER LAYER : . $M_1 = -2712$ KGM (BOTTOM)

$\Rightarrow F_a = \frac{271200}{1600 \times 0,98 \times 33} = 5,2$ CM²

. $M_1 = 9770$ KGM

$\Rightarrow F_a = \frac{977000}{1600 \times 0,93 \times 33} = 19,9$ CM² ⇒ 4Φ22 + 4Φ12 (BOTTOM WALL)

- OUTER LAYER : . $M = 3170$ KGM (BOTTOM)

$\Rightarrow F_a = \frac{317000}{1600 \times 0,98 \times 33} = 6,13$ CM²

. $M = 8208$ KGM $\Rightarrow F_a = \frac{820800}{1600 \times 0,94 \times 33} = 16,54$ CM² ⇒ 4Φ20 + 4Φ12 (BOTTOM WALL)

. $M = 900$ KGM

$\Rightarrow F_a = \frac{90000}{1600 \times 0,99 \times 33} = 1,72$ CM²

use $F_{a\,min} = 3$ CM² ⇒ 4Φ12 = 4,52 CM² (2 LAYERS)

* AT LOCATION OF BEAM SUPPORT (2 BEAMS OF MAINTENANCE BRIDGE)

$N = P = \frac{31.150}{2 \times 2} = 7.788$ KG

$M = 3170$ KGM ; $N = 7.788$ KG

$e = M/N = 3170/7788 = 0,41\,M = 41$ CM

$F_a = 7788\,(41 + 20 - 7)/1600 \times 26 = 10,11$ CM²

⇒ 4Φ18 = 10,18 CM²

→

* BOTTOM SLAB OF PIPE GALLERY :

. THE WEIGHT OF COVER :

. SLAB : $0,4 \times 2500 \times 5 \times 12$
$+ 1,8 \times 3,5 \times 0,2 \times 2500$
$+ 9,4 \times (4,6 \times 2,2 - 1,5^2) \times 2500 + 0,4 \times 2500 \times 4 \times 1$ ≈ 75.000 KG

. BEAM : $2 \times [0,4 \times 0,4 \times 1 \times 2500$
AND COLUMN $+ 0,5 \times 0,5 \times 3,7 \times 2500$ = 5500 KG

. WALL OF MANHOLE AND COVER :

$0,25 \times 2500 \times 1,5 \times 6$
$+ 0,3 \times 2500 \times 2,5 \times 2,6$
$+ (3,5 + 3 + 1,5) \times 6,3 \times 0,3 \times 2500$
$+ 1,5 \times 1 \times 0,3 \times 2500$ = 49425 KG

. WALL OF PIPE GALLERY :

$1,5 \times 2 \times 0,5 \times 4 \times 2500$

= 95.000 KG

. BOTTOM SLAB : $7,5 \times 13 \times 0,5 \times 2500$ = 121.875 KG

. BACKFILLING : $78,9 \times 1,2 \times 1800$ = 170.424 KG

. LIVE LOAD : $13 \times [5,7 + 2,5] \times 500$ = 53.300 KG

LL BOTTOM SLAB : $13 \times [5,7 + 2,5] \times 500$ = 53.300 KG

. SLUDGE IN MANHOLE :

$3,5 \times 2,3 \times 5,5 \times 1300$
$+ 1,5 \times 1 \times 2 \times 1000$ = 60.558 KG

684.382 KG

. PRESSURE OF SOIL : $p = 684.382 / 13 \times 8,2$ ≈ 6400 KG/M²

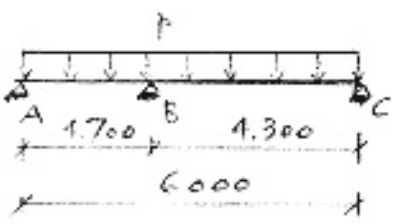
$\Rightarrow a = \sqrt{40/6,4} = 2,5$ M. $\Rightarrow$ n = 28 piles.

