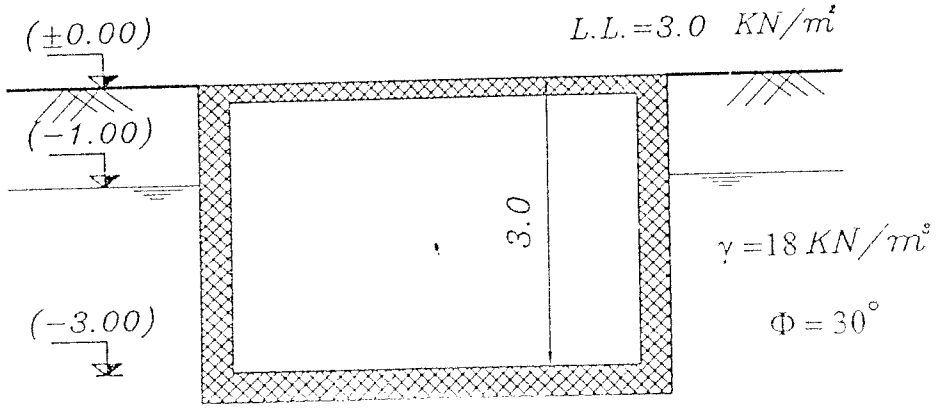
DESIGN OF REINFORCED CONCRETE TANKS

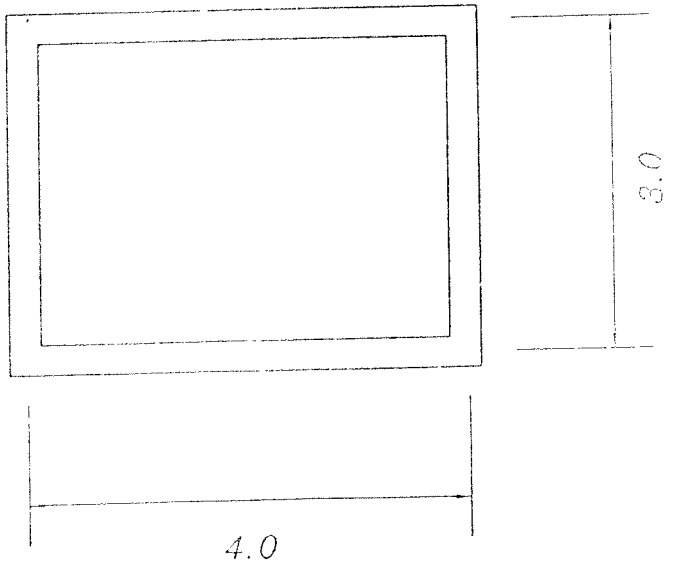
EXERCISE "6"

For the reinforced concrete ground tank shown in the figure, it is required to:

(a) Conduct a complete statical calculations and design for all the tank elements.
(b) Give complete working drawings including sections (1:20) and plans (1:50) for the designed elements.

Materials: f_{cu} =25 MPa and steel 360/520.





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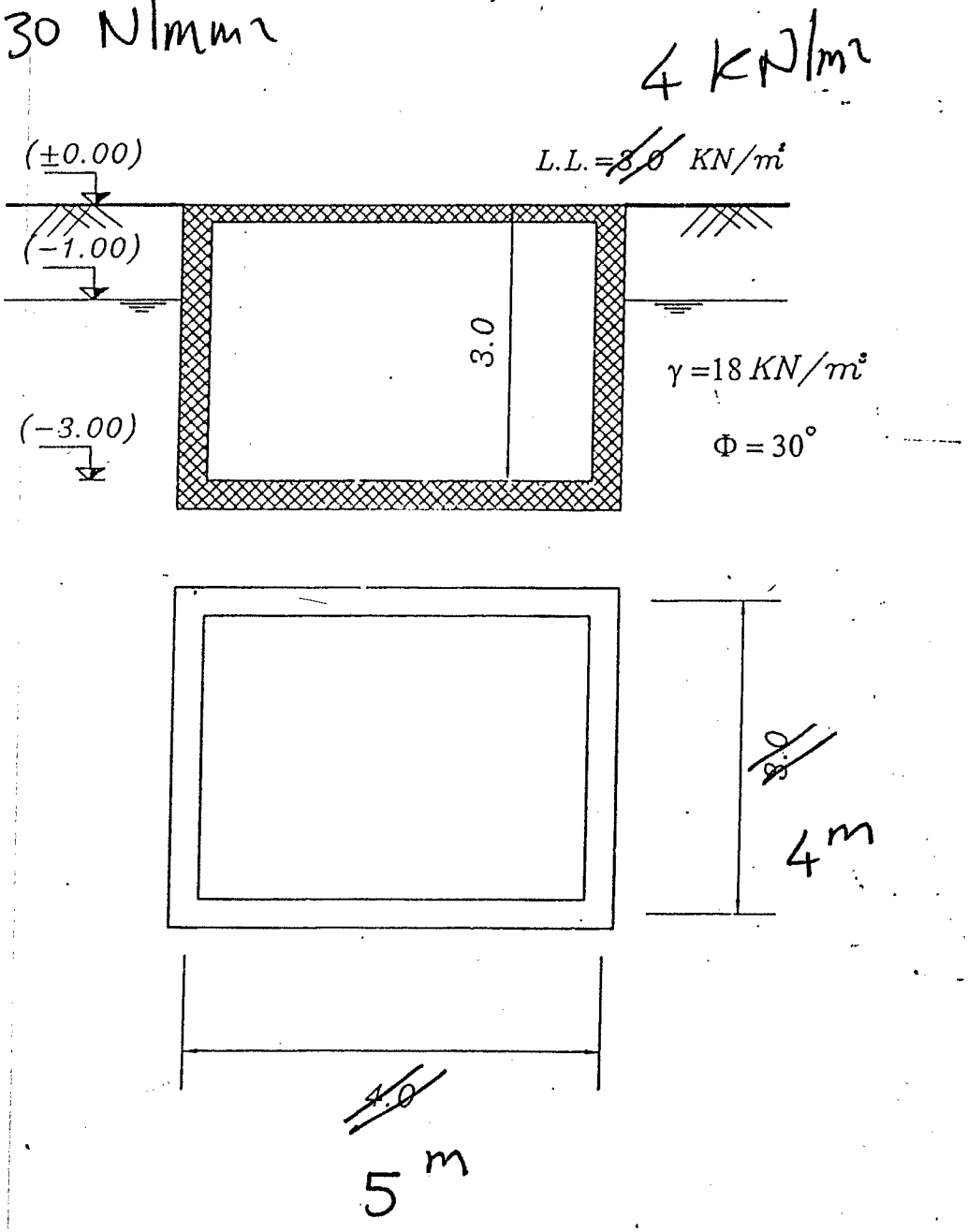
Materials: ~~f_{cu} = 25~~ MPa and steel 360/520.

