سنتر و مركز

الفارس

للخدمات الطلابية والعلمية

الفرقة الرابعة مدني

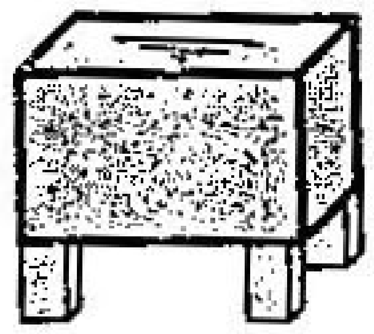
Reinforced Concrete Water tanks

Reinforced concrete design

4th year

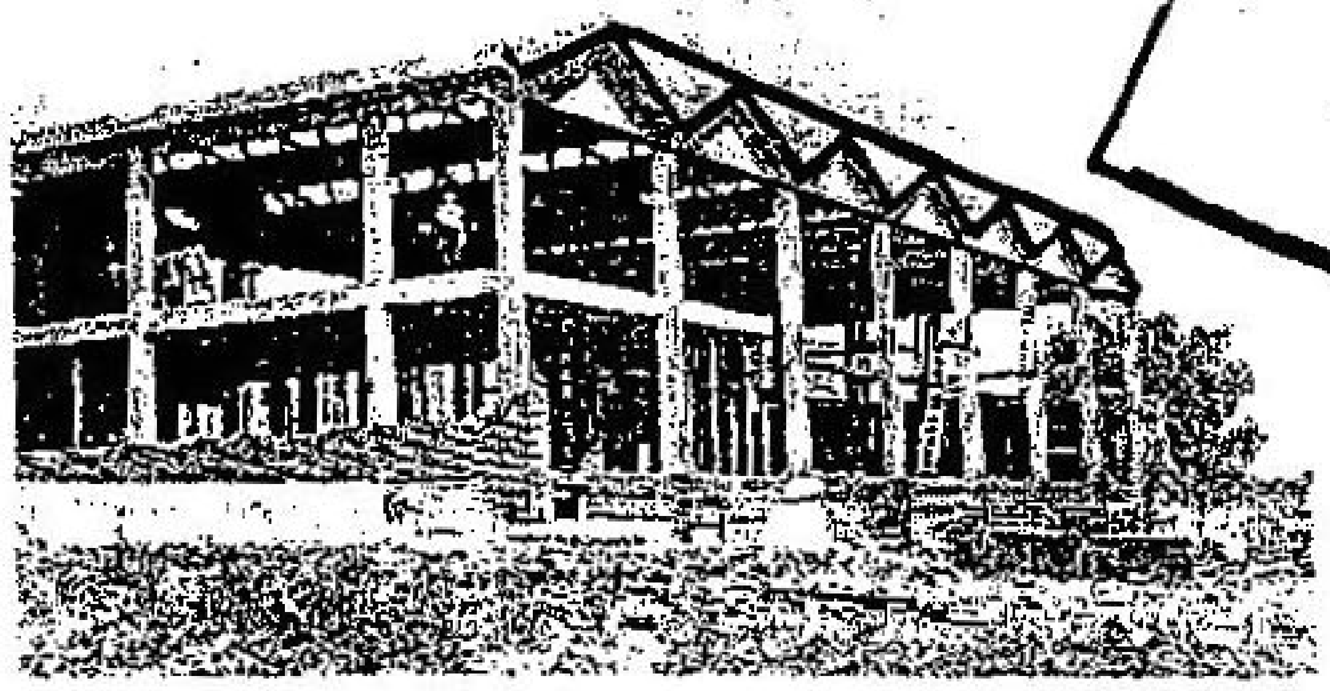
Part 1 (Tanks) الخزانات

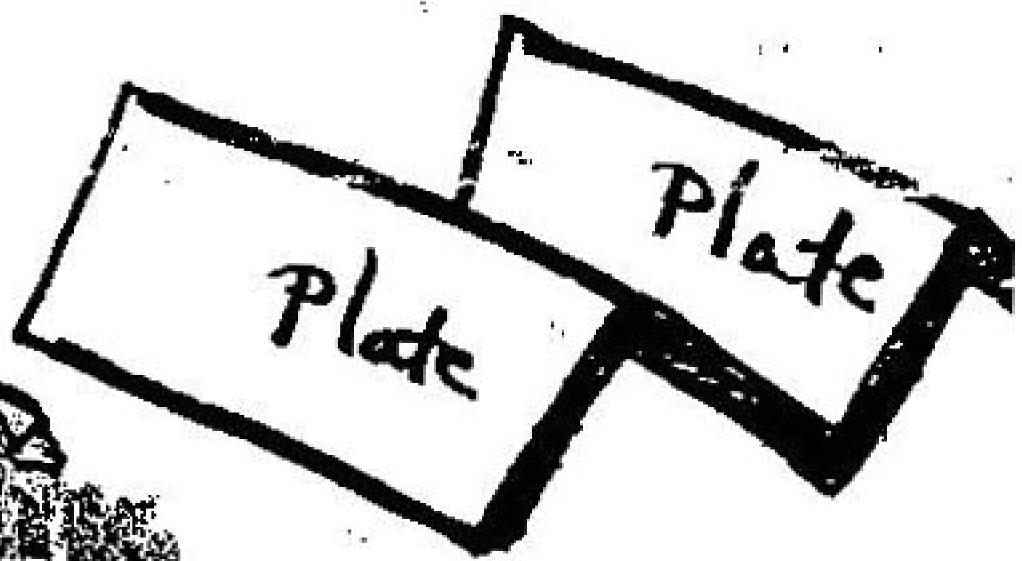
A- Circular Tanks:  On ground Or elevated.

B- Rectangular Tanks:  On ground or elevated.

Part (2) Folded plates

نوع من أنواع التغطيات عبارة عن plates من الخرسانة المسلحة مرتكزة على كمرات عميقة في البداية والنهاية





Part (3) Bridges: الكباري الخرسانية المسلحة

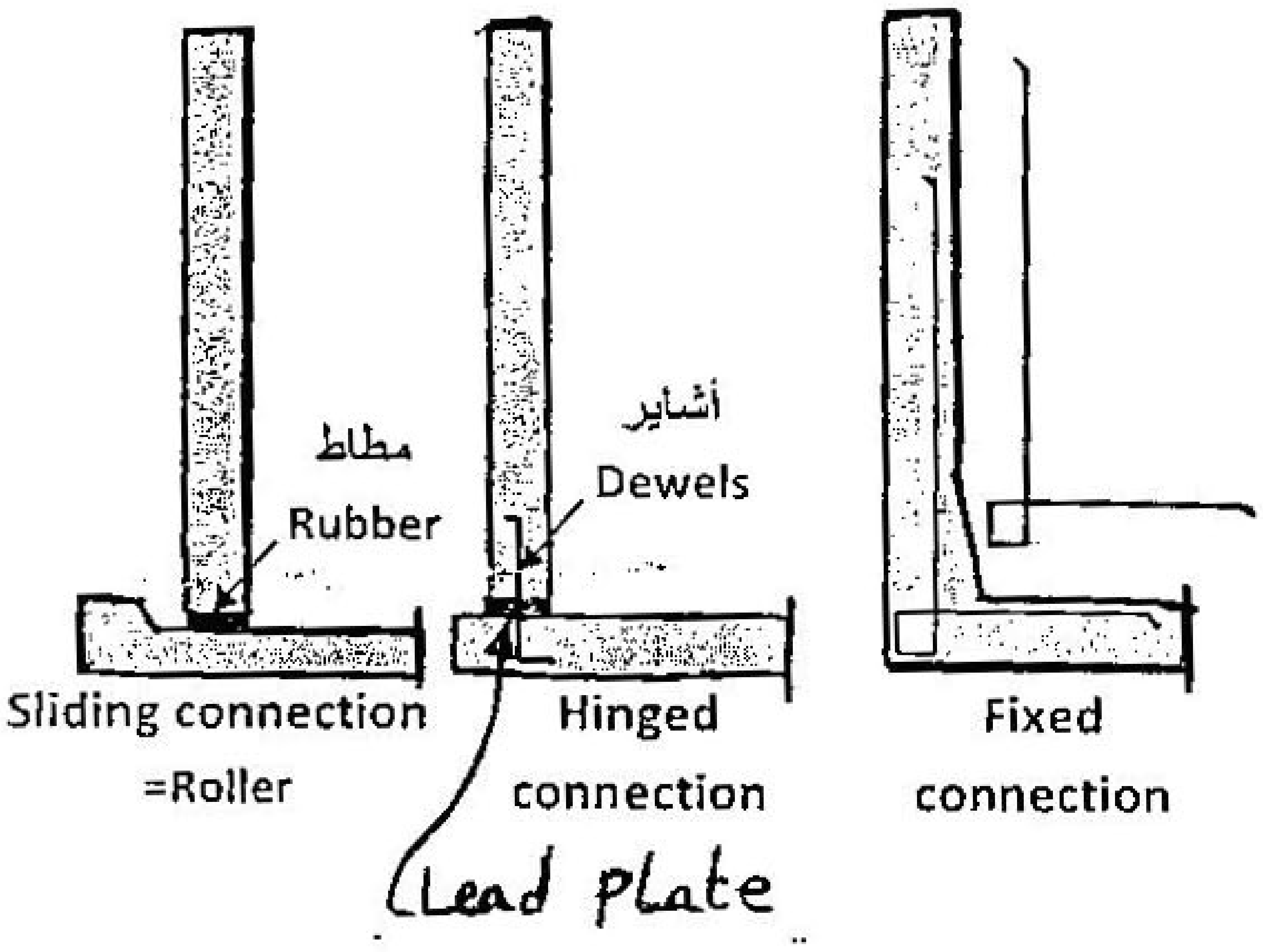
Part (4) Lateral forces

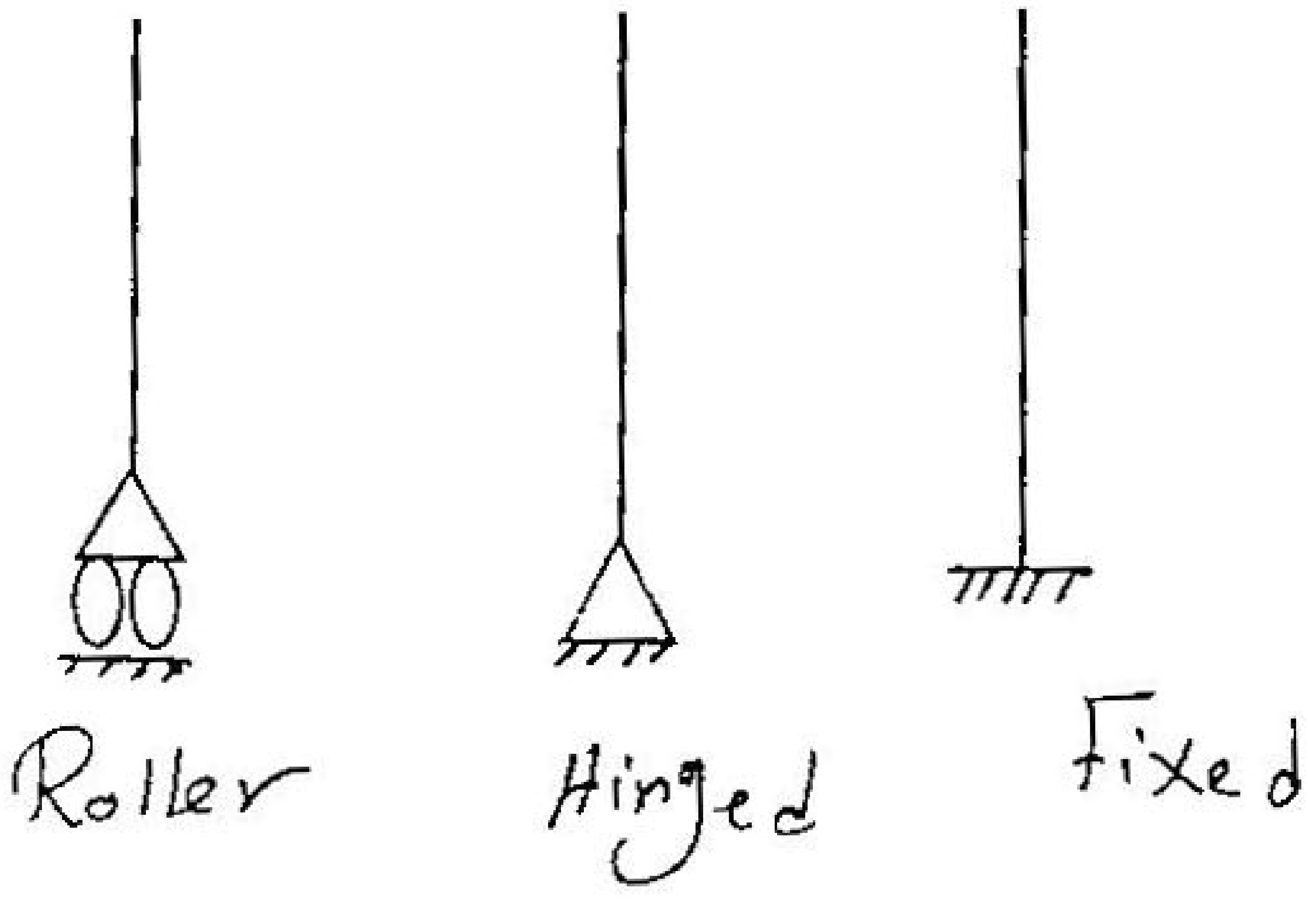
أحمال الرياح والزلازل الأفقية وتوزيعها على العناصر الإنشائية.

Circular Tanks

Wall الحائط

حل الحائط لا يعتمد على نوع التربة تحت القاعدة
ولكنه يعتمد على نوع الاتصال بين الحائط والقاعدة :

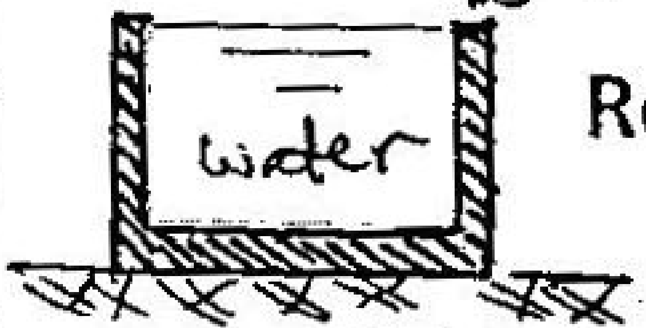




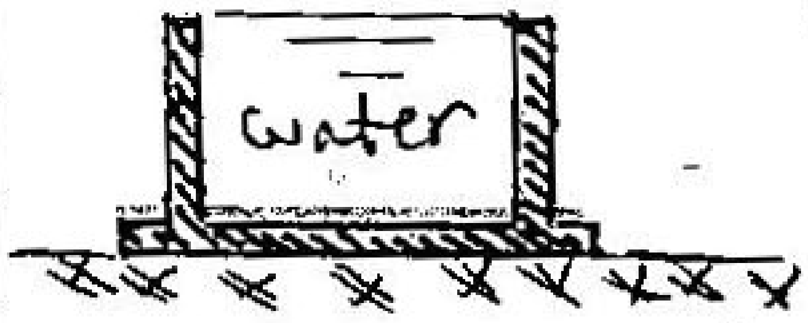
Base القاعدة

وهي قد تكون :

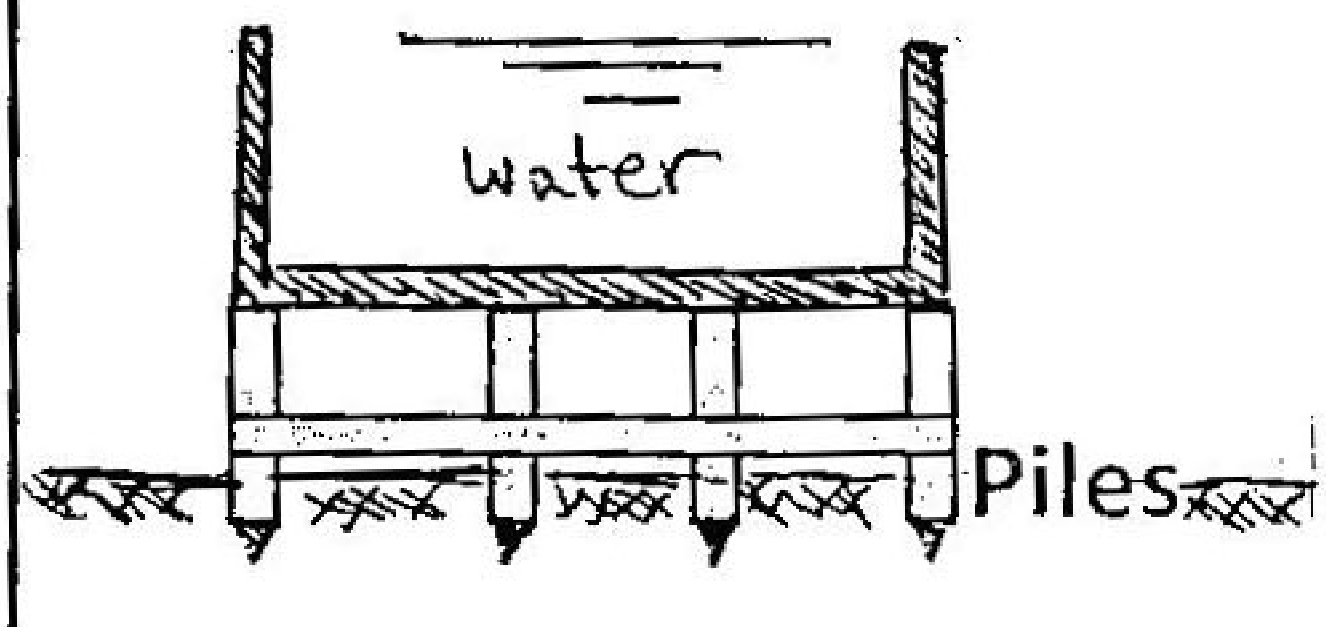
1- على تربة صخرية
Rocky soil



2- على تربة انضغاطية
medium soil (sand or clay)

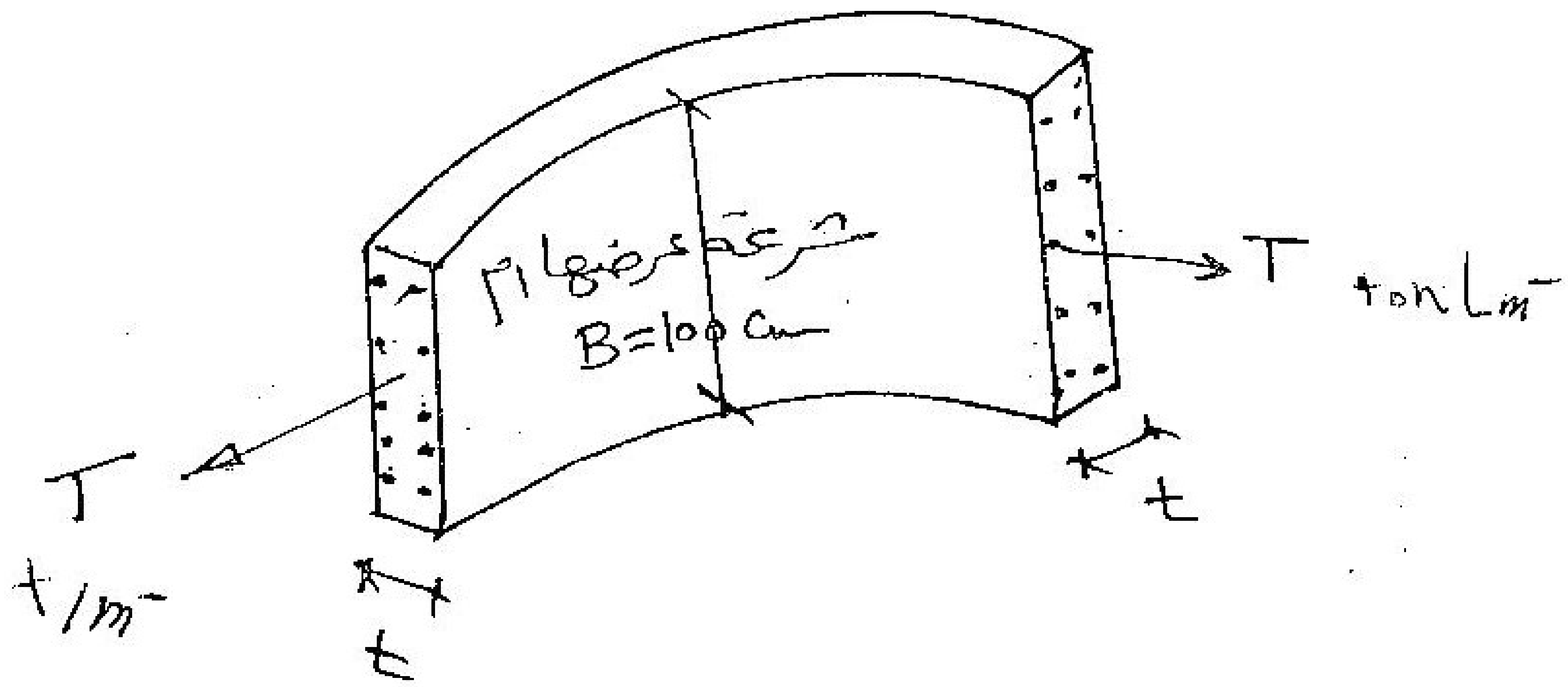


3- على تربة ضعيفة weak soil فتحتاج إلى خوازيق لرفعها فيعامل الخزان على أنه elevated



Design of sections in Tanks

(1) Sections subjected to tension only. T = ٧ t/m



Stage (I) : working design

$$t_{cm} = \xi \cdot T_{ton} \not< 20 \text{ cm}$$

$$\xi = 0.6$$

Stage (II) : Ultimate $T_u = 1.5\ T$

$$A_s = \frac{T_u * 10^3}{2\,(f_y/\gamma_s)}$$

لكل وجه من القطاع

→ $f_y = 3600$ kg/cm² for steel (36/52) #

→ $\gamma_s = 1.15$ معامل أمان الحديد

→ $A_s \not< \left(\frac{0.15}{100} B.d\right)$ # or $\left(\frac{0.25}{100} B.d\right)$ ⌀ ($d = t - 5$cm)

لكل وجه

$\not<$ 5 #10/m

Example: * design section subjected To

$T = 25\ t/m$, $f_{cu} = 250\ kg/cm^2$, $f_y = 3600\ kg/cm^2$

for a water Tank.

Sol.

Stage (I) $t = \xi . T = 0.6 * 25 = 15\ cm \not< 20$

$\therefore$ use $t = 20\ cm$

Stage (II) Ultimate $T_u = 1.5\ T = 37.5\ t/m$

لكل جهة من القطاع

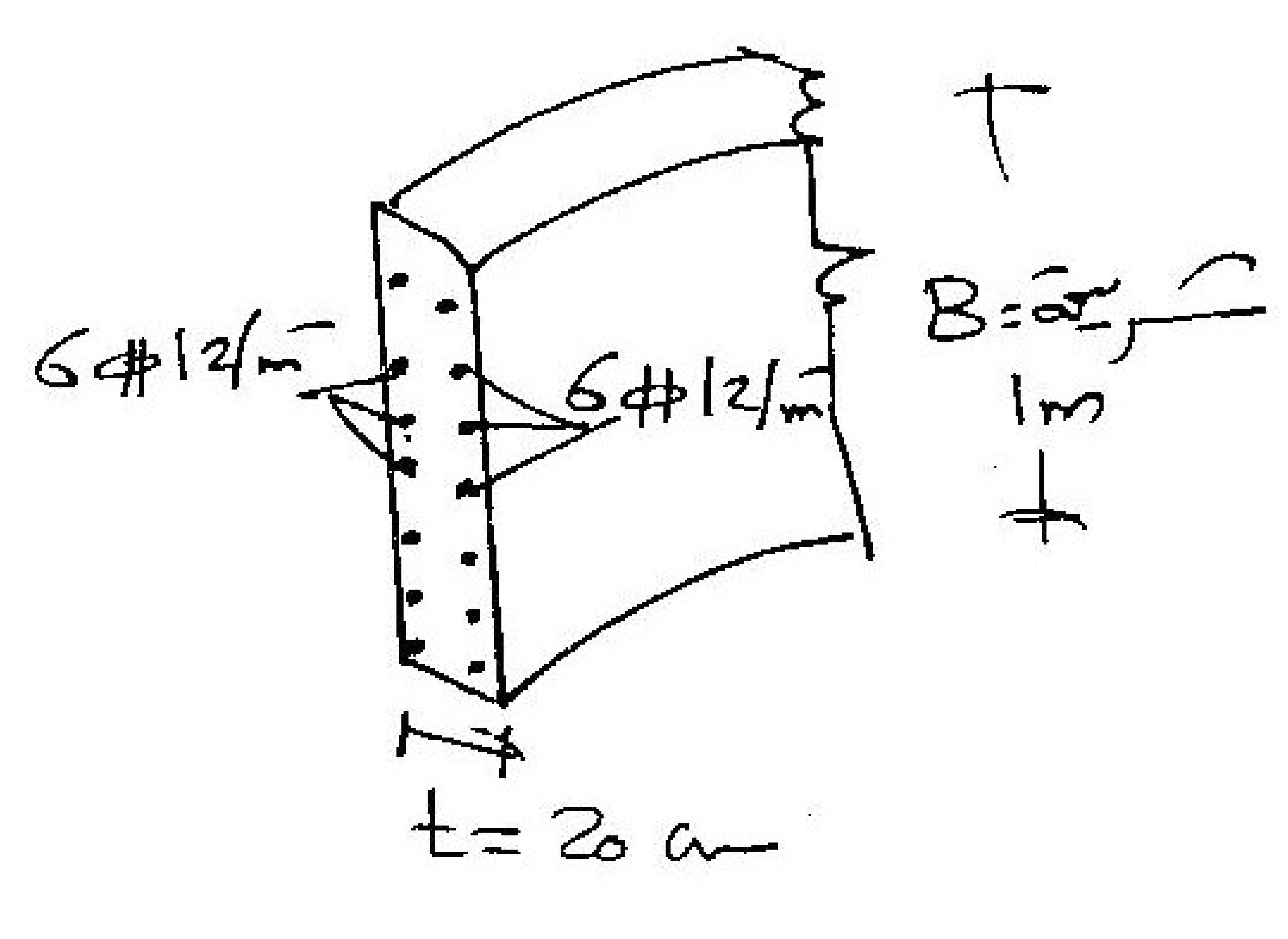
$$A_s = \frac{T_u * 10^3}{2\,(f_y/\gamma_s)} = \frac{37.5 * 10^3}{2\left(\frac{3600}{1.15}\right)} = 6\ cm^2/m$$

$$\therefore A_{s_{min}} = \frac{0.15}{100} * B * d$$

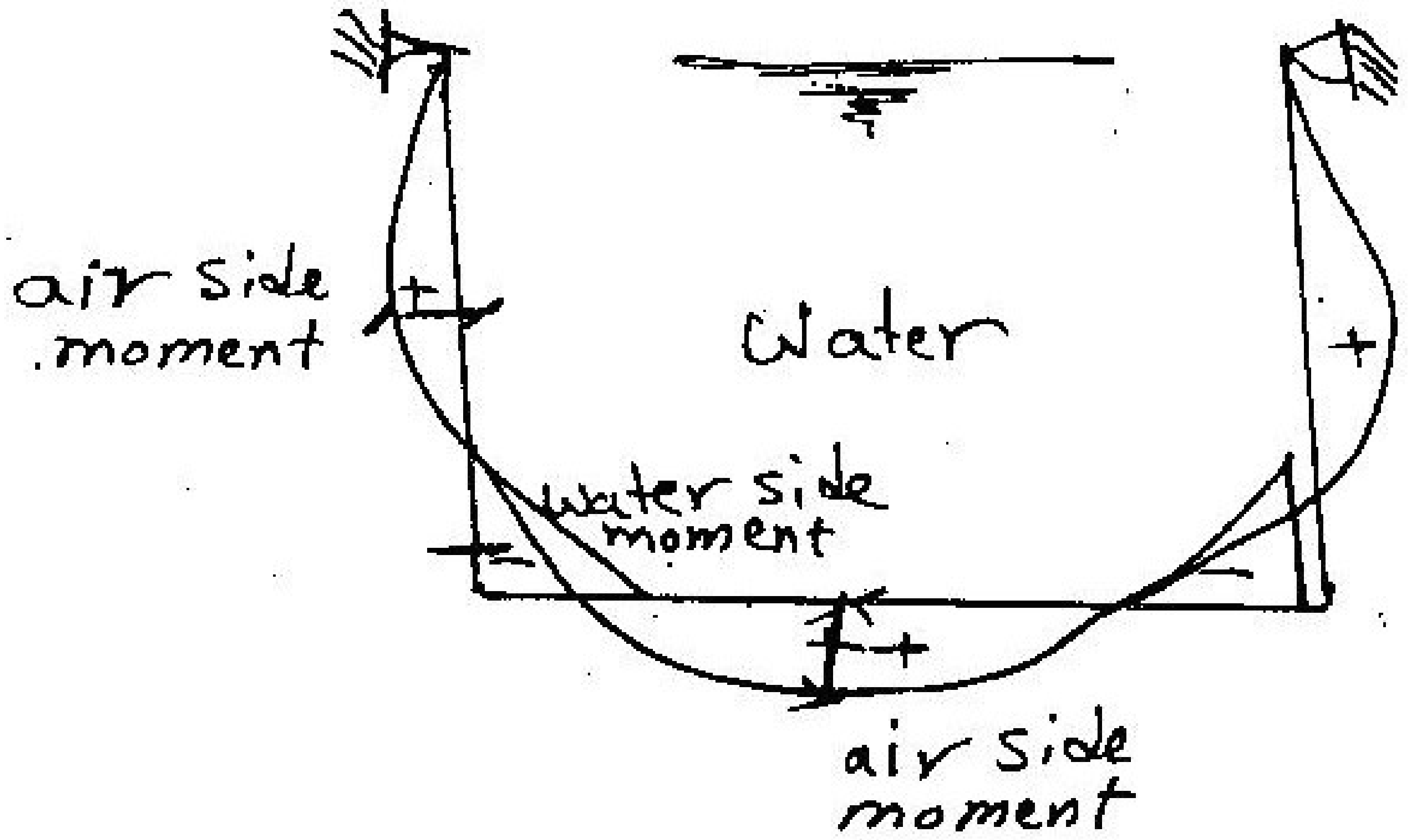
$$= \frac{0.15}{100} * 100 * 15 = 2.25\ cm^2/m$$

$\therefore$ use $A_s = 6\ cm^2/m = 6\ \#12/m$

لاحظ أن ٦ أقل عدد أسياخ في متر الطول موضوعة أسياخ



(2) Sections subjected to Moment:



القطاع الأخطر هو القطاع الموجود به عزم ناحية المياه water side

حيث العزم يولد شروخ ناحية المياه ويصدأ حديد التسليح .

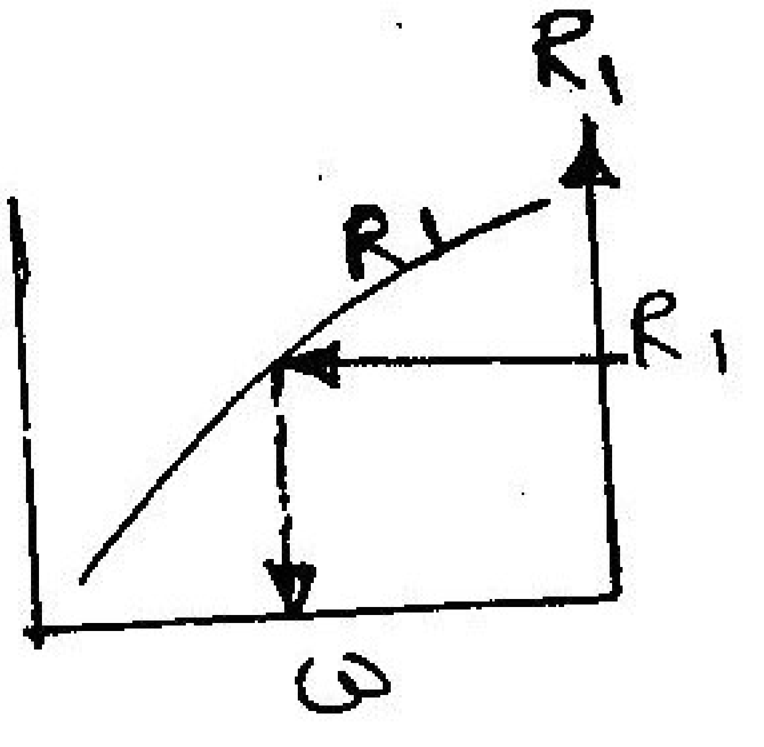
Design of water side moment:

stage (I) : (working) $t = \sqrt{\dfrac{M * 10^5}{\psi \cdot B}} \Rightarrow$ cm

$\psi = 3.2$; $B = 100$ cm (شريحة)

stage (II) (Ultimate) $M_u = 1.5\, M$ & $d = t - 5$ cm

$$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2}$$



$\therefore \omega =$ (أوميجا) from curve. $\simeq$ **1.3 R_1**

$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$$

ناحية الشد كلها

$A_s \nless \frac{0.15}{100} B \cdot d$ for St.36/52 (#)

$\nless \frac{0.25}{100} B \cdot d$ for St.24/35 (ϕ)

Air side moment :

نصمم stage (II) مباشرة

Use $t = 25$ cm

$d = t - 5$ cm

$$R_1 = \frac{M_u \times 10^5}{f_{cu} \cdot B \cdot d^2}$$

$\therefore \omega = \ldots$

$$A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$$

$$\not< \frac{0.15}{100} B \cdot d \; (\#) \quad \text{or} \quad \frac{0.25}{100} B \cdot d \; (\phi)$$

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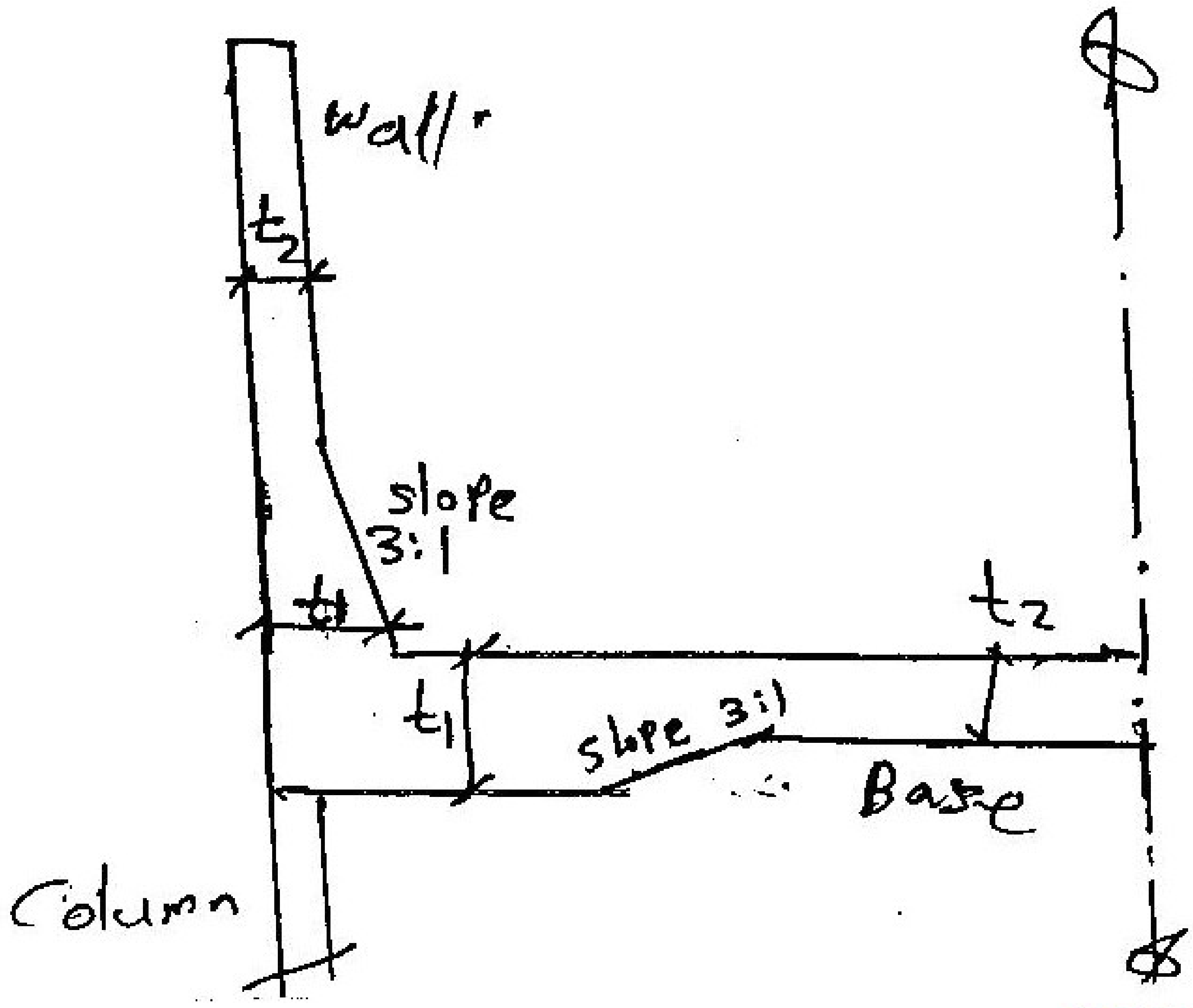
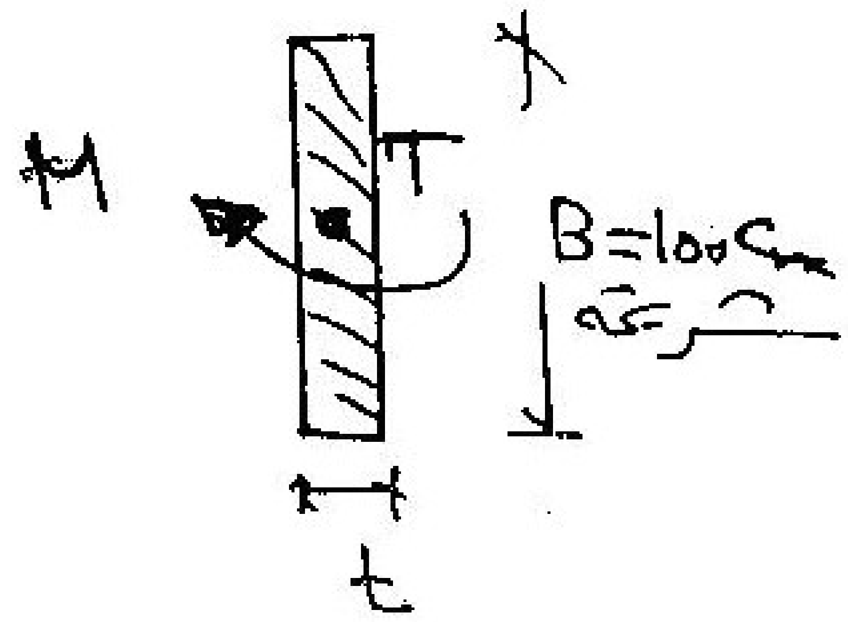
* دائماً تخانة القطاع في water side أكبر من air side

ولذلك ممكن عمل **Haunch** عند العزم في (water side)



(3) Sections subjected to (M عزوم + T شد)

water side



لاعتبار الشد (T)

stage (I): $t = \sqrt{\dfrac{M*10^5}{\psi \cdot B}} + 5\ cm$

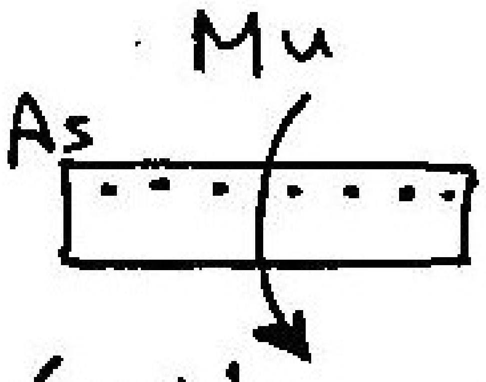
$\psi = 3.2$, $B = 100\ cm$

check: σ_t (tension stress) $= \dfrac{6M*10^5}{B \cdot t^2} + \dfrac{T*10^3}{B \cdot t} \ngtr f_{ct}$ (مقاومة الخرسانة في الشد من الجدول)

لو كانت unsafe نزود التخانة شوية

stage (II) ultimate $M_u = 1.5\ M$, $T_u = 1.5\ T$

$e = \dfrac{M_u}{P_u}$; $d = t - 5\ cm$



$(e/t) \geq 0.5$

⇒ big eccentricity

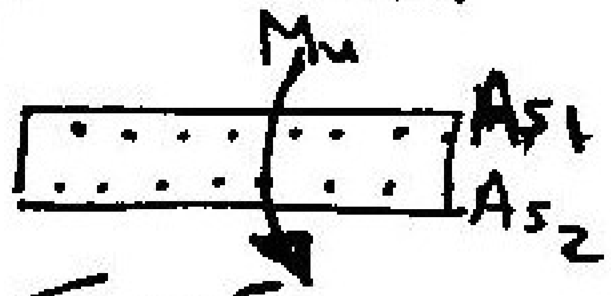
$e_s = e - \dfrac{t}{2} + \text{Cover}\ (0.05) = \searrow$

$M_{us} = T_u \cdot e_s = \searrow$

$R_1 = \dfrac{M_{us}*10^5}{f_{cu} \cdot B \cdot d^2} = \searrow$

⇒ $\omega = \searrow$

⇒ $A_s = \left[\omega \cdot \dfrac{f_{cu}}{f_y} B \cdot d\right] + \left[\dfrac{T_u*10^3}{(f_y/\gamma_s)}\right]$ (ناحية العزم كله)



$(e/t) < 0.5$

⇒ Small eccentricity

A_{s_1} (ناحية العزم) $= \dfrac{T_u*10^3}{(f_y/\gamma_s)} \cdot \left(\dfrac{\frac{d-d'}{2} + e}{d-d'}\right)$

A_{s_2} (الناحية التانية) $= \dfrac{T_u*10^3}{(f_y/\gamma_s)} \cdot \left(\dfrac{\frac{d-d'}{2} - e}{d-d'}\right)$

(4) Sections subjected to $\left(\underset{\text{water side}}{M} + \underset{\text{Compression}}{N} \right)$

يمكن اهمال (N) حيث أنها تعمل لصالح الشروخ
كمعامل أمان

ويتم التصميم على $\left(\underset{\text{water side}}{M} \right)$ فقط

Stage (I) : $t = \sqrt{\dfrac{M}{\psi \cdot B}} = \text{—}$

Stage (II) : Ultimate $M_u = 1.5\,M$

$$R_1 = \frac{M_u \times 10^5}{f_{cu} \cdot B \cdot d^2} = \text{—}$$

$$\therefore \omega = \text{—}$$

$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d = \text{—}$$

ناحية العزم كله

$$\not< \left(\underset{\#}{\frac{0.15}{100} B \cdot d} \right) \text{ or } \left(\underset{\phi}{\frac{0.25}{100} B \cdot d} \right)$$

$$\not< 5\,\#\,10/m^{-}$$

⑤ Sections subjected to ($M_{air\,side}$ + $T_{ش}$)

air side ← طالما أن العزم ناحية الهواء

نصمم مباشرة ع stage (II)

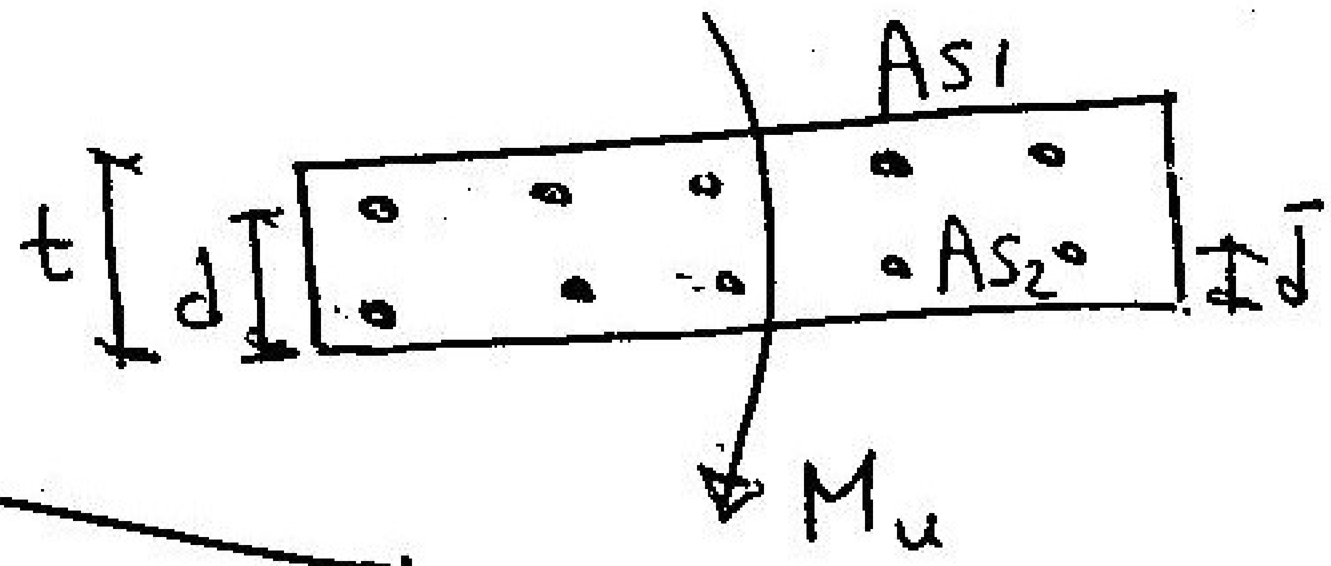
use $t = 25$ cm

$d = 20$ cm

$M_u = 1.5\,M$, $T_u = 1.5\,T$

$e = \dfrac{M_u}{T_u} = ✓$

$e/t = ✓$



$e/t \geq 0.5$

⇓

$e_s = e - \dfrac{t}{2} + cover$

$M_{us} = T_u \cdot e_s$

$R_1 = \dfrac{M_{us} \times 10^5}{f_{cu} \cdot B \cdot d^2}$

$\omega = $ ——

$A_s = \omega \cdot \dfrac{f_{cu}}{f_y} \cdot b \cdot d + \left(\dfrac{T_u}{f_y/\gamma_s}\right)$

كله بيحط ناحية العزم فقط.

$e/t < 0.5$

الحديد من الناحيتين

$A_{s1} = \dfrac{T_u \times 10^3}{f_y/\gamma_s}\left(\dfrac{\left(\frac{d-d'}{2}\right)+e}{d-d'}\right)$

ناحية العزم كبيرة

$A_{s2} = \dfrac{T_u \times 10^3}{f_y/\gamma_s}\left(\dfrac{\left(\frac{d-d'}{2}\right)-e}{(d-d')}\right)$

بالناحية التانية صغيرة

Examples: $f_{cu} = 250\ kg/cm^2$; $f_y = 3600\ kg/cm^2$

(1) **Water side Moment $M = 10\ t.m$**

Stage (I): $t = \sqrt{\frac{M}{\psi \cdot B}} = \sqrt{\frac{10 * 10^5}{3.2 * 100}} = 55.9\ cm$
$= 60\ cm$

$\therefore d = t - 5_{cm} = 55\ cm$

Stage (II): ultimate $M_u = 1.5\ M = 15\ t.m$

$$R_1 = \frac{M_u}{f_{cu} \cdot B \cdot d^2} = \frac{15 * 10^5}{250 * 100 * (55)^2} = 0.02$$

$\therefore \omega = 0.025$

$$A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d = 0.025 * \frac{250}{3600} * 100 * 55$$

$= 9.5\ cm^2/m$

$$A_{s\,min} = \frac{0.15}{100} * B * d = \frac{0.15}{100} * 100 * 55$$

$= 8.25\ cm^2/m$

$= 8 \# 12/m$

※ أقل عدد أسياخ في المتر ⑤

Ex:
(2) air Side Moment $M = 5$ t.m

Ultimate مباشرة Stage (II) يعني

→ use $t = 25$ سم ; $d = 20$ سم

$M_u = 1.5 M = 7.5$ t.m

$$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{7.5 * 10^5}{250 * 100 * 20^2} = 0.075$$

$\therefore \omega = 0.1$

$$A_s = 0.1 * \frac{250}{3600} * 100 * 20 = 13.8 \text{ cm}^2/\text{m}'$$

$$= \left(\omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d\right)$$

$$\therefore A_{s\,min} = \frac{0.15}{100} * B * d = \frac{0.15}{100} * 100 * 20 = 3 \text{ cm}^2/\text{m}'$$

$\therefore$ use $A_s = 13.8$ cm²/m' $= 7\#16/\text{m}'$

Ex:
(3) Water Side Moment $M = 6$ t.m , $T = 10$ t/m'

Stage (I): $t = \sqrt{\frac{M}{\psi \cdot B}} + 5 = \sqrt{\frac{6 * 10^5}{3.2 * 100}} + 5 = 48.5$ سم

$t = 50$ سم

$d = 45$ سم

Check : σ_t

$$\sigma_t = \left(\frac{6M}{B \cdot t^2} + \frac{T}{B \cdot t}\right) = \left(\frac{6 * 6 * 10^5}{100 * 50^2}\right) + \left(\frac{10 * 10^3}{100 * 50}\right)$$

$$= 16.4 \text{ kg/cm}^2 \ngtr f_{ct} = 18.5 \text{ kg/cm}^2$$

$\therefore$ OK

Stage (II) **Ultimate** $M_u = 1.5M = 9 \; t.m/m$

$T_u = 1.5T = 15 \; t/m$

$$\therefore e = \frac{M_u}{T_u} = \frac{9}{15} = 0.6 \, m$$

$$\therefore e/t = \frac{0.6}{0.5} = 1.2 > 0.5 \Rightarrow$$ **Big eccentric**

$$e_s = e - \frac{t}{2} + \text{Cover}$$

$$= \left(0.6 - \frac{0.5}{2} + 0.05\right) = 0.4 \, m$$

$$\therefore M_{us} = T_u \cdot e_s = 15 * 0.4 = 6 \; t.m/m$$

$$\therefore R_1 = \frac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{6 * 10^5}{250 * 100 * 45^2} = 0.0118$$

$$\therefore \omega = 0.015$$

$$\therefore A_s = \frac{\omega \cdot f_{cu}}{f_y} \cdot B \cdot d + \frac{T_u * 10^3}{f_y/\gamma_s}$$

كله أصبح العزم

$$= \left(0.015 * \frac{250}{3600} * 100 * 45\right) + \left(\frac{15 * 10^3}{(3600/1.15)}\right)$$

$$= 9.5 \; cm^2/m$$

$$A_{s_{min}} = \frac{0.15}{100} B \cdot d = \frac{0.15}{100} * 100 * 45$$

$$= 6.75 \; cm^2/m$$

use $A_s = 9.5 \; cm^2/m = 5\Phi 16/m$

Table (1-1): ξ, & ψ values are given in following table:

Concrete grade (kg/cm^2)		f_{cu}	250	275	300
Axial tension		f_{cto}	18	19	20
$t = \xi T$		ξ	0.6	0.56	0.53
Flexure (simple bending)	$t \geq 60$ cm	f_{ct}	18	19	20
		ψ	3.0	3.2	3.3
$t(cm) = \sqrt{\frac{6M}{bf_{ct}}}$	$t = 40$	f_{ct}	19	20	21
		ψ	3.2	3.3	3.5
	$t = 20$	f_{ct}	23	25	26
		ψ	3.8	4.2	4.3
$t(cm) = \sqrt{\frac{M}{\psi b}}$	$t \leq 10$	f_{ct}	30	32	34
		ψ	5.0	5.3	5.7

$\xi = 0.6$

$\psi = 3.2$

$f_{ct} = 18\ kg/cm^2$

Table: (1-2) η values are given in following table:

Virtual thickness t	≤ 10	20	40	≥ 60
η	1.0	1.3	1.6	1.7

* في حالة وجود قطاع عليه ضغط

(N Compression) فقط

* نختار حديد min 5#10/m يمين وشمال

* وقطاع $t_{min} = 20$ cm

ULTIMATE LIMIT DESIGN CHARTS FOR SIMPLE BENDING & ECCENTRIC FORCE (TENSION FAILURE)

FOR ALL GRADES OF CONCRETE AND STEEL

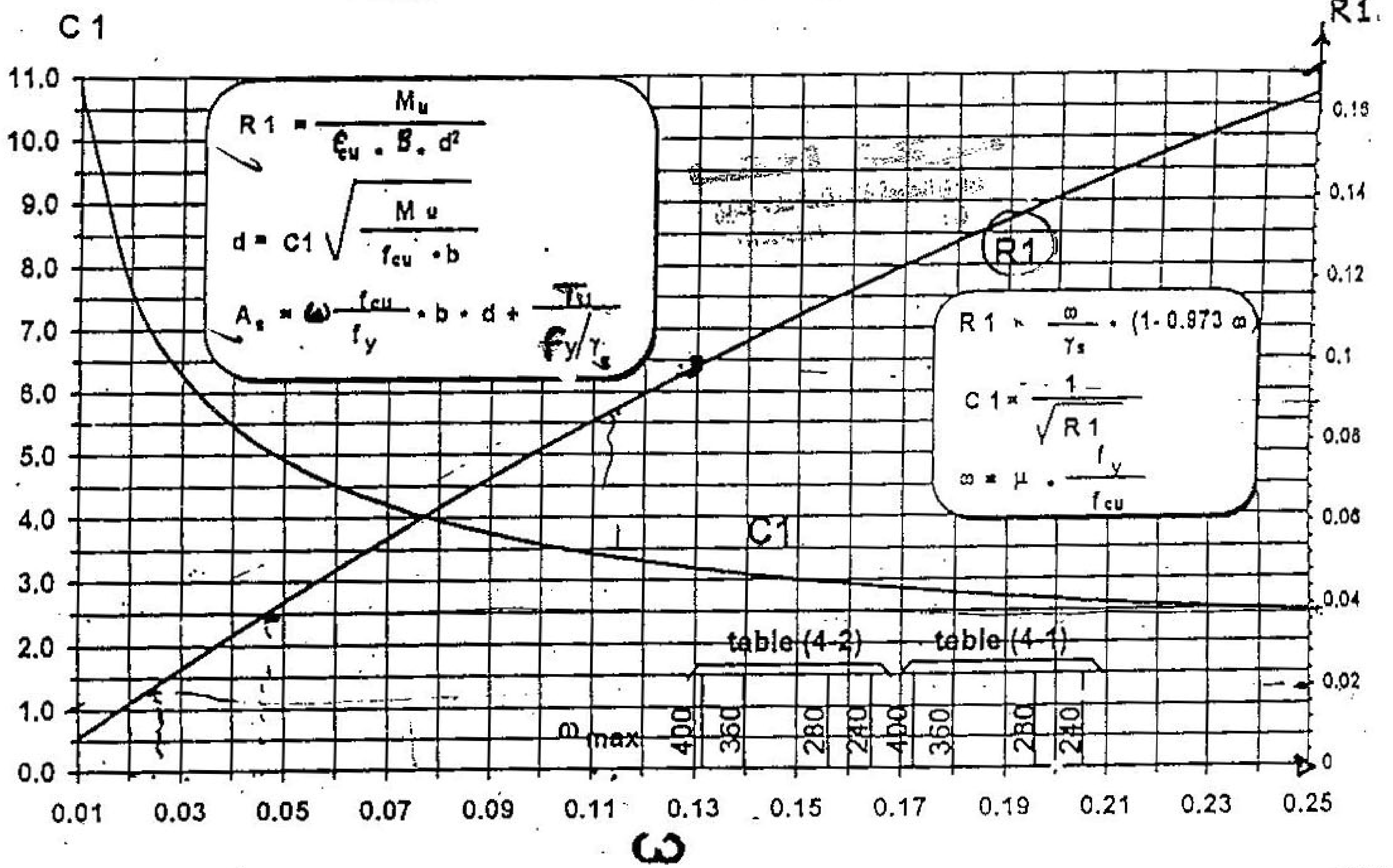


Chart (D) As But not less than 0.25%.b.d for st. 240 0.15%.b.d for st. 360 As min

جـ ٢
ص ١٧٥

سنتر و مركز

الفارس

للخدمات الطلابية والعلمية

الفرقة الرابعة مدنى

Reinforced Concrete Water tanks

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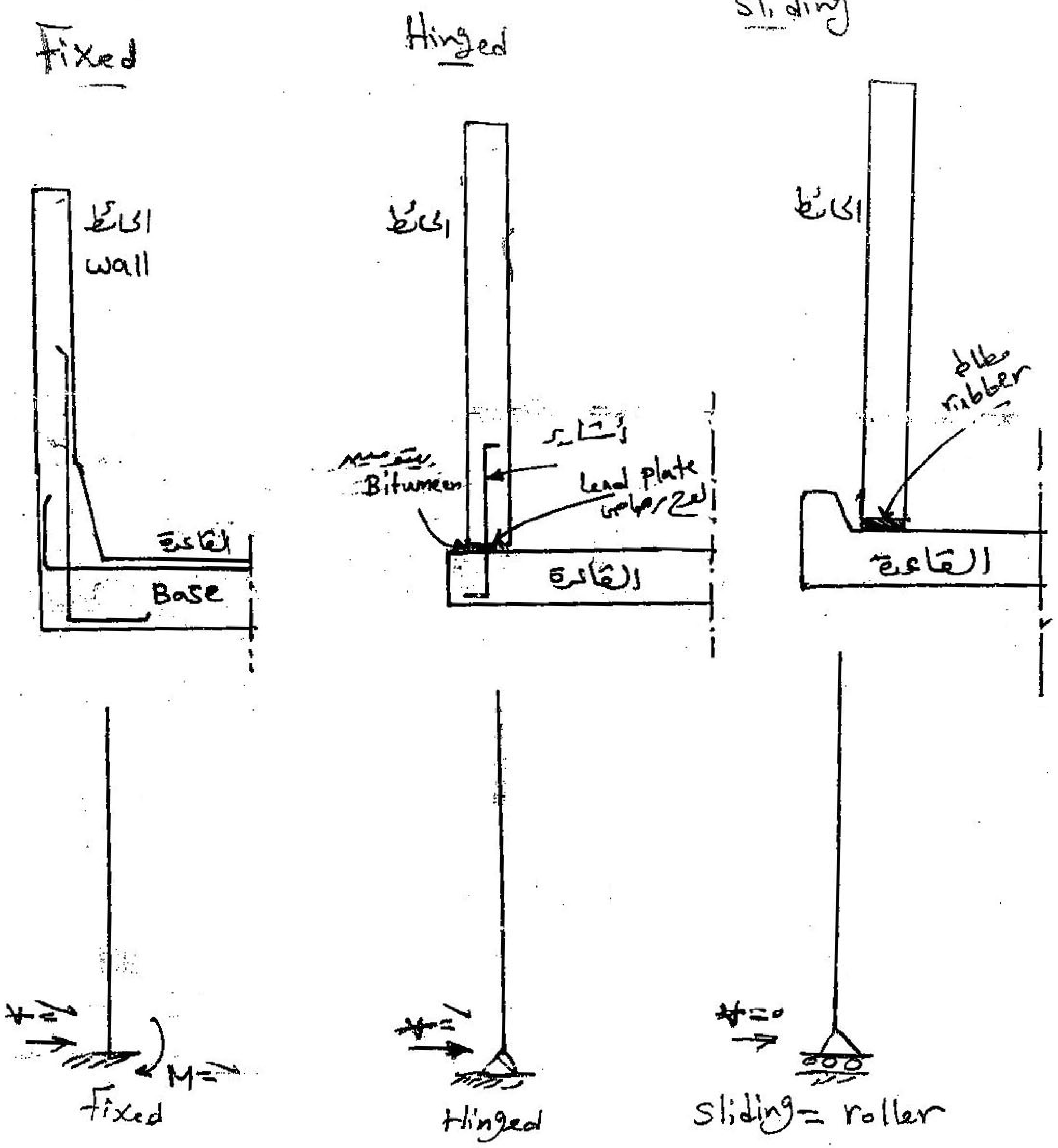
الخزانات الدائرية " Circular Tanks "

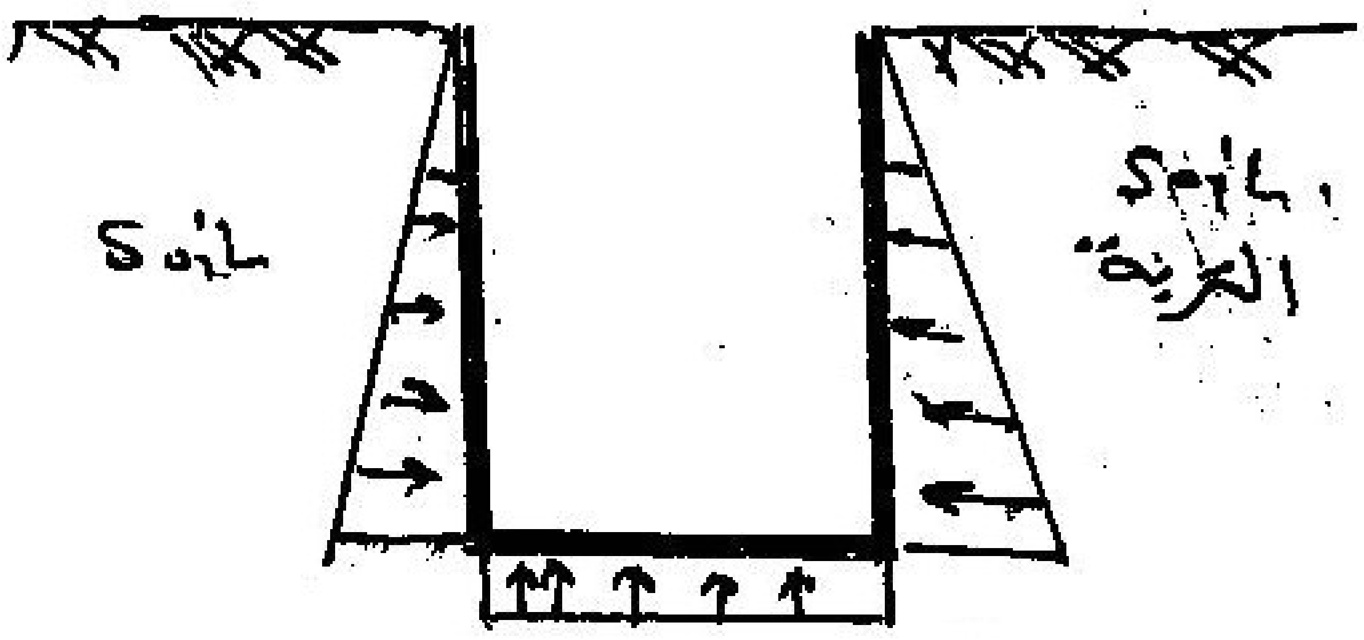
أنواع حسب إتصال الحائط بالقاعدة

Fixed — Hinged — Sliding



1 Loads on Walls: نوعية الأحمال ع الحوائط

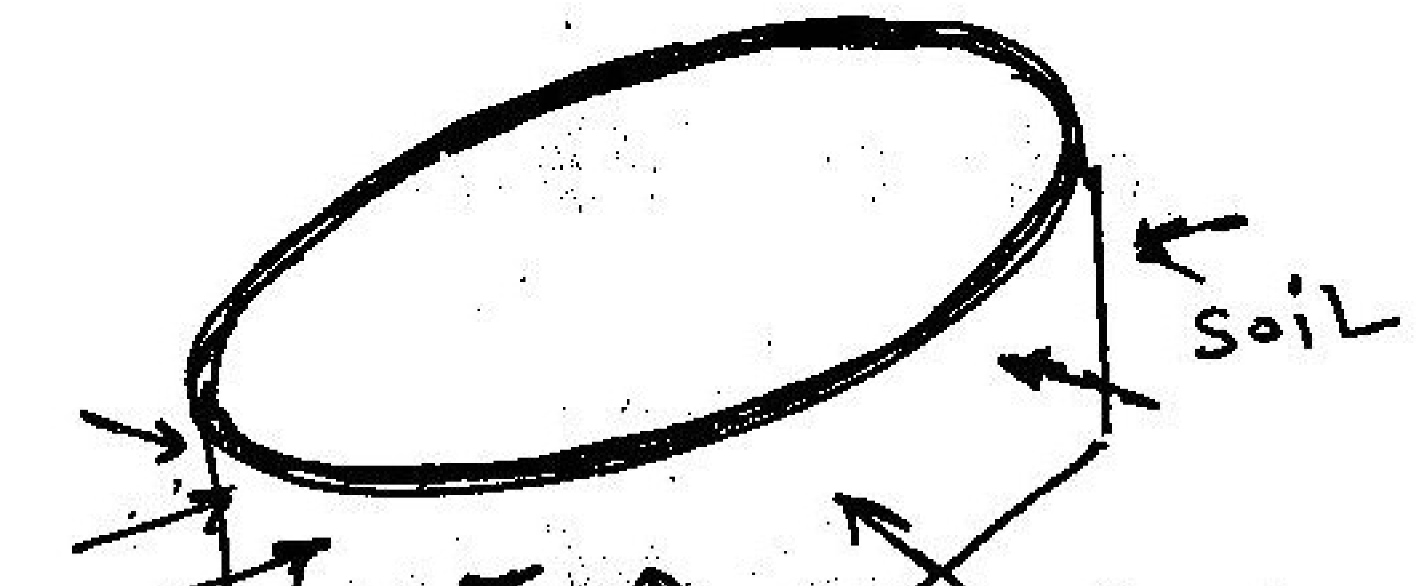
External soil pressure.
ضغط تربة خارجي



$$Pressure = K_a \cdot \gamma_{soil} \cdot H$$

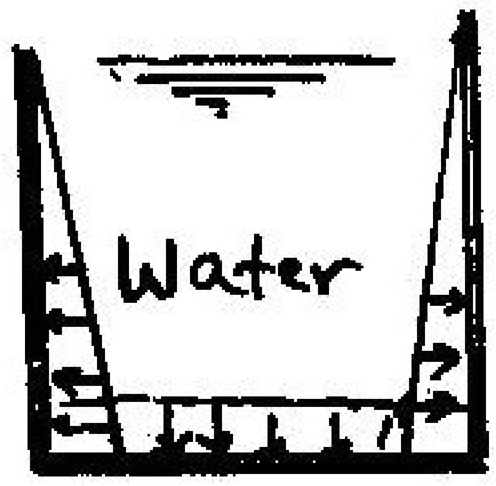
$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi} \simeq 0.33$$

ϕ = friction angle of soil.



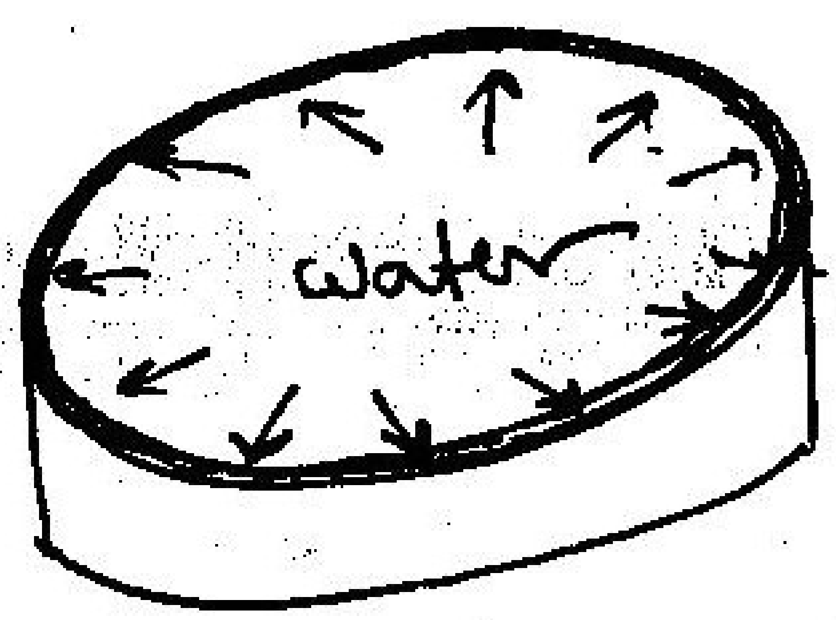
الحوائط عليها ضغط

Internal Water Pressure
ضغط ماء داخلي



$$Pressure = \gamma_{water} \cdot H$$

$$\gamma_{water} = 1\ t/m^3$$



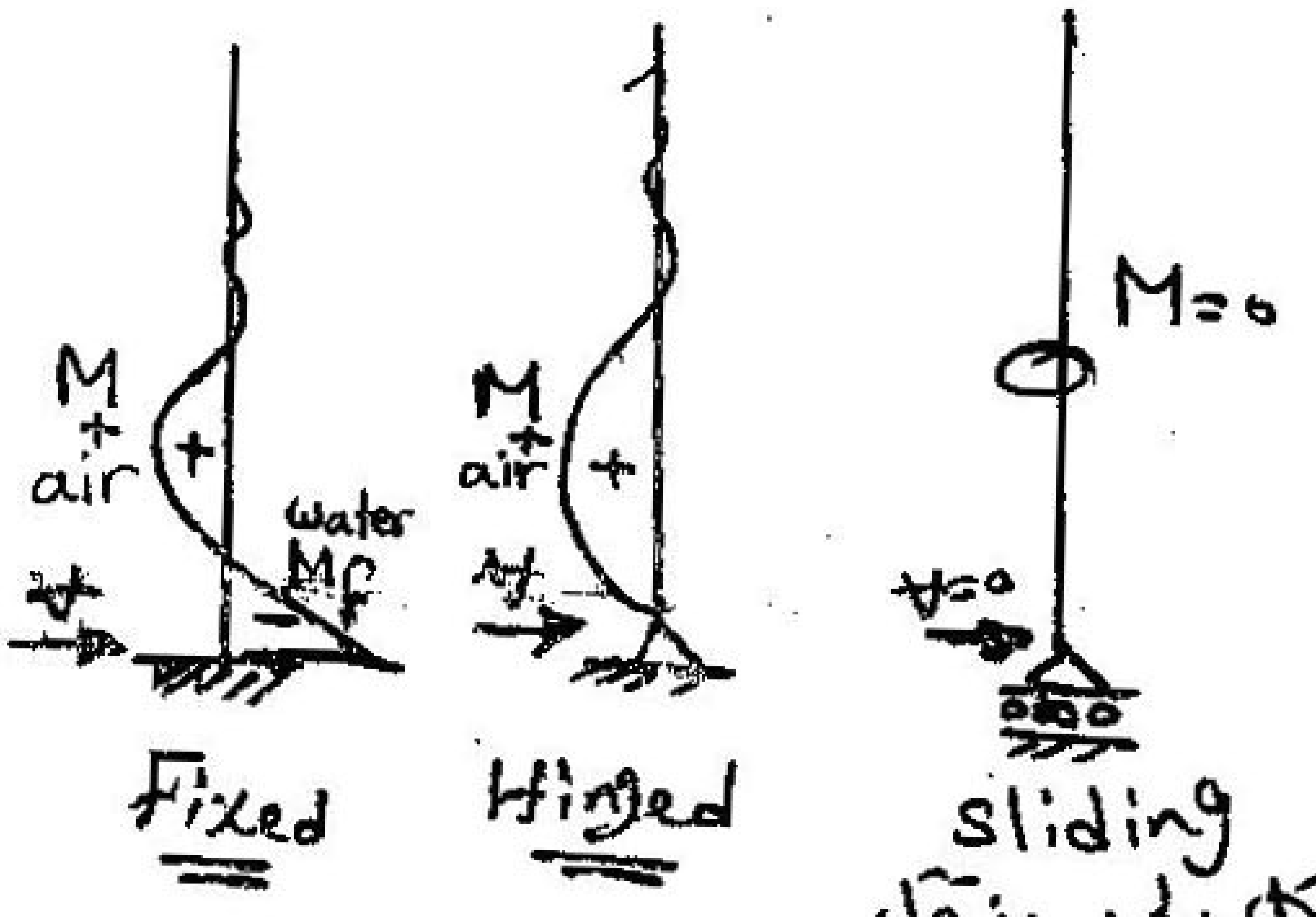
الحوائط عليها شد

2 Straining actions on walls

vertical (VL. direction)

حمل ينتقل فى شريحة رأسية للحائط متصلة مع القاعدة وهو يولد

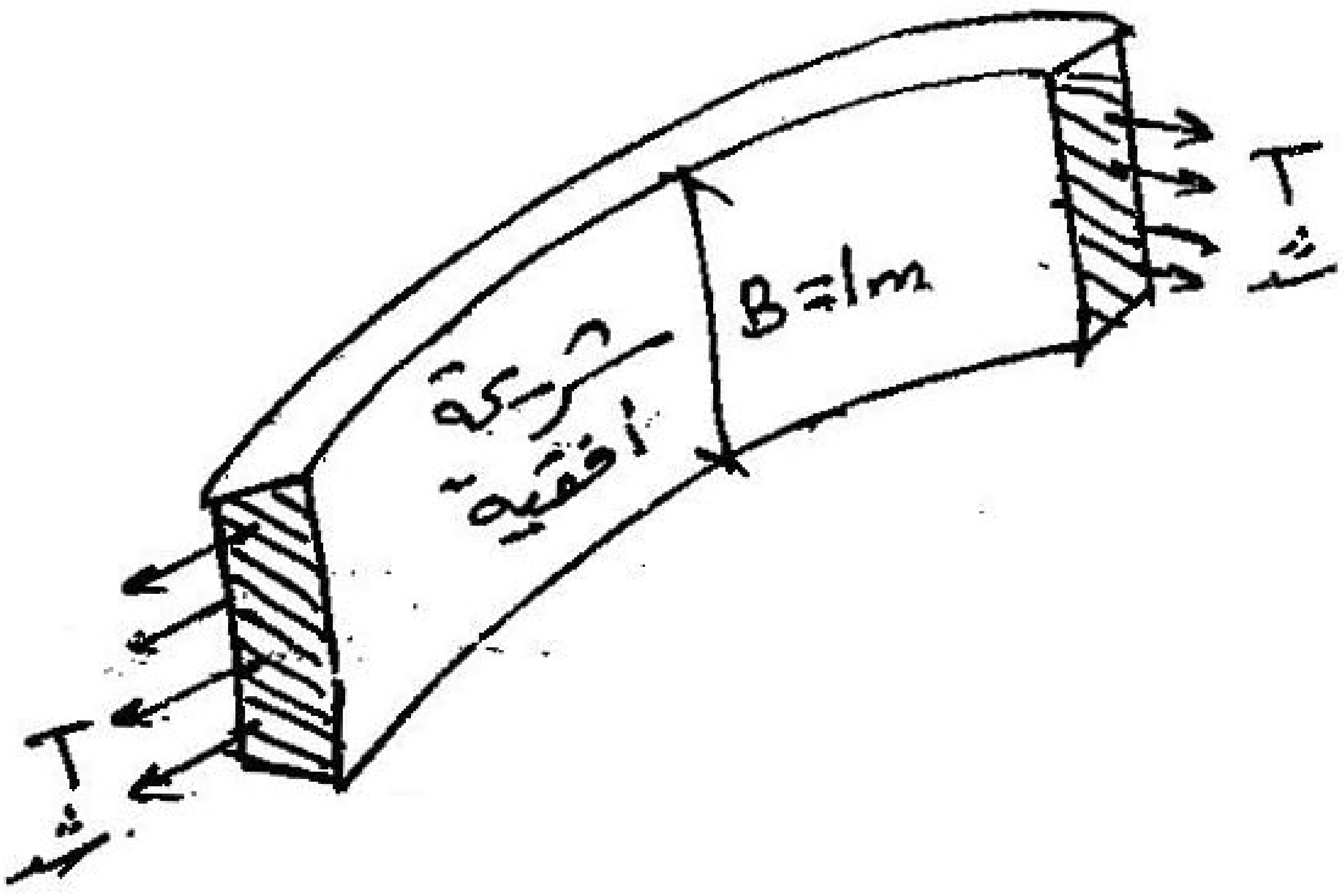
- Moment (M)
- shear (V)

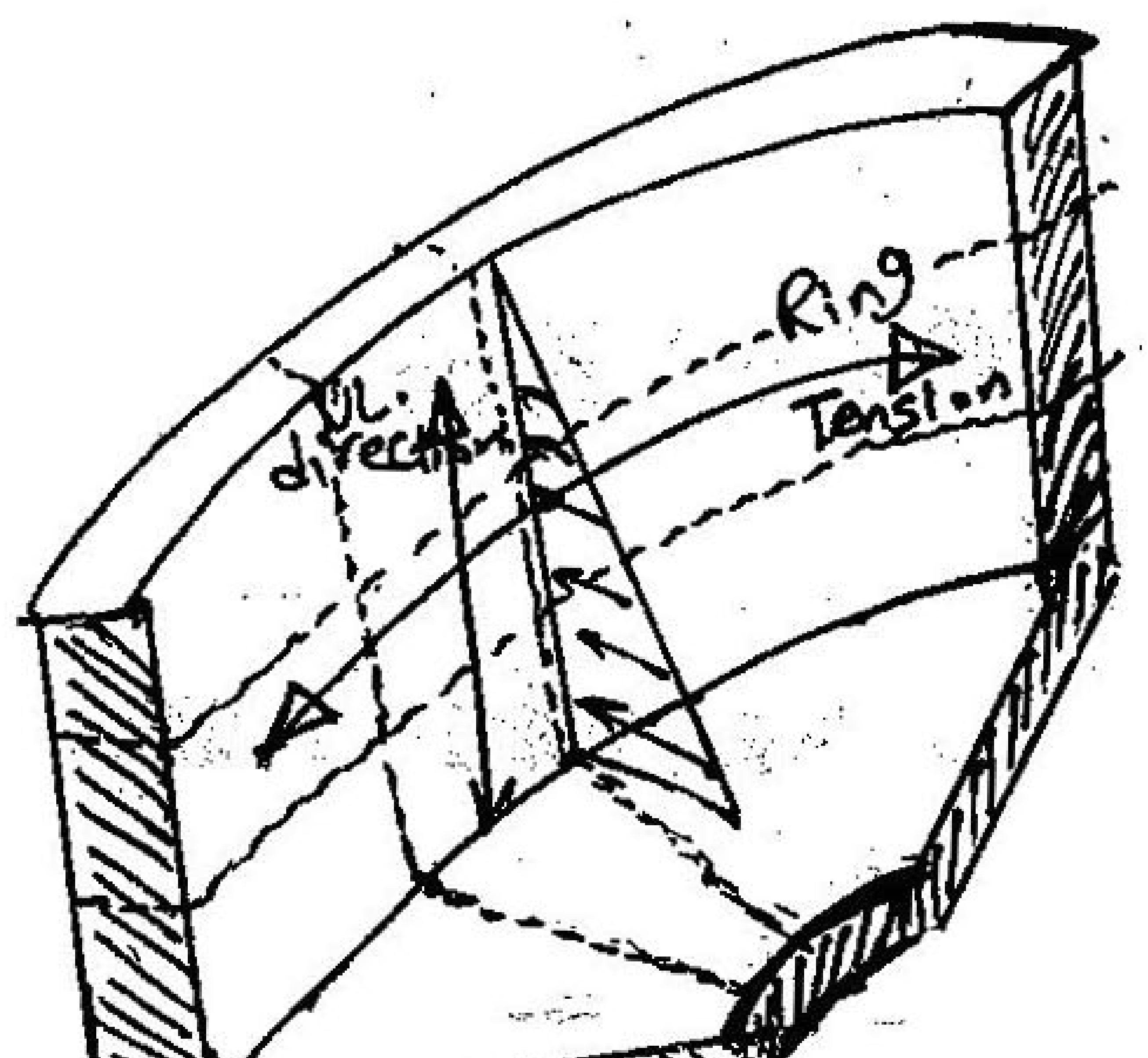


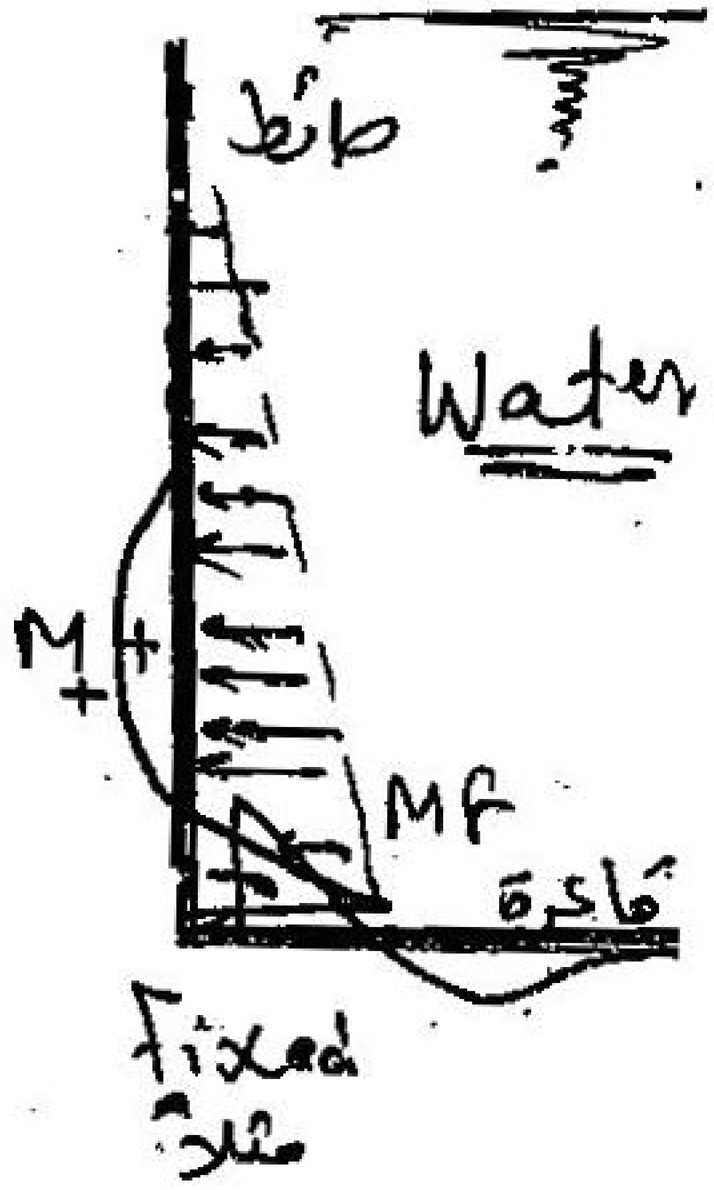
كل الحمل ينتقل فى Ring فقط

Ring direction

* شد أفقى (حلقات افقية) نتيجة ضغط مياه داخلى
* أو ضغط أفقى (حلقات افقية) نتيجة ضغط التربة الخارجى.







VL. strip

Methods of solution

طرق حل الحوائط

⇓

straining actions حساب

(1) Sliding Tanks : Special Method

كل الحمل ينتقل من شرائح أفقية

Ring direction.

(2) Hinged Tanks: P. C. A = Portland Cement Association

هيئة الأسمنت البورتلاندى

Using Tables

→ Vl. direction (shear + ; M_{+ve})

→ Ring direction T_{ring}.

(3) Fixed Tanks:

→ P.C.A (Tables)

→ Reissner (Curves)

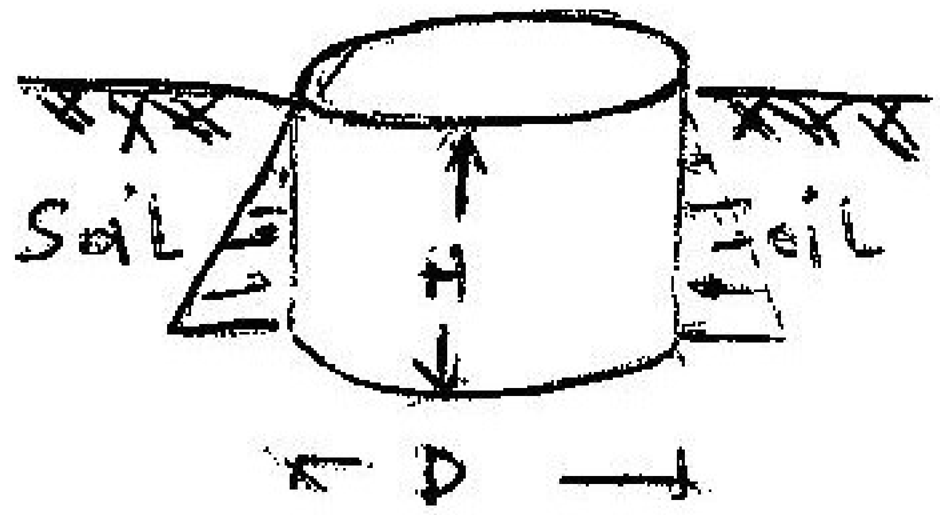
→ Simplified method (tables + Curves)

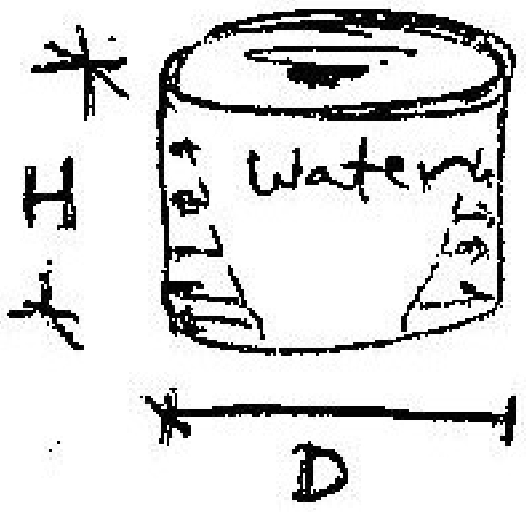
→ Approximate Method.

طريقة تقريبية باستخدام معاملات (factors)

[1] Sliding Tank by Special Method :

كل الأحمال تتحمل على الحلقات على هيئة Ring tension فقط





فقط $N_{max\ ring} = K_a \cdot \gamma_{soil} \cdot H \cdot r$

$T_{max\ ring} = \gamma_{water} \cdot H \cdot r$

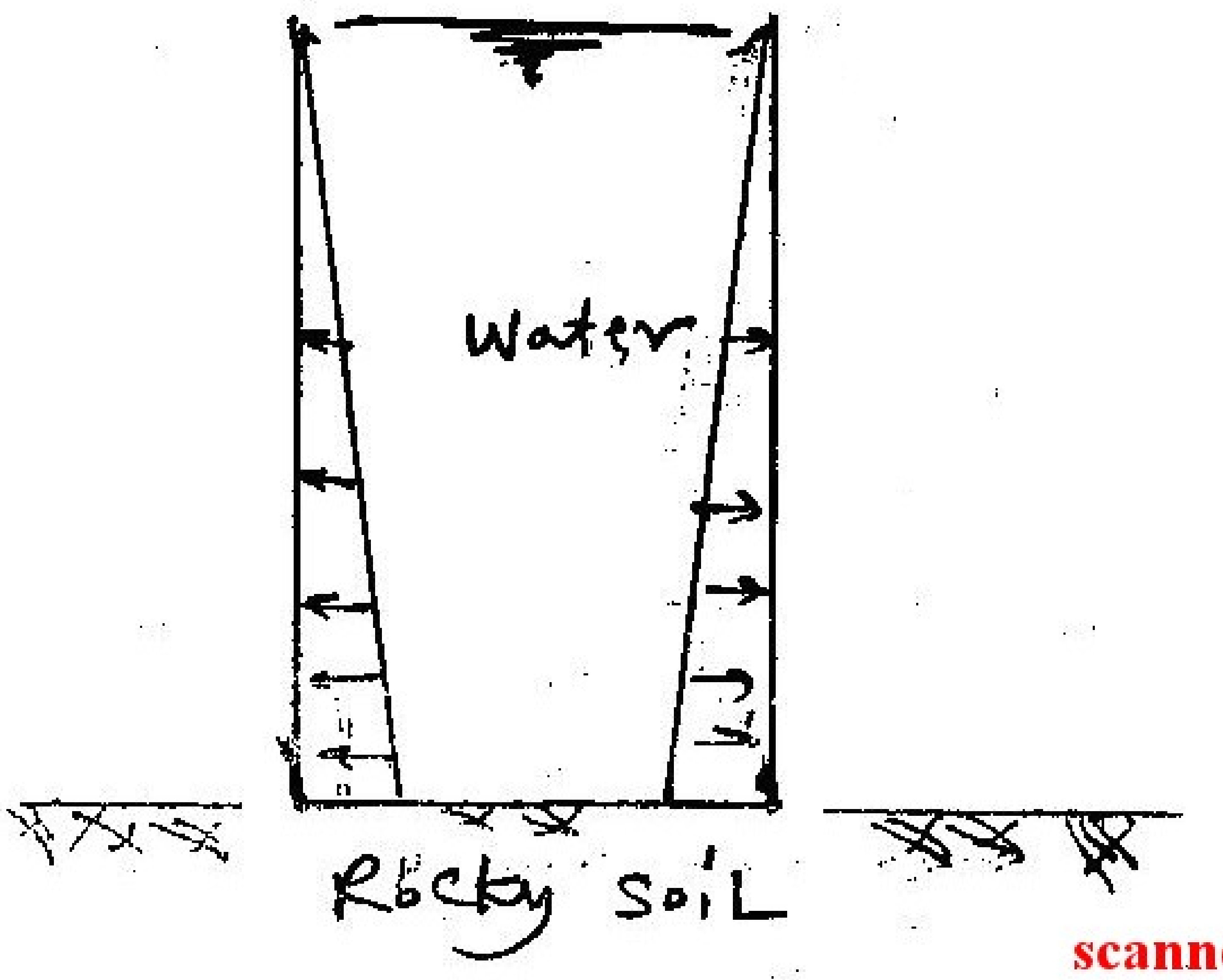
$\gamma_{water} \rightarrow 1\ t/m^3$

$r \rightarrow (r = \frac{D}{2})$ نصف القطر

Example:

Design a sliding Tank on Rocky Soil (على تربة صخرية)

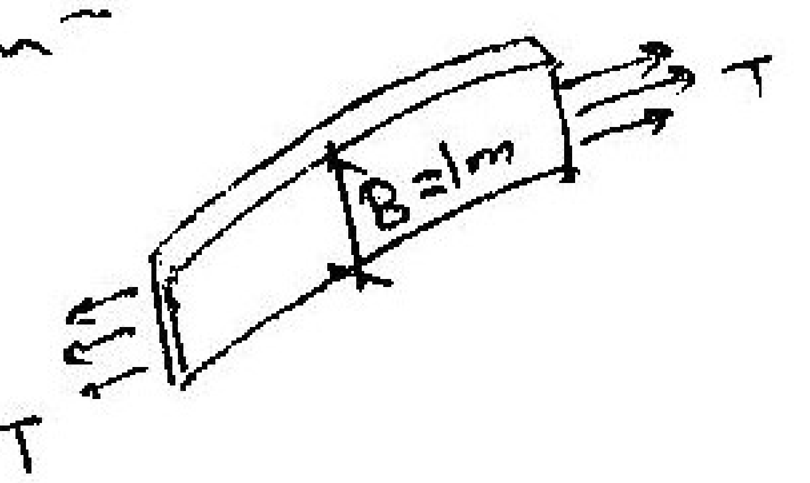
- $H = 10\ m$, $D = 8\ m$
- $f_{cu} = 250\ kg/cm^2$
- $f_y = 3600\ kg/cm^2$



Solution: [1] Wall: Ring tension لأن γ يتدرج

$$T_{max\ ring\ direction} = \gamma_{water} \cdot H \cdot r$$

$$= 1 * 10 * 4 = 40\ t/m$$



Design: Tension only

stage(I): No cracking = working

$$t = \xi \cdot T_{max} = 0.6 * 40 = 24\ cm$$

$$\therefore t \simeq 25\ cm$$

stage(II): ultimate:

$$A_s\ (\text{كل وجه من القطاع}) = \frac{T_u * 10^3}{2\,(f_y/\gamma_s)} = \frac{(1.5 * 40) * 10^3}{2\left(\frac{3600}{1.15}\right)}$$

$$A_s = 9.6\ cm^2/m$$

$$\therefore A_{s\,min} = \frac{0.15}{100} B \cdot d = \frac{0.15}{100} * 100 * 20$$

$$A_{s\,min} = 3\ cm^2$$

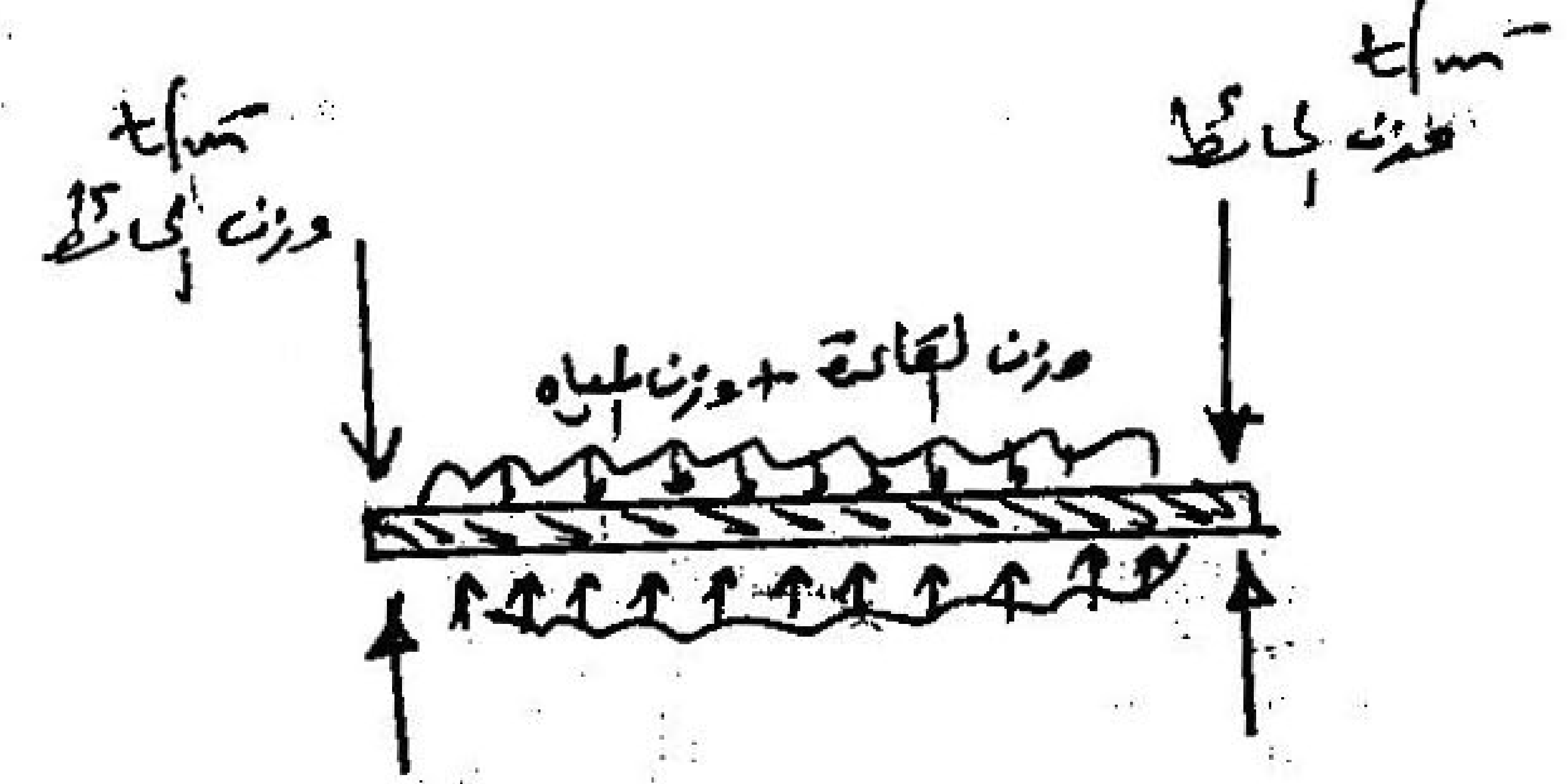
$$\therefore \text{use } A_s = 9.6\ cm^2 \simeq 5\#16/m$$ كل جهة

* ولكن هذا الحديد سيكون مكلف جداً ولا نحتاجه إلا عند أقصى شد عند قاع الخزانات.

⇐ لذلك نقوم بأخذ قطاعات كل (2m) من بداية الخزان من فوق وحساب الشد عندها (γ. h.r) وحساب الحديد اللازم لها.

h (الارتفاع من أعلى)	$T = \gamma . h . r$ (الشد)	$As = \frac{1.5T \times 10^3}{2(f_y/\gamma_s)}$	
2m	8 t/m	1.9 cm²/m	→ min 5#10/m
4m	16 t/m	3.84 cm²/m	→ 5#10/m
6m	24 t/m	5.76 cm²/m	→ 6#12/m
8m	32 t/m	7.7 cm²/m	→ 7#12/m
10m	40 t/m	9.6 cm²/m	→ 5#16/m

Base: حل القاعدة



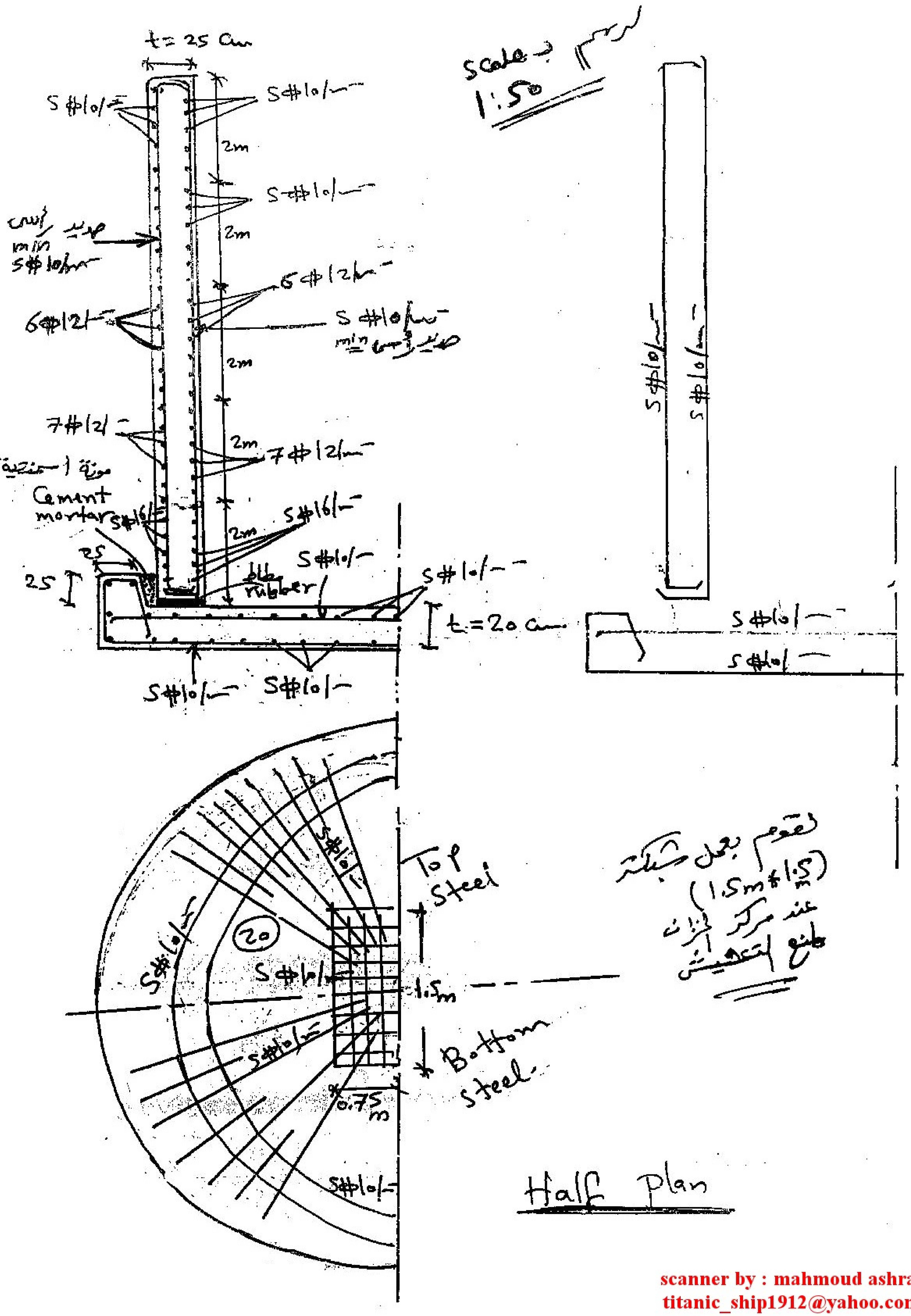
* طالما أن القاعدة على أرضية صخرية (Rock) فإن كل الأحمال ترتد على نفسها (سواء كانت مركزة أو موزعة)

ولا ينتج على القاعدة أي إجهادات.

use $t_{min} = 20$ cm.

use As = 5#10/m
(Top, bottom)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



t = 25 cm
Scale 1:50
5ϕ10/m
2m
حديد رأسي min 5ϕ10/m
6ϕ12/m
5ϕ10/m min حديد رأسي
7ϕ12/m
مونة أسمنتية
Cement mortar
5ϕ16/m
25
rubber
t = 20 cm
Top steel
20
1.5m
Bottom steel
0.75m
نقوم بعمل شبكة (1.5m*1.5m) عند مركز الخزان لمنع التعشيش
Half plan

Reinforced concrete (Water Tanks)

Fixed walls with base

Analysis of walls: حل الحائط

1- Reissner method. curves
2- Simplified method. curves + Tables
3- P.C.A method. Tables
4- Approximate method. معادلات factors

Analysis of base : حل القاعدة

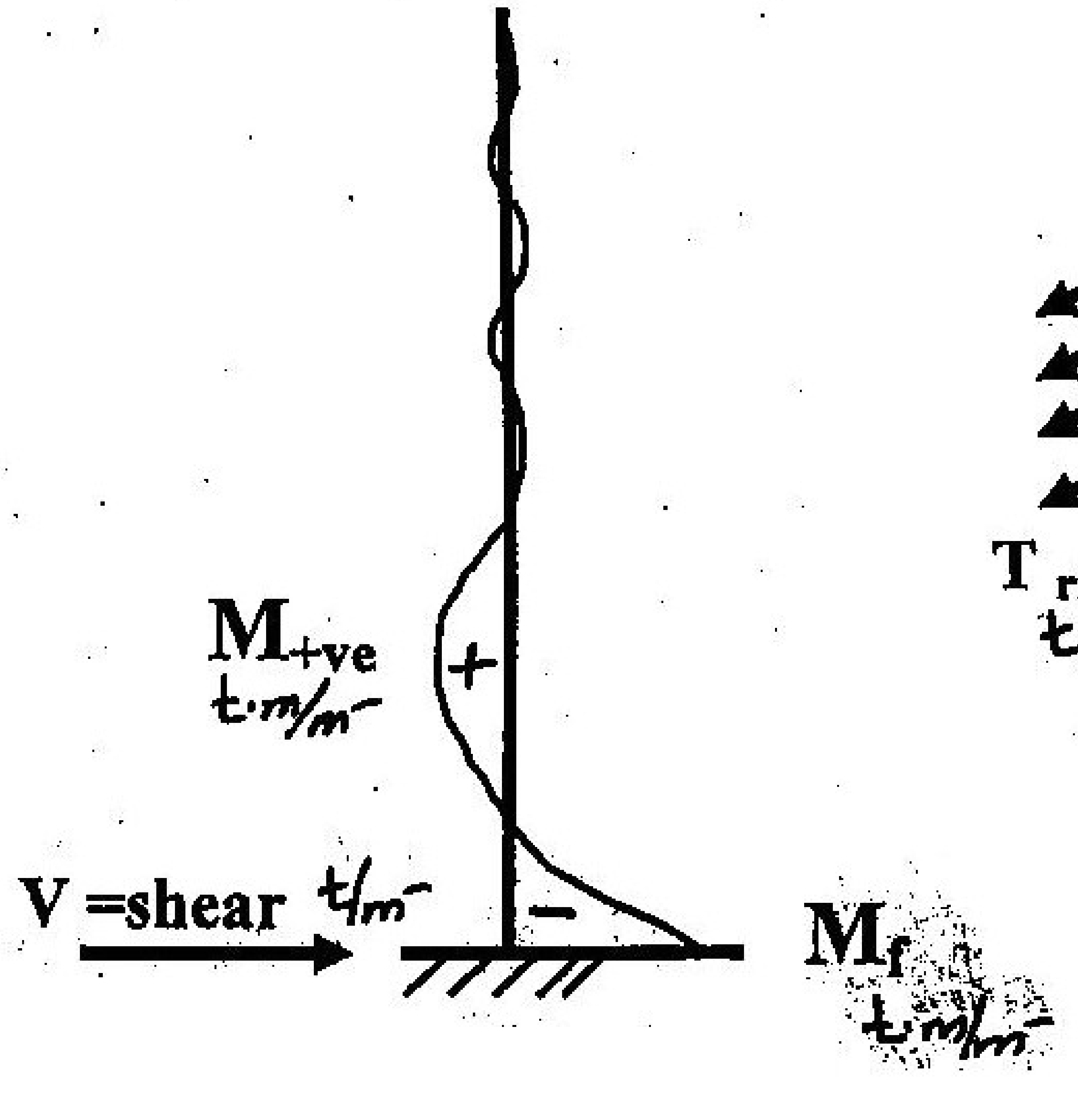
على حسب نوع التربة

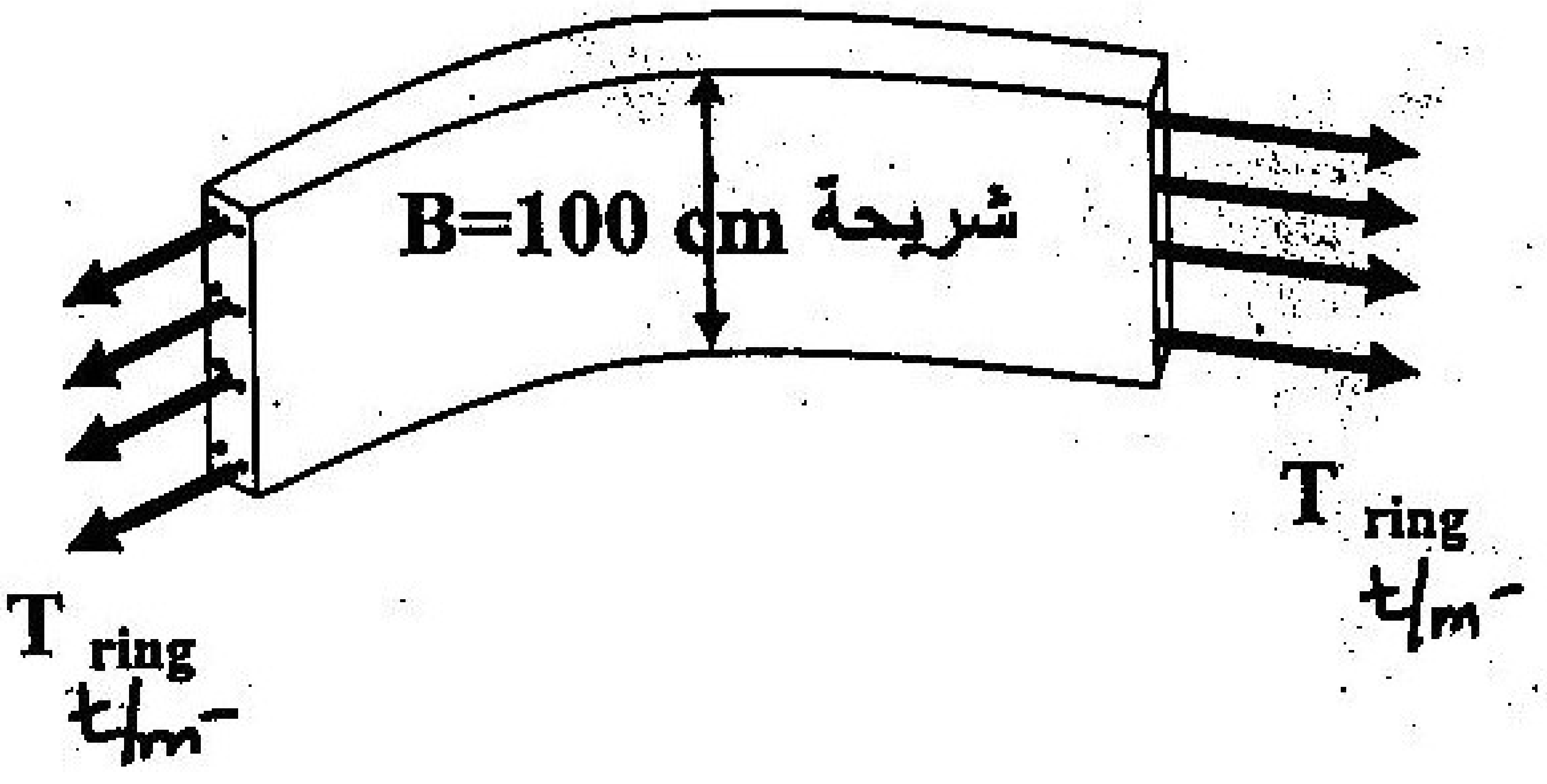
وسيتم دراستها لاحقا.

فى هذه المذكرة سنقوم بدراسة الحائط فقط = يعنى الحصول على قيم العزوم والشد عليها (straining actions) ثم لاحقا سنقوم بعكس العزوم السفلية (Mf) والـ (V) shear على القاعدة وحلها .

Fixed walls:

(VL. direction) + (Ring direction)





Reissner Method: page (3-1)

1- $n = 0.5 + \sqrt{0.25 + \frac{fct.H}{R^2.\gamma}}$

نعوض فى المعادلة بوحدات kg,cm

γ =0.001 kg/cm^3

H= (سم) ارتفاع الخزان

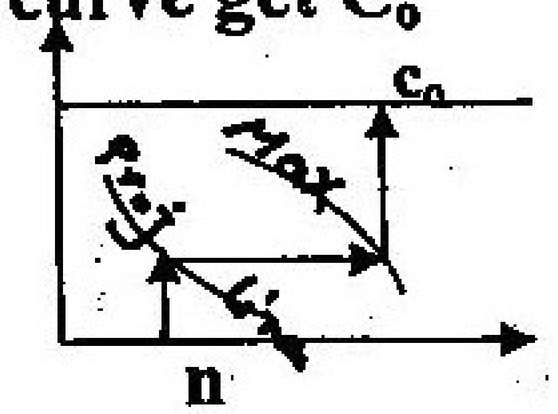
R=(سم) نصف قطر الخزان

f_{ct} = 20 kg/cm^2 → تحمل الخرسانة ف الشد

2- $t_{\text{wall at base (cm)}} = \frac{1.73\,H^2}{R.n^2}$ الوحدات سم

من هنا لأخر المعادلات الوحدات ton ,m

3- From curve get C_o



→T_{ring}= c_o.γ.H.R t/m

4- $M_f = \frac{\gamma R^2.t^2.n(n-1)}{6H}$ t.m

5- $M_{+ve} = \frac{M_f}{5}$ t.m

6- $V_{shear} = \frac{\gamma R^2.t^2.n^2(2n-1)}{6H^2}$ t/m

Simplified Method: page (3-2)

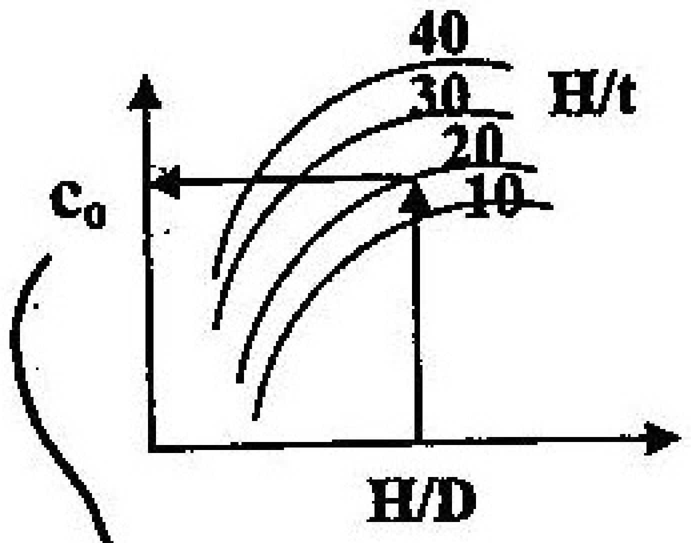
الوحدات هنا كلها ton ,m

1- From $\frac{H}{R^2}$ → get c1,c2,c3

H/R^2		
C1		
C2		
C3		

2- $t_{\text{wall at base (cm)}}$ = c3. .γ.H.R

3- From curve get C_o



→T_{ring}= c_o.γ.H.R t/m

4- $M_f = \frac{\gamma.H.D.t_{wall}}{c1}$ t.m

5- $M_{+ve} = \frac{M_f}{5}$ t.m

6- $V_{shear} = c2\,\frac{\gamma H^2}{2}$ t/m

P.C.A : P.(3-4) to (3-16)

Assume t= 25 cm مبدئيا

→ $(H^2/D.t)$ = ↘

1- From Table (1): →get c_o

$H^2/D.t$		
1		
5		
16 - - -	- - - - - -	→ c_o

ناخذ اكبر معامل C_o موجب فى الصف

→T_{ring}= c_o.γ.H.R

2- From table (7) :

ناخذ أكبر معامل موجب وسالب

c_o +ve and -Ve

$M_f = c_o\,\gamma H^3$ السالب

$M_{+ve} = c_o\,\gamma H^3$ الموجب

3- From table (12) :(Fixed)

Triangular load

→Get : c_o

$V_{shear} = c_o\,\gamma H^2$ (t/m)

Approximate Method

If Deep tank ($\frac{H}{R^2} \geq 0.25$)

→T_{ring}= 0.65γ.H.R (t/m)

→t_{wall} (cm) → from reissner

$M_f = \gamma.H.D.t/7.5$ (t.m)

$M_{+ve} = M_f/5$ (t.m)

$V_{shear} = 0.25\,\gamma\,H$ (t/m)

If Medium tank :

(0.025< (H/R^2) <0.25)

→T_{ring}= 0.5γ.H.R (t/m)

→t_{wall} (cm) → from reissner

$M_f = \gamma.H.D.t/9$ (t.m)

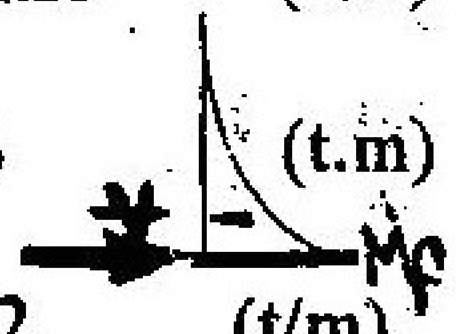
$M_{+ve} = M_f/5$ (t.m)

$V_{shear} = 0.3\,\gamma\,H$ (t/m)

If Shallow tank ($\frac{H}{R^2} \leq 0.025$)

→T_{ring}= 0.2γ.H.R (t/m)

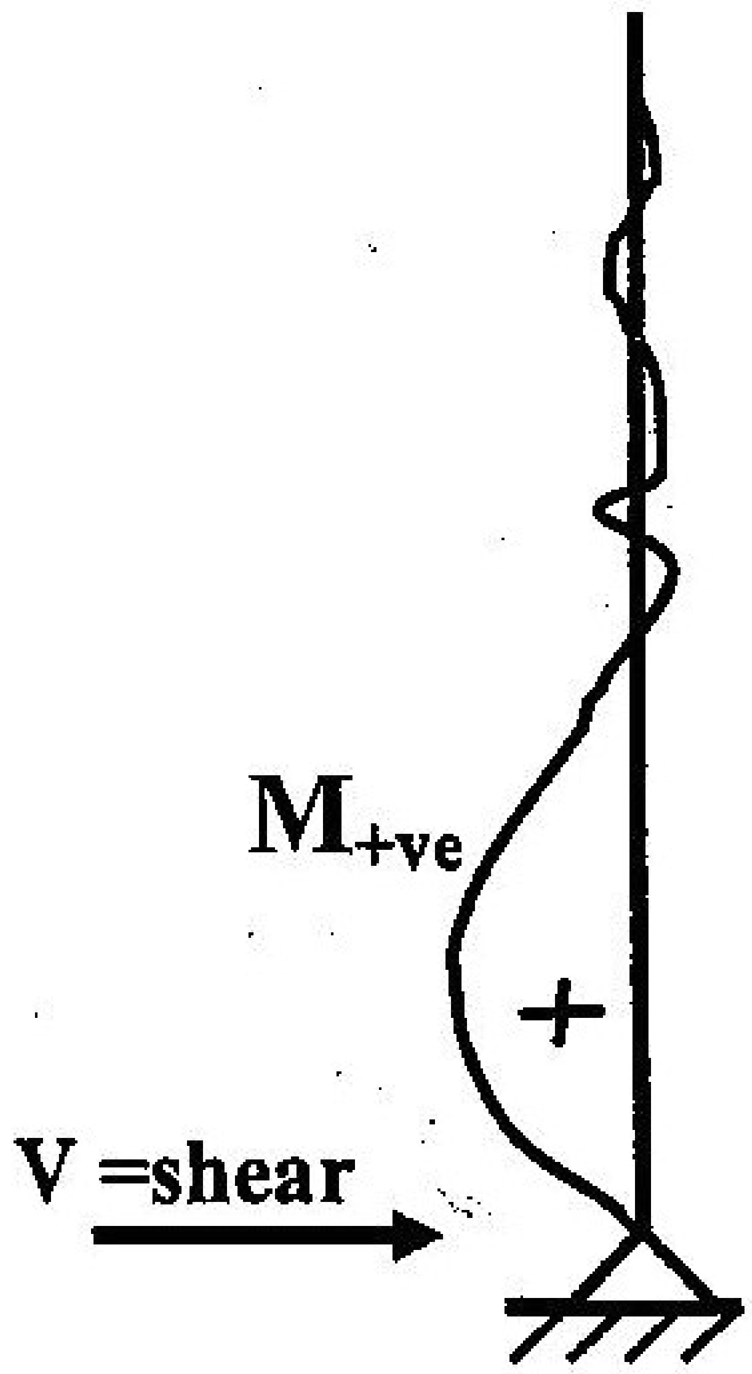
$M_f = \gamma H^3/6$ (t.m)

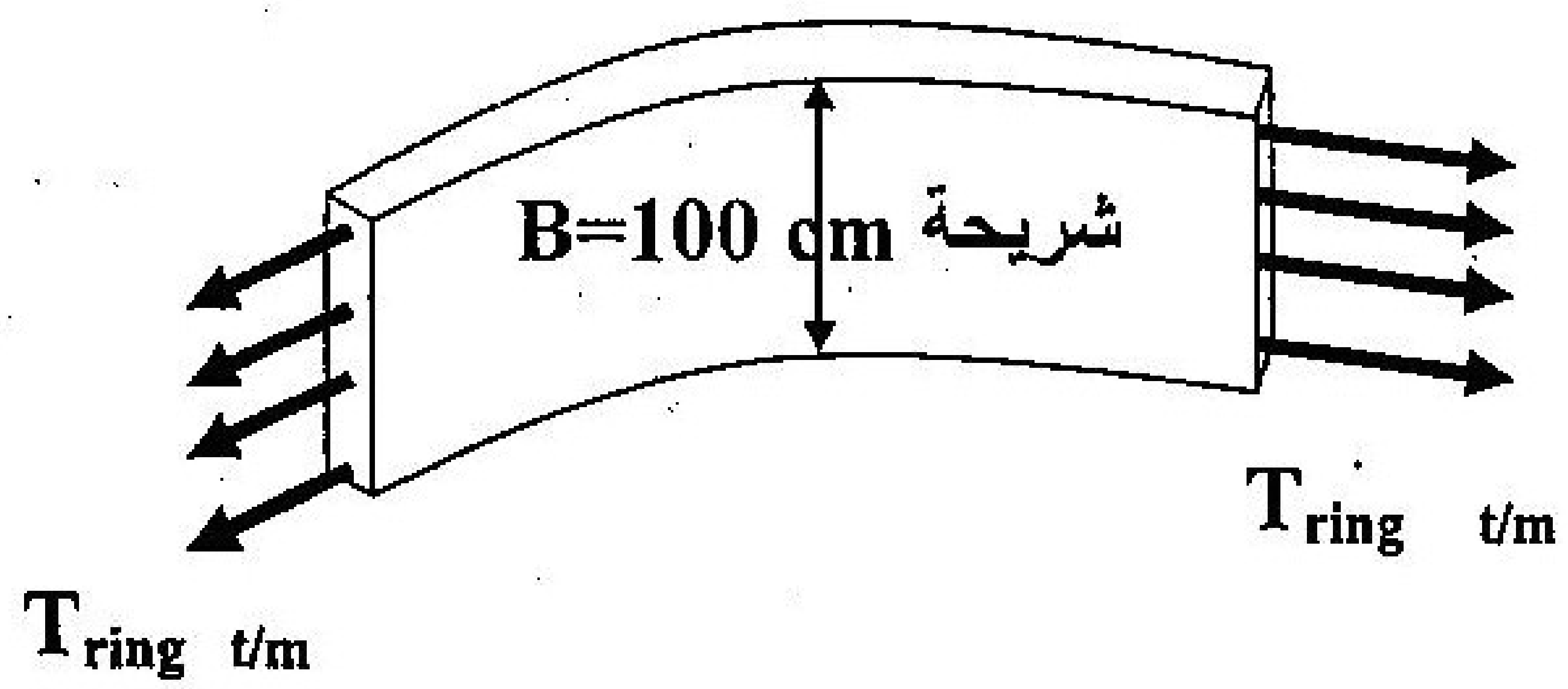


$V_{shear} = \gamma H^2/2$ (t/m)

Hinged walls: (P.C.A only)

(VL. direction) + (Ring direction)





P.C.A : P.(3-4) to (3-16)

Assume t= 25 cm مبدنيا

→ $(H^2/D.t)$ =

1- From Table (2): →get c_o

$H^2/D.t$		
1		
5		
16 ---	------	→ c_o

ناخذ اكبر معامل C_o موجب فى الصف

→$T_{ring} = c_o.\gamma.H.R$

2- From table (8) :

نأخذ أكبر معامل موجب فى الصف

c_o +ve

$M_{+ve} = c_o \gamma H^3$ الموجب

3- From table (12) :

→Get : c_o (Hinged)

$V_{shear} = c_o \gamma H^2$

Example :

Calculate the straining actions for the fixed wall containing water :

H=10m

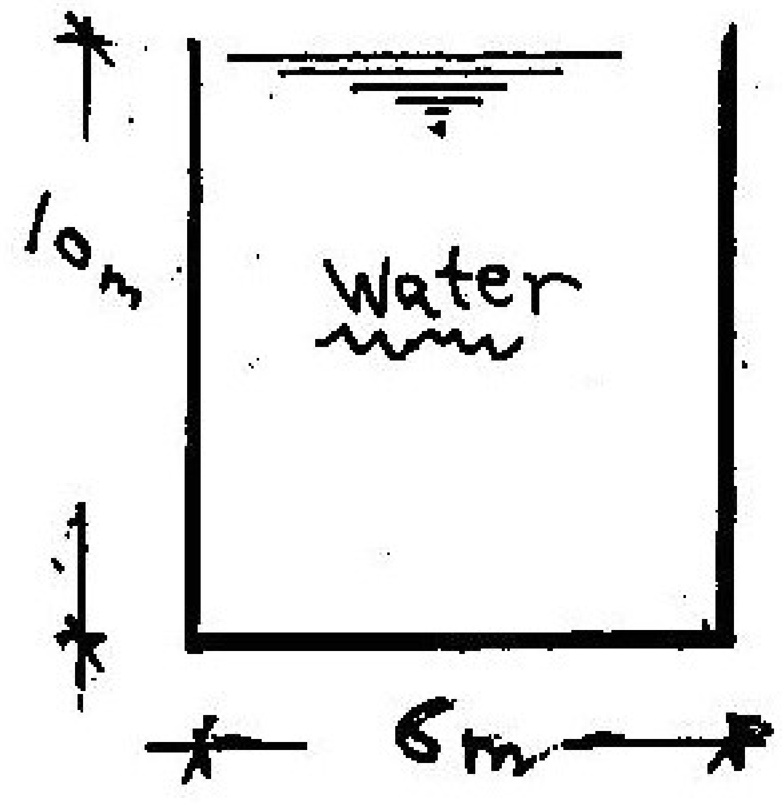
D=6m

By : - Reissner.

-Simplified.

-P.C.A tables.

-Approximate method.



Solution:

(1) Using Reissner :

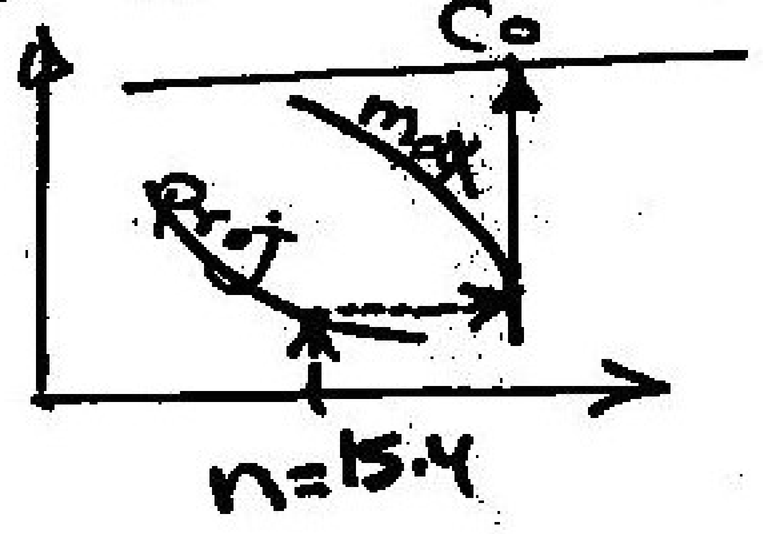
$$\rightarrow n = 0.5 + \sqrt{0.25 + \frac{f_{ct} \cdot H}{\gamma \cdot R^2}}$$

$$= 0.5 + \sqrt{0.25 + \frac{20 * 1000}{0.001 * (300)^2}} = 15.4$$

$$\rightarrow t_{wall\ at\ base}(cm)\ \text{Empirical} = \frac{1.73\, H^2}{R \cdot n^2} = \frac{1.73\,(1000)^2}{300 * (15.4)^2} = 24.3\ cm$$

$\therefore$ Use $t_{wall} = 25\ cm$

$\rightarrow$ from Curve P(3-1) $\Rightarrow$ get $C_o = 0.88$



$$\rightarrow T_{\substack{max \\ ring}} = Co.\ \gamma H R = 0.88 * 1 * 10 * 3$$

$$= 26.4\ t/m^-$$

$$\rightarrow M_f = \frac{\gamma R^2 \cdot t^2 \cdot n(n-1)}{6H} = \frac{1 * 3^2 * (0.25)^2\ 15.4(15.4-1)}{6 * 10}$$

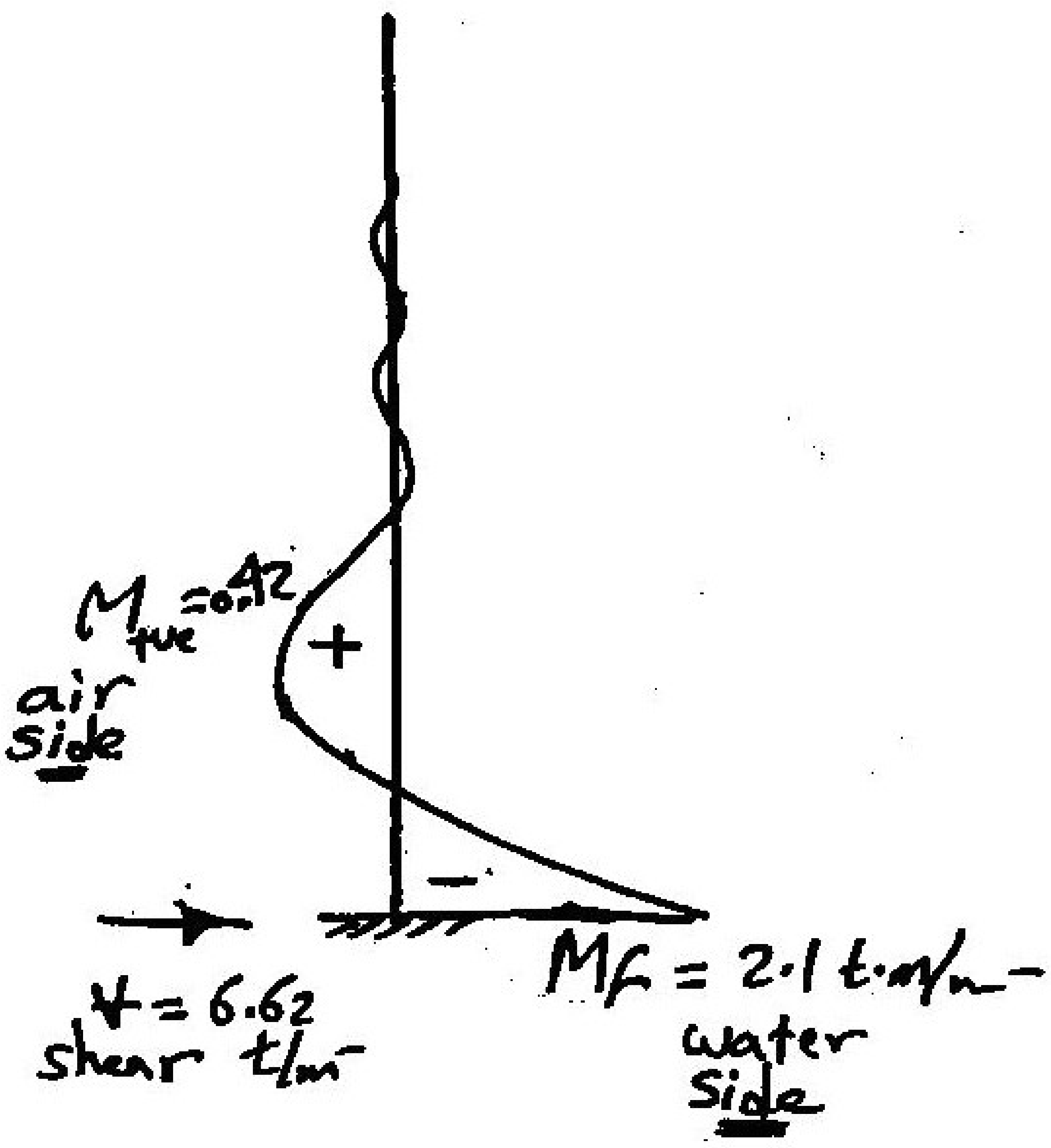
$$M_f = 2.1\ t.m/m^-$$

$$\rightarrow M_{+ve} = \frac{M_f}{5} = \frac{2.1}{5} = 0.42\ t.m/m^-$$

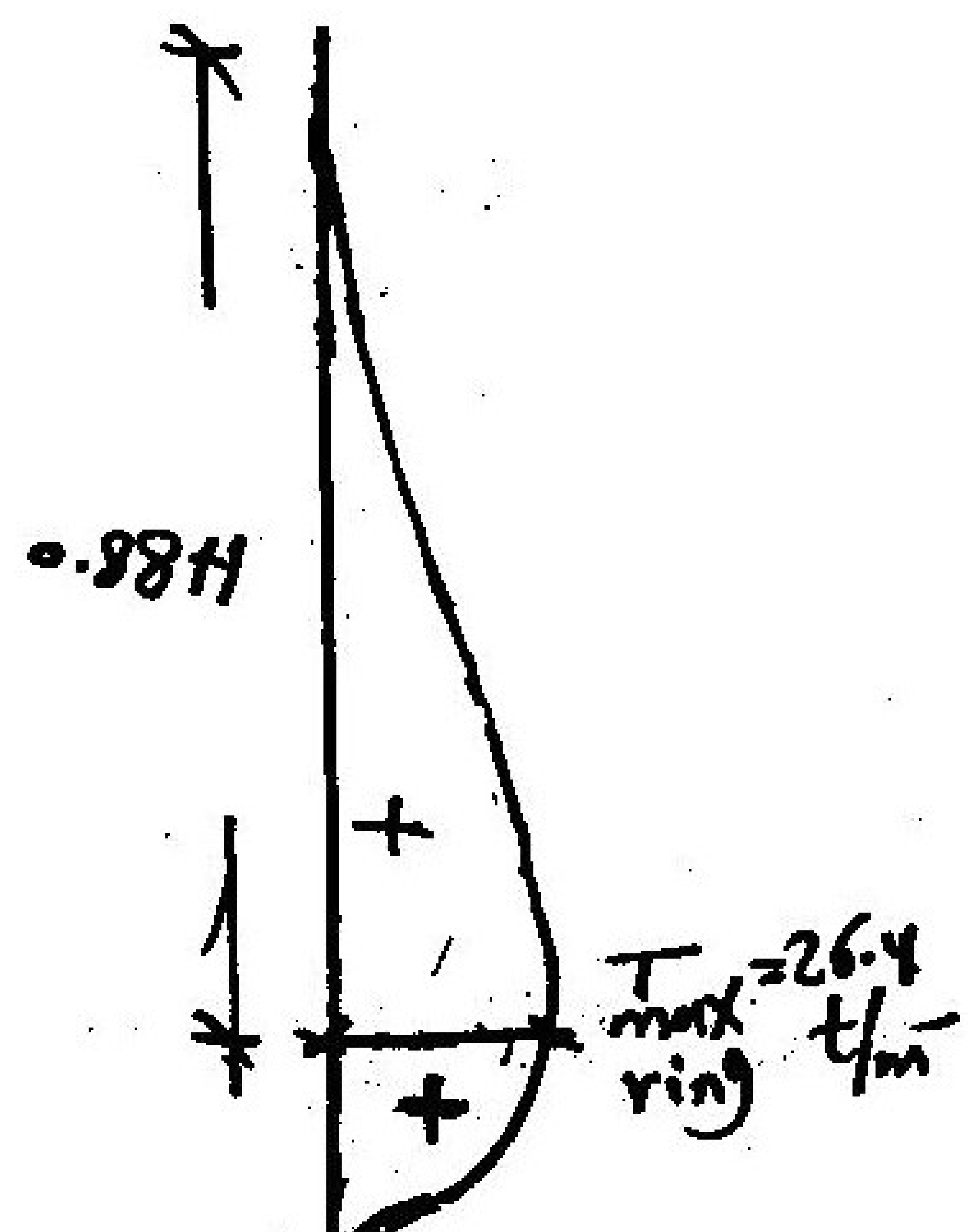
$$\rightarrow \underset{shear}{V} = \frac{\gamma R^2 \cdot t^2 \cdot n^2(2n-1)}{\gamma H^2} = \frac{1 * 3^2 * (0.25)^2 * (15.4)^2 (2 * 15.4 - 1)}{6 * (10)^2}$$

$$\underset{shear}{V} = 6.62\ t/m^-$$

VL. direction



Ring direction



(2) Using Simplified Method:

$\rightarrow \frac{H}{R^2} = \frac{10}{(3)^2} = 1.11$

$\rightarrow$ from table P. (3-2) $\Rightarrow$ $C_1 = 7.46$

$C_2 = 0.1325$

$C_3 = 0.895$

$\rightarrow t_{\text{wall at base}}$ (cm) $= C_3 \gamma H R$

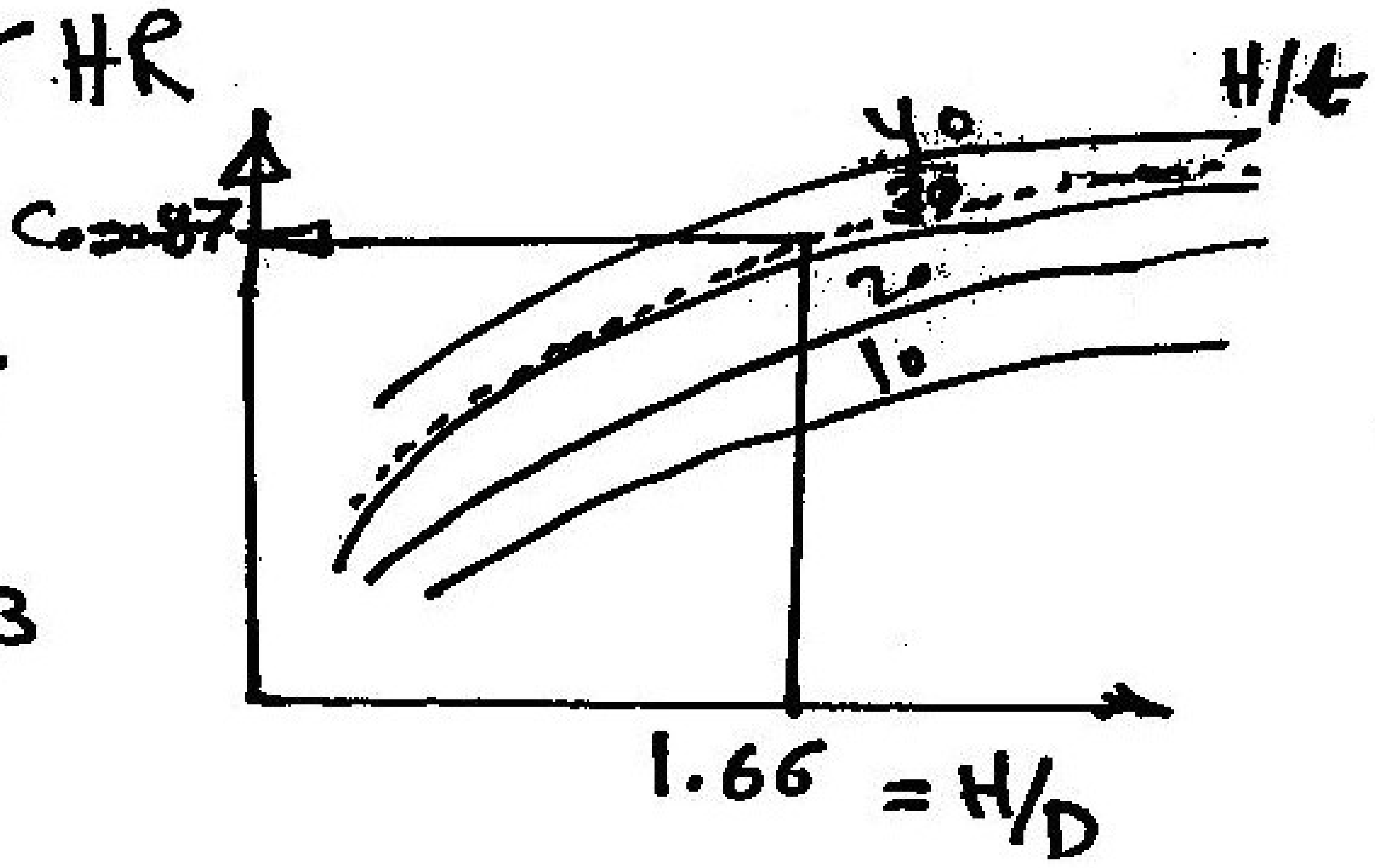
$= 0.895 * 1 * 10 * 3 = 26.85$ cm

$\therefore$ use $t = 30$ cm

$\rightarrow T_{ring\ max} = C_0 . \gamma H R$

$\because H/D = \frac{10}{6} = 1.66$

$\because H/t = \frac{10}{0.3} = 33.3$



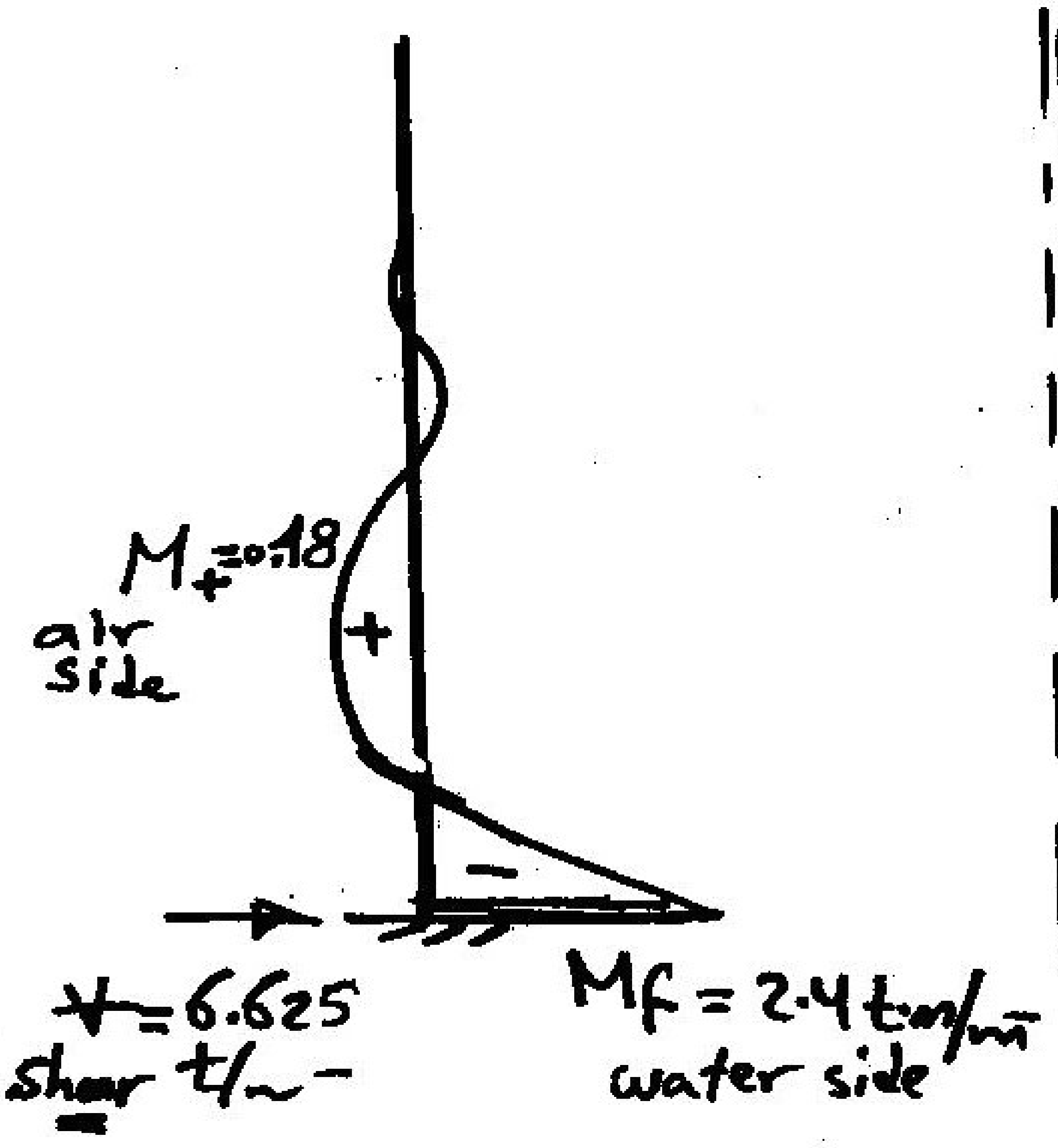
$\therefore T_{ring\ max} = 0.87 * 1 * 10 * 3 = 26.1$ t/m

$\rightarrow M_f = \frac{\gamma H D . t_{wall}}{C_1} = \frac{1 * 10 * 6 * (0.3)}{7.46} = 2.4$ t.m/m

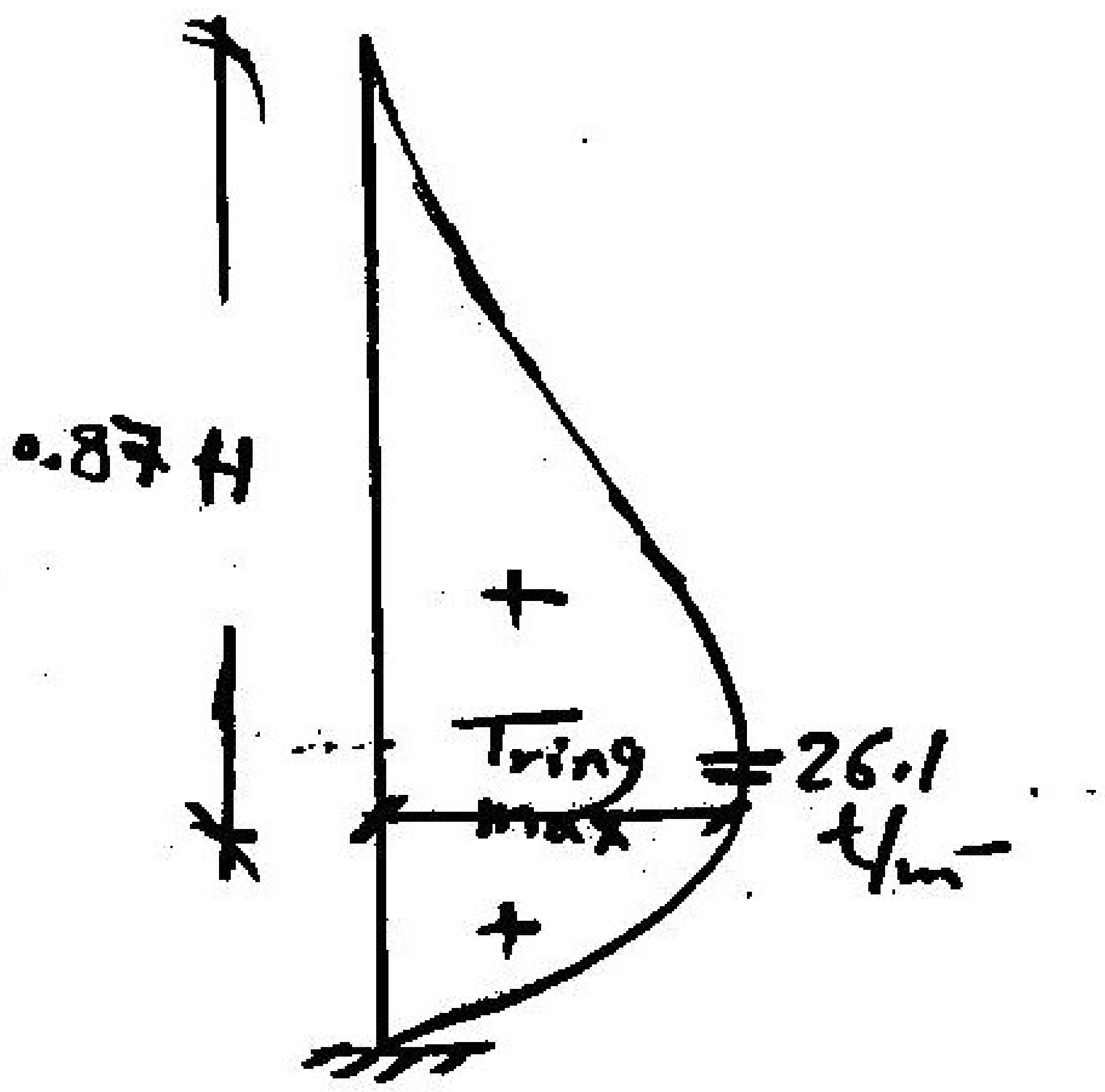
$\rightarrow M_{+ve} = \frac{M_f}{5} = \frac{2.4}{5} = 0.48$ t.m/m

$\rightarrow V_{shear} = C_2 . \frac{\gamma H^2}{2} = 0.1325 * \frac{1 * (10)^2}{2} = 6.625$ t/m

Vl. strip



Ring direction



(3) Using P.C.A Tables: P.(3-4) → (3-16)

assume $t_{wall} = 25$ cm

$$\therefore \frac{H^2}{D.t} = \frac{(10)^2}{6(0.25)} = 66.6$$

→ To get Max ring tension (table ①)

$T = C_o \cdot \gamma H R$ ندخل بجدول P.(3-16)

$H^2/D.t$	
56	نأخذ أكبر Co = 0.838

(56) آخر رقم هو ← (pointing to the 56 row)

$$\therefore T_{max\ ring} = C_o \cdot \gamma H R = 0.838 * 1 * 10 * 3 = 25.14 \text{ t/m}$$

→ to get Moments ⇒ table (7):

ندخل الجدول المكمل P.(3-16)

$$M = C_o \cdot \gamma H^3$$

$H^2/D\cdot t$	
56 →	نأخذ أكبر معامل سالب وأكبر معامل موجب

$$C_{o\,-ve} = -0.0023$$

$$C_{o\,+ve} = +0.004$$

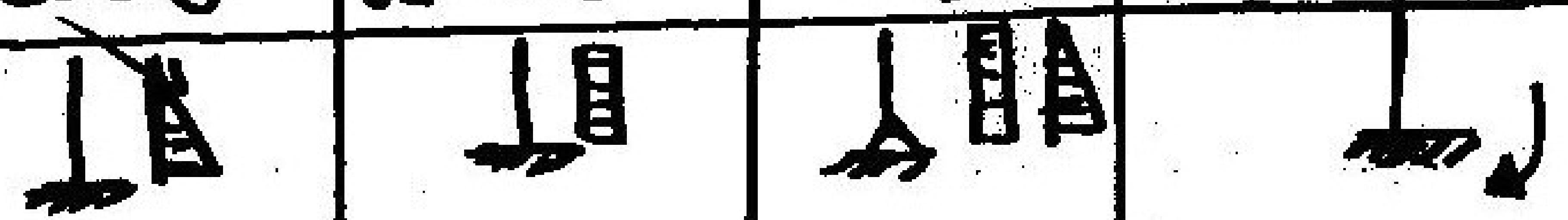
$$\therefore M_{f\,\text{السالب}} = C_o \cdot \gamma H^3 = 0.0023 * 1 * (10)^3 = 2.3 \ t.m/m$$

$$\therefore M_{+ve\,\text{الموجب}} = C_o \cdot \gamma H^3 = 0.004 * 1 * (10)^3 = 0.4 \ t.m/m$$

→ to get shear (V) ⇒ table (12)

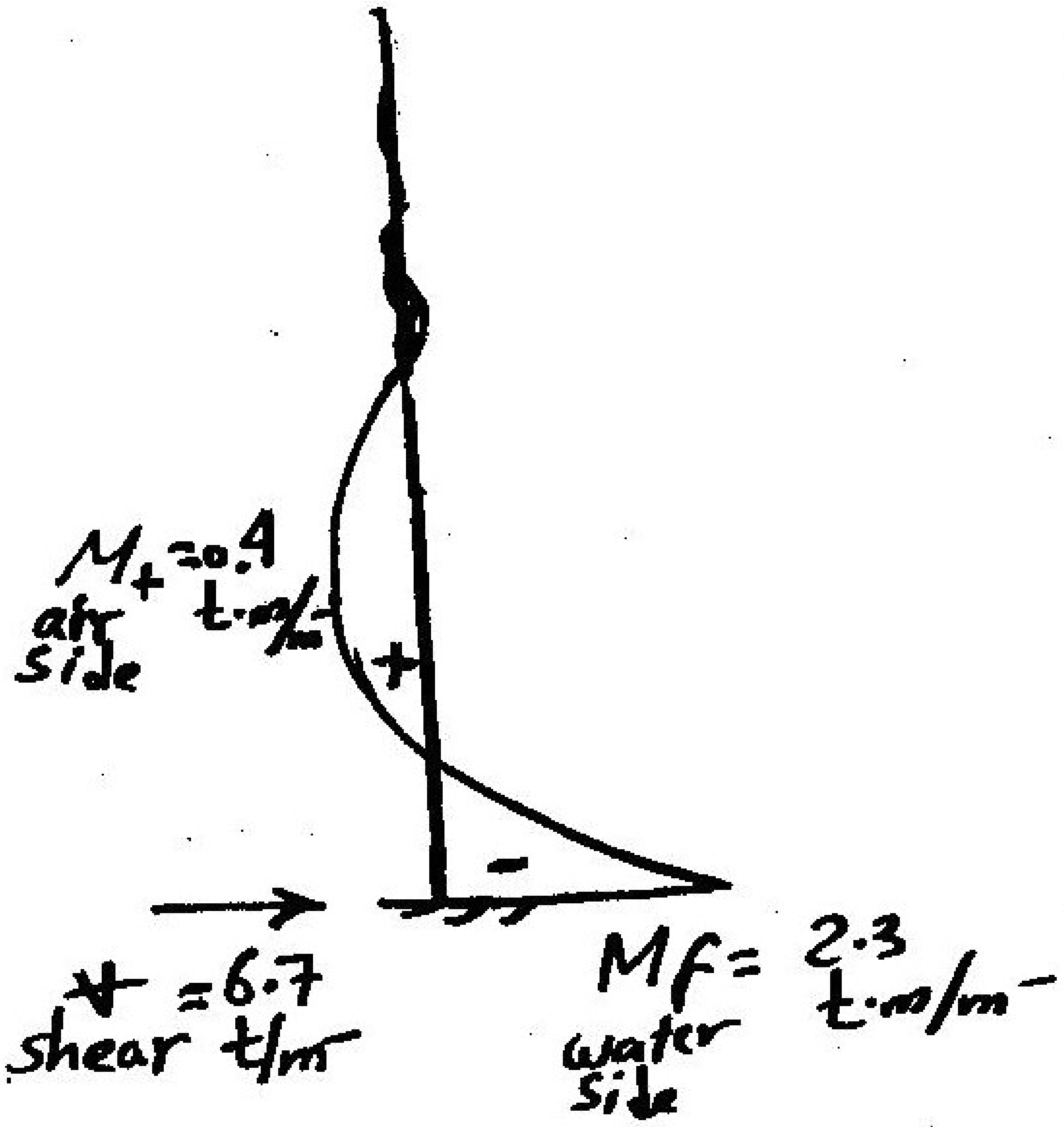
ندخل الجدول المكمل

$$V = C_o \cdot \gamma H^2$$

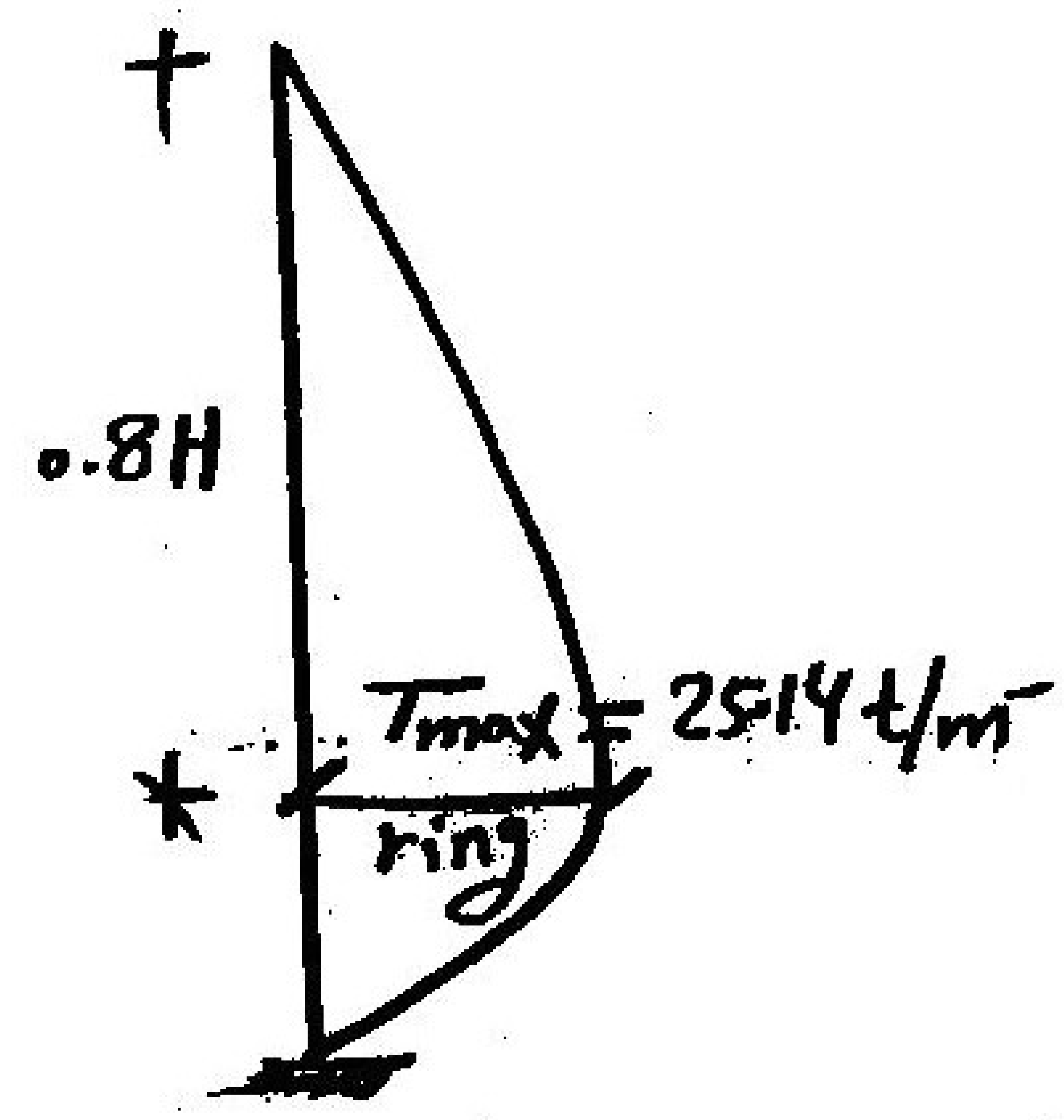
$H^2/D\cdot t$	Fixed حمل مثلث	Fixed حمل مستطيل	Hinged	Moment at edge
				
56 →	0.067			

$$\therefore V = 0.067 * 1 * (10)^2 = 6.7 \ t/m$$

VL. Strip



Ring direction



(4) Using Approximate method:

$\rightarrow \frac{H}{R^2} = \frac{10}{(3)^2} = 1.11 > 0.25 \Rightarrow$ **deep tank**

$\rightarrow$ from reissner $\therefore n = 15.4$

$\rightarrow t_{(cm)} = \frac{1.73 H^2}{R \cdot n^2} = \frac{1.73 * (1000)^2}{(300)(15.4)^2} = 24.3$

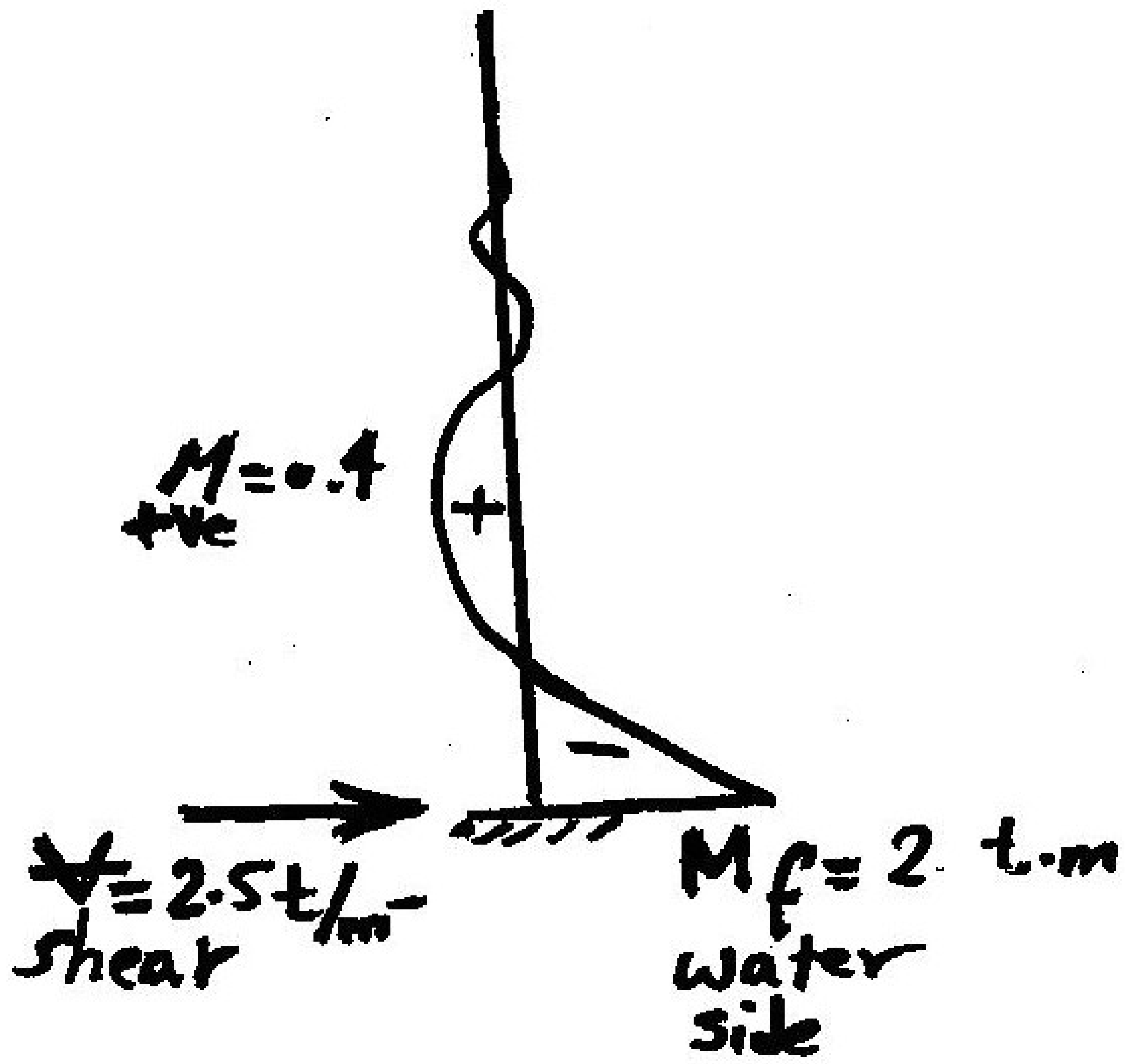
$\therefore$ use $t = 25$ cm

$\rightarrow M_f = \frac{\gamma H D t}{7.5} = \frac{1 * 10 * 6 * 0.25}{7.5} = 2$ t.m/m

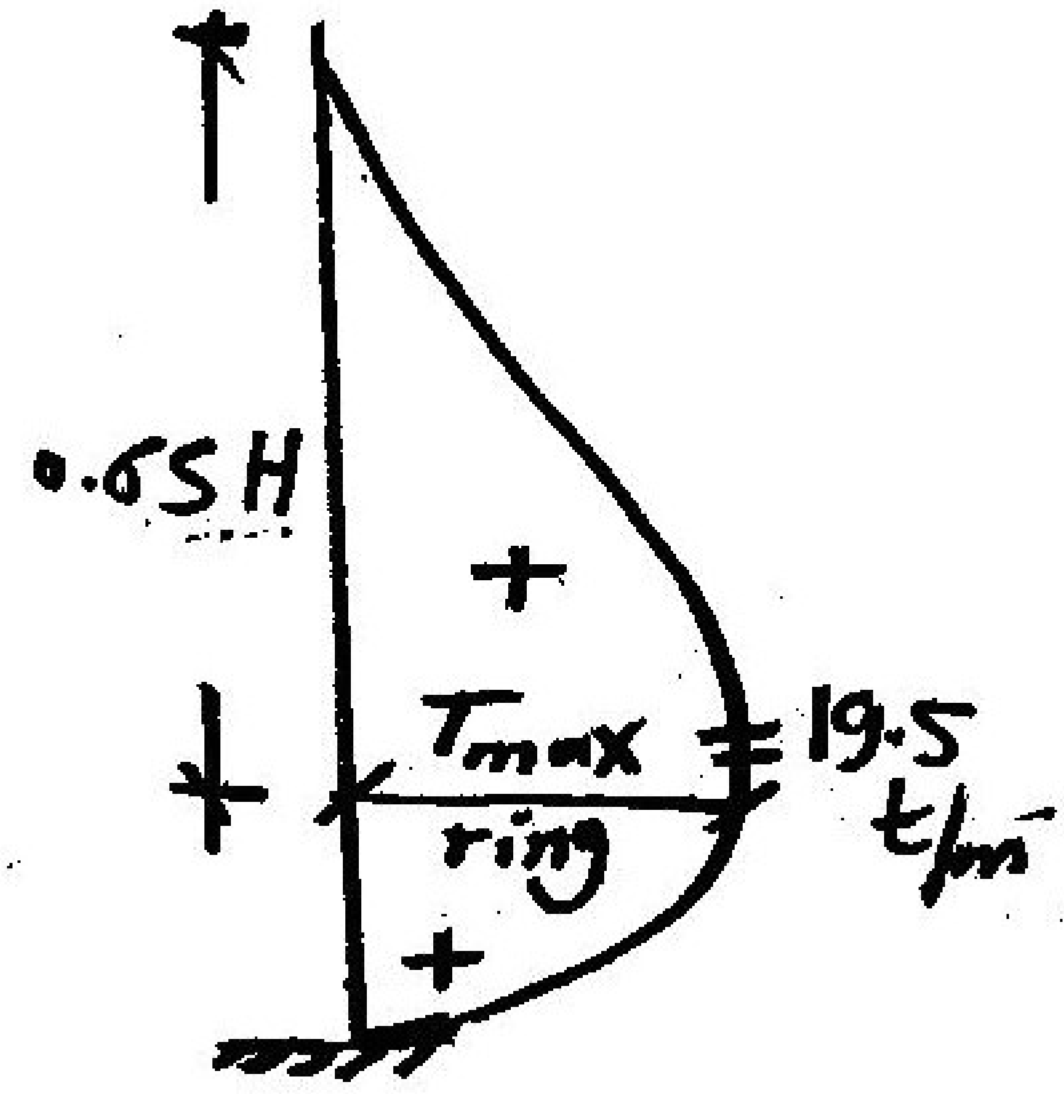
$\rightarrow M_{+ve} = \frac{M_f}{5} = \frac{2}{5} = 0.4$ t.m/m

→ $V_{shear} = 0.25\ \gamma H = 0.25 * 1 * 10 = 2.5\ t/m'$

→ $T_{max\ ring} = 0.65 \gamma H R = 0.65 * 1 * 10 * 3 = 19.5\ t/m'$



VL. direction



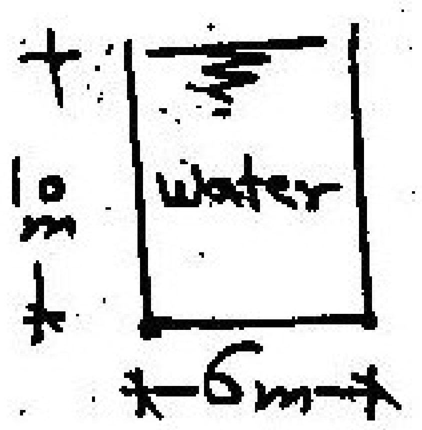
Ring direction

Example:

Calculate Straining actions For **Hinged** **Wall**

$D = 6\,m$

$H = 10\,m$



Sol: Hinged wall $\Rightarrow$ P.C.A tables

$\rightarrow$ assume $t = 25\,cm$

$\rightarrow \dfrac{H^2}{D \cdot t} = \dfrac{(10)^2}{6(0.25)} = 66.6$

$\longrightarrow$ to get Max ring tension table (2)

نفتح الجداول المكملة P. (3-16)

ونأخذ أكبر معامل (Co) موجب

$\therefore C_o = 0.911$

$\therefore T_{max\ ring} = C_o \cdot \gamma H R = 0.911 * 1 * 10 * 3 = 27.33\ t/m^-$

$\longrightarrow$ to get $M_{+ve} \Rightarrow$ table (8)

نفتح الجداول المكملة ونأخذ أكبر (Co) موجب

$\therefore C_o = 0.0008$

$\therefore M_{+ve} = C_o \cdot \gamma H^3 = 0.0008 * 1 * (10)^3$

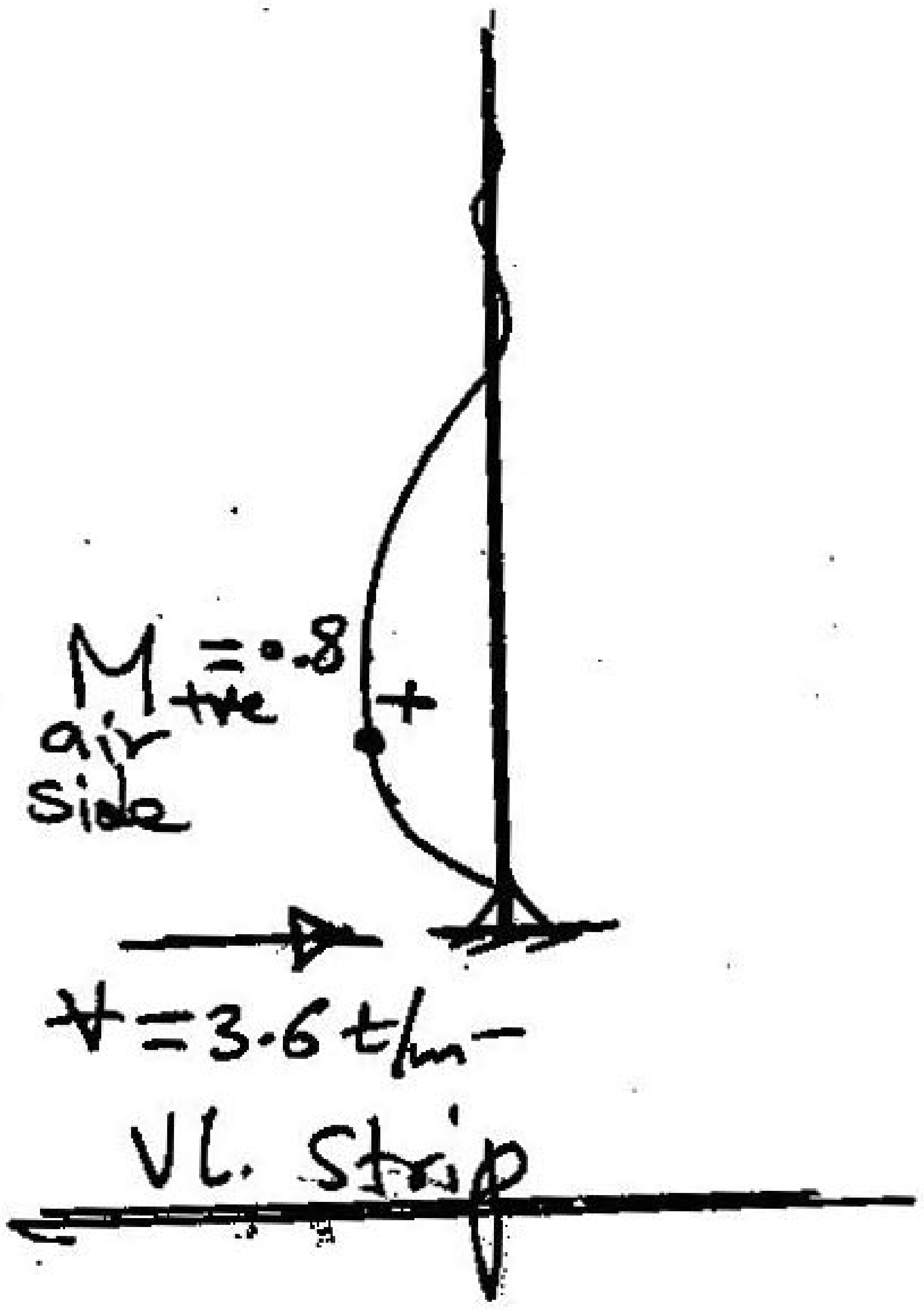
$= 0.8\ t.m/m^-$

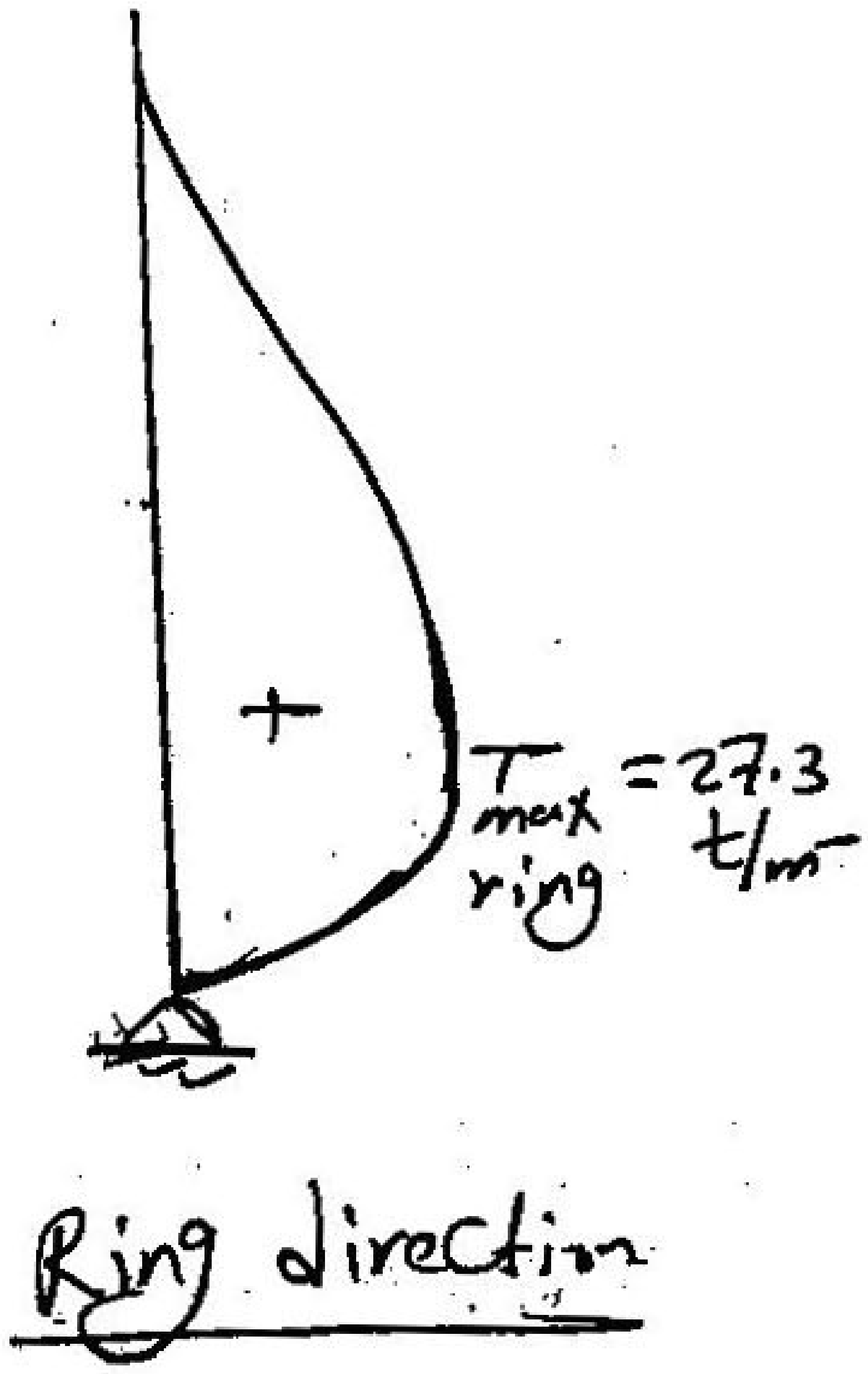
$\longrightarrow$ to get Shear (V) $\Longrightarrow$ table (12)

نفتح الجدول المكمل ونأخذ المعامل عند Hinged

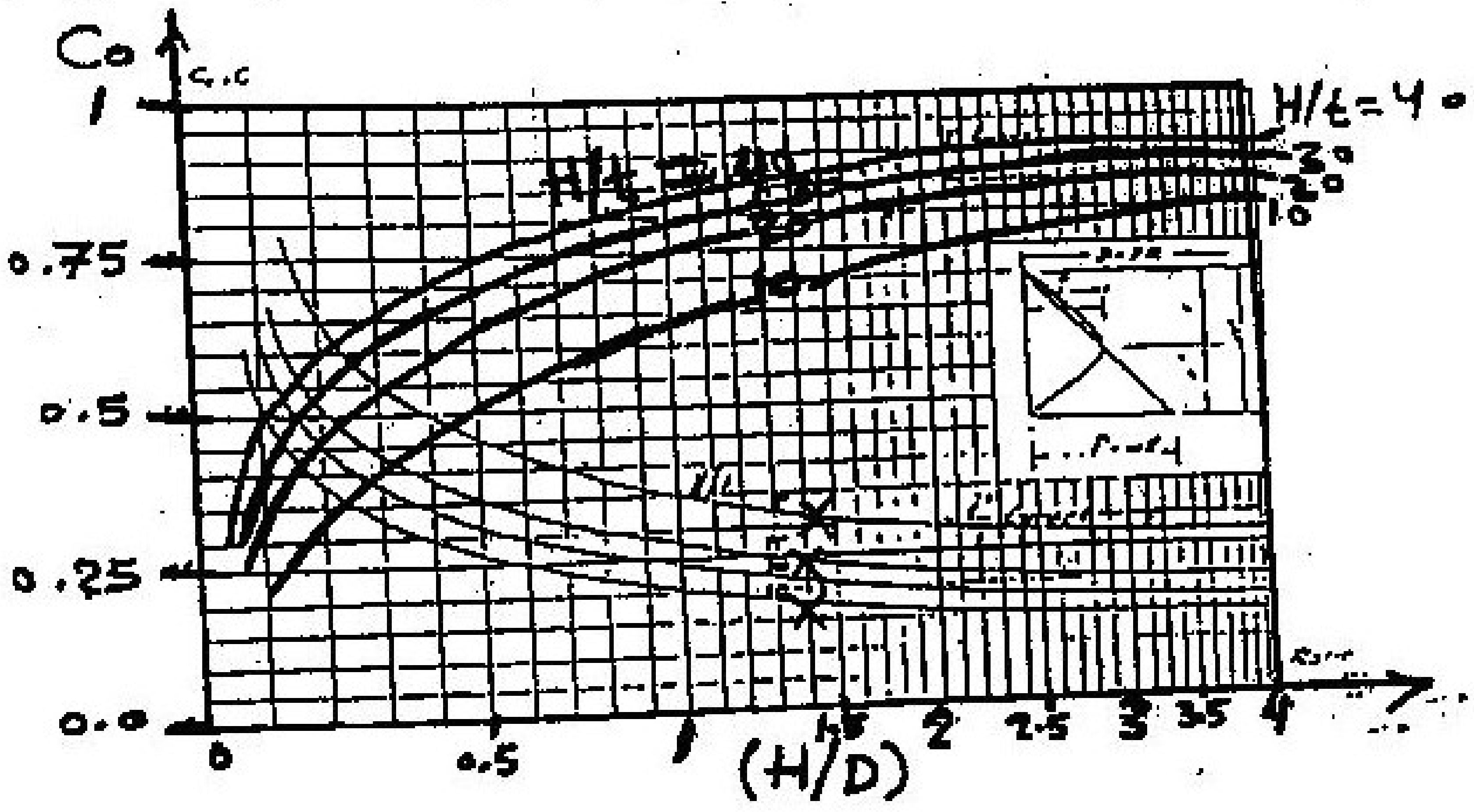
$\therefore C_o = 0.036$

$$\therefore V_{shear} = C_o \cdot \gamma H^2 = 0.036 * 1 * (10)^2$$
$$= 3.6 \ t/m$$





→ Simplified Curves :



→ Simplified table :

H/R2	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.1	0.08	0.06	0.04	0.02	0.01
n	16.4	15.2	13.9	12.5	10.9	9.00	6..50	4.77	4.32	3.82	3.26	2.46	1.93
C1	7.40	7.44	7.49	7.55	7.65	7.82	8.22	8.80	9.04	9.4	10.1	11.7	14.4
C2	.118	.127	.138	.154	.175	.211	.284	.375	.409	.455	.525	.646	.769
C3	.800	.895	.890	.882	.870	.852	.812	.756	.736	.708	.663	.570	.462

Reissner Curves

Ring Tension ($T = Co. \gamma . H.R$) Where : $Co = y. \frac{K}{\gamma} . \frac{t_x}{t}$

W = Weight of Liquid / m^3

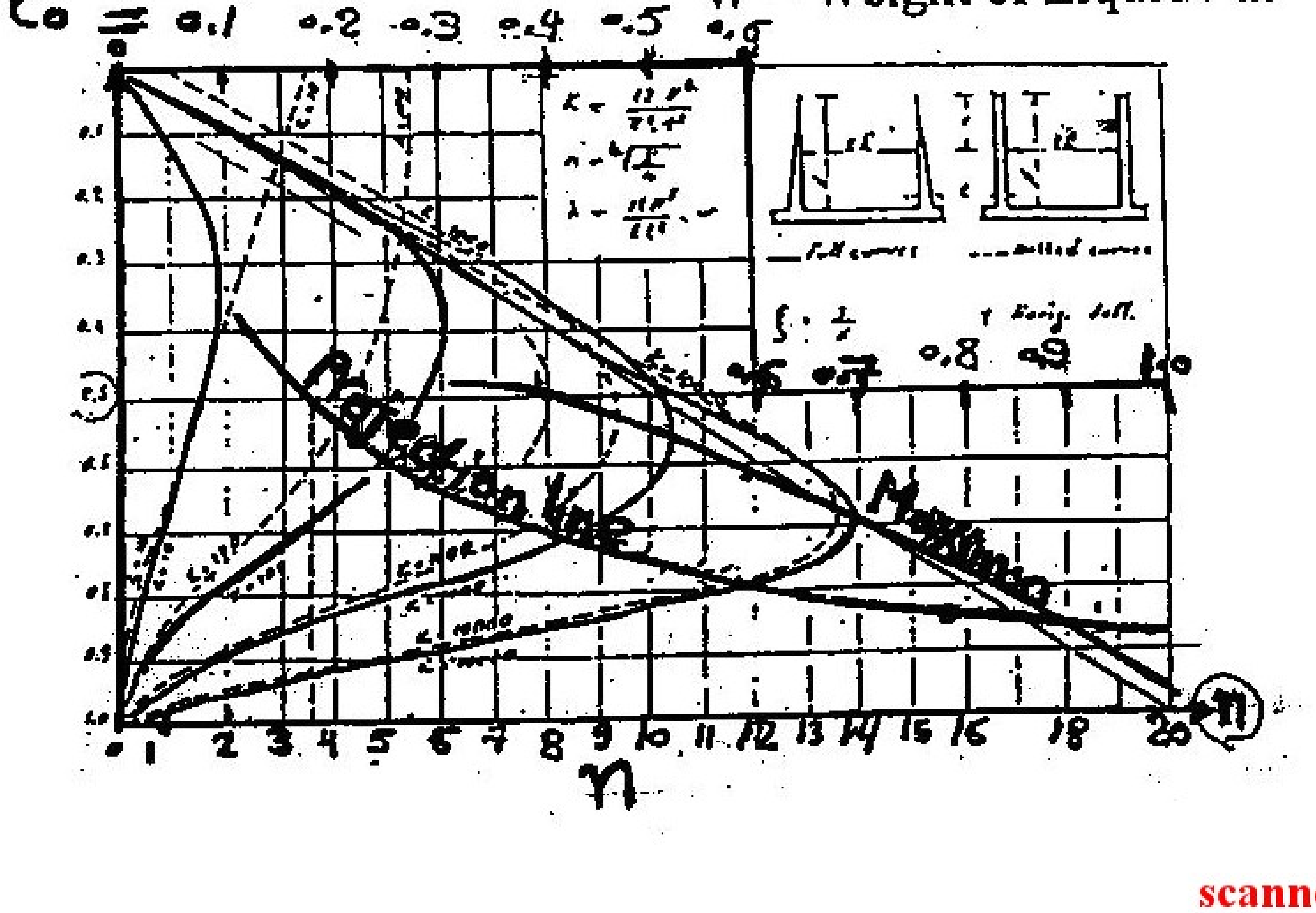
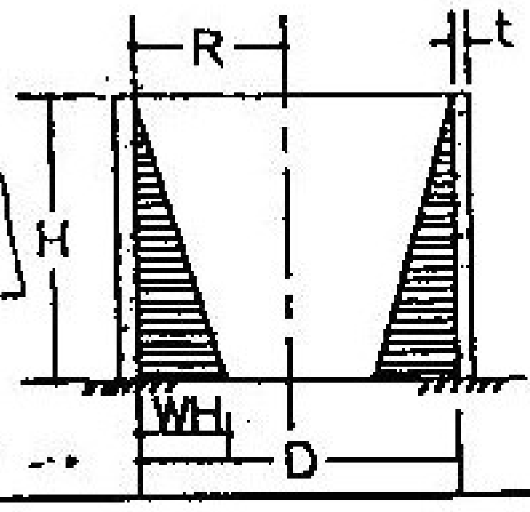


Table I : **Tension in circular rings**
Triangular Load
Fixed base, free top
T = coeff. * wHR
Positive sign indicates tension

T = Co. γHR

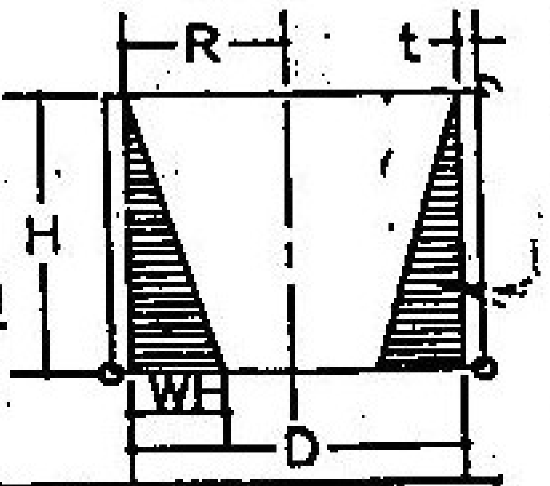
· assume t = 25 cm = 0.25 m.



$\frac{H^2}{Dt}$	Coefficients at point									
	0.0H	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H
0.4	+0.149	+0.134	+0.120	+0.101	+0.082	+0.066	+0.049	+0.029	+0.014	+0.004
0.8	+0.263	+0.239	+0.215	+0.190	+0.160	+0.130	+0.096	+0.063	+0.034	+0.010
1.2	+0.283	+0.271	+0.254	+0.234	+0.209	+0.180	+0.142	+0.099	+0.054	+0.016
1.6	+0.265	+0.268	+0.268	+0.266	+0.250	+0.226	+0.185	+0.134	+0.075	+0.023
2.0	+0.234	+0.251	+0.273	+0.285	+0.285	+0.274	+0.232	+0.172	+0.104	+0.031
3.0	+0.134	+0.203	+0.267	+0.322	+0.357	+0.362	+0.330	+0.262	+0.157	+0.052
4.0	+0.067	+0.164	+0.256	+0.339	+0.403	+0.429	+0.409	+0.334	+0.210	+0.073
5.0	+0.025	+0.137	+0.245	+0.346	+0.428	+0.477	+0.469	+0.398	+0.259	+0.092
6.0	+0.018	+0.119	+0.234	+0.344	+0.441	+0.504	+0.514	+0.447	+0.301	+0.112
8.0	-0.011	+0.104	+0.218	+0.335	+0.443	+0.534	+0.575	+0.530	+0.381	+0.151
10.	-0.011	+0.098	+0.208	+0.323	+0.437	+0.542	+0.608	+0.589	+0.440	+0.179
12.	-0.005	+0.097	+0.202	+0.312	+0.429	+0.543	+0.628	+0.633	+0.494	+0.211
14.	-0.002	+0.098	+0.200	+0.306	+0.420	+0.539	+0.639	+0.666	+0.541	+0.241
16.	0.000	+0.099	+0.199	+0.304	+0.412	+0.531	+0.641	+0.687	+0.582	+0.265

Table II : **Tension in circular rings**
Triangular Load
Hinged base, free top
T = coeff. * wHR
Positive sign indicates tension

T = Co. γHR



$\frac{H^2}{Dt}$	Coefficients at point									
	0.0H	0.1H	0.2H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H
0.4	+0.474	+0.440	+0.395	+0.352	+0.308	+0.264	+0.215	+0.165	+0.111	+0.057
0.8	+0.423	+0.402	+0.381	+0.358	+0.330	+0.297	+0.249	+0.202	+0.145	+0.076
1.2	+0.350	+0.355	+0.361	+0.362	+0.358	+0.343	+0.309	+0.256	+0.186	+0.098
1.6	+0.271	+0.303	+0.341	+0.369	+0.385	+0.385	+0.362	+0.314	+0.233	+0.124
2.0	+0.205	+0.260	+0.321	+0.373	+0.411	+0.434	+0.419	+0.369	+0.280	+0.1[illegible]1
3.0	+0.074	+0.179	+0.281	+0.375	+0.449	+0.506	+0.519	+0.479	+0.375	+0.210
4.0	+0.017	+0.137	+0.253	+0.367	+0.469	+0.545	+0.579	+0.553	+0.447	+0.256
5.0	-0.008	+0.114	+0.235	+0.356	+0.469	+0.562	+0.617	+0.606	+0.503	+0.294
6.0	-0.011	+0.103	+0.223	+0.343	+0.463	+0.566	+0.639	+0.643	+0.547	+0.327
8.0	-0.015	+0.096	+0.208	+0.324	+0.443	+0.564	+0.661	+0.697	+0.621	+0.386
10.	-0.008	+0.095	+0.200	+0.311	+0.428	+0.552	+0.666	+0.730	+0.678	+0.433
12.	-0.002	+0.097	+0.197	+0.302	+0.417	+0.541	+0.664	+0.750	+0.720	+0.477
14.	-0.000	+0.098	+0.197	+0.299	+0.408	+0.531	+0.659	+0.761	+0.752	+0.513
16.	+0.002	+0.100	+0.198	+0.299	+0.403	+0.521	+0.650	+0.764	+0.776	+0.536

(ملحوظة العزم السالب ناحية المياه)

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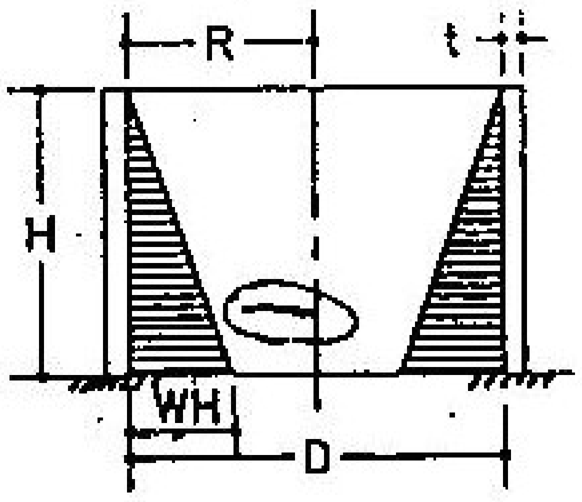
Table VII : Moments in cylindrical wall

Triangular Load

Fixed base, free top

Mom. = $C_o \gamma H^3$

Positive sign indicates tension in the outside.