+ CALCULATION PRESSURE OF BOTTOM SLAB :

$$pc = \frac{682.163 - (121875 + 53300)}{13 \times 8,2} = 4756 \text{ KG/M}^2$$

x BEAM L = 6M OF BOTTOM SLAB :

$p = 4756 \times 12/2 = 28.536$ KG/M



$$M_B = -\frac{1}{11} p l^2 = -\frac{1}{11} \times 28536 \times 4,3^2 = -47.967 \text{ KGM}$$

$$M_{BC} = \frac{1}{14} p l^2 = \frac{28536 \times 4,3^2}{14} = 37.688 \text{ KGM}$$

* BEAM B_2 : DL + LL SLAB : $p_1 = 3300\ KG/M^2 \times 2{,}65 \times 1 = 8745\ KG/M$

$p_2 = 0{,}4 \times 0{,}8 \times 2500 = 800\ KG/M$

SUM $= 9.545\ KG/M$

$$M_a = \frac{-pl^2}{8} = \frac{-9545 \times 6^2}{8} = -42.953\ KGM$$

TAKEN SECTION 40×80 CM

$$M_t = 0{,}070\, pl^2 = 0.070 \times 9545 \times 6^2 = 24.054\ KGM$$

* REINFORCEMENT :

. $M = -42.953$ KGM

$$\Rightarrow F_a = \frac{4295300}{1600 \times 0{,}85 \times 68} = 46{,}5\ CM^2$$

$\Rightarrow 8\phi 28 = 49{,}3\ CM^2$

. $M = 24.054$ KGM

$$\Rightarrow F_a = \frac{2405400}{1600 \times 0{,}92 \times 68} = 24\ CM^2$$

$\Rightarrow 8\phi 20 = 25{,}14\ CM^2$

* BEAM B_1 :

. DL+LL SLAB : $p_1 = 3300\ KG/M^2 \times 2{,}05 \times 1 = 6765\ KG/M$

$p_2 = [1 \times 6 \times (500 + 500)$
$+ 0{,}2 \times 1{,}5 \times 2500 \times 6$
$+ 0{,}4 \times 0{,}8 \times 2500 \times 6] / 6 = 2550\ KG/M$

SUM $= 9315\ KG/M$

$$M_a = \frac{-pl^2}{8} = \frac{-9315 \times 6^2}{8} = -41.918\ KGM$$

$M_t = 0{,}070\, pl^2 = 0{,}070 \times 9315 \times 6^2 = 23.474\ KGM$

Taken section : 40×80 CM

. $M = -41918$ KGM

$$\Rightarrow F_a = \frac{4191800}{1600 \times 0{,}86 \times 68} = 44{,}8\ CM^2$$

$\Rightarrow 8\phi 28 = 493\ CM^2$

. $M = 23474$ KGM

$$\Rightarrow F_a = \frac{2347400}{1600 \times 0{,}87 \times 68} = 24{,}80\ CM^2$$

$\Rightarrow 8\phi 20 = 25{,}14\ CM^2$

* REINFORCEMENT : (BEAM OF BOTTOM SLAB – L = 6M) B_3

. M = – 47.967 KGM

$$\Rightarrow Fa = \frac{4796700}{1600 \times 0.93 \times 73} = 44,2\ cm^2$$

$$\Rightarrow 8\phi 28 = 49.26\ cm^2$$

. M = 37.688 KGM

$$\Rightarrow Fa = \frac{3768800}{1600 \times 0.94 \times 78} = 32,2\ cm^2$$

$$\Rightarrow 7\phi 25 = 34,4\ cm^2$$

* GUTTER :

M1 = 0,15 x 0,58 x 1 x 2500 x 0,38 + 0,2 x 0,3 x 2500 x 0,15
+ 0,3 x 0,38 x 1000 x 0,15 + 15 x 0,8 + 60 x 0,4

≈ 1582,5 KGM

- REINFORCEMENT :

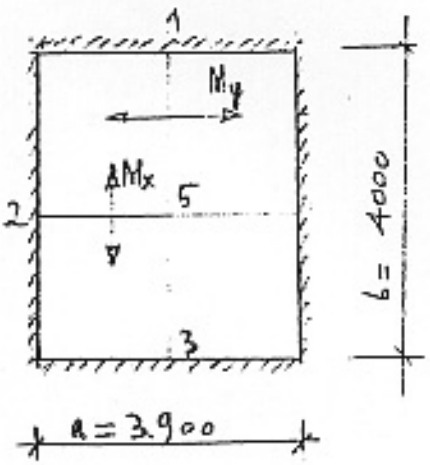
$$Fa = \frac{15825}{1600 \times 0,99 \times 15} = 0,67\ cm^2$$