30 N/mm²



Sheet # 6

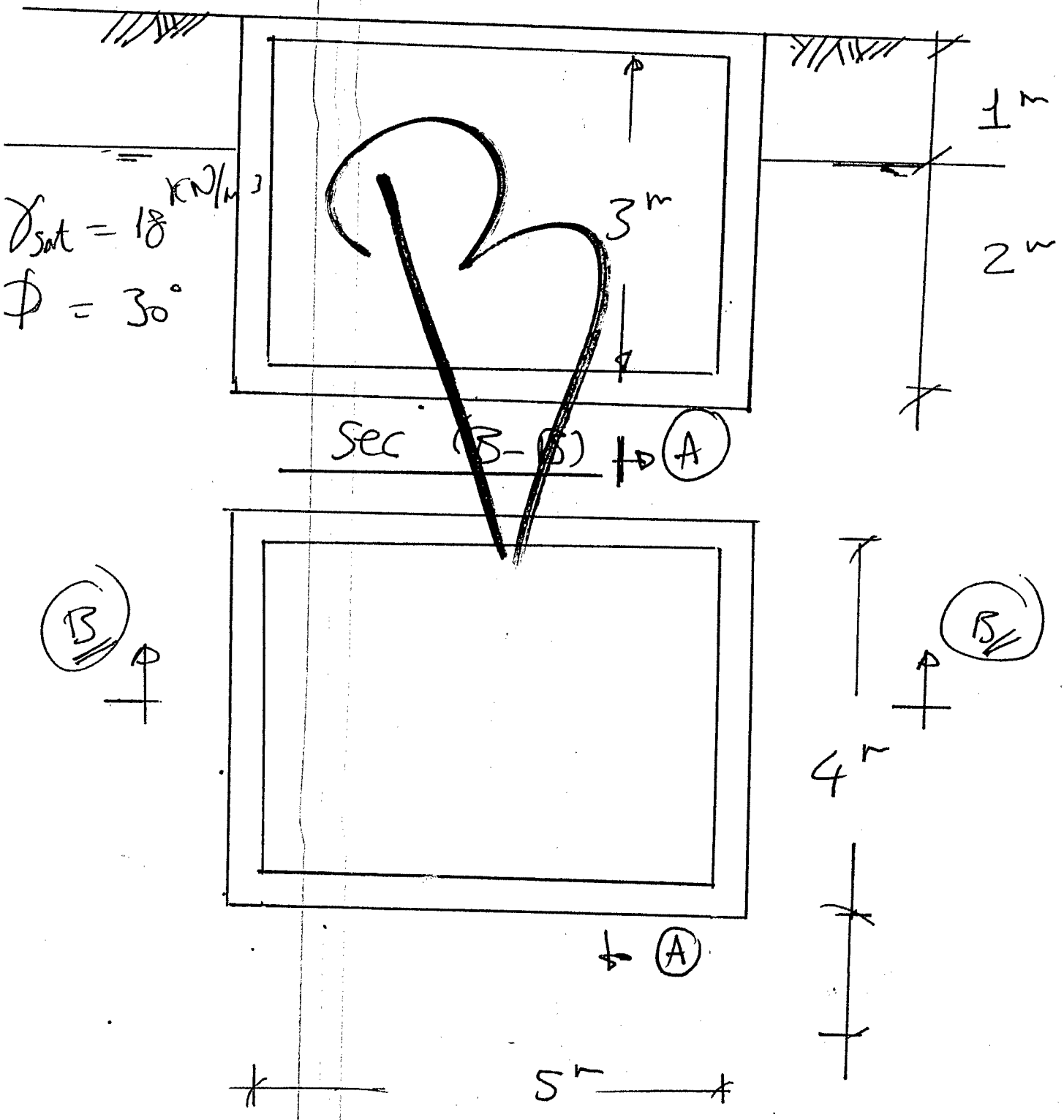
1

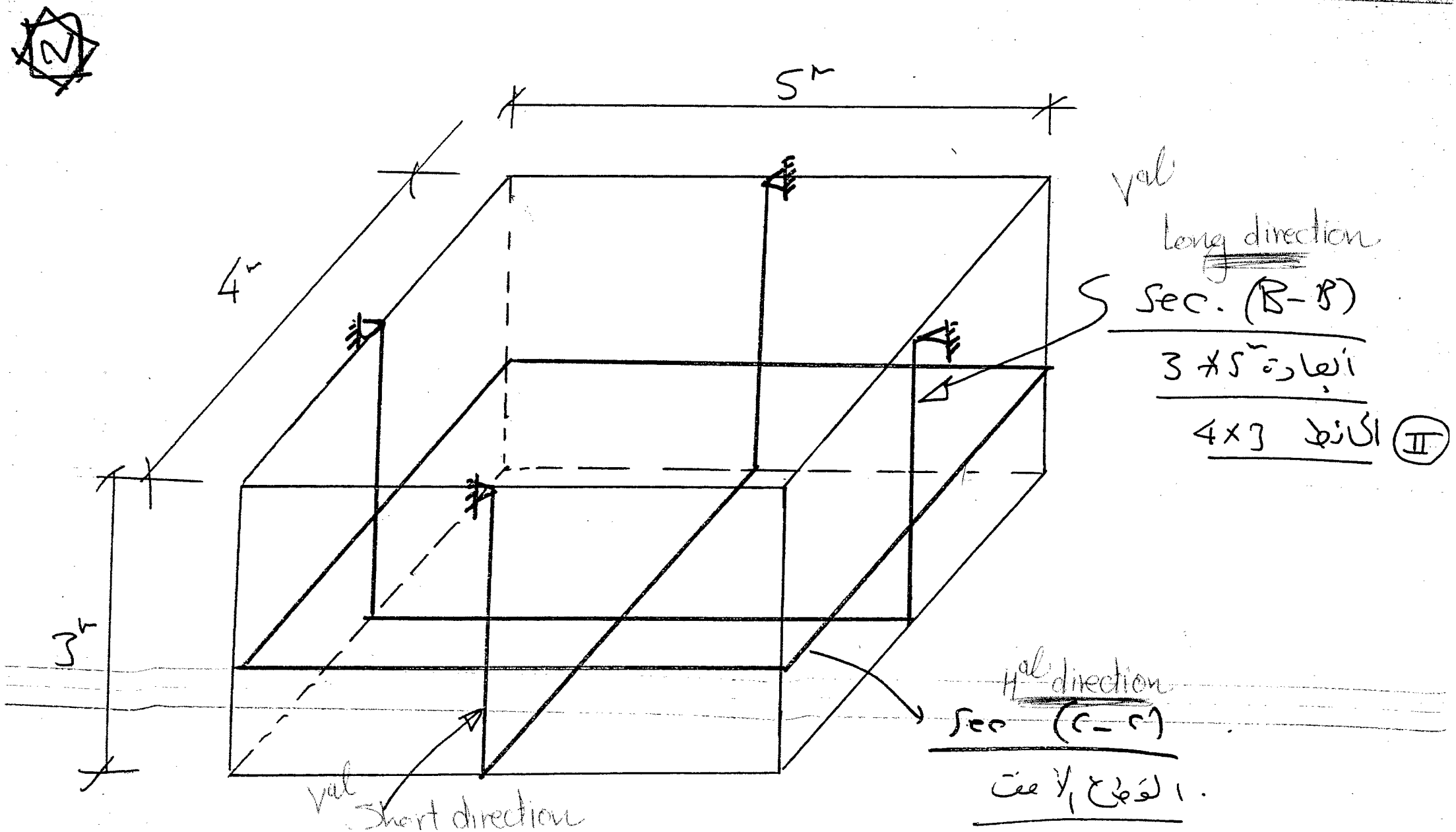
Problem # 1

$f_{cu} = 30\ N/mm^2$

St. 360/520

L.L = 4 KN/m²

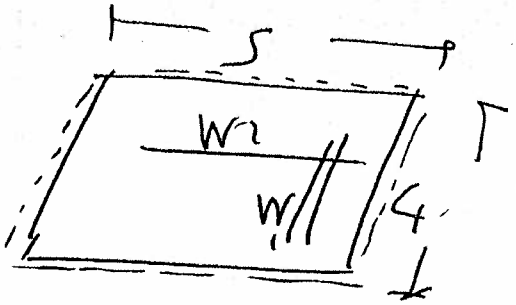



5م
4م
3م
val
Long direction
Sec. (B-B)
أبعاد: 3×5م
الكمرة (II) 3×4
val
Short direction
Sec (A-A)
أبعاد: 3×4
الكمرة (I) 3×5
Val
Sec (C-C)
القطاع لأعلى.

1) Roof

$r = \frac{5}{4} = 1.25 < 2$

T.W.S



$$t_{min} = \frac{span}{35} = \frac{4000}{35} = 114 \simeq 120 \text{ mm}$$

Loading

S.W = 0.12 * 25 = 3 KN/m²

G.L = 1.5

L.L = 4

Roof = 8.5 KN/m²

L.L = 4 KN/m² < 5 KN/m²

* يتم التقريع بواسطة الواصفات العامة

r = 1.25

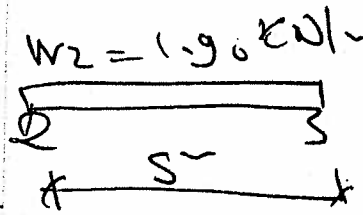
$\alpha = 0.5r - 0.15 = 0.475$

$\beta = \frac{0.35}{r^2} = 0.224$

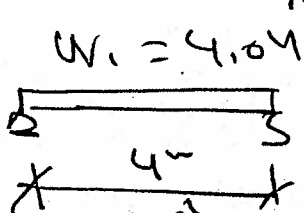
$W_1 = \alpha W = 0.475(8.5) = 4.04$ KN/m²

$W_2 = \beta W = 0.224(8.5) = 1.90$ KN/m²

Struc.



$M = \frac{W_2 l^2}{8} = 3.41$



$M = \frac{W_1 (W)^2}{8} = 8.08$

Design

$f_{cu} = 30 \text{ N/mm}^2$ | $f_c = 8.5 \text{ N/mm}^2$

$t = 120$ | $f_s = 200 \text{ N/mm}^2$

St. 360/520

$K_1 = 0.83$

$K_2 = 174$

$$d = K_1 \sqrt{\frac{M}{b}} = 0.83 \sqrt{\frac{8.08 * 10^6}{1000}} = 74.9$$

let $t = 120$ mm

$d' = 30 \rightarrow 40$

$d_1 = 90$ mm ← A_s short c.c

$d_2 = 80$ → A_s long c.c

$$A_{s\,short} = \frac{M}{K_2 d_1} = \frac{8.08 * 10^6}{174 * 90} = 516 \text{ mm}^2$$

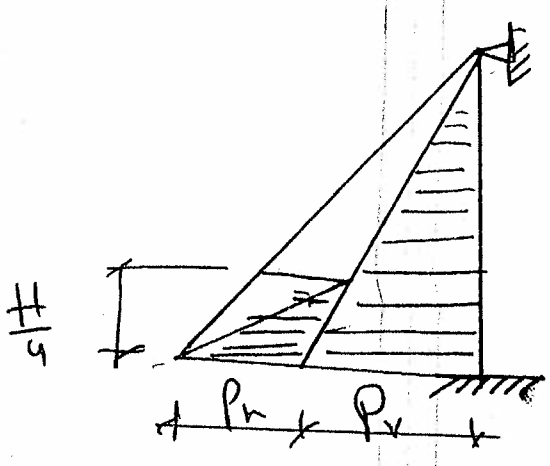
7 #16/m

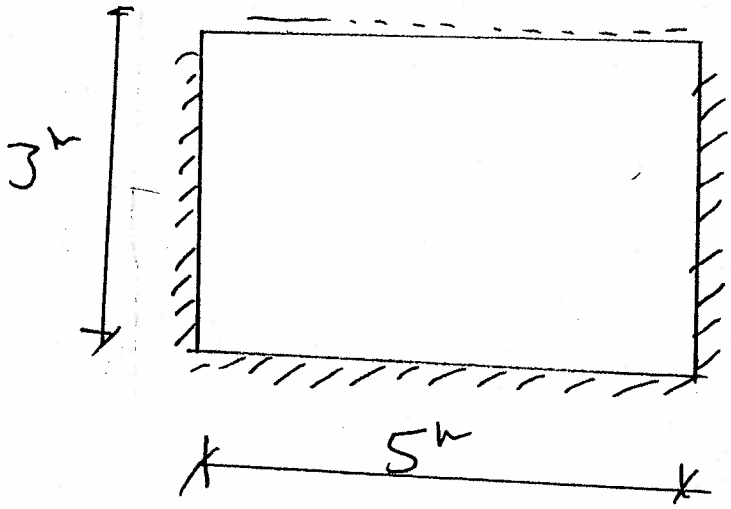
$$A_{s\,long} = \frac{M}{K_2 d_2} = \frac{3.41 * 10^5}{174 * 80} = 245 \text{ mm}^2$$

5 #10/m

2] The wall

Wall #(I) Sec (f)-A)





$$r = \frac{5*0.76}{3*0.87} = 1.46 \approx 2$$ T.w.s

$$\alpha = \frac{r^4}{(1+r^4)} = 0.82$$

$$\beta = \frac{1}{(1+r^4)} = 0.18$$

$\alpha + \beta = 1$

Case of Loading

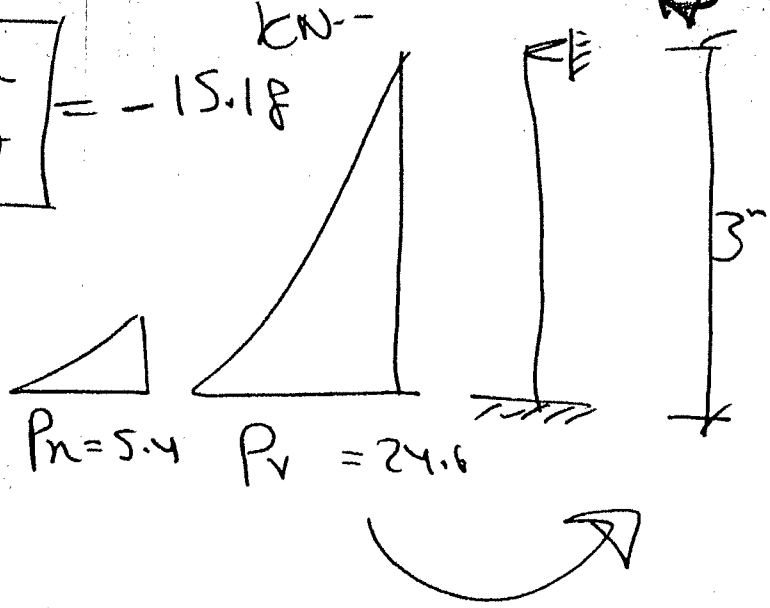
a) Water $P = \gamma_w H = 30\ KN/m^2$

$P_v = \alpha P = 0.82(30) = 24.6\ KN/m^2$

$P_h = \beta P = 0.18(30) = 5.4\ KN/m^2$

(6)