Fixed

$\frac{H^2}{Dt}$	Coefficients at point									
	0.1H	0.21H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H	1.0H
0.4	+.0005	+.0014	+.0021	+.0007	-.0042	-.0150	-.0302	-.0529	-.0816	-.1205
0.8	+.0011	+.0037	+.0063	+.0080	+.0070	+.0023	-.0068	-.0224	-.0465	-.0795
1.2	+.0012	+.0042	+.0077	+.0103	+.0112	+.0090	+.0022	-.0108	-.0311	-.0602
1.6	+.0011	+.0041	+.0075	+.0107	+.0121	+.0111	+.0058	-.0051	-.0232	-.0505
2.0	+.0010	+.0035	+.0068	+.0099	+.0120	+.0115	+.0075	-.0021	-.0185	-.0436
3.0	+.0006	+.0024	+.0047	+.0071	+.0090	+.0097	+.0077	+.0012	-.0119	-.0333
4.0	+.0003	+.0015	+.0028	+.0047	+.0066	+.0077	+.0069	+.0023	-.0080	-.0268
5.0	+.0002	+.0008	+.0016	+.0029	+.0046	+.0059	+.0059	+.0028	-.0058	-.0222
6.0	+.0001	+.0003	+.0008	+.0019	+.0032	+.0046	+.0061	+.0029	-.0041	-.0187
8.0	.0000	+.0001	+.0002	+.0008	+.0016	+.0028	+.0035	+.0029	-.0022	-.0146
10.	.0000	.0000	+.0001	+.0004	+.0007	+.0019	+.0029	+.0028	-.0012	-.0122
12.	.0000	.0001	+.0001	+.0002	+.0003	+.0013	+.0023	+.0026	-.0005	-.0104
14.	.0000	.0000	.0000	.0000	+.0001	+.0008	+.0019	+.0023	-.0001	-.0090
16.	.0000	.0000	-.0001	-.0002	-.0001	+.0004	+.0013	+.0019	+.0001	-.0079

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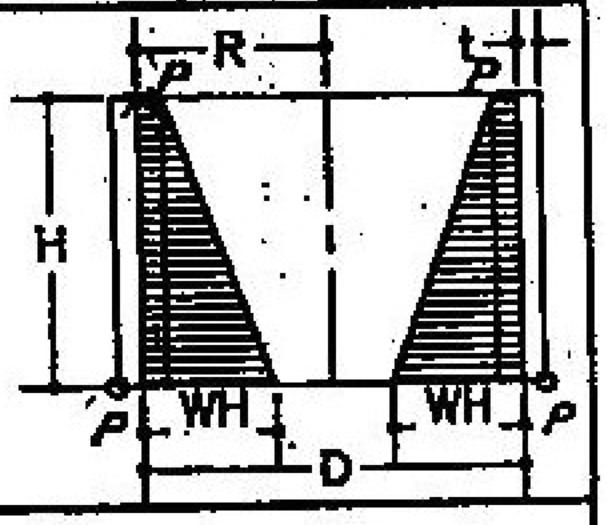
Table VIII : Moments in cylindrical wall

Trapezoidal Load

Hinged base, free top

Mom. = $C_o (\gamma H^3 + pH^2)$

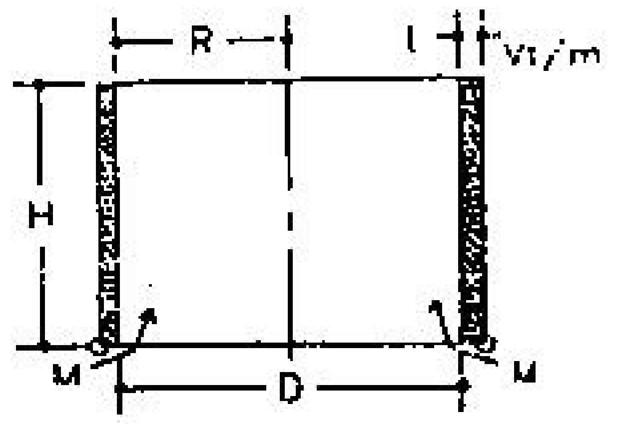
Positive sign indicates tension in the outside.



Hinged

$\frac{H^2}{Dt}$	Coefficients at point									
	0.1H	0.21H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H	1.0H
0.4	+.0020	+.0072	+.0151	+.0230	+.0301	+.0348	+.0357	+.0312	+.0197	0
0.8	+.0019	+.0064	+.0133	+.0207	+.0271	+.0319	+.0329	+.0292	+.0187	0
1.2	+.0016	+.0058	+.0111	+.0177	+.0237	+.0280	+.0296	+.0263	+.0171	0
1.6	+.0012	+.0044	+.0091	+.0145	+.0195	+.0236	+.0255	+.0232	+.0155	0
2.0	+.0009	+.0033	+.0073	+.0114	+.0158	+.0199	+.0219	+.0205	+.0145	0
3.0	+.0004	+.0018	+.0040	+.0063	+.0092	+.0127	+.0152	+.0153	+.0111	0
4.0	+.0001	+.0007	+.0016	+.0033	+.0057	+.0083	+.0109	+.0118	+.0092	0
5.0	.0000	+.0001	+.0006	+.0016	+.0034	+.0057	+.0080	+.0094	+.0078	0
6.0	.0000	.0000	+.0002	+.0008	+.0019	+.0039	+.0062	+.0078	+.0068	0
8.0	.0000	.0000	-.0002	.0000	+.0007	+.0020	+.0038	+.0057	+.0054	0
10.	.0000	.0000	-.0002	-.0001	+.0002	+.0011	+.0025	+.0043	+.0045	0
12.	.0000	.0000	-.0001	-.0002	.0000	+.0005	+.0017	+.0032	+.0039	0
14.	.0000	.0000	-.0001	-.0001	-.0001	.0000	+.0012	+.0026	+.0033	0
16.	.0000	.0000	.0000	-.0001	-.0002	-.0004	+.0008	+.0022	+.0029	0

Table XI : **Moments in cylindrical wall**
Moment Per m, M, applied at base
Hinged base, free top
Mom. = coeff. * M
Positive sign indicates tension in outside



$\frac{H^2}{Dt}$	Coefficients at point									
	0.1H	0.21H	0.3H	0.4H	0.5H	0.6H	0.7H	0.8H	0.9H	1.0H
0.4	+.013	+.051	+.109	+.196	+.296	+.414	+.547	+.692	+.843	1
0.8	+.009	+.040	+.090	+.164	+.253	+.375	+.503	+.659	+.824	1
1.2	+.006	+.027	+.063	+.125	+.206	+.316	+.454	+.616	+.802	1
1.6	+.003	+.011	+.035	+.078	+.152	+.253	+.393	+.570	+.775	1
2.0	-.002	-.002	+.012	+.034	+.096	+.193	+.340	+.519	+.748	1
3.0	-.007	-.022	-.030	-.029	+.010	+.087	+.227	+.426	+.692	1
4.0	-.008	-.026	-.044	-.051	-.034	+.023	+.150	+.354	+.645	1
5.0	-.007	-.024	-.045	-.061	-.057	-.015	+.095	+.296	+.606	1
6.0	-.005	-.018	-.040	-.058	-.065	-.037	+.057	+.252	+.572	1
8.0	-.001	-.009	-.022	-.044	-.068	-.062	+.002	+.178	+.515	1
10.	0	-.002	-.009	-.028	-.053	-0.067	-.031	+.123	+.467	1
12.	0	-.000	-.003	-.016	-.040	-.064	-.049	+.081	+.424	1
14.	0	0	0	-.008	-.029	-.059	-.060	+.048	+.387	1
16.	0	0	+.002	-.003	-.021	-.051	-.066	+.025	+.354	1

Table XII : **Shear at base of cylindrical wall** Hinged or fixed

V = coef. * { γH^2 (triangular) / [illegible] (rectangular) / M/H (mom. at base) }

Positive sign indicates shear acting inward

$\frac{H^2}{Dt}$	Triangular Load, fixed base	Rectangular Load, fixed base	Triangular or Rectangular Load, hinged base	Moment at edge
0.4	+ 0.436	+ 0.755	+ 0.245	- 1.58
0.8	+ 0.374	+ 0.552	+ 0.234	- 1.75
1.2	+ 0.339	+ 0.460	+ 0.220	- 2.00
1.6	+ 0.317	+ 0.407	+ 0.204	- 2.28
2.0	+ 0.299	+ 0.370	+ 0.189	- 2.57
3.0	+ 0.262	+ 0.310	+ 0.158	- 3.18
4.0	+ 0.236	+ 0.271	+ 0.137	- 3.68
5.0	+ 0.213	+ 0.243	+ 0.121	- 4.10
6.0	+ 0.197	+ 0.222	+ 0.110	- 4.49
8.0	+ 0.174	+ 0.193	+ 0.096	- 5.18
10	+ 0.158	+ 0.172	+ 0.087	- 5.81
12	+ 0.145	+ 0.158	+ 0.079	- 6.38
14	+ 0.135	+ 0.147	+ 0.073	- 6.88
16	+ 0.127	+ 0.137	+ 0.068	- 7.36

Fixed   Hinged

الجداول المكملة لـ (50)

Table XIII . Supplementary coeff. for values of H^2 / Dt Greater than 16 *:
(Extension of Tables I to XII)

H^2 / Dt	Coeff. at point — Table I					Coeff. at point — Table II				
	.75H	.80H	.85H	.90H	.95H	.75H	.80H	.85H	.90H	.95H
20	+0.716	+0.654	+0.520	+0.325	+0.115	+0.812	+ 0.817	+ 0.756	+0.603	+ 0.344
24	+0.746	+0.702	+0.577	+0.372	+0.137	+0.816	+ 0.839	+ 0.793	+0.647	+ 0.377
32	+0.782	+0.768	+0.663	+0.459	+0.182	+0.814	+ 0.861	+ 0.847	+0.271	+ 0.436
40	+0.800	+0.805	+ 0.731	+0.530	+0.217	+0.802	+ 0.866	+ 0.880	+0.778	+ 0.483
48	+0.791	+0.828	+ 0.785	+0.593	+0.254	+0.791	+ 0.864	+ 0.900	+0.820	+ 0.527
56	+0.763	+0.838	+ 0.824	+0.636	+0.285	+0.781	+ 0.859	+ 0.911	+0.852	+ 0.563

H^2 / Dt	Table III					Table IV				
	.75H	.80H	.85H	.90H	.95H	.75H	.80H	.85H	.90H	.95H
20	+0.949	+0.825	+0629	+0.379	+0128	+1.062	+1.017	+0.906	+0.703	+ 0.394
24	+0.986	+0.879	+0.694	+0.430	+0.149	+1.066	+1.039	+0.943	+0.747	+ 0.427
32	+1.026	+0.953	+0.788	+0.519	+0.189	+1.064	+1.061	+0.997	+0.821	+ 0.486
40	+1.040	+0.996	+ 0.859	+0.591	+0.226	+1.052	+1.066	+1.030	+0.878	+ 0.533
48	+1.043	+1.022	+ 0.911	+0.652	+0.262	+1.041	+1.064	+1.050	+0.920	+ 0.577
56	+1.040	+1.035	+ 0.949	+0.705	+0.294	+1.021	+ 1.059	+ 1.061	+0.952	+ 0.613

H^2 / Dt	Table V					Table VI				
	.00H	.05H	.10H	.15H	.20H	.75H	.80H	.85H	.90H	.95H
20	-16.44	- 9.98	- 4.90	- 1.59	+0.22	+15.30	+25.9	+36.9	+43.3	+ 35.3
24	-18.04	-10.34	- 4.54	- 1.00	+0.68	+13.20	+25.9	+40.7	+51.8	+ 45.3
32	-20.84	-10.72	- 3.70	- 0.04	+1.26	+ 8.10	+23.2	+45.9	+65.4	+ 63.6
40	-23.34	-10.86	- 2.86	+0.72	+1.56	+ 3.28	+19.2	+46.5	+77.9	+83.5
48	- 25.52	-10.82	- 2.06	+1.26	+1.86	- 0.70	+14.1	+45.1	+87.2	+103.0
56	- 27.54	-10.68	- 1.36	+1.60	+1.62	- 3.40	+9.2	+42.2	+94.0	+121.0

H^2 / Dt	Table VII					Table VIII				
	.80H	.85H	.90H	.95H	1.00H	.75H	.80H	.85H	.90H	.95H
20	+.0015	+.0014	+.0005	-.0018	-.0063	+.0008	+ .0014	+ .0020	+.0024	+ .0020
24	+.0012	+.0012	+.0007	-.0013	-.0053	+.0005	+ .0010	+ .0015	+.0020	+ .0017
32	+.0007	+.0009	+ .0007	-.0008	-.0040	.0000	+ .0005	+ .0009	+.0014	+ .0013
40	[illegible]	+.0005	+.0006	-.0005	- .0032	.0000	+.0003	+ .0006	+.0011	+ .0011
48	.0000	+.0001	+ .0006	-.0003	- .0026	.0000	+ .0001	+ .0004	+.0008	+ .0010
56	.0000	.0000	+ .0004	-.0001	- .0023	.0000	.0000	+ .0003	+.0007	+ .0008

H^2 / Dt	Table IX					Table X				
	.80H	.85H	.90H	.95H	1.00H	.05H	.10H	.15H	.20H	.25H
20	+.0015	+.0013	+.0002	-.0024	- .0073	+0.032	+0.039	+0.033	+0.023	± 0.014
24	+.0012	+.0012	+.0004	-.0018	-.0061	+0.031	+0.035	+0.028	+0.018	+ 0.009
32	+.0008	+.0009	+.0006	-.0010	-.0046	+0.028	+0.029	+0.020	+0.011	+ 0.004
40	+.0005	+.0007	+.0007	-.0005	- .0037	+0.026	+0.025	+0.015	+0.006	+ 0.001
48	+.0004	+.0006	+.0006	-.0003	- .0031	+0.024	+0.021	+0.011	+0.003	0.000
56	+.0002	+.0004	+.0005	-.0001	- .0026	+0.023	+0.018	+0.002	+0.002	0.000

H^2 / Dt	Table XI					Table XII			
	.80H	.85H	.90H	.95H	1.00H	Tri. Fixed	Rect. Fixed	T. or R. Hinged	Mom. at Edge
20	- 0.015	+0.095	+0.296	+0.606	+1.000	+0.114	+ 0.122	+ 0.062	- 9.20
24	- 0.037	+0.057	+0.250	+0.572	+1.000	+0.102	+ 0.112	+ 0.055	- 9.94
32	- 0.062	+0.002	+0.178	+0.515	+1.000	+0.089	+ 0.096	+ 0.048	- 10.36
40	- 0.067	-0.031	+0.123	+0.467	+1.000	+0.080	+ 0.086	+ 0.043	- 11.62
48	- 0.064	-0.049	+0.081	+0.424	+1.000	+0.072	+ 0.079	+ 0.039	- 12.76
56	- 0.059	-0.060	+ 0.048	+0.387	+1.000	+0.067	+ 0.074	+ 0.036	- 13.76

* For points not shown in the supplementary tables, ring tension & moment may be determined approximately by sketching curves similar to those in the text.

الفرقة الرابعة مدنى

Reinforced Concrete Water tanks

Analysis of Base for fixed Tanks

حل القاعدة للخزانات لـ fixed
يعتمد على نوع التربة

1 On rocky soil

صخر

$B/C \geq 3\ kg/cm^2$

لا يحدث تشكل للقاعدة ولا يتولد عليها عزوم من رد فعل التربة.

⇓

لكن عزوم المحيط (M_P) ترتد على القاعدة لمسافة معينة (l) ثم تموت.

2 On medium soil

⇓

Compressible soil

Example:

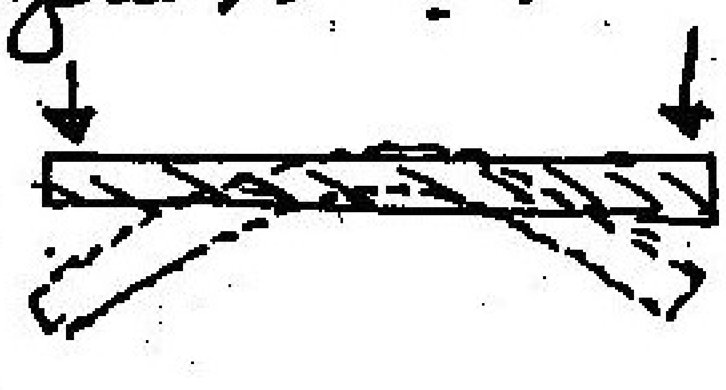
- Sand
- clay
- sandy clay

⇓

يحدث تشكل للقاعدة deformation
يتولد عليها عزوم

⇓

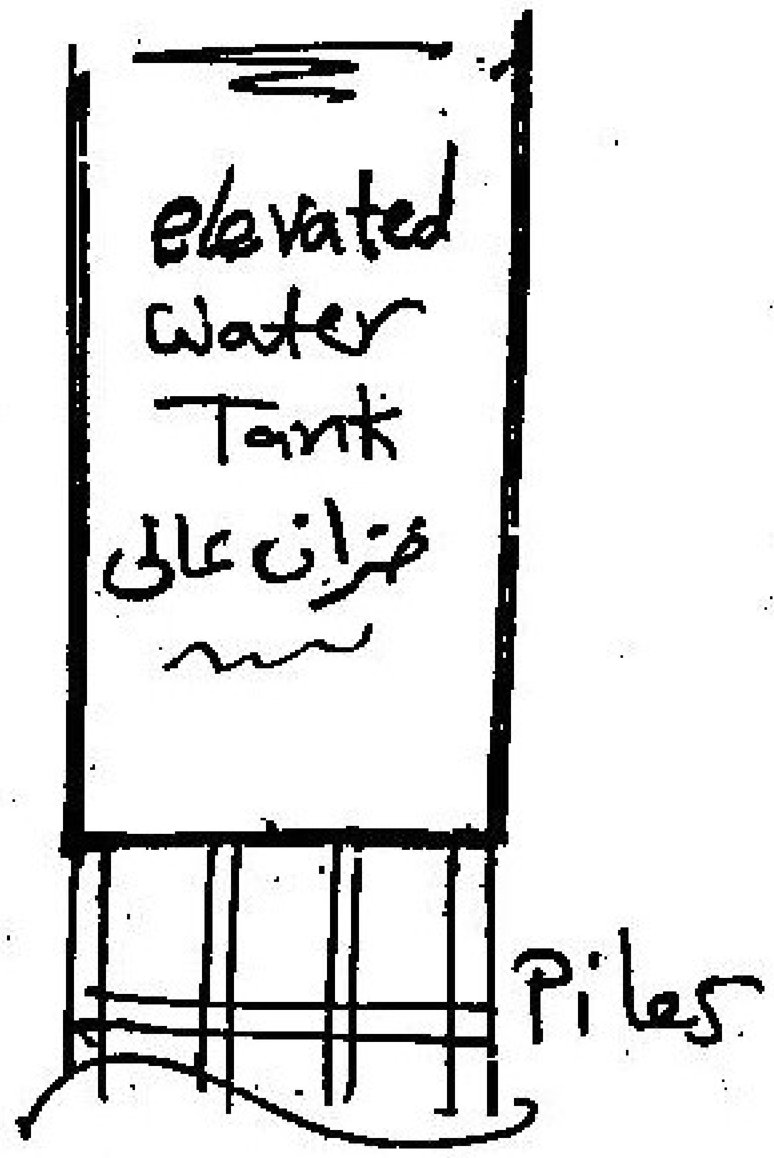
يجب دراستها.



3 On weak soil

التربة ضعيفة جداً يجب استخدام خوازيق للوصول الى منسوب تأسيس قوي.

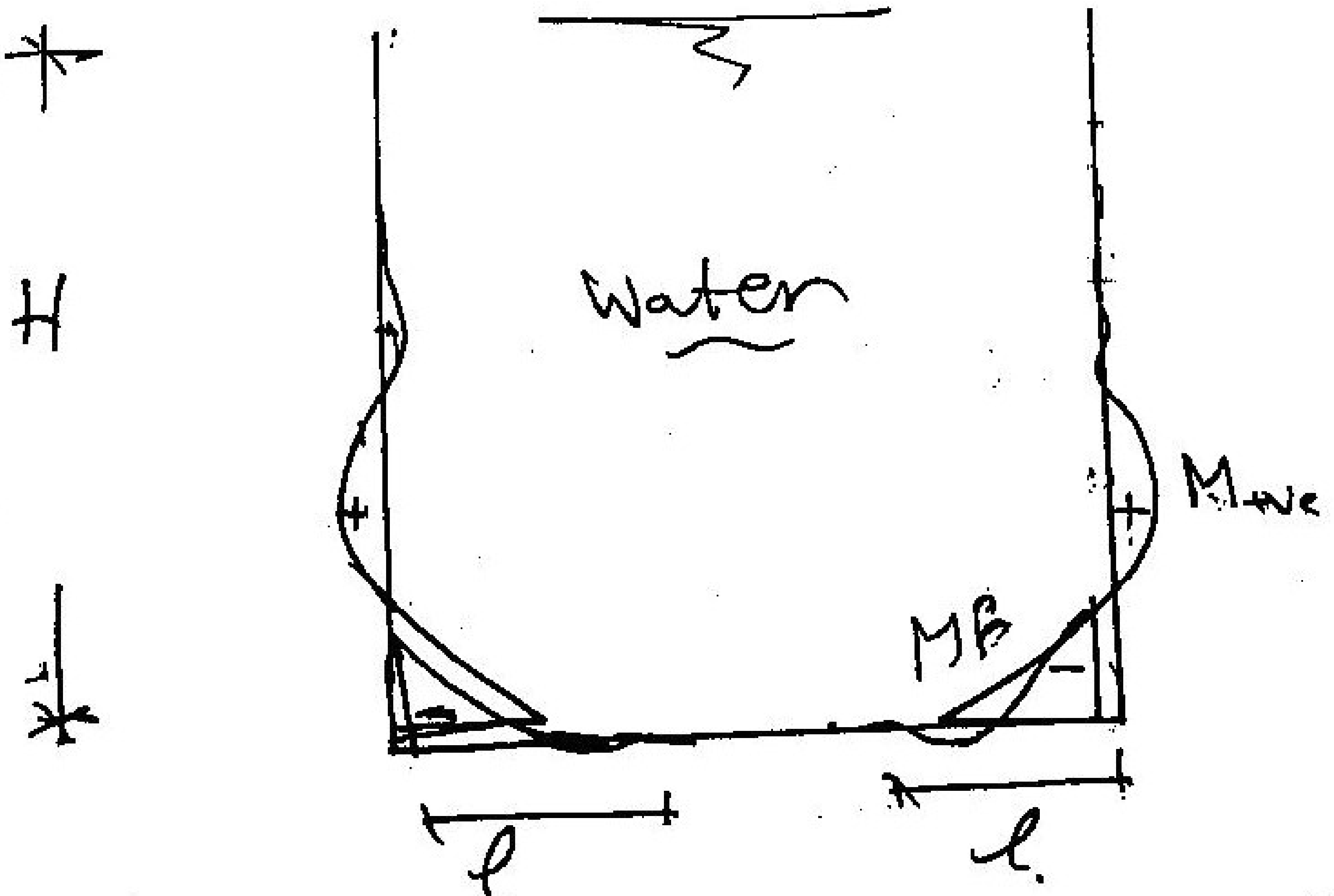
ويعامل الخزان هنا على انه elevated



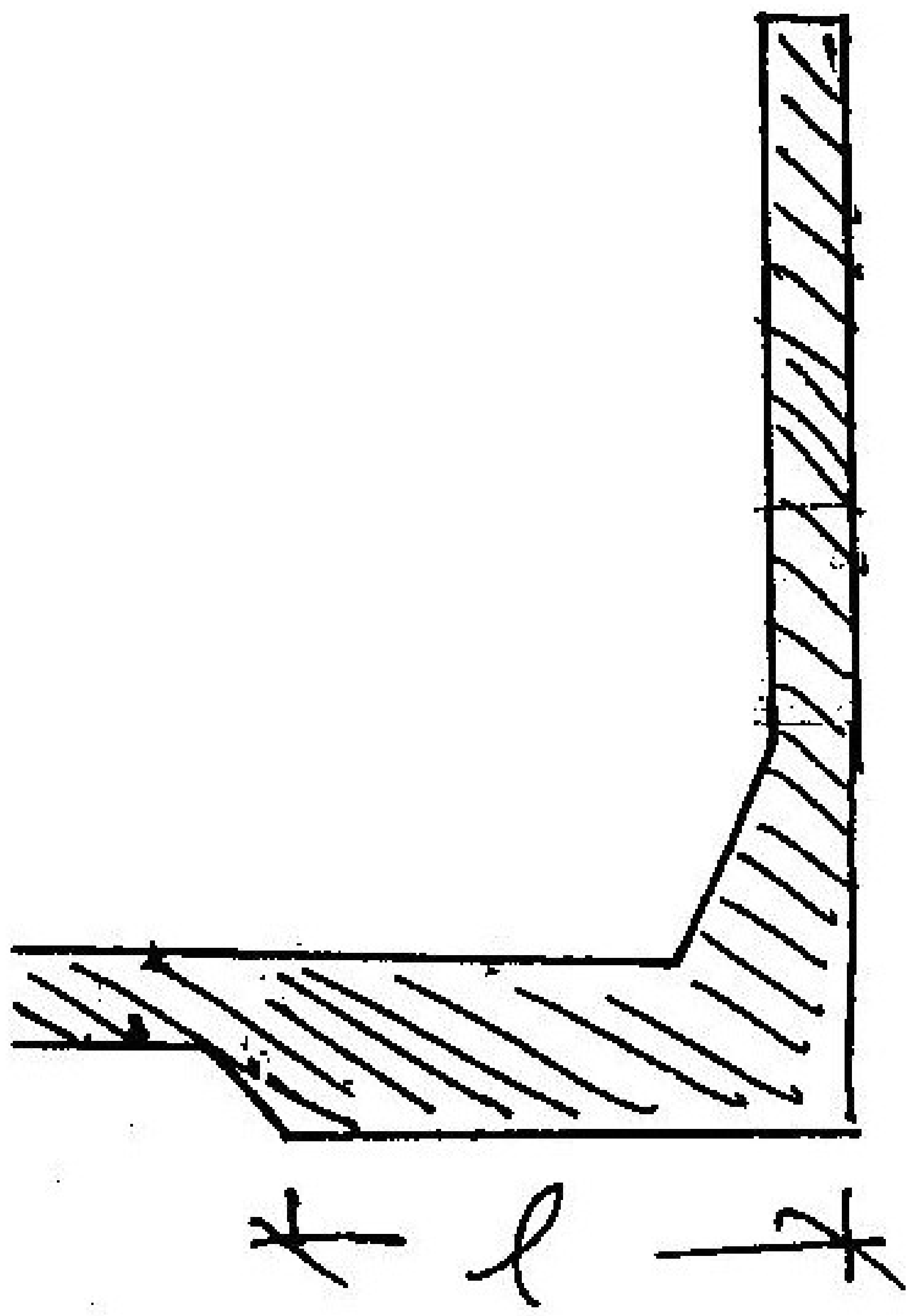
1 on Rocky Soil:

← يتم عكس عزم الحائط (Mf) على القاعدة لمسافة (ℓ) ثم يموت

← كما يتم عكس (V) ليعمل شد في القاعدة.



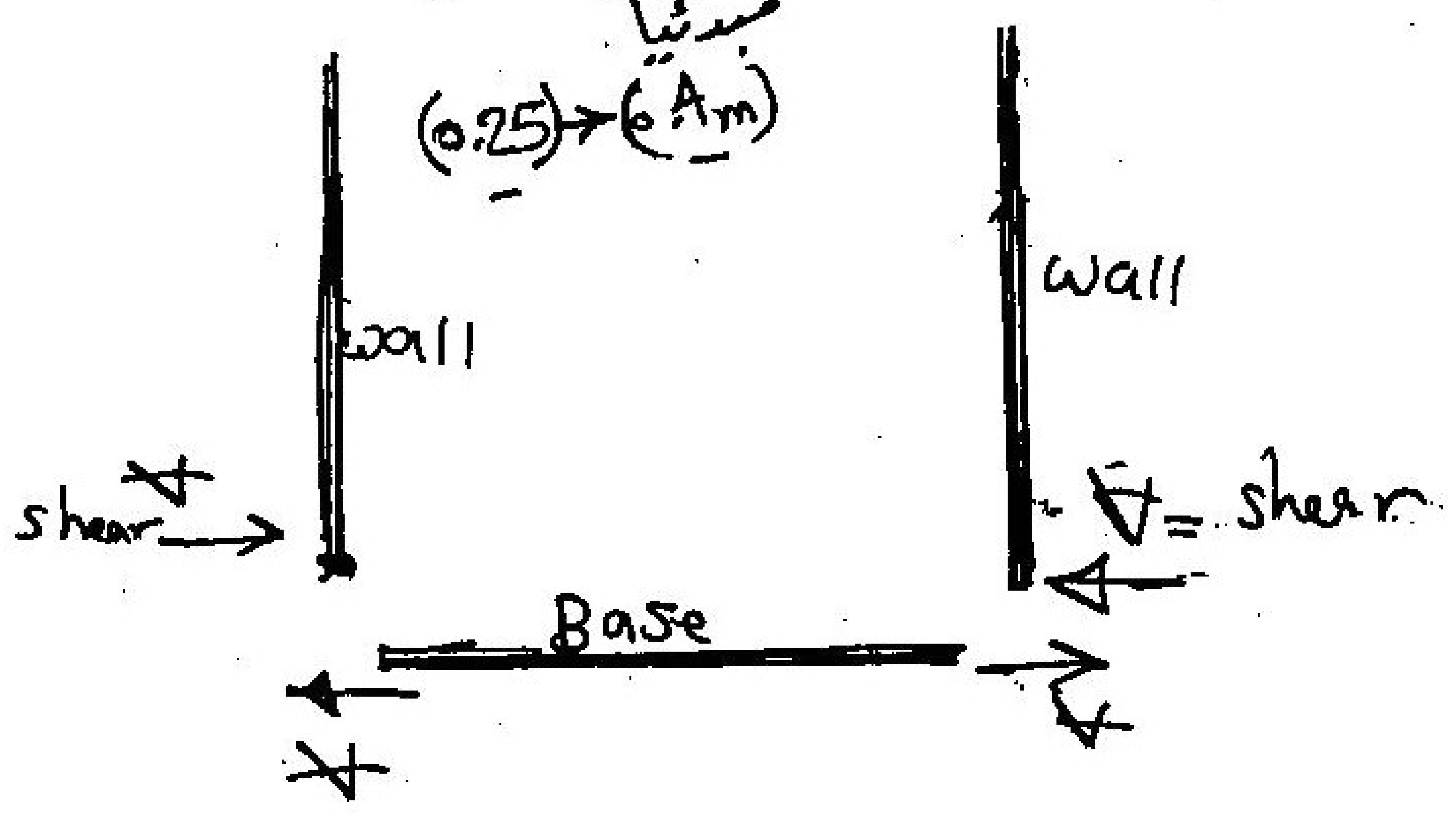
حيث: $\ell_{(m)} = 2\sqrt{\dfrac{M_f}{\omega}}$



ω = وزن القاعدة + وزن المياه

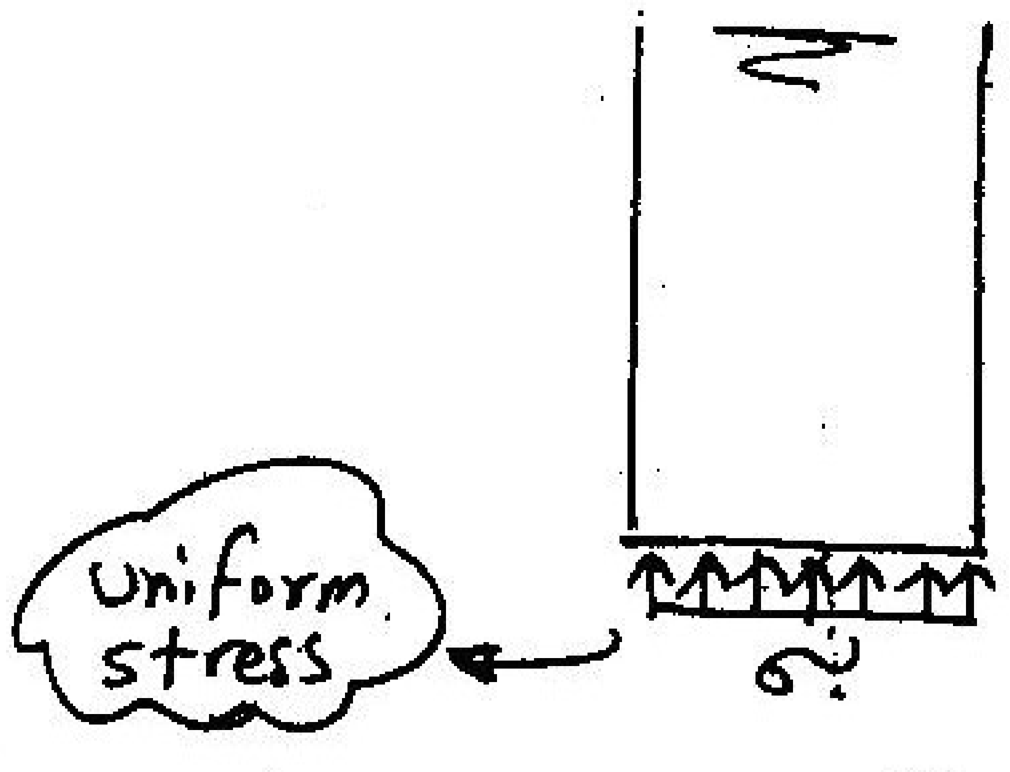
$= (\gamma \cdot H) + (t_{base} \cdot \gamma_{R.C}) = ✓\ t/m^2$

↑ 1   ↑ m   ↑ تفرض مبدئيا (0.25) → (0.4 m)



② On Medium soil:

$\frac{D}{H} \leq 1.5$



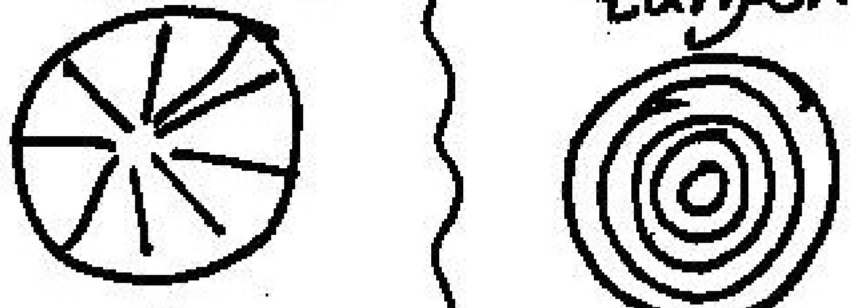
ناخذ القاعدة كلها ونحلها plate

steps:

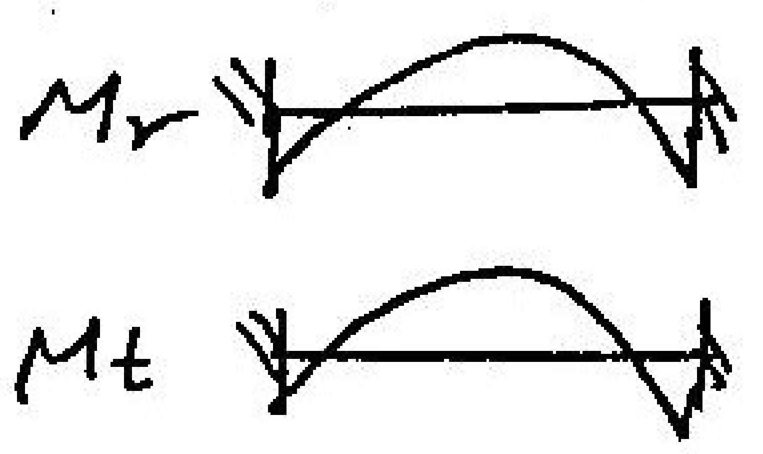
① get $q \;\&\;$ B/c

② Draw B.M.D for Base

Mr radial — Mt tangential



Mr حديد — Mt حديد

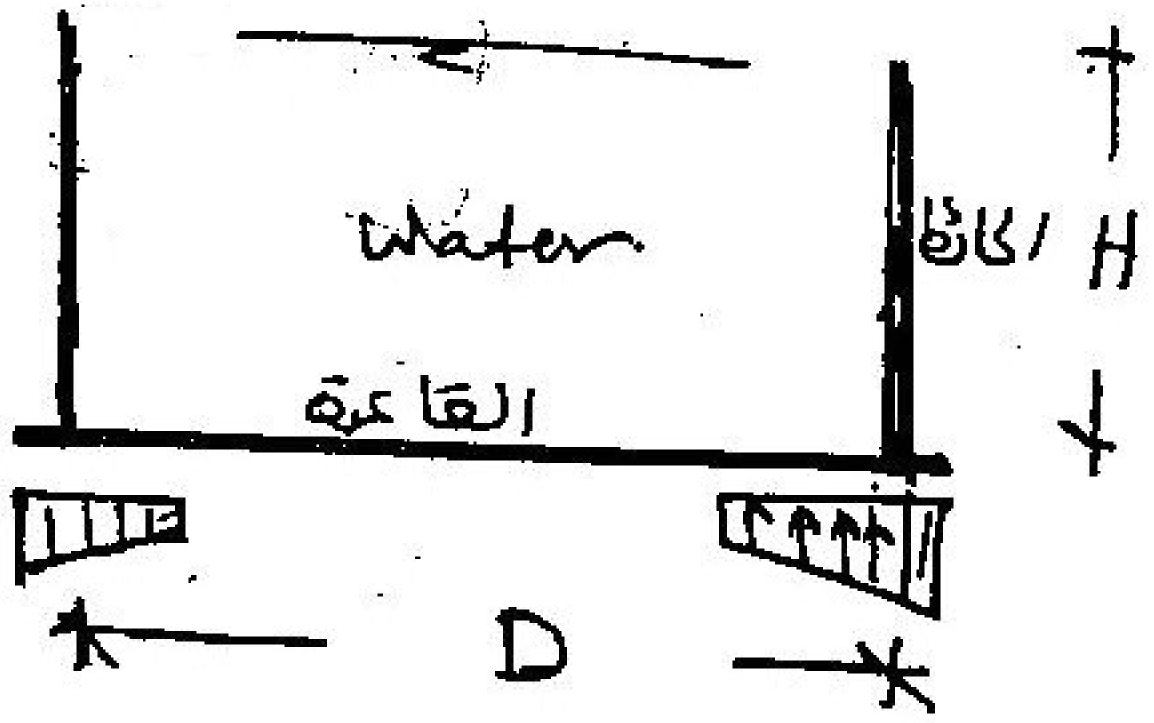


P.(3-24)

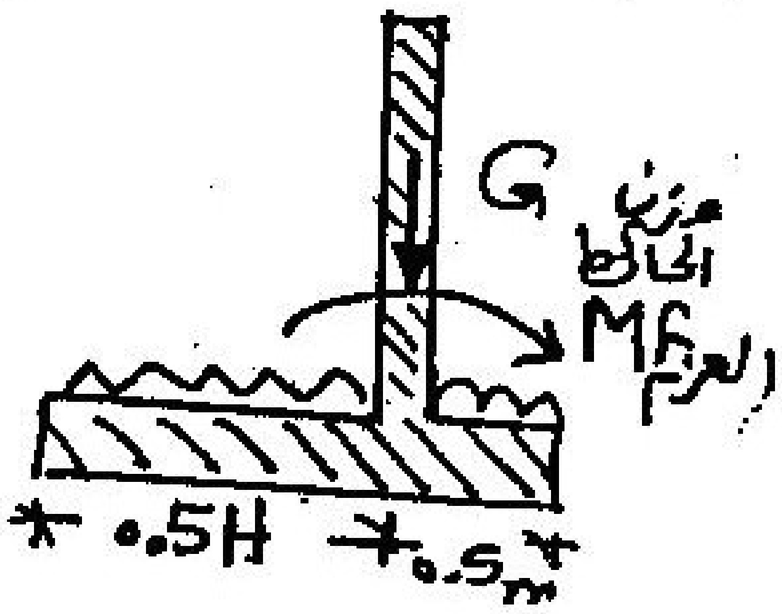
③ Make equilibrium for Base & Wall

نعمل اتزان لعزوم الحائط والقاعدة للحصول على العزم النهائي للحائط مع القاعدة (Mf) ثم نصمم عليه.

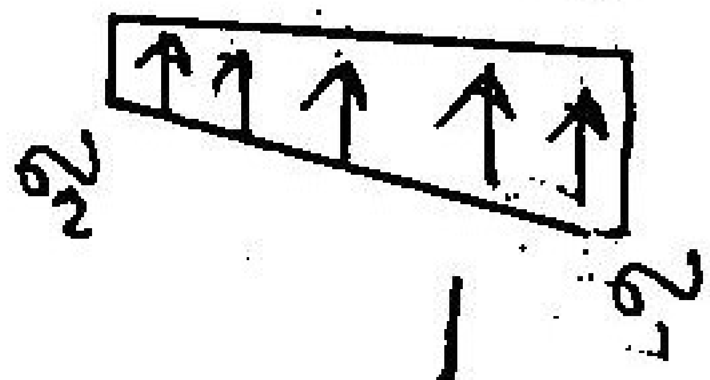
$\frac{D}{H} > 1.5$

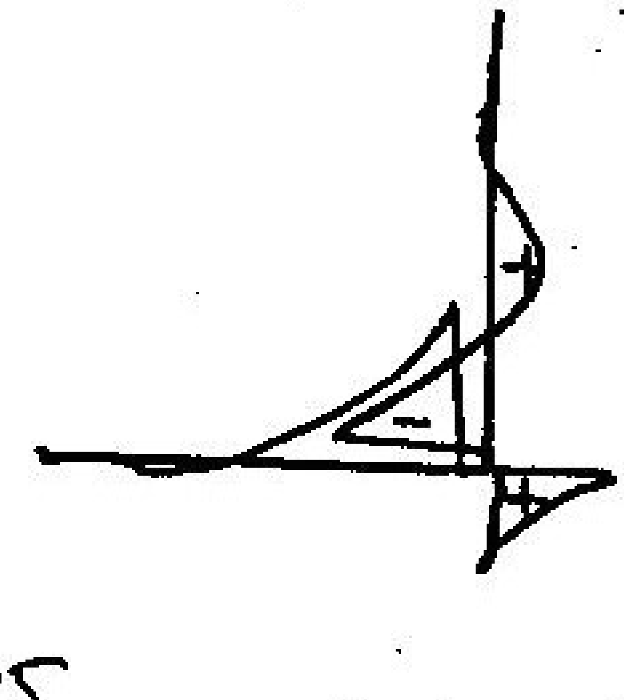


ناخذ جزء من القاعدة مع الحائط ونحلهم Wedge



stress





steps

① get $(q_1, q_2) \;\&\;$ B/c

② draw B.M.D final

③ Design sections.

④ Draw reinf. details

Example

→ Fixed Tank on Rocky soil.

→ D = 6m , H = 10 m

→ f_{cu} = 250 kg/cm² , f_y = 3600 kg/cm²

Required :

(1) Calculate straining actions for wall using simplified method and for base

(2) Complete design of sections for the Tank.

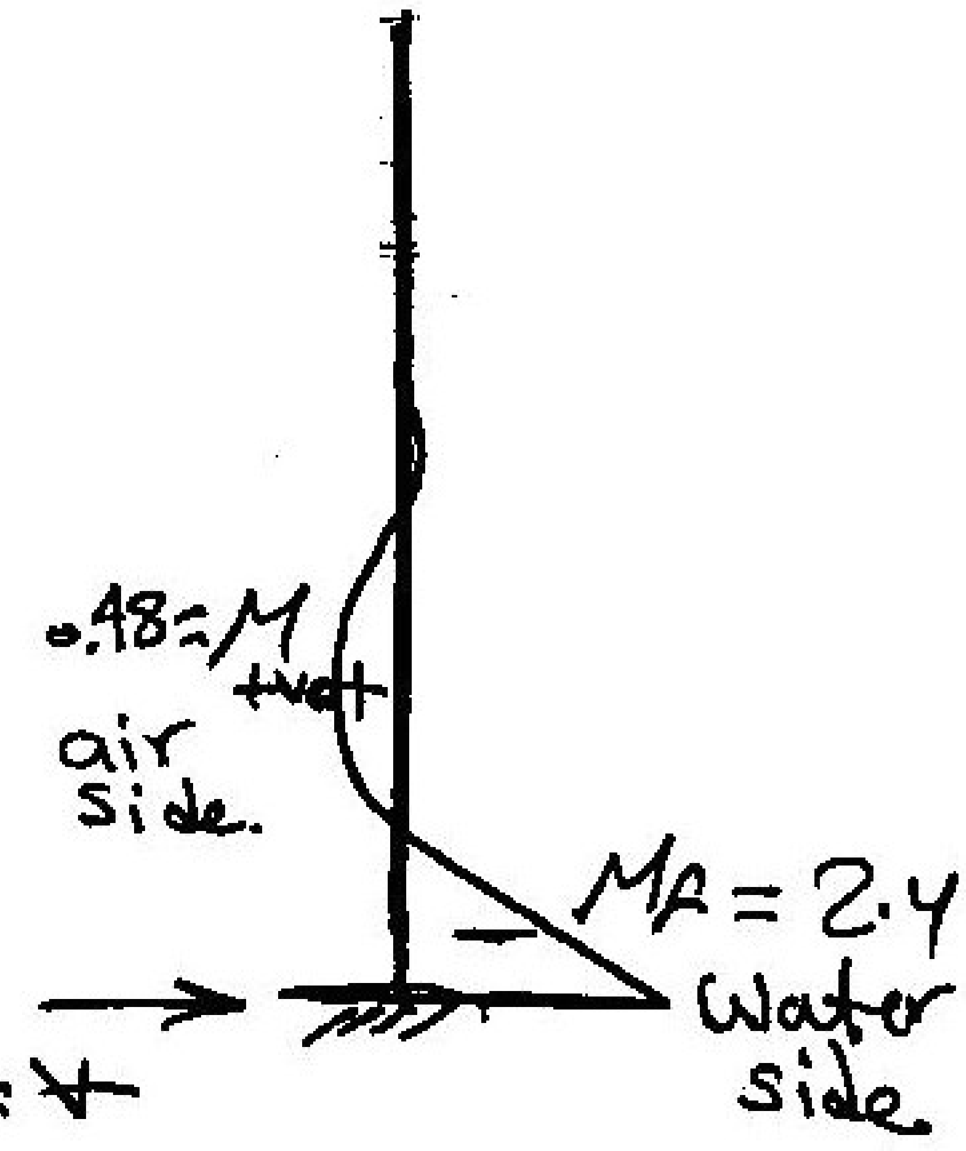
(3) Draw reinforcement details

Solution

* عزم الماء ووزنه لا يؤثر على القاعدة لأن الصخر (تربة قوية) يعمل رد فعل عليه فيلاشيه

(1) Wall → الحائط في هذه المسألة محلولة من المذكرة السابقة.

* M_f = 2.4 t.m/m
* M_{+ve} = 0.48 t.m/m
* V_{shear} = 6.625 t/m
* $T_{ring\,max}$ = 26.1 t/m



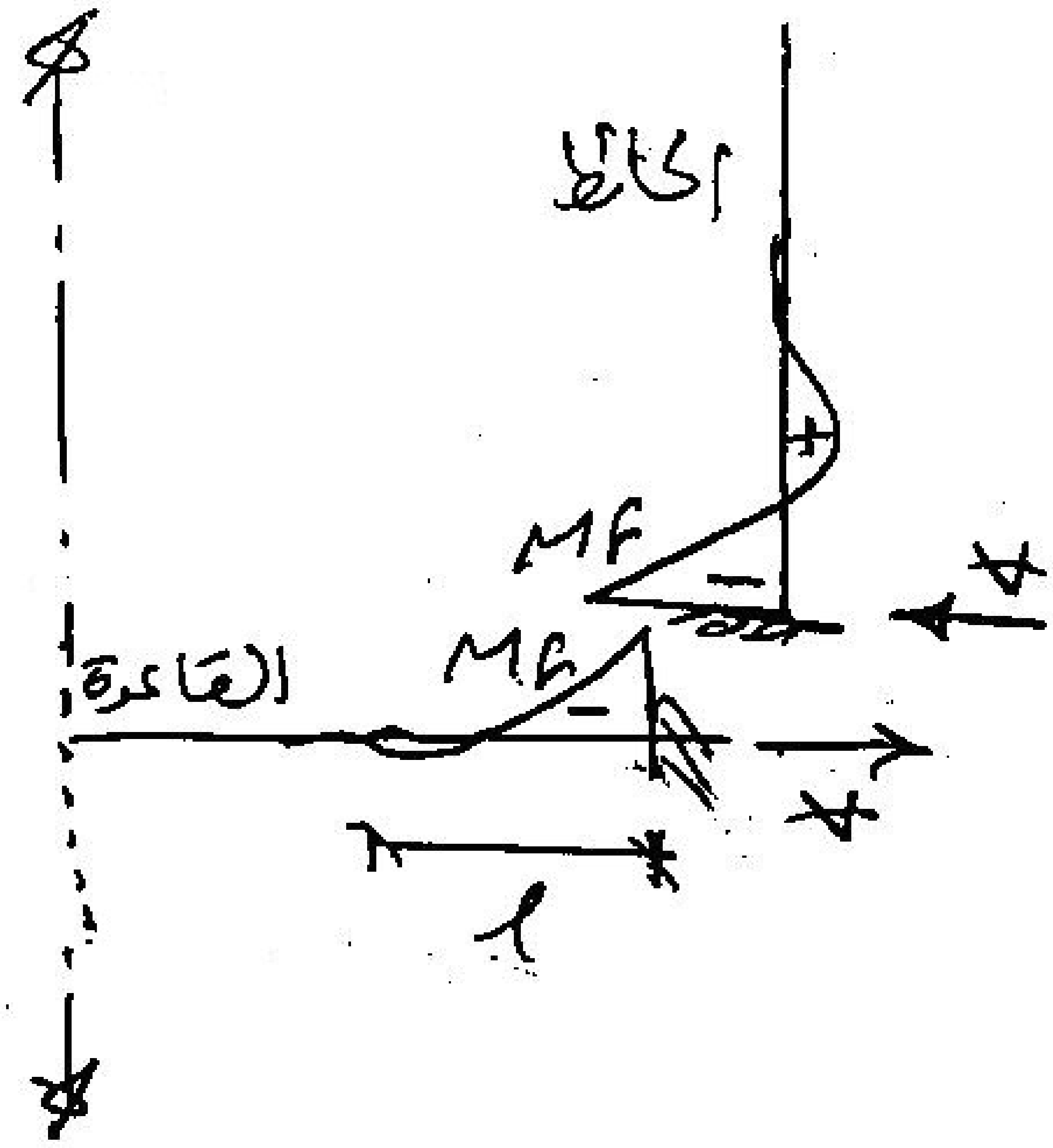
(2) (Base) : (القاعدة)

حيث أن القاعدة على تربة صخرية Rock

⇓

← عزم الحائط يرتد فقط على القاعدة لمسافة $l = 2\sqrt{\frac{M_f}{w}}$

← القوة (V) ترتد على القاعدة لتعمل شد فيها.



$$w = (t_{base} \cdot \gamma_{R.c}) + (\gamma_{water} \cdot H)$$

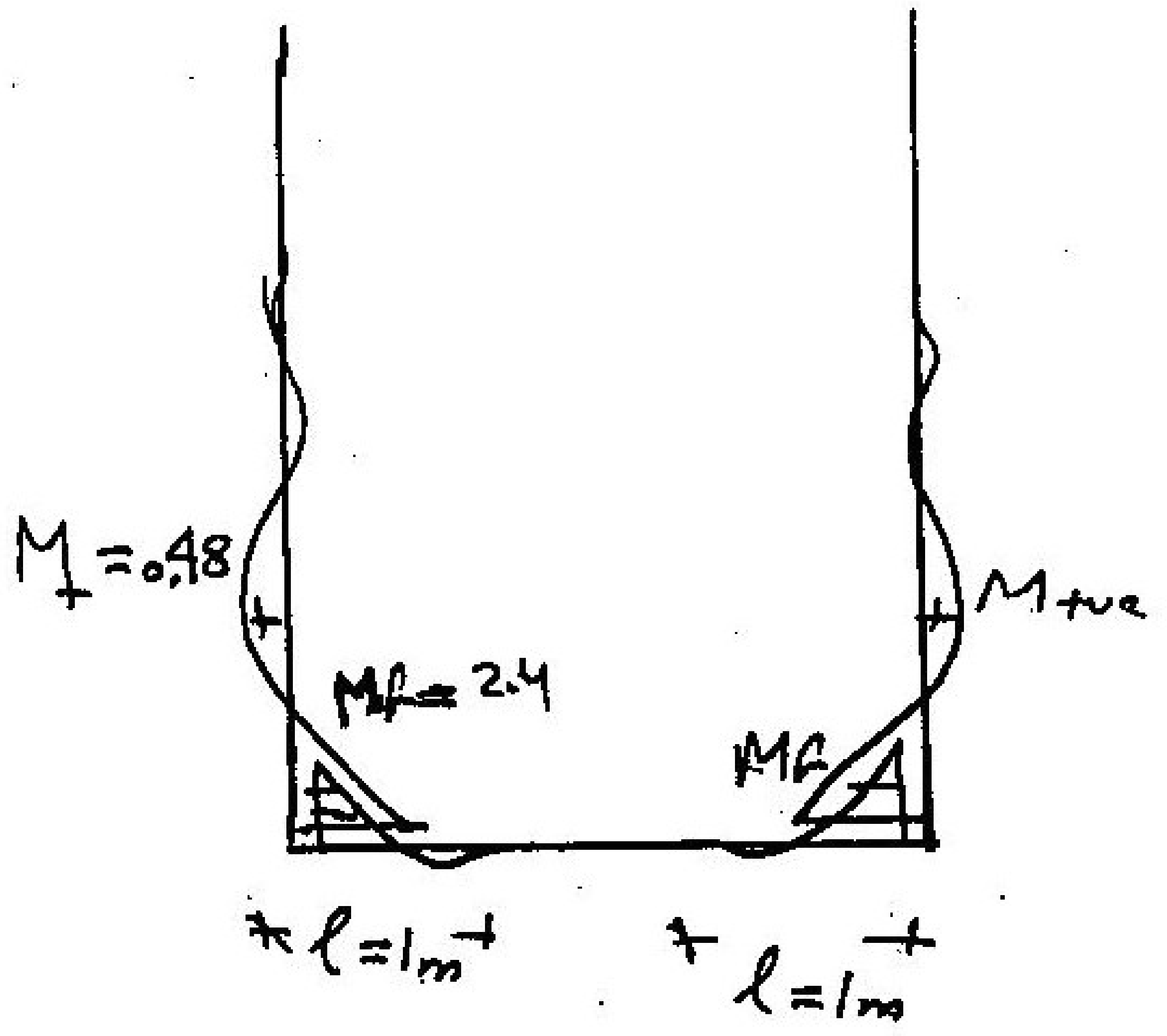
$$= (0.4 * 2.5) + (1 * 10) = 11 \ t/m^2$$

($t_{base} = 0.4$ فرض مبدئي)

$$\therefore l = 2\sqrt{\frac{M_f}{w}} = 2\sqrt{\frac{2.4}{11}} = 0.93 \ m$$

$\therefore$ use $l \simeq 1 \ m$

* Total B.M.D, N.F.D for Tank



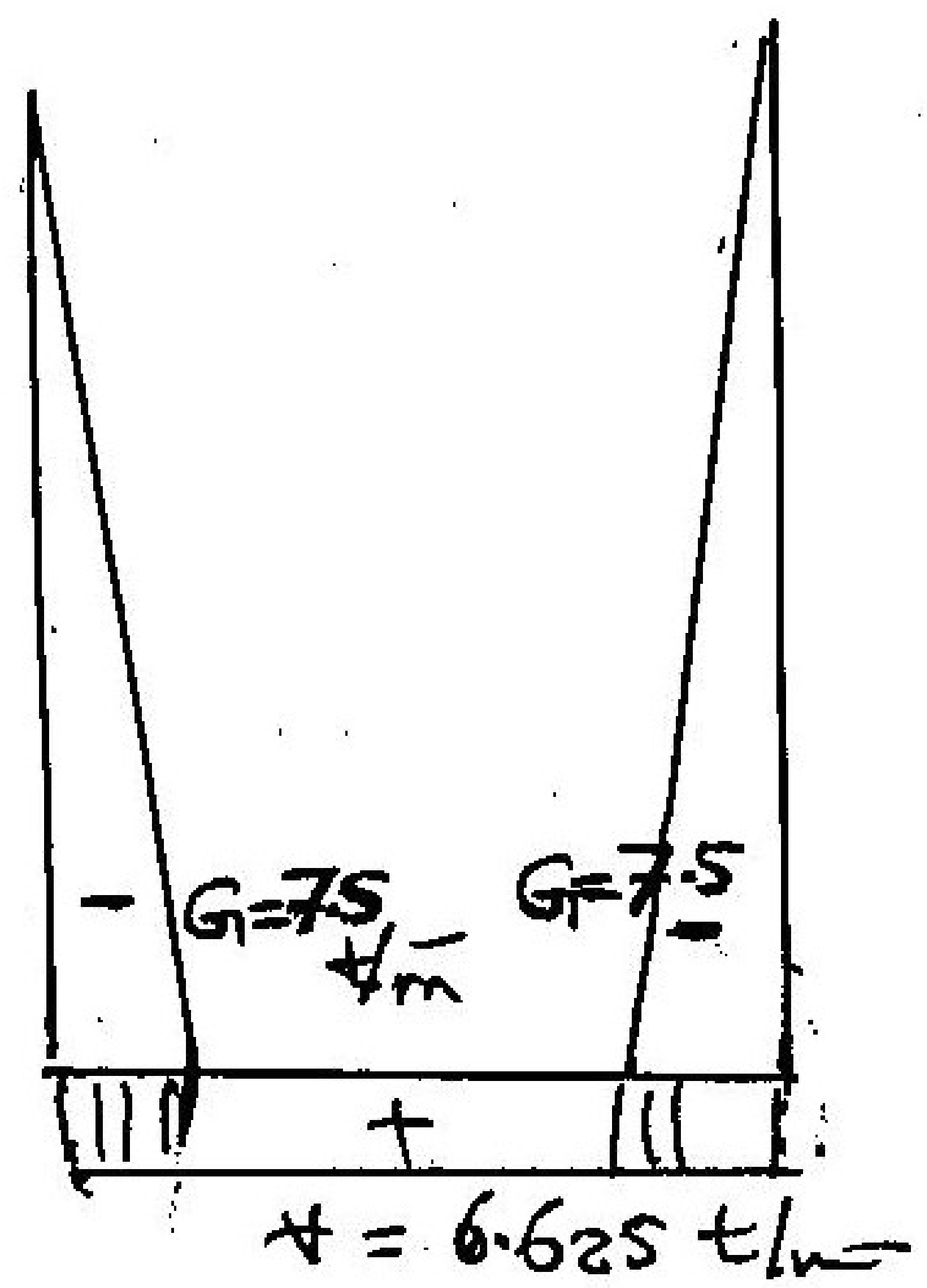
B.M.D

(G) وزن الحائط
يمثل ضغط على الحائط
يتزايد كلما نزلنا لأسفل

$$G = (t_{wall} \cdot H \cdot \gamma_{R.C})$$

$$= (0.3 * 10 * 2.5) = 7.5 \ t/m$$

simplified



N.F.D

∴ **Design of sections :**

(1) **Ring direction :** $T_{max\ ring} = 26.1\ t/m$ (from simplified)

Stage (I) $t_{wall} = \xi . T = 0.6 * 26.1 = 15.7\ cm$

∴ use $t = 20\ cm$

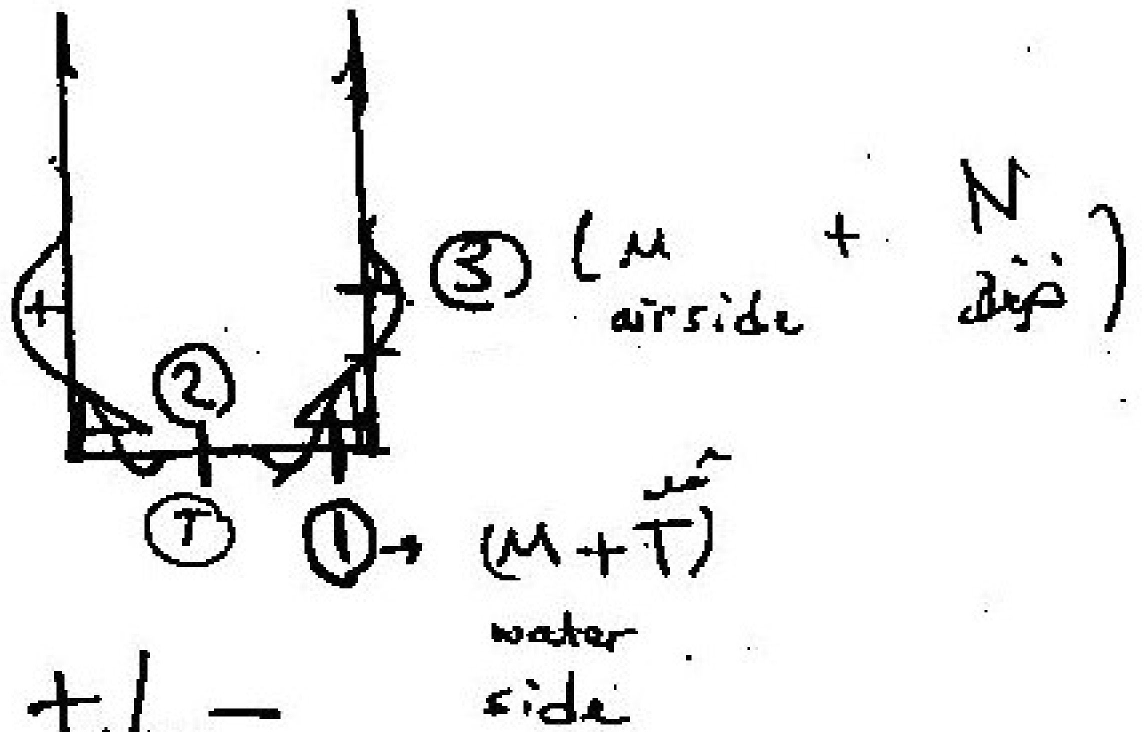
Stage (II) $A_s = \frac{T_u * 10^3}{2\ (f_y/\gamma_s)} = \frac{(1.5 * 26.1) * 10^3}{2\left(\frac{3600}{1.15}\right)} = 6.25\ cm^2/m$

ولا تعوض عن ع

$A_{s_{min}} = \frac{15}{100} . B . d$

∴ use 6 # 12/m each side

(2) **VL. direction :**



Sec (1) :

$M_{water\ side} = 2.4\ t.m$, $T = 6.625\ t/m$

Stage (I) $t = \sqrt{\frac{M * 10^5}{\psi . B}} + 5\ cm$

$= \sqrt{\frac{2.4 * 10^5}{3.2 * 100}} + 5 \simeq 35\ cm$

عرض 1م

Check : $\frac{6M * 10^5}{B . t^2} + \frac{T * 10^3}{B . t} \ngtr f_{ct}$

$\approx \frac{6 * 2.4 * 10^5}{100 * (35)^2} + \frac{6.625 * 10^3}{100 * 35} = 13.6\ kg/cm^2$

$\therefore \sigma < f_{ct} = 18\ kg/cm^2$ Safe

stage II : Ultimate $M_u = 1.5 * 2.4 = 3.6\ t.m/m'$

$T_u = 1.5 * 6.625 = 9.93\ t/m'$

$\therefore e = \frac{M_u}{T_u} = 0.36\ m$

$\therefore e/t = \frac{0.36}{0.35} = 1.03 > 0.5$

$\therefore$ Big eccentricity

$\therefore e_s = e - t/2 + 0.05$

$= 0.36 - \frac{0.35}{2} + 0.05 = 0.235\ m$

$\therefore M_{us} = T_u \cdot e_s = 9.93 * 0.235 = 2.33\ t.m/m'$

$\therefore R_1 = \frac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{2.33 * 10^5}{250 * 100 * (30)^2} = 0.01$

$d = t - 5 = 30\ cm$

$\therefore \omega = 0.015$

$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d + \frac{T_u * 10^3}{(f_y/\gamma_s)}$

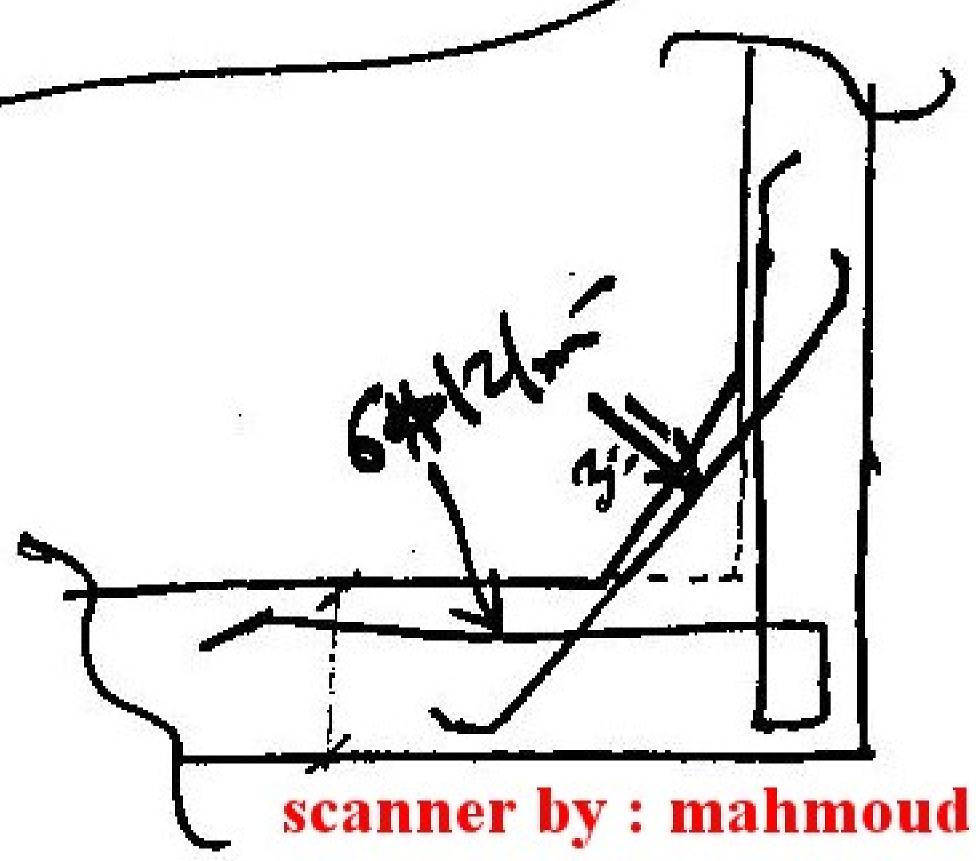
[illegible] العزم

$= \frac{0.015 * 250 * 100 * 30}{3600} + \frac{9.93 * 10^3}{(3600/1.15)} = 6.3\ cm^2/m'$

$A_{s\,min} = \frac{0.15}{100} B d$

صغيرة XX

Use $6\#12/m'$



Sec (2)   Tension only

$T = 6.625 \ t/m$

stage (I) $t = \frac{\xi}{f} \cdot T = 0.6 * 6.625 < 20 cm$

$\therefore$ use $t = 20 cm$

stage (II) $A_s = \frac{T_u * 10^3}{2(f_y/\gamma_s)} = \frac{1.5 * 6.625 * 10^3}{2\left(\frac{3600}{1.15}\right)} = 1.6 \ cm^2/m$

لكل جهة

use $5 \# 10/m$

للقاعدة سفلى وعلوى (فرش وغطاء)

Sec (3)   M air side + N compression neglect

$M = 0.48 \ t.m/m$

stage (II) ندخل مباشرة على

use $t_{wall} = 20 cm \Rightarrow$ from Design of ring direction

$\therefore d = 15 \ cm$

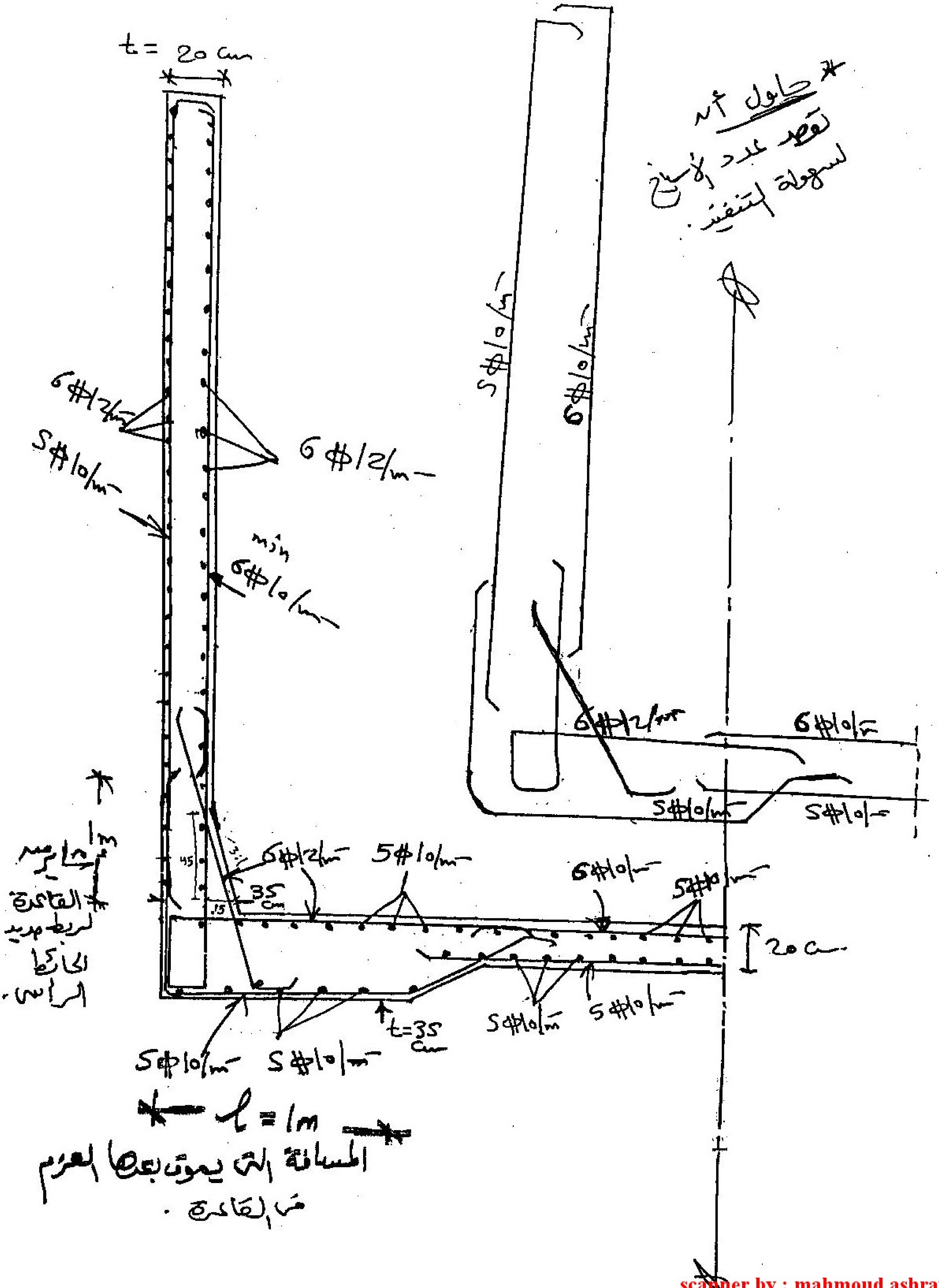
$\therefore M_u = 1.5 M = 1.5 * 0.48 = 0.72 \ t.m/m$

$\therefore R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2} =$

$\therefore \omega =$

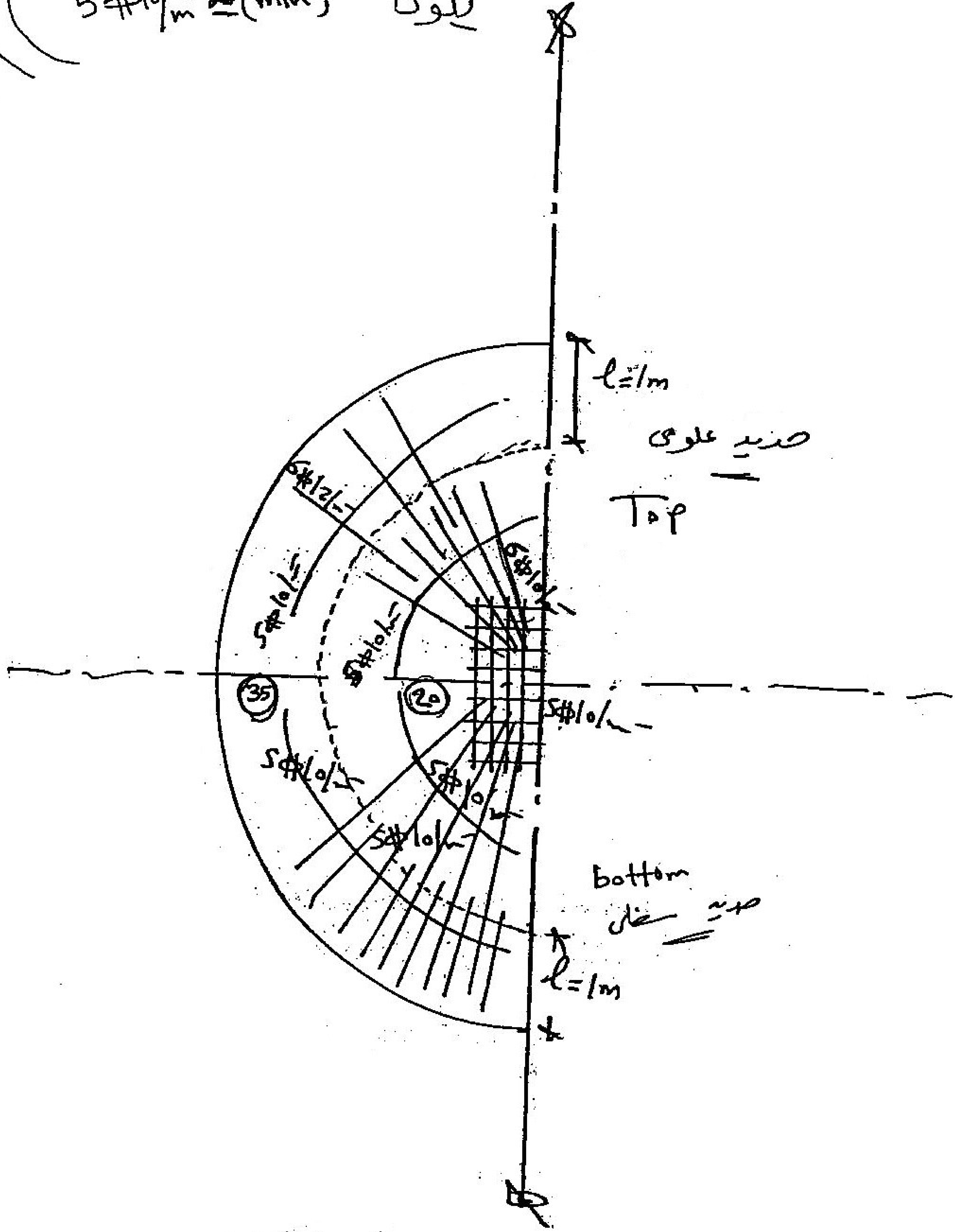
$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d = 5 \# 10/m$

ناحية العزم (خارج الخزان).



t = 20 cm
* حاول أن تقلل عدد الأسياخ لسهولة التنفيذ.
5Φ10/m
6Φ10/m
6Φ12/m
5Φ10/m
6Φ12/m
5Φ10/m
min 6Φ10/m
6Φ12/m
6Φ10/m
5Φ10/m
5Φ10/m
1m
من مستوى القاعدة لربط حديد الحائط الرأسي.
45
35 cm
6Φ12/m
5Φ10/m
6Φ10/m
5Φ10/m
20 cm
5Φ10/m
5Φ10/m
t=35 cm
5Φ10/m
5Φ10/m
l = 1m
المسافة التي يموت بعدها العزوم من القاعدة.

tangential لحديد (rocky soil) دائماً القاعدة الموجودة على
5 ∅ 10/m (min) يكون

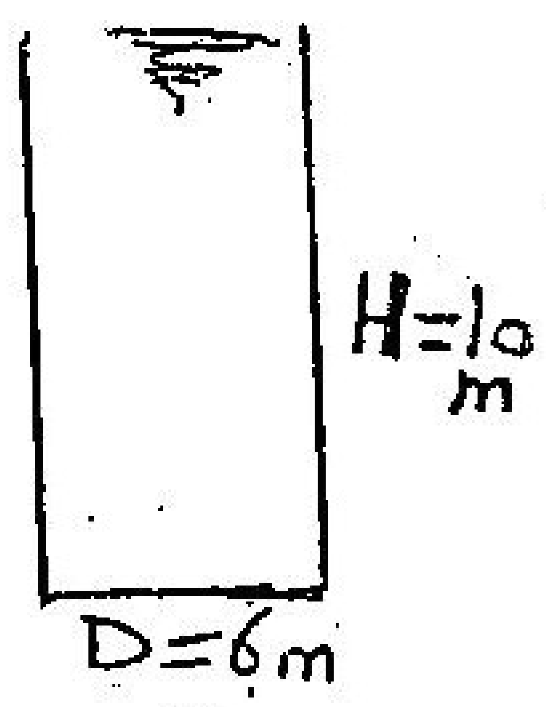


Half plan

Reinforced Concrete " Water Tanks "6"

Example: - **Fixed** Tank on **Sandy soil**

- B/c = 1.6 Kg/cm²
- H = 10m , D = 6m
- f_{cu} = 250 kg/cm²
- f_y = 3600 kg/cm²



Required (1) make complete design for wall and base.

(2) Draw reinf. **details**.

Solution:

(A) wall حل الحائط

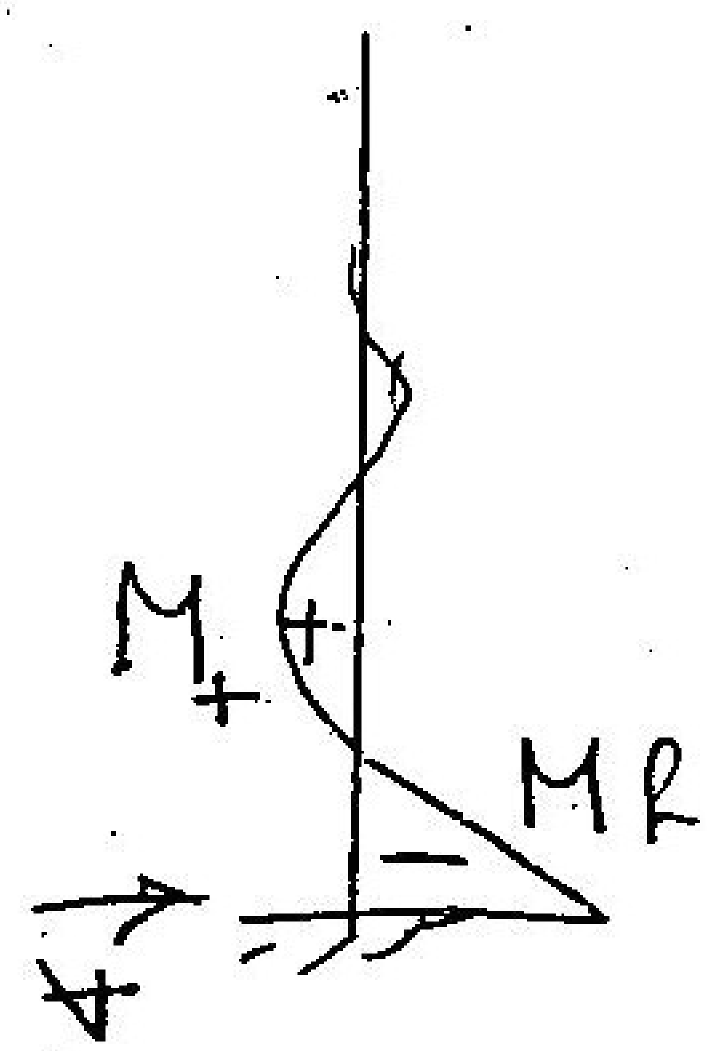
حل الحائط بحلول مستعجل باستخدام Simplified

M_f = 2.4 t.m/m

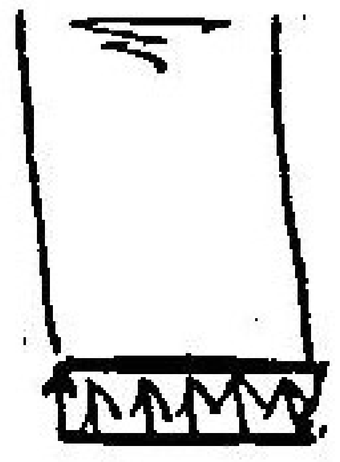
M_{+ve} = 0.48 t.m/m

V_{shear} = 6.6 t/m

$T_{max\ ring}$ = 26.1 t/m



(B) Base : حل القاعدة



$$\frac{D}{H} = \frac{6}{10} < 1.5$$

$\therefore$ نأخذ القاعدة كلها على بعضها fixed plate

(1) check stress on soil :

$$\sigma_{soil} = (\gamma_{water} \cdot h_{water}) + (t_{base} \cdot \gamma_{R.C}) + G * \left(\frac{2\pi R}{\pi R^2}\right)$$

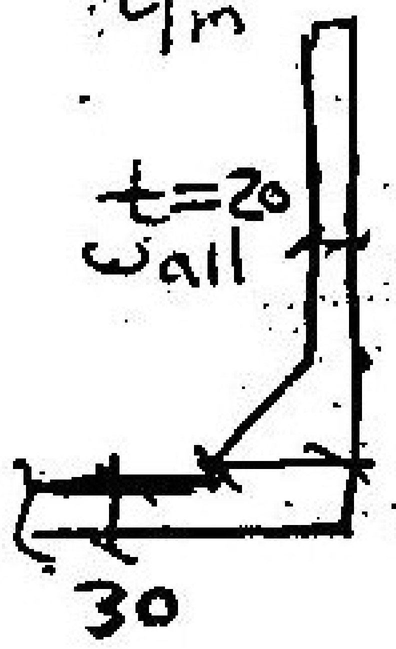
($2\pi R$: المحيط ; πR^2: المساحة للقاعدة)

$$G = t_{wall} \cdot h_{wall} \cdot \gamma_{R.C}$$

وزن الحائط t/m'

$$= 0.2 * 10 * 2.5 = 5 \, t/m'$$

(0.2: فرض مبدئي)



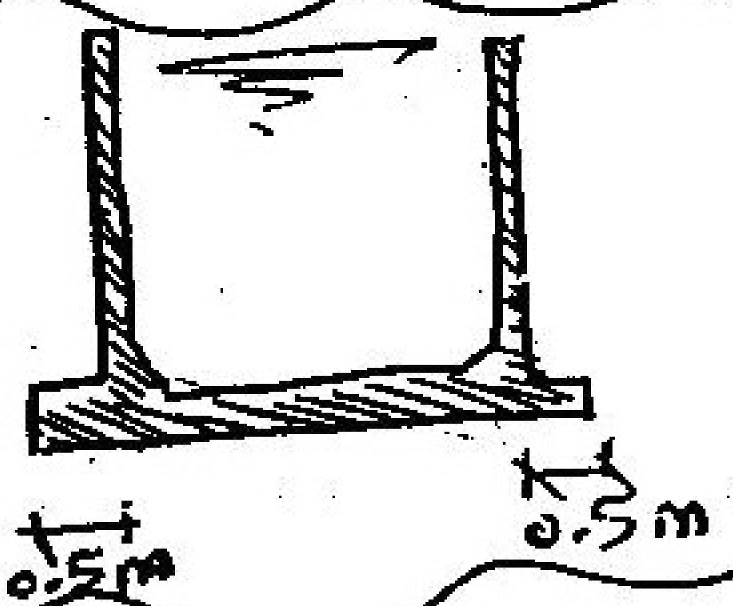
$$\therefore \sigma_{soil} = (1 * 10) + (0.3 * 2.5) + 5\left(\frac{2}{3}\right)$$

$$= 14 \; t/m^2$$

$$\therefore B/c = 1.6 \; Kg/cm^2 = 16 \; t/m^2$$

$$\therefore \sigma_{soil} < B/c \Rightarrow \text{Safe.}$$

* If Not Safe → نعمل رفرفة لزيادة مساحة القاعدة.



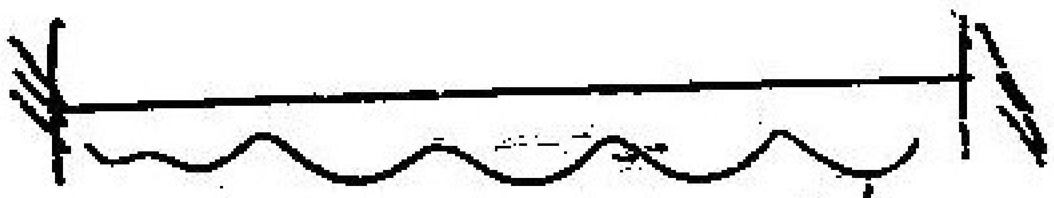
(2) Moments at base:

نحسب الحمل الصافي الذي يعمل moment

وهو الناتج من رد الفعل الناتج من الحوائط فقط

$$\omega_{net} = G * \frac{2\pi R}{\pi R^2} = \left(G * \frac{2}{R}\right)$$

$$= \left(5 * \frac{2}{3}\right) = 3.33 \ t/m^2$$



$\omega_{net} = 3.33 \ t/m^2$

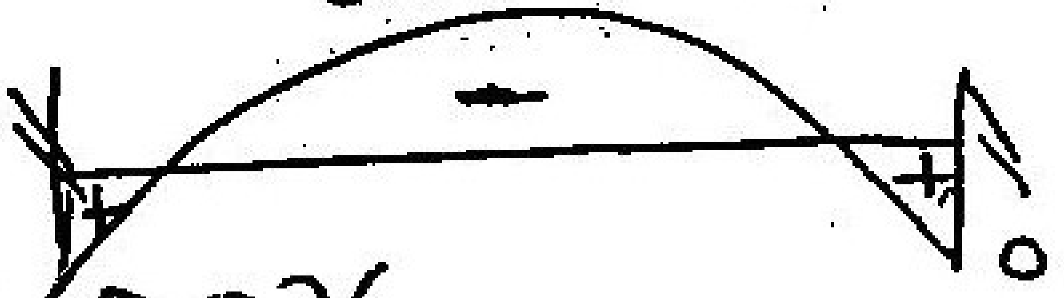
$\Rightarrow P = \omega_{net} * Area = 3.33 * \pi * (3)^2$

$= 94.15$ ton

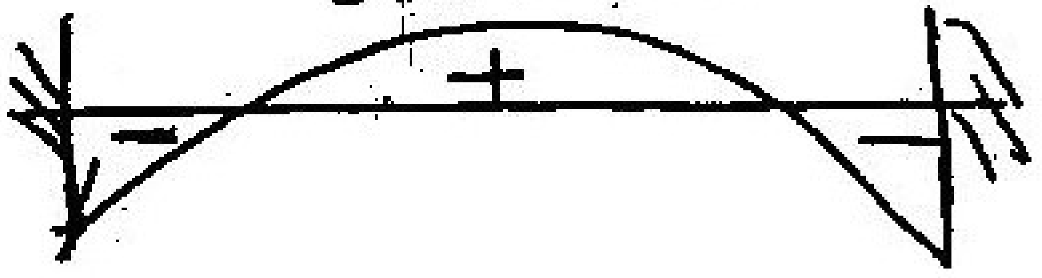
(P: تركيز الحمل)

P. (3-24)

M_{radial}

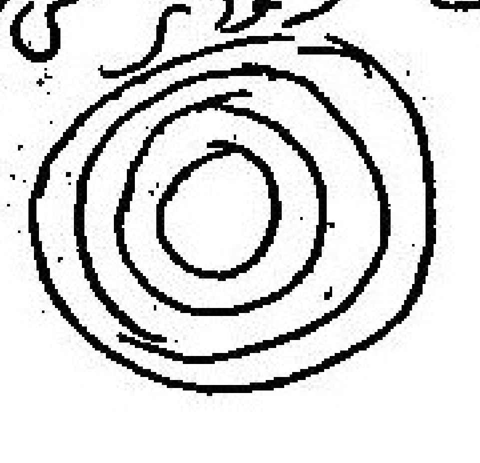


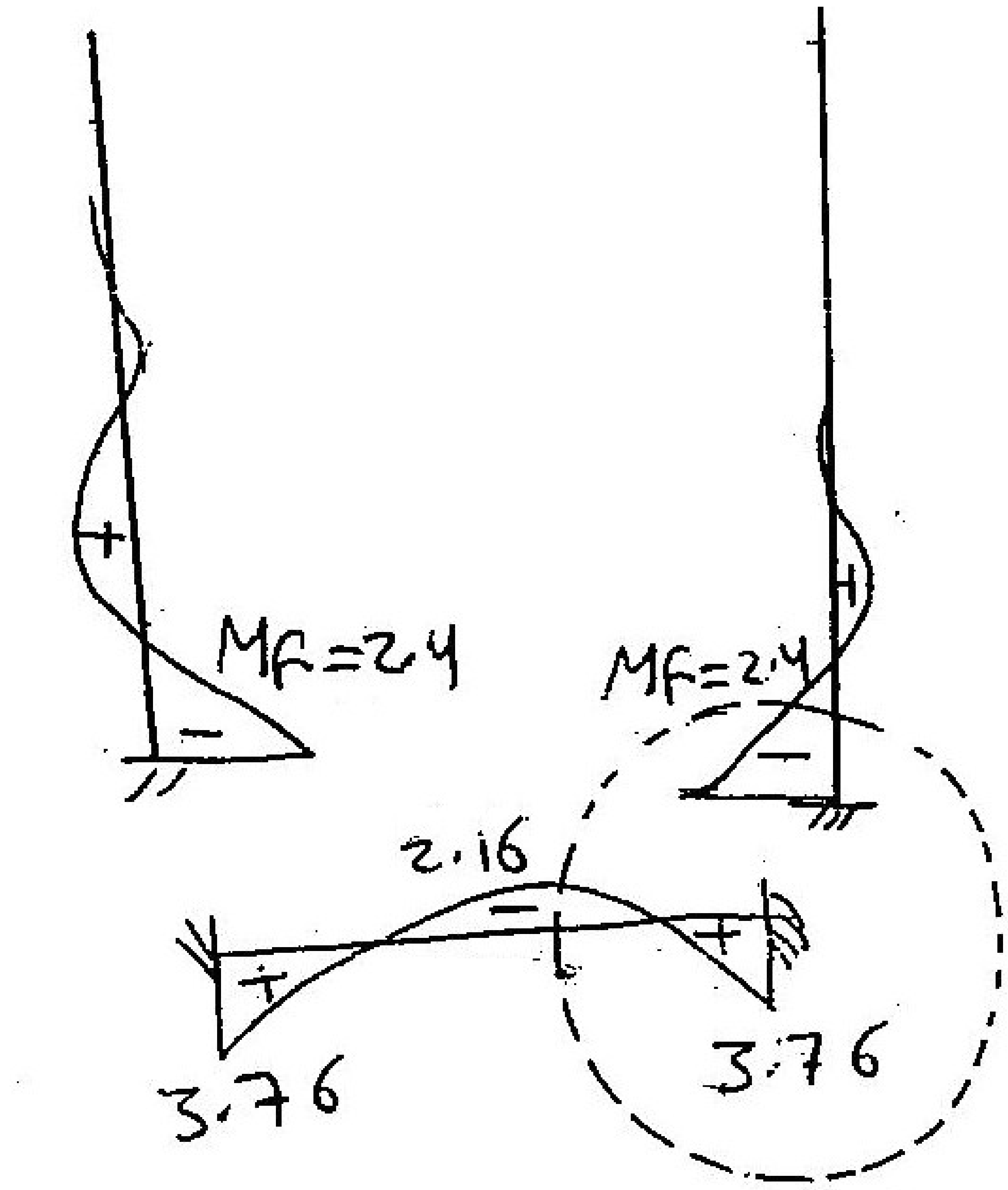
$M_{tangential}$



- المفروض العزم M_{radial} يتزن مع العزم (M_f) للبلاطة

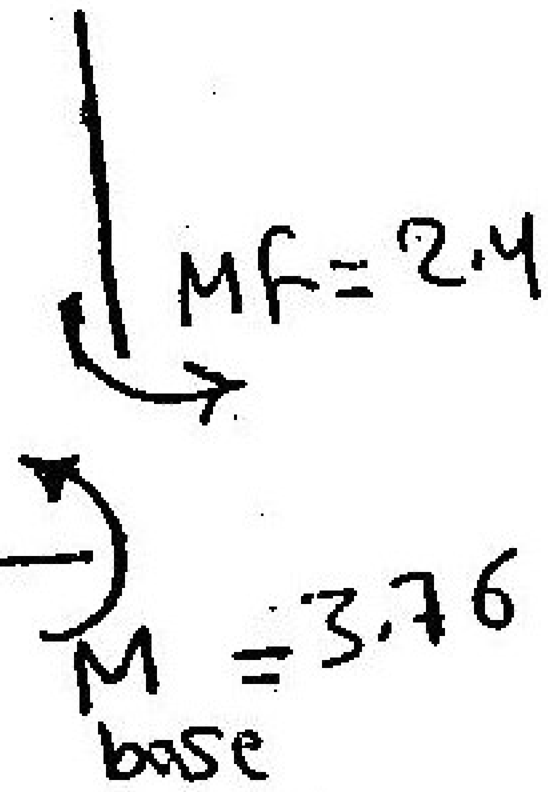
- والعزم $M_{tangential}$ يحتاج حديد على هيئة دوائر في القاعدة





لابد أن نعمل اتزان للحائط مع القاعدة باستخدام Moment distribution

انظر الصفحة المرفقة.



$$K_{wall} = C_o \cdot \frac{E \cdot t^3}{H} = \frac{2.4 * E * (0.2)^3}{10} = 1.92 * 10^{-3} E$$

P(3-19)

$(H^2/D.t)$	------	83
C_o	------	2.4

$$K_{base} = \frac{0.104 * E \cdot t_{base}^3}{R} = \frac{0.104 * E * 0.3^3}{3} = 9.36 * 10^{-4} E$$

P(3-19)

$$D.F_{wall} = \frac{K_{wall}}{K_{base} + K_{wall}} = 0.67$$

$$\therefore D.F_{base} = 1 - D.F_{wall} = 0.33$$

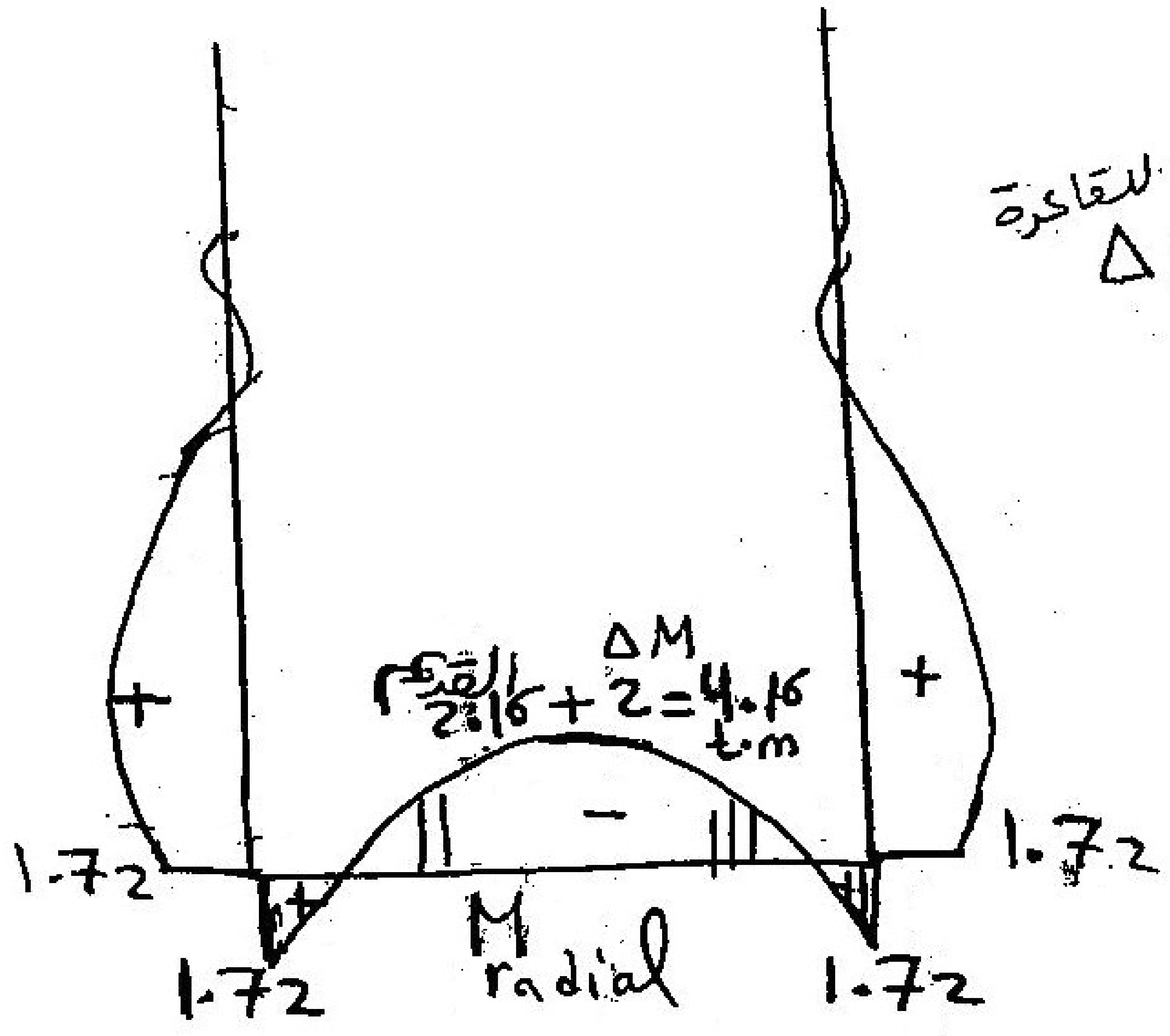
	Wall (Df = 0.67)	base (Df = 0.33)
M_{fixed} =	+2.4	+3.76
D.M =	-4.12	-2.04
Final =	-1.72	+1.72

عكس عقارب الساعة
نعتبره موجب (+)

D.M = (مجموع العزوم × D.F) بالسالب

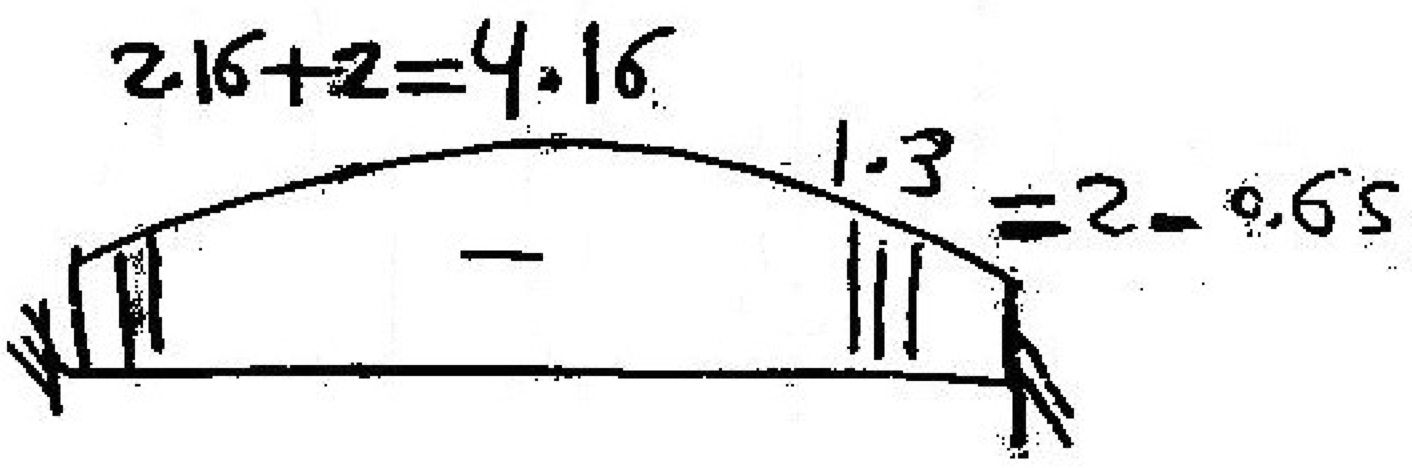
∴ D.M = (-6.16 × D.F)

Final B.M.D

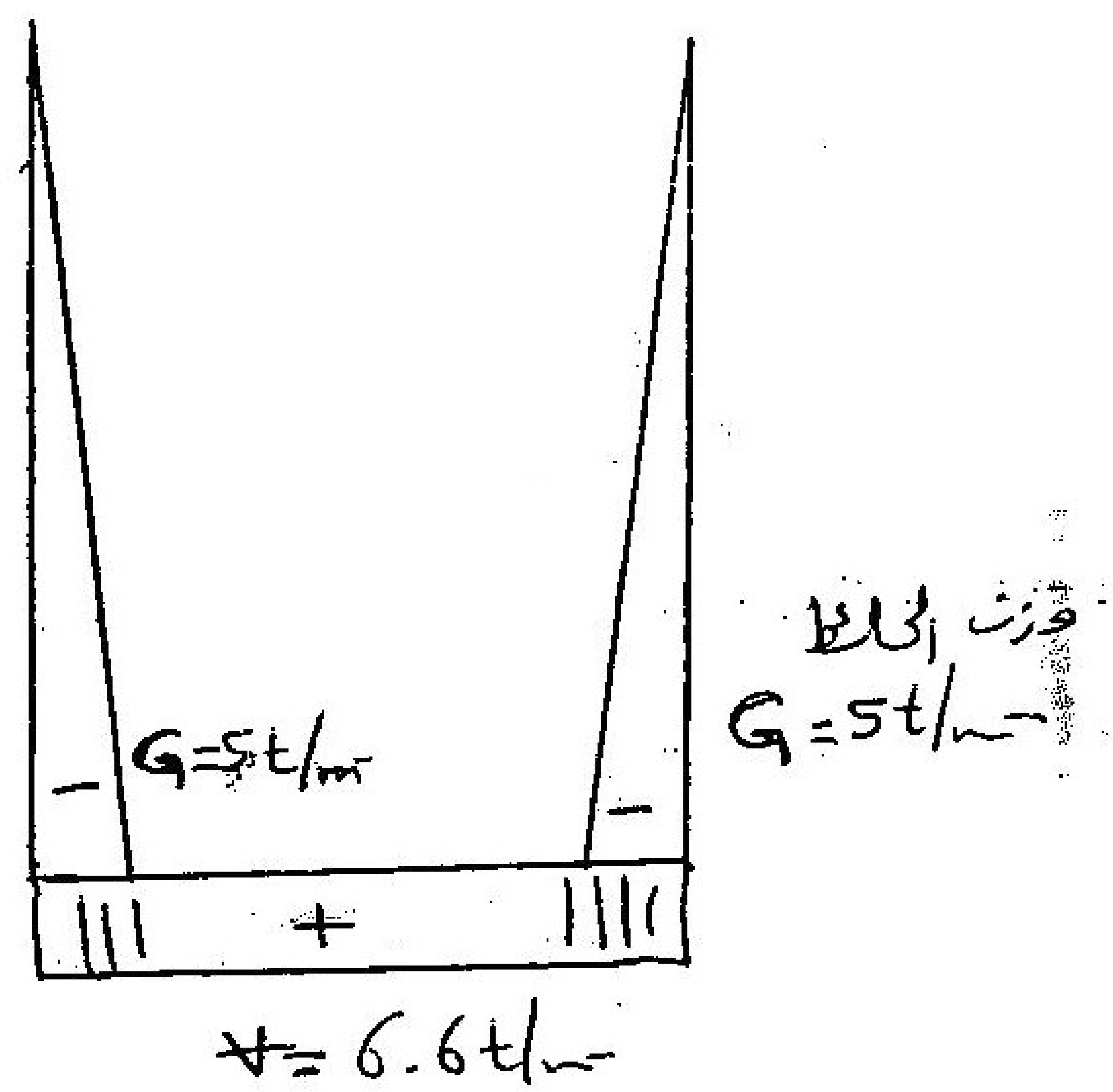


الجديد القديم للقاعدة
ΔM = 3.76 - 1.72
≃ 2 t.m

M tangential
كل العزوم
تحركت لأعلى
بمقدار ΔM أيضاً
= 2 t.m



N.F.D



* **Design of sections**

(1) **Ring direction** :: $T_{max\,ring} = 26.1\ t/m$

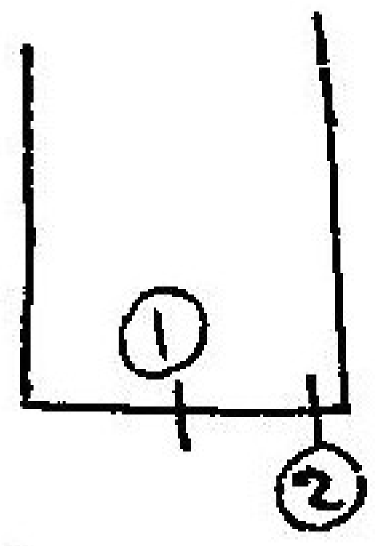
→ $t_{wall} = f.T = 0.6 * 26.1 \simeq 20\ cm_{min}$

→ $A_s = \frac{T_u * 10^3}{2\left(\frac{f_y}{\gamma_s}\right)} = \frac{1.5 * 26.1 * 10^3}{2\left(\frac{3600}{1.15}\right)} = 6.2\ cm^2/m$

لكل وجه

∴ use $A_s = 6\Phi 12/m$ each side

(2) VL. direction :



Sec (1) water side $M = 4.16\ t.m/m$; $T = 6.6\ t/m$

stage (I) $t_{base} = \sqrt{\frac{M*10^5}{\psi.B}} + 5_{cm} = \sqrt{\frac{4.16*10^5}{3.2*100}} + 5$

$\simeq 40\ cm$

* check tension stress: $\sigma_t \ngtr f_{ct}$

$\therefore \frac{6M*10^5}{B.t^2} + \frac{T*10^3}{B.t} \ngtr f_{ct} = 20\ kg/cm^2$

$\therefore$ safe

stage (II) ultimate

$T_u = 1.5T = 10\ t/m$

$M_u = 1.5M = 6.24\ t.m/m$

$e = \frac{M_u}{T_u} = 0.62\ m$

$e/t = \frac{0.62}{0.4} > 0.5$ big eccent.

$\therefore e_s = e - t/2 + \underset{0.05\,m}{cover} = 0.47\ m$

$\therefore M_{us} = T_u . e_s = 10 * 0.47 = 4.7\ t.m$

$\therefore R_1 = \frac{M_{us}*10^5}{f_{cu}. B d^2} = \frac{4.7*10^5}{250*100*(35^2)} = 0.015$

$\therefore \omega = 0.02$

$$\therefore A_s \text{ ناحية العزوم} = \left(\omega \frac{f_{cu}}{f_y} B d\right) + \left(\frac{T_u \times 10^3}{f_y / \gamma_s}\right)$$

$$= 8 \ cm^2/m$$

use 8 Φ12/m حديد علوي للقاعدة
(Radial & tangential)
حيث قيم العزوم (Mt & Mr) متساوية تقريباً

---

sec (2) $M_{air\ side} = 1.72 \ t.m/m$, $T = 6.6 \ t/m$

t = 40cm ثابتة تخانتها القاعدة
من خطوة سابقة

stage (II) مباشرة

$M_u = 1.5 M$, $T_u = 1.5 T$

$e = \frac{M_u}{T_u} = \searrow$

$e/t = \searrow$

$e_s = \searrow$

$M_{us} = \searrow$

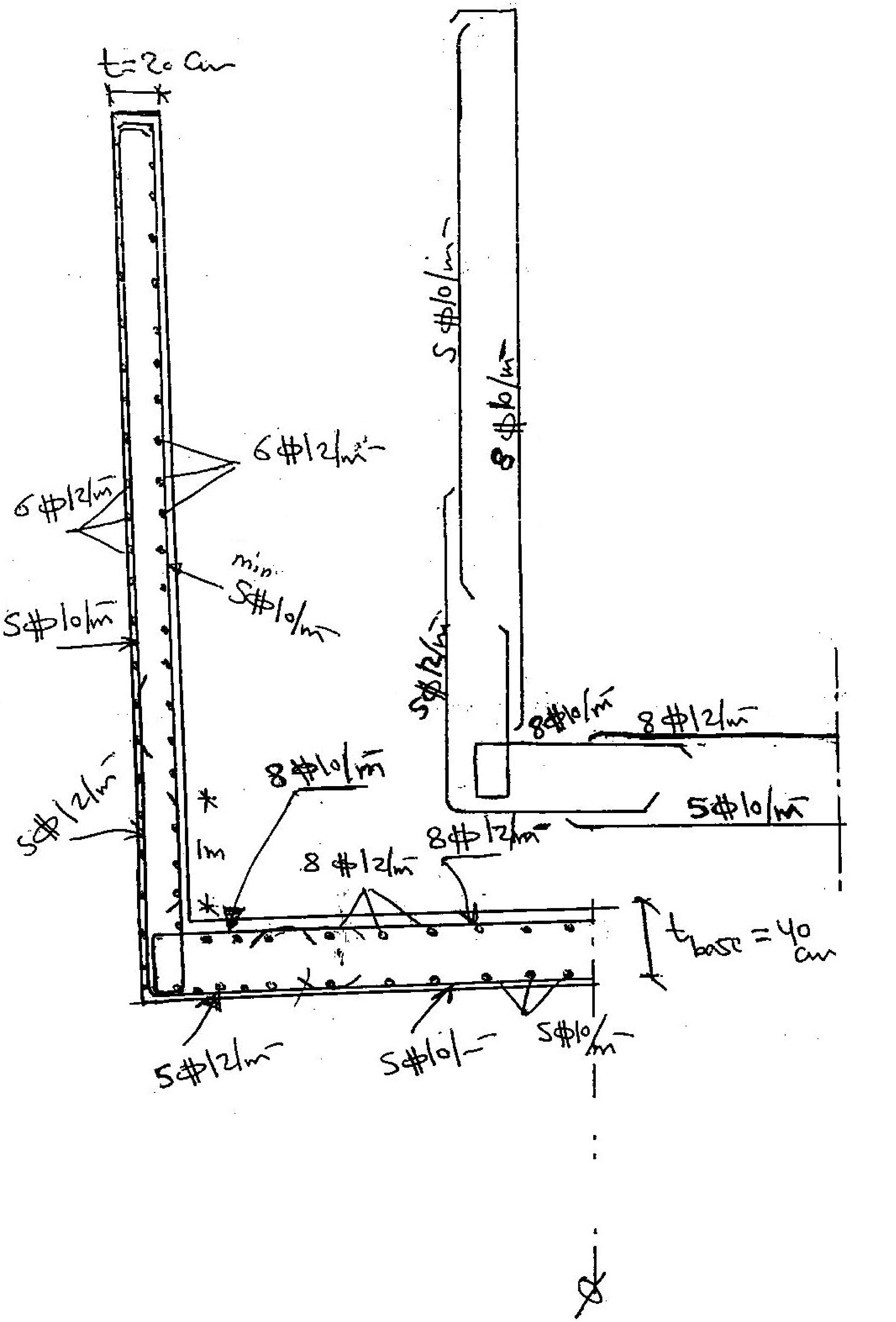
$R_1 = \searrow$

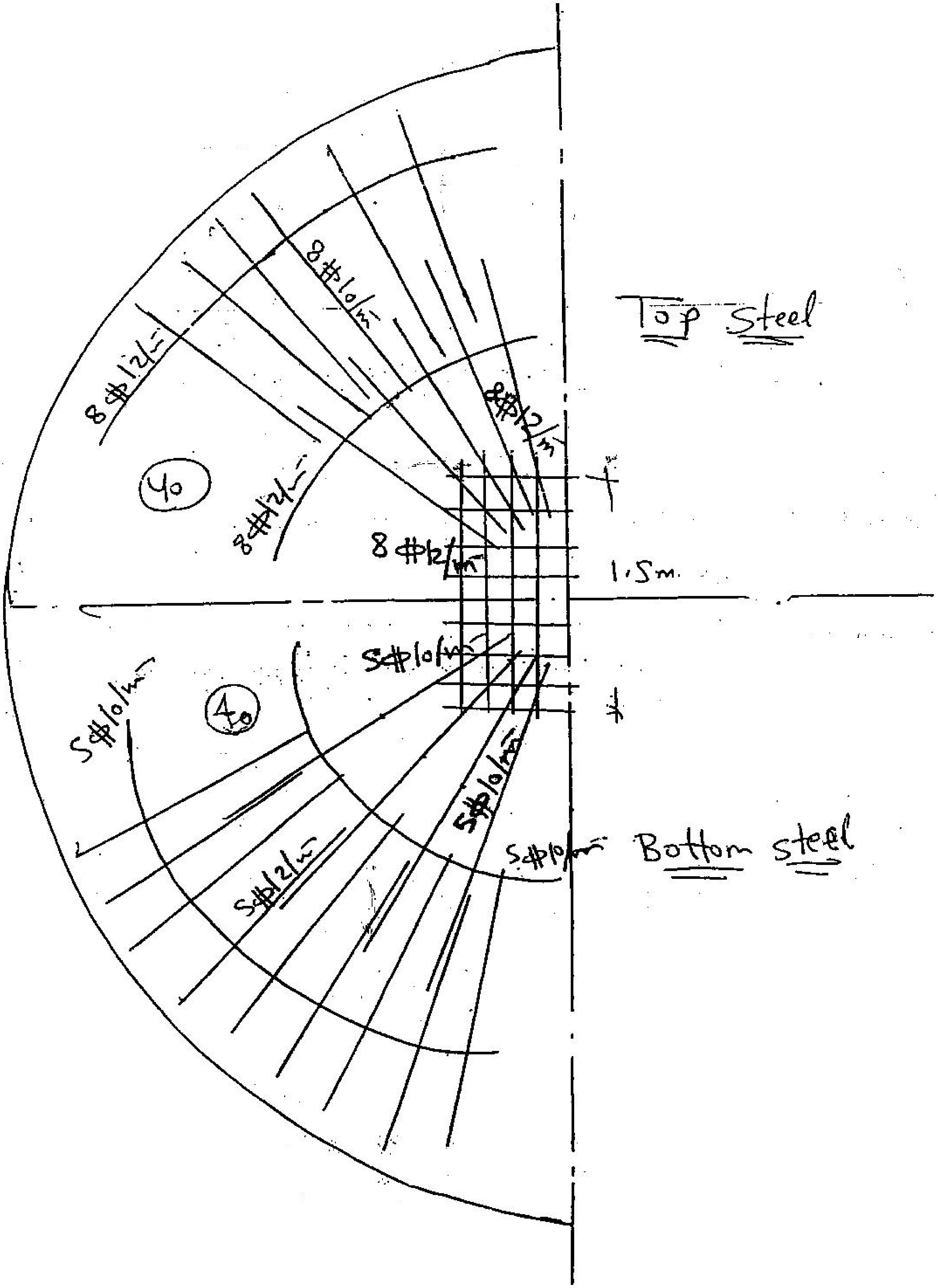
$\omega = \searrow$

$$A_s = \left(\omega \cdot \frac{f_{cu}}{f_y} B . d\right) + \left(\frac{T_u \times 10^3}{f_y / \gamma_s}\right)$$

check $A_{s_{min}} = \frac{0.15}{100} B d = 5.25 \ cm^2/m$

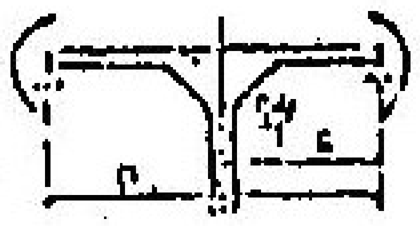
$= 5 Φ 12/m$


t=20 cm
6Φ12/m'
6Φ12/m'
min 5Φ10/m'
5Φ10/m'
5Φ12/m'
8Φ10/m'
1m
8Φ12/m'
8Φ12/m'
t_base = 40 cm
5Φ12/m'
5Φ10/m'
5Φ10/m'
5Φ10/m'
8Φ10/m'
5Φ12/m'
8Φ10/m'
8Φ12/m'
5Φ10/m'


Top Steel
8 Φ10/m
8Φ12/m
8 Φ12/m
8Φ12/m
8 Φ12/m
40
1.5m.
5Φ10/m
40
5Φ10/m
5Φ10/m
5Φ10/m
5Φ10/m
5Φ12/m
Bottom steel

Stiffness of Wall and base

Table 2.15: Moments in circular slab with center support and hinged edge due to moment per ft. M applied at edge ; Moment = coeff. x M. Positive sign indicates compression in top surface.



c/D	0.05R	0.10R	0.15R	0.20R	0.25R	0.30R	0.40R	0.50R	0.60R	0.70R	0.80R	0.90R	1.00R
	Radial moments, Mr												
.05	-2.65	-1.12	-.622	-.333	-.129	+.029	+.168	+.450	+.596	+.718	+.824	+.917	+1.0
.10		-1.95	-1.03	-.584	-.305	-.103	+.187	+.394	+.558	+.692	+.808	+.909	+1.0
.15			-1.59	-.930	-.545	-.280	+.078	+.323	+.510	+.663	+.790	+.900	+1.0
.20				-1.37	-.842	-.499	-.057	+.236	+.451	+.624	+.768	+.891	+1.0
.25					-1.80	-.765	-.216	+.130	+.392	+.577	+.740	+.880	+1.0
	Tangential moments, Mt												
.05	-.530	-.980	-.847	-.688	-.544	-.418	-.211	-.042	+.095	+.212	+.314	+.405	+.486
.10		-.588	-.641	-.608	-.518	-.419	-.233	-.072	+.066	+.185	+.290	+.384	+.469
.15			-.319	-.472	-.463	-.404	-.251	-.100	+.035	+.157	+.263	+.363	+.451
.20				-.272	-.372	-.368	-.261	-.123	+.007	+.129	+.240	+.340	+.433
.25					-.239	-.305	-.259	-.145	-.020	+.099	+.214	+.320	+.414

Table 2.16: Moments in circular slab without center support and fixed edge under uniform load

Mom. = coeff. x pR^2

Positive sign indicates compression in surface loaded

Coefficient at point										
0.00R	0.10R	0.20R	0.30R	0.40R	0.50R	0.60R	0.70R	0.80R	0.90R	1.00R
Radial moments, Mr										
+.075	+.073	+.067	+.057	+.043	+.025	+.003	-.023	-.053	-.087	-.125
Tangential moments, Mt										
+.075	+.074	+.071	+.066	+.059	+.050	+.039	+.026	+.011	-.006	-.025

Table XVIII. : Load on center support for circular slab

Circular Slab: (pR^2 hinged & fixed)
Load = coeff. x M (moment at edge)

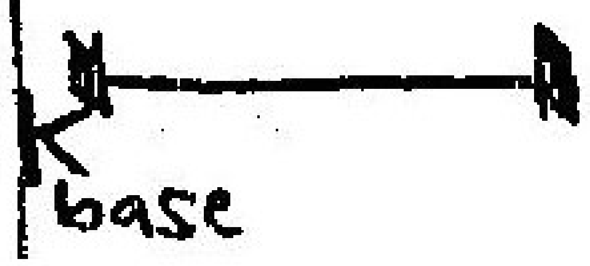
c/D	0.05	0.10	0.15	0.20	0.25
Hinged	1.320	1.387	1.463	1.542	1.625
Fixed	0.839	0.919	1.007	1.101	1.200
M at Edge	8.16	8.66	9.29	9.99	10.81

Table XIX. : Stiffness of Circular Plate with Center Support: k = coeff. ; Et^3/R

Base — without center support

c/D	0.05	0.10	0.15	0.20	0.25
Coeff.	0.290	0.304	0.332	0.358	0.387

Without center support: $K = 0.104\,Et^3/R$ $= 0.104\,Et^3/R = K_{base}$



Wall ⟹ **Table 2.17** Stiffness of Cylindrical Wall, near edge hinged, far edge free : k = coeff. x Et^3/H

$K = C_o(E \cdot t^3/H)$ for Wall

$\frac{H^2}{D \cdot t} =$

H^2/Dt	0.4	0.8	1.2	1.6	2	3	4	5	6	8	10	12	14	16	20	24	32	40	48	50
C_o	.139	.27	.345	.399	.445	.548	.635	.713	.783	.903	1.01	1.11	1.2	1.28	1.43	1.57	1.81	2.03	2.22	2.4

INTEINAL FORCES IN CIRCUALLAR PLATES

Notations: ν = Poissons ratio (for concrete = 0 – 1/6)

D = Flexural rigidity of the plate = $Et^3/12(1-\nu^2)$

1. Solid Circular Plate Subjected to a uniformly distributed load :

(Fig. 1) : p = uniform load (const.) , Total load $P = pa^2\pi$

$$Q_r = \frac{P}{2a\pi}\rho \; ; \quad \text{where } \rho = r/a \qquad A = \frac{P}{2a\pi}$$

a) Edge Fixed

$$\delta = \frac{Pa^2}{64D\pi}(1-\rho)^2 \; ; \qquad \phi = \frac{Pa}{16D\pi}\cdot(1-\rho^2)\rho$$

$$M_r = \frac{P}{16\pi}\left[1+\nu-(3+\nu)\rho^2\right] \; ; \qquad M_t = \frac{P}{16\pi}\cdot\left[1+\nu-(1+3\nu)\rho^2\right]$$

b) Edge Simply Supported

$$\delta = \frac{Pa^2}{64D\pi}(1-\rho^2)\left[\frac{5+\nu}{1+\nu}-\rho^2\right] ; \qquad \phi = \frac{Pa}{16D\pi}\left[\frac{3+\nu}{1+\nu}-\rho^2\right]\rho$$

$$M_r = \frac{P}{16\pi}(3+\nu)(1-\rho^2) \qquad M_t = \frac{P}{16\pi}\left[3+\nu-(1+3\nu)\rho^2\right]$$

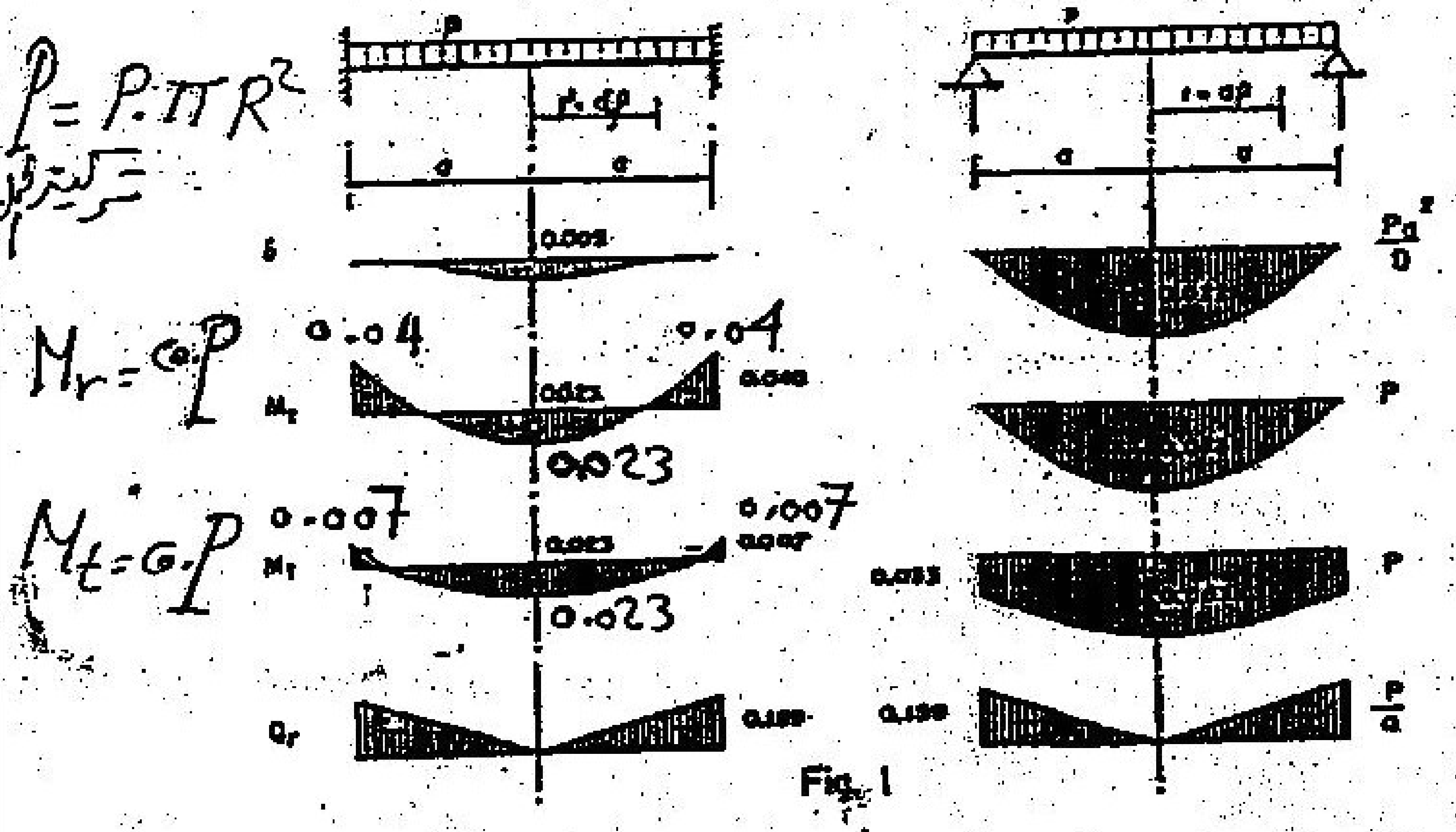
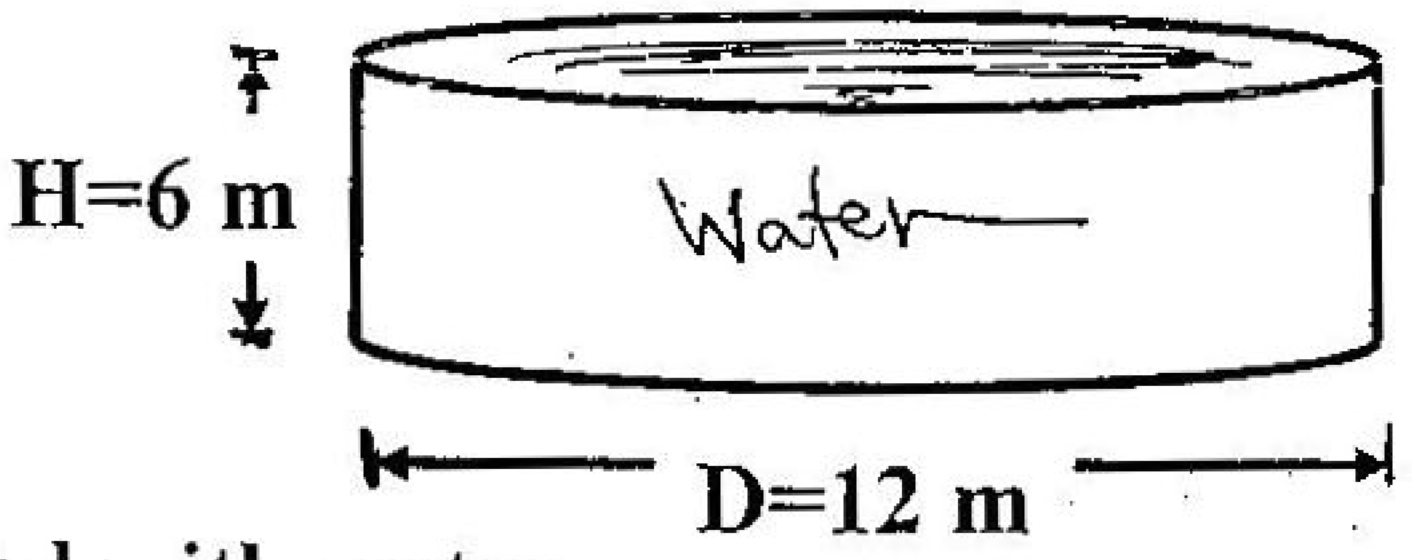


Fig. 1

7

Fixed circular tanks on medium soil



- The tank is filled with water.
- Soil under base is clay with B/C= 1.0 kg/cm^2
- f_{cu}=250kg/cm^2, f_y=3600 kg/cm^2

Required:

1- Make analysis for wall using Simplified method.
2- Check stress on soil.
3- Make analysis for base.
4- Design critical sections and Draw reinforcement details.

Solution :

(1) Wall : Using Simplified method ;

Step① $\frac{H}{R^2} = \frac{6}{(6)^2} = 0.16$. P(3-2) بالكتاب

H/R^2	0.16
C_1	8.5
C_2	0.3
C_3	0.72

Step② $t_{\text{wall at base (cm)}} = C_3 \gamma H R$

$= 0.72 * 1 * 6 * 6 = 26$ cm

∴ take $t = 30$ cm

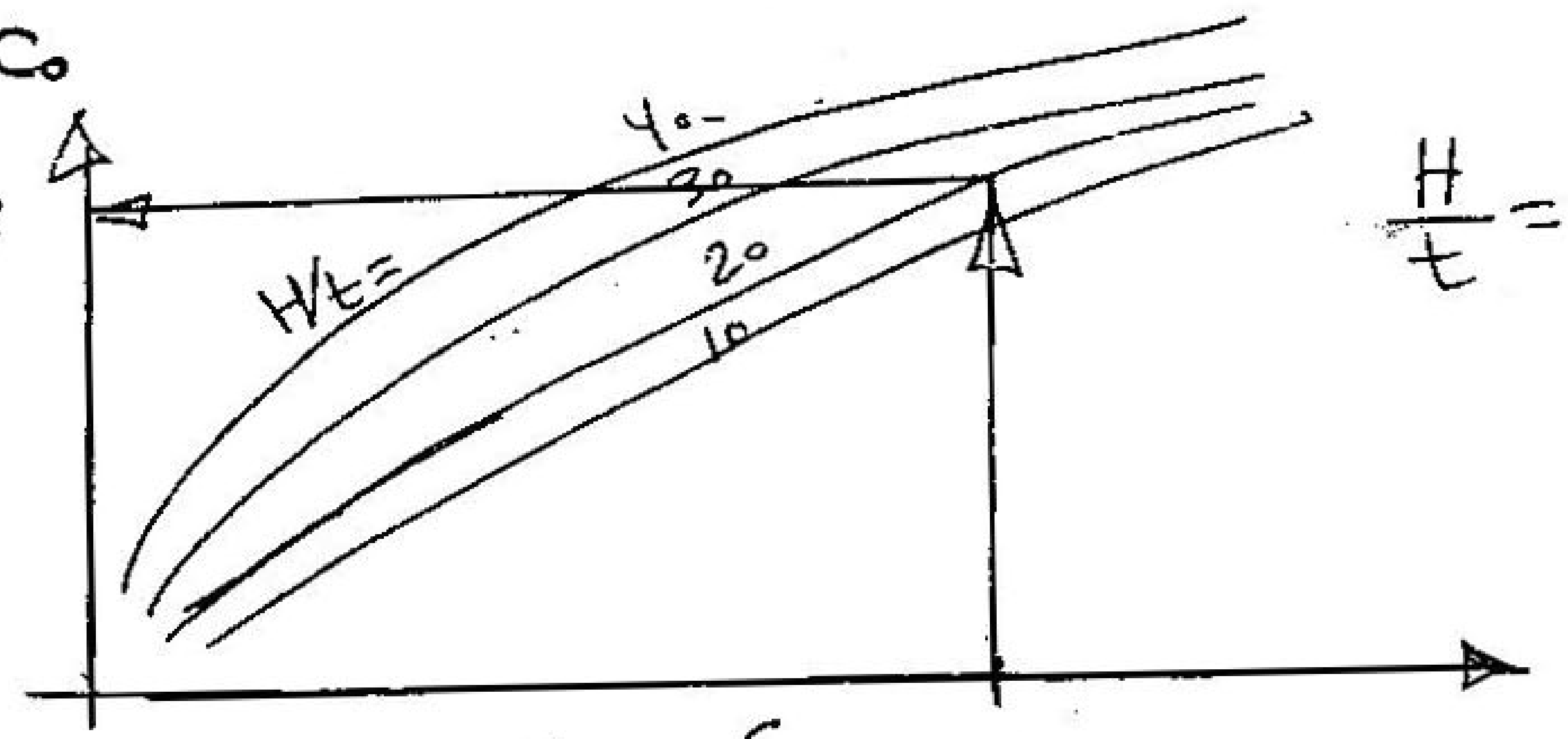
Step (3) $M_f = \frac{\gamma H D t}{C_1} = \frac{1 * 6 * 12 * 0.3}{8.5} = 2.54 \ t.m/m^-$

Step (4) $M_{+ve} = \frac{M_f}{5} = \frac{2.54}{5} = 0.5 \ t.m/m^-$

Step (5) $\forall_{shear} = C_2 \cdot \frac{\gamma H^2}{2} = 0.3 * \frac{1 * 6^2}{2} = 5.4 \ t/m^-$

Step (6) $T_{ring\ max} = C_0 \cdot \gamma H R$

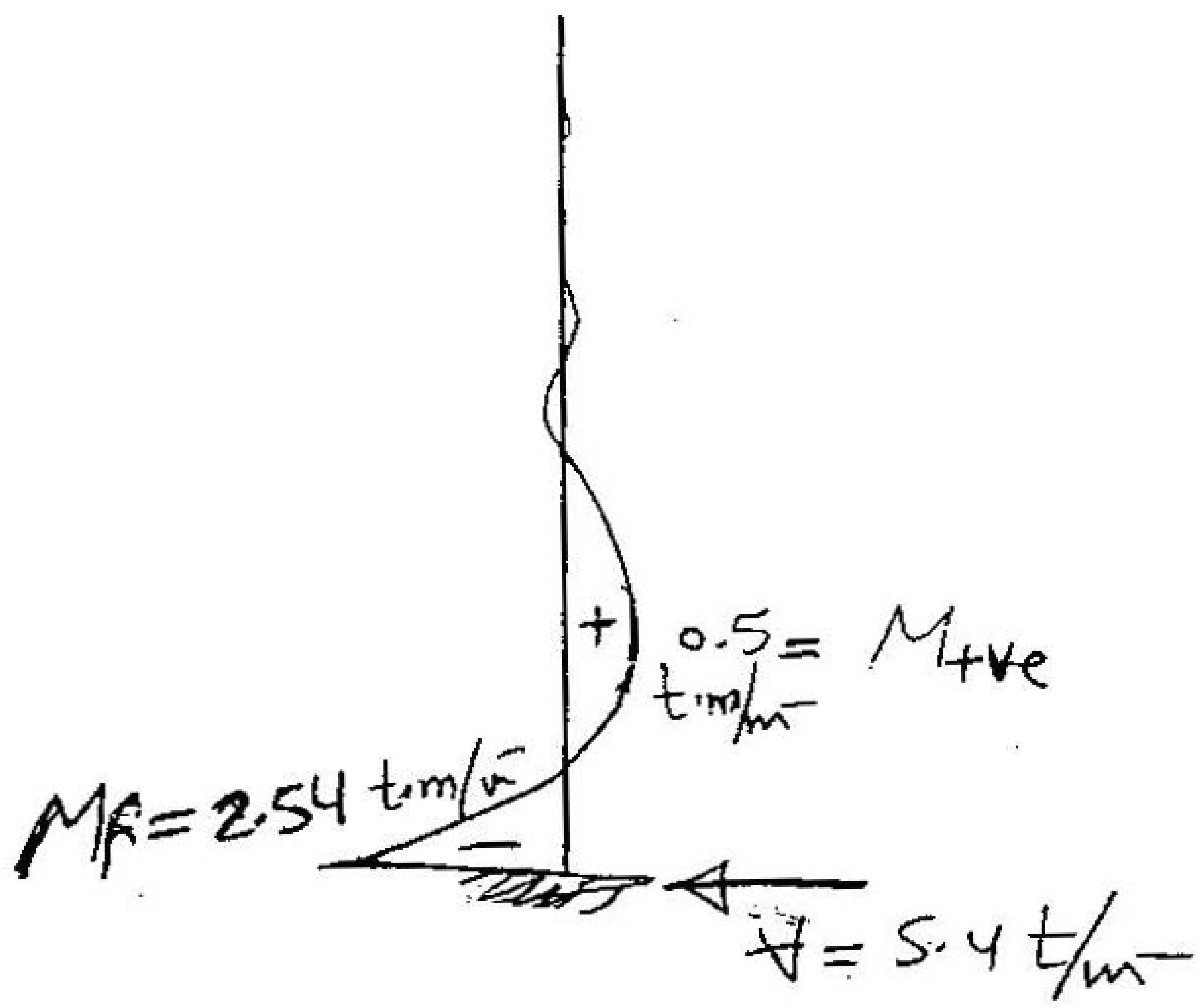
from Curve P. (3-2)



$\frac{H}{t} = \frac{6}{0.3} = 20$

$\frac{H}{D} = \frac{6}{12} = 0.5$

So $T_{ring\ max} = 0.63 * 1 * 6 * 6 = 22.6 \ t/m^-$



(2) Base القاعدة

(A) Check of soil stress under Base

∵ Medium soil (Clay B/c = 1.0 kg/cm²)

$$\frac{D}{H} = \frac{12}{6} = 2 > 1.5$$

∴ جزء من القاعدة يتحمل الإجهاد الناتج من الحائط .

($X \simeq 0.5H$) wedge

⟹ W_1 = وزن المياه + وزن القاعدة

$= \gamma \cdot H + t_{base} \cdot \gamma_{R.C}$

$= (1 * 6) + (0.3 * 2.5)$ (فرض)

$= 6.75\ t/m^2$

⟹ W_2 = وزن القاعدة فقط

$= t_{base} \cdot \gamma_{R.C}$

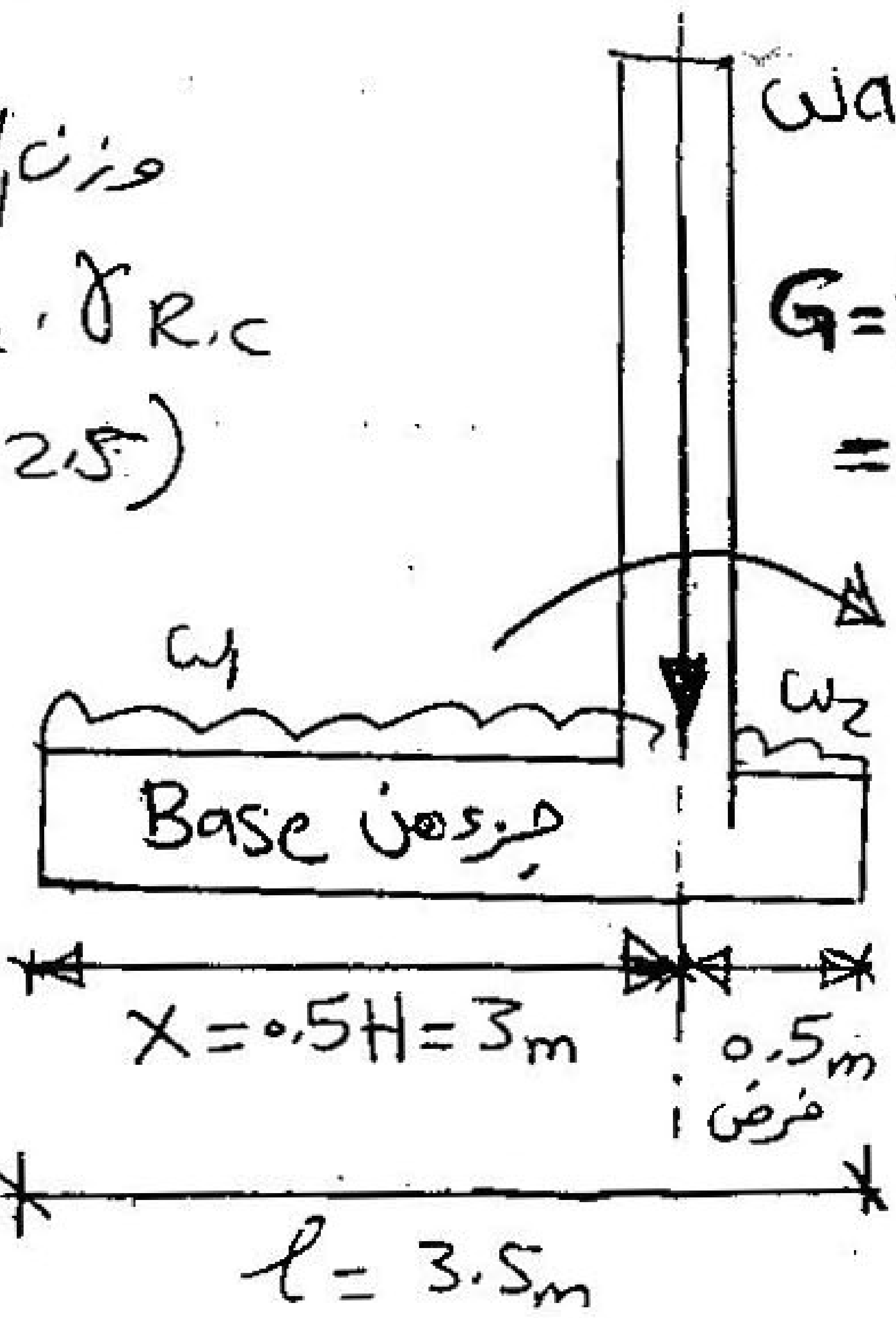
$= 0.3 * 2.5$

$= 0.75\ t/m^2$

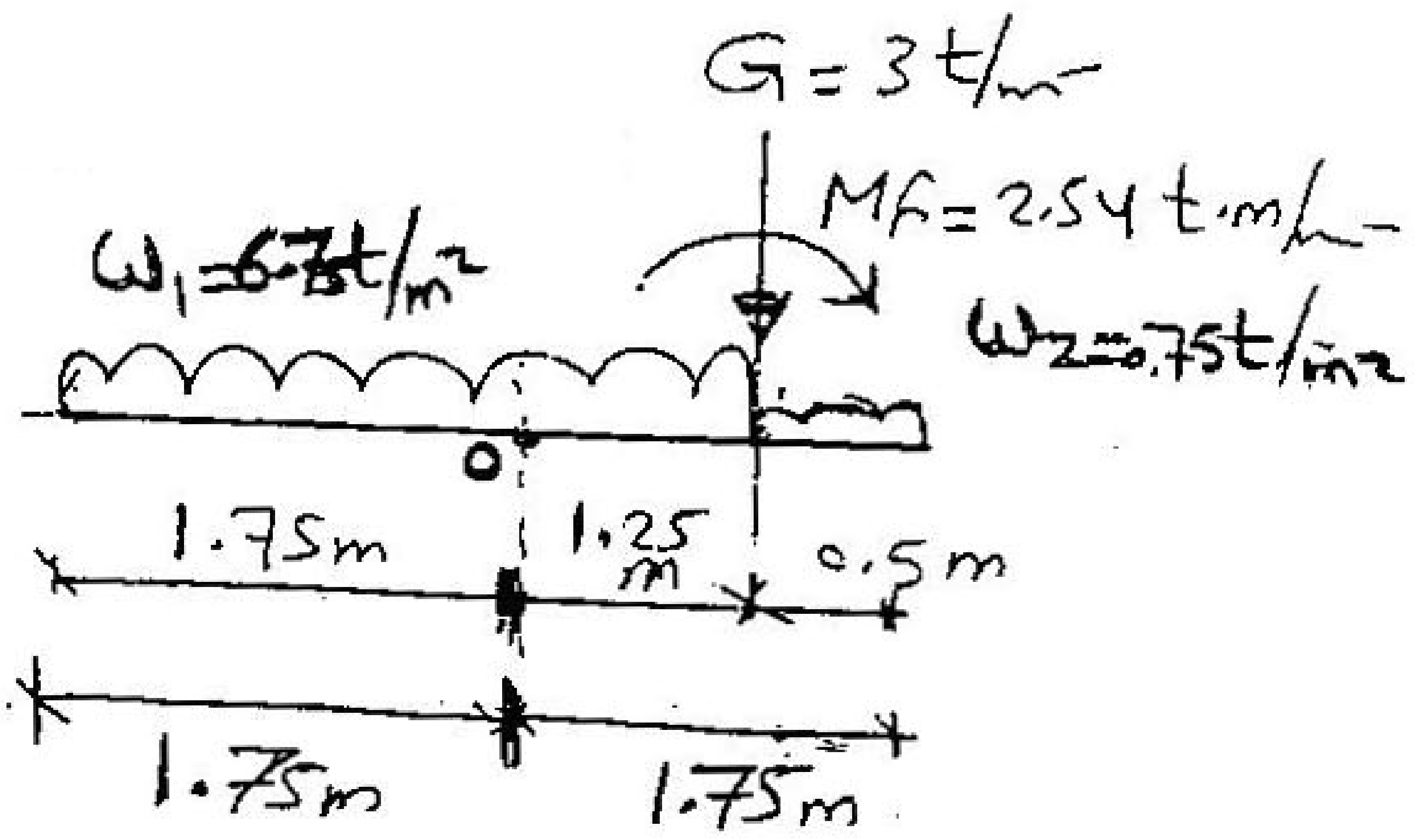
$G = t_{wall} * H_{wall} * \gamma_{R.C}$

$= 0.2 * 6 * 2.5 = 3\ t/m$

$M_f = 2.54\ t.m/m$



∴ نأخذ نقطة (O) عند منتصف الطول (l) ونحسب عندها مجموع عزوم القوى . + العزم من الحائط M_f



$$M_o) = \underset{Mf}{2.54} + (0.75 * 0.5 * 1.5) + \left(6.75 * 1.25 * \frac{1.25}{2}\right) - \left(6.75 * 1.75 * \frac{1.75}{2}\right) + (\underset{G}{3 * 1.25})$$

$$\therefore M_o) = 1.79 \ t.m/m$$

$$\therefore N = (3) + (0.75 * 0.5) + (6.75 * 3) = 23.625 \ t/m$$

Normal force

مجموع القوى الرأسية كلها على wedge

$$\therefore \sigma_{soil\ 1,2} \ (t/m^2) = \pm \frac{6 M_o}{B \ell^2} + \frac{N}{B \cdot \ell}$$

$$= \pm \frac{6 * 1.79}{1 * (3.5)^2} + \frac{23.625}{(1 * 3.5)}$$

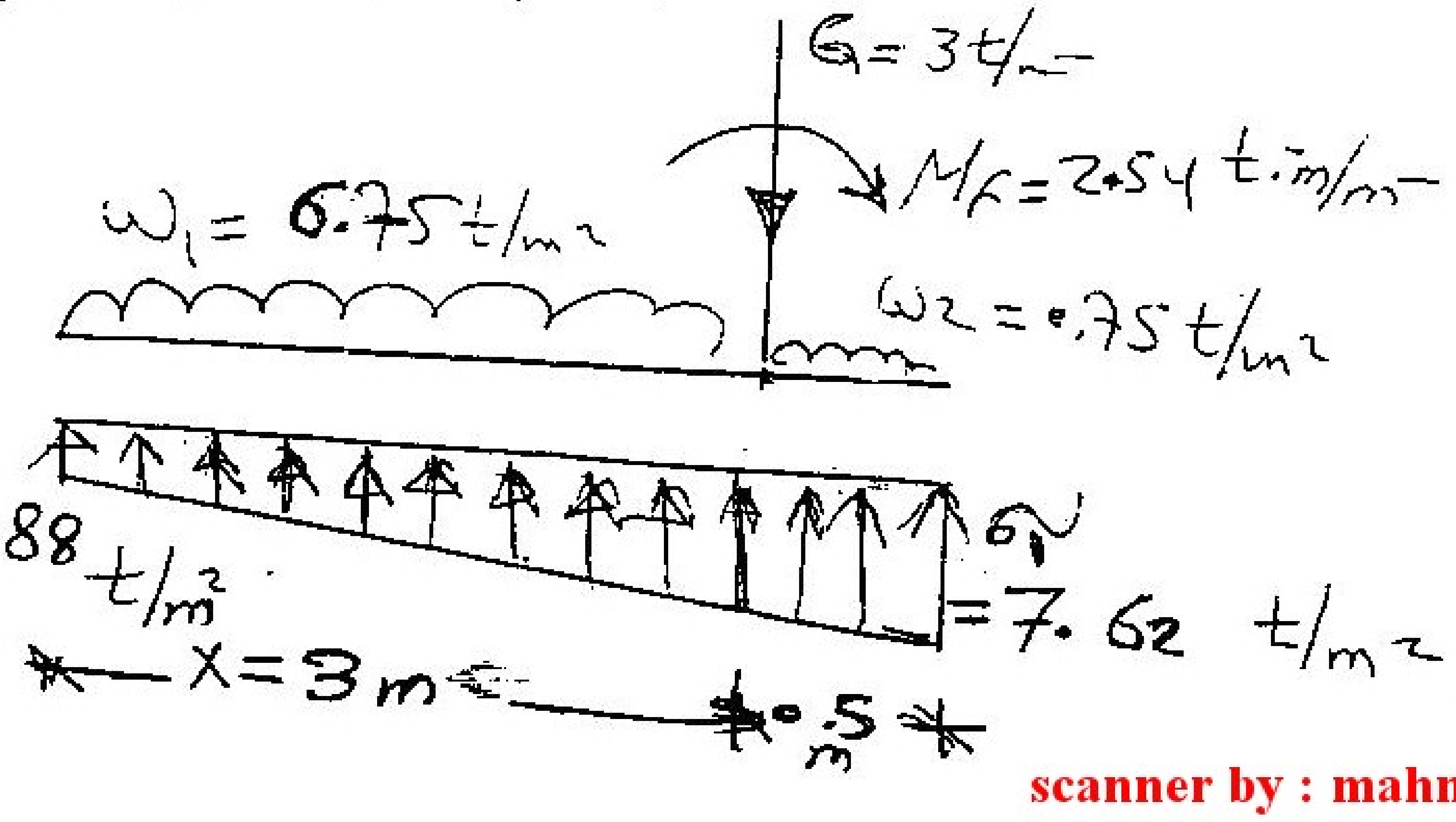
B = 1 m شريحة

$$\sigma_{1,2} = \pm 0.87 + 6.75$$

$$\sigma_{soil\ 1} = 7.62 \ t/m^2 \ \ngtr B/c = 10 \ t/m^2$$

$$\sigma_{soil\ 2} = 5.88 \ t/m^2 \ \ngtr B/c = 10 \ t/m^2$$

$\therefore$ Safe

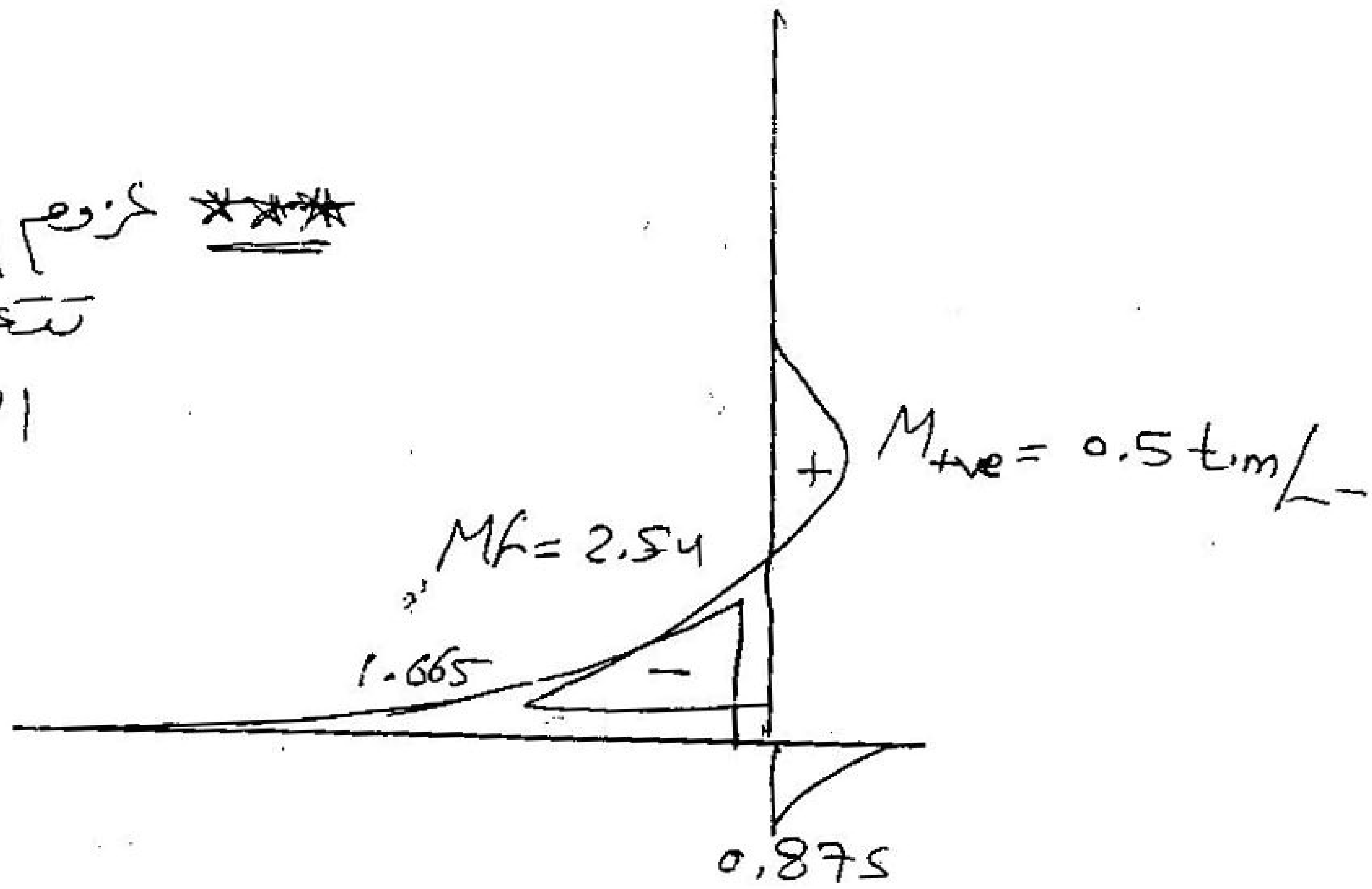


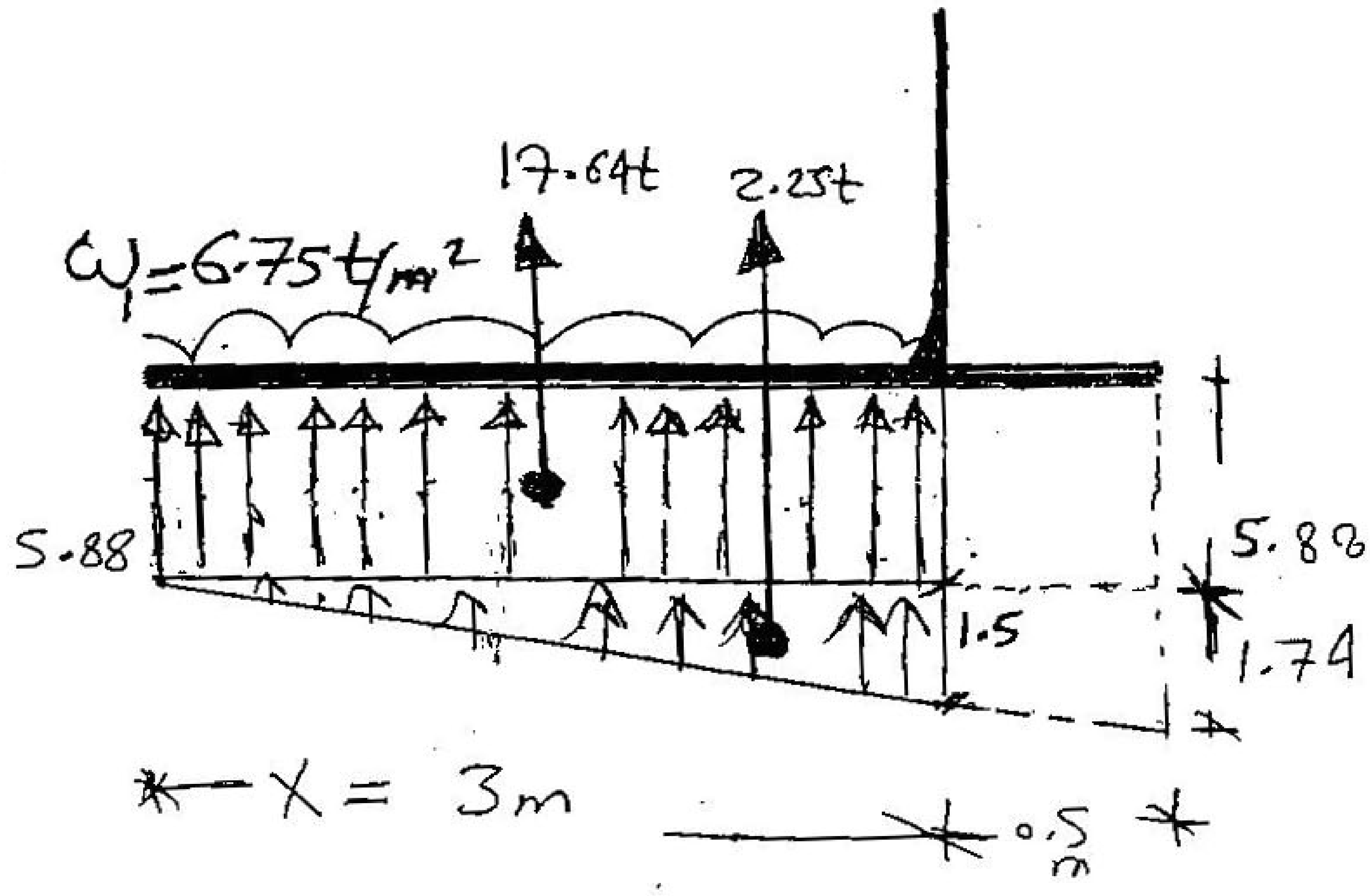
Moments at wedge

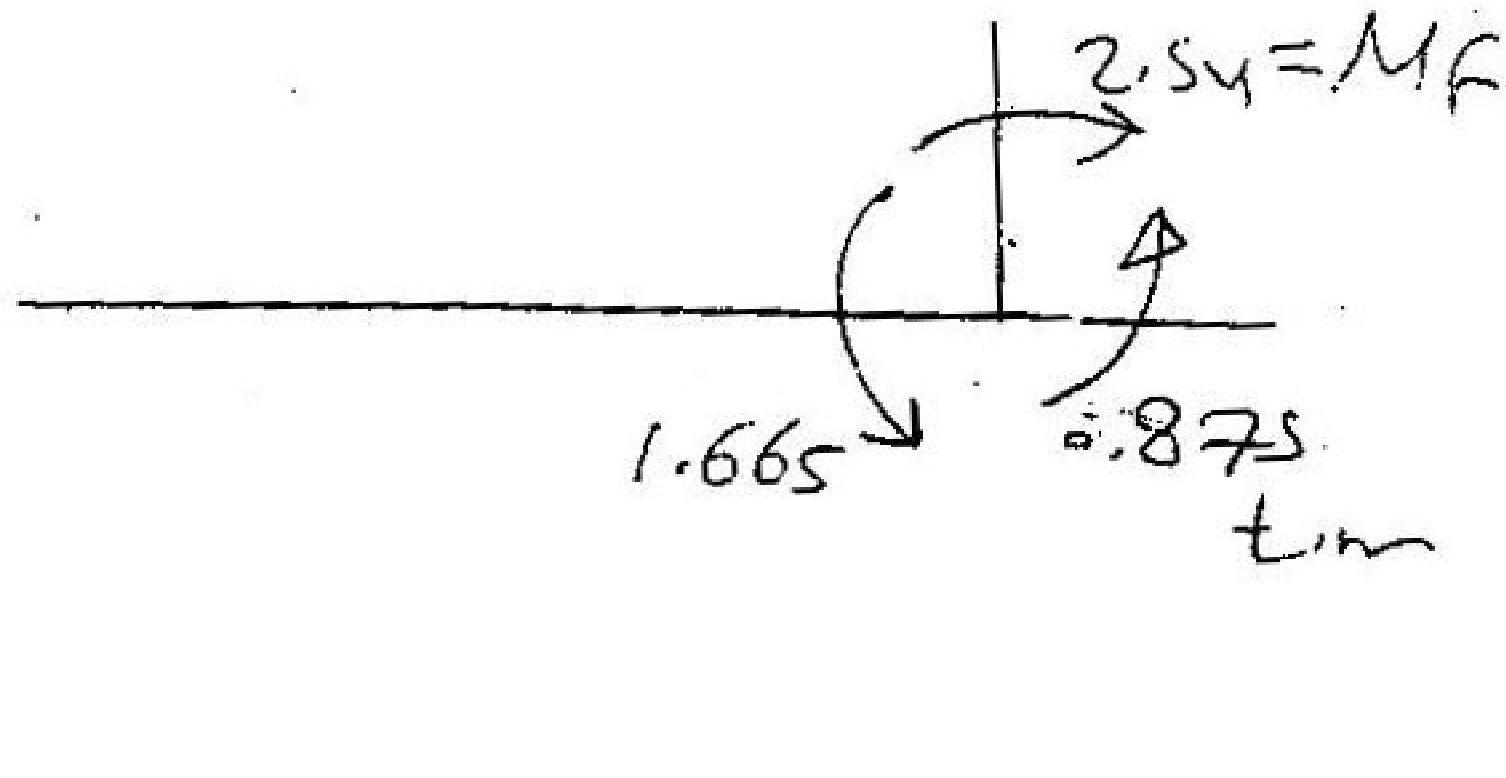
*** عزوم دي لن تتغير عن الحسابات الأولية نهائياً

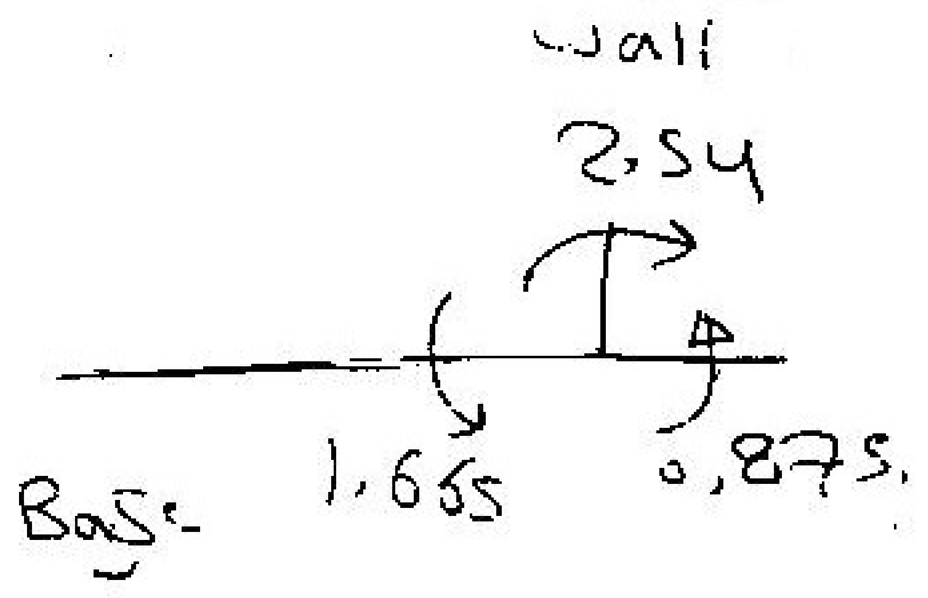
Mf = 2.54

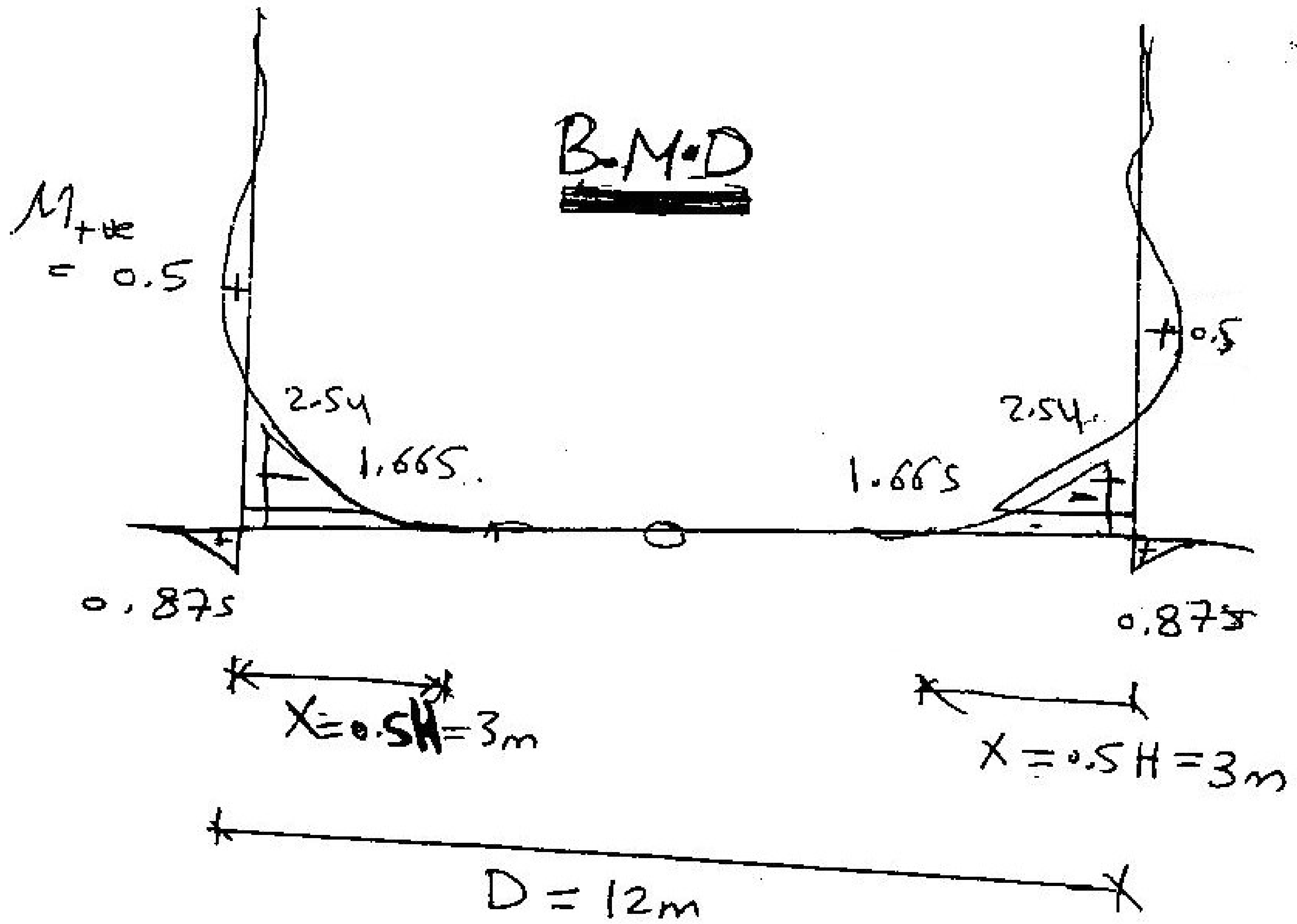
M+ve = 0.5

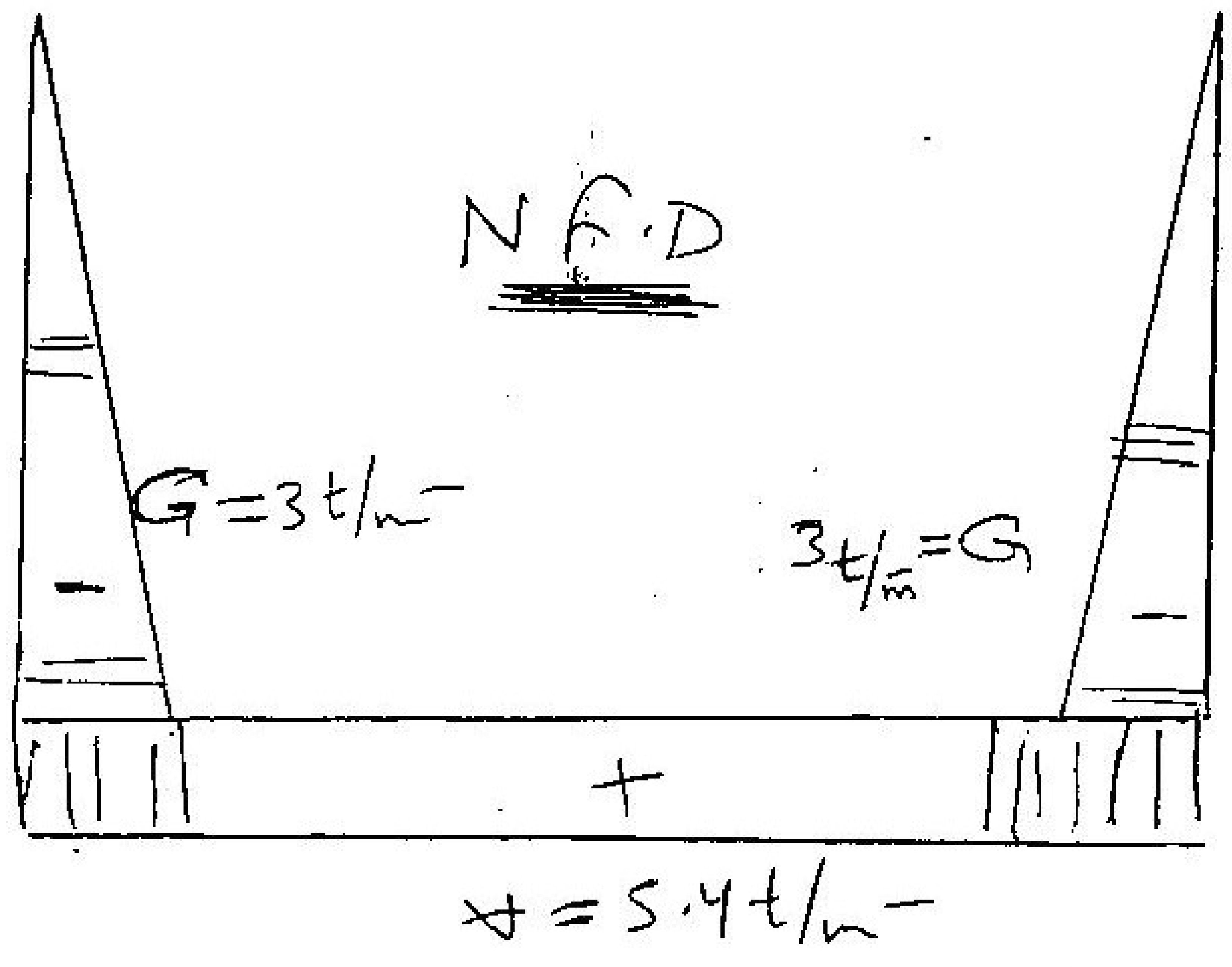







wall
2.54
1.665
0.875
Base


B.M.D
M+ve = 0.5
+0.5
2.54
1.665
2.54
1.665
0.875
0.875
X = 0.5H = 3m
X = 0.5H = 3m
D = 12m


N.F.D
G = 3t/m
3t/m = G
+
-
-
= 5.4t/m

Design of sections :-

① Ring direction:

$T_{max\ ring} = 22.6\ t/m'$

Stage (I) $t = \xi . T = 0.6 * 22.6 = 14\ cm \ngtr 20\ cm$

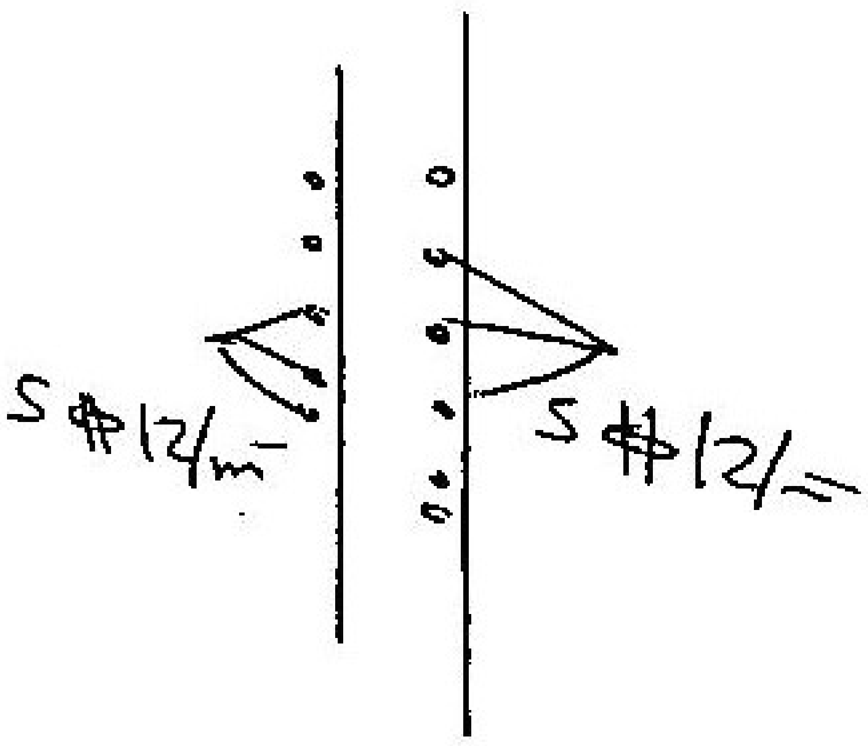
$\therefore$ use $t = 20\ cm$

Stage (II) $A_s = \frac{T_u * 10^3}{2\left(\frac{f_y}{\delta_s}\right)} = \frac{1.5 * 22.6 * 10^3}{2\left(\frac{3600}{1.15}\right)}$ (ultimate)

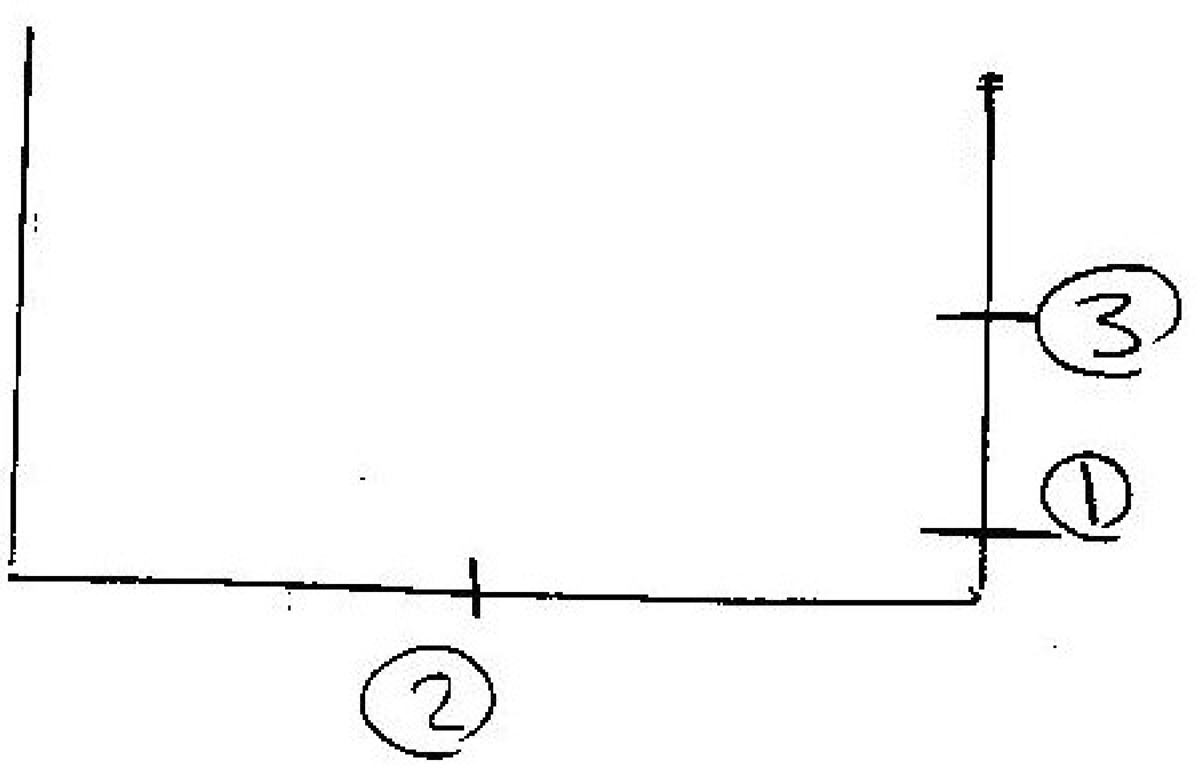
للتصميم قطاع

$\therefore A_s = 5.4\ cm^2/m'$

$= 5 \# 12/m'$



② VL. direction:



Sec ① $M_{water\ side} = 2.54\ t.m/m'$, $N_{compression} = 3\ t/m'$ Neglected

Sec ② $M = 0$; $T = 5.4\ t/m'$

Sec ③ $M_{air\ side} = 0.5\ t.m/m'$, $N_{compression}$

See (1) $M_{water\ side} = 2.54\ t.m/m$

(N) وتم إهمال الضغط

stage (I) $t = \sqrt{\frac{M \times 10^5}{\psi \cdot B}} = \sqrt{\frac{2.54 \times 10^5}{3.2 \times 100}}$

$\therefore t = 28.1\ c \simeq 30\ cm$

stage (II) $M_u = 1.5\ M = 3.81\ t.m$

$R_1 = \frac{M_u \times 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{3.81 \times 10^5}{250 \times 100 \times 25^2}$

$\therefore R_1 = 0.024$

$\therefore \omega = 0.031$

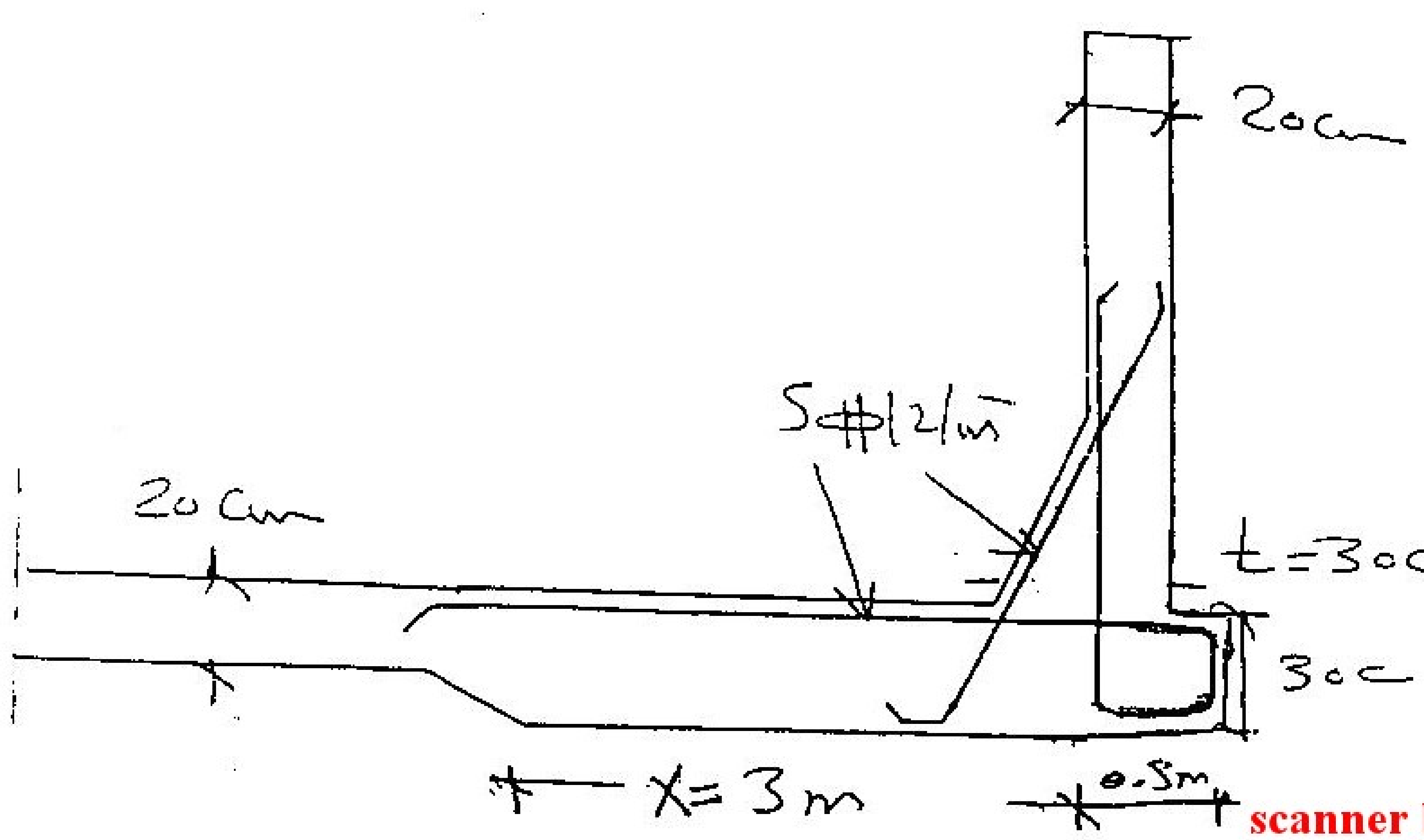
$\therefore A_s = \frac{\omega \cdot f_{cu}}{f_y} B \cdot d = 5.38\ cm^2/m$

ناحية العزم

$A_{s_{min}} = \frac{0.15}{100} B\ d = 3.75\ cm^2/m$

$\therefore$ use $A_s = 5.38 = 5 \phi 12/m$

من القاعدة تطلع للحائط على شكل مقص.



Section (2) $T_{only} = 5.4\ t/m$

Stage (I) use $t = f \cdot T = 20\ cm$

Stage (II) $As = \frac{T_u \times 10^3}{2(f_y/\delta_s)} = 5\#10/m$

تسليح على الوجهين

Section (3) Main side: $M = 0.5\ t.m/m$

Stage (II) $M_u = 1.5 M = 0.75\ t.m/m$

$\therefore t = 20\ cm$

Ring design للقطاع

$\therefore d = 15\ cm$

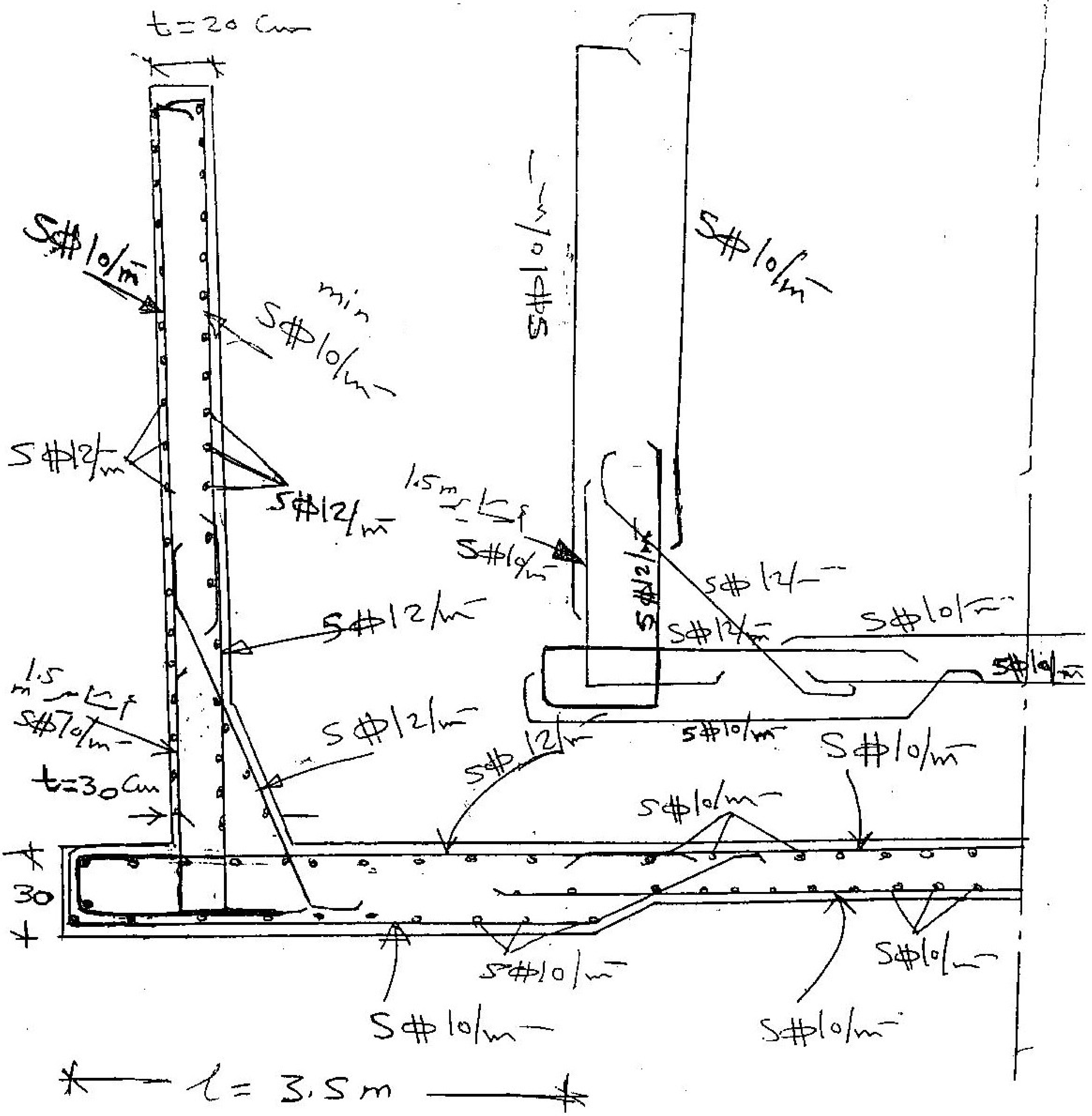
$$R_1 = \frac{M_u}{f_{cu} \cdot B \cdot d^2} = \checkmark$$

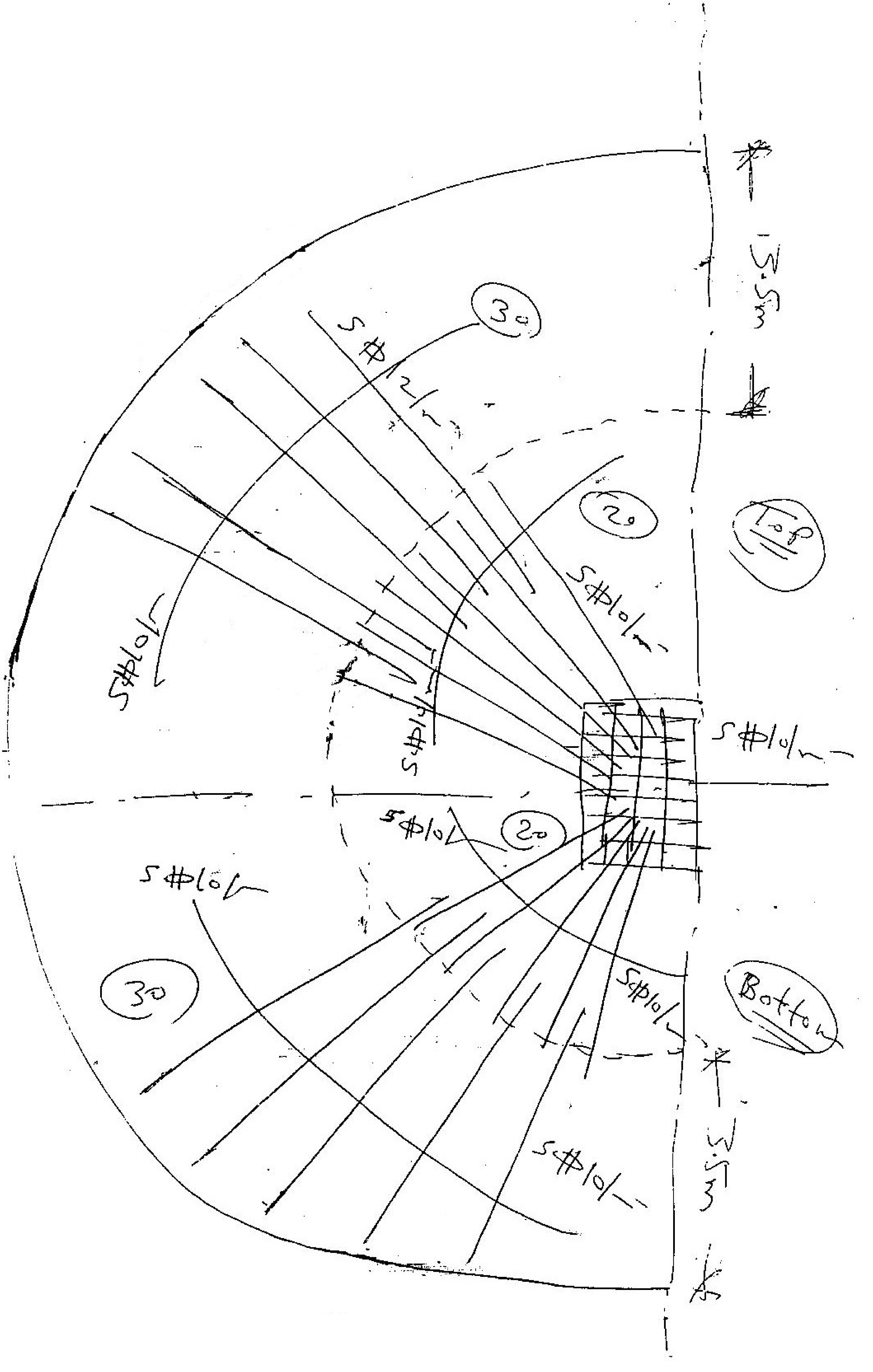
$\omega = \checkmark$

$$\therefore As = \frac{\omega \cdot f_{cu}}{f_y} \cdot B \cdot d = \text{صغيرة}$$

use $As_{min} = 5\#10/m$

صب رأسي خارجي (ناحية الهواء) air side

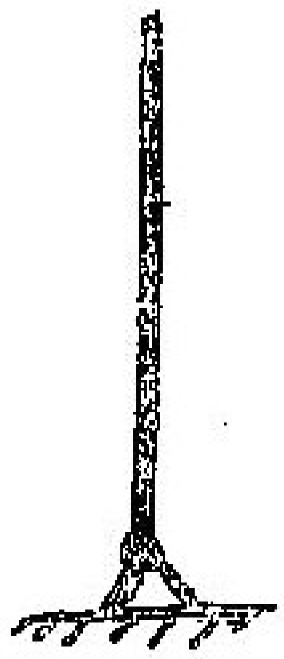

t=20 Cm
S⌀10/m
min
S⌀10/m
S⌀12/m
S⌀12/m
S⌀10/m
1.5 m
S⌀10/m
S⌀12/m
S⌀12/m
S⌀12/m
S⌀10/m
S⌀12/m
S⌀10/m
S⌀12/m
S⌀10/m
S⌀10/m
S⌀12/m
S⌀10/m
t=30 Cm
30
S⌀10/m
S⌀10/m
S⌀10/m
S⌀10/m
S⌀10/m
l = 3.5 m


5#12/m
5#10/m
5#10/m
5#10/m
5#10/m
5#10/m
5#10/m
5#10/m
5#10/m
5#10/m
30
20
20
30
Top
Bottom
3.5m
3.5m

Example

Design **Hinged** Tank on

Rocky soil.