USE $Fa_{min} = 4,5\ cm^2 \Rightarrow \phi 10\ a\ 150$

PIPE GALLARY

- MANHOLE W = 3,500 M , H = 6M

. WALL 3.5M x 6M :



$a/b = 3,9/4 \approx 1$

$p = 1000 \times 6 = 6000\ KGM^2$

$My_2 = 0,025 \times 6000 \times 3,9^2 = 2282\ KGM$

$My_5 = -0,09 \times 6000 \times 3,9^2 = -822\ KGM$

$Mx_1 = -0,018 \times 6000 \times 3,9^2 = -1644\ KGM$

$Mx_3 = -0,033 \times 6000 \times 3,9^2 = -3012\ KGM$

$Mx_5 = 0,009 \times 6000 \times 3,9^2 = 822\ KGM$

Take e = 30 cm

. M = -3012 KGM

$$\Rightarrow Fa = \frac{301200}{1600 \times 0,97 \times 25} = 7,8\ cm^2$$

$\Rightarrow 8\ \phi 12 = 9,05\ cm^2$

. M = 2282 KGM

$$\Rightarrow Fa = \frac{228200}{1600 \times 0,98 \times 25} = 5,82\ cm^2$$

$\Rightarrow 5\ \phi 12 = 5,65\ cm^2$

. M = -1644 KGM

$$\Rightarrow Fa = \frac{164400}{1600 \times 0,99 \times 25} = 4,15\ cm^2$$

$\Rightarrow 4\ \phi 12 = 4,52\ cm^2$

* ALL VALUE MOMENT ≤ 1644 KGM , USE $F_{a\,min} = 4{,}5\ CM^2$
$\Rightarrow \phi 10 \text{ a } 150$

* MANHOLE 1000 x 1000 x 2500

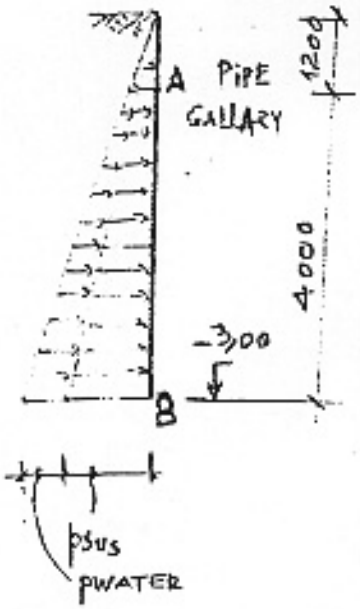
Taken $t = 300MM$

ALL VALUES MOMENT ARE VERY SMALL ;

. USE $F_{a\,min} = 4{,}5\ CM^2 \Rightarrow \phi 10 \text{ a } 150$

* WALL OF PIPE GALLERY :