$$FEM = \frac{P_V L}{15} + \frac{P_h H^2}{117} = -15.18 \text{ kN.m}$$

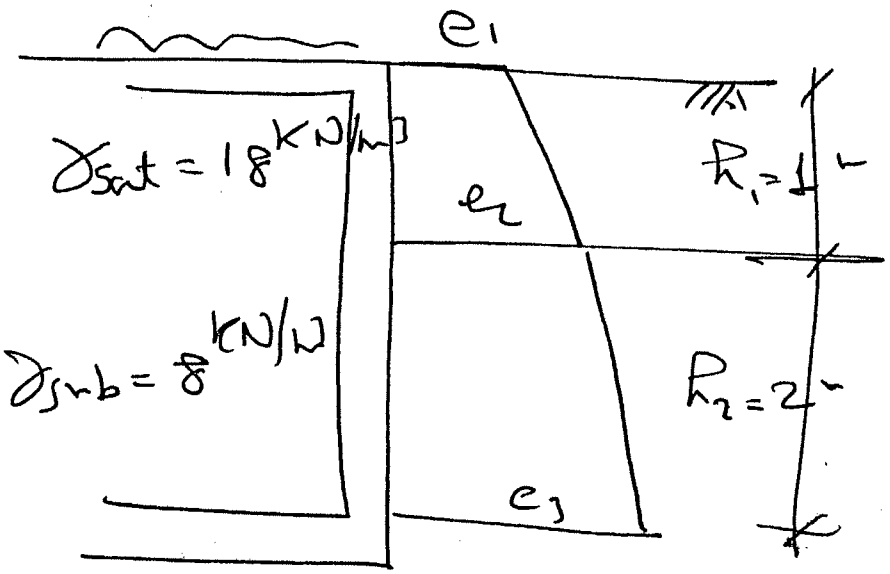


b) Case of Earth

$\phi = 30°$

$K_a = 1/3$

L.L = 4 kN/m²

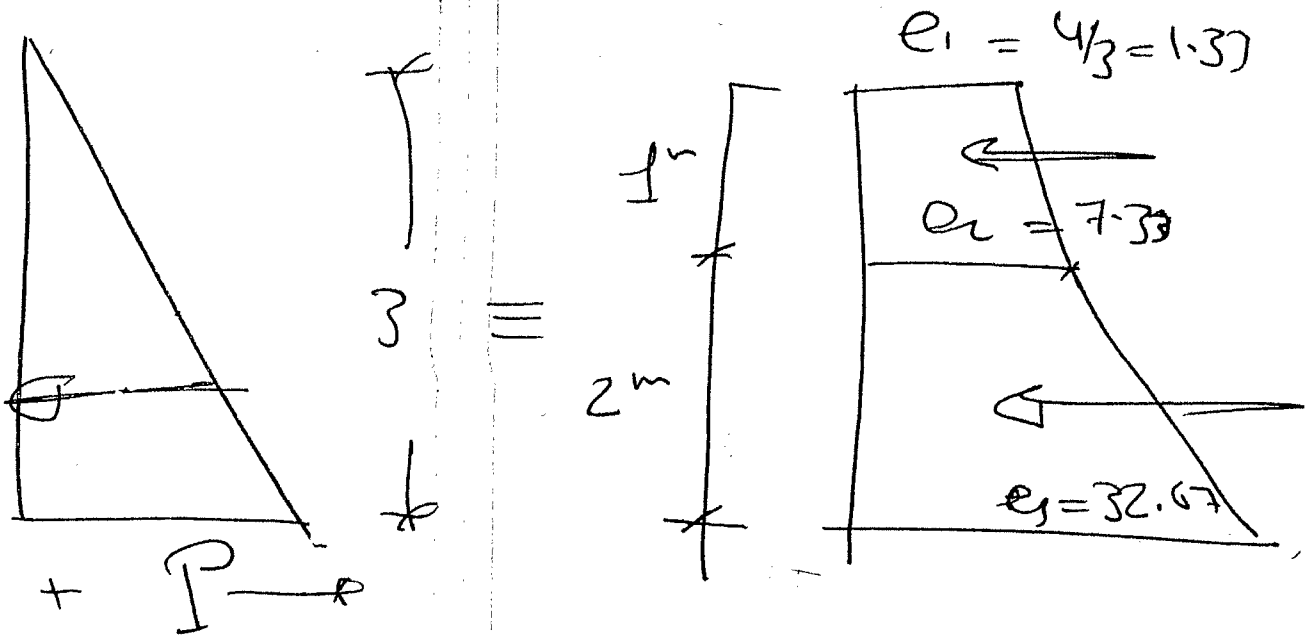


$$e_1 = K_a * L.L. = \frac{1}{3}(4) = \frac{4}{3} \text{ kN/m}^2$$

$$e_2 = e_1 + K_a * h_1 * \gamma_{sat} = \frac{4}{3} + \frac{1}{3} * 1 * 18 = 7.33 \text{ kN/m}^2$$

$$e_3 = e_2 + K_a * h_2 * \gamma_{sub} + \gamma_w h_2 =$$

$$= 7.33 + \frac{1}{3} * 2 * 8 + 10 * 2 = 32.66 \text{ kN/m}^2$$



$$\frac{1}{2}P(3) = \left(\frac{e_1+e_2}{2}\right)(1) + \left(\frac{e_2+e_3}{2}\right)(7)$$

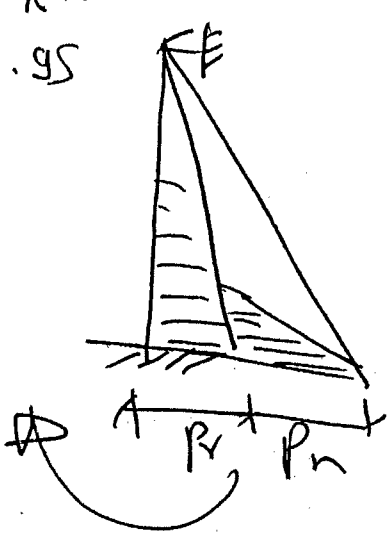
$$\boxed{P = 29.55}$$

$P_v = \alpha P = 0.82(29.55) = 24.23$

$P_h = \beta P = 0.18(29.55) = 5.32$

$P = 29.55$

$$\boxed{F.EM = \frac{P_v \times 12}{15} + \frac{P_h \times 12}{117}} = +14.95 \text{ KN.m}$$



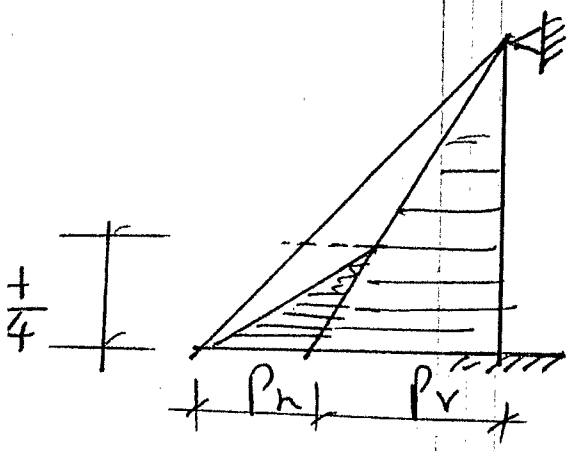
3) Case of Empty

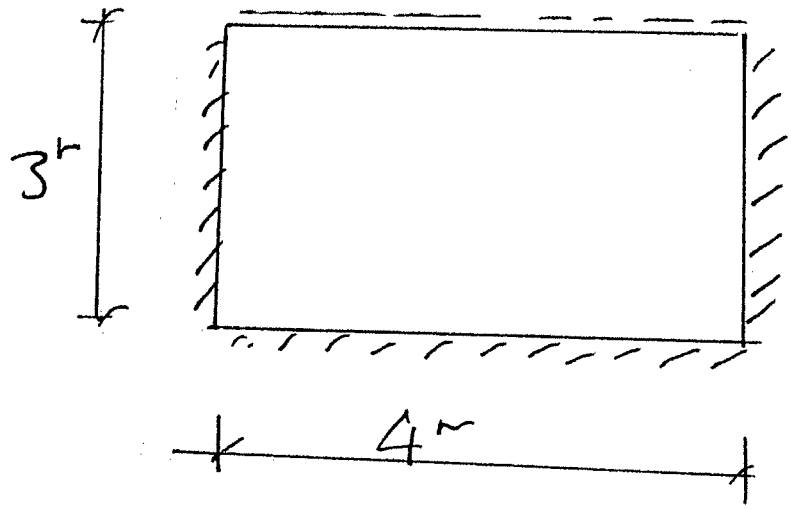
$M = 0.0$

2] The wall

Wall #(II)

Sec. (B-B)





$$r = \frac{4 * 0.78}{3 * 0.87} = 1.16 < 2 \quad \text{T.W.S}$$

$$\alpha = \frac{r^4}{1 + r^4} = 0.644$$

$$\beta = \frac{r}{1 + r^4} = \frac{0.356}{1}$$

* Case of Loading

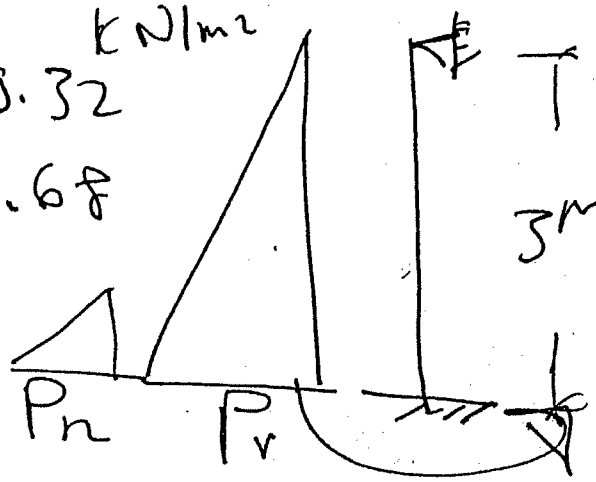
$$P = \gamma_w H = 30 \ KN/m^2$$

a) Case of water pressure only

$$P_v = \alpha . P = 0.644 * 30 = 19.32 \ KN/m^2$$

$$P_h = \beta P = 0.356 * 30 = 10.68$$

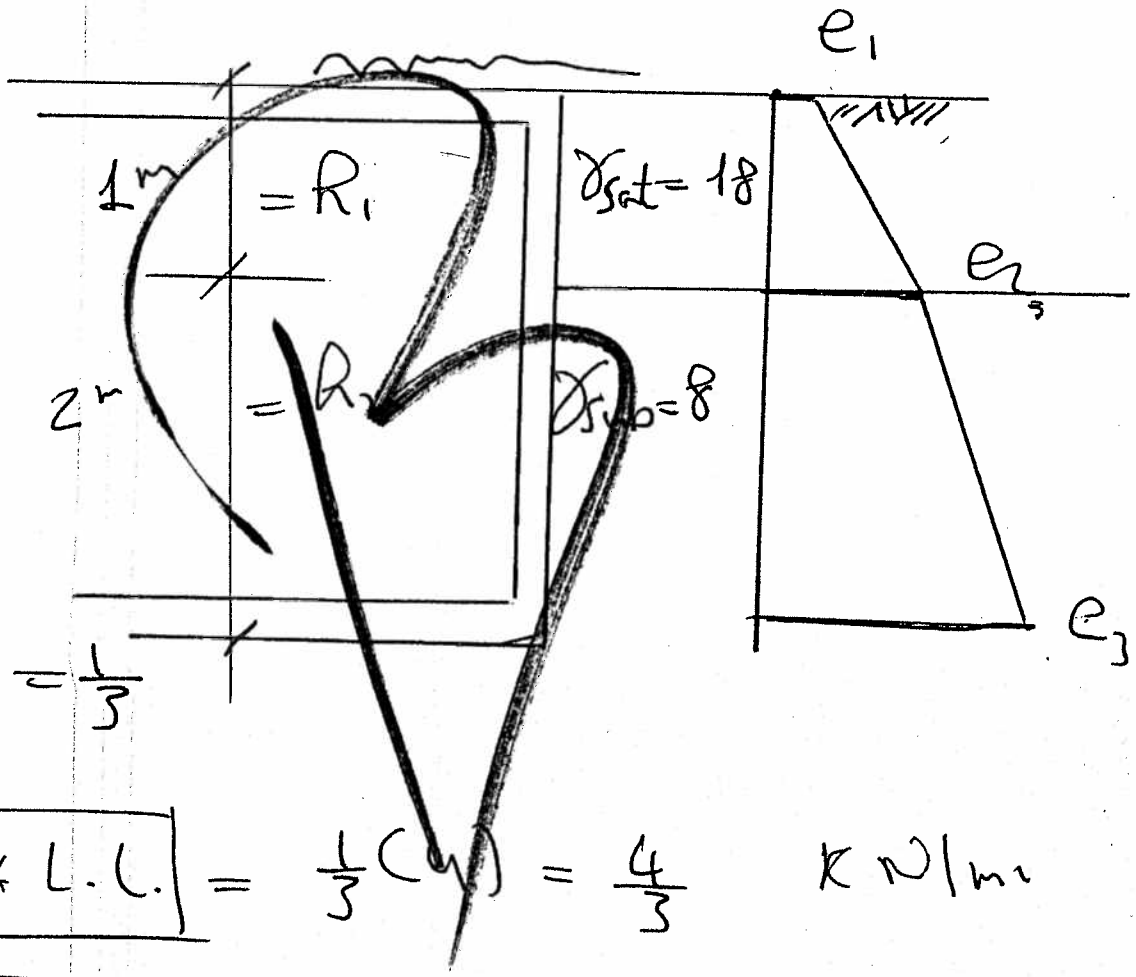
$$F.EM = \frac{P_v H^2}{15} + \frac{P_h H^2}{117}$$