$H = 10\,m$, $D = 8\,m$

$f_{cu} = 250\ kg/cm^2$, Steel (36/52)

Sol. **Wall** ⟹ using **P.C.A** Method

$$\frac{H^2}{D.t} = \frac{10^2}{8 * 0.25} = 50$$

تخانة

فرض $t = 0.25\ m$

(1) **Ring Tension** : $T_{max} = C_o \cdot \gamma H R$

Table (2) " الحل "

$H^2/D.t$	
$50 \simeq 48$	⟶ $C_{o\,max} = 0.9$

∴ $T_{max} = 0.9 * 1 * 10 * 4 = 36\ t/m$

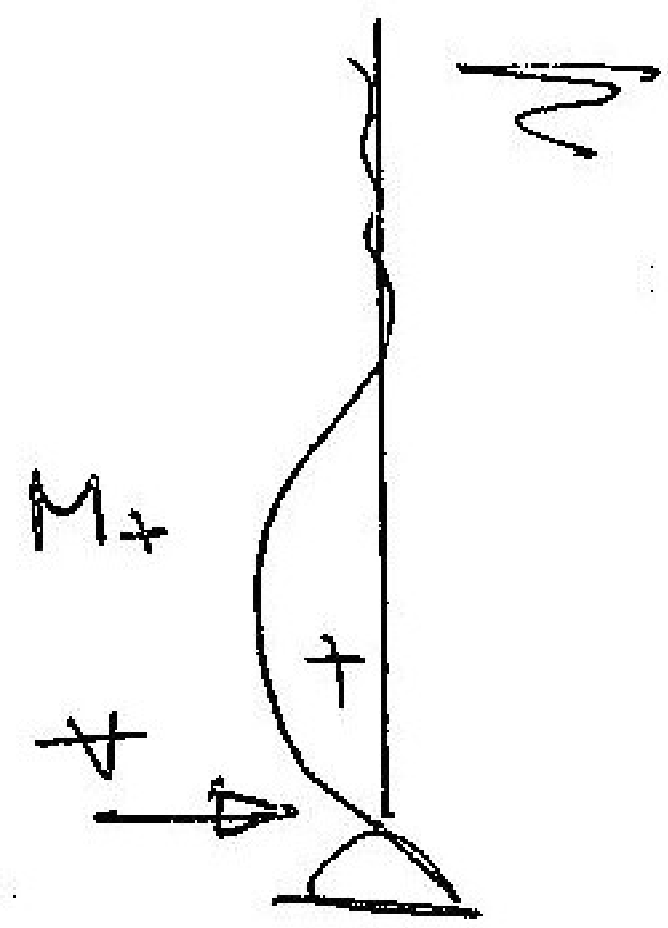
Moment : $M_{+ve} = C_o \cdot \gamma H^3$

table (8) الجدول

$\therefore C_o = 0.001$

$\therefore M_{+ve} = 0.001 * 1 * 10^3$

$= 1 \ t.m/m'$



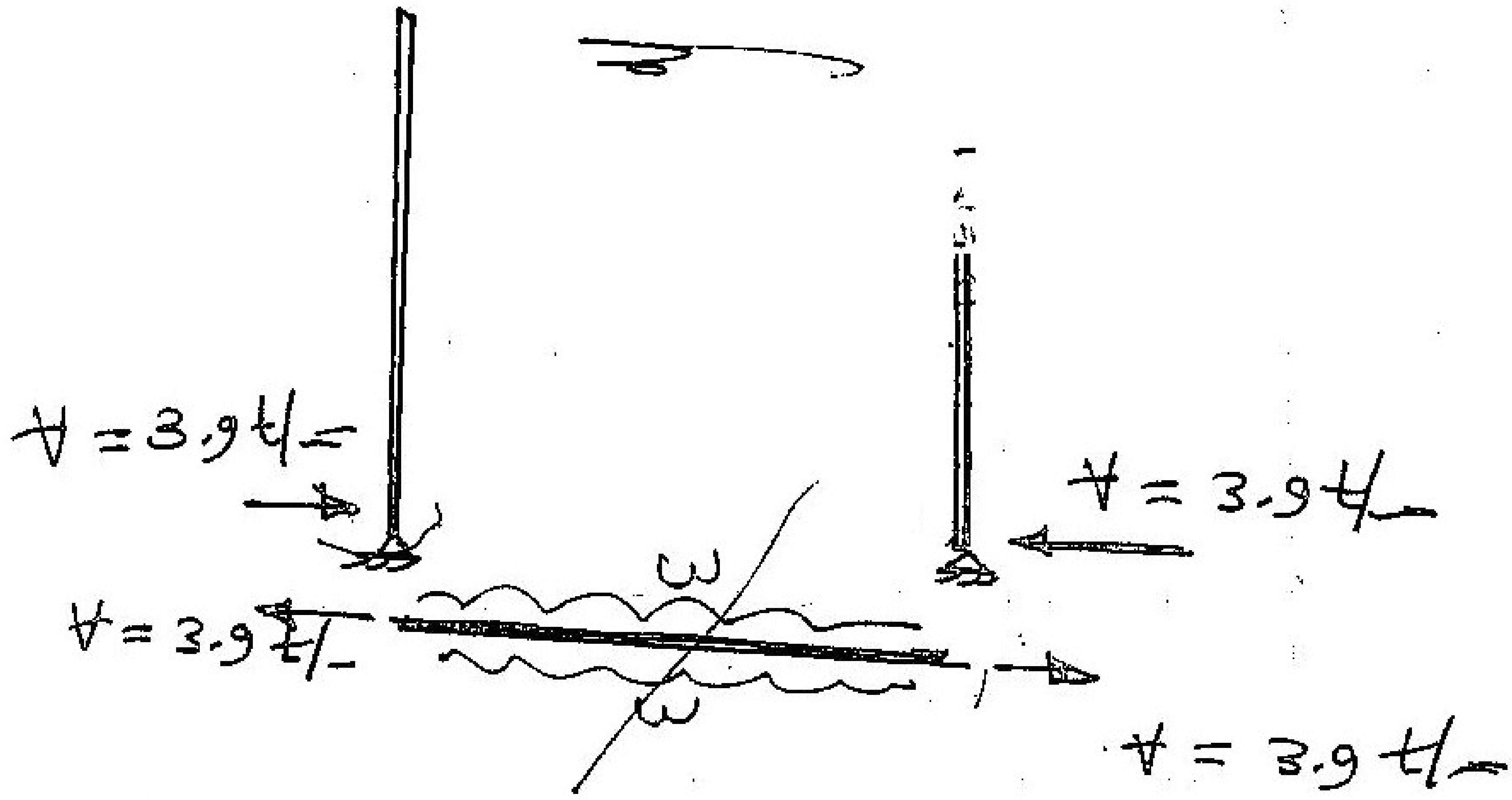
$V_{shear} = C_o \cdot \gamma H^2$

table (12) الجدول

$H^2/D.t$		
48	→	0.039 Hinged

$\therefore V_{shear} = 0.039 * 1 * 10^2 = 3.9 \ t/m'$

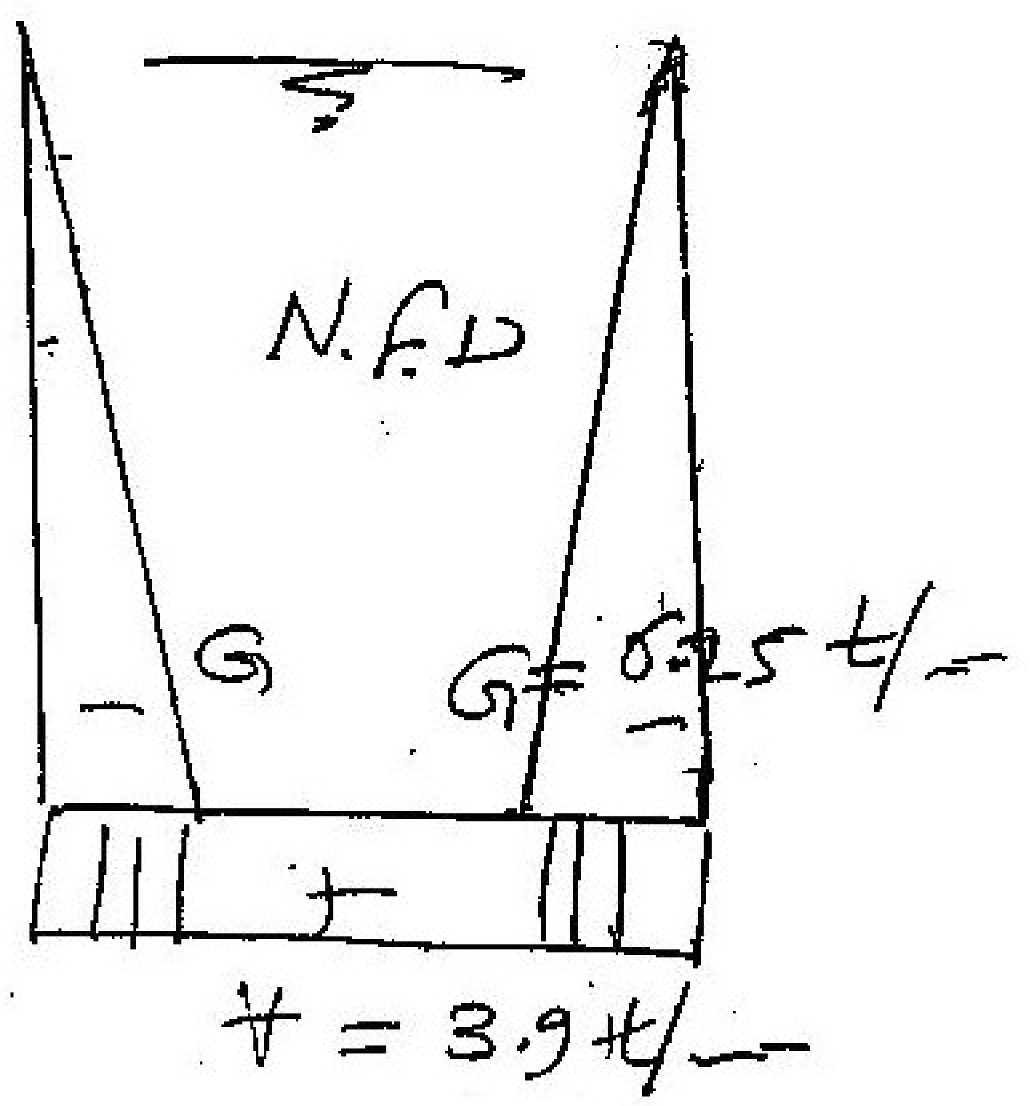
base : القاعدة

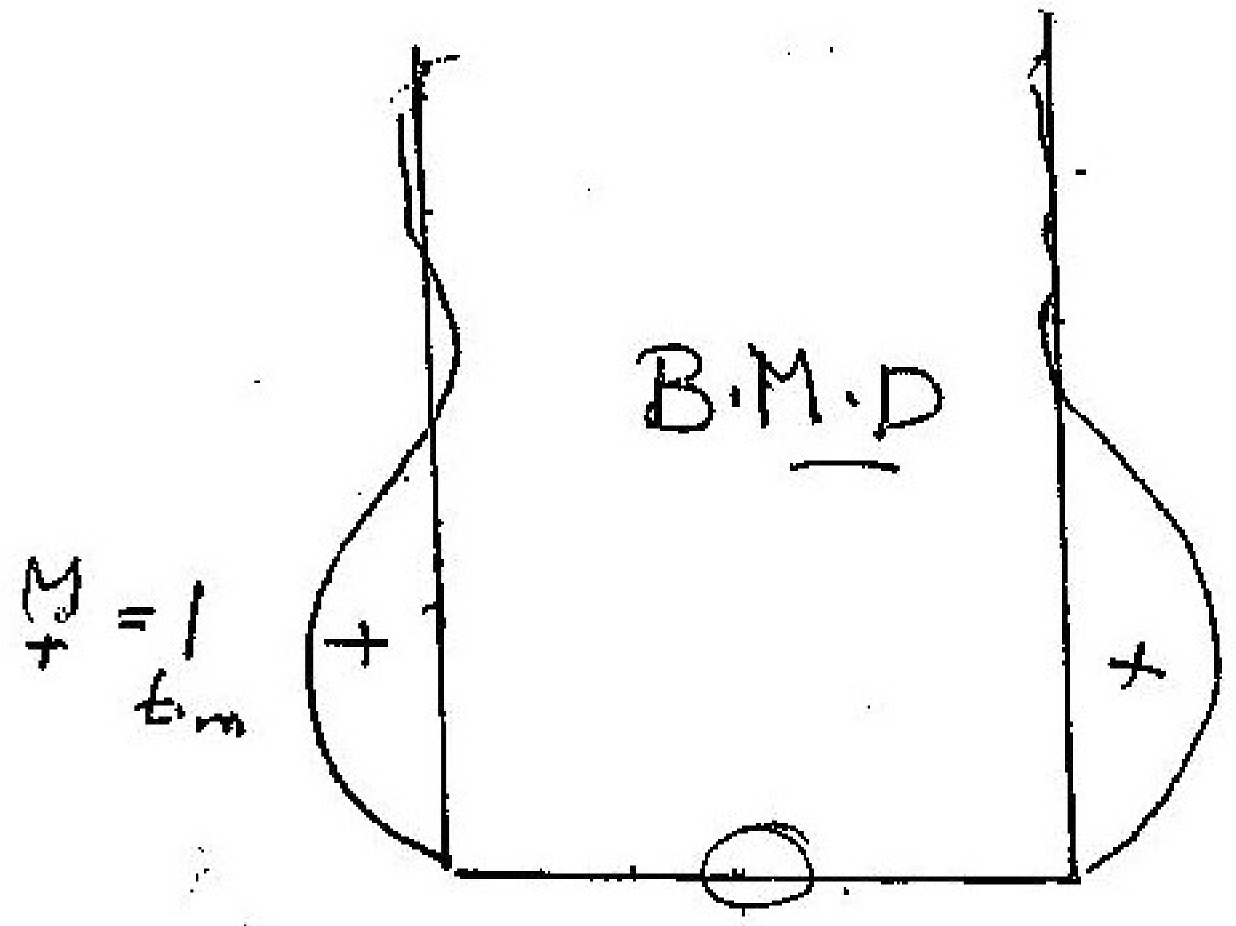


كل الأحمال الموزعة مركزة بترتكز على نفسها ولا تعمل عزوم

⇓

Rocky soil.





$$G = t_{wall} \cdot H_{wall} \cdot \gamma_{R.C}$$ (وزن كل حائط)

$$= 0.25 * 10 * 2.5 = 6.25\ t/m$$

Design :

(1) Ring direction :

$T_{max} = 36 \ t/m$

Stage (1) : $t = \xi \cdot T_{max} = 0.6 * 36$

$= 21.6$

$\therefore t = 25 \ cm$

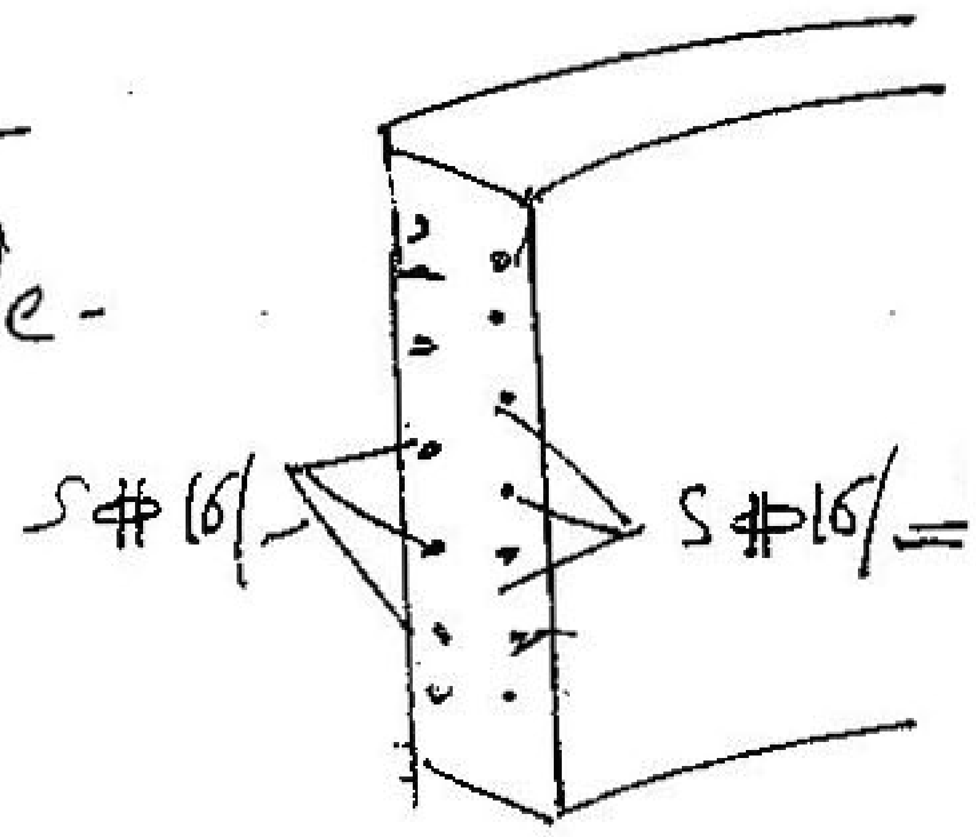
Stage (2)

$T_u = 1.5 \ T = 54 \ t/m$

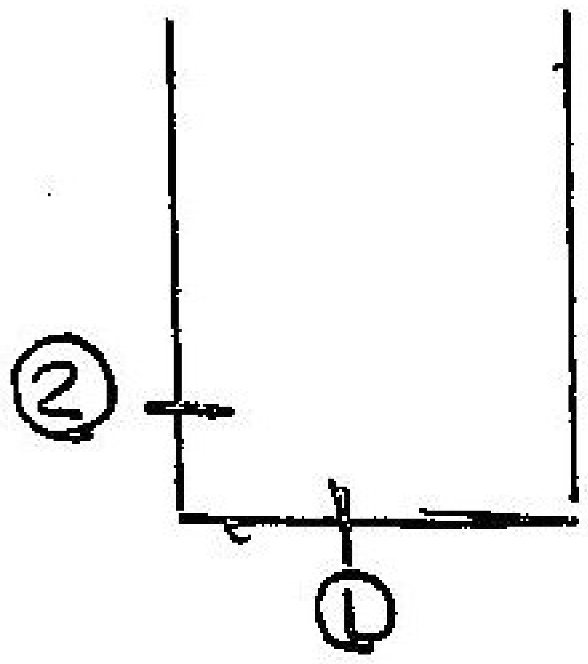
$$A_s = \frac{T_u * 10^3}{2(f_y/\gamma_s)} = \frac{54 * 10^3}{2\left(\frac{3600}{1.15}\right)}$$

$A_s = 8.9 \ cm^2/m$

$\therefore$ use $5 \# 16 / m$ each side.



VL. direction



Sec (1) ;

$T_{only} = 3.9$ t/m

stage (1) $t = \xi \cdot T =$ صغيرة جداً

∴ use $t_{min} = 20$ cm

Stage (II)

$A_s = \frac{T_u * 10^3}{2 (f_y / \gamma_s)}$ ⟹ Use $A_{s\,min} = 5 \# 10 / m$ each side.

Sec (2) : $M_{air\ side} = 1$ t.m و $N =$ neglected ضعيف

⇓

Stage (II) مباشرة

$t = 25$ cm

$d = 20$ cm

$R_1 = \frac{M_u}{f_{cu} \cdot b \cdot d^2} = \frac{1 * 1.5 * 10^5}{250 * 100 * 20^2}$ (ultimate للتوصيل)

$= 0.015$

∴ $\omega = 0.02$

$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d = 0.02 * \frac{250}{3600} * 100 * 20$$

$$= 4 \ cm^2/m$$

$$A_{s_{min}} = \frac{0.15}{100} * 100 * 20 = 3 \ cm^2/m$$

$\therefore$ use $6 \# 10/m$

(حديد طولى خارجى) ناحية الضغط

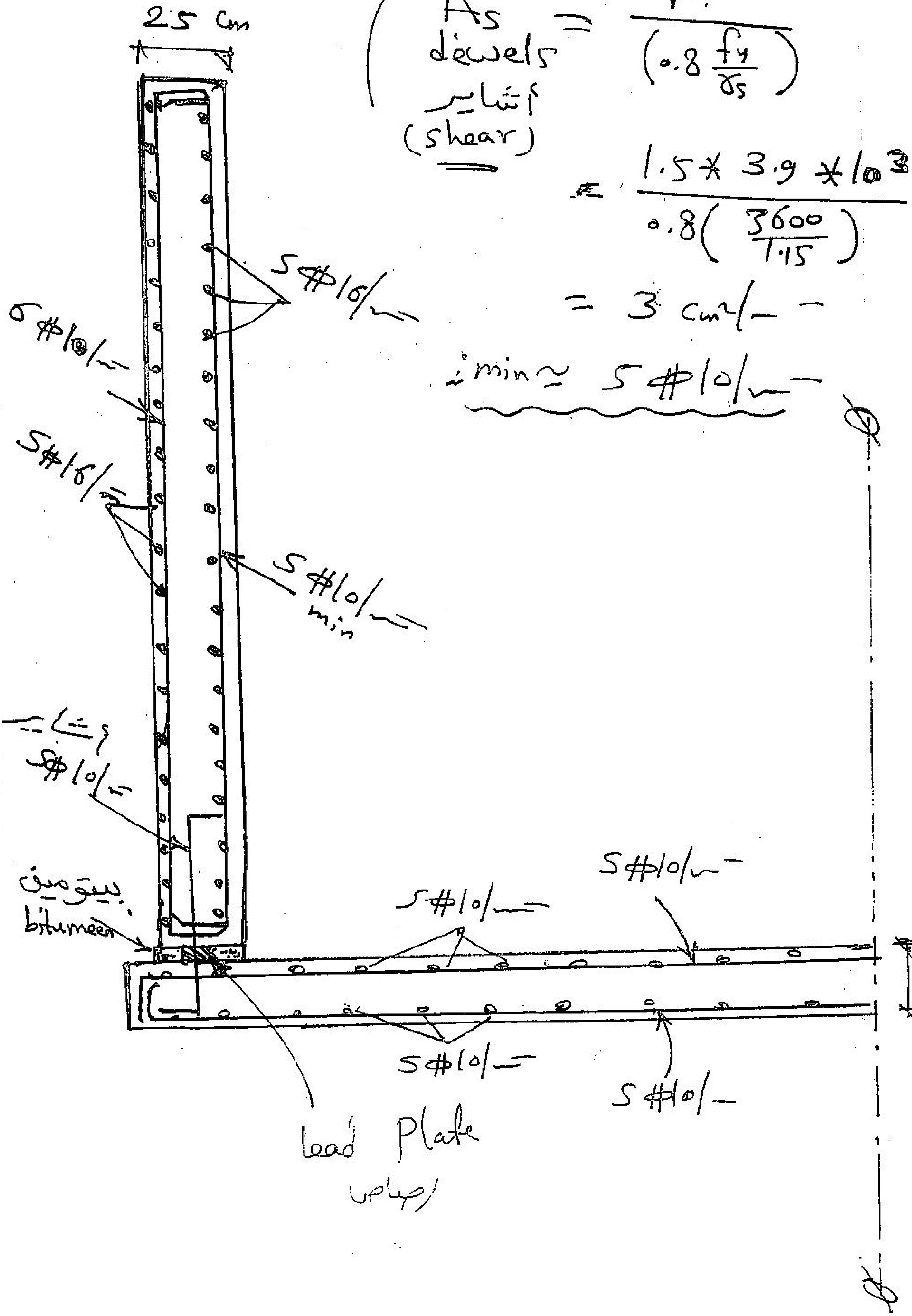
——————————

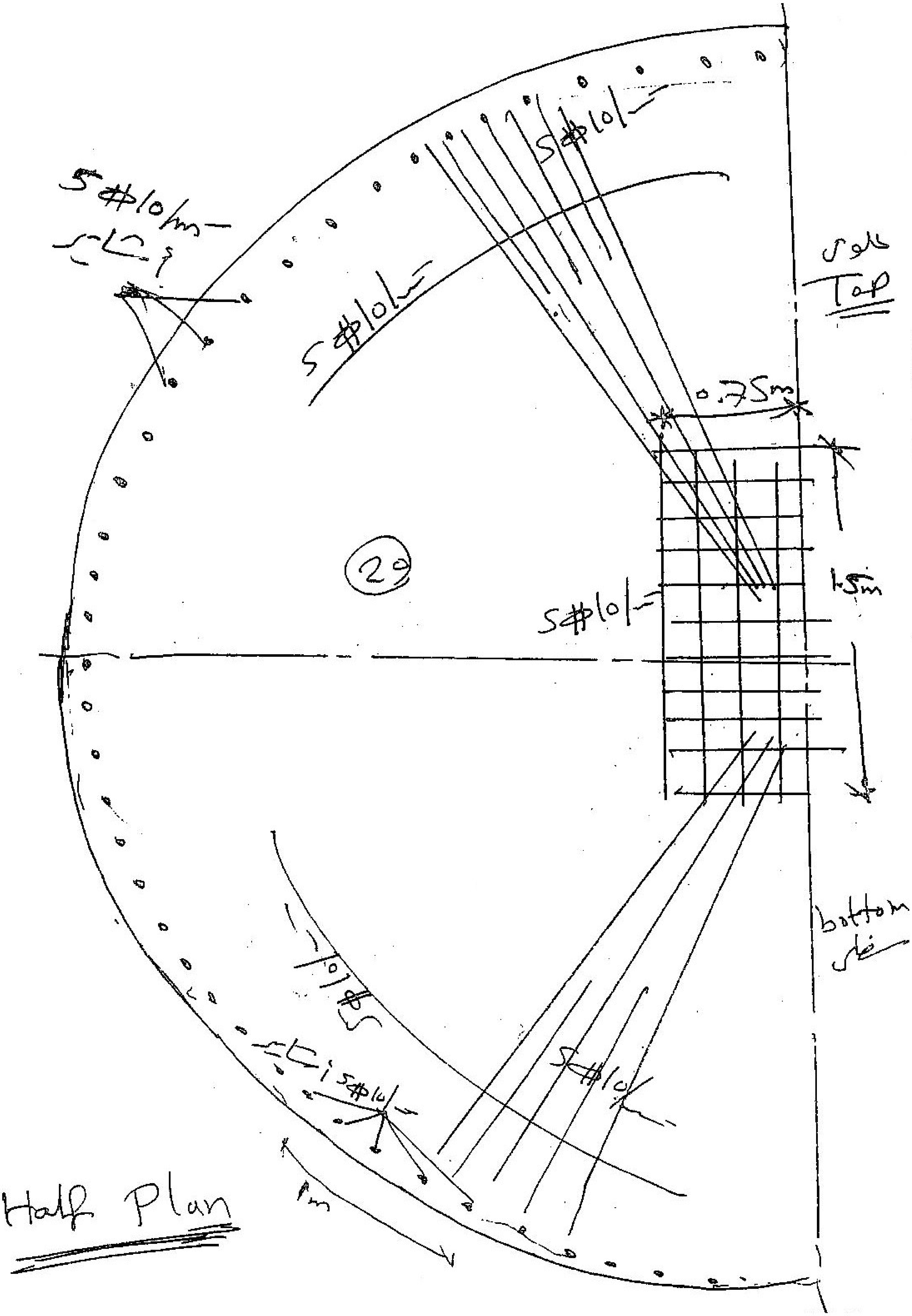
$$A_s \text{ dowels (اشاير) (shear)} = \frac{V_u}{\left(0.8\,\frac{f_y}{\gamma_s}\right)} \qquad V_u \rightarrow \text{shear} * 1.5$$

$$= \frac{1.5 * 3.9 * 10^3}{0.8\left(\frac{3600}{1.15}\right)}$$

$$= 3\ \text{cm}^2/\text{m}$$

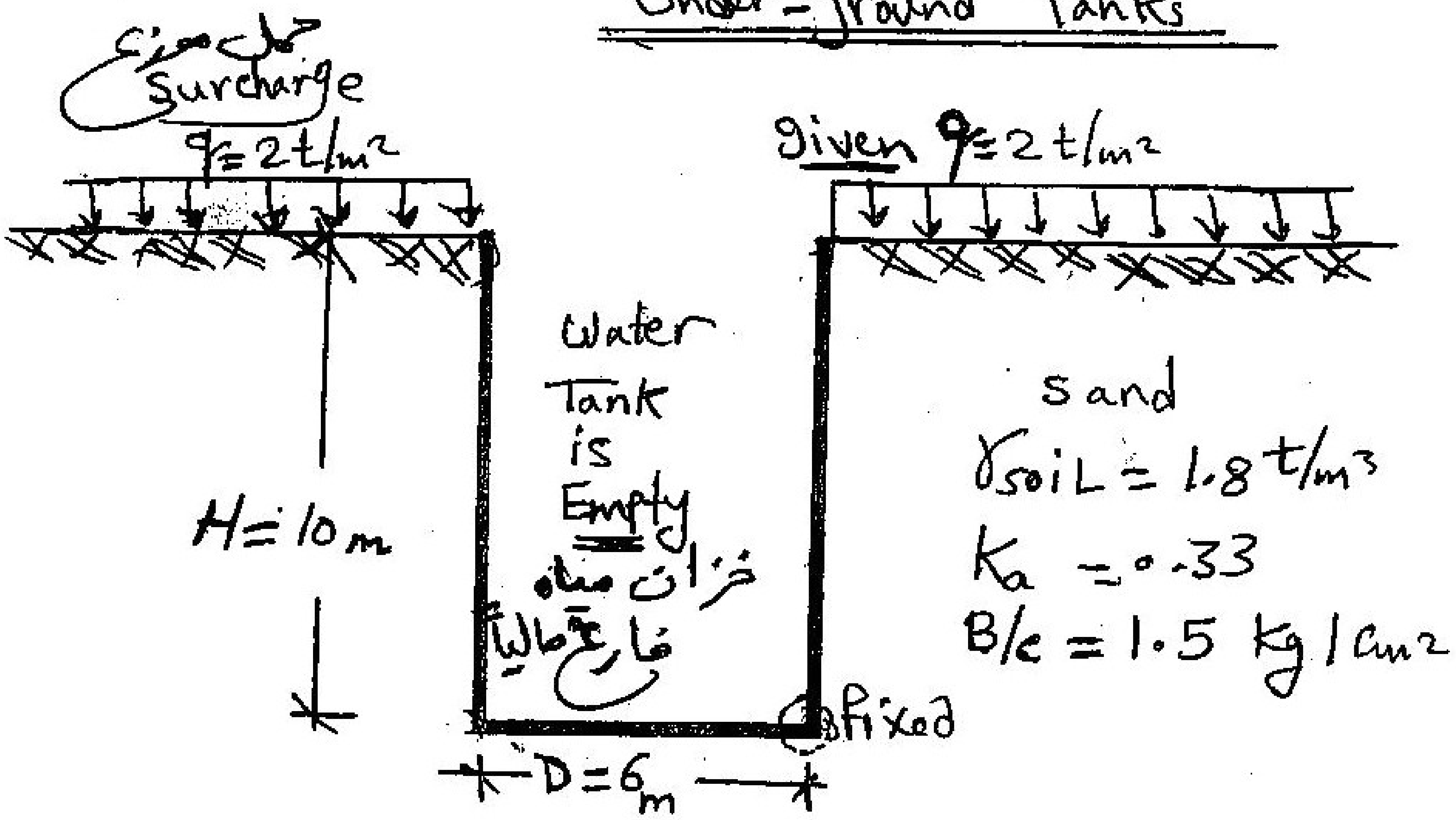
$$\therefore \text{min} \simeq 5\#10/\text{m}$$




5Φ10/m
5Φ10/
5Φ10/
0.75m
1.5m
5Φ10/
29
Top
bottom
5Φ10/
5Φ10/
Half Plan

Example "Circular Tanks"

Under-ground Tanks



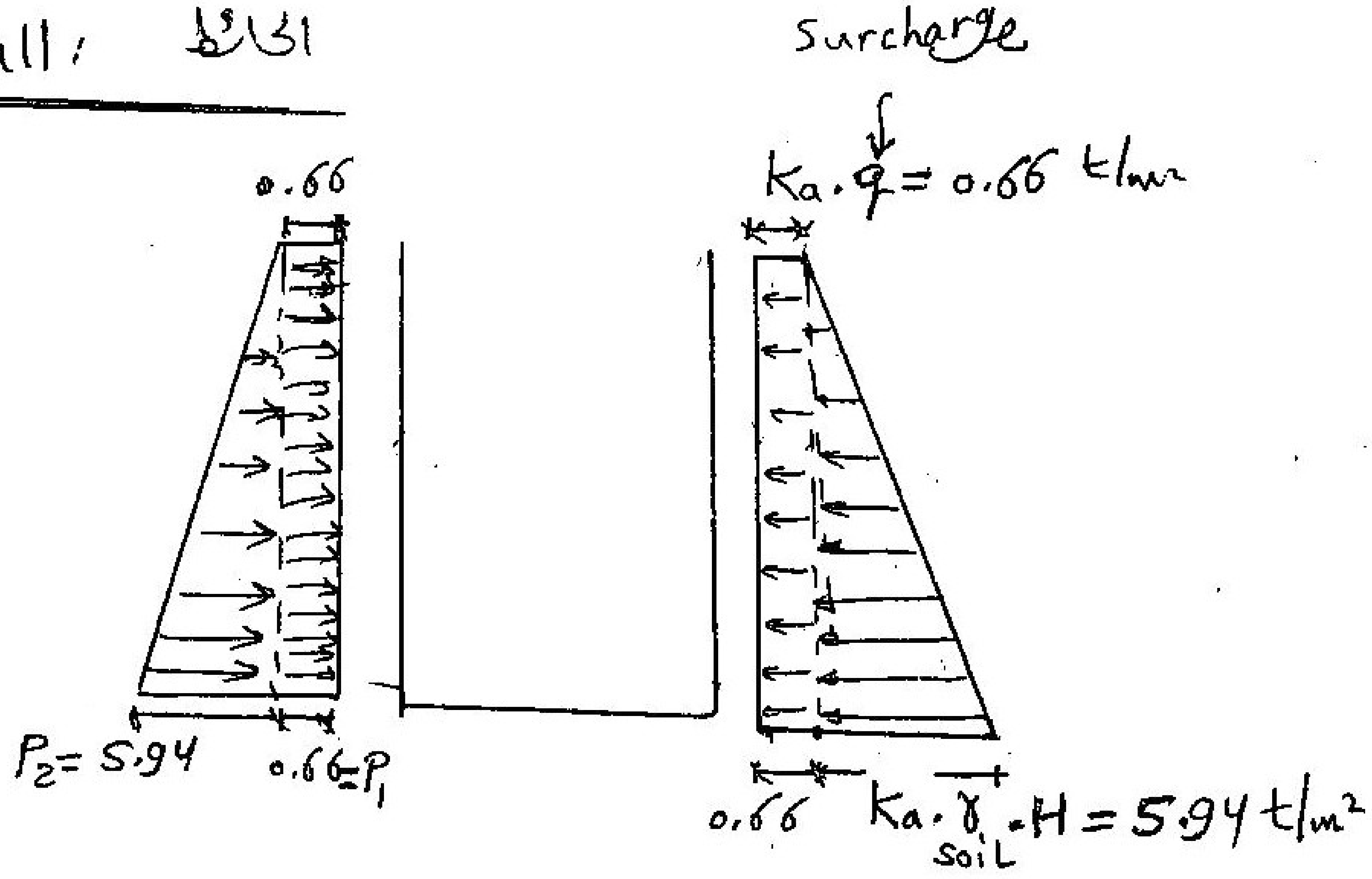
given:
- $f_{cu} = 250\ kg/cm^2$
- $f_y = 3600\ kg/cm^2$
- Tank is empty
- walls are fixed with base

Required:

1. Solve wall to get straining actions using P.C.A method.
2. Solve base and check stress on soil
3. Make equilibrium between wall and base.
4. design critical sections
5. Reinf. details.

Solution:

(1) Wall: الحائط

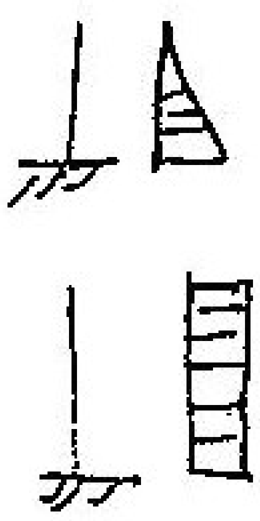
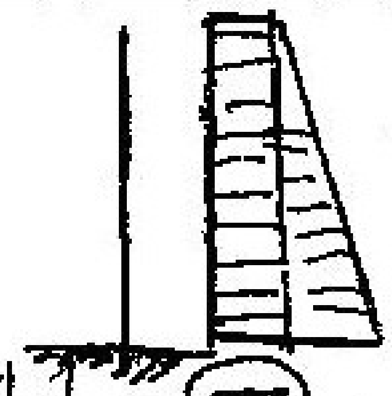
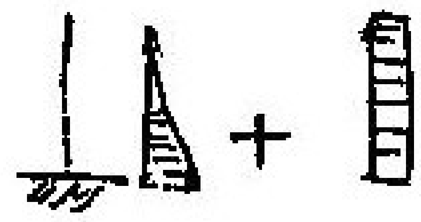


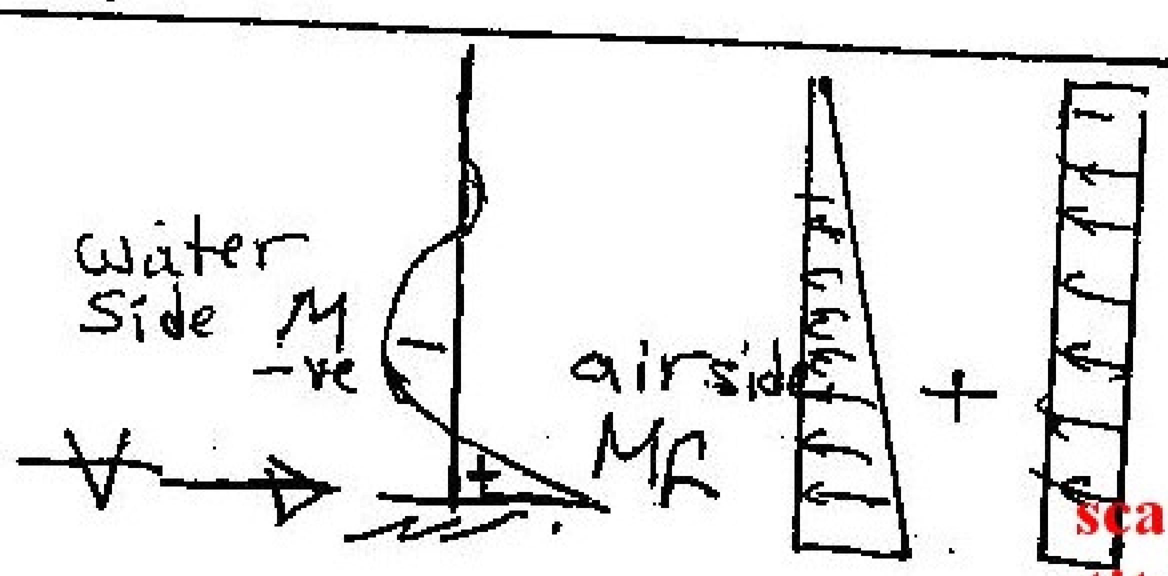
Pressure at wall

assume $t_{wall} = 0.25\ m$

$$\therefore \frac{H^2}{D \cdot t} = \frac{(10)^2}{6 * (0.25)} = 66.6$$

الجداول المستخدمة في الحل : للحائط wall (P.C.A) الجداول كاملة.

Ring Compression	Moments (M_f, M_e)	Shear (V)
table ① + Table ③ (III) 	 table ⑦ + ⑨ (VII, IX)	 table (12) (XII)



Ring Compression:

$$N_{max} = C_o(K_a \cdot \gamma_{soil} \cdot H \cdot R) + C_o(P_1 \cdot R)$$

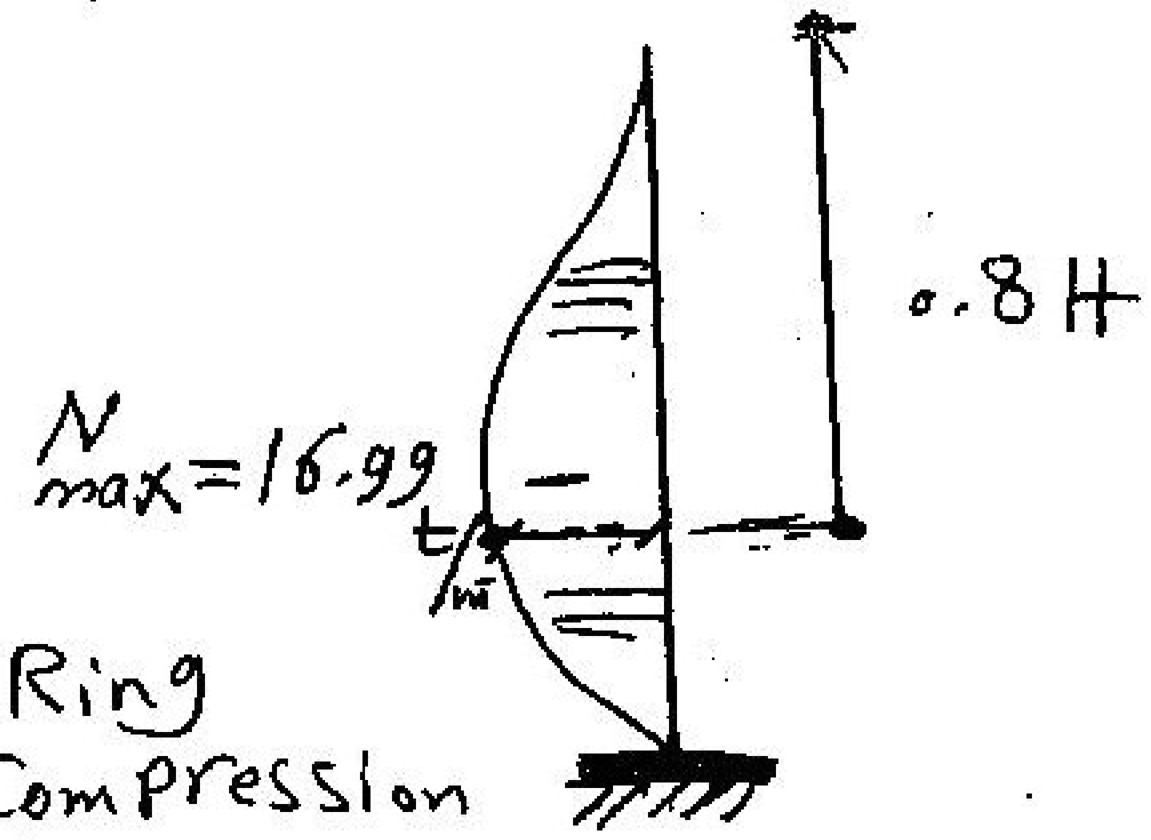
N_{max} Compression in Ring

C_o (first term) → table ① الجدول

C_o (second term) → table ③ الجدول

$$= (0.838 * 0.33 * 1.8 * 10 * 3) + (1.04 * 0.66 * 3)$$

$$= 16.99 \text{ ton}$$



Ring Compression distribution

Moments:

$$M_f = C_o(K_a \cdot \gamma_{soil} \cdot H^3) + C_o(P_1 \cdot H^2)$$

M_f air side at fixed

C_o (first term) → table ⑦

C_o (second term) → table ⑨

ناخذ المعامل (Co) عند (1H)

$$= [0.0023 * 0.33 * 1.8 * (10)^3] + [0.0026 * 0.66 * (10)^2]$$

$$= 1.53 \ t.m/m$$

$$M_{water\ side} = C_o(K_a \cdot \gamma_{soil} \cdot H^3) + C_o(P_1 \cdot H^2)$$

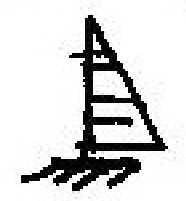
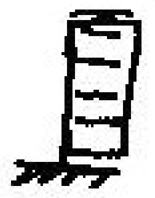
ناخذ أكبر معامل (Co)

$$= 0.0004 * 0.33 * 1.8 * (10)^3 + 0.0005 * 0.66 * (10)^2$$

$$= 0.27 \ t.m/m$$

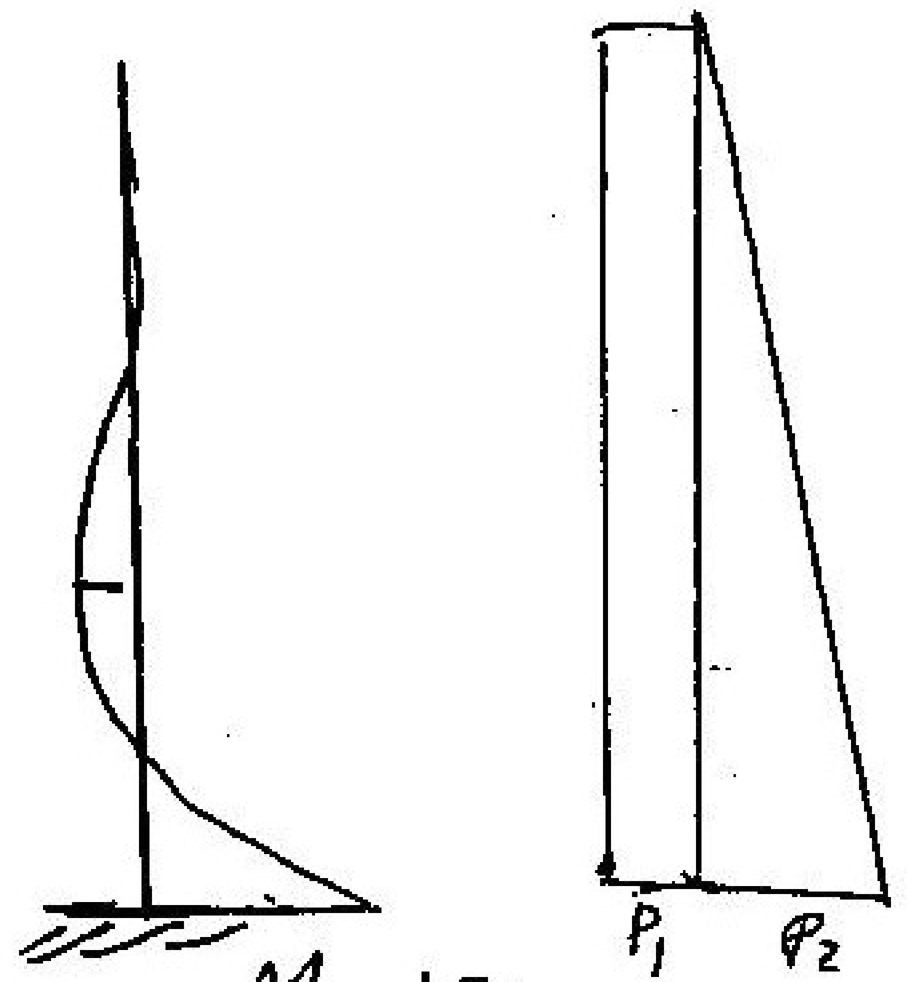
shear ($\forall$) table (12)

$$\forall = C_o\left(K_a \cdot \gamma_{soil} \cdot H^2\right) + C_o\left(P_1 \cdot H\right)$$

$$= 0.067 * \left(0.33 * 1.8 * (10)^2\right) + 0.074 * 0.60 * 10$$

$$= 4.4 \ t/m$$



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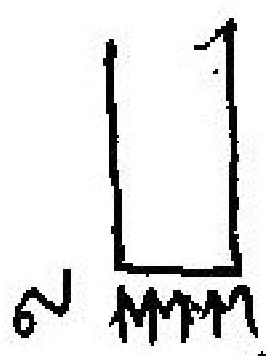
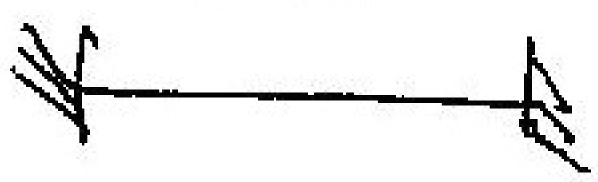
(2) Base rested on medium soil (Sand)



$B/c = 1.5 \ kg/cm^2$

$\therefore B/c = 15 \ t/m^2$

$\because D/H < 1.5 \Longrightarrow$ القاعدة كلها على uniform stress



(A) Check stress on soil.

وزن الحائط $G = t_{wall} \cdot H_{wall} \cdot \gamma_{R.c}$ t/m

$= 0.25 * 10 * 2.5 = 6.25 \ t/m$

$$\sigma_{on\ soil} = \left(t_{base} \cdot \gamma_{R.c}\right) + \left(G * \frac{2}{R}\right)$$

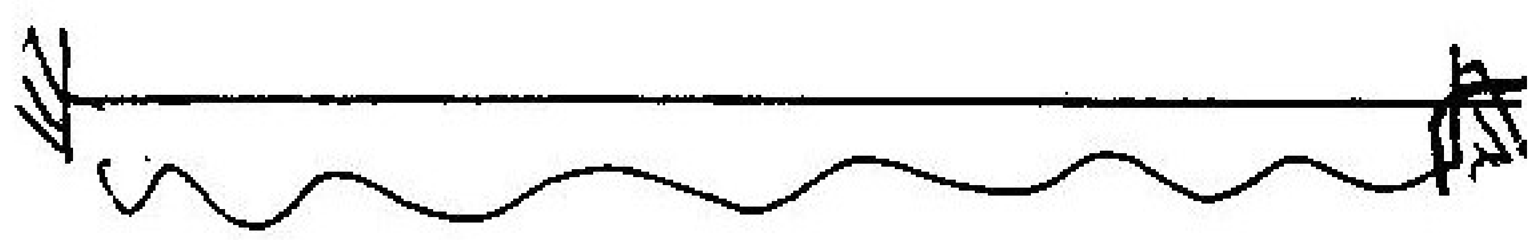
صبة وزن مياه بيطلع فوق الأساس .

$\therefore \sigma_{\text{on soil}} = (0.3 * 2.5) + (6.25 * \frac{2}{3})$

$= 4.91\ t/m^2 < B/C = 15\ t/m^2$

Safe

(B) Moments at Base: → Mr, Mt



العزم م القاعدة
دائما تكون
من تأثير الخارج فقط

$\omega_{net} = G * 2/R$

$= (6.25 * \frac{2}{3})$

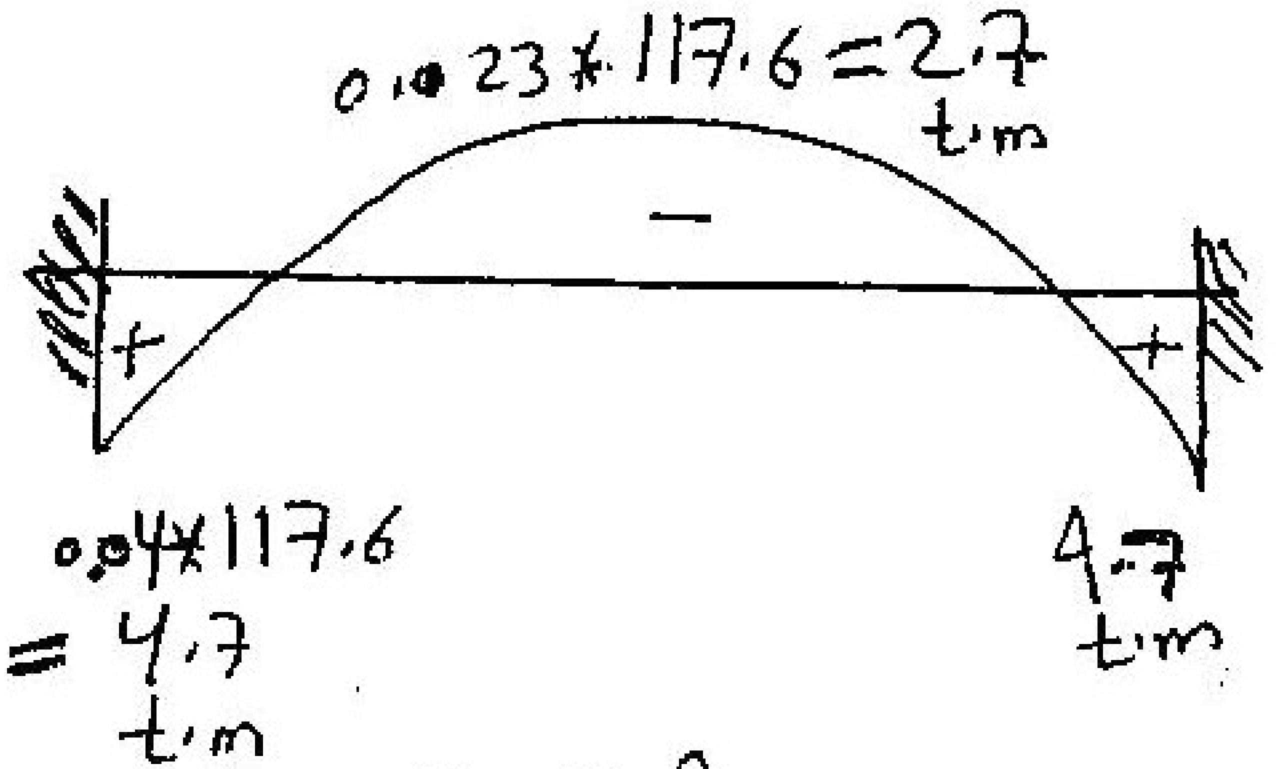
$= 4.16\ t/m^2$

$\therefore P = \omega_{net} * \text{Area} = 4.16 * \pi * (3)^2$ (πR^2)

تأثير كل ω_{net}

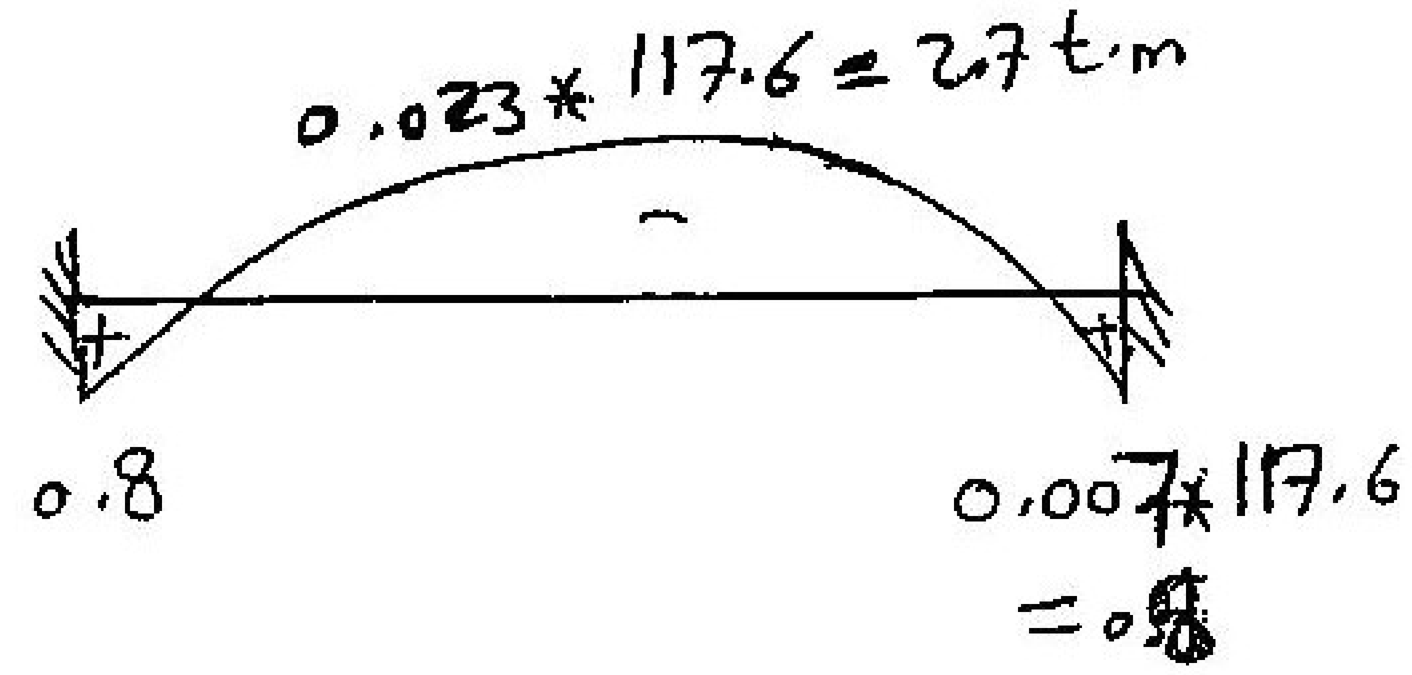
$\therefore P = 117.6$ ton

$\therefore$ **Mr**



Radial moment

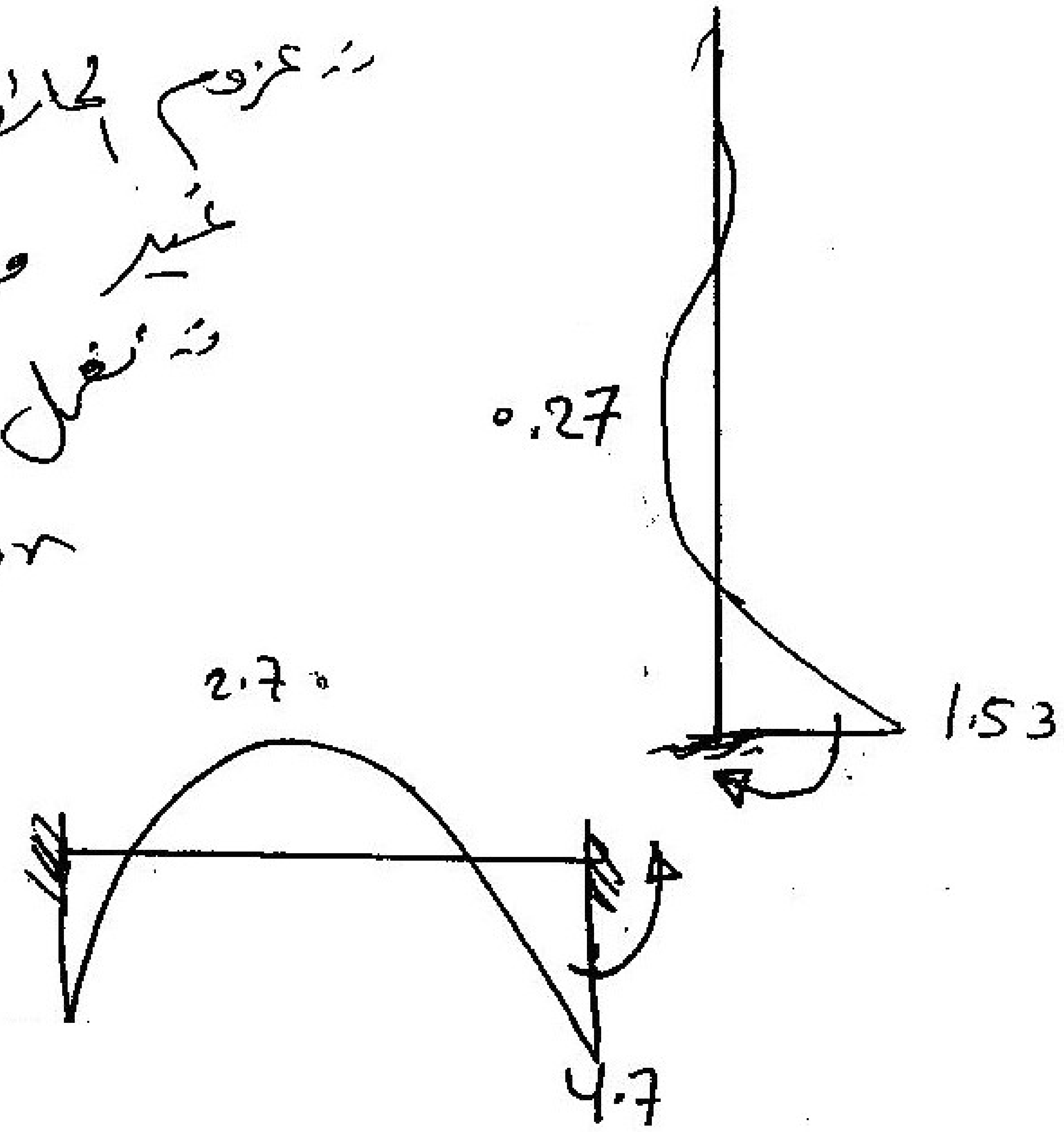
Mt



tangential Moments

∴ عزوم الحائط مع القاعدة غير متزنة .

∴ نعمل Moment distribution



Stiffness

$$K_{base} = \frac{0.104 E t^3}{R} = \frac{0.104 * E * (0.3)^3}{3} = 9.36 * 10^{-4}$$

$$K_{wall} = \frac{C_o \cdot E t^3}{H} = \frac{2.4\ E (0.25)^3}{10} = 3.75 * 10^{-3}$$

$$\therefore D.F_{base} = \frac{9.36 * 10^{-4}}{(9.36 * 10^{-4} + 3.75 * 10^{-3})} = 0.2$$

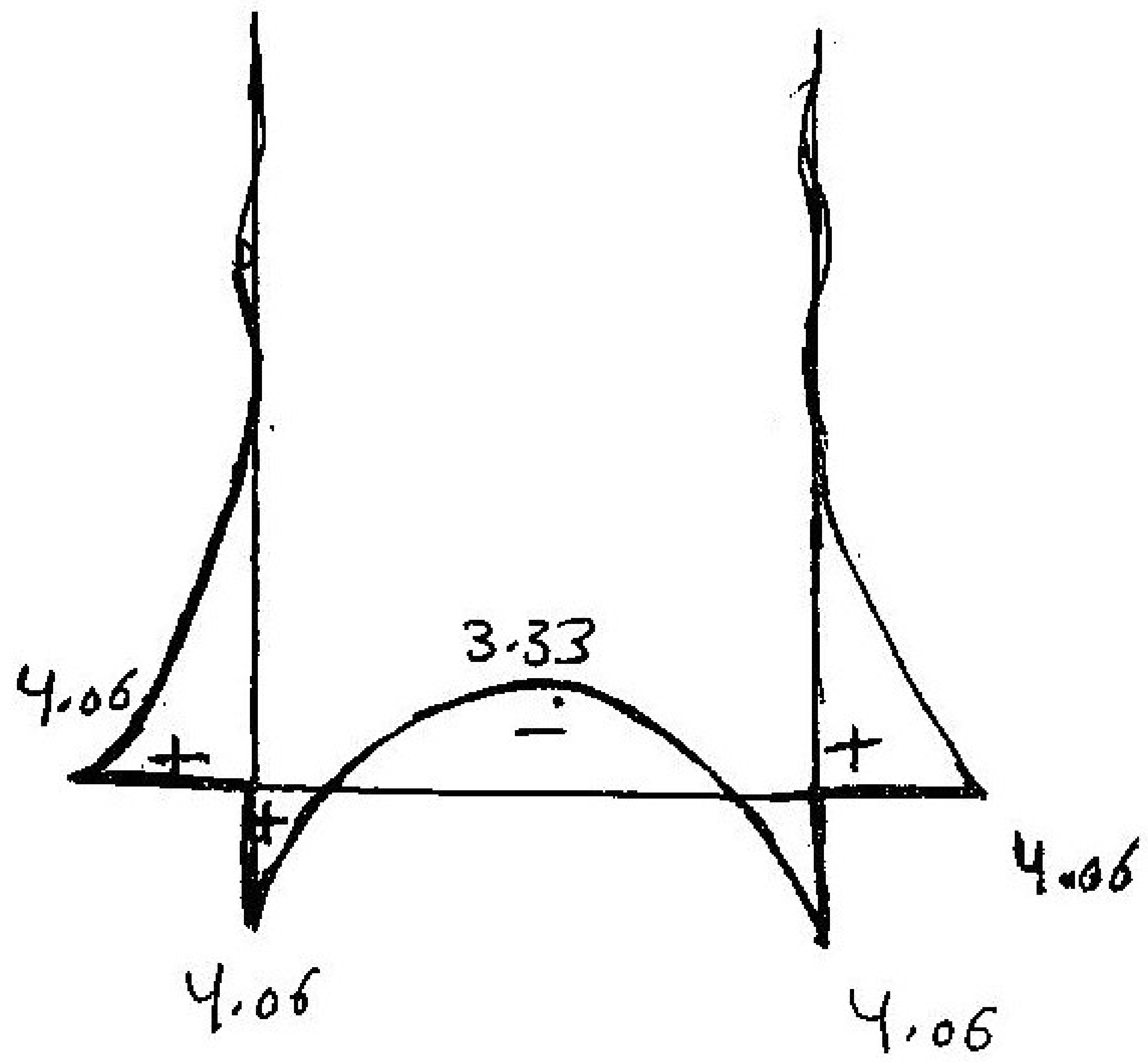
$$\therefore D.F_{wall} = 1 - D.F_{base} = 0.8$$

---

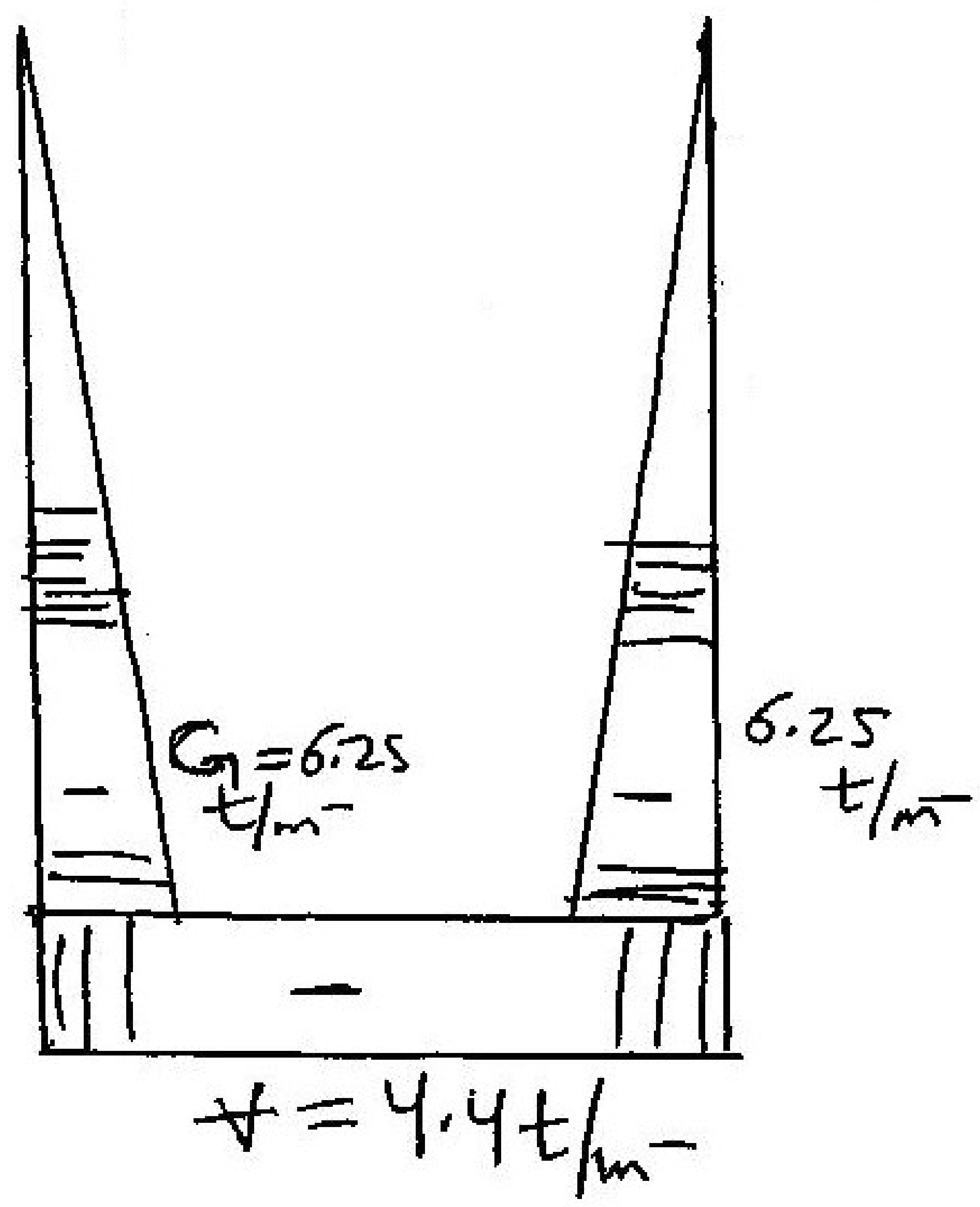
equilibrium of moments اتزان العزوم

	D.f = 0.8 Wall	D.f = 0.2 Base.
Fixed moment	−1.53	4.7
D.M	−2.536	−0.634
final moments	−4.06	+4.06

∴ كل عزوم القاعدة ترتفع لأعلى بمقدار $\Delta M = (0.634)$



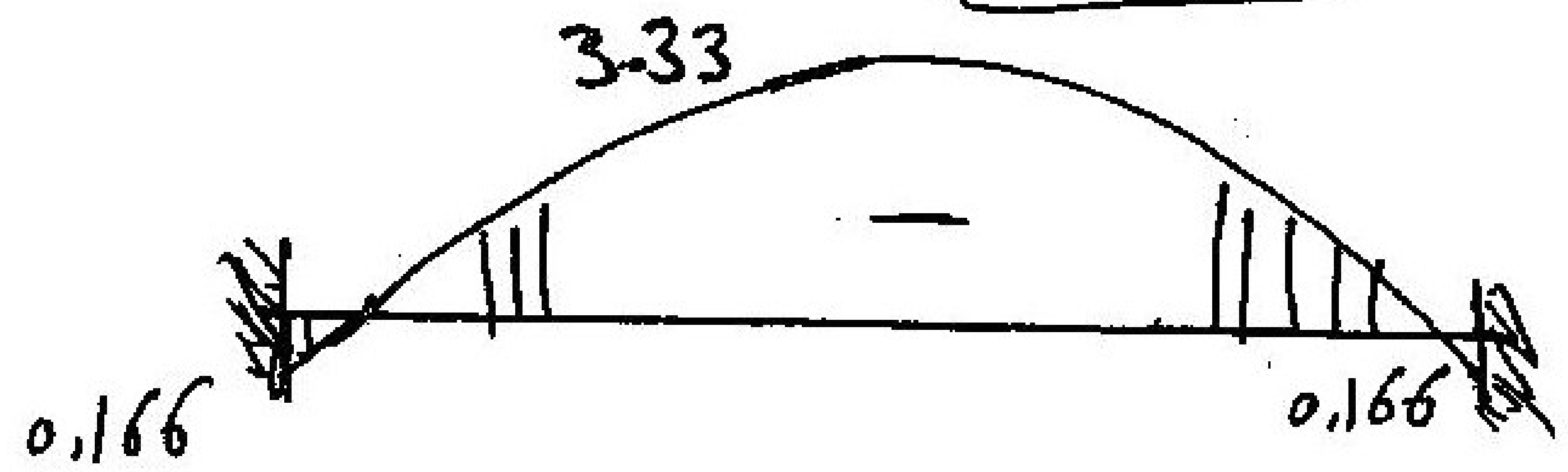
Moments



Normal force.

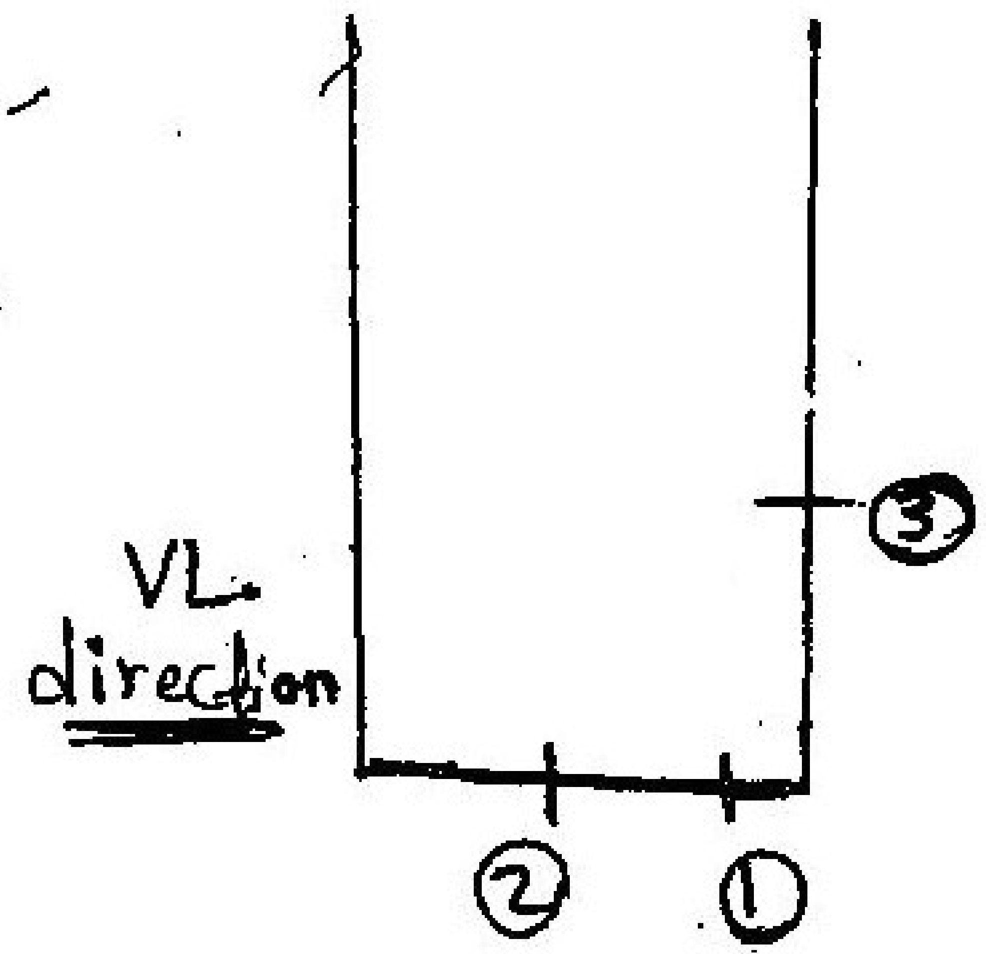
نقوم بتعديل الـ (Mt) أيضاً برفع قيم العزوم لأعلى

بمقدار **0.634**



Design of sections :

- يجب أن نراعي أن الخزان مخصص أساساً للمياه لكن من هذا الوقت هو فارغ فغير مسموح بحدوث شروخ ناحية المياه



(1) Ring direction :

$$N_{max} = 16.99 \text{ ton}$$
Compression

stage II مباشرة

Z_o = min نأخذ تخانة

ويمكن تصميم هذا القطاع بمعادلة تصميم الأعمدة :

$$P_u = 0.35 f_{cu} . A_c + 0.67 f_y . A_s$$

$\therefore P_u = 1.5 * N = 1.5 * 16.99 = 25.48$ ton

$\therefore 25.48 * 10^3 = 0.35 * 250 * (100 * 20) + 0.67 * 3600 * A_s$ ($A_c = B * t$)

$\therefore A_s = -Ve$

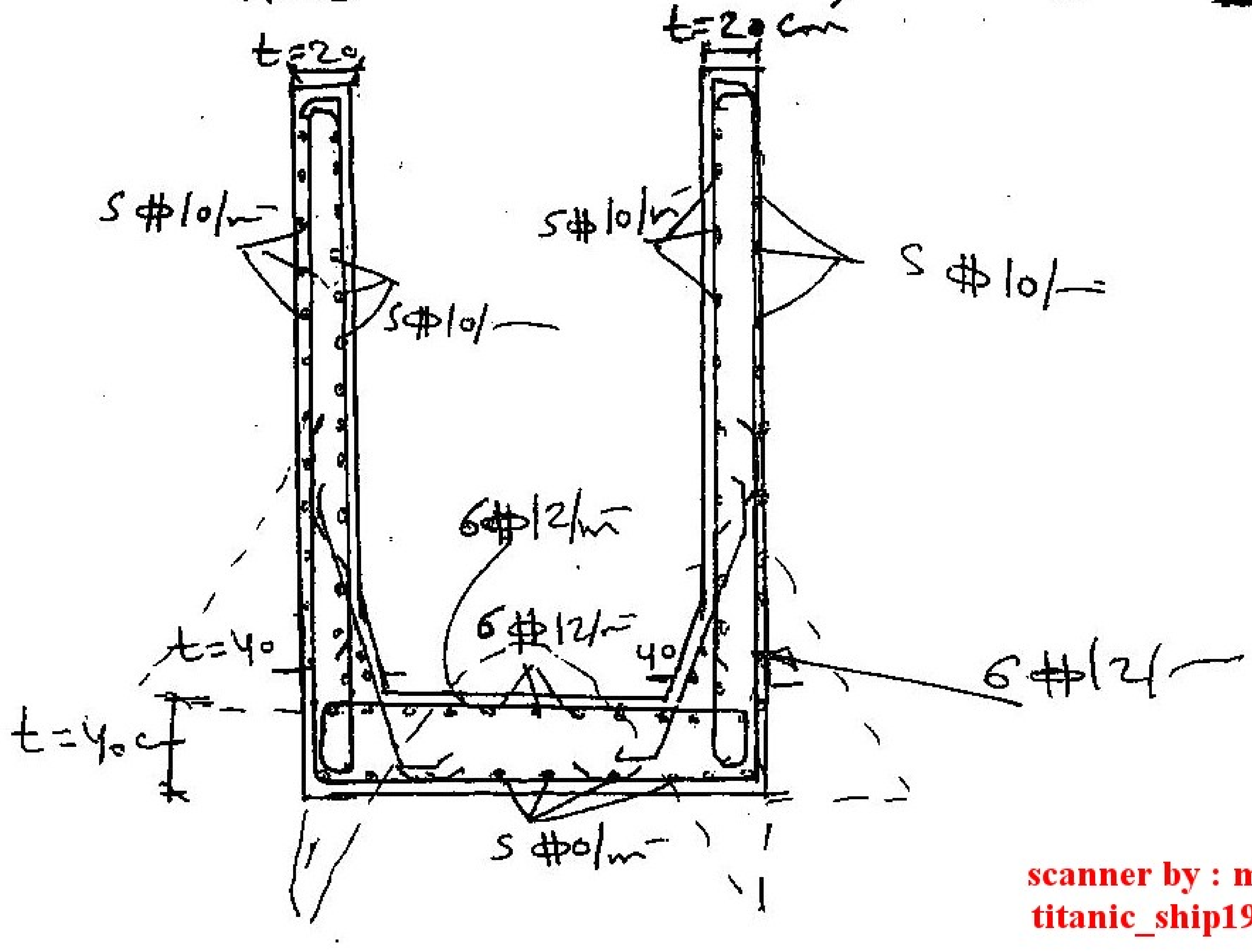
$\therefore$ Use $A_{s_{min}} = 5\Phi 10/m$ **each side**

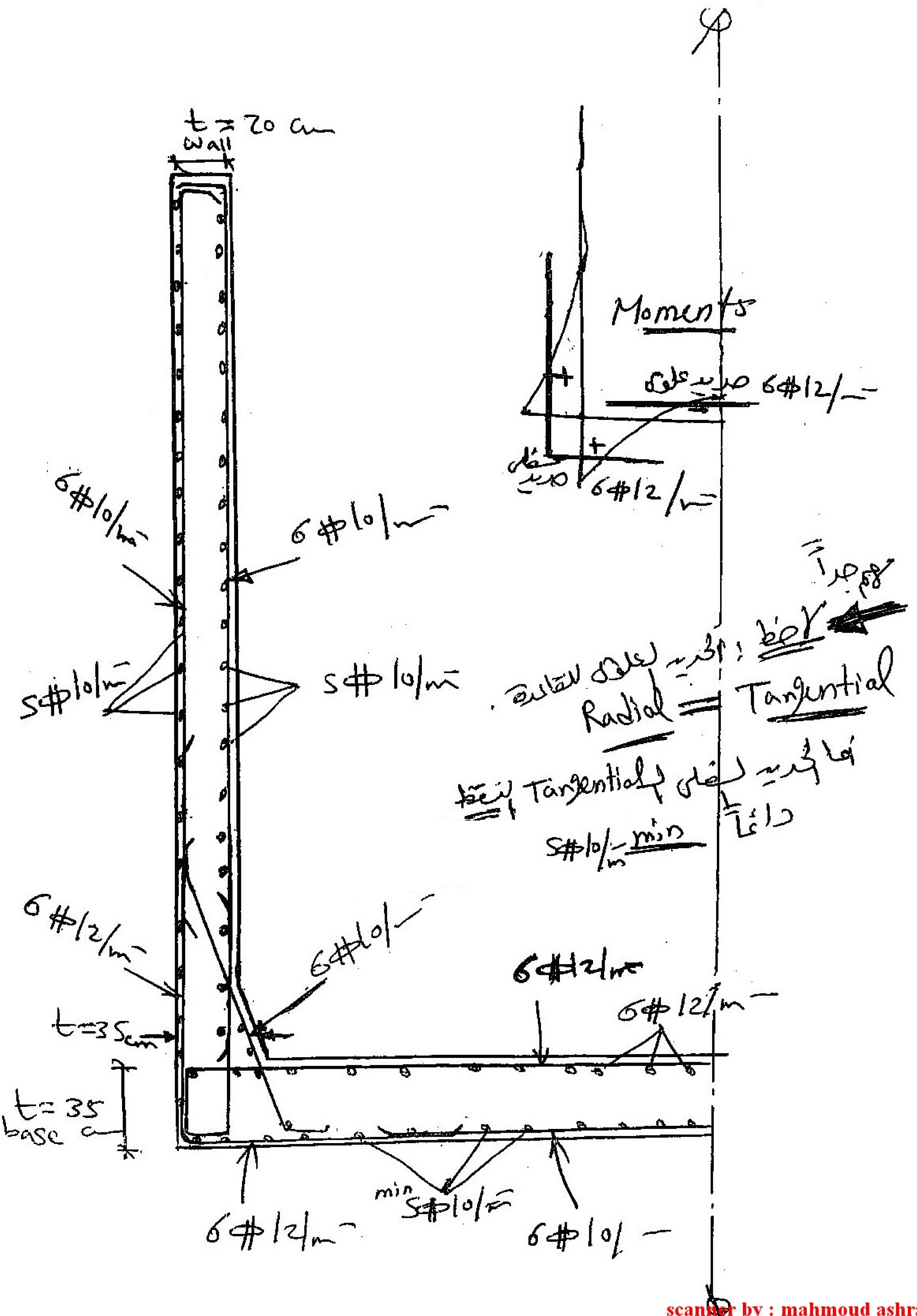
VL. direction

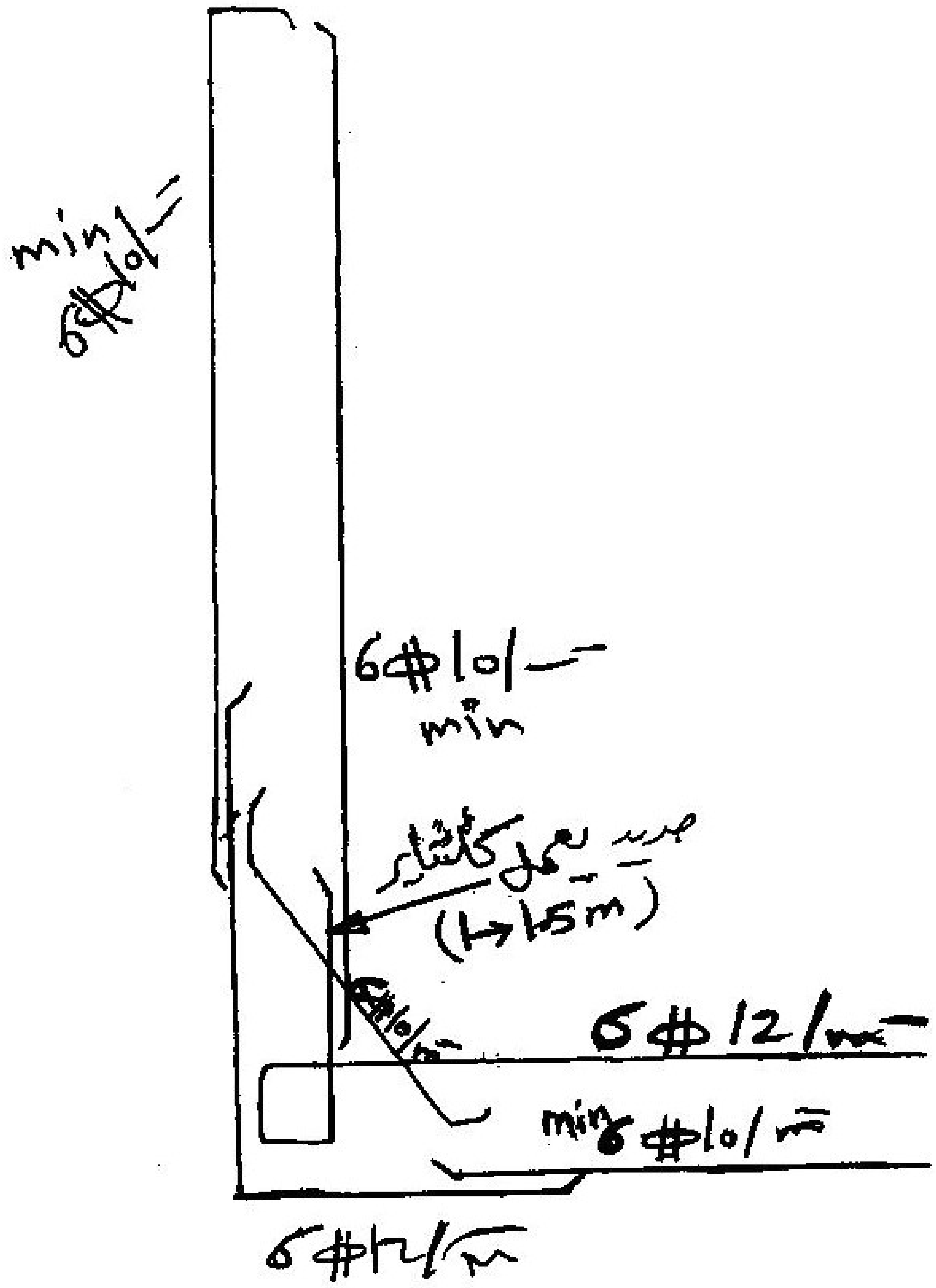
Sec ② $(M_{water\ side} + N_{compression}) \Rightarrow t = 35$ cm, $A_s = 5\Phi 12/m$

Sec ① $(M_{air\ side} + N_{compression}) \rightarrow t = 35$ cm from ②, $\Rightarrow A_s = 6\Phi 12/m$

Sec ③ $(M_{reverse} + N_{compression}) \rightarrow$ use $5\Phi 10/m$ min $t = 20$ cm




t = 20 cm
Wall
Moments
صديد علوي 6#12/m
صديد سفلي
6#12/m
6#10/m
6#10/m
مهم جداً
لاحظ: الحديد العلوي للقاعدة
Radial = Tangential
أما الحديد السفلي Tangential يتبع
دائماً
5#10/m min
5#10/m
5#10/m
6#12/m
6#10/m
6#12/m
6#12/m
t = 35 cm
t = 35 cm
base
6#12/m
min 5#10/m
6#10/m



تم عمل Haunch هناك كان ليس بسبب العزم الـ (water side)

ولكن لأن العزم الـ air side كبير = 4.06 t.m

⇐ أخذنا تخانة الحائط من أسفل مثل الحالة -

$t = 35\,cm$

مثل القطاع sec ①

ثم نصغرها بعد ذلك = 20 سم

Table XIII. Supplementary coeff. for values of H^2 / Dt Greater than 16 *:
(Extension of Tables I to XII)

H^2 / Dt	Coeff. at point					Coeff. at point				
	Table I					*Table II*				
	.75H	.80H	.85H	.90H	.95H	.75H	.80H	.85H	.90H	.95H
20	+0.716	+0.654	+0.520	+0.325	+0.115	+0.812	+ 0.817	+ 0.756	+0.603	+ 0.344
24	+0.746	+0.702	+0.577	+0.372	+0.137	+0.816	+ 0.839	+ 0.793	+0.647	+ 0.377
32	+0.752	+0.768	+0.663	+0.459	+0.182	+0.814	+ 0.861	+ 0.847	+0.271	+ 0.436
40	+0.800	+0.905	+ 0.731	+0.530	+0.217	+0.802	+ 0.866	+ 0.880	+0.778	+ 0.483
48	+0.791	+0.828	+ 0.785	+0.593	+0.254	+0.791	+ 0.864	+ 0.900	+0.820	+ 0.527
56	+0.763	+0.838	+ 0.824	+0.636	+0.285	+0.781	+ 0.859	+ 0.911	+0.852	+ 0.563
	Table III					*Table IV*				
	.75H	.8[illegible]	.85H	.90H	.95H	.75H	.80H	.85H	.90H	.95H
20	+0.919	+0.825	+0.519	+0.379	+0128	+1.062	+1.017	+0.906	+0.703	+ 0.394
24	+0.986	+0.879	+0.694	+0.450	+0.149	+1.066	+1.039	+0.943	+0.747	+ 0.427
32	+1.026	+0.953	+0.788	+0.519	+0.189	+1.064	+1.061	+0.997	+0.821	+ 0.486
40	+1.040	+0.996	+ 0.859	+0.591	+0.226	+1.052	+1.066	+1.030	+0.878	+ 0.533
48	+1.043	+1.022	+ 0.911	+0.652	+0.262	+1.041	+1.064	+1.050	+0.920	+ 0.577
56	+1.040	+1.035	+ 0.949	+0.705	+0.294	+1.021	+ 1.059	+ 1.061	+0.952	+ 0.613
	Table V					*Table VI*				
	.00H	.05H	.10H	.15H	.20H	.75H	.80H	.85H	.90H	.95H
20	-16.44	-9.98	- 4.90	-1.59	+0.22	+15.30	+25.9	+36.9	+43.3	+ 35.3
24	-18.04	-10.34	-4.54	-1.00	+0.68	+13.20	+25.9	+40.7	+51.8	+45.3
32	-20.59	-10.72	-3.20	- 0.04	+1.26	+ 8.10	+23.2	+45.9	+65.4	+ 63.6
40	-23.34	-10.86	-2.86	+0.72	+1.56	+3.28	+19.2	+46.5	+77.9	+83.5
48	- 25.52	-10.82	-2.06	+1.26	+1.66	- 0.70	+14.1	+45.1	+87.2	+103.0
56	- 27.54	-10.68	- 1.36	+1.60	+1.62	- 3.40	+9.2	+42.2	+94.0	+121.0
	Table VII					*Table VIII*				
	.80H	.85H	.90H	.95H	1.00H	.75H	.8[illegible]	.85H	.90H	.95H
20	+.0015	+.0014	+.0005	-.0018	-.0063	+.0008	+ .0014	+ .0020	+.0024	+ .0020
24	+.0012	+.0012	+.0007	-.0013	-.0053	+.0005	+ .0010	+ .0015	+.0020	+ .0017
32	+.0007	+.0009	+ .0007	-.0008	-.0040	.0000	+ .0005	+ .0009	+.0014	+ .0013
40	+.0002	+.0005	+.0006	-.0005	-.0032	.0000	+ .0003	+ .0006	+.0011	+ .0011
48	.0000	+.0001	+ .0006	-.0003	-.0026	.0000	+ .0001	+ .0004	+.0008	+ .0010
56	.0000	.0000	+ .0004	-.0001	-.0023	.0000	.0000	+ .0003	+.0007	+ .0008
	Table IX					*Table X*				
	.80H	.85H	.90H	.95H	1.00H	.05H	.10H	.15H	.20H	.25H
20	+.0015	+.0013	+.0002	-.0024	-.0073	+0.032	+0.039	+0.033	+0.023	+ 0.014
24	+.0012	+.0012	+.0004	-.0018	-.0061	+0.031	+0.035	+0.028	+0.018	+ 0.009
32	+.0008	+.0009	+.0006	-.0010	-.0046	+0.028	+0.029	+0.020	+0.011	+ 0.004
40	+.0005	+.0007	+.0007	-.0005	-.0037	+0.026	+0.025	+0.015	+0.006	+ 0.001
48	+.0004	+.0006	+.0006	-.0003	-.0031	+0.024	+0.021	+0.011	+0.003	0.000
56	+.0002	+.0004	+.0005	-.0001	-.0026	+0.023	+0.018	+0.002	+0.002	0.000
	Table XI					*Table XII*				
	.80H	.85H	.90H	.95H	1.00H	Tri. Fixed	Rect. Fixed	T. or R. Hinged	Mom. at Edge	
20	-0.015	+0.095	+0.296	+0.606	+1.000	+0.114	+0.122	+ 0.062	-8.30	
24	- 0.037	+0.057	+0.250	+0.572	+1.000	+0.102	+0.111	+ 0.055	-8.94	
32	- 0.062	+0.002	+0.178	+0.515	+1.000	+0.089	+0.096	+ 0.048	-10.36	
40	- 0.067	-0.031	+0.325	+0.467	+1.000	+0.080	+0.086	+ 0.043	-11.42	
48	- 0.064	-0.049	+0.081	+0.424	+1.000	+0.072	+0.079	+0.039	-12.56	
56	- 0.059	-0.060	+ 0.048	+0.387	+1.000	+0.067	0.074	+ 0.036	-13.76	

* For points not shown in the supplementary tables, ring tension & moment may be determined approximately by sketching curves similar to those in the text.

الفرقة الرابعة مدني

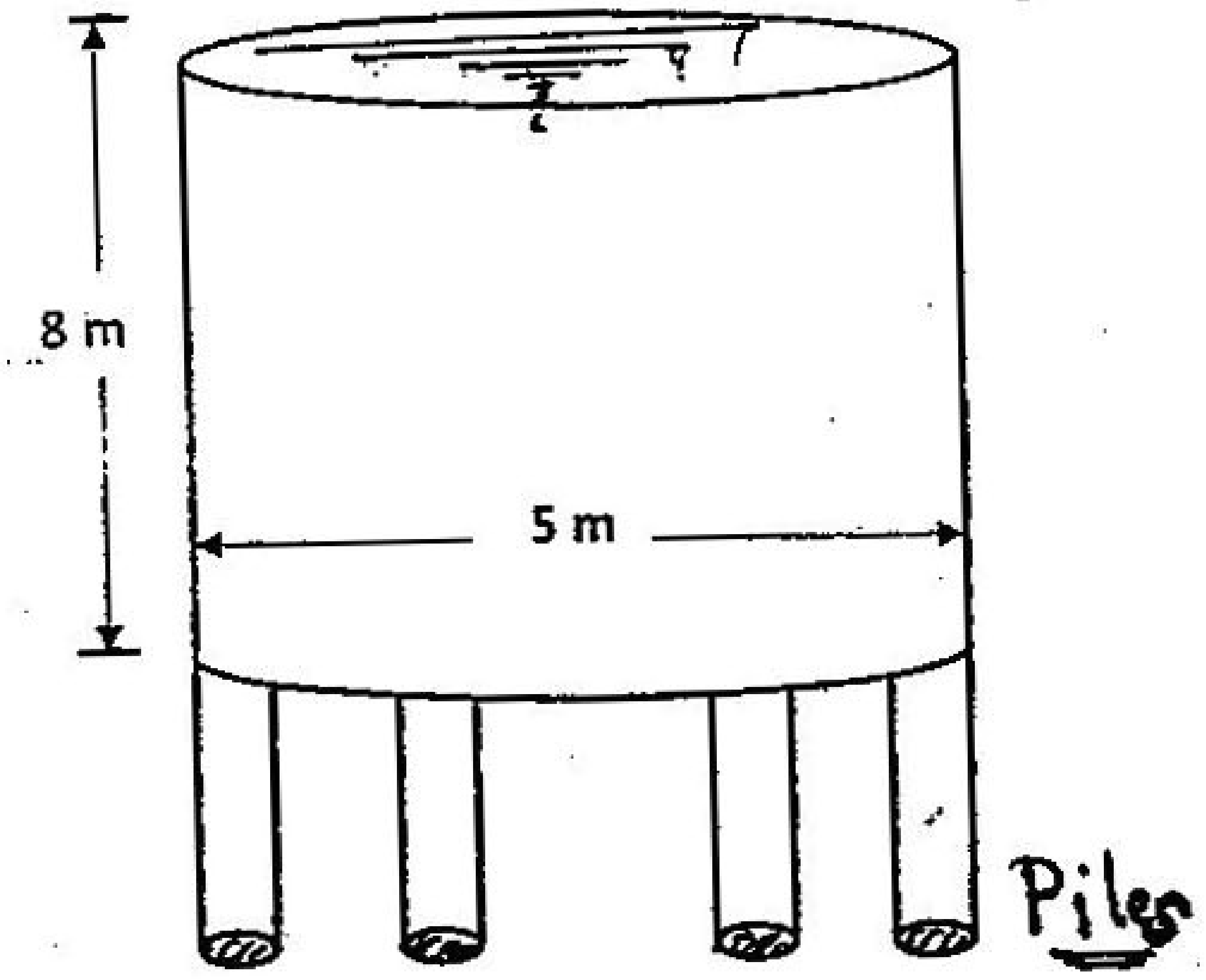
Reinforced Concrete Water tanks

Elevated circular tanks

Mid term 2008

10

The shown fixed circular tank is supported by 6 piles on the outer perimeter. It is required to :



1- Calculate the straining actions for wall by reissnar and straining actions for base.
2- Make equilibrium for moments between wall& base.
3- Design critical sections.
4- Draw reinf. Details.

Solution:

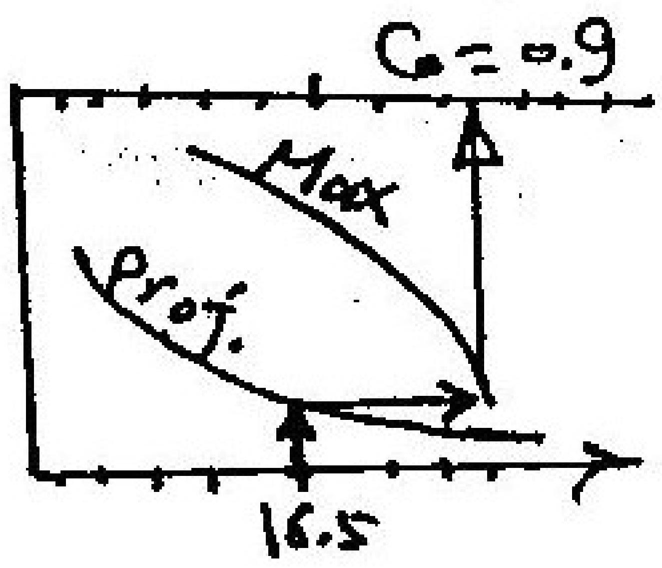
(1) Wall : using reissnar :

$$\rightarrow \quad n = 0.5 + \sqrt{0.25 + \frac{20 * 800}{(250)^2 * 0.001}} = 16.5$$

$$\rightarrow \quad t = \frac{1.73\,H^2}{R \cdot n^2} = \frac{1.73 * (800)^2}{250 * (16.5)^2} = 16.26 \text{ cm}$$

Use $t \simeq 20$ cm

→ from Curves (P.(3-1)) ⇒ $C_o = 0.9$



$\therefore T_{max\ ring} = C_o \cdot \gamma H R$

$= 0.9 * 1 * 8 * 2.5 = 18\ t/m^-$

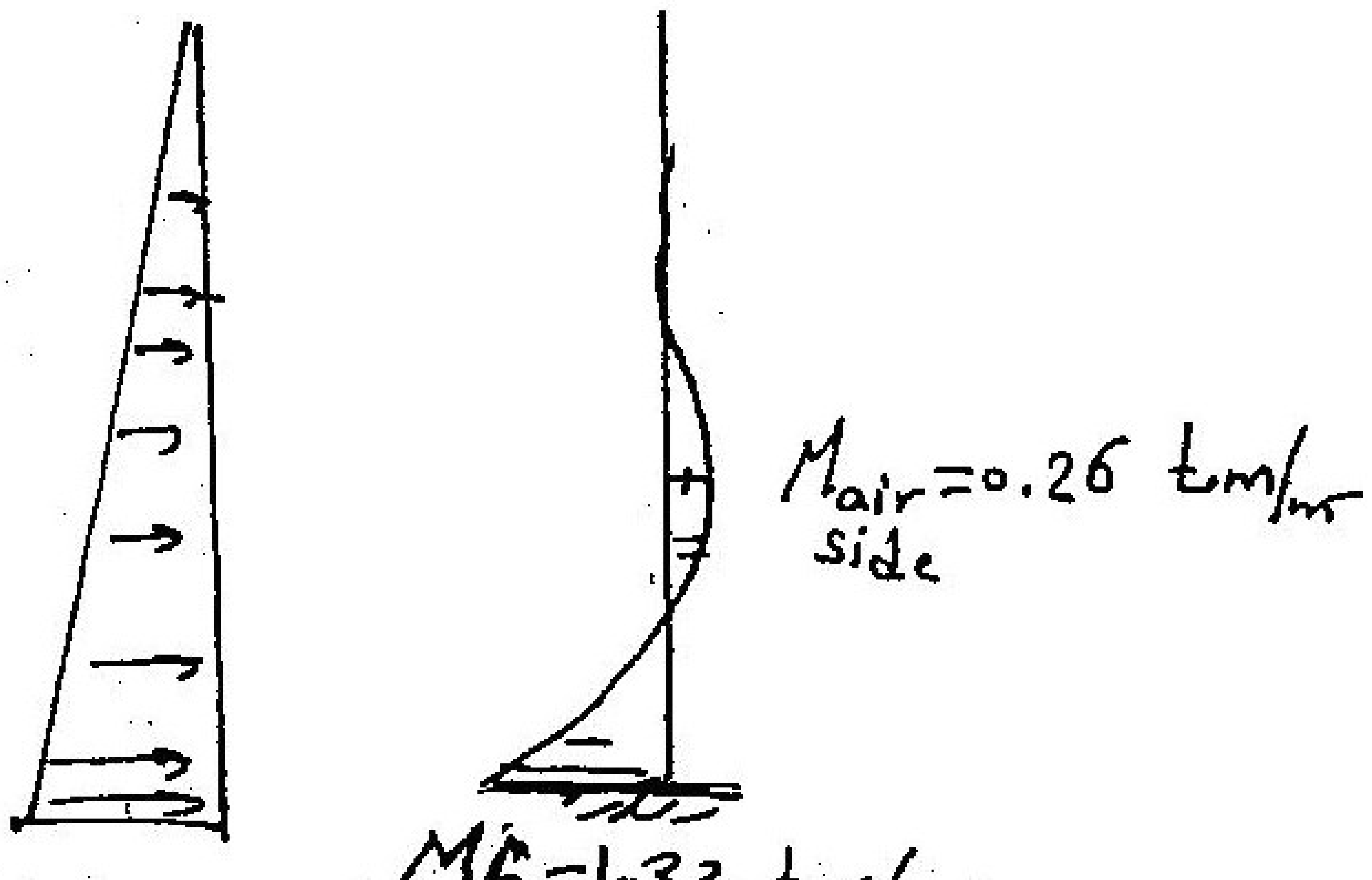
→ $M_f = \frac{\gamma R^2 t^2 n(n-1)}{6H} = \frac{1*(2.5)^2*(0.2)^2*16.5(16.5-1)}{6*8}$

$\therefore M_f = 1.33\ tm/m^-$

→ $M_{+ve} = \frac{M_f}{5} = 0.26\ tm/m^-$

→ $V_{shear} = \frac{\gamma R^2 t^2 n^2(2n-1)}{6H^2} = \frac{1*(2.5)^2*(0.2)^2*(16.5)^2(2*16.5-1)}{6*(8)^2}$

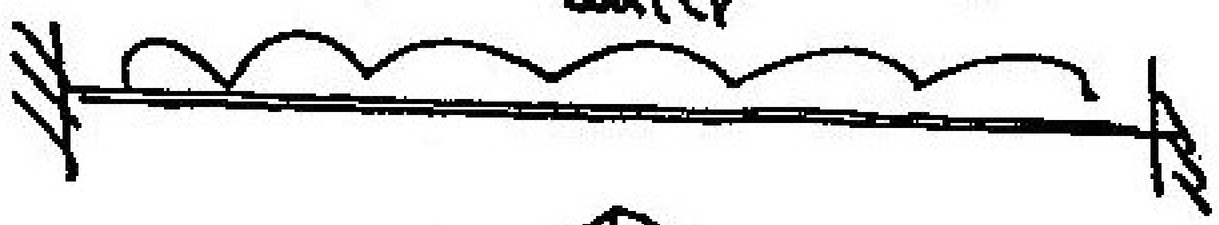
$\therefore V_{shear} = 5.7\ t/m^-$



(2) Base:

ثخانة القاعدة ↓   فرض مبدئي ↓

$$\omega = t_b \cdot \gamma_{R.c} + \gamma_{water} \cdot H = (0.4 * 2.5 + 1 * 8) = 9\ t/m^2$$



تركيز الحمل

$P = \omega * Area$

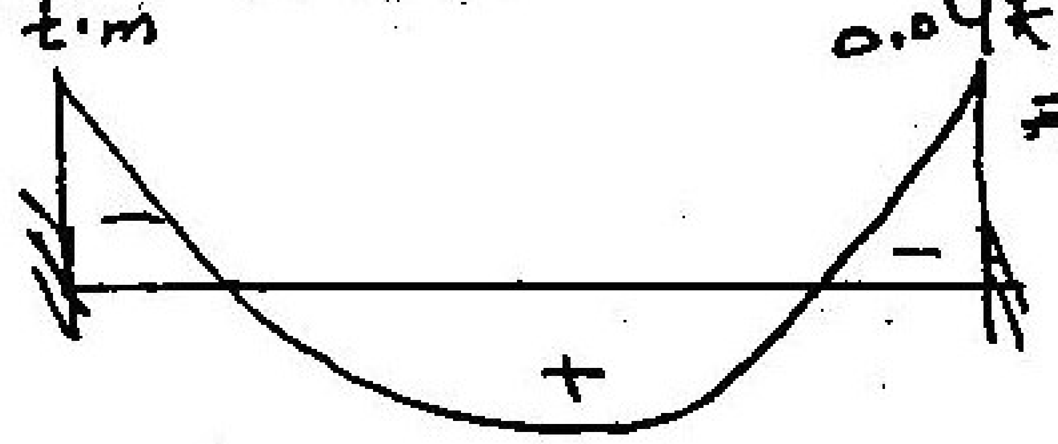
$= 9 * \pi (2.5)^2$

$= 176$ ton

بالكتاب

From P.(3-23)

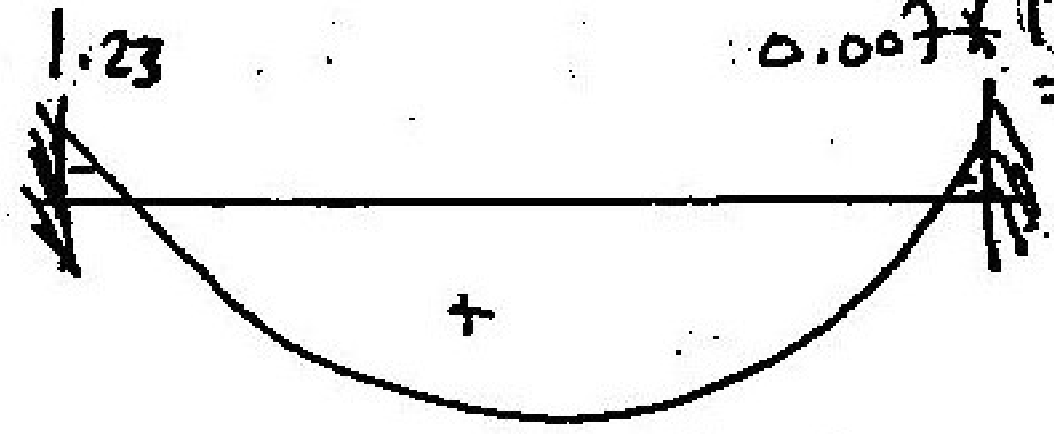
Radial moments



0.023 * 176

= 4 t.m

Tangential Moments



0.023 * 176

= 4 t.m

---

(3) Equilibrium of Base & Wall:

P.(3-19)

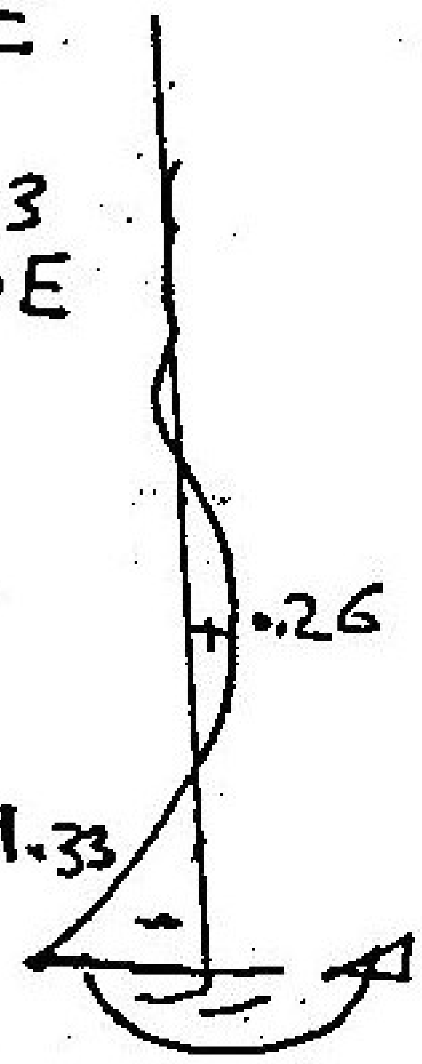
→ From ressiner

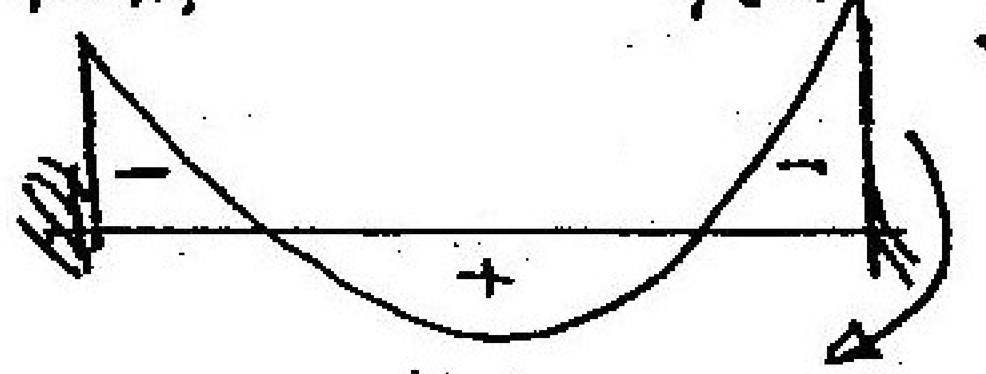
$$\Rightarrow K_{wall} = \frac{C_o \cdot E \cdot t^3}{H} = \frac{2.4 E (0.2)^3}{8} = 2.4 * 10^{-3} E$$

$$\Rightarrow K_{base} = \frac{0.104 E t^3}{R} = \frac{0.104 E (0.4)^3}{2.5} = 2.6 * 10^{-3} E$$

$$\Rightarrow D.f_{wall} = \left(\frac{2.4}{2.6 + 2.4}\right) = 0.48$$

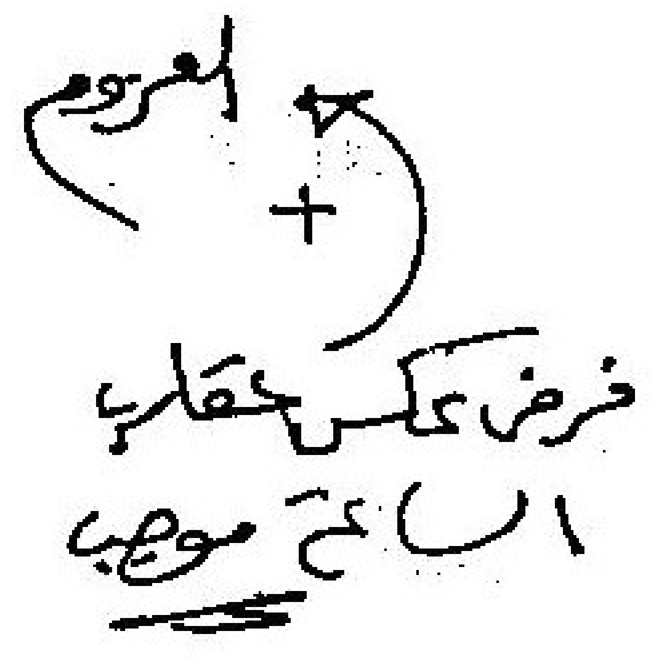
$$\Rightarrow D.f_{base} = 1 - 0.48 = 0.52$$



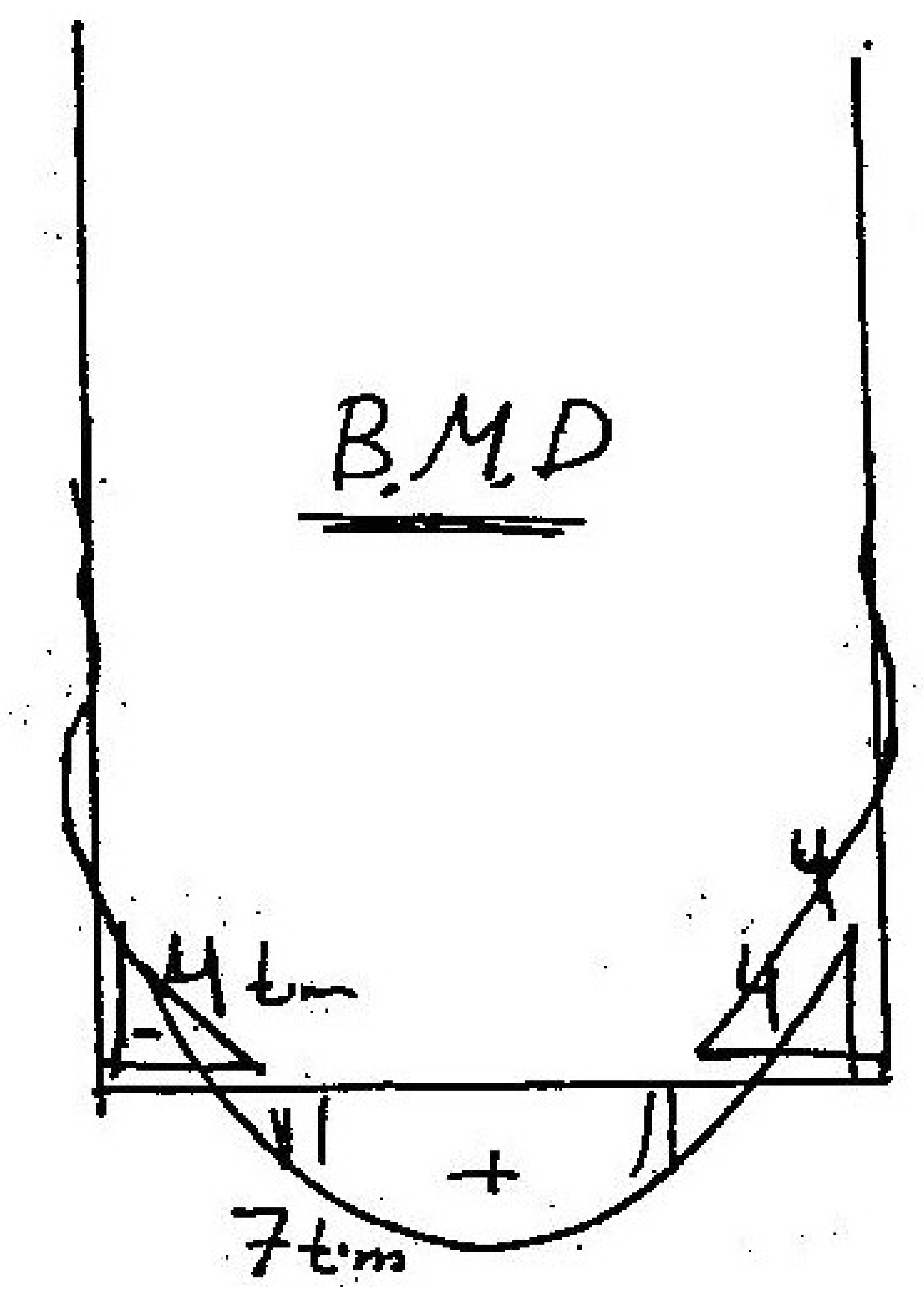


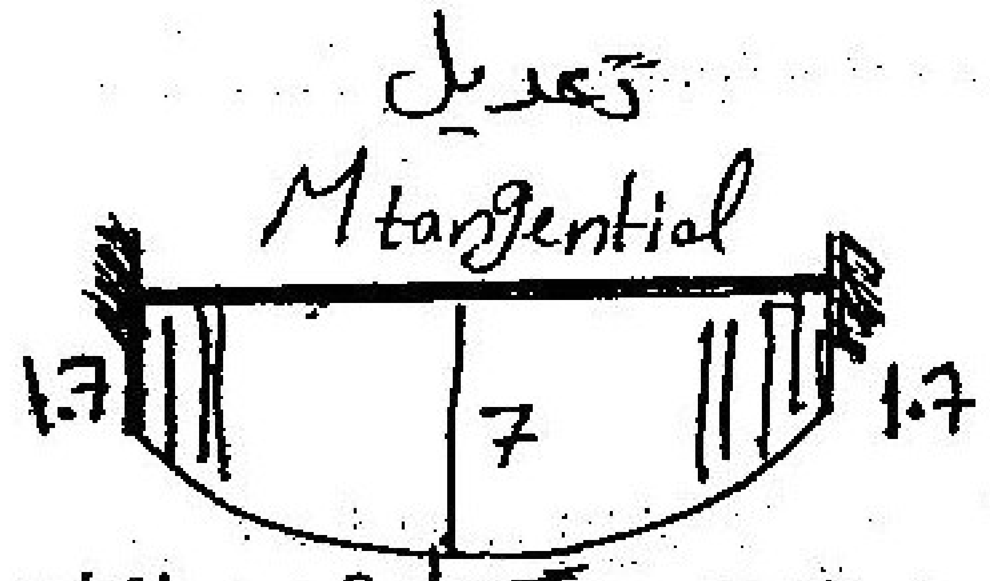
M_{radial}

	Wall (D.f = 0.48)	Base (D.f = 0.52)
fixed moments	1.33	−7
D.M	2.72	2.94
final moments	+4	−4



$$D.M = -(1.33 - 7) * \begin{cases} Df_{wall} \\ Df_{base} \end{cases}$$





ثم توصيل كل عزوم القاعدة لأسفل بمقدار (2.94)

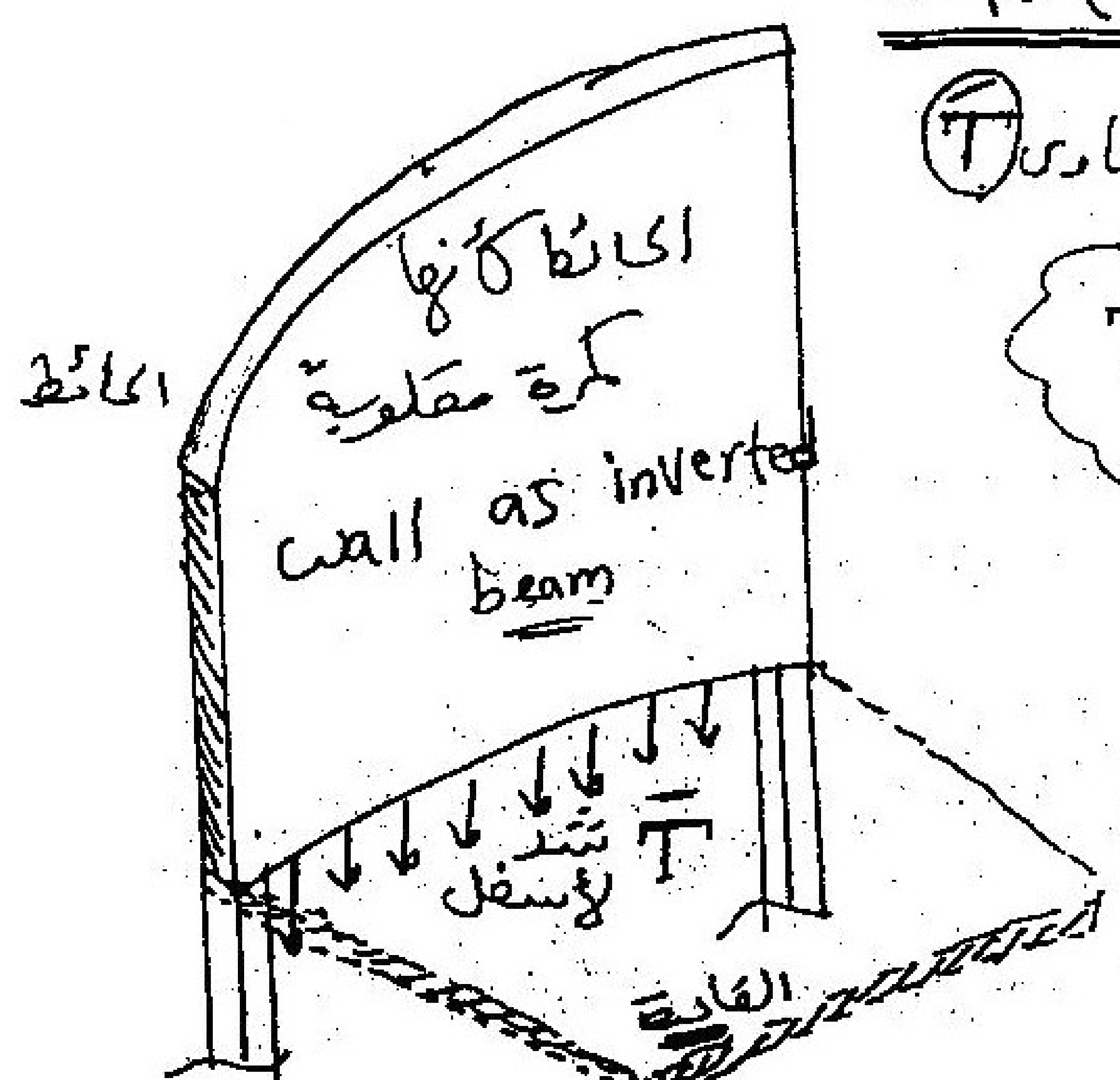
* حساب الـ (Normal force)

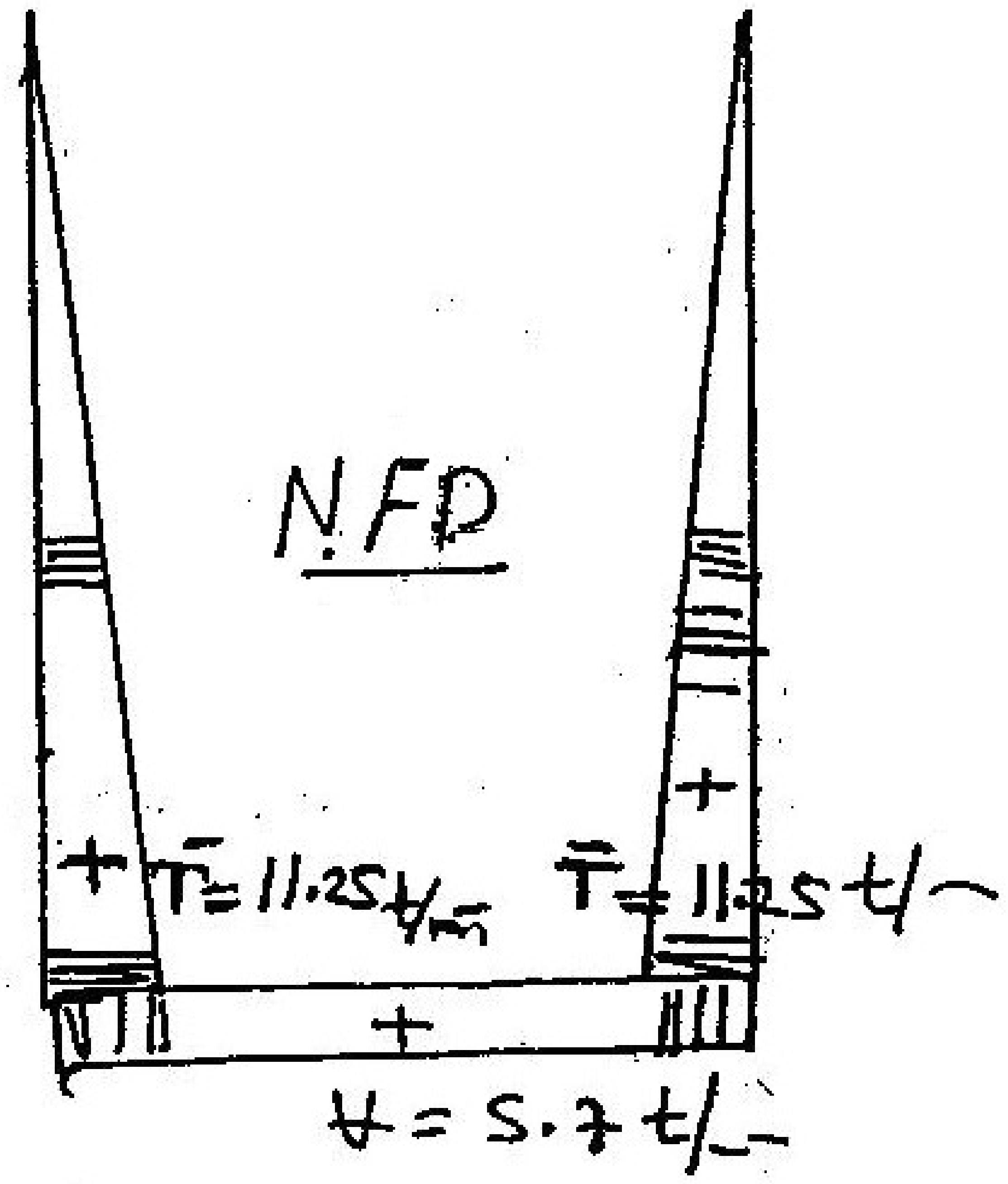
(T) قوة الشد بفعل القاعدة لأسفل تساوى

$$\bar{T} = \underset{\text{الحمل على القاعدة}}{W} * \left(\frac{Area}{\text{المحيط}}\right)$$

$$= 9 * \frac{\pi R^2}{2\pi R}$$

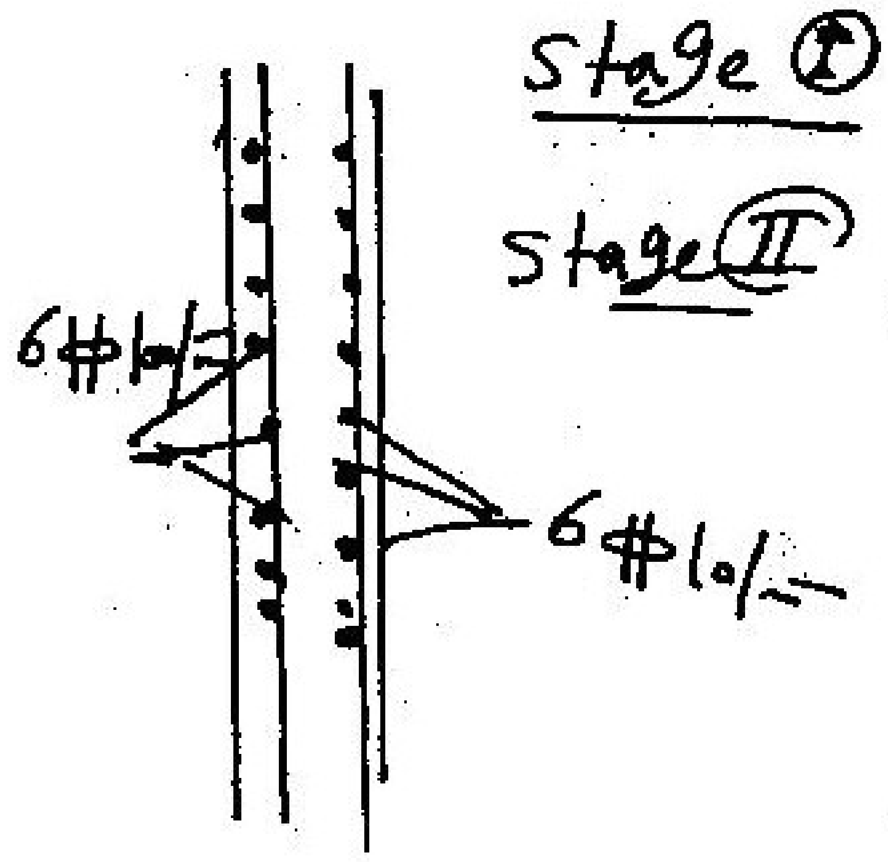
$$= 9 * \left(\frac{2.5}{2}\right) = 11.25\ t/m$$





Design of sections:

① Ring direction: $T_{max\,ring} = 18\ t/m$



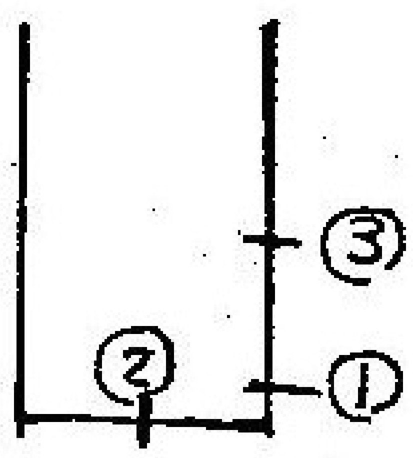
Stage Ⓘ $t = f \cdot T \nless 20cm \Rightarrow t = 20cm$

Stage Ⓘⓘ $A_s = \dfrac{T_u * 10^3}{2\left(\frac{f_y}{\gamma_s}\right)} = \dfrac{1.5 * 18 * 10^3}{2\left(\frac{3600}{1.15}\right)} = 4.3\ cm^2/m$

∴ use 6 ϕ 10/m each side

---

② VL. direction:-



Sec ① $M_{water\ side} = 4\ t.m/m$; $T = 11.25\ t/m$

Sec ② $M_{air\ side} = 7\ t.m/m$; $T = 5.7\ t/m$

Sec ③ $M \simeq 0$; $T = 5.75\ t/m$

Section	t	As
①	45 cm	5#16/m
②	45 cm	5#16/m
③	min = 20 cm	5#10/m — min

* نبدأ بتصميم القطاع (water side) ⇐ t = 45 cm ونثبت التخانة

على طول القاعدة صمم العزم من المتوسط كبير وليس صفر zero

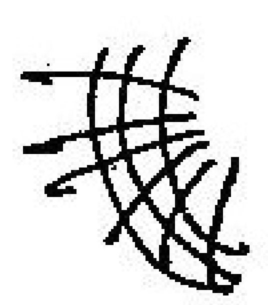
لكن الحائط نثبت لها التخانة بعد ذلك = 2m صمم العزم

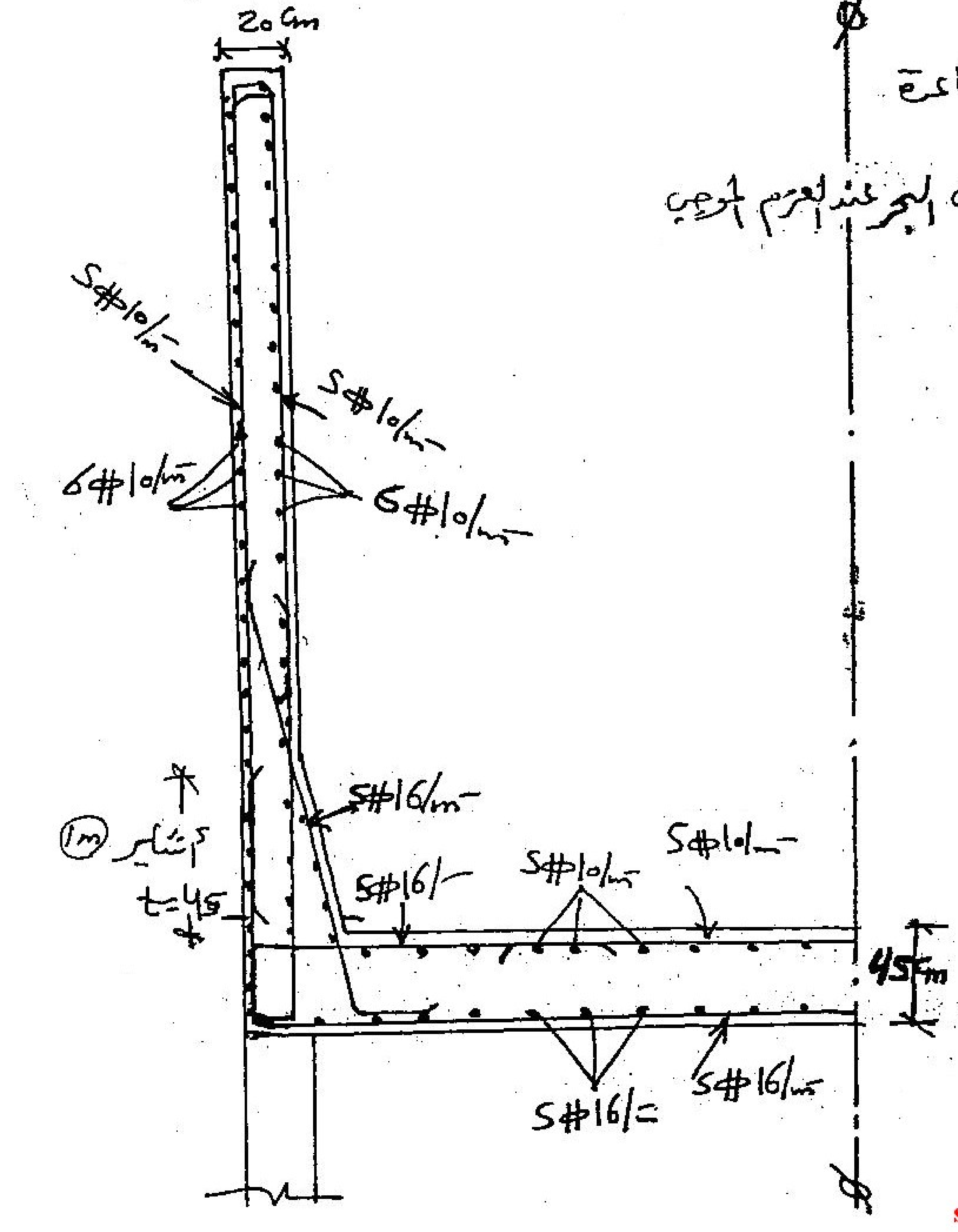
تلاشي.

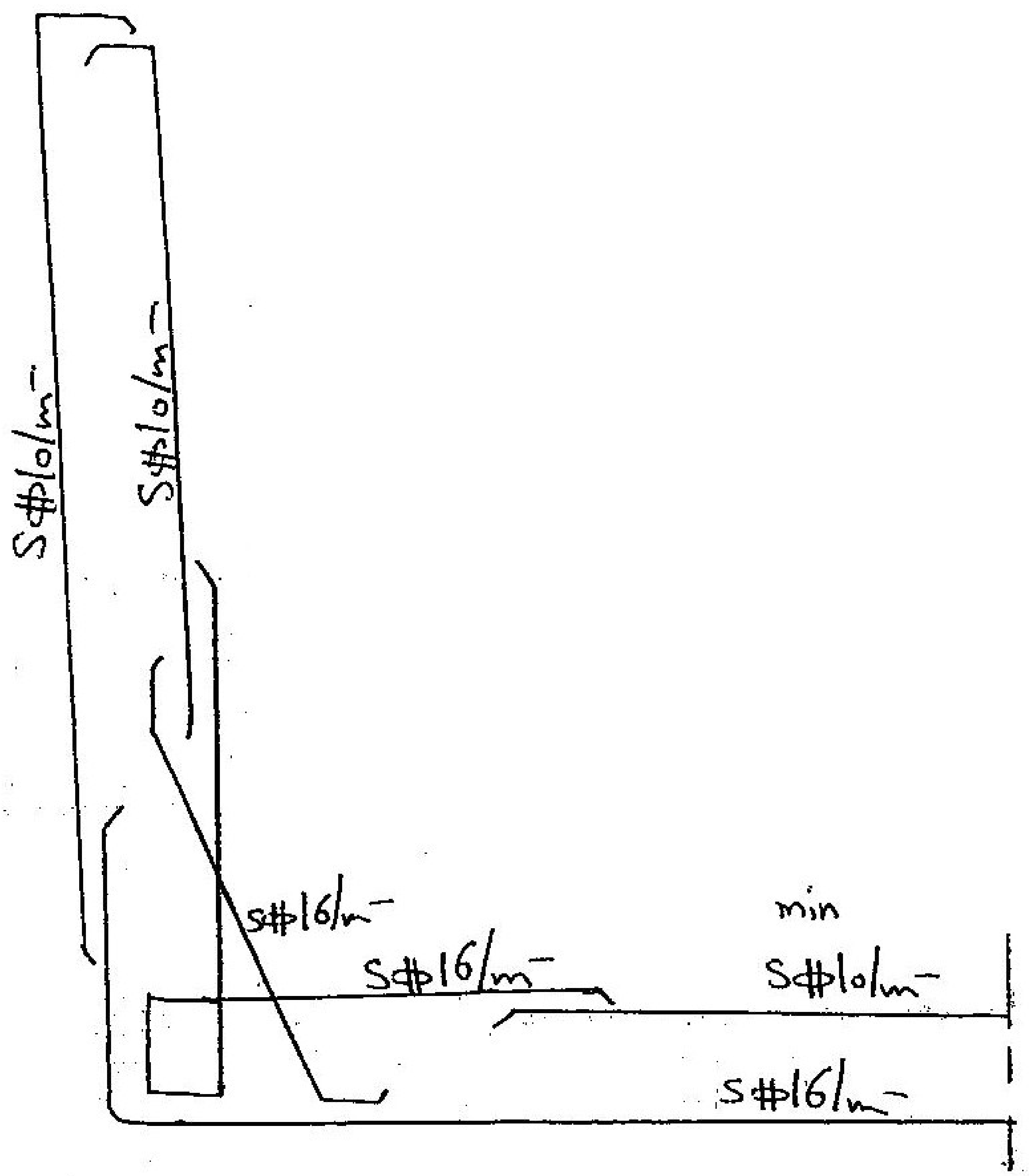
دائماً تسليح القاعدة

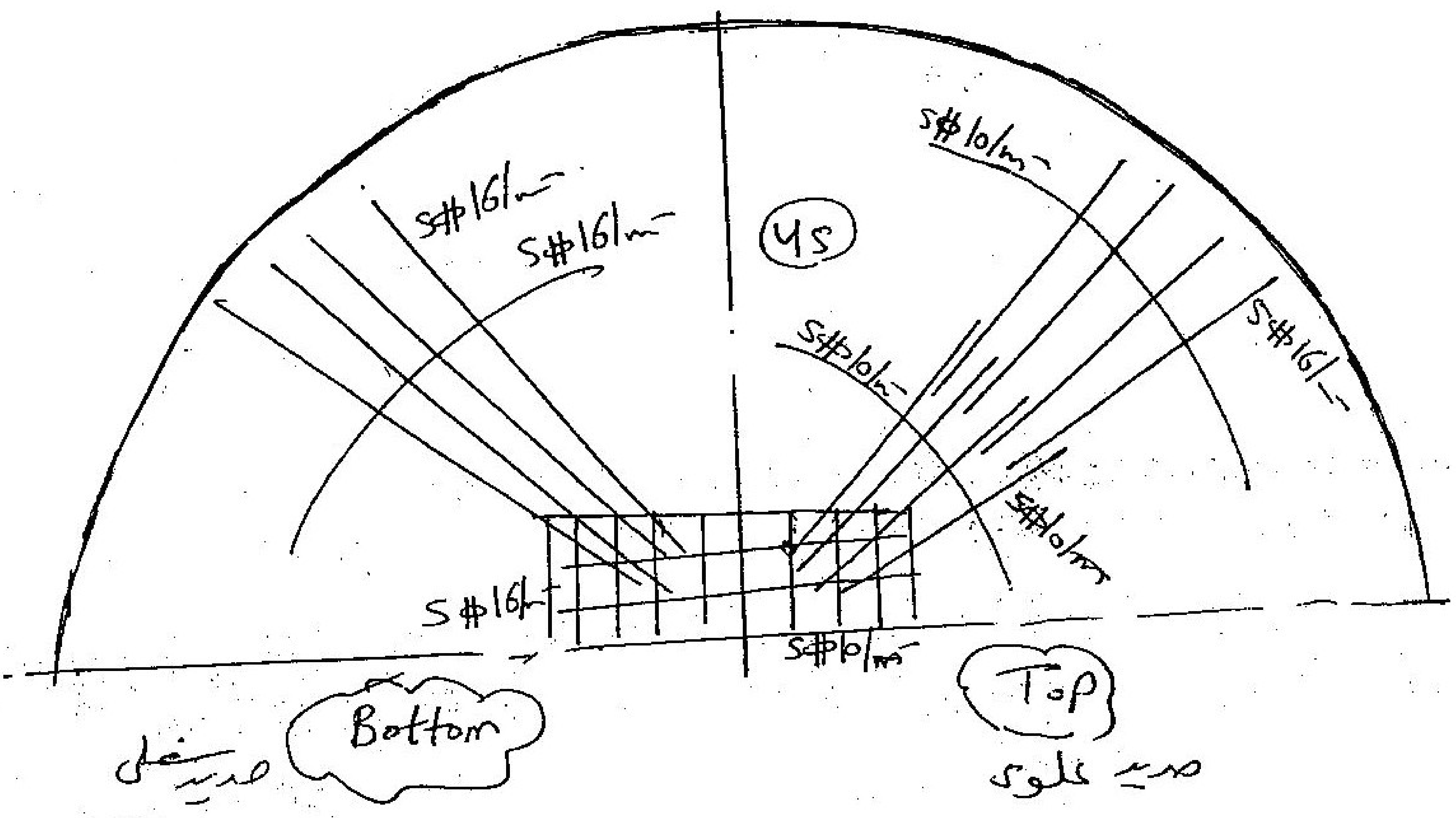
Radial = Tangential

من منتصف البحر عند العزم الموجب

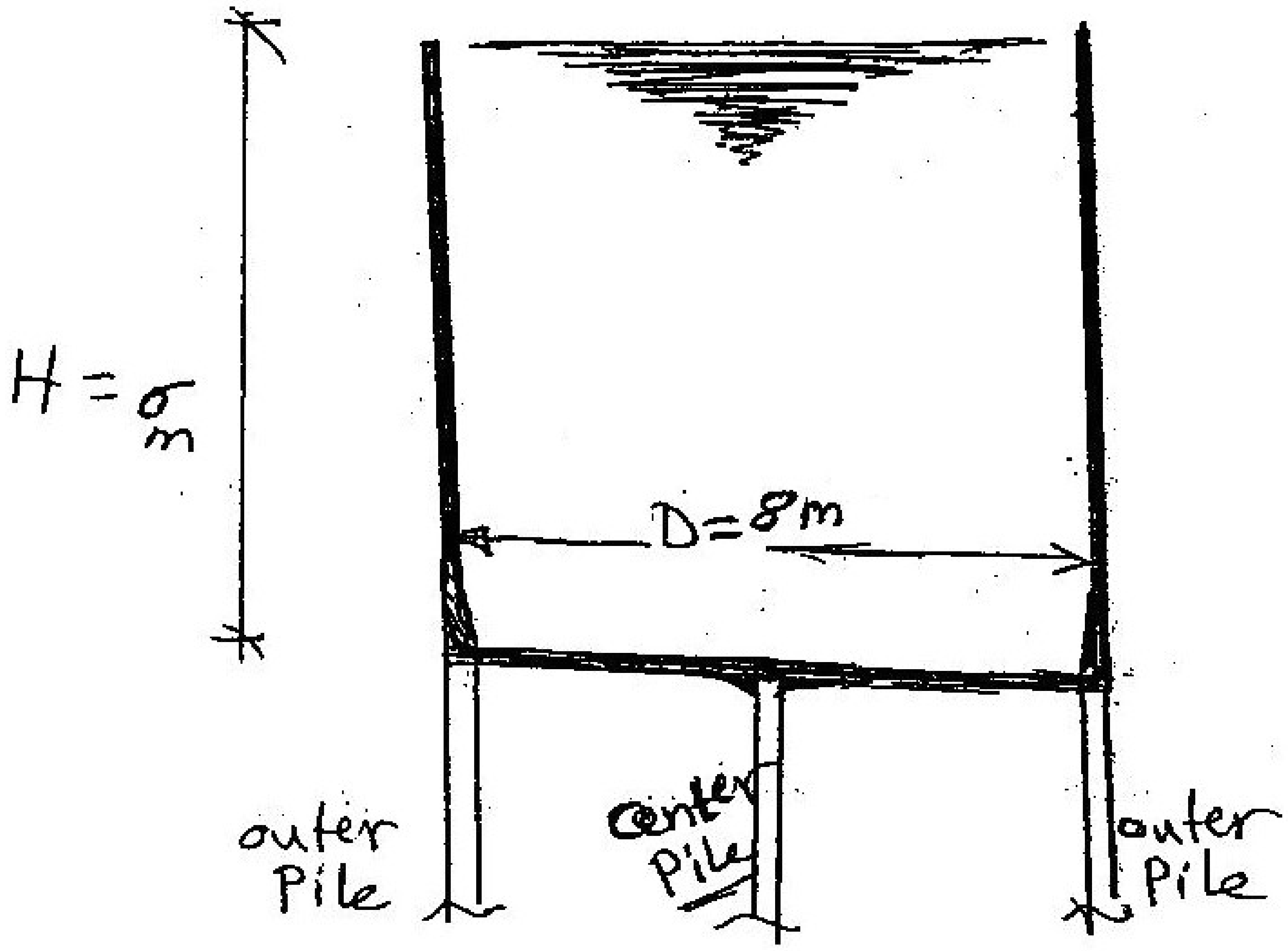




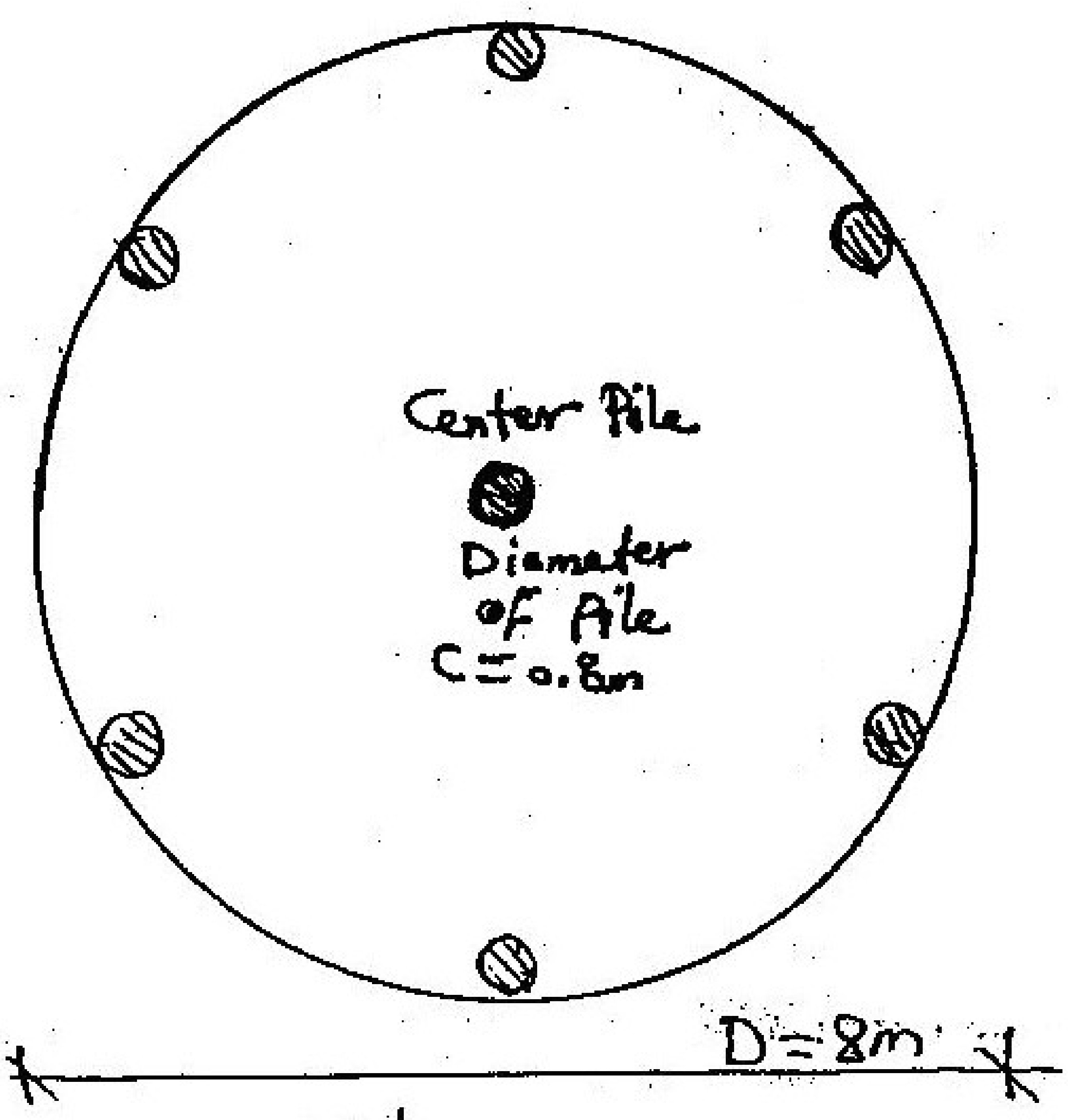

S#10/m
S#10/m
S#16/m
S#16/m
min
S#10/m
S#16/m


S#10/m
S#16/m
S#16/m
45
S#10/m
S#16/m
S#10/m
S#16/m
S#10/m
Bottom
Top
حديد سفلي
حديد علوي

Elevated Tanks with Center Support



Sec. elevation



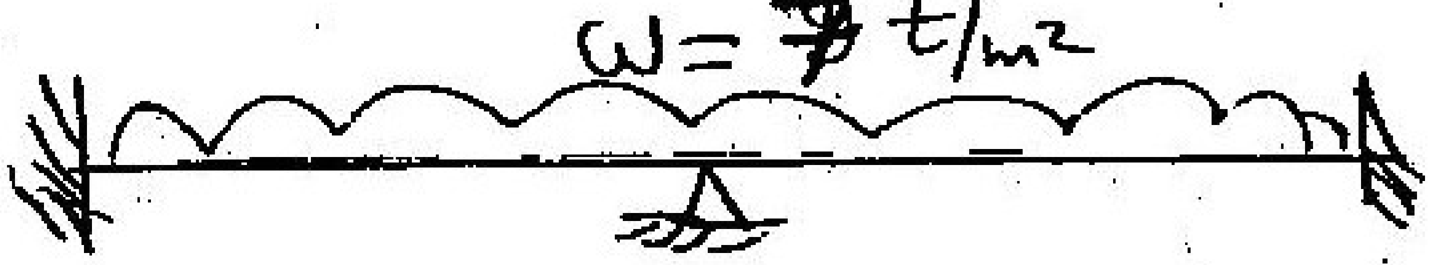
Plan

خطوات الحل :

① نحل الحائط كما سبق ونحسب $(M_f, M_{tve}, \vartheta, T_{ring})$ عادي

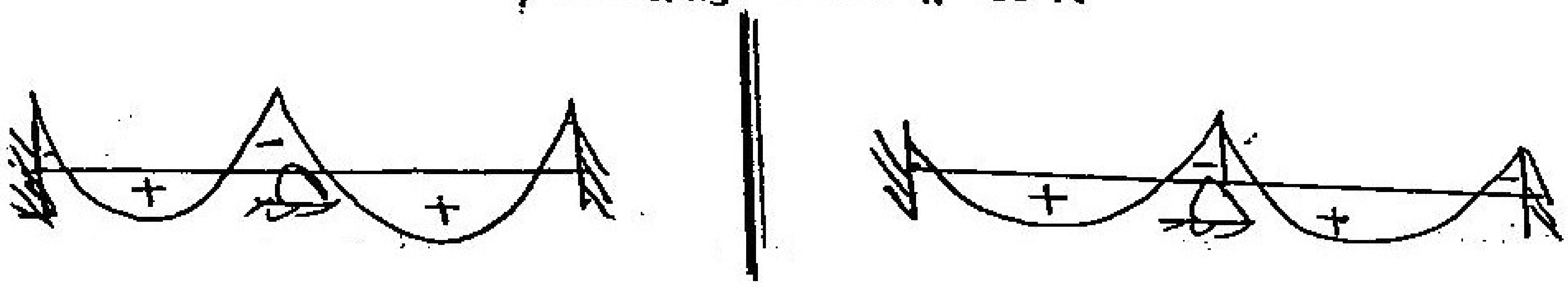
② نحل القاعدة وعليها حمل $w = (t_b \cdot \gamma_{R.C} + \gamma_{water} H)$

$= 7 \; t/m^2$



Radial moments — Tangential moments

$$Moments = C_o * w R^2$$



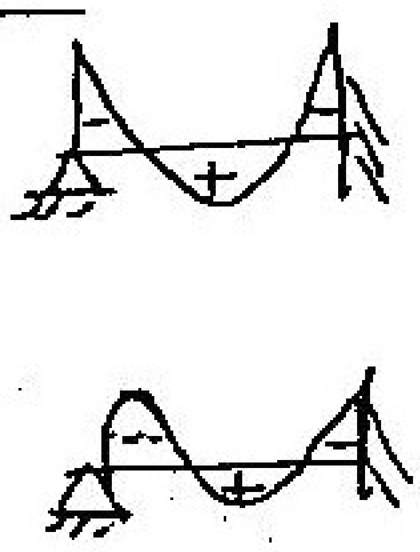
* نحسب العزوم من صفحة P.(3-17) بالكتاب حسب (C/D)

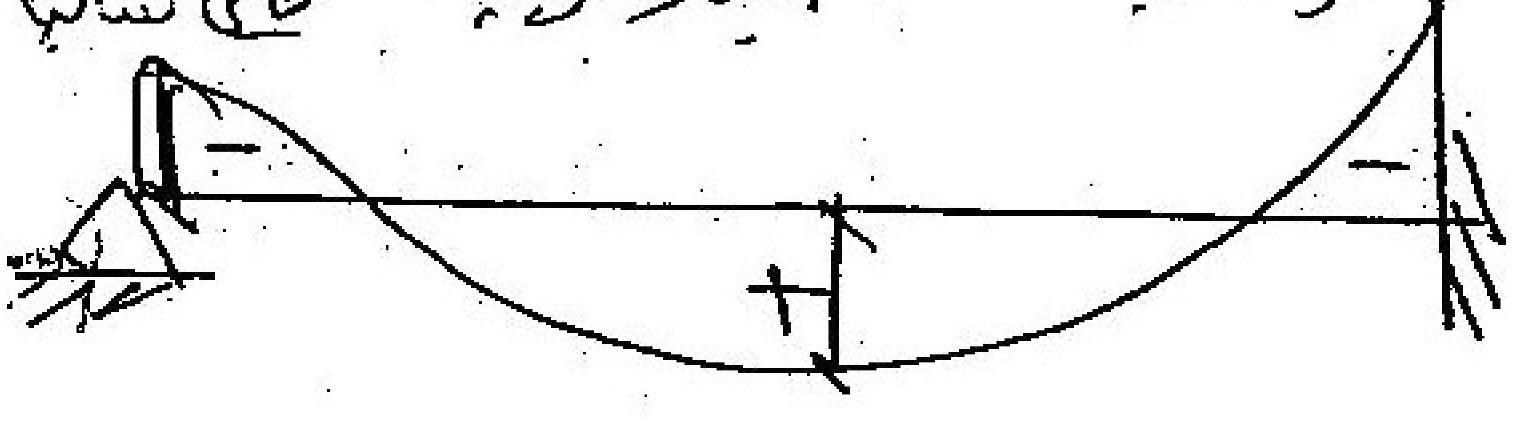
حيث (C) هو قطر الجازوة & (D) هو قطر الخزان.

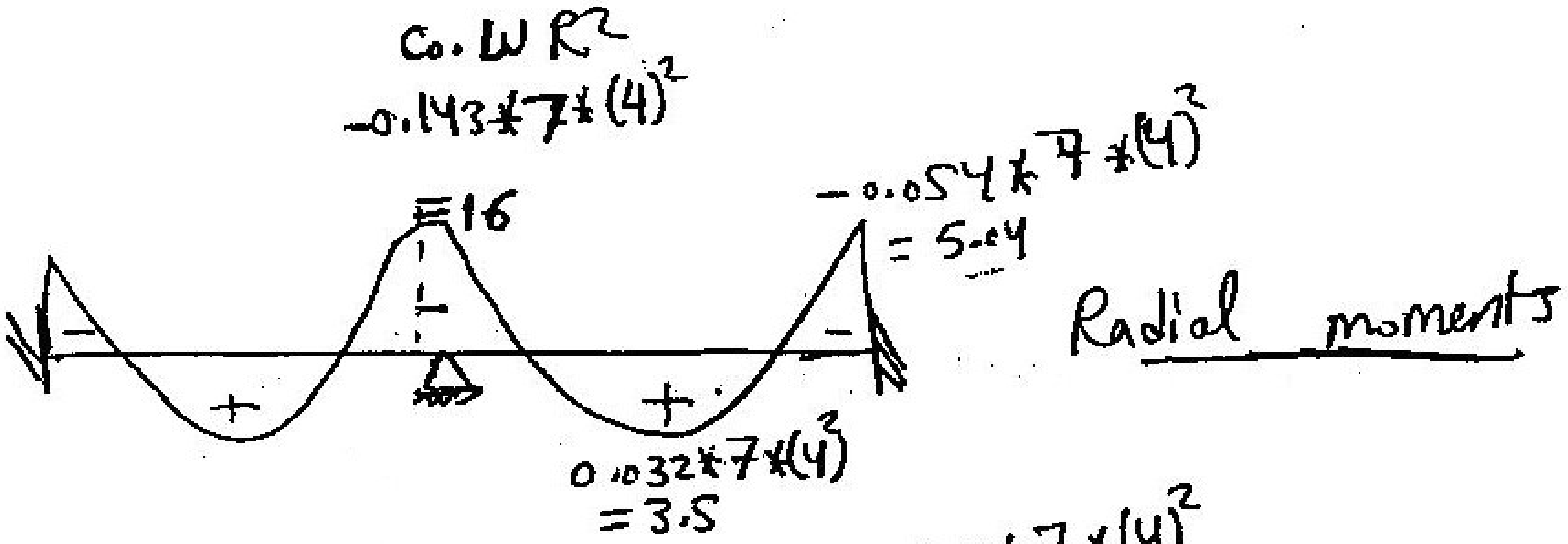
Ex: $C = 0.8 \; m$, $D = 8 \; m \Rightarrow (C/D) = 0.1$

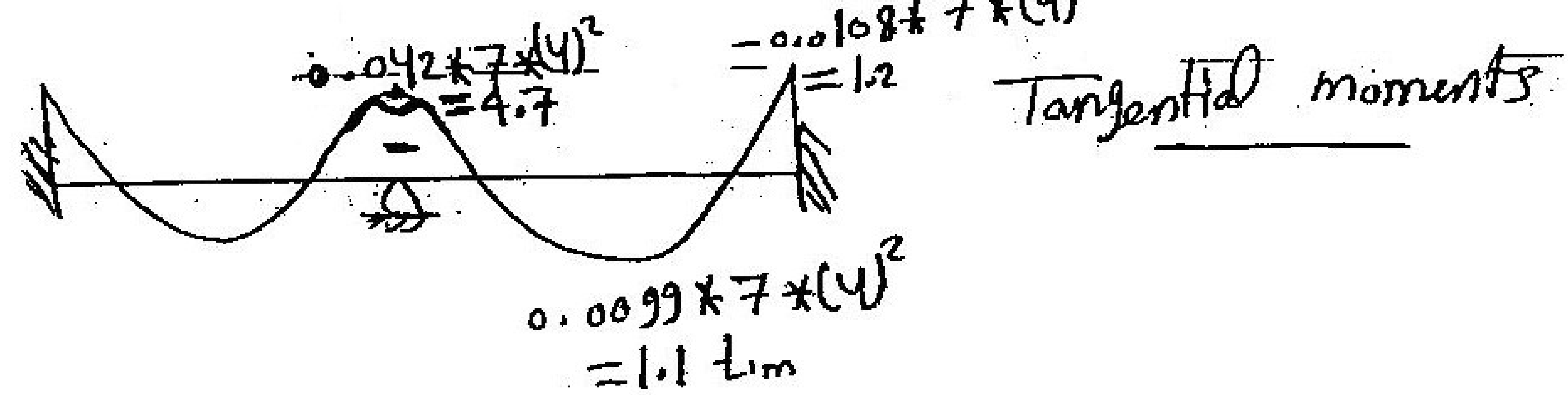
ثم ندخل ونأخذ معاملات حساب العزوم (C_o) للنصف الـ (Plate).

	C/D	1R		
		Radial moments		
Radial	0.1	−0.143 (أول سالب)	+0.0326 (أكبر موجب)	−0.0541 (آخر سالب)
		Tangential moments		
Tangential	0.1	−0.0421	+0.0099	−0.0108
		ثاني سالب	أكبر موجب	آخر سالب

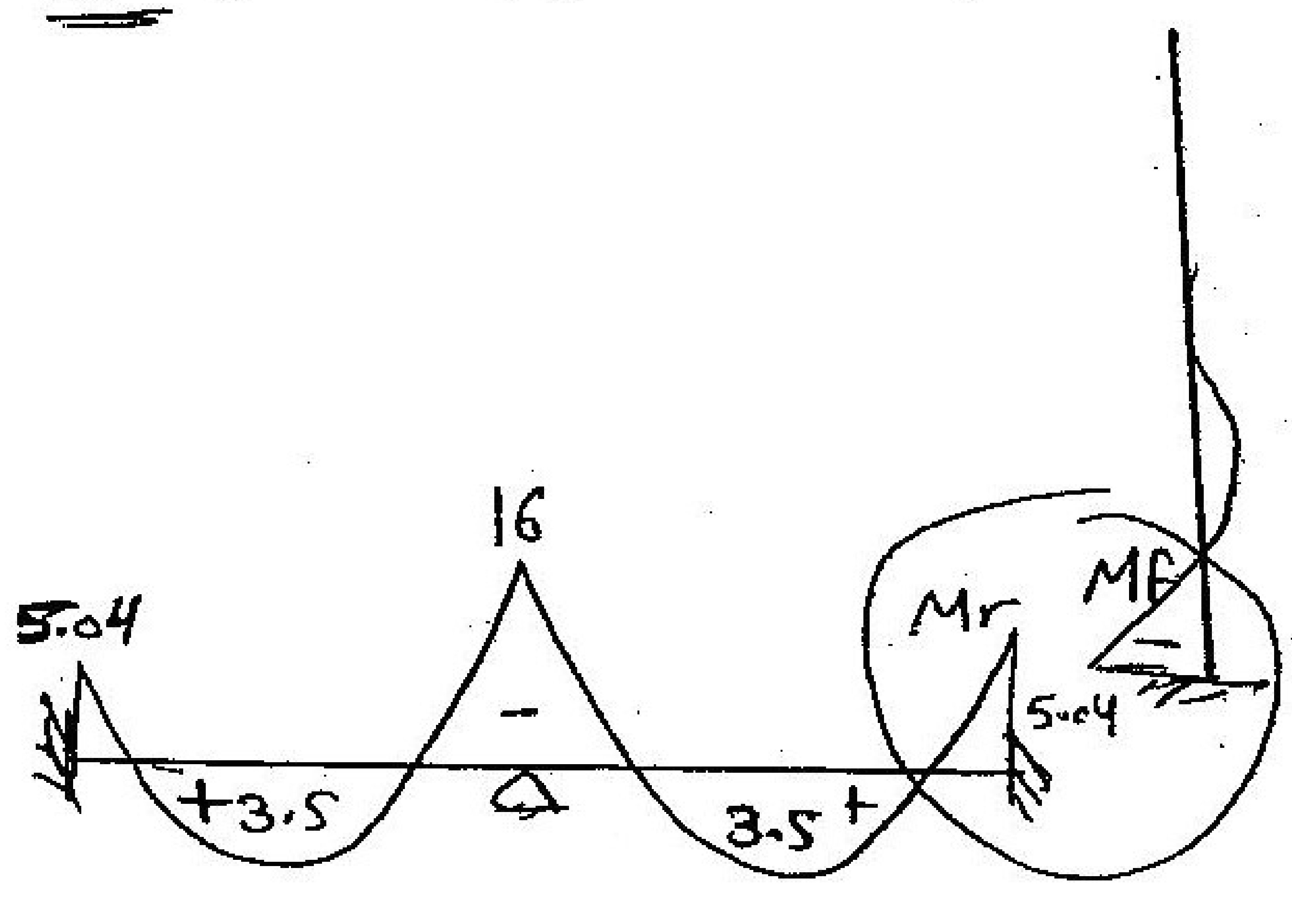








(٣) نعمل اتزان بين عزم الحائط وعزم القاعدة (M_{radial})



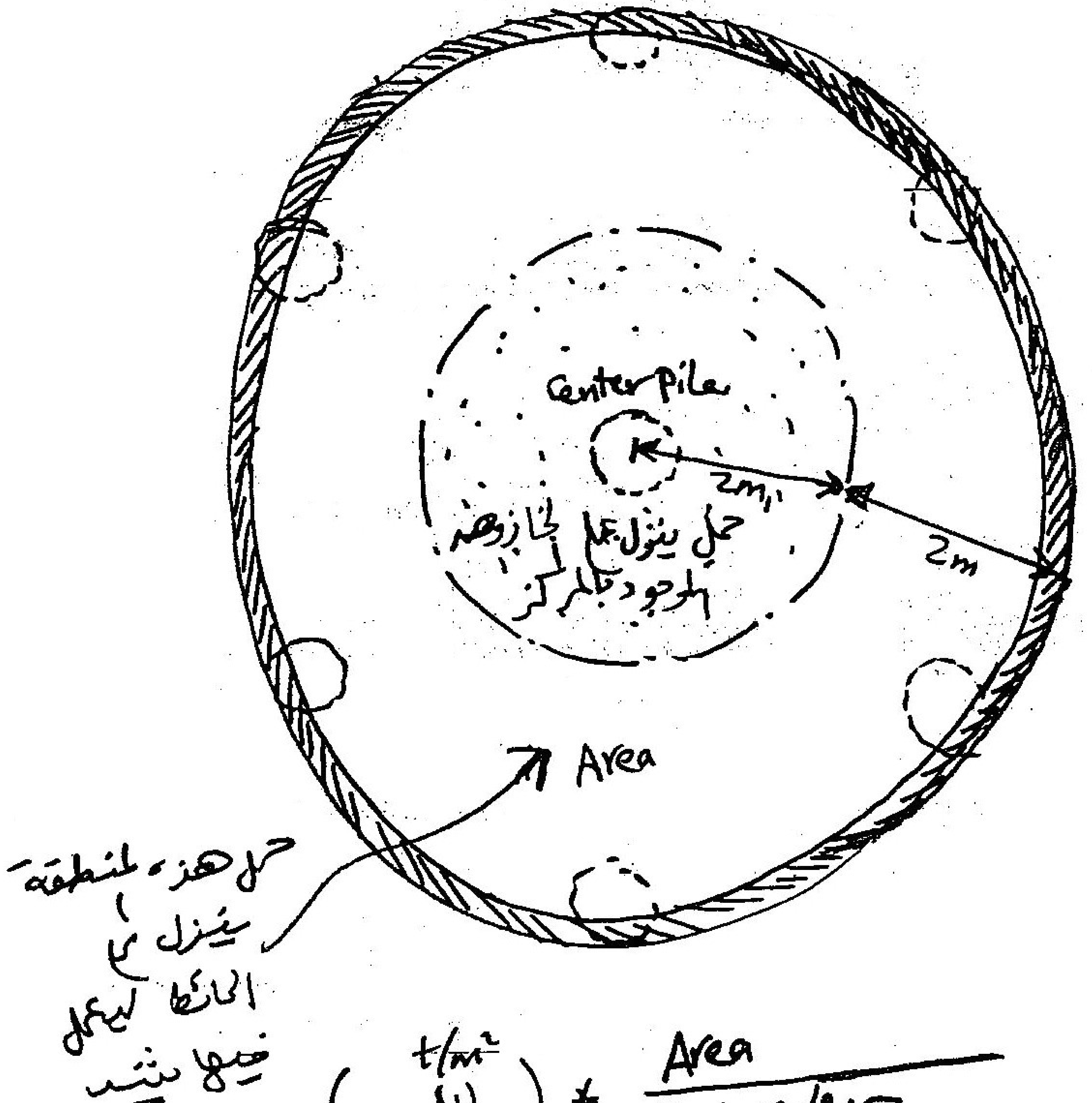
* يمكن بطريقة تقريبية أخذ متوسط العزمين طالما أن العزمين معاً في نفس الاتجاه:

$$M_{average} = \left(\frac{M_f + M_r}{2}\right)$$

النهائي

تم التصحيح والتسليح.

طب أ tension ع الحائط :

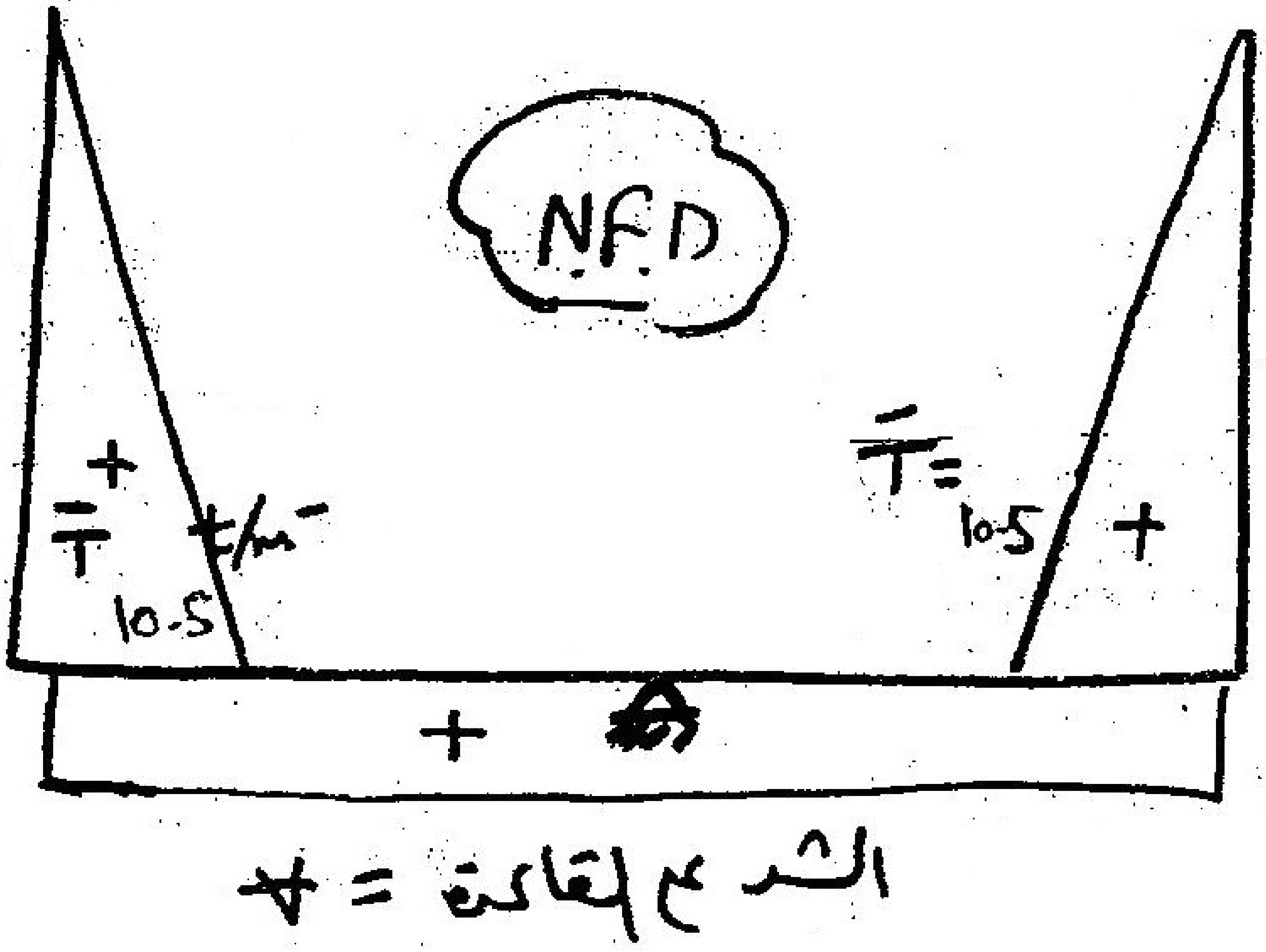


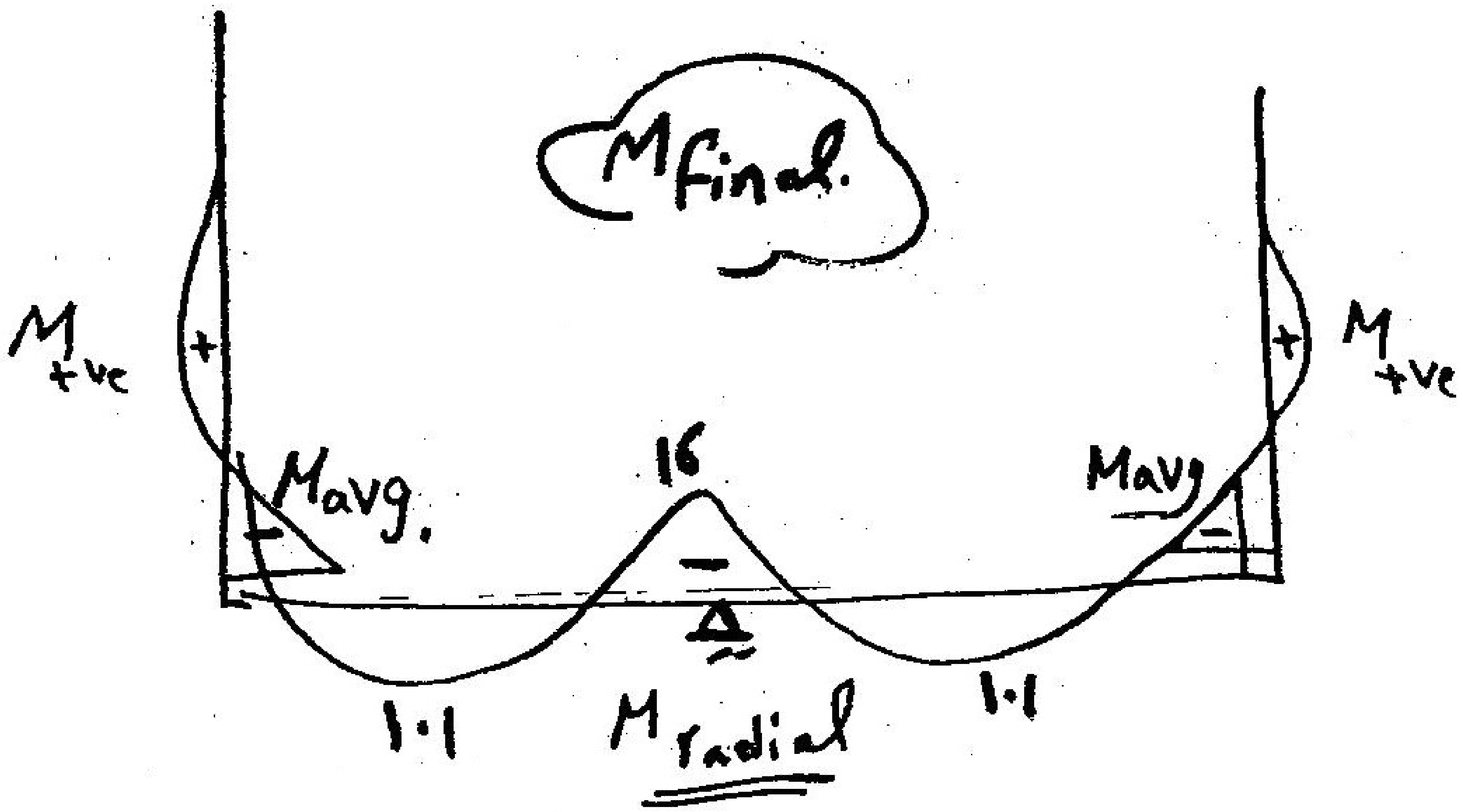
$$\bar{T} = \left(\underset{\text{حمل إنشائية}}{\overset{t/m^2}{w}} \right) * \frac{Area}{perimeter}$$

$$Area = \frac{\pi}{4}\left(8^2 - 4^2\right)$$

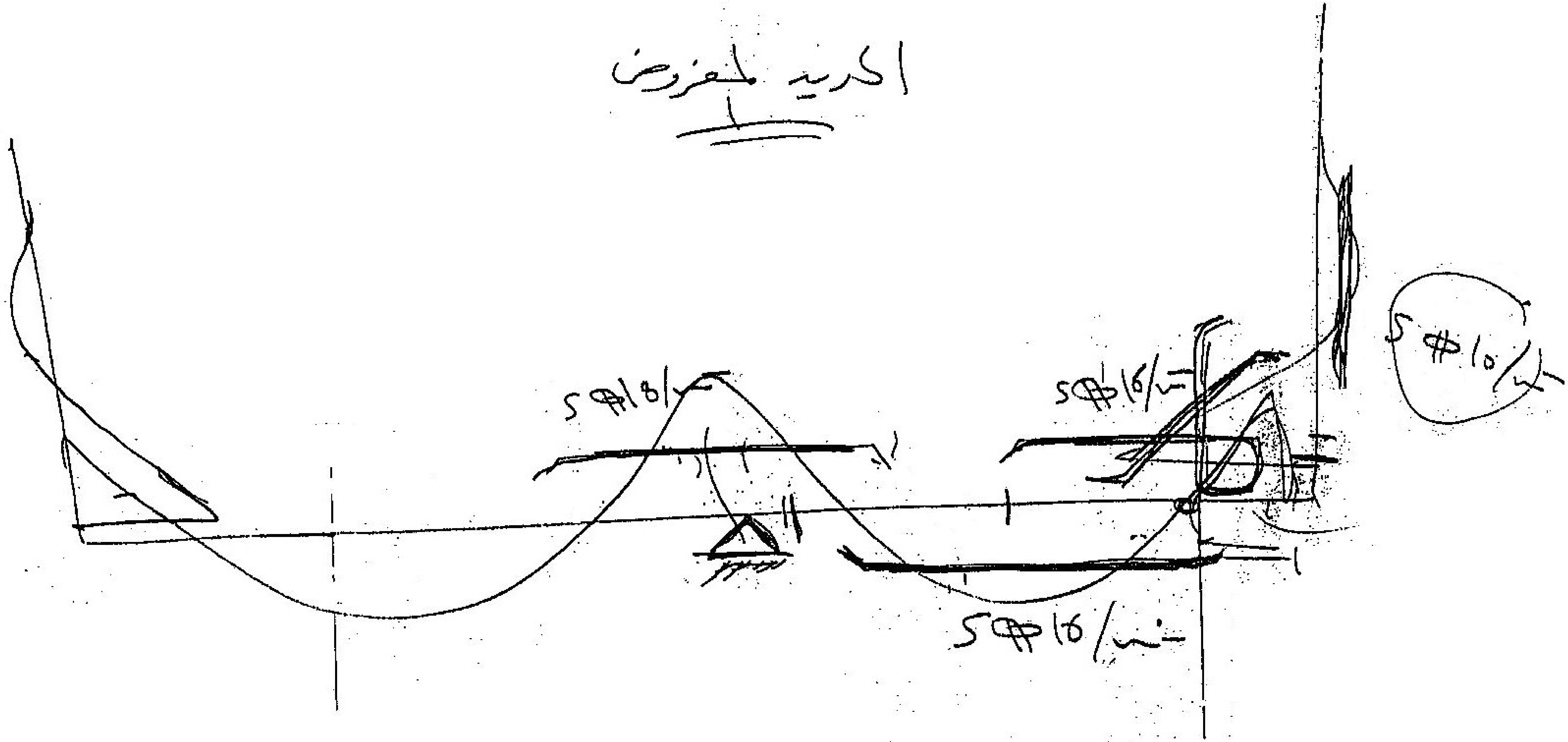
$$= 37.7\ m^2$$

$$\therefore \bar{T} = 7 * \frac{37.7}{2\pi(4)} = 10.5\ t/m$$


N.F.D
+
T̄
t/m⁻
10.5
T̄ =
10.5
+
+
الشرح لقاعدة = +


M final.
M +ve
+
M +ve
+
Mavg.
16
Mavg
−
−
−
1.1
M radial
1.1

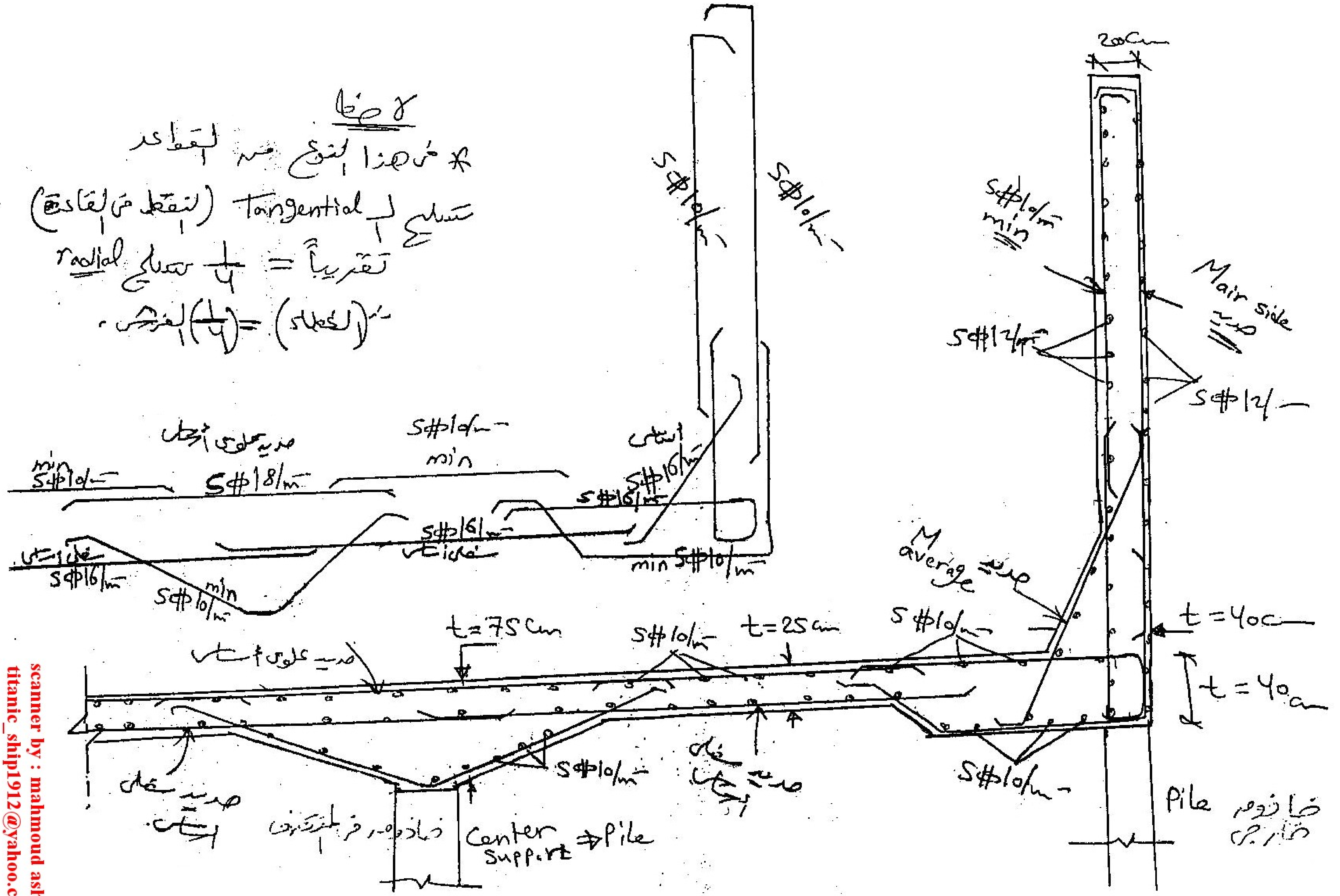
الحديد بالعرض



ملاحظة

* في هذا النوع من القواعد تسليح الـ Tangential (المقطع من القاعدة) تقريباً = $\frac{1}{4}$ تسليح radial

(الكلية) = $\left(\frac{1}{4}\right)$ العرض .



Moment = $C_o * W * R^2$

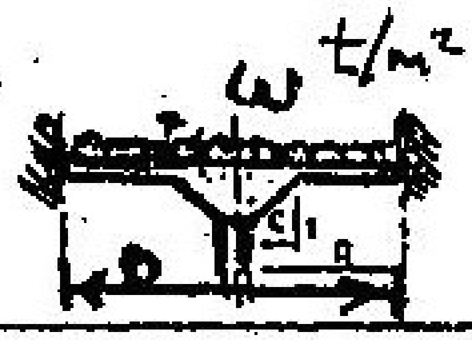


Table 3.1/4: Moments in circular slab with center support and fixed edge under uniform load : Moment = coeff. × wR^2
Positive sign indicates compression in surface loaded

c/D	0.05R	0.10R	0.15R	0.20R	0.25R	0.30R	0.40R	0.50R	0.60R	0.70R	0.80R	0.90R	1.0R
	Radial moments, M_r (Radial)												
0.05	-.2100	-.0729	-.0275	-.0026	+.0133	+.0238	+.0342	+.0347	+.0277	+.0142	-.0049	-.0294	-.0589
0.10		-.1433	-.0624	-.0239	-.0011	+.0136	+.0290	+.0326	+.0276	+.0158	-.0021	-.0255	-.0541
0.15			-.1089	-.0521	-.0200	+.0002	+.0220	+.0293	+.0269	+.0169	+.0006	-.0216	-.0490
0.20				-.0662	-.0429	-.0161	+.0133	+.0249	+.0254	+.0176	+.0029	-.0178	-.0441
0.25					-.0698	-.0351	+.0029	+.0194	+.0231	+.0177	+.0049	-.0143	-.0393
	Tangential moments, M_t (Tangential)												
0.05	-.0417	-.0700	-.0541	-.0381	-.0251	-.0145	+.0002	+.0085	+.0118	+.0109	+.0055	-.0003	[illegible]
0.10		-.0287	-.0421	-.0354	-.0258	-.0168	-.0027	+.0059	+.0099	+.0098	+.0061	[illegible]	[illegible]
0.15			-.0218	-.0284	-.0243	-.0177	-.0051	+.0031	+.0080	.0086	+.0057	-.0006	[illegible]
0.20				-.0172	-.0203	-.0171	-.0070	+.0013	+.0063	.0075	+.0052	-.0003	[illegible]
0.25					-.0140	-.0150	-.0085	-.0005	+.0046	.0054	+.0048	.0000	[illegible]

Revision 1

22 جـ ١/٨

سنتر و مركز

الفارس

للخدمات الطلابية والعلمية

الفرقة الرابعة مدني

Reinforced Concrete Water tanks

Zagazig University

4^{th} year civil engineering

Reinforced Concrete Design

Faculty of Engineering

Mid term Exam 2007

Q(1)

For the given open circular tank shown in figure 1.

It is required to make analysis for wall and base considering the tank totally full of water and resting on rocky soil; for the following cases:

A- Wall fixed with base and free at top using (Reissnar) ;(20% of total degree).
B- Wall Hinged with base and free at top (P.C.A); (15% of total degree).
C- Wall fixed with base and free at top (Simplified); (15% of total degree).

Q(2)

Use the last analysis for wall in case A and reanalysis of base if the tank is rested on soil with bearing capacity = 1.2 kg/cm^2 . Make complete analysis, design and give full reinforcement details.

f_{cu} = 250 kg/cm^2 , f_y=3600 kg/cm^2.

Analysis of base and make equilibrium at connection (15% of total degree)

Design critical sections (15% of total degree).

Reinforcement details (30% of total degree).

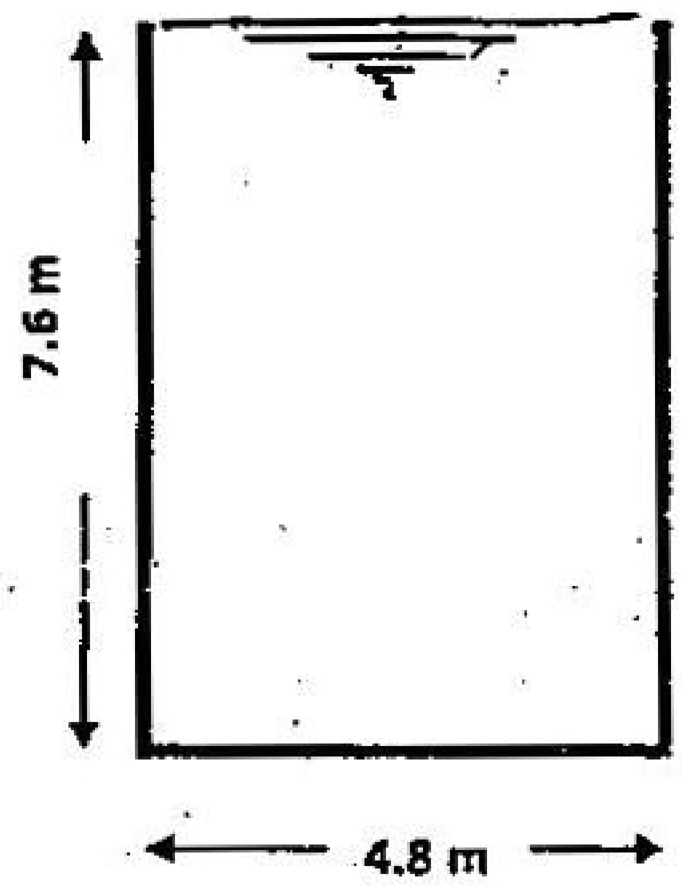


Fig.1

Sol.

(A) Fixed Tank: $H = 7.6\,m$, $D = 4.8\,m$

Wall (Reissner)

① $n = 0.5 + \sqrt{0.25 + \dfrac{20 * 760}{0.001 * (240)^2}} = 16.7$

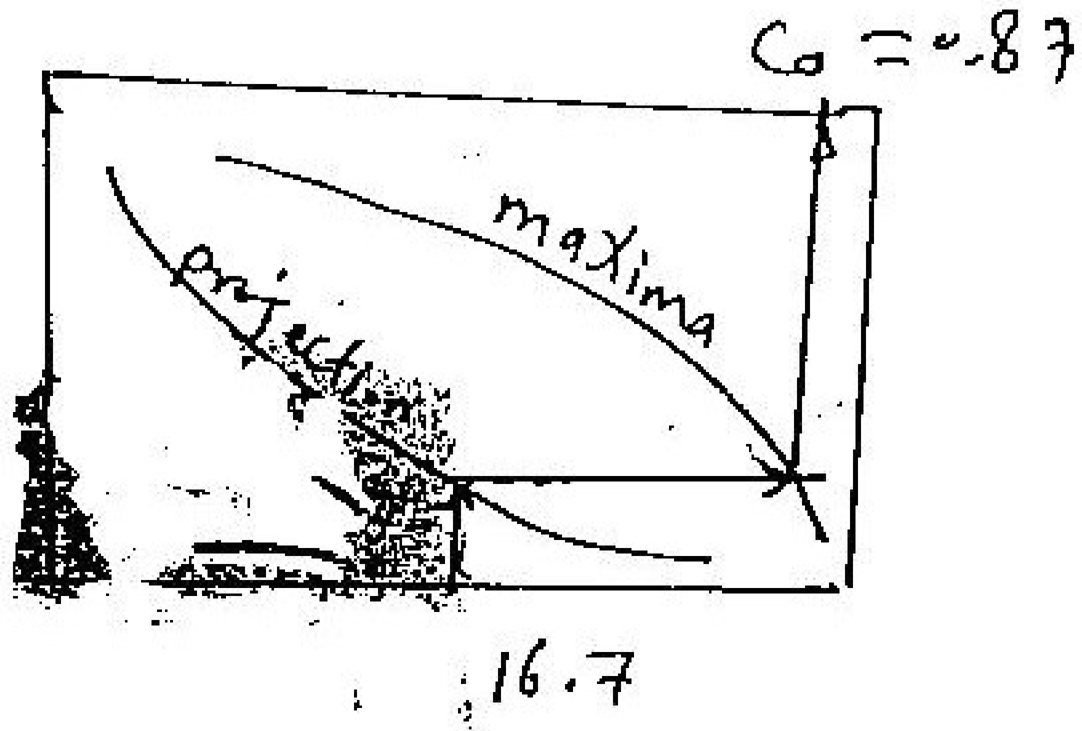
② $t_{wall} = \dfrac{1.73\,H^2}{R.n^2} = \dfrac{1.73 * (760)^2}{10 * (16.7)^2} = 14.9\,cm.$

use $t_{min} = 20\,cm$

③ from Curves

P. (3-1)

(Check ton m)



$\therefore\ C_o = 0.87$

$T_{ring\,max} = C_o.\ \gamma HR = 0.87 * 1 * 7.6 * 2.4$

$= 15.9\ t/m$

④ $M_f = \dfrac{\gamma R^2 t^2\ n(n-1)}{6H}$

$= \dfrac{1 * (2.4)^2 * (0.2)^2 * 16.7 * (16.7-1)}{6 * 7.6} = 1.32\ t.m/m$

$$M_{+ve} \simeq \frac{Mf}{5} = \frac{1.32}{5} = 0.26 \ t.m/m$$

$$V_{shear} = \frac{\gamma R^2 \cdot t^2 \ n^2 (2n - 1)}{6 H^2}$$

$$= \frac{1 * 2.4^2 * (0.2)^2 * (16.7)^2 * (2 * 16.7 - 1)}{6 * (7.6)^2}$$

$$\therefore V = 6 \ t/m$$

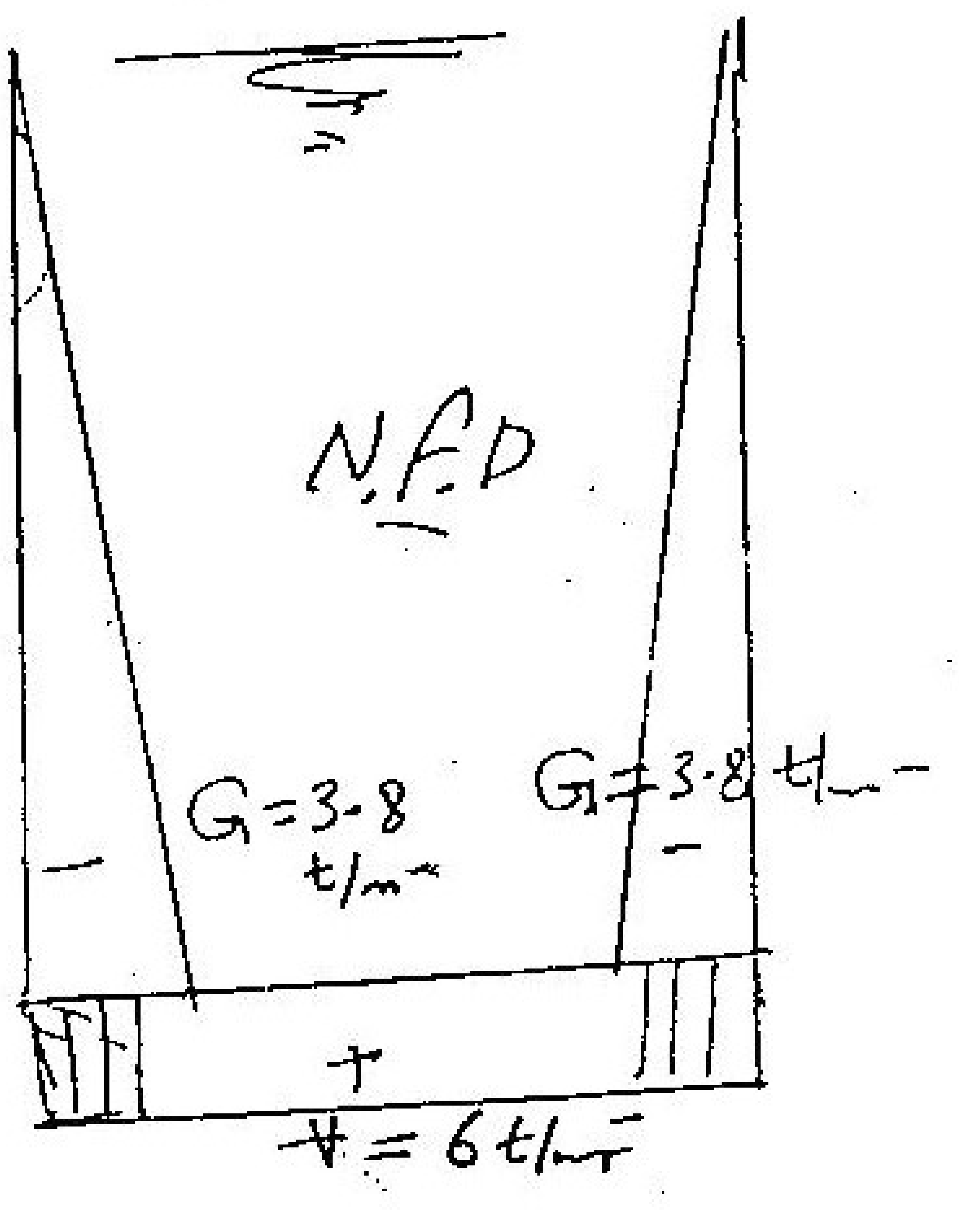
Base: القاعدة on rocky soil.