TEMPORARY CASE : HWL = GROUND LEVEL



$p_B = p_W + p_{SUS} + p_V$

$p_W = 1000 \times 5{,}4 = 5400\ KG/M^2$

$p_{SUS} = (\gamma' - \gamma_W) \times H \times k$

$= (1800 - 1000) \times 5{,}4 \times 0{,}50$

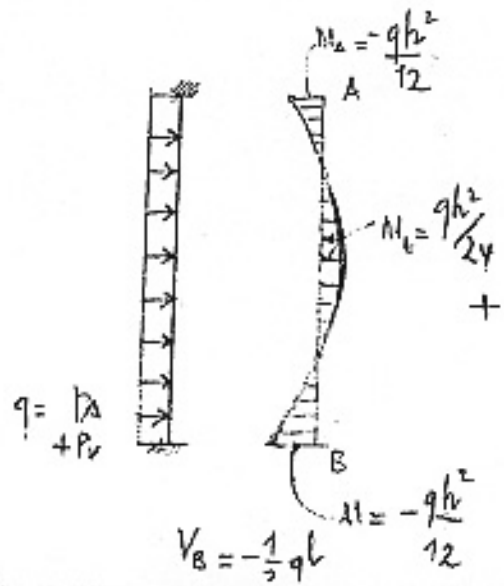
$= 2160\ KG/M^2$

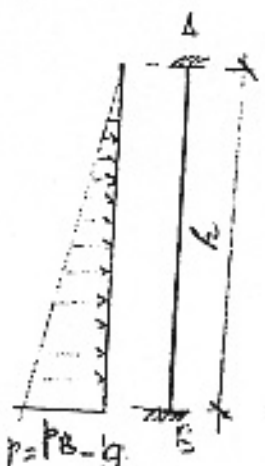
$\Rightarrow p_B = 5400 + 2160 + 500 = 8060\ KG/M^2$

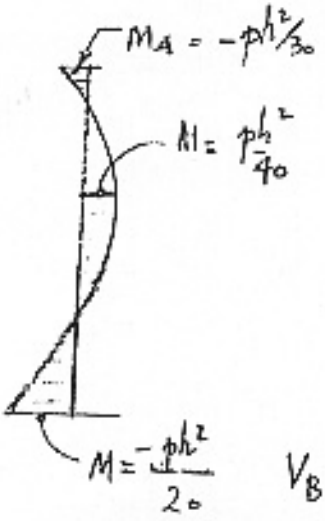
$p_V = 1000 \times K_a = 1000 \times 0{,}5 = 500\ KG/M^2$

$q = p_A + p_V = 1000 \times 1{,}2$
$+ (1800 - 1000) \times 1 \times 0{,}50 + 500$
$= 2100\ KG/M^2$

$p = p_B - q = 8060 - 2100 = 5960\ KG/M$







$$M_A = -\left(\frac{2100 \times 4^2}{12} + \frac{5960 \times 4^2}{30}\right) = -5979 \text{ KGM}$$

$$M_t = \frac{2100 \times 4^2}{24} + \frac{5960 \times 4^2}{40} = 3784 \text{ KGM}$$

$$M_B = -\left(\frac{2100 \times 4^2}{12} + \frac{5960 \times 4^2}{20}\right) = -7568 \text{ KGM}$$

* REINFORCEMENT ($t = 50$ cm)

. $M = -5979$ KGM

$$\Rightarrow \quad Fa = \frac{5979 \times 100}{1600 \times 0.97 \times 43} = 9{,}00 \text{ cm}^2$$

$\Rightarrow 4\phi 10 + 4\phi 14 = 9.3$ CM

. $M = 3784$ KGM

$$\Rightarrow \quad Fa = \frac{378400}{1600 \times 0{,}98 \times 43} = 5{,}6 \text{ cm}^2$$

$\Rightarrow 4\phi 14 = 6.16 \text{ cm}^2$

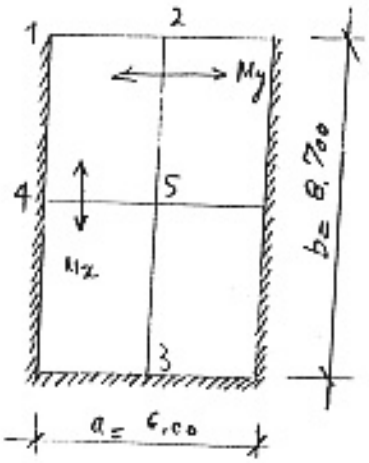
. $M = 7568$ KGM

$$\Rightarrow \quad Fa = \frac{756800}{1600 \times 0{,}95 \times 43} = 11{,}6 \text{ cm}^2$$