$$F.E.M._{water} = -12.41$$

b) Case of Earth pressure

L.L. = 4 KN/m²



$\phi = 30°$

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1}{3}$$

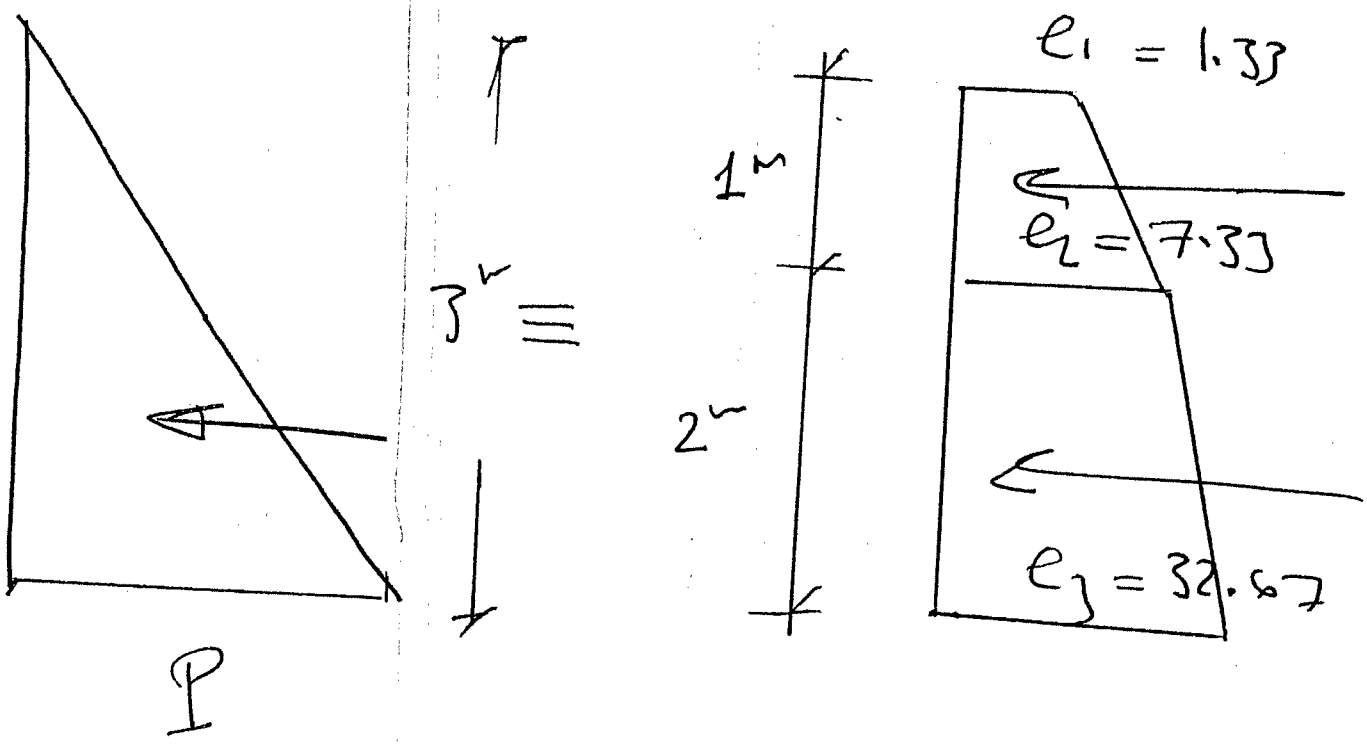
$$e_1 = K_a * L.L. = \frac{1}{3}(4) = \frac{4}{3} \quad KN/m^2$$

$$e_2 = e_1 + K_a * R_1 \gamma_{sat}$$

$$= \frac{4}{3} + \frac{1}{3}(1)(18) = 7.33 \ KN$$

$$e_3 = e_2 + K_a * R_2 * \gamma_{sub} + \gamma_w * R_2$$

$e_3 = 7.33 + \frac{1}{3} * 2 * 8 + 10 * 2 = 32.67$ kN/m²



P

$\frac{1}{2}(P)(3) = \left(\frac{e_1+e_2}{2}\right)(1) + \left(\frac{e_2+e_3}{2}\right)(2)$

$\boxed{P = 29.55}$ kN/m

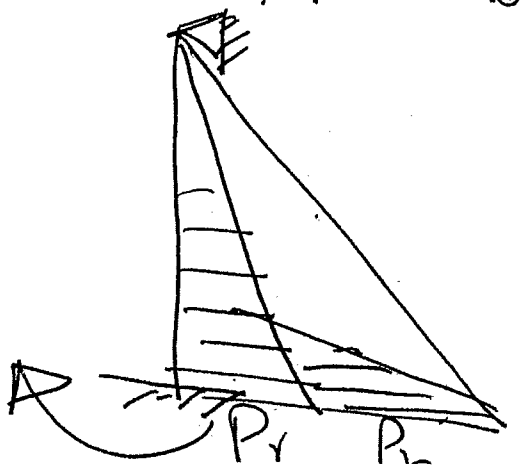
$P_r = \alpha P = 19.03$

$P_n = \beta P = 10.52$

$\boxed{F.EM = \frac{P_r H^2}{15} + \frac{P_n H^2}{117}}$

$\circlearrowleft M_1 = +12.23$ kN.m

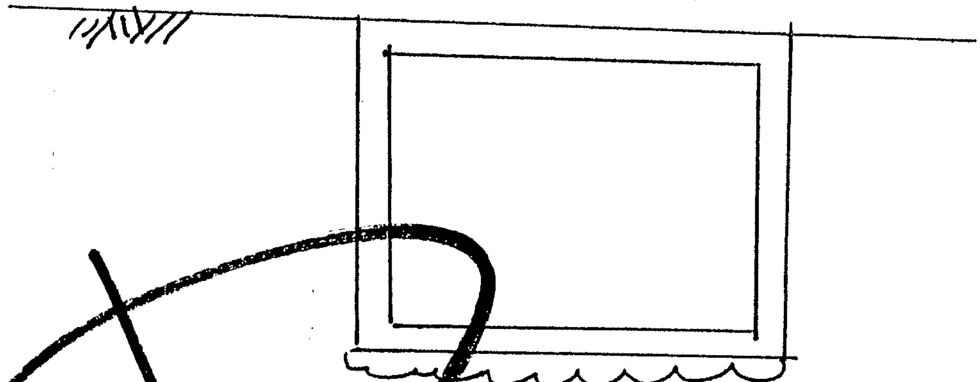
Grav. of Entb $y = 0.0$



(C) Case of empty tank

$f_{wall} = 0.0$

[3] The Floor



$$w_{floor} = \frac{Roof + Wall}{Area\ of\ floor}$$

$M^{max} = 15.18$

$$t_w = \sqrt{\frac{M \times 10^6}{3}} + 50\ mm = 300\ mm$$

* Roof load $= W_{Roof} \times Area$

$= 8.5 \times 5 \times 4 = 170$ KN

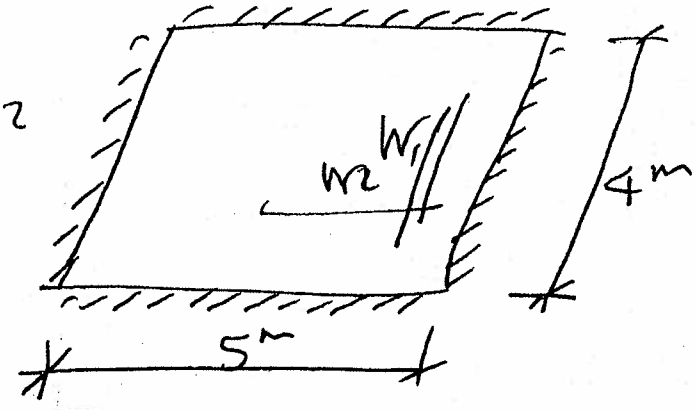
Wall load $= h_w \times t_w \times \gamma_{RC} \times$ (اطوال الحوائط)

$= 3 \times 0.3 \times 25 \times (4\times2+5\times2) = 405$ KN

$$W_{F\,bar} = \frac{(170 + 405)}{(4*5)} = 28.75 \text{ KN/m}^2$$

$$r = \frac{5 * 0.76}{4 \times 0.76} = 1.25 < 2$$

T.W.S



$$\alpha = \frac{r^4}{1+r^4} = 0.71$$

$$\beta = \frac{1}{1+r^4} = 0.29$$

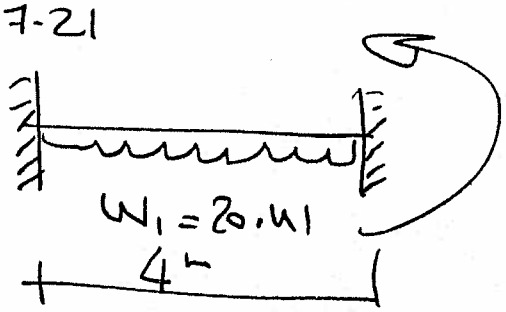
$$\alpha + \beta = 1$$

$$W_1 = \alpha W_F = 0.71(28.75) = 20.41 \text{ KN/m}^2$$

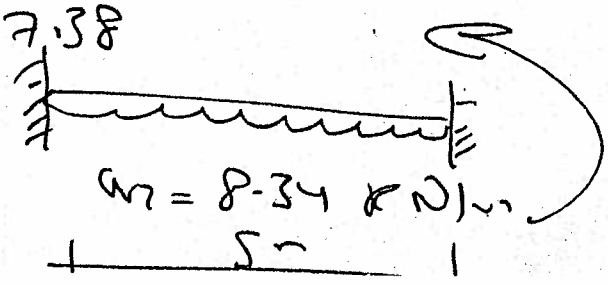
$$W_2 = \beta W_F = 0.29(28.75) = 8.34 \text{ KN/m}^2$$

$$W_F = 28.75 \text{ KN/m}^2$$

$$F.E.M_{Short} = \frac{W_1 (4)^2}{12} = -27.21$$



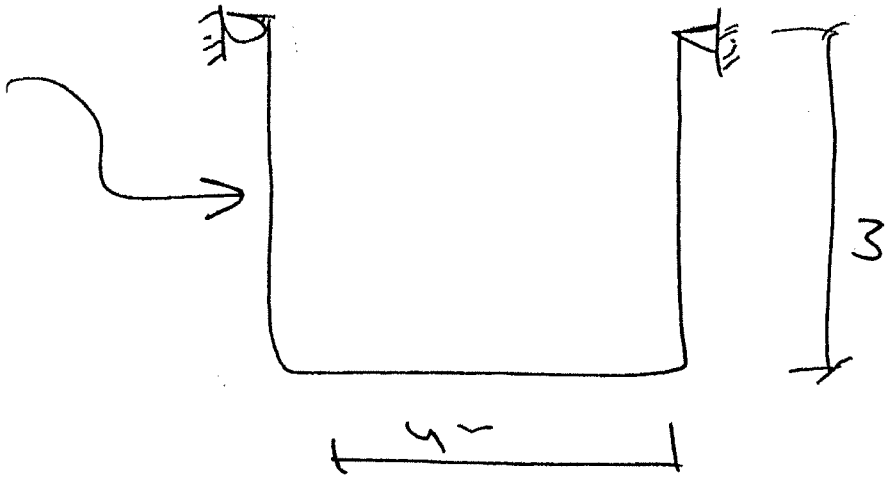
$$F.E.M_{long} = \frac{W_2 (5)^2}{12} = -17.38$$



Sec (A-A)

Wall #(I)

ابعاد
3 * 5 m



D.f.