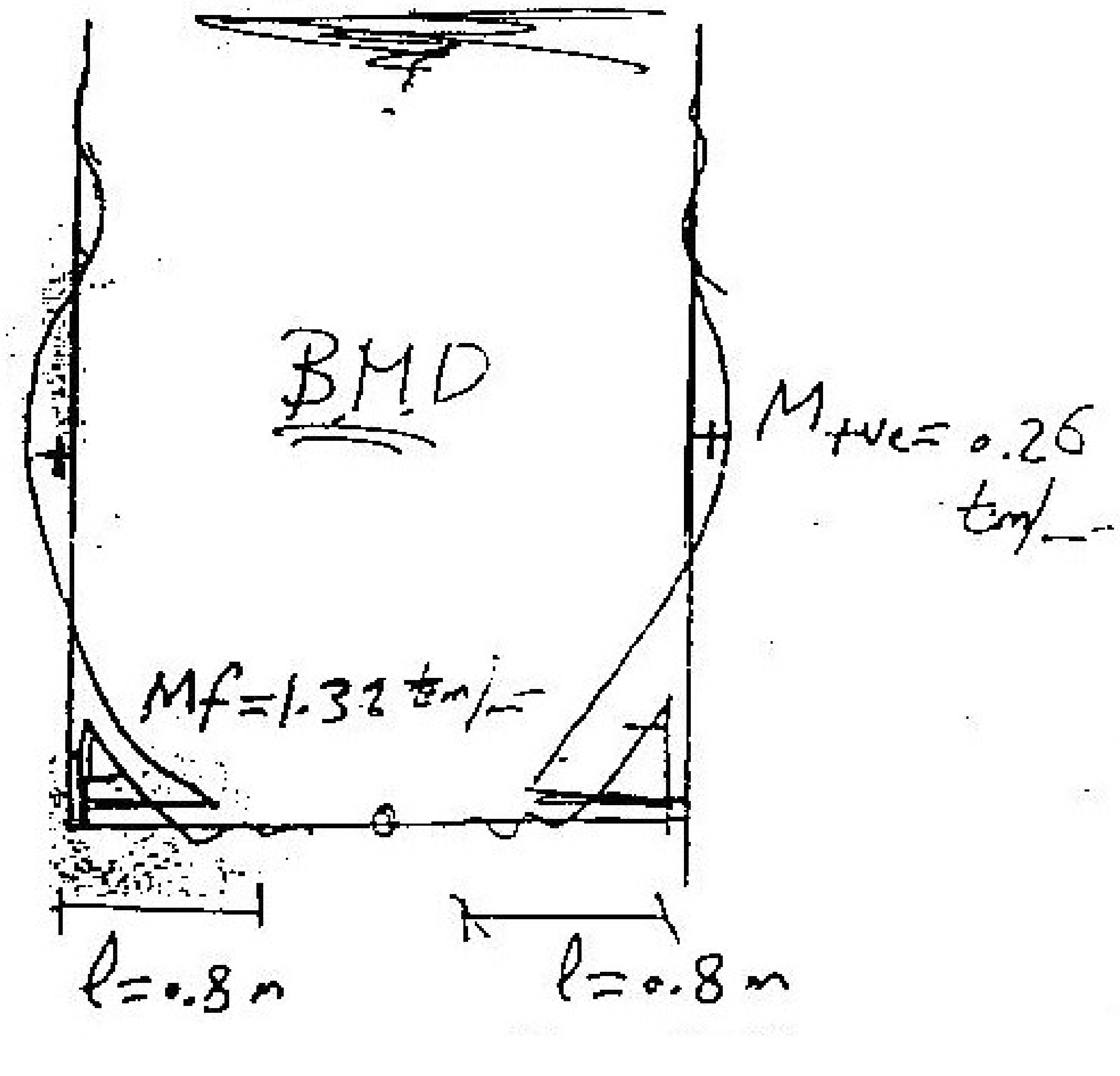
نستخدم حائط ترك لها كمية مسافة $\left(l = 2\sqrt{\frac{Mf}{\omega}}\right)$ ثم نحو

$$\omega = (t_b \cdot \gamma_{R.C}) + (\gamma_w \cdot H_w)$$

$$= 0.2 (2.5) + (1 * 7.6) = 8.1 \ t/m^2$$

$$\therefore l = 2\sqrt{\frac{Mf}{\omega}} = 2\sqrt{\frac{1.32}{8.1}} = 0.8 m$$





وزن الحائط $G = t_{wall} \cdot H_{wall} \cdot \gamma_{R.C}$

$$= (0.2 * 7.6 * 2.5) = 3.8 \ t/m^2$$

(B) Hinged Tank $H = 7.6\ m$, $D = 4.8\ m$

using P.C.A Tables P-(3-4) → (3-16)
بالكتاب

① $\left(\frac{H^2}{D.t}\right) = \frac{7.6^2}{4.8 * 0.25} = 48.13$

Assume $t = 0.25m$

② Ring tension $T_{max\ ring} = C_o . \gamma H R$

$(C_o) \Rightarrow$ from table (2) الحل

$H^2/D.t$	
48	→ ناخد أكبر معامل في الصف $C_o = 0.9$

$\therefore T_{max\ ring} = 0.9 * 1 * 7.6 * 2.4 = 16.4\ t/m$

③ $M_{+ve} = C_o . \gamma H^3$

⇓

$(C_o) \Rightarrow$ from table (8) الحل

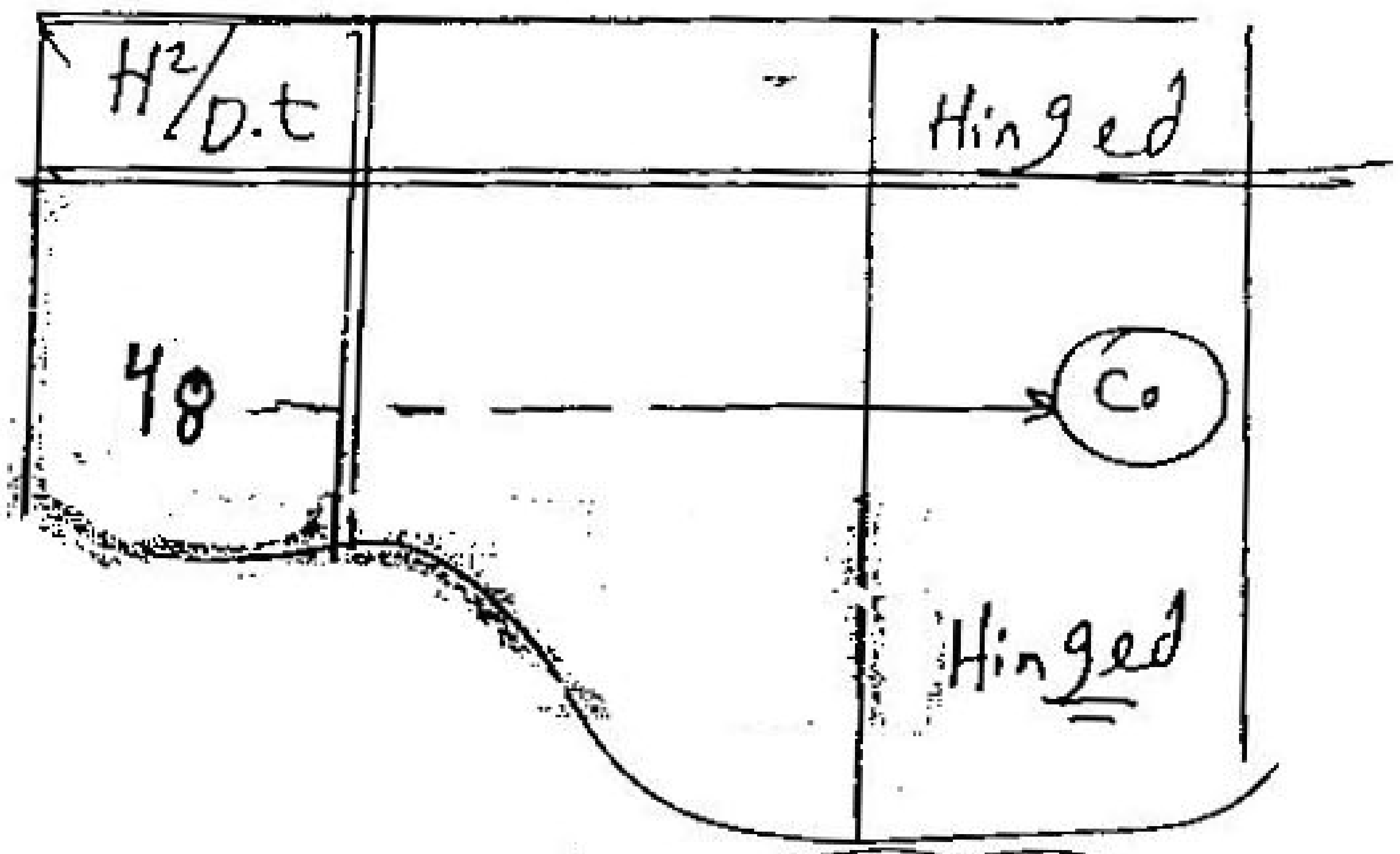
$H^2/D.t$	
48	ناخد أكبر معامل موجب $\therefore C_o = 0.001$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

$\therefore \; M_{+ve} = 0.001 * 1 * (7.6)^3 = 0.438 \; t.m/m$

④ $V_{shear} = C_0 \cdot \gamma H^2$

$(C_0) \Rightarrow$ from table (12) الملحق



$\therefore \; C_0 = 0.039$

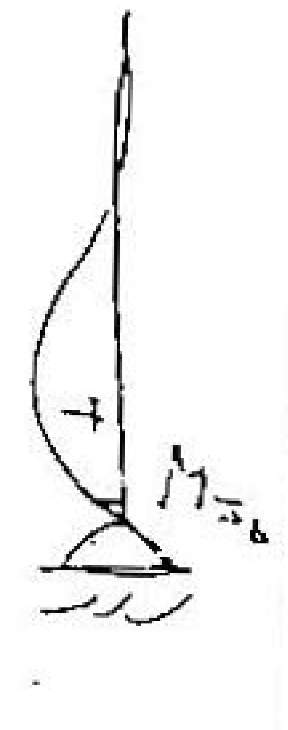
$\therefore \; V_{shear} = 0.039 * 1 * (7.6)^2 = 2.25 \; t/m$

القاعدة

Base: on rocky soil.

كل الأحمال بتوزع والحركة بترجع لنفسها.

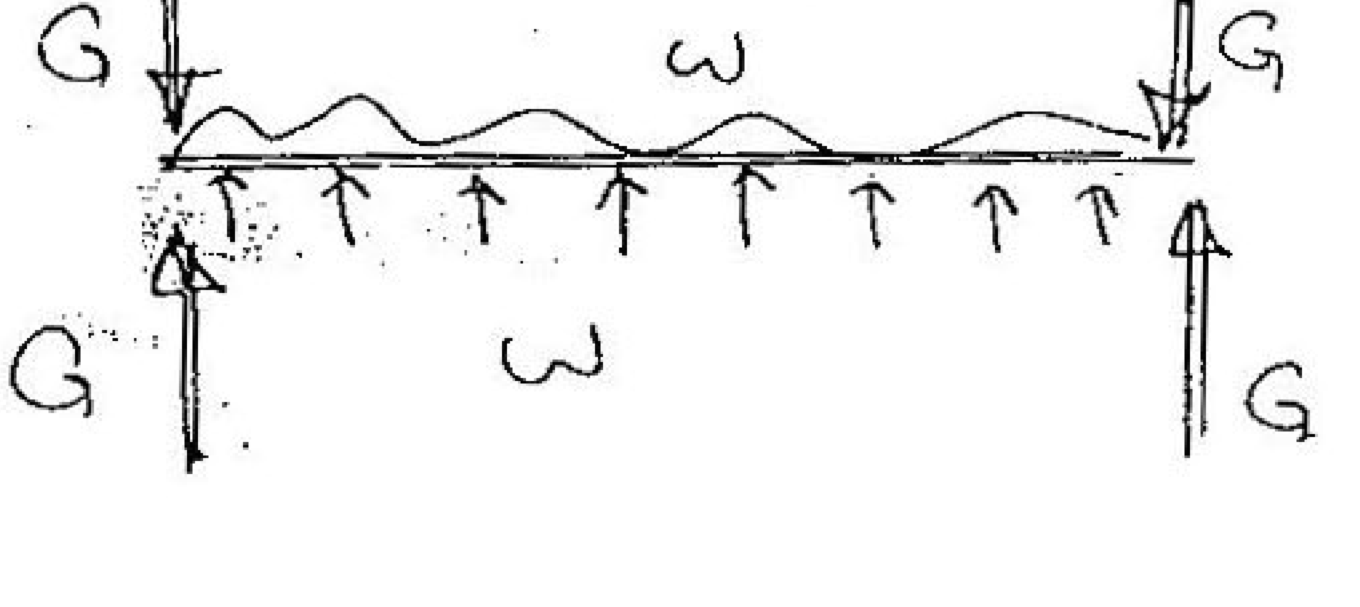
$\therefore \; M = Zero$

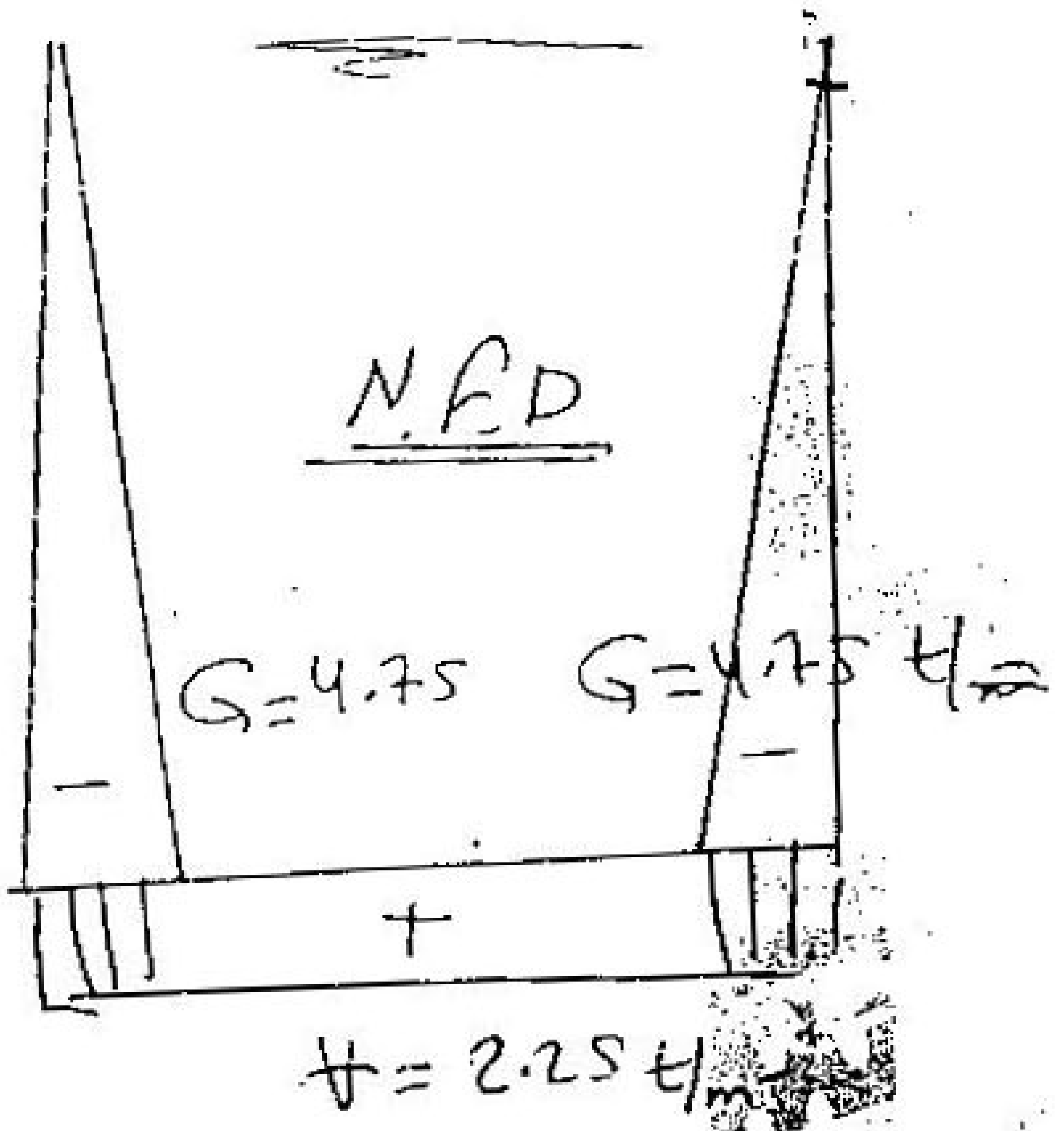


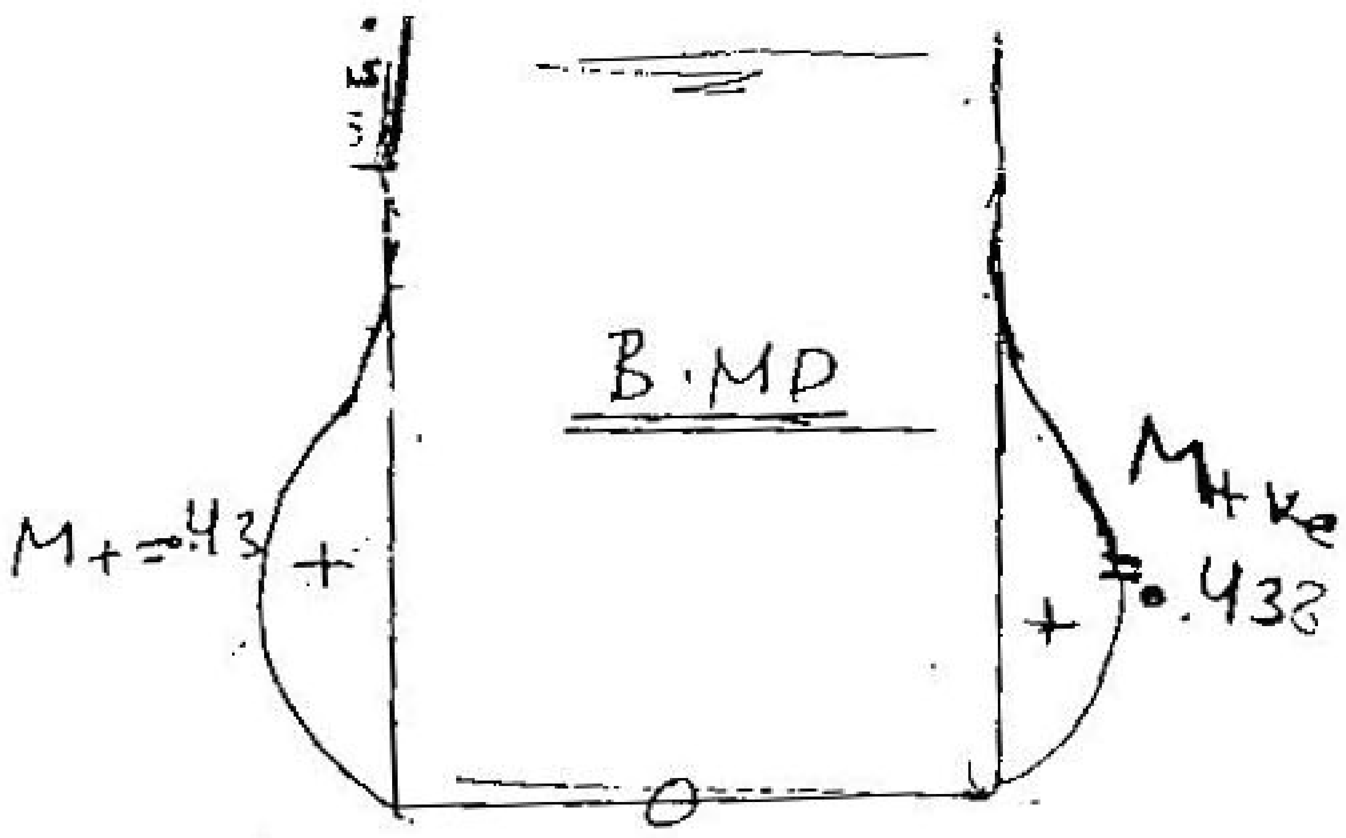
وصحيح أنه لا يوجد عزوم في الحائط يشترك مع القاعدة.

$M = 0$

Hinged







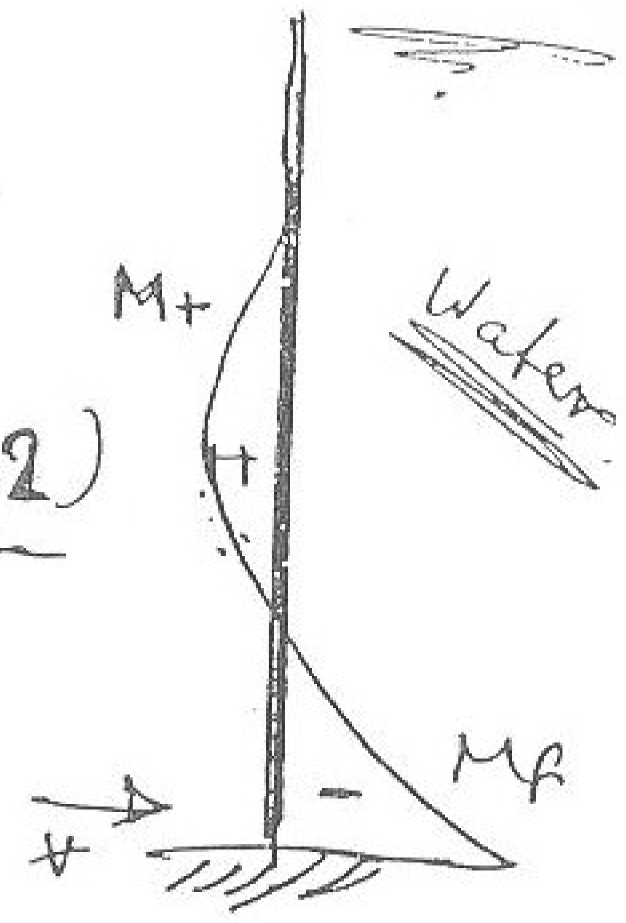
$$G = t_{wall} \cdot H_{wall} \cdot \gamma_{R.C}$$

$$= .25 \times 7.6 \times 2.5 = 4.75 \; t/m$$

(C) Simplified Method : P (3-2)

Fixed Tank : $H = 7.6\,m$

$D = 4.8\,m$



Steps :

(1) $\frac{H}{R^2} = \frac{7.6}{(2.4)^2} = 1.319$

∴ From table P-(3-2)

$= 7.4$

$C_2 = .115$

∴ $C_3 = 0.813$

(2) $t_{wall} = C_3 \cdot \gamma H R = 0.813 * 1 * 7.6 * 2.4$

$t = 14.8$ cm

use $t = 20$ cm

(3) $M_f = \frac{\gamma H D t}{C_1} = \frac{1 * 7.6 * 4.8 * 0.2}{7.4}$

∴ $M_f = 0.98$ t.m/m

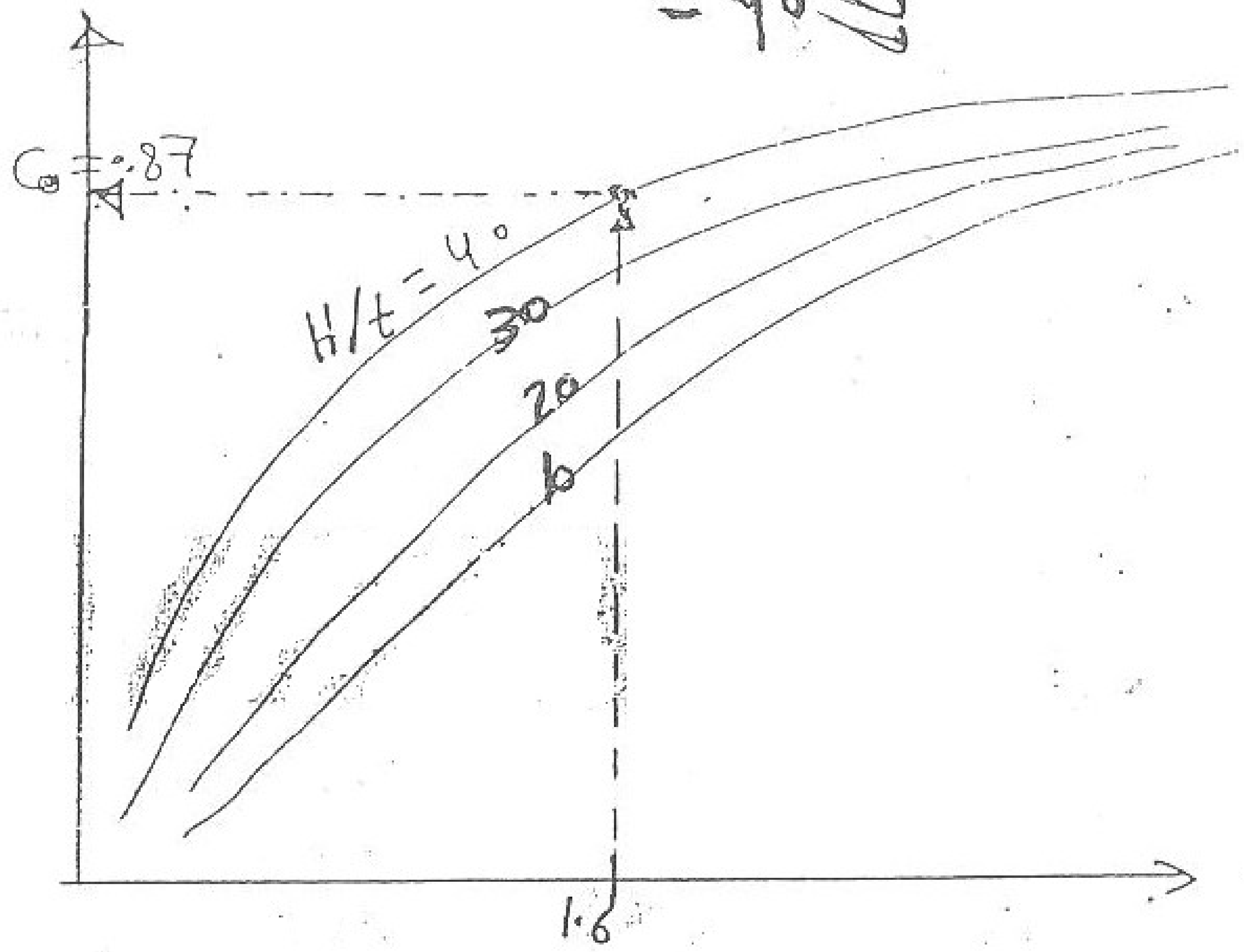
$M_{+ve} \simeq \frac{M_f}{5} = 0.2$ t.m

$V_{Shear} = C_2 \cdot \left(\frac{\gamma H^2}{2}\right) = 0.115 * \frac{1 * (7.6)^2}{2} = 3.32$ t/m

(4) $T = C_o \cdot \gamma H R$

$$\frac{H}{D} = \frac{7.6}{4.8} = 1.58 \simeq 1.6$$

$$\frac{H}{t} = \frac{7.6}{0.2} = 38 \simeq 40$$



step = 0.05

Curve P. (3-2)

$H/D = 1.6$

step = 0.1

$$C_o \simeq 0.87$$

$$T_{max\,ring} = C_o \cdot \gamma H R = 0.87 * 1 * 7.6 * 2.4$$

$$\therefore T_{max\,ring} = 15.86 \text{ t/m}$$

الحالة

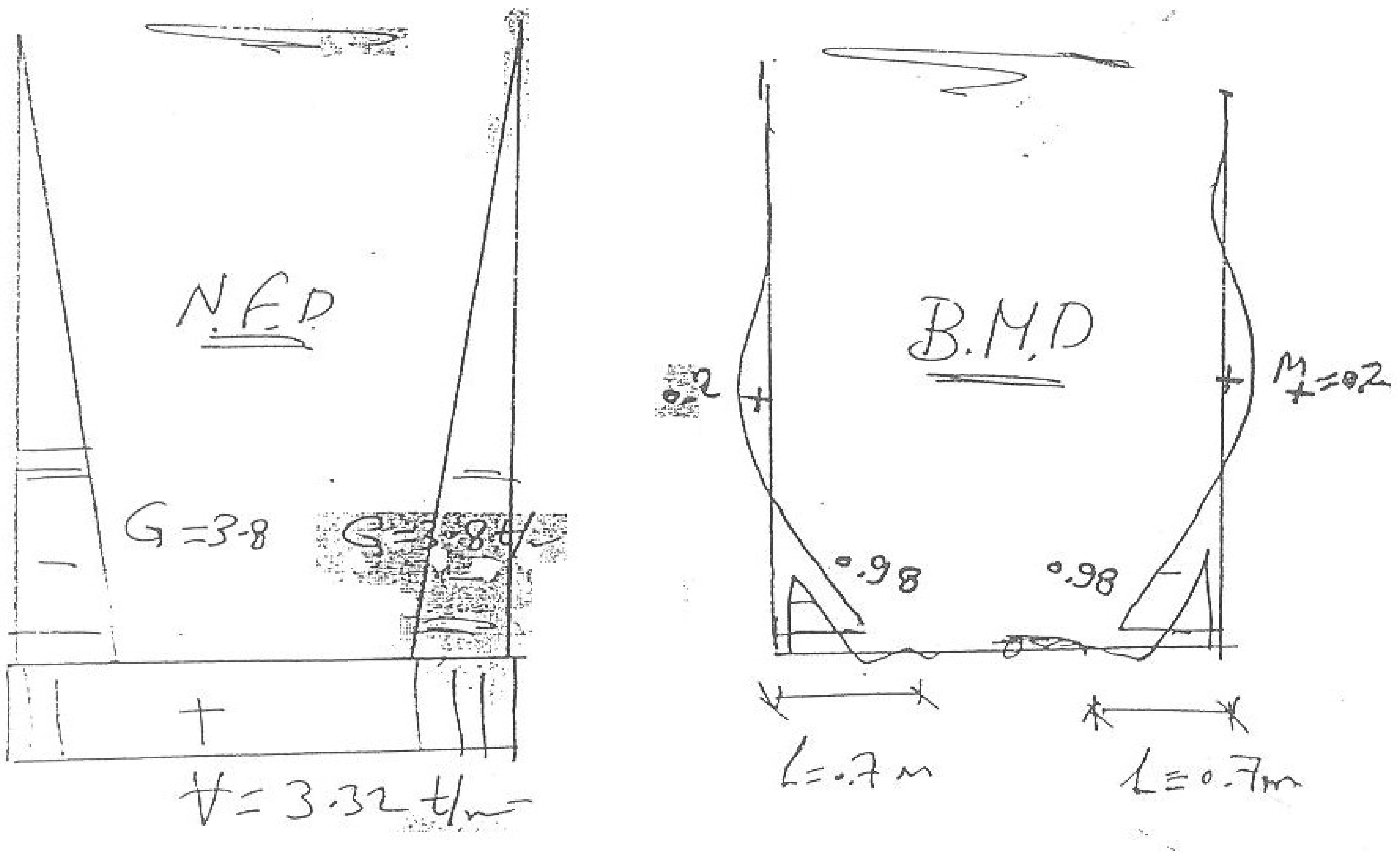
Base on rocky soil.

∴ عزم الحائط (Mf) بيرتد بإشارة مسافة

$$l = 2\sqrt{\frac{M_f}{w}} = 2\sqrt{\frac{0.98}{8.1}} = 0.7\,m$$

$$w = t_b \cdot \gamma_{RC} + \gamma_w \cdot H_w$$

$$w = (0.2 \times 2.5) + (1 \times 7.6) = 8.1\ t/m^2$$



Q. (2) * medium soil. B/c = 1.2 kg/cm²

$$\frac{D}{H} = \frac{4.8}{7.6} = 0.63 < 1.5$$

∴ uniform Stress

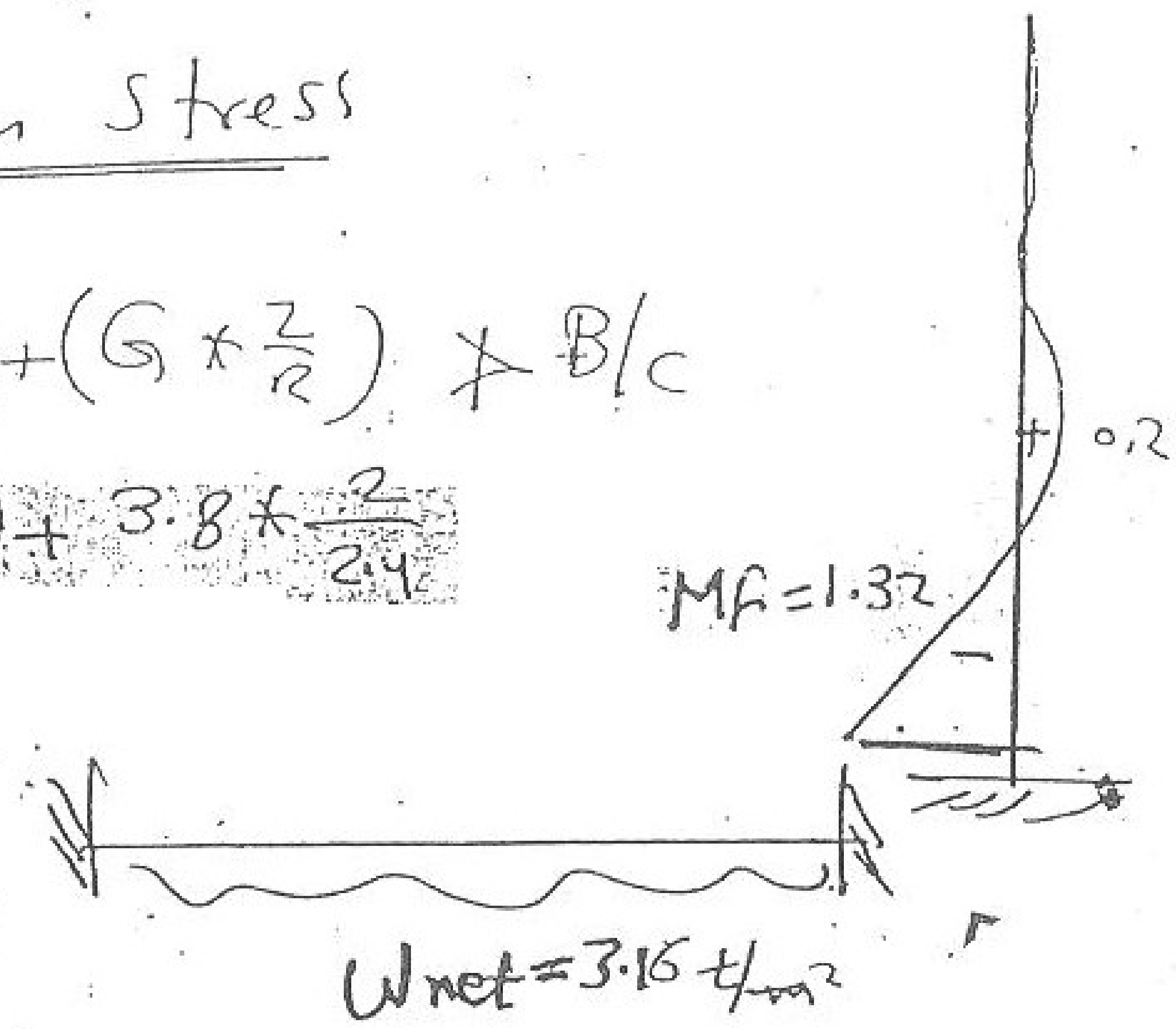
$\sigma_{soil} = (\gamma_w \cdot H_w) + (t_b \cdot \gamma_{R.C}) + (G * \frac{2}{R}) \ngtr B/c$

$= (1 * 7.6) + (0.2 * 2.5) + 3.8 * \frac{2}{2.4}$

$= 11.2$ t/m²

∵ B/c = 12 t/m²

∴ σ_{soil} << B/c (ok)



$W_{net} = G * \frac{2}{R} = 3.8 * \frac{2}{2.4} = 3.16$ t/m²

الحل لذي يريد ليحصل منه
على العلامة
(حل لحوائط)

⟹ Analysis of Base as fixed Plate

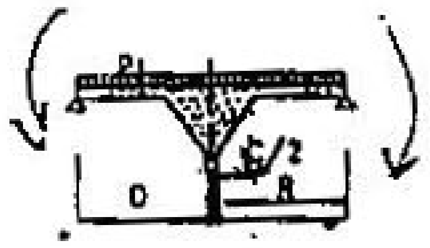
∴ المركز $P_{total} = W_{net} * \pi R^2$

$= 3.16 * \pi * (2.4)^2$

$P_{total} = 57.18$ ton

∴ Moment = P_{total} * factors

Table XVI : Moments in circular slab with center support and hinged edge due to moment per m., M, applied at edge :
Moment = coeff. * M
Positive sign indicates compression in top surface.



	c/D	0.05R	0.10R	0.15R	0.20R	0.25R	0.30R	0.40R	0.50R	0.60R	0.70R	0.80R	0.90R	1.00R
Radial Moments (Mr)	.05	-2.65	-1.12	-.622	-.333	-.129	+.029	+.268	+.450	+.596	+.718	+.824	+.917	+1.0
	.10		-1.95	-1.03	-.584	-.305	-.103	+.187	+.394	+.558	+.692	+.808	+.909	+1.0
	.15			-1.59	-.930	-.545	-.280	+.078	+.323	+.51	+.663	+.790	+.900	+1.0
	.20				-1.37	-.842	-.499	-.057	+.236	+.451	+.624	+.768	+.891	+1.0
	.25					-1.20	-.765	-.216	+.130	+.392	+.577	+.740	+.880	+1.0
Tangential Moment (Mθ)	.05	-.530	-.980	-.847	-.688	-.544	-.418	-.211	-.042	+.095	+.212	+.314	+.405	+.486
	.10		-.388	-.641	-.608	-.158	-.419	-.233	-.072	+.066	+.185	+.290	+.384	+.469
	.15			-.319	-.472	-.463	-.404	-.251	-.100	+.035	+.157	+.263	+.363	+.451
	.20				-.272	-.372	-.368	-.261	-.123	+.007	+.129	+.240	+.340	+.433
	.25					-.239	-.305	-.259	-.145	-.0200	+.099	+.214	+.320	+.414

Table XVIII : Load on center support for circular slab
Load = coeff.x : (pR^2 hinged & fixed)
* Reaction on Column (M moment at edge)

c/D	0.05	0.10	0.15	0.20	0.25
Hinged	1.320	1.387	1.463	1.542	1.625
Fixed	0.839	0.919	1.007	1.101	1.200
M at Edge	8.16	8.66	9.29	9.99	10.81

Table XIX : Stiffness of Circular Plate with Center Support :
$k = coeff. x \cdot Et^3/R$

c/D	0.05	0.10	0.15	0.20	0.25
Coeff.	0.290	0.309	0.332	0.358	0.387
Without Center Support	$k = 0.104\ Et^3/R$				

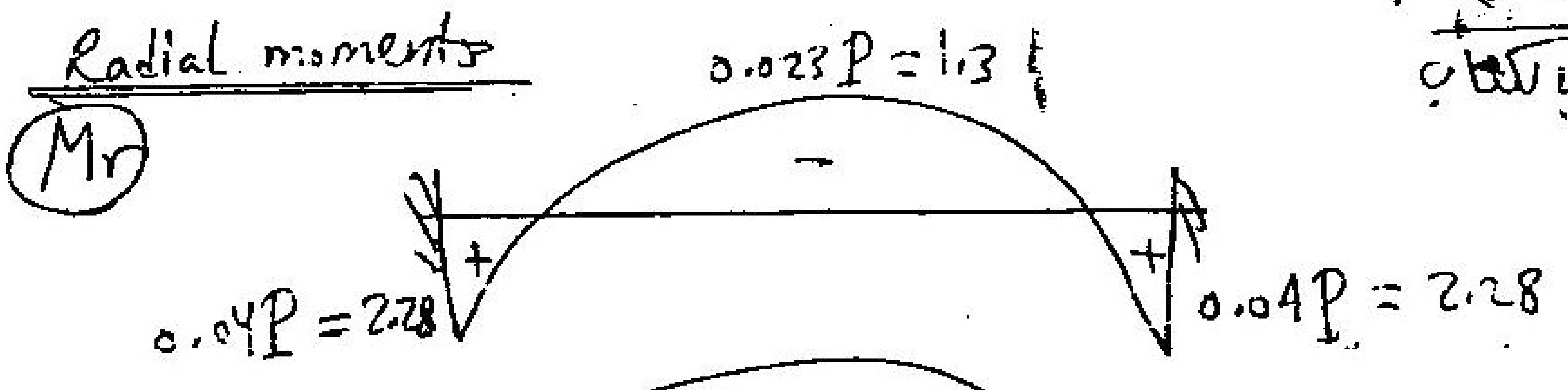
Base

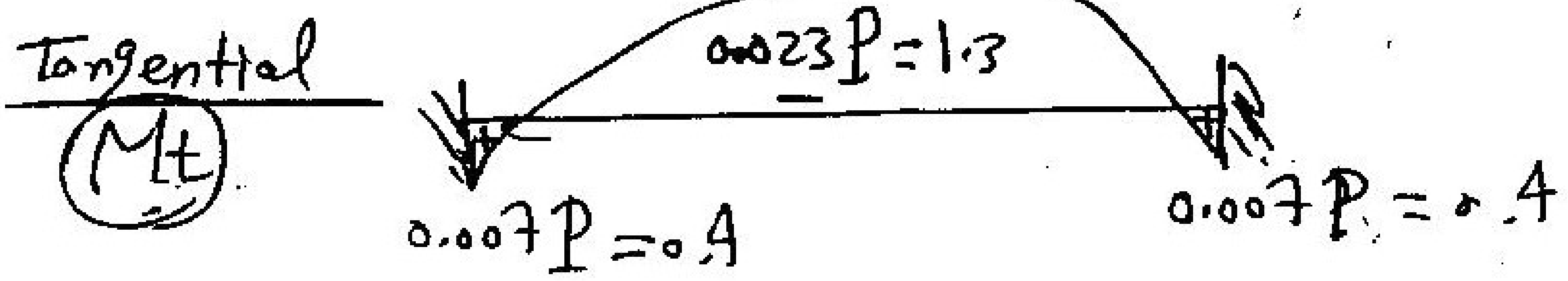
Table XX : Stiffness of Cylindrical Wall, near edge ~~hinged~~ fixed, far edge free :

$k = coeff. * Et^3/H$ → Wall

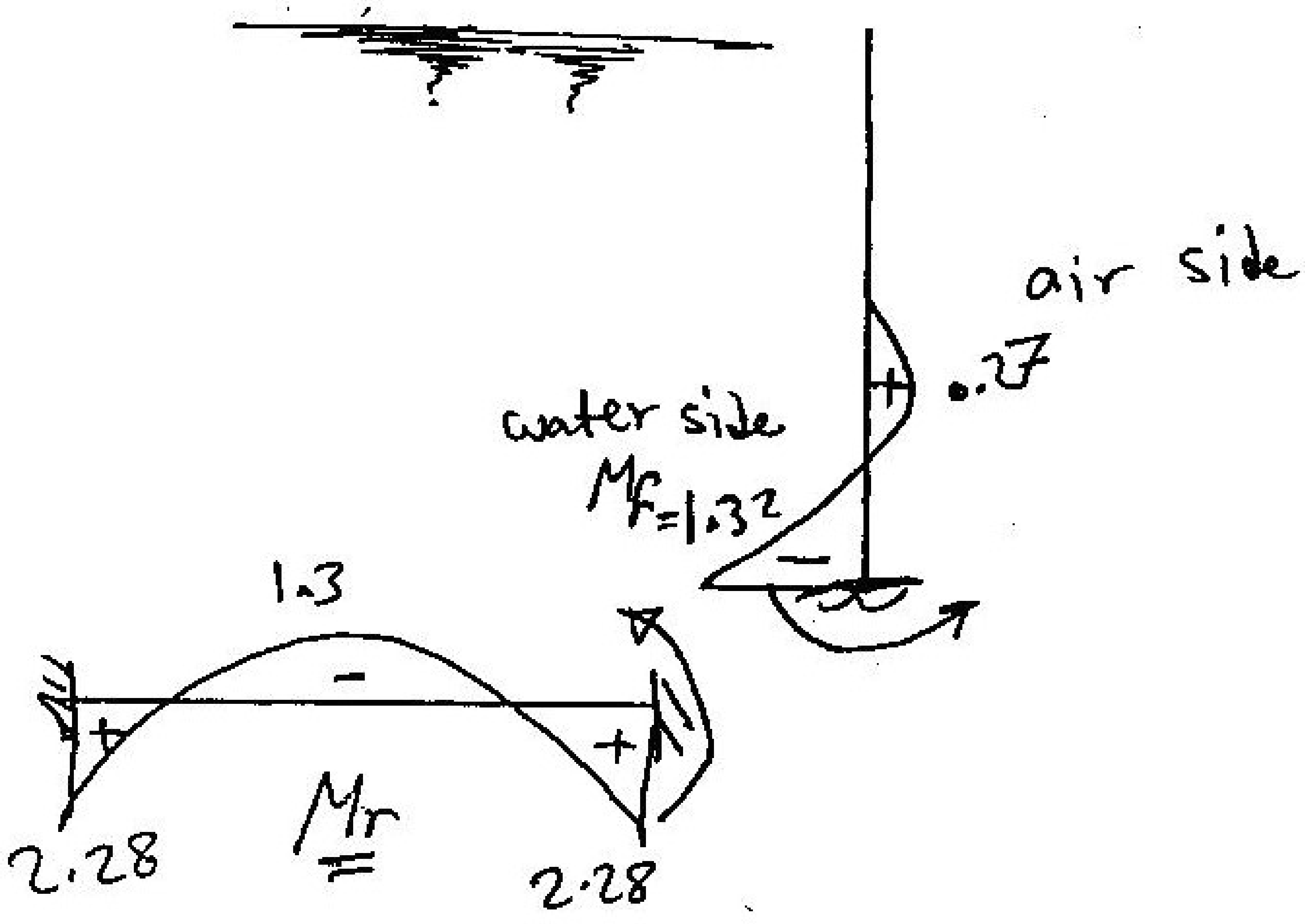
H^2/Dt	0.4	0.8	1.2	1.6	2	3	4	5	6	8	10	12	14	16	20	24	32	40	48	50
coeff.	.139	.27	.345	.399	.445	.548	.635	.713	.783	.903	1.01	1.11	1.2	1.28	1.43	1.57	1.81	2.03	2.22	2.4

P-(3-23) بالكتاب





ثم نقوم بعمل الاتزان بين (Mr) ونرسم الـ (Mf)



P(3-19)

$$\rightarrow k_{wall} = \frac{C_o \cdot E \cdot t^3}{H} = \frac{2.4\,E\,(0.25)^3}{7.6} = 4.9 \times 10^{-3} E$$

$$\rightarrow k_{base} = \frac{0.104\,E\,t^3}{R} = \frac{0.104\,E\,(0.25)^3}{2.4} = 6.7 \times 10^{-4} E$$

$$\rightarrow D.f_{wall} = \frac{4.9 \times 10^{-3}}{(4.9 \times 10^{-3} + 6.7 \times 10^{-4})} = 0.88$$

$$\rightarrow D.f_{base} = 1 - D.f_{wall} = 0.12$$

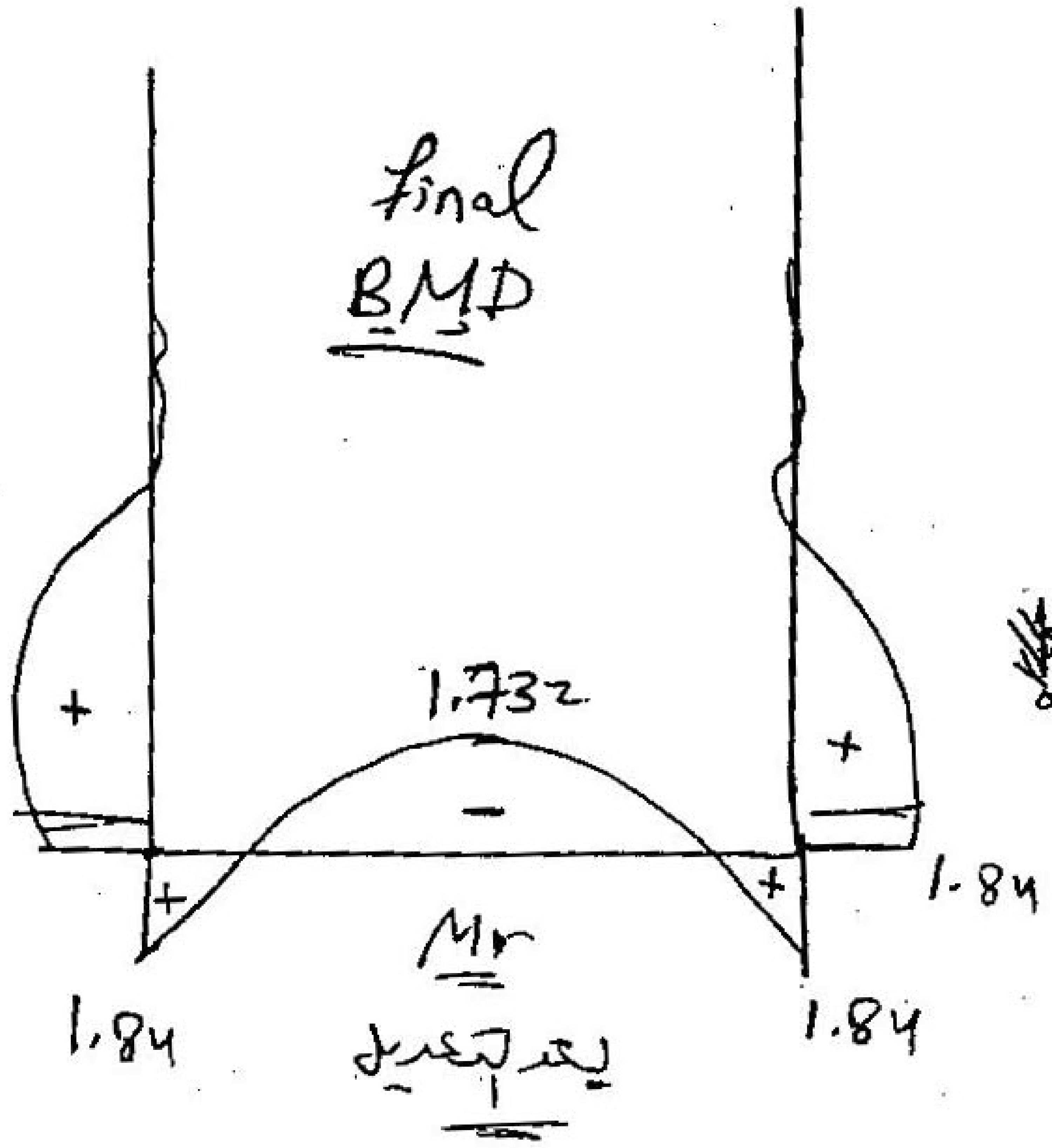
$D.f_{wall} = 0.88$ $D.f_{base} = 0.12$

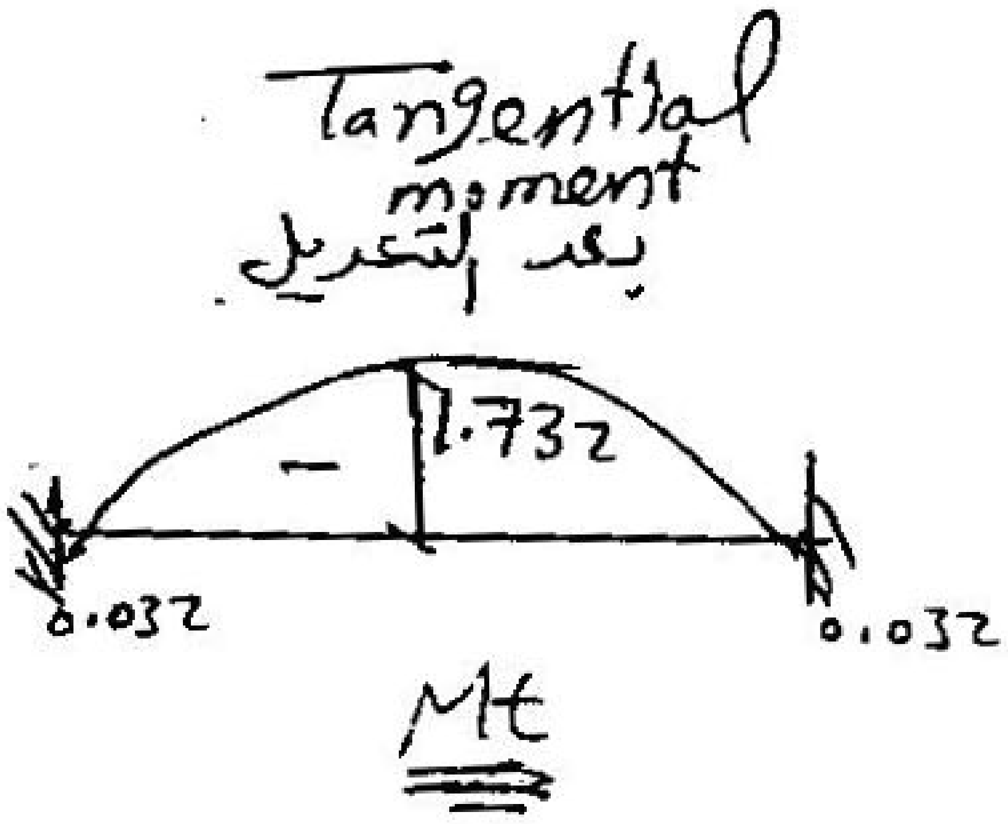
	Wall	Base
fixed moment	1.32	2.28
D.M	-3.168	-0.432
final moment	-1.84	1.84

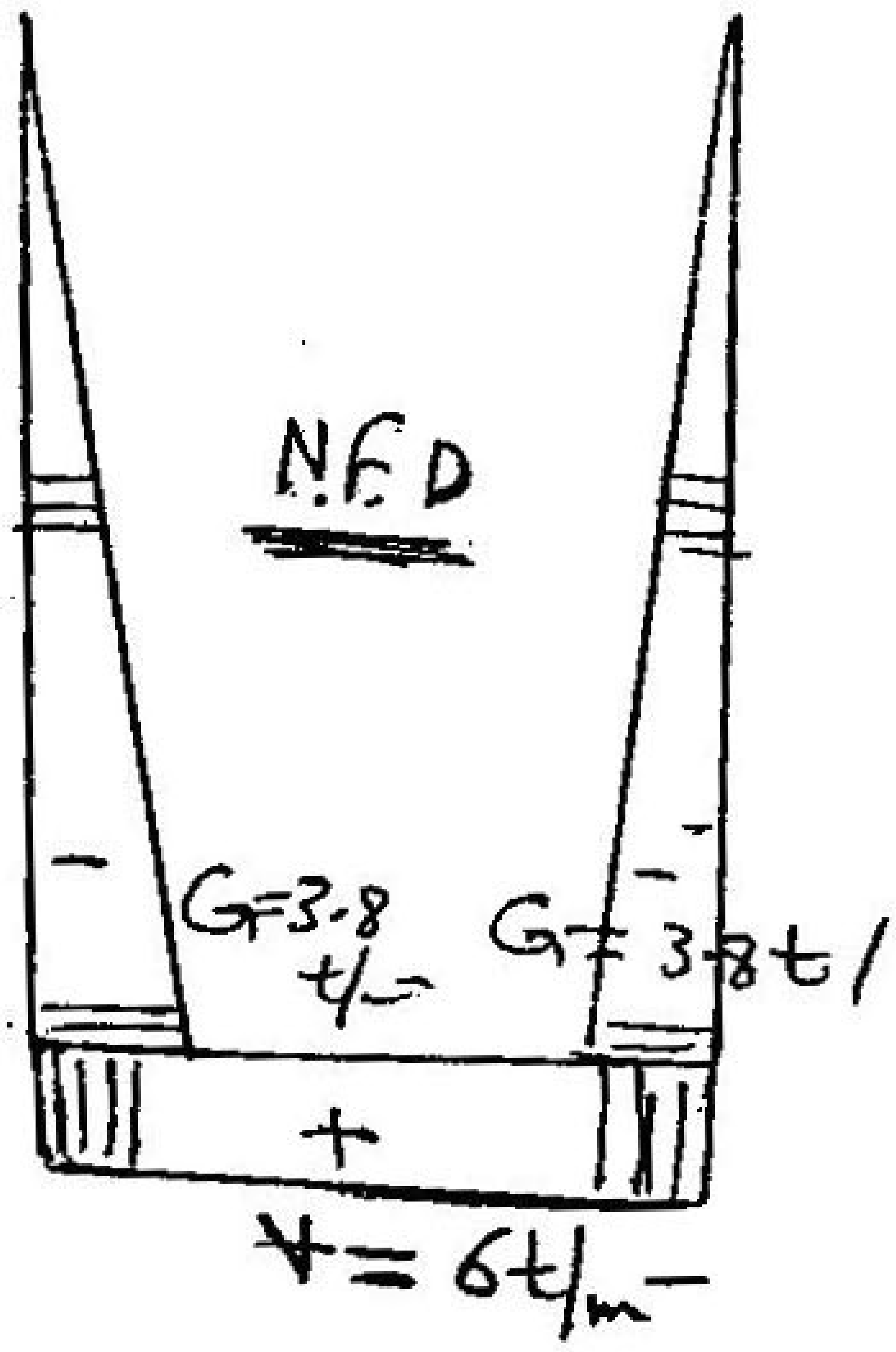
نفرض العزم عكس العقارب موجب

$$D.M = -(1.32 + 2.28) * D.f \begin{cases} 0.88 & \text{Wall} \\ 0.12 & \text{Base} \end{cases}$$

ثم تحريك عزوم القاعدة كلها لأعلى بمقدار 0.432







Design of sections :

(1) Ring direction : $T_{max\ ring} = 15.9\ t/m$

stage (I) $t = \xi \cdot T = 0.6 * 15.9 = 9.6\ cm$

∴ use $t = 20\ cm$

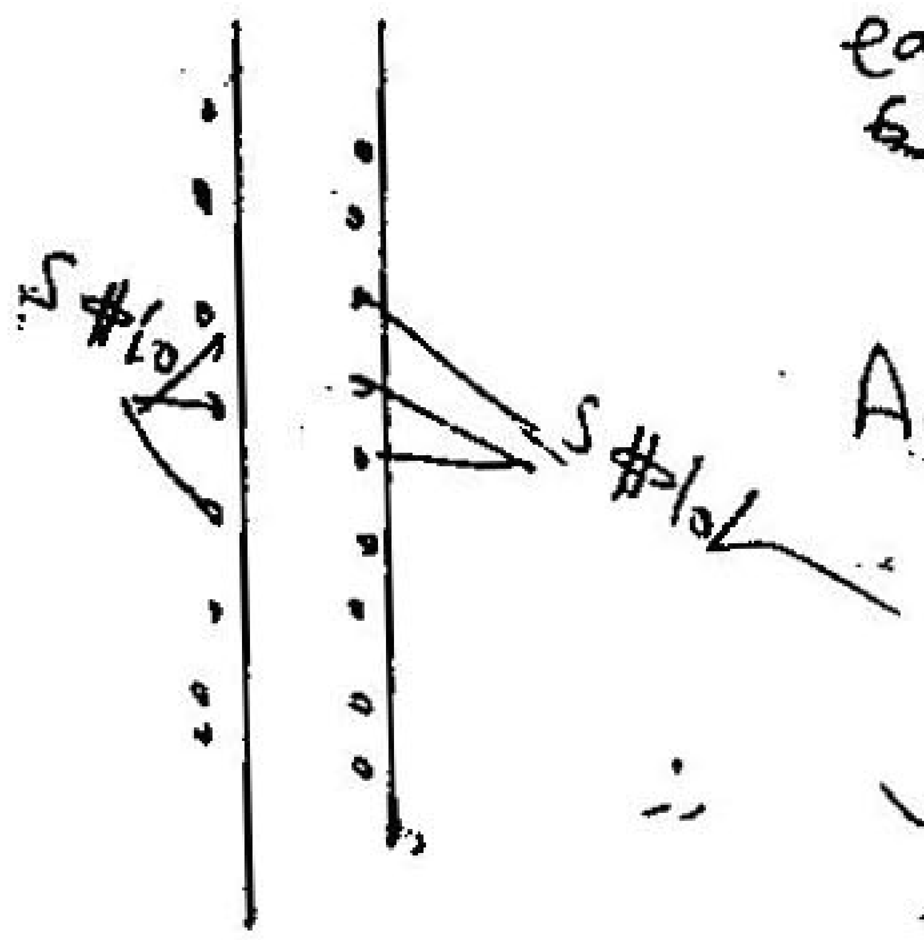
stage (II) $A_{s\ \text{each side}} = \frac{T_u * 10^3}{2\left(\frac{f_y}{\delta_s}\right)} = \frac{(1.5 * 15.9) * 10^3}{2\left(\frac{3600}{1.15}\right)}$

$= 3.8\ cm^2/m$

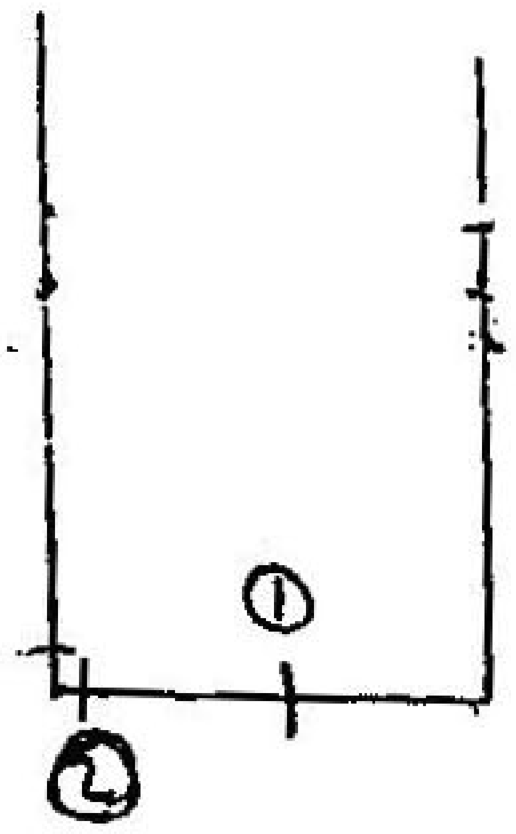
$A_{s_{min}} = \frac{0.15}{100} B\, d = \frac{0.15}{100} * 100 * 15$

$= 2.25\ cm^2/m$ XX

∴ use $A_{s\ \text{each side}} = 5 \# 10/m$



VL. direction:



Sec (1) $M_{water\ side} = 1.73$ t.m , $T = 6$ t/m

Stage (I)

$$t = \sqrt{\frac{M \times 10^5}{\psi \cdot B}} + (2 \rightarrow 3) \text{ cm}$$

$\psi = 3.2$, B = 100 cm

t = 30 cm

d = 25 cm

Check : $\sigma_t = \frac{6M}{B \cdot t^2} - \frac{T}{B \cdot t} \not> f_{ct}$

$$= \frac{6 \times 1.73 \times 10^5}{100 \times (30)^2} + \frac{6 \times 10^3}{100 \times 30}$$

13.5 kg/cm² $\not> f_{ct} = 18$ kg/cm²

ok Safe

Stage (II) ultimate

$T_u = 1.5T = 9$ t/m

$M_u = 1.5M = 2.6$ t.m/m

$$e = \frac{M_u}{T_u} = 0.28 \ m$$

$$e/t = \frac{0.28}{0.3} = 1 > 0.5$$

Big eccentric section.

$$e_s = e - \frac{t}{2} + 0.05 = 0.18 \ m$$

$$M_{us} = T_u \cdot e_s = 1.62 \ t.m$$

$$R_1 = \frac{M_{us} \times 10^5}{f_{cu} \cdot B \cdot d^2} = 0.01$$

$$\therefore \omega = 0.015 \Rightarrow A_s = \frac{\omega f_{cu} \cdot B \cdot d}{f_y} + \frac{T_u \times 10^3}{f_y/\gamma_s}$$

$$\therefore A_s = 5.5 \ cm^2/m' \simeq 5 \# 12/m'$$

حديد علوى من القاعدة كلها ناحية العرض.

Sec (2)

$$M_{air\ side} = 2.28 \ t.m/m'$$

$$T = 6 \ t/m'$$

نصمم القطاع على stage (II) مباشرة

t = 30 سم

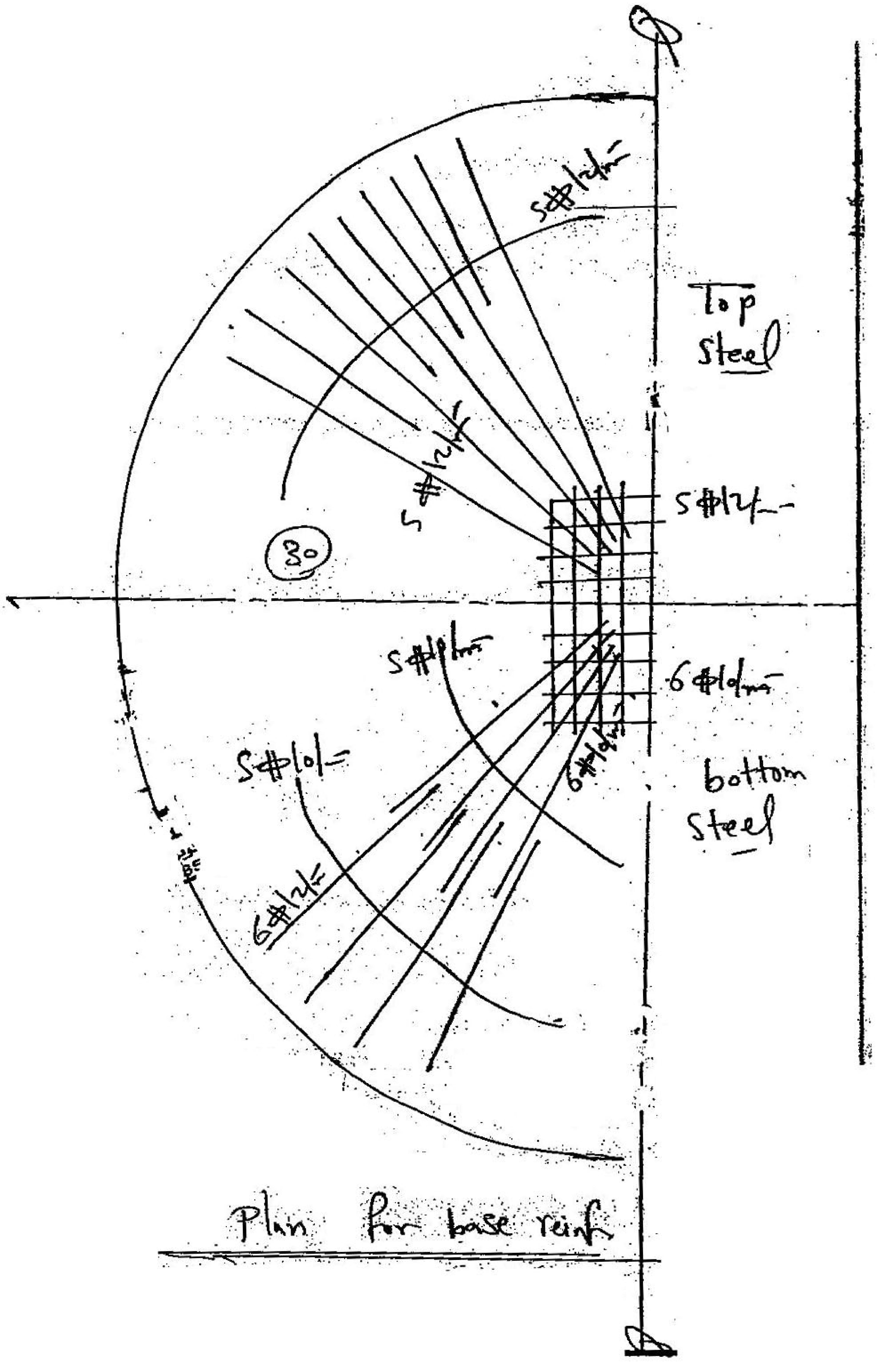
من تصميم القطاع السابق

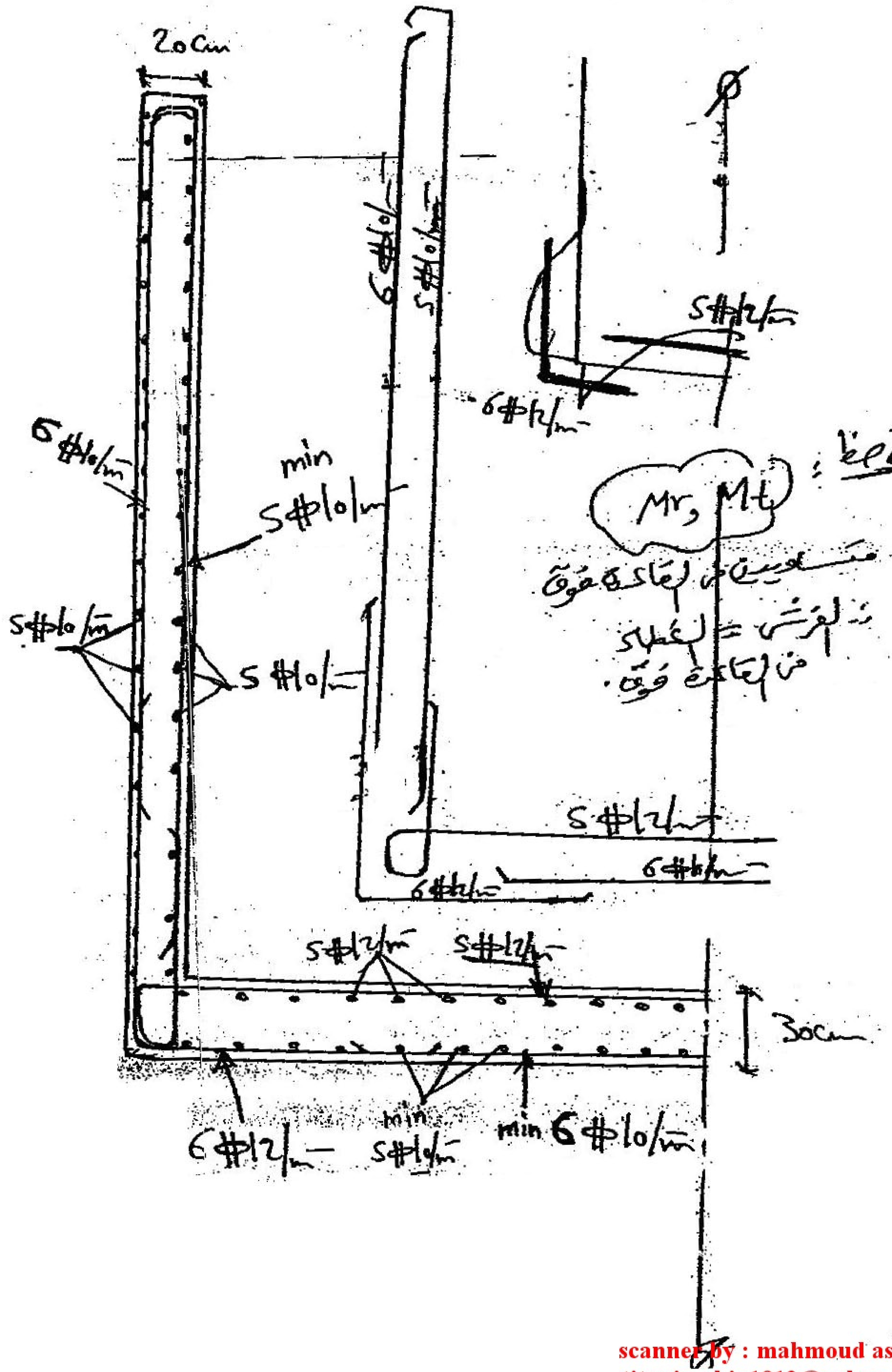
d = 25 سم.

$T_u \rightarrow$, e , e_s , $M_u = \rightarrow$, M_{us} , R_1 , $\omega \rightarrow$

$\Rightarrow A_s = 6.5\ cm^2/m$

$= 6\ \Phi 12/m$





Revision 2

12 ث

سنتر و مركز

الفارس

للخدمات الطلابية والعلمية

الفرقة الرابعة مدني

Reinforced Concrete Water tanks

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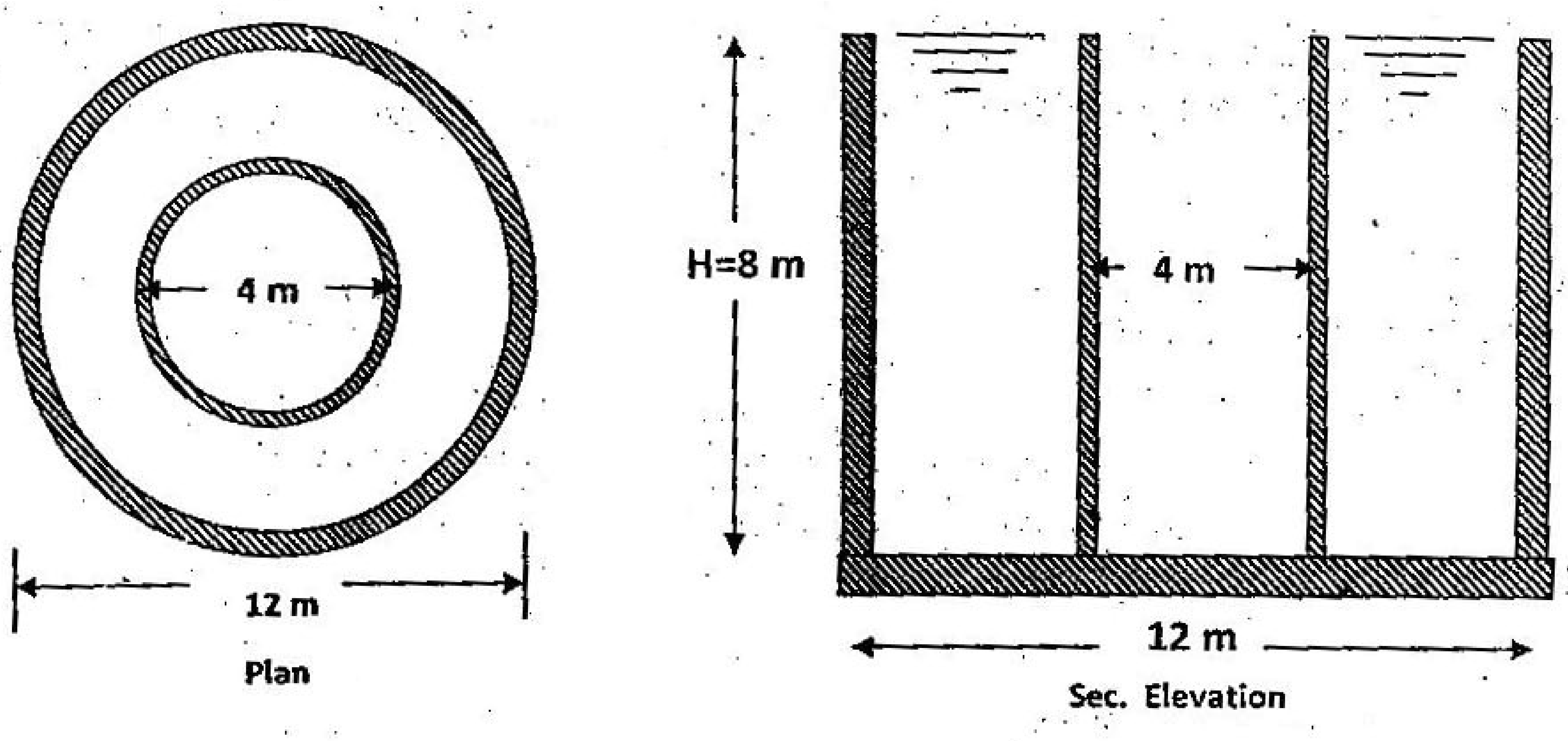
((Revision)) Circular tanks

The shown fixed circular tank composed of two cylindrical walls; the outer part is always filled by water and the inner part is empty. The tank is rested on rocky soil. It is required to :



1- Calculate the straining actions for wall by Approximate method and straining actions for base.

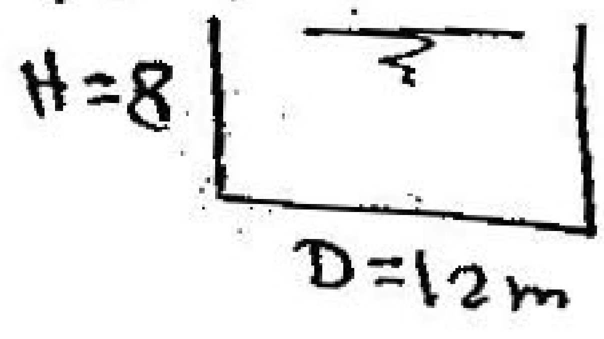
2- Design critical sections.

3- Draw reinf. Details.

Solution:

[1] Walls: (using Approximate Method)

(A) outer wall : (ضغط داخلي)



$$\frac{H^2}{R_2} = \frac{8}{(6)^2} = 0.22$$

$$\therefore \quad 0.025 < \frac{H}{R_2} < 0.25 \Rightarrow \text{(Medium)}$$

From reissner: (kg, cm)

$$\Rightarrow n = 0.5 + \sqrt{0.25 + \frac{f_{ct} \cdot H}{\gamma \cdot R^2}}$$

$$= 0.5 + \sqrt{0.25 + \frac{20 * (800)}{0.001 * (600)^2}} = 7.18$$

$$\Rightarrow t_{\substack{wall \\ at\ base}} = \frac{1.73 H^2}{R \cdot n^2} = \frac{1.73 * (800)^2}{600 * (7.18)^2}$$

$$= 35.8 \text{ cm}$$

$$\therefore \text{use } t_{\substack{wall \\ at\ base}} = 40 \text{ cm}$$

$$T_{ring} = 0.6\, \gamma H R = 0.6 * 1 * 8 * 6$$

$$= 28.8 \text{ t/m}$$

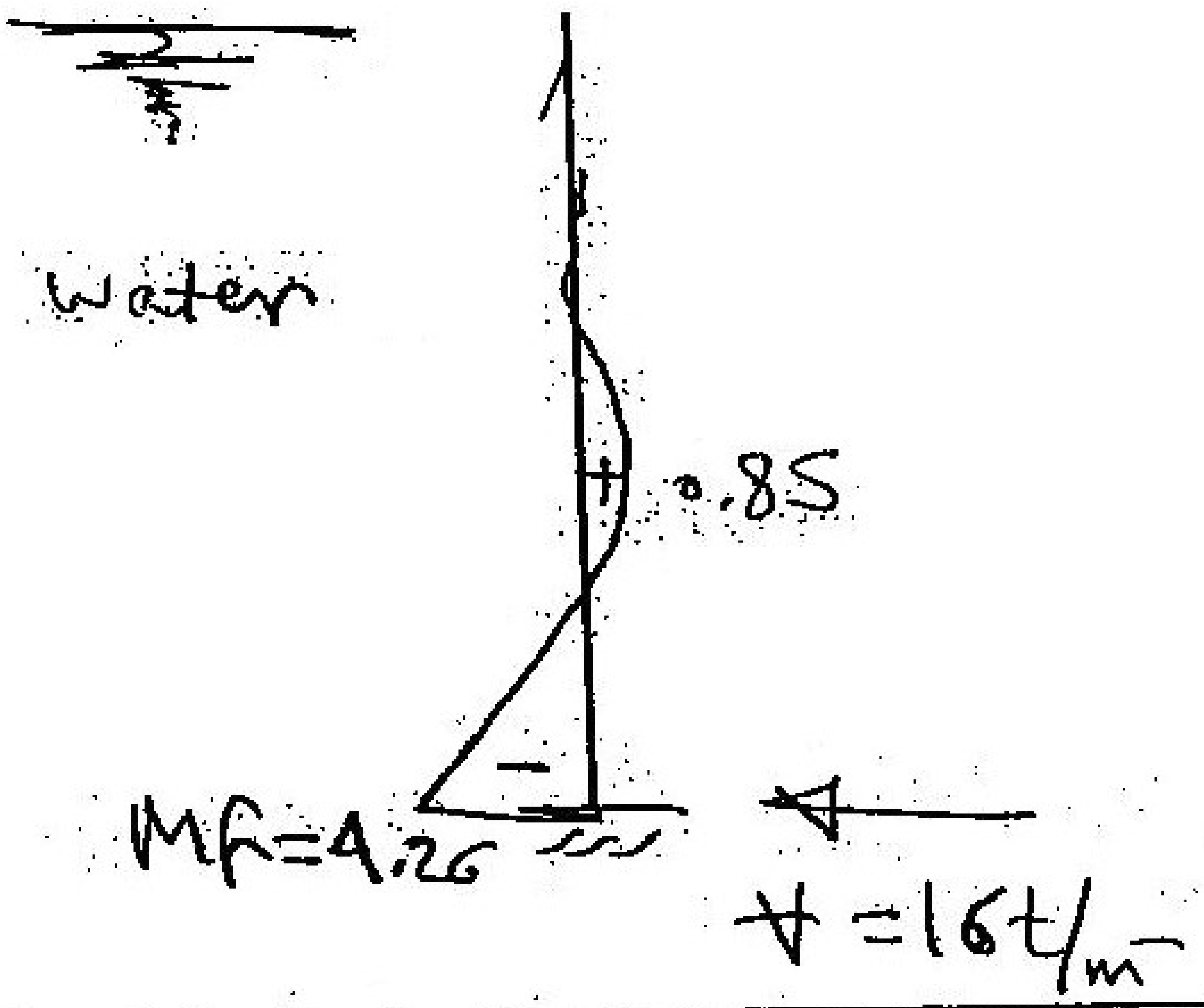
$$M_f = \frac{\gamma H D \cdot t}{9} = \frac{1 * 8 * 12 * (0.4)}{9} = 4.26 \text{ t.m/m}$$

$$M_{+ve} = \frac{M_f}{5} = 0.85 \text{ t.m/m}$$

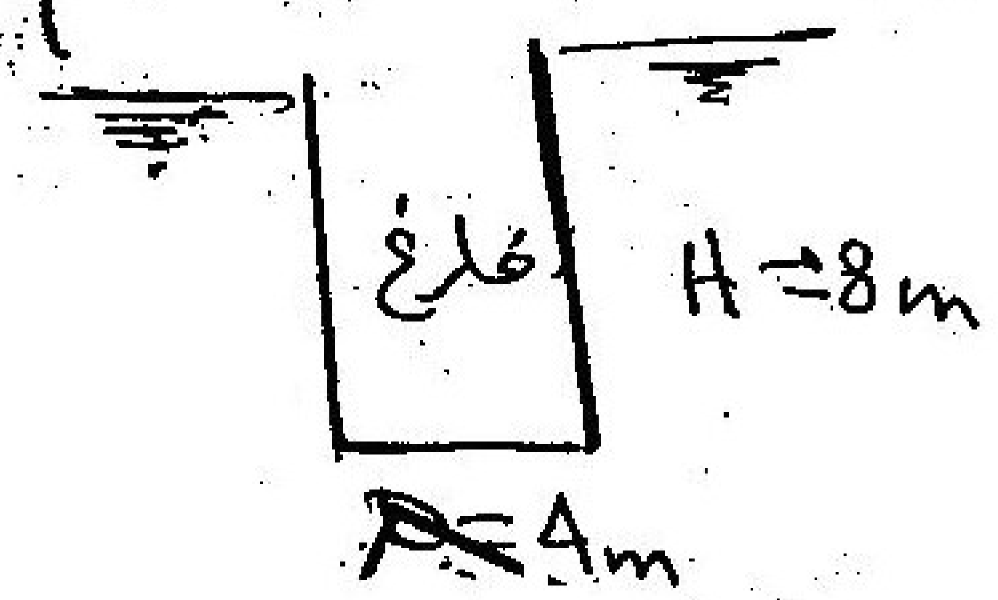
$$V_{shear} = (0.12 \rightarrow 0.3)\, \gamma H^2$$

$$\simeq 0.25\, \gamma H^2 = 0.25 * 1 * (8)^2$$

$$= 16 \text{ t/m}$$



B Inner Wall (داخلي)



$$\frac{H}{R^2} = \frac{8}{(2)^2} = 2 > 0.25$$

∴ deep tank

from reissnar

$$\Rightarrow n = 0.5 + \sqrt{0.25 + \frac{f_{ct} \cdot H}{\gamma \cdot R^2}} = 20.5$$

$$\Rightarrow t_{\text{wall at base}} = \frac{1.73 H^2}{R \cdot n^2} = \frac{1.73 * (800)^2}{200 * (20.5)^2} = 13 \text{ cm}$$

∴ use $t_{min} = 20$ cm

$$N_{\text{compression maximum in Ring}} = 0.85\, \gamma H R = 0.85 * 1 * 8 * 2 = 13.6 \text{ t/m}$$

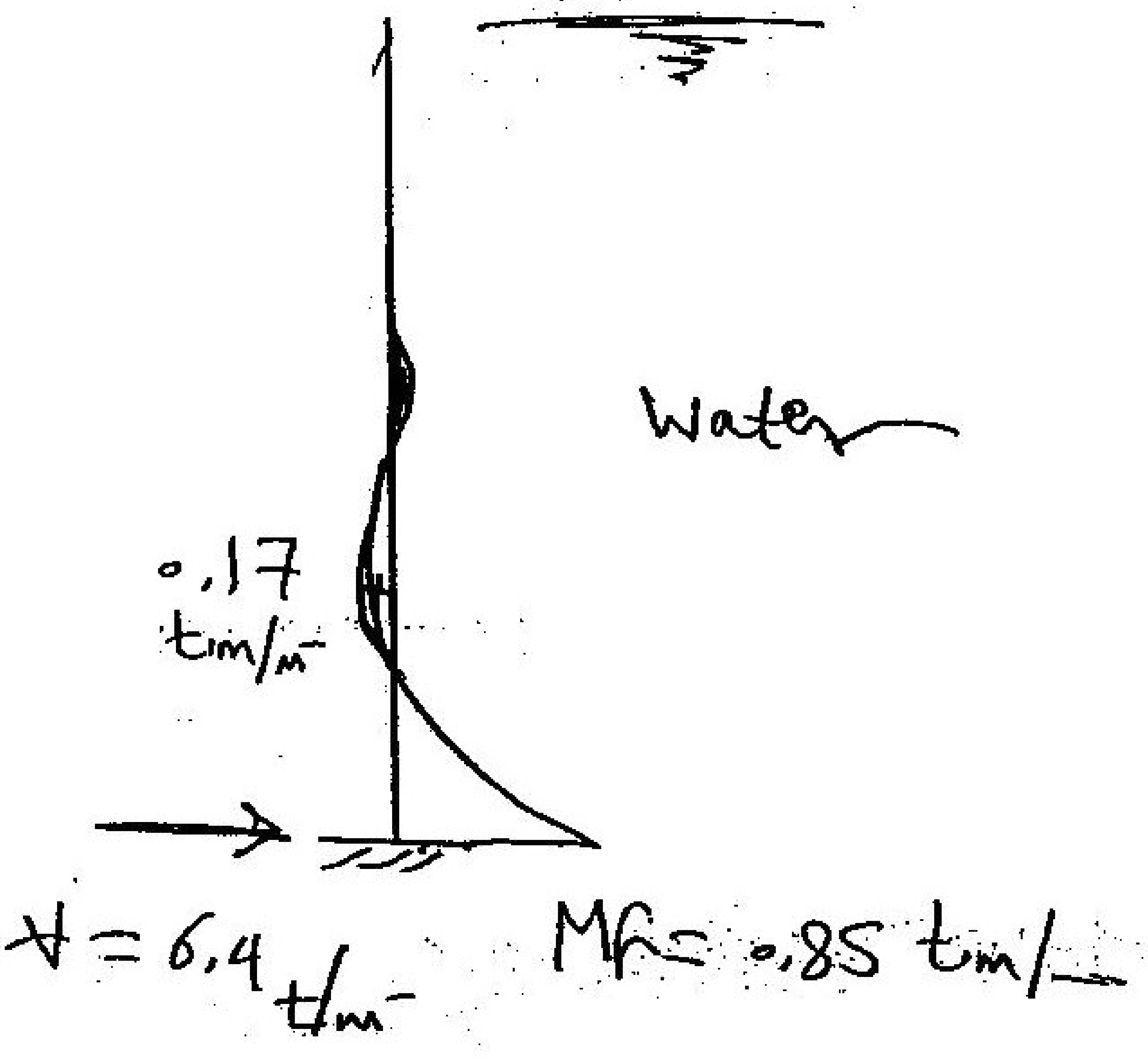
$$M_f = \frac{\gamma . H . D . t}{7.5} = \frac{1 * 8 * 4 * 0.2}{7.5} = 0.85 \ t.m/m$$

$$M_{+ve} = \frac{M_f}{5} = 0.17 \ t.m/m$$

$$V_{shear} = (0.05 \rightarrow 0.12)\gamma H^2 \simeq 0.1 \gamma H^2$$

$$= 0.1 * 1 * (8)^2$$

$$= 6.4 \ t/m$$



2 Base: on rocky soil

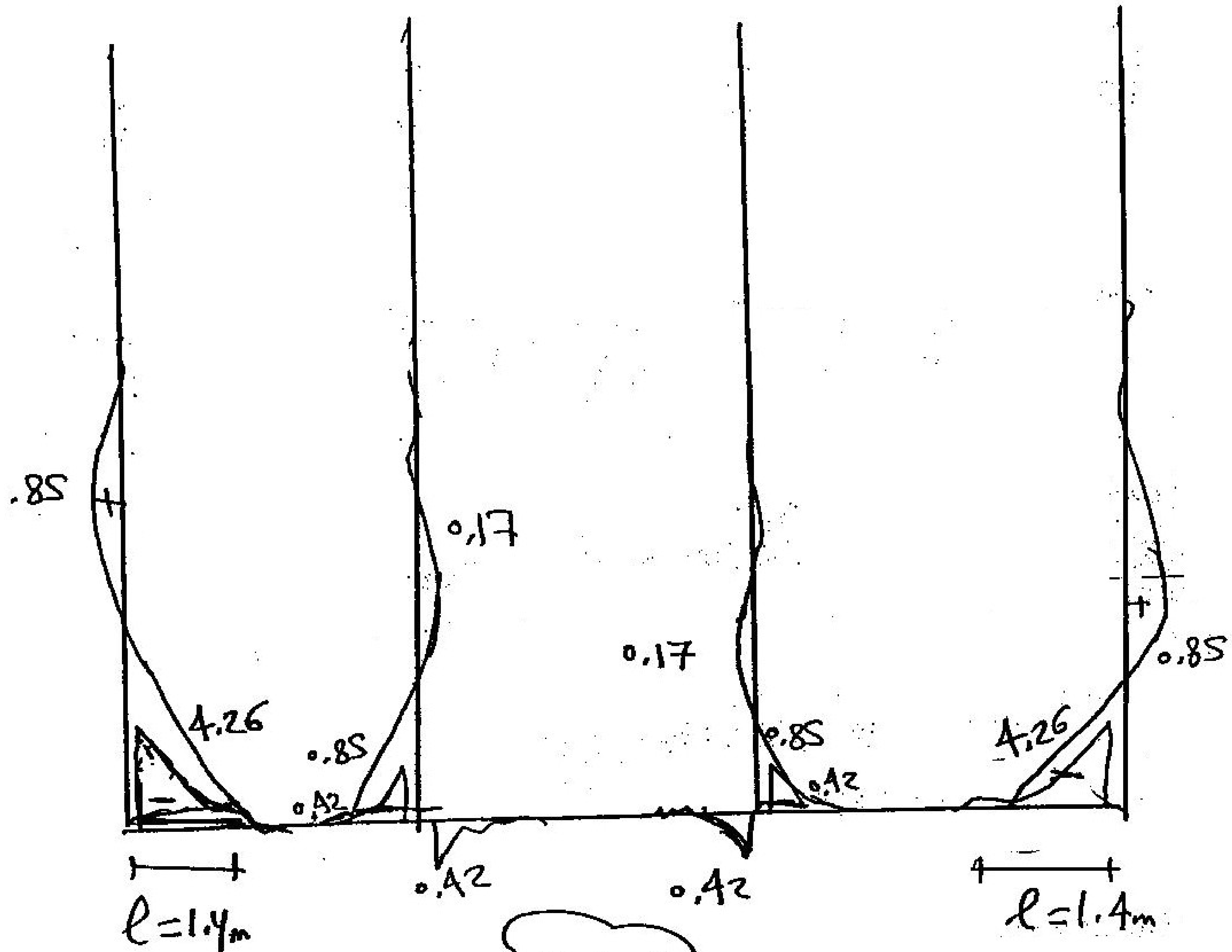
كل العزوم للحوائط ترتد الى البلاطة بطول مسافة (l).

$$w = t_b \cdot \gamma_{R.C} + \gamma_w \cdot H_w$$

$$= 0.4 * (25) + (1 * 8) = 9 \, t/m^2$$

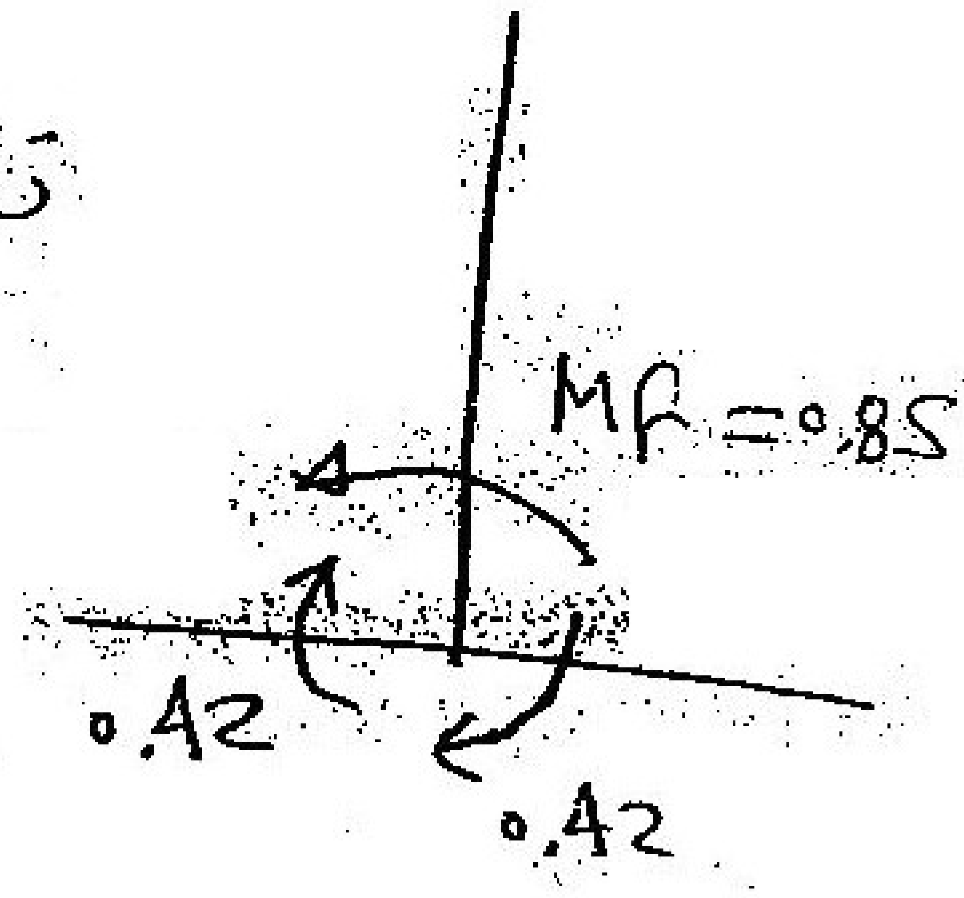
فرض تخانة البلاطة

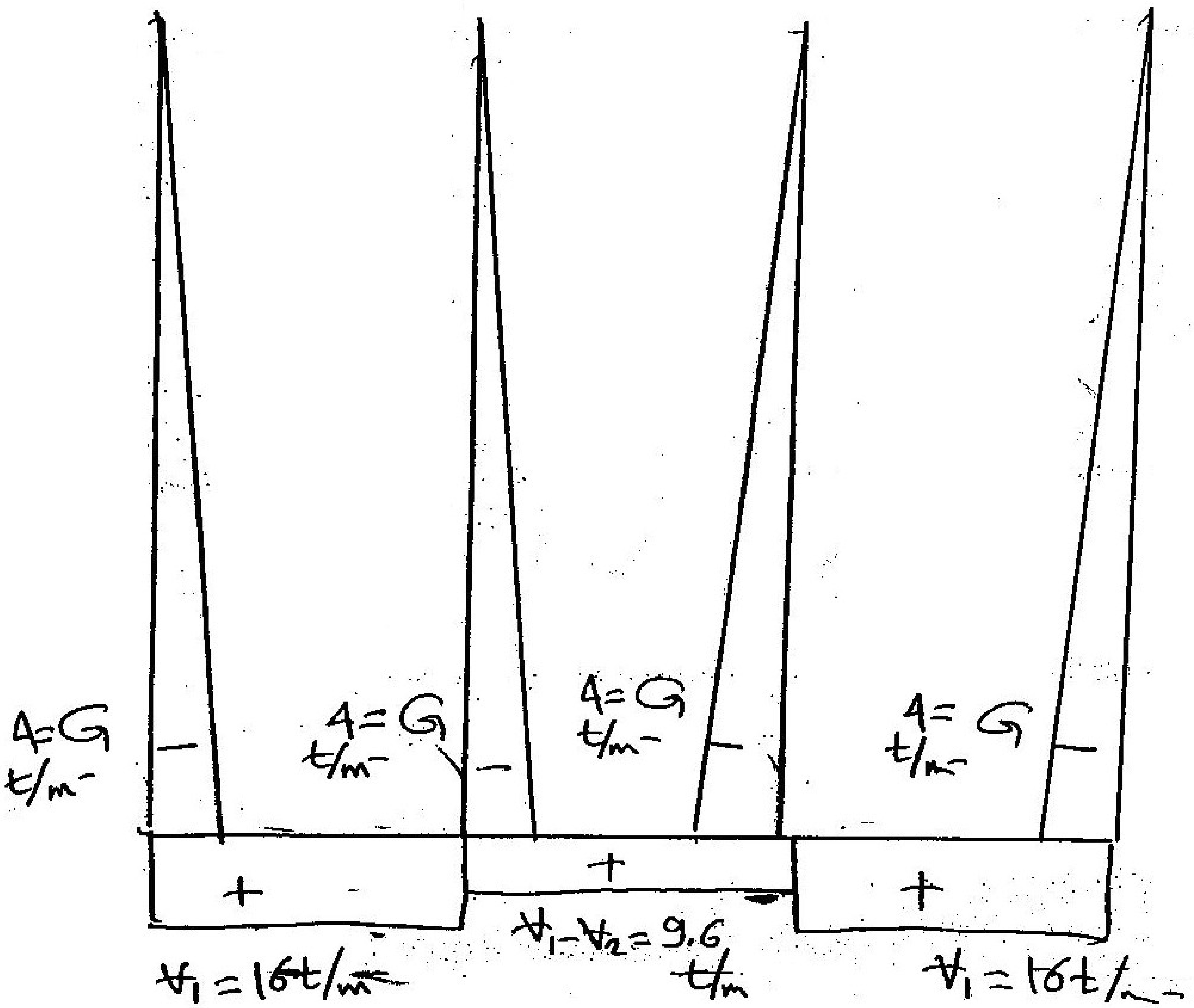
$$\therefore l = 2\sqrt{\frac{M_F}{w}} = 2\sqrt{\frac{4.26}{9}} = 1.4 \, m$$



B.M.D

نفرض ان عزوم كابولى الداخلى
تتوزع القائم بالتساوى
يمين وشمال



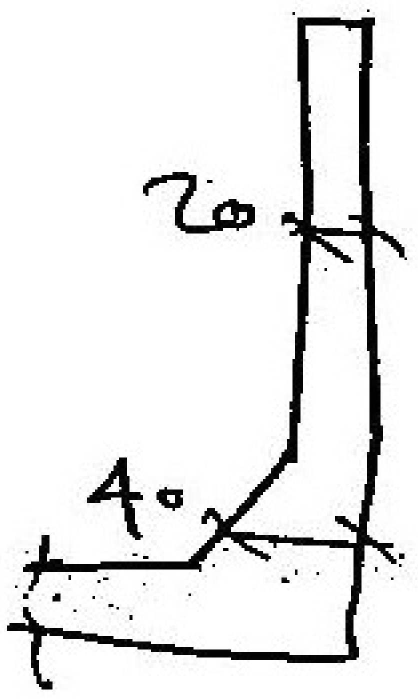


N.F.D

$$G = t_{wall} \cdot H \cdot \gamma_{R.C} = 0.2 * 8 * 2.5$$

وزن حائط

$$= 4\ t/m'$$



Design of sections:

[I] Ring direction:

⊗ Outer Part: $T_{max\ ring} = 28.8\ t/m$

(I) $t = f \cdot T = 20\ cm$

(II) $A_{s\ each\ side} = \frac{T_u \times 10^3}{2(f_y/\gamma_s)} = 6.9\ cm^2/m$

$= 7 \Phi 12/m$ each side

⊗ Inner Part:

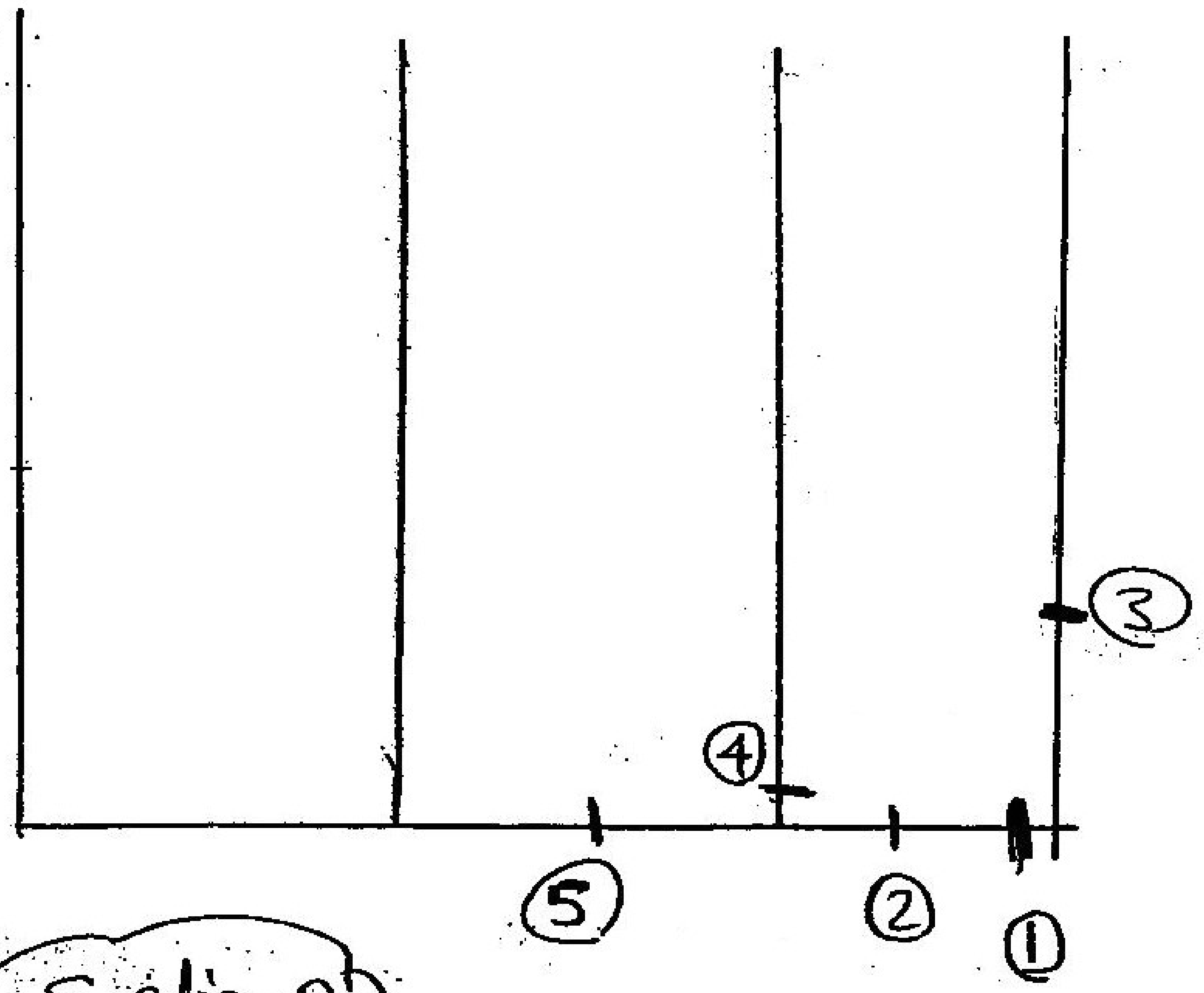
Compression in ring

use $t_{min} = 20\ cm$

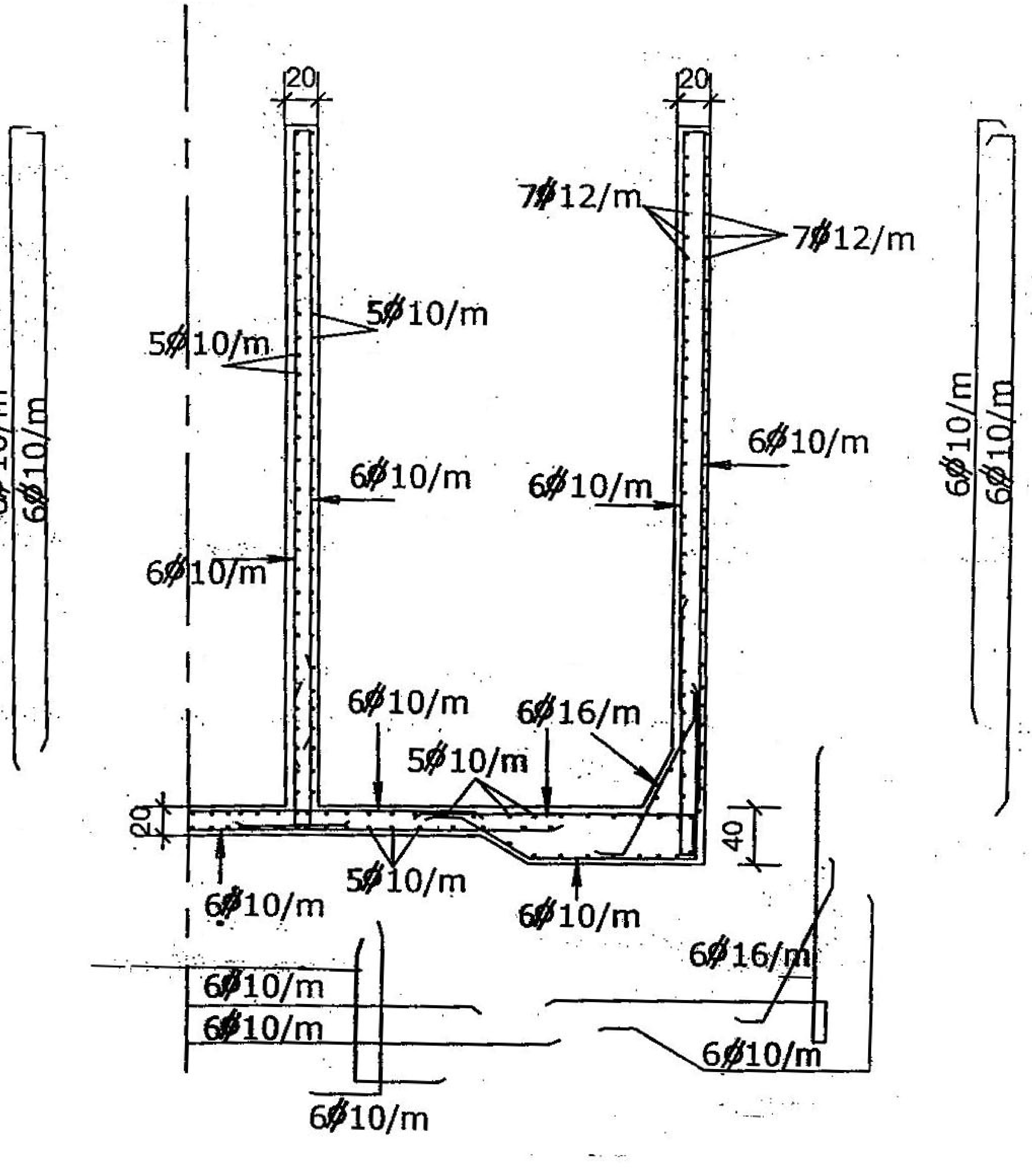
use $A_{s\ min} = 5 \Phi 10/m$ each side

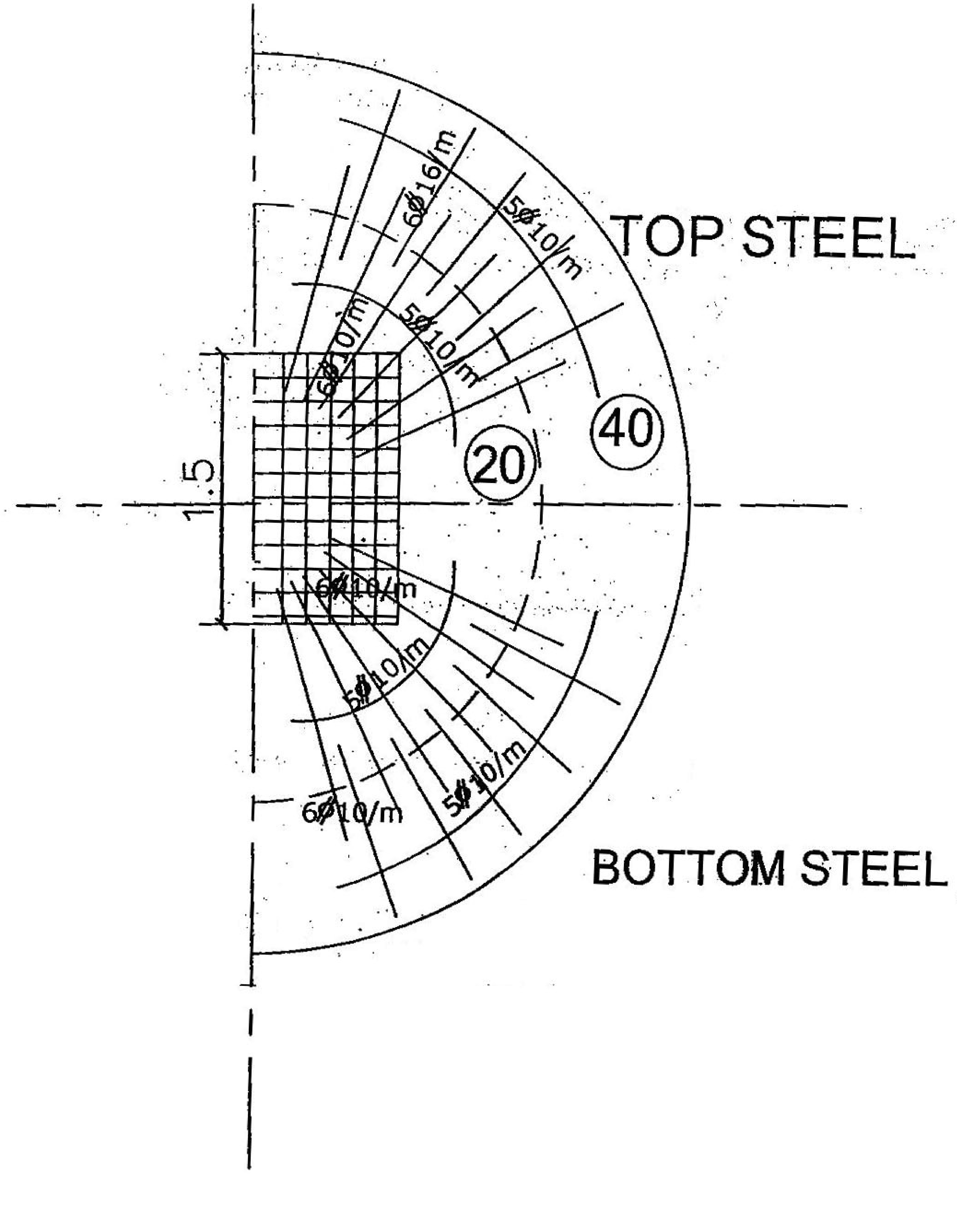
[2] Vertical Strips

Section	Straining Actions	Results
①	$M_{water} = 4.26$ tm, $T = 16$ t/m'	→ $t = 40$ cm, $A_s = 6\Phi16$/m'
②	Tension only $T = 16$ t/m'	→ $t = 20$ cm, $A_s = 5\Phi10$/m' each side
③	$M_{airside} = 0.85$ tm, Compression	→ $t = 20$ cm, $5\Phi10$/m'
④	$M_{air\ side} = 0.85$ tm, Compression	→ $t = 20$ cm, $5\Phi10$/m'
⑤	Tension only $T = 9.6$ t/m'	→ $t = 20$ cm, $5\Phi10$/m' each side



Sections


20
20
7Ø12/m
7Ø12/m
5Ø10/m
5Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø16/m
5Ø10/m
5Ø10/m
20
40
6Ø10/m
6Ø10/m
6Ø16/m
6Ø10/m
6Ø10/m
6Ø10/m
6Ø10/m


6Ø16/m
5Ø10/m
6Ø10/m
5Ø10/m
TOP STEEL
40
20
1.5
6Ø10/m
5Ø10/m
5Ø10/m
6Ø10/m
BOTTOM STEEL

جديد

سنتر و مركز

الفارس

الفرقة الرابعة مدنى

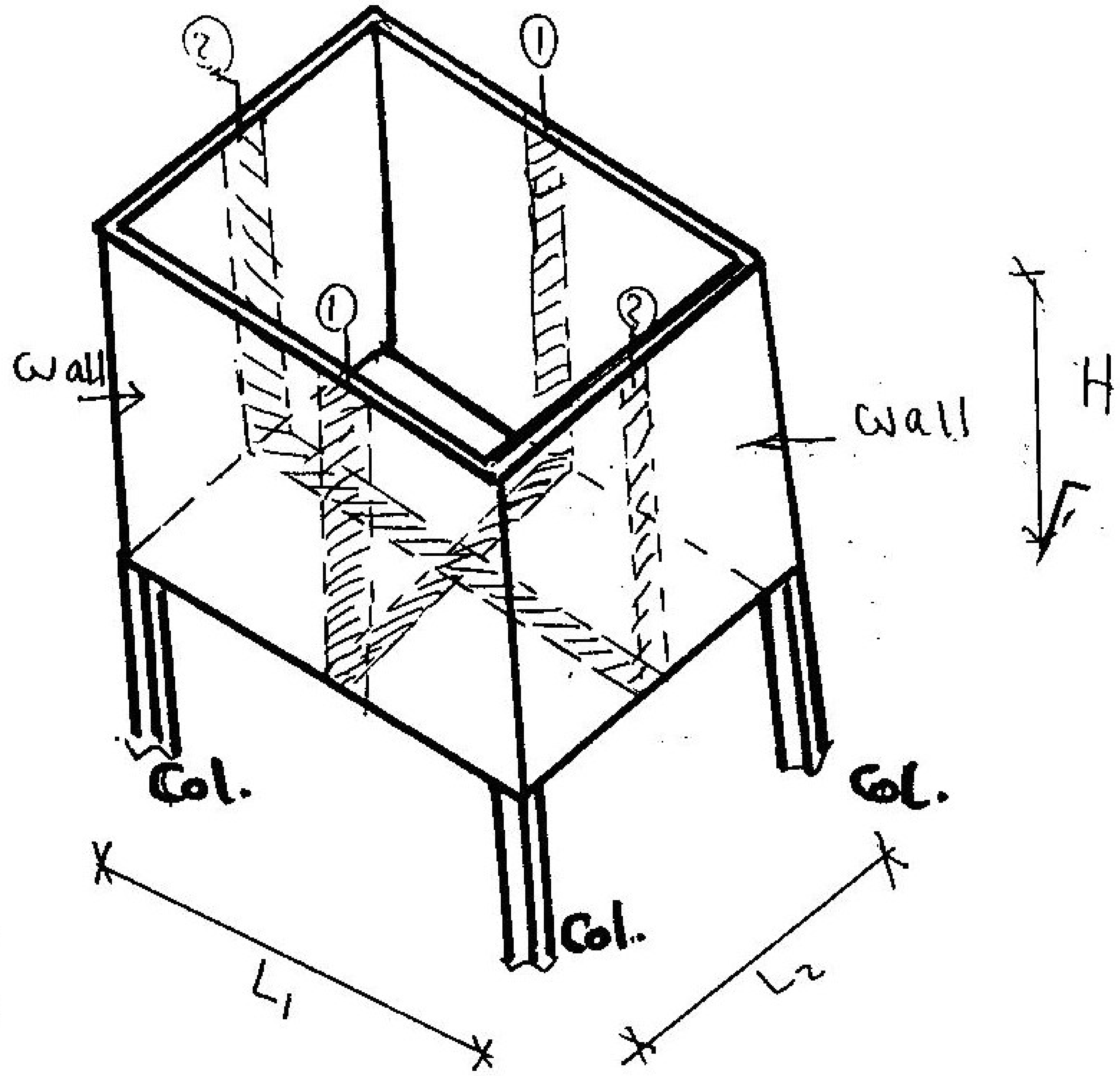
Reinforced Concrete Water Tanks

elevated

لمتابعة كل ماهو جديد لدينا .... زورونا على موقعنا

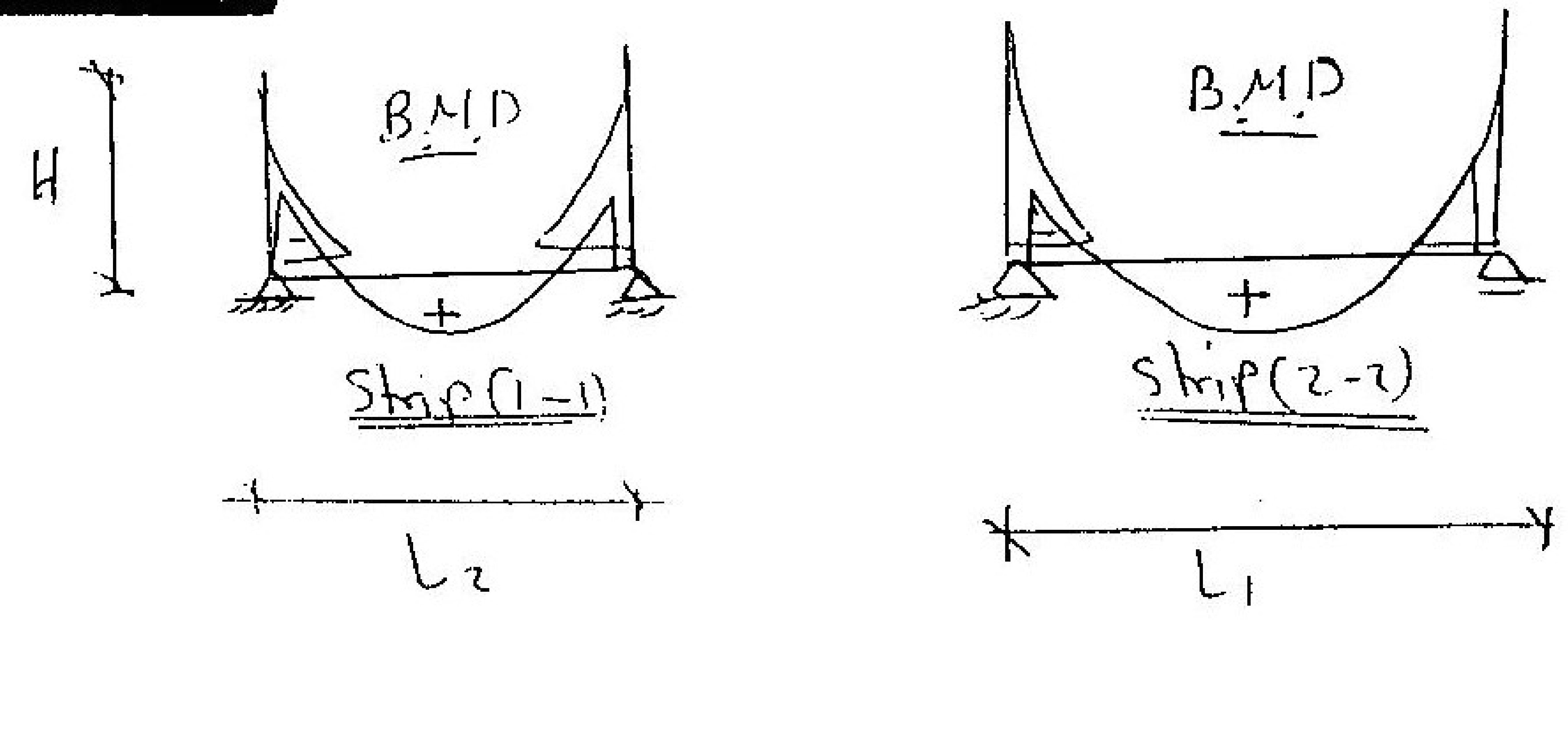
www.zag4all.com

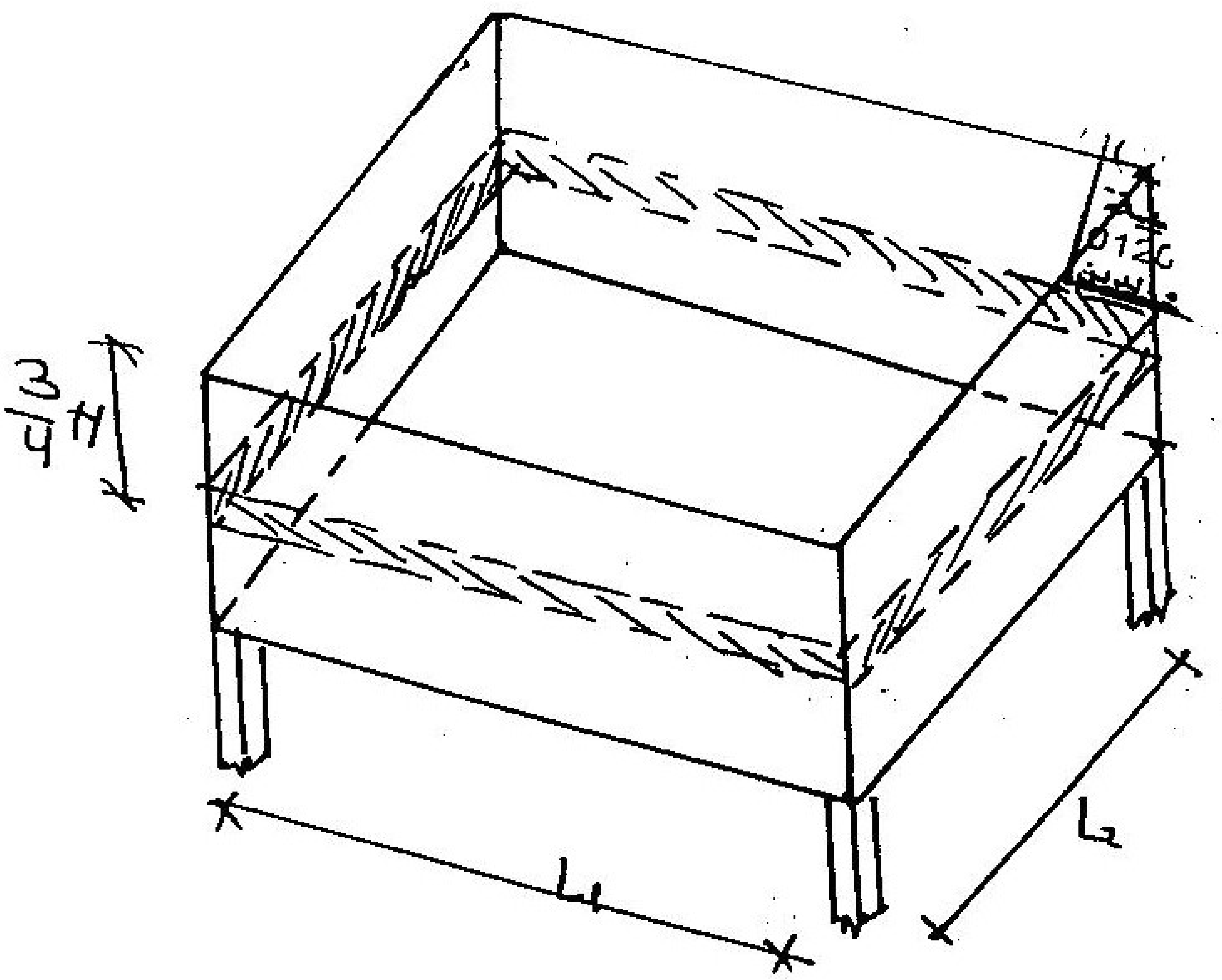
"Rectangular Tanks"



نقوم بتقسيم الخزان إلى مجموعة شرائح رأسية + أفقية.

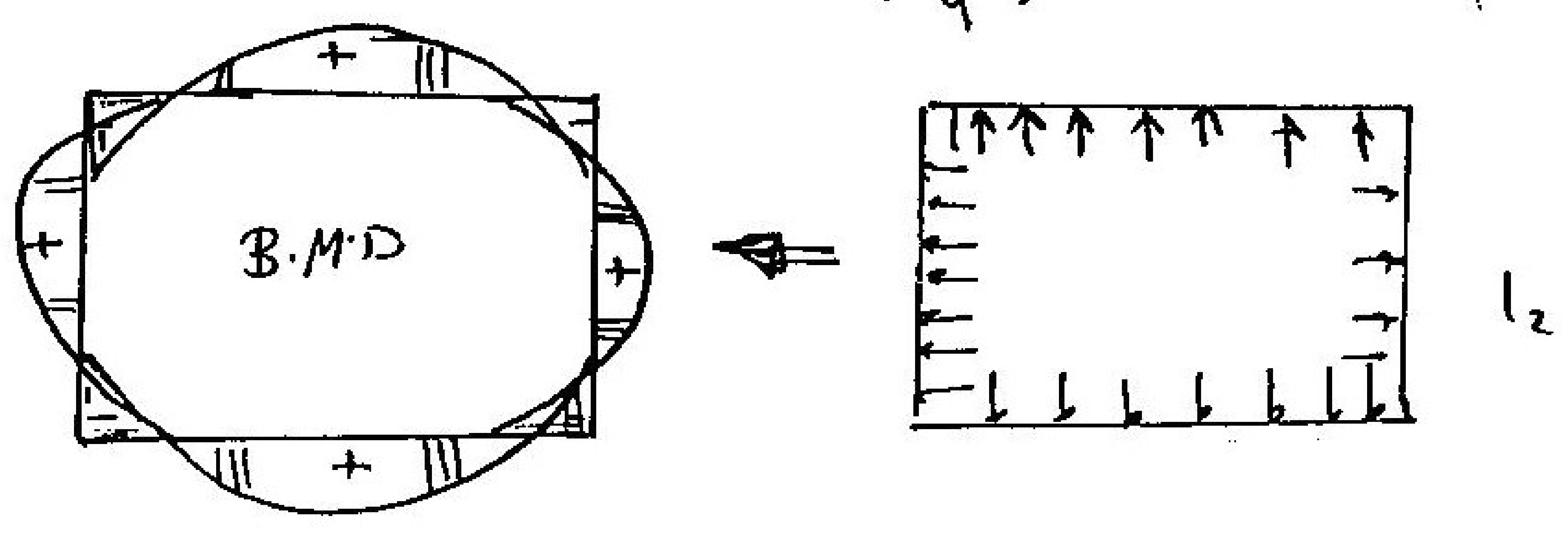
(*) VL. Strips:





" HL. strip "   " الشريحة الأفقية "

ناخذها دائماً عند $(\frac{3}{4}H)$ مدفونة.

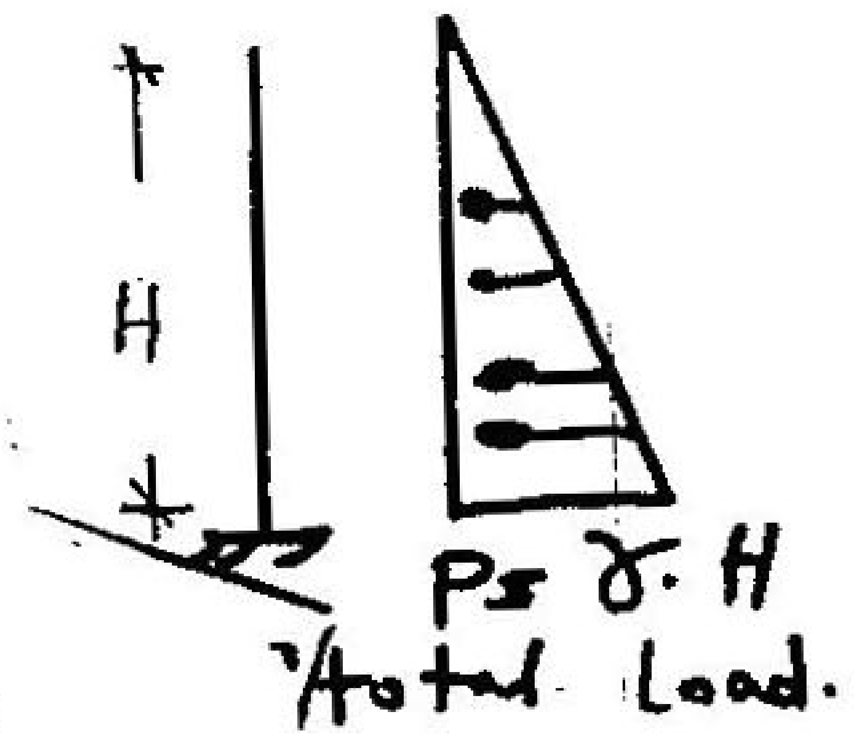


Loads الأحمال

① on walls:

$P = \gamma . H$ ضغط المياه ع الحوائط.

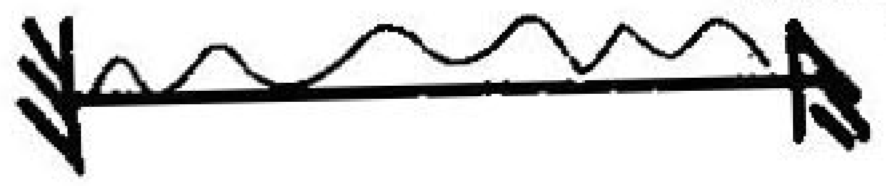
$\gamma = 1\ t/m^3$



② on base = (floor) القاعدة

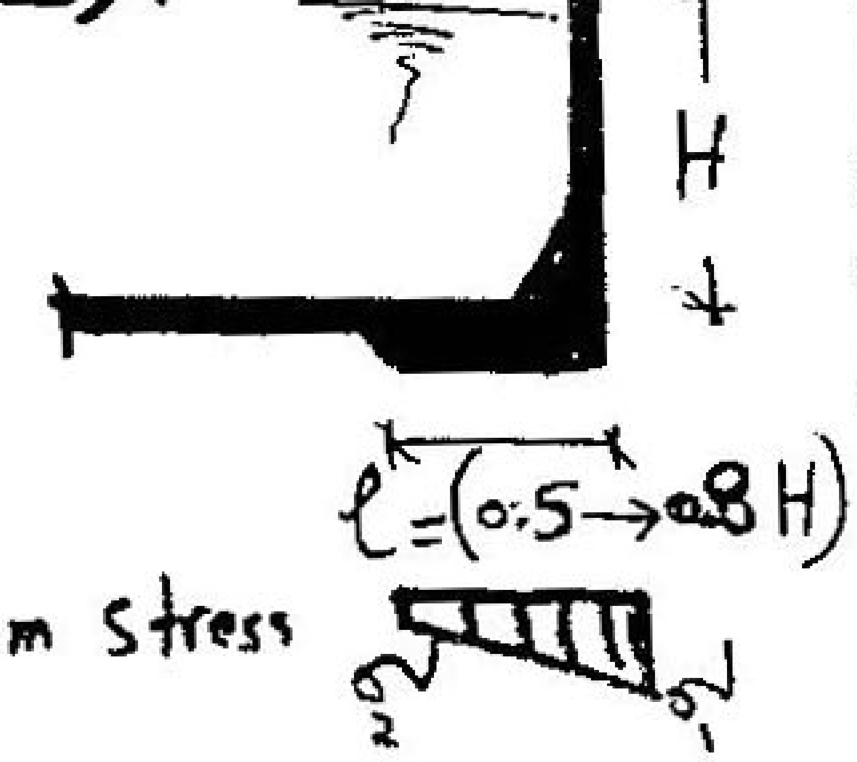
(A) elevated Tank:

$\omega = t_b . \gamma_{R.C} + \gamma_{water} . H$

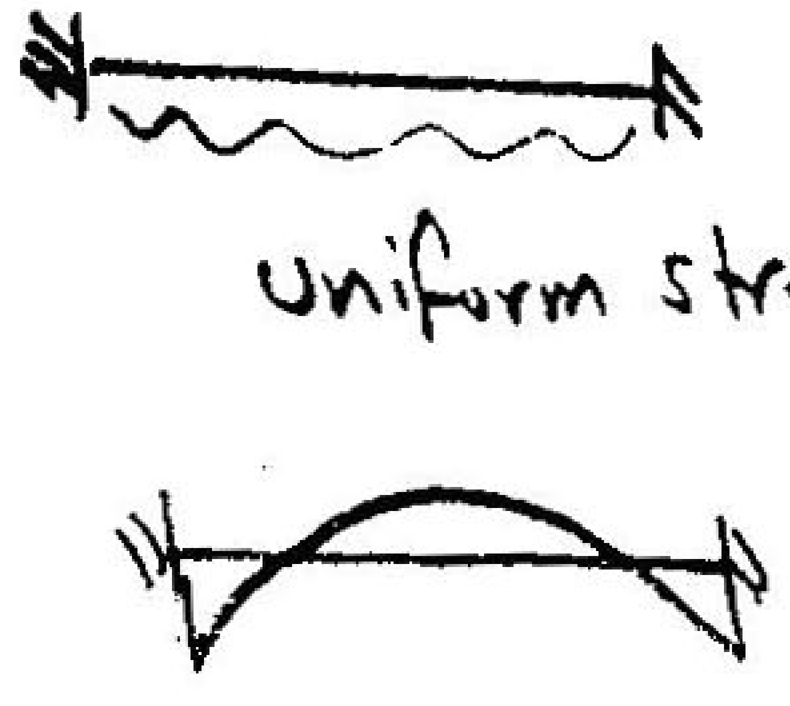


(B) on medium soil:

$\frac{L}{H} > 1.5$ (L: طول القاعدة القصير, H: ارتفاع الحائط)



$\frac{L}{H} < 1.5$

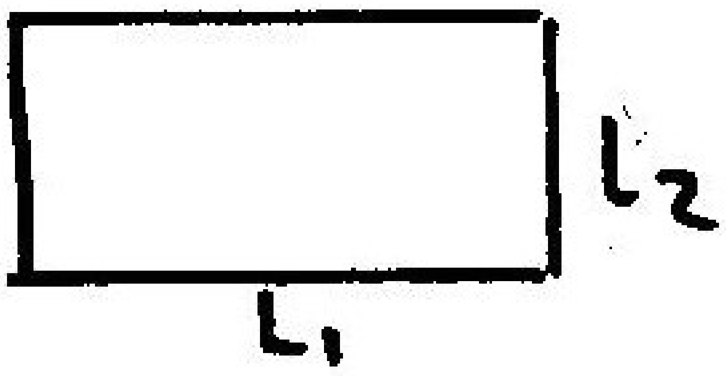


(C) on Rocky soil: $\ell = 2\sqrt{\frac{M_f}{\omega}}$

نزود الحائط لتدعيم القاعدة مسافة (ℓ) ثم تموت.

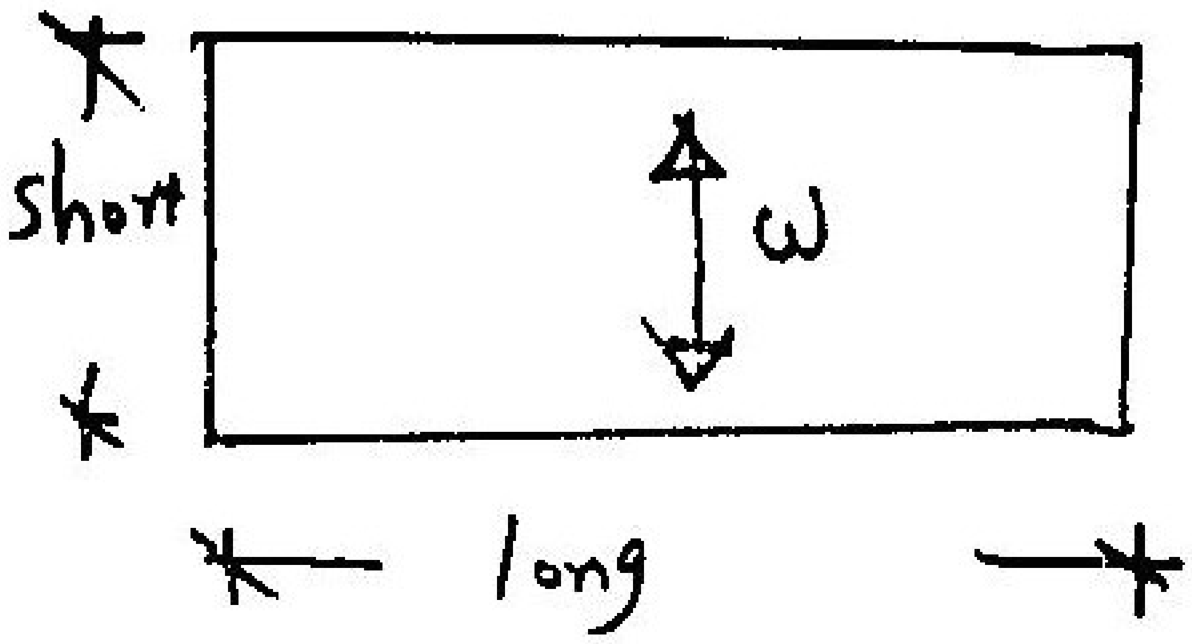
Load distribution: .. توزيع الأحمال ..

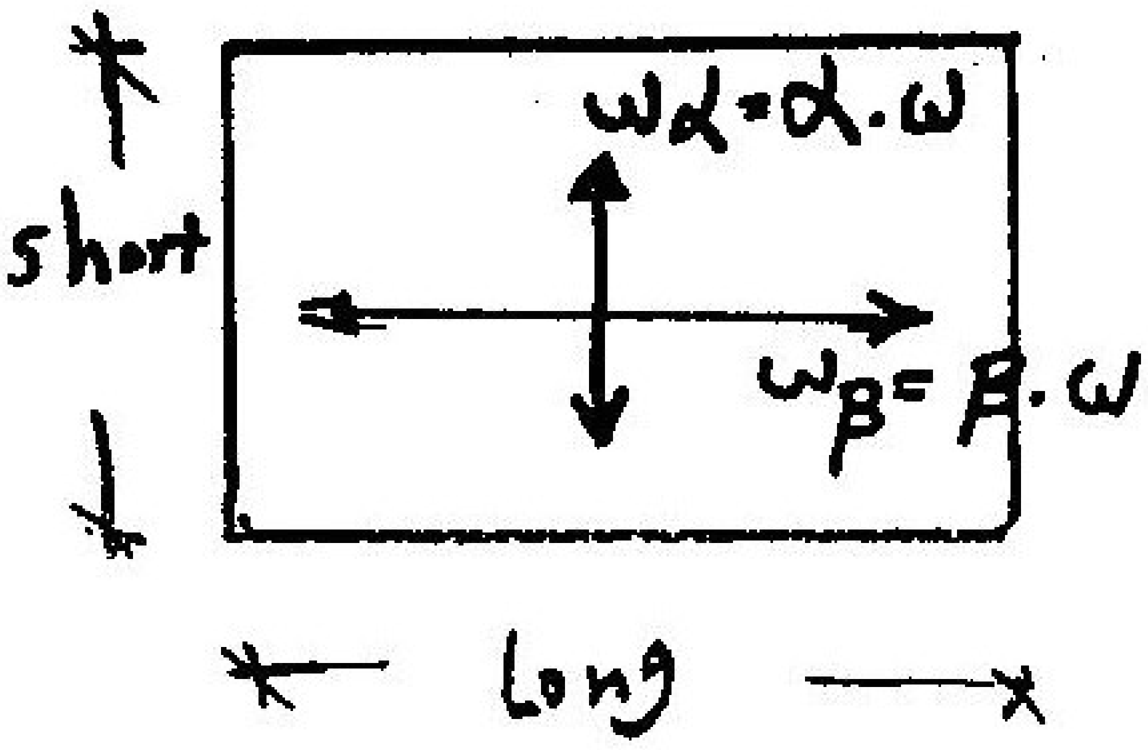
① load distribution on (base)



plan

$\frac{long}{short} \geq 2$	$\frac{long}{short} < 2$
one_way	two_way
كل الحمل مع القاعدة يتحمله في البحر القصير .	$\therefore r = \frac{long}{short} =$ ✓
	(grashof) ومن جدول P(1-12) بالكتاب
	(α) للقصير (β) للطويل

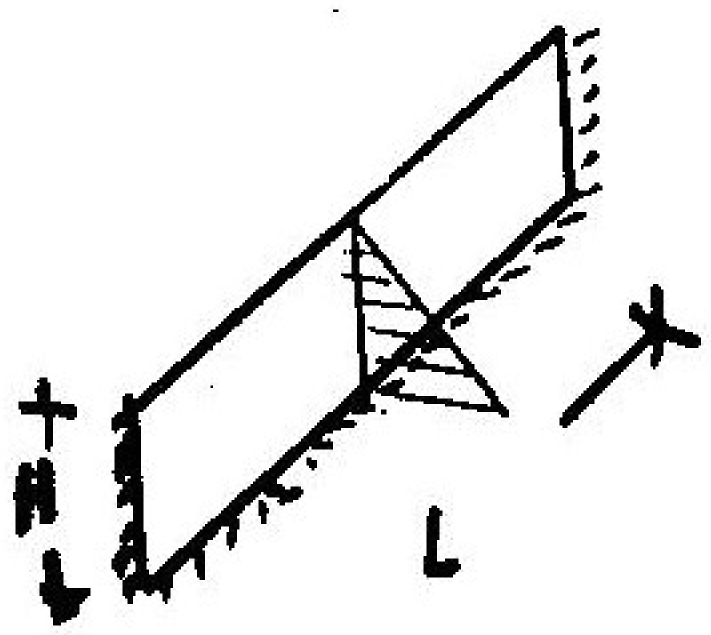




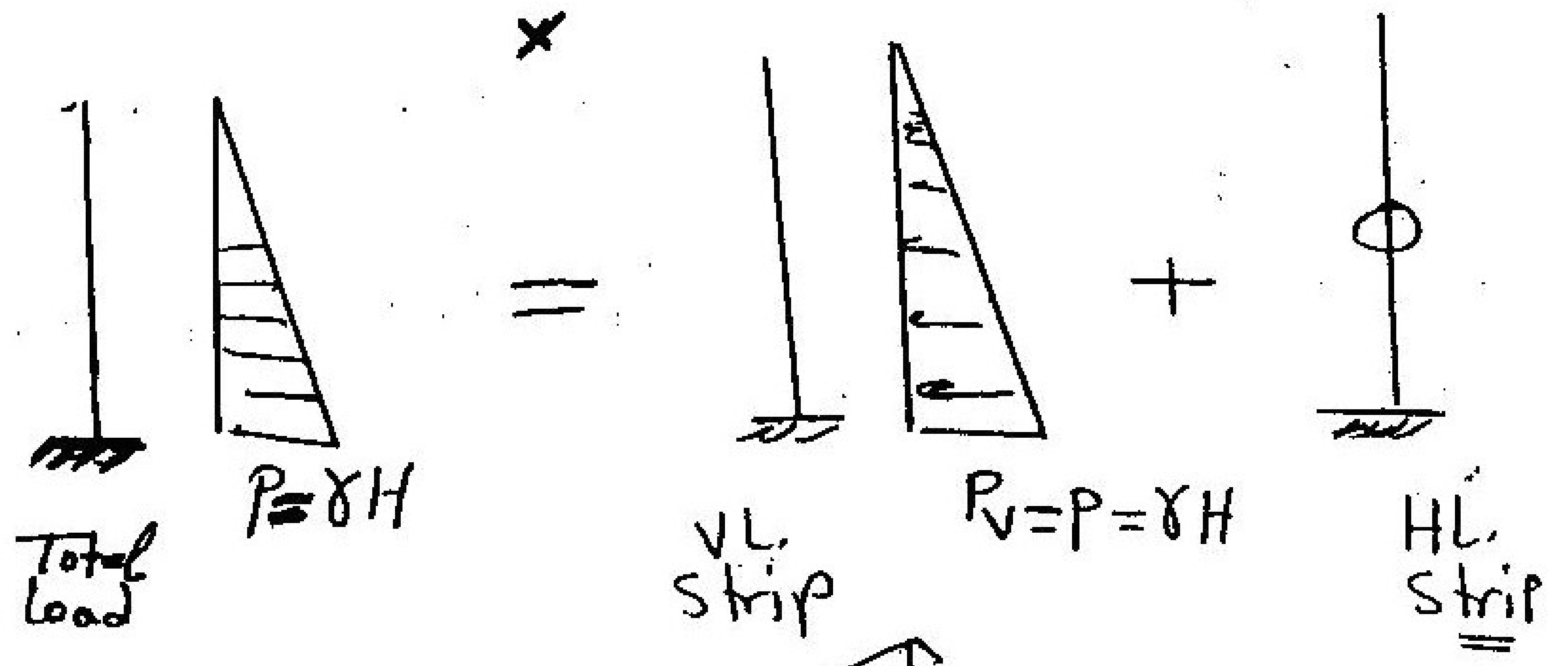
(2) load distribution on walls:
→ HL. Strip.
→ VL. Strip.

(A) if $\frac{L}{H} \geq 2$

∴ **shallow tank**



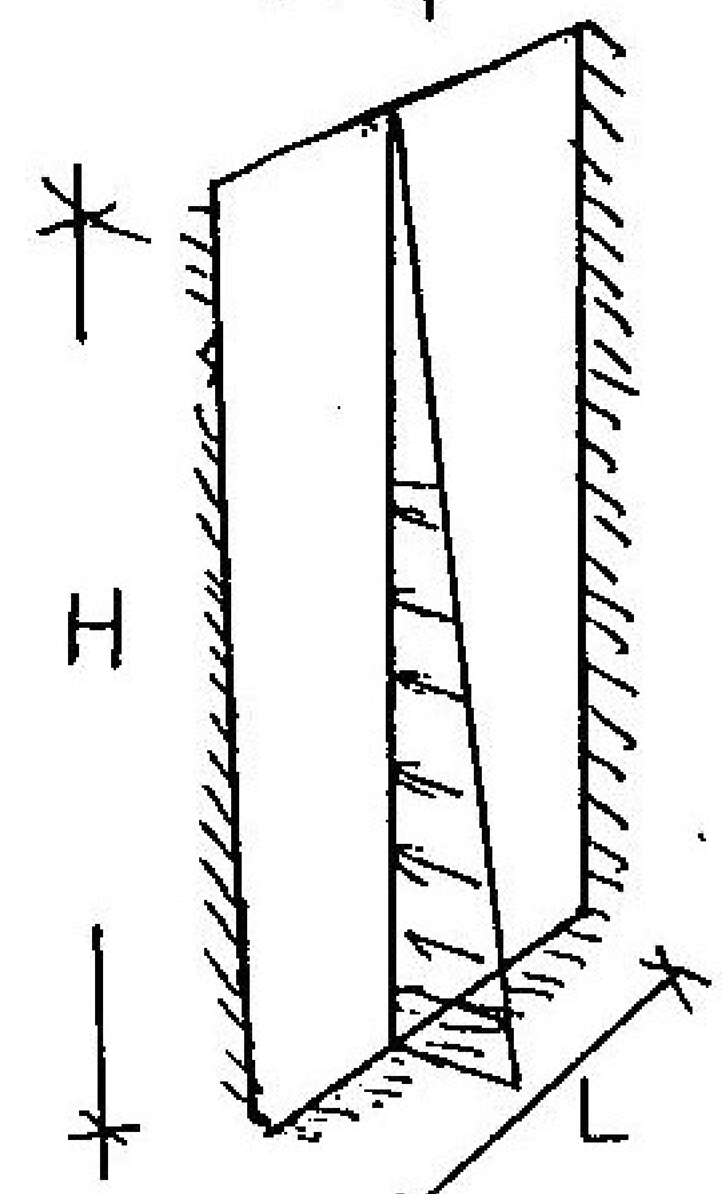
∴ كل الأحمال تنتقل للاتجاه الرأسي فقط



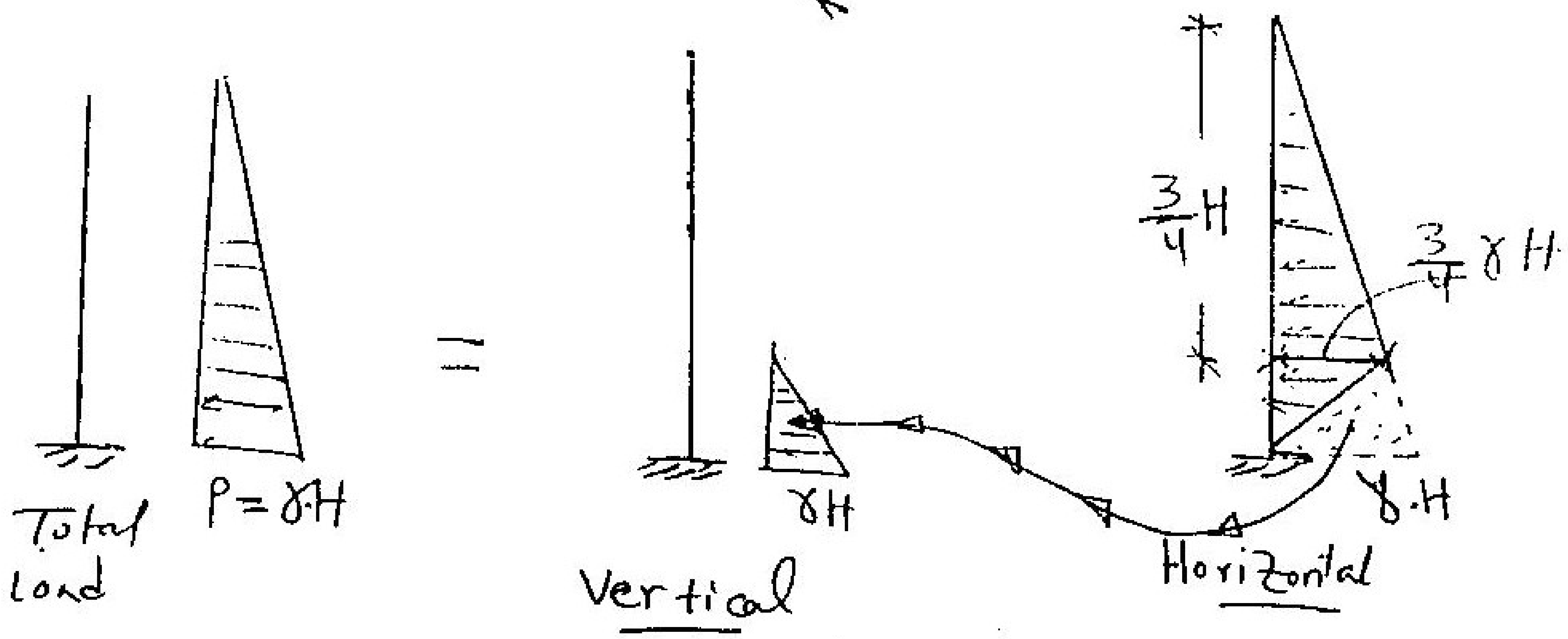
(B) if $\frac{L}{H} \leq 0.5$

∴ **deep Tank**

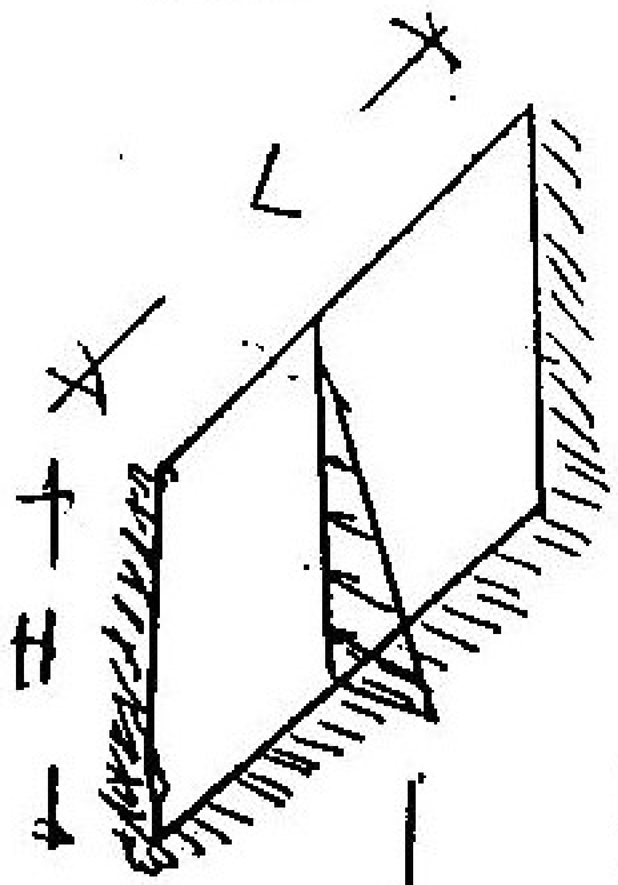
$\frac{H}{L} \geq 2$



معظم الأحمال تنتقل في الاتجاه الأفقي

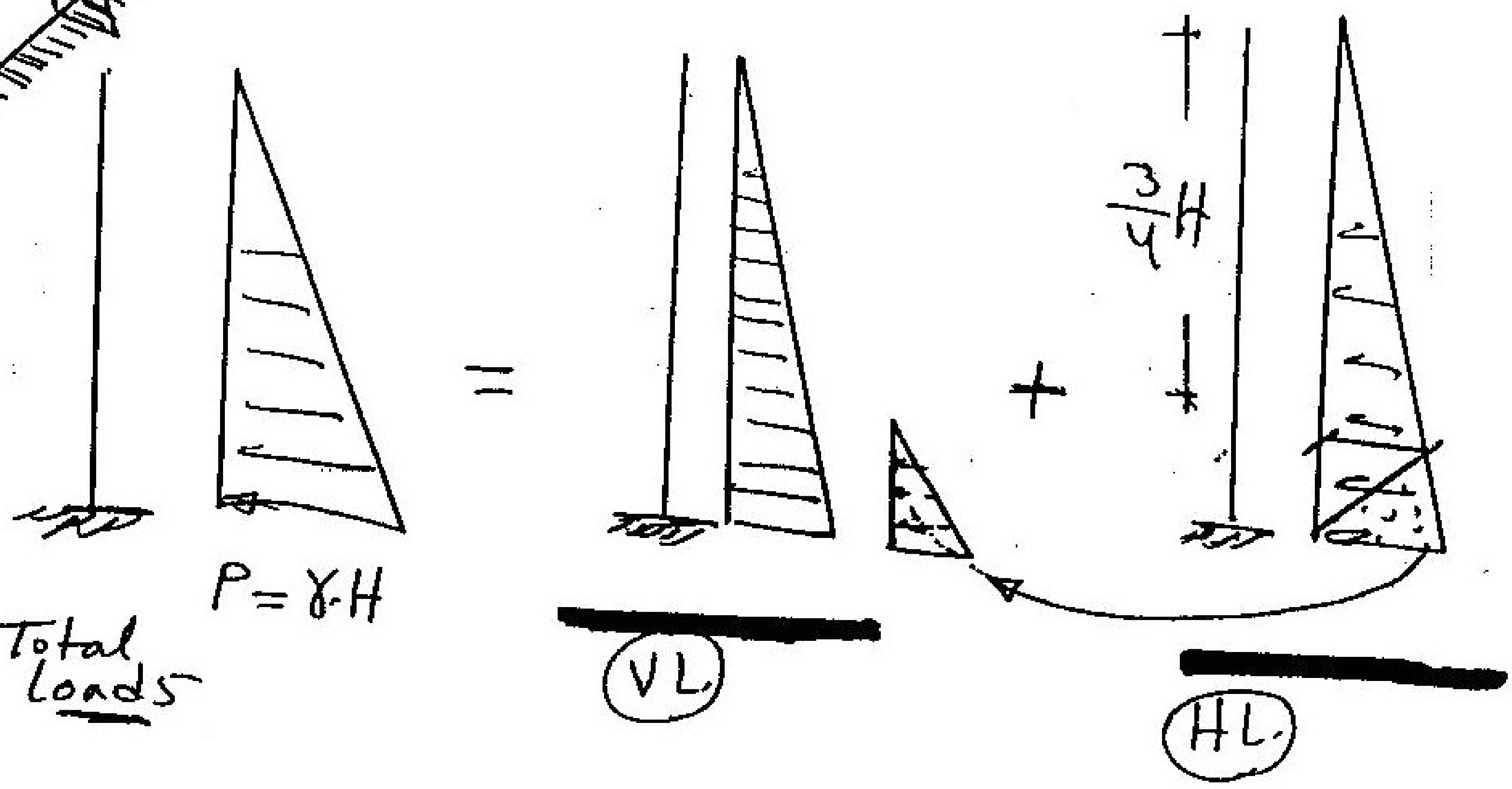


(c) if $\left(0.5 < \frac{L}{H} < 2\right)$



$\therefore$ **Medium Tanks**

$\therefore$ الأحمال تذهب في شرائح (VL.) & (HL.)



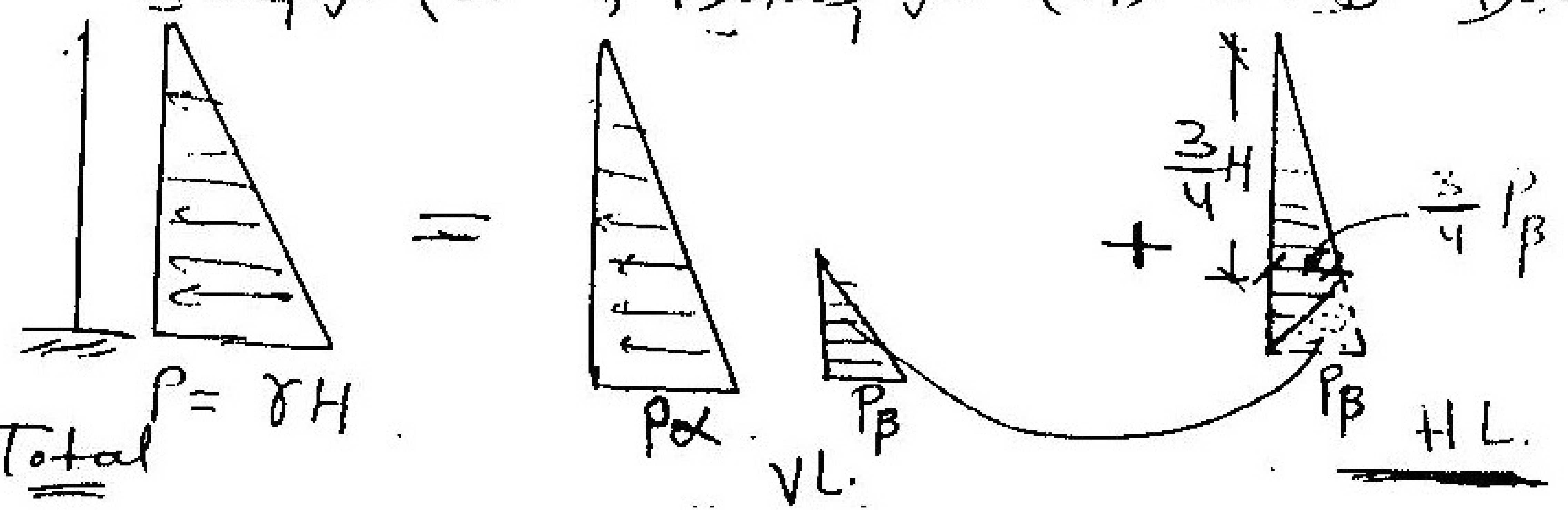
$\therefore r = \frac{\text{long}}{\text{short}}$

$\therefore (\alpha, \beta) = \sim$ from grashof P.(1-12)

للاتجاه القصير $P_\alpha = \alpha.(\gamma.H)$

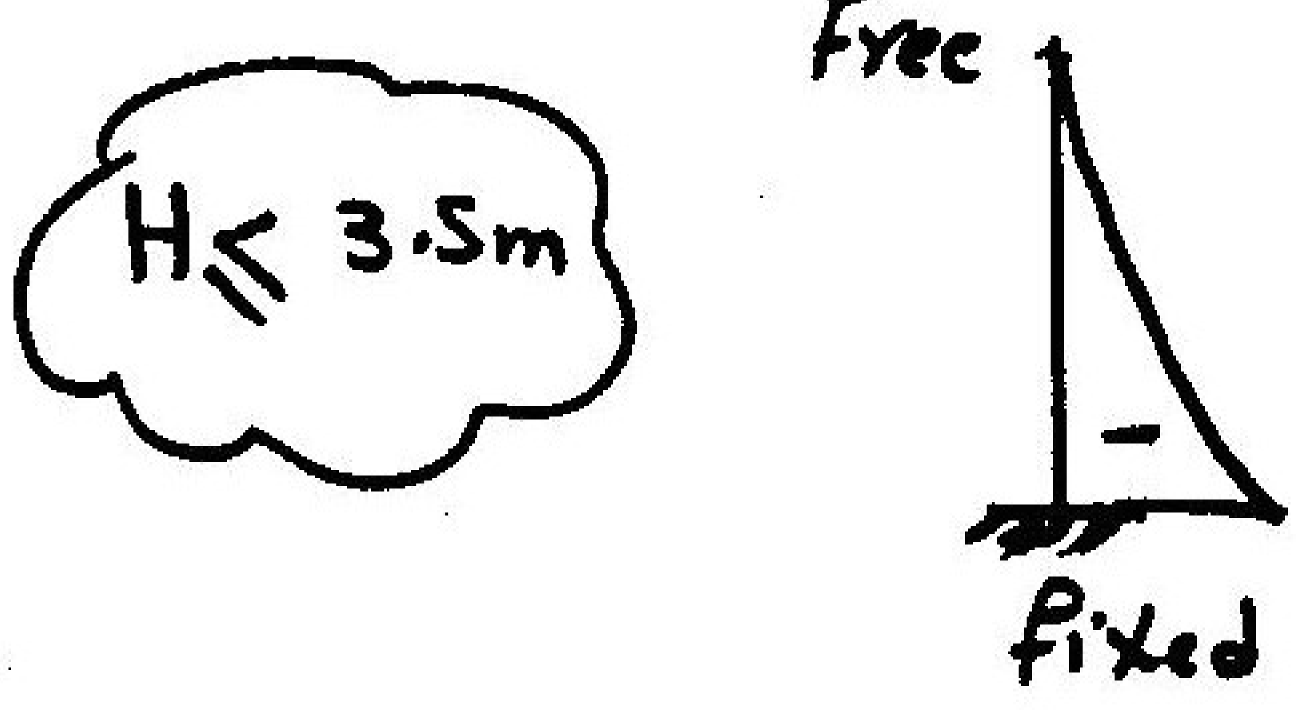
للاتجاه الطويل $P_\beta = \beta.(\gamma.H)$

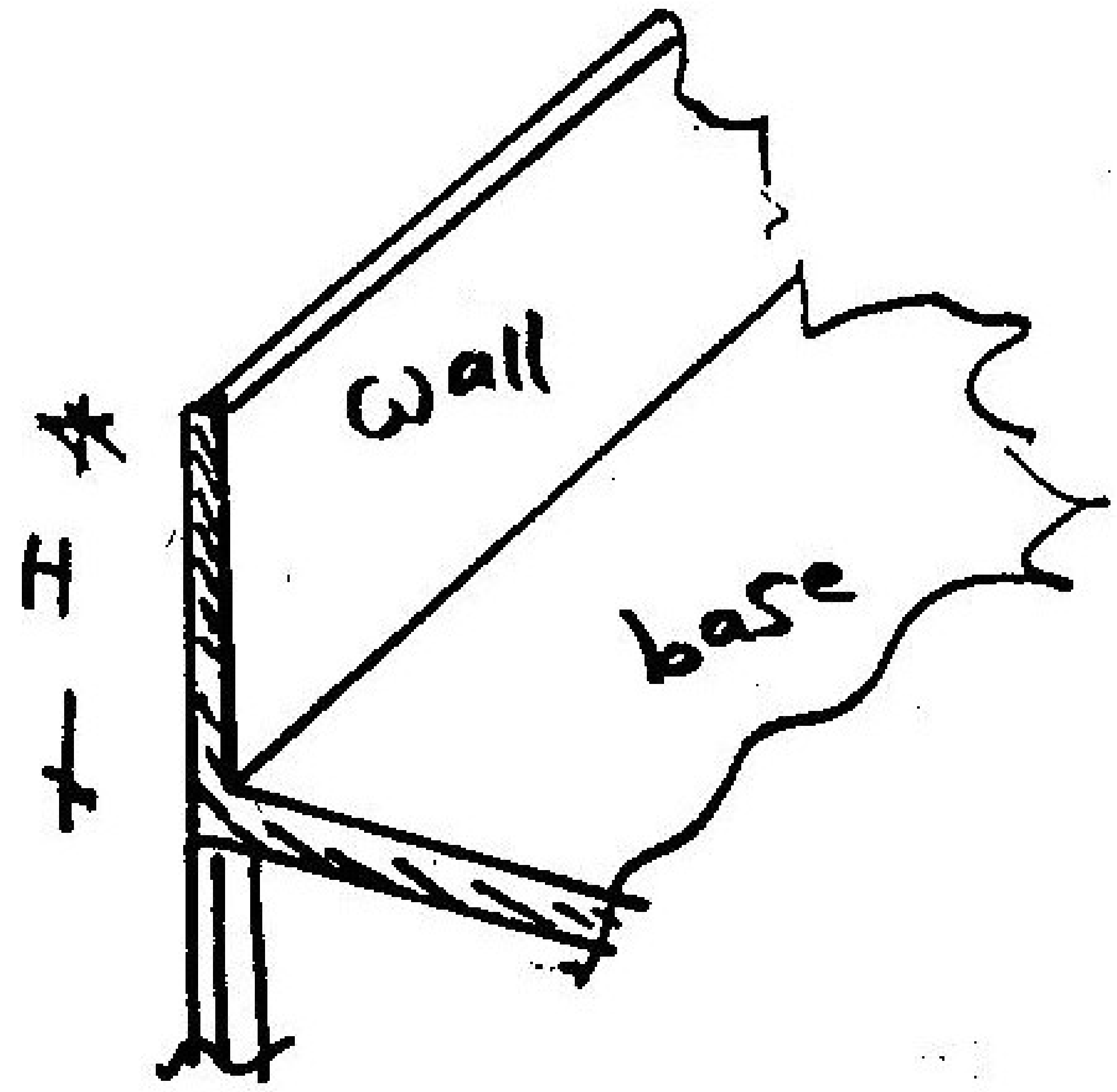
مثلاً لو كانت (H) هي القصيرة & (L) هي الطويلة



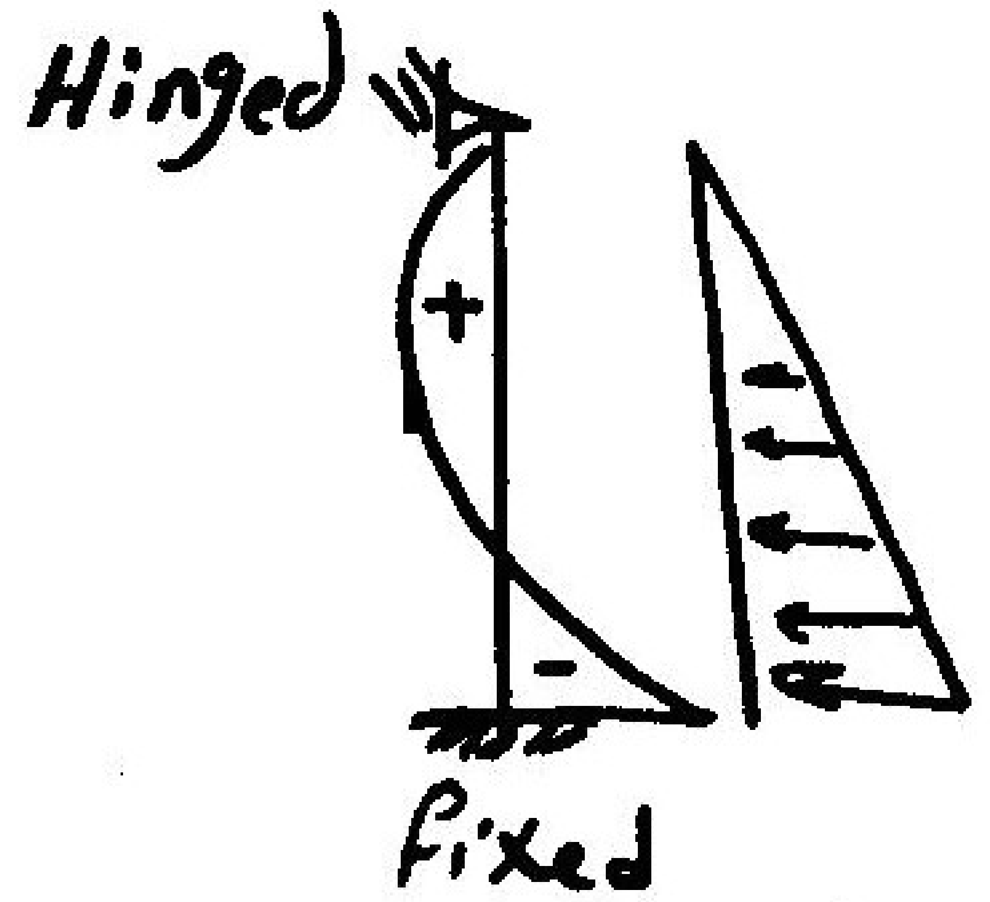
"Top support"

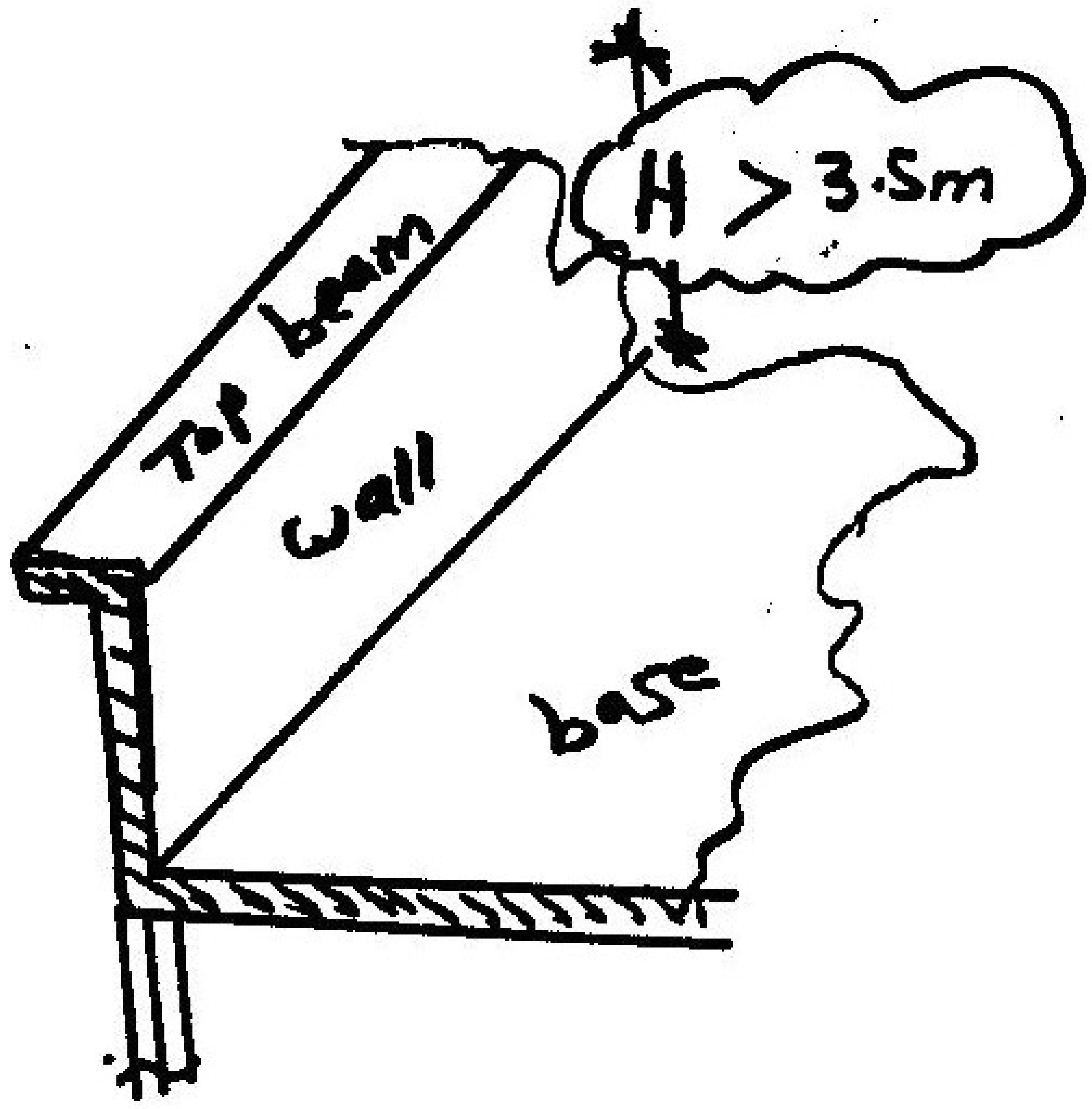
(1) free at top:



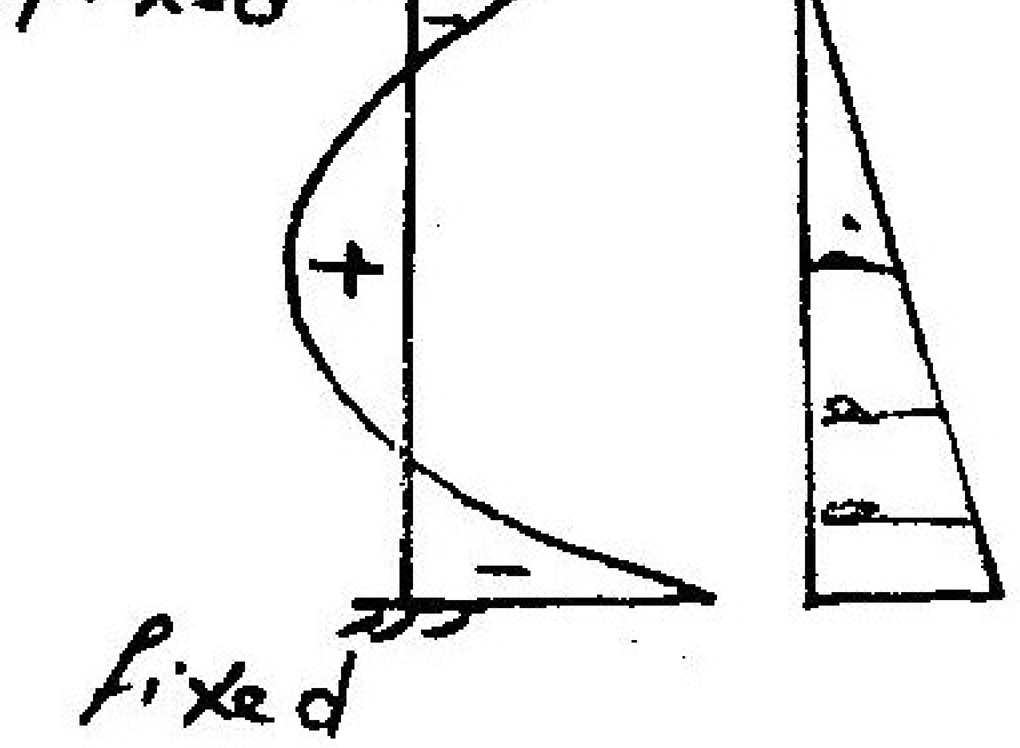


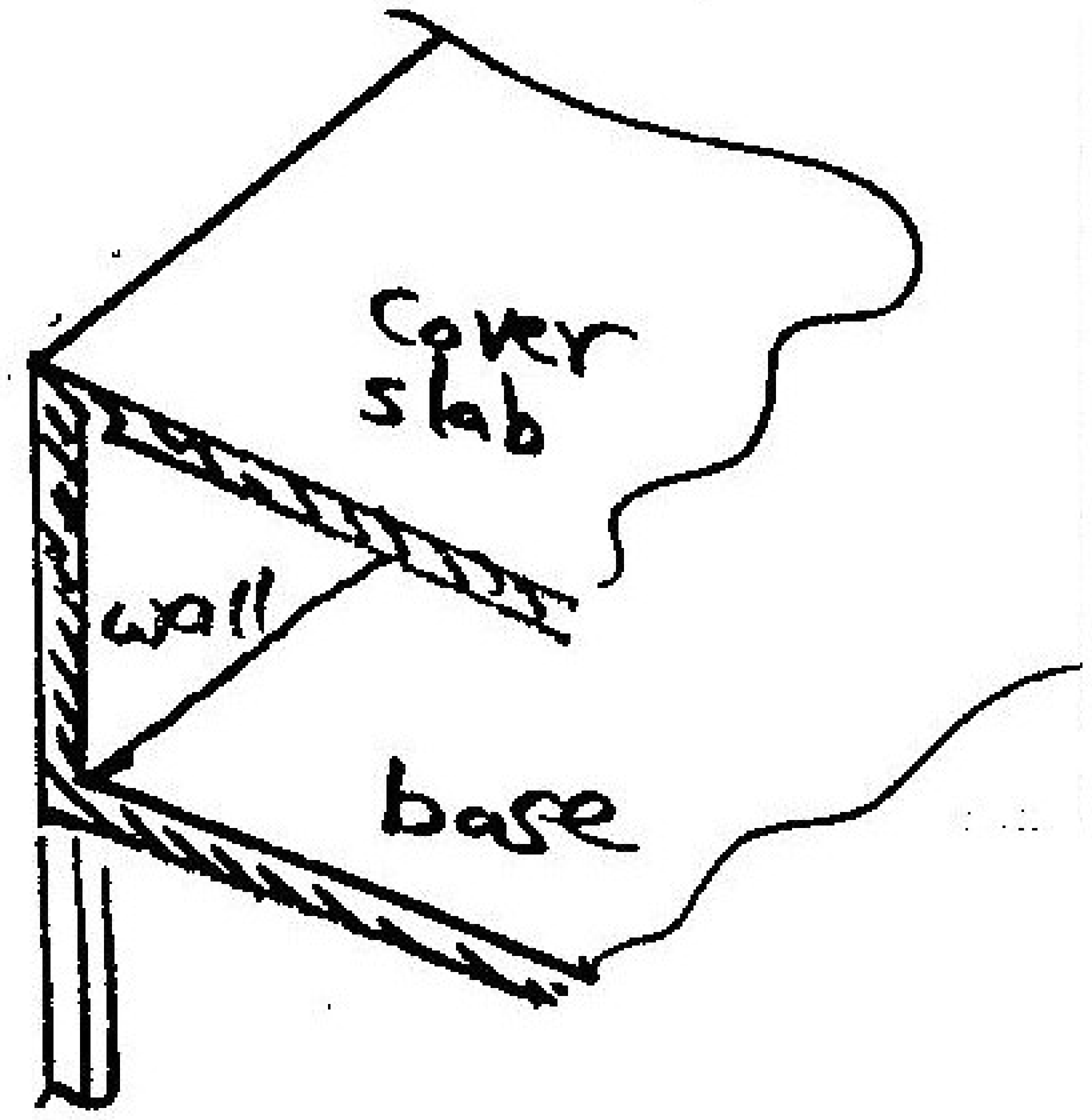
(2) Top beam:



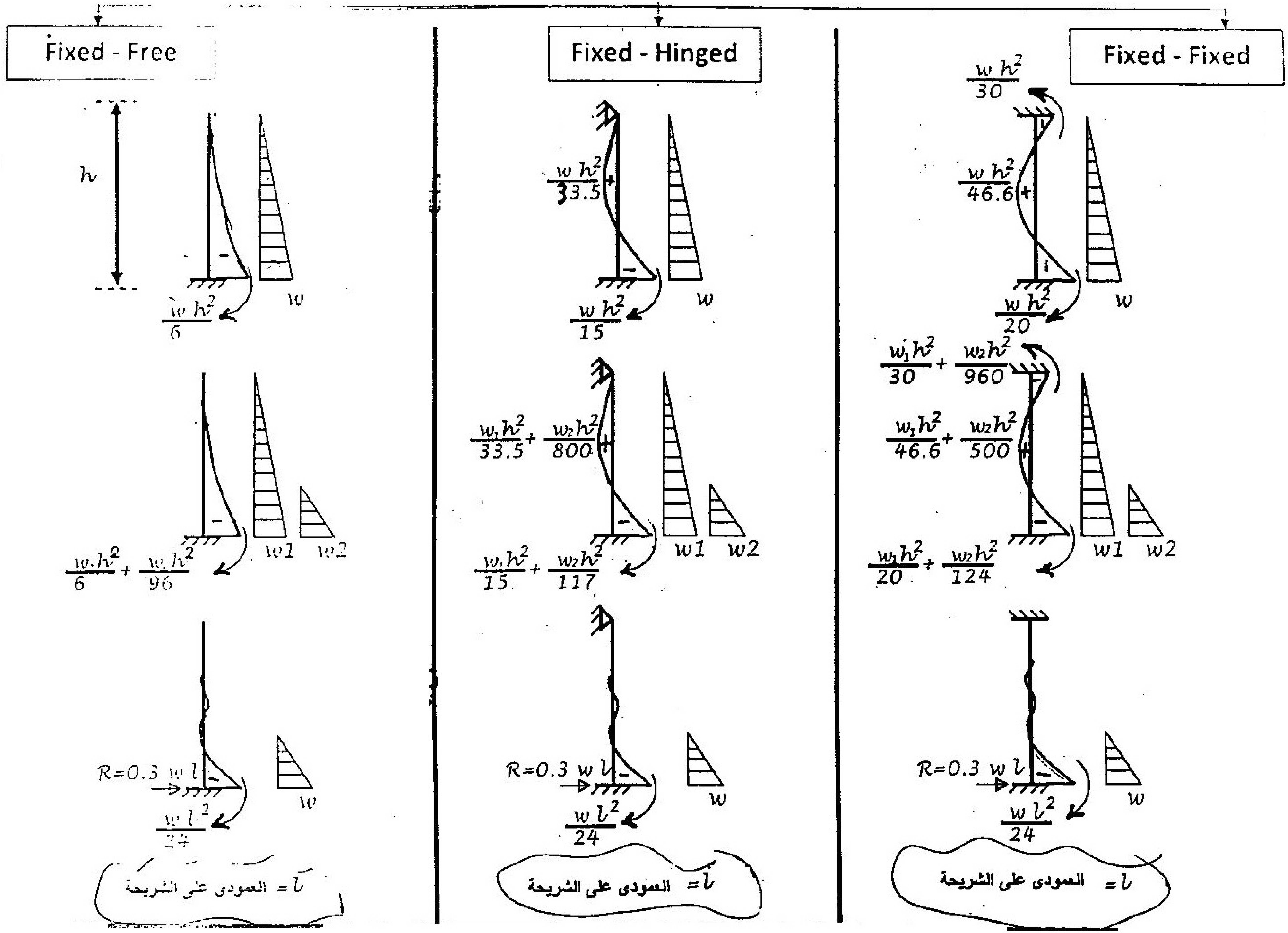


(3) Cover slab: في حالة الخزان مغطى ببلاطة

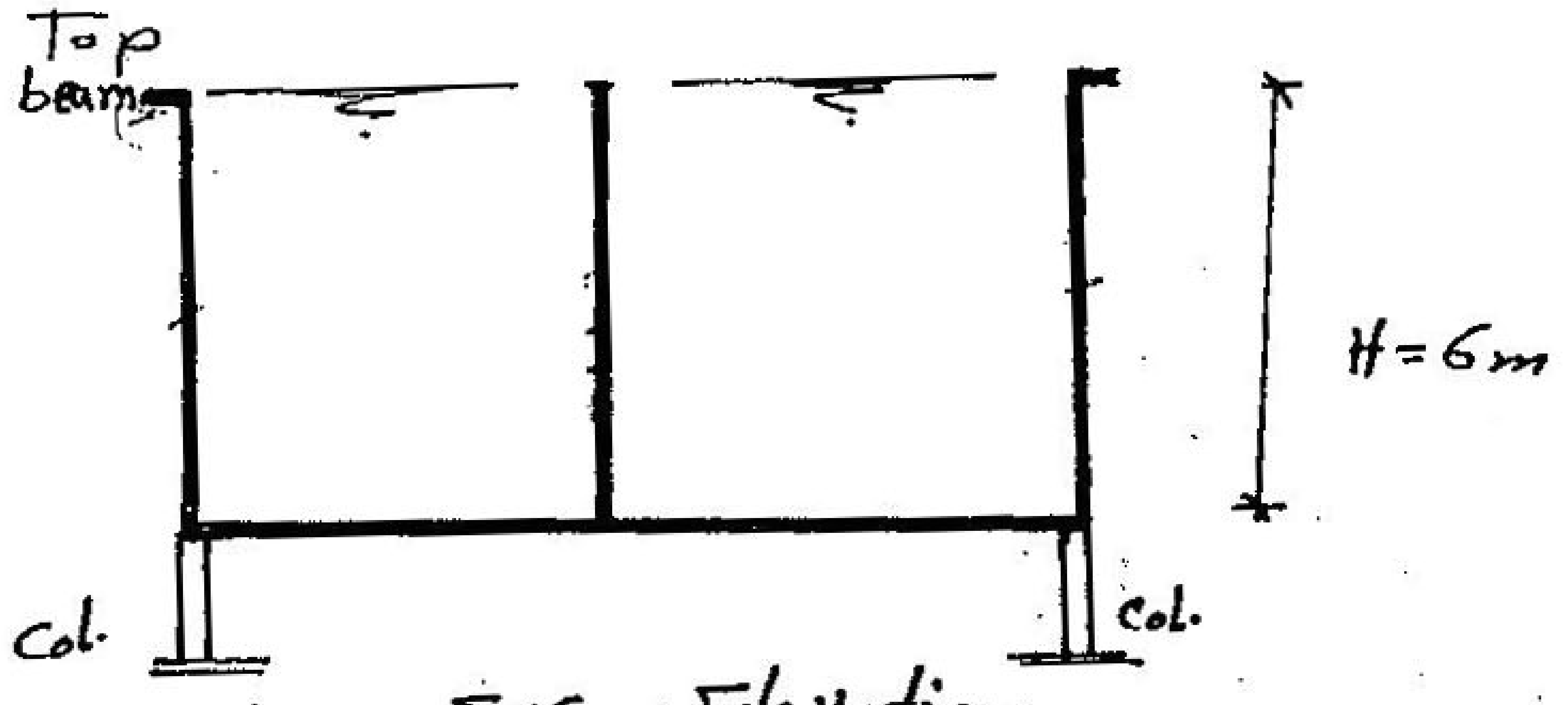




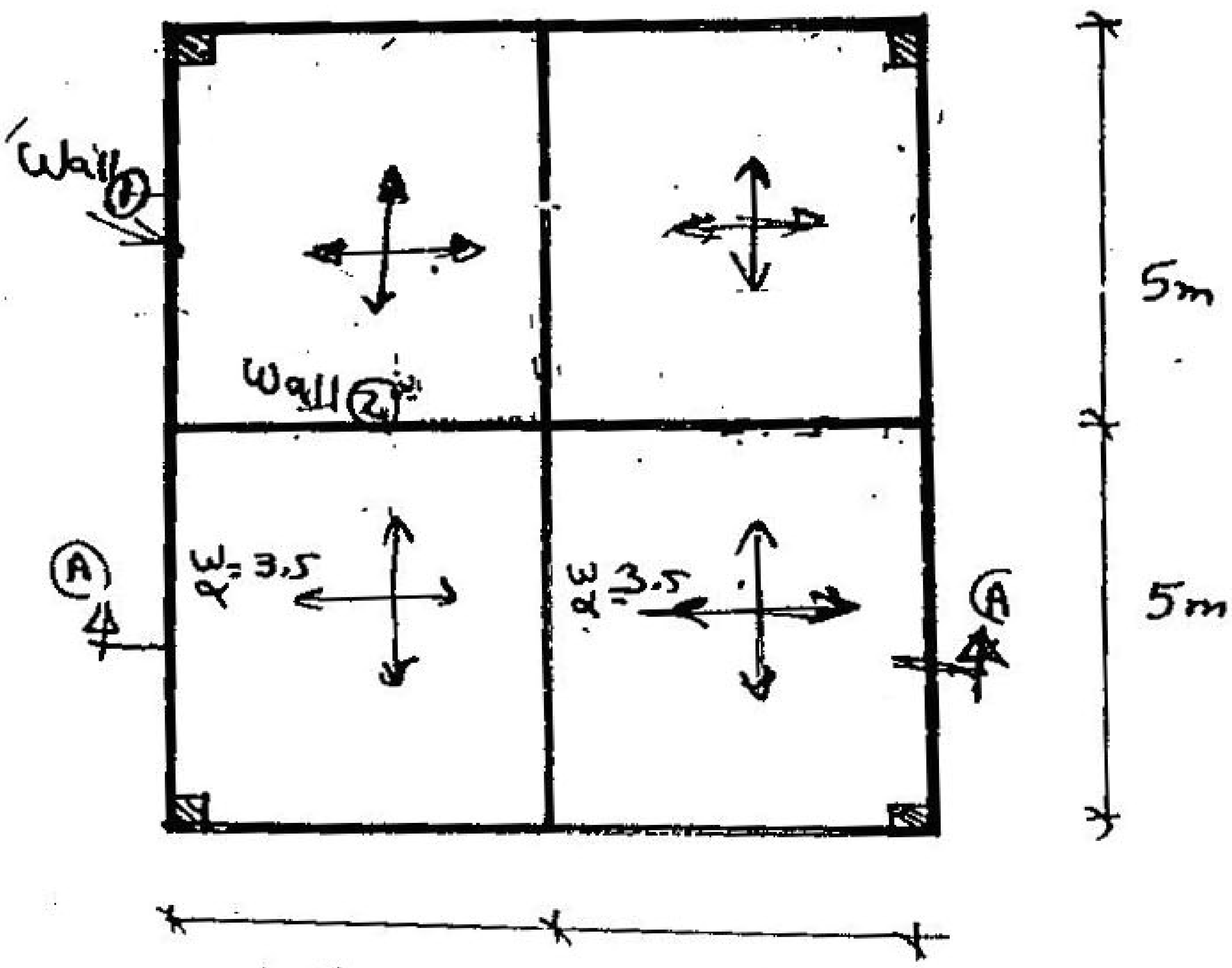
Moments in vertical strips (Rectangular tanks)



Example (1)



Sec. Elevation
Sec (A-A)



Plan

For the elevated Rectangular Tank given in figure. It is required to make complete design for all Tank elements; give complete Reinforcement details

$f_{cu} = 250\ kg/cm^2$, $f_y = 3600\ kg/cm^2$

Solution:

(1) loads:

Walls : $P = \gamma . H = 1*6 = 6\ t/m^2$

base : $\omega = \gamma_w . H + (\gamma_{R.C} * t_b)$

$= 1*6 + (2.5 * 0.4) = 7\ t/m^2$

فرض تخانة القاعدة .