$\Rightarrow 8\phi 14 = 12{,}34 \text{ cm}^2$

. Horizontal Reinf : $Fa_{min} = 4\phi 14 = 6{,}16 \text{ cm}^2$

4 BOTTOM SLAB OF PIPE GALLARY :



$p = 4756 KG/m^2$; $b/a = \frac{8.7}{6} = 1,5$

$M_{y1} = -0,085 pa^2 = -0,085 \times 4756 \times 6^2$

$= -14553 KG_M$

$M_{y2} = 0,045 pa^2 = 0,045 \times 4756 \times 6^2$

$= 7705 KG_M$

$M_{y4} = -0,079 pa^2 = -13.526 KG_M$

$M_{y5} = 0,036 pa^2 = 6164 KG_M$

$M_{x3} = -0{,}056\,pa^2 = -9588$ KGM

$M_{x5} = 0{,}005\,pa^2 = 856$ KGM

* REINFORCEMENT :

• $M = -14{,}553$ KGM

$\Rightarrow F_a = \frac{14.55300}{1600 \times 0{,}94 \times 38} = 25{,}5\ cm^2$

$\Rightarrow 4\phi14 + 4\phi25 = 25{,}8\ cm^2$

• $M = -13{,}526$ KGM

$\Rightarrow F_a = \frac{1352600}{1600 \times 0{,}94 \times 38} = 23{,}7\ cm^2$

$\Rightarrow 4\phi14 + 4\phi25 = 25{,}8\ cm^2$

• $M = 7705$ KGM

$\Rightarrow F_a = \frac{770500}{1600 \times 0{,}97 \times 43} = 11{,}5\ cm^2$

$\Rightarrow 8\phi14 = 12{,}32\ cm^2$

• $M = 6164$ KGM

$\Rightarrow F_a = \frac{616400}{1600 \times 0{,}98 \times 43} = 9{,}1\ cm^2$

$\Rightarrow 4\phi12 + 4\phi14 = 10{,}5\ cm^2$

• $M = -9588$ KGM

$\Rightarrow F_a = \frac{958800}{1600 \times 0{,}96 \times 38} = 16{,}4\ cm^2$

$\Rightarrow 4\phi14 + 4\phi18 = 16{,}4\ cm^2$

• $M = 856$ KGM $\Rightarrow$ $F_{a\,min} = 4\phi14 = 6{,}16\ cm^2$

* CHECK ABOUT THICKNESS OF BOTTOM SLAB :

- ALLOWABLE PILE CAPACITY : 40 T/pile
- SOIL PRESSURE : 7,5 T/m²
- DISTANCES OF PILES : $\sqrt{40/7,5}$ ≈ 2,3 M □ → 35 piles
- SHEARING STRESS AROUND TOP OF PILE : f_{sp} = 2,2 kg/cm² < 3,6 kg/cm²

* CHECK ABOUT UP LIFT FORCE (BY WATER OUTSIDE THE TANK) (TEMPORARY)

- WEIGHT OF :
  - . WALL ; 3,14 x 12,8 x 0,4 x 4,55 x 2500 = 182.874 KG
  - . BOTTOM SLAB : 3,14 x 7,4 x 7,4 x 0,5 x 2500 = 214.933 KG
  - SUM = 397.807 KG
- UP LIFT FORCE :
  - ≈ 3,14 x 7,4 x 7,4 x 3,75 ≈ 644.800 KG
  - ⇒ 644.800 − 397.807 ≈ 246.992 KG
- USING PILES FOR AGAINST UP LIFT FORCE :
  - . UP LIFT FORCE ACTING AT 1 PILE (TEMPERARY)
    (246.992) / 35 ≈ 7055 KG/1 PILE

* CHECK ABOUT VERTICAL BUCKLING (ARROW) :

$$f = \frac{P}{L} = \frac{PL^3}{384EI} = \frac{13,40\,(10^2 \times 14)^3 \times 13}{384 \times 2\times10^5 \times 10^2 \times 5^3}$$

$$= 0,00047 < \frac{1}{250} = 0,004 \Rightarrow f = 6,6\,MM$$

* CHECK ABOUT CRACK'S WIDTH :

$$a_{f(mm)} = k c_1 \eta \frac{\sigma_a}{E_a} \times 1\,(3.5 - 100\mu)\sqrt[3]{d_{(mm)}}$$

$$= 1,2 \times 1,5 \times 1 \cdot \frac{1600}{2\times10^6} \times 20\,(3,5 - 100 \times 0,0046)\sqrt[3]{14} \approx 0,2\,MM.$$