$K_w = \frac{3}{H} = \frac{3}{3} = 1$ — 2/3 = 0.67

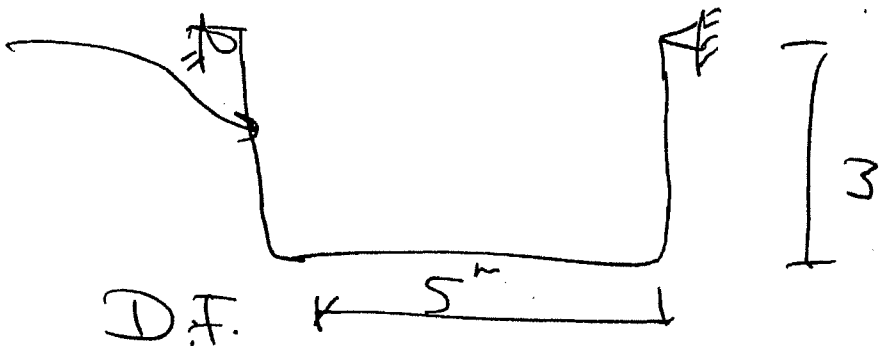
$K_f = \frac{2}{l} = \frac{2}{4} = 0.5$ — 1/3 = 0.33

1.5 — 1

Sec. (B-B)

Wall #(II)

ابعاد
3 * 4 m



D.F.

$K_w = \frac{3}{H} = \frac{3}{3} = 1$ — 0.714

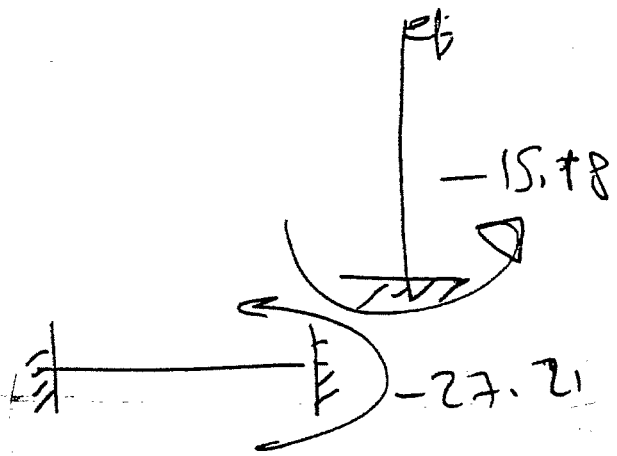
$K_f = \frac{2}{5} = 0.4$ — 0.286

1.4 — 1

(14)

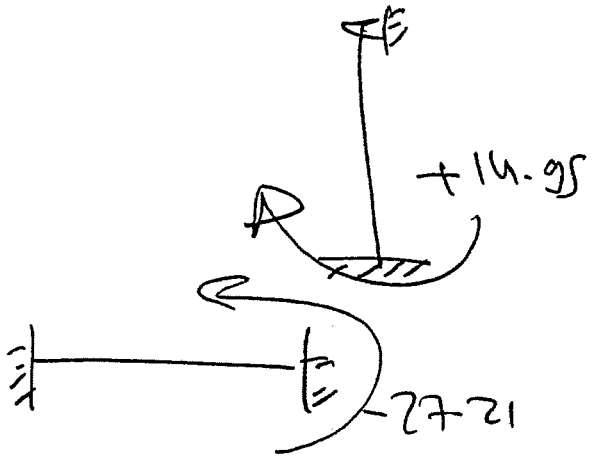
Sec (A-A) (Short Direction)

Water



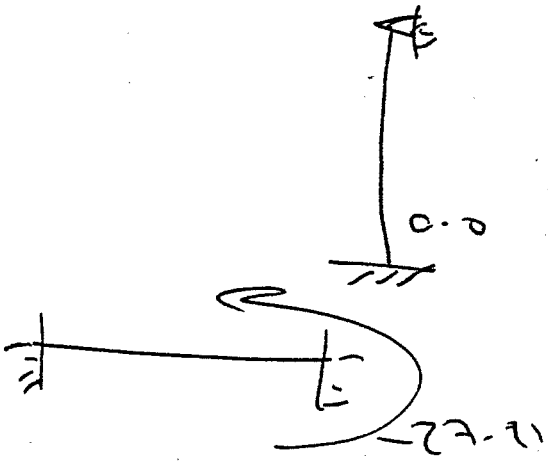
	Wall	floor
D.f.	0.67	0.33
F.E.M	-15.18	-27.21
B.M	+28.40	+13.99
Final	+13.22	-13.22

Earth



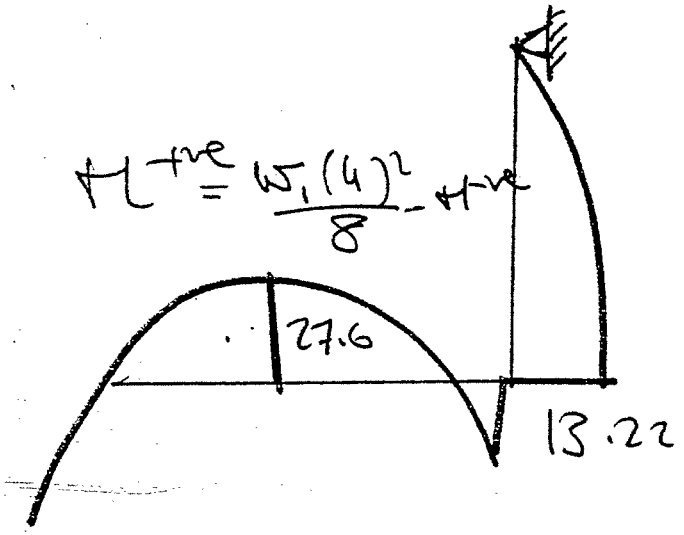
Wall	floor
0.67	0.33
+14.95	-27.21
+8.21	+4.05
+23.16	-23.16

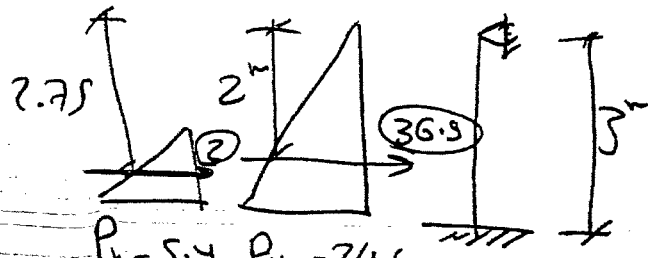
Empty



Wall	floor
0.67	0.33
0.0	-27.21
+18.23	+8.98
+18.23	18.23

(9) Water

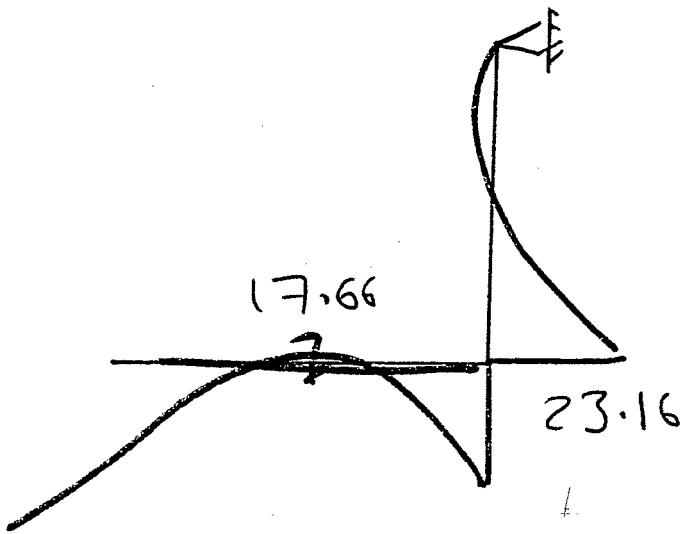


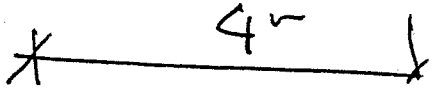


13.22

$T_{Floor} = Q_{wall} = 22$ kN

E-P.

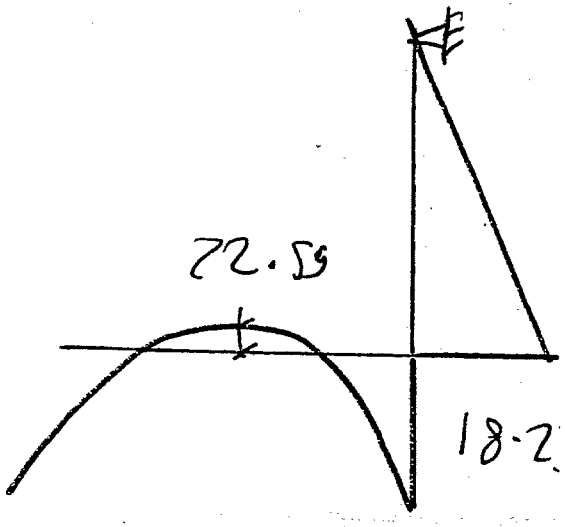




$M^{max}_{wall} = 23.16$

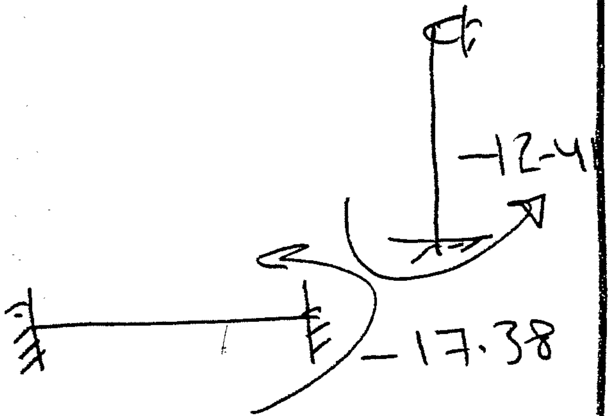
$T = 0.0$

Empty



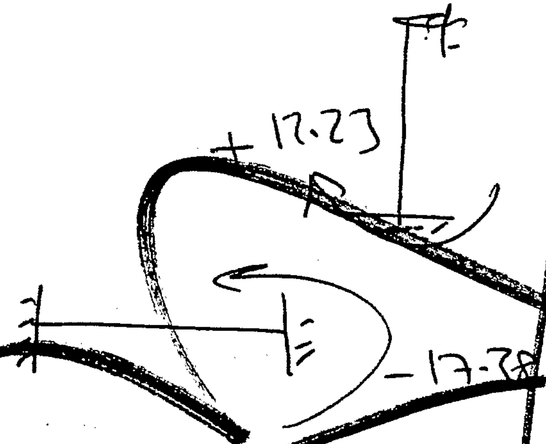
Sec (B-B) Long direction

Water



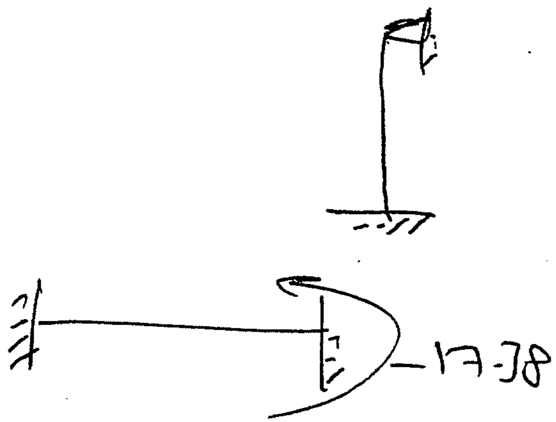
	Wall	Floor
D.F.	0.714	0.786
FEM	-12.41	-17.38
B.M	+21.27	+8.52
M_{final}	+8.86	-8.86