(2) Load distribution :

Walls : : wall(1) $L = 5$: from plan

$H = 6m$: from elevation

*الحوائط تقسم بعضها الى قطع

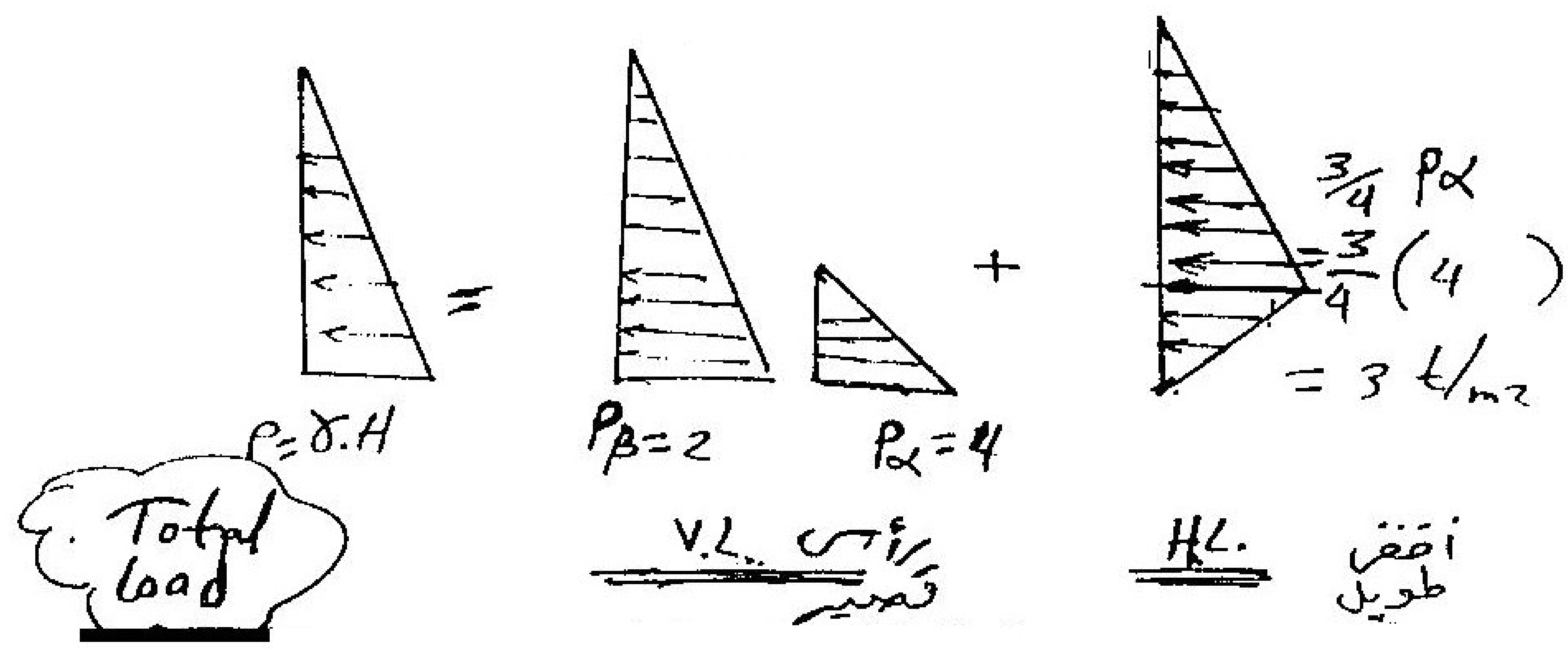
$\frac{L}{H} = \frac{5}{6} = 0.83 \lessgtr^{2}_{0.5}$ two way (medium)

$\therefore r = \frac{long}{short} = \frac{6}{5} = 1.2$

from grashof P. (1-12) → $\alpha = 0.672$, $\beta = 0.328$

$\therefore P\alpha = 0.672 * 6 = 4\ t/m^2$ للاتجاه القصير (افقى)

$\therefore P\beta = 0.328 * 6 = 2\ t/m^2$ (رأسى) للاتجاه الطويل



base :

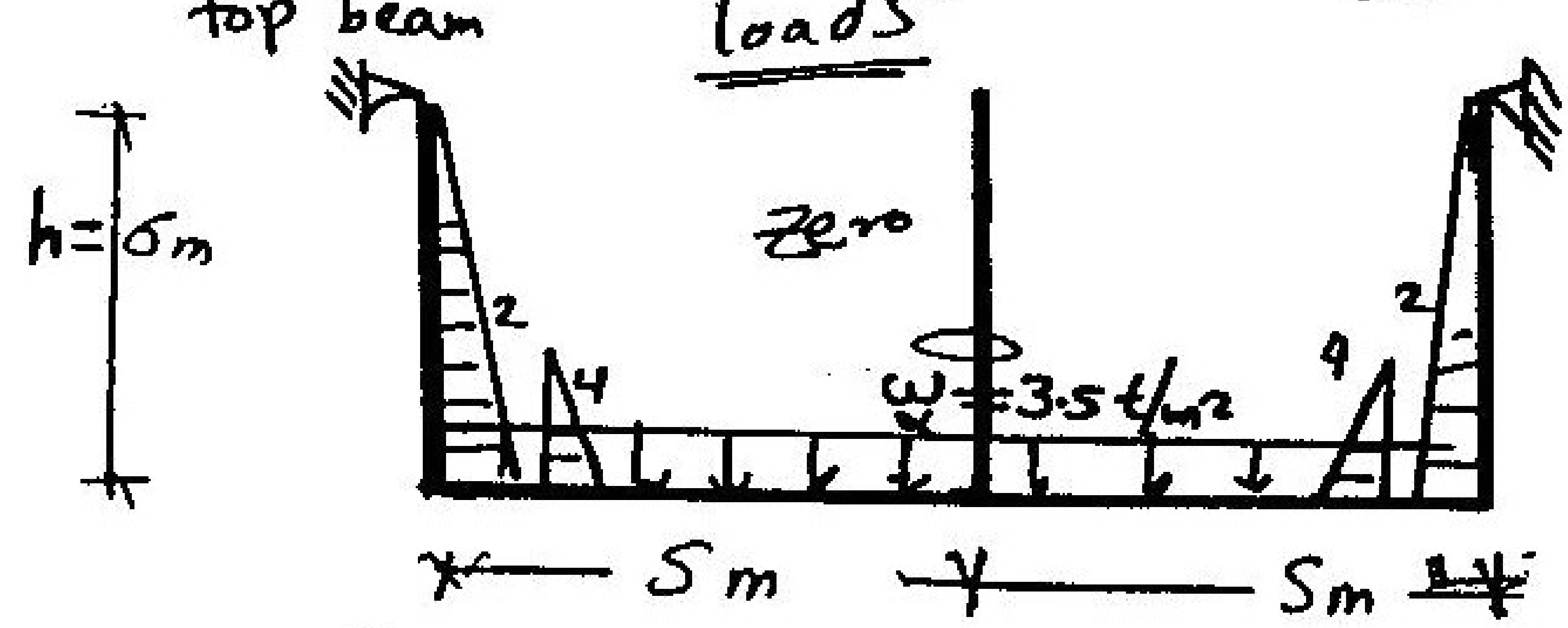
$r = \frac{long}{short} = \frac{5}{5} \pm 1 \Rightarrow \alpha = \beta = 0.5$

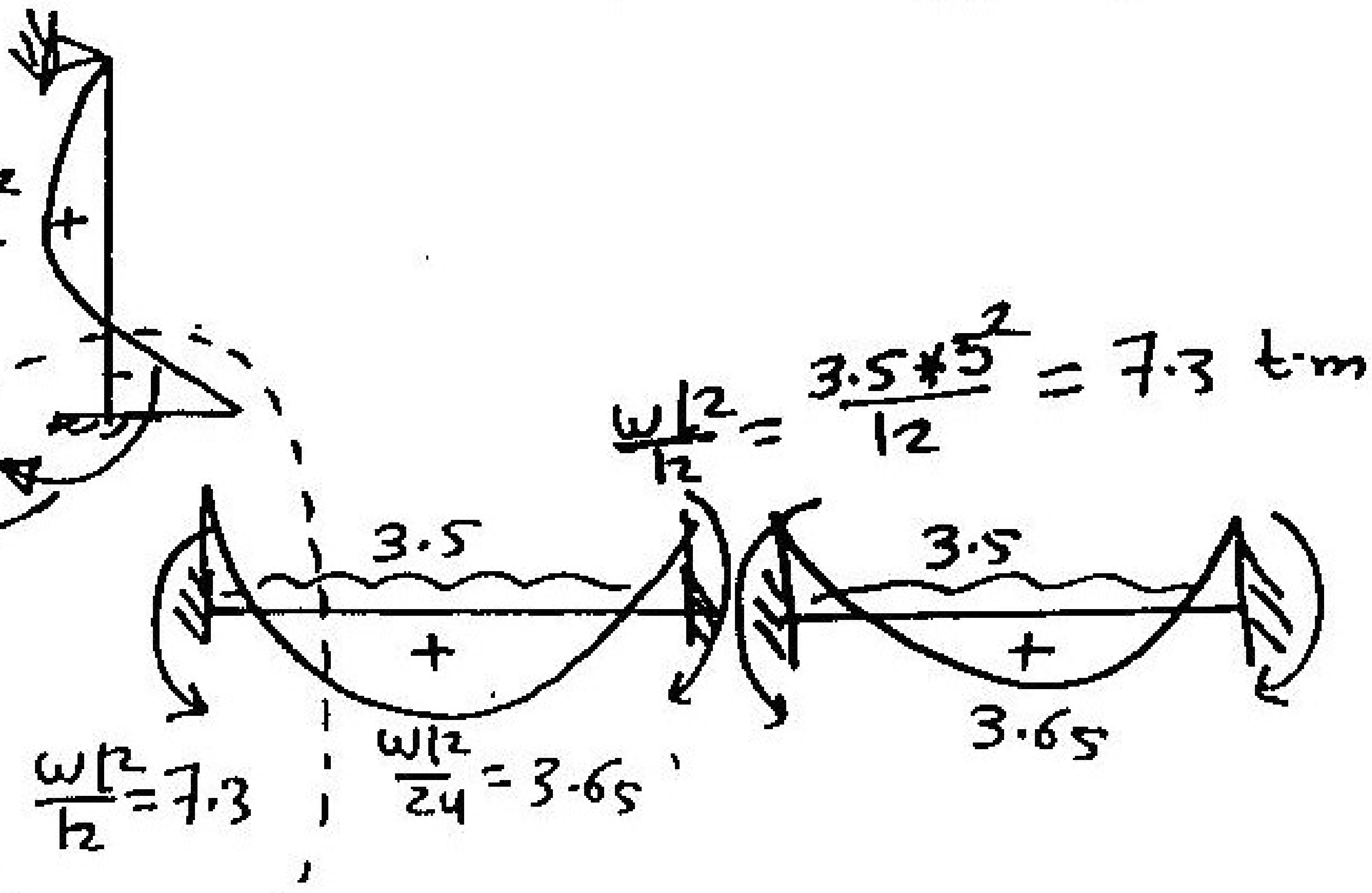
$\therefore w_\alpha = w_\beta = 0.5 * 7 = 3.5\ t/m^2$

(3) strips الشرائح

V.L. strip (الشرائح الرأسية)

القاعدة تعتبر بلاطة مرتكزة على الحائط (معلقة)





$M_{+ve} = \frac{w_1 \cdot h^2}{33.5} + \frac{w_2 \cdot h^2}{800} = 2.3\ t.m$

$\left(\frac{w_1 * h^2}{15} + \frac{w_2 h^2}{117}\right) = \frac{2 * 6^2}{15} + \frac{4 * 6^2}{117} = 6\ t.m$

$\frac{wl^2}{12} = \frac{3.5 * 5^2}{12} = 7.3\ t.m$

$\frac{wl^2}{12} = 7.3$

$\frac{wl^2}{24} = 3.65$

العزوم غير متزنة

Moment distribution ⟸

$$\left(\frac{I}{H} * \frac{3}{4}\right) = \frac{1}{6} * \frac{3}{4} = 0.12$$

→ wall (fixed - Hinged)

$$\left(\frac{I}{L}\right) = \frac{1}{5} = 0.2$$

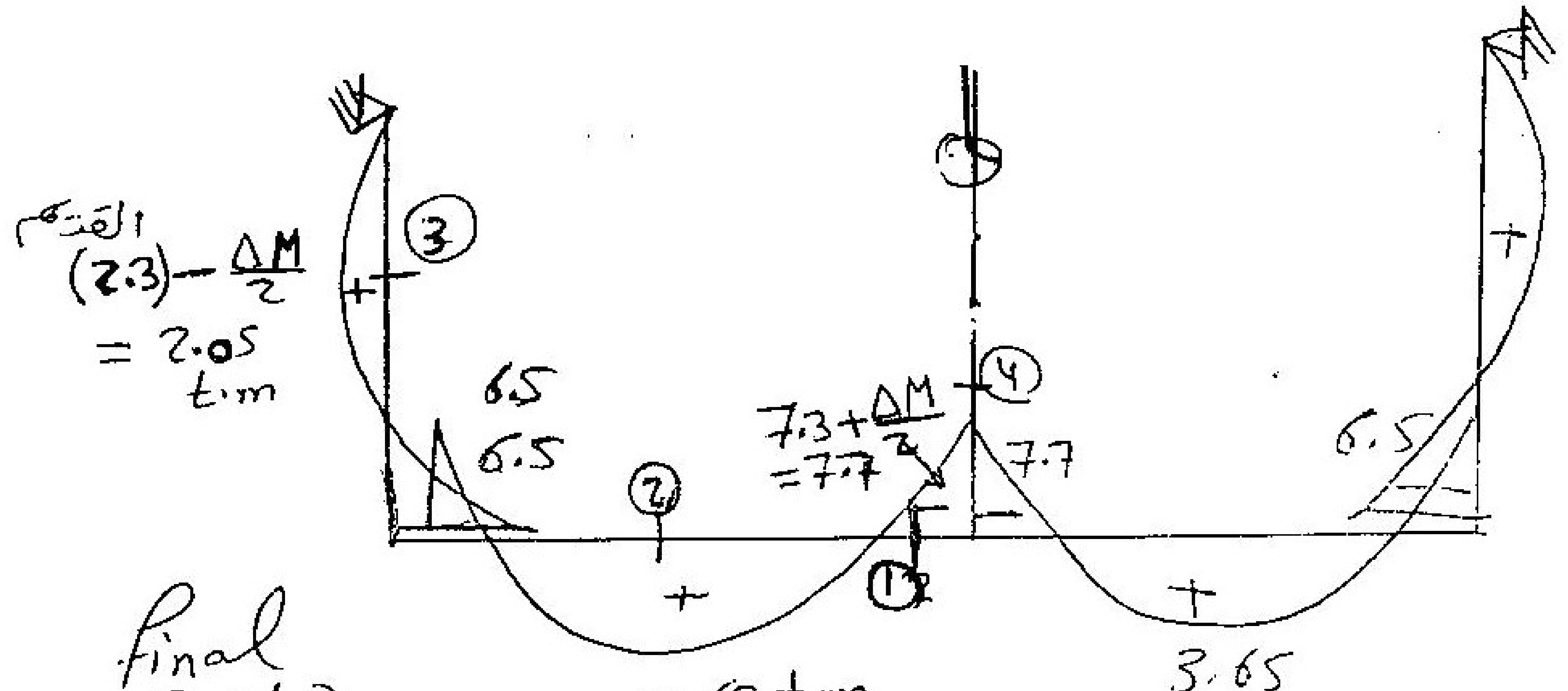
Base fixed - fixed

$$D.f_{wall} = \frac{0.12}{0.2 + 0.12} = 0.38$$

$$D.f_{base} = 1 - 0.38 = 0.62$$

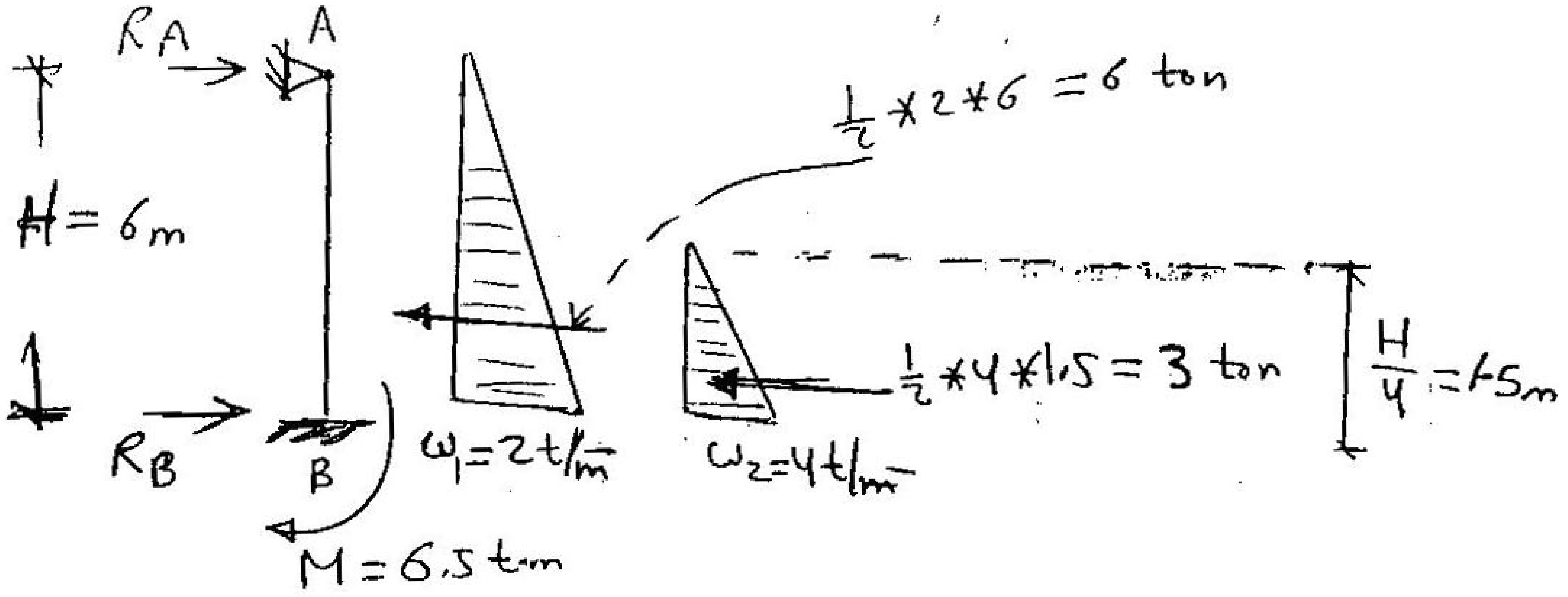
عكس العقارب موجب +

	Wall $D.f = 0.38$	Base $D.f = 0.62$
Fixed moment	-6	$+7.3$
D.M	$-0.5 = \Delta M$	$-0.8 = \Delta M$
Final (M)	-6.5	$+6.5$



Final B.M.D

+ To get reactions :-



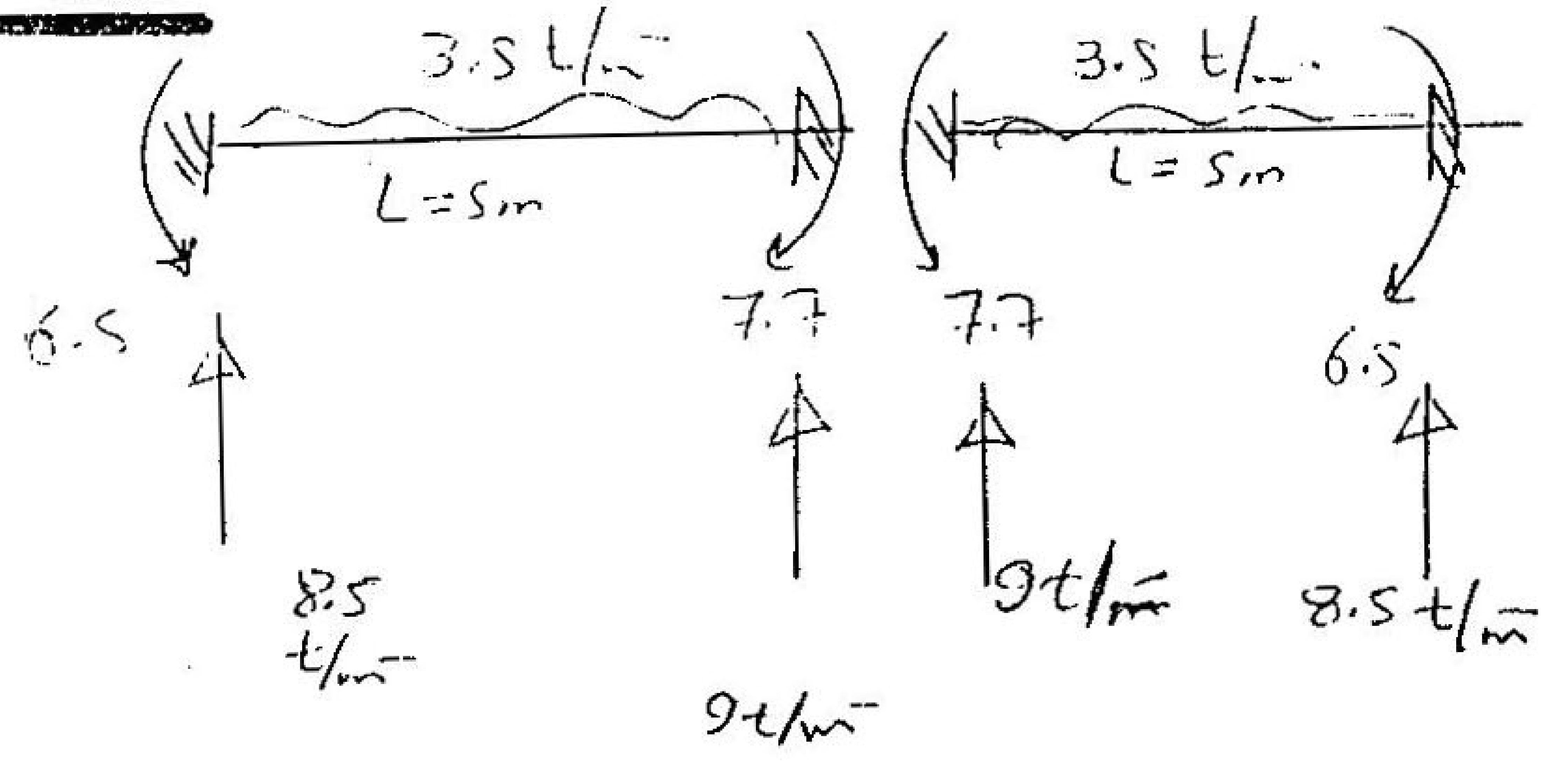
$$\sum M_B = 0 \Rightarrow \left(6 * \frac{6}{3}\right) + \left(3 * \frac{1.5}{3}\right) - 6.5 - R_A * 6 = 0$$

$$\therefore R_A = 1.16 \text{ ton/m}$$

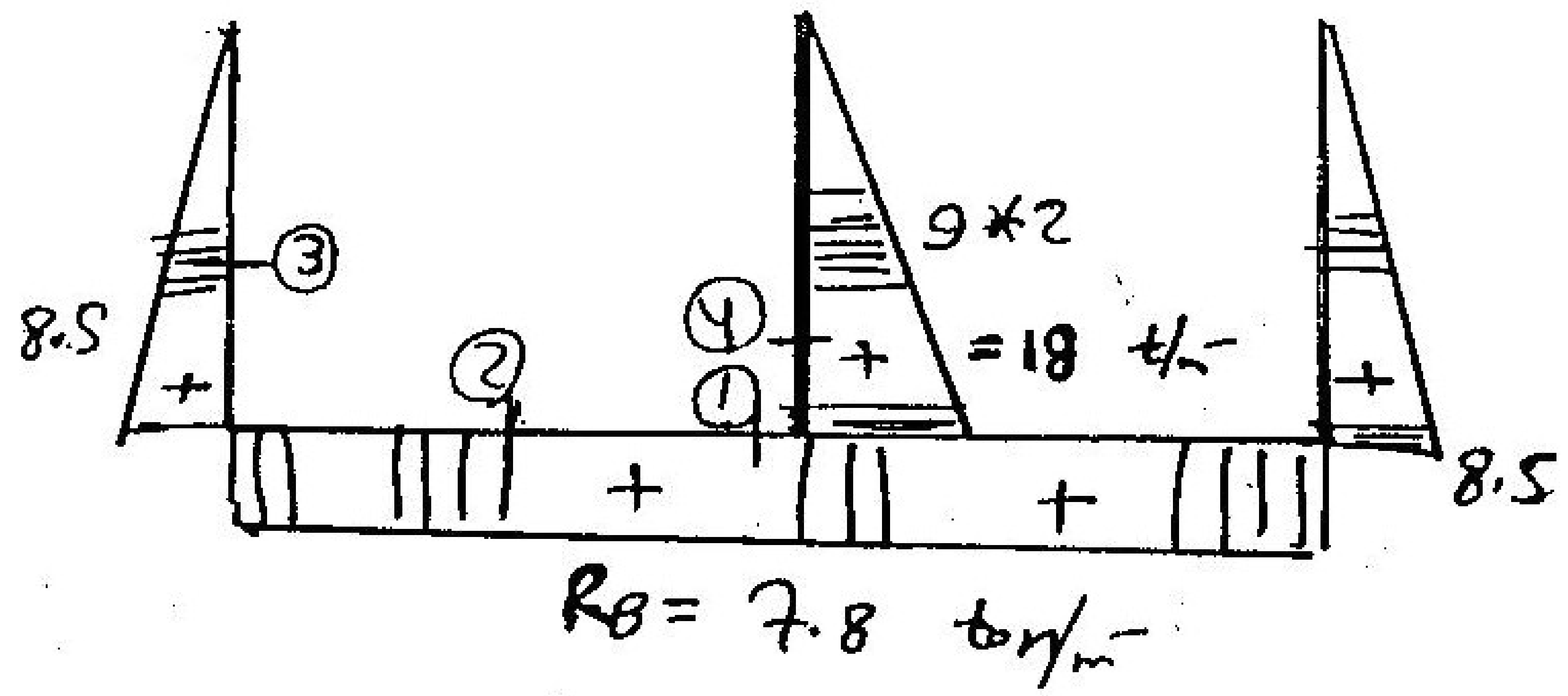
$$\sum F_x = 0 \Rightarrow R_A + R_B = 6 + 3$$

$$\therefore R_B = 7.8 \text{ t/m}$$

(Base)

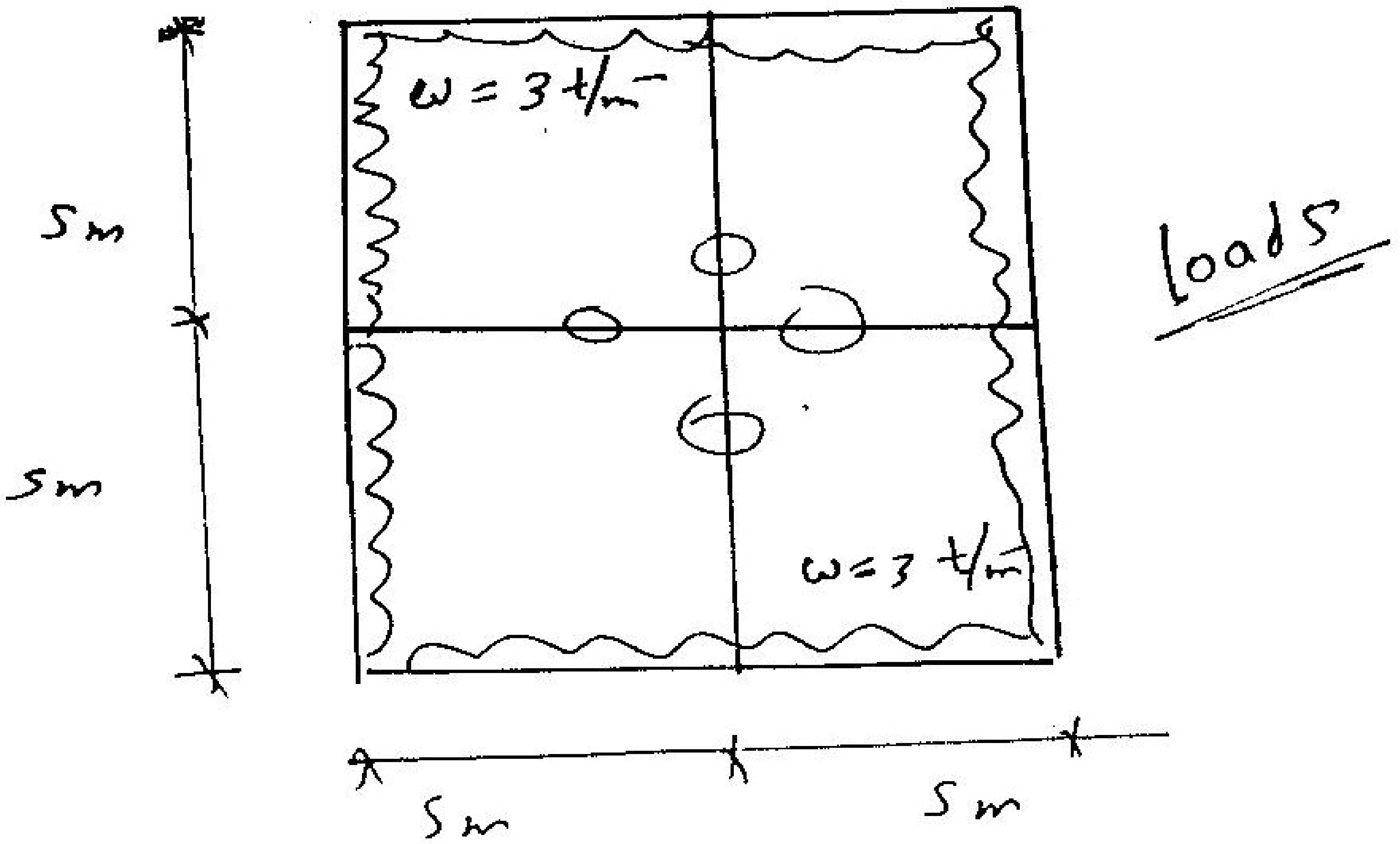


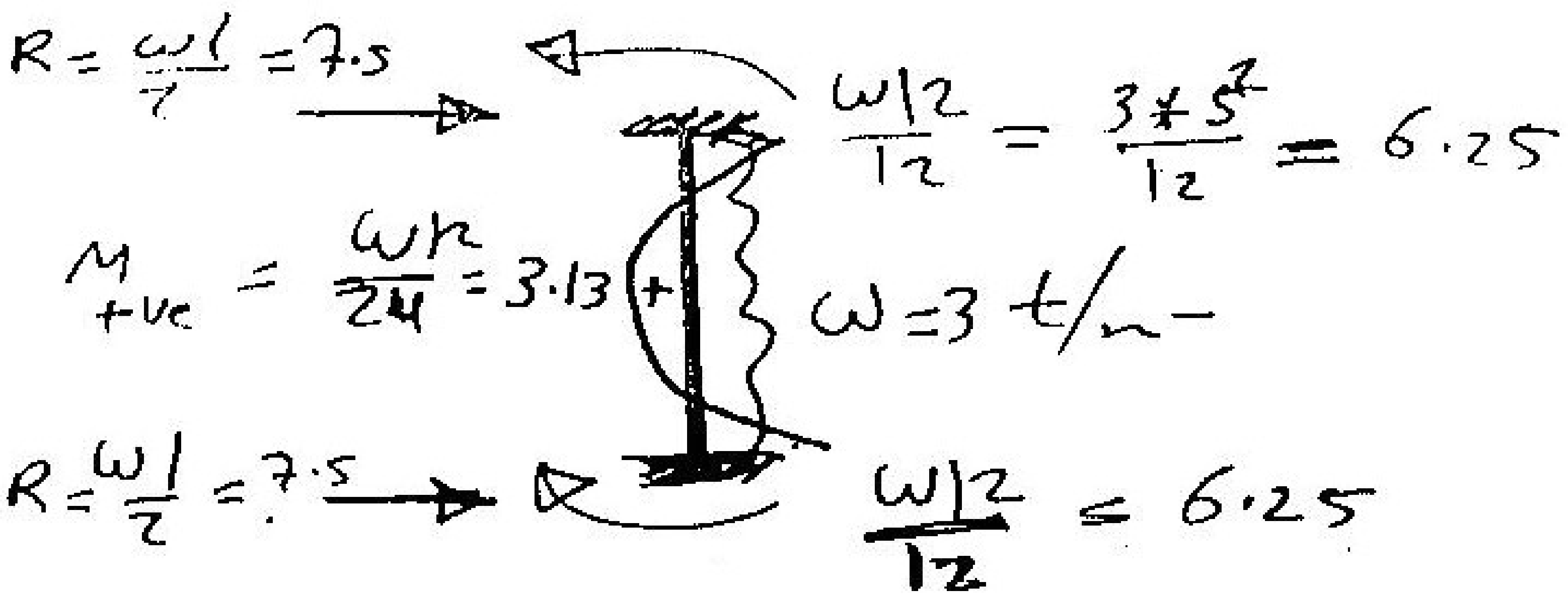
N.F.D

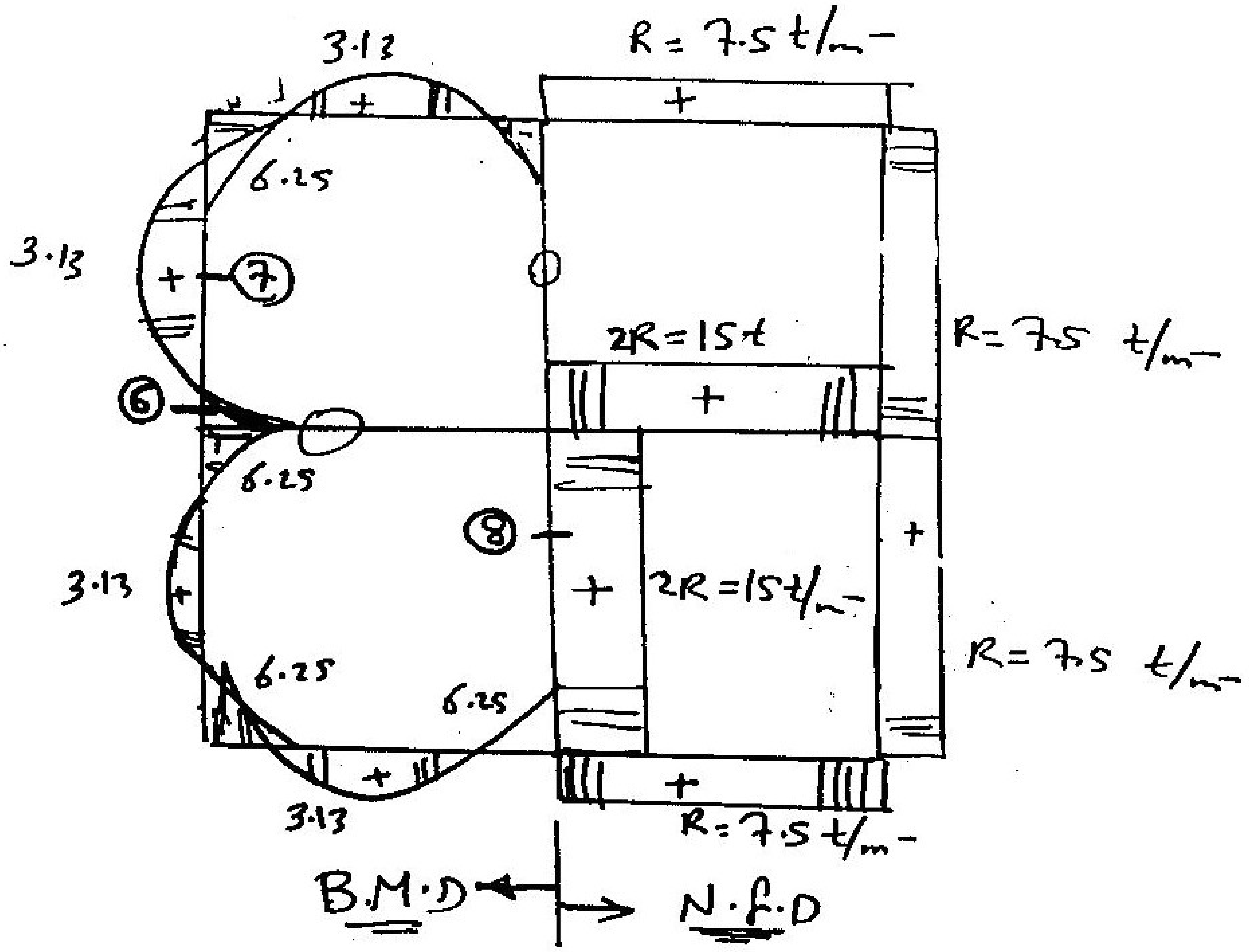


HL. strips "الشريحة الأفقية"

عند أقصى حمل أفقي At (3/4 H)







Design of sections:

* VL. Strip:

Sec (1) $M_{water\ side} = 7.7\ t.m/m$, $T = 7.8\ t/m$

stage (I): $t = \sqrt{\frac{M}{\psi \cdot B}} + 5\ cm$

$= \sqrt{\frac{7.7 \times 10^5}{3.2 \times 100}} + 5 = 55\ cm$

Check: $\sigma_t = \left(\frac{6.M \times 10^5}{B \cdot t^2}\right) + \left(\frac{T \times 10^3}{B \cdot t}\right) \ngtr f_{ct}$

ok.

Stage (II) Ultimate

$T_u = 1.5\,T = 11.7\ t/m$; $M_u = 1.5\,M = 11.5\ tm/m$

$$e = \frac{M_u}{T_u} = 0.98$$

$$e/t > 0.5$$

$$\therefore e_s = e - \frac{t}{2} + cover$$

$$= 0.98 - \frac{0.55}{2} + 0.05 = 0.75\ m$$

$$\therefore M_{us} = T_u \cdot e_s = 11.7 * 0.75$$

$$= 8.8\ tm/m$$

$$R_1 = \frac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} = 0.014$$

$$\omega = 0.018$$

أوميجا

$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d + \frac{T_u * 10^3}{f_y/\gamma_s}$$

$$= \left(0.018 * \frac{250}{3600} * 100 * 50\right) + \left(\frac{11.7 * 10^3}{(3600/1.15)}\right)$$

$$= 10\ cm^2/m$$

$$= 5 \# 16/m$$

Check:

$$A_{s_{min}} = \frac{0.15}{100} B \cdot d = 7.5\ cm^2/m$$

xx

ok

section(2) $M_{\text{air side}} = 3.65$ t.m , $T = 7.8$ t/m

Stage (II)

$\because$ $t = 55$ cm
$d = 50$ cm   ([illegible])

$M_u = 1.5\,M$

$T_u = 1.5\,T$

$e = \dfrac{M_u}{T_u}$

$e/t \geq 0.5 \Rightarrow$ big eccentricity

$e_s = e - \dfrac{t}{2} + 0.05$

$M_{us} = T_u \cdot e_s$

$R_1 = \dfrac{M_{us}}{f_{cu} \cdot B \cdot d^2}$

$\omega = 1.3\,R_1 = \sim$

$A_s = \left(\omega \cdot \dfrac{f_{cu}}{f_y} \cdot B \cdot d\right) + \left(\dfrac{T_u \times 10^3}{f_y / \gamma_s}\right)$

$= 6.3$ cm²/m

$\because$ $A_{s_{min}} = \left(\dfrac{0.15}{100} B\,d\right) = 7.5$ cm²/m

$\therefore$ use $A_{s_{min}} = 7.5$ cm²/m
$= 7 \,\#\, 12$/m

شغل

Section ③

$M_{air} = 2.05 \ t.m \quad , T \simeq 4.3 \ t/m$

Stage (II)

<u>use</u> $t = 25$ cm

$d = 20$ cm

$M_u = 1.5 M \quad , \quad T_u = 1.5 T$

$e \ ; \ e/t \ ; \ e_s \ ; \ M_{us} \ , \ R_1 \ , \ \omega$

$\therefore A_s = \left(\omega \cdot \frac{f_{cu}}{f_y} b.d \right) + \left(\frac{T_u * 10^3}{f_y / \gamma_s} \right)$

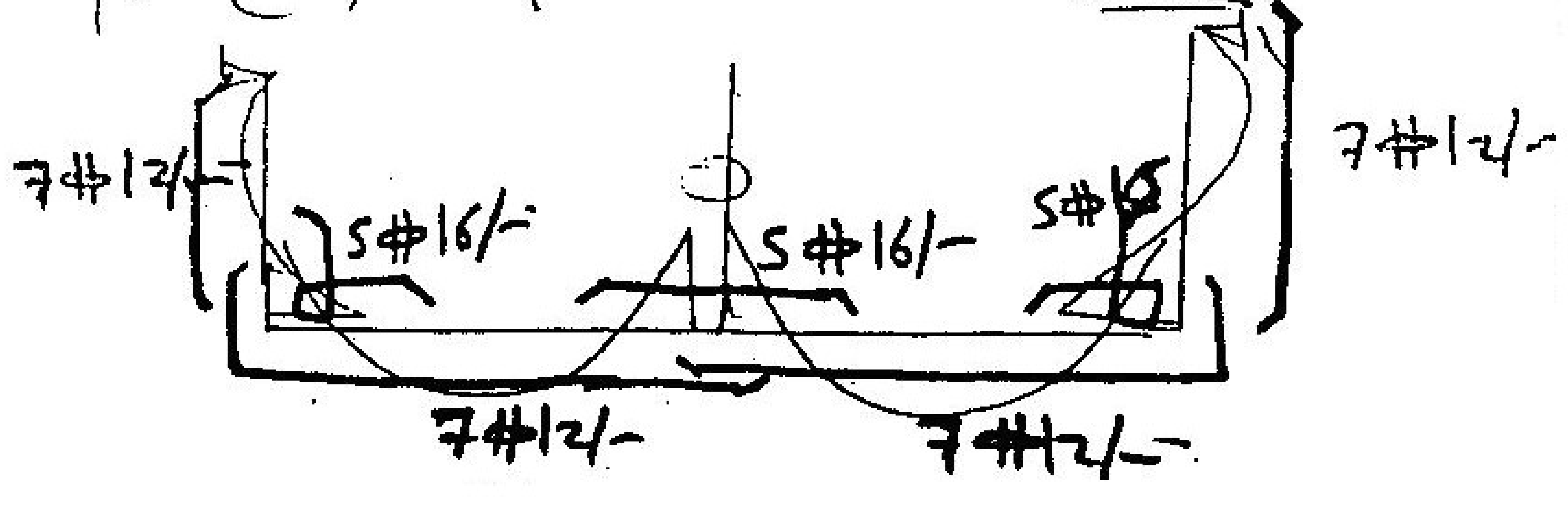
$= 5 \ cm^2/m$

$A_{s_{min}} = \frac{0.15}{100} B.d = \frac{0.15}{100} \times 100 \times 20$

$= 3 \ cm^2/m$ XX

$\therefore$ use $A_s = 5 \ cm^2/m = 5 \# 12/m$ (crossed out)

لتأمين تقسيم الحديد الطالع من القاعدة $7 \# 12/m$



sec (4) (T only) ⇒ T = 17.5 ton/m

stage (I) $t \simeq 25$ cm.

stage (II) $(As) = \frac{T_u}{2(f_y/\gamma_s)} = \frac{1.5 * 18 * 10^3}{2\left(\frac{3600}{1.15}\right)}$

لكل ناحية

$= 4.5$ cm²/m

$\simeq 6 \Phi 10$/m each side

« Hl. strip »

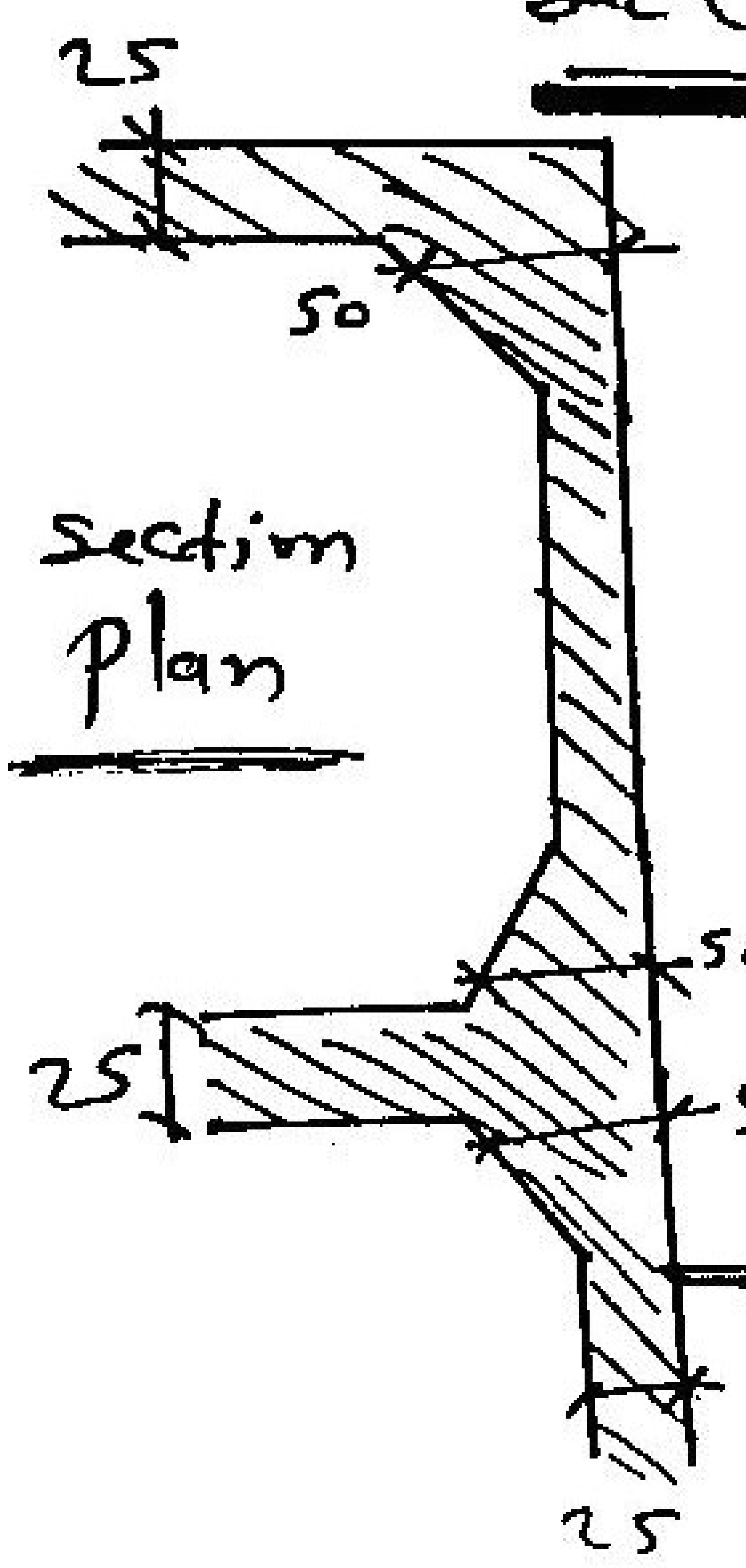
Sec (6) $M_{water} = 6.25$ t.m/m , $T = 7.5$ t/m

Stage (I): $t = \sqrt{\frac{6.25 \times 10^5}{3.2 \times 100}} + 5 \simeq 50$ cm

Stage (II): e , es , Mus , R , ω

use 8 Φ 12/m

Sec (7)



$M_{air\ side} = 3.13$ t.m/m , $T = 7.5$ t/m

⟹ $M_u = 4.7$ t/m , $T_u = 11.25$ t/m

use $t \simeq 25$ cm

$e = \frac{M_u}{T_u} = \leftarrow$

$e_s = \leftarrow$

$M_{us} = T_u \cdot e_s$

use 8 Φ 12/m

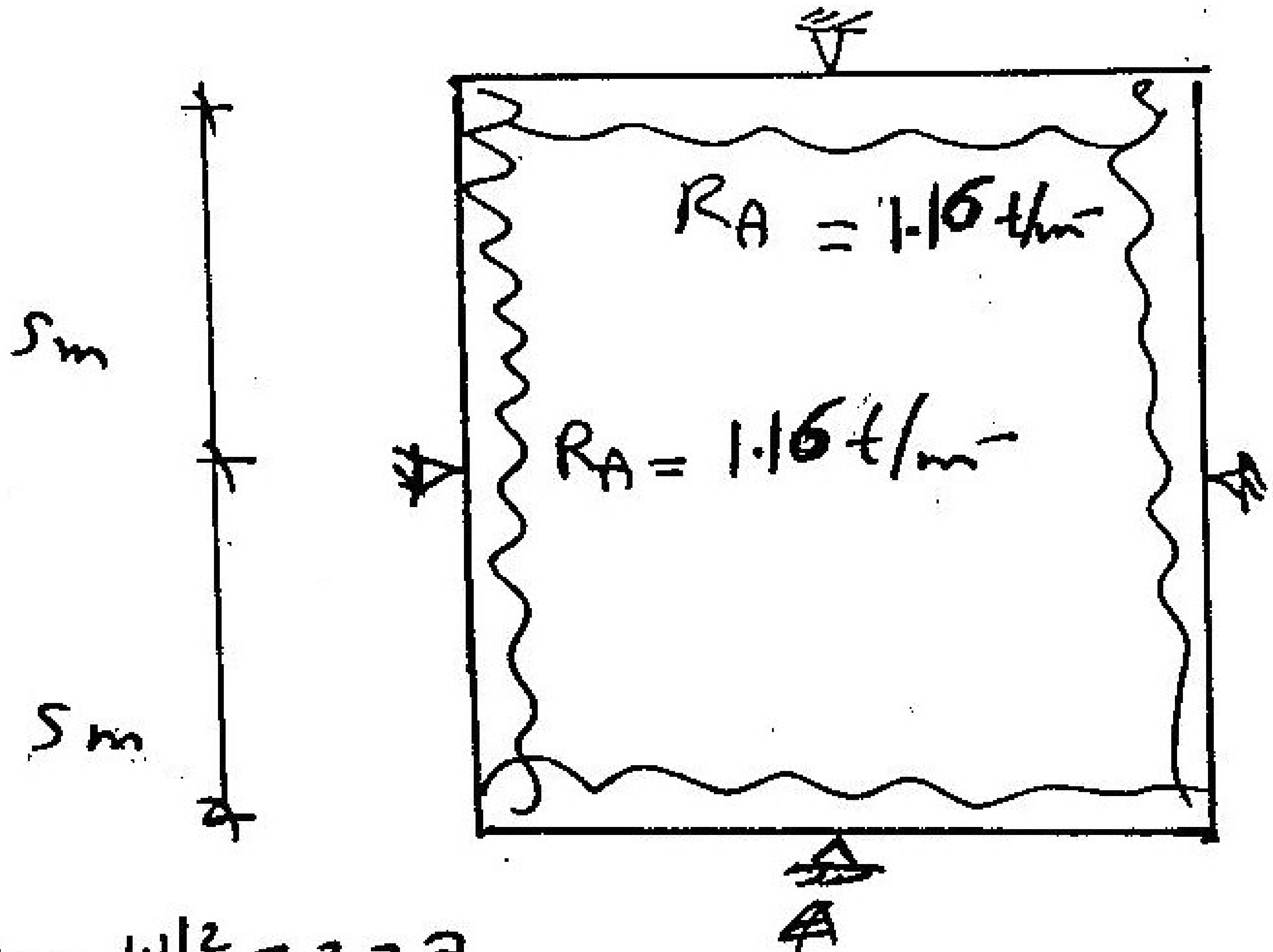
Sec (8) : (T) only ; $T = 15$ t/m

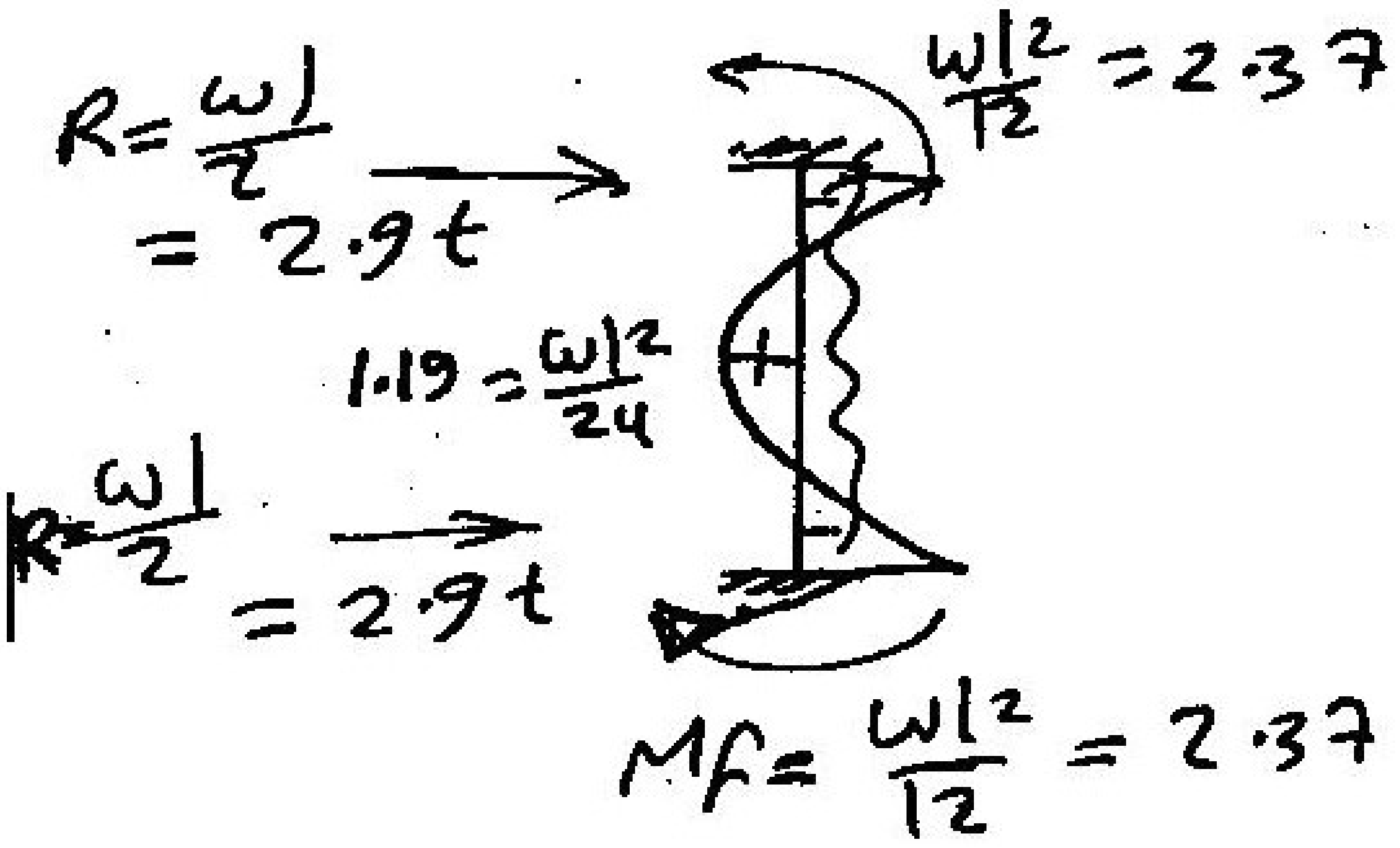
use t = 25 cm

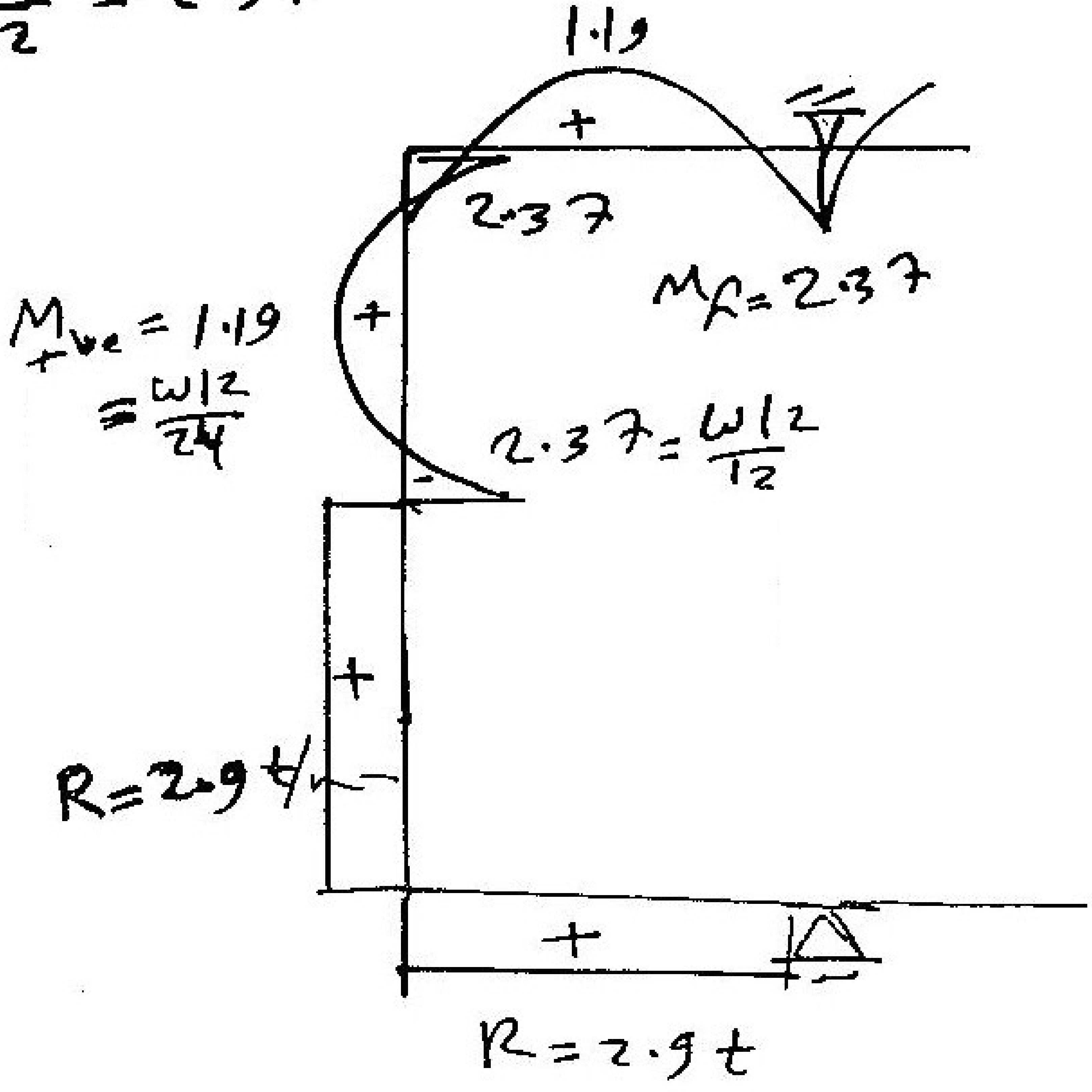
use (As) ≃ 8 Φ 10/m

تكملة

Top beam: (تتحمل لـ Reaction مباشرة الرأسية.)







Design: $M_{max} = 2.37$ t.m , $T_{max} = 2.9$ ton
water side

stage (I): $t = \sqrt{\frac{2.37 \times 10^5}{3.2 \times 30}} + 5 \simeq 60$ cm

using $b = 30$ cm

$\therefore d = 55$ cm

stage (II): $e = \frac{M_u}{T_u} = \frac{1.5 \times 2.37}{1.5 \times 2.9} = 0.81$ m

$e/t > 0.5 \Rightarrow$ big eccentric section

$\therefore e_s = \leftarrow$

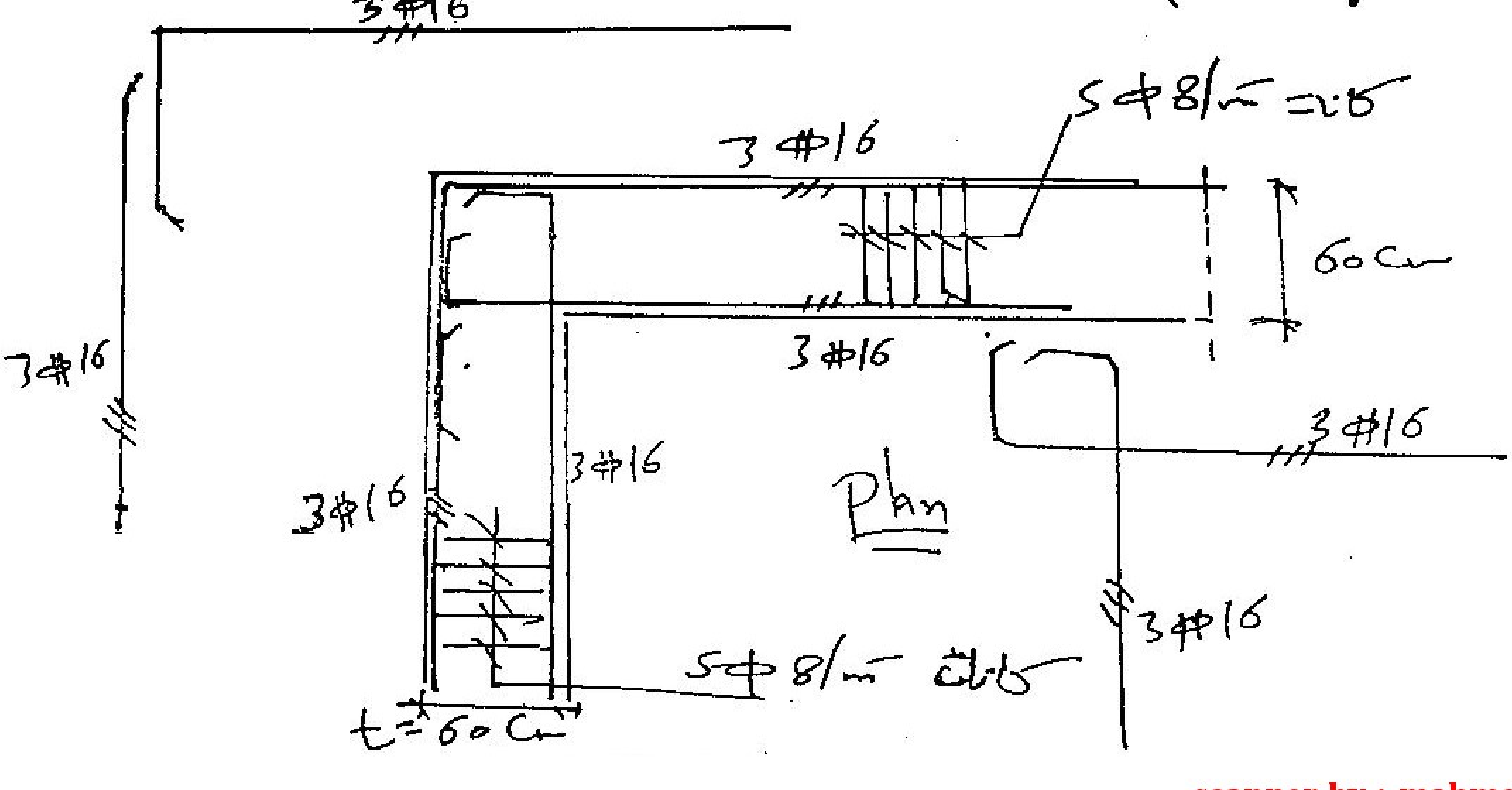
$\therefore M_{us} = e_s \times T_u$

$\therefore R_1 = \leftarrow$

$As = \leftarrow$

$\therefore As_{min} = \frac{11}{3600} \times 30 \times 55 = 5$ cm²

للكمرات $\Rightarrow$ $= 3\phi16$



LOAD DISTRIBUTION ON TWO-WAY SLABS

Table: (1-11-a) Load Distribution According to A. R. E.

r	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
α	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85
β	0.35	0.29	0.25	0.21	0.18	0.16	0.14	0.12	0.11	0.09	0.08

Table: (1-11-b) Load Distribution According to Marcus.

r	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
α	.396	.473	.543	.606	.660	.706	.746	.778	.806	.830	.849
β	.396	.323	.262	.212	.172	.140	.113	.093	.007	.063	.053

Table: (1-11-c) Load Distribution According to Grashoff.

r	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
α	.50	.595	.672	.742	.797	.834	.869	.893	.914	.928	.941
β	.50	.405	.328	.258	.203	.166	.131	.107	.086	.072	.059

r = m .b /m. a; where m = 0.87 for continuity at one end of solid slab.
m = 0.67 for continuity at both ends of solid slab, while m = 1.0 for discontinuous slab.

EQUIVALENT LOAD FOR DESIGN OF BEAMS:

Table: (1-12) Coefficient of Equivalent Load for two-way solid slabs.

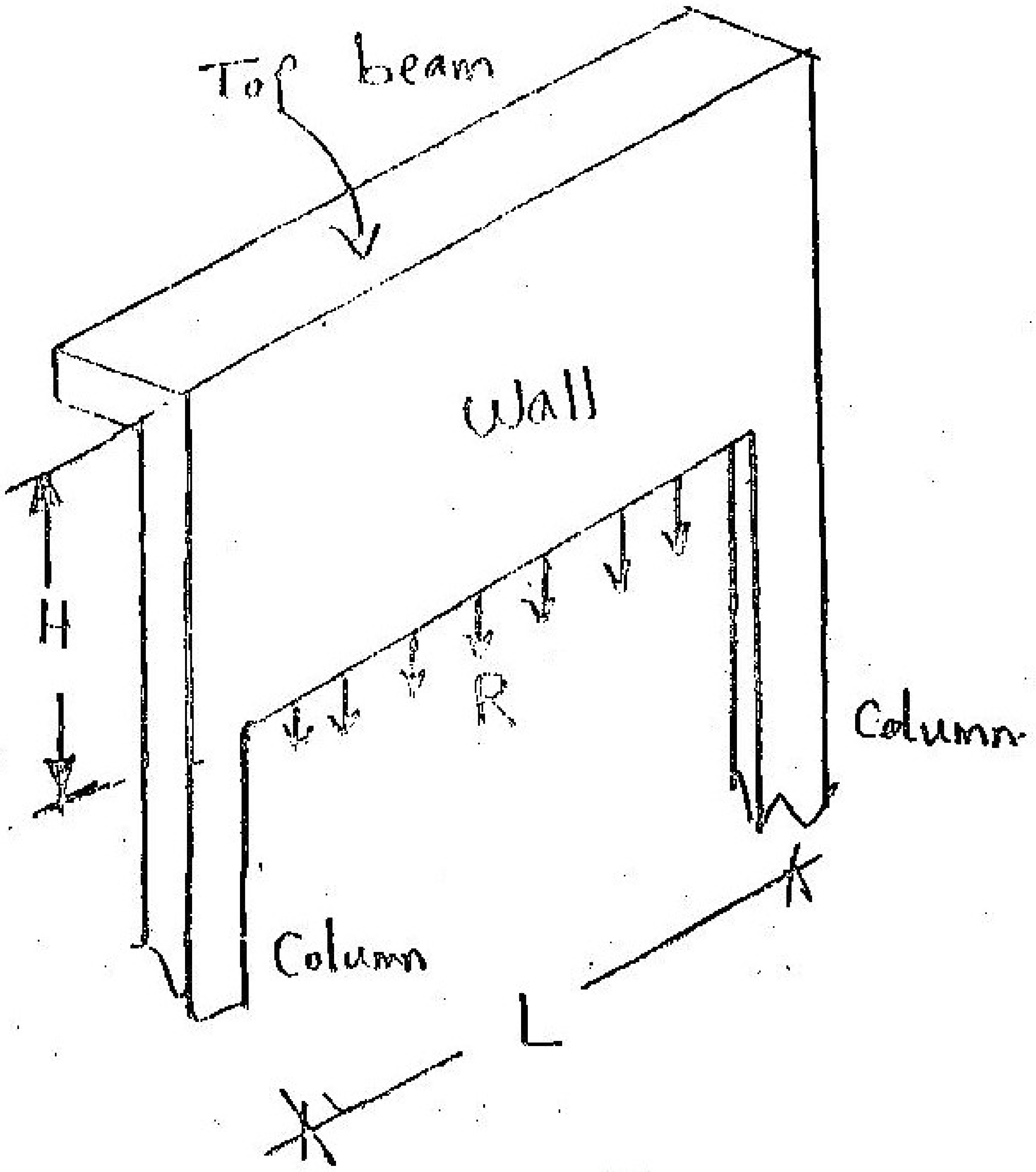
r	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
α	.667	.725	.769	.803	.829	.852	.870	.885	.897	.908	.917
β	.50	.545	.583	.643	.667	.688	.131	.706	.722	.737	.750

الفرقة الرابعة مدني

Reinforced Concrete Water Tanks

" Design of wall as beam "

تصميم الحائط على أنها كمرة — P.(3-40)

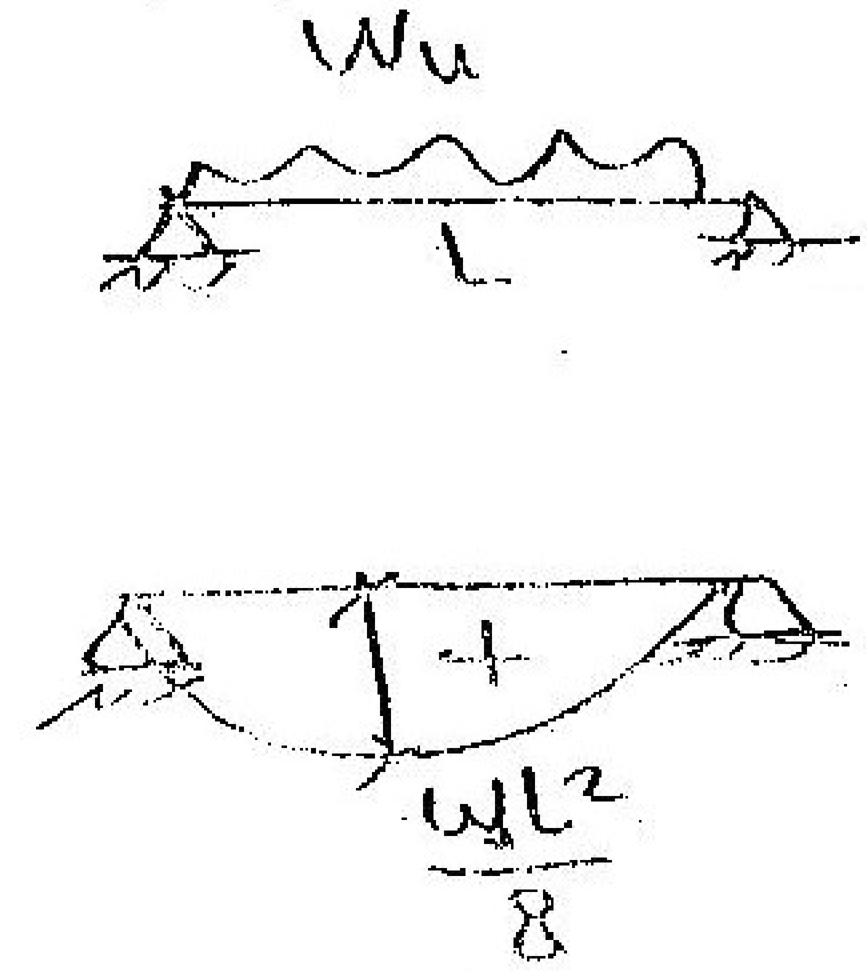


$$W = R + \text{own wt.} + \text{top beam}$$

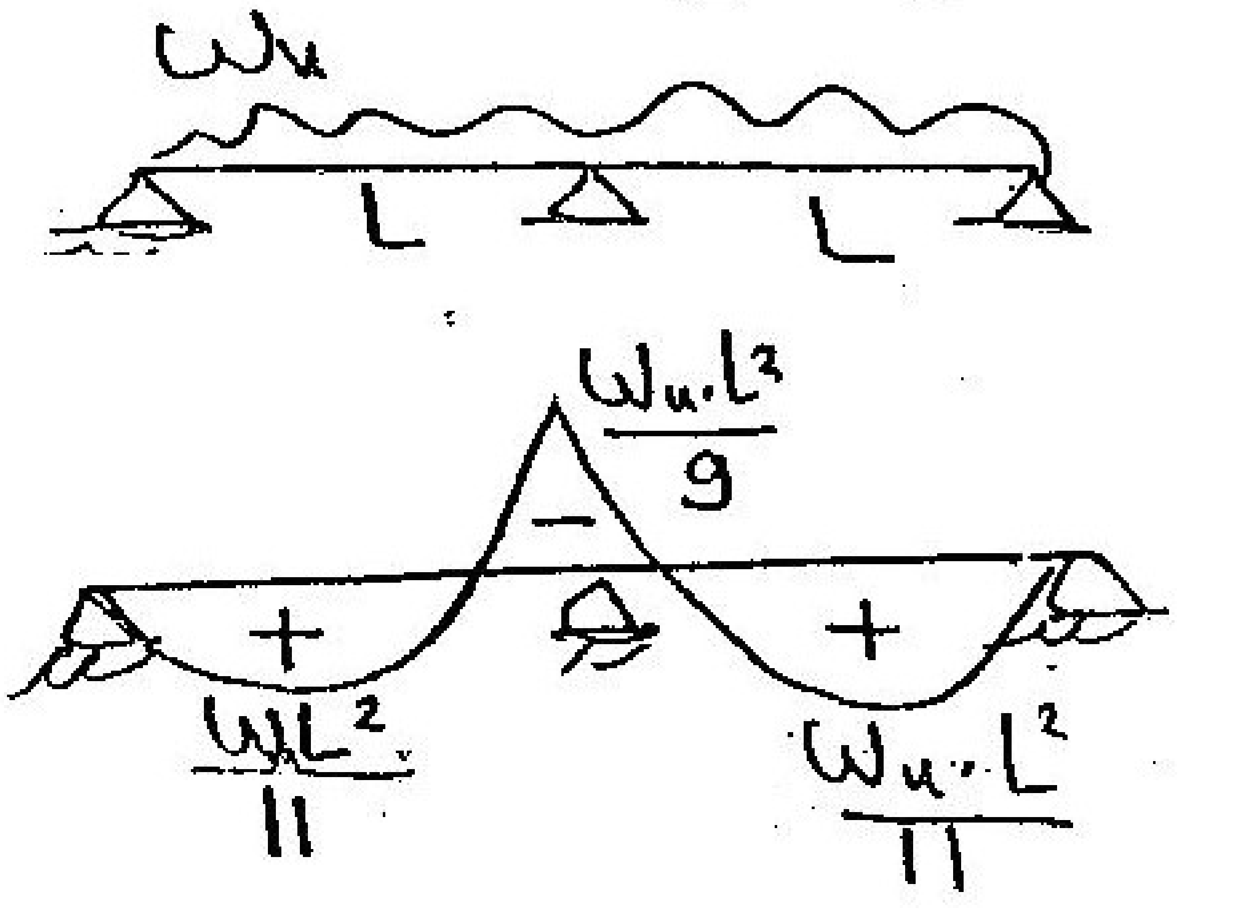
- R: من البلاطة شد لأسفل
- own wt.: وزن الحائط $(t_{wall} \cdot H \cdot \gamma_{R.C})$
- top beam: وزن الكمرة العلوية $(b * t * \gamma_{R.C})$

$$\therefore \; W_u = 1.5\, w$$

Simple

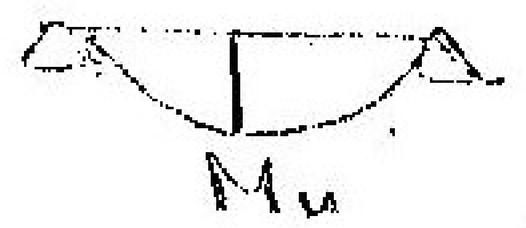


Continious beam



"design"

Simple Wall



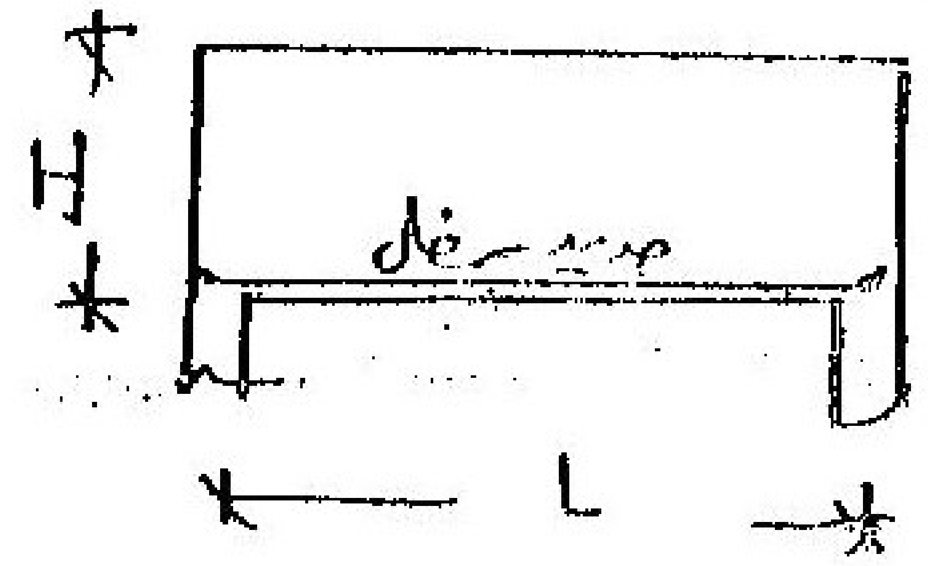
If $\frac{H}{L} > 0.8 \Rightarrow$ deep beam

$y_{ct} = 0.87 * (H \text{ or } L)$ أيهما أصغر

$T_u = \frac{M_u}{y_{ct}} = \checkmark$ ton

سفلي $A_s = \frac{T_u * 10^3}{(f_y/\gamma_s)} = \checkmark$ cm²

صديد سفلي



* في حالة الـ M لا يكون (deep)

⇓ كمرة عادية خالص

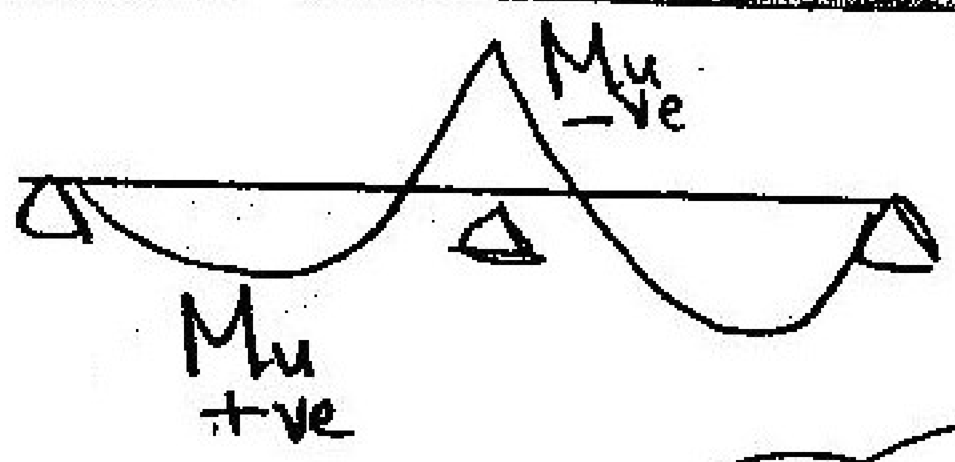
slender beam

$\therefore R_1 = \frac{M_u * 10^5}{f_{cu} \cdot b \cdot d^2} = \checkmark$

$\omega = 1.3 R_1 = \checkmark$

$A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d = \checkmark$

Continious Wall



If $\frac{H}{L} > 0.4 \Rightarrow$ deep beam

For $M_{+ve} \Rightarrow y_{ct} = 0.43 L$

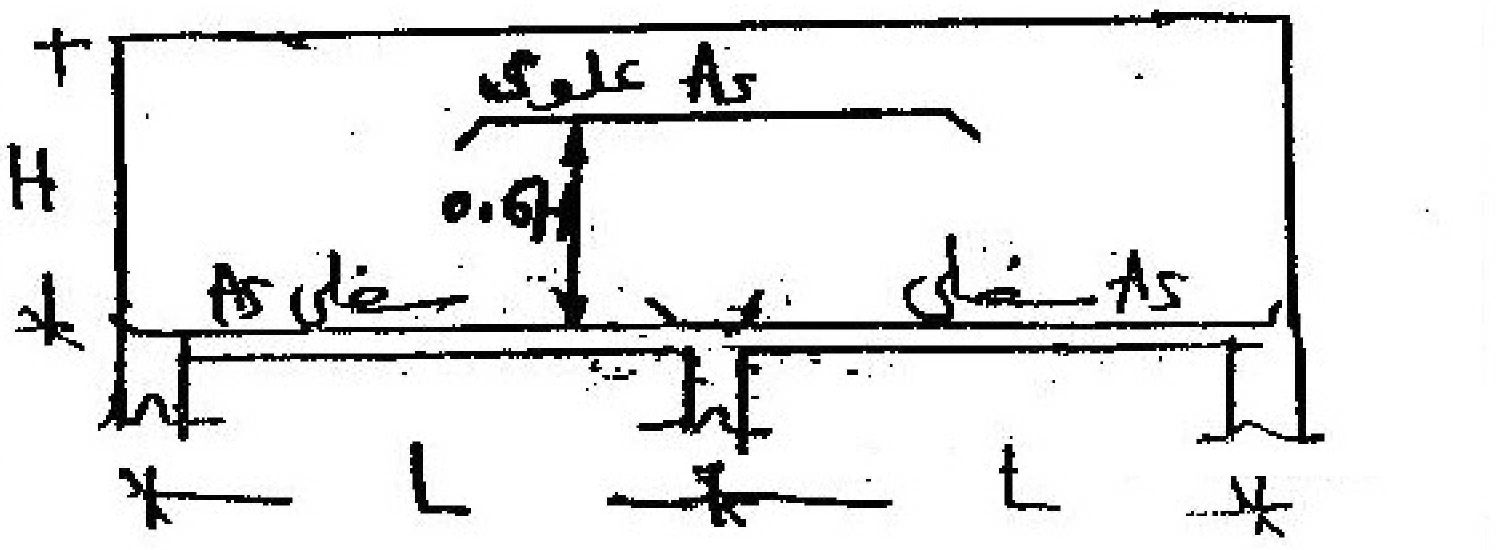
$T_u = \frac{M_{+ve}}{y_{ct}} = \checkmark$ ton

سفلي $A_s = \frac{T_u * 10^3}{(f_y/\gamma_s)} = \checkmark$ cm²

for $M_{-ve} \Rightarrow y_{ct} = 0.37 L$

$T_u = \frac{M_{-ve}}{y_{ct}} = \checkmark$ ton

علوي $A_s = \frac{T_u * 10^3}{(f_y/\gamma_s)} = \checkmark$ cm²



* في حالة الـ لا يكون (deep)

⇓ كمرة عادية خالص

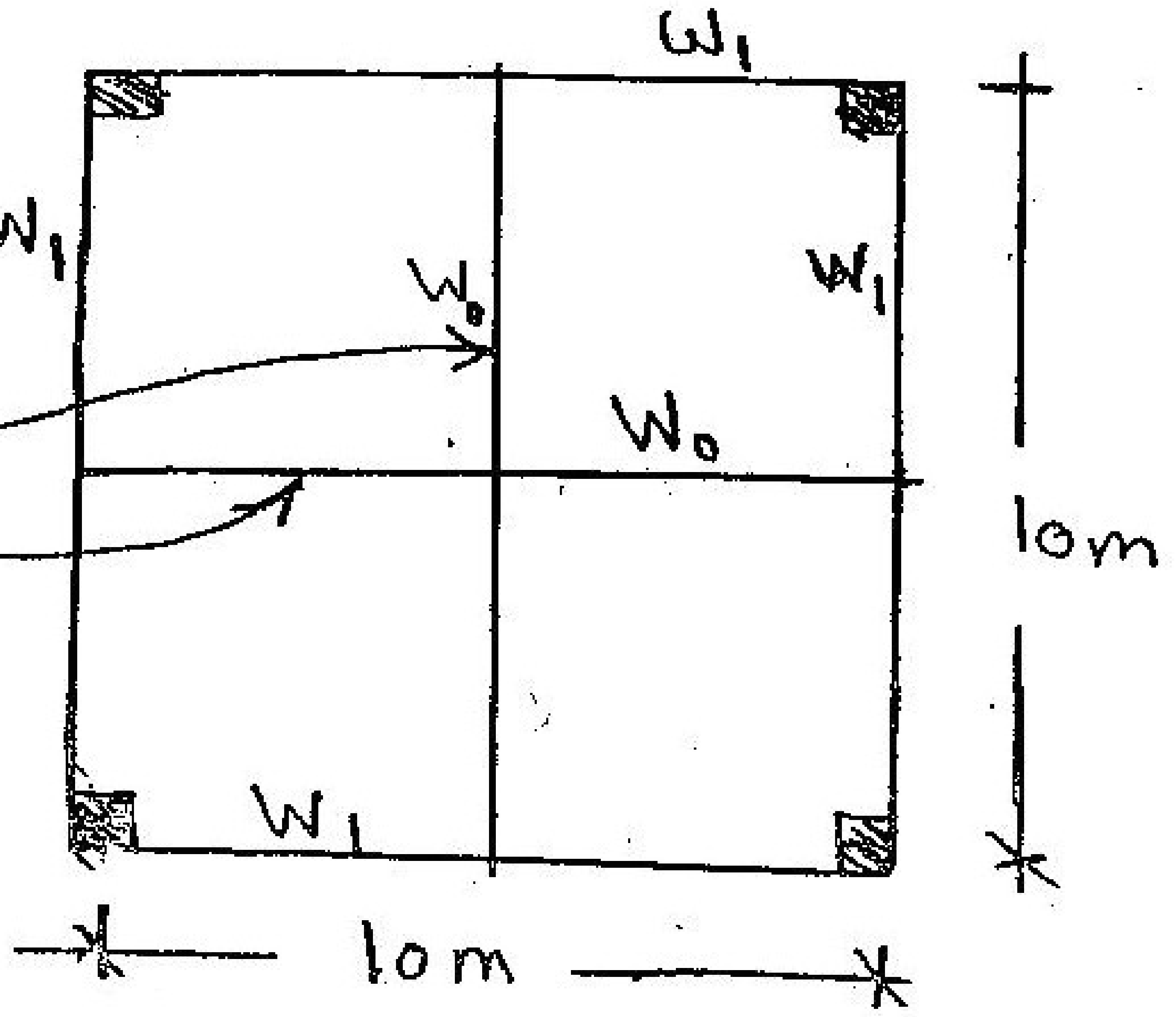
slender beam

$\therefore R_1 = \frac{M_u * 10^5}{f_{cu} \cdot b \cdot d^2} = \checkmark$

$\Rightarrow \omega = 1.3 R = \checkmark$

$\Rightarrow A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d = \checkmark$

" Example "

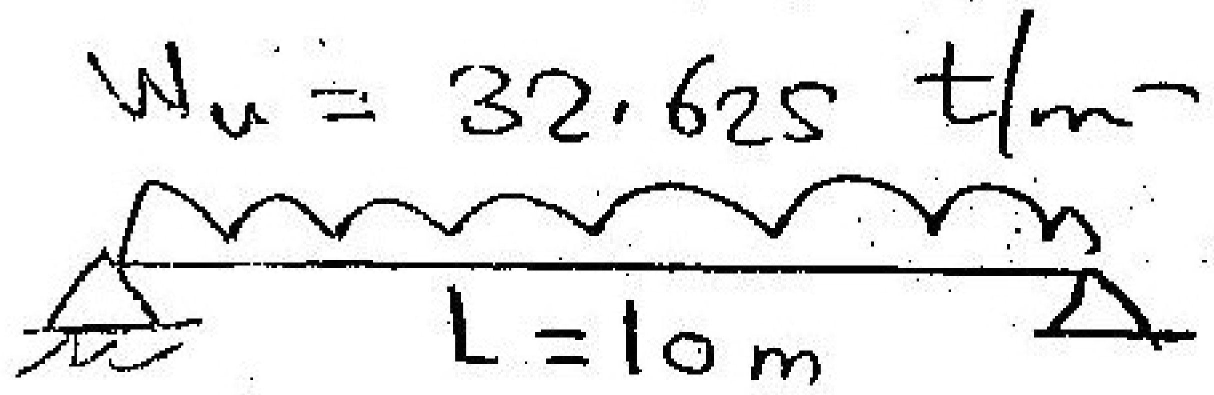


(W_0) كمرتين ثانويتين كل كمرة تتحمل أحمالها و تريحها على (W_1)

أي لا الكمرات (W_0) تعتبر Panelled beams

⇒ Simple

(W_0) ⇒ الكمرات الداخلية

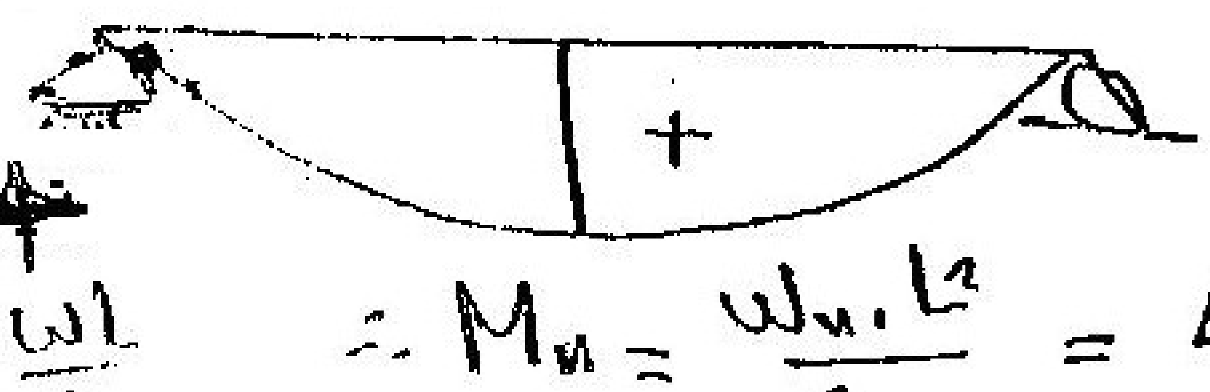


$\Rightarrow W = \text{own wt.} + R_{slab}$

$= (t_{wall} \cdot H \cdot \gamma_{R.C}) + 18$

$= (0.25 * 6 * 2.5) + 18 = 21.75 \text{ t/m}$

$\Rightarrow W_u = 1.5\,W = 1.5 * 21.75 = 32.625 \text{ t/m}$

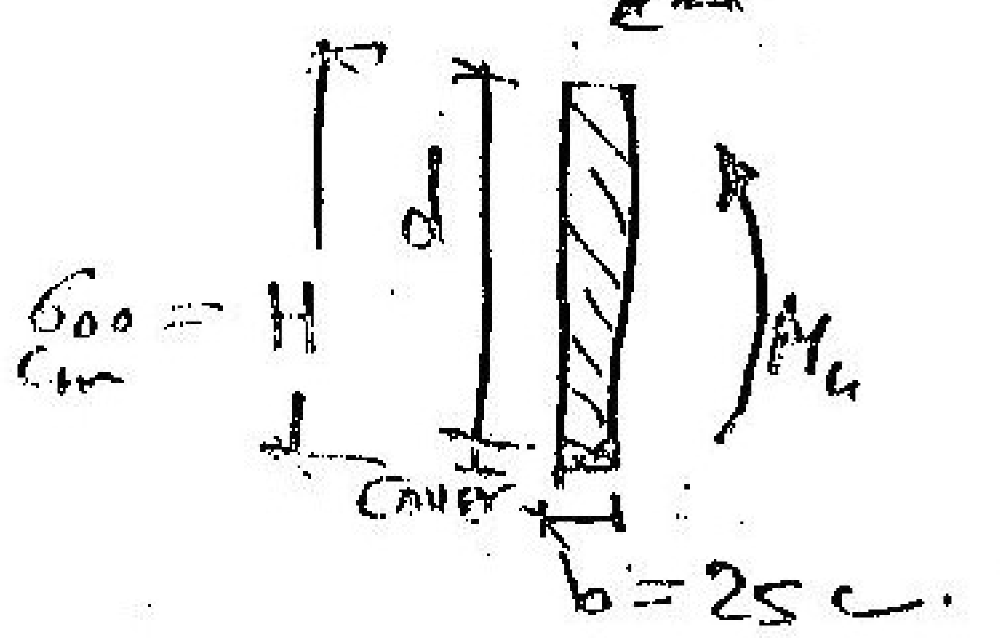


$R_o = \frac{WL}{2} = 163 \text{ ton}$

$\therefore M_u = \frac{W_u \cdot L^2}{8} = 408 \text{ t.m}$

$\therefore \frac{H}{L} = \frac{6}{10} = 0.6 < 0.8 \Rightarrow$ (Slender beam)

$\therefore R_1 = \frac{M_u * 10^5}{f_{cu} \cdot b \cdot d^2} = \frac{408 * 10^5}{250 * 25 * (595)^2} = 0.018$



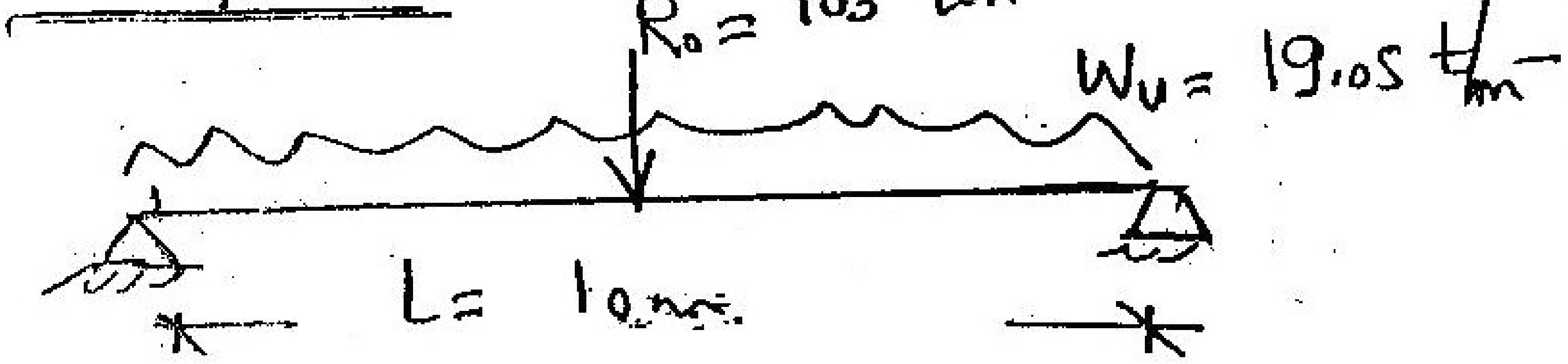
$\therefore \omega = 0.023$

$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} b \cdot d = 0.023 * \frac{250}{3600} * 25 * 595$

$= 23.75 \ cm^2$

$= (5 \ \Phi 25)$

(W₁) الحائط الأرضى



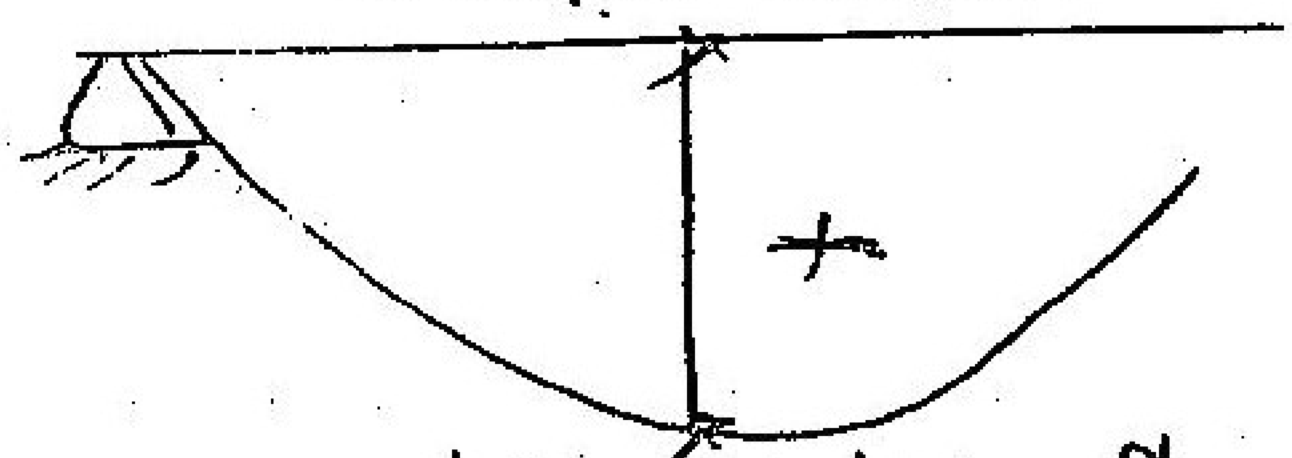
$W_u = 1.5 \, (\text{own wt} + \text{top beam} + R_{slab})$

$\qquad\qquad (t \cdot H \cdot \gamma_{R.c} \qquad b \cdot t \cdot \gamma_{R.c})$

$= 1.5 \, (0.25 * 6 * 2.5 + 0.3 * 0.6 * 2.5 + 8.5)$

$= 19.05 \ t/m$

simple beam



$$M_u = \frac{W_u L^2}{8} + \frac{PL}{4} = 645.6 \ t.m$$

$\therefore \frac{H}{L} = \frac{6}{10} = 0.6 < 0.8 \Rightarrow$ slender

$$\therefore R_1 = \frac{M_u * 10^5}{f_{cu} \cdot b \cdot d^2} = \frac{645.6 * 10^5}{250 * 25 * (595)^2} = 0.029$$

$\therefore \omega = 0.037$

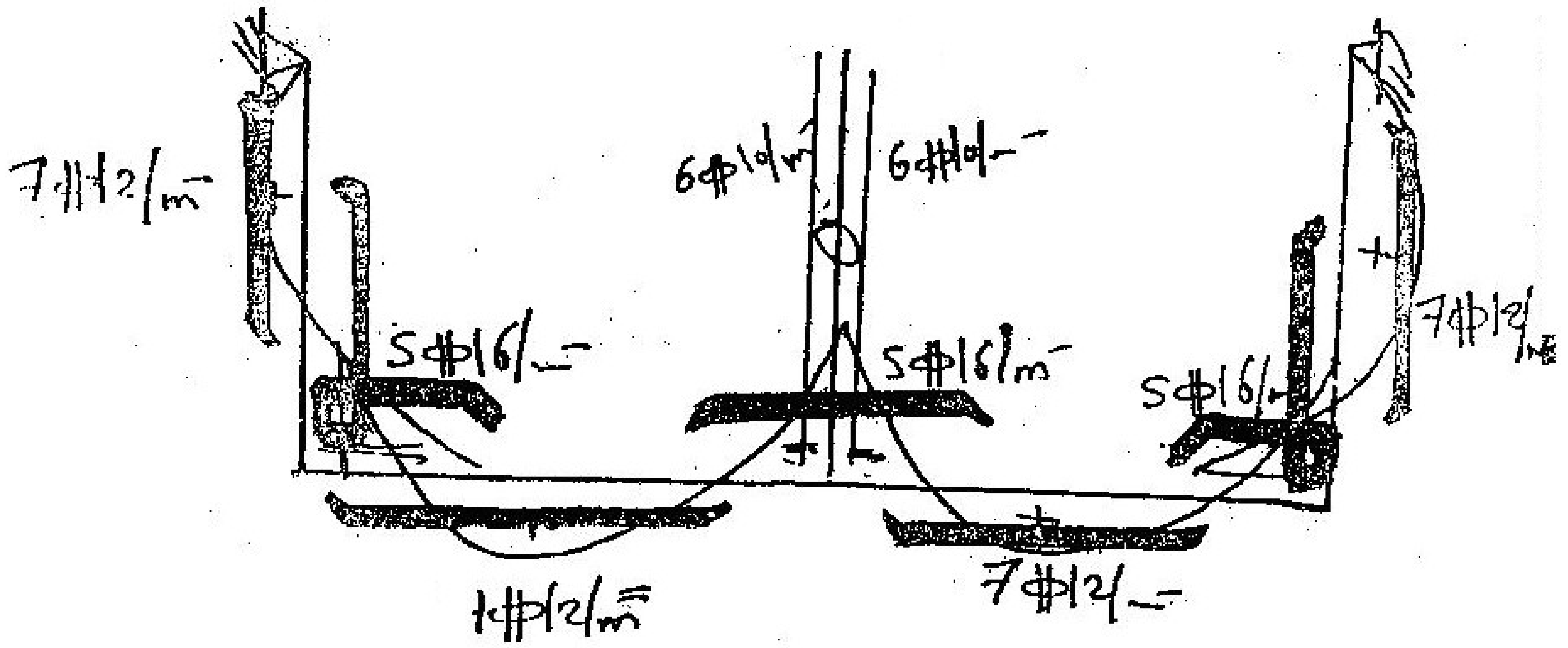
$$\therefore A_s = \omega \frac{f_{cu}}{f_y} b.d = 0.029 * \frac{250}{3600} * 25 * 595$$

$$= 39.18 \ cm^2$$

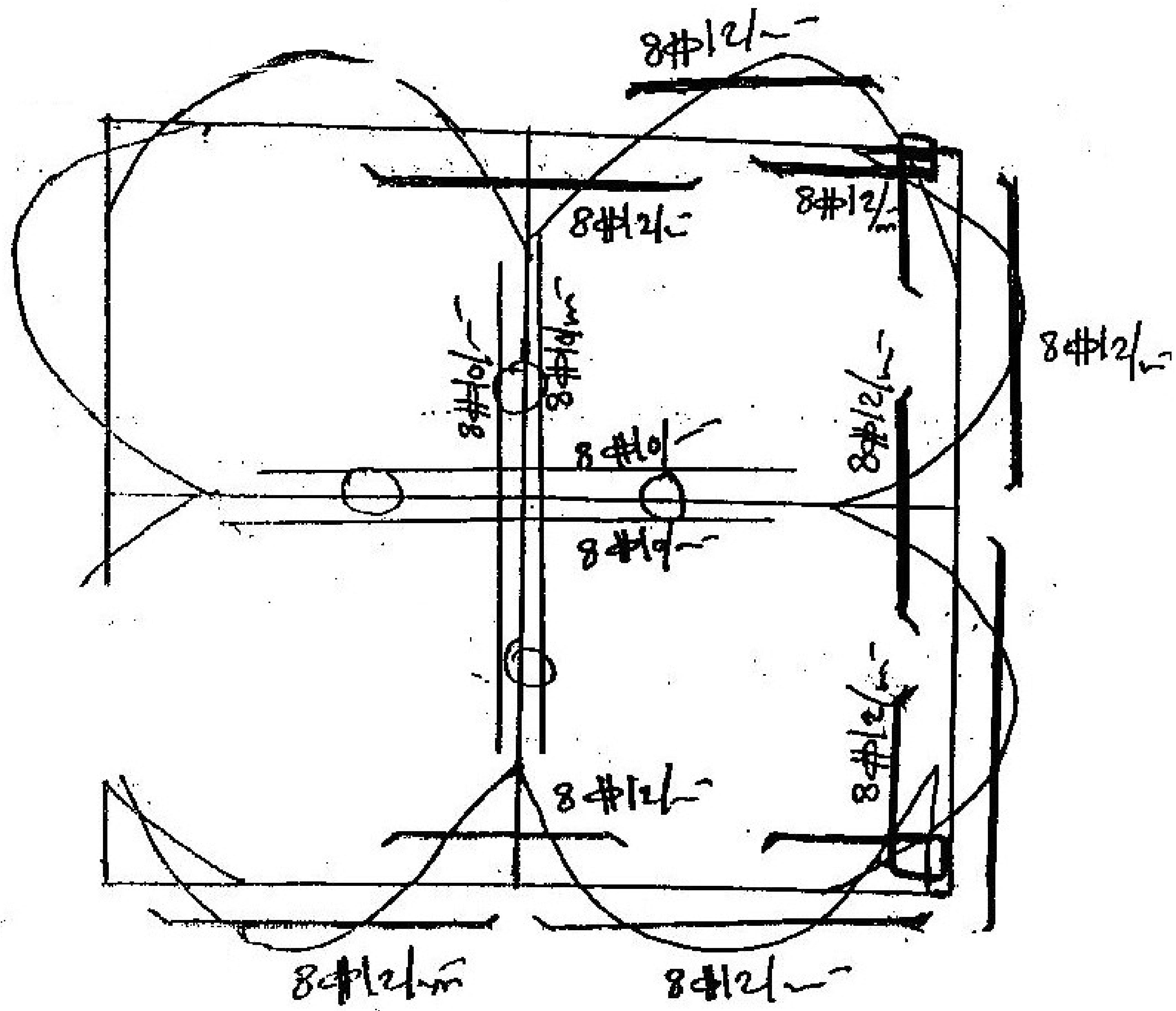
$\therefore$ use 8 Φ25

* Reinforcement details :

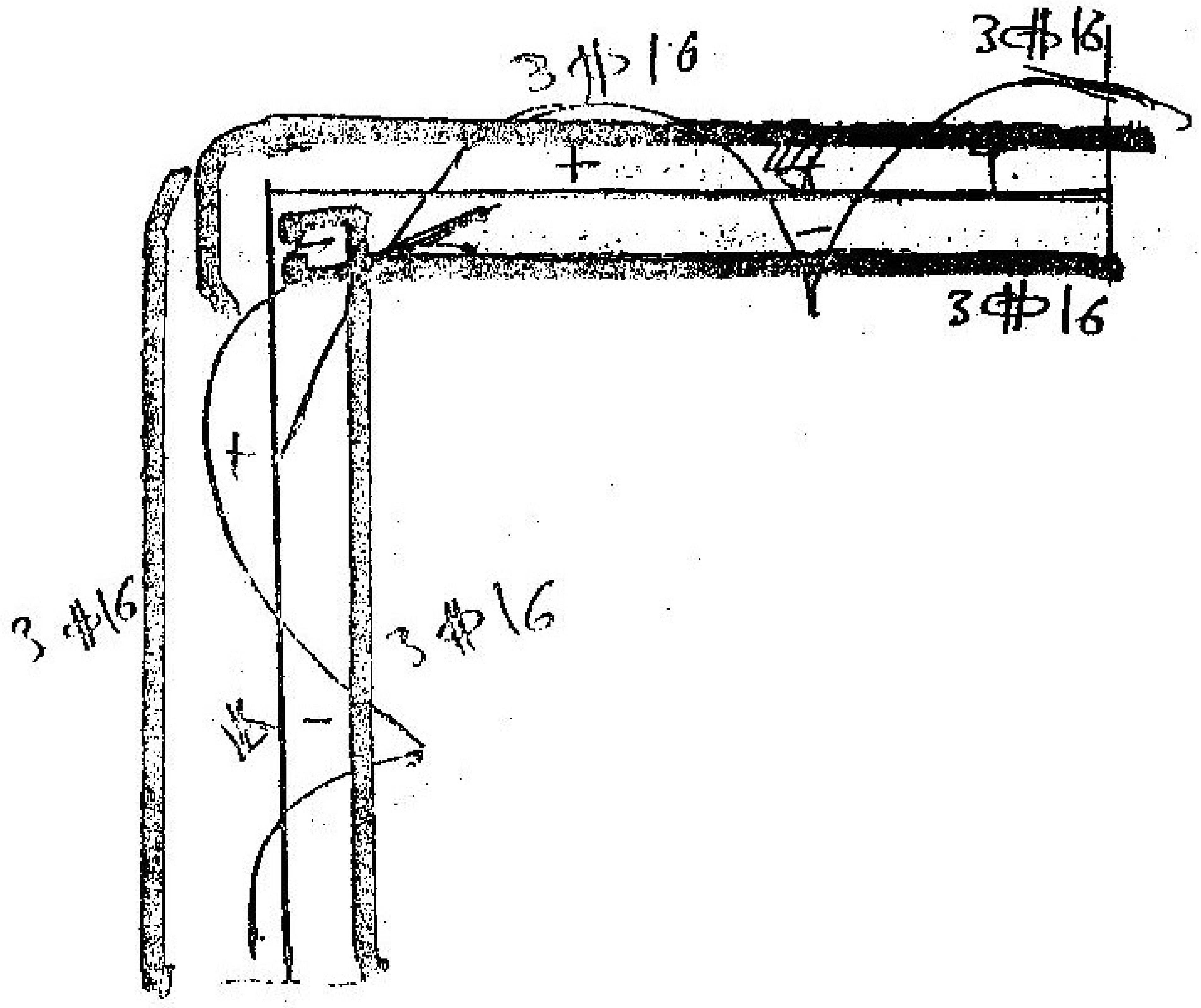
VL. strip :



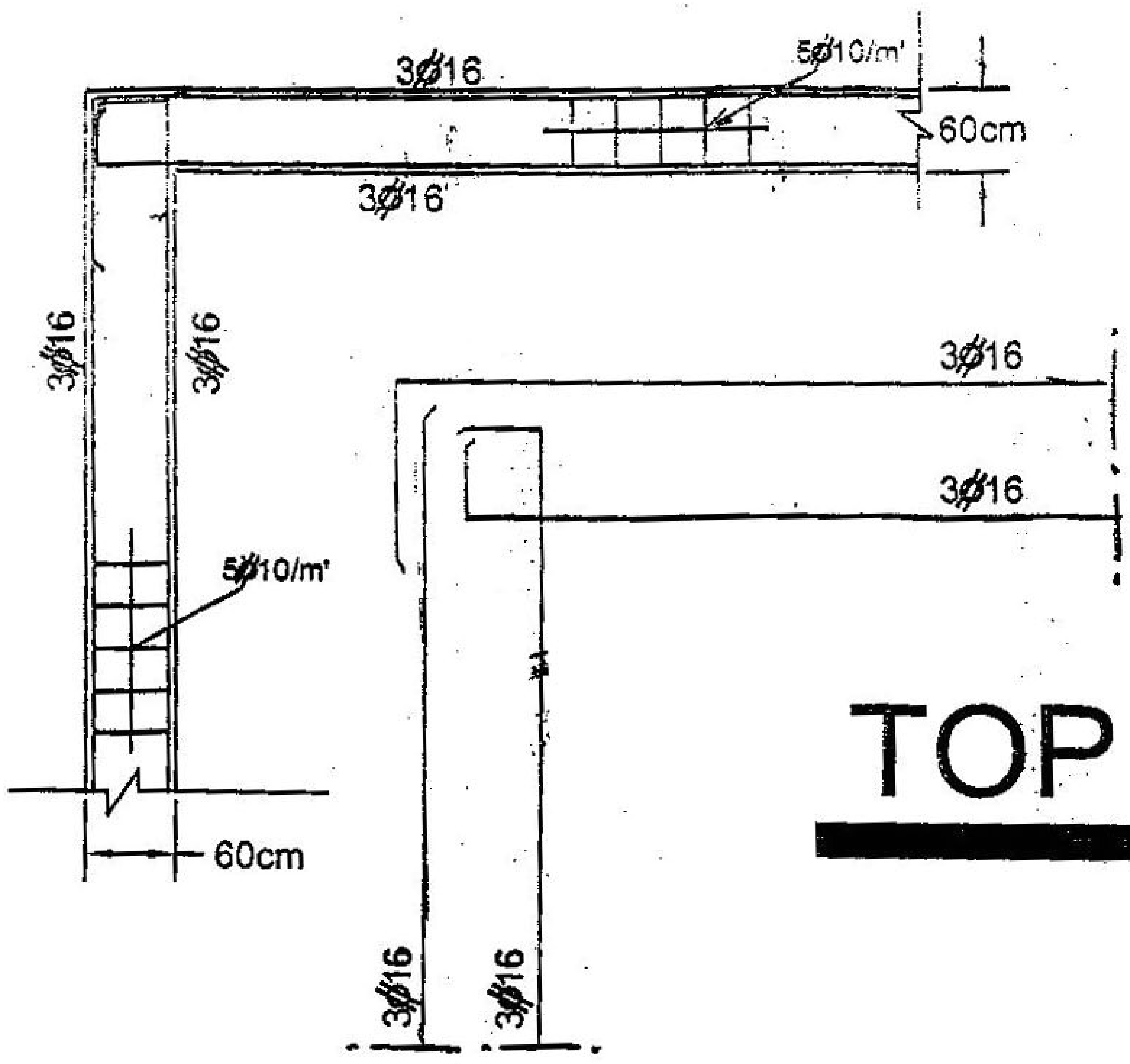
HL. Strip :

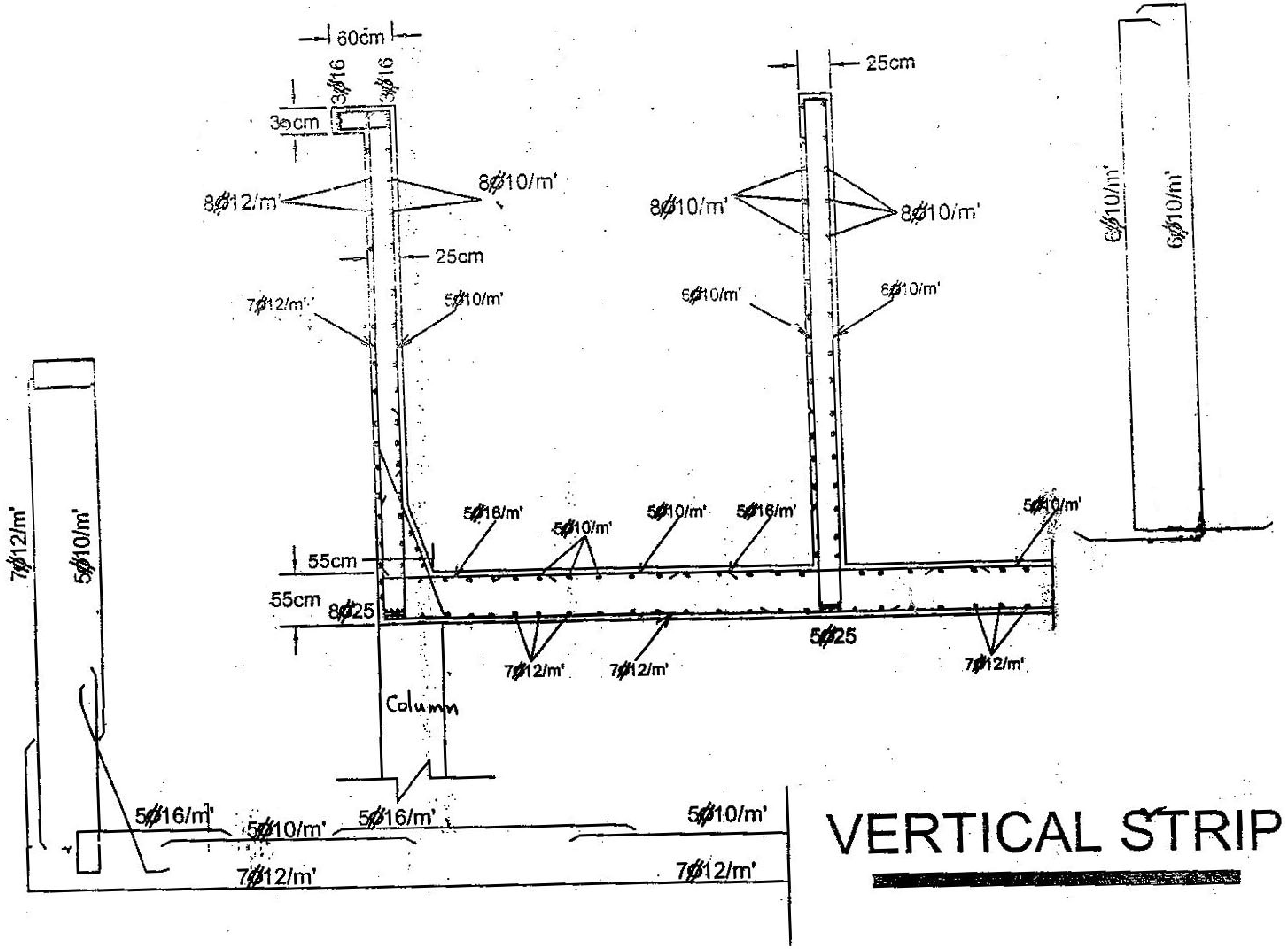


Top beam :

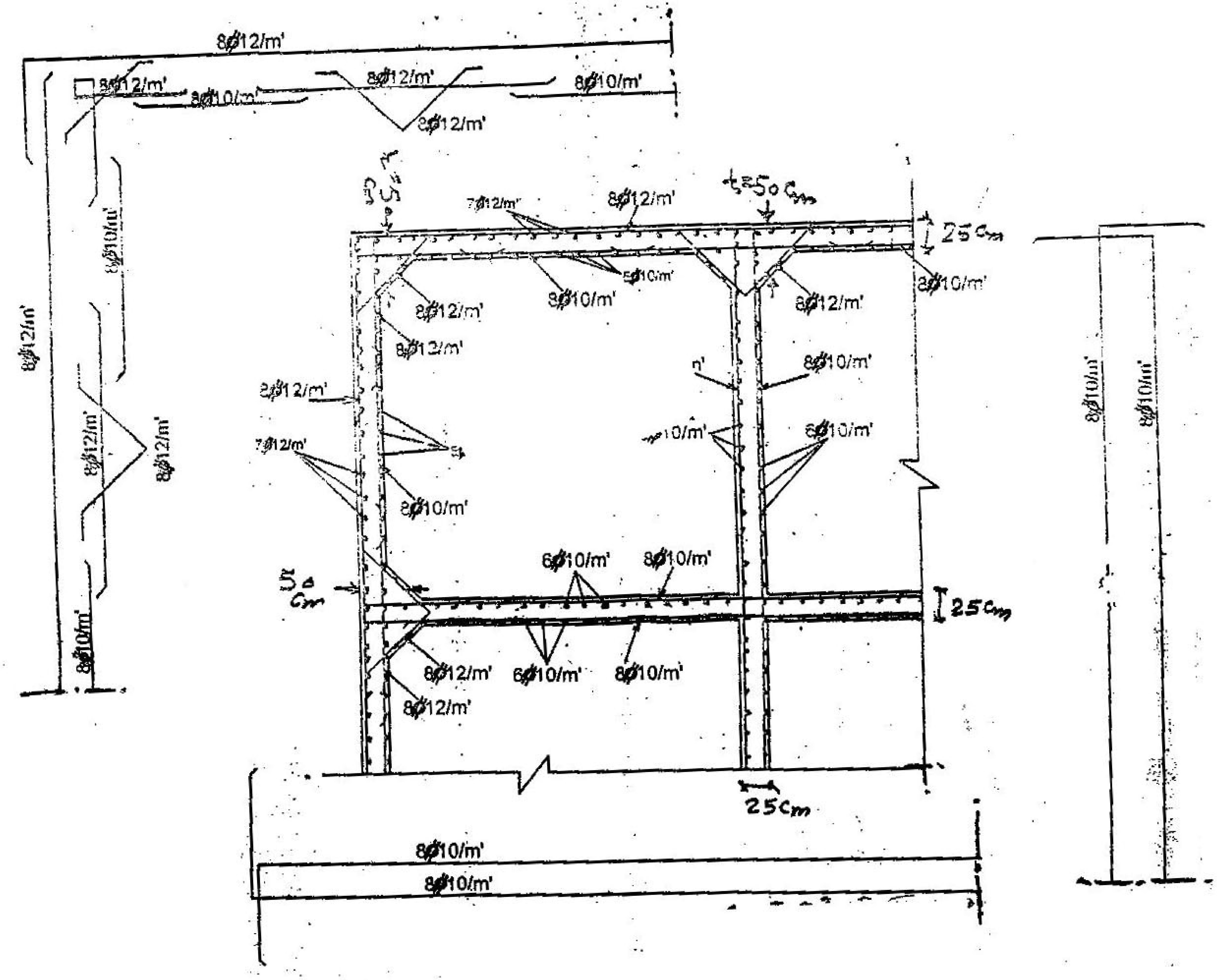


TOP BEAM


3Ø16
5Ø10/m'
60cm
3Ø16'
3Ø16
3Ø16
5Ø10/m'
60cm
3Ø16
3Ø16
3Ø16
3Ø16



VERTICAL STRIP



HORIZONTAL STRIP at 3/4 H

سنتر و مركز

الفارس

١٥ عاماً

الفرقة الرابعة مدنى

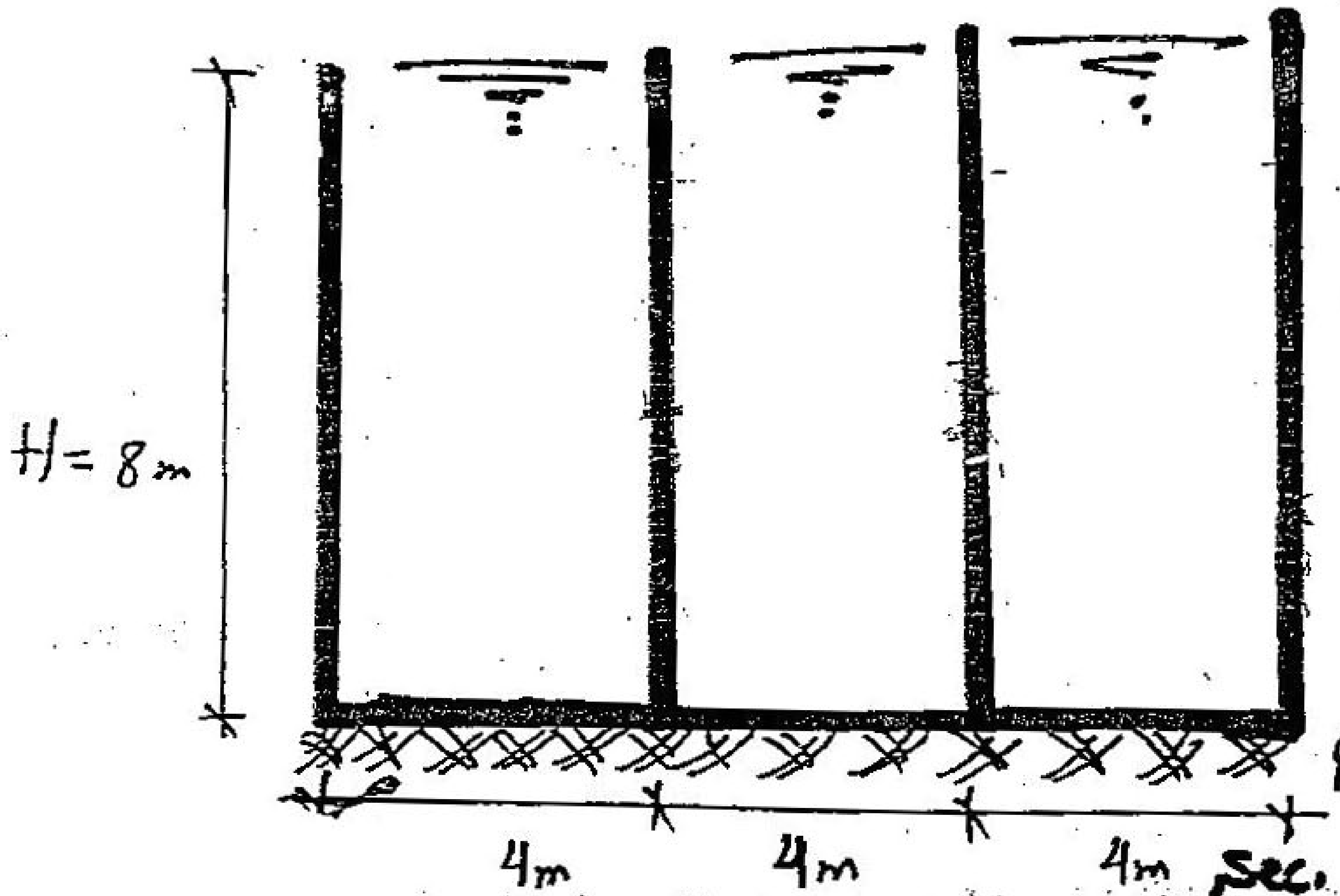
Reinforced Concrete Water Tanks

Rocky

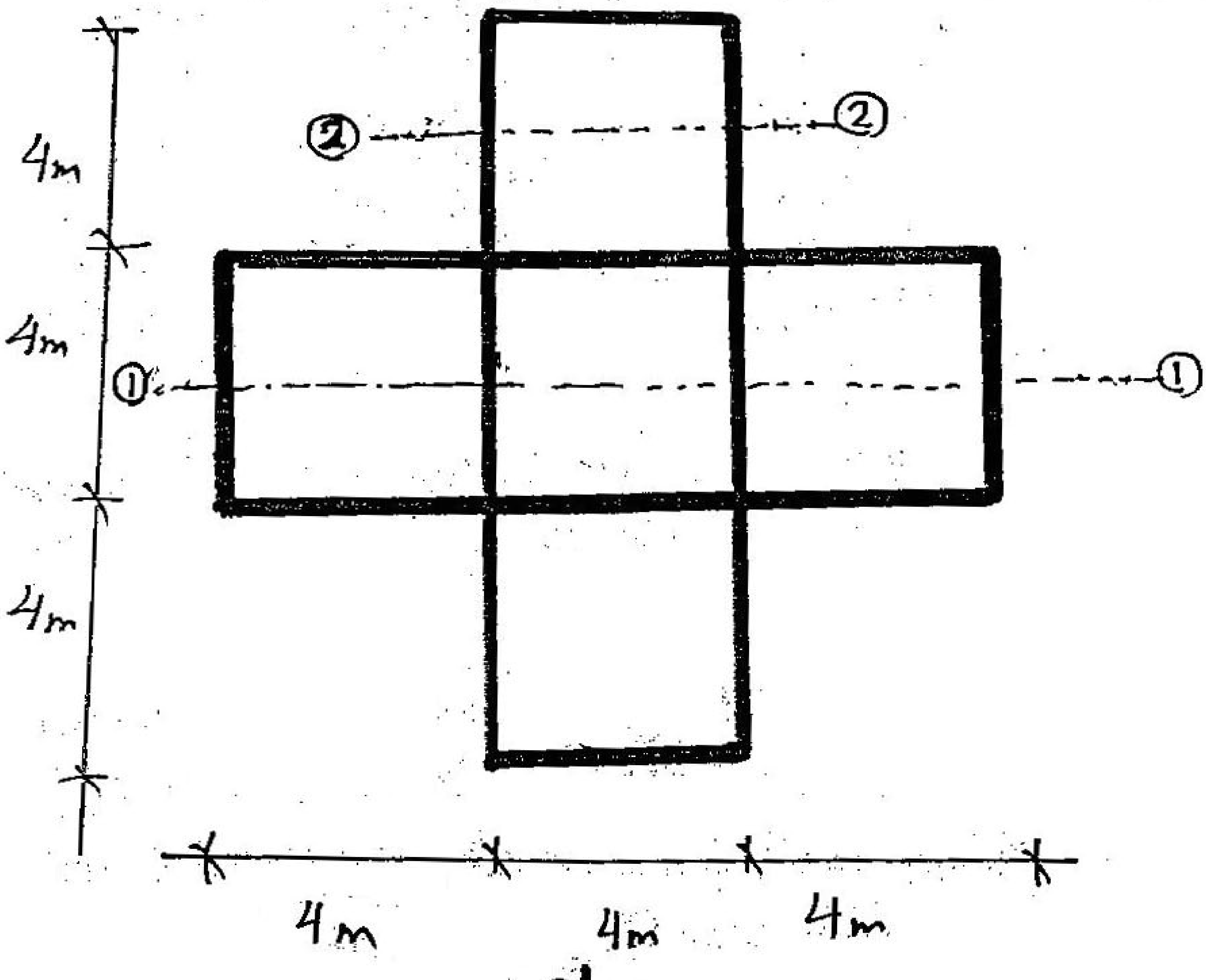
Example

R.C. Tanks

steel 36/52 *
$f_{cu} = 250 \, kg/cm^2$



Sec. elevation (1-1)

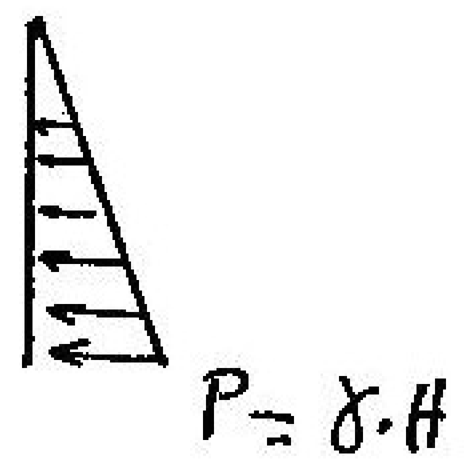


Plan

Solution:

① Loads:

Walls: $P_{total} = \gamma . H = 1 * 8 = \quad t/m^2$



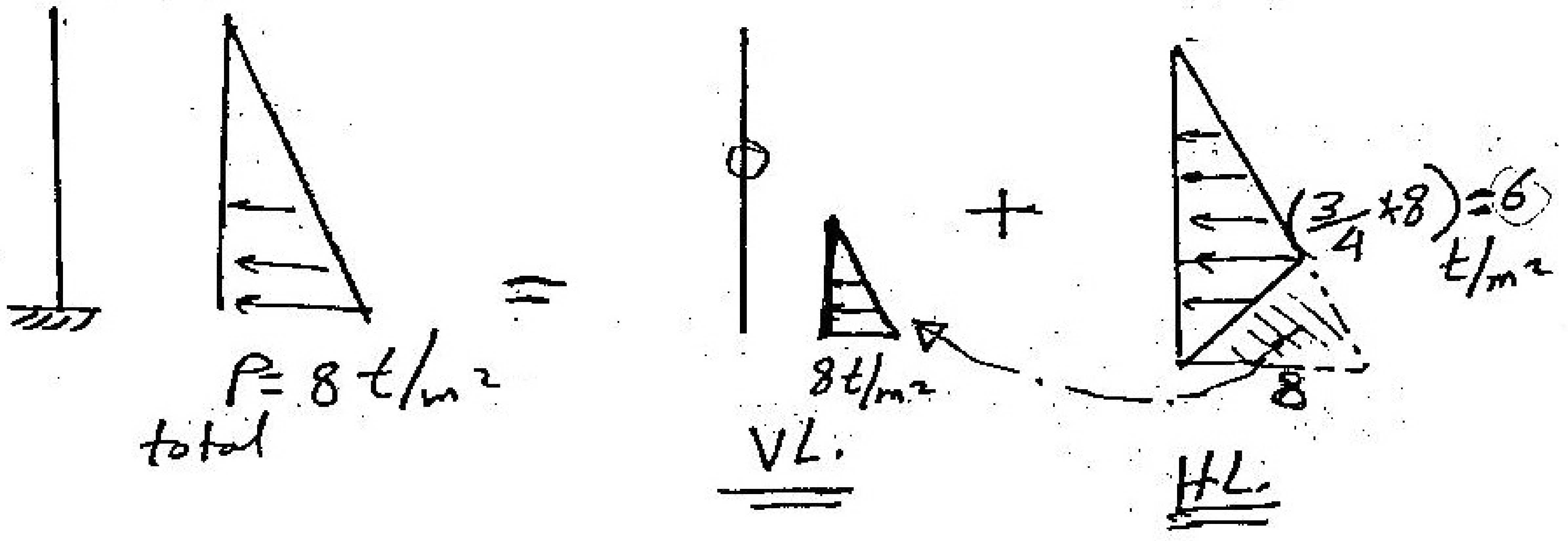
base: $W = t_b . \gamma_{R.c} + \gamma_w . H_w = .4(2.5) + (1*8) = 9 \; t/m^2$

② Load distribution:

Walls: $H = 8m$, $L = 4m$

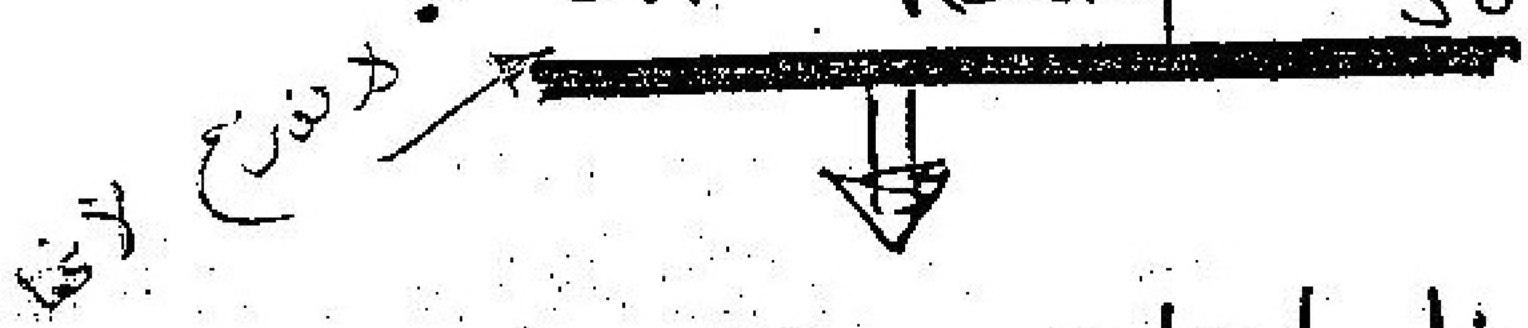
$\frac{H}{L} = \frac{8}{4} = 2 \Rightarrow$ one way (deep tank)
بالاتجاه الأفقي

∴ الحمل يسير في الاتجاه الأفقي



base

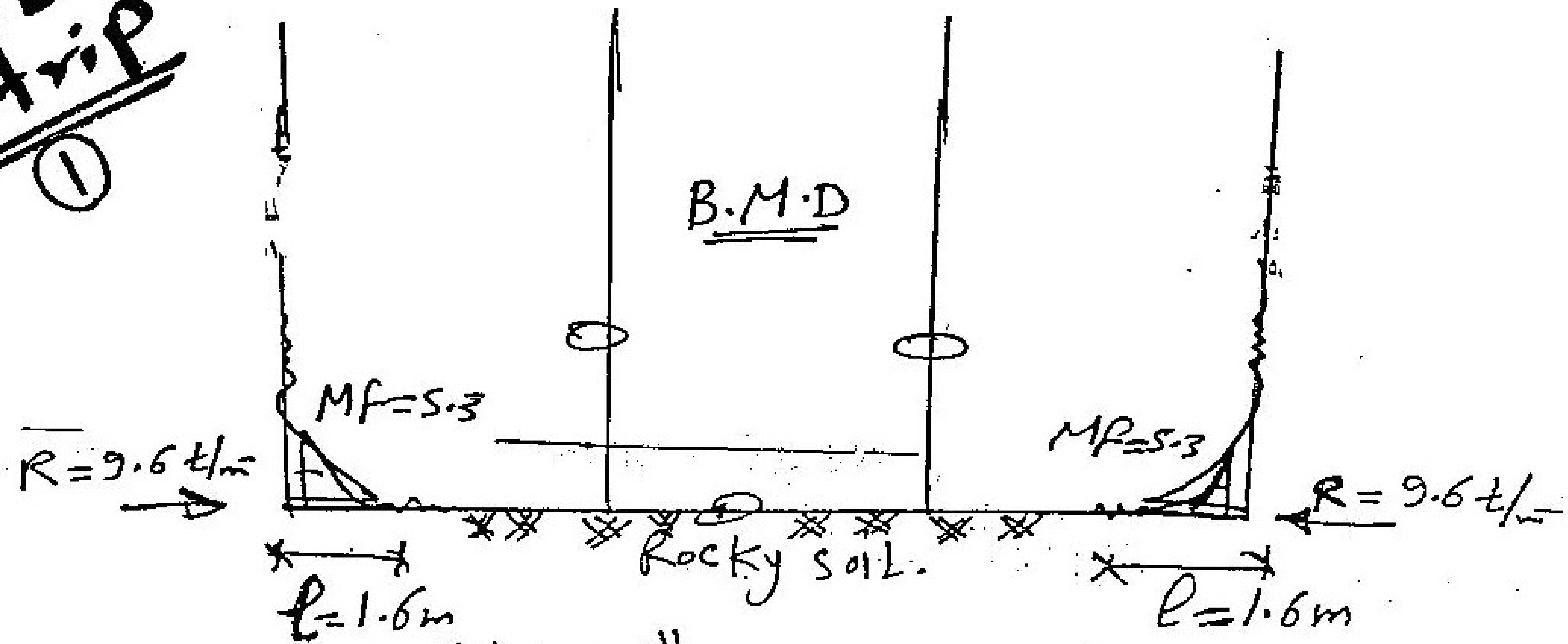
∴ on Rocky soil.



No calculation.

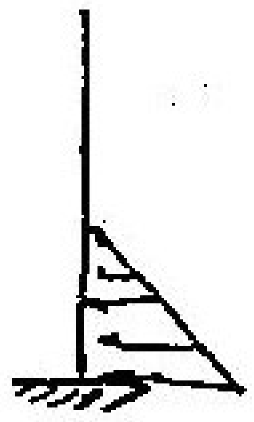
$l = 2\sqrt{\frac{M_f}{W_{base}}}$ ← العزم من الحائط

VL. Strip ①



العزوم على الحائط

$$\because M_f = \frac{WL^2}{24} = \frac{8 * 4^2}{24} = 5.3 \ t.m/m$$



$$R = 0.3\,WL = 0.3 * 8 * 4 = 9.6 \ t/m$$

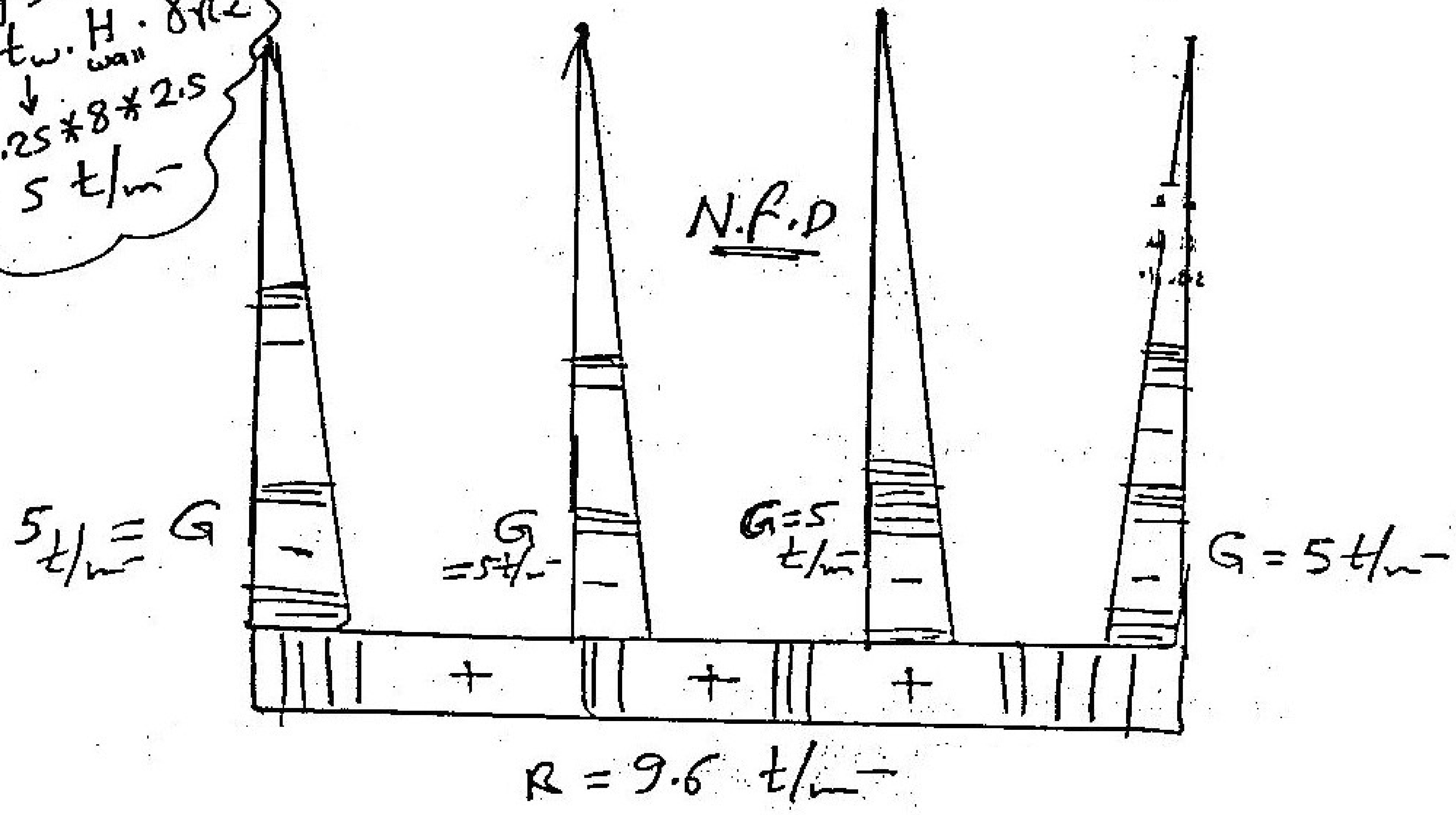
المسافة التي يموت عندها العزم

$$\therefore l = 2\sqrt{\frac{M_f}{W_{base}}} = 2\sqrt{\frac{5.3}{9}} = 1.53 \ m$$

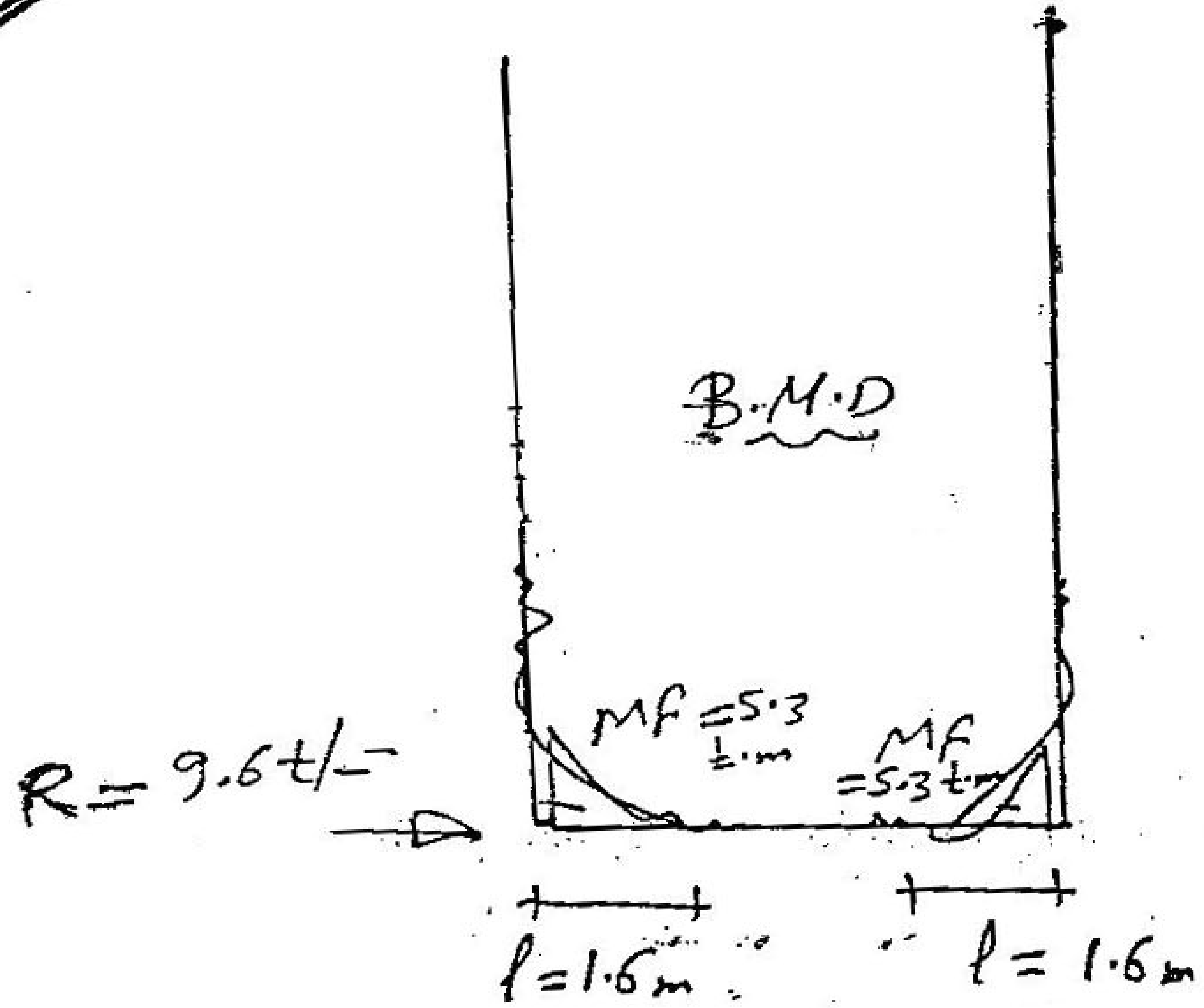
$$\simeq 1.6 \ m$$

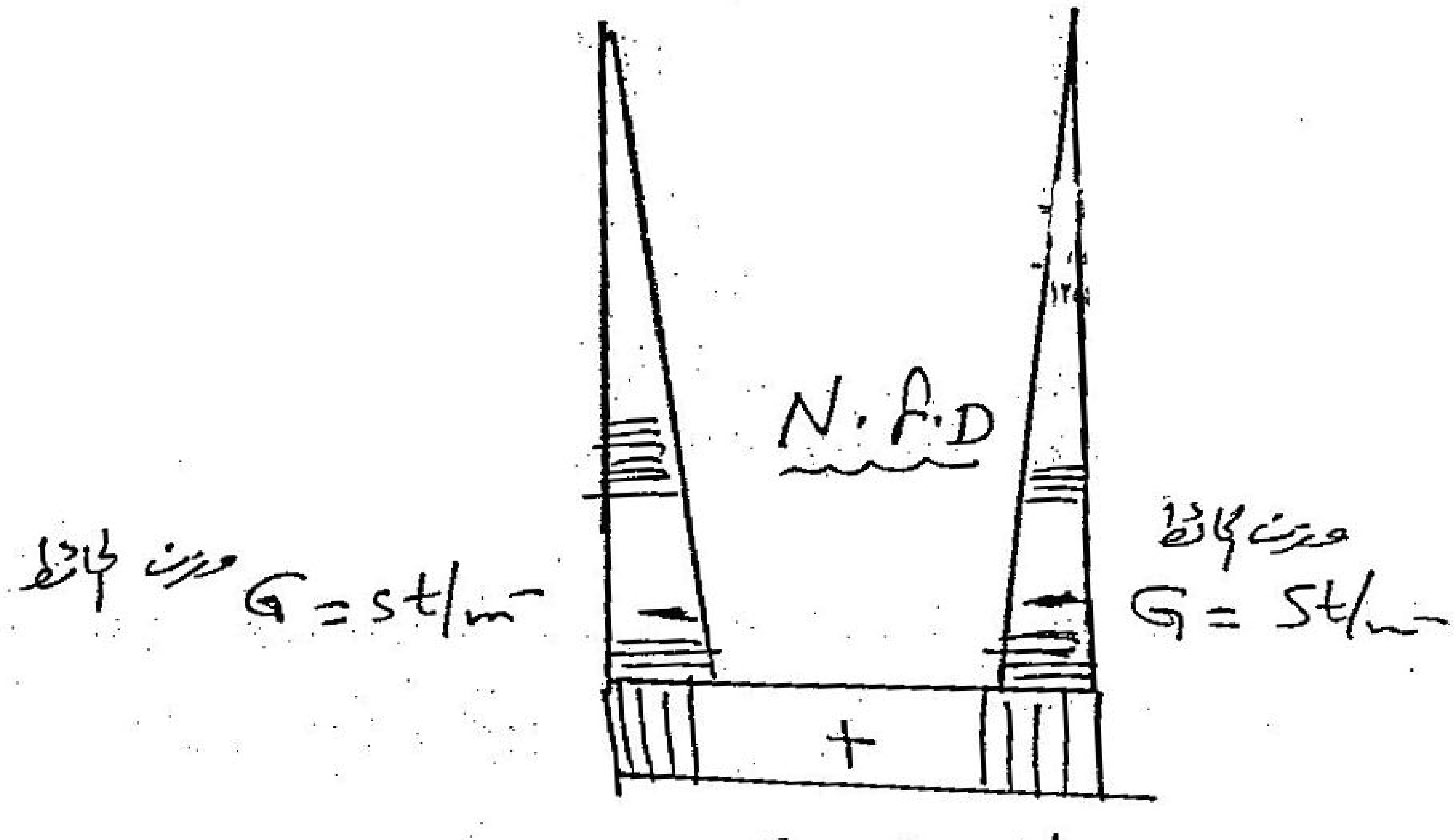
عرض الحائط

$$G = t_w \cdot H_{wall} \cdot \gamma_{RC} = 0.25 * 8 * 2.5 = 5 \ t/m$$



V.L. Strip ②

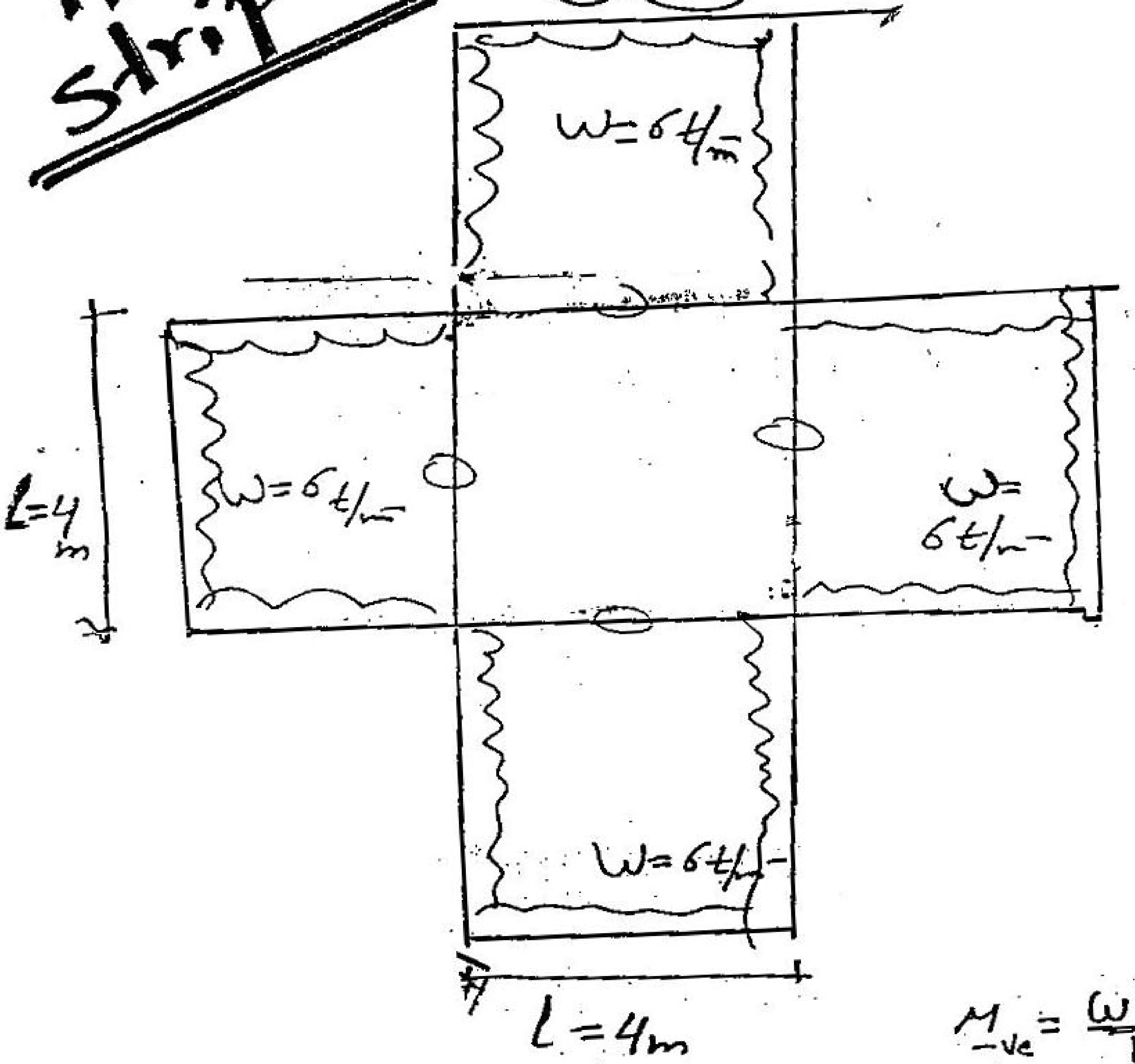


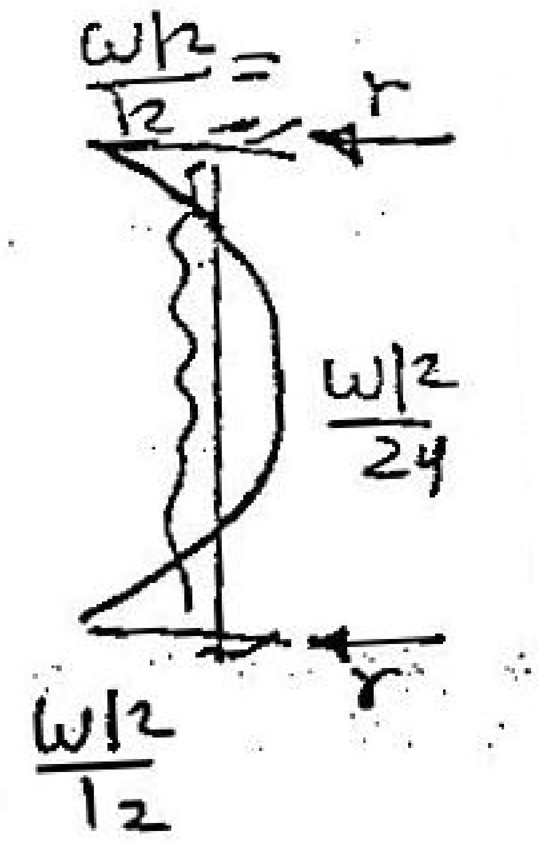


H.L. strip

At $\frac{3}{4}H$

$W = 6\ t/m$

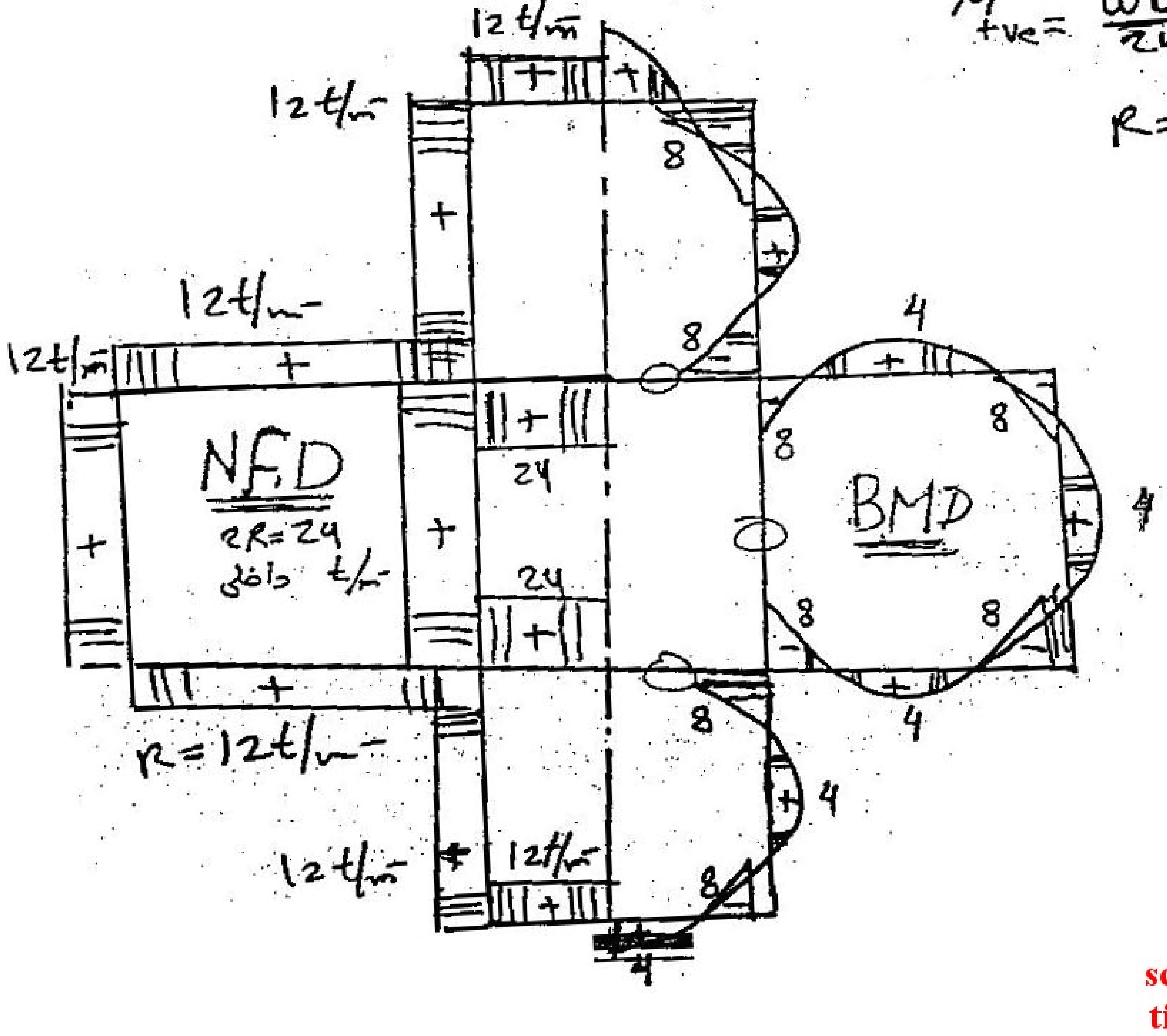




$M_{-ve} = \frac{WL^2}{12} = 8\ t.m/m$

$M_{+ve} = \frac{WL^2}{24} = 4\ t.m/m$

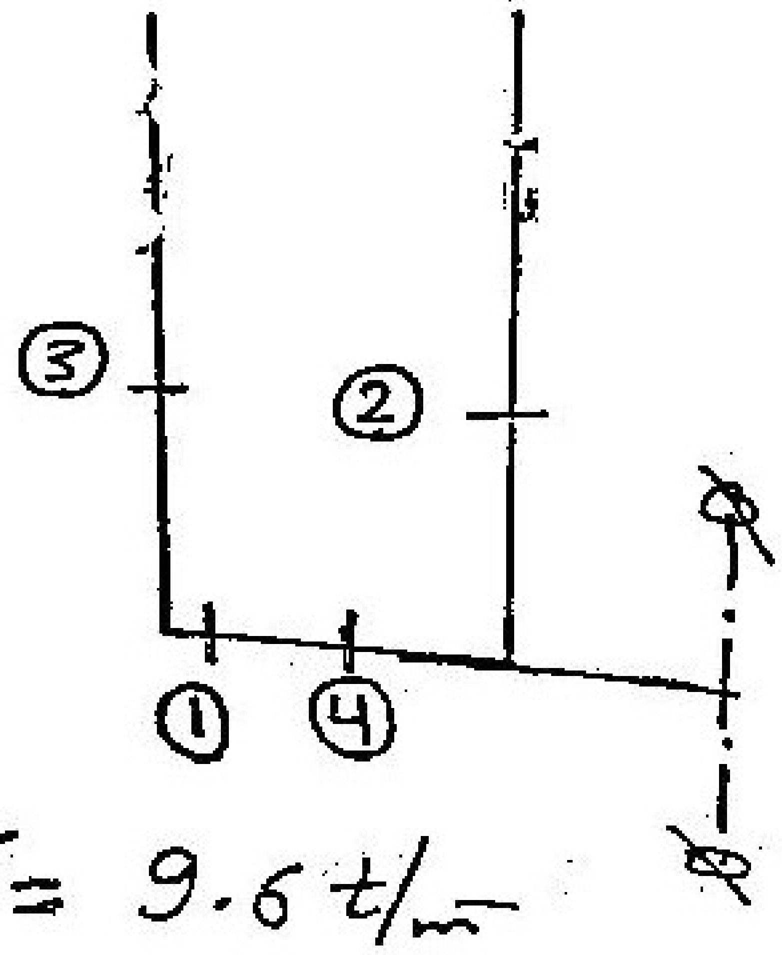
$R = \frac{WL}{2} = 12\ t/m$



Design of sections :

VL.

Sec ①



sec (1) $M = 5.3\ t.m/m'$, $T = 9.6\ t/m'$

stage (I) : $t = \sqrt{\frac{5.3*10^5}{3.2*100}} + 5 = 50\ cm$

stage (II) : $M_u = 1.5*5.3 = 8\ t.m/m'$

$T_u = 1.5*9.6 = 14.4\ t/m'$

$e = \frac{M_u}{T_u} = 0.55m$

$e/t >> 0.5 \Rightarrow$ big eccentric

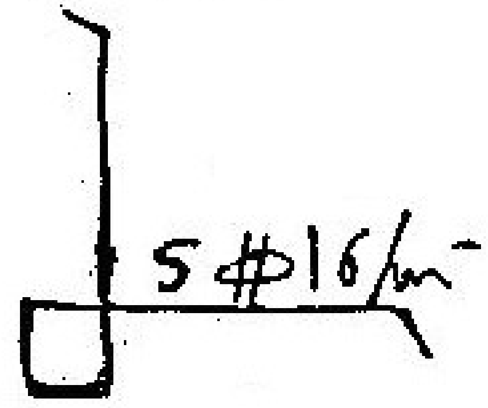
$e_s = (0.55 - \frac{0.5}{2} + 0.05) = 0.35\ m$

$M_{us} = 14.4 * 0.35 = 4.33\ t.m/m'$

$R_1 = \frac{4.33*10^5}{250*100*45^2} = 0.009$

$\omega = 0.017$

$\therefore A_s = \frac{\omega . f_{cu}}{f_y} B d + \left(\frac{T_u*10^3}{f_y/\gamma_s}\right) = 5\#16/m'$



Sec (2) , **Sec (3)** $\Rightarrow$ Compression

use $t = 20\ cm$

use $5\#10/m'$

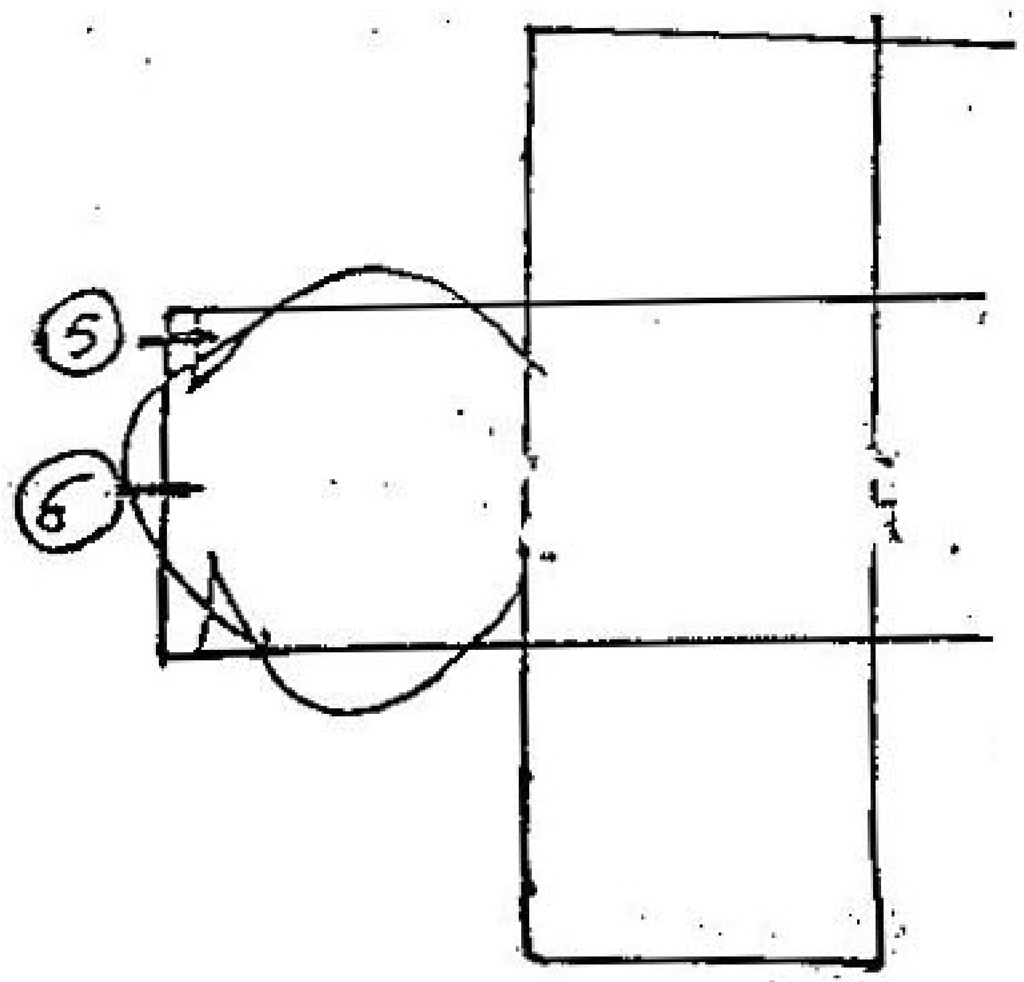
sec (4) : T = 9.6 t/m' only

∴ use t = 20 cm

As = 5 Φ 10/m'

(Top , bottom)

HL.



sec (5) $M_{\text{water side}}$ = 8 t.m , T = 12 t/m'

stage (I) : working $t = \sqrt{\frac{8*10^5}{3.2*100}} + 5$

= 55 cm

stage (II)

H.W

use 6 Φ 16/m'

حاضر

6Φ16/m'

Sec. (6) :

(M air side) = 4 t.m/m' , T = 12 t/m'

stage (II) direct مباشرة

use t = 25 cm

$M_u = 6$ t.m/m' , $T_u = 18$ t/m'

$\therefore e = \frac{M_u}{T_u}$

$\therefore e_s = \longleftarrow$

$\therefore M_{us} = \longleftarrow$

$\therefore R_1 = \longleftarrow$

$\omega = \longleftarrow$

$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d + \frac{T_u \times 10^3}{f_y / \gamma_s}$

H.W

$\therefore$ use 7Φ16/m' خارجي

"Wall as beam"

طالما مفيش هناك (SOIL) بأي نوع

⇓

∴ لا نصمم الحائط على انه كمرة لانه مرتكز على التربة.

Ring Top beam

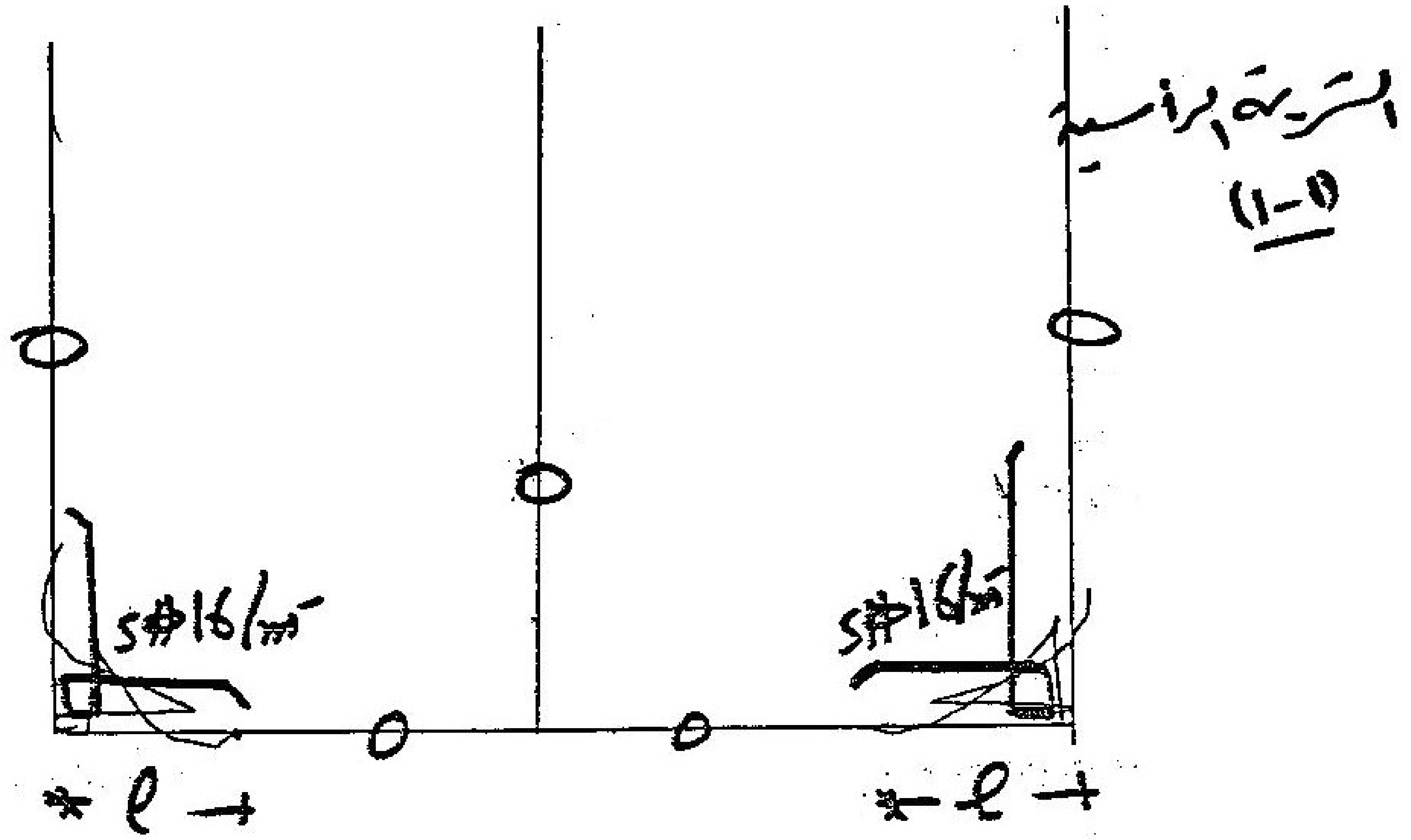
وطالما لم يعطى Top beam

∴ لا نضعها.

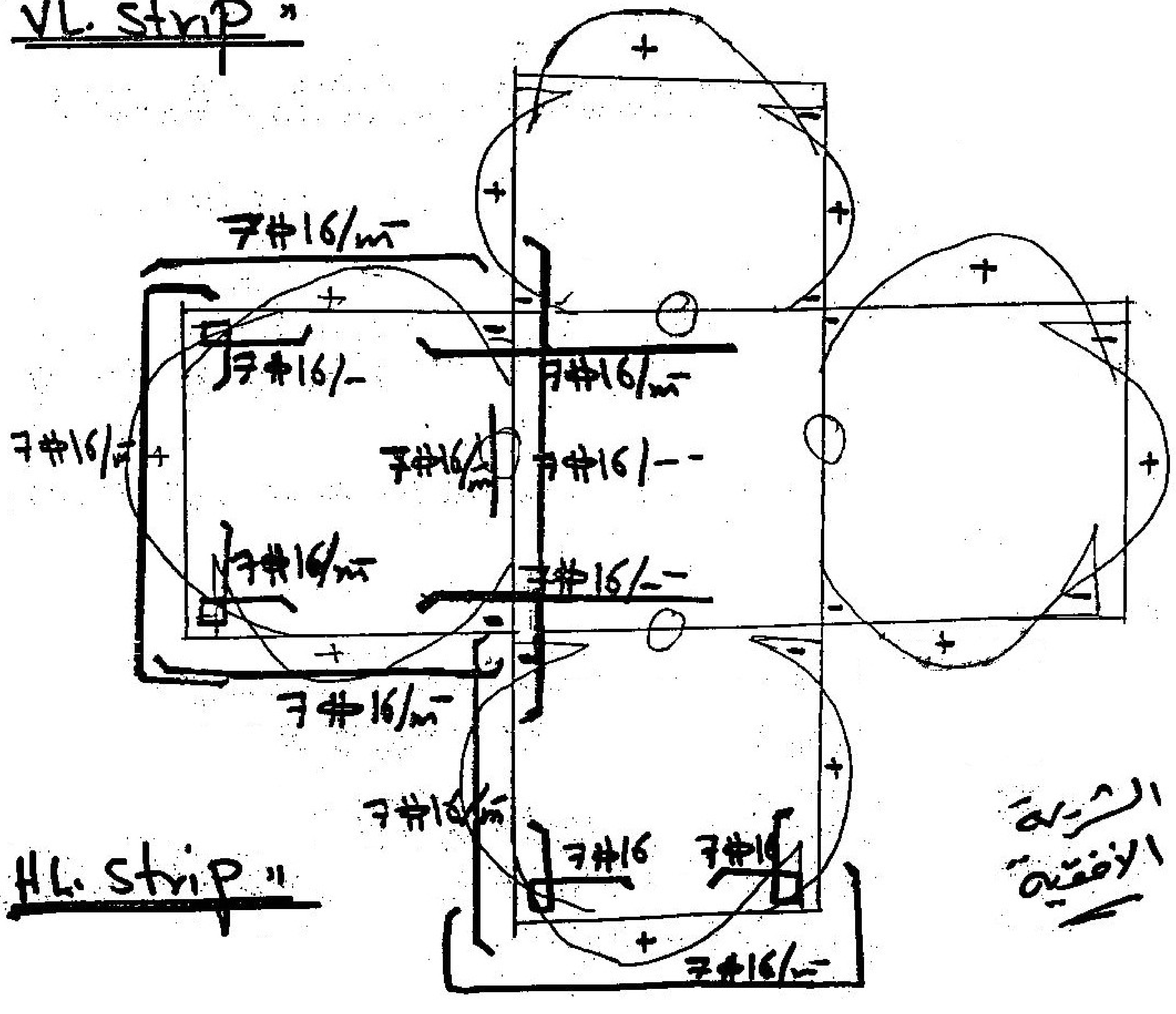
If Tank is deep وأحيانا

∴ No top beam

details of Reinforcement:



"VL. strip"

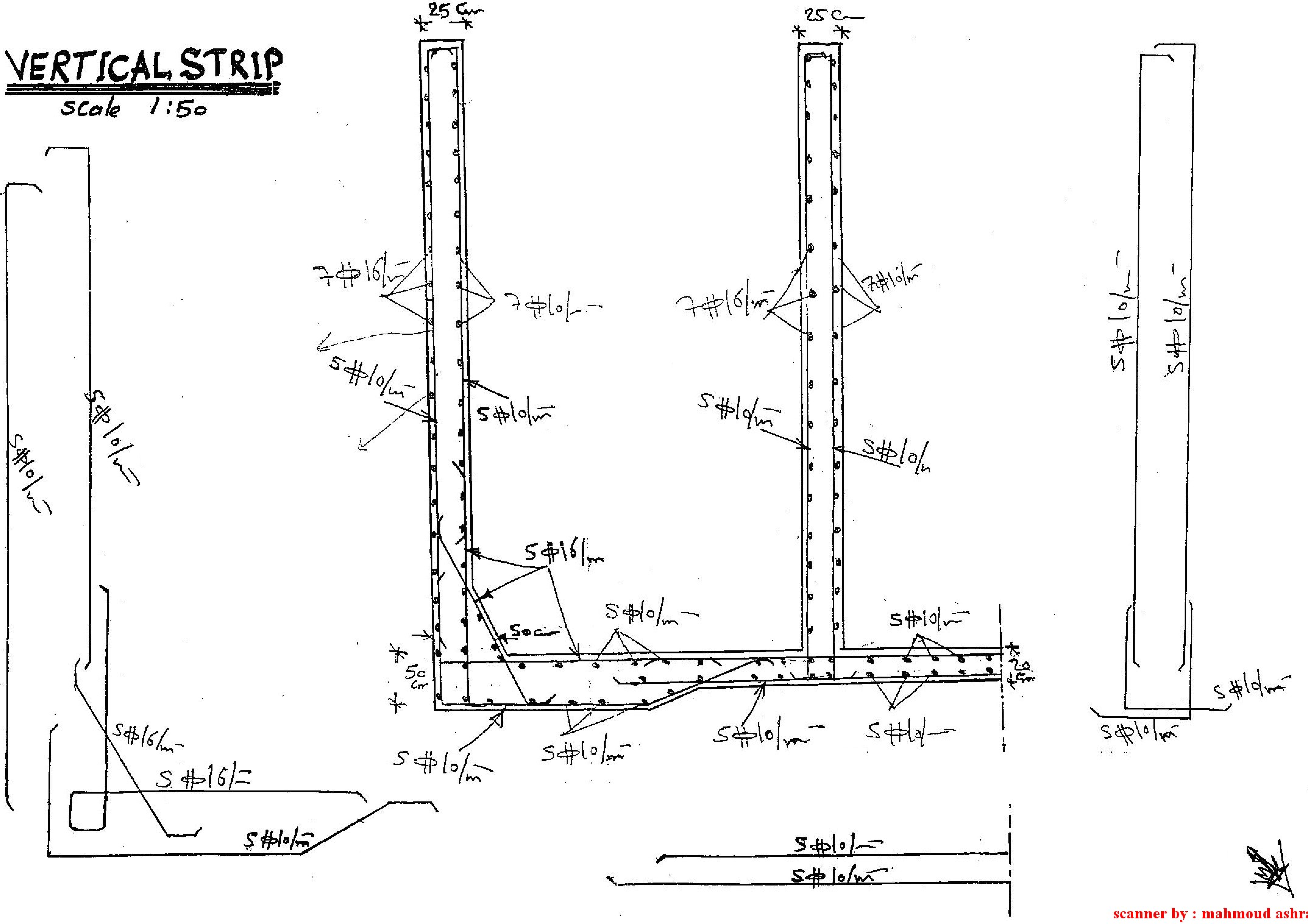


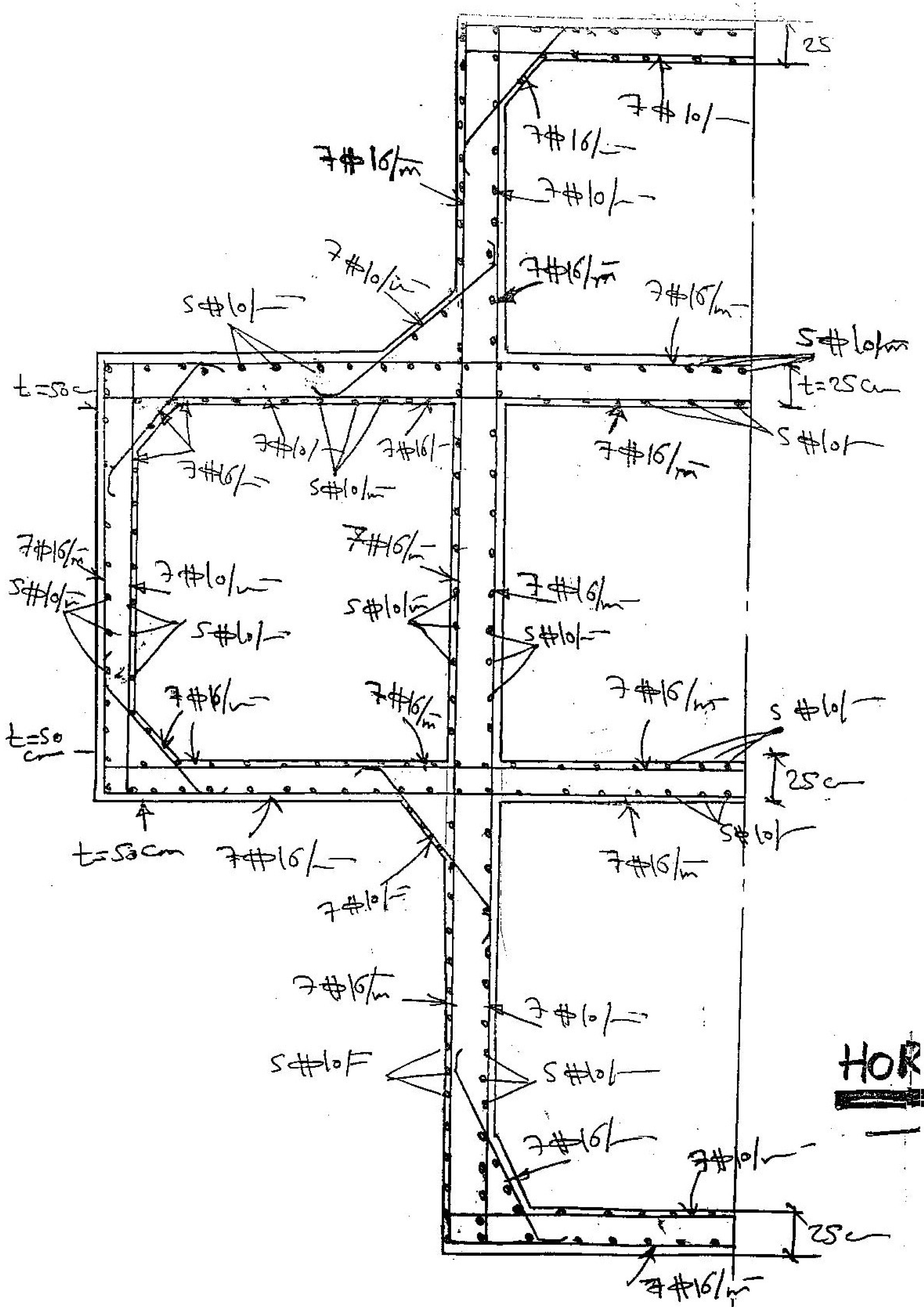
"HL. strip"

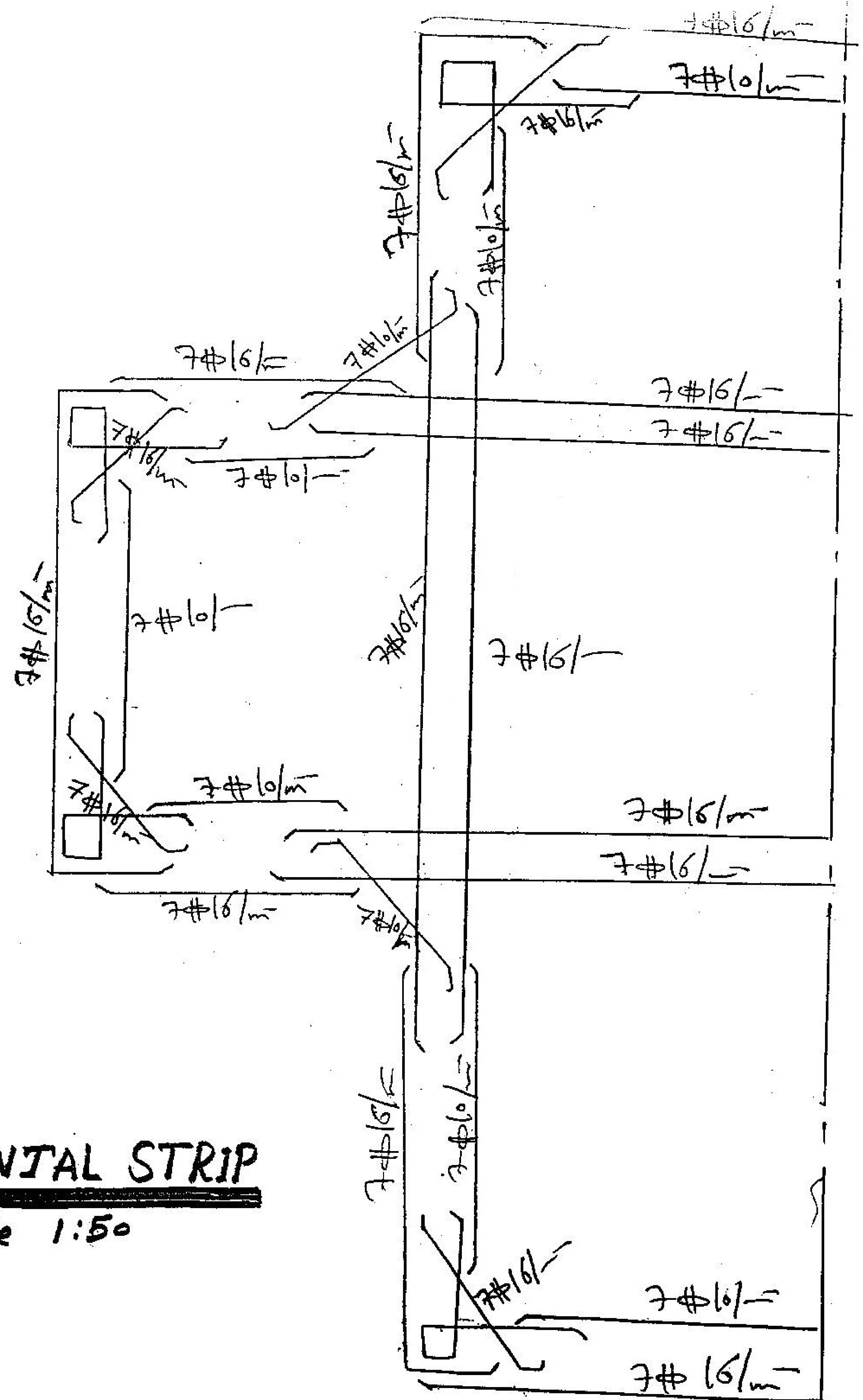
الشريحة الأفقية

VERTICAL STRIP

Scale 1:50







HORIZONTAL STRIP

Scale 1:50

١٥٠

سنتر و مركز

الفارس

الفرقة الرابعة مدني

Reinforced Concrete Water Tanks

medium

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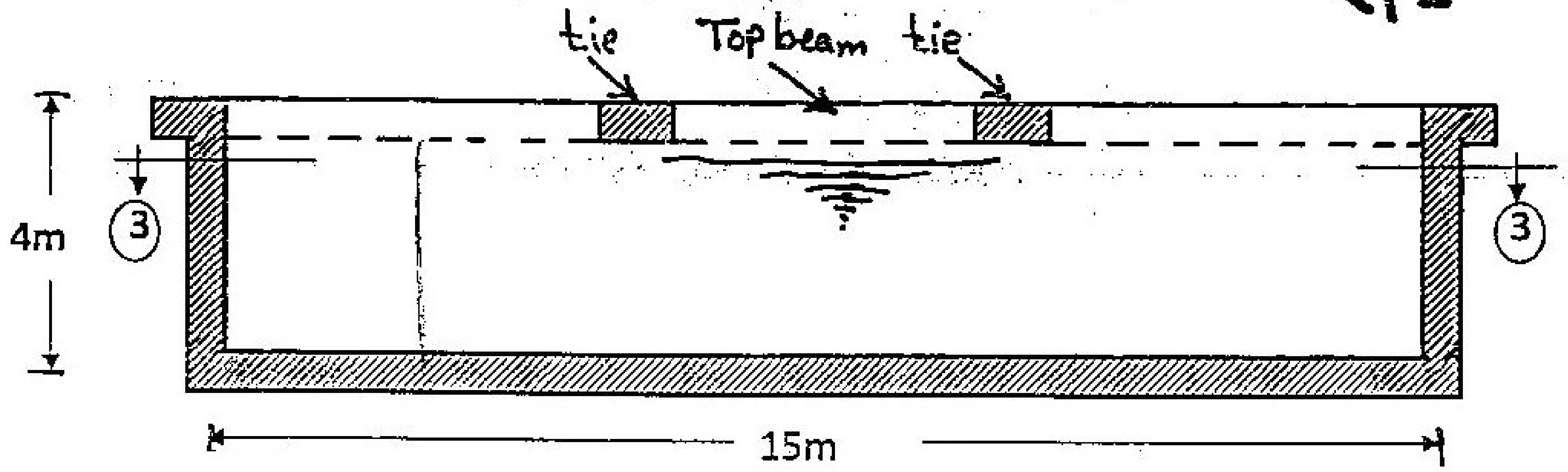
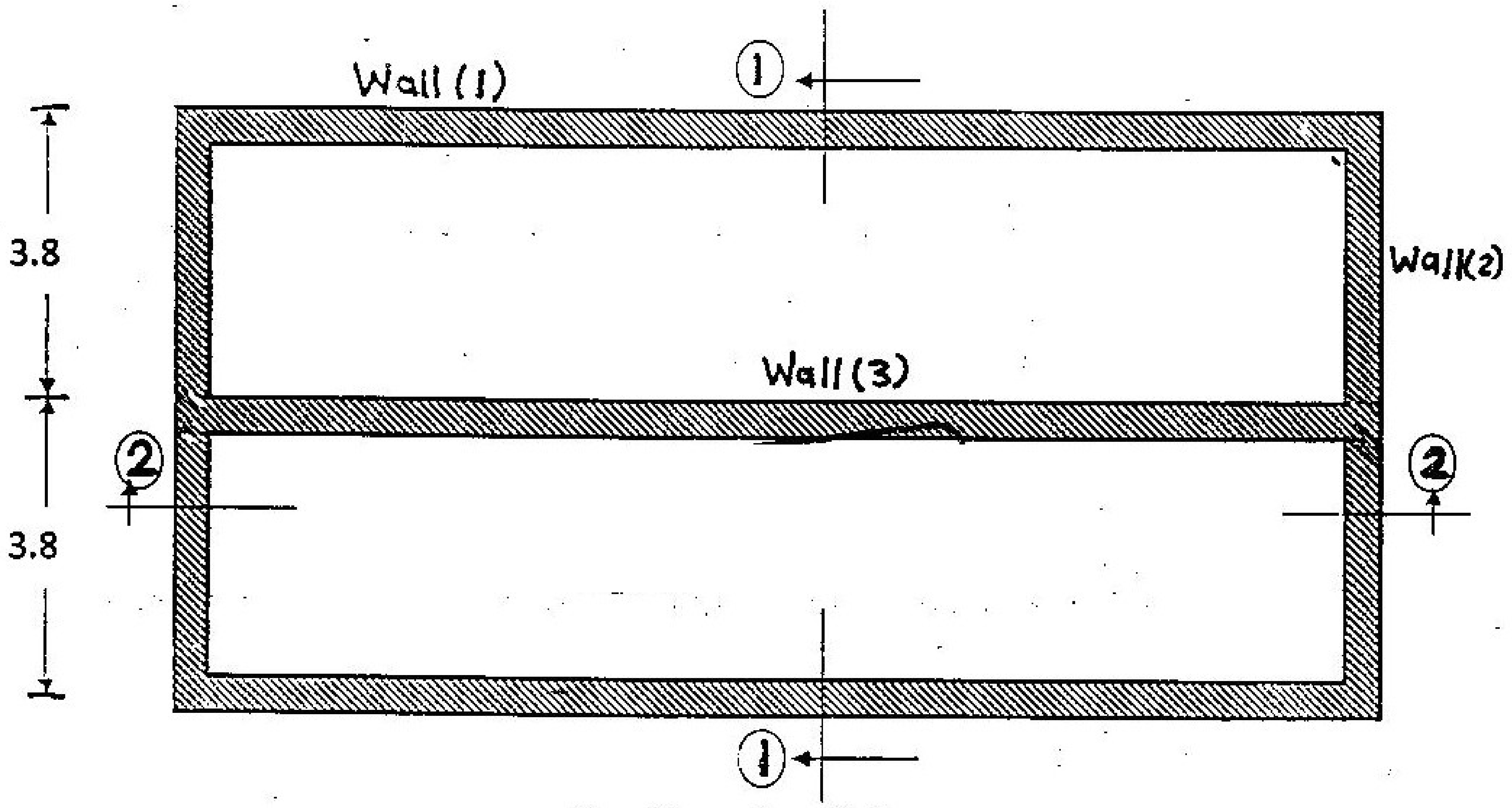
Rectangular Tanks

on Compressible Soil (Medium soil)



Section elevation 2-2



Section plan 3-3

Given:

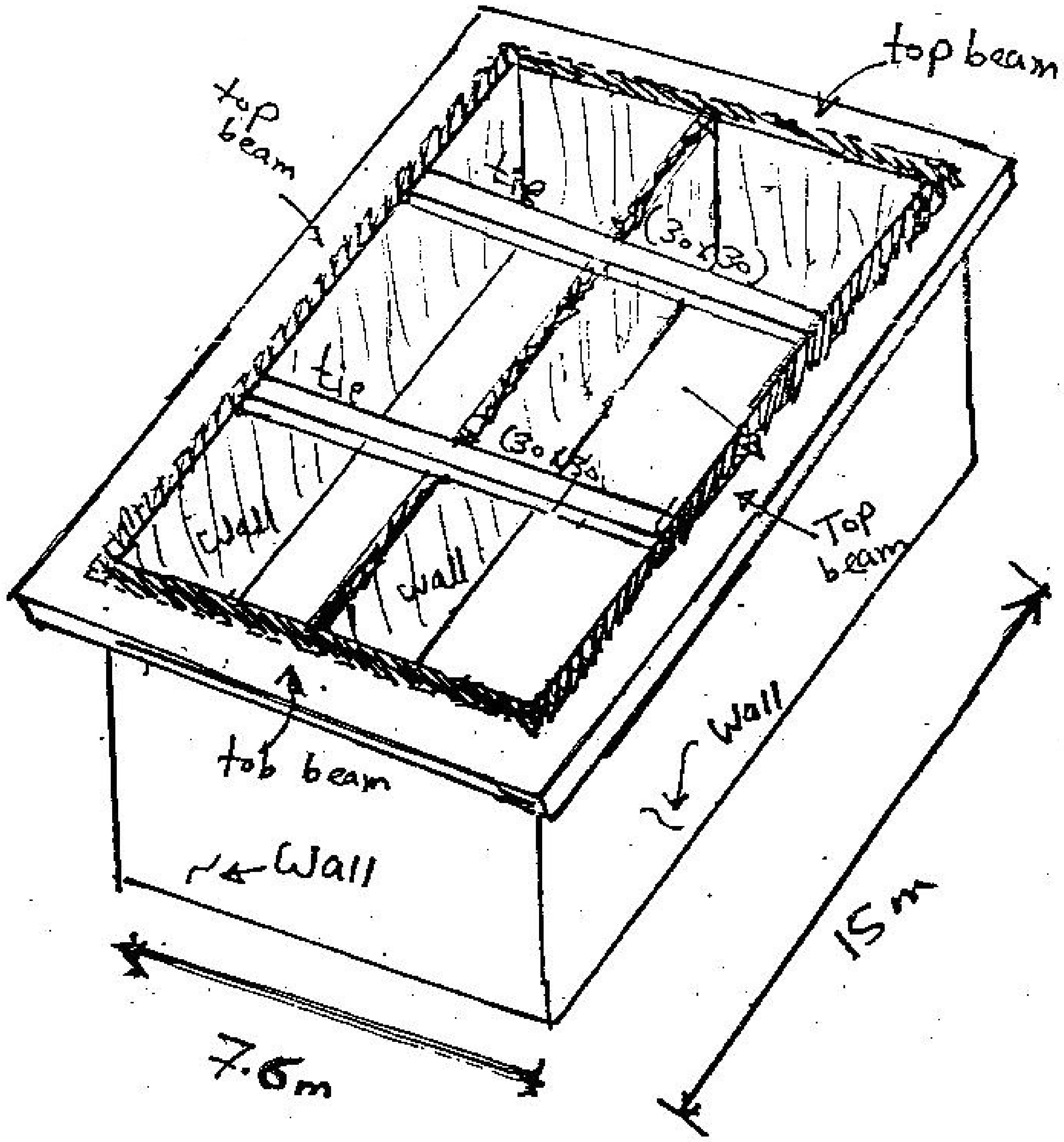
f_{cu}=250 kg/cm^2 , f_y=3600 kg/cm^2

Soil under tank is stiff clay with B/C = 1 kg/cm^2

Required:

1- Complete analysis and design for all tank elements.
2- Check soil stress under tank.
3- **Draw all reinforcement details.**

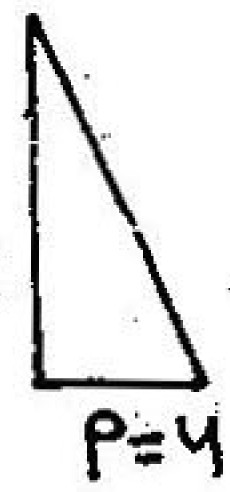
* هنا ربط (tie) يربط الـ(Top beams) لتقليل بحرها



Solution:

(1) Loads:

Walls: $P_{total} = \gamma . H = 1 * 4 = 4\ t/m^2$



Base: القاعدة مرتكزة على تربة إنضغاطية .

∴ الحمل يرتفع القاعدة من أسفل لأعلى

عبارة عن رد فعل التربة .

(للقاعدة (الطول الصغير)

$$\therefore \frac{L}{H} = \frac{3.8}{4} = 0.95 < 1.5$$

∴ uniform stress under base.

★ Check soil stress:

$$\sigma_{soil} = (t_{base} \cdot \gamma_{R.C}) + (\gamma_{water} \cdot H) + \left(\frac{G * \text{محيط الحوائط}}{\text{مساحة الخزان}}\right) + \left(\frac{Wt.\ of\ Top\ beam * \text{محيطها}}{\text{مساحة الخزان كله}}\right)$$

t/m^2 — وزن القاعدة — وزن المياه — وزن الحوائط

$t_{wall} \cdot H \cdot \gamma_{R.C}$ — فرض مبدئي: $b \cdot t \cdot \gamma_{R.C}$

$$\sigma_{soil} = (0.4 * 2.5) + (1 * 4) + \left(\frac{0.25 * 4 * 2.5 * 60.2}{7.6 * 15}\right) + \frac{0.3 * 0.9 * 2.5 * 45.2}{7.6 * 15}$$

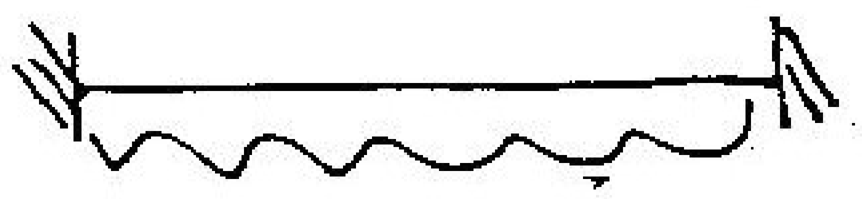
$$= 6.58\ t/m^2$$

$$\therefore \sigma_{soil} << (B/C = 10\ t/m^2)$$

∴ Safe

Loads under base — الأحمال تحت القاعدة

*** الأحمال الناتجة من (الحوائط) و (Top beam) هي الوحيدة التي تسبب عزوم على القاعدة.



$$W_{net} = \left(\frac{G * \text{محيط الحوائط}}{\text{مساحة الخزان}}\right) + \left(\frac{\text{top beam (وزنها)} * \text{محيطها}}{\text{مساحة الخزان}}\right)$$

$$= 1.58 \ t/m^2$$

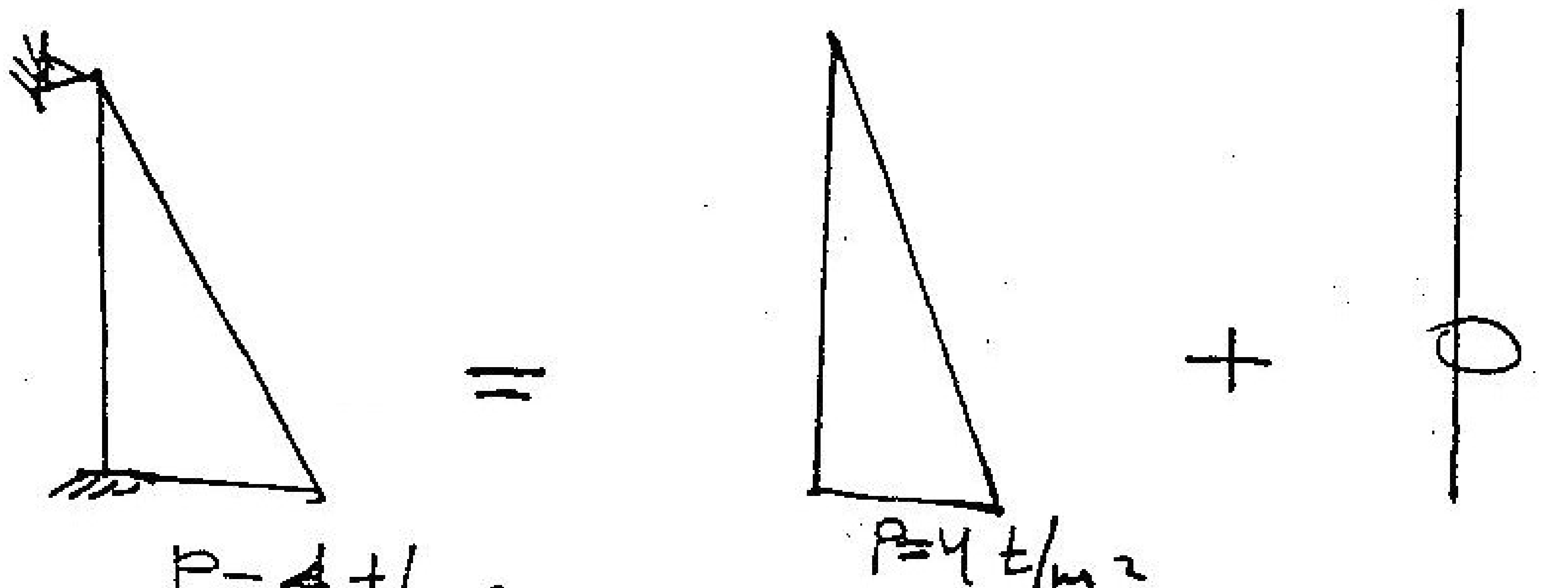
(2) Load distribution:

Walls

Wall (1) ⇒ $H = 4m$; $L = 15m$

$\therefore \frac{L}{H} > 2 \Rightarrow$ one way in VL. direction

Shallow Tank



$P = 4 \ t/m^2$ = $P = 4 \ t/m^2$ (VL.) + (HL.)

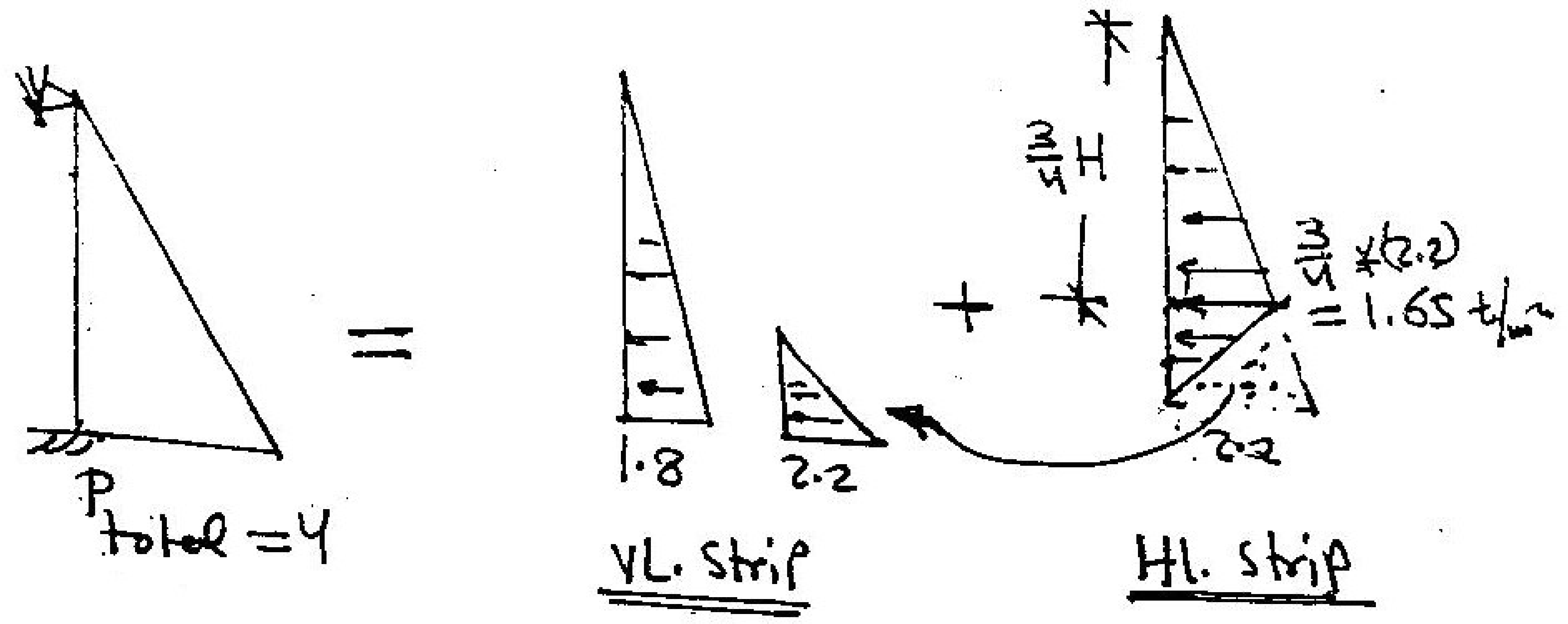
(VL. strip) * كل الأحمال تنتقل في الشريحة الرأسية.

Wall (2) $H = 4m$, $L = 3.8m \Rightarrow r = \frac{4}{3.8} = 1.05$

$\therefore \alpha = 0.55$
$\therefore \beta = 0.45$ from grashoff P(1-2)

للاتجاه القصير $P_\alpha = 0.55 * 4 = 2.2 \ t/m^2 \Rightarrow$ HL. Strip

للاتجاه الطويل $P_\beta = 0.45 * 4 = 1.8 \ t/m^2 \rightarrow$ VL. Strip



Wall (3) $\Rightarrow$ Zero loads

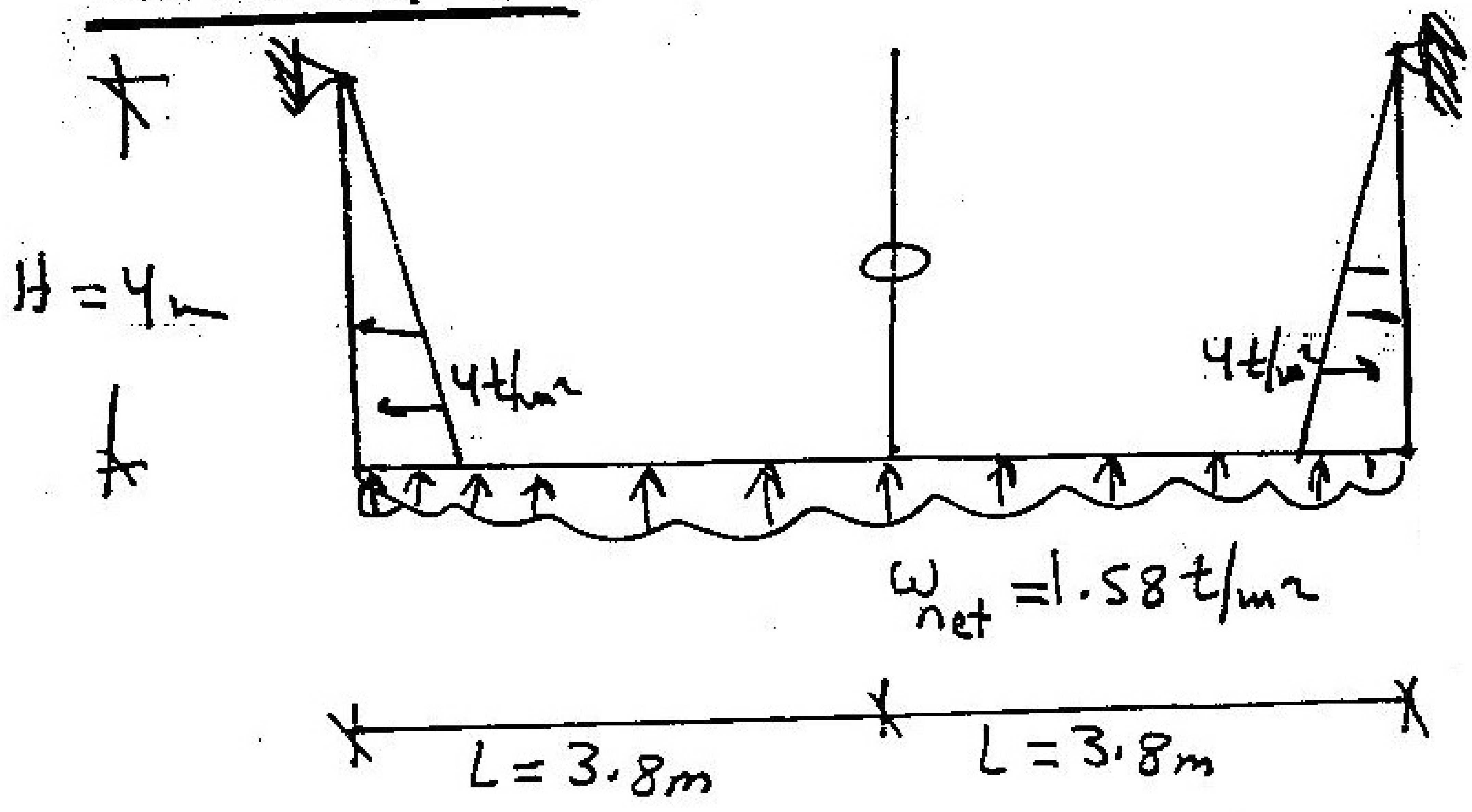
For Base : $r = \frac{long}{short} = \frac{15}{3.8} \gg 2$

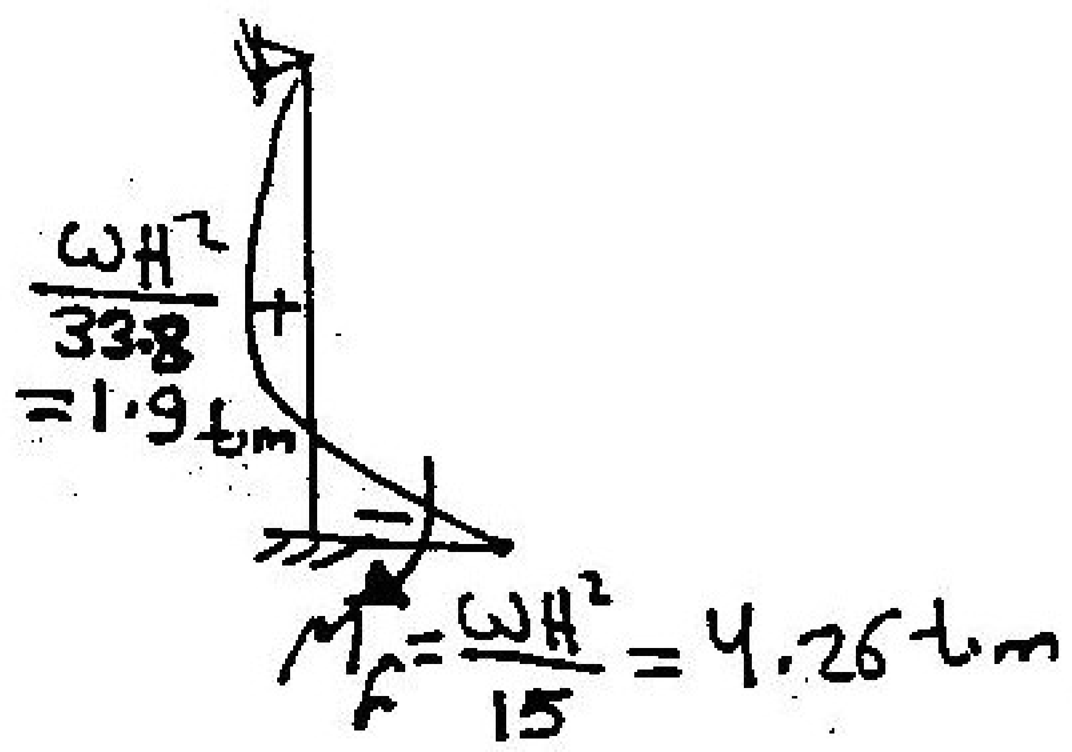
$\therefore$ one way

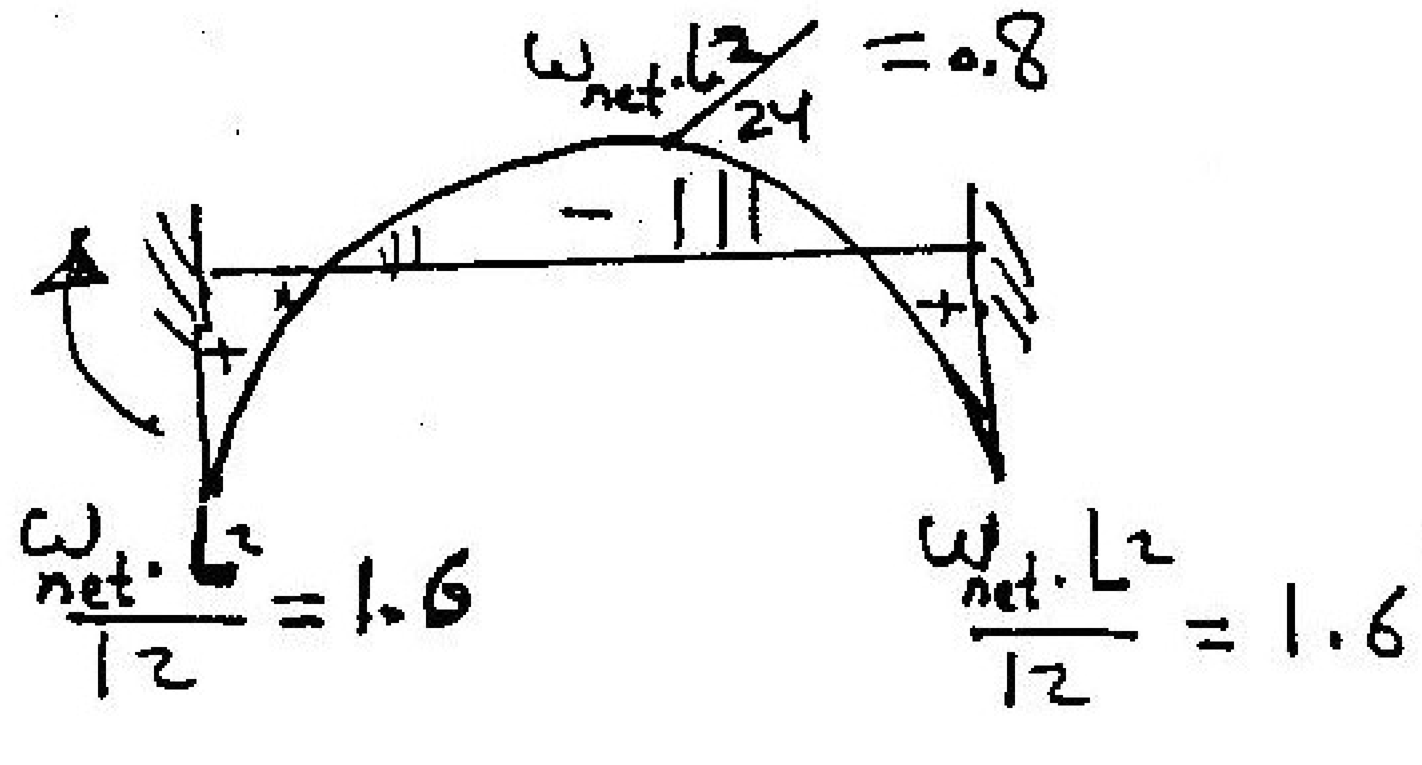
كل الأحمال على البلاطة (ω_{net}) تنتقل للاتجاه القصير

$$\omega_{net} = 1.58 \ t/m^2$$

VL. Strip (1-1)







وحيث ان عزوم القاعدة مع الحائط غير متزنة .

فيجب عمل اتزان للعزوم باستخدام

Moment distribution

$$K_{wall} = \frac{3}{4}\frac{I}{H} = \frac{3}{4} * \frac{1}{4} = 0.1875$$

$$K_{base} = \frac{I}{L} = \frac{1}{3.8} = 0.263$$

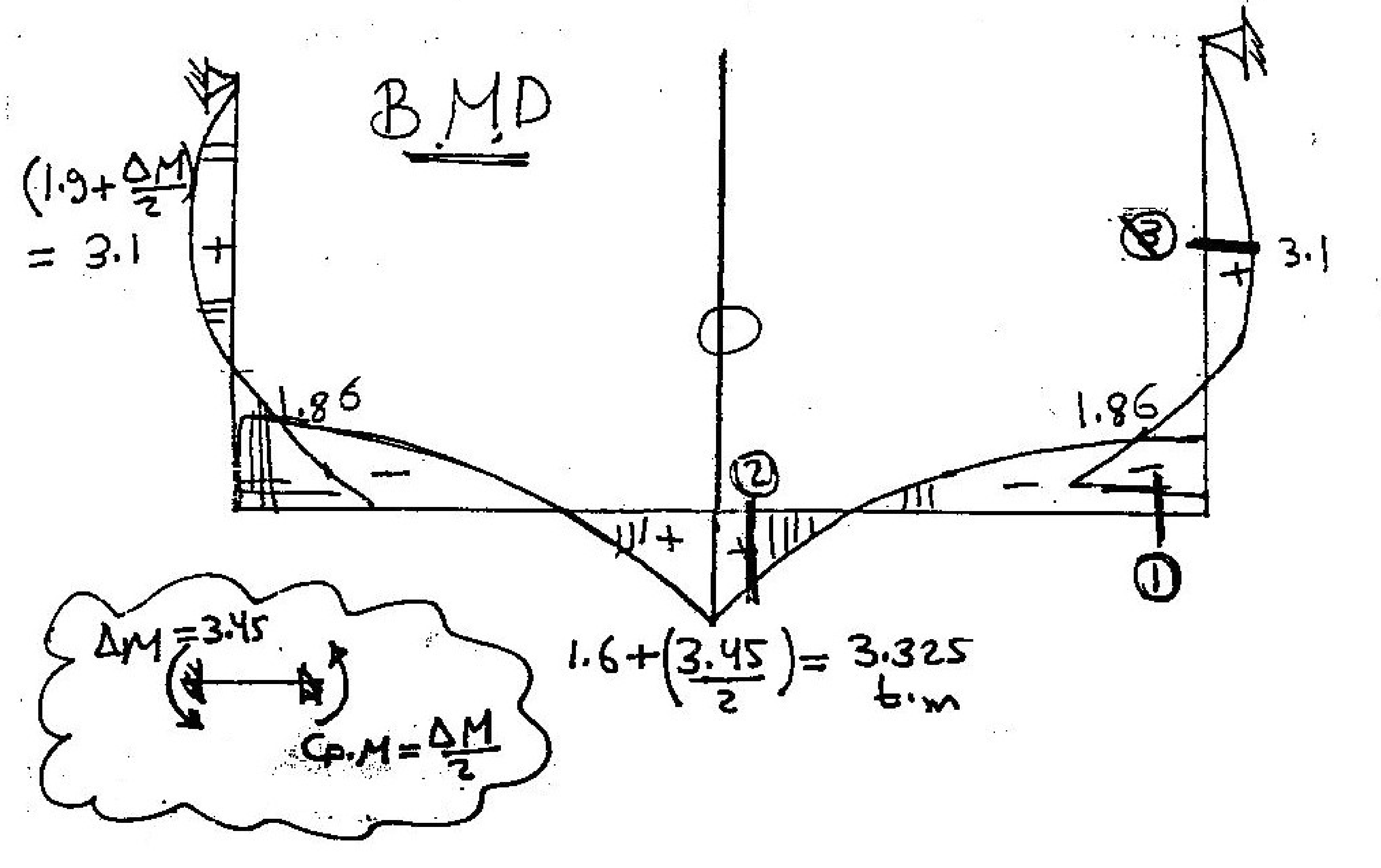
$$\therefore D.f_{wall} = \frac{0.1875}{0.1875 + 0.263} = 0.41$$

$$\therefore D.f_{base} = 1 - 0.41 = 0.59$$

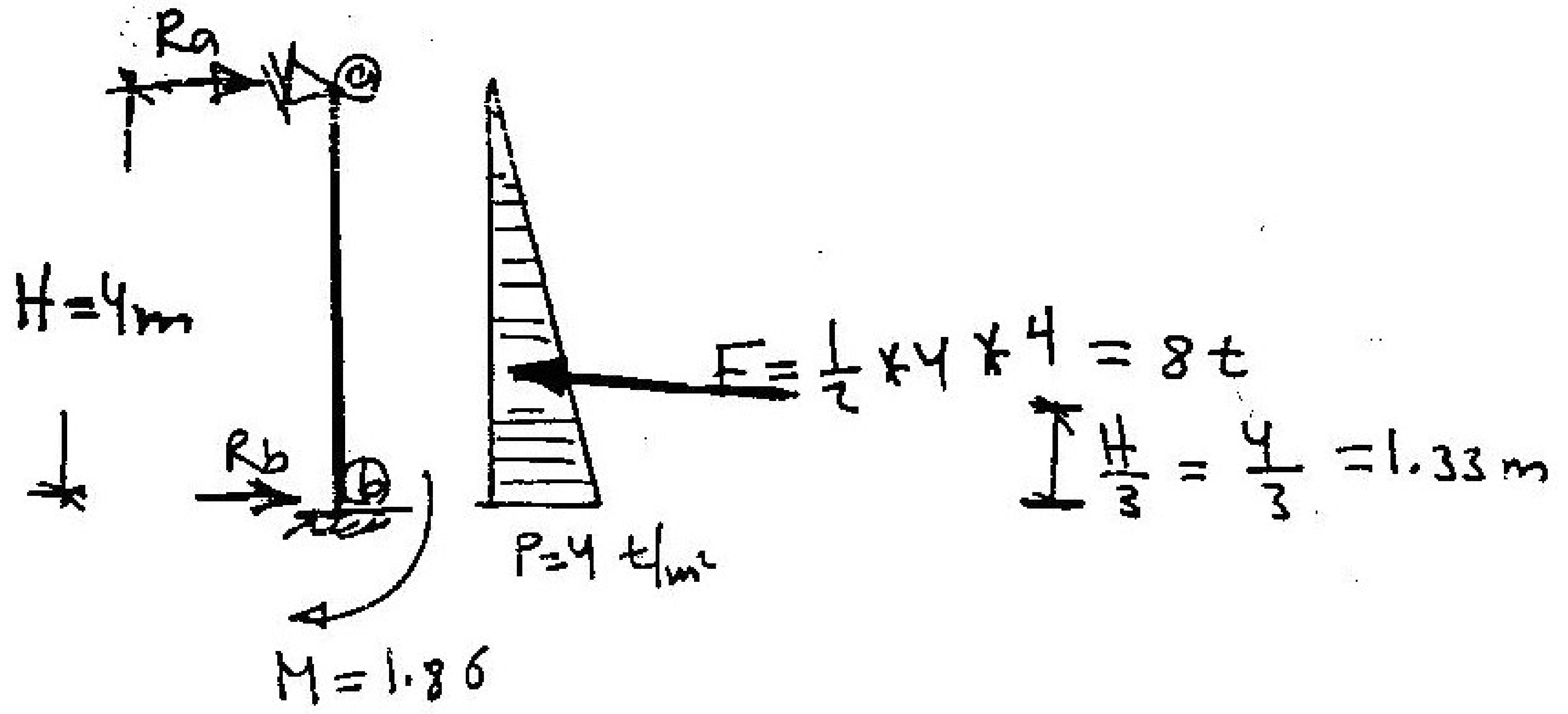
نفرض العزوم عكس عقارب الساعة موجبة (+)

	D.f = 0.41	D.f = 0.59
	Wall	Base
F.E.M	−4.26	−1.6
D.M	2.4	3.45
final(M)	−1.86	+1.86

B.M.D



Reactions From Wall



$$\Sigma M_b = 0 \Rightarrow (\overset{F}{8} * 1.33) - (R_a * 4) - 1.86 = 0$$

$\therefore$ $R_a = 2.2$ ton — يذهب للـ Top beam

$$\Sigma F_x = 0 \Rightarrow R_a + R_b - 8 = 0$$

$\therefore$ $R_b = 5.8$ ton — يذهب للـ أساسات.

---

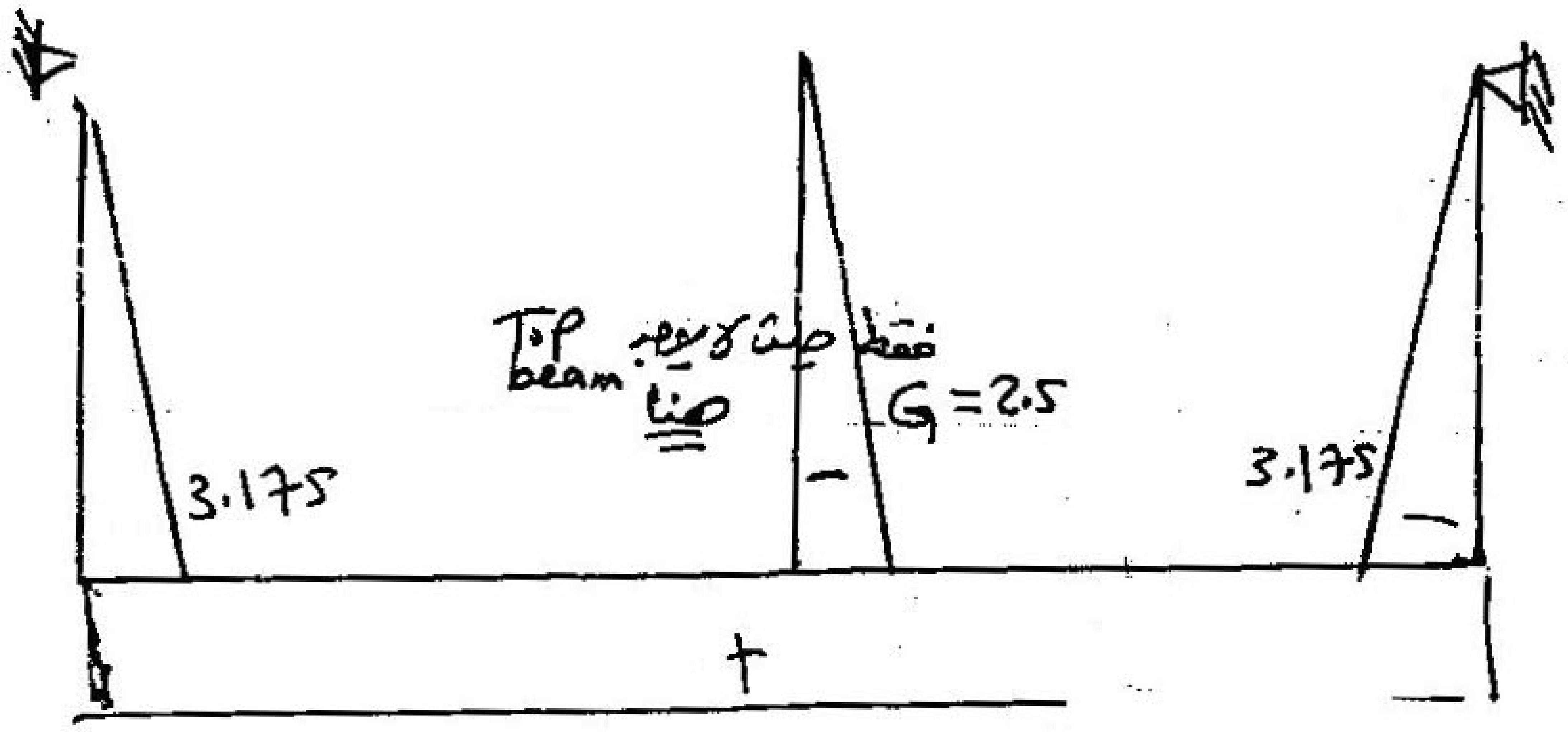
* لاحظ أن أي حمل على التربة فإنه لم (Normal force) على الحائط

هي وزنها + [(G) + وزن الـ (Top beam)] وهو ضغط Compression

$$\text{Normal force} = (t_{wall} \cdot H \cdot \gamma_{RC}) + (b \cdot t \cdot \gamma_{RC})_{\text{Top beam}}$$

$$= (0.25 * 4 * 2.5) + (0.3 * 0.9 * 2.5)$$

$$= 3.175\ t/m$$



$R_b = 5.8\ t$

Design of sections:

Sec (1) $M_{water\ side} = 1.86\ t.m$, $T = 5.8\ t/m$

Stage (I): $t = 30\ cm$.

Stage (II): $A_s = 5\ \Phi 12/m$

Sec (2) $M_{air} = 3.325\ t.m$, $T = 5.8\ t/m$

Stage (II) using $t = 30\ cm$

تخانة نفس القطاع بايمر

$A_s = 5\ \Phi 16/m$

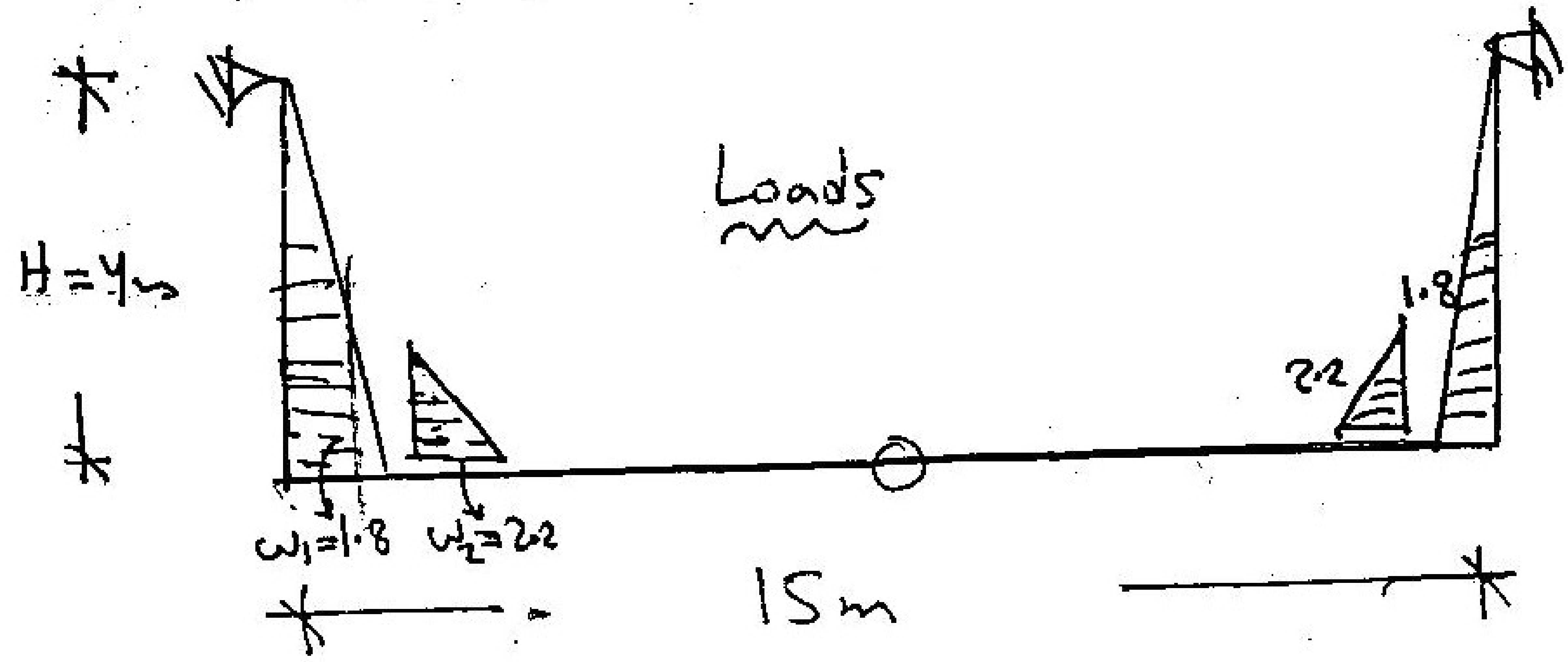
Sec (3) $M_{air} = 3.1$, (N) Compression

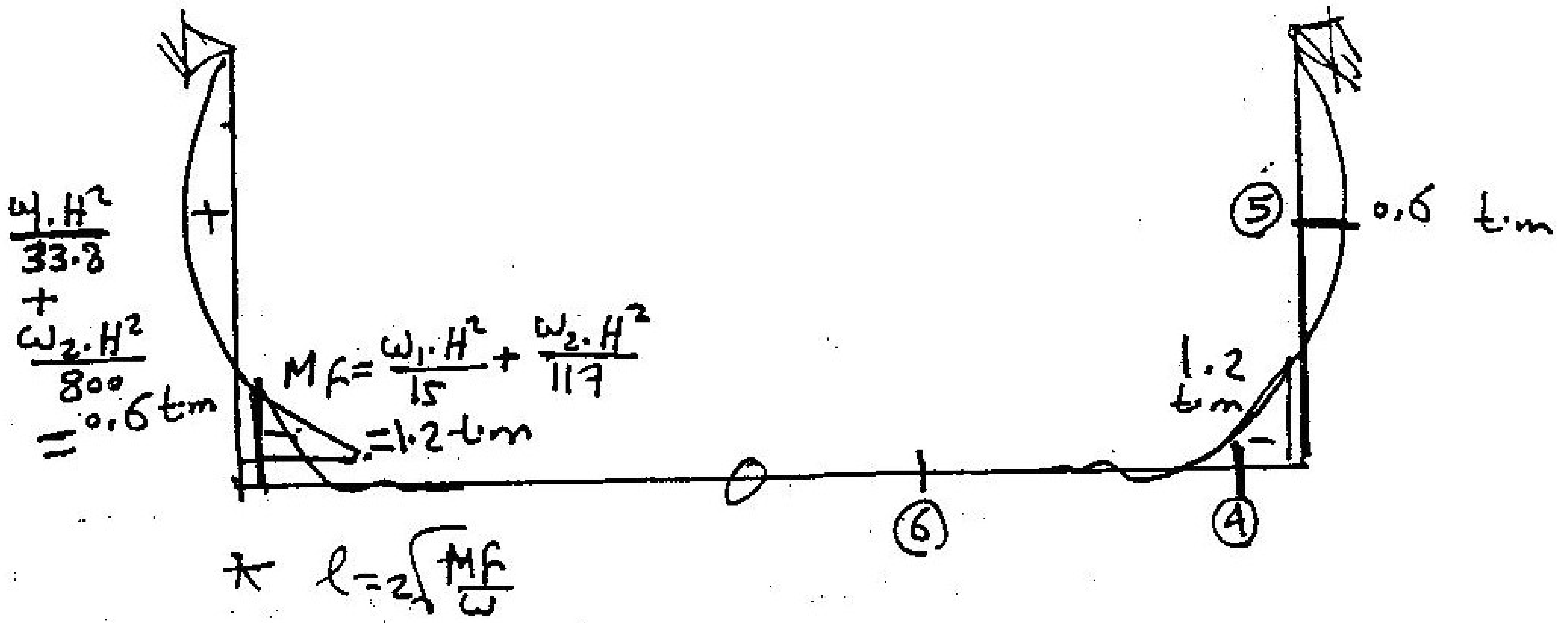
⇓

Stage (II) $t = 25\ cm$.

$A_s = 5\ \Phi 16/m$

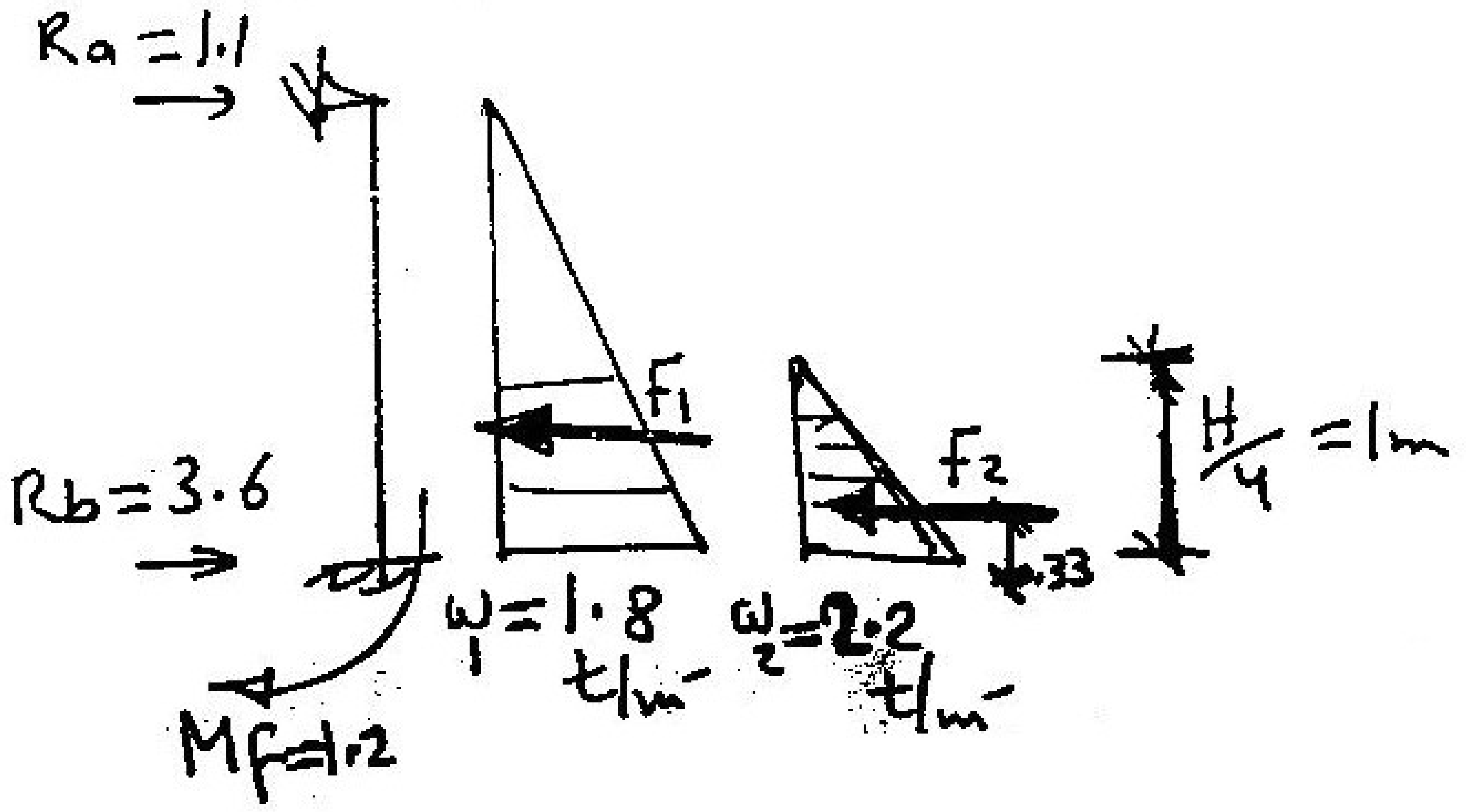
VL. Strip (2-2)





* $l = 2\sqrt{\frac{M_f}{w}}$

* طالما ان القاعدة ليس عليها احمال في هذه الشريحة فإنه عزوم الحائط ترتد القاعدة مسافة صغيرة (l) ثم تموت مثل Rocky

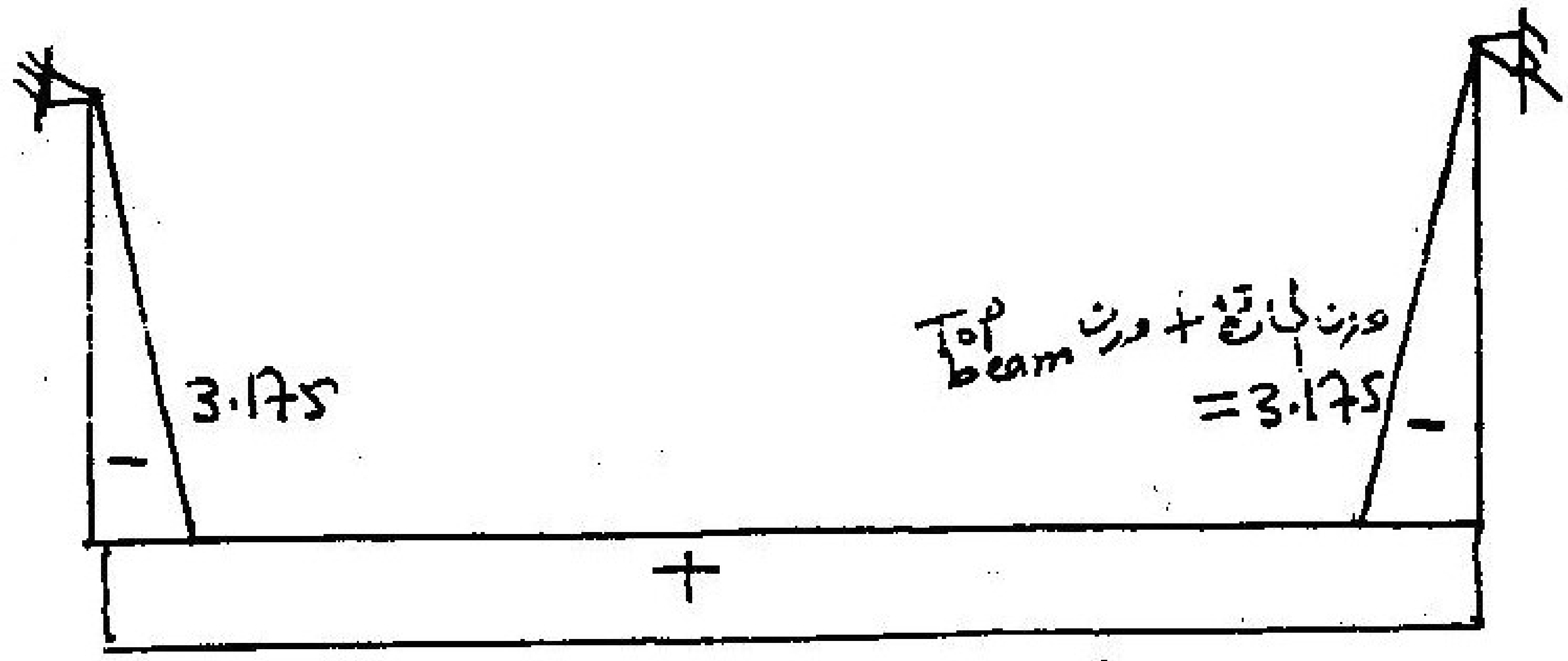


$\Sigma M_A = 0$

$\Rightarrow R_a = 1.1$ t/m

$\Sigma f_x = 0$

$\Rightarrow R_b = 3.6$ t/m



$R_b = 3.6$ t/m ← شد في اتجاهين.

Design of Sections:

Sec (4): $M_{water} = 1.2$ tm ; $T = 3.6$ t/m

Stage (I) → $t = 25$ cm

Stage (II) → $A_s = 5 \Phi 12$/m

Sec (5): $M_{air} = 0.6$ tm , N = Compression

Stage (II): using $t = 25$ cm.

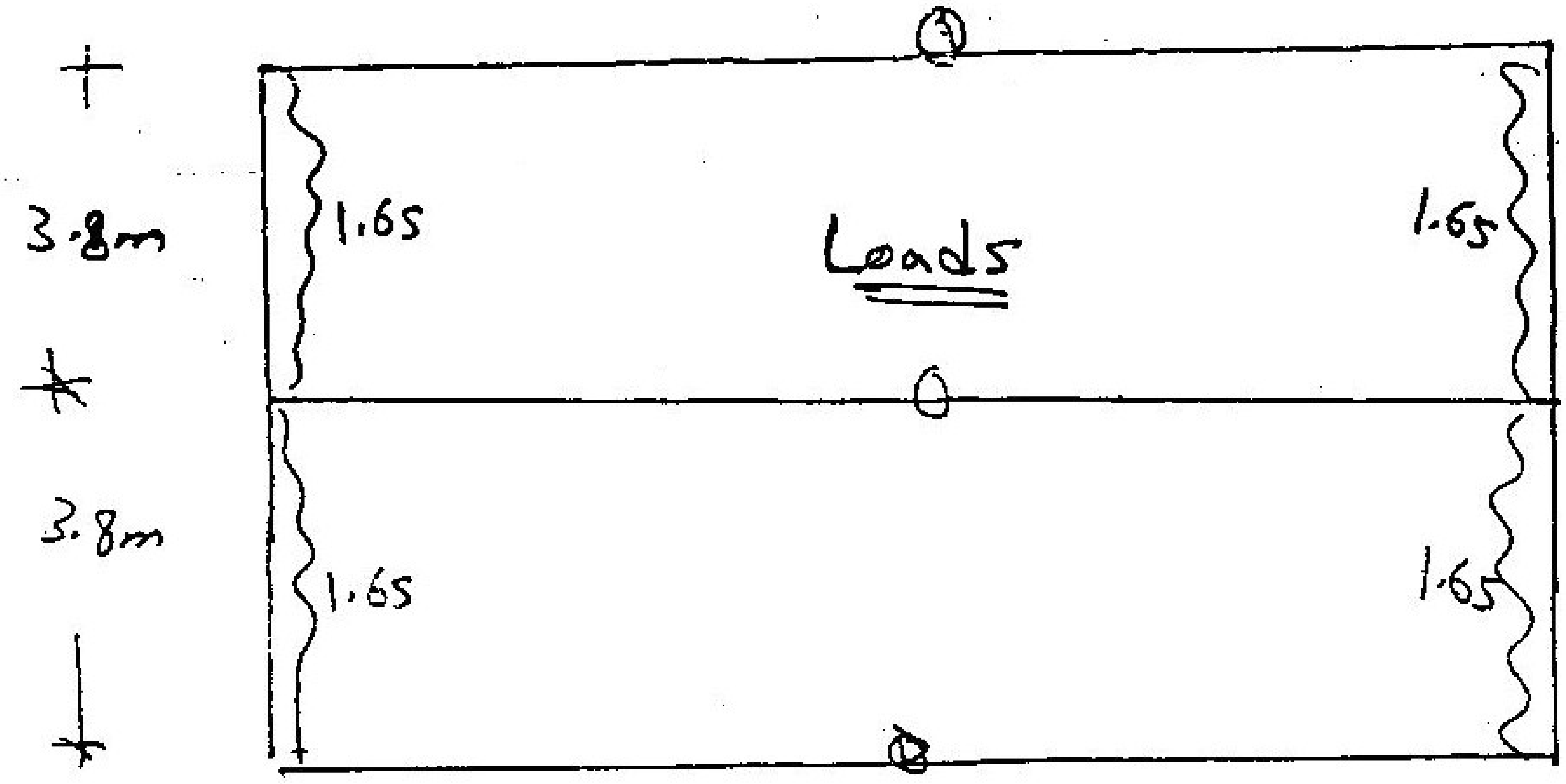
$A_s = 5 \Phi 10$/m (min)

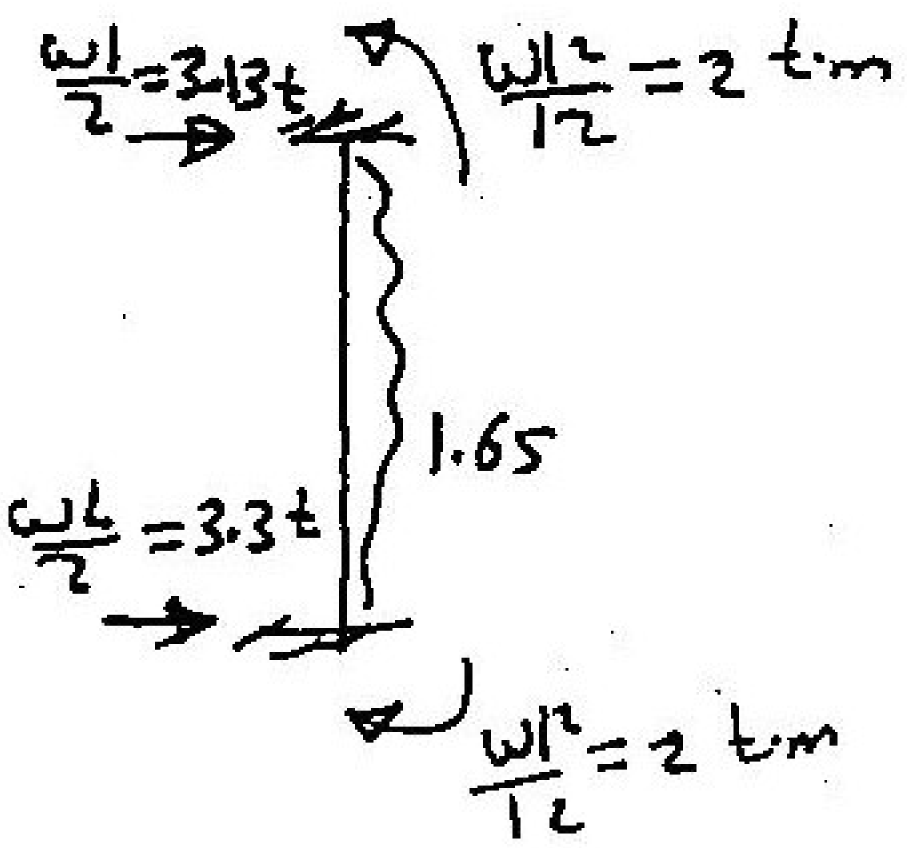
Sec (6): $T_{only} = 3.6$ t/m

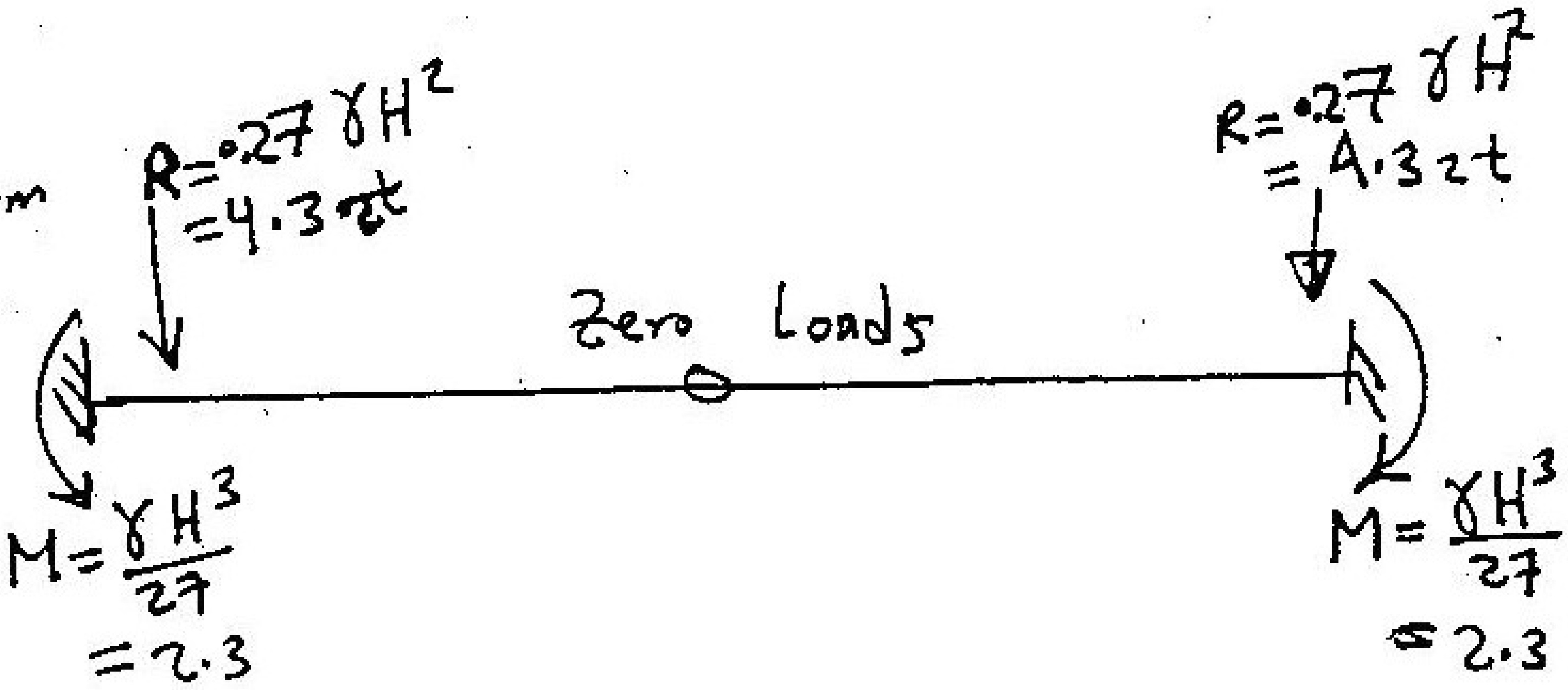
Stage (I) $t = 20$ cm (min)

Stage (II) $A_s = 5 \Phi 10$/m (each side

HL. Strip: At $\left(\frac{3}{4}H\right)$





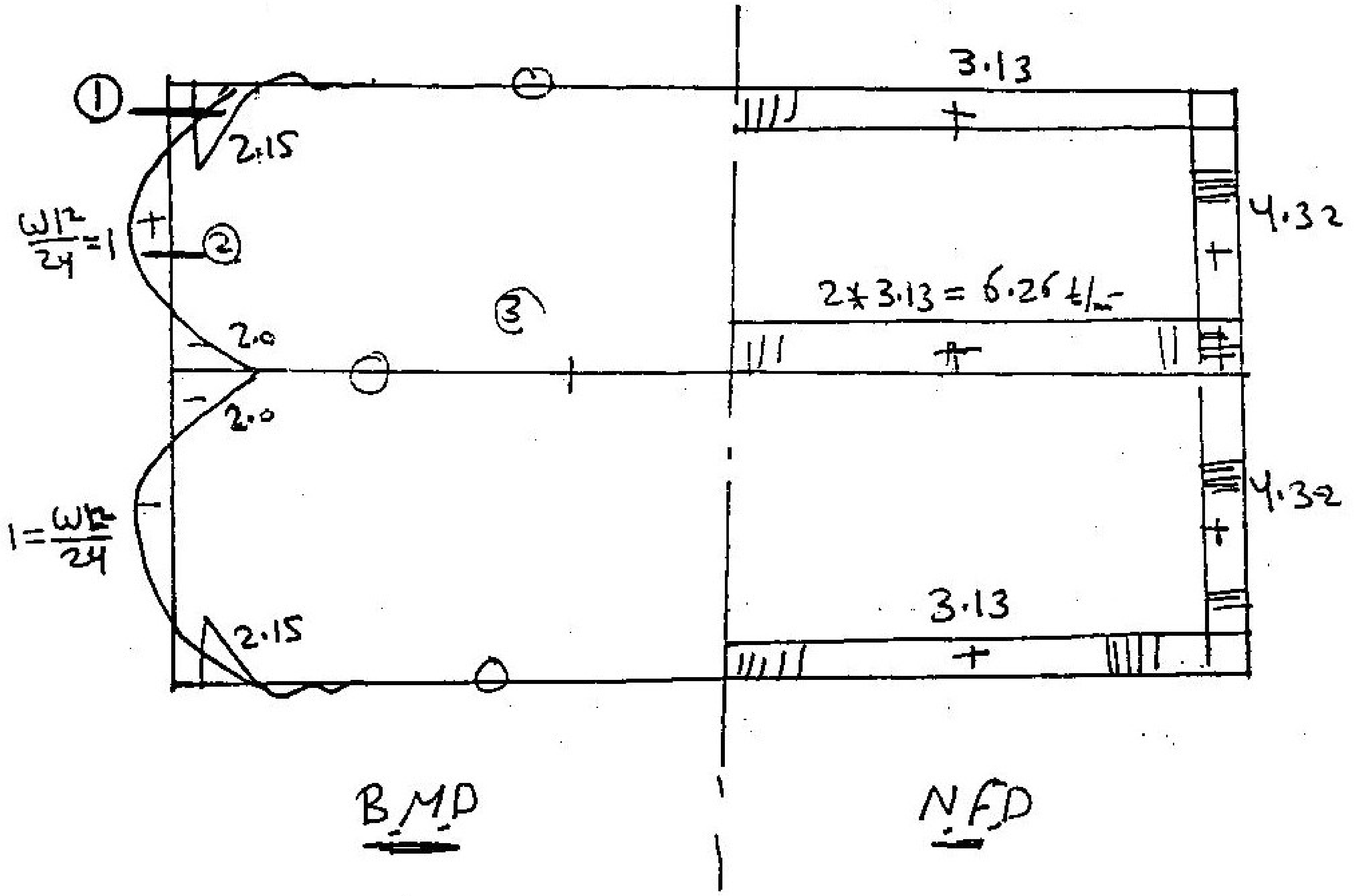


* في حالة أي حائط خارجي في الخزان في (HL. Strip) ليس عليه أحمال

- ناخذ قيمة للعزوم = Empirical $\frac{\gamma H^3}{27}$ ثم نكونه.
- وناخذ قيمة الـ Reaction = $.27\,\gamma H^2$

ناخذ عند الـ Connection قيمة العزوم المتوسطة واختصاراً للوقت.

$$M_{avg} = \left(\frac{2 + 2.3}{2}\right) = 2.15 \text{ t.m}$$



*** Design of sections**

Sec (1) → $M_{water} = 2.15$, $T = 4.32$

stage (I) → t = 30 cm.

stage (II) → As = 5 Φ 12/m

Sec (2) → $M_{air} = 1$ t.m , $T = 4.32$

stage II t = 25 cm.

As = 5 Φ 10/m (min)

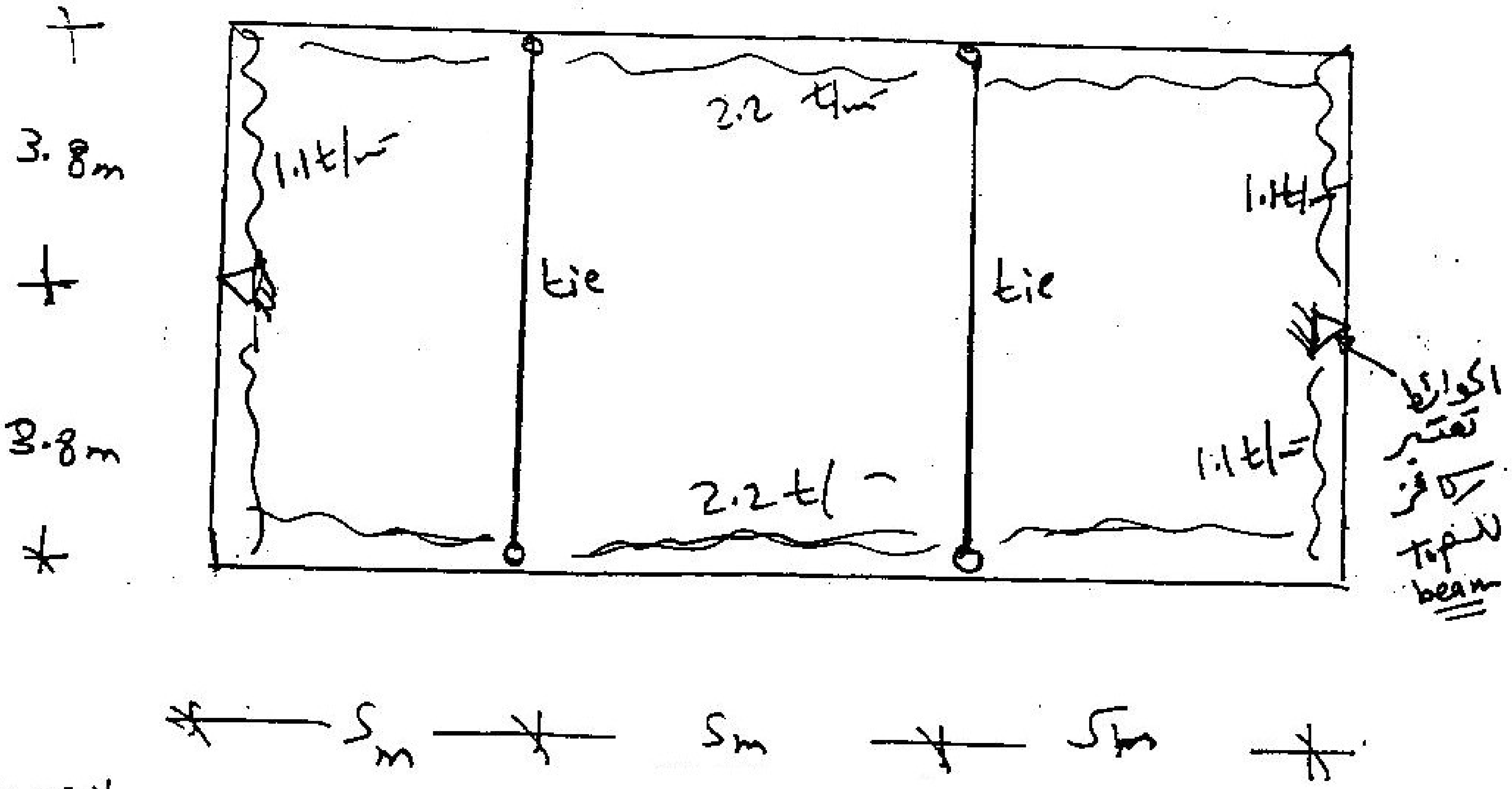
Sec (3) T only ⇒ (5 Φ 10/m) : min (t = 20 cm)

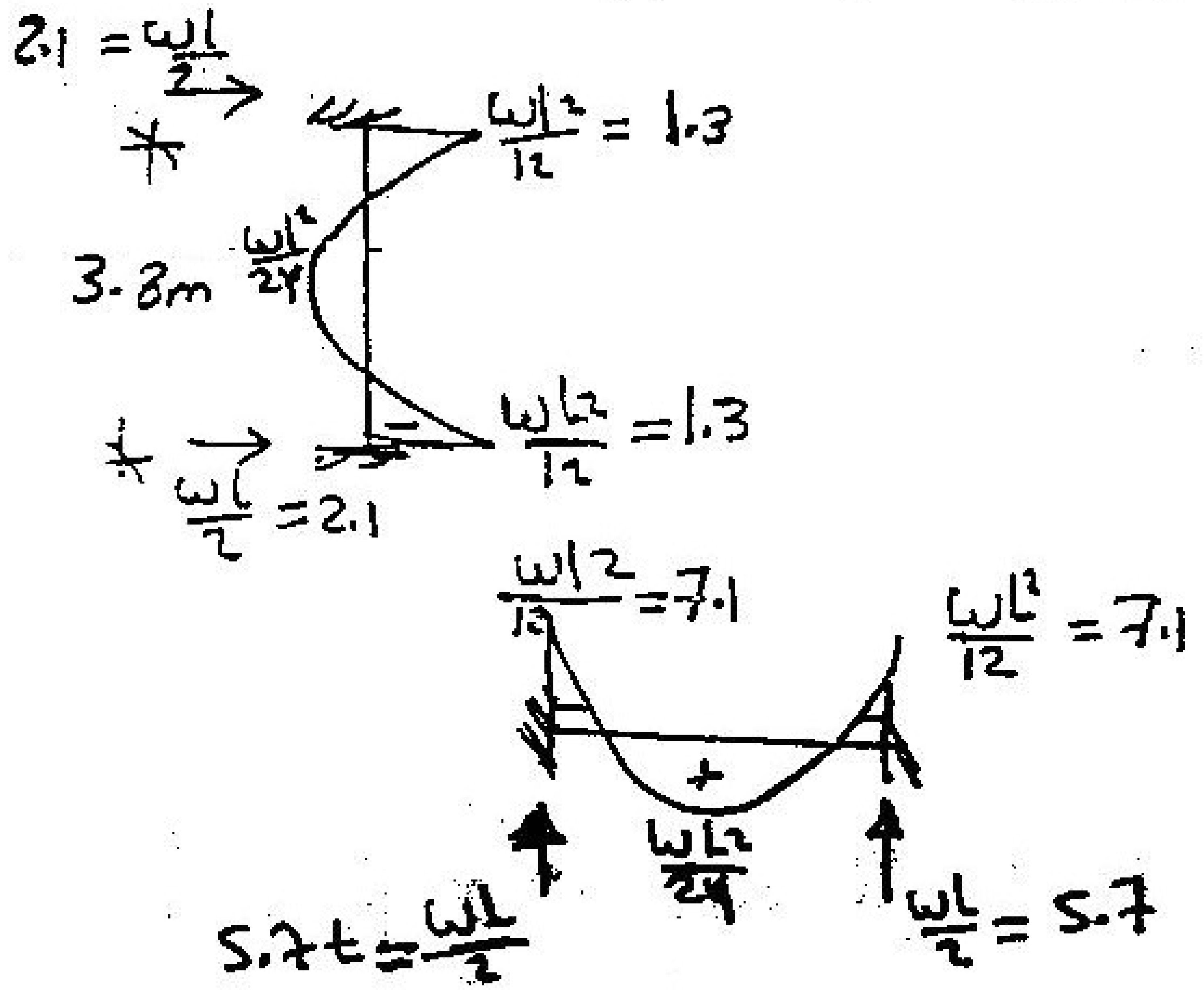
Top Beam:

- نحسب مراعاة ان الـ Top beam يرتكز دائماً على

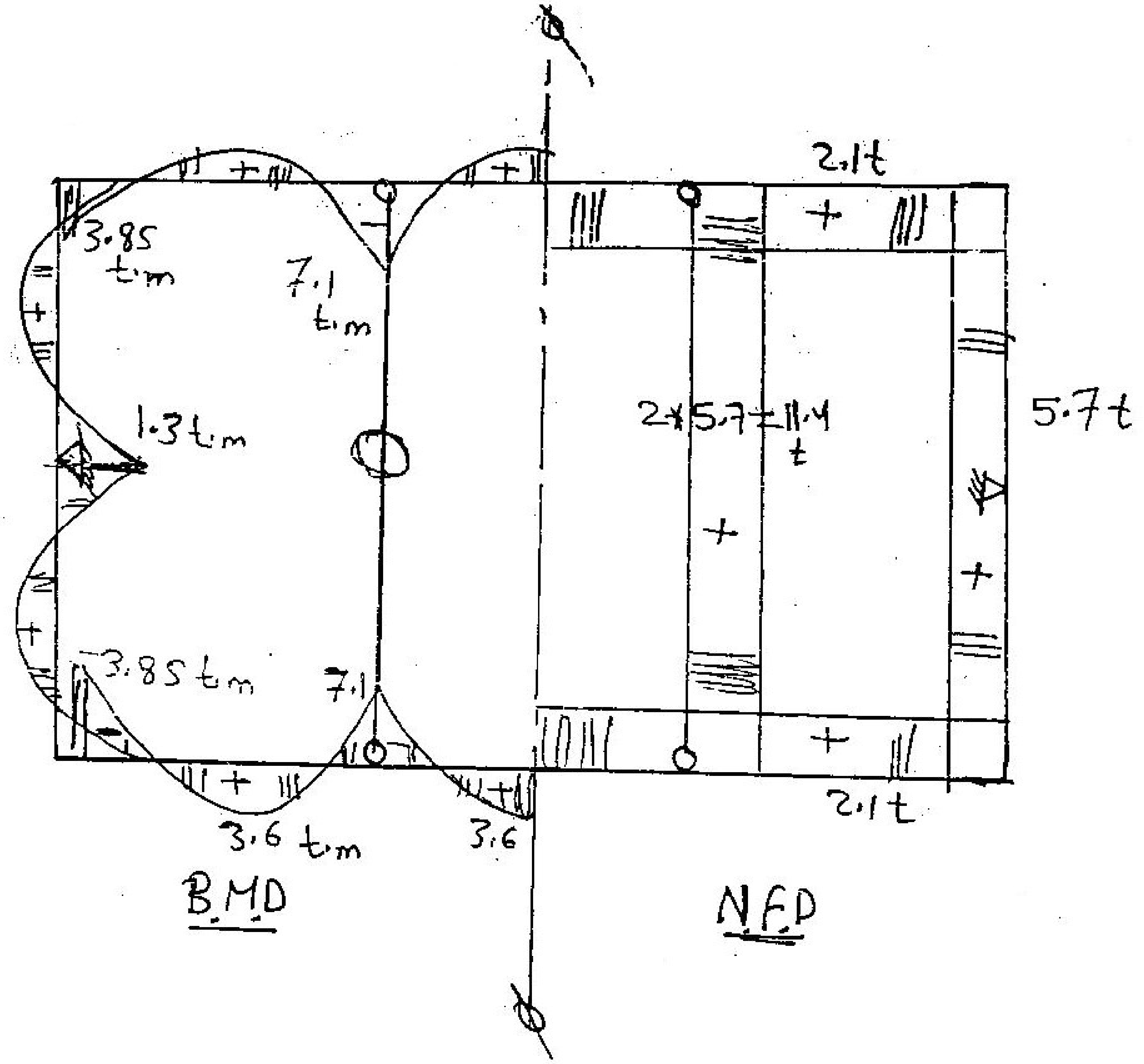
tie — حوائط داخلية

لكن عند رسم الـ (Top beam) نرسم معها الـ Tie فقط
ولا نرسم الحوائط





$$M_{avg} = \frac{1.3 + 7.1}{2} = 3.85 \text{ tm}$$



Design of sections

$$M_{waterside} = 7.1 \ t.m, \quad T = 2.1$$

Stage (I) $t = \sqrt{\frac{M \times 10^5}{\psi \cdot b}} + 5 = \sqrt{\frac{7.1 \times 10^5}{3.2 \times 30}} + 5 = 90 \ cm$

assume $b = 30$ cm

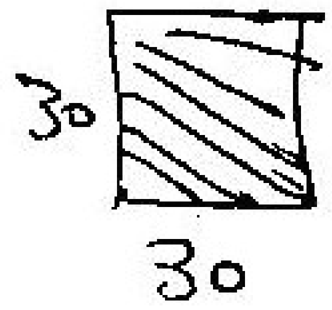
Stage (II) $As = 5 \Phi 16$

Design of tie : = Tension member.

$$T_{only} = 11.4 \text{ ton}$$

Stage (I) Assume Section 30*30 cm دائماً

Check $\frac{T*10^3}{b.t} \leq f_{ct}$



$$\frac{11.4*10^3}{30*30} \leq 18 \text{ kg/cm}^2$$

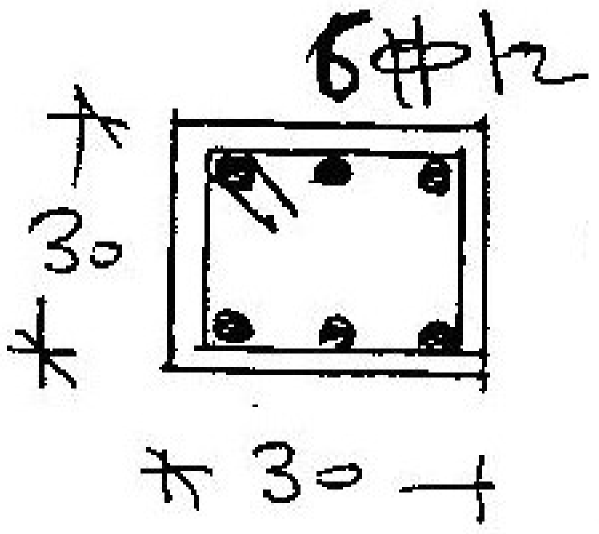
ok

Stage (II) $A_s = \frac{T_u*10^3}{(f_y/\gamma_s)} = \frac{(11.4*1.5)*10^3}{(3600/1.15)}$

$= 5.4 \text{ cm}^2$

$= 6\#12$

لابد عدد زوجي



tie Section

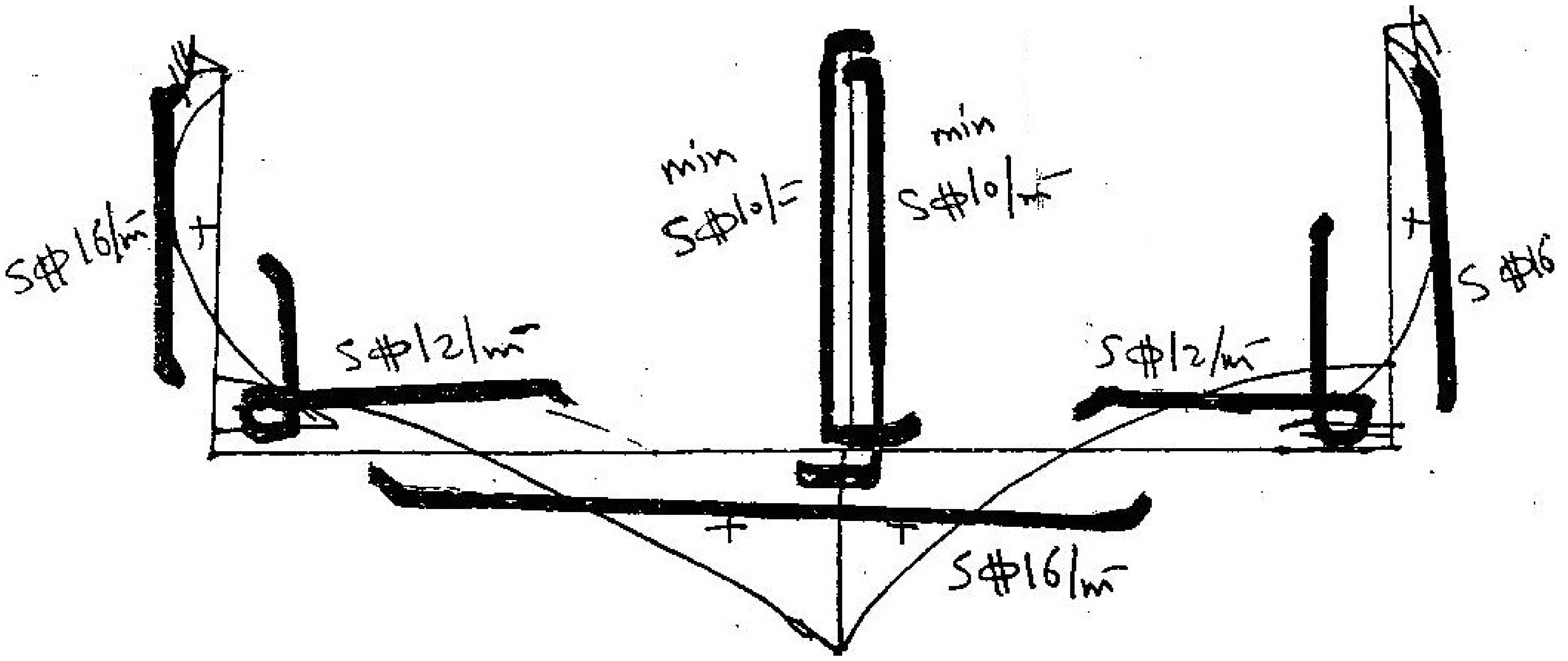
---

* Wall as beam:

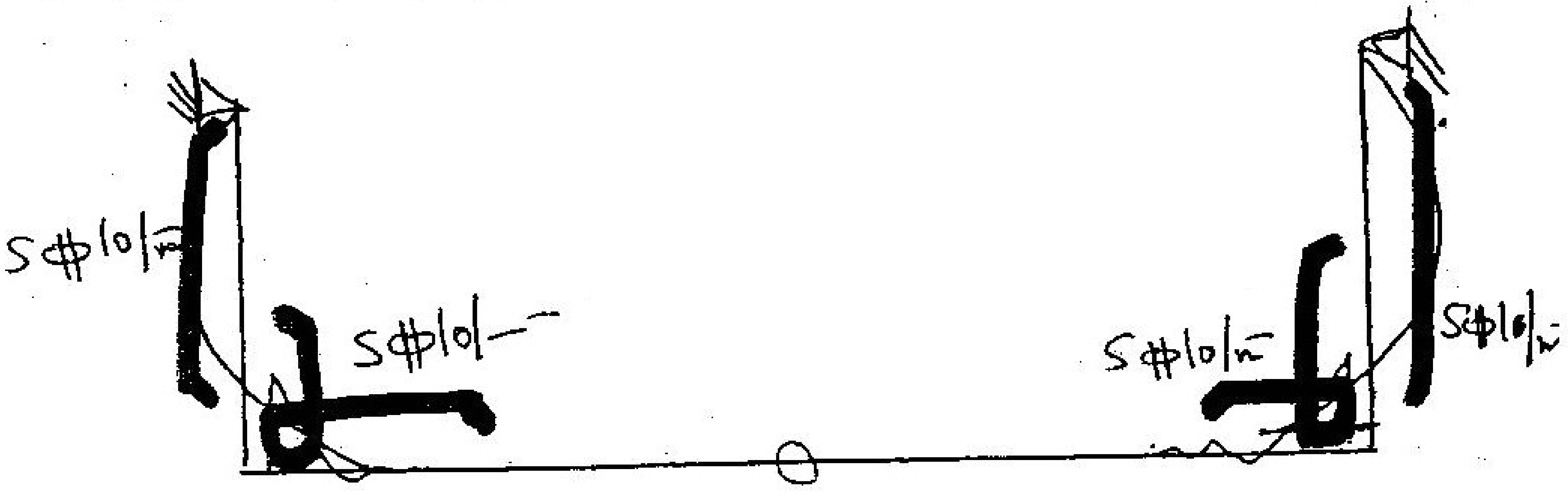
طالما ان تحركات على التربة فلا يوجد (wall as beam)

Reinforcement details :-

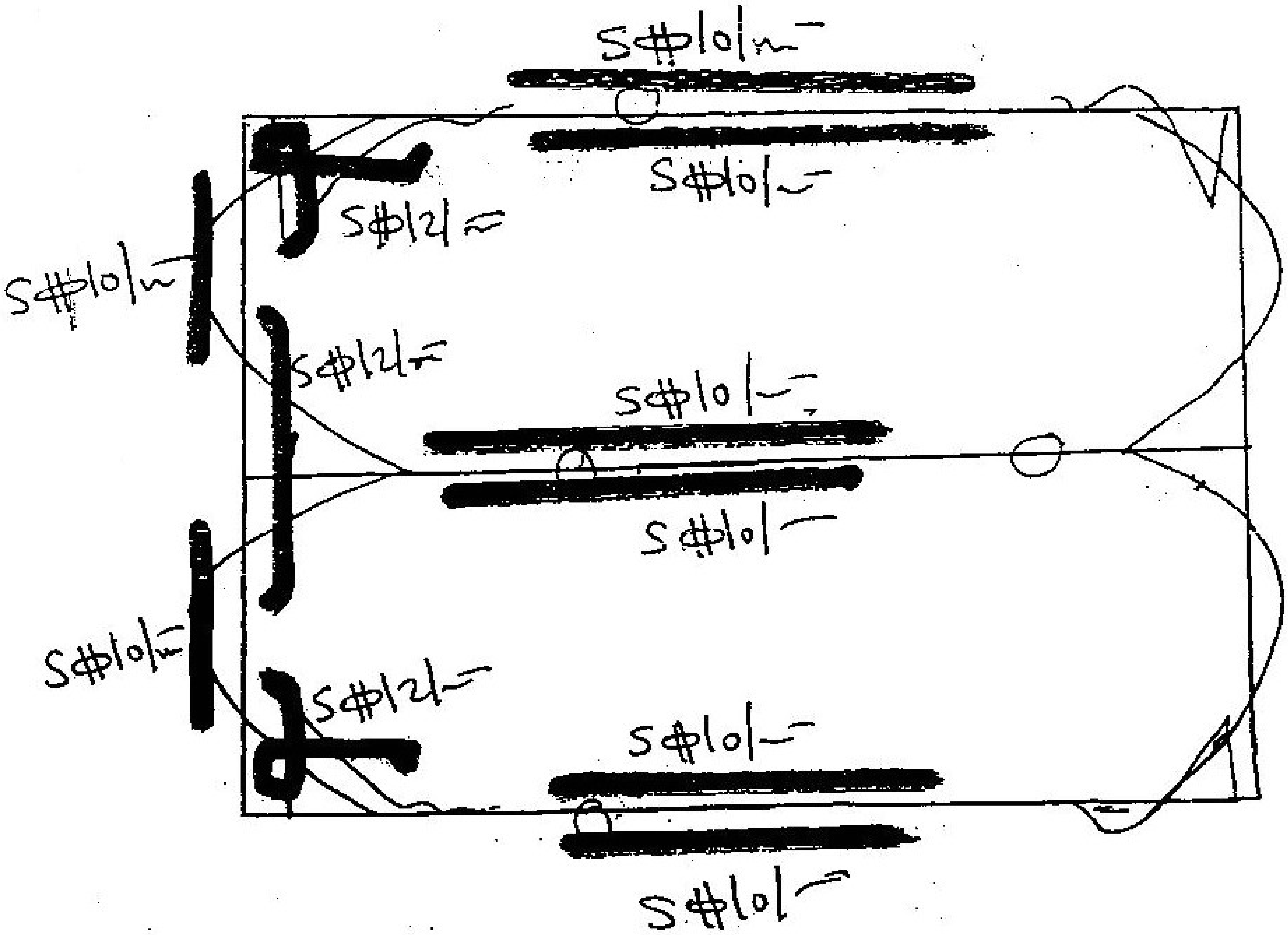
VL. Strip (1-1):

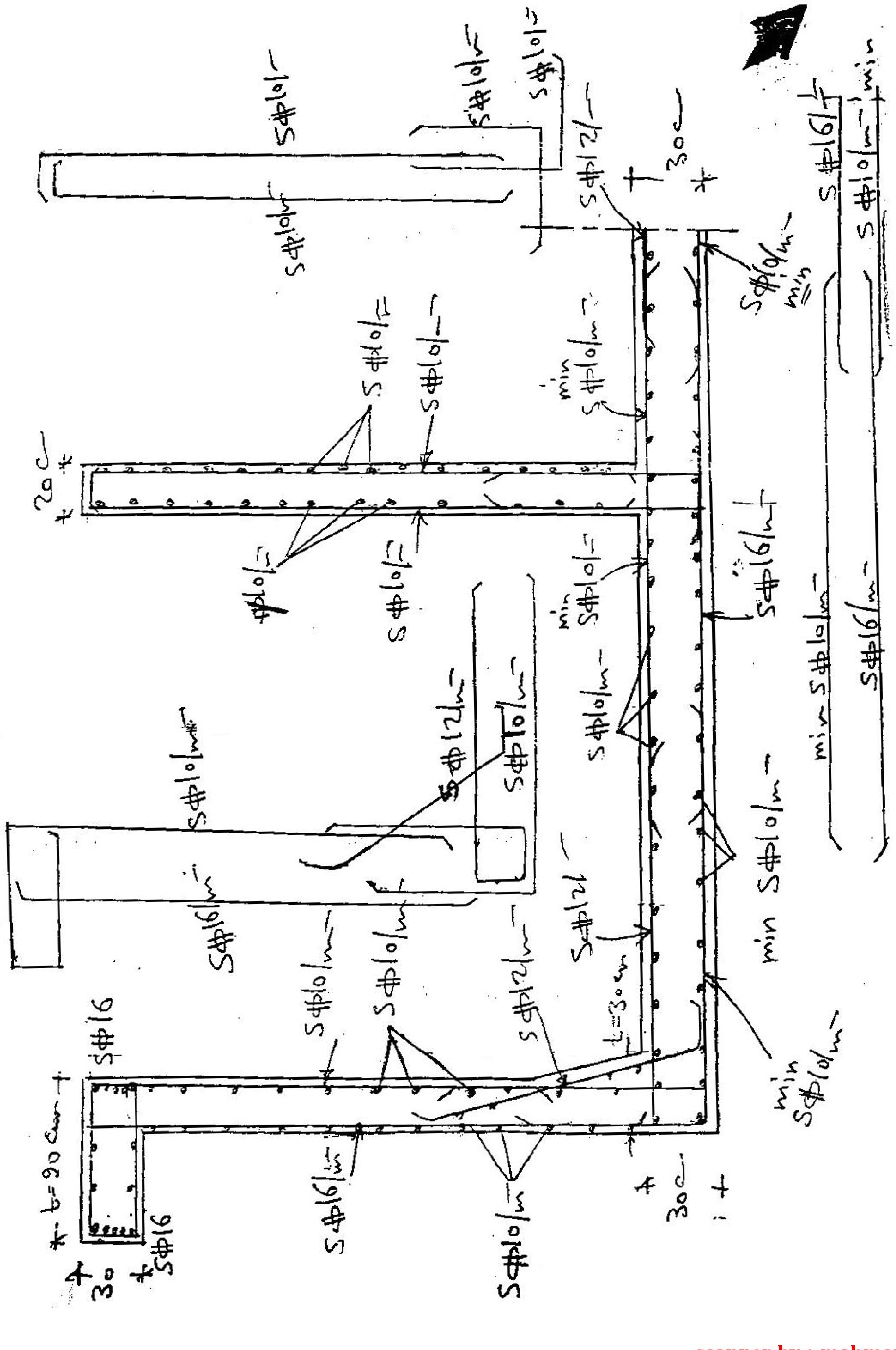


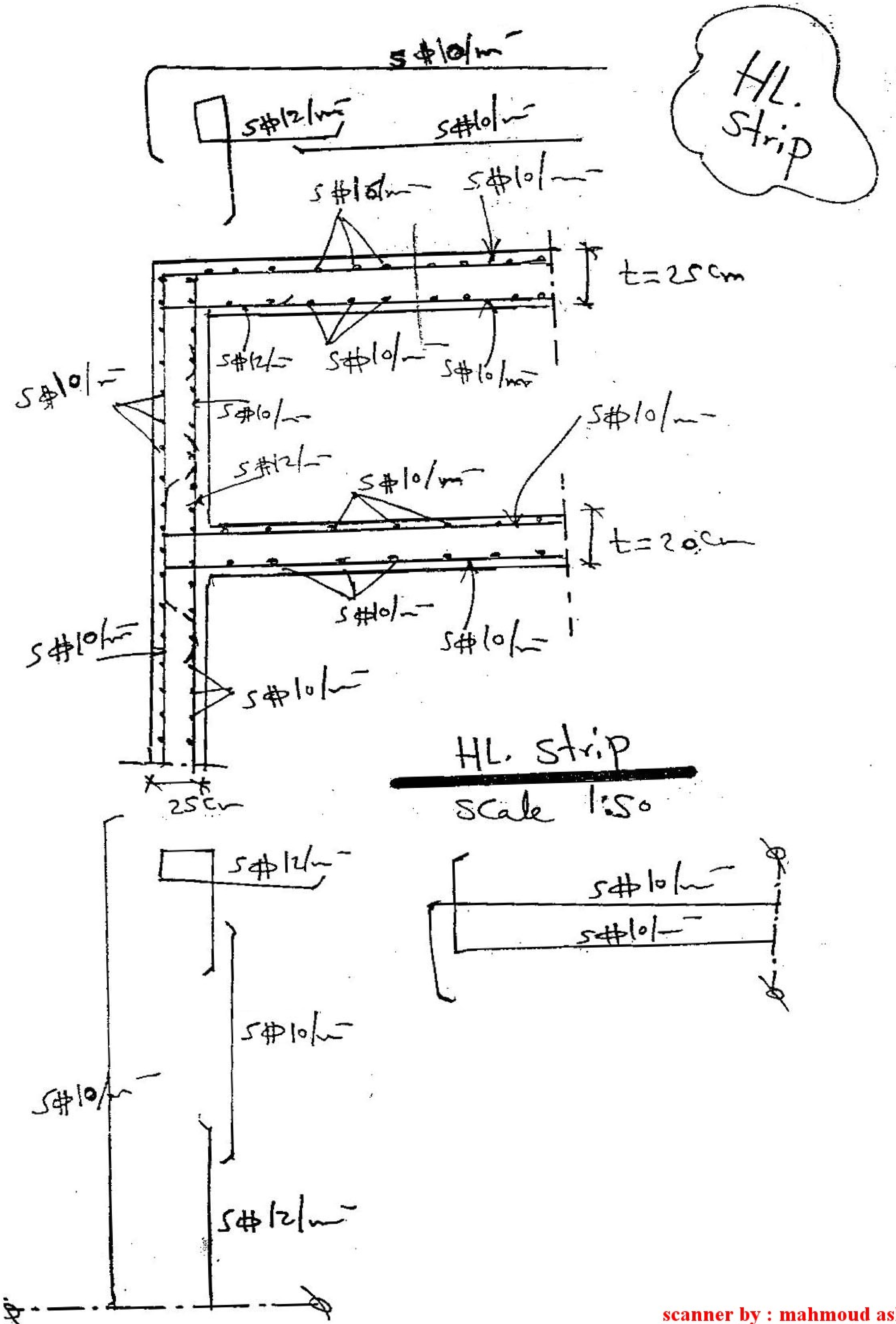
VL. Strip (2-2)



HL. Strip:


5Φ10/m
5Φ10/m
5Φ12/m
5Φ10/m
5Φ12/m
5Φ10/m
5Φ10/m
5Φ10/m
5Φ12/m
5Φ10/m
5Φ10/m

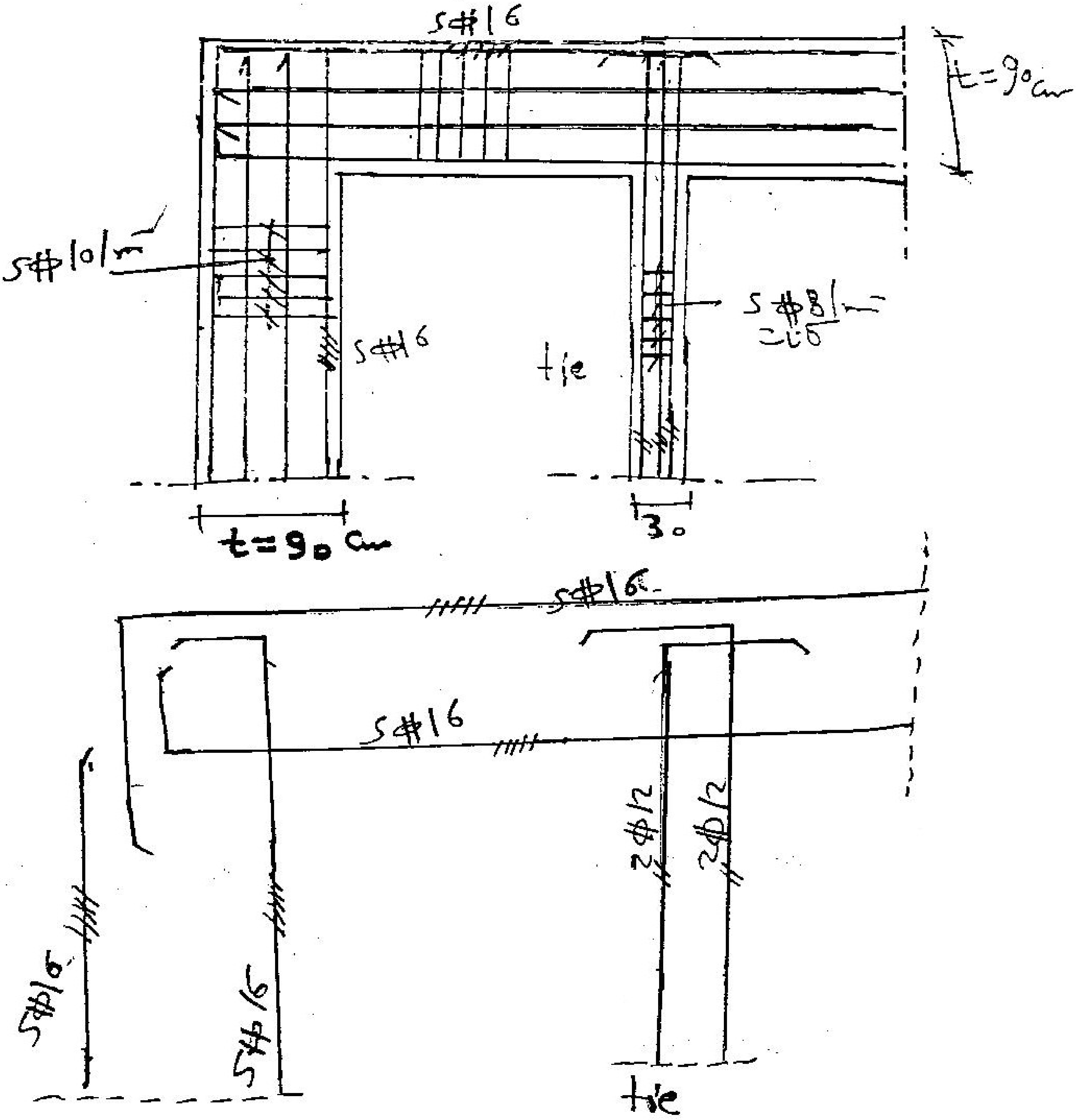




HL. Strip
Scale 1:50

Top beam

Scale 1:50



سنتر و مركز

الفارس

17 / ١ / ٢٠٠٨

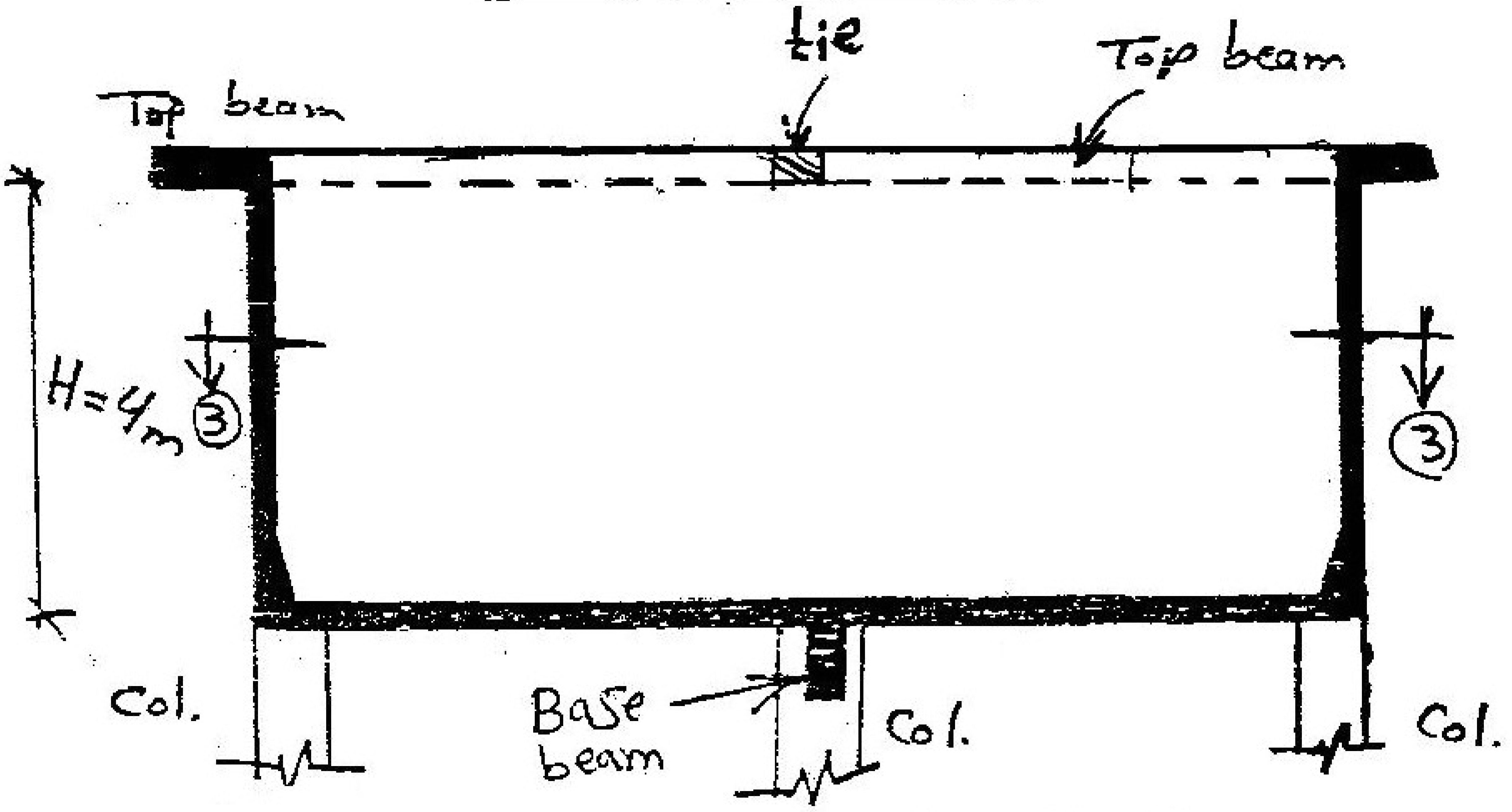
الفرقة الرابعة مدنى

Reinforced Concrete Water Tanks

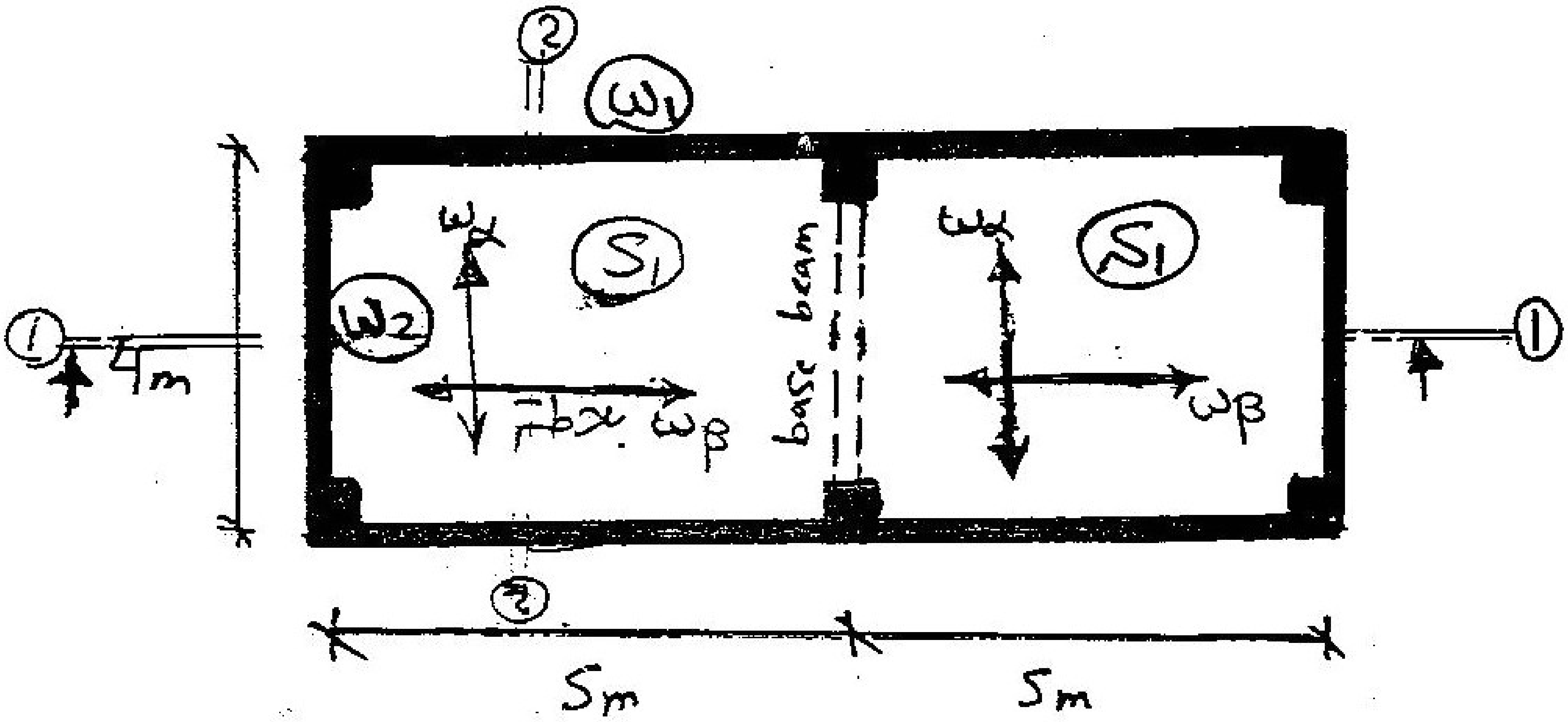
elevated

Revision Rectangular Tanks (1)

"Example" — REC. TANKS



Sec. elevation (1-1)



Section plan (3-3)

$f_{cu} = 250$ kg/cm²

Steel (36/52)

Solution :-

(1) Loads :

Walls $P_{total} = \gamma_w \cdot H_w = 4\ t/m^2$

base $w_{total} = t_b \cdot \gamma_{R.C} + \gamma_{water} H_w = 5\ t/m^2$

(2) load distribution :

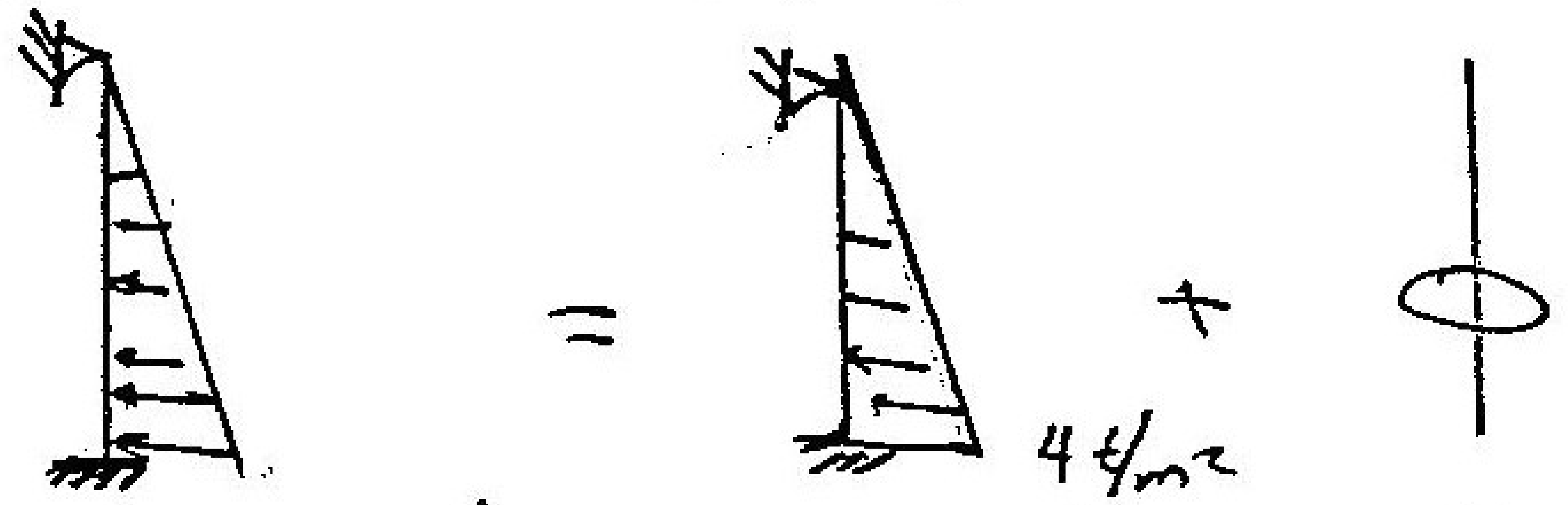
Walls

* لاتقسم الحائط للاحمال .

$\underline{W_1}$: $H = 4m$, $L = 10\ m$

$\frac{L}{H} = \frac{10}{4} > 2 \Rightarrow$ one way in VL.

كل الأحمال تسير في اتجاه رأسي . (Short direction)

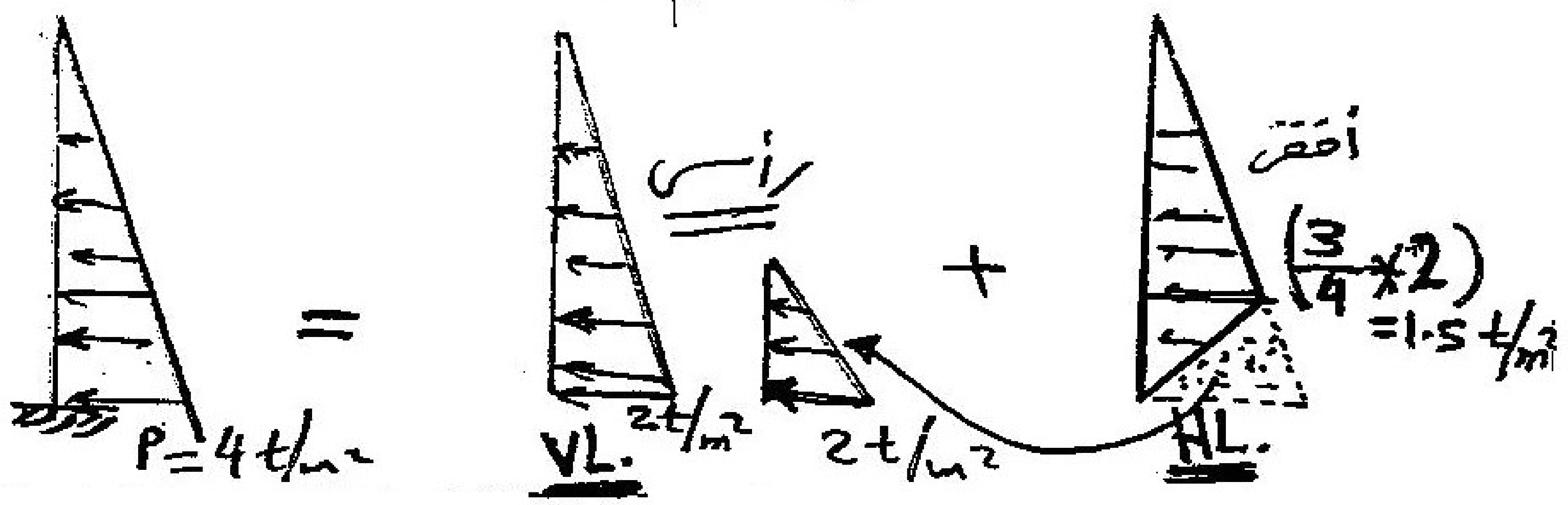


$P_{total} = 4\ t/m^2$ Vertical   Horizontal

$\underline{W_2}$: $H = 4m$, $L = 4m$

$\Rightarrow r = \frac{4}{4} = 1 \Rightarrow \alpha = \beta = 0.5$

$\therefore w_\alpha = w_\beta = \left(\frac{1}{2} * 4\right) = 2\ t/m^2$



base

$L_1 = 5m$, $L_2 = 4m$

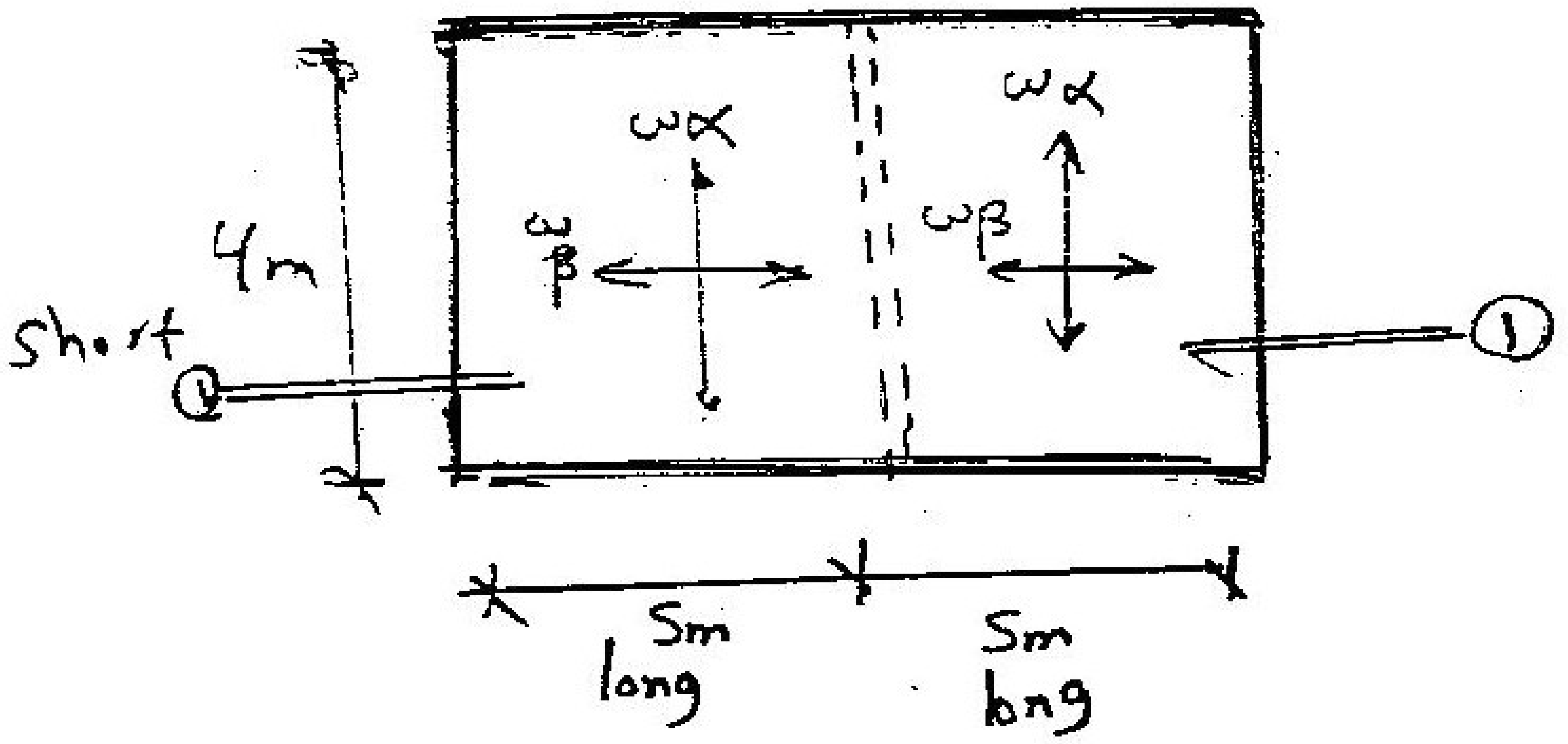
$r = \frac{5}{4} = 1.25 < 2$ ⇒ two way slab

⇓

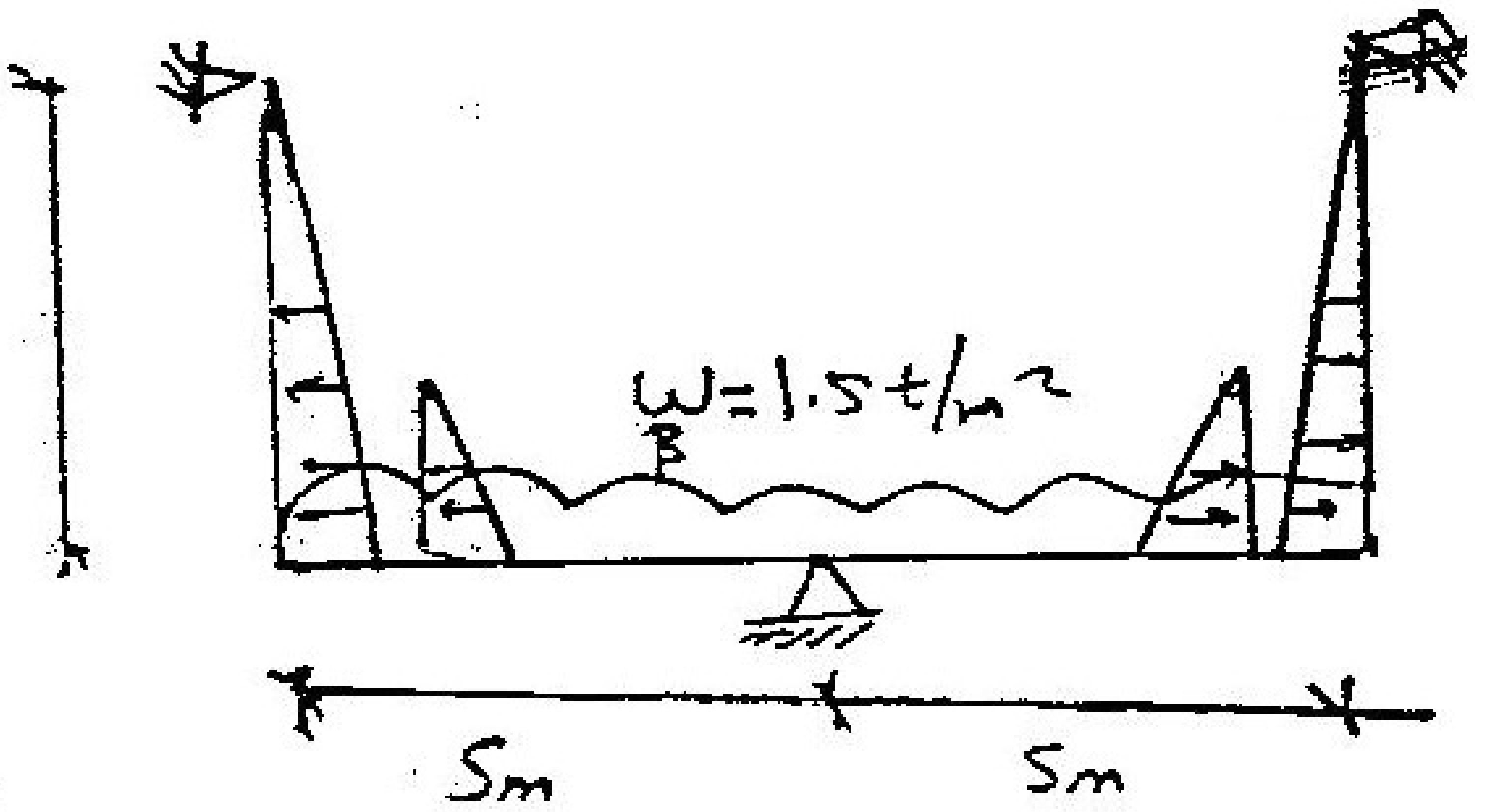
$\therefore \alpha = 0.7$, $\beta = 0.3$

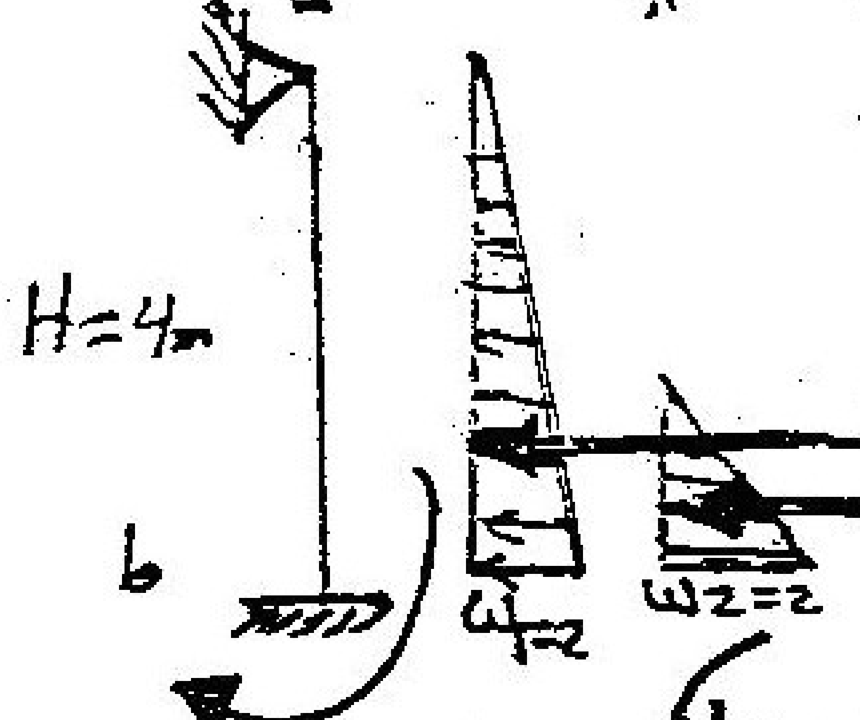
$\therefore w_\alpha = 0.7 * 5 = 3.5\ t/m^2$ (الاتجاه القصير)

$w_\beta = 0.3 * 5 = 1.5\ t/m^2$ (الاتجاه الطويل)



VI. Strip: ①—①



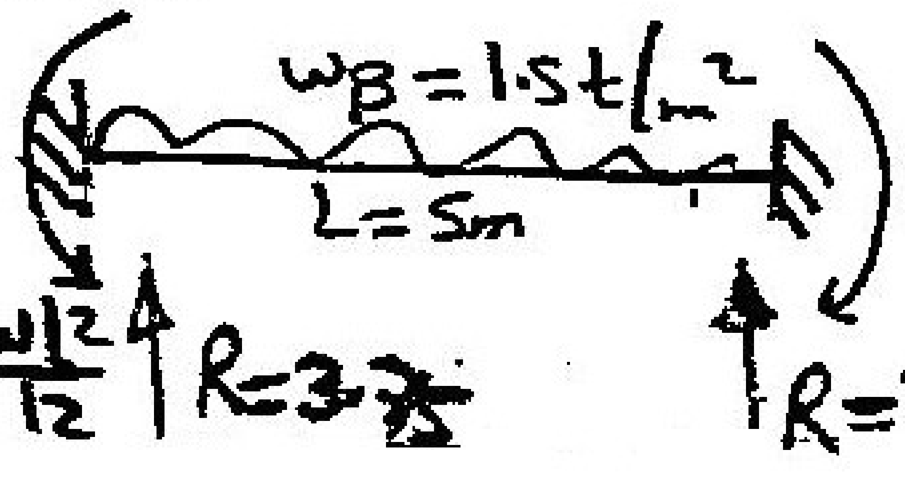


$F_1 = \frac{1}{2} * 2 * 4 = 4$ ton

$F_2 = \left(\frac{1}{2} * 2 * \frac{4}{4}\right) = 1$ ton

$\frac{w_1 \cdot H^2}{15} + \frac{w_2 \cdot H^2}{117}$

$= 2.4$ t.m



$\frac{wl^2}{12} = \frac{1.5 * 5^2}{12} = 3.12$ t.m

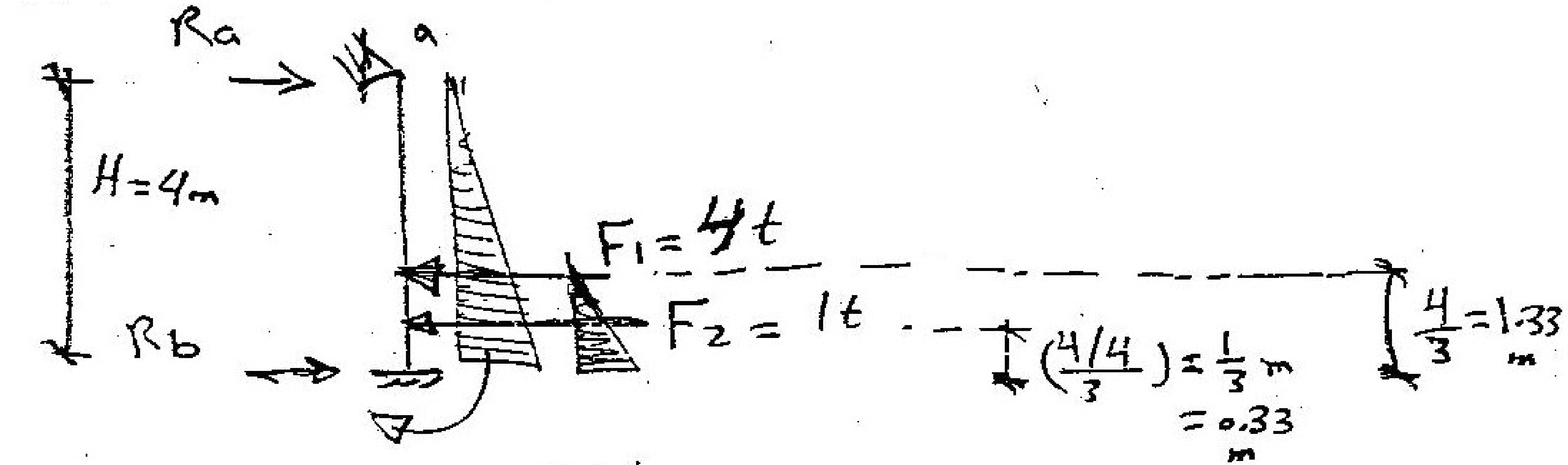
يمكن أخذ $M_{average}$

To get reactions.

Moment distribution تقريباً بدلاً من

$$M_{avg} = \left(\frac{M_{wall} + M_{base}}{2}\right) = \frac{2.4 + 3.12}{2}$$

$$= 2.76 \ t.m/m$$



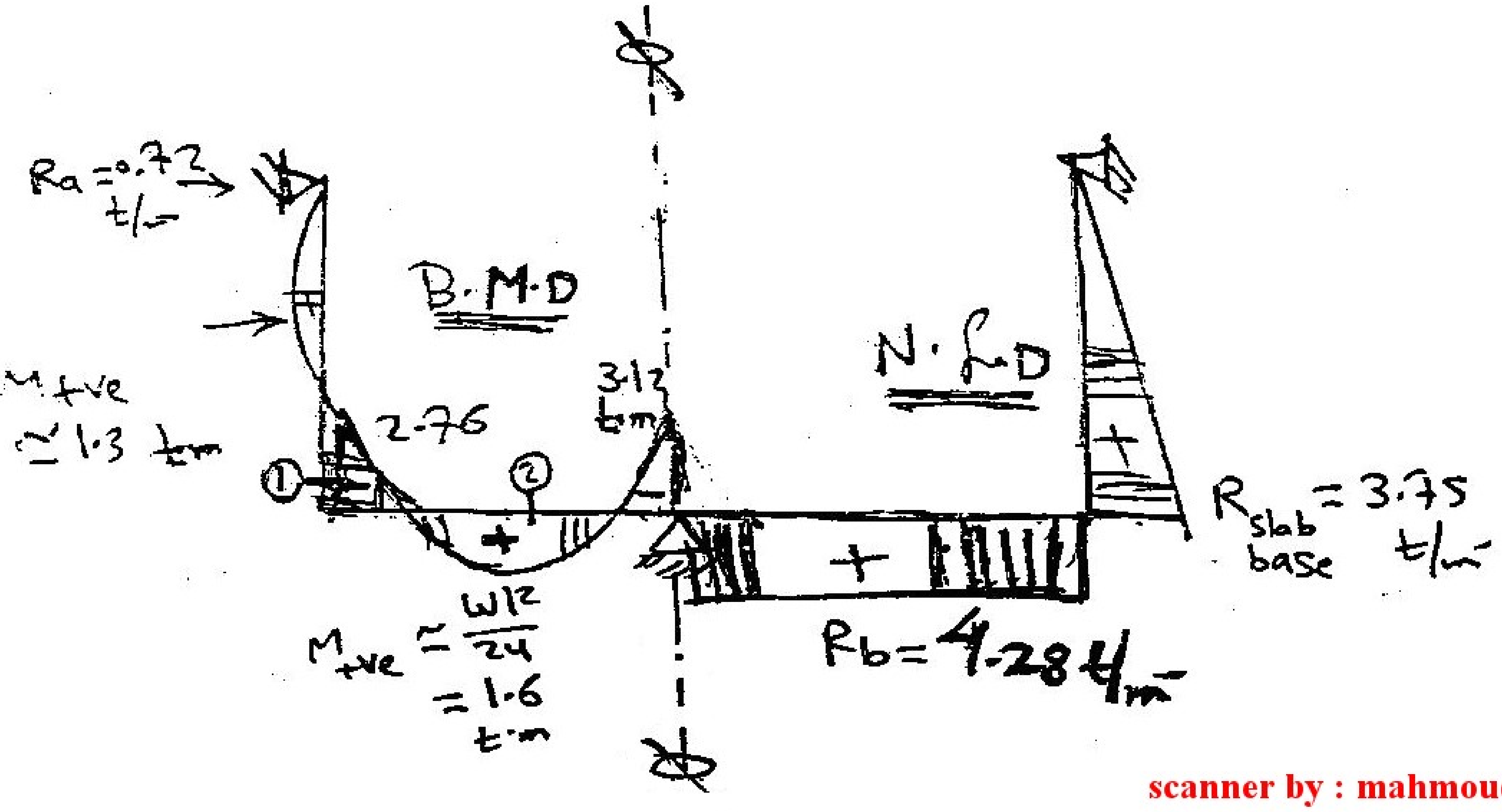
$M_{avg} = 2.76$ t.m

$$\Sigma M_b = 0 \Rightarrow (4 * 1.33) + (1 * 0.33) - 2.76 - Ra * 4 = 0$$

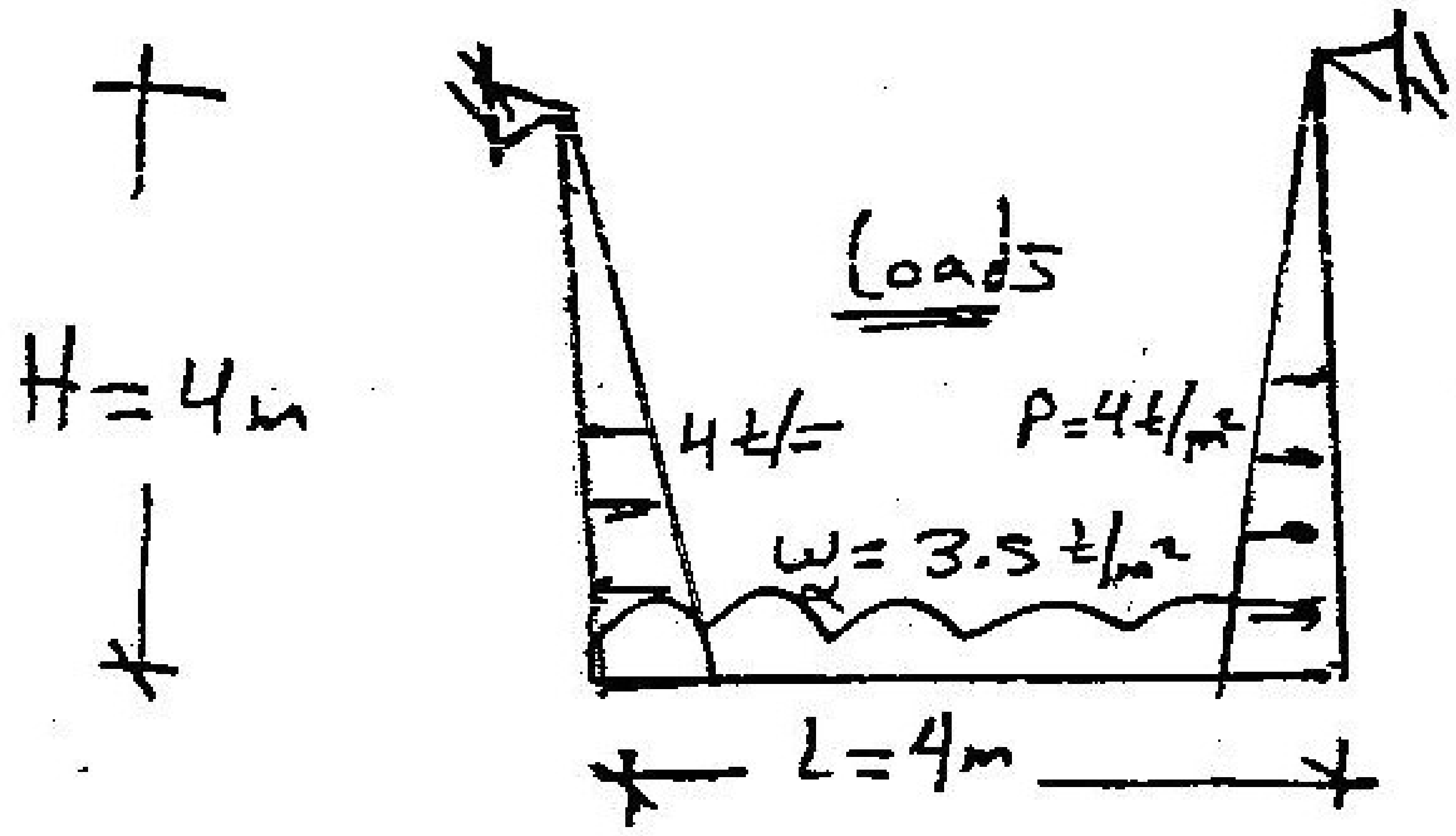
$$\therefore Ra = 0.72 \ t/m$$

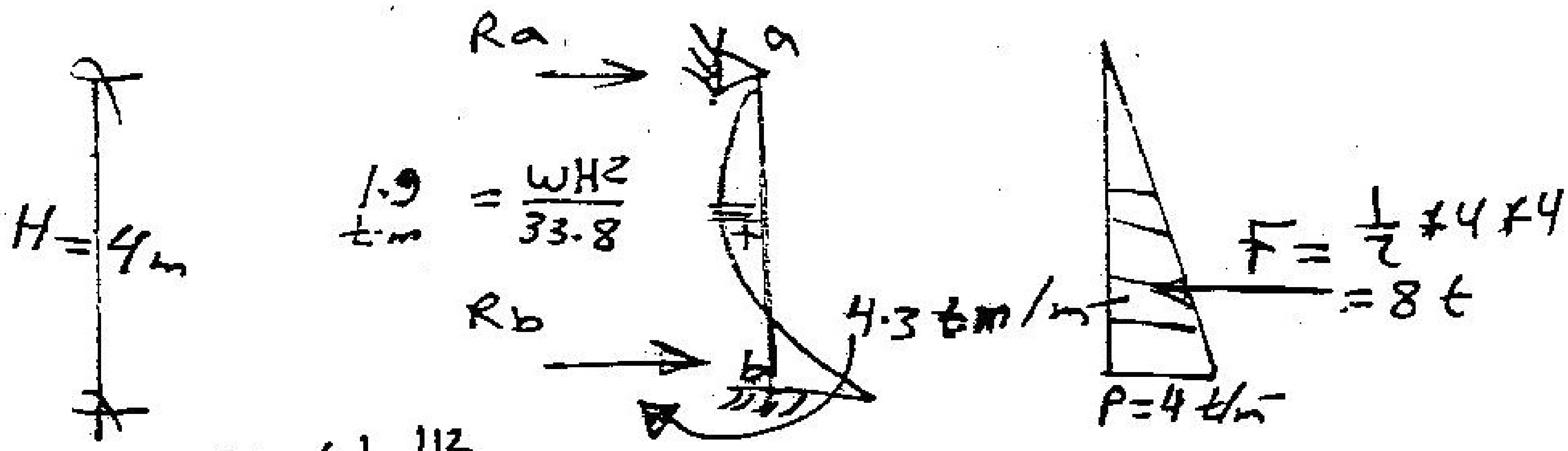
$$\Sigma fx = 0 \Rightarrow 4 + 1 = Ra + Rb$$

$$\therefore Rb = 4.28 \ t/m$$



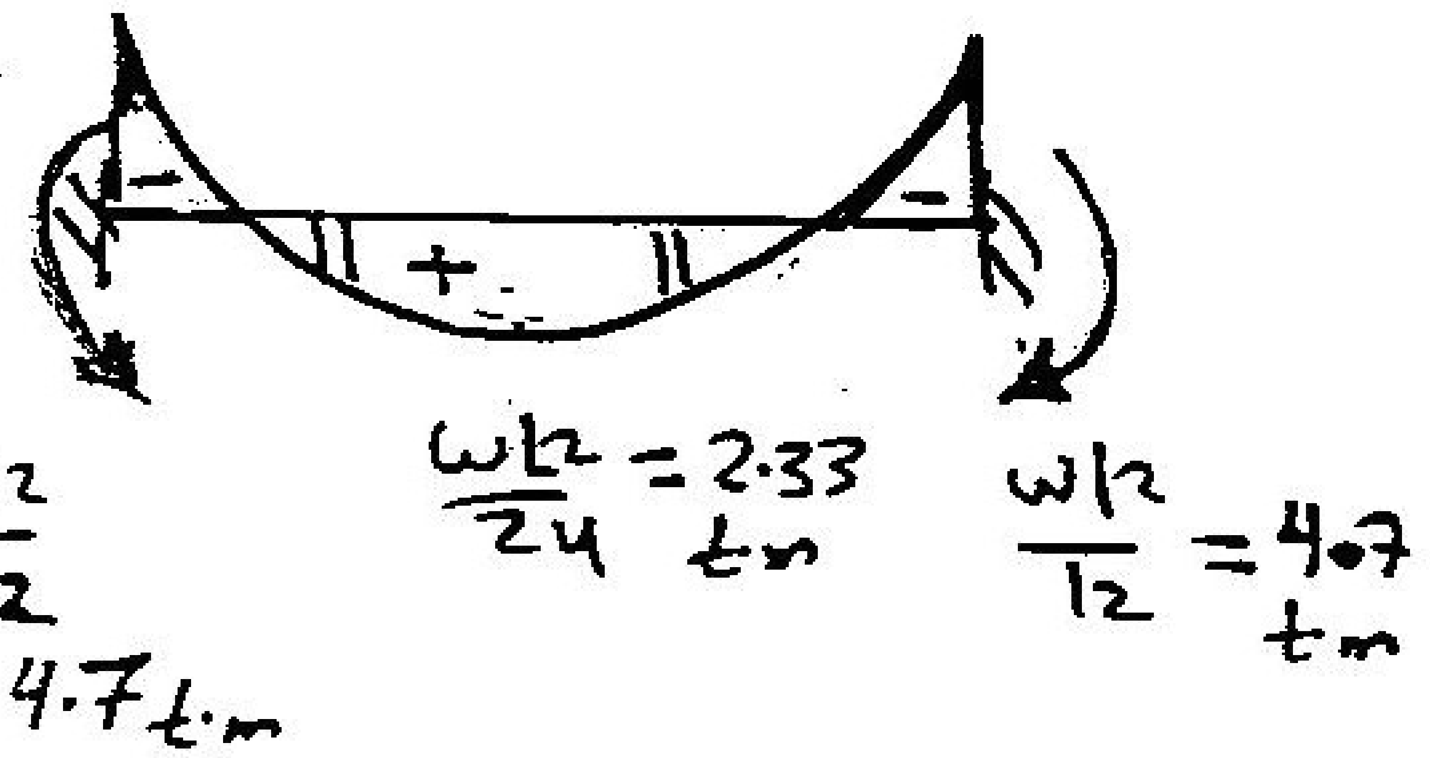
VL. Strip (2-2) :





$$M_{f\,wall} = \frac{w \cdot H^2}{15}$$

$$= \frac{4 * 4^2}{15} = 4.3$$

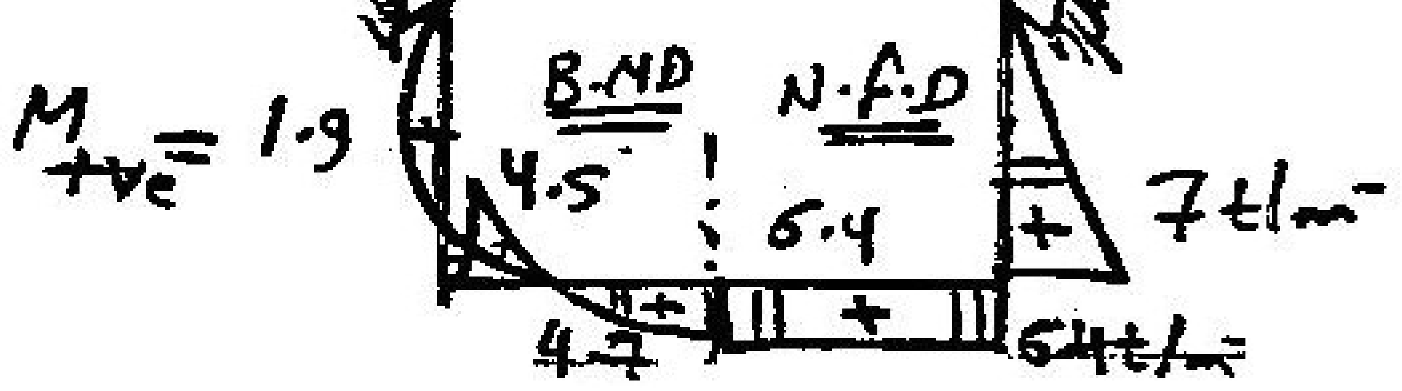


$$M_{avg} = \left(\frac{4.3 + 4.7}{2}\right) = 4.5 \ t.m/m$$

$$\Sigma M_b = 0 \Rightarrow Ra * 4 + 4.3 - 8 * \frac{4}{3} = 0$$

$$\therefore Ra = 1.6 \ t/m$$

$$\Sigma f_y = 0 \Rightarrow R_b = 6.4 \ t/m$$



* Design VL. strip. (1-1)

sec ①: $M_{water\ side} = 2.76\ t.m/m$, $T = 3.75\ t/m$

stage (I) $t = \sqrt{\frac{2.76 \times 10^5}{3.2 \times 100}} + 5 = 40\ cm$

stage (II) → e^{Tu}, e_s, M_u = ←, M_{us}, R_1

→ ω, A_s = ←

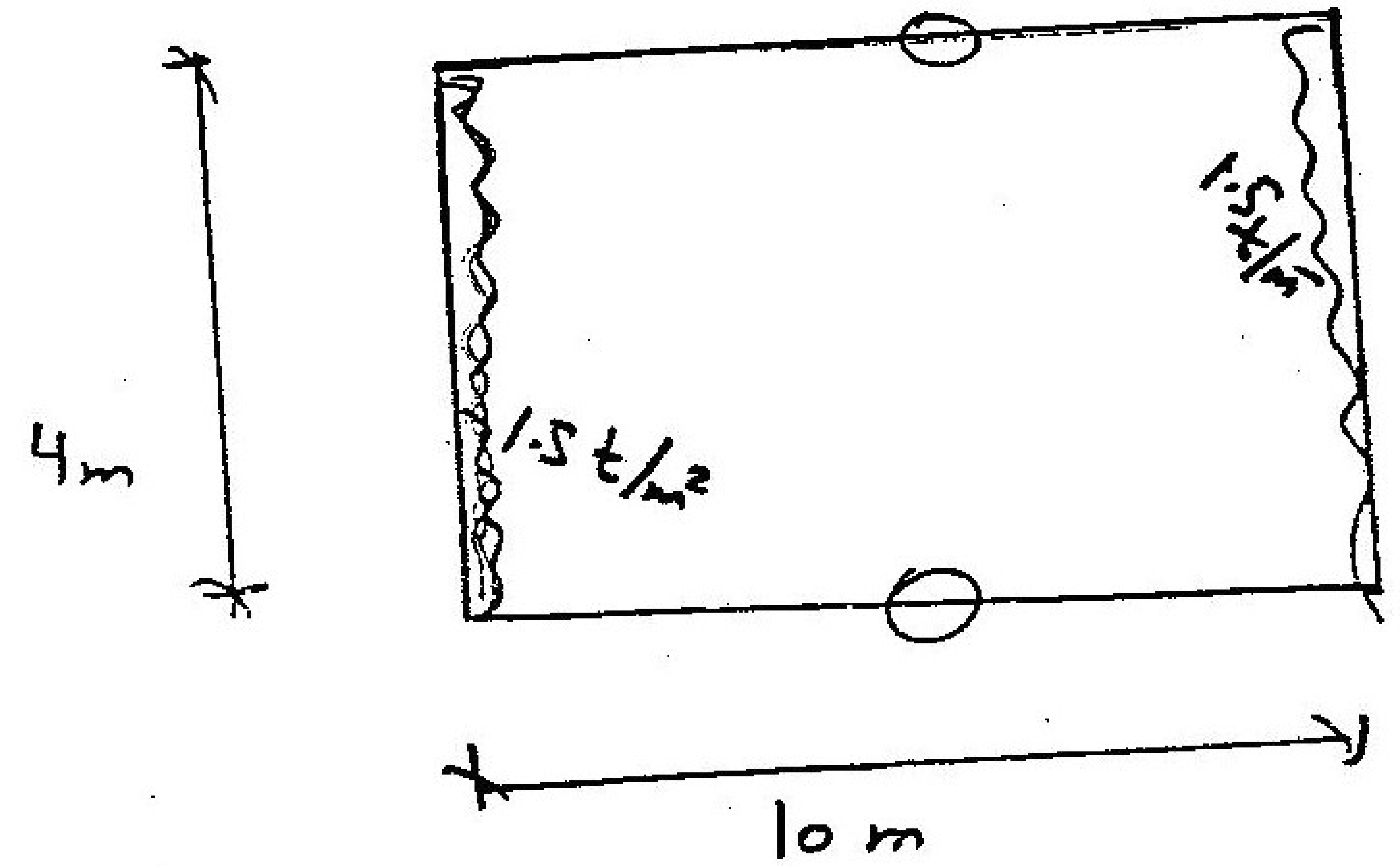
∴ use 5 Φ16/m

sec ②: Air side.
$M = 1.6\ t.m$, $T = 4.28\ t/m$

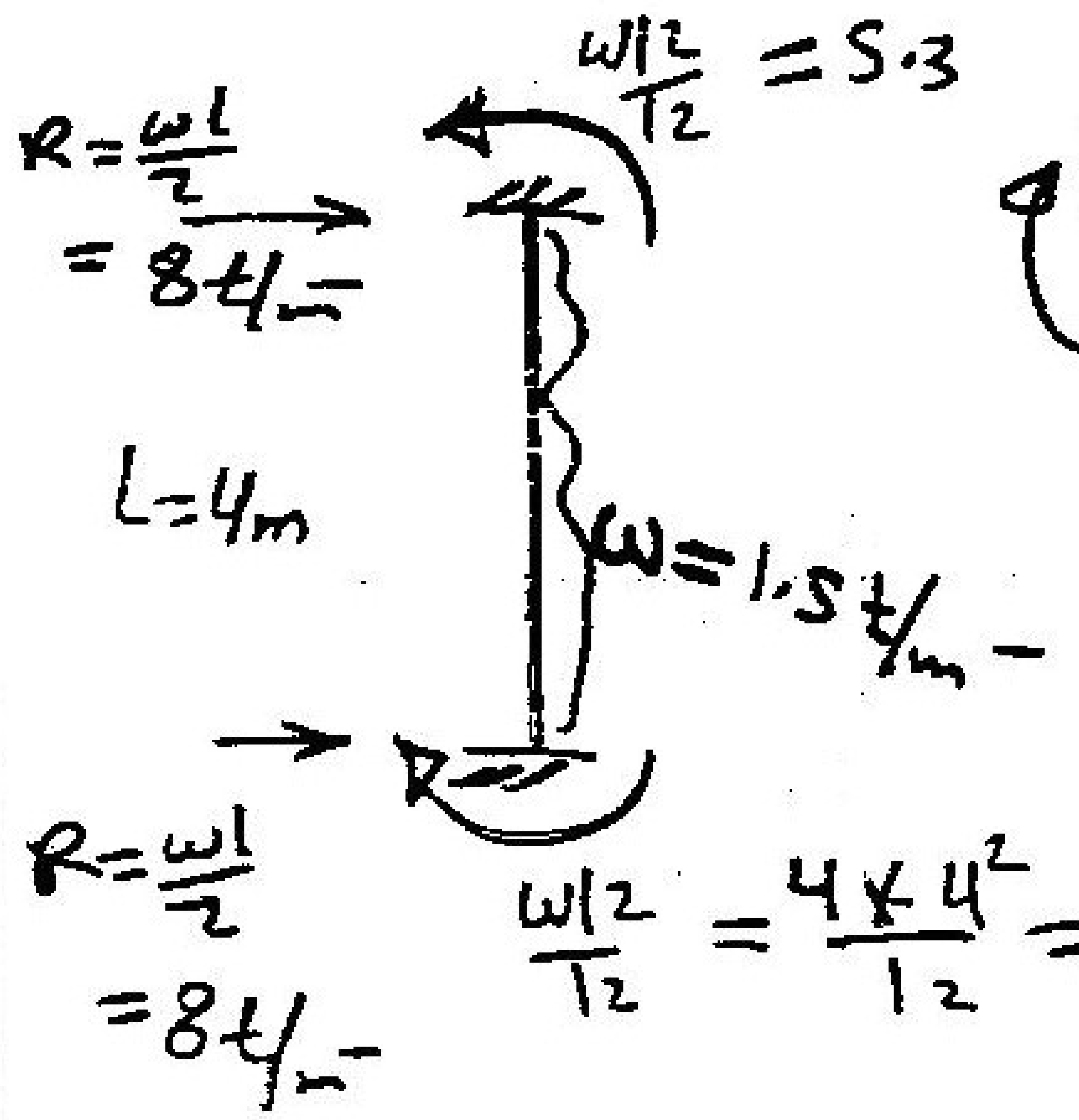
use $t = 25\ cm$

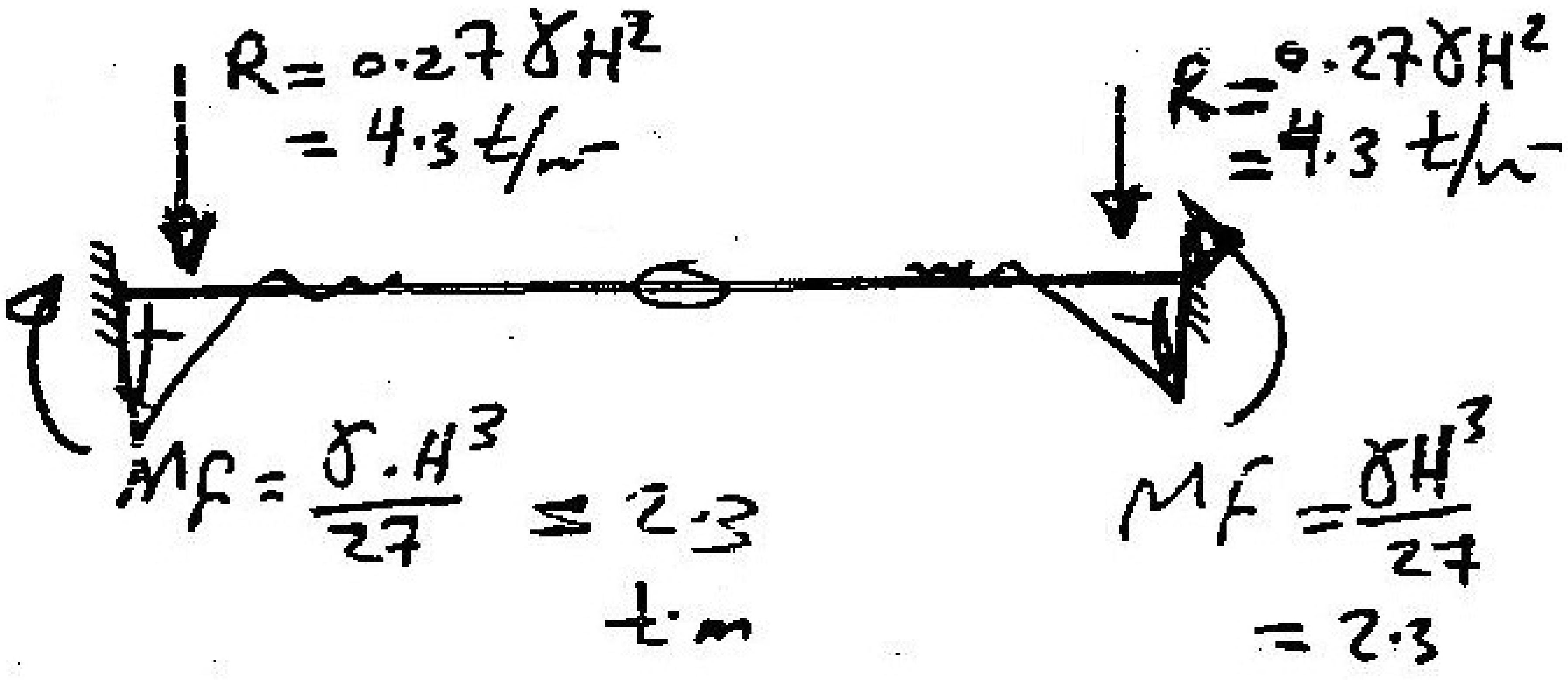
$A_s = 5\ \Phi 12/m$

* HL. strip :-



لاحظ أنه لا يقسم حائط إلا حائط عمودي عليه.





في حالة ان الحائط في الاتجاه الافقي لا يوجد عليه أحمال نهائياً .

∴ بنأخذ قيمة عزم تقريبي

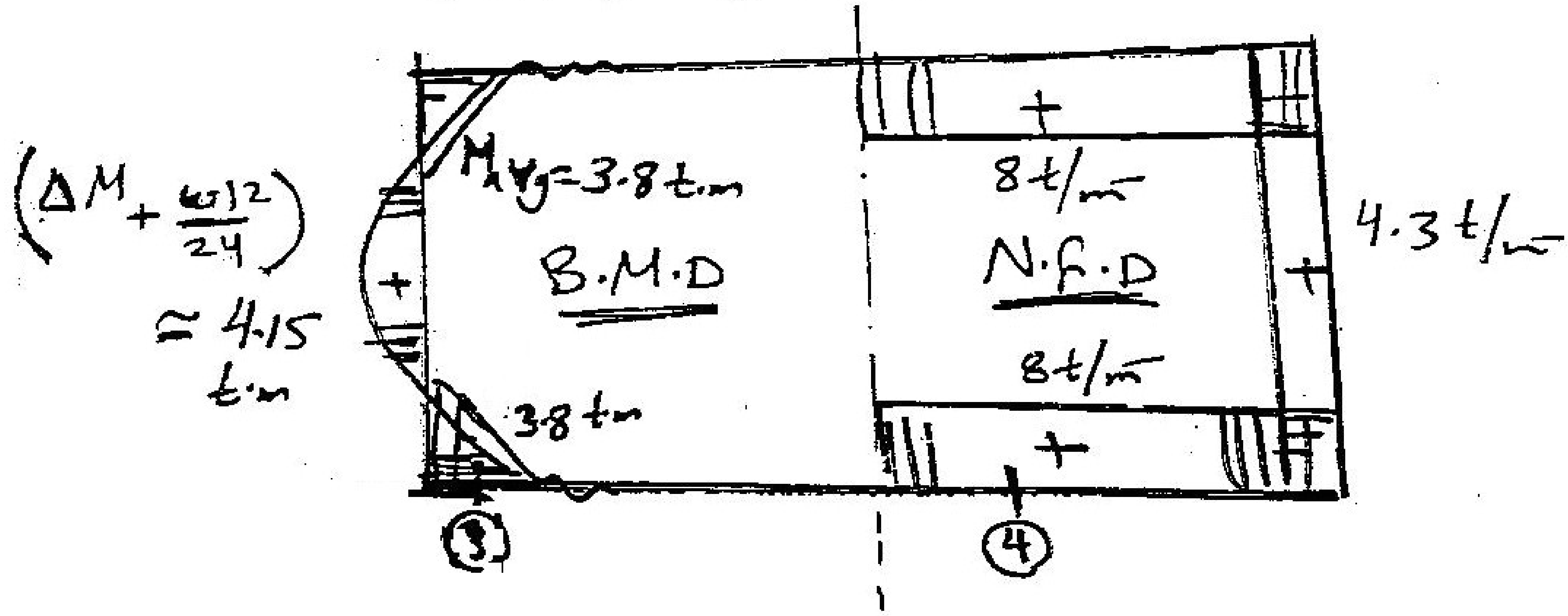
تحقق ⟹ ★ $M_f = \left(\frac{\gamma H^3}{27}\right) = 2.3\ t.m/m$

ورد فعل تقريبي

★ $R = \left(0.27\,\gamma H^2\right) = 4.3\ t/m$

$$M_{avg} = \left(\frac{5.3 + 2.3}{2}\right) = 3.8\ t.m/m$$

$$\therefore \Delta M = 5.3 - 3.8 = 1.5\ t.m$$



Design: (Hl. strip)

Sec (3)

$M_{\text{water side}} = 3.8\ t.m/m^{-}, \quad T = 8\ t/m^{-}$

Stage (I)

$$t = \sqrt{\frac{3.8 * 10^5}{3.2 * 100}} + 5 = 40\ cm$$

Stage (II) $A_s = 5 \# 16/m^{-}$

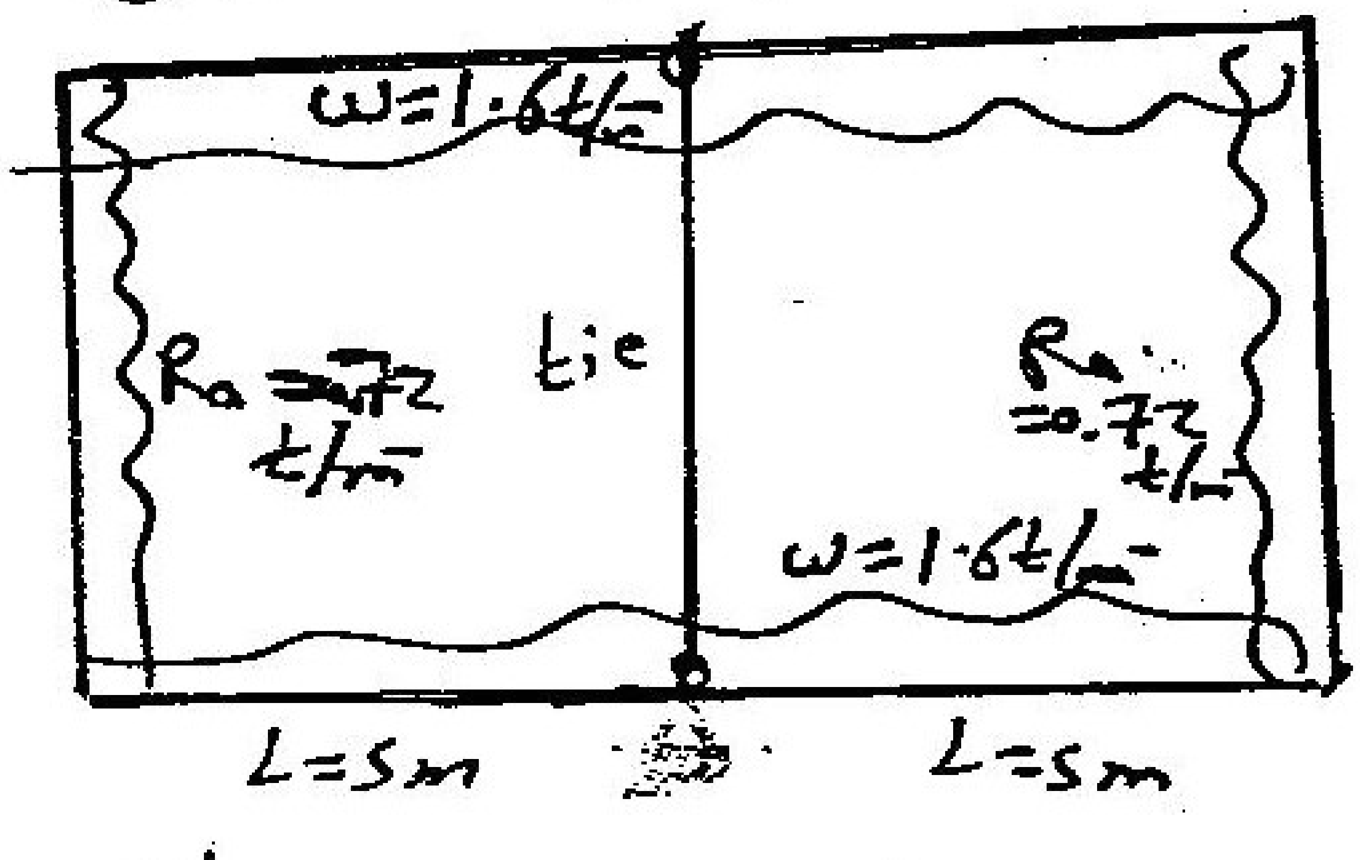
Sec (4) Tension only $T = 8\ t/m^{-}$

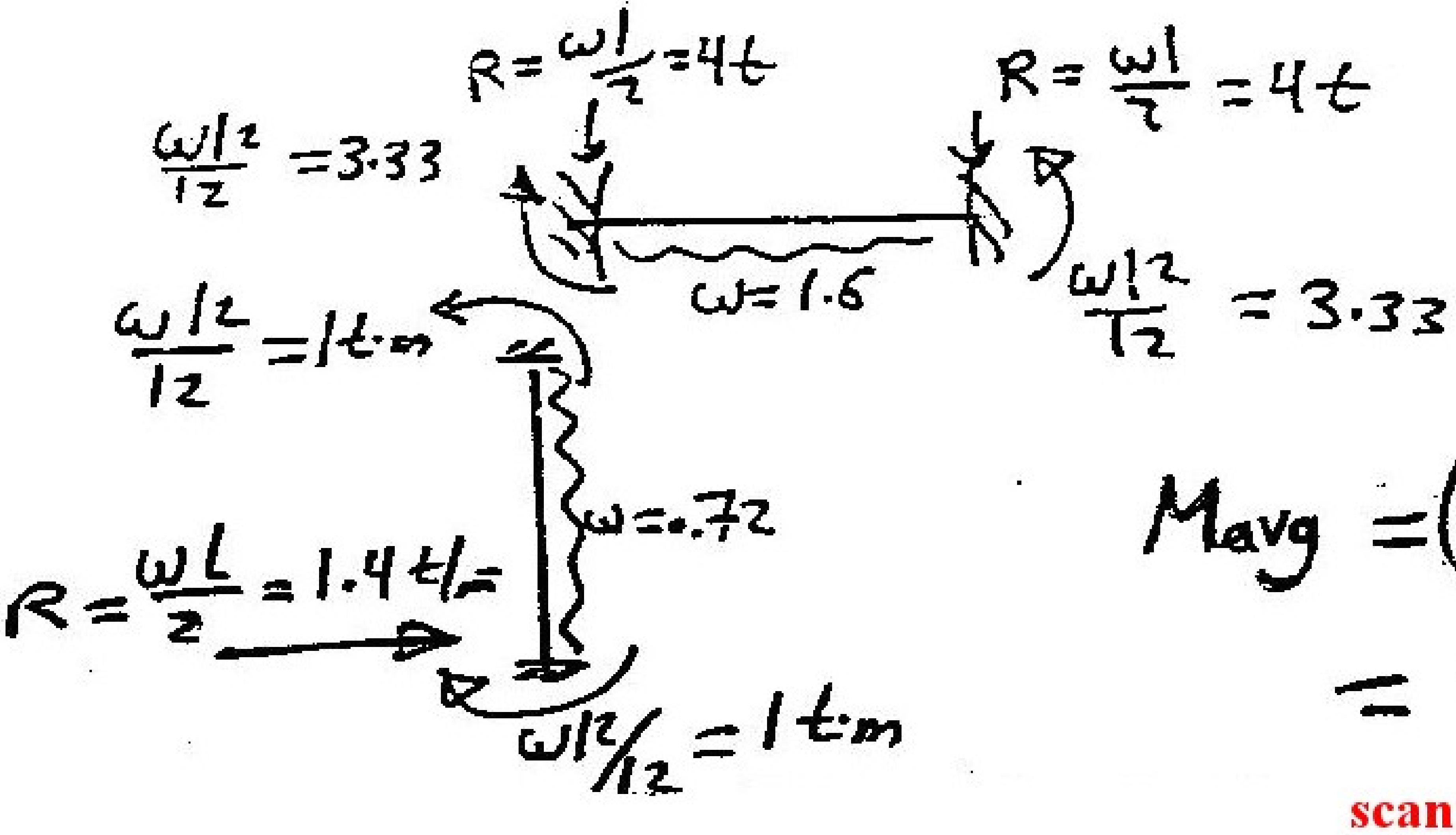
use $t = 25\ cm.$

$\left(\frac{A_s}{2}\right) = 5 \# 10/m^{-}$ each side.

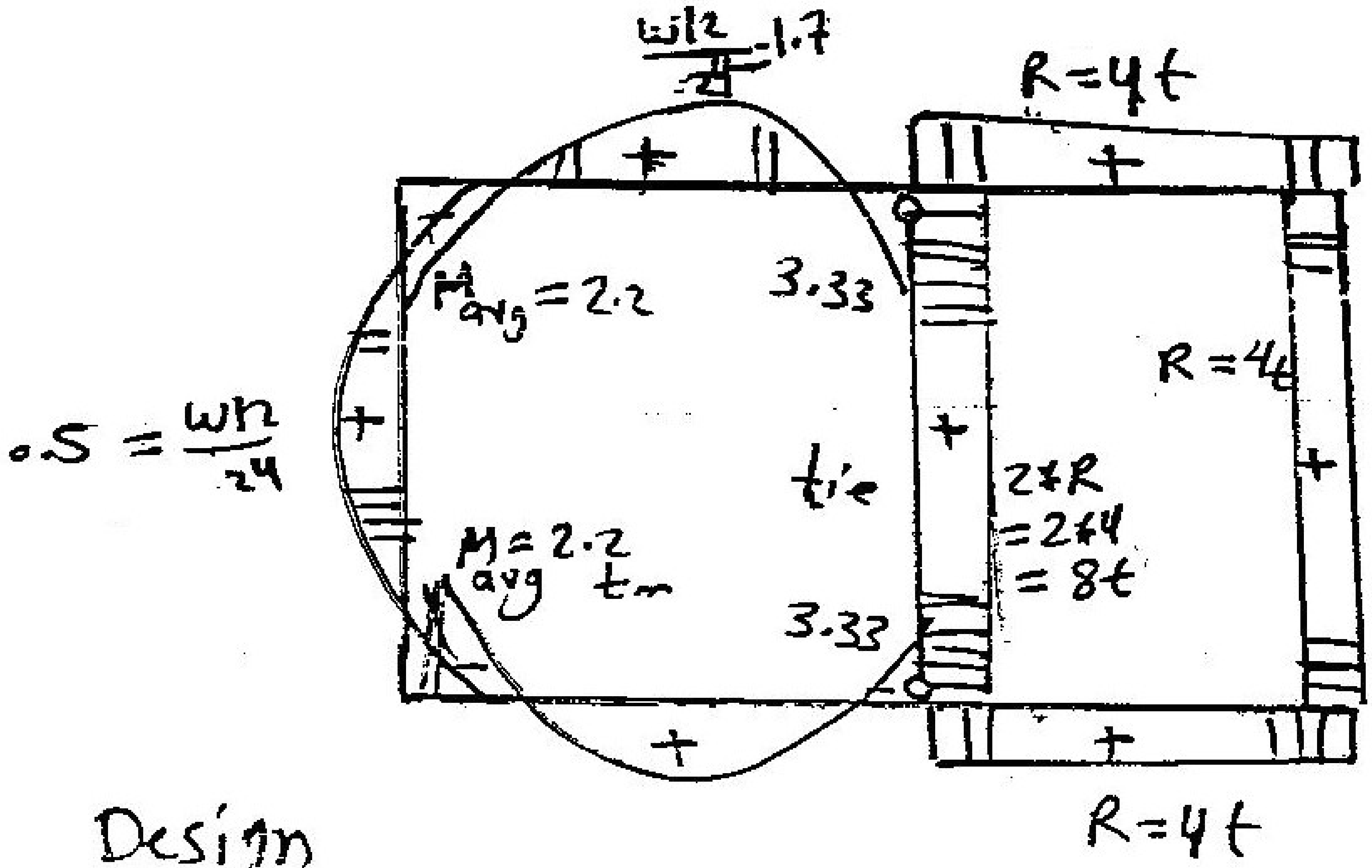
(Top beam): (Top beam فقط)

* الـ (tie) لا يدخل إلا في حل أ
حيث أنه يعتبر رابطة لها





$$M_{avg} = \left(\frac{3.33 + 1}{2}\right) = 2.2\ t.m$$



Design

$M_{max} = 2.2$ tm , T = 4 ton
water side

Stage (I) use $t = \sqrt{\frac{2.2 * 10^5}{3.2 * 30}} + 5 = 60$ cm

use b = 30 cm

Stage (II) ∵ $e = \frac{M_u}{T_u}$

∴ e_s = ← , M_{us} = ←

∴ R_1 = ← , ω = ←

∴ As = ←

∴ use = 3 Φ 16

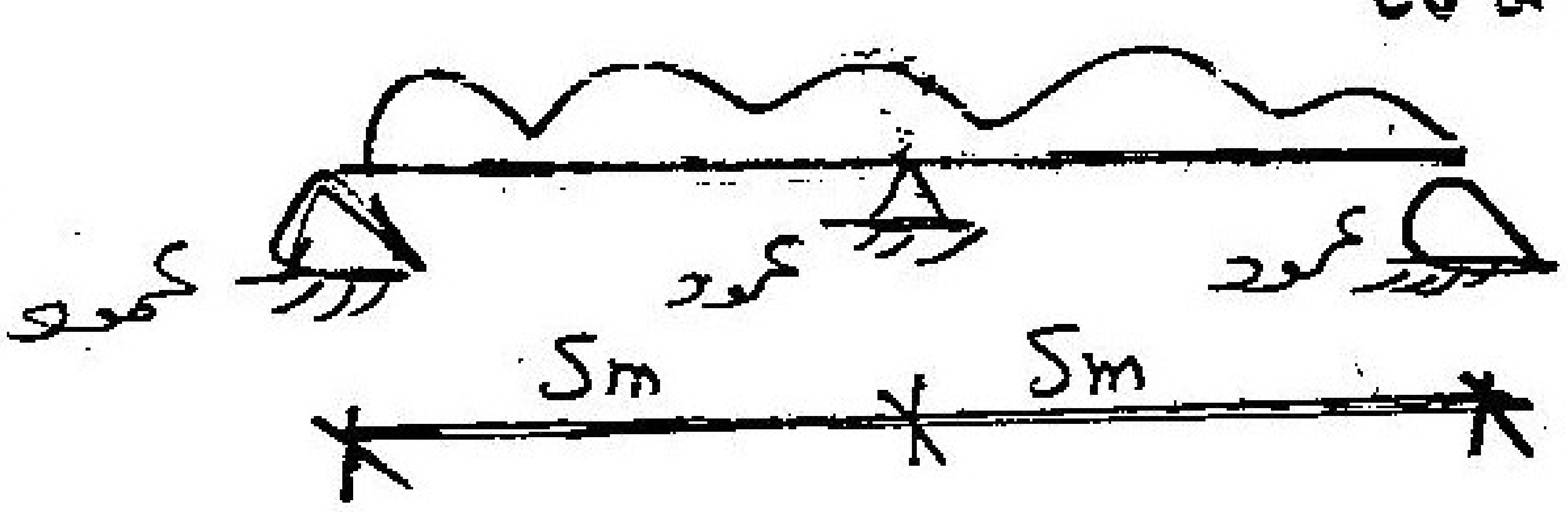
Tie T only = 8t

min use 30 * 30  30 = t cm

$As = \frac{T_u * 10^3}{f_y / \gamma_s} = \frac{1.5 * 8 * 10^3}{(3600/1.15)} = 4 \Phi 12$

deep beam Wall at beam (W_1)

Continous $\frac{H}{L} = \frac{4}{5} = 0.8 > 0.4 \Rightarrow$ deep



$W_u = 1.5$ (own wt + tap beam + R_{slab})

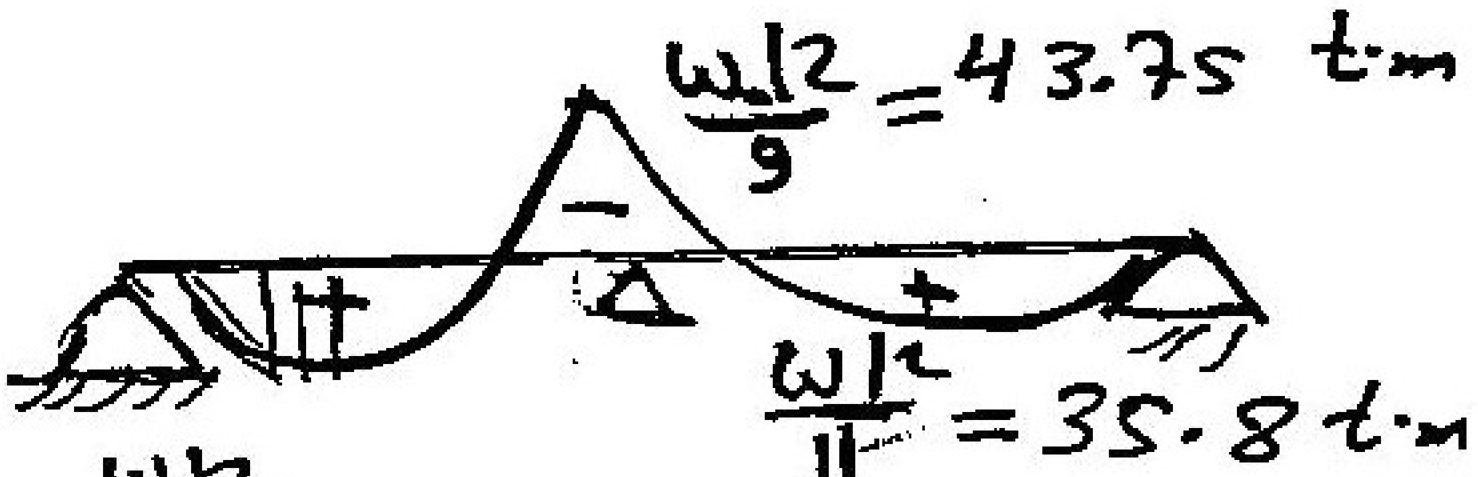
Ultimate تأثير الـ

tap beam: $b.t.\gamma_{RC}$ = $0.3 * 0.6 * 2.5$

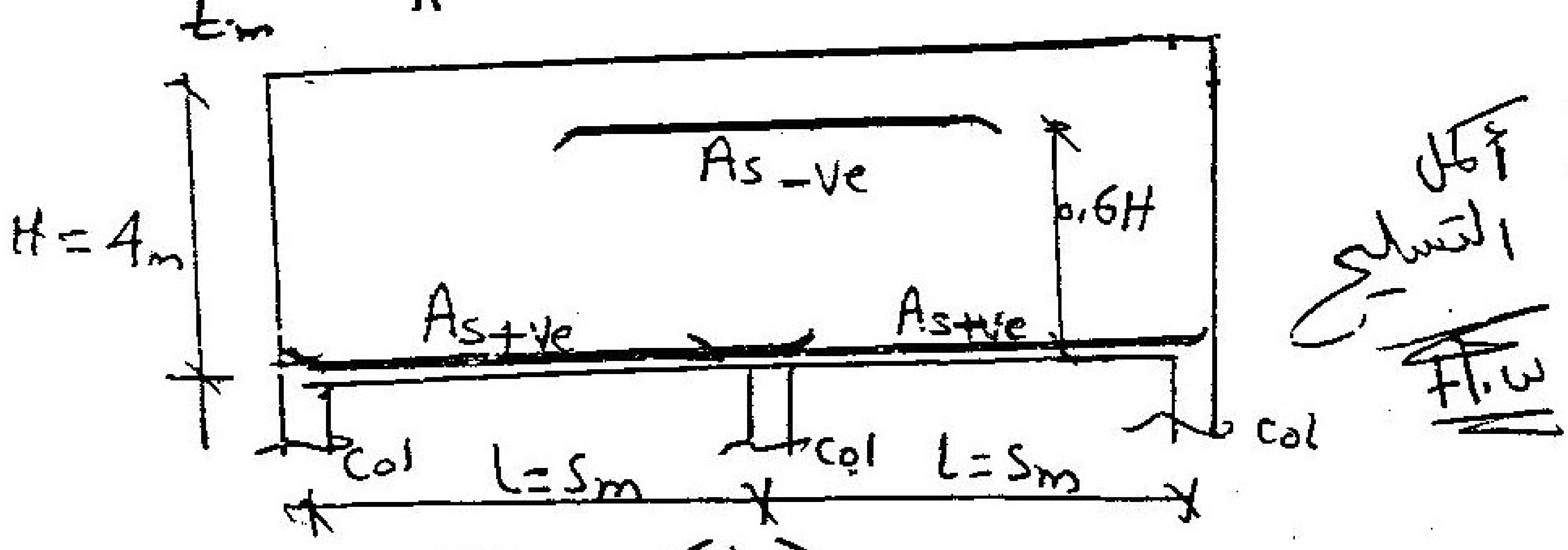
$= 1.5\,(0.25 * 4 * 2.5 + 0.5 + 7)$

(t, H, γ_{RC}) — 0.5 فرض — 7 من الشريحة VL. strip (2-2)

$\therefore W_u = 15.75\ t/m$



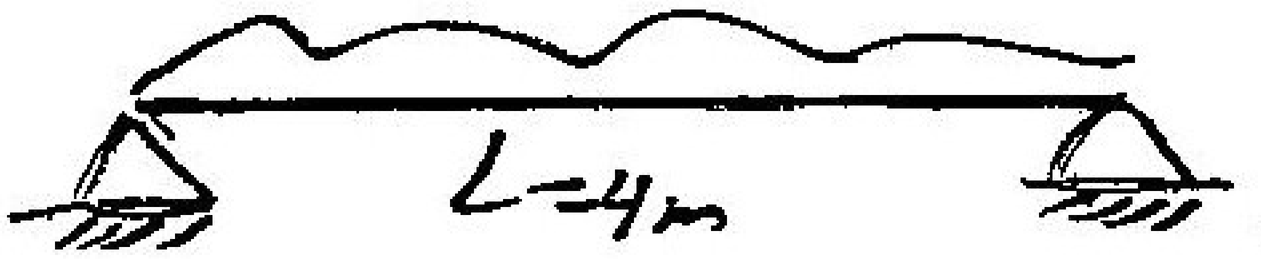
$35.8\ t.m = \frac{wl^2}{11}$



$y_{ct} = 0.43\ L \Leftarrow$ M+ve | M-ve $\Rightarrow y_{ct} = 0.37\ L$

base beam. — كمرة القاعدة (عادية)

$W = \text{own wt} + R_{slab}$



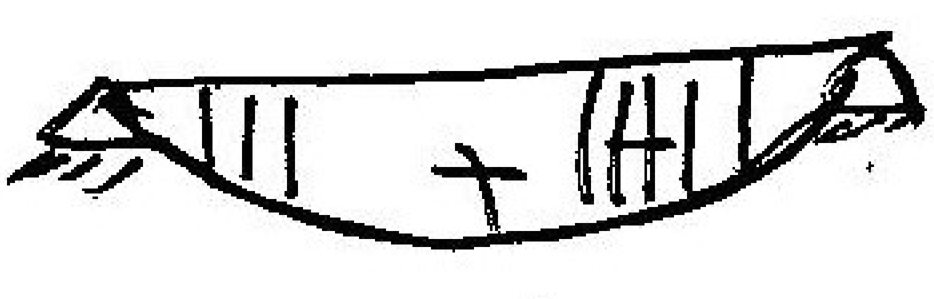
∴ Assume own wt = 1 t/m

∴ $R_{slab} = 2 * 3.75 = 7.5$ t/m

لأنها كمرة داخلية تتحمل reaction لـ 1m من البلاطة يمين ويسار

∴ $W = 1 + 7.5 = 8.5$ t/m

∴ $W_u = 1.5 * 8.5 = 12.75$ t/m



$M_u = \frac{wL^2}{8} = 25.5$ t.m

⇓

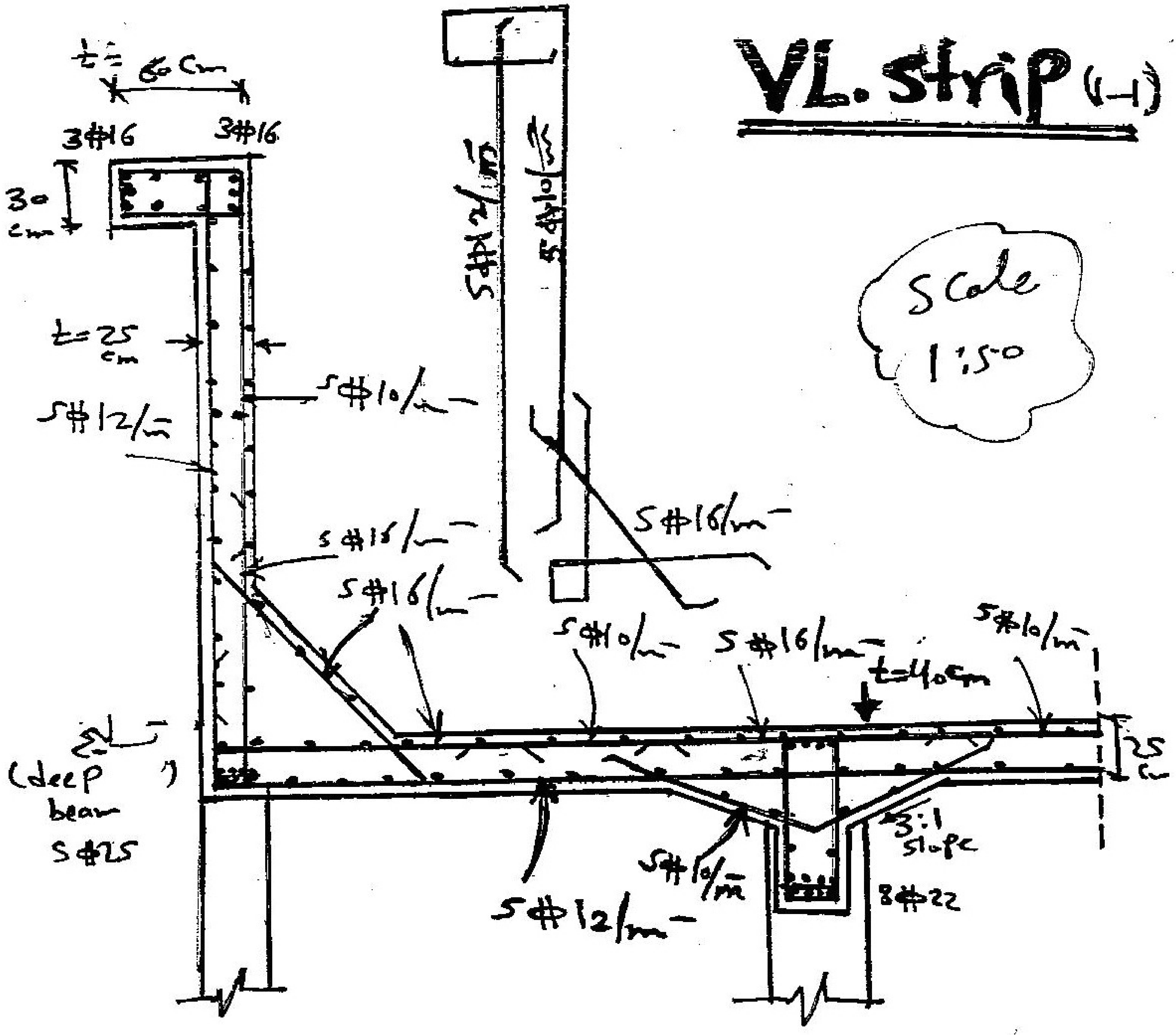
صمم كمرة عادي مثل سنة ٣ مدني

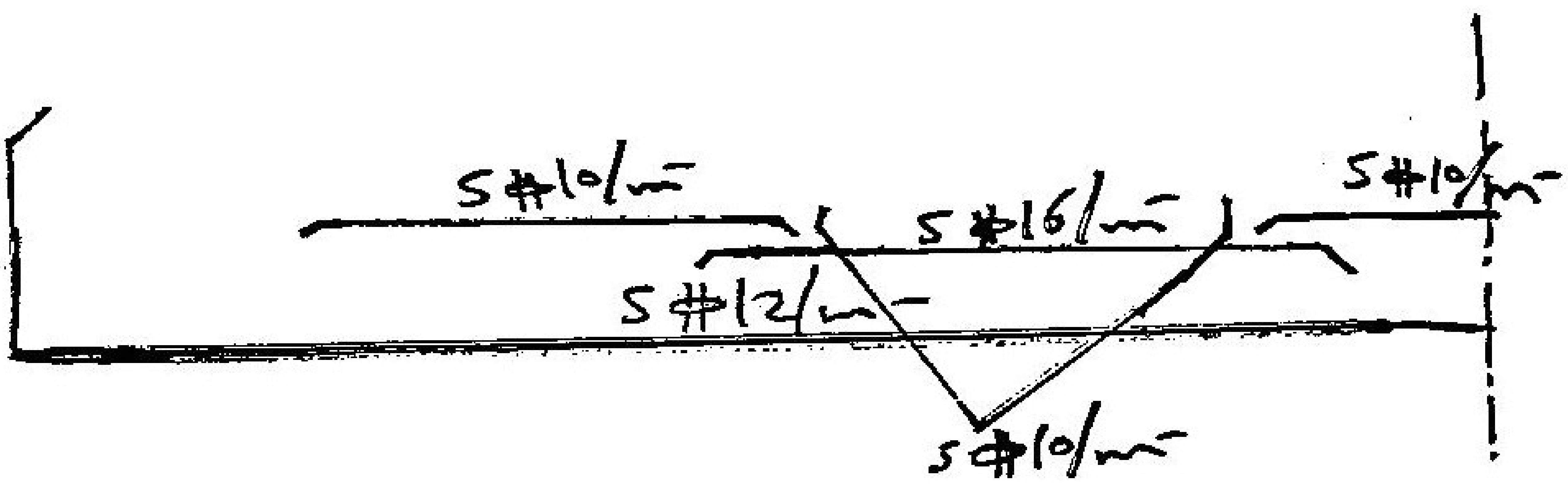
$R_1 = \frac{M_u}{f_{cu} \cdot b \cdot d^2} = \text{—} \Rightarrow \omega = \text{—}$

$A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d \nless \frac{11}{f_y} \cdot b \cdot d$

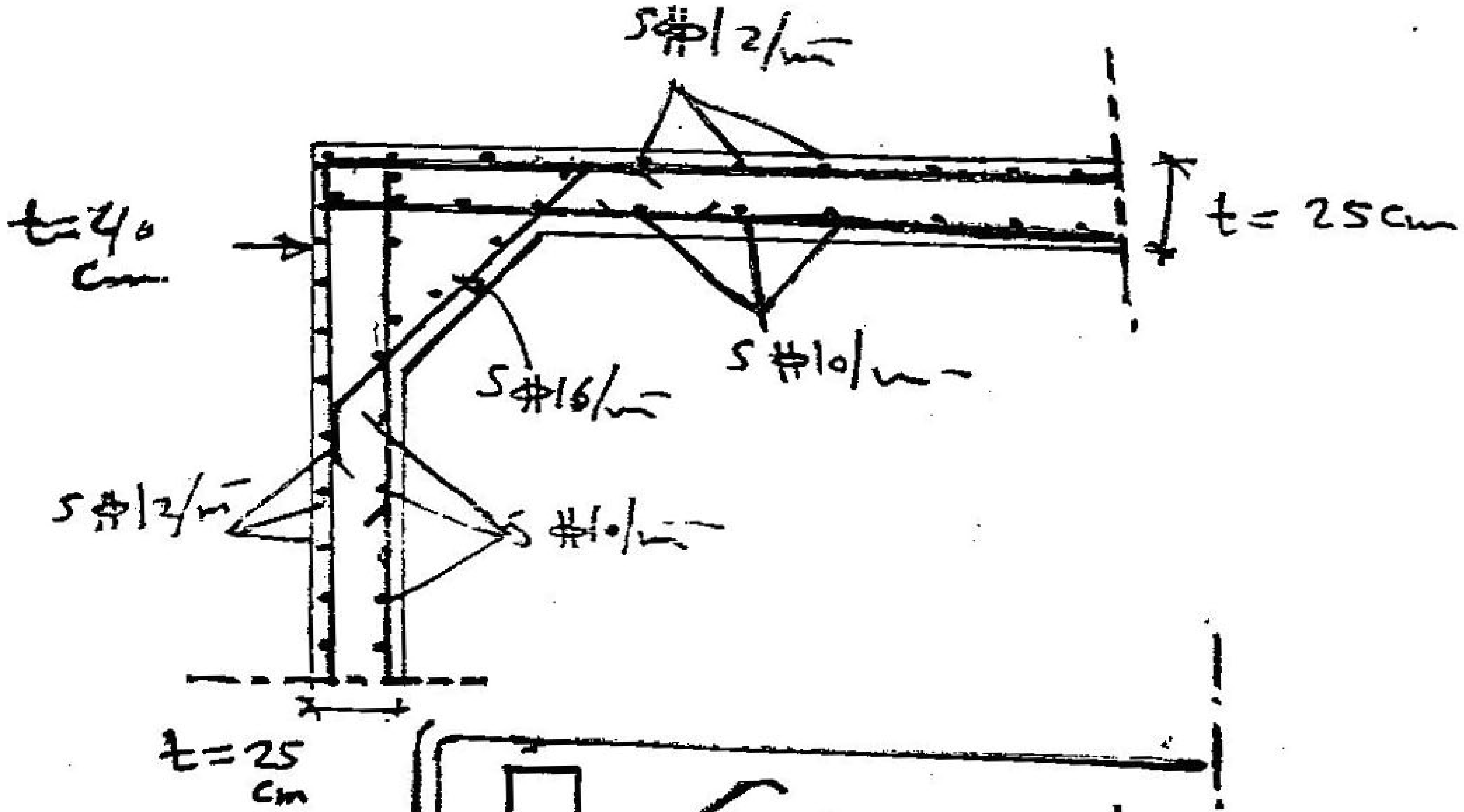
VL. strip (1-1)

Scale 1:50

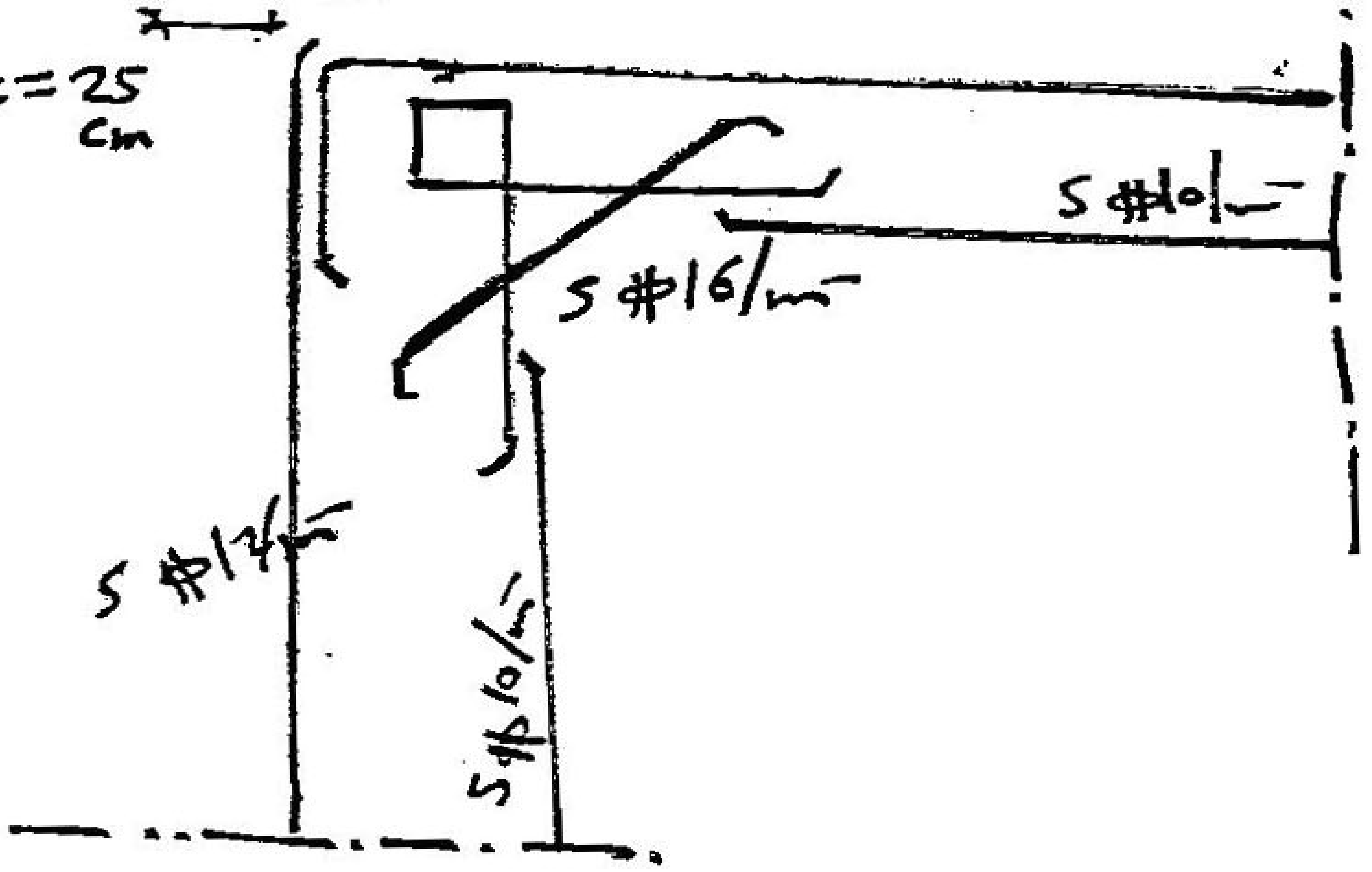




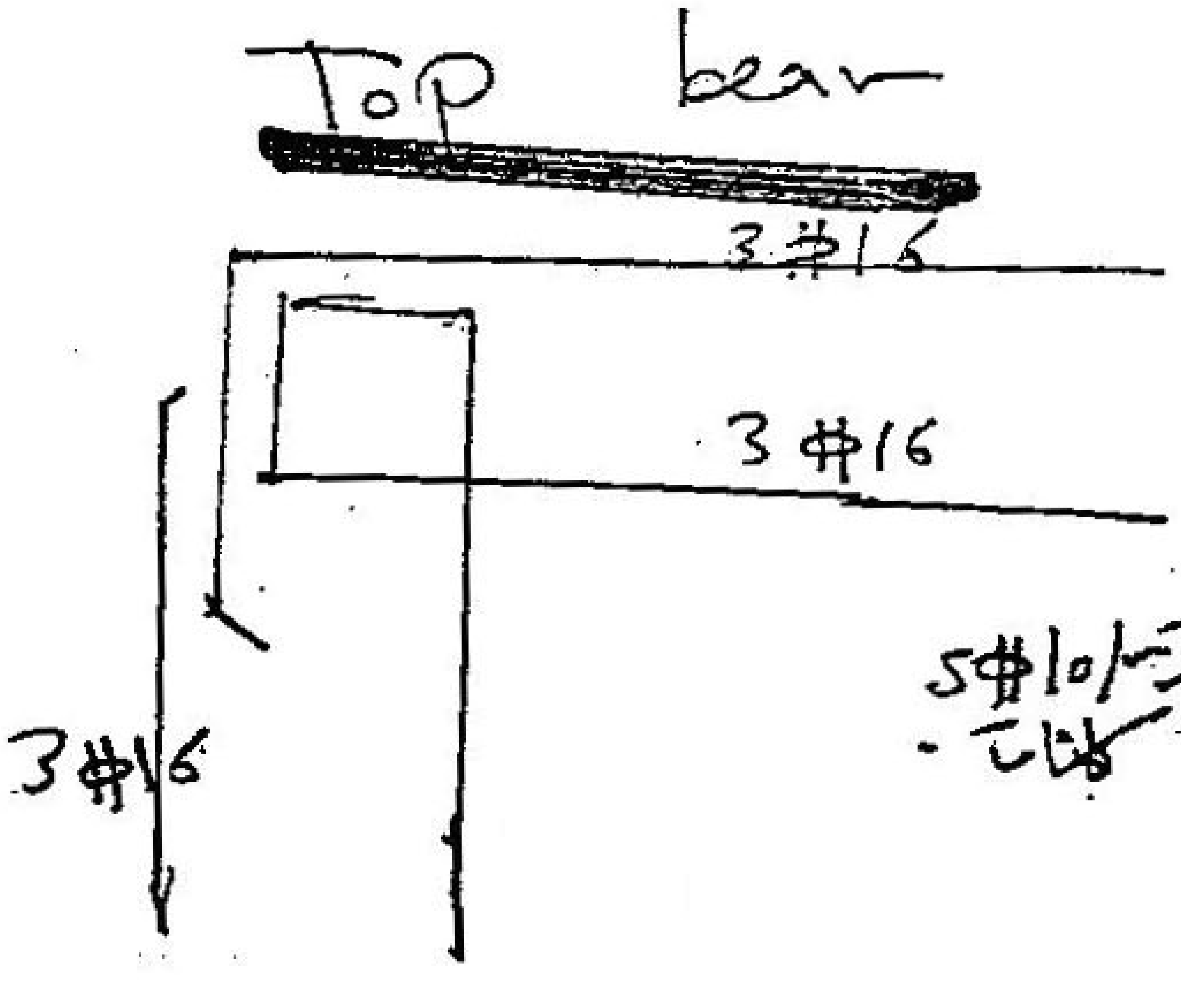
HL. strip



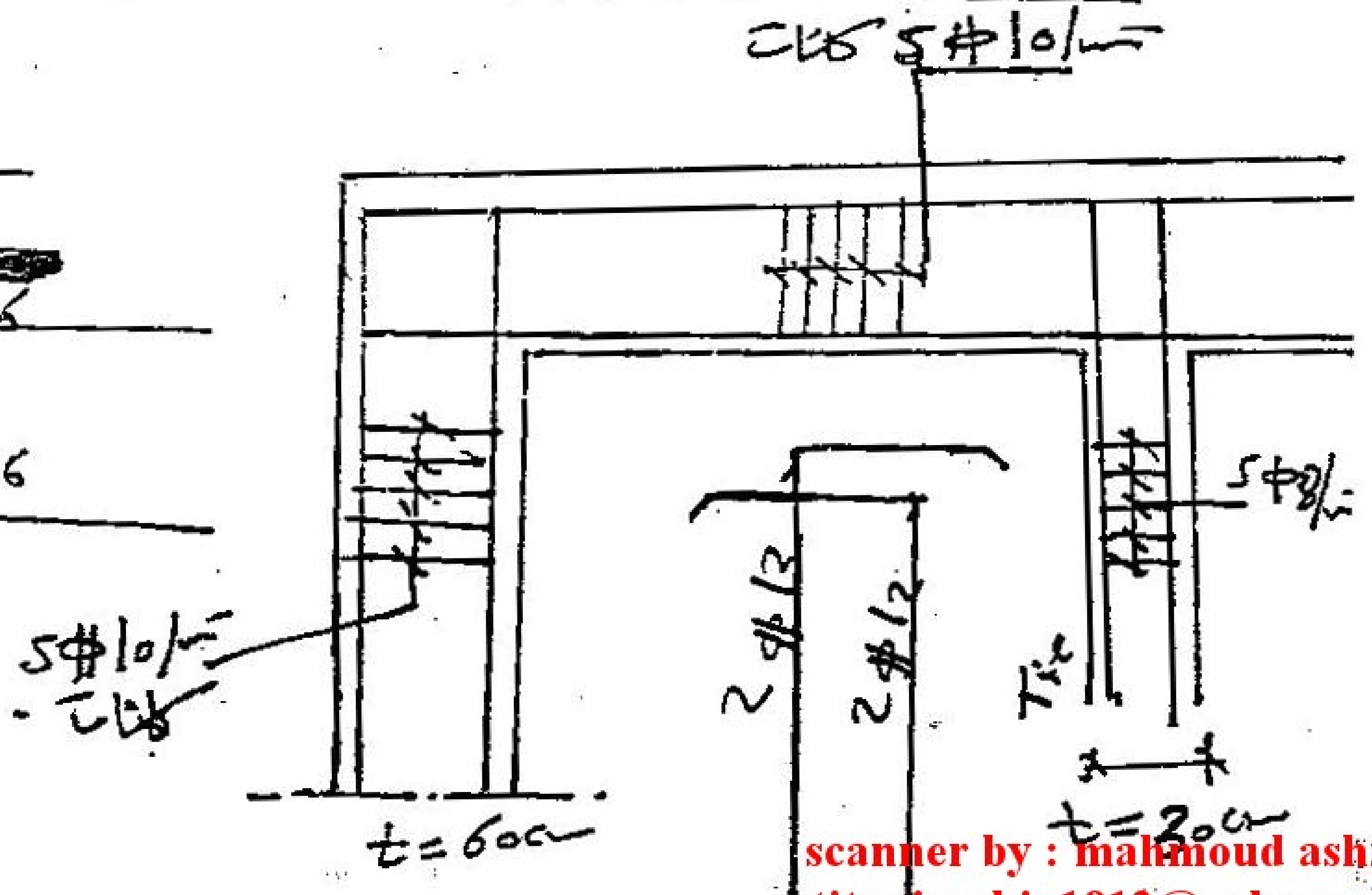
5 ϕ12/m
t = 40 cm
t = 25 cm
5 ϕ16/m
5 ϕ10/m
5 ϕ12/m
5 ϕ10/m
t = 25 cm



5 ϕ10/m
5 ϕ16/m
5 ϕ12/m
5 ϕ10/m



Top bear
3 ϕ16
3 ϕ16
3 ϕ16



5 ϕ10/m
5 ϕ8/m
5 ϕ10/m
2 ϕ12
2 ϕ12
t = 60 cm
t = 20 cm

(18)

Nour center

الخرسانه المسلحه

الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

elevated

"18"

سلم ١

Revision Rectangular Tanks (2)

Faculty of Eng.
Structural Eng. Deprt.
4th year – Civil

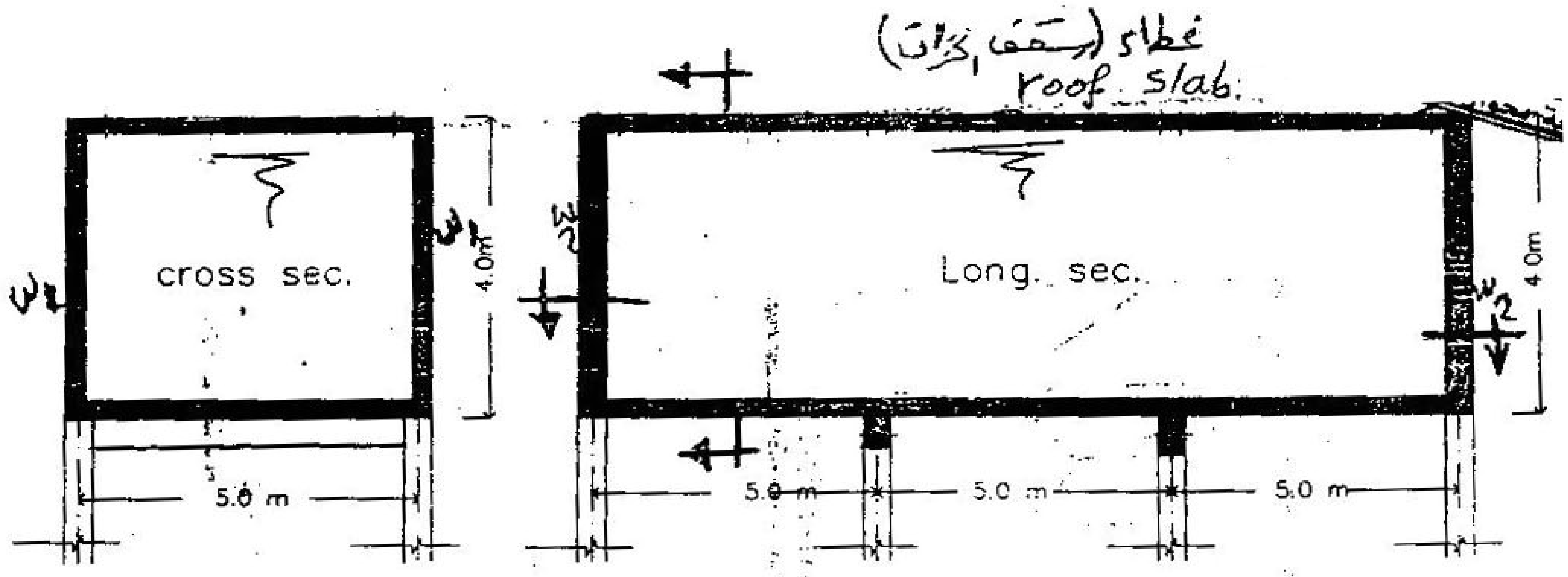
Final term EX.
Time 3.0 h 2006-2007
Reinforced concrete (3)

Tank with cover slab

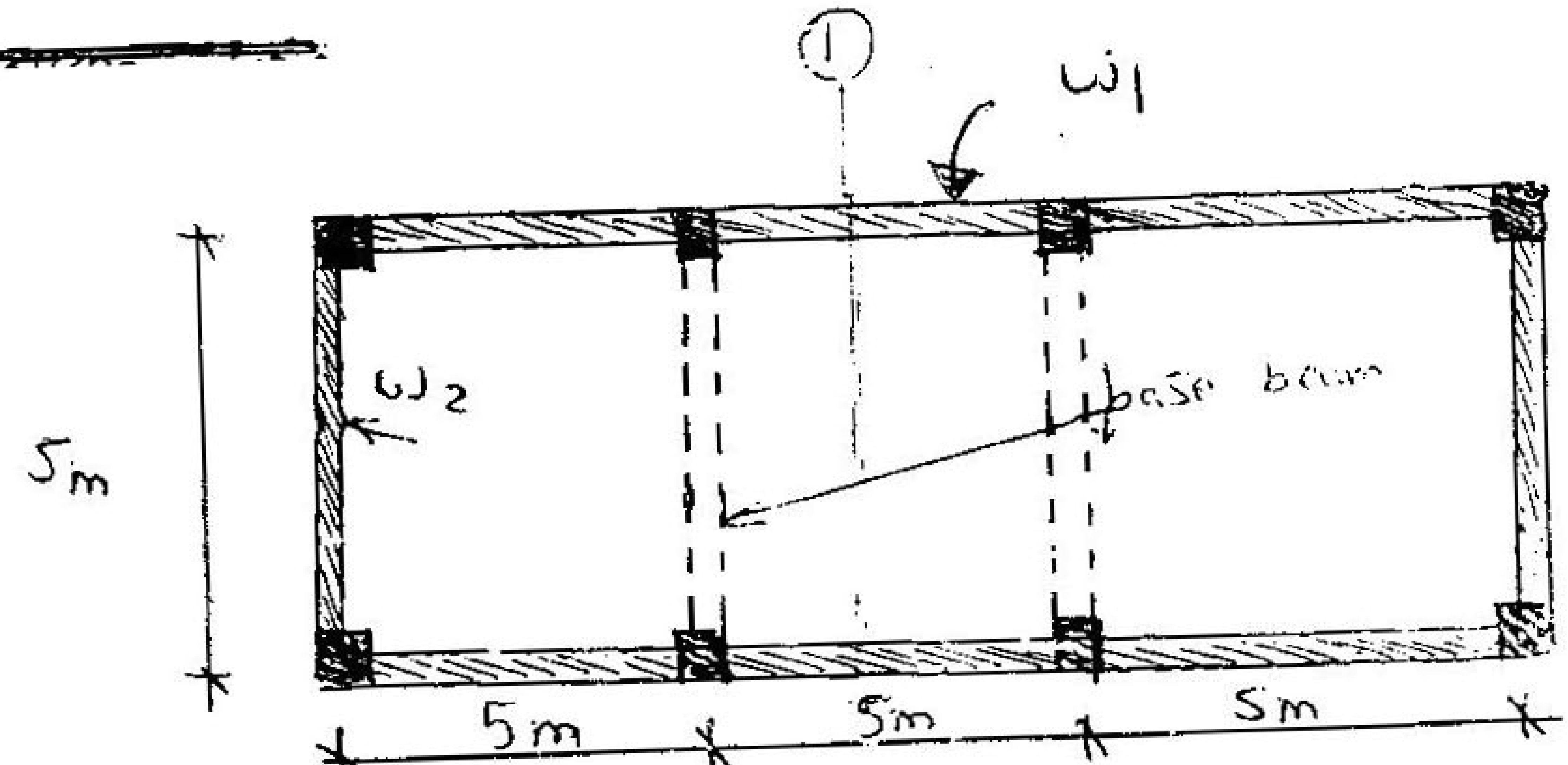
- Answer the following three questions (2-pages)
- Any missing data may be assumed properly
- Tables and charts (hand books) only are allowed
- F_{cu} = 300 kg/cm², and steel grade =36/52

Q-1 :(45 %) It is required to make a complete **analysis and design** with all reinforcement Details for all structural elements (Walls , floor, beams and roof) of the shown elevated water tank in Fig (1).