Earth



Wall	Floor
0.714	0.786
+12.23	-17.38
+3.68	+1.47
+15.91	-15.91

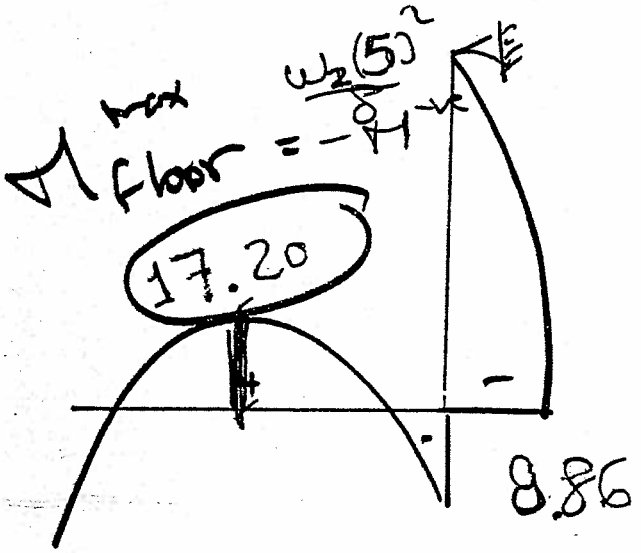
Empty

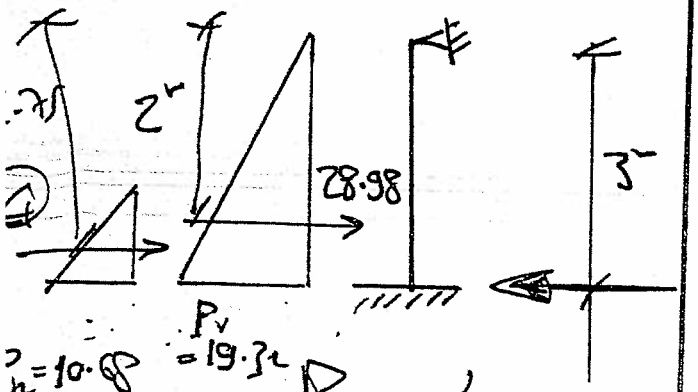


Wall	Floor
0.714	0.286
0.0	-17.38
+12.41	+4.97
+12.41	-12.41

(17)

Water

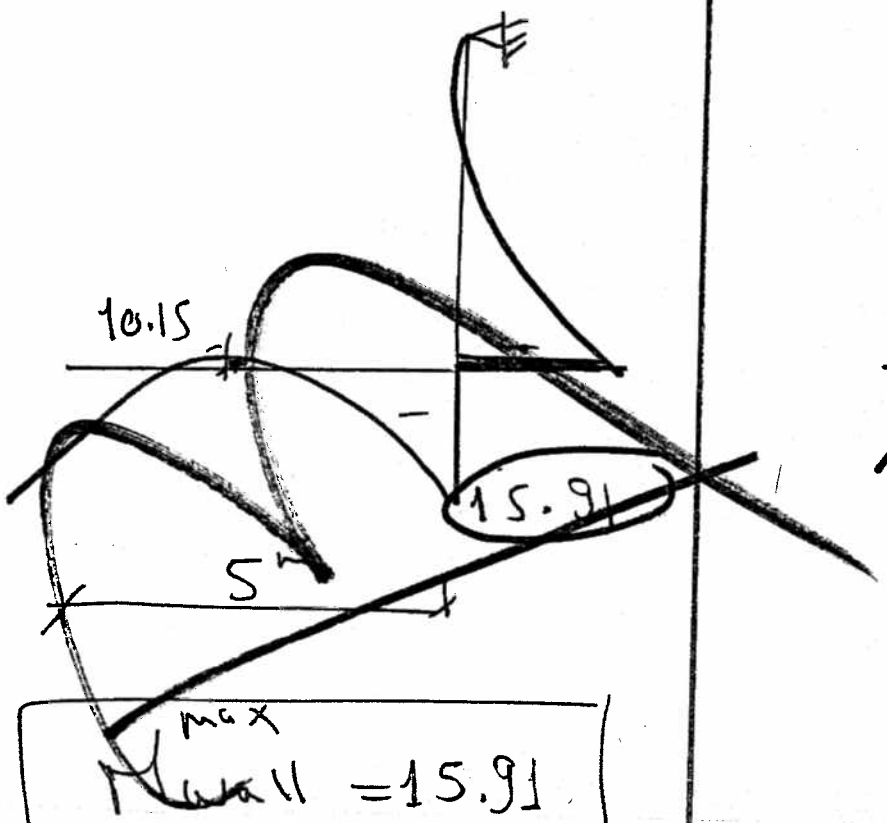




$T_1 = 8.86$

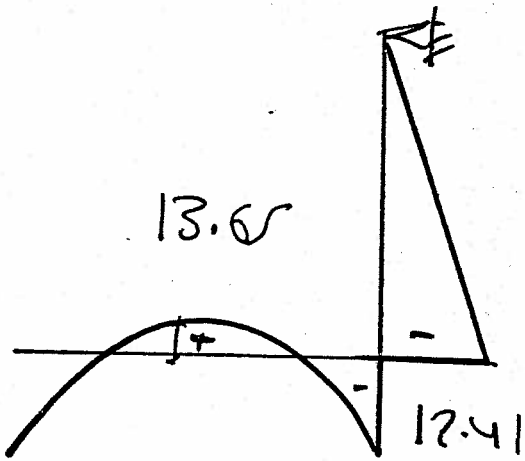
$T_{floor} = Q_{wall} = 20$ KN

E.P.



$T = 0.0$

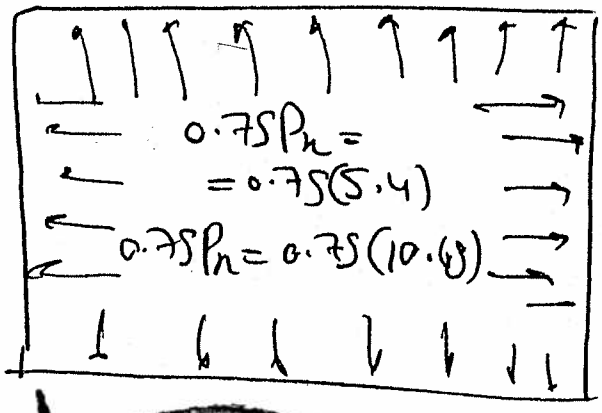
Empty

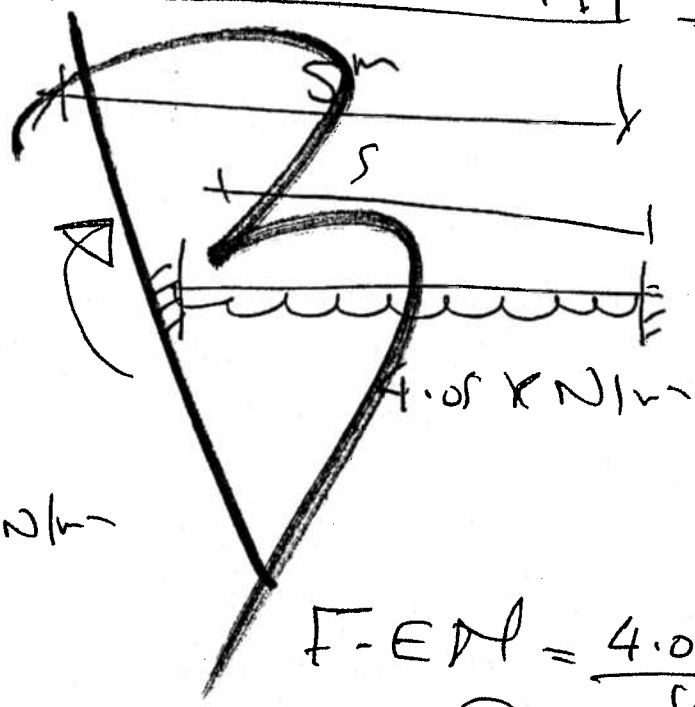


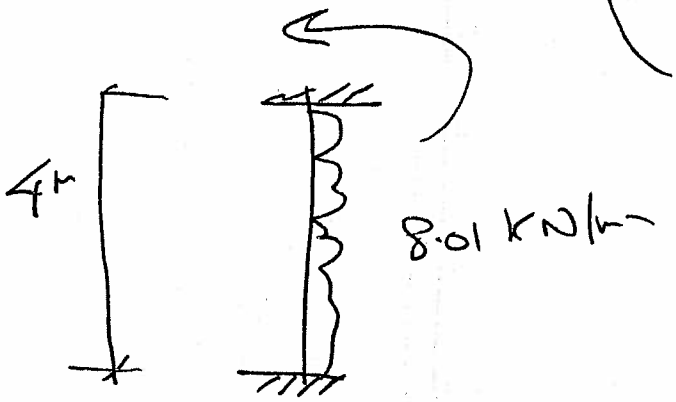
h2nd Direction

Water

Plan







$$F\text{-}EM = \frac{4.05(5)^2}{12}$$

Wall (I)

$$= 8.44 \text{ KN.m}$$

$$F\text{-}EM = \frac{8.01(4)^2}{12}$$

Wall (II)

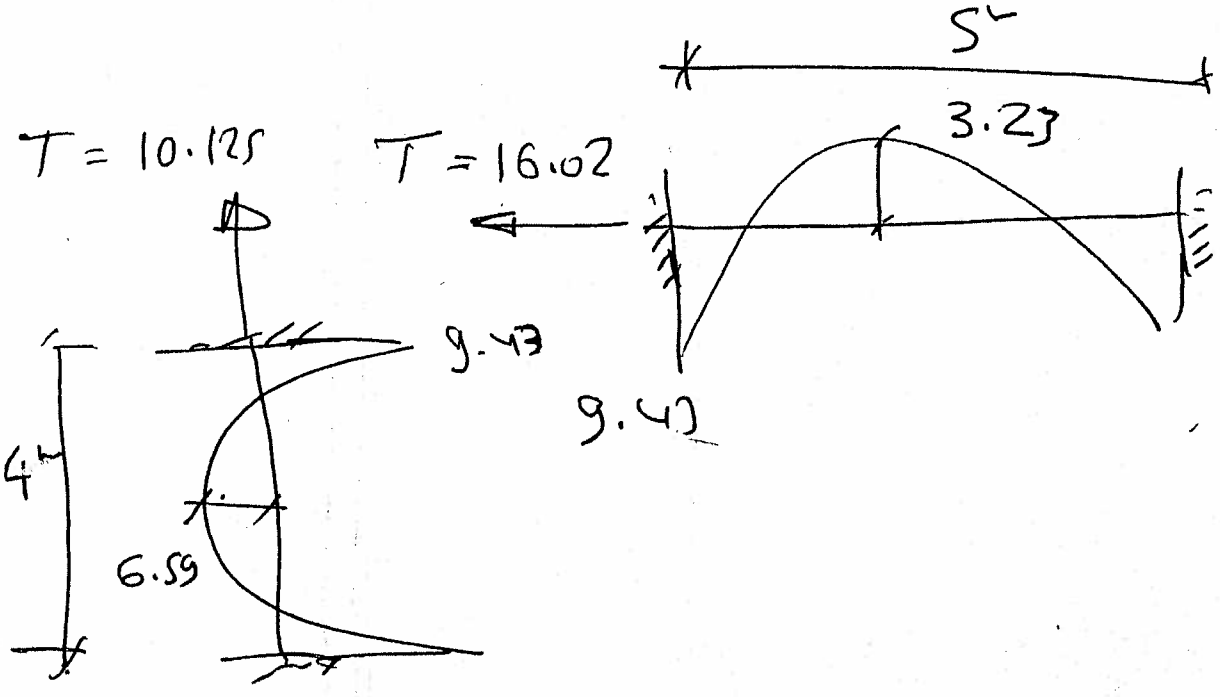
$$= 10.68 \text{ KN.m}$$

$K_{Wall\ (I)} = \frac{2}{5} = 0.4$

$K_{Wall\ (II)} = \frac{2}{4} = 0.5$

	D.f
	0.44
	0.56
	1

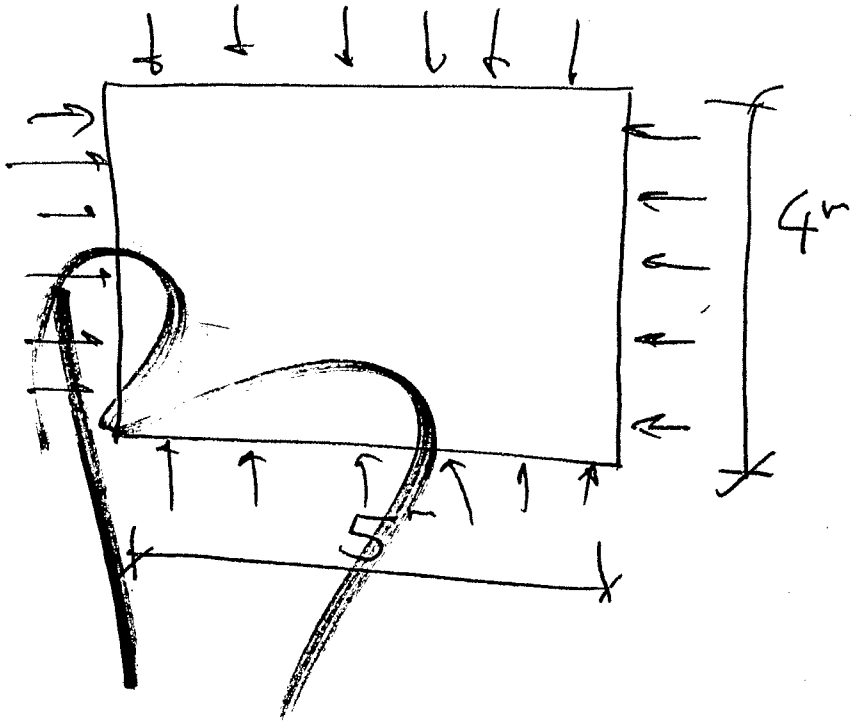
	Wall (I)	Wall (II)
D.f	0.44	0.56
F.E.M.	− 8.44	+ 10.68
T.D	− 0.99	− 1.25
M final	− 9.43	+ 9.43