Q2 : (25 %) It is required to make a complete design with all reinforcement for main girder (A) **only** for the shown R.C. bridge shown in Fig. (2), spacing of cross girders is 3.5 m.



* Sol.



Sec. Plan

(1) Total Loads:

(1) Walls: $P = \gamma H = 4\ t/m^2$

(2) base: $\omega = t_b \cdot \gamma_{RC} + \gamma_w H_w$ (القاعدة)

$= 0.4(2.5) + (1 * 4) = 5\ t/m^2$

(3) Roof (Cover slab) $\omega = (t_s \cdot \gamma_{R.C}) = (0.25 * 2.5) = 0.625\ t/m^2$

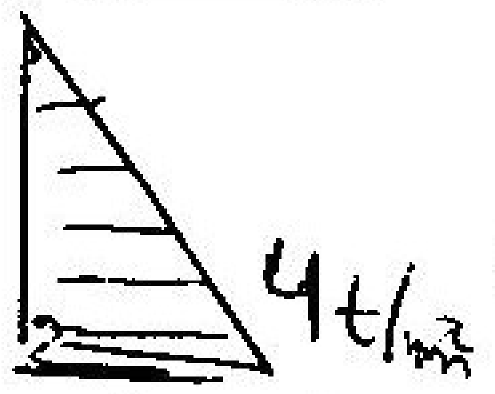
(t_s: تخن السقف 25cm)

---

(2) Load distribution: يقسم الأحمال

★ Wall (W_1) $H = 4$, $L = 15m$

$\therefore \frac{L}{H} >> 2 \Rightarrow$ shallow tank



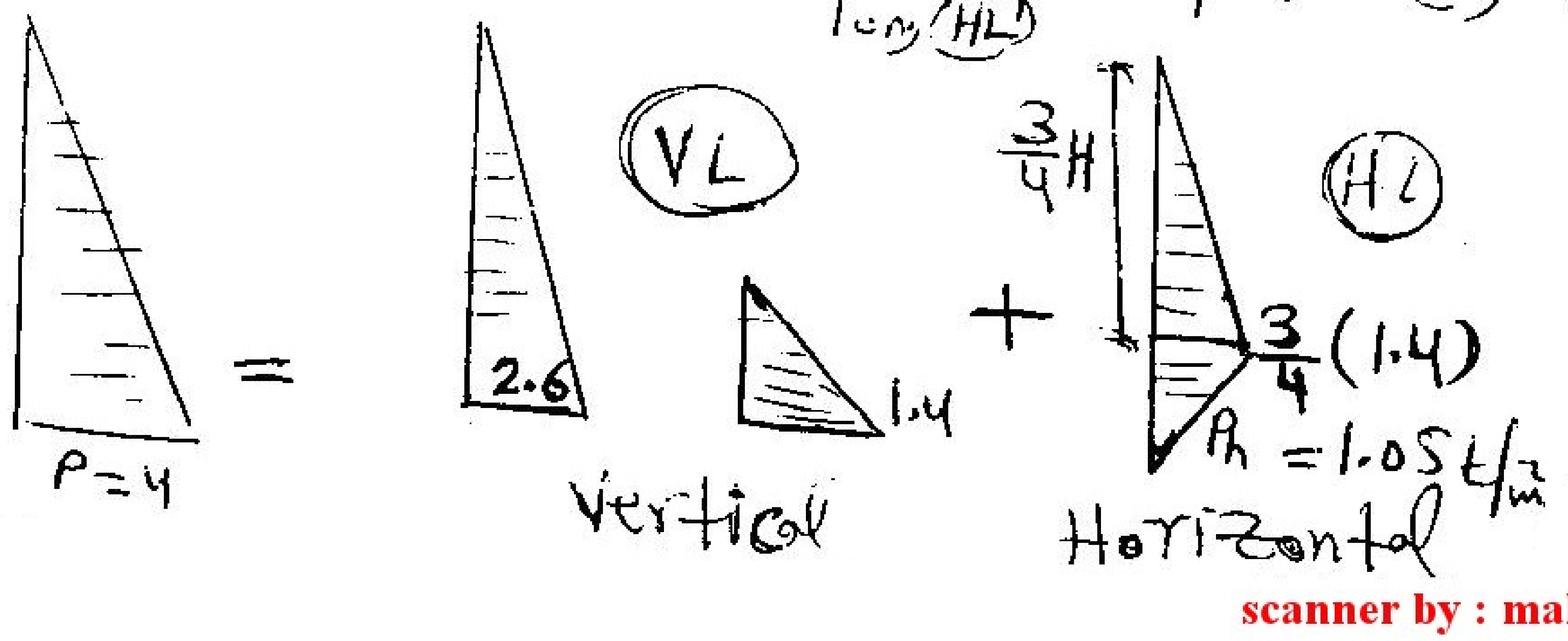
كل الحمل في اتجاه رأسي

★ Wall (W_2): $H = 4m$, $L = 5m$ (medium)

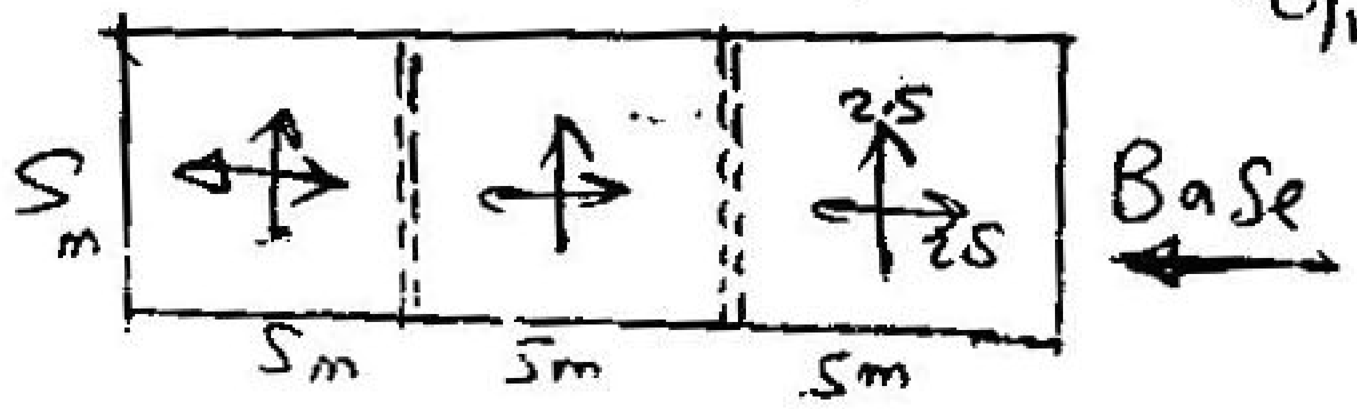
$r = \left(\frac{long}{short}\right) = \frac{5}{4} = 1.25$

$\alpha = 0.65 \Rightarrow P\alpha = \alpha \cdot P = 2.6\ t/m^2$ short (VL)

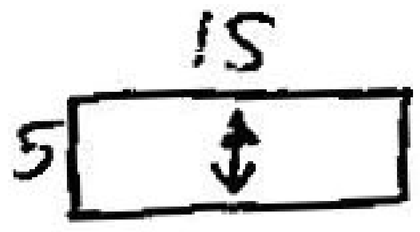
$\therefore \beta = 0.35 \Rightarrow P\beta = \beta \cdot P = 1.4\ t/m^2$ long (HL)



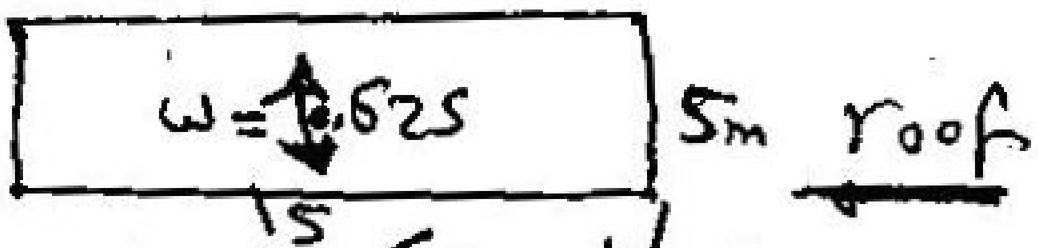
القاعدة base: $r = \left(\frac{5}{5}\right) = 1 \Rightarrow w_\alpha = w_\beta = \frac{w_b}{2} = 2.5\ t/m^2$



السقف Roof:



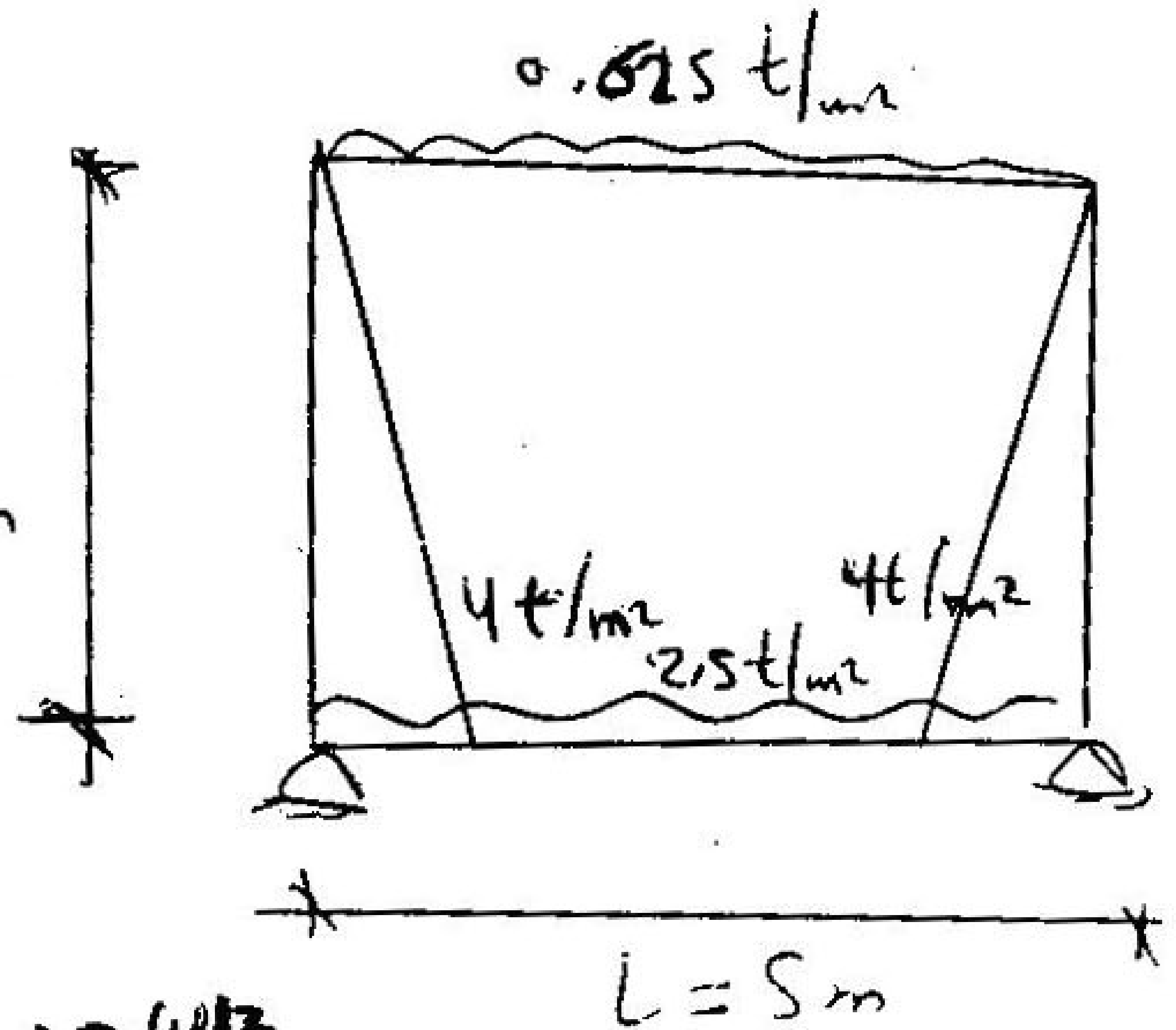
$r = \frac{long}{short} = \frac{15}{5} >> 2$

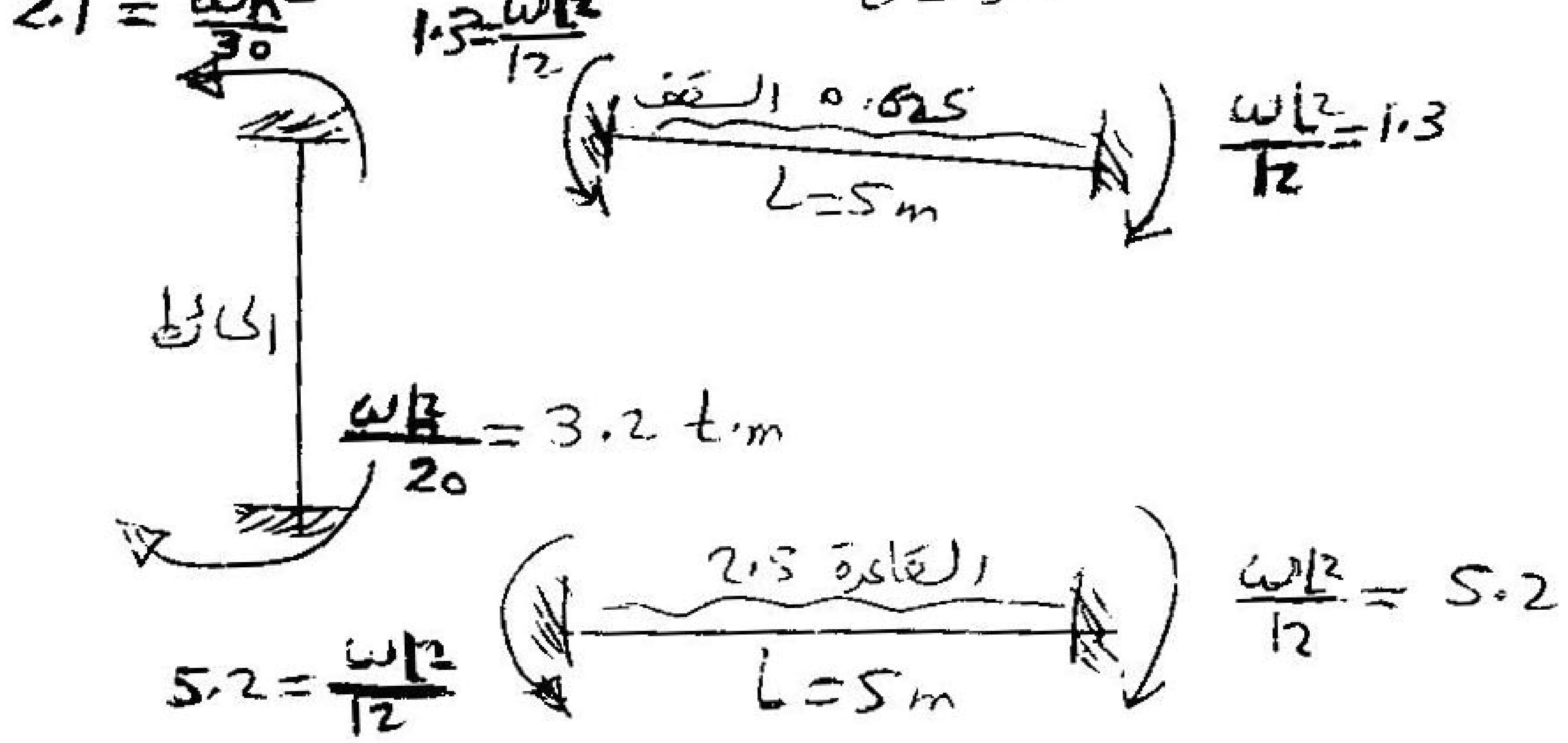


⇒ one way ⇒ $w = 0.625\ t/m^2$

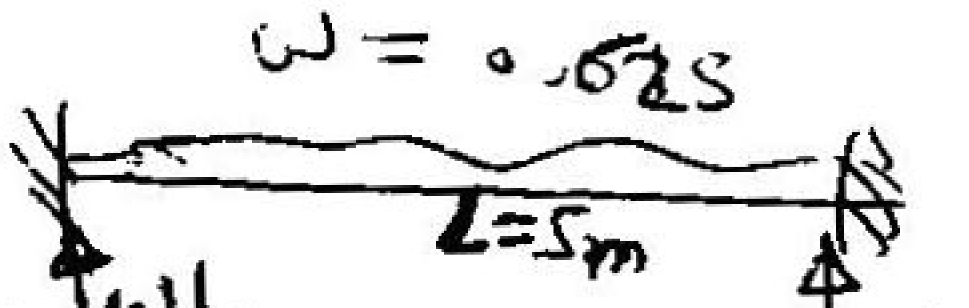
كل الحمل في الاتجاه القصير

VL. Strip (1—1)

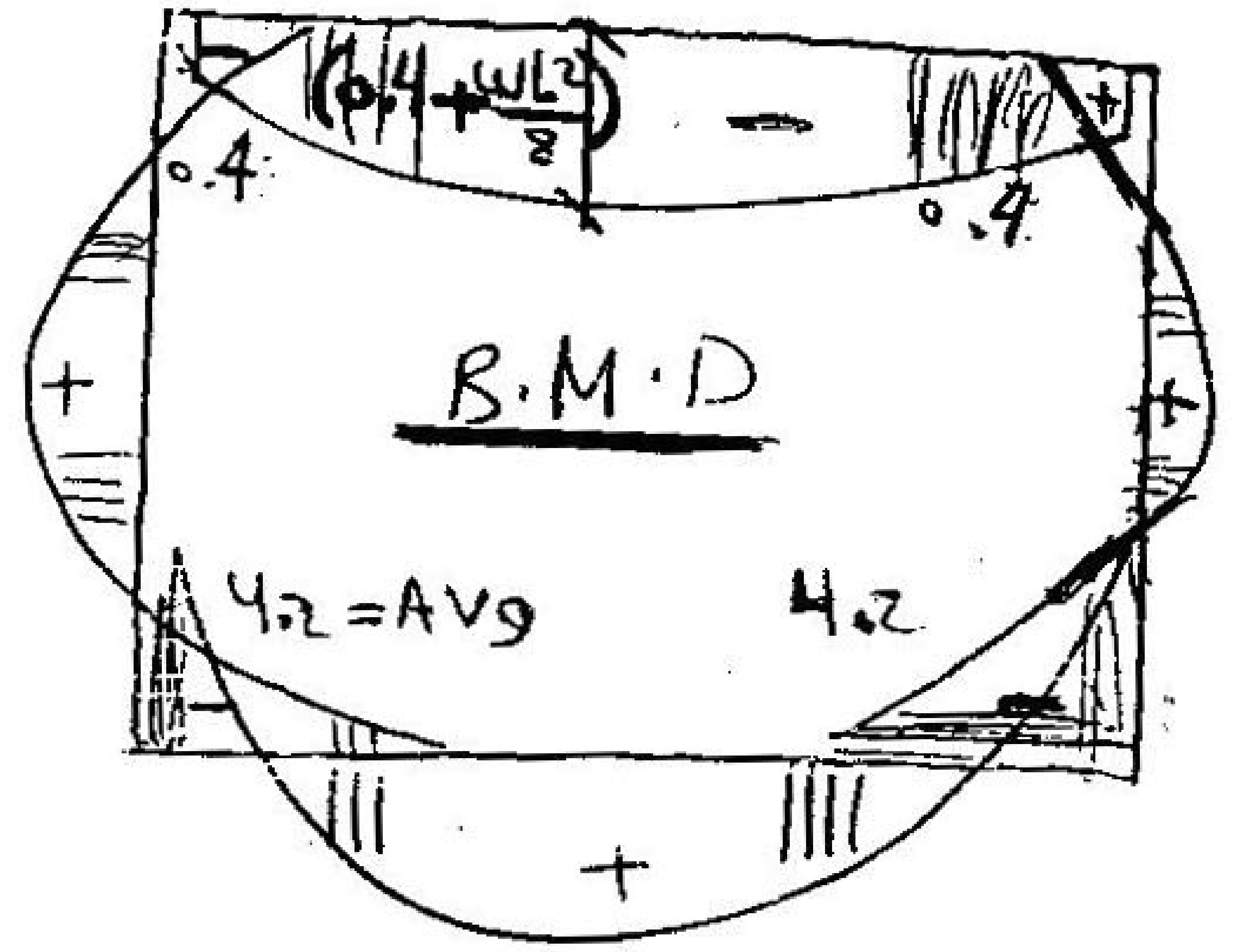




roof

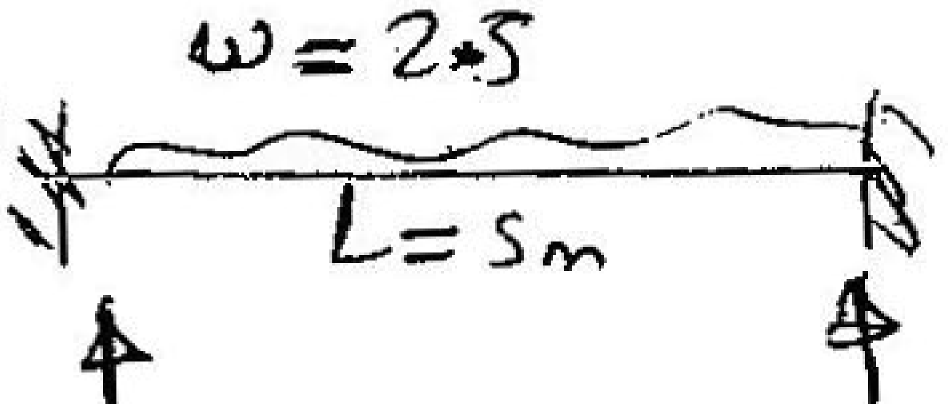


$R = 1.5 = \frac{wL}{2}$ $\quad$ $1.5 = \frac{wL}{2}$

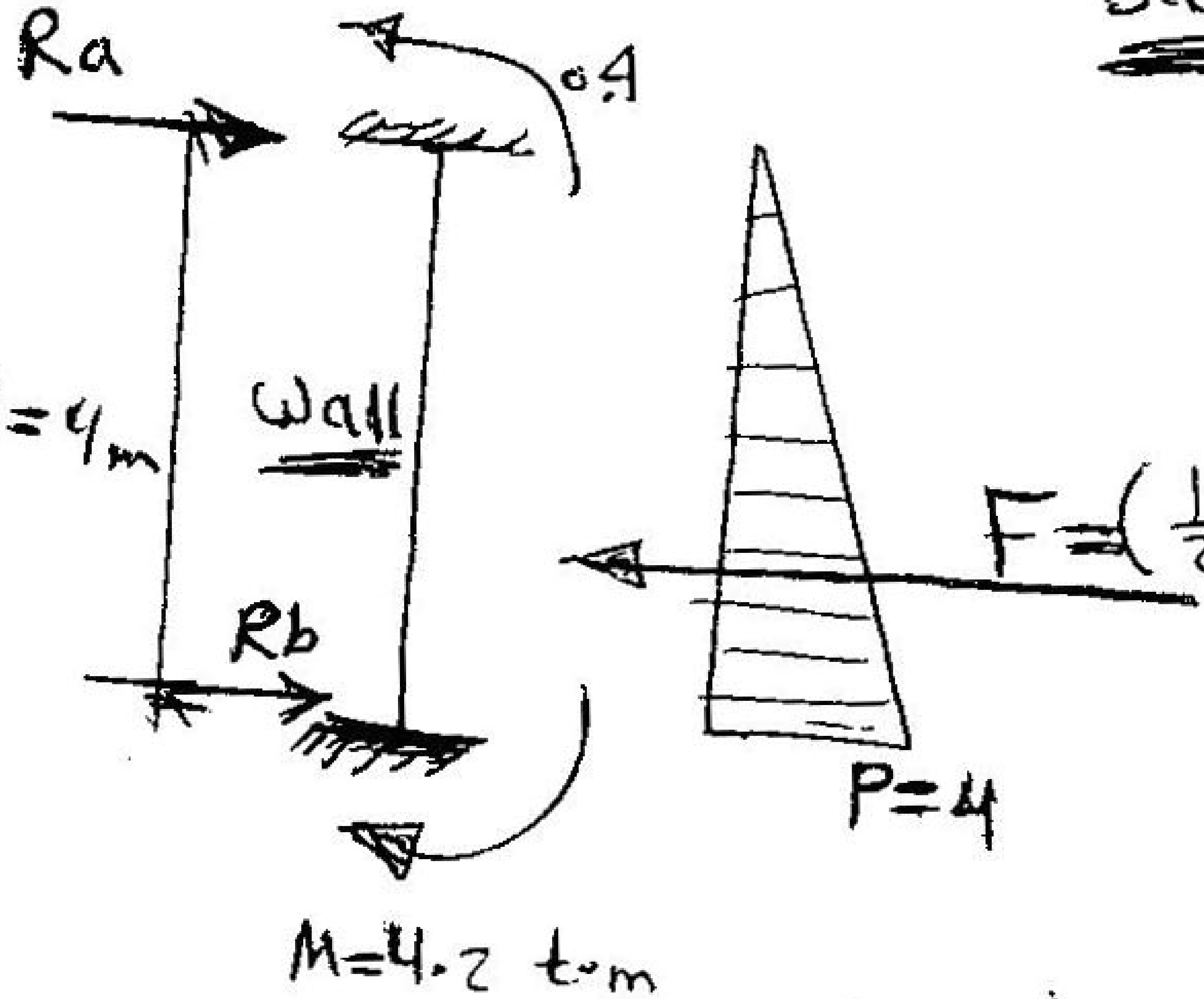


$\left(\frac{wl^2}{12} + \Delta M\right) = 3.6\ t.m$

Base



$\frac{wL}{2} = 6.25$ $\quad$ $\frac{wL}{2} = 6.25$



$F = \left(\frac{1}{2} * 4 * 4\right) = 8\ t$

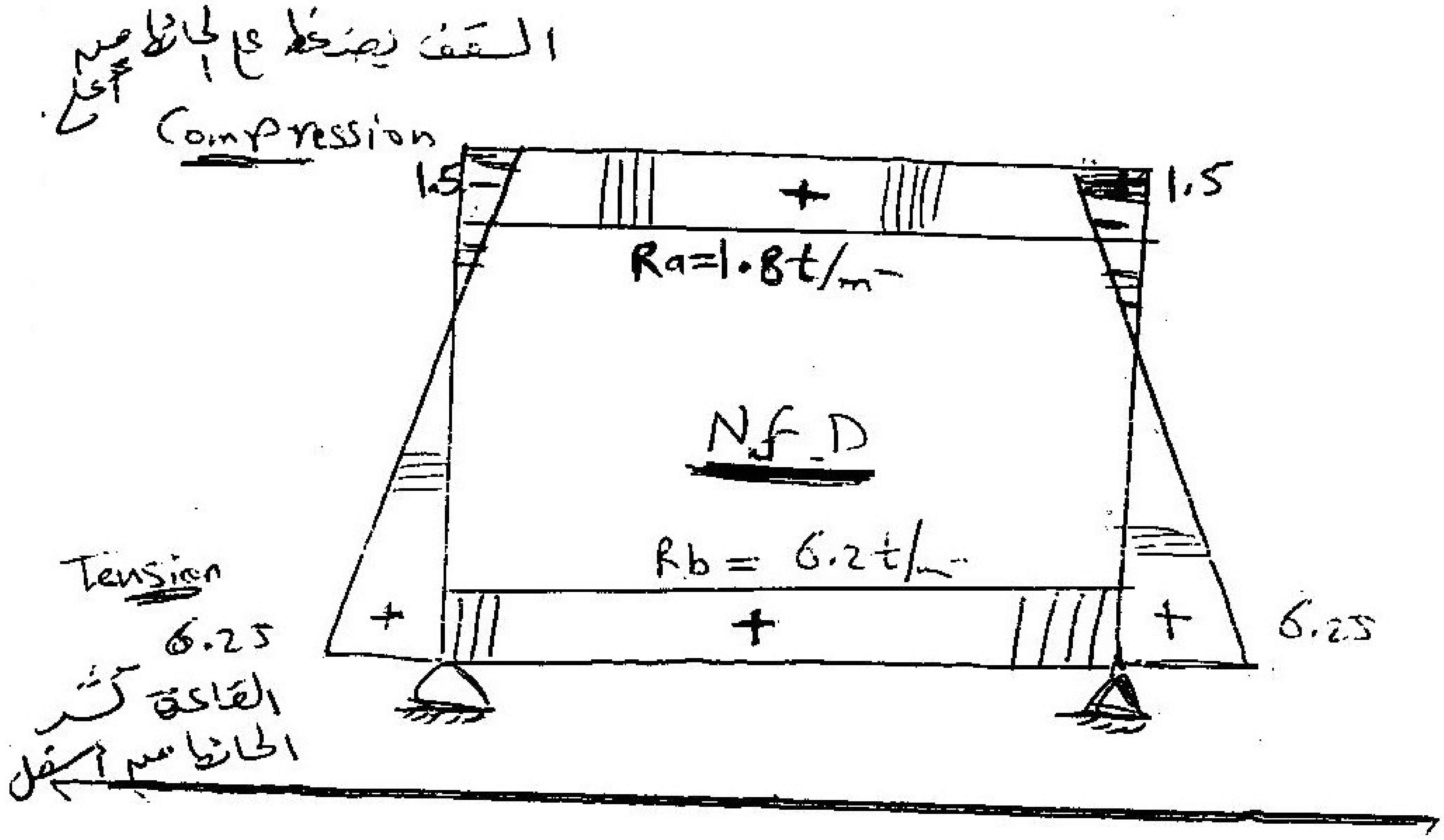
$M = 4.2\ t.m$

$\Sigma M_b = 0$

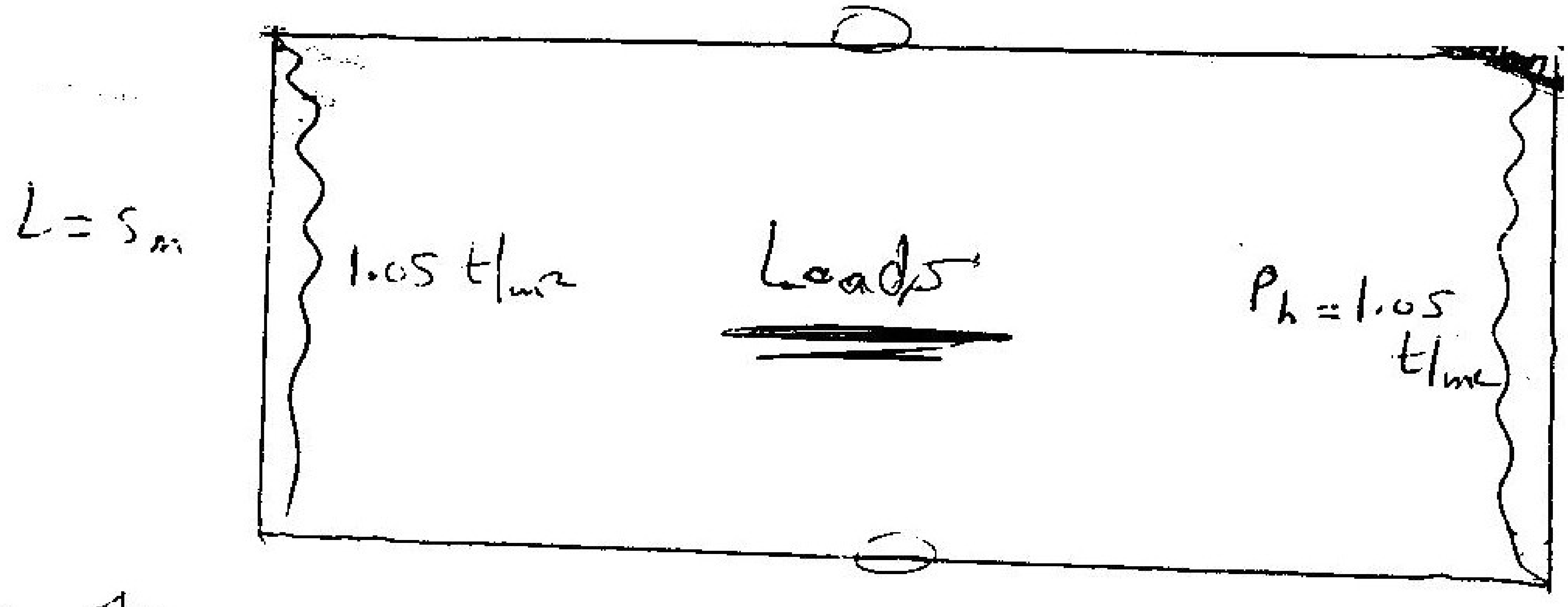
$\therefore \left(8 * \frac{4}{3}\right) + (0.4) - (Ra * 4) - 4.2 = 0$

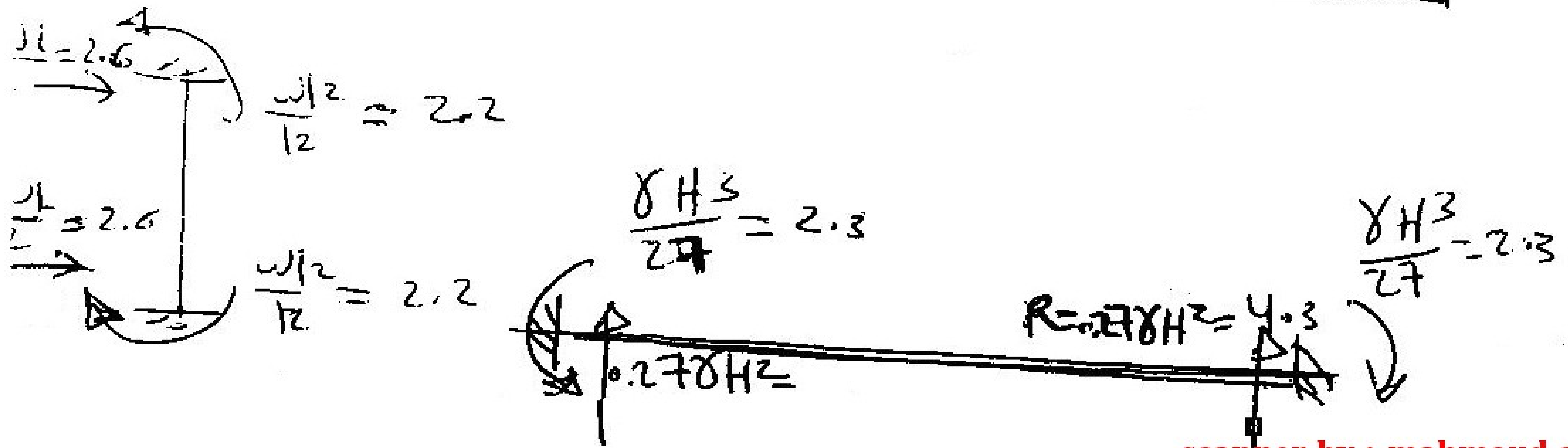
$\therefore Ra = 1.8\ t/m$

$$\Sigma F_x = 0 \Rightarrow R_b = 6.2 \ t/m$$

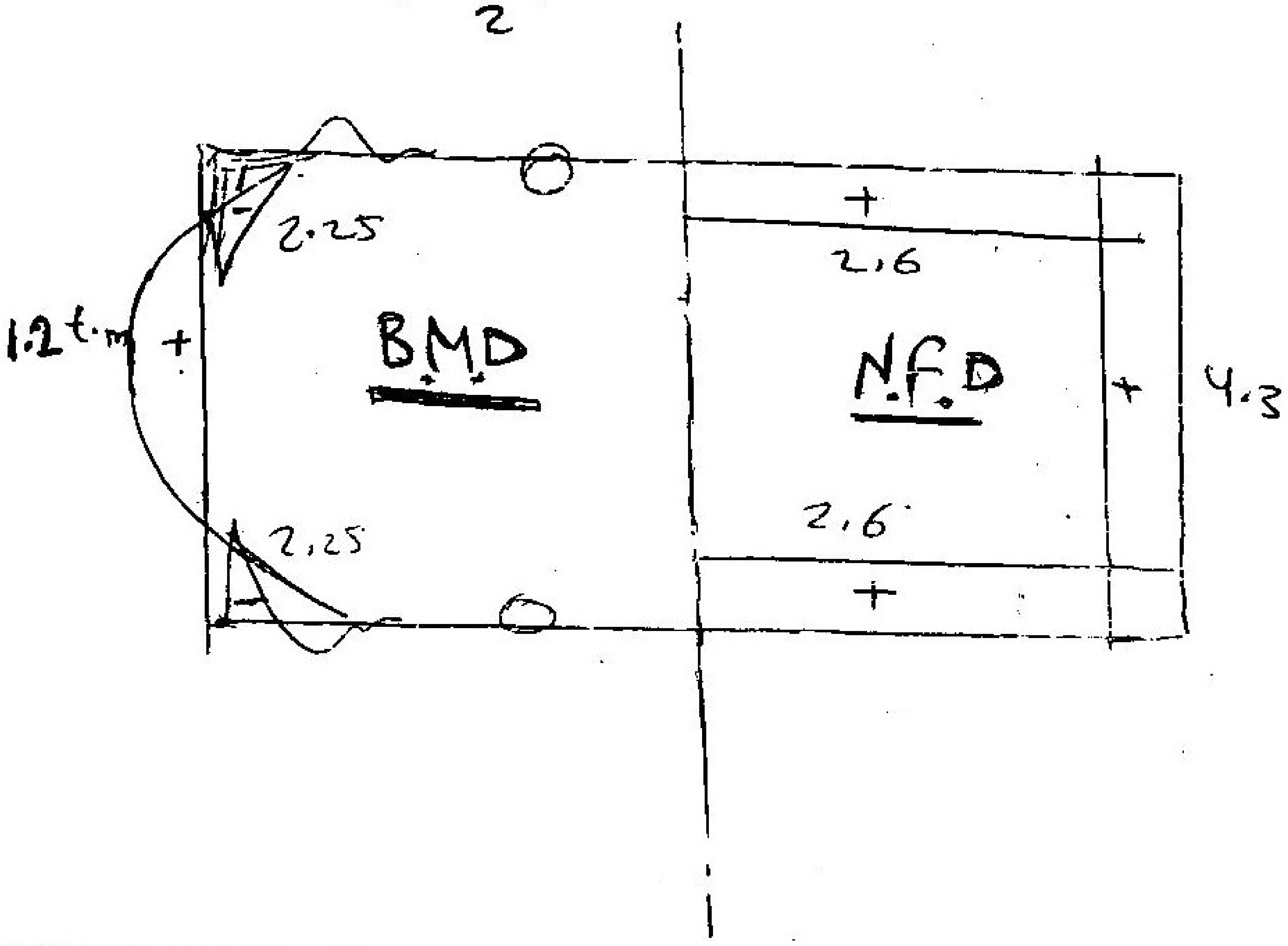


Hl. Strip : at $\left(\frac{3}{4}H\right)$



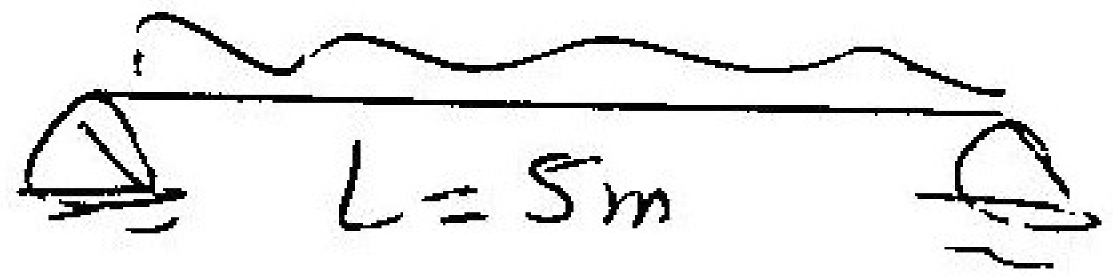


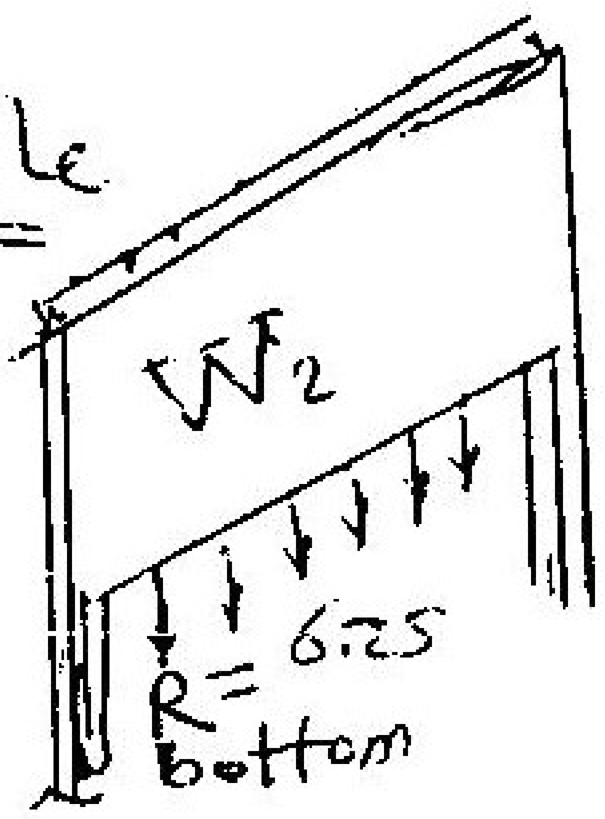
$$M_{avg} = \frac{(2.3 + 2.2)}{2} = 2.25 \text{ t.m}$$



Wall as beam: (W2) Simple

$\omega = (\text{own wt.} + R_{slab})$





$\text{own wt.} = t_w \cdot H_w \cdot \gamma_{Rc} = .25(4)(2.5)$

$= 2.5 \text{ t/m}$

$W = (R_{bottom} + \text{own wt})$

$\therefore W = (2.5 + 6.25) = 8.75 \text{ t/m}$

$W_u = 1.5\,w = 8.75 \times 1.5 = 14\ t/m$

$M_u = \frac{w_u L^2}{8} = \left(\frac{14 \times 5^2}{8}\right) = 48\ t.m$

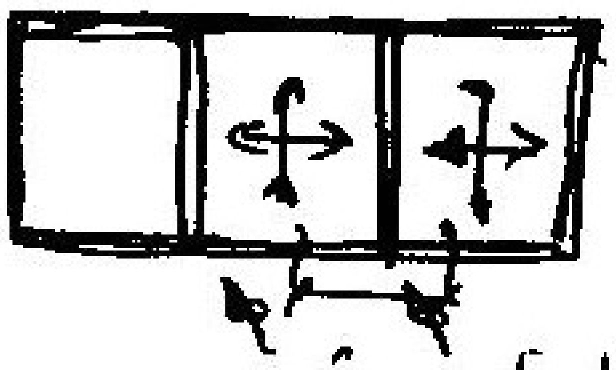
$y_{ct} = 0.87\,H = 0.87 \times 4 = 3.48\ m$

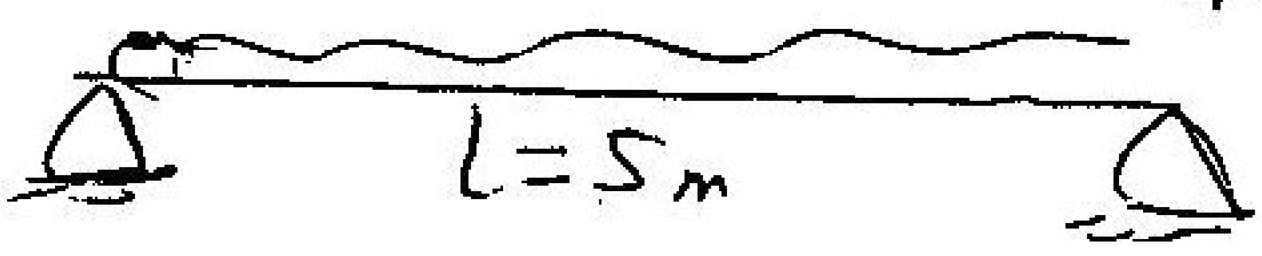
$T_u = \frac{M_u}{y_{ct}} = \frac{48}{3.48} = 13.793\ ton$

$A_s = \frac{T_u}{(f_y/\gamma_s)} = 4.5\ cm^2 = 4\ \Phi 12$

خطأ

(base beams): $w = (own\ wt) + (w_{slab} \times \text{spacing between beam})$





$\therefore\ w = (b \cdot t \cdot \gamma_{R.C}) + (2.5 \times 5)$

$w = (0.3 \times 0.9 \times 2.5) + (2.5 \times 5)$

$= 13.175\ t/m$

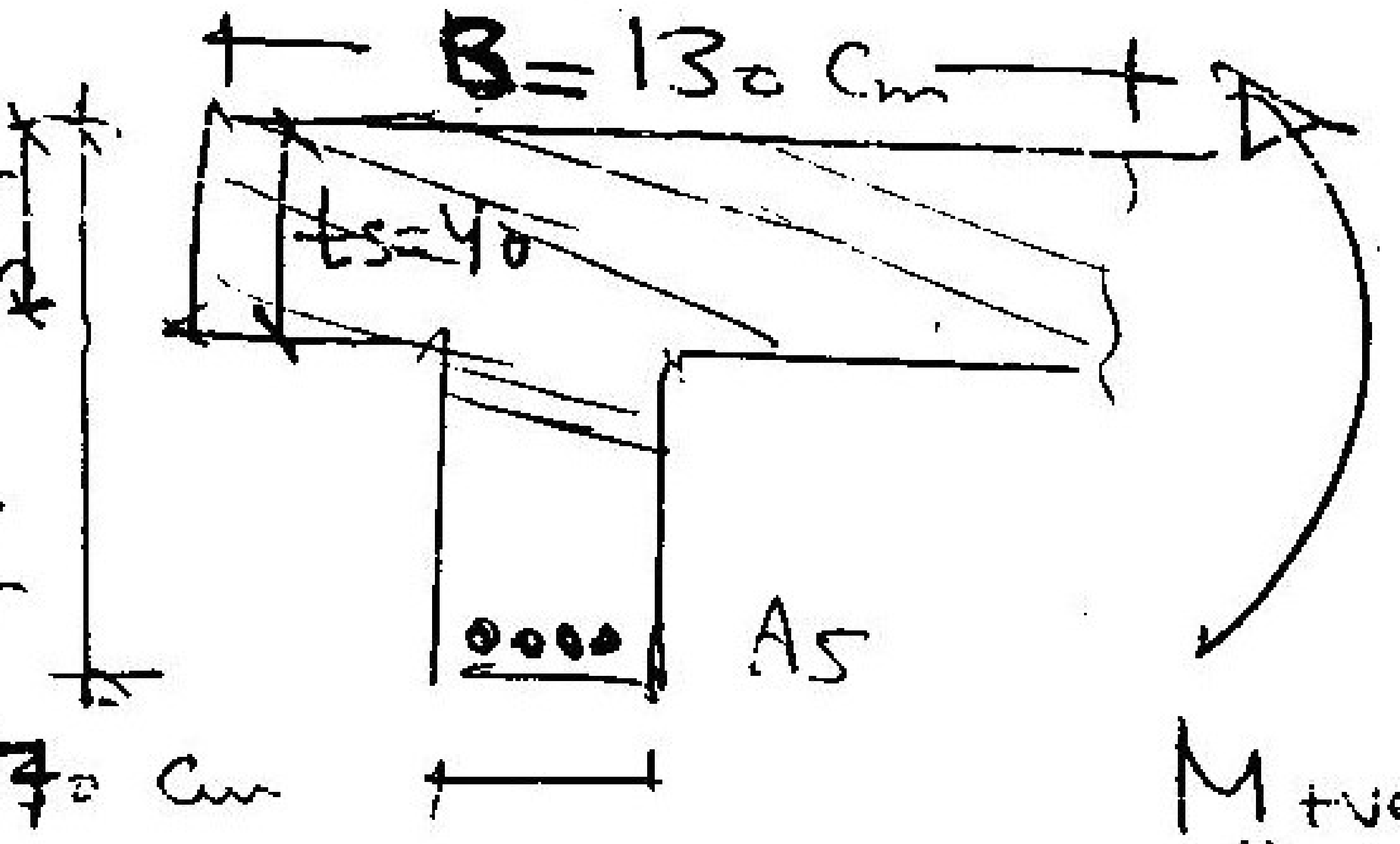
$\therefore\ W_u = 1.5 \times 13.175 = 20\ t/m$

$M_u = \left(\frac{W_u \cdot L^2}{8}\right) = \left(\frac{20 \times 5^2}{8}\right) = 62.5\ t.m$

الشد خارج ناحية الهواء

(air side)

design as (T-section), $Z \leq t_s$



$M_{u\,+ve} = 62.5$ t.m

$B = 16(40)+30 = 670$ cm

min $= \phi - \phi = 500$ cm

$= \frac{L}{5} + b = \left(\frac{500}{5} + 30\right) = 130$

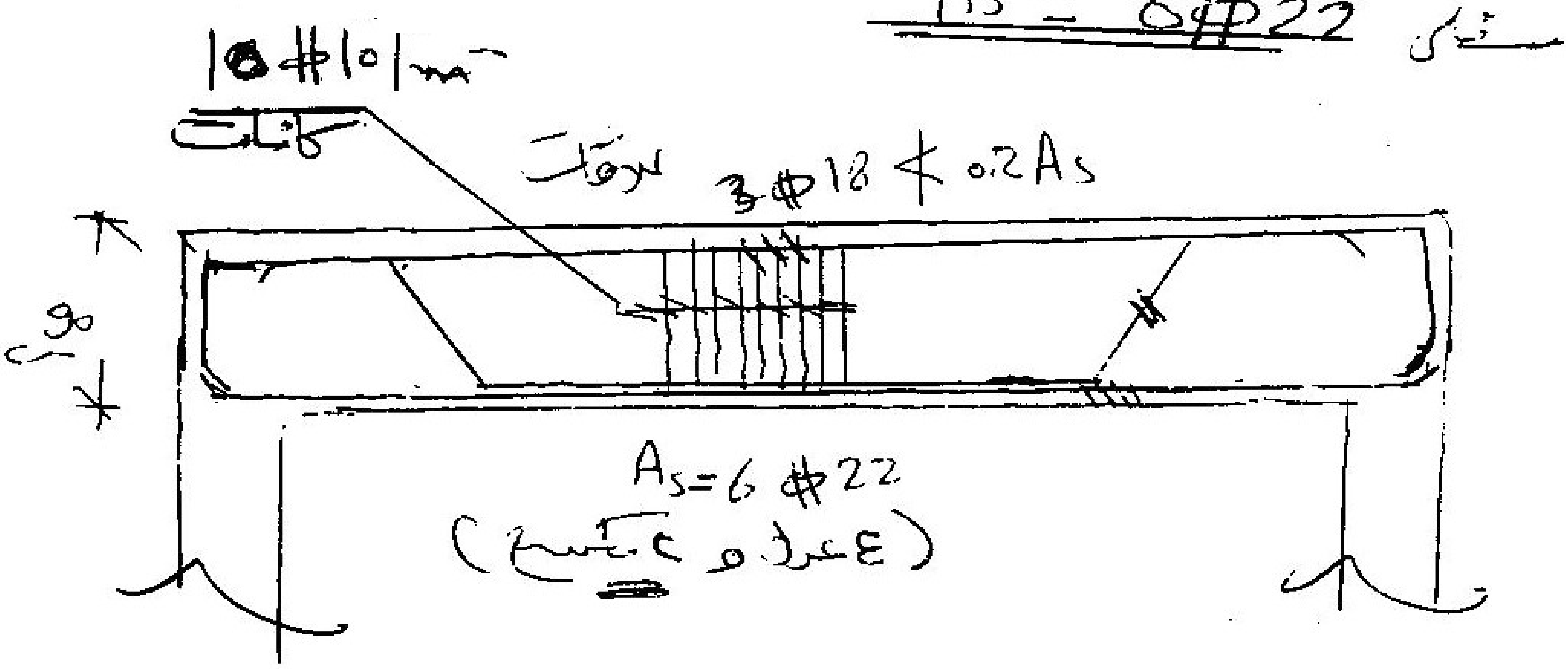
$$R_1 = \frac{M_u}{f_{cu} \cdot B \cdot d^2} = \frac{62.5 \times 10^5}{250 \times 130 \times (85)^2} = 0.026$$

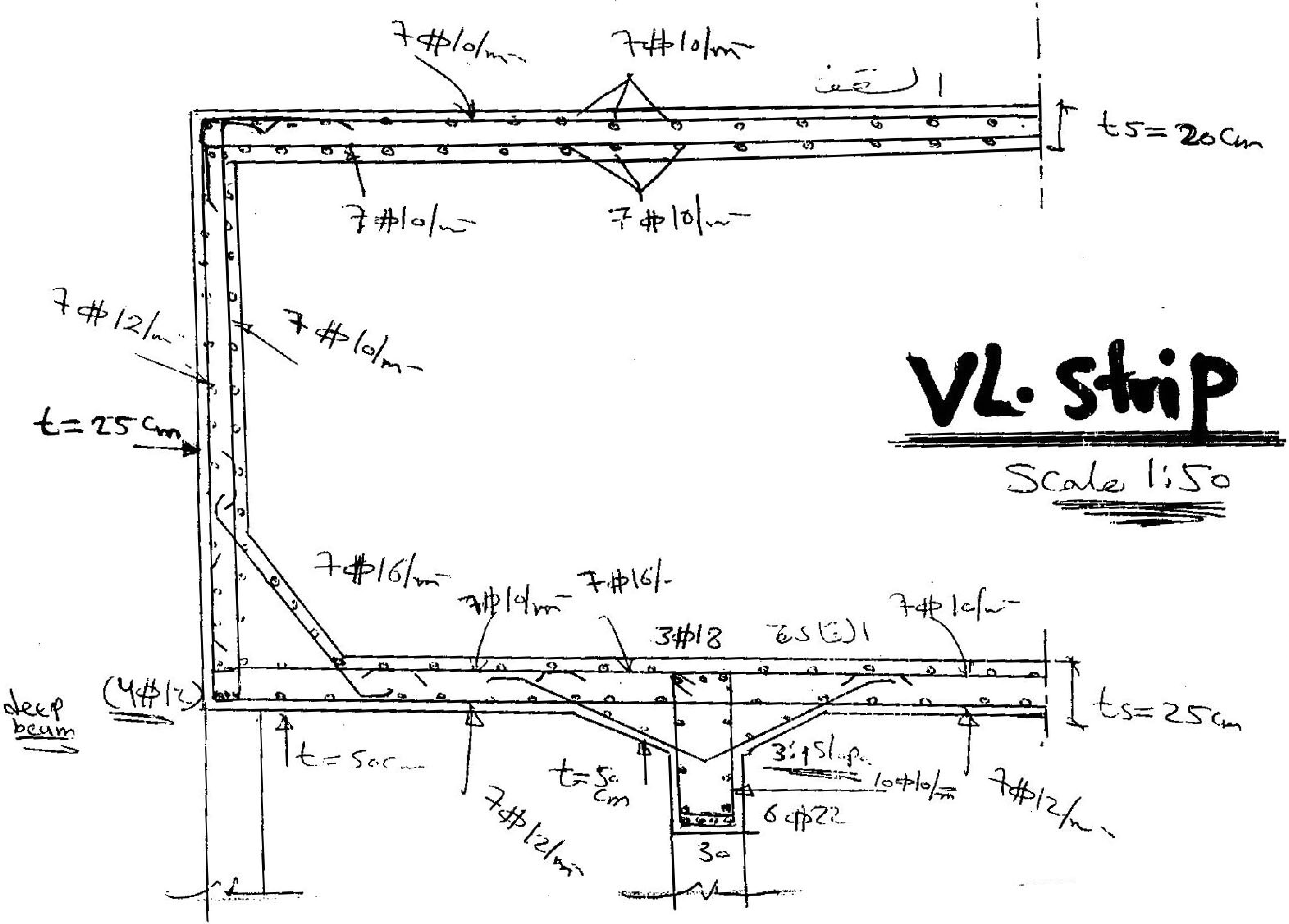
$\therefore \ \omega = 0.03$

$$A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d = 0.03 \times \frac{250}{3600} \times 130 \times 85$$

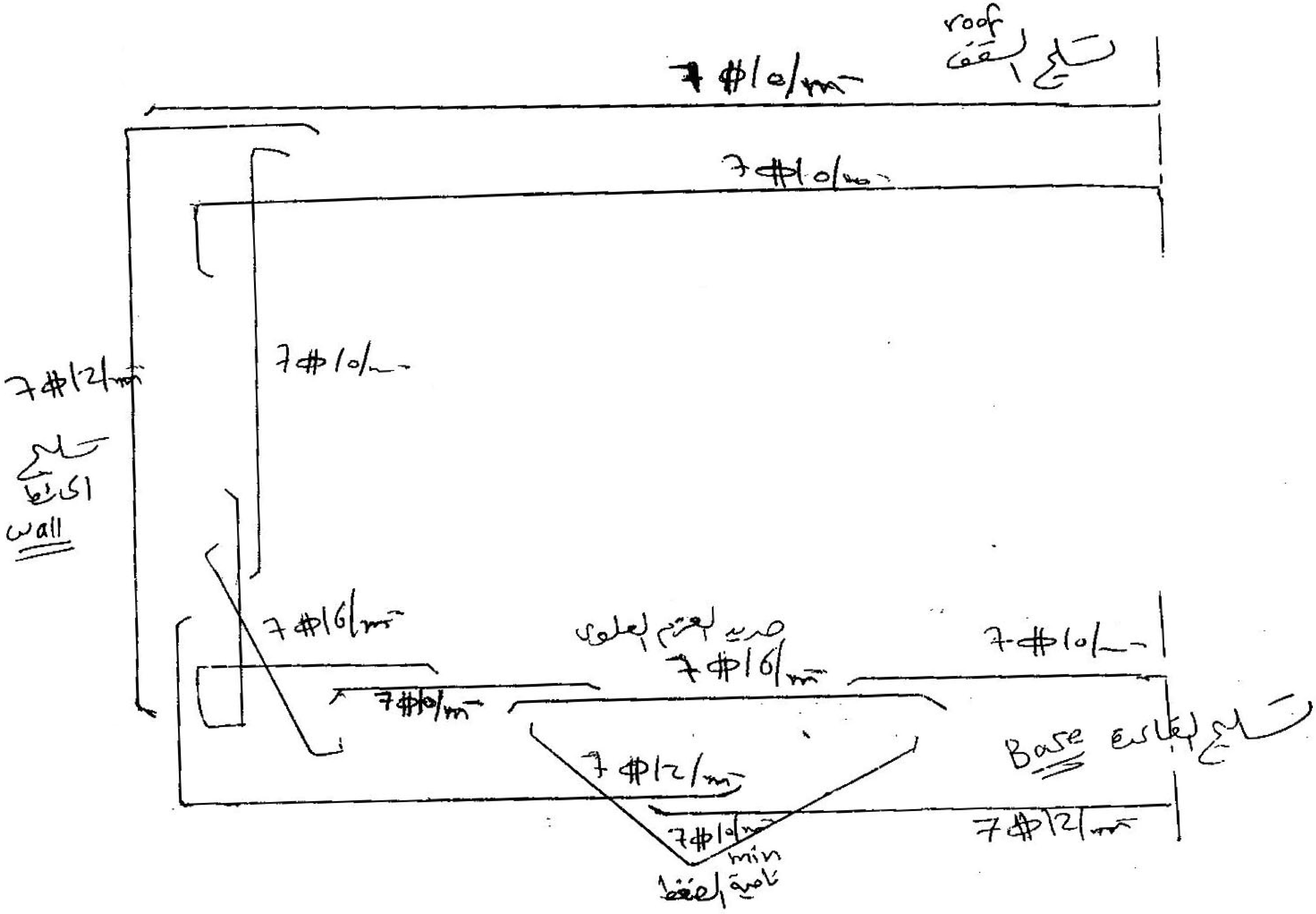
$A_s = 23\ cm^2$

$A_s = 6\phi22$





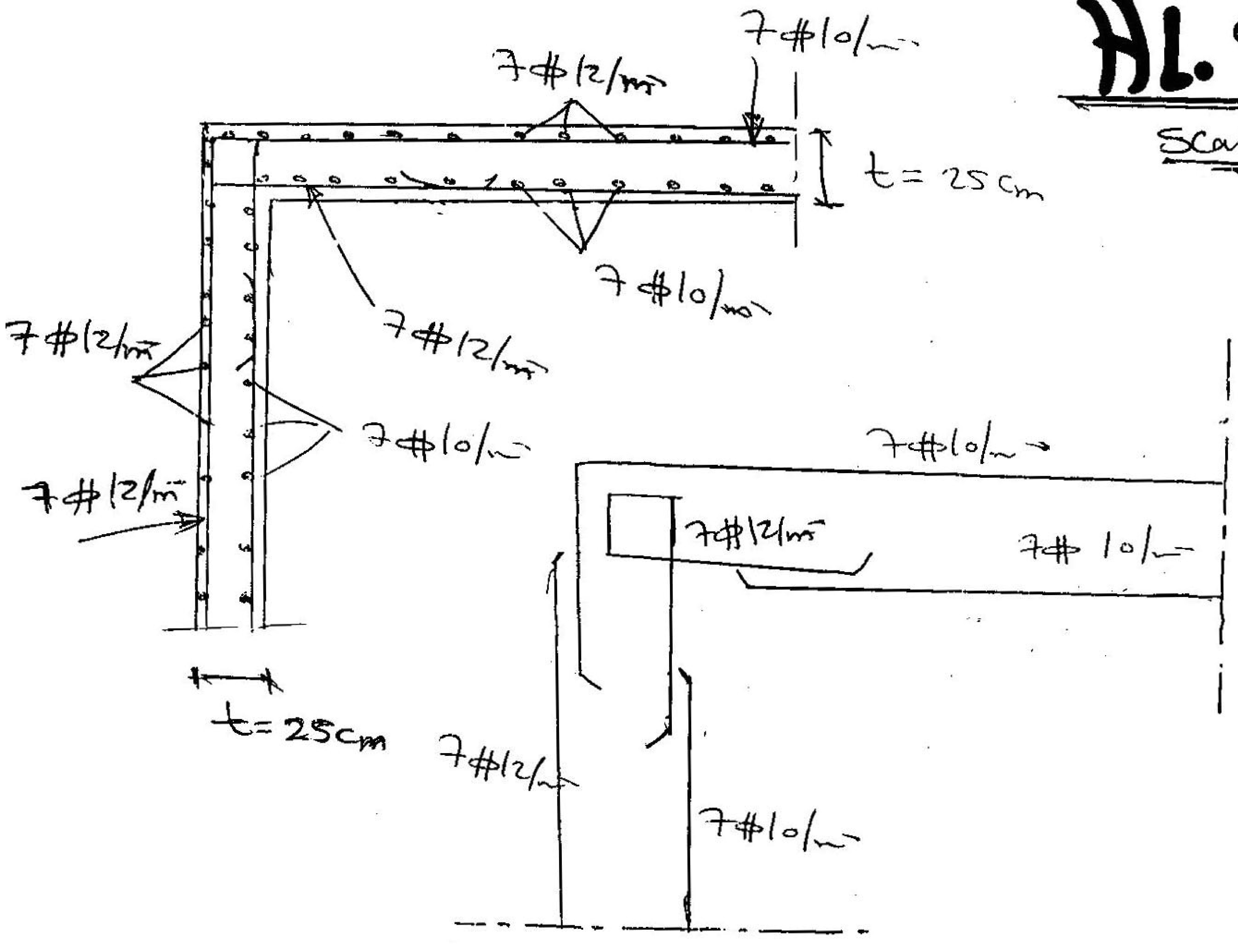
VL. Strip
Scale 1:50
7Φ10/m
7Φ10/m
7Φ10/m
7Φ10/m
ts=20cm
7Φ12/m
7Φ10/m
t=25cm
7Φ16/m
7Φ10/m
7Φ16/m
3Φ18
7Φ10/m
(4Φ12)
deep beam
ts=25cm
t=50cm
t=50cm
7Φ12/m
3:1 slope
10Φ10/m
6Φ22
30
7Φ12/m



roof
تسليح السقف
7 Φ10/m
7 Φ10/m
7 Φ12/m
7 Φ10/m
تسليح
الحائط
wall
7 Φ16/m
7 Φ16/m
7 Φ10/m
7 Φ10/m
Base
تسليح القاعدة
7 Φ12/m
7 Φ10/m
min
7 Φ12/m

HL. Strip

Scale 1:50



(19)

Nour center

الخرسانه المسلحه

الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

elevated

«19»

Revision Rectangular Tanks (3)

Final Exam

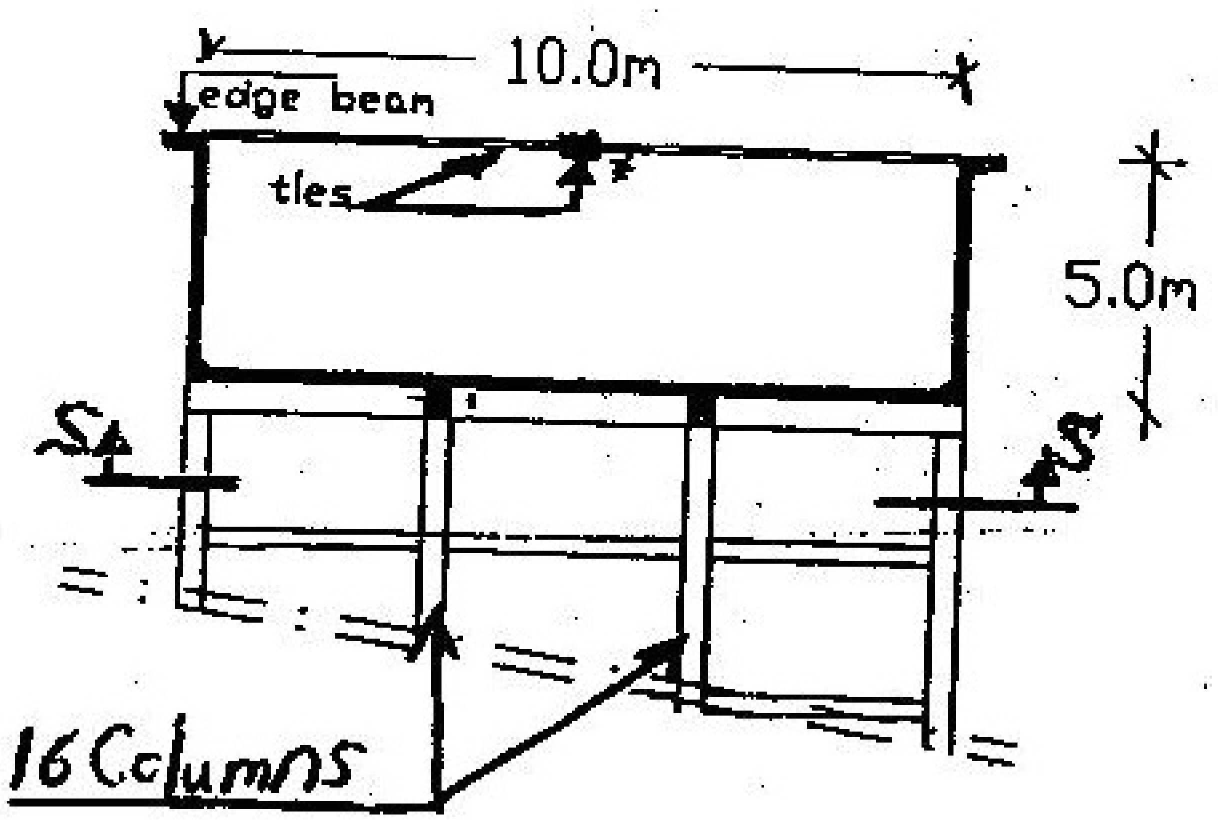
2006,2009

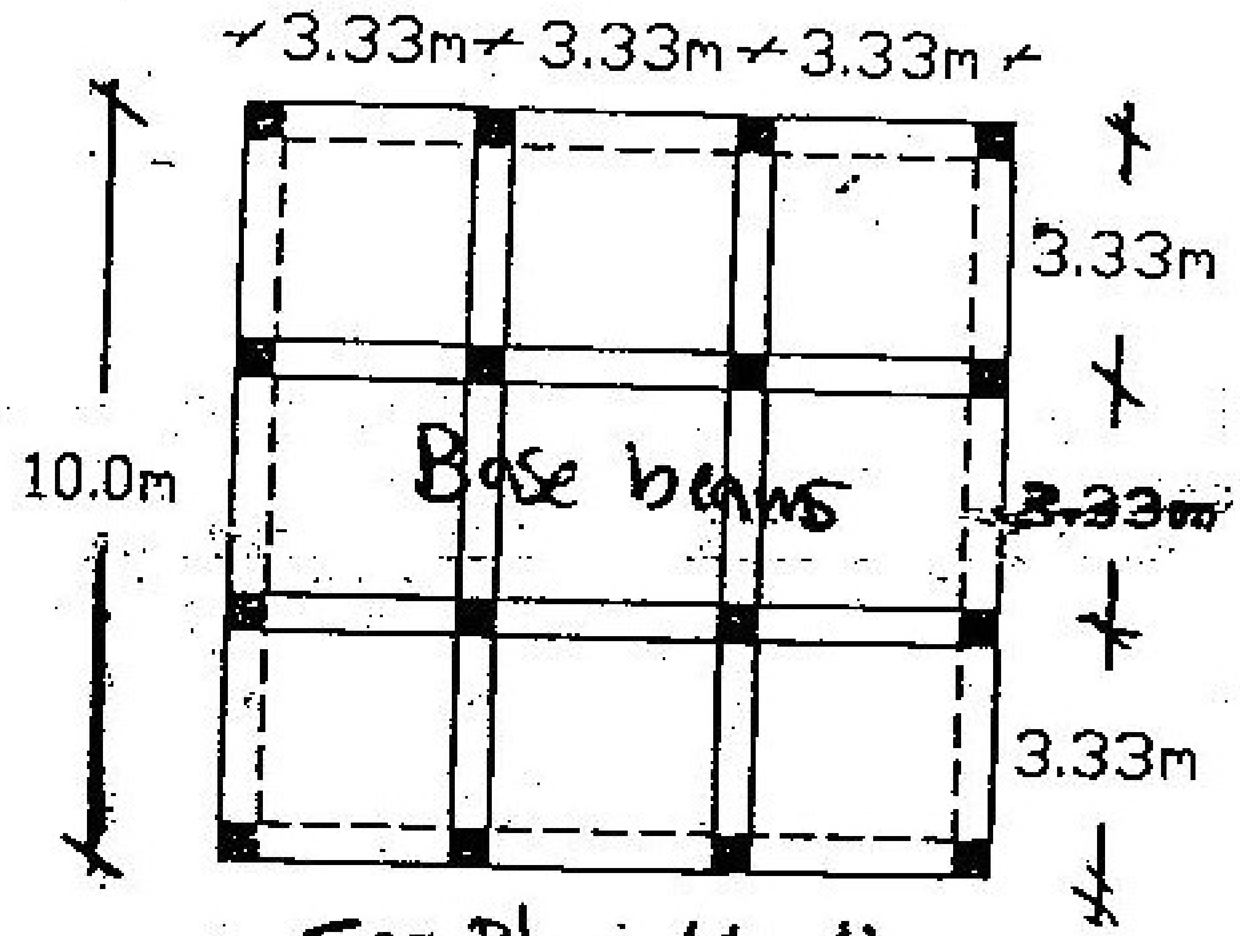
Zagazig University
Faculty of Eng.
Structural Eng. Deprt.
4th year - Civil

Reinforced concrete(3)
Final term EX.
Time 3.0 h 2005-2006

- Answer the following three questions (2-pages)
- Any missing data may be assumed properly
- Tables and charts (hand books) only are allowed
- F_{cu}= 300 kg/cm^2, and steel grade =36/52

Q-1 :(50 %) It is required to make a complete design with all reinforcement Details for all structural elements (Walls and floor) of shown elevated water tank with capacity 500 m^3

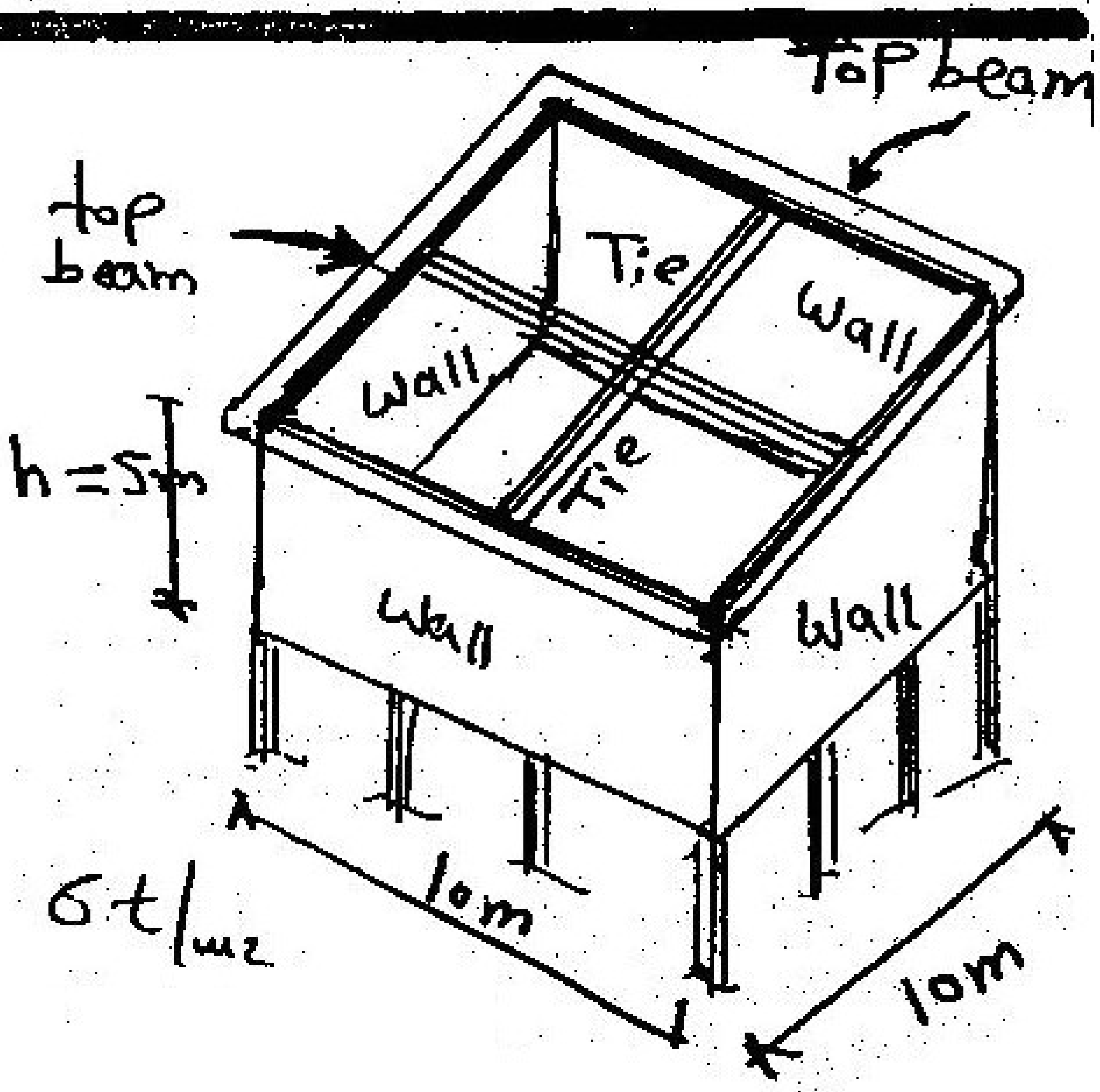




Sec Plan (S-S)

Sol.

(1) Total Loads :



Walls : $P = \gamma \cdot H = 5\ t/m^2$

elevated base: $W = t_b \cdot \gamma_{R.c} + \gamma_w \cdot H_w$

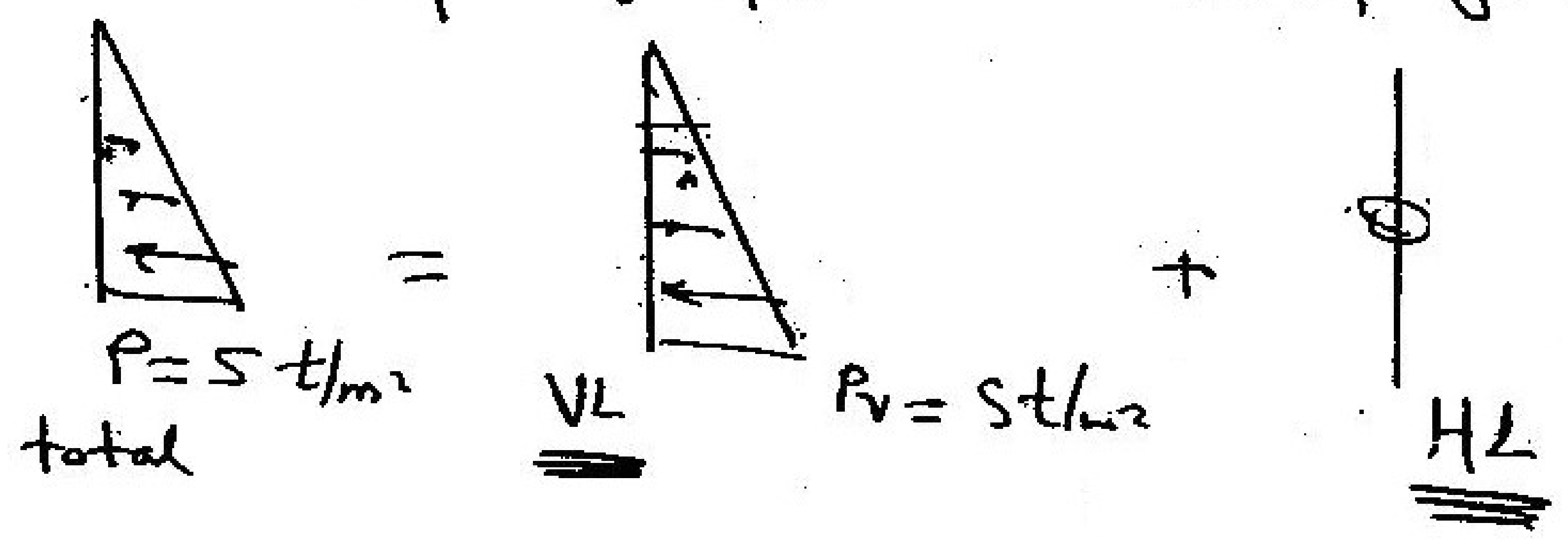
$= 0.4(2.5) + 1 * 5 = 6\ t/m^2$

(2) **Load dist.:** " لا يقسم حائط الا حائط "

Walls: $H = 5m$, $L = 10m$

$\because \left(\frac{L}{H}\right) \geq 2 \Rightarrow$ **Shallow Walls**

∴ كل الأحمال تنتقل في الاتجاه الرأسي



---

base: * القاعدة تقسم على base beams أو حوائط

$r = \left(\frac{3.33}{3.33}\right) = 1 \Rightarrow w_\alpha = w_\beta = \alpha * w$

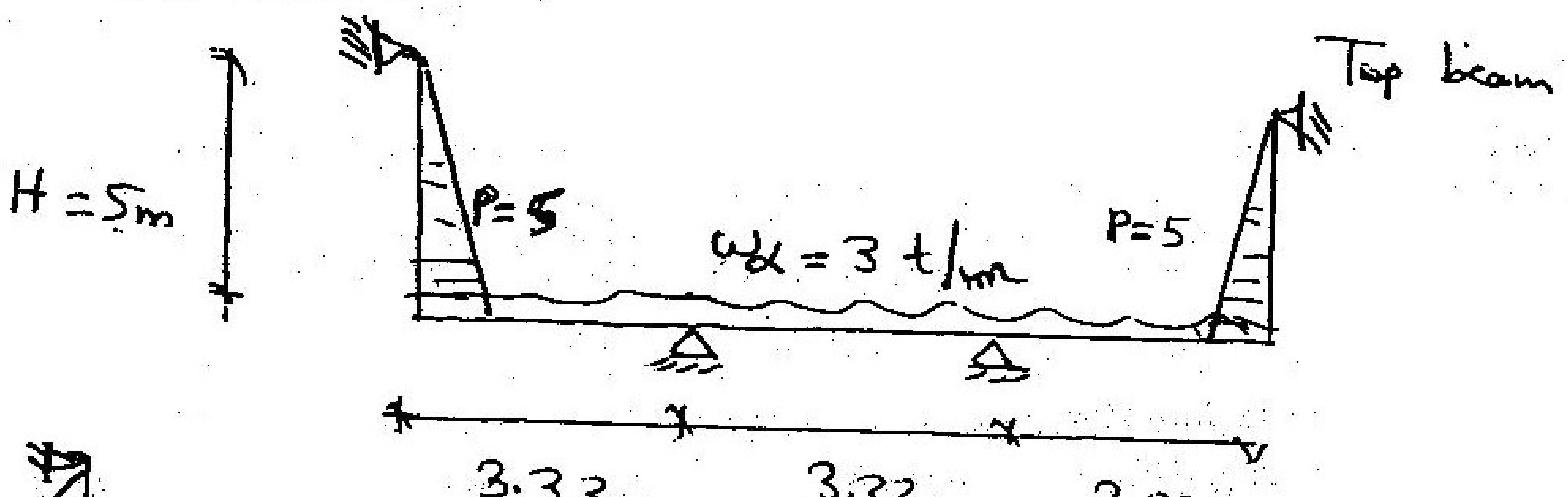
$\alpha = \beta = 0.5$

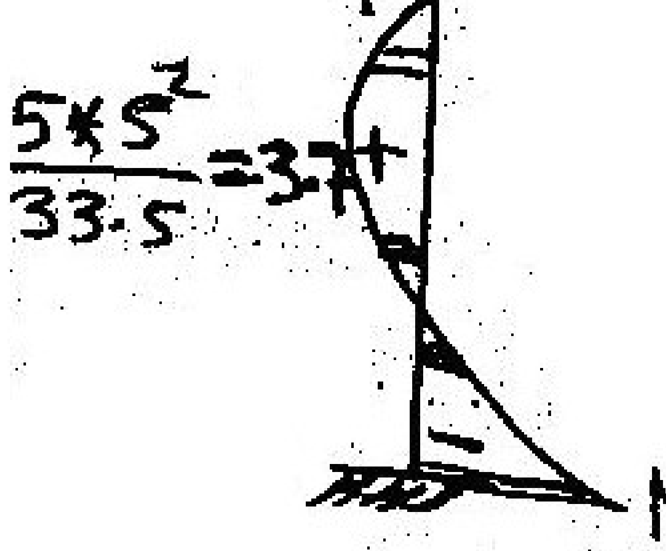
$= 0.5 * 6$

$w = 3\ t/m^2$

---

(3) **V.L. strip:**

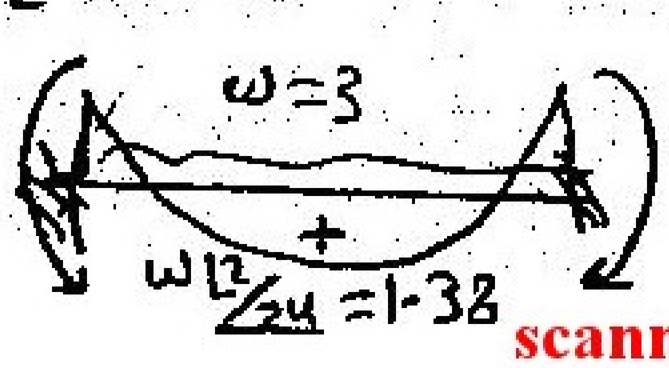




$M_f = \frac{5*5^2}{15} = 8.33\ t.m$

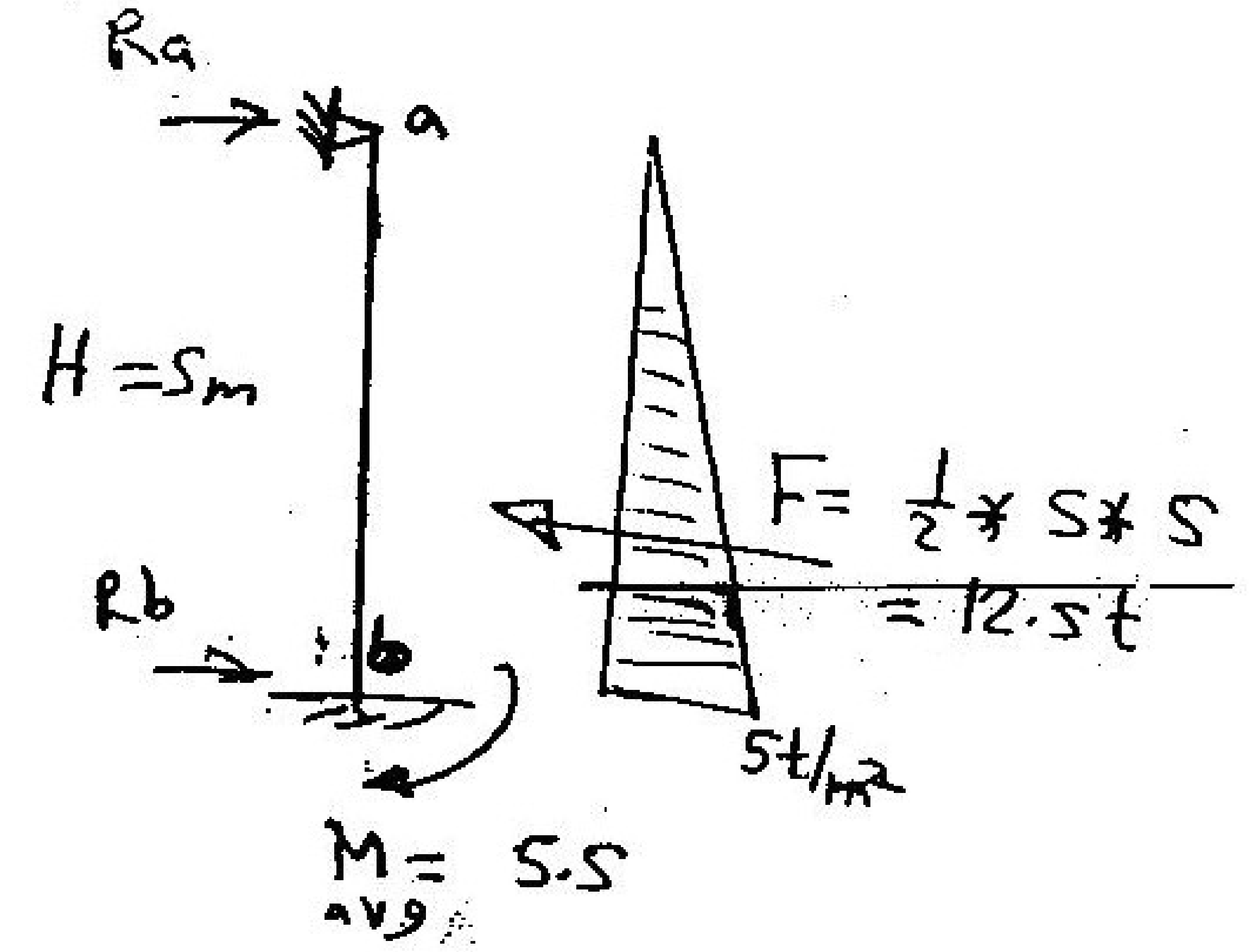
$\frac{wL^2}{12} = 2.7$

$\frac{wL^2}{12} = 2.7$



$M_{avg} = \left(\frac{8.33 + 2.7}{2}\right) = 5.5 \text{ t.m}$

$\Delta M = 8.3 - 5.5$
$\therefore \Delta M = 2.8 \text{ t.m}$



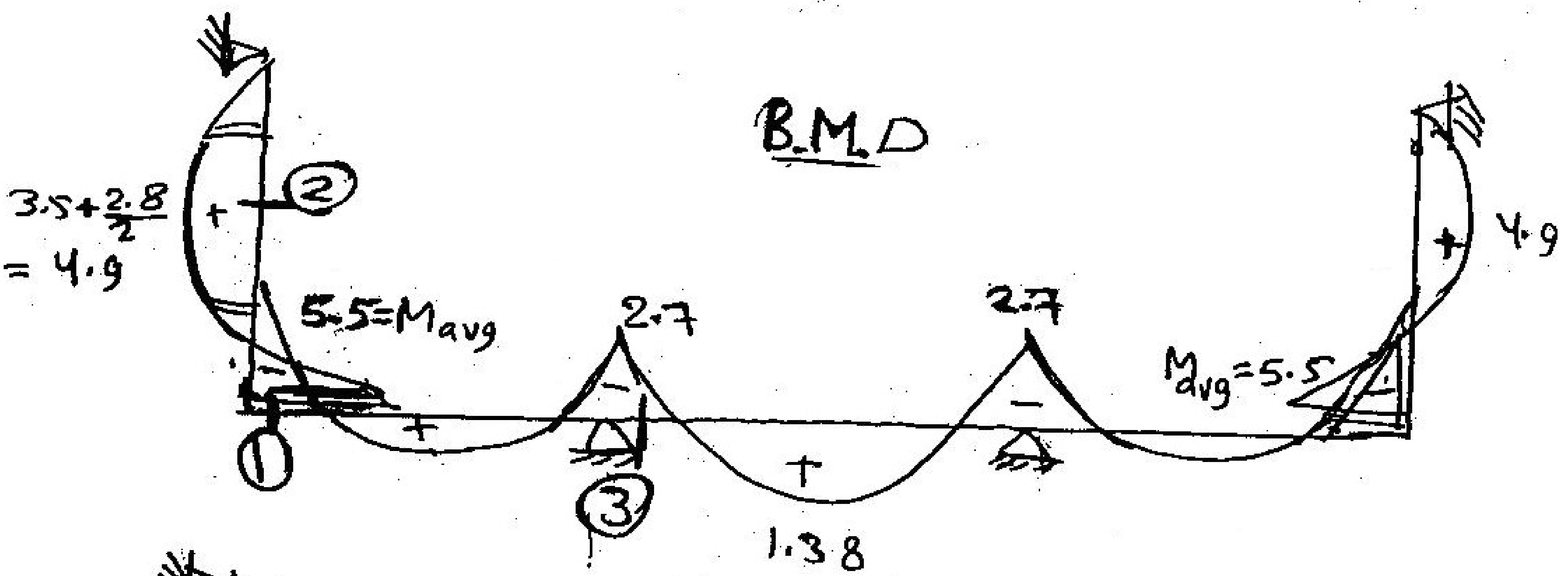
Reactions

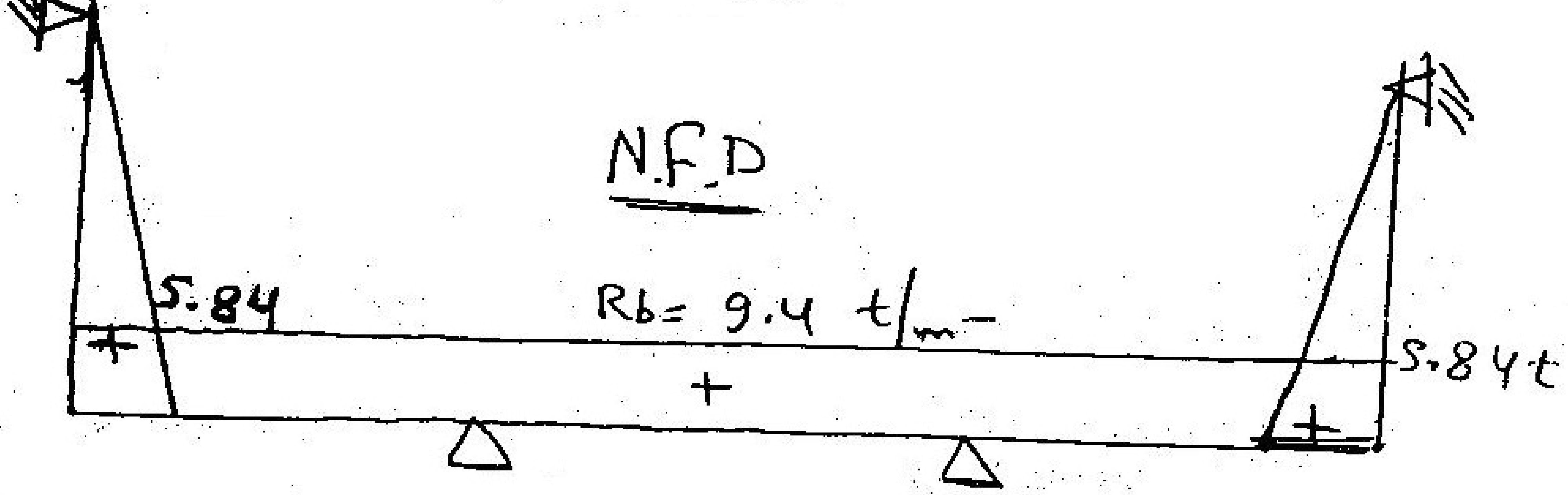
$\sum M_b = 0$

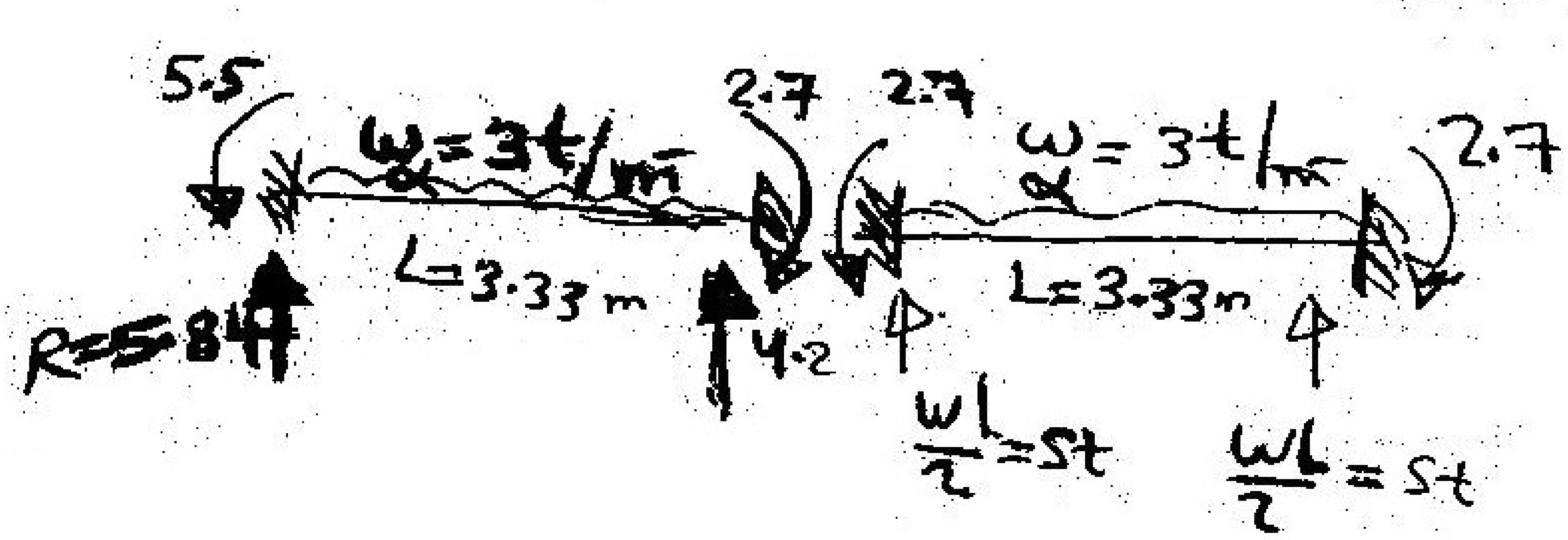
$\therefore \left(12.5 * \frac{5}{3}\right) - Ra * 5 - 5.5 = 0$

$\therefore$ **Ra = 3.1 t/m**

$\therefore \sum F_X = 0 \Rightarrow$ **Rb = 9.4 t**

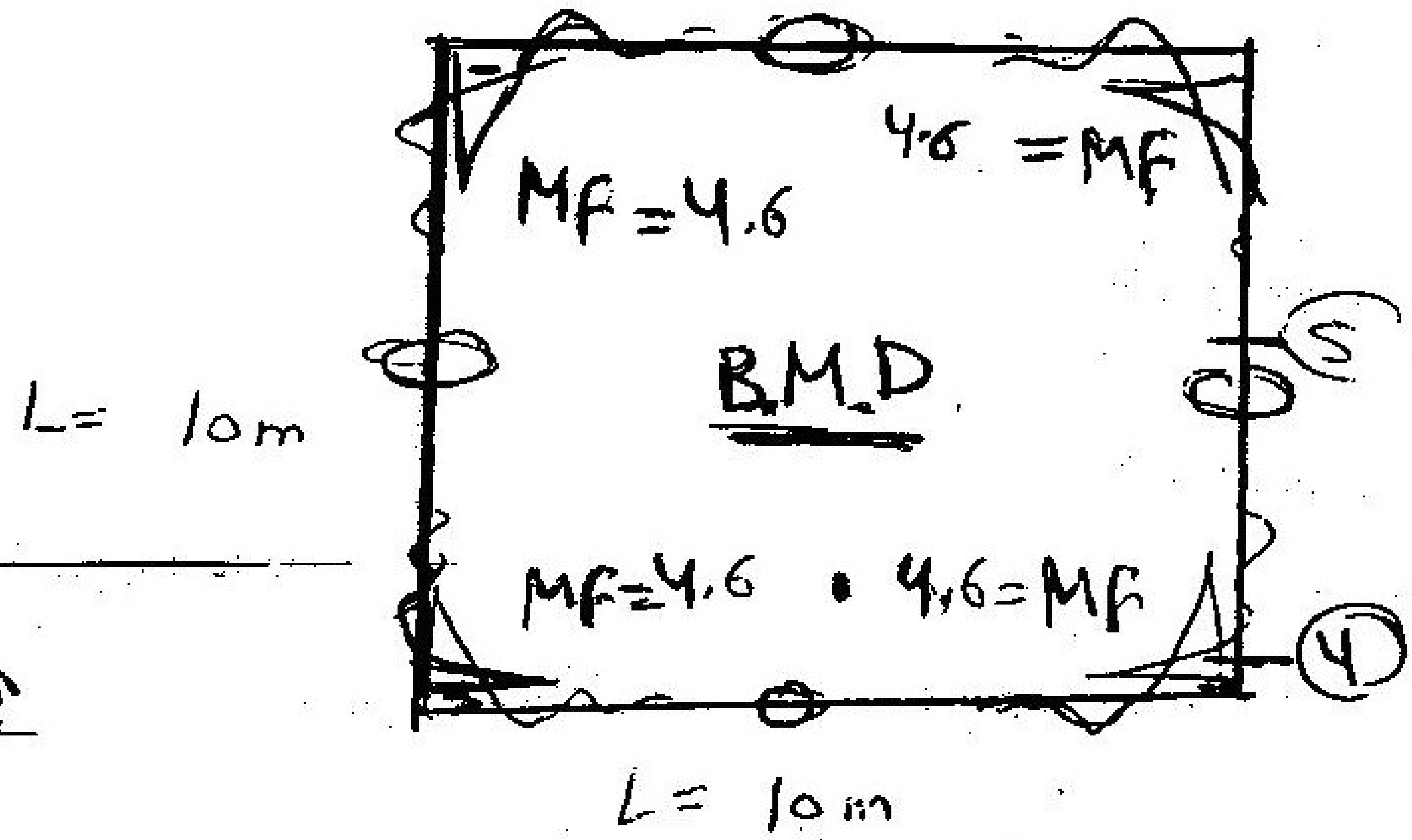






* HL. Strip at $\left(\frac{3}{4}H\right)$

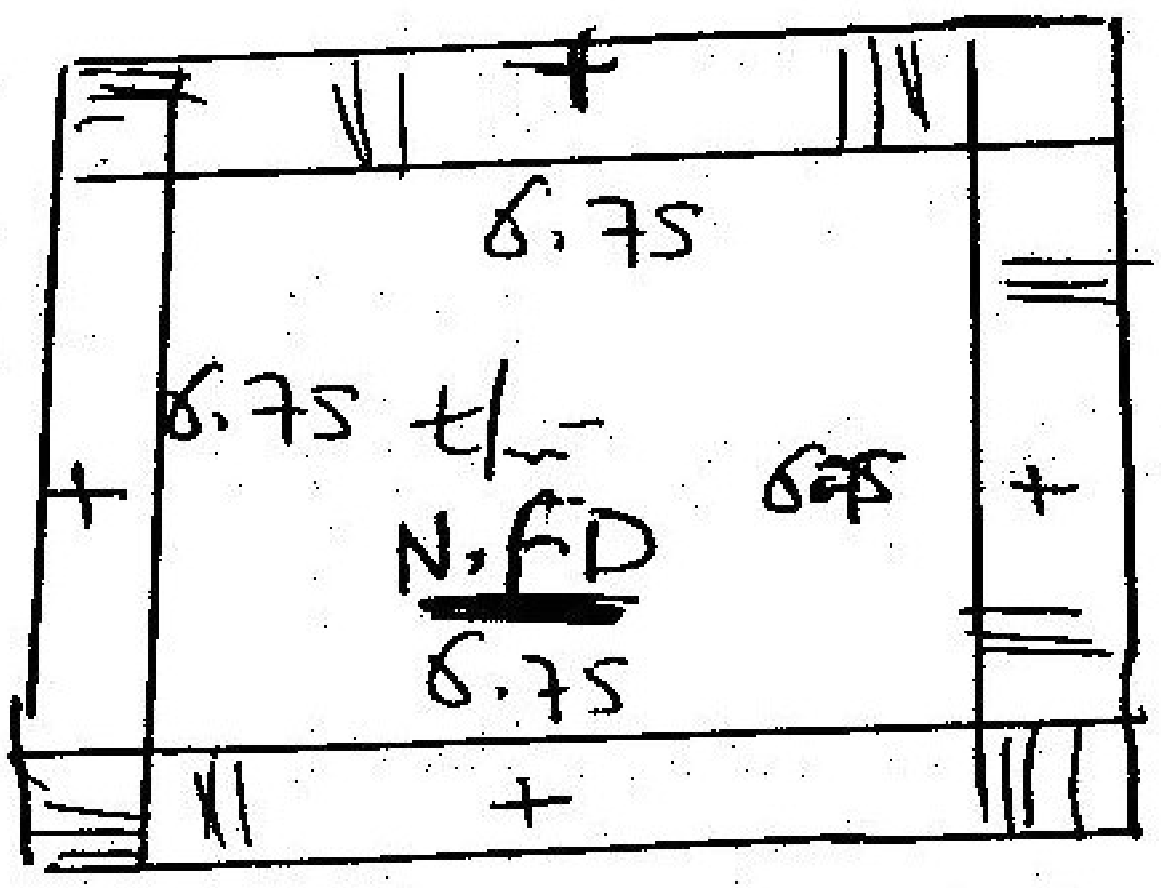
"From plan"



* طالما الحائط الخارجية في HL strip ليس عليها أحمال.

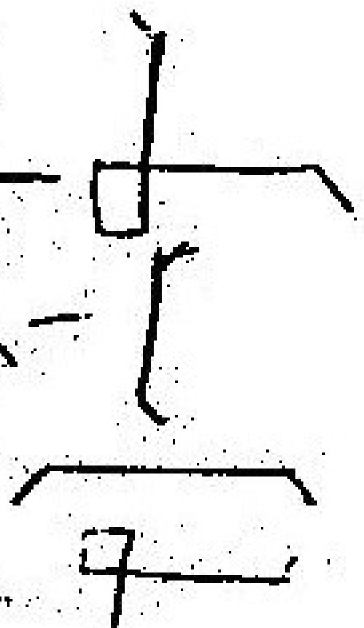
(No Loads) ⟹ $M_f = \frac{\gamma H^3}{27} = \frac{1*5^3}{27} = 4.6$ t.m/m (Empirical)

$R_{Reaction} = 0.27\,\gamma H^2 = 0.27 * 1 * 5^2 = 6.75$ t/m



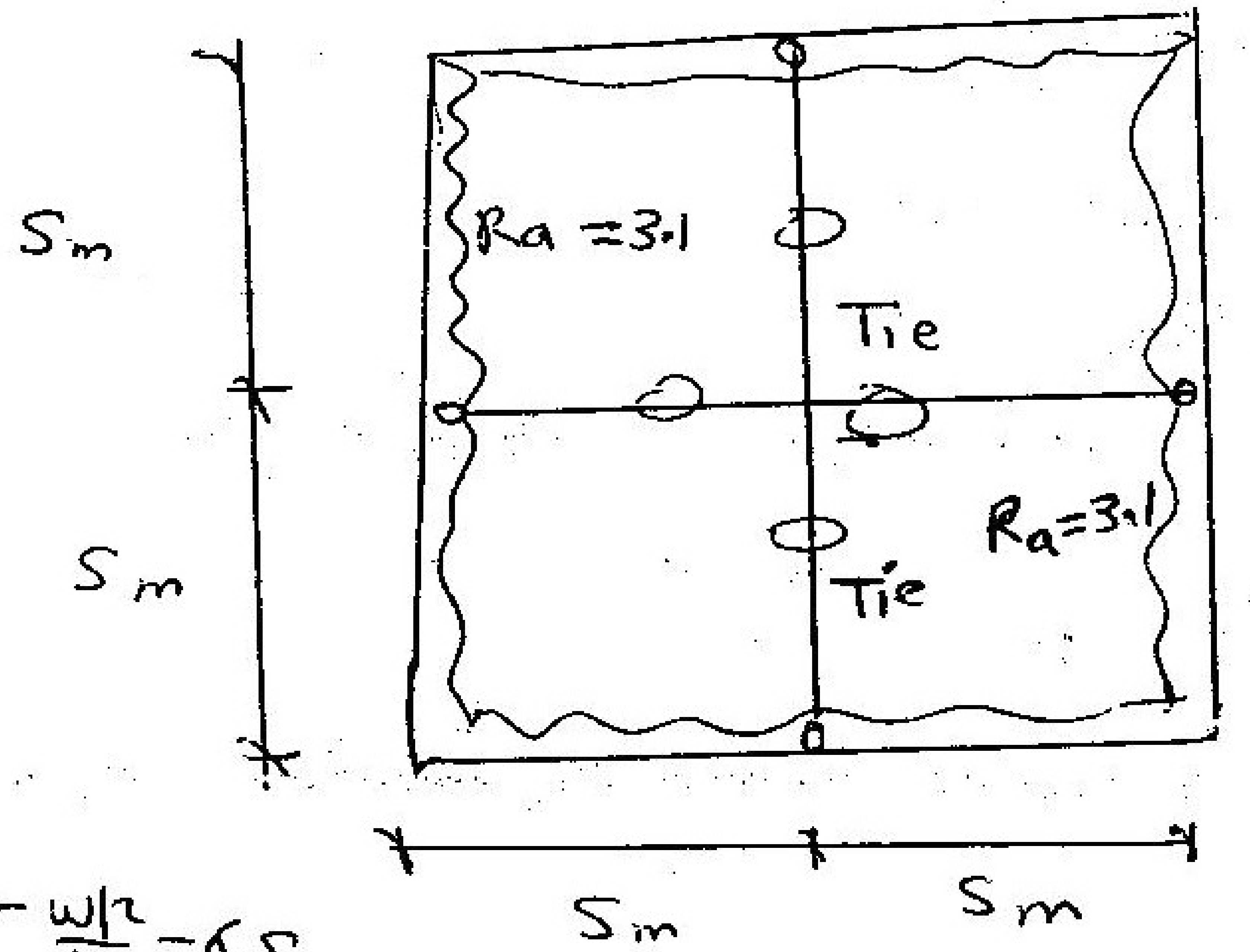
Design of sections

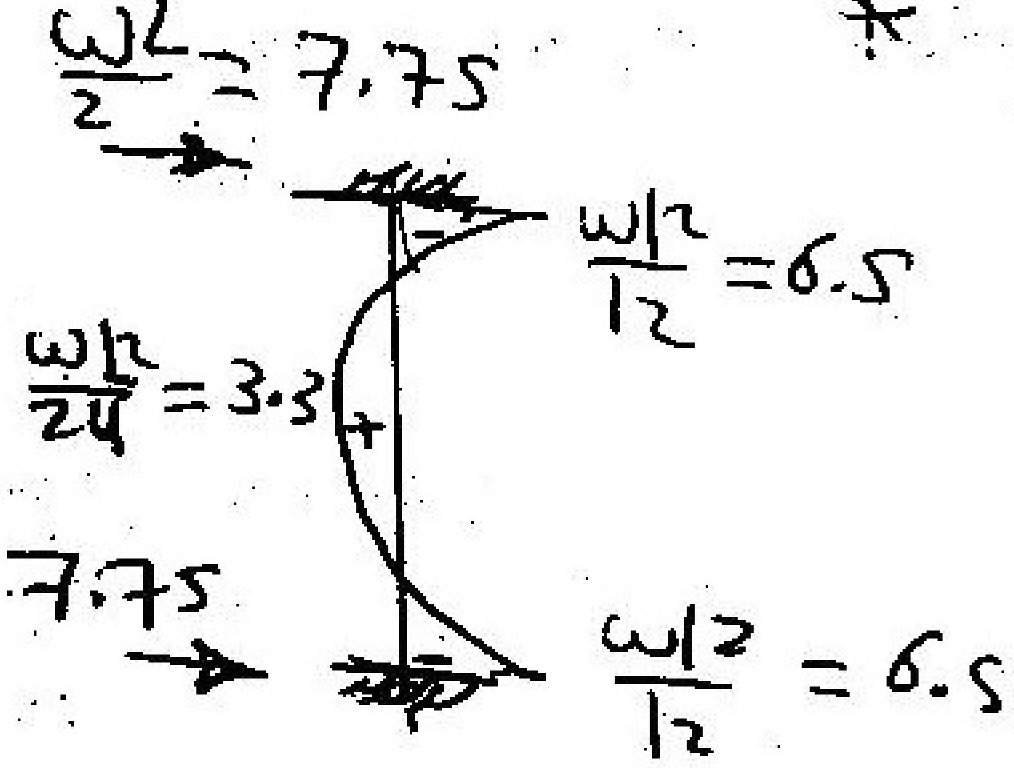
sec.	M	T	t	As
1	5.5 (W)	9.4	50 cm	7 Φ16/m
2	4.9 (air)	5.8	25 cm	7 Φ16/m
3	2.7 (W)	9.4	35 cm	7 Φ12/m
4	4.6 (W)	6.75	50 cm	7 Φ16/m
5	0	6.75	25	7 Φ10/m

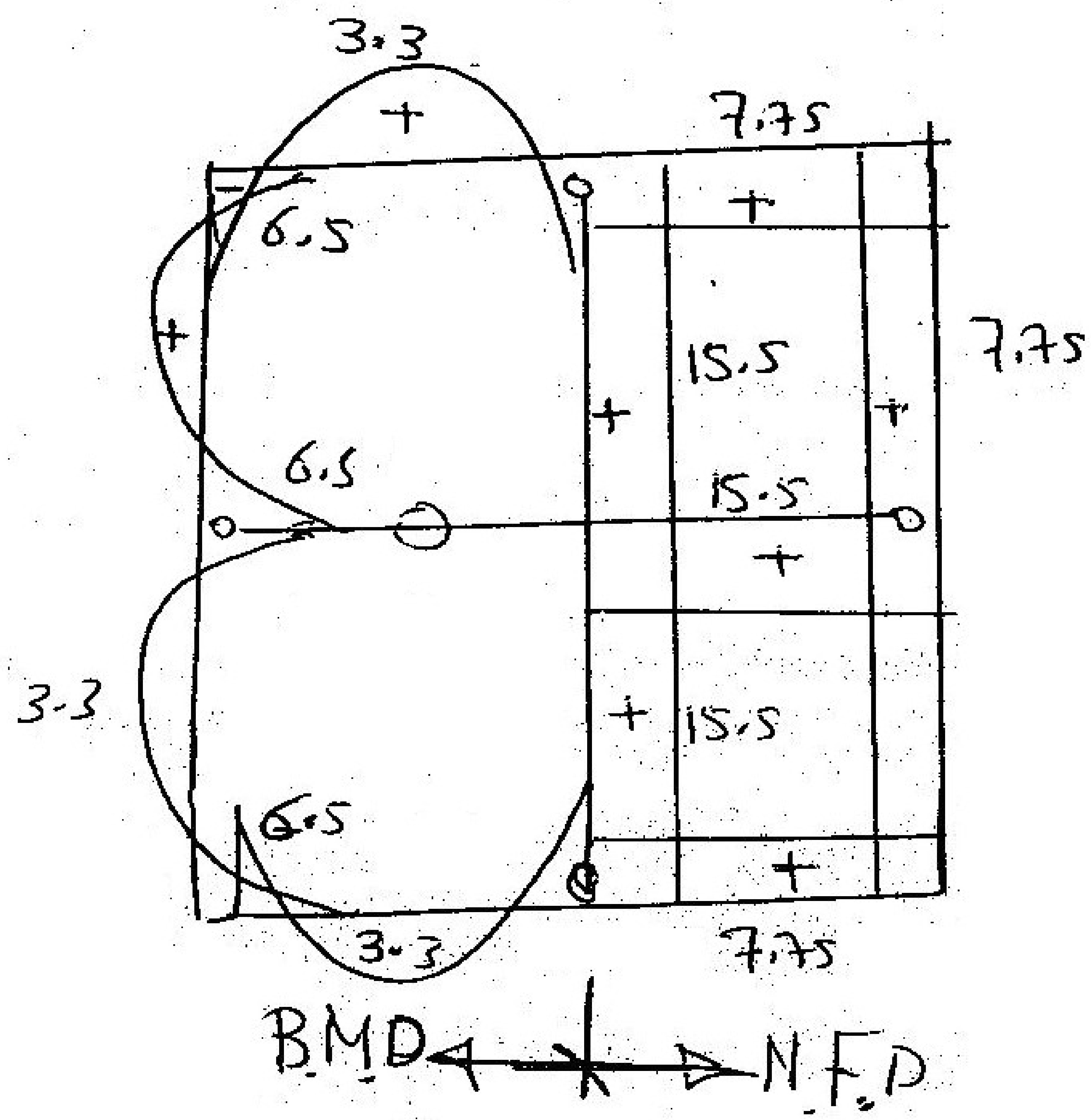


"Top beams"

الركائز
Supports = → ties / → walls







design of section for Top beam:-

$M_{-ve} = 6.5$ t.m ; $T = 7.75$ t/m

water side

$$t = \sqrt{\frac{M}{\psi \cdot b}} + 5 = \sqrt{\frac{6.5 * 10^5}{3.2 * 30}} + 5 = 90 \text{ cm}$$

using b = 30 cm

∴ use $As = 4 \Phi 16$

(Tie):

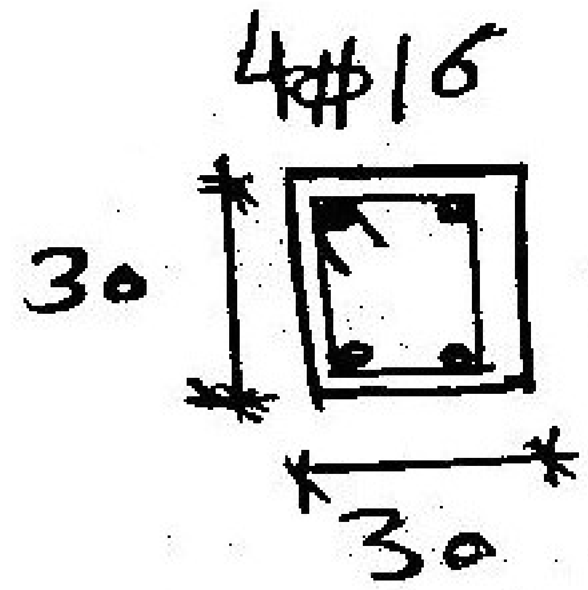
T = 15.5 ton

use: 30 * 30

$T_u = 1.5\, T = 23.25$ ton/m

$$As = \frac{T_u}{(f_y/\gamma_s)} = \frac{23.25 * 10^3}{(3600/1.15)}$$

$= 4 \Phi 16$

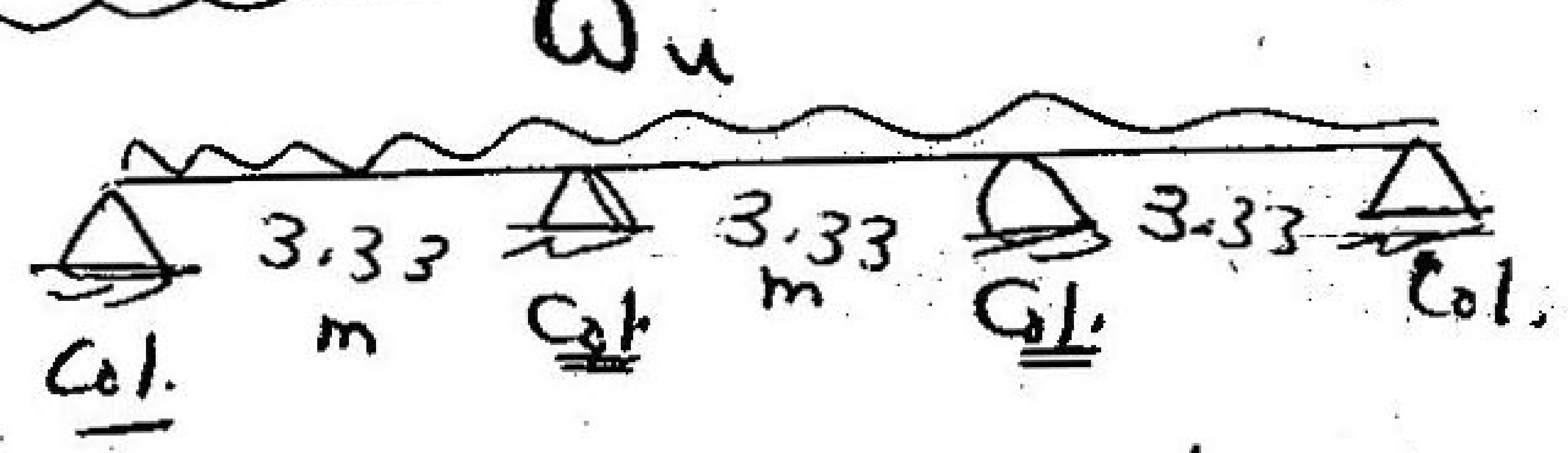


Walls as beams:

(supports) → (أفقيا)

$$\frac{H}{L} = \frac{5}{3.33} = 1.5 \gg 0.4 \Rightarrow \text{(deep beam)}$$

∵ Continous beam



$$w = \text{own wt} + \text{top beam wt.} + R_{slab}$$

(R_{slab} ↓ N.F. wall)

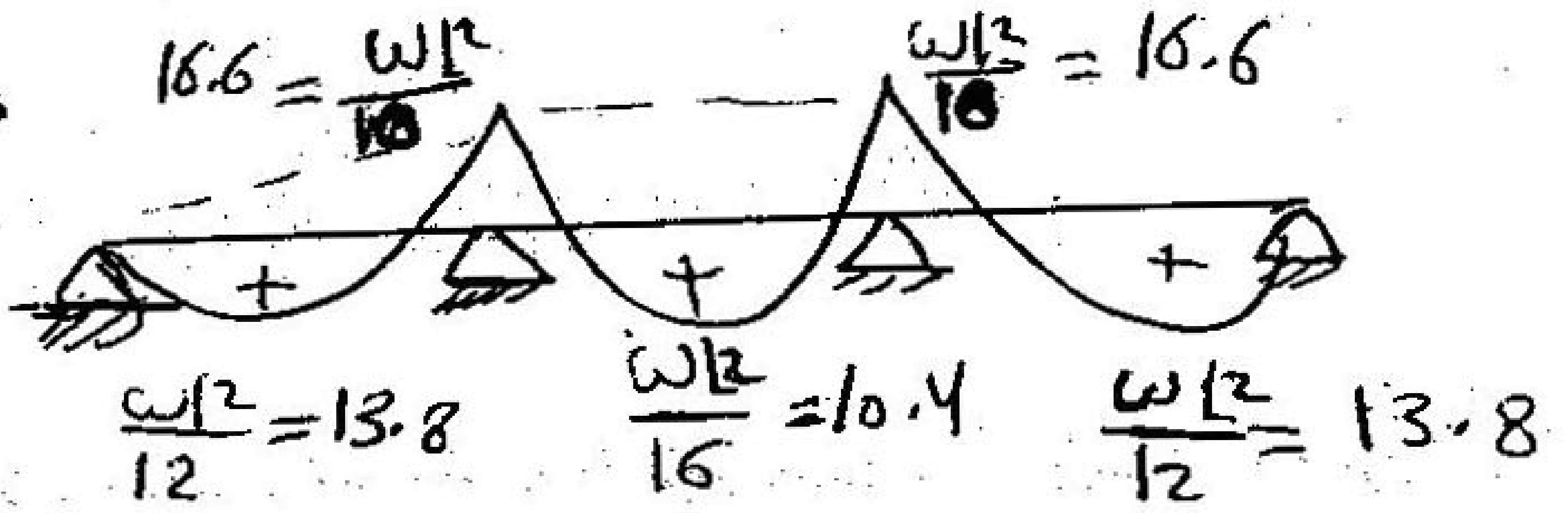
$$= (t_w \cdot H_w \cdot \gamma_{R.C}) + b \cdot t \cdot \gamma_{R.C} + \text{N.F. wall}$$

$$= 0.25(5)\,2.5 + (0.3 * 0.9 * 2.5) + 5.84$$

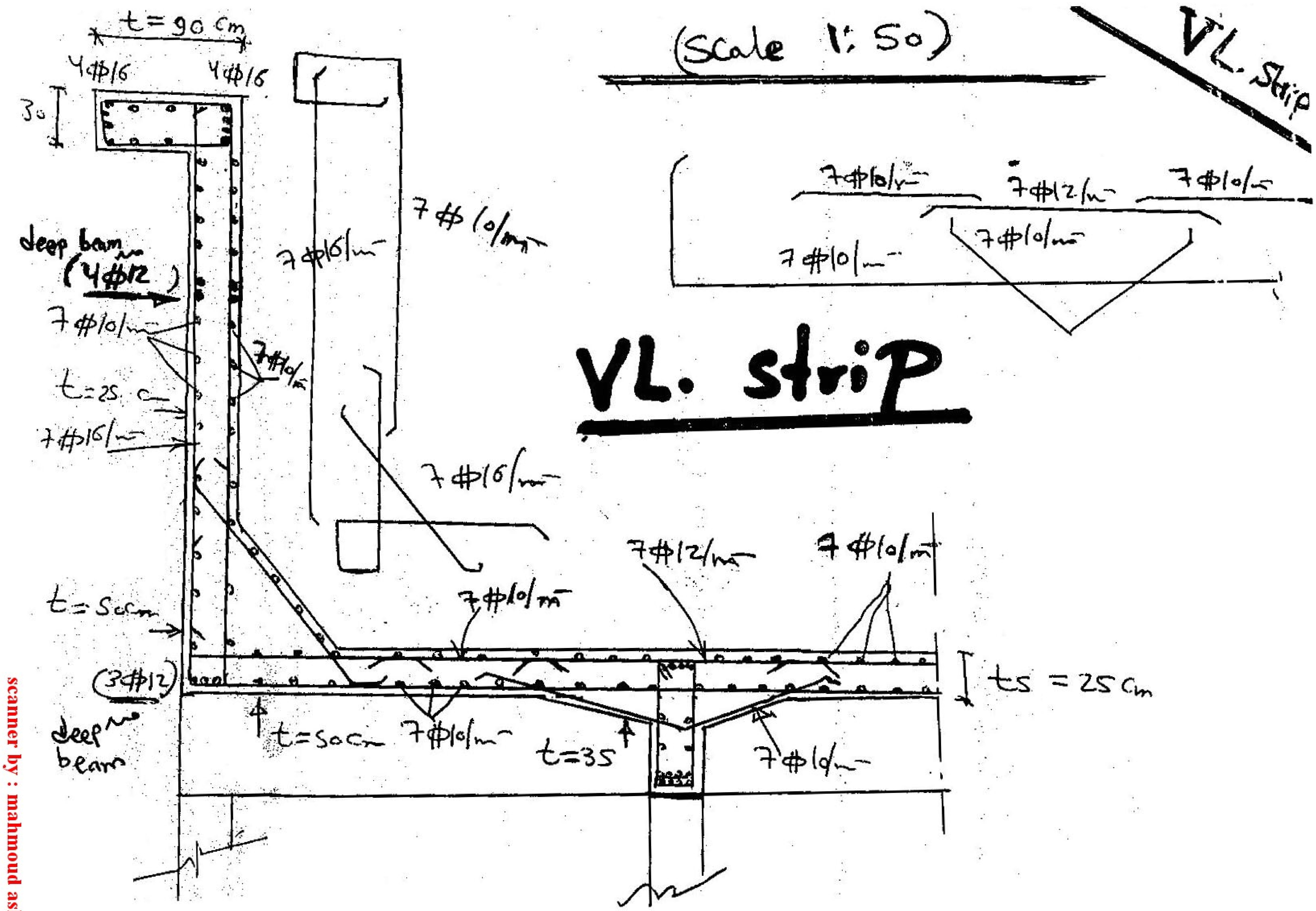
$$w = 9.64 \ t/m$$

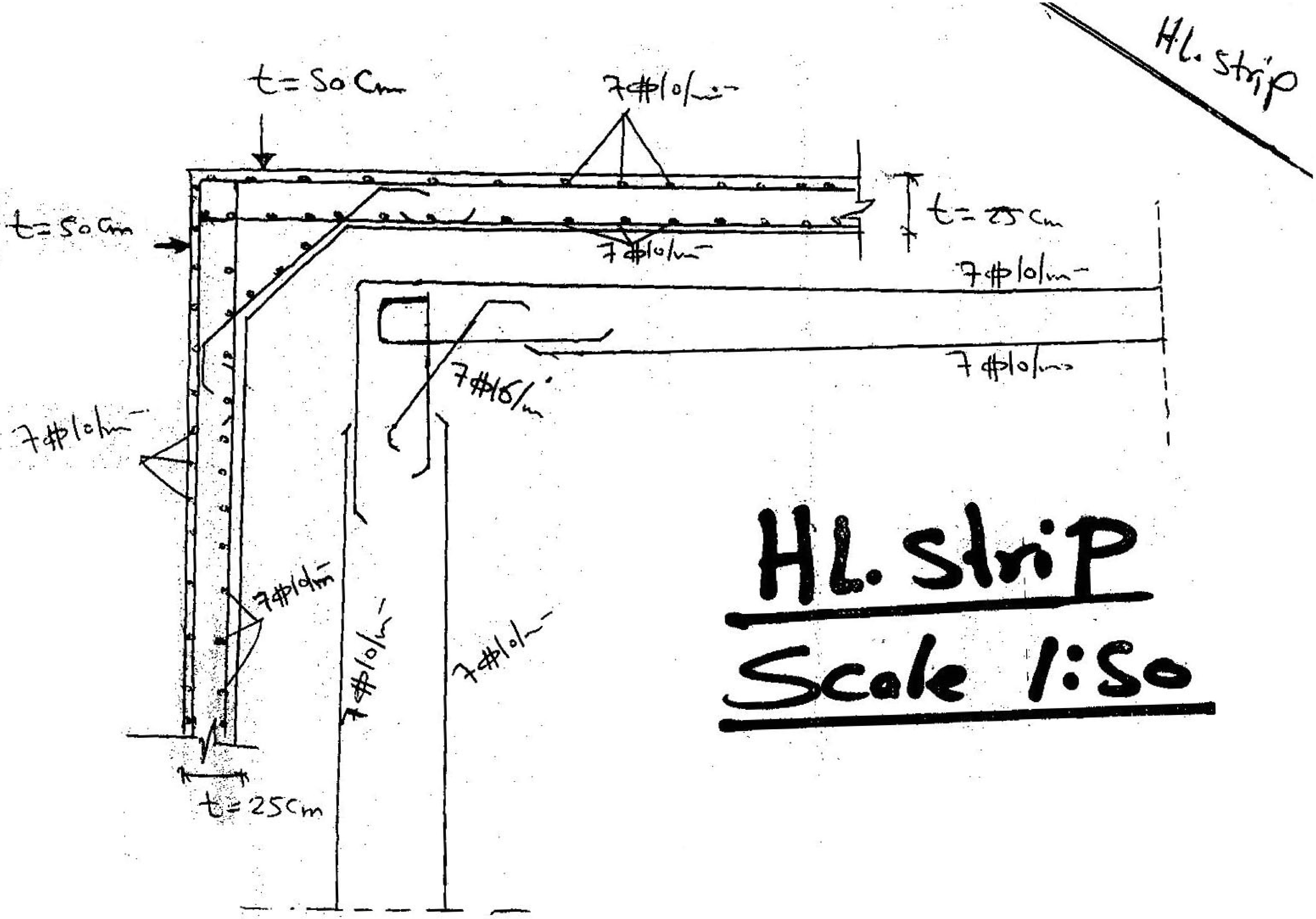
$$\therefore w_u = 9.64 * 1.5 = 15 \ t/m$$

صب كمر [illegible] 1-1 →



$M_{-ve} = 16.6$	$M_{+ve} = 13.8$
$y_{ct} = 0.37\,L = 1.23\,m$	$y_{ct} = 0.43\,L = 1.43\,m$
$T_u = \frac{M}{y_{ct}} = \frac{16.6}{1.23} = 13.5 \ t.m$	$T_u = \frac{M}{y_{ct}} = \frac{13.8}{1.43} = 9.65$
$A_s = \frac{T_u}{f_y/\gamma_s} = \frac{13.5 * 10^3}{(3600/1.15)}$	$A_s = \frac{T_u}{f_y/\gamma_s} = 3.1 \ cm^2$
$= 4.3 \ cm^2$	
$= 4\Phi12$ علوي	(0.6 H) علوي على ارتفاع $= 3\Phi12$

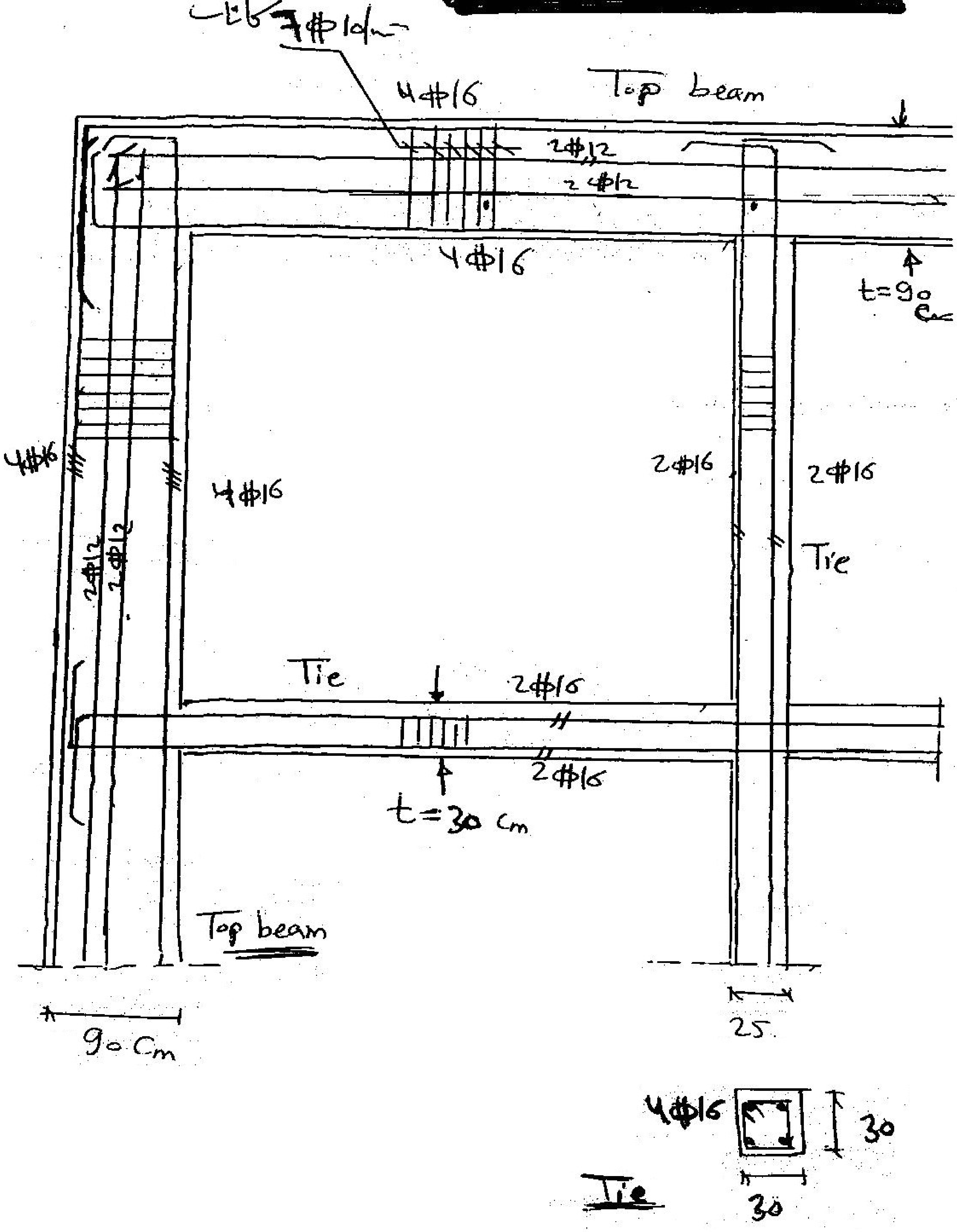

(Scale 1:50)
VL. Strip
VL. strip
t=90 cm
4Φ16
4Φ16
30
deep beam (4Φ12)
7Φ10/m
t=25 cm
7Φ16/m
t=50 cm
(3Φ12)
deep beam
7Φ10/m
7Φ16/m
7Φ10/m
7Φ16/m
7Φ10/m
7Φ12/m
7Φ10/m
7Φ10/m
t=50 cm
7Φ10/m
t=35
7Φ10/m
ts = 25 cm
7Φ10/m
7Φ12/m
7Φ10/m
7Φ10/m
7Φ10/m



Hl. StriP
Scale 1:50

"Top beam"

Top beam & tie



(20)

ر١-

Nour center

الخرسانه المسلحه

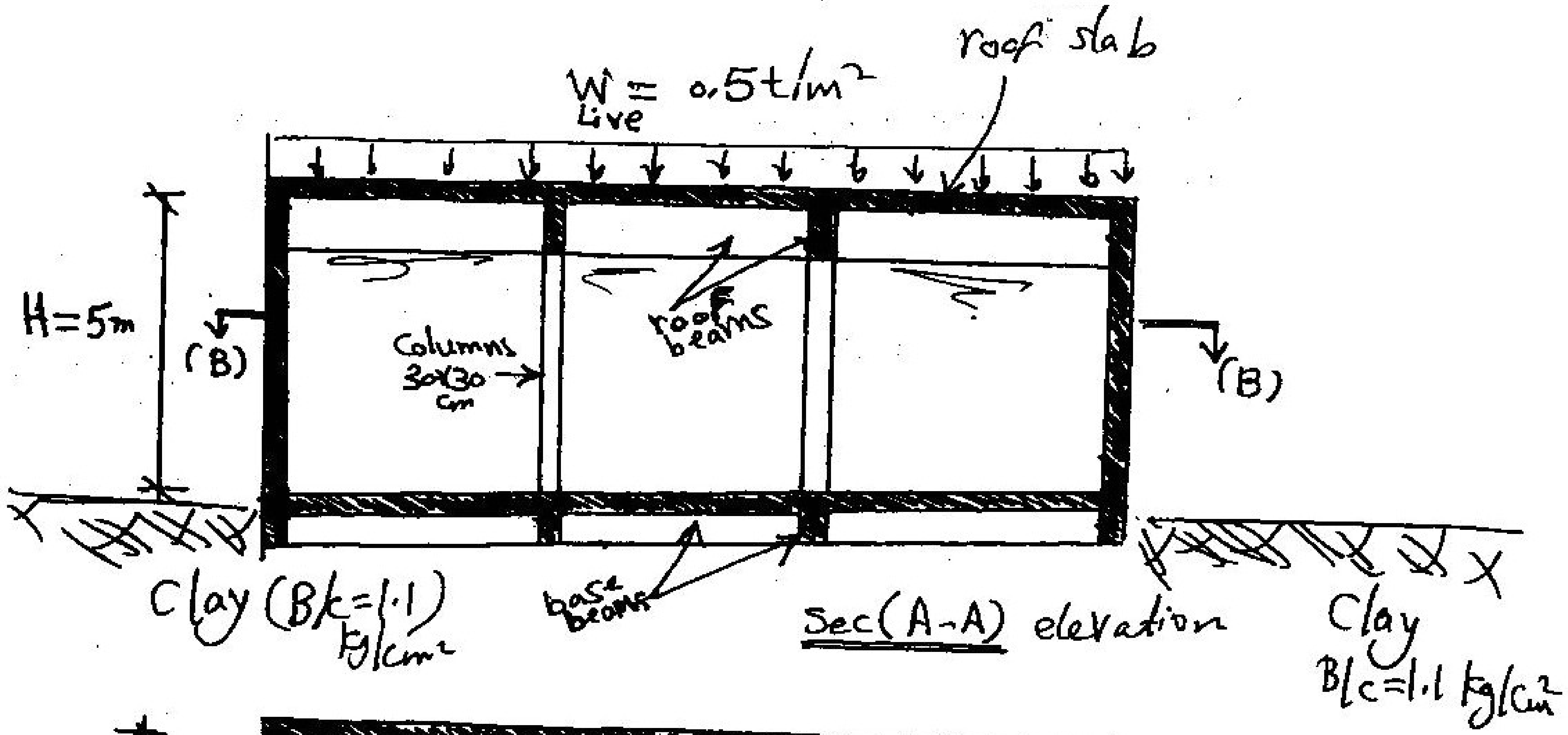
الفرقة الرابعه مدنى

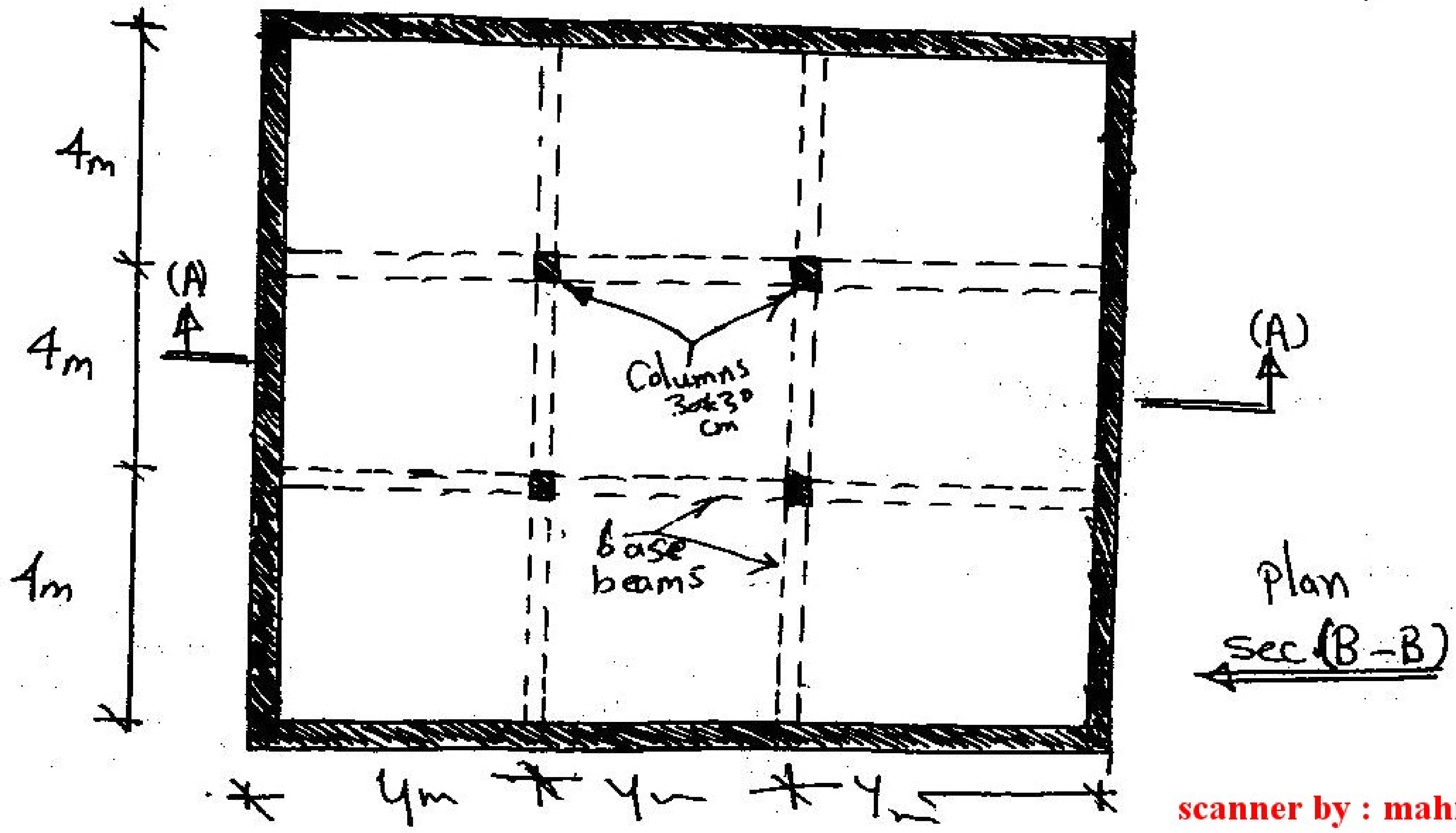
اسم يتردد ..... فكر يتجدد

mediam

"20" Revision. "Rectangular Tanks"

for the shown square rectangular Tank rested on clay ($B/c = 1.1\ kg/cm^2$). It is required to make complete design and details of reinforcement for all elements.





Solution:

(1) loads.

Walls: $P = \gamma_{water} \cdot H = 1 * 5 = 5\ t/m^2$

الضغط العمودي لأسفل

Roof: assume $t_{roof} = 25\ cm$

$$\omega_{roof} = (t_{roof} \cdot \gamma_{R.c}) + \text{live loads}$$

$$= (0.25 * 2.5) + 0.5 = 1.125\ t/m^2$$

Base: on medium soil. (clay)

طول القطعة العامة للقاعدة $\therefore \left(\frac{L}{H}\right) = \frac{4}{5} < 1.5 \Rightarrow$ uniform stress

check stress on soil.