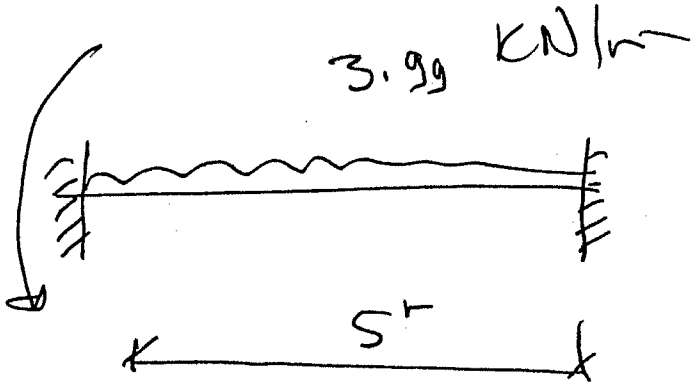
Rigid Direction

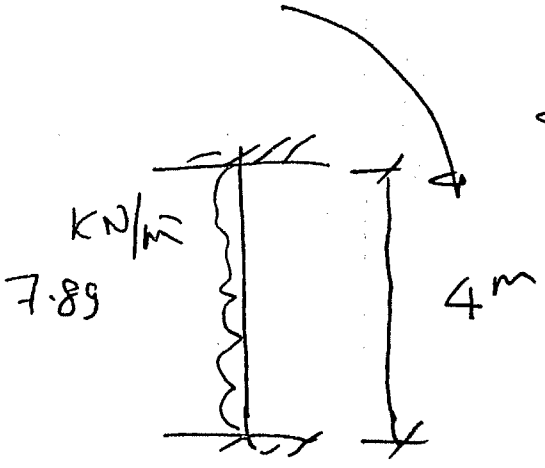
Earth

$0.75P_h = 0.75(5.37)$



$0.75P_h = 0.75(10.52)$





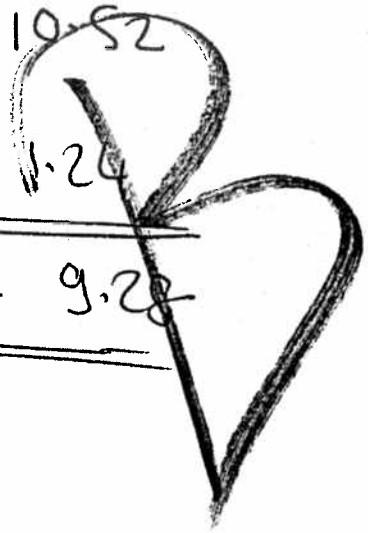
$$F\text{-}EM_{\substack{wall \\ (II)}} = \frac{7.89(4)^2}{12}$$

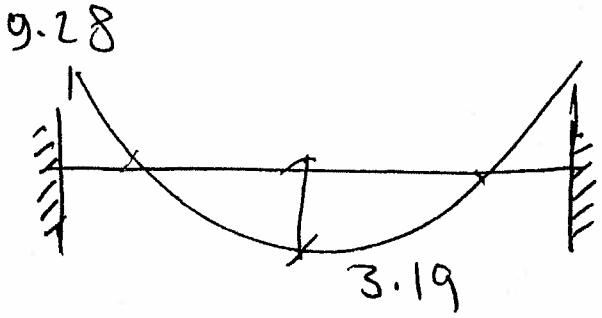
$$= \underline{10.52}$$

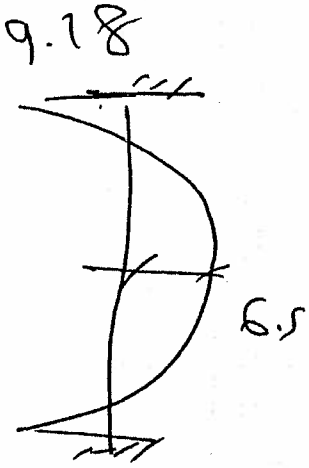
$$F\text{-}EM_{\substack{wall \\ (I)}} = \frac{3.99(5)^2}{12}$$

$$= \underline{8.31}$$

	Wall (I)	Wall (II)
D.f.	0.44	0.56
F.E.M	+8.31	-16.52
B.M	+0.97	+1.24
M_{final}	+ 9.28	- 9.28







FT = 0.0 → Earth

Design of floor

$M = 27.6$ KN.m
$T = 22$ KN
from water
Short Direction

$$t = \sqrt{\frac{M \times 10^4}{3}} + 30 = 350 \text{ mm}$$

$d' = 40$

$d = 310$ mm

$$e = \frac{M}{T} = \frac{27.6}{22} = 1.25 \text{ m} > t/2 \quad \text{large-e}$$

* $M_s = M - T(d - t/2)$

$= 27.6 - 22(0.31 - \frac{0.35}{2}) = 24.63$ KN.m

* $A_s = \frac{M_s}{\beta f_s d} + \frac{T}{f_s}$

$= \frac{24.63 * 10^6}{0.94 * 200 * 310} + \frac{22 * 1000}{200} = 532.6$ mm²

7 #10/m

OR 5 #12/m

minimal بس ← #10

$A_{s\min} = 1.5t = 525$ mm² → 7 #10/m (553 mm²)

Check of Stresses

→ 14#10/m = 1106 mm²

$$f_{ct(N)} = \frac{T + 50 A_s}{A_c + n A_s}$$

$$= \frac{22000 + 50(1106)}{1000 * 350 + 10(1106)} = 0.22 \ N/mm^2$$

$$I = \frac{bt^3}{12} + nA_s\left(\frac{t}{2} - d'\right)^2 + nA_s\left(\frac{t}{2} - d''\right)^2$$

$$= \frac{1000(350)^3}{12} + 10 * 553(175 - 40)^2$$

$$+ 10 * 553(175 - 40)^2 = 3774.5 * 10^6 \ mm^4$$

→ t/2

$$f_{ct(M)} = \frac{M}{I} y = \frac{27.6 * 10^6}{3774.5 * 10^6}(175) = 1.78$$

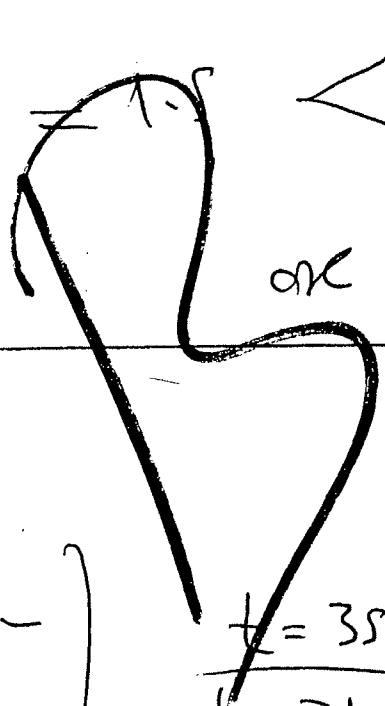
$$t_v = t\left(1 + \frac{f_{ct(N)}}{f_{ct(M)}}\right) = 410 \ mm$$

$$\therefore \eta \cong 1.6$$

$$\frac{f_{ctv}}{\gamma} = \frac{0.6\sqrt{30}}{1.6} = 2.05 \text{ N/mm}^2$$

$$\left[f_{ct(N)} + f_{ct(M)} \right]$$

$$0.27 + 1.28 = 1.5 < f_{ctv/\gamma}$$



Design of wall

$M = 23.16$ KN.m

$T = 0.0$

$t = 350$ $d' = 40$

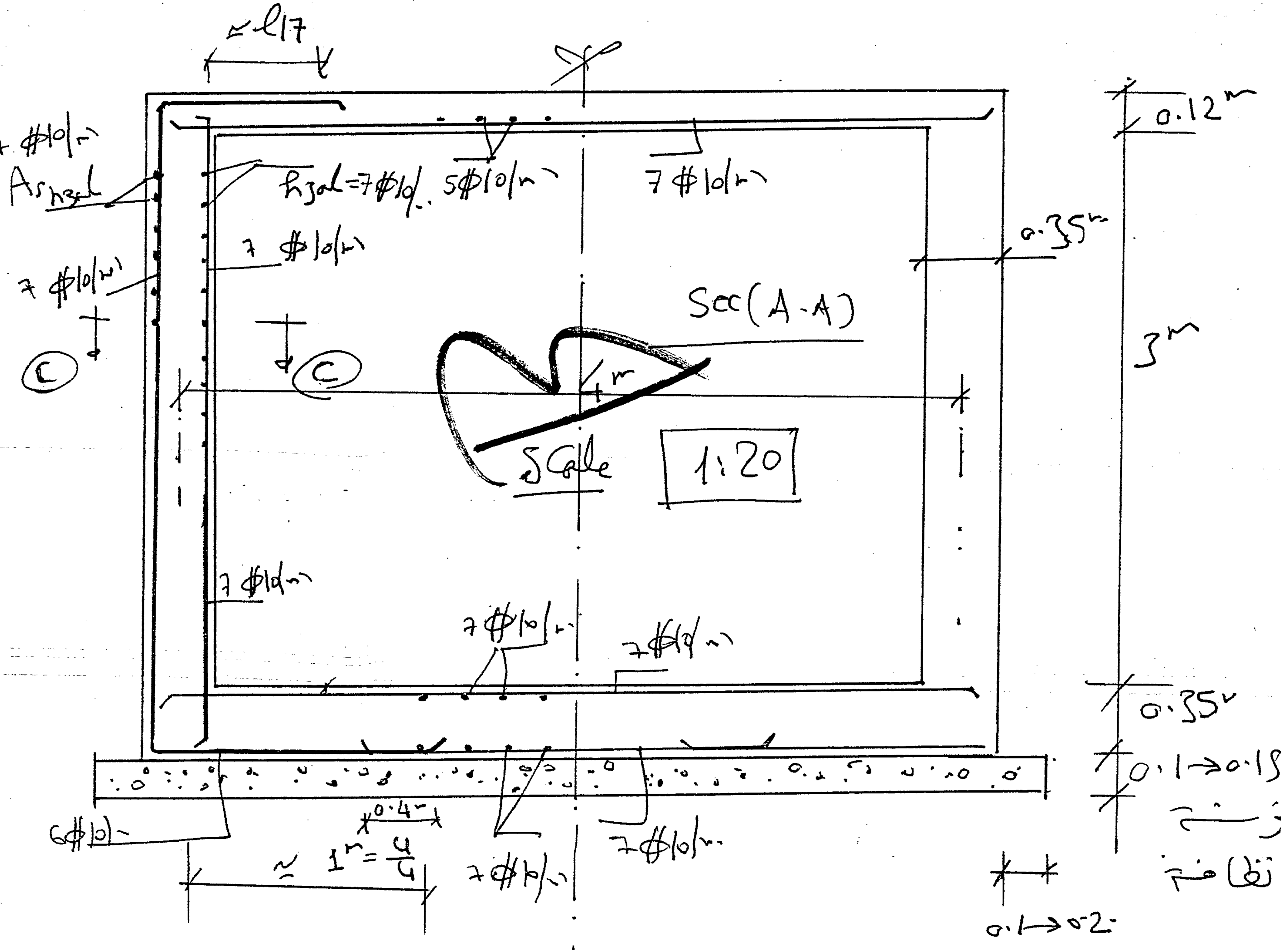
$d = 310$ mm

$$A_s = \frac{M}{\beta f_{yd} d} = \frac{23.16 * 10^6}{0.94 * 200 * 310} = 397.4$$

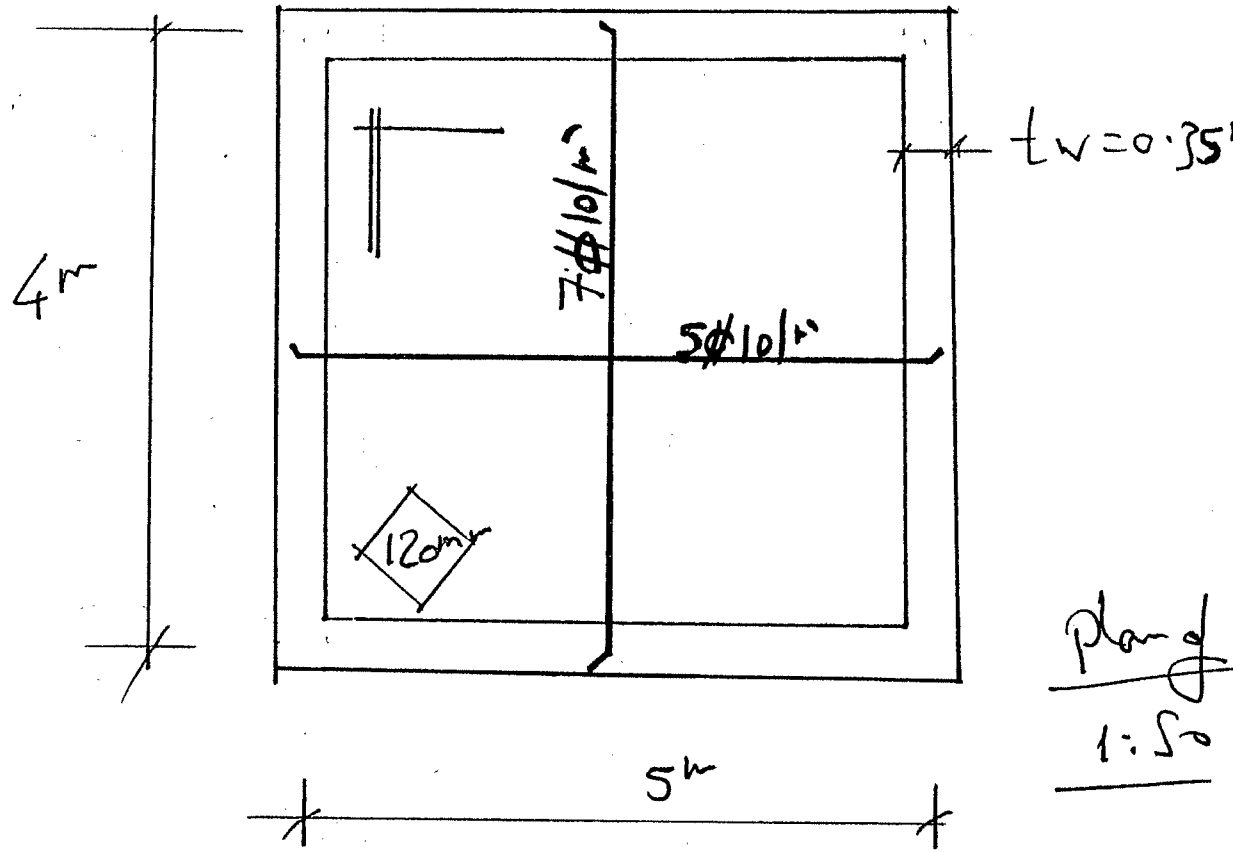
$A_{s,min} = 1.5t = 525$

min 7Φ10/m

7Φ10/m تسليح الجزء العلوي

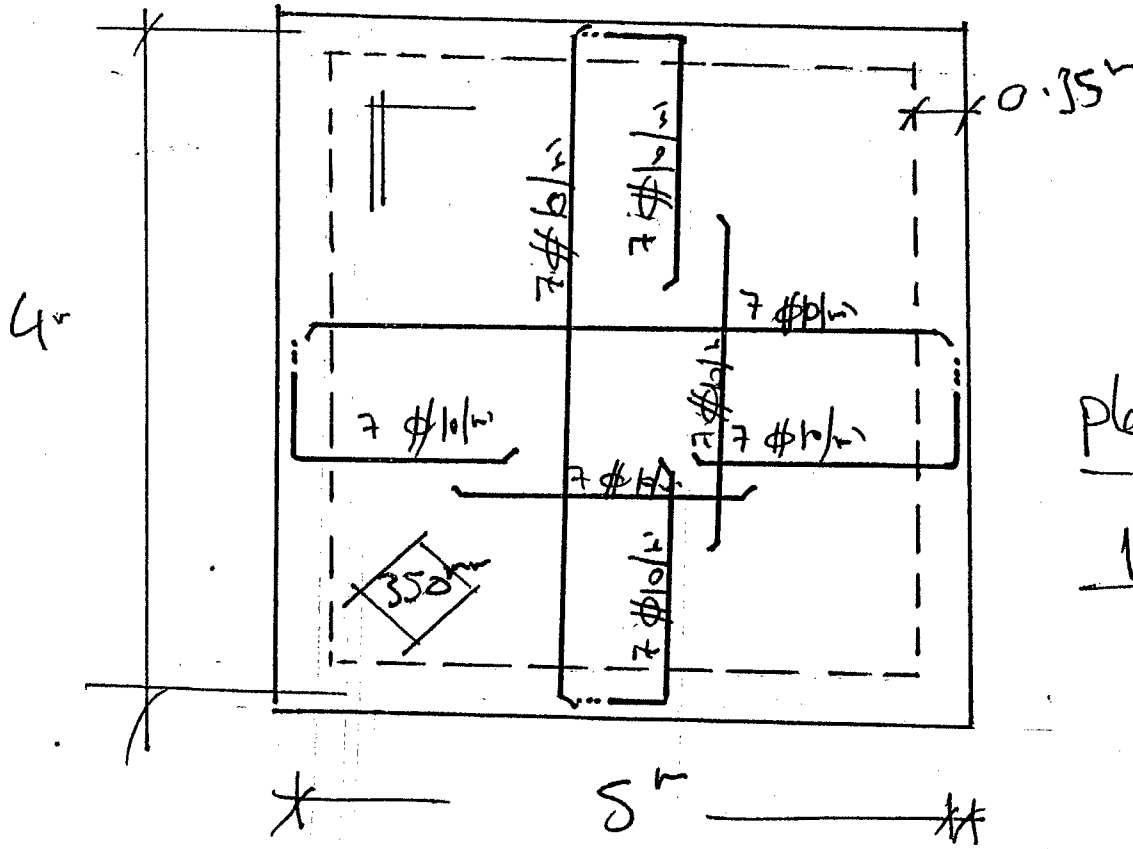


≃ l17
7 ϕ10/m
As_hzal
7 ϕ10/m
hzal = 7ϕ10/m 5ϕ10/m
7 ϕ10/m
7 ϕ10/m
0.12m
0.35m
Sec (A-A)
4m
Scale
1:20
3m
7 ϕ10/m
7 ϕ10/m
7 ϕ10/m
0.35m
0.1 → 0.15
6ϕ10/m
0.4m
≃ 1m = 4/4
7 ϕ10/m
7 ϕ10/m
0.1 → 0.2



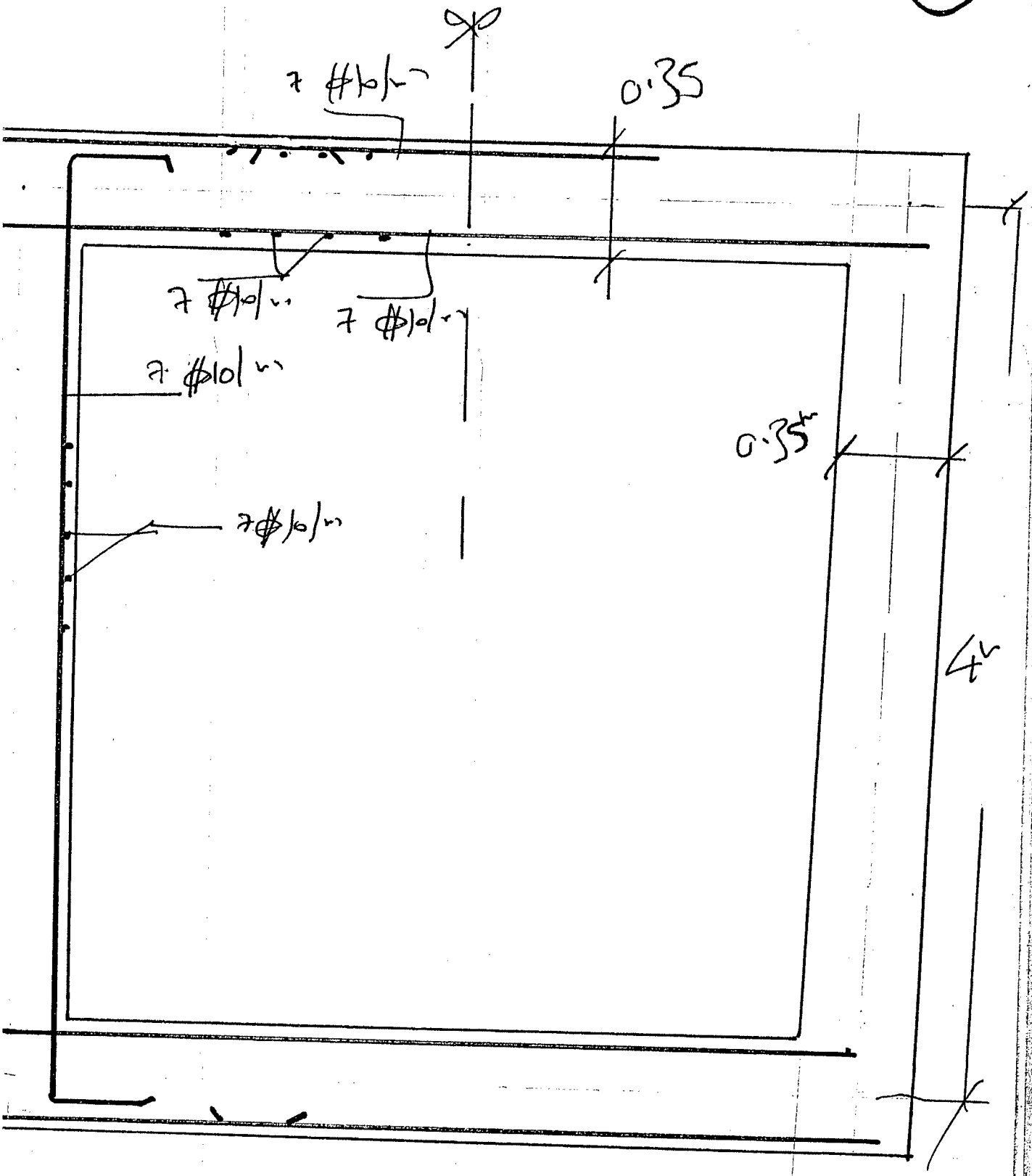
Plan of Roof

1 : 50



Plan of Floor

1 : 50



Sec (C-C)

1:20