σ_{soil} = مجموع أحمال القاعدة (وزنها + المياه) + مجموع أوزان الحوائط + مجموع أوزان الأعمدة + مجموع أوزان السقف العلوي + مجموع أوزان الكمرات

مجموع أحمال القاعدة (وزنها + المياه):

$$t_b \cdot \gamma_{R.c} + \gamma_{water} \cdot H = (0.4 * 2.5) + 1 * 5 = 6\ t/m^2$$

مجموع أوزان الحوائط:

$$\frac{G * \text{محيط الحوائط}}{\text{مساحة الخزان كله}} = \frac{(0.25 * 5 * 2.5) * (4 * 12)}{(12 * 12)} = 1.04\ t/m^2$$

مجموع أوزان الأعمدة:

$$\frac{\text{وزن العمود} * \text{عدد الأعمدة}}{\text{مساحة الخزان كله}} = \frac{4 * (0.3 * 0.3 * 5) * 2.5}{12 * 12} = 0.03\ t/m^2$$

مجموع أوزان السقف العلوي:

$$t_{roof}\,\gamma_{R.c} + w_{live} = (0.25 * 2.5) + 0.5 = 1.125\ t/m^2$$

مجموع أوزان الكمرات:

نفرض الكمرات (30*80) cm

$$\frac{\text{وزن الكمرة } t/m * \text{محيط الكمرات}}{\text{مساحة الخزان كله}} = \frac{8 * 12 * (0.3 * 0.8 * 2.5)}{12 * 12} = 0.4\ t/m^2$$

(own wt.)

$$\therefore \sigma_{soil\ total} = 6 + 1.04 + 0.03 + 1.125 + 0.4 = 8.6\ t/m^2$$

$$\therefore \sigma_{soil} \ll B/c = 11\ t/m^2$$

$\therefore$ Safe

$$W_{net} = \sigma_{soil} - [\gamma_{water} \cdot H + t_{base} \cdot \gamma_{R.C}]$$

(أحمال القاعدة مباشرة)

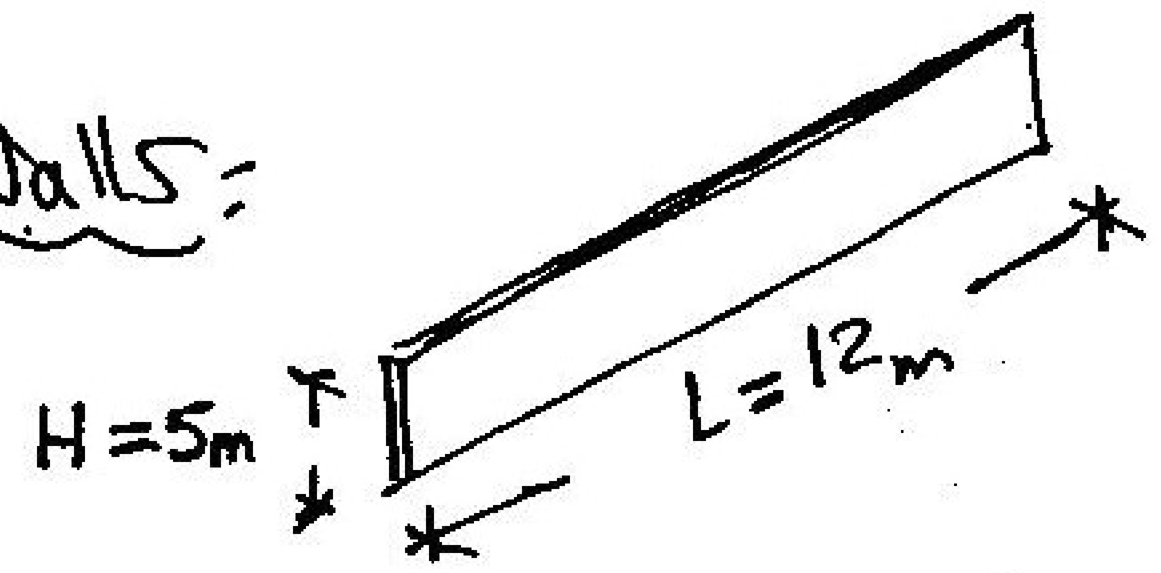
الحمل الصافي الذي تتعرض له القاعدة ليصمم عليها لزوم

$$= 8.6 - (6)$$

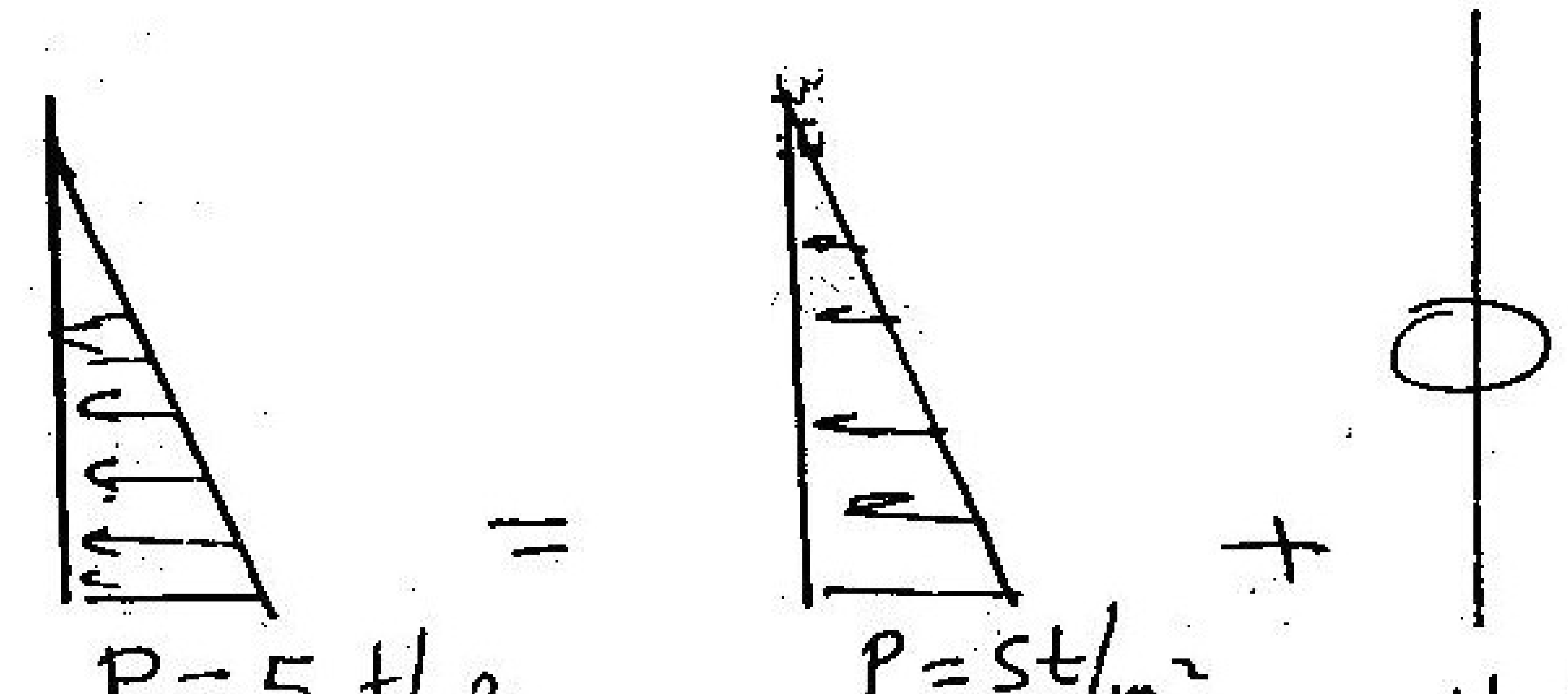
$$W_{net} = 2.6\ t/m^2$$

Load distribution:

Walls:



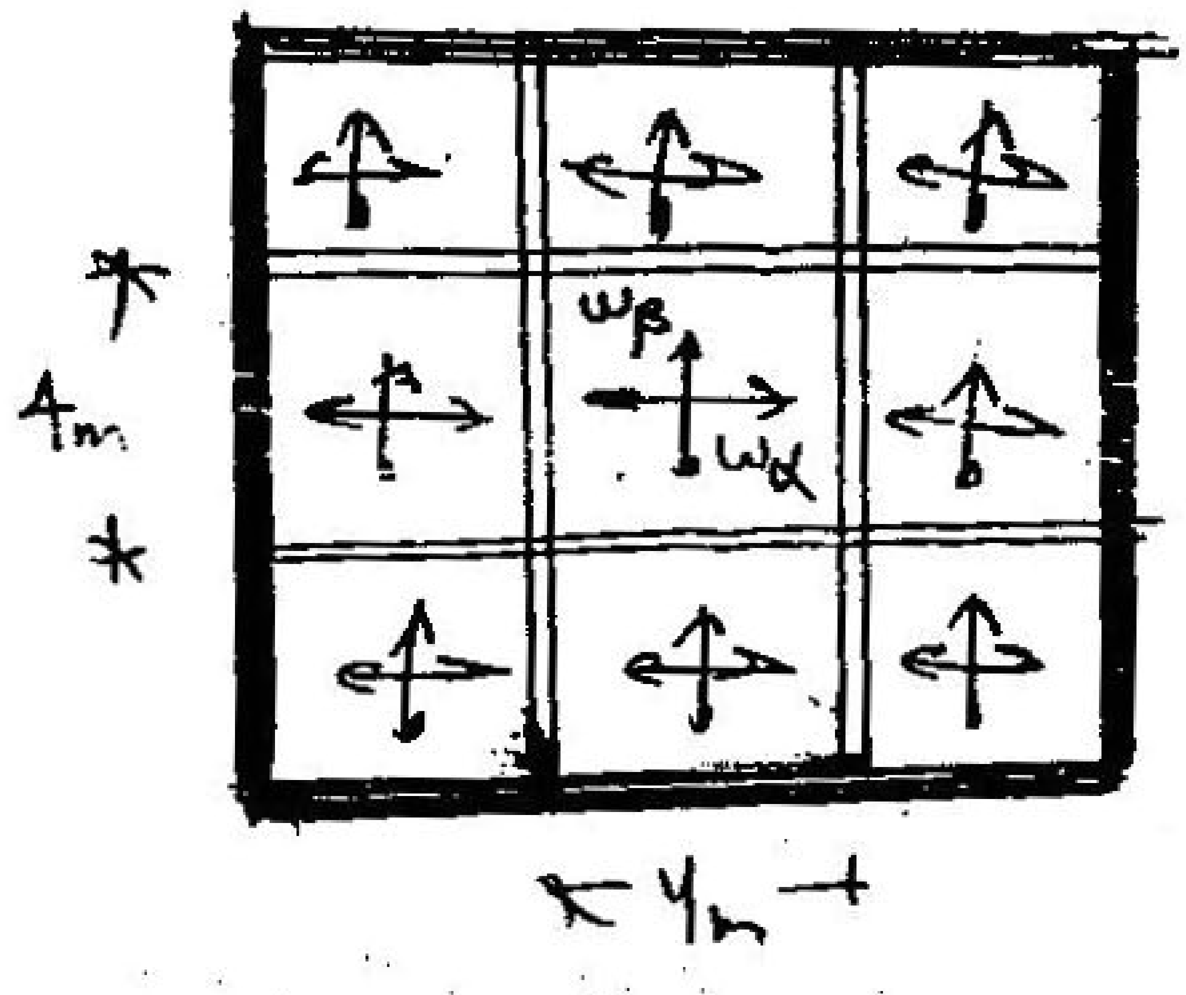
$\frac{L}{H} > 2 \Rightarrow$ one way in V.L. direction



P = 5 t/m² total = P = 5 t/m² vertical + Horizontal

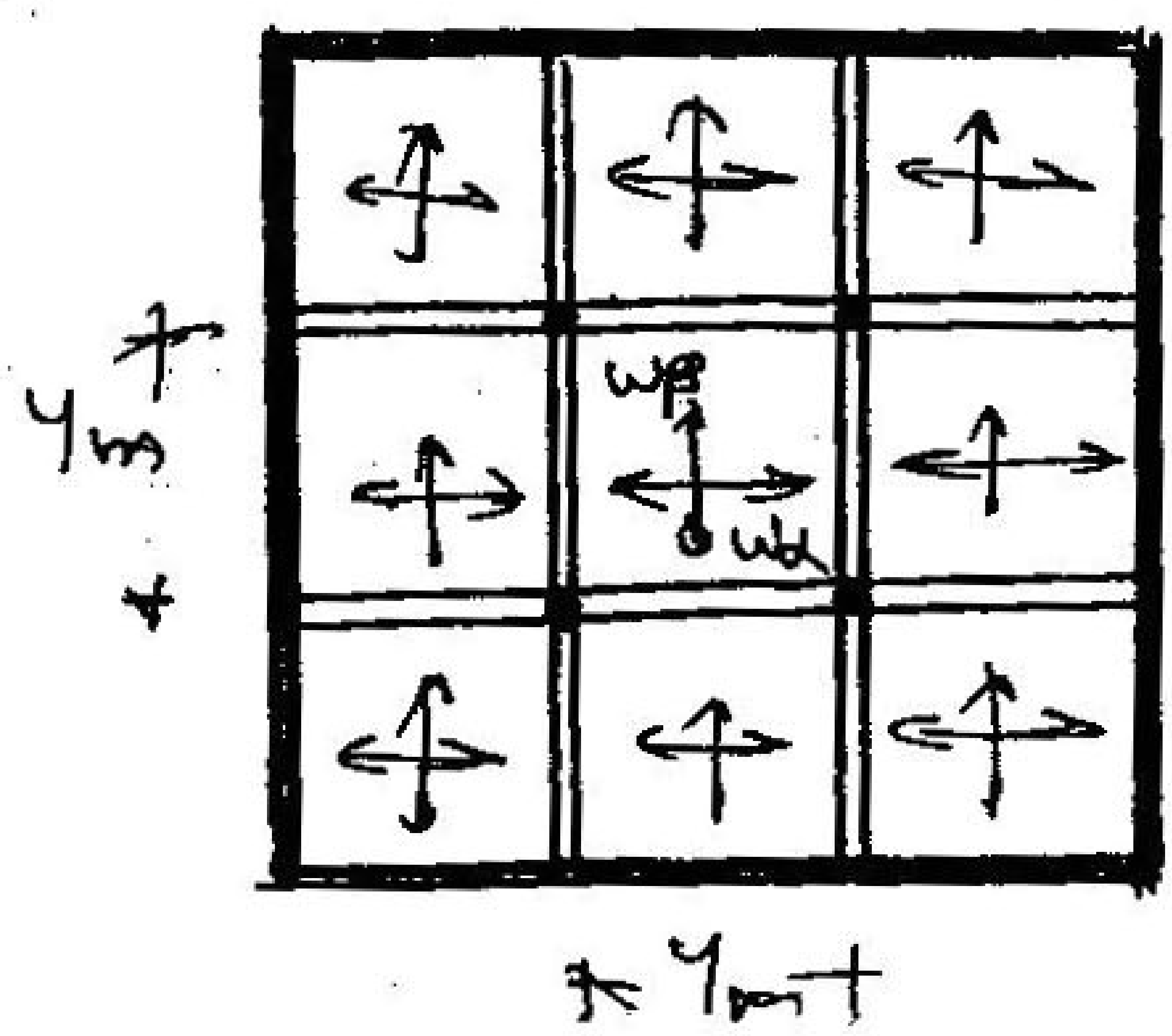
roof : $r = \frac{4}{4} = 1 \Rightarrow w_\alpha = w_\beta = (0.5 * w_{roof}) = 0.5 * 1.125$

$= 0.56 \ t/m^2$

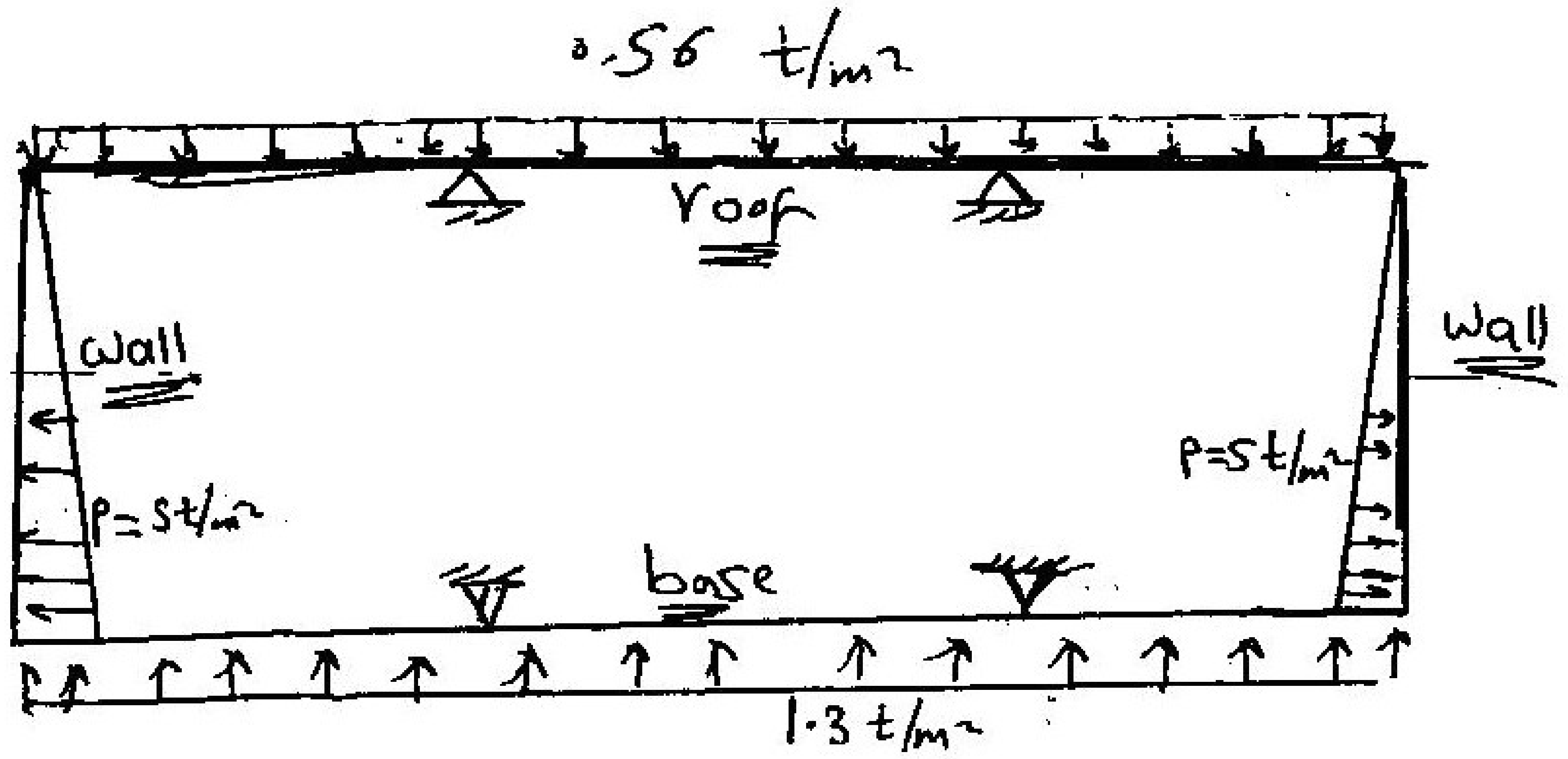


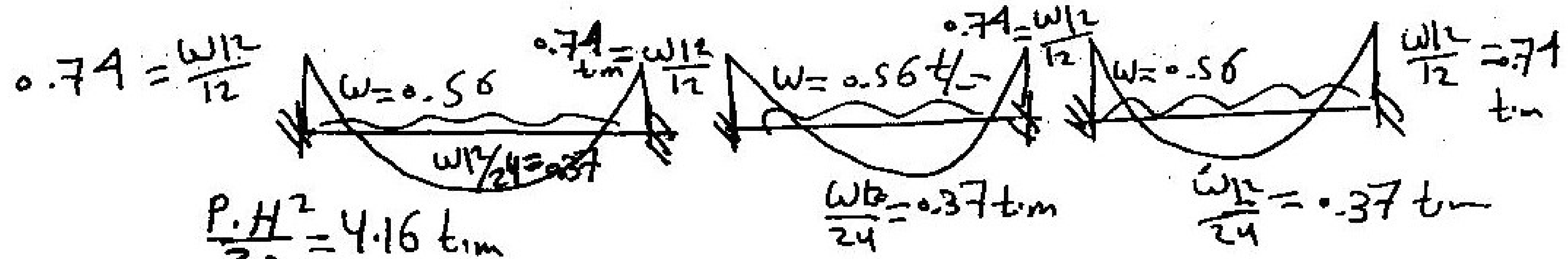
Base : $r = \frac{4}{4} = 1 \Rightarrow w_\alpha = w_\beta = (w_{net} * 0.5)$

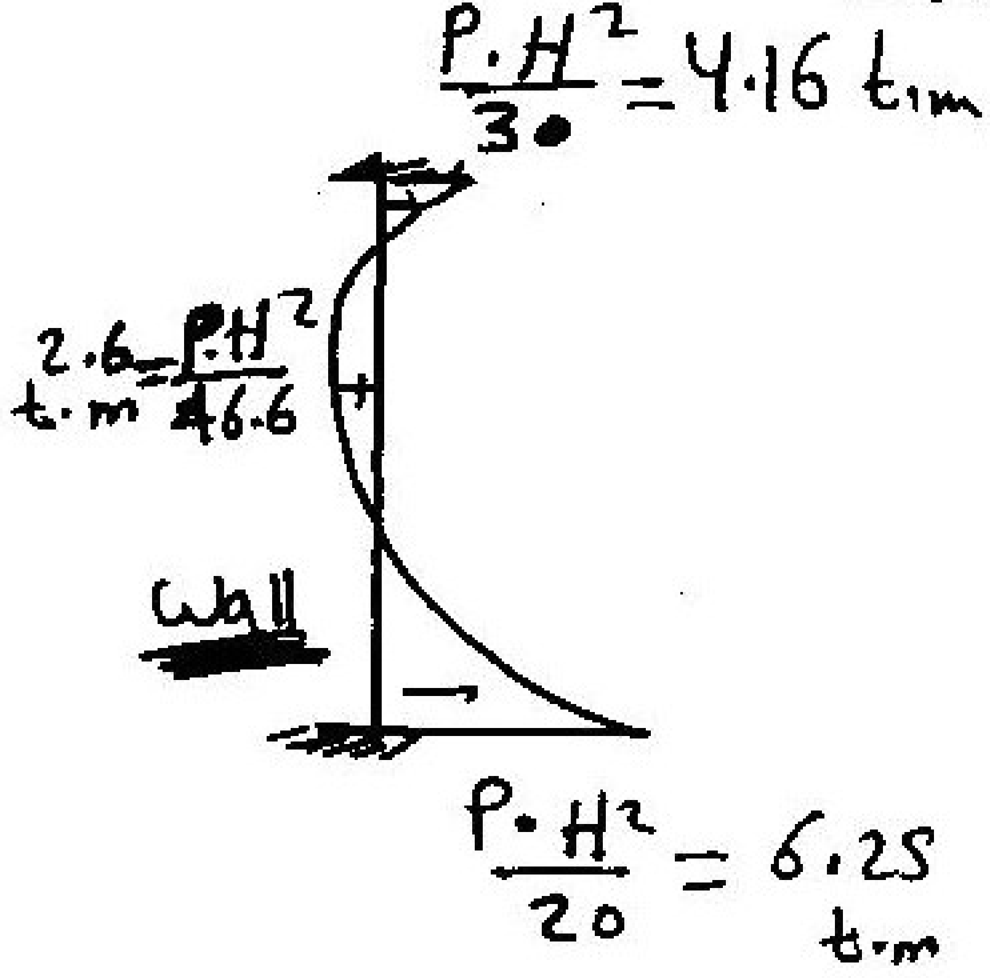
$= 2.6 * 0.5 = 1.3 \ t/m^2$

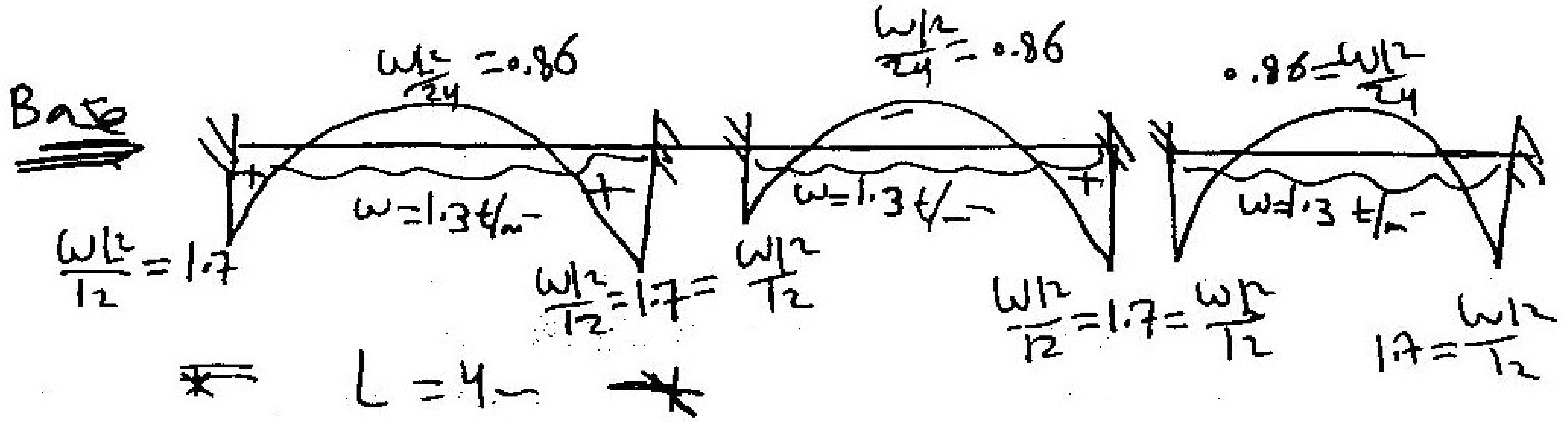


VI. Strip: (A-A)


0.56 t/m2
roof
wall
wall
P=5t/m2
P=5t/m2
base
1.3 t/m2


0.74 = Wl2/12
W=0.56
0.74 t.m = Wl2/12
Wl2/24 = 0.37
0.74 = Wl2/12
W = 0.56 t/m
Wl2/24 = 0.37 t.m
W = 0.56
Wl2/12 = 0.74 t.m
Wl2/24 = 0.37 t.m

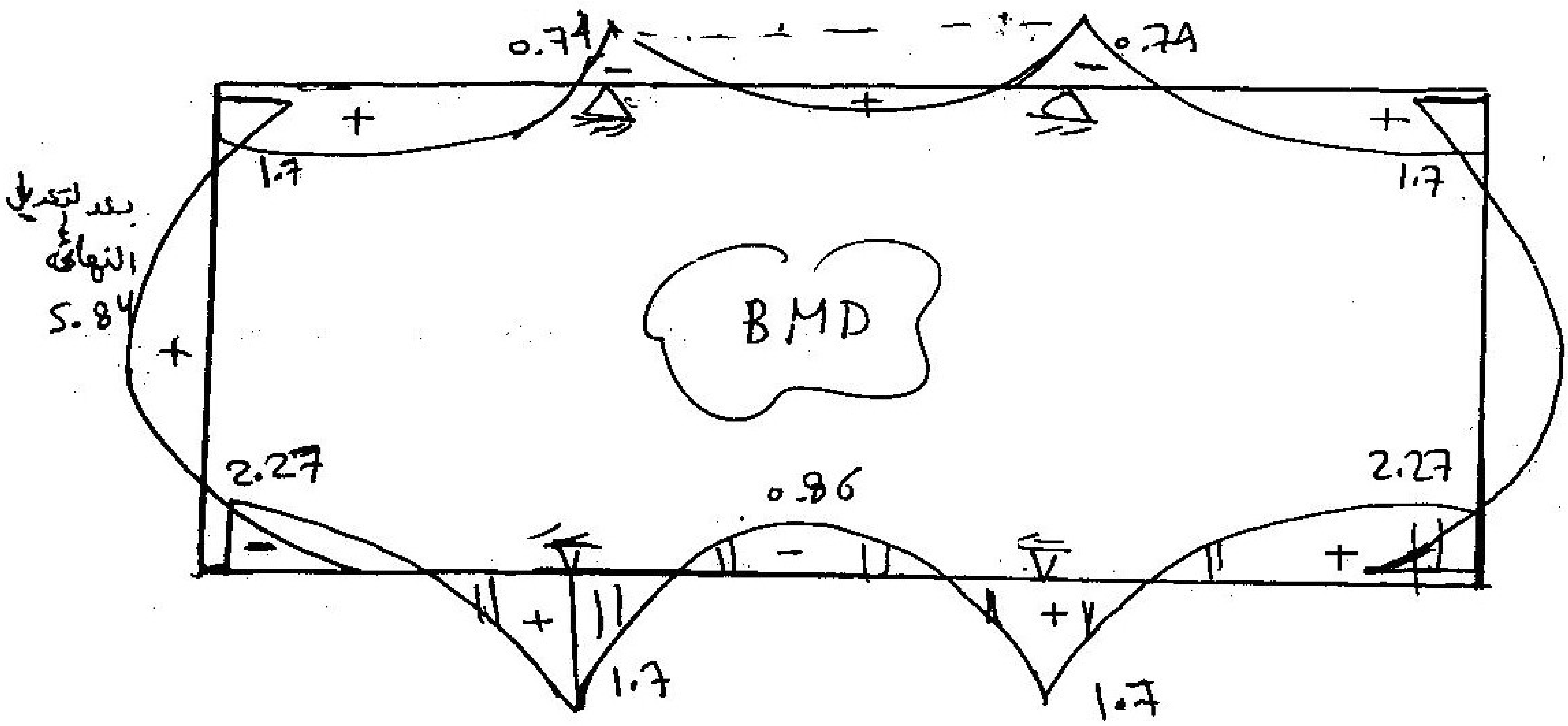

P.H2/30 = 4.16 t.m
2.6 t.m = P.H2/46.6
wall
P.H2/20 = 6.25 t.m


Base
Wl2/24 = 0.86
Wl2/24 = 0.86
0.86 = Wl2/24
W=1.3 t/m
W=1.3 t/m
W=1.3 t/m
Wl2/12 = 1.7
Wl2/12 = 1.7 = Wl2/12
Wl2/12 = 1.7 = Wl2/12
1.7 = Wl2/12
L = 4 m

∴ العزوم غير متزنة ⟵ نعمل إتزان عزوم

$$M_{avg\ top} = \left(\frac{4.16 - 0.74}{2}\right) = 1.7 \ t.m$$

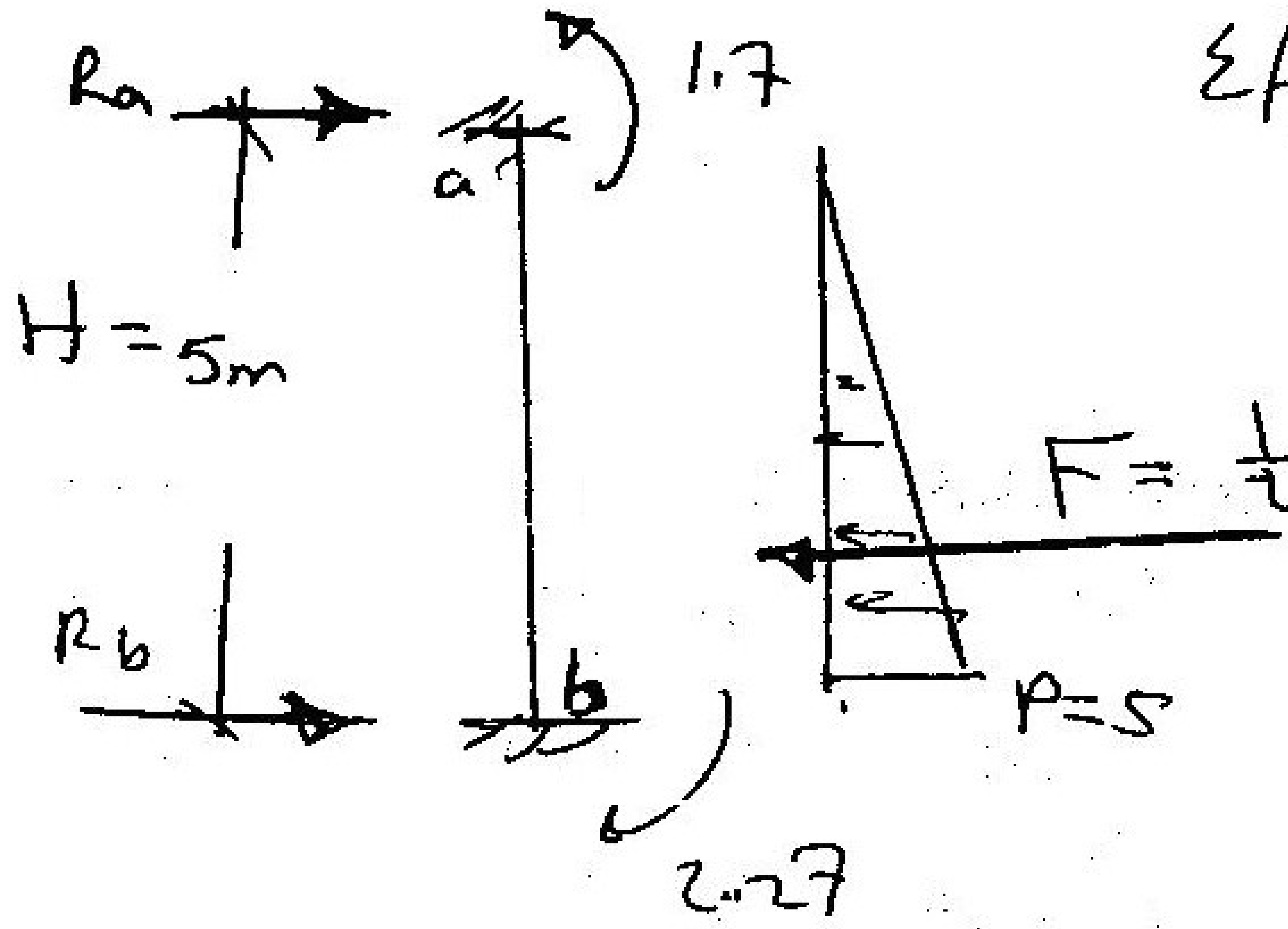
$$M_{avg\ bottom} = \left(\frac{6.25 - 1.7}{2}\right) = 2.27 \ t.m$$



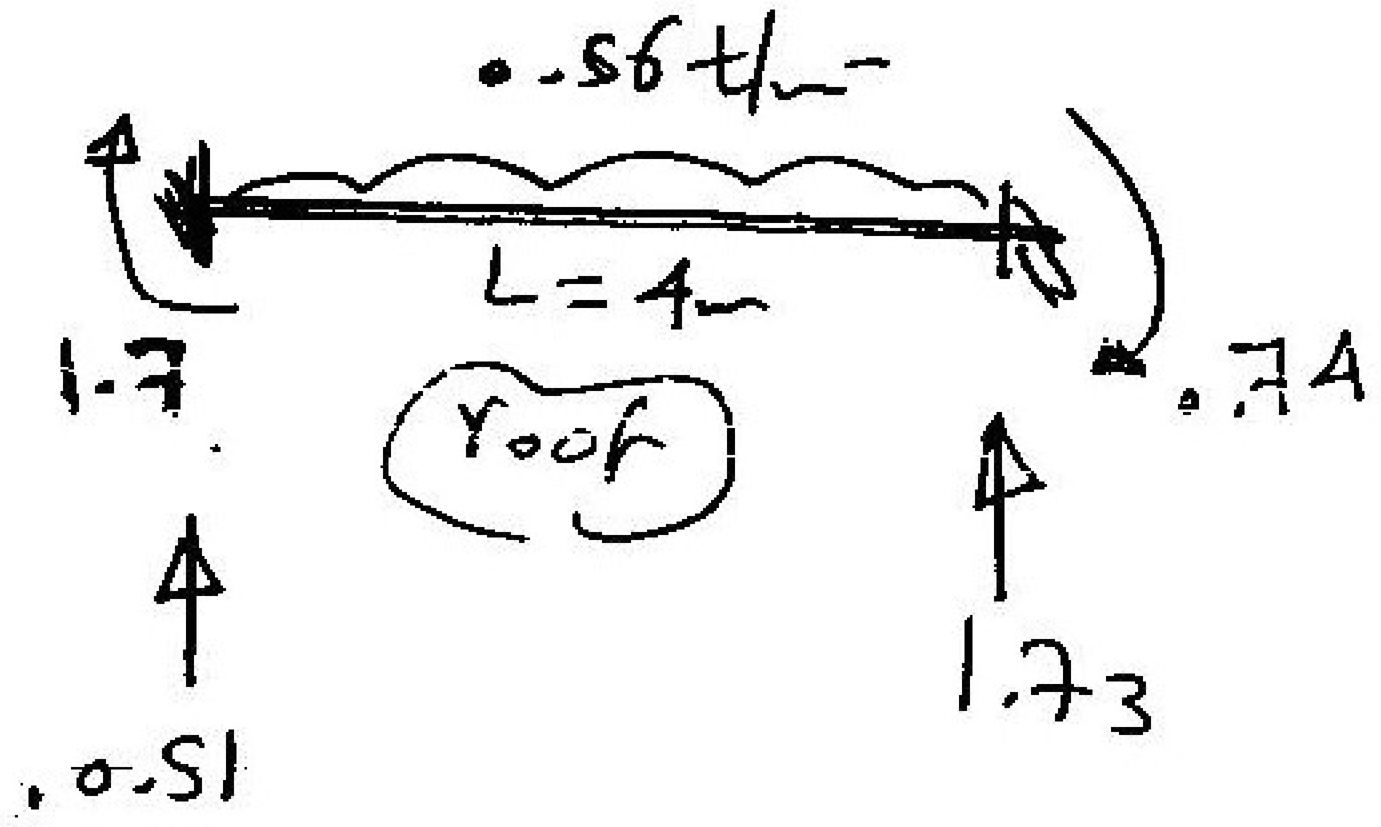
__get reactions:__

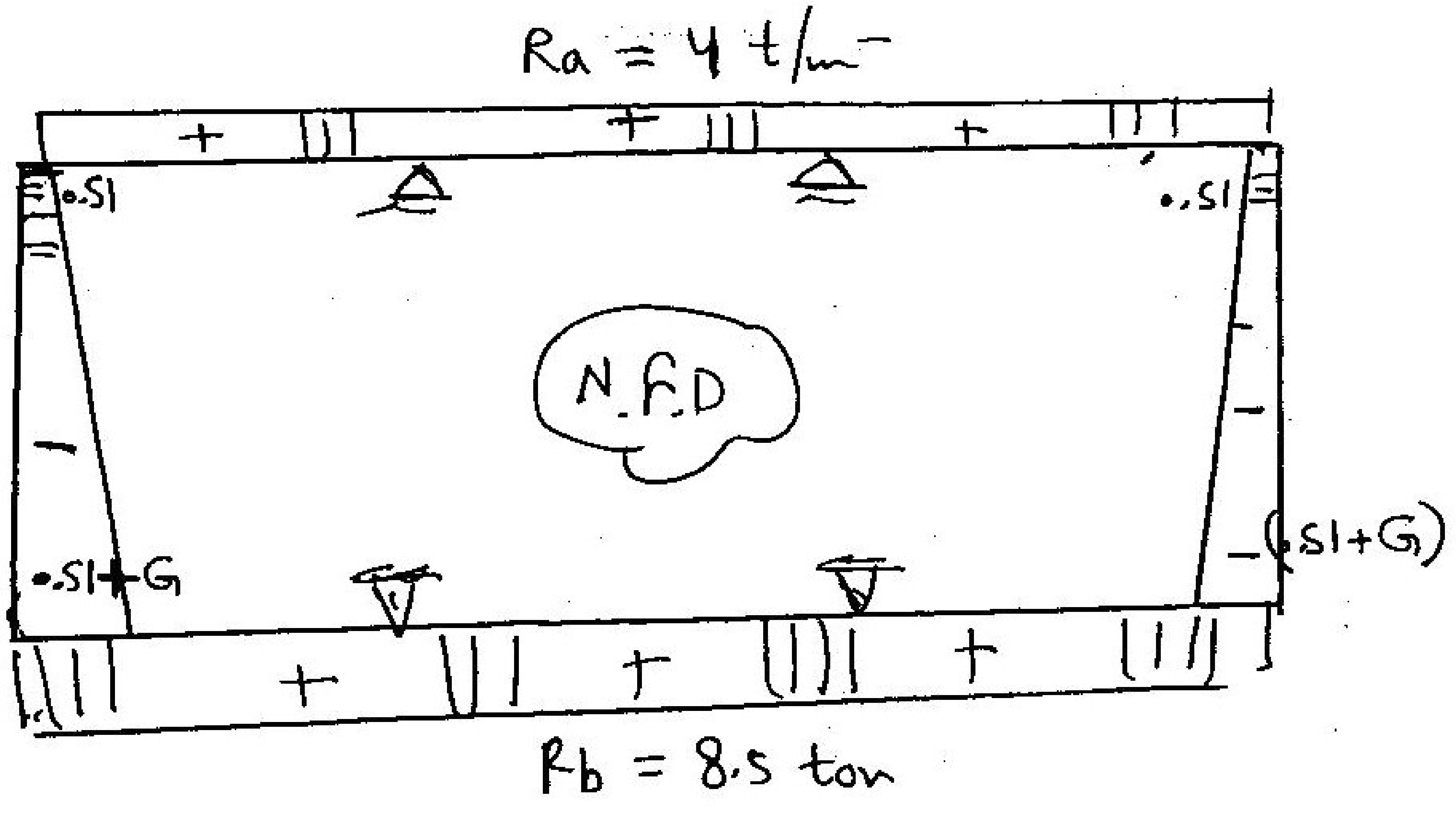
$\Sigma M_b) = 0 \Rightarrow R_a = 4 \ t/m$

$\Sigma F_x = 0 \Rightarrow R_b = 8.5 \ t/m$



$F = \frac{1}{2} * P * H = 12.5 \ ton$





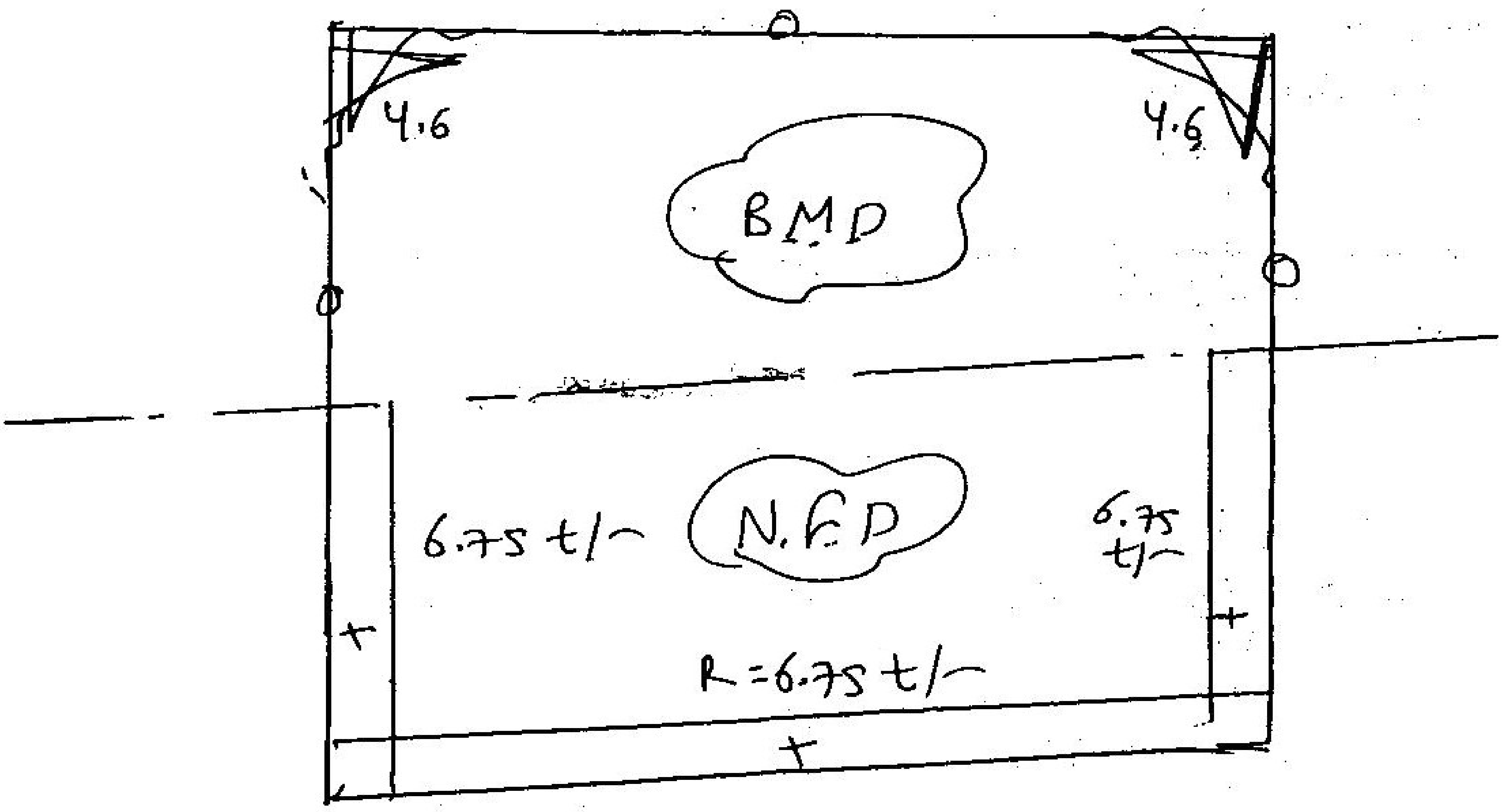
(air) X (water) تم تصميم قطاع

H.L. strip

Empirical ولعنص أصل

$R = 0.27\gamma H^2 = 6.75$ ton/m

$M_f = \frac{\gamma H^3}{27} = 4.6$ t.m/m
water side

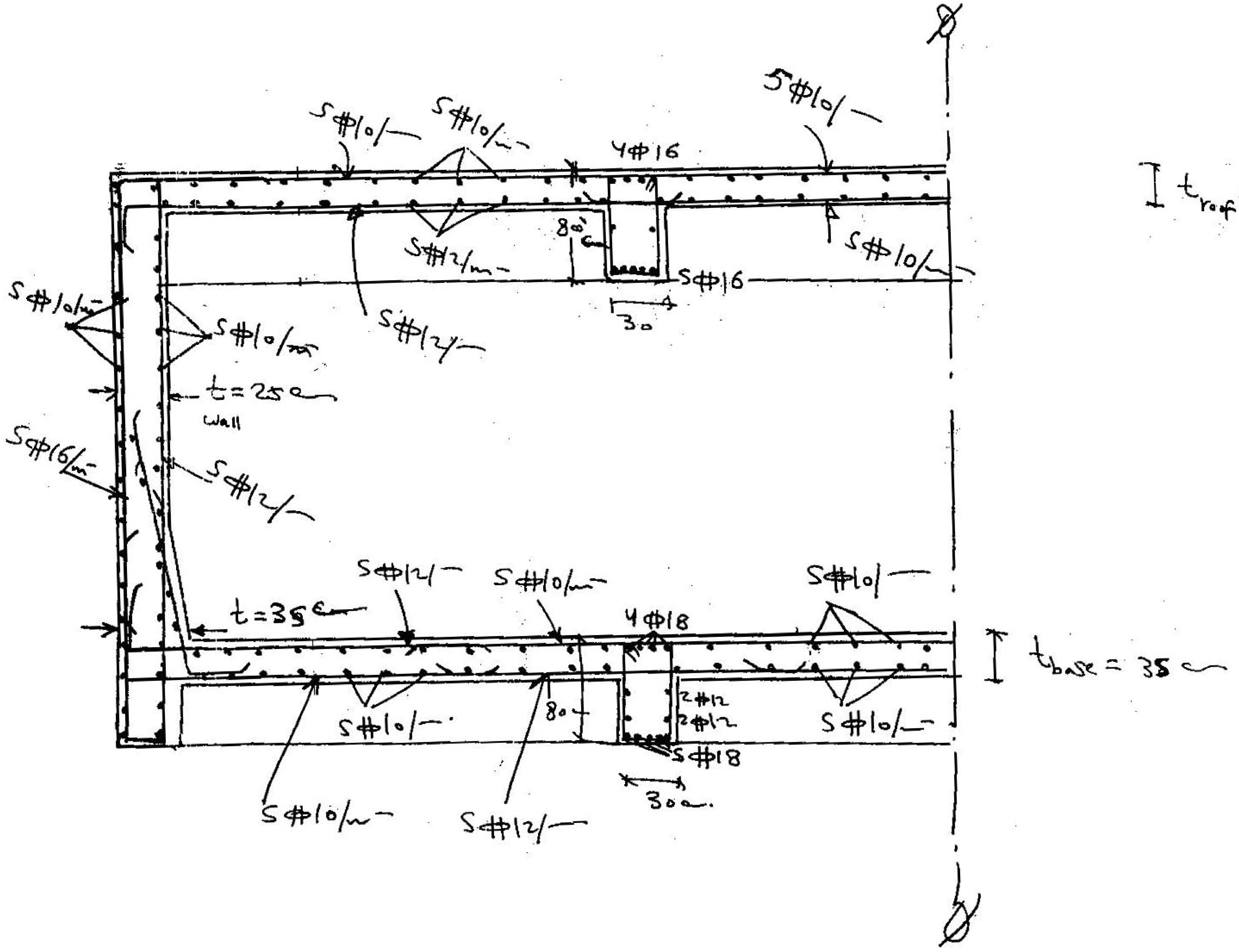


H.L. strip

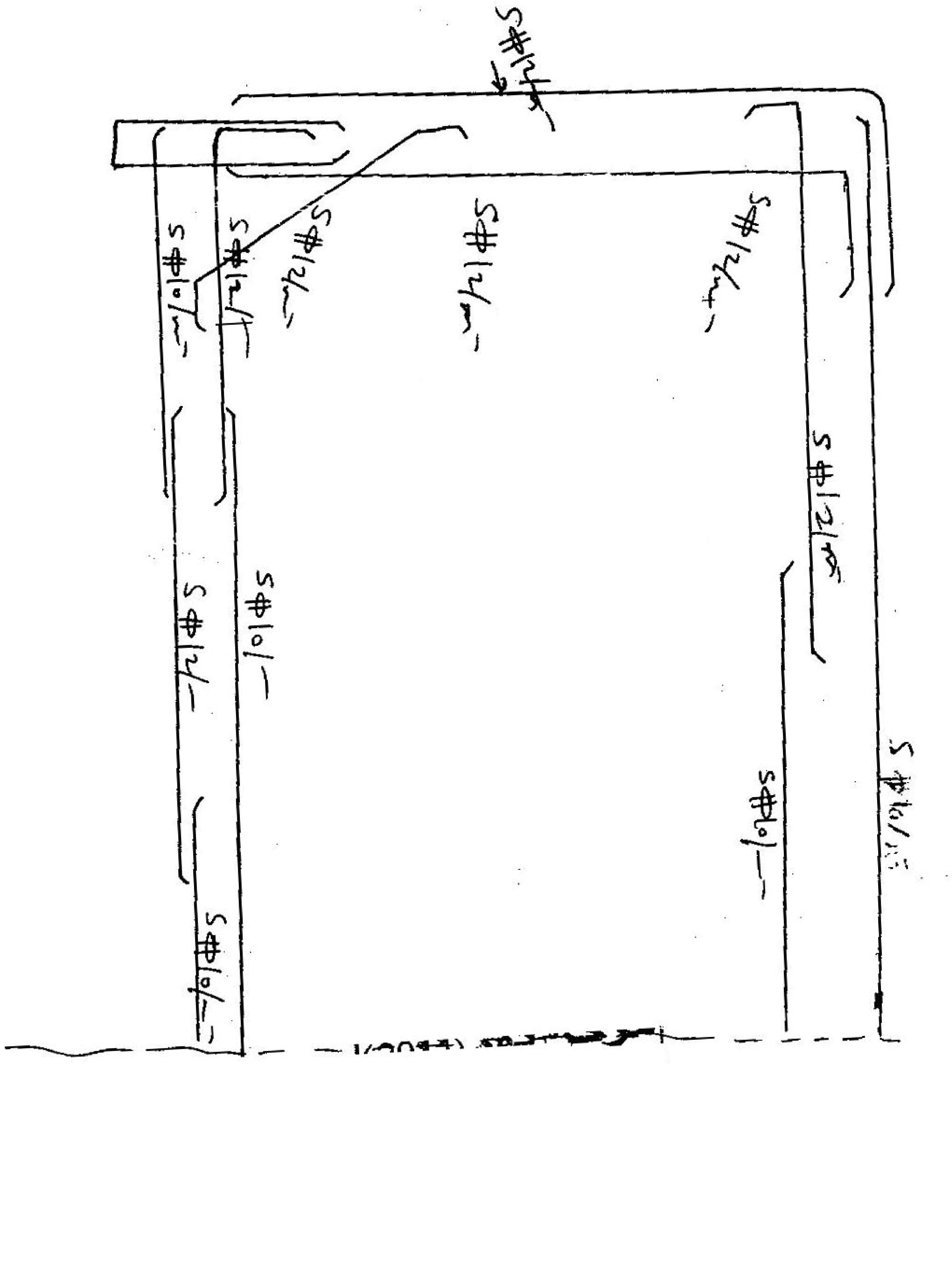
$M_{water} = 4.6$ t.m/m
$T = 6.75$ t/m

water side

ونصمم القطاع ٢

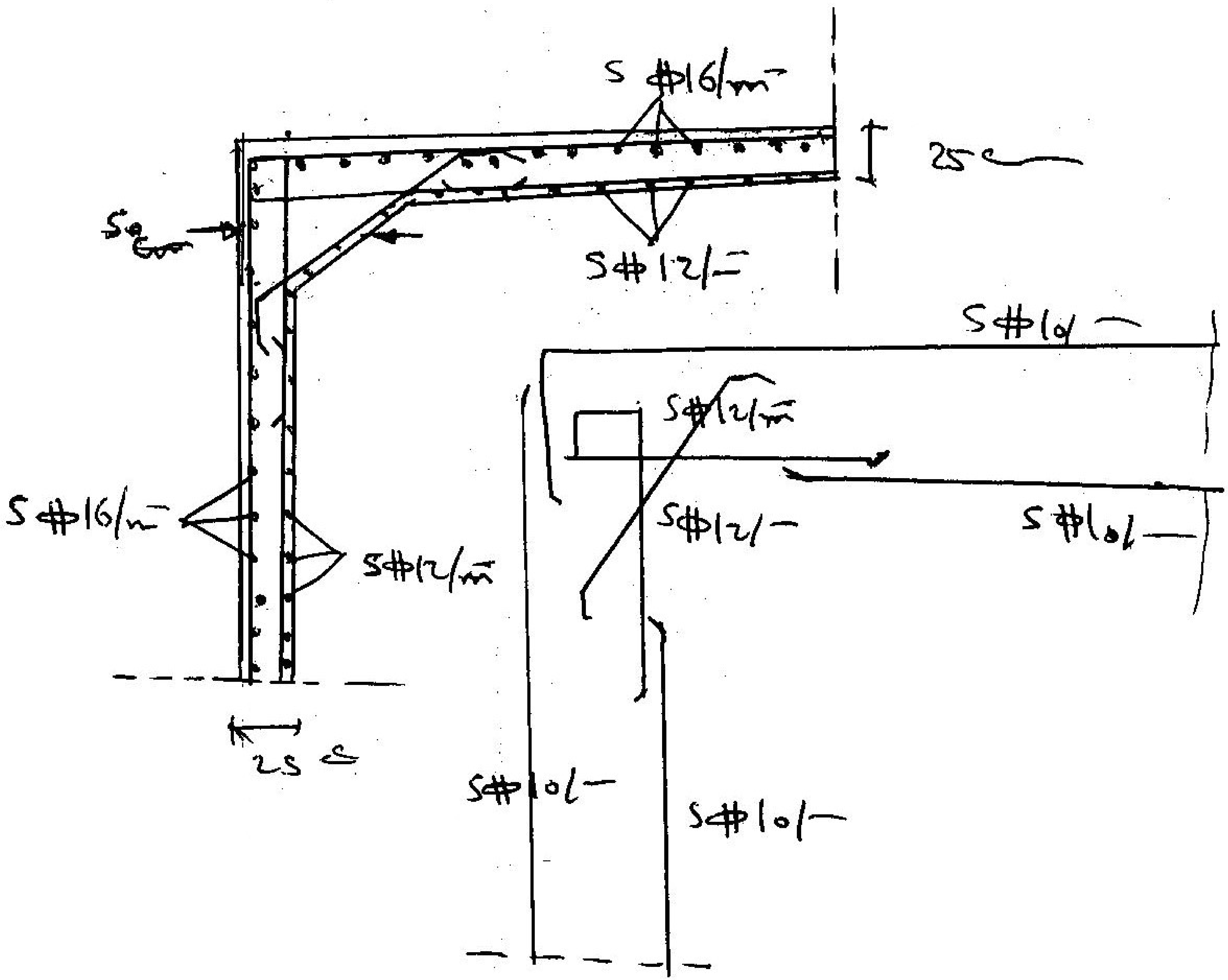


5Φ10/m
5Φ10/m
5Φ10/m
4Φ16
8o
5Φ12/m
5Φ16
30
5Φ10/m
5Φ10/m
5Φ12/m
5Φ10/m
t = 25 cm
wall
5Φ16/m
5Φ12/m
t_{roof} = 25 cm
5Φ12/m
5Φ10/m
5Φ10/m
t = 35 cm
4Φ18
t_{base} = 35 cm
80
2Φ12
2Φ12
5Φ10/m
5Φ10/m
5Φ18
30 cm
5Φ10/m
5Φ12/m



5Φ12/m
5Φ10/m
5Φ12/m
5Φ12/m
5Φ12/m
5Φ12/m
5Φ12/m
5Φ10/m
5Φ12/m
5Φ10/m
5Φ10/m
5Φ10/m

HL. strip



5 ϕ16/m
25 cm
5ϕ12/m
5ϕ 6 cm
5ϕ16/m
5ϕ12/m
25 cm
5ϕ10/m
5ϕ12/m
5ϕ12/m
5ϕ10/m
5ϕ10/m
5ϕ10/m

18

سنتر و مركز

الفارس

الفرقة الرابعة مدنى

Reinforced Concrete Water Tanks

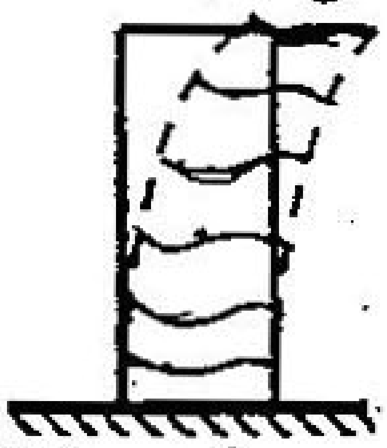
Lateral Loads

الأحمال العرضية (الأفقية) على المنشآت

أحمال الزلازل

(Seismic or earthquake loads)

هي القوة المؤثرة على المنشأ inertial force نتيجة الهزة الأرضية للمنشأ وهى تزداد بالارتفاع عن منسوب الأساسات حيث أخر دور يتحرك بأقصى عجلة أثناء الزلزال.



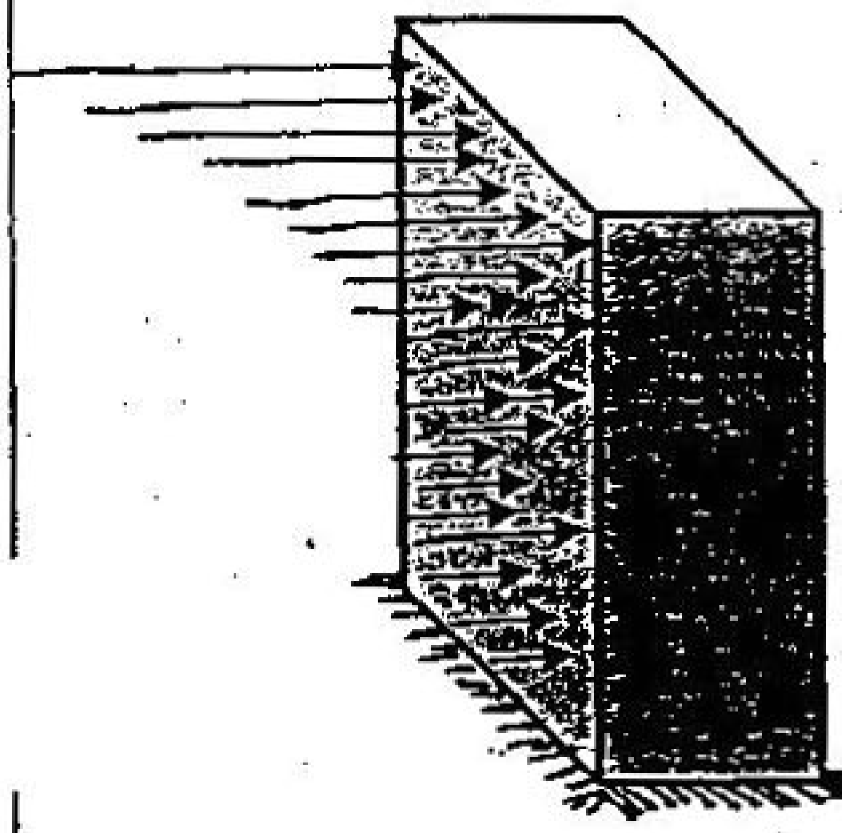
Force = Mass * acceleration

* مكان تأثير قوة الزلزال في مركز الكتلة للمنشأ(center of mass)

أحمال الرياح

(wind loads)

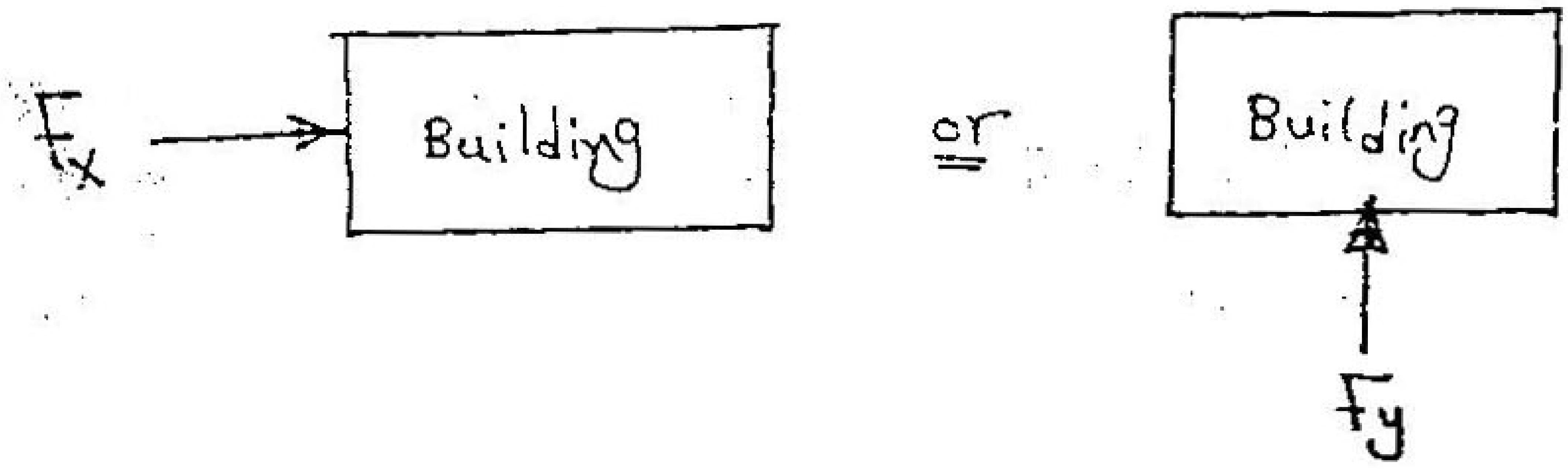
وهى عبارة عن تركيز ضغط الرياح على واجهات المنشأ وتزداد كلما ارتفعنا عن سطح الأرض.



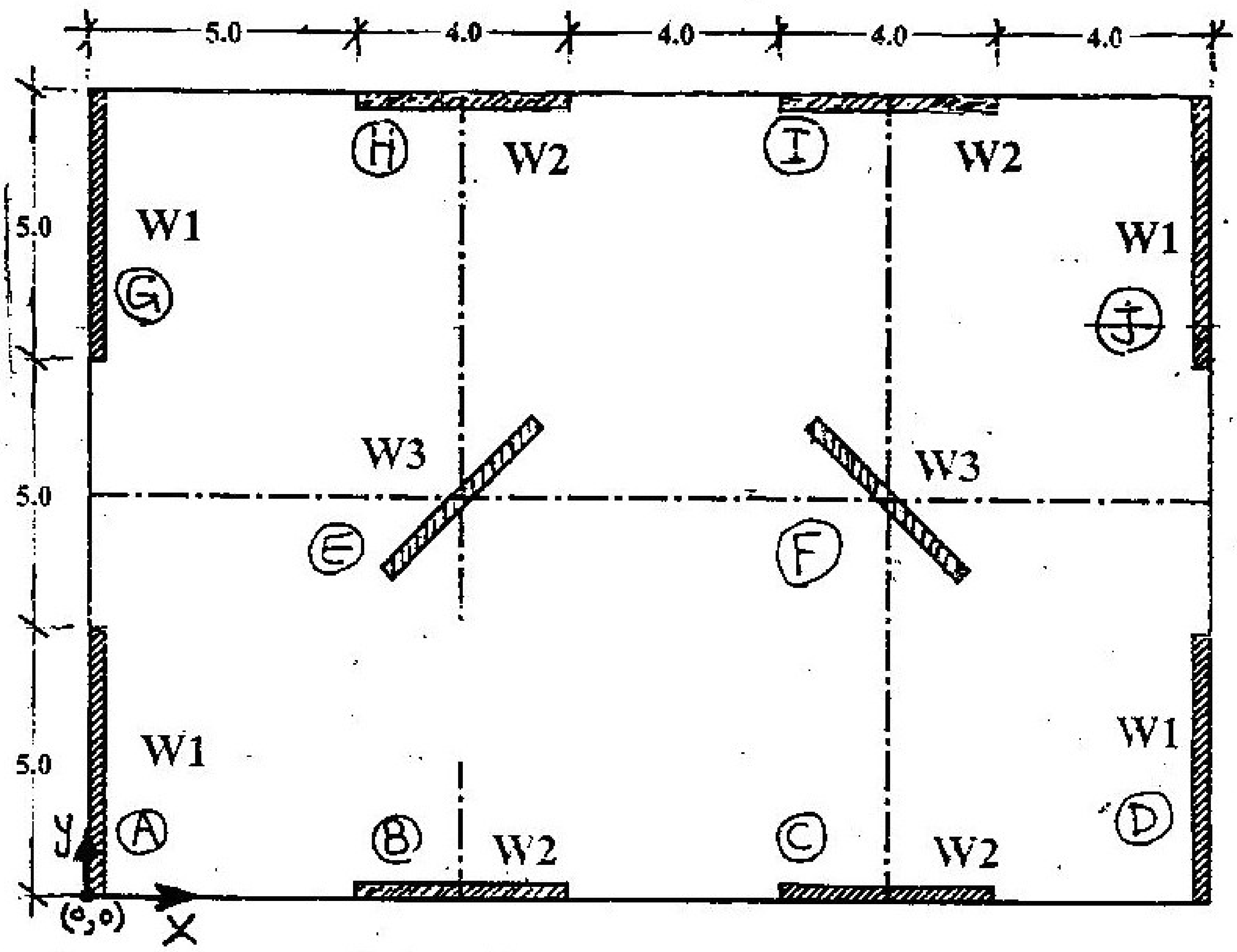
* مكان تأثير قوة الرياح في منتصف الواجهة.

*** نأخذ القوة الأكبر تأثيرا على المنشأ من الرياح أو الزلازل ولا يتم الجمع بينهما.

***ندرس كل اتجاه للمنشأ بمفرده (X or Y) ولا يتم أخذ القوى الأفقية للاتجاهين معاً.



Example



For the shown structural plan (flat slab system):

Given that : Number of stories = 10

ts =20 cm

Live load = 0.2 t/m2

Covering = 0.15 t/m2

Partitions (walls) = 0.2 t/m2

Floor height = 3 m

Shear wall sections { W1 =30*500 cm , W2=25*400cm , W3=25*400cm}

Required :

1 –center of mass c_m.

2- center of rigidity c_r.

3- calculate earthquake force in Y- direction and distribute it to shear walls.

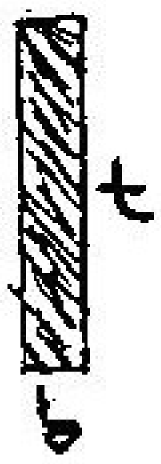
Solution:

* Center of mass (C_m) & Center of rigidity (C_r)

نقوم بوضع كل الحوائط في جدول :-

	Wall	weight (ton) W_i	X_i	y_i	I_x	I_y	$\bar{X}=X_i-X_r$ (بدون اشارة)	$\bar{Y}=Y_i-Y_r$ (بدون اشارة)
w_1	A	11.25	0.15	2.5	3.125	0	10.73	5
w_2	B	7.5	7	0.125	0	1.33	3.88	7.375
w_2	C	7.5	15	0.125	0	1.33	4.12	7.375
w_1	D	11.25	20.85	2.5	3.125	0	9.97	5
w_3	E	7.5	7	7.5	0.665	0.665	3.88	0
w_3	F	7.5	15	7.5	0.665	0.665	4.12	0
w_1	G	11.25	0.15	12.5	3.125	0	10.73	5
w_2	H	7.5	7	14.875	0	1.33	3.88	7.375
w_2	I	7.5	15	14.875	0	1.33	3.88	7.375
w_1	J	11.25	20.85	12.5	3.125	0	9.97	5
بلاطة السقف	slab	267.75	10.5	7.5				
	Σ	357.75	—	—	13.83	6.65	—	—

* Weight of walls $= b \cdot t \cdot \gamma_{Rc} * H_{floor}$



for wall (W_1) $= 0.3 * 5 * 2.5 * 3 = 11.25$ ton

for wall (W_2) $= 0.25 * 4 * 2.5 * 3 = 7.5$ ton

for wall (W_3) $= 0.25 * 4 * 2.5 * 3 = 7.5$ ton

- **Weight of slab** = (Ws * Area of floor)

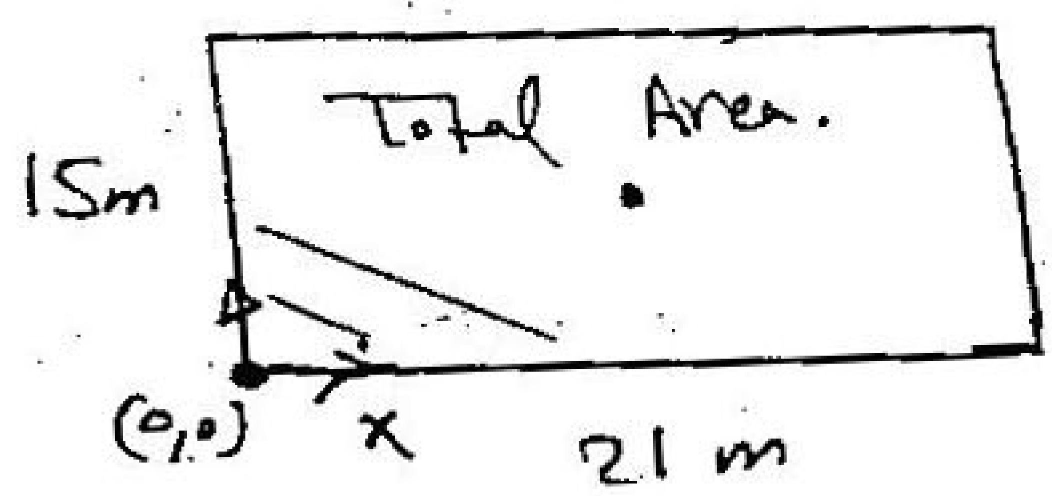
طالما live < 0.5 t/m^2

∴ نهمل (live)

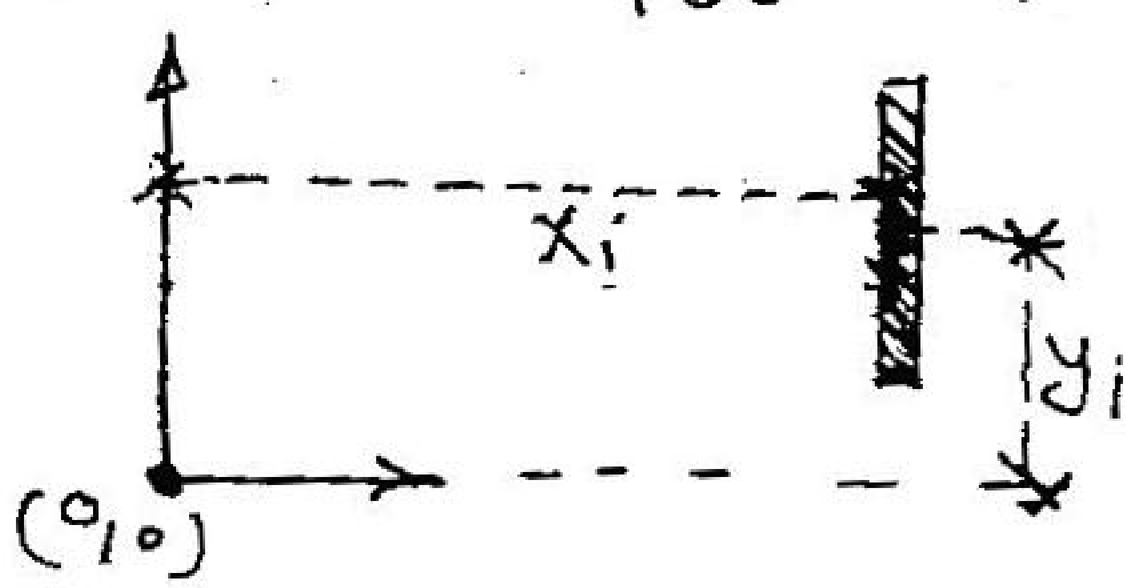
$= (t_s \cdot \gamma_{R.C} + \text{covering} + \text{Partitions} + \text{live})$ (live crossed out)

$\therefore$ weight of slab $= (0.2 * 2.5 + 0.15 + 0.2) * (15 * 21)$ (Area)

$= 267.75$ ton



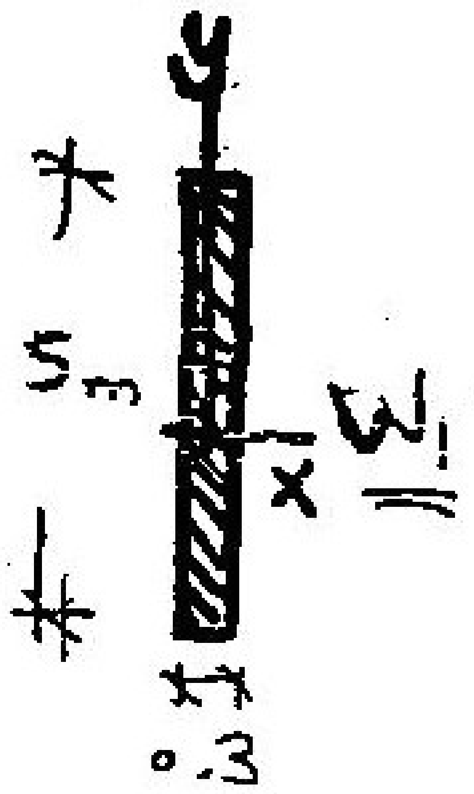
- X_i, y_i } * بعد مركز الحائط عن (0,0)



- $I = \frac{b \cdot t^3}{12}$

I_x = inertia about $\underline{\underline{X}}$

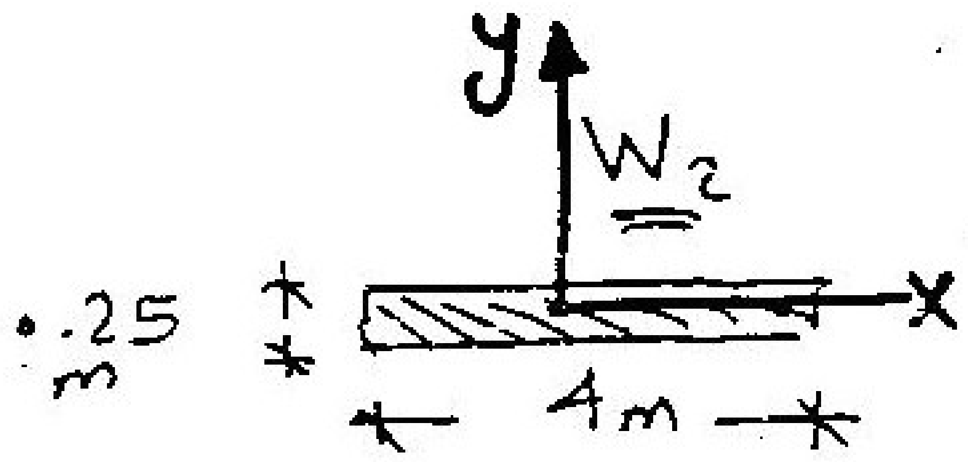
I_y = inertia about $\underline{\underline{y}}$



$$I_x = \frac{0.3 * 5^3}{12} = 3.125\ m^4$$

$$I_y = \text{Neglected} \simeq \text{Zero}$$

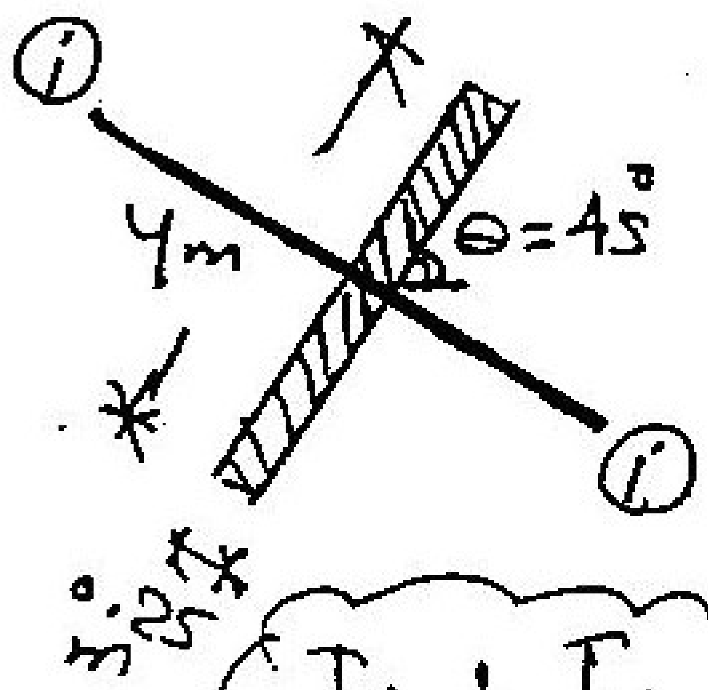
صغيرة جداً



$$I_x = \text{Neglected} \simeq \text{Zero}$$

$$I_y = \frac{0.25 * 4^3}{12} = 1.33\ m^4$$

"الحوائط المائلة"



$$I_i = \frac{b \cdot t^3}{12} = \frac{0.25 * 4^3}{12} = 1.33\ m^4$$

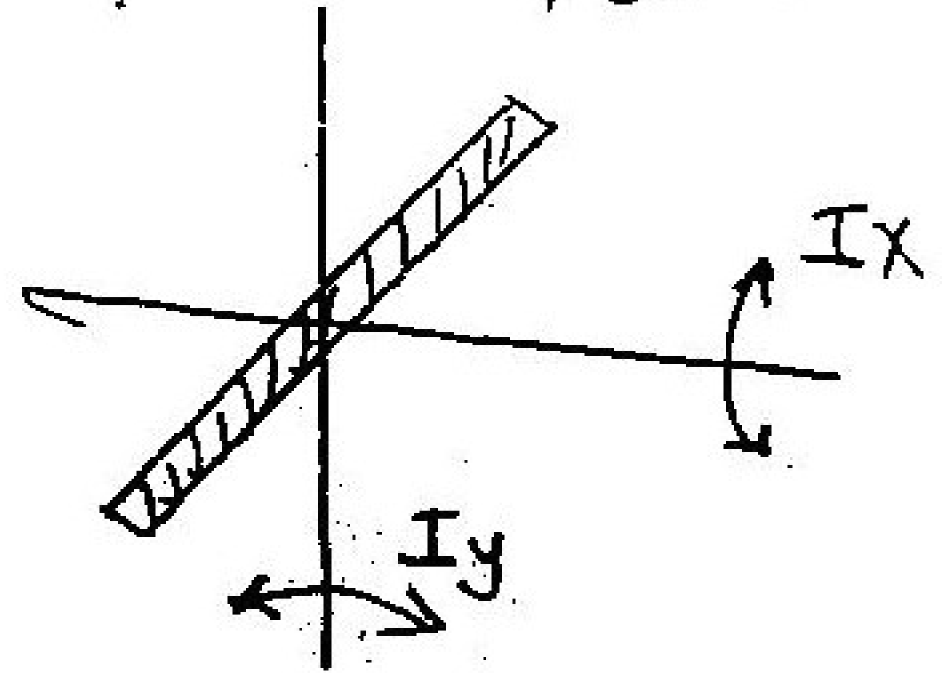
على الحائط

ثم نقوم بتحليل ال (inertia) الي I_x و I_y

$$I_x = I_i \cdot \sin^2\theta = 1.33 * (\sin 45)^2 = 0.665\ m^4$$

$$I_y = I_i \cdot \cos^2\theta = 1.33 * (\sin 45)^2 = 0.665\ m^4$$

$(\theta) =$ زاوية ميل الحائط مع الأفقي (الزاوية الحادة)



* Center of mass : (Cm) مركز الكتلة للمنشأ

$$X_m = \frac{\sum W_i \cdot X_i}{\sum W_i} = \frac{3778.875}{357.75} = 10.56\ m$$

$$y_m = \frac{\sum W_i \cdot y_i}{\sum W_i} = \frac{=}{=} = 7.5\ m$$

من التماثل في اتجاه (y)

---

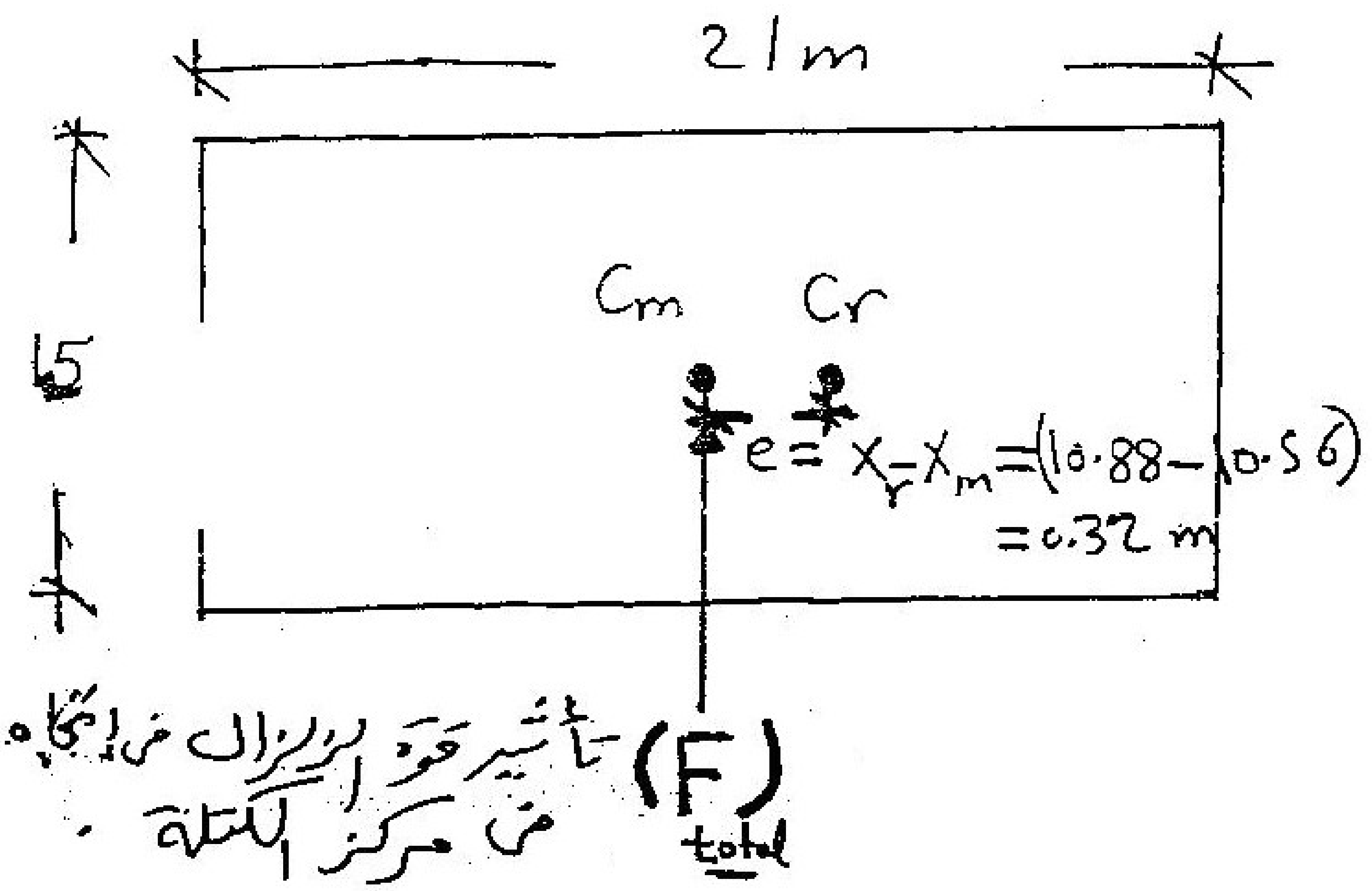
* Center of rigidity : (Cr)

مركز قوة المنشأ = مركز الجساءة .

$$X_r = \frac{\sum I_{x_i} \cdot X_i}{\sum I_x} = \frac{150.6}{13.83} = 10.88\ m$$

$$y_r = \frac{\sum I_{y_i} \cdot y_i}{\sum I_y} = \frac{=}{=} = 7.5\ m$$

من التماثل في اتجاه (y)



$(F)_{total}$ تأثير قوة الزلزال في اتجاه (y) يعمل في مركز الكتلة .

* لو فرضنا أننا حسبنا قوة الزلزال في اتجاه (y) وكانت

$$F_{y_{total}} = 31 \text{ ton}$$

مثلاً

وسوف نقوم بحساب أحمال الزلازل لاحقاً في المذكرة التالية بإذن الله

* يتولد عزم التواء على المنشأ M_T **torsional moment**

$$M_T = F_{total} * e = 31 * 0.32 = 9.92 \text{ m}$$

---

* distribution of earthquake force to walls:

توزيع أحمال الزلزال على الحوائط المسلحة في اتجاه (y)

Torsion قوة ناتجة عن اللي

ولها مركبتين (f_{x_t}, f_{y_t})

$$f_{x_t} = \frac{I_{y_i} \cdot \bar{y}_i \cdot M_T}{J_r}$$

$$f_{y_t} = \frac{I_{x_i} \cdot \bar{x}_i \cdot M_T}{J_r}$$

direct force قوة مباشرة

* قوة في اتجاه قوة الزلزال فقط

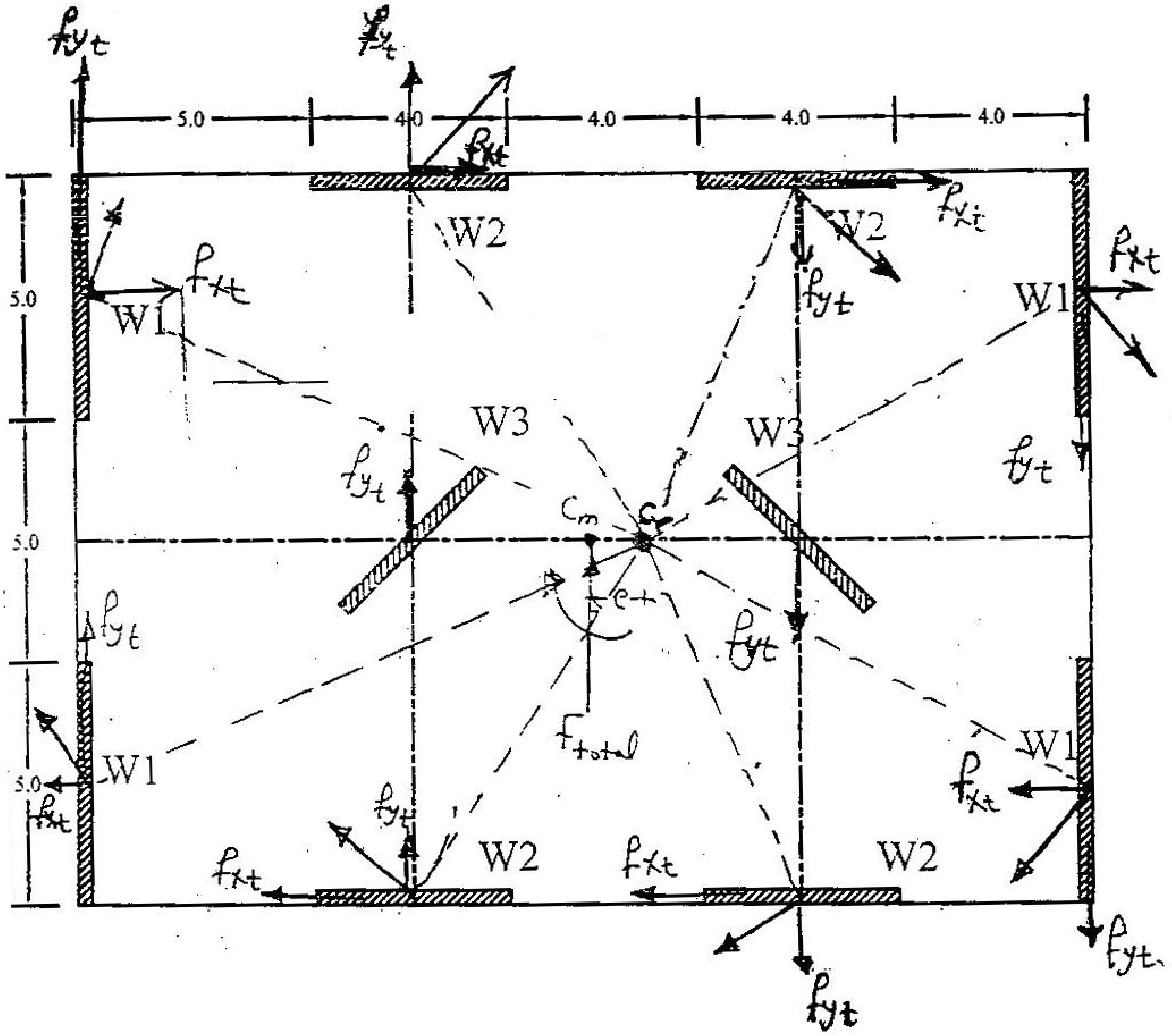
$$f_y = \frac{I_{x_i}}{\sum I_x} * F_{y_{total}}$$

$$f_x = \frac{I_{y_i}}{\sum I_y} * F_{x_{total}}$$

لو القوة في اتجاه (X) فقط

Where: $J_r = \sum I_{x_i} \cdot \bar{x}_i^2 + \sum I_{y_i} \cdot \bar{y}_i^2$

Polar moment of inertia



$$J_r = 3.125 * (10.73)^2 * 2 + 0.665 * (3.88)^2$$

$$+ 3.125 * (9.97)^2 * 2 + 0.665 * (4.12)^2$$

$$+ 1.33 * (7.375)^2 * 4$$

$$\therefore J_r = 1651.5 \ m^6$$

Wall	I_{x_i}	$\bar{X}_i$	I_{y_i}	$\bar{y}_i$	direct force f_y	Forces from Torsion f_{x_t}	f_{y_t}
A	3.125	10.73	0	5	7	0	0.2
B	0	3.88	1.33	7.375	0	0.06	0
C	0	4.12	1.33	7.375	0	0.06	0
D	3.125	9.37	0	5	7	0	0.19
E	0.665	3.88	0.665	0	1.5	0	0.015
F							
G							
H							
I							
J							
$\Sigma =$	13.83		6.65				

$$f_{x_t} = \frac{I_{y_i} \cdot \bar{y}_i \cdot M_T}{J_r}$$

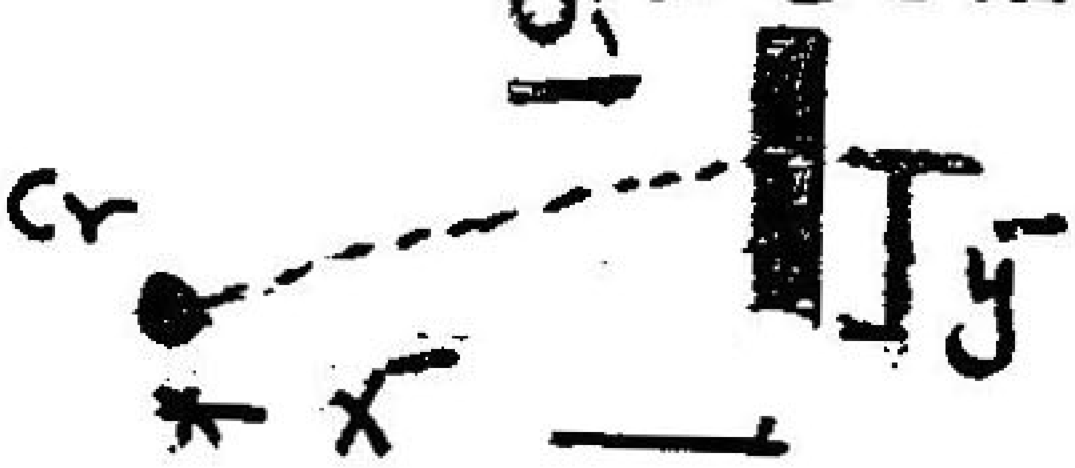
force in wall due to Torsion

$$f_{y_t} = \frac{I_{x_i} \cdot \bar{X}_i \cdot M_T}{J_r}$$

force in wall due to torsion

$\bar{X}_i$ = بعد مركز الحائط عن (C_r) في (x) = $X_i - X_r$

$\bar{y}_i$ = بعد مركز الحائط عن (C_r) في (y) = $y_i - y_r$



اعمال الزلازل

سنتر و مركز

الفارس

١٩..

الفرقة الرابعة مدنى

Reinforced Concrete Water Tanks

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أحمال الزلازل

+

تصميم الحوائط المسلحة

Earthquake forces

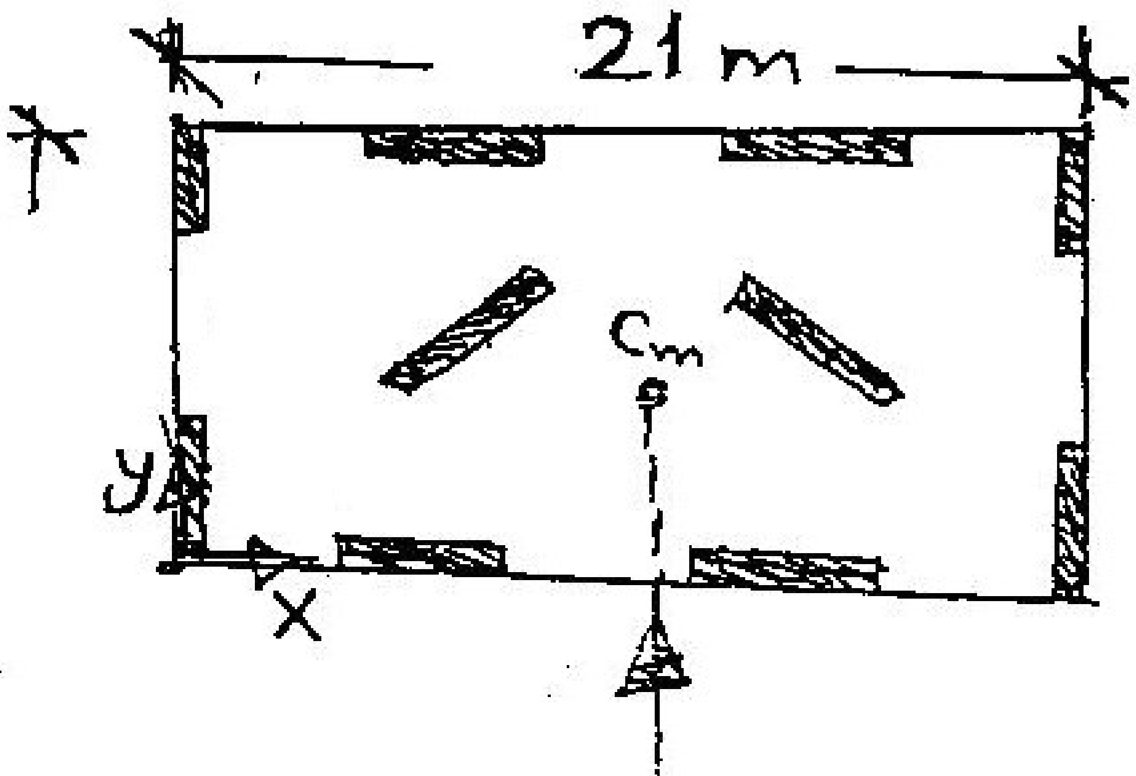
&

Design of shear walls

Earthquake Loads

تابعة للمذكرة رقم (21)

حسابات قوى الزلازل



∀ . قوة الزلزال فى اتجاه (y) هى المطلوبة فقط هنا

$$\forall = Z \cdot I \cdot C \cdot K \cdot S \cdot W$$

قوة الزلزال الكلية
Base shear

$Z = 0.1$ or $\boxed{0.2}$ or 0.3

حسب المنطقة الزلزالية

$Z = 0.2$ القاهرة والزقازيق *****

$I = 1 \longrightarrow$ منشآت عادية

$= 1.25 \longrightarrow$ منشآت هامة جداً

$\therefore I = 1$ *****

$$C = \frac{1}{15\sqrt{T}} \geqslant 0.12 \quad \& \quad T = \frac{0.09H}{\sqrt{B}}$$

حيث (B) هى عرض المنشأ الموازى لقوة الزلزال المدروسة .

(H) هو الارتفاع الكلى للمنشأ من منسوب الأساسات .

$S = 1.3$ ثابتة
Soil factor
حسب طلب الدكتور في المحاضرة

$K = 1.33$ ثابتة
structural system factor
for shear walls

$W =$ (ton) وزن المنشأ كله

if live $\leq 0.5\ t/m^2$

$\therefore W =$ dead only

if live $> 0.5\ t/m^2$

$W = (\text{dead}) + \frac{1}{2}(\text{Live})$

* توزيع قوة الزلزال الكلية (V) على كل دور

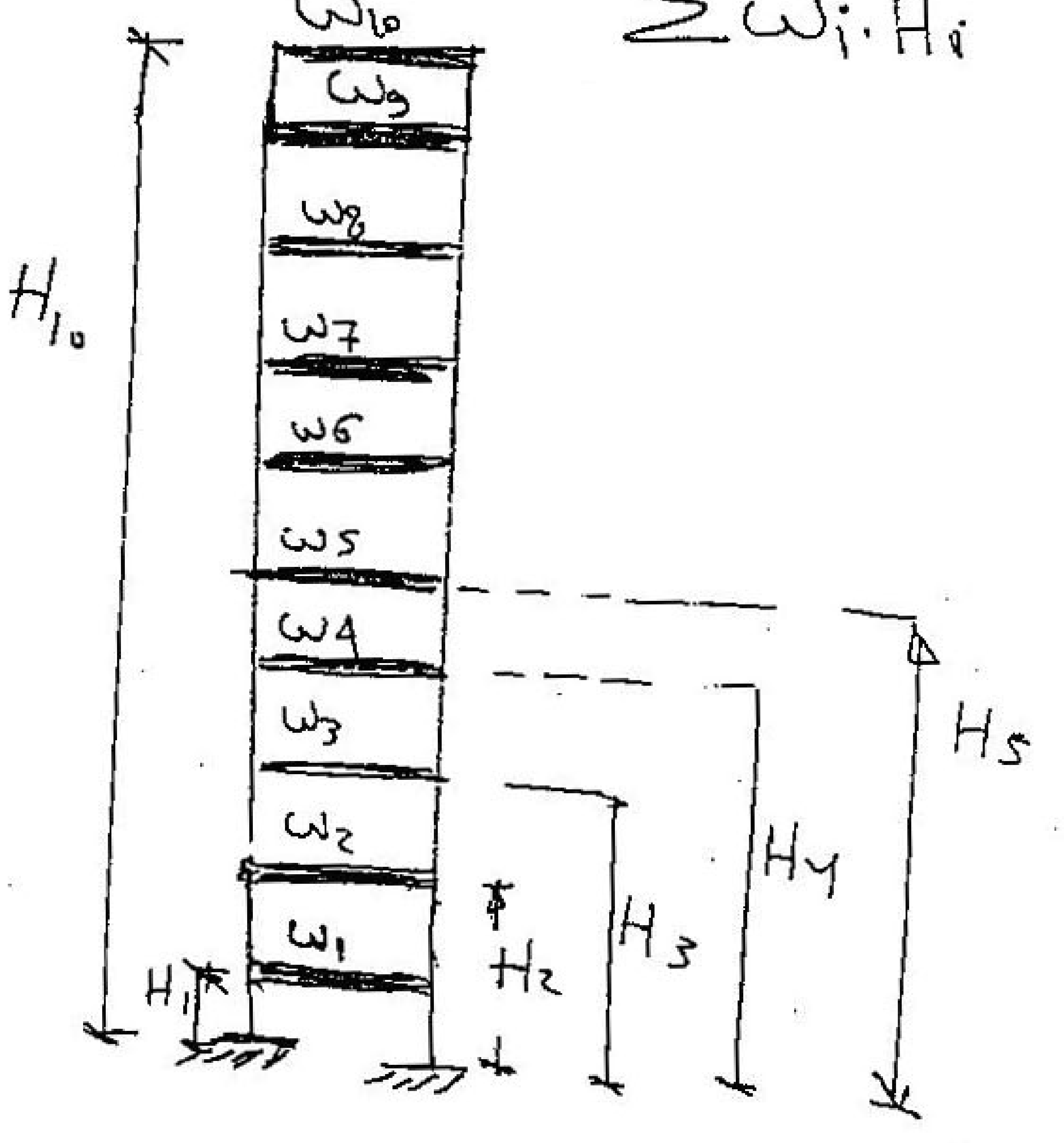
أولاً: نحسب قوة إضافية تؤثر على منسوب آخر دور F_{top}

F_{top}

- if $T \leq 0.7$ $\Rightarrow F_{top} = 0$
- if $T > 0.7$ $\Rightarrow F_{top} = 0.07 * T * V \ngtr 0.25V$

ثانياً: نوزع القوة الباقية على كل دور حسب وزنه وارتفاعه.

$$F_i = \frac{W_i \cdot H_i}{\sum W_i \cdot H_i} * (V - F_{top})$$



$W_i =$ وزن الدور

$H_i =$ ارتفاع سقف الدور من الأساسات

* في النهاية نضيف القوة F_{top} على قوة آخر دور

Example : (21) هنا المثال تكملة لمذكرة رقم

$W = 10 * 357.75 = 3577.5$ ton

وزن المنشأ كله — عدد الأدوار — وزن الدور الواحد

dead

من الجدول مذكرة (21)

$Z = 0.2$ → المنطقة الزلزالية الثالثة (الزقازيق)

$I = 1$ → منشأ سكني عادي

$T = \frac{0.09 H}{\sqrt{B}} = \frac{0.09 * 30}{\sqrt{15}} = 0.69$

$C = \frac{1}{15\sqrt{T}} = \frac{1}{15\sqrt{0.69}} = 0.08 \ngtr 0.12$ ok

$K = 1.33$ → (ثابتة) for shear walls + cores

$S_{soil} = 1.3$ → ثابت للتربة

$\therefore V_{\text{total base shear}} = Z \cdot I \cdot C \cdot K \cdot S \cdot W$

قص قاعدي (V)

$= 0.2 * 1 * 0.08 * 1.33 * 1.3 * 3577.5$

$V = 98.96$ ton

قوة الزلزال الكلية

* توزيع قوة الزلزال على كل الأدوار :

$$T = 0.69 < 0.7 \Rightarrow f_{top} = 0$$

$$\therefore f_i = \frac{W_i \cdot H_i}{\sum W_i \cdot H_i} \left(V - f_{top}\right)$$

قوة الزلزال المؤثرة على كل دور

الارتفاع من منسوب الأساسات ← H_i ، وزن كل دور ← W_i

floor	H_i	W_i	$W_i \cdot H_i$	f_i
1	3	357.75	↓	1.8
2	6	357.75	↓	3.6
3	9	357.75	↓	5.4
4	12	357.75	↓	7.2
5	15	357.75	↓	9
6	18	357.75	↓	10.8
7	21	357.75	↓	12.6
8	24	357.75	↓	14.4
9	27	357.75	↓	16.2
10	30	357.75	↓	18
Σ		3577.5	59028.75	98.96

* حيث أن وزن كل الأدوار متساوي :

$$\therefore \sum w_i \cdot H_i = \left(\sum H_i\right) * W_i$$

$$= (3+6+9+12+15+18+21+24+27+30) * 357.75$$

$$= 59028.75 \text{ t.m}$$

$$\therefore f_i = \frac{w_i \cdot H_i}{\sum w_i \cdot H_i}\left(V - f_{top}\right)$$

$$\therefore f_i = \frac{357.75 * H_i \,(98.96 - 0)}{59028.75} \simeq 0.6\, H_i$$

ثم نعوض عن كل دور بارتفاعه لحساب القوة في الجدول السابق.

(29)

Nour center

الخرسانه المسلحه

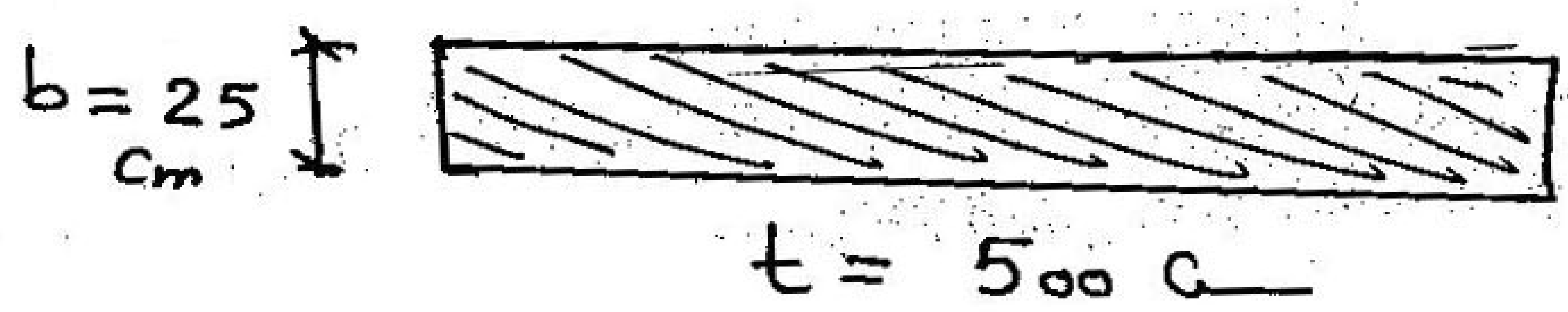
الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

Shear wall

" Design of Shear Walls "

Example : Design the shown shear wall due to the given straining actions.



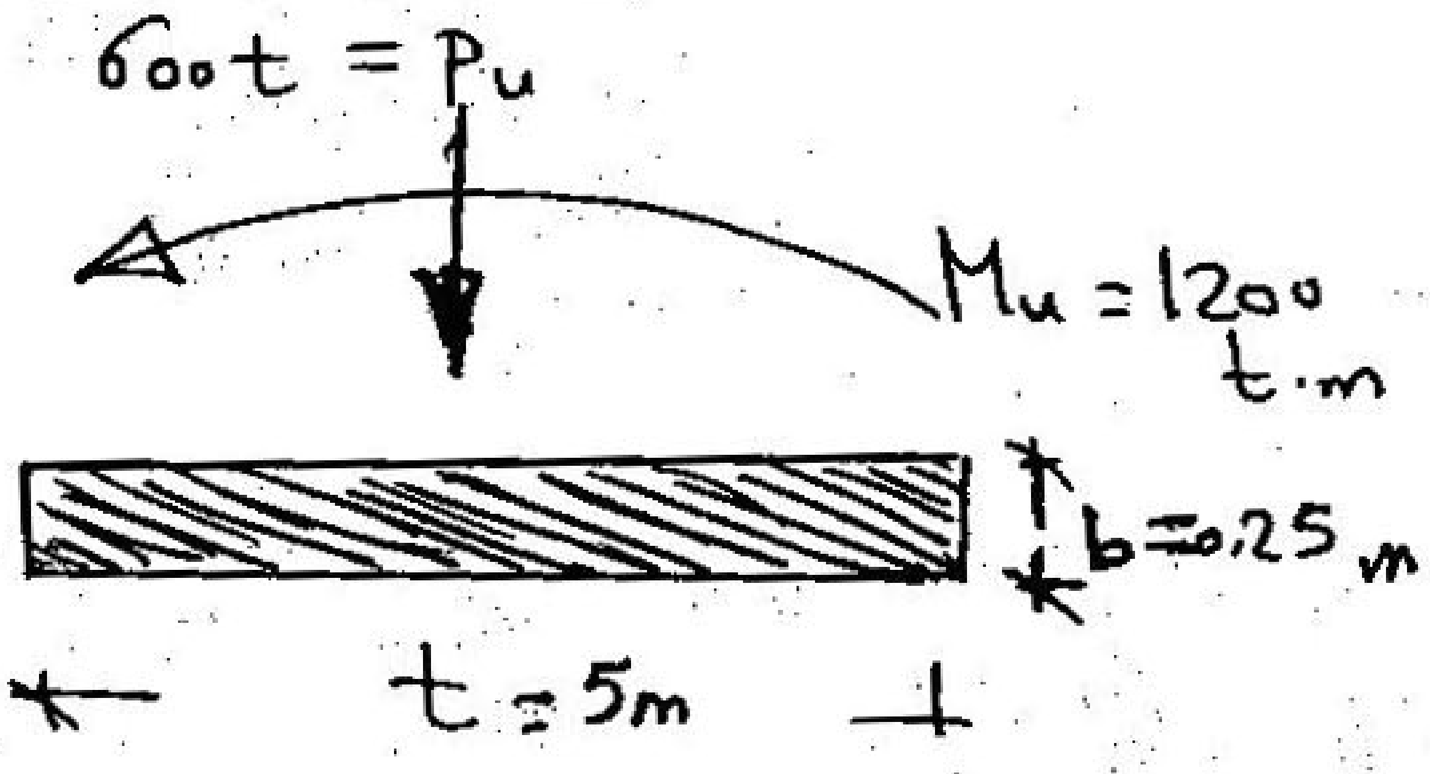
given

$P_{dead} = 300$ ton , $P_{Live} = 100$ ton

$M_u = 1200$ ton.m
due to earthquakes

$Q_u = 50$ ton
shear due to earthquakes

Solution :



$P_u = 1.5 (P_{dead} + P_{live})$

$= 1.5 * 400$

$= 600$ ton

$$\sigma_{1,2} = -\frac{P_u}{b.t} \pm \frac{M_u \cdot (\frac{t}{2})}{I}$$

t = الموازى للعزم

b = العمودى على العزم

$$\therefore I = \frac{b.t^3}{12} = \frac{0.25 * (5)^3}{12} = 2.6 \ m^4$$

$$\therefore \sigma_{1,2} = -\left(\frac{600}{0.25 * 5}\right) \pm \frac{1200 * \left(\frac{5}{2}\right)}{2.6}$$

$$= -480 \pm 1153.8$$

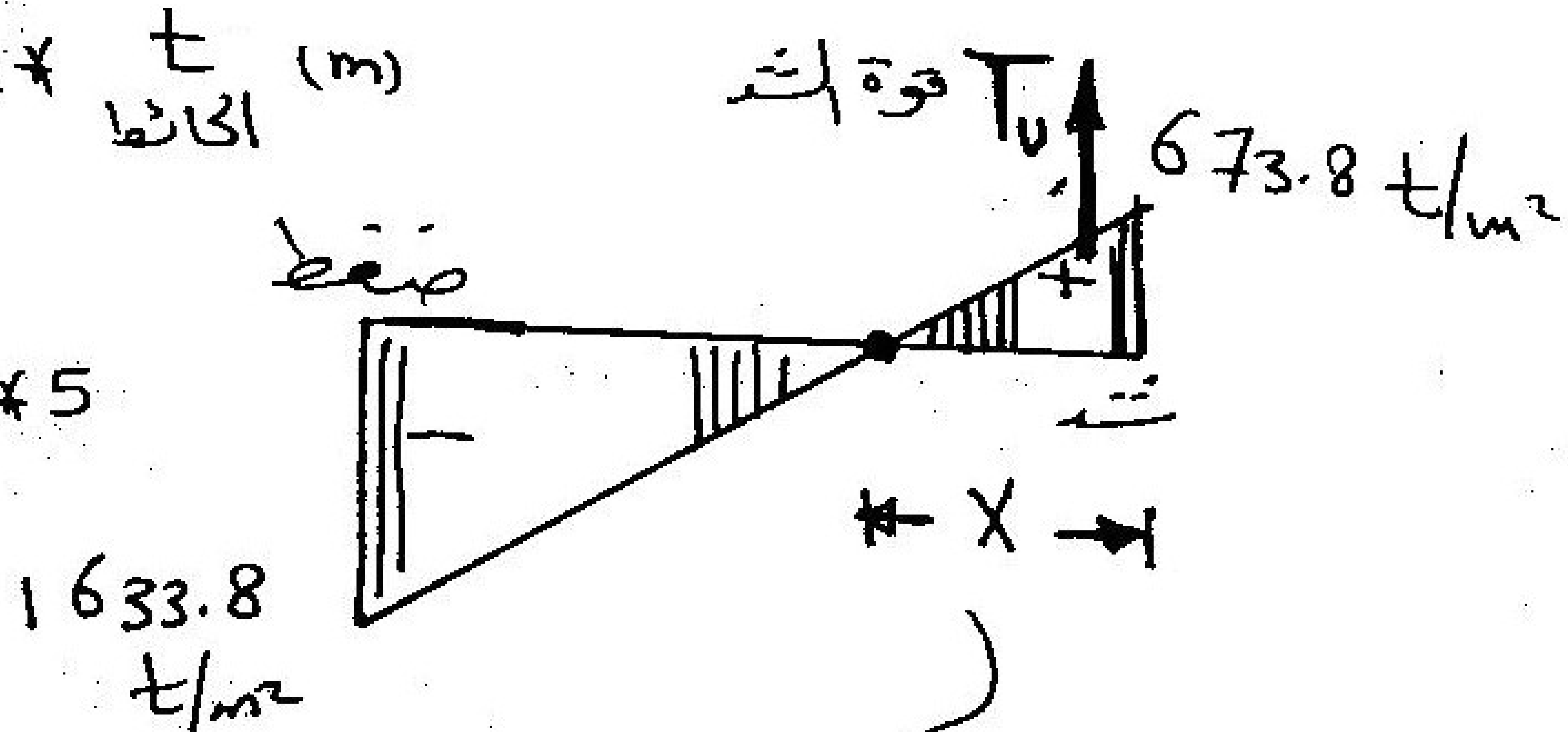
ضغط $\sigma_1 = -1633.8 \ t/m^2 = -163.38 \ kg/cm^2$

شد $\sigma_2 = +673.8 \ t/m^2 = 67.38 \ kg/cm^2$

$$X = \left(\frac{\sigma_{شد}}{\sigma_{شد} + \sigma_{ضغط}}\right) * t_{الحائط} \ (m)$$

$$= \frac{673.8}{(673.8 + 1633.8)} * 5$$

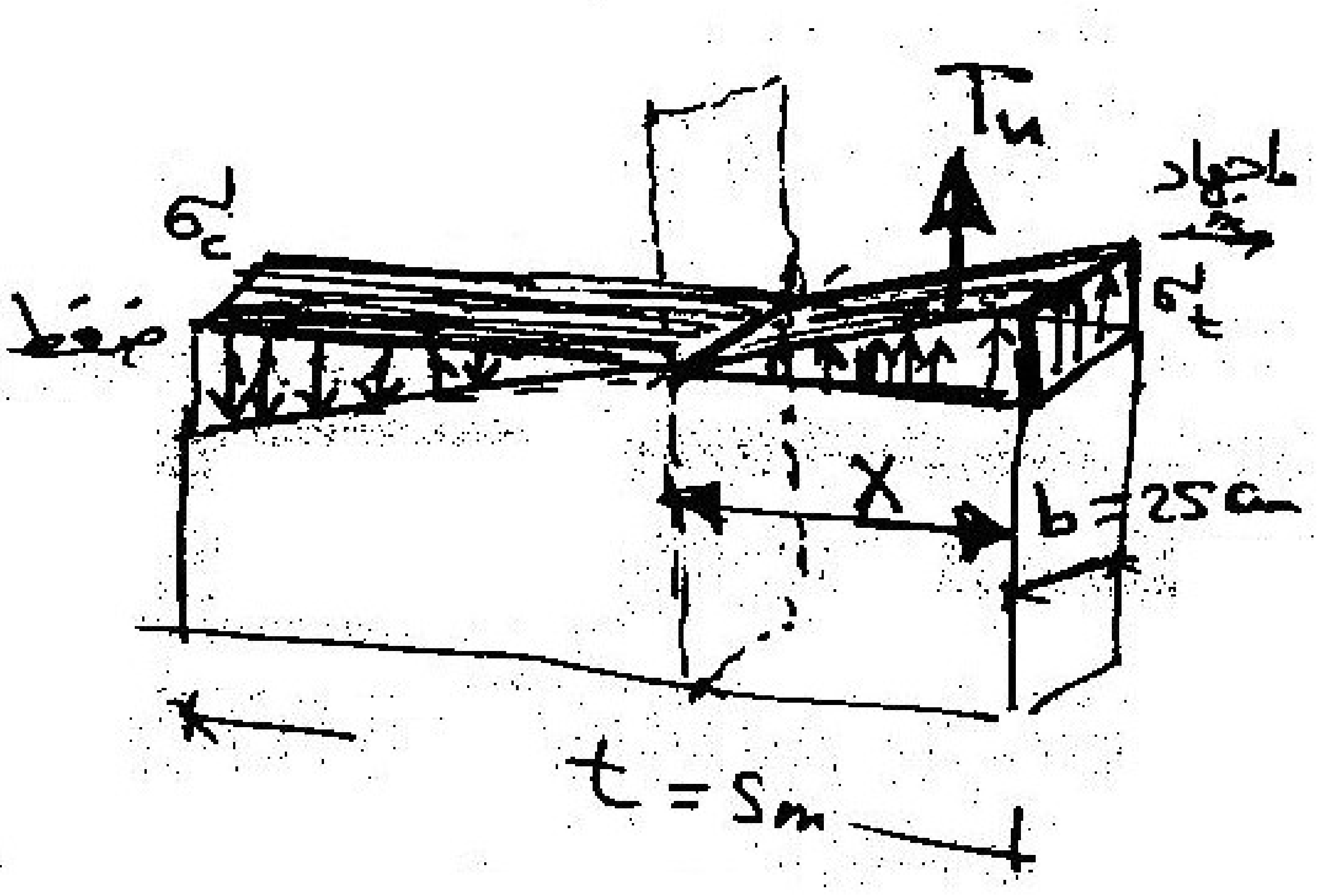
$$= 1.46 m$$



$$\therefore T_u = \left(\frac{1}{2} * 673.8 * 1.46\right) * 0.25 \ (b)$$

T_u تركيز قوة الشد

(هي مساحة المثلث *b)



$$\therefore T_u = 123 \ ton$$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

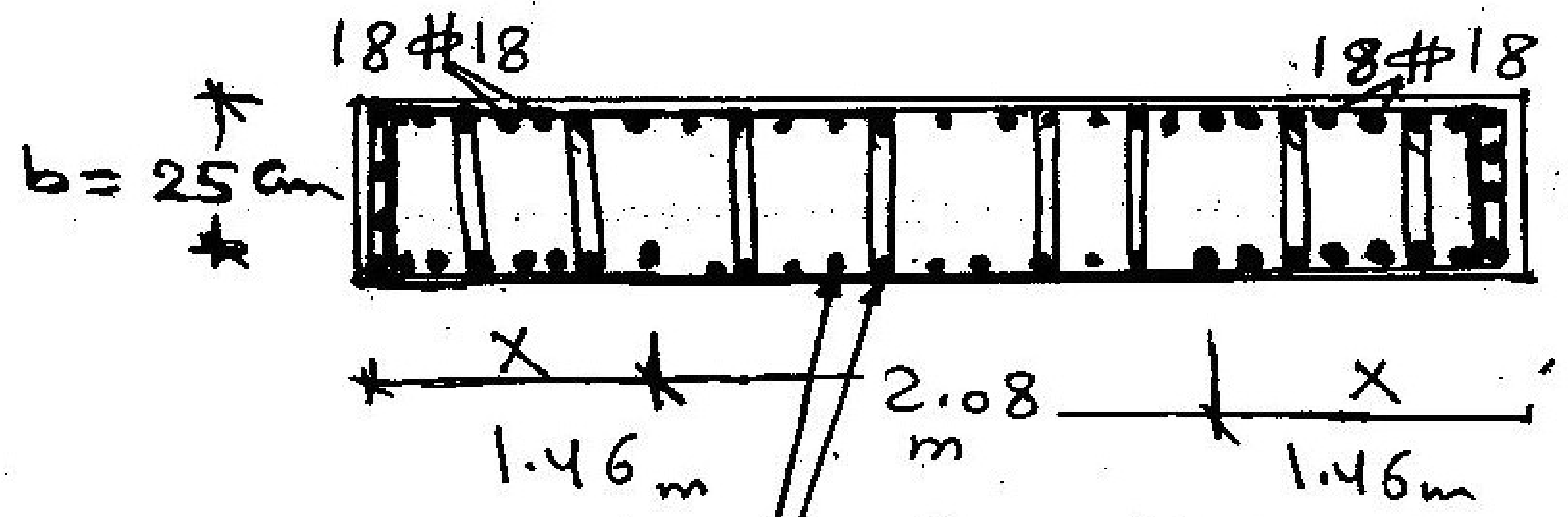
$$A_{s} = \frac{T_u * 10^3}{0.9\left(\frac{f_y}{\gamma_s}\right)} = \frac{123 * 10^3}{0.9\left(\frac{3600}{1.15}\right)} = 43.6\ cm^2$$

صد ١ ش

معامل لزيادة الحديد ، حيث الاجهاد غير منتظم.

∴ use 18 #18

ونضع هذا الحديد يمين ومثله شمال حيث عزوم الزلازل تكون دائماً Reversible يعنى ممكن الشد يكون يمين أو شمال



$$A_{s\,min} = \frac{0.4}{100} * \frac{100 * b}{2}$$

صد رأسي min

1m شريحة

2 ← لكل وجه

$$= \frac{0.4}{100} * \frac{100 * 25}{2} = 5\ cm^2/m^-$$

$$= 5 \# 12/m^-$$

$$\therefore A_{s\,total} = (36 \# 18) + (5 \# 12) * 2.08 * 2$$

For wall

لوجود وجهين

$$= 114.94\ cm^2$$

Check : friction shear : * نقاوم كل القوة للقص بالحديد الطولي بدلا من الخرسانة والكانات

$$A_{s\,\text{total for wall}} \geq \frac{Q_u * 10^3}{0.5\,(f_y/\gamma_s)} - \frac{P_u * 10^3}{(f_y/\gamma_s)}$$

$$\therefore 114.94\ \text{cm}^2 \geq \left(\frac{50 * 10^3}{0.5\left(\frac{3600}{1.15}\right)} - \frac{600 * 10^3}{(3600/1.15)} \right)$$

$\therefore$ **Very Safe**

Stirrups : حيث ان ال shear (safe) ج

Use min stirrups

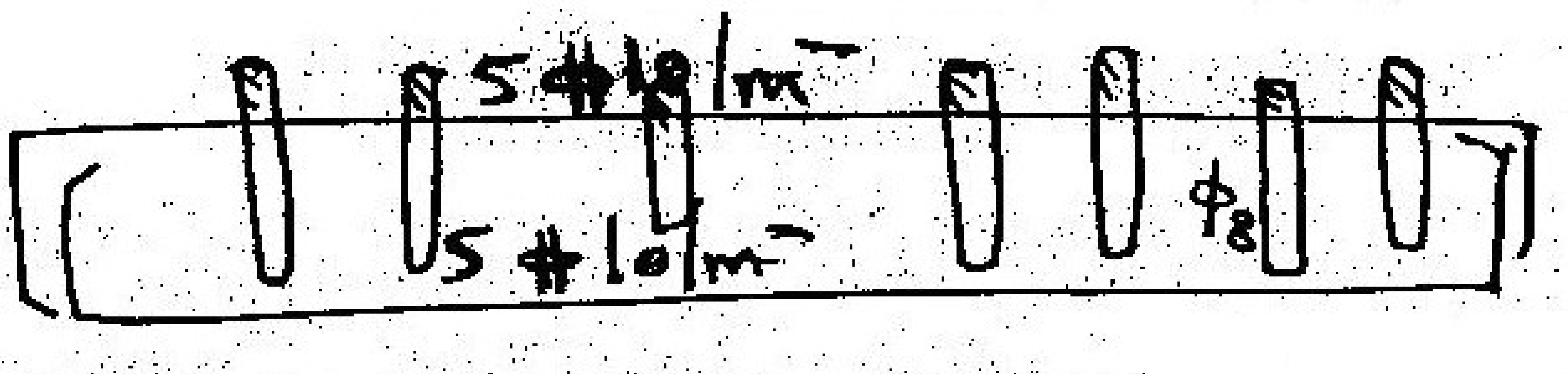
حركة (100 cm) ← B

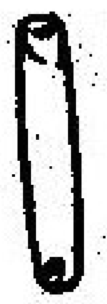
$$A_{st\,min} = \left(\frac{0.3}{100} \cdot \frac{B * b}{2} \right) = \frac{0.3}{100} * \frac{100 * 25}{2}$$

للاتجاهين ← 2

$$= 3.75\ \text{cm}^2/\text{m}$$

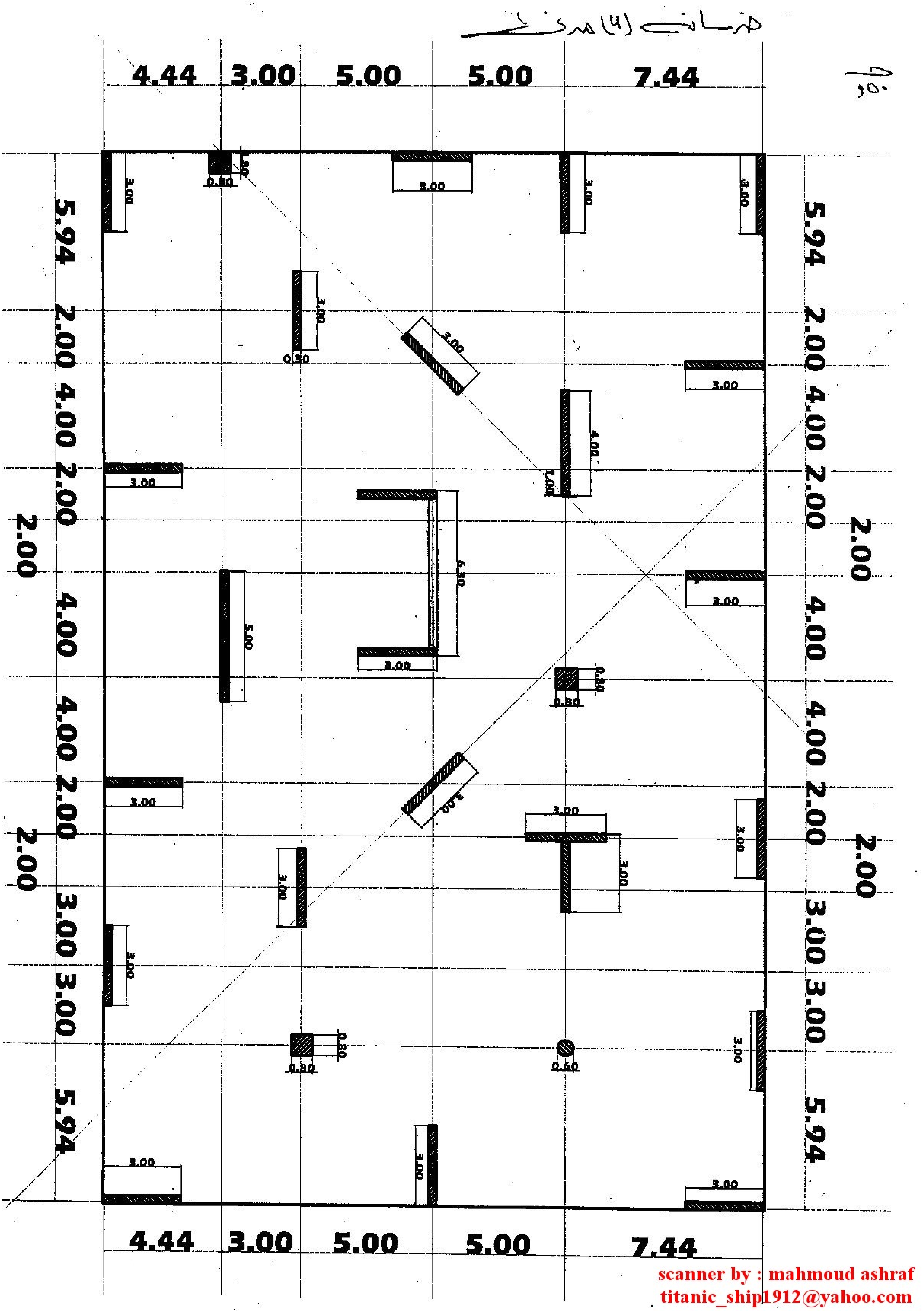
$\therefore$ use $5\phi 10/\text{m}$



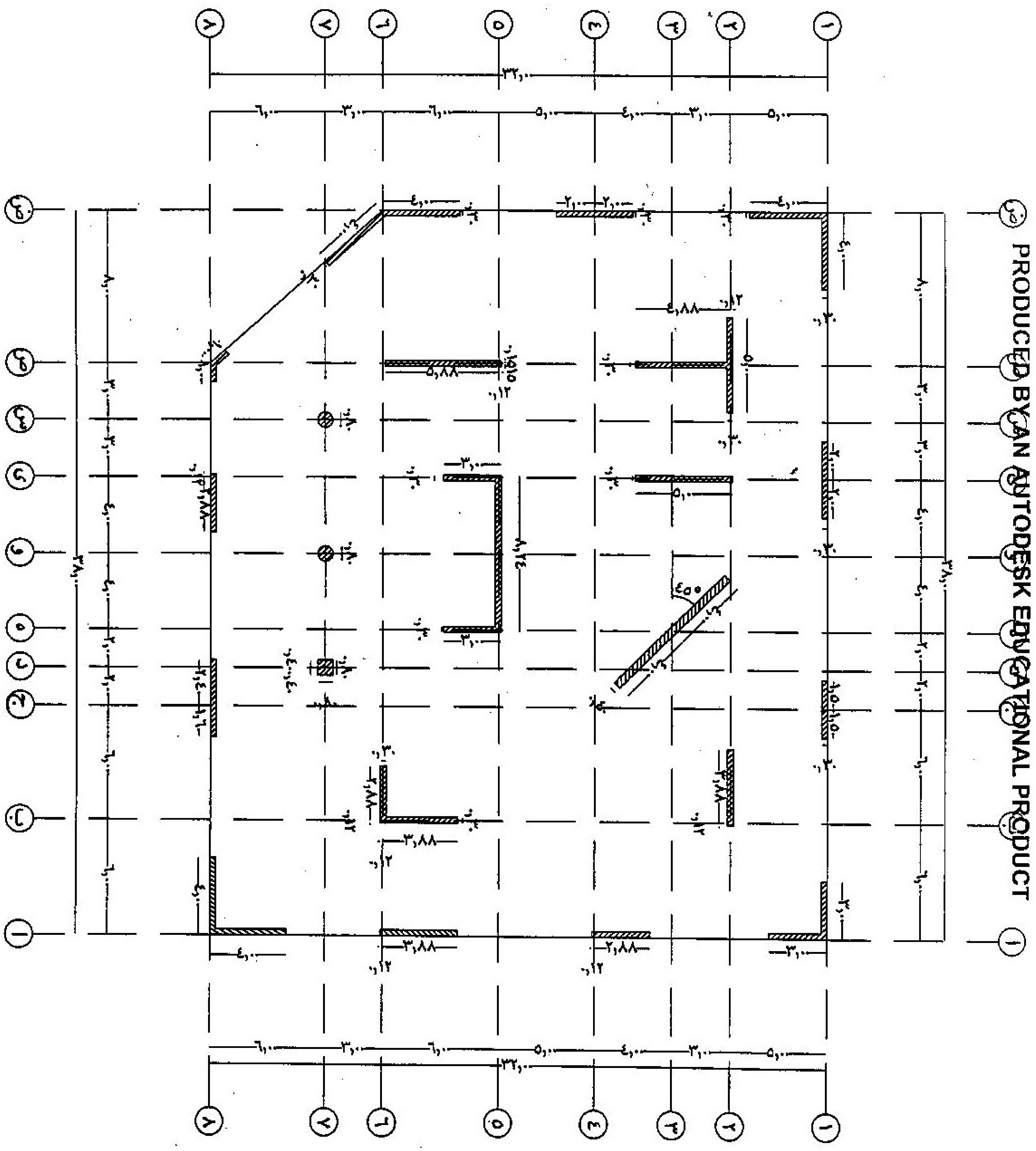


ونضع كل 30 سم كانة حباية لربط الأسياخ من الجهتين

او نضع كانات عادية



4.44
3.00
5.00
5.00
7.44
5.94
2.00
4.00
2.00
2.00
4.00
4.00
2.00
2.00
3.00
3.00
5.94
3.00
0.80
0.30
4.00
6.30
5.00
0.60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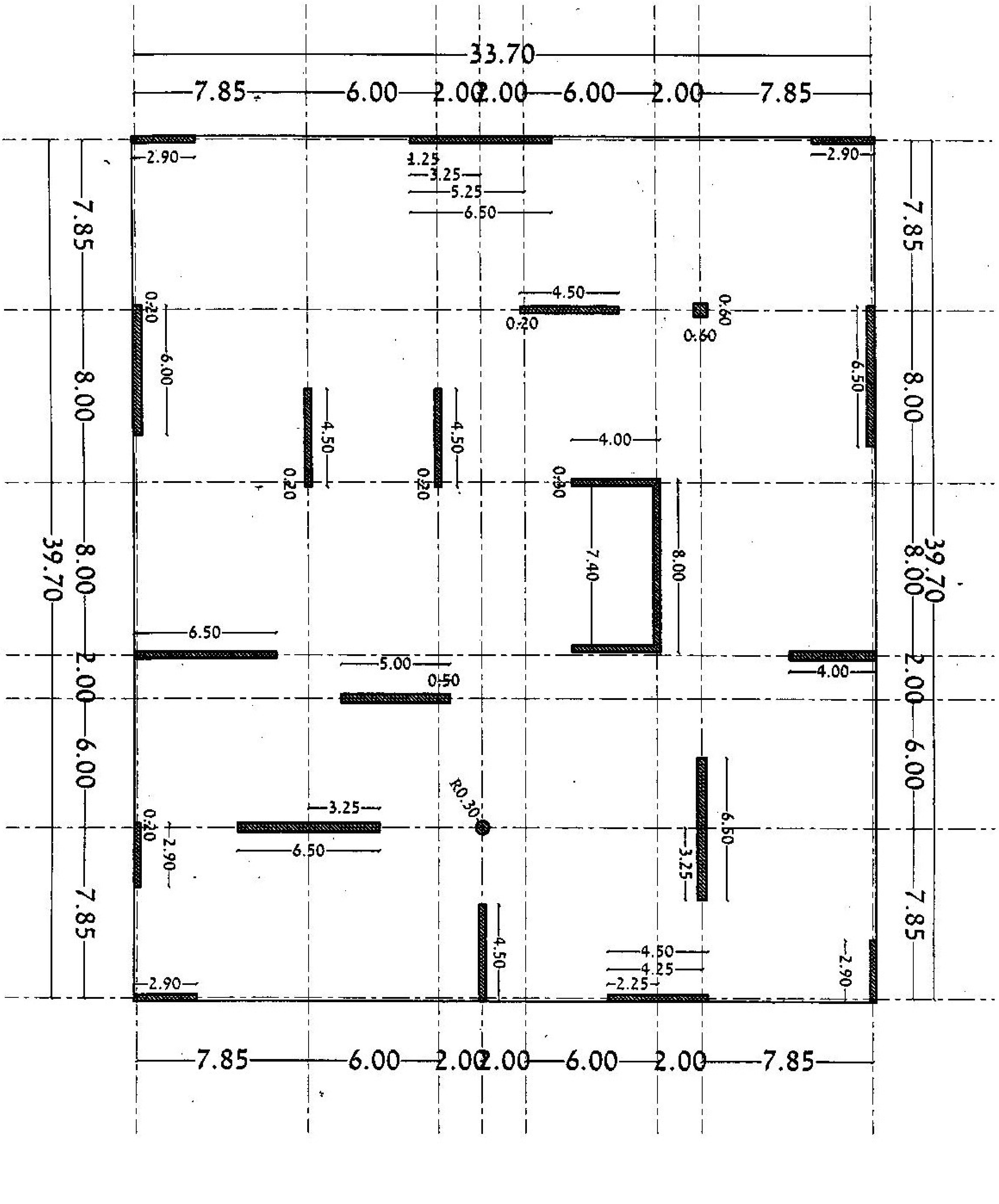
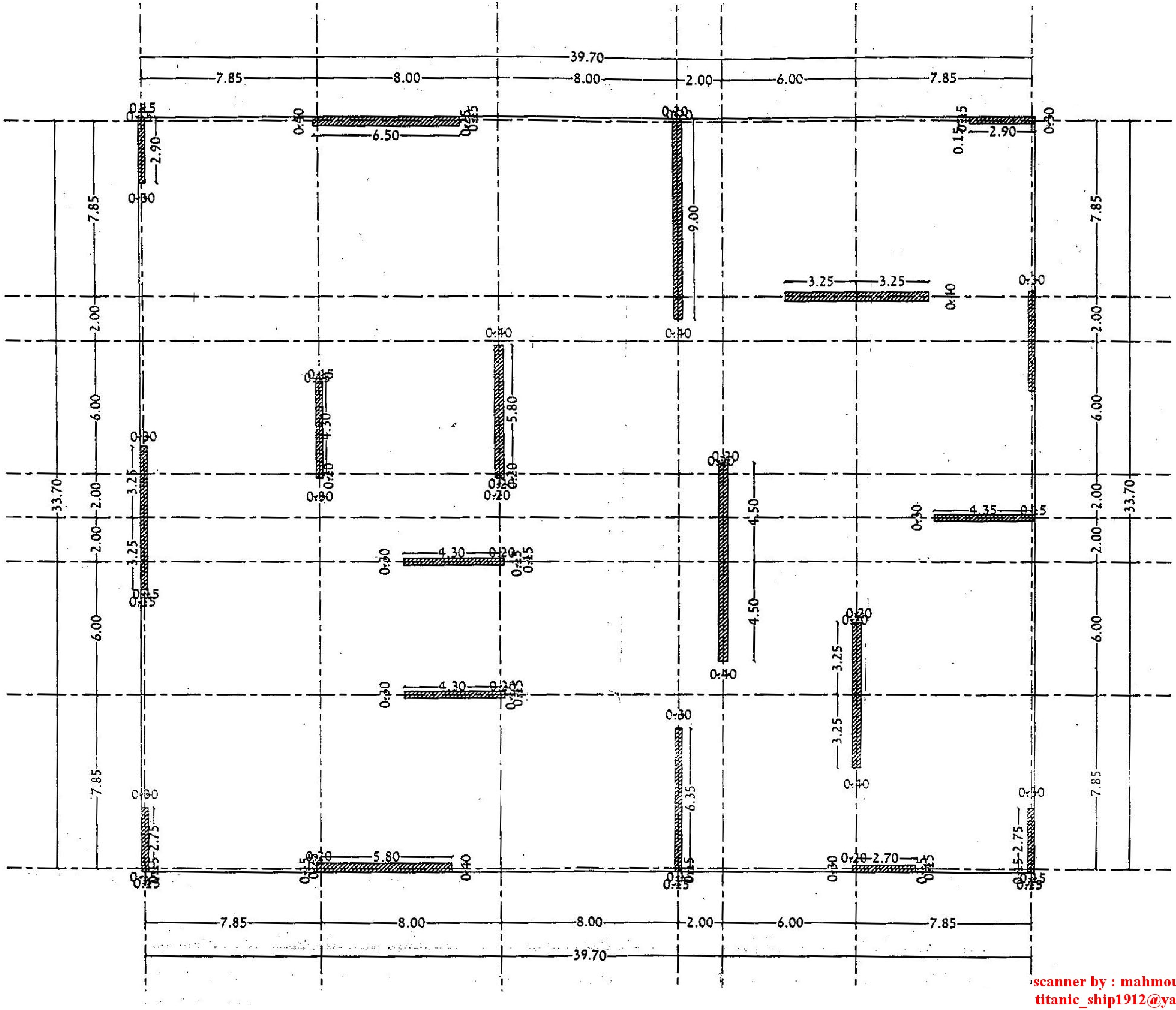

33.70
7.85
6.00
2.00
2.00
6.00
2.00
7.85
39.70
8.00
2.00
R0.30


39.70
7.85
8.00
8.00
2.00
6.00
7.85
6.50
2.90
9.00
3.25
4.30
5.80
4.50
4.35
3.25
2.00
6.00
33.70
6.35
2.75
2.70

22.

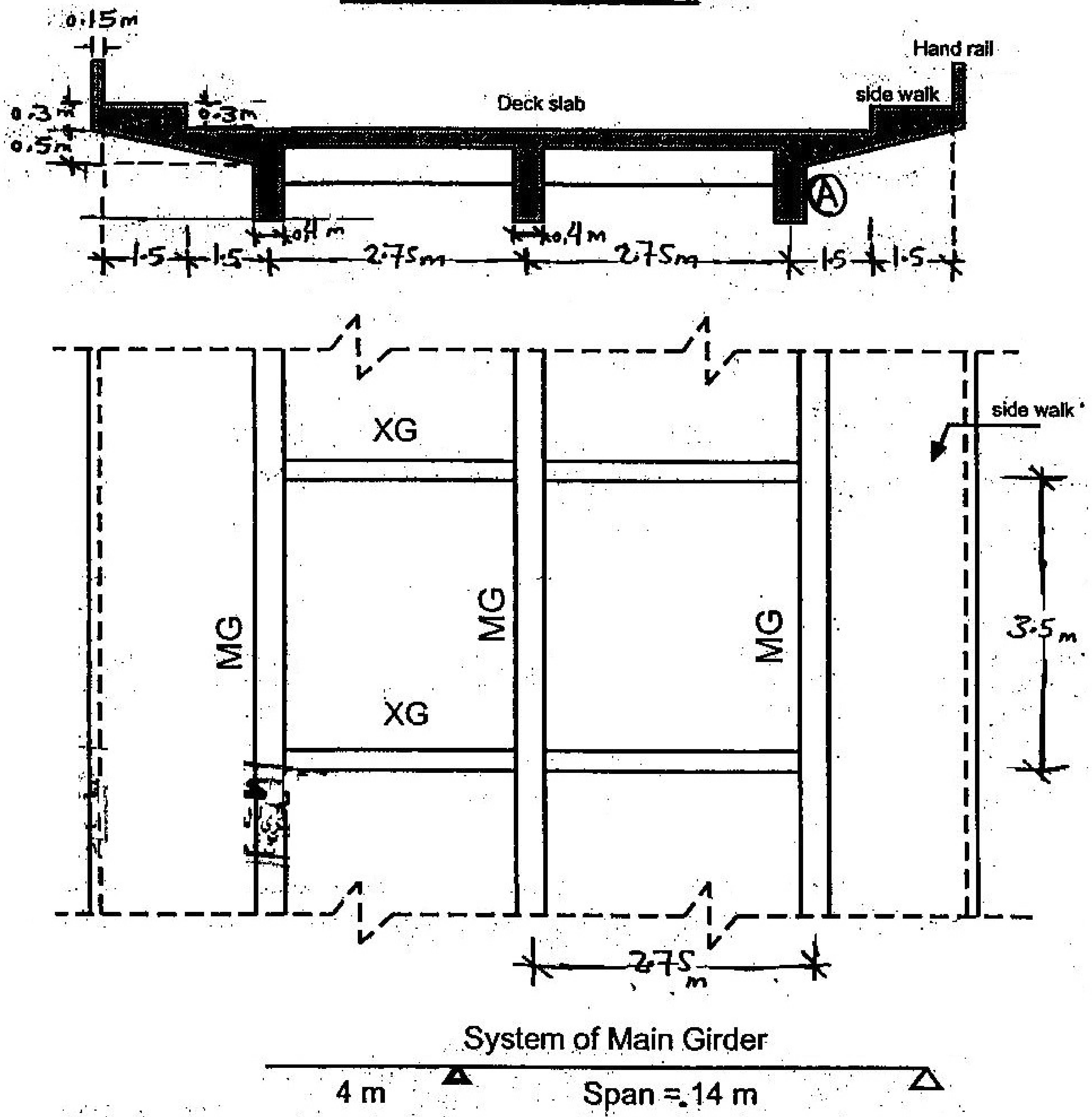
سنتر و مركز

الفارس

الفرقة الرابعة مدني

Reinforced Concrete Water Tanks

EXAMPLE



fcu=250kg/cm^2, fy=3600 kg/cm^2

Spacing between cross girders=3.5m

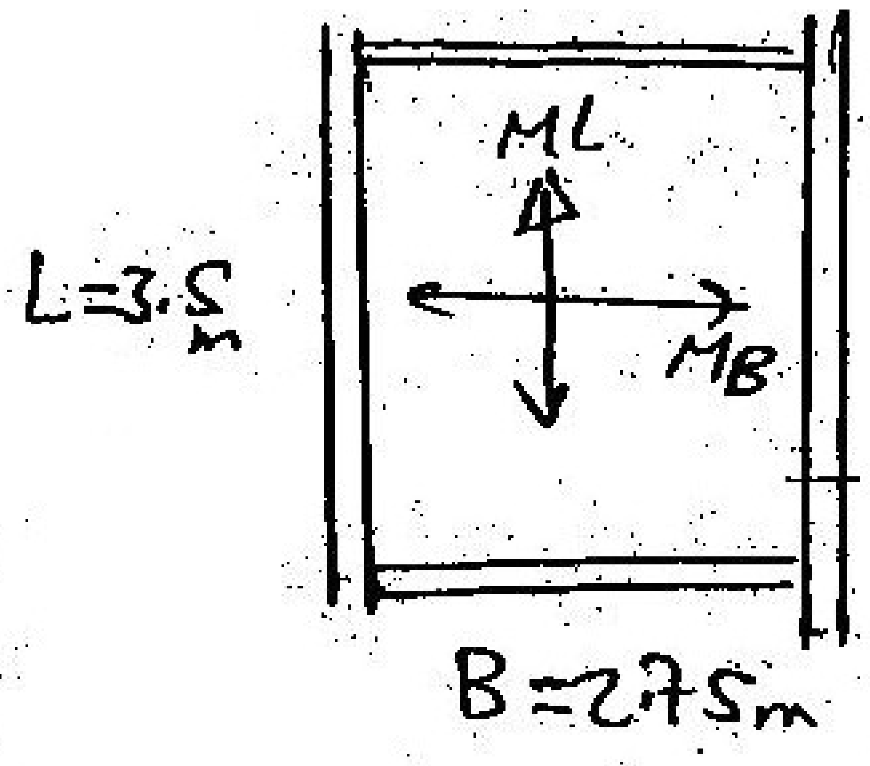
Required:

1-design deck slab and side walk.

2-design main girder (A) and cross girders

Solution

(1) Design of Deck slab :



Dead Loads :

$$w = t_s \gamma_{R.C} + t_{Asphalt}\,\gamma_{Asphalt}$$

$$= 0.25(2.5) + (0.08 * 2.2)$$

$$= 0.8 \ t/m^2$$

$\Rightarrow P = w * Area = 0.8 * 2.75 * 3.5 = 7.7$ ton

تكتب الحمل

$\therefore \frac{u}{B} = 1 \ , \ \frac{v}{L} = 1 \Rightarrow$ حيث ان الحمل موزع على البلاطة كلها

$\therefore K = \frac{long}{short} = \frac{3.5}{2.75} = 1.27 \simeq 1.25$

ناخذ أقرب رقم ليها.

use P. (4-6) بالكتاب

$m_1 = 4.52 * 10^{-2} = 0.0452$ $\qquad m_2 = 2.67 * 10^{-2} = 0.0267$

$$M_{B\,short} = P(m_1 + 0.15\,m_2) = 7.7(0.0452 + 0.15 * 0.0267) = 0.38 \ t.m/m$$

$$M_{L\,long} = P(m_2 + 0.15\,m_1) = 7.7(0.0267 + 0.15 * 0.0452) = 0.26 \ t.m/m$$

Live loads → تضع عجلة (10t) في منتصف البلاطة

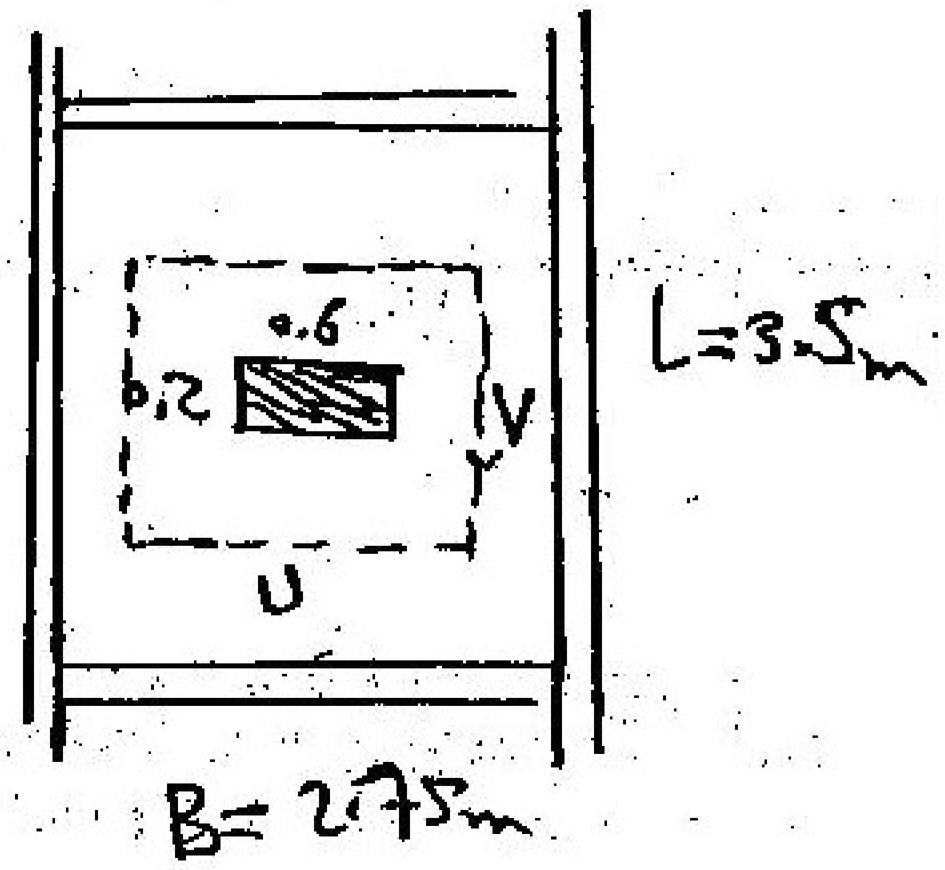
نوجد معامل الصدم في الكباري

$$I = (0.4 - 0.008B) = (0.4 - 0.008 * 2.75)$$

impact factor

$$\therefore I = 0.37$$

$$\therefore P(1+I) = 10(1+0.37) = 13.7 \text{ ton}$$



$$\therefore U = 0.6 + 2t_{asphalt} = 0.6 + (2 * 0.08)$$

$$= 0.76 \text{ m}$$

تقريبا →

$$\therefore V = 0.2 + 2t_{asphalt}$$

$$= 0.36 \text{ m}$$

تقريبا →

$$\therefore \frac{U}{B} = \frac{0.76}{2.75} = 0.28$$

$$\therefore \frac{V}{L} = \frac{0.36}{3.5} = 0.1$$

Using P. (4-6) → $m_1 = 0.17$, $m_2 = 0.17$

$$\therefore M_{B\,short} = M_{L\,long} = P(1+I)(m_1 + 0.15\, m_2)$$

$$= 13.7(0.17 + 0.15 * 0.17)$$

$$= 2.67 \text{ t.m}$$

Total Moments

$$M_B = 0.8\,(\overset{\text{dead}}{0.38} + \overset{\text{live}}{2.67}) = 2.44 \text{ t.m/m}$$

معامل للاستمرار ← 0.8

$$M_L = 0.8\,(0.26 + 2.67) = 2.34 \text{ t.m/m}$$

Ultimate moment: for design

$$M_u = 1.5\, M_{max} = 1.5 * 2.44 = 3.7 \text{ t.m/m}$$

$$R_1 = \frac{M_u * 10^5}{f_{cu}\, B\, d^2} = \frac{3.7 * 10^5}{250 * 100 * (23)^2} = 0.027$$

$$\therefore \omega = 0.033$$

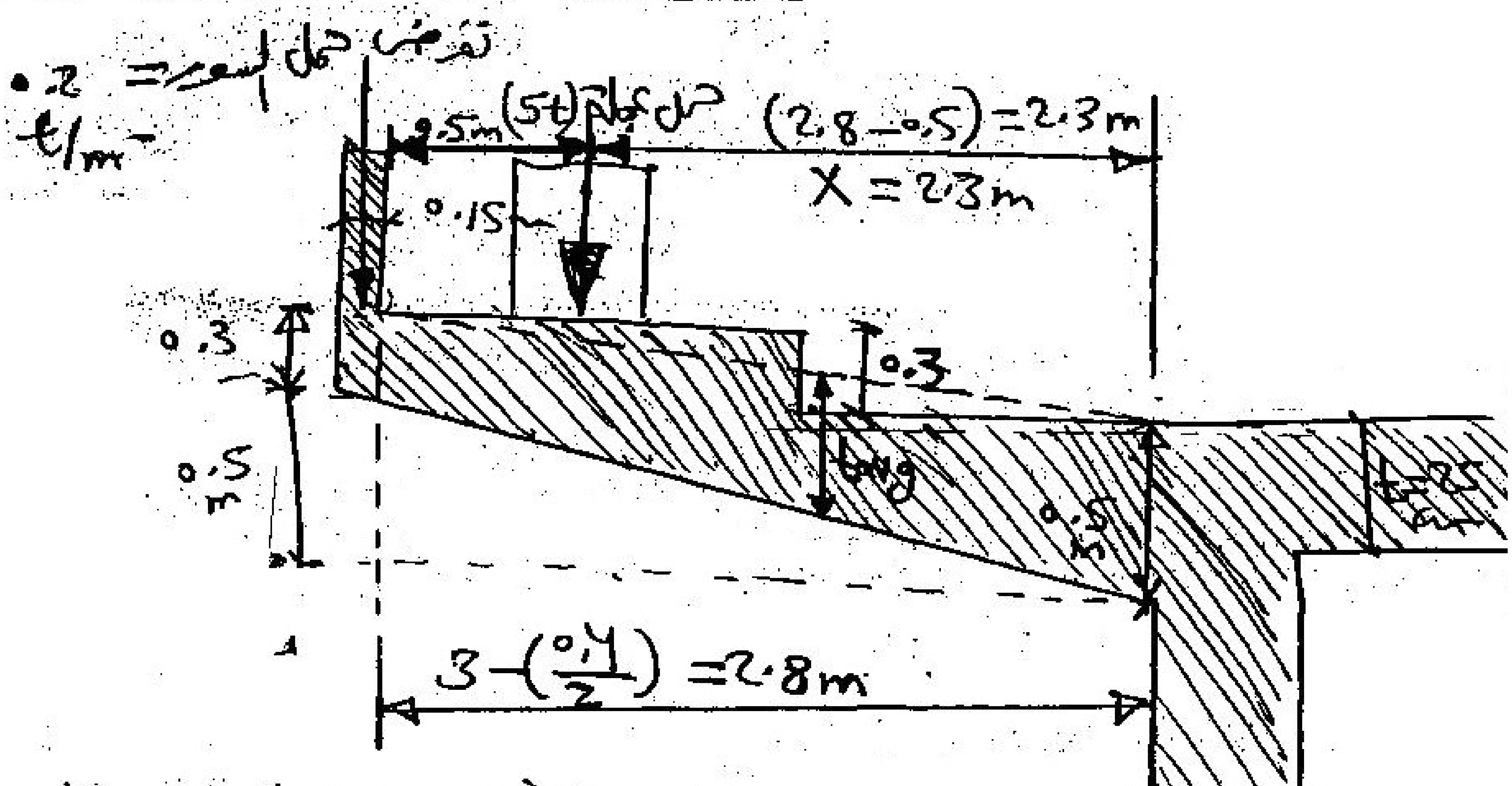
$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} B \cdot d = 5.5 \text{ cm}^2/\text{m}$$

$$= 5 \# 12/\text{m}$$

فرش وغطاء حيث العزم متقاربين جداً

لدرجة هينة.

(2) Side walk

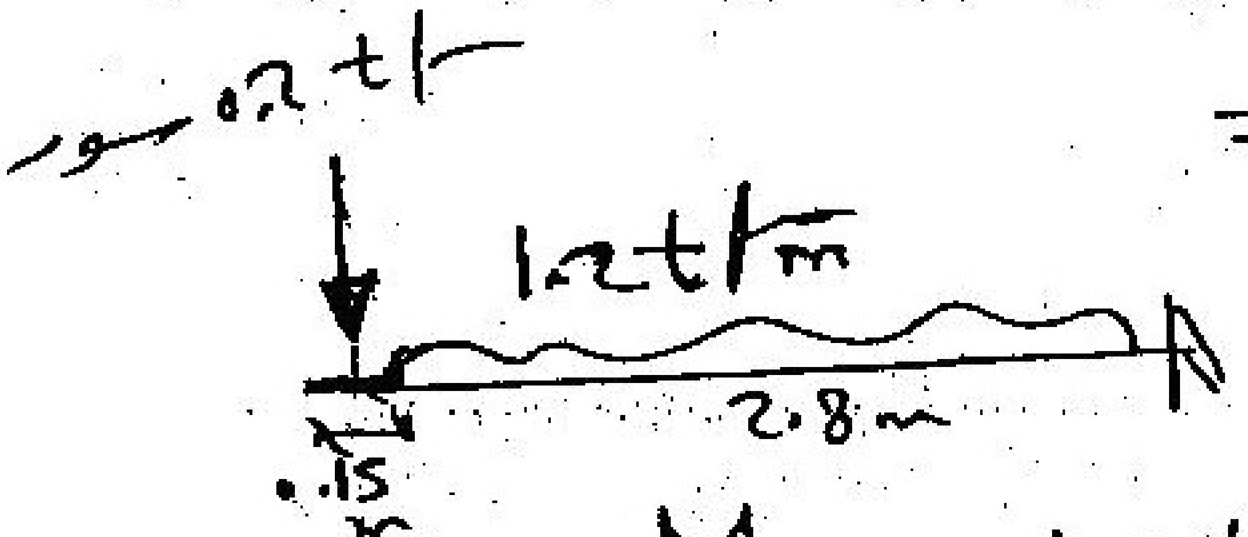


$$t_{avg} \approx \left(\frac{0.5 + 0.3}{2}\right) = 0.4 \text{ m}$$

0.4m

Dead loads : $\omega = t_{avg} \cdot \gamma_{R.C} + \text{Covering}$

$$= (0.4 * 2.5) + \underset{\text{فرض}}{0.2} = 1.2 \ t/m^2$$



$$M_{dead} = \frac{1.2 * (2.8)^2}{2} + 0.2 * \left(2.8 + \frac{0.15}{2}\right)$$

$$= 5.28 \ t.m/m$$

Live loads :-

نضع حمل عجلة (5t) بدون Impact على مسافة

$$B_e = 0.2 + 1.2X$$

$$= 0.2 + (1.2 * 2.3) = 2.96 \text{ m}$$

عرض العجلة ←   factor   مسافة

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titanic_ship1912@yahoo.com

محل العجلة   بعد العجلة عن القطاع الحرج

$$\therefore M_{Live} = \left(\frac{P * X}{Be}\right) = \frac{5 * 2.3}{2.96} = 3.9 \text{ t.m/m}$$

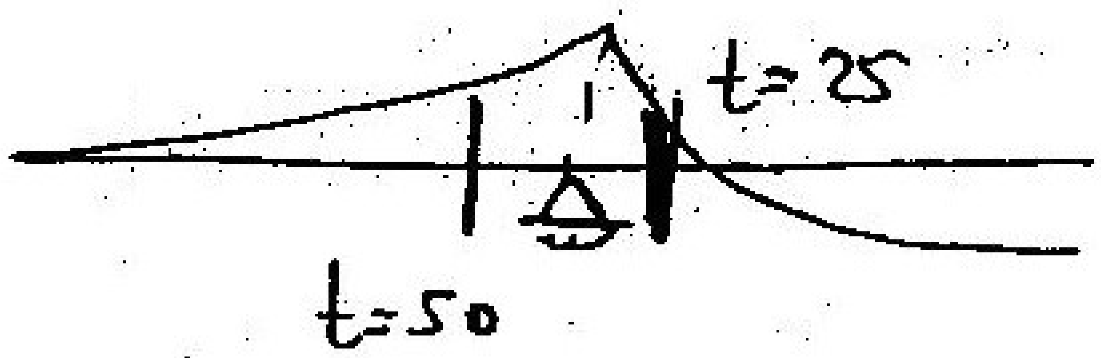
$$\therefore M_{Total} = M_{dead} + M_{live}$$

$$= (5.28 + 3.9) = 9.18 \text{ t.m/m}$$

$$\therefore M_{u\,ultimate} = 1.5\, M_{total} = 1.5 * 9.18 = 13.77 \text{ t.m/m}$$

نصمم القطاع الأخطر وهو في البلاطة المجاورة للكابولي

حيث أن له نفس العزم مع الاتزان وتخانة أقل.



$$\therefore t_{critical} = 25 \text{ cm} \Rightarrow d = 23 \text{ cm}$$

$$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{13.77 * 10^5}{250 * 100 * (23)^2}$$

$$= 0.1$$

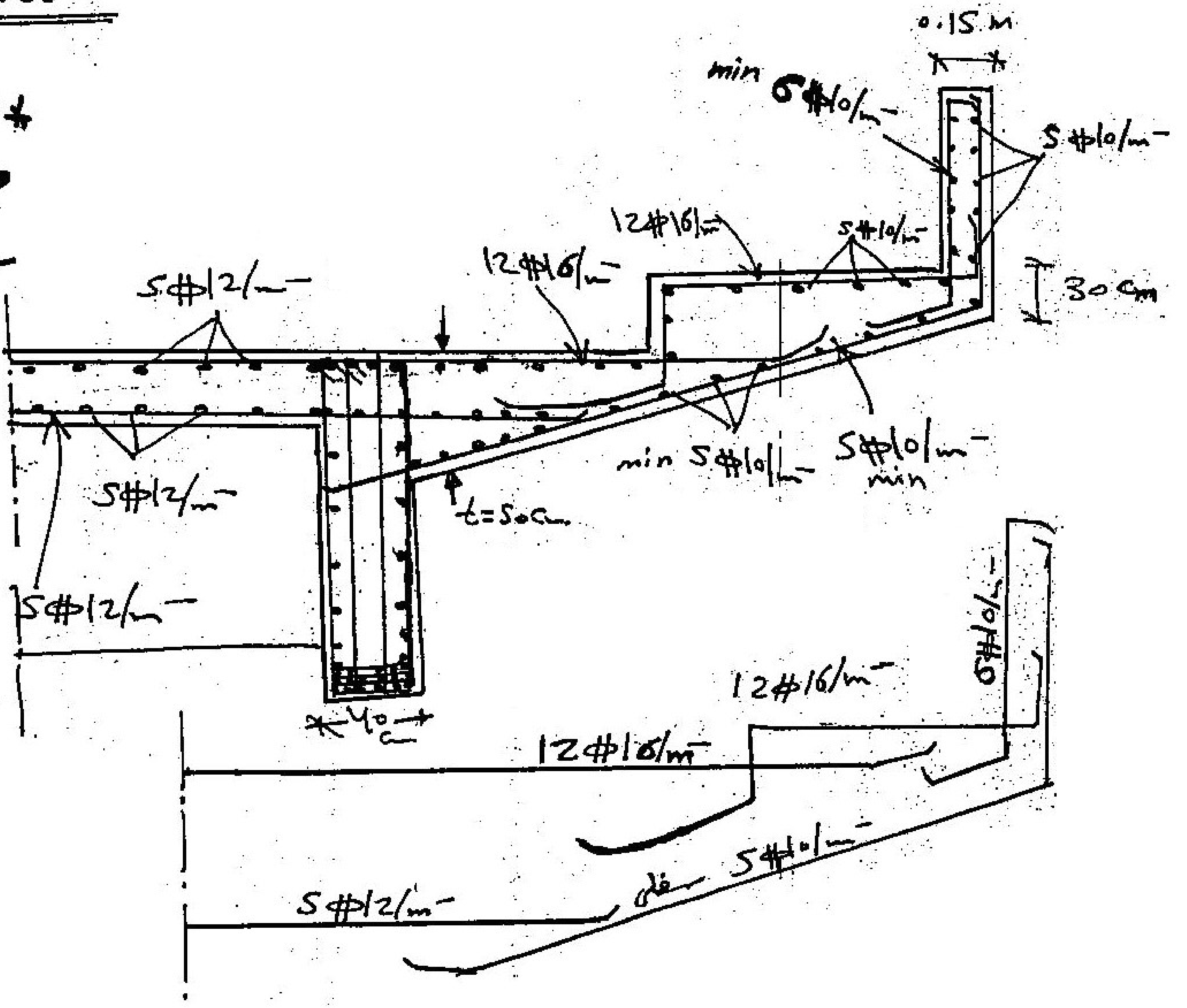
$$\omega = 0.13$$

$$A_s = 0.13 * \frac{250}{3600} * 100 * 23 = 20.76 \text{ cm}^2/\text{m}$$

use $\Rightarrow$ 11 Φ 16/m

Scale 1:25

* نوحد عدد الأسياخ في السفلي
و نوحد عدد الأسياخ في العلوي
(12#16) ع (6#10/m')



(27)

١/٧/٥

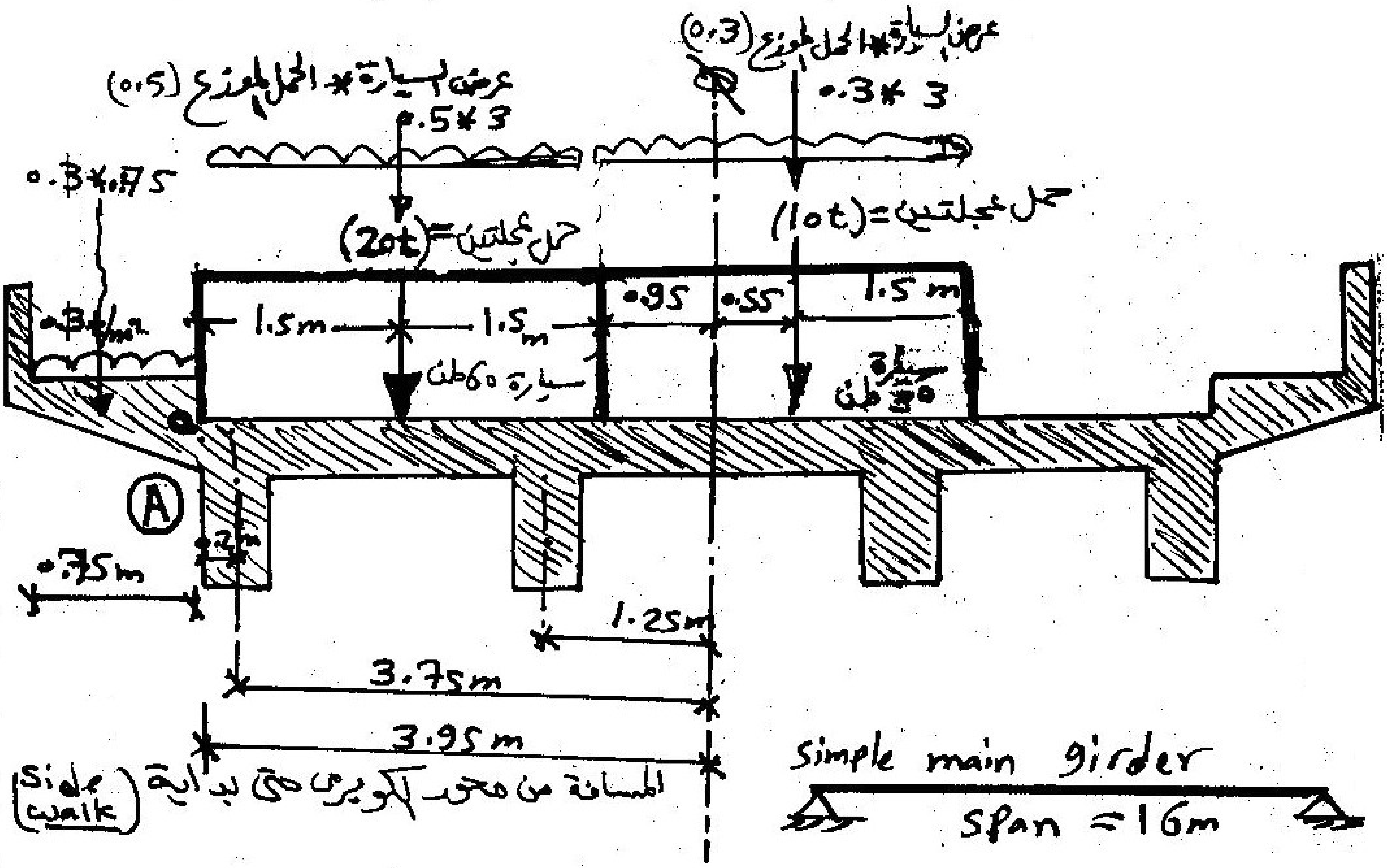
Nour center

الخرسانه المسلحه

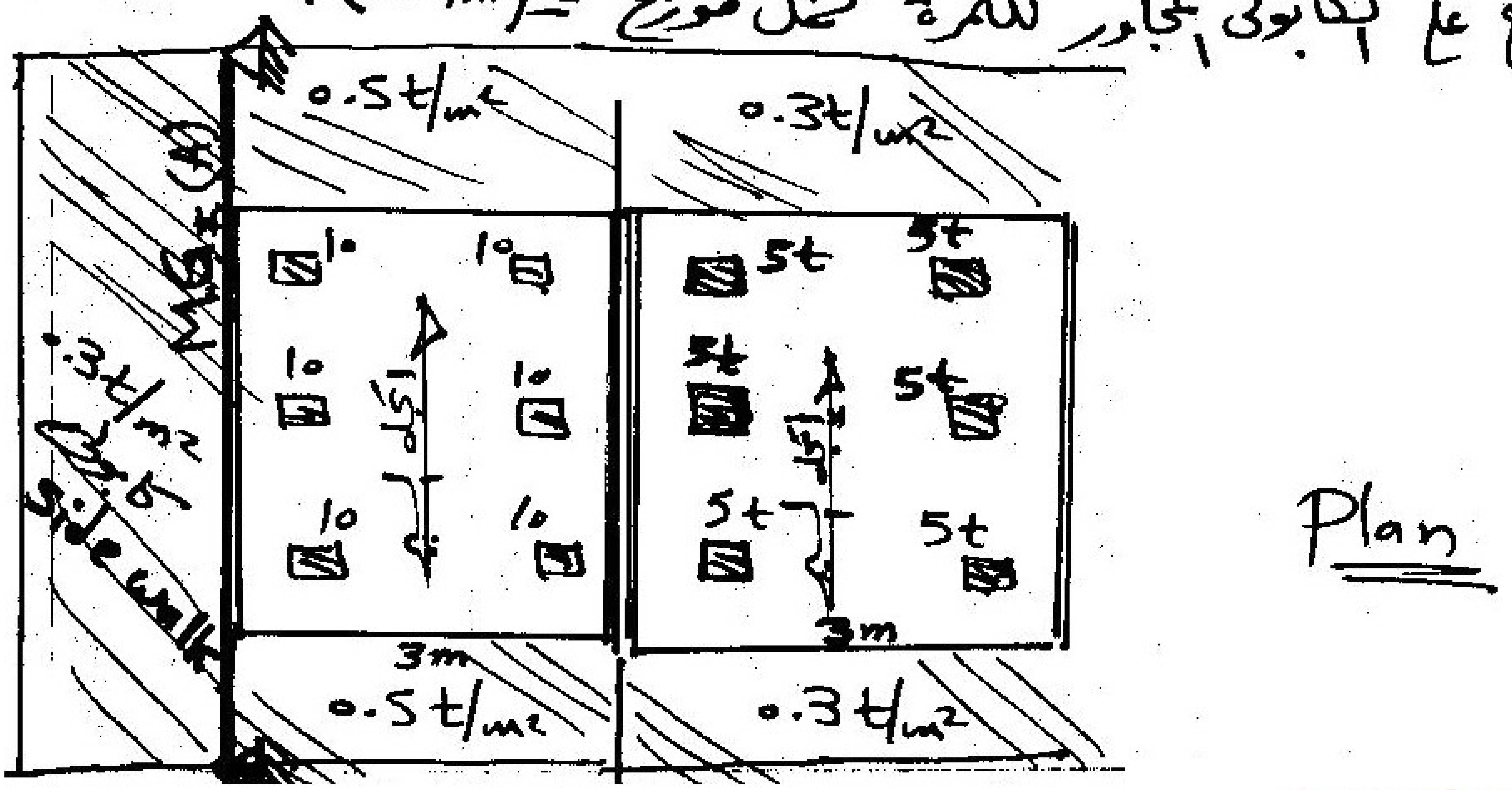
الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

Design of Main girder (A)



* نضع سيارة (60t) بجوار الكمرة المراد تصميمها ونضع أمامها وخلفها حمل موزع (0.5t/m²) ونأخذ معهم الـ (Impact).
* وبجوار السيارة السابقة نضع سيارة (30t) ونضع أمامها وخلفها حمل موزع (0.3t/m²) ولا نأخذ معهم الـ (Impact).
* ونضع على الكابولي المجاور للكمرة حمل موزع = (0.3t/m²).



Plan

$$R_i = \frac{P}{N}\left(1 + \frac{N \cdot e \cdot L_i}{\sum L^2}\right)$$

الحمل على الكمرة

$P = \leftarrow$ (ton) الحمل المدروس

$N =$ عدد الـ M.G.

$e =$ مسافة الحمل المدروس عن محور الكوبري Φ

$L_i =$ مسافة الكمرة المدروسة عن محور الكوبري Φ

إشارتها موجبة إذا كانت ناحية الكمرة المدروسة

إشارتها سالبة إذا كانت الناحية الثانية من الكوبري.

$$\sum L^2 = (2 * 1.25^2) + (2 * 3.75^2) = 31.25\ m^2$$

لجميع الكمرات

$$I = 0.4 - 0.008(16) = 0.27$$

impact factor

طول main girder

---

① **due to Trucks: (30t, 60t)**

$$R_1 = \frac{20 * (1 + 0.27)}{4}\left(1 + \frac{4 * 2.45 * 3.75}{31.25}\right)$$

حمل مركز من أحمال السيارات

بعد محور الكوبري عن الكمرة الطرفية (A) وهي أخطر كمرة وهي المطلوبة في الامتحان

$$+ \frac{10}{4}\left(1 + \frac{4 * -0.55 * 3.75}{31.25}\right) = 15.65\ ton$$

(e) بالسالب

② **due to live loads: (0.5 t/m², 0.3 t/m²)**

$$R_2 = \frac{0.5 * 3 * (1 + 0.27)}{4}\left(1 + \frac{4 * 2.45 * 3.75}{31.25}\right)$$

حمل موزع

$$+ \frac{0.3 * 3}{4}\left(1 + \frac{4 * -0.55 * 3.75}{31.25}\right) = 1.2\ t/m$$

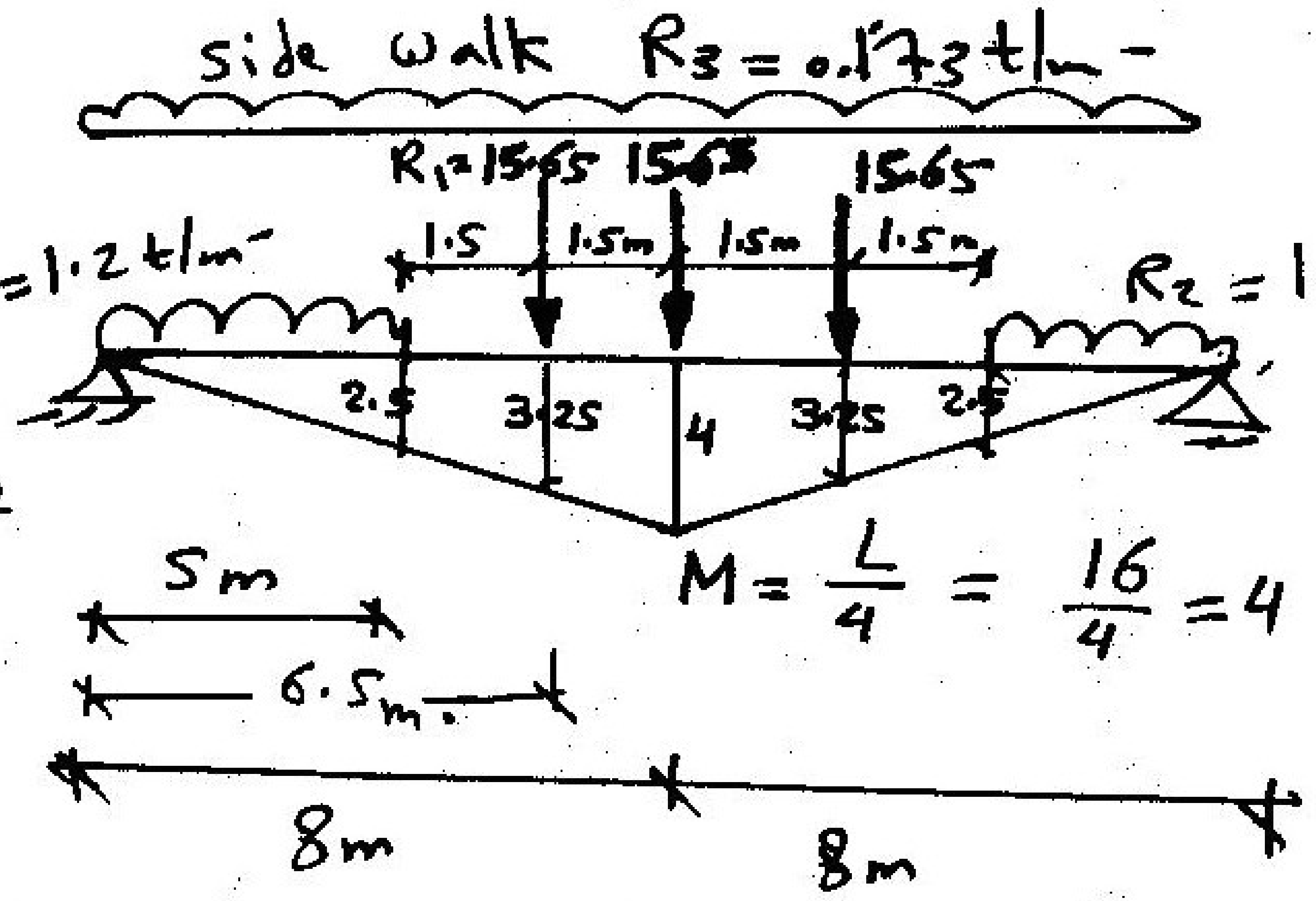
(3) due to side walk Load = 0.3 t/m²

$$R_3 = \frac{(0.3 * 0.75)}{4}\left(1 + \frac{4 * 4.325 * 3.75}{31.25}\right)$$

عزم

$$= 0.173 \ t/m$$

(I.L) للحصول على أقصى عزم موجب للكمرة يتم رسم *



I.L.M+ve

$M = \frac{L}{4} = \frac{16}{4} = 4$

$\frac{1}{2}$ = الميل

$$\therefore M_{max} = (15.65 * 3.25 * 2) + (15.65 * 4)$$
$$+ 1.2 * \left(\frac{1}{2} * 5 * 2.5\right) * 2$$
$$+ 0.173 * \left(\frac{1}{2} * 4 * 16\right)$$

$$\therefore M_{max} = 184.861 \ t.m$$ ⟹ from Live load

Dead Loads

* ناخذ عرض الكوبري كله بما فيه الكوابيل

$$W = (\text{own wt}_{M.G}) + \left(\frac{\text{slab Dead Load } (W_s) * \text{عرض الكوبري كله}}{\text{عدد } MG}\right)$$

* Assume $t_{main\ girder} = \frac{span}{10} = \frac{16}{10} = 1.6\ m$

$\therefore$ own wt $= b \cdot t \cdot \gamma_{R.C}$

$= .4 (1.6) * 2.5 = 1.6\ t/m$

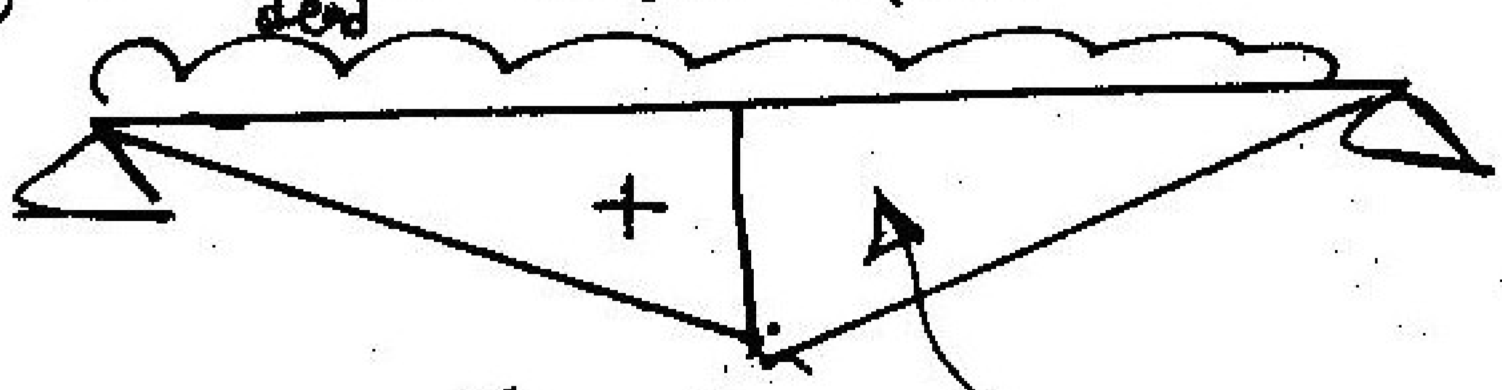
$$\therefore W_{dead} = 1.6 + \frac{.8 * (9.4)}{4} = 3.5\ t/m$$

من المذكرة السابقة

$.8 = (W_s)_{dead} = t_s \cdot \gamma_{R.C} + t \cdot \gamma_{Asphalt}$

$W_{dead} = 3.5\ t/m$

I.L M_{+ve}



M= 4

$$\therefore M_{Dead\ Load} = W_{dead} * \text{Area of I.L}$$

$$= 3.5 * \left(\frac{1}{2} * 4 * 16\right) = 112\ t.m$$

$$\therefore \boxed{M_{total} = M_{Dead} + M_{Live}}$$

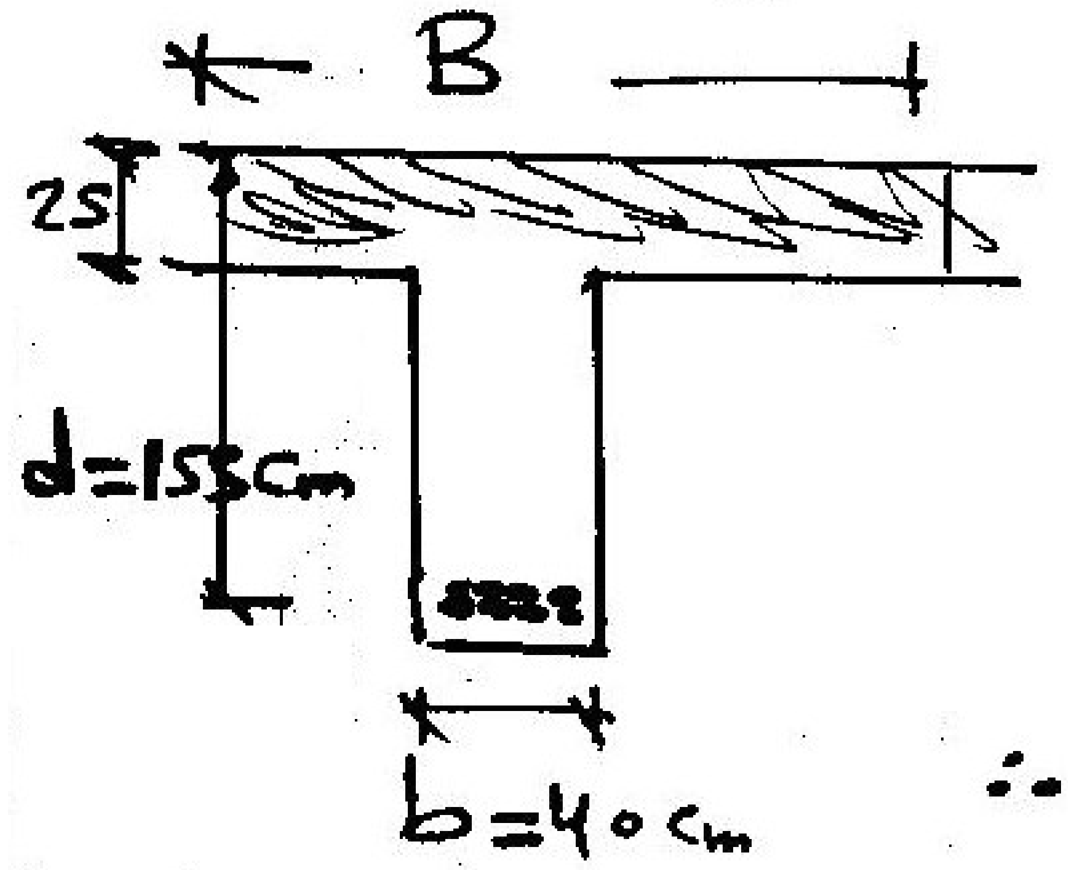
$= 112 + 184.861$

$= 297\ t.m$

$\therefore M_u = 1.5\, M_{total} = 445 \; t.m$

$R_1 =$ **T-section**

$B = \min \begin{cases} 16\,t_s + b = (16 \times 25) + 40 = 440 \; cm \\ \text{c.c main girders} = 250 \; cm \\ \frac{L}{5} + b = \frac{1600}{5} + 40 = 360 \; cm \end{cases}$



$\therefore$ simple beam

$\therefore$ $L' = L$

$\therefore B = 250 \; cm$

$$R_1 = \frac{M_u \times 10^5}{f_{cu} \cdot B \cdot d^2} = \frac{(445 \times 10^5)}{250 \times 250 \times 155^2}$$

عرض flange في الضغط ↗

$= 0.03$

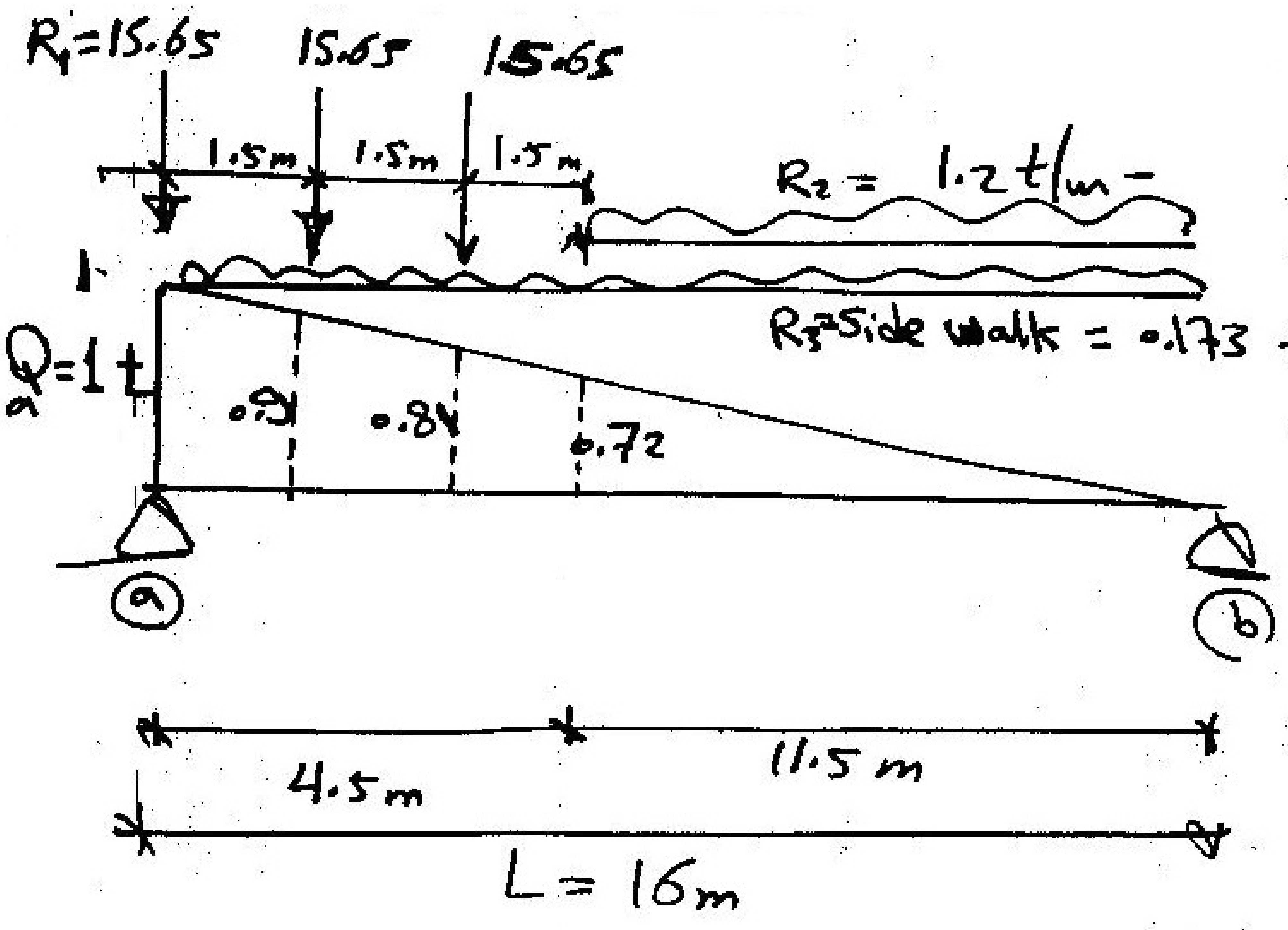
$\therefore \omega = 0.035$

$$\therefore A_s = \omega \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$$

$$= 0.035 \times \frac{250}{3600} \times 250 \times 155 = 94.2 \; cm^2$$

$\therefore$ **use 16 # 28**

(Shear)



I.L. Q_a

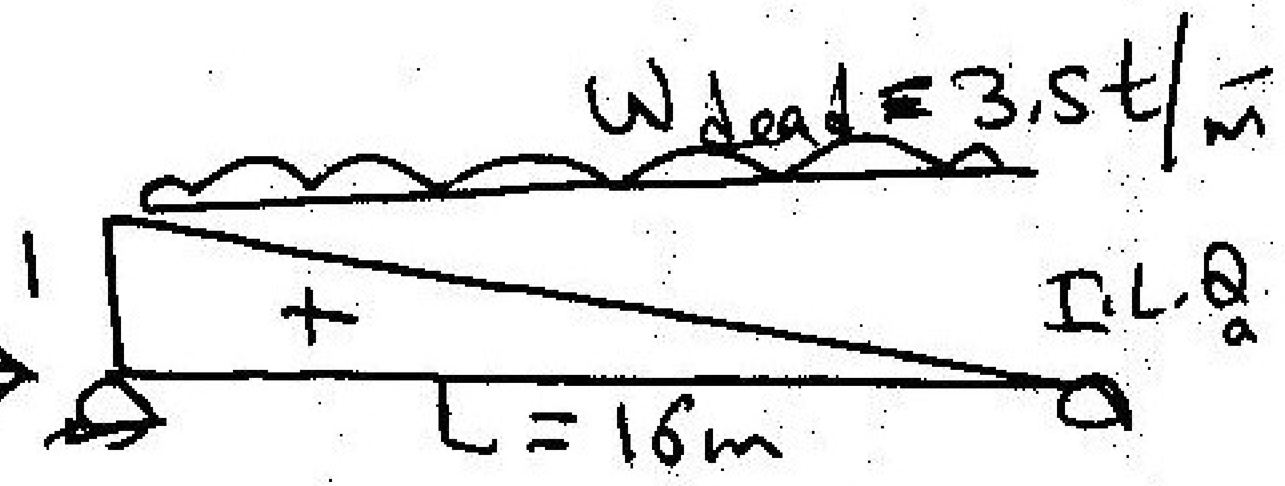
* نضع قيم الأحمال المركزة عند أقصى قيم لل (I.L)

$$\therefore Q_{max\ live} = (15.65 * 1) + (15.65 * 0.9) + (15.65 * 0.81)$$

$$+ \left(1.2 * \frac{1}{2} * 11.5 * 0.72\right)$$

$$+ \ 0.173 * \left(\frac{1}{2} * 1 * 16\right) = 65.4\ \text{ton}$$

* due to dead load ⇒



$$Q_{max\ dead} = W_{dead} * \text{Area}_{(I.L)} = 3.5 * \frac{16 * 1}{2} = 28\ \text{ton}$$

$$\therefore Q_u = 1.5\left(Q_{dead} + Q_{live}\right)$$

$$= 1.5 * (28 + 65.4) = 140.1\ \text{ton}$$

$$\therefore Q_{critical\ at\ (\frac{d}{2})} = Q_u - w_u\left(\frac{c + d}{2}\right)$$

$$\simeq 0.85 * Q_u = 119\ \text{ton}$$

$\because\; q_u = \dfrac{Q_{cr} * 10^3}{b \cdot d} = \dfrac{119 * 10^3}{40 * 155} = 19.19\ \text{kg/cm}^2$

shear stress

$q_{allow\ (concrete)} = 0.75\sqrt{\dfrac{f_{cu}}{\gamma_c}} = 0.75\sqrt{\dfrac{250}{1.5}} = 9.6\ \text{kg/cm}^2$

factor of safety = 1.5

$\therefore\; q_u >>> q_{allow}$

$\therefore$ need bent bars, stirrups

$q_{steel} = q_u - \dfrac{q_{allow}}{2} = 19.19 - \dfrac{9.6}{2} = 14.4\ \text{kg/cm}^2$

assume stirrups $8\phi 10/m$ (عدد الكانات / م) → 3600

$\therefore\; q_{str} = \dfrac{n \cdot a_{str} \cdot f_{y\,str}/\gamma_s}{b \cdot s} = \dfrac{4 * 0.785 * 3600/1.15}{40 * 12.5} = 19.6$

$n = 4$ فرع ; $b \geq 40$ cm

$a_{str} = \phi 10 = 0.785\ \text{cm}^2$

$s = \left(\dfrac{100}{\text{عدد الكانات}}\right) = \dfrac{100}{8} =$

$\therefore\; q_{str} >> q_{steel} \Rightarrow$ safe.

---

* وأصلاً كدة السقف كبير جداً سوف تستنتج منه

(shear is very safe) عند كبير

Cross girders:

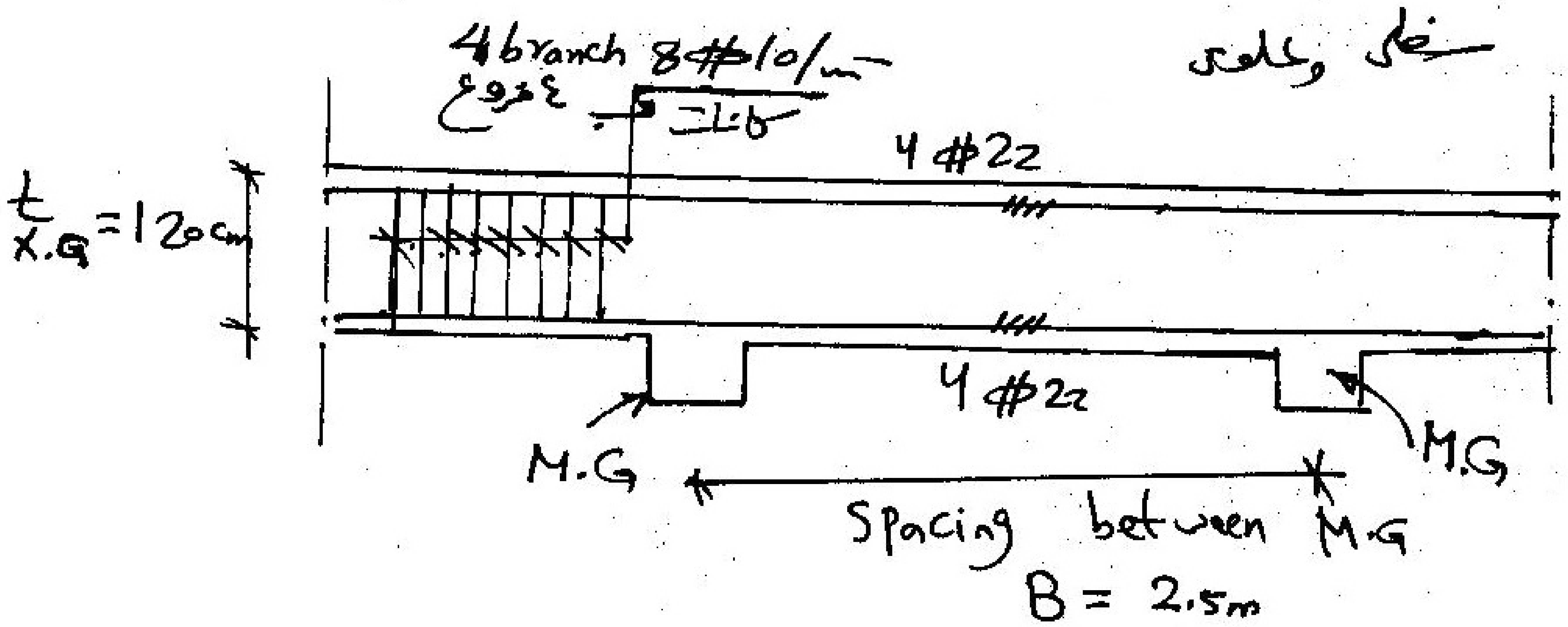
$$t_{X.G} \simeq \left(\frac{3}{4}\right) t_{M.G}$$

$$\simeq \frac{3}{4} * 1.6_m = 1.2m$$

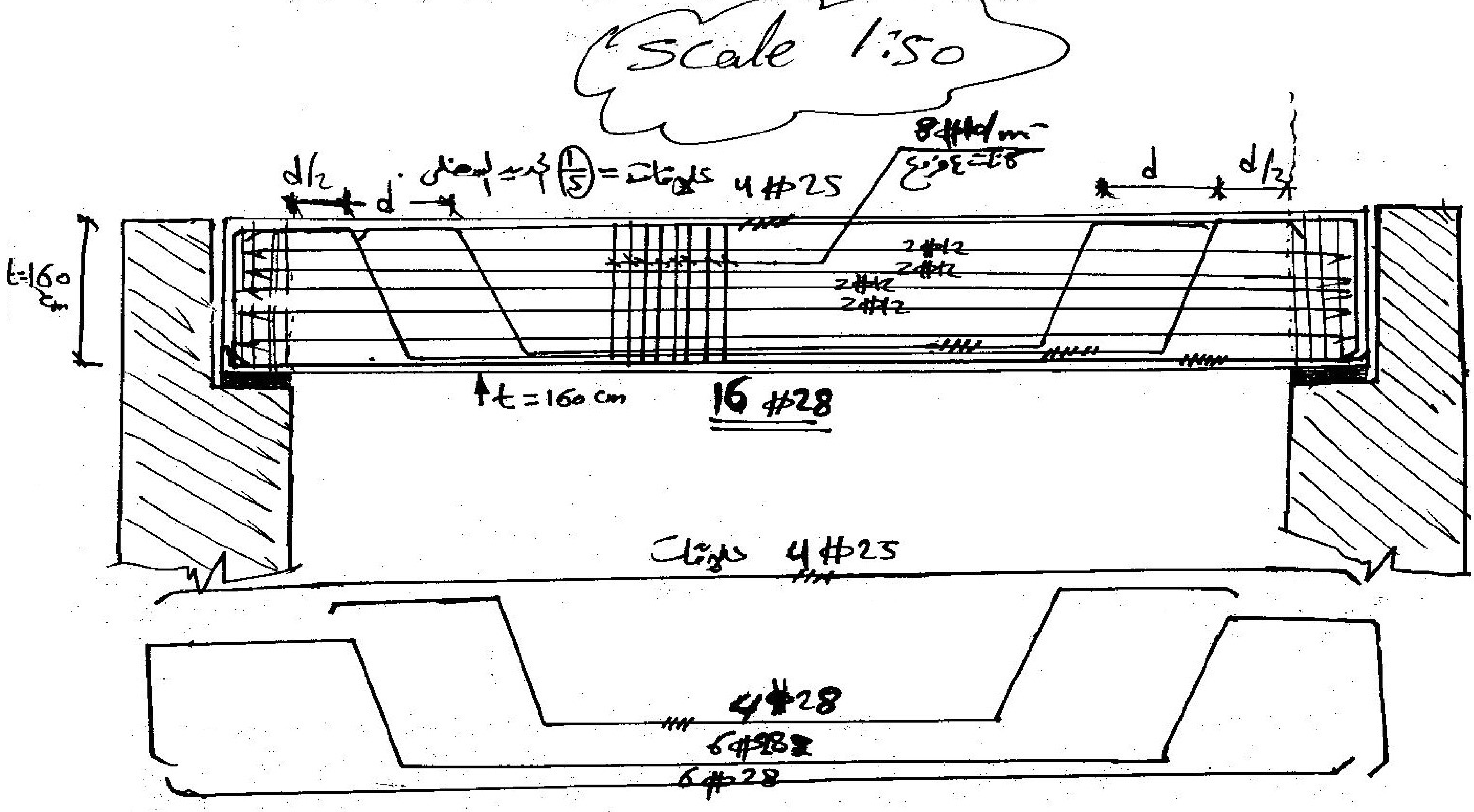
$$A_{s\,X.G\,min} = \frac{11}{3600} * \underset{b}{40} * \underset{d}{115} = 14\ cm^2$$

$$= 4\phi 22$$

علوي وسفلي

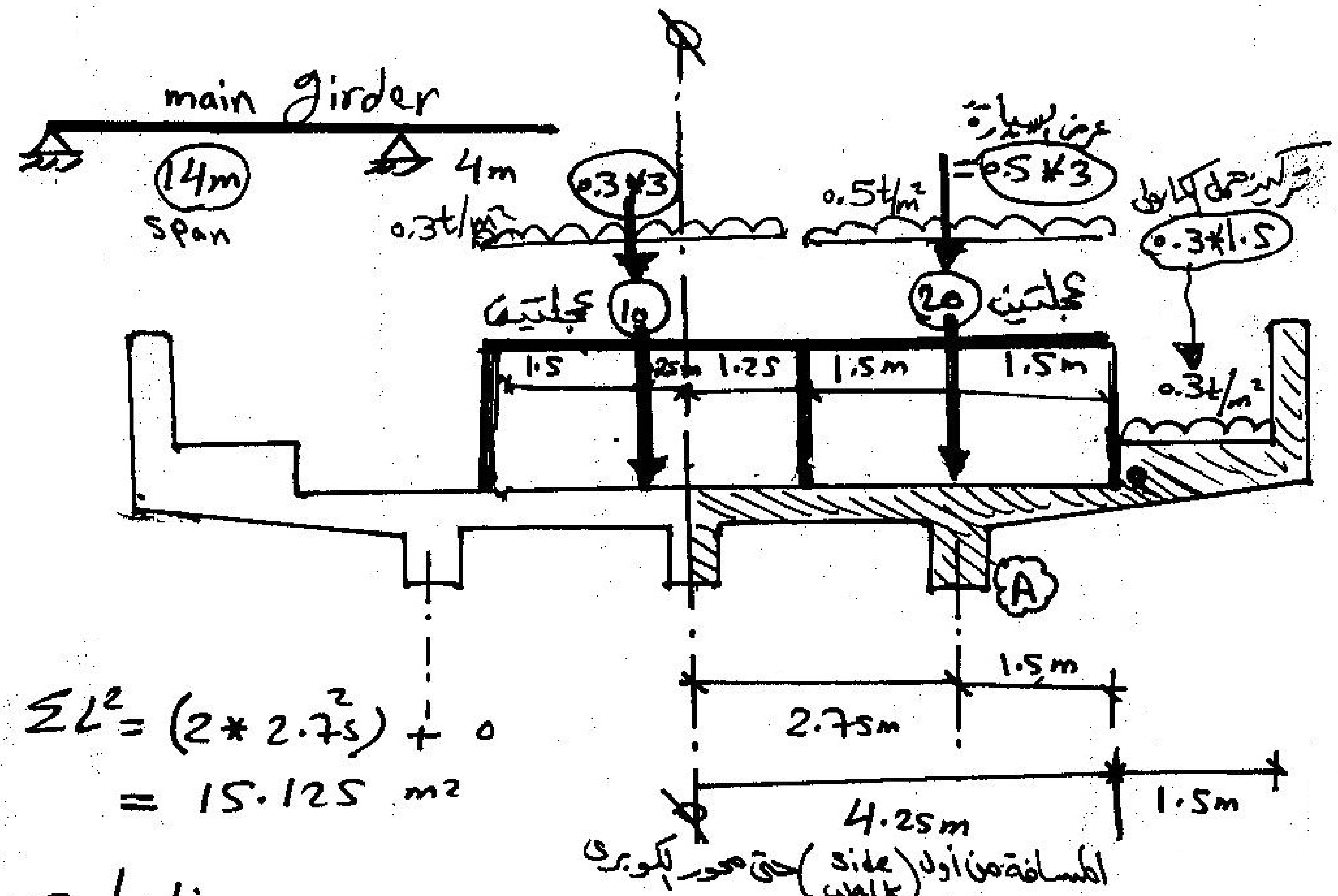


أقصى عدد في الصف ١ = $\left(\frac{b}{6}\right) = \left(\frac{40}{6}\right) = 16$ سيخ.



★ ملحوظة: حديد الانكماش لا نقوم بتفريده وهو يوضع كل 30 سم.

Example (2) "Main girder": (A)



$\Sigma L^2 = (2 * 2.75^2) + 0$
$= 15.125\ m^2$

Solution:

※ due to Live Loads

(1) **Truck (30 ; 60) Ton** : بجوار الكمرة (A).

Impact → $I = 0.4 - (0.008 * 14) = 0.29$

حمل مركز

$$R_1 = \frac{20\,(1 + \overset{I}{0.29})}{3}\left[1 + \frac{3 * 2.75 * 2.75}{15.125}\right] + \frac{10}{3}\left[1 + \frac{3 * 2.75 * -0.25}{15.125}\right] = 24.4 \text{ ton}$$

(2) **Live Loads ($0.3\,t/m^2$, $0.5\,t/m^2$)** (أمام وخلف السيارات)

حمل موزع

$$R_2 = \frac{0.5 * 3 * (1 + 0.29)}{3}\left[1 + \frac{3 * 2.75 * 2.75}{15.125}\right] + \frac{0.3 * 3}{3}\left[1 + \frac{3 * 2.75 * -0.25}{15.125}\right] = 1.87 \text{ ton/m}$$

(3) **Side walk Live load = 0.3 t/m²** : على الكابولي

$$R_3 = \frac{0.3 * 1.5}{3}\left[1 + \frac{3 * 5 * 2.75}{15.125}\right] = .65\ t/m^-$$

حمل موزع

✱ Dead loads :

$$W_{dead} = \text{own wt main girder} + \frac{\text{slab dead} * \text{عرض الكوبري كله}}{\text{MG عدد } 3}$$

✱ assume $t = \frac{span}{10} = \left(\frac{14}{10}\right) = 1.4\ m$

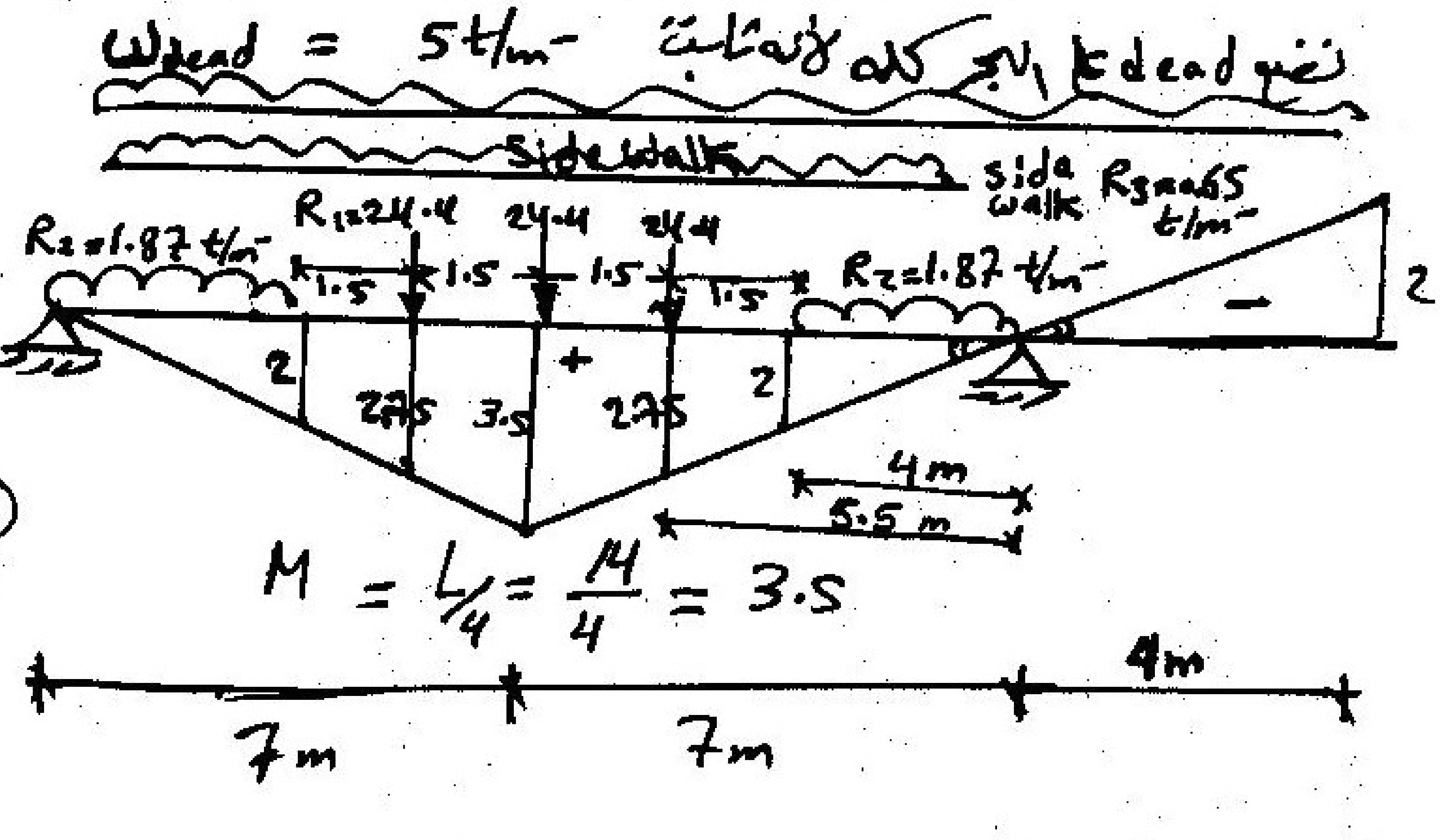
∴ own $wt = (0.4 * 1.4 * 2.5) = 1.4\ t/m^-$

$$\therefore W_{dead} = 1.4 + \left(\frac{0.8 * 12.5}{3}\right) \simeq 5\ t/m^-$$

لعزوم و أيضا الرأسية

I.L.M +ve

$\frac{1}{2}$ = الميل



7 → 3.5
4 → ???
??? = 2

✱ نضع الحمل الميت dead على البحر كله

✱ ونضع الأحمال الحية live loads على البحر الذي يعطي أقصى عزوم موجبة فقط .

$$\therefore M_{+ve} = (24.4 * 3.5) + (2 * 24.4 * 2.75)$$

$$+ 2 * 1.87 * (\tfrac{1}{2} * 2 * 4) + 0.65 * (\tfrac{1}{2} * 14 * 3.5)$$

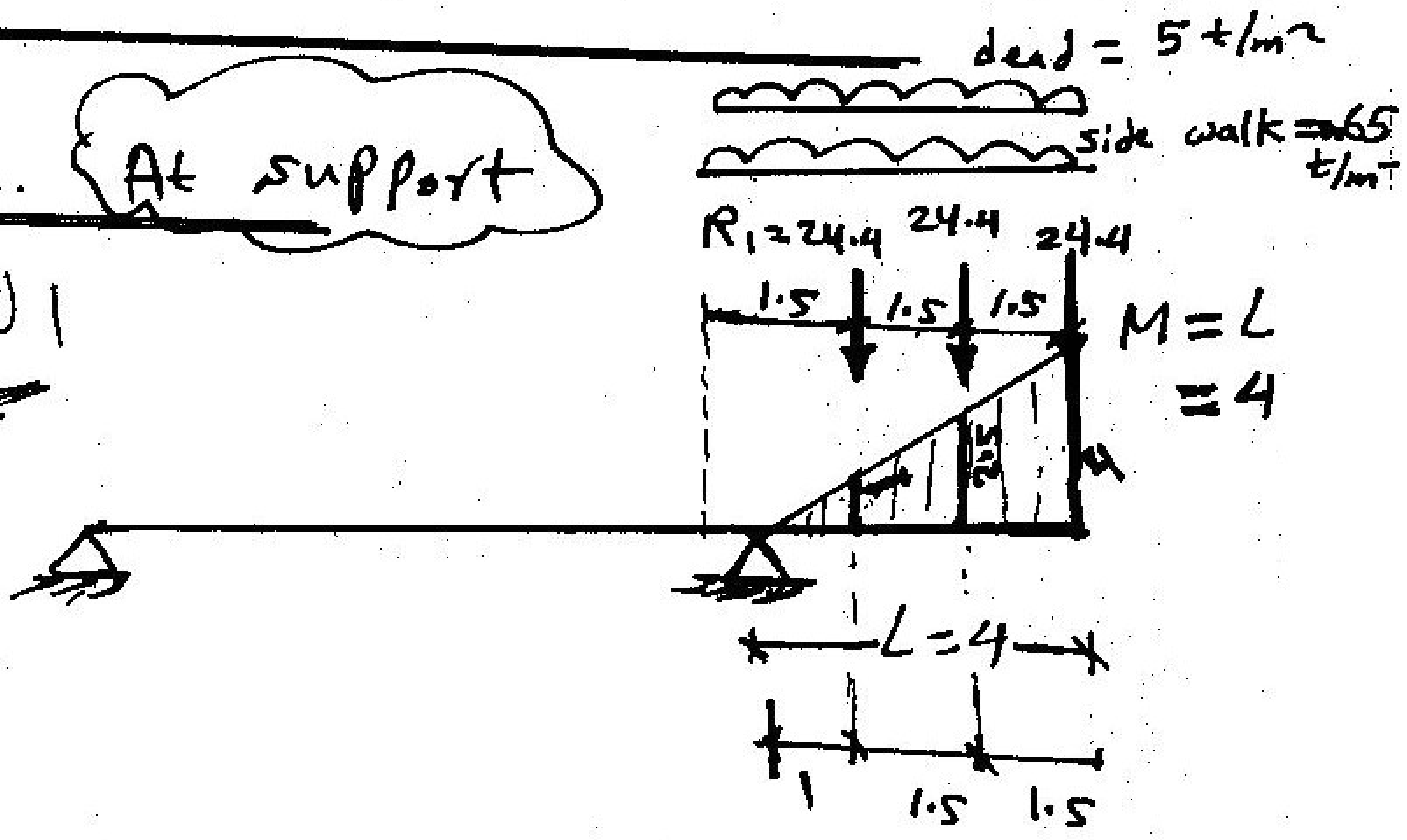
$$+ 5 * (\tfrac{1}{2} * 14 * 3.5) - 5 * (\tfrac{1}{2} * 4 * 2)$$

$$= 352.9 \ t.m$$

---

* I.L. M_{-ve}. At support

العزوم السالبة



$$\therefore M_{-ve} = (24.4 * 4) + (24.4 * 2.5) + (24.4 * 1)$$

$$+ 5 * (\tfrac{1}{2} * 4 * 4) + (0.65 * \tfrac{1}{2} * 4 * 4)$$

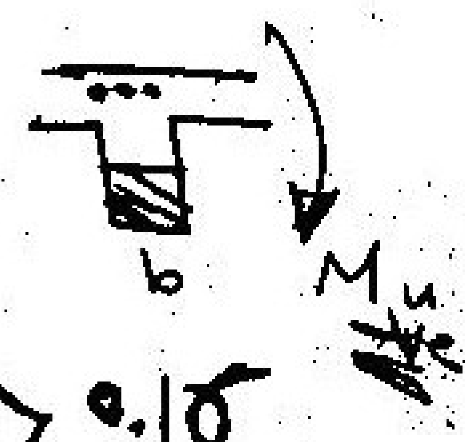
$$= 228.2 \ t.m$$

$$\therefore M_{u_{+ve}} = 1.5 * M_{+ve} = 1.5 * 352.9 = 529.35 \ t.m$$

$$\therefore M_{u_{-ve}} = 1.5 * M_{-ve} = 1.5 * 228.2 = 342.3 \ t.m$$

③ Design $M_{u_{-ve}} = 342.3$ t.m (Rec-Section)

$b = 40$ cm



$$R_1 = \frac{M_u}{f_{cu} \cdot b \cdot d^2} = \frac{342.3 * 10^5}{250 * 40 * (135)^2} = 0.18 > 0.15$$

كسرة فجأة
over reinforced

$\therefore$ increase (t)

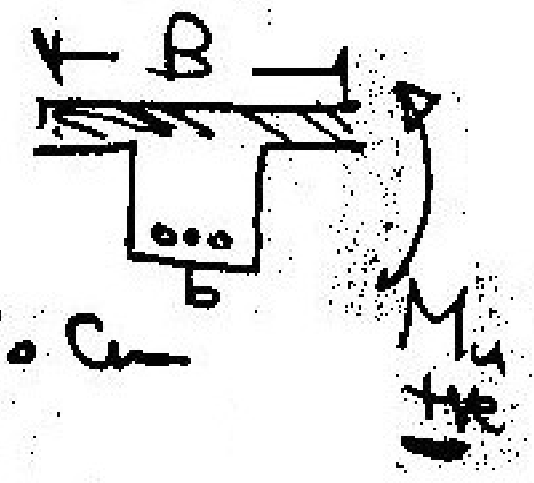
$\therefore$ use $t = 200$ cm

$\therefore d = 195$ cm

$$\therefore R_1 = \frac{M_u}{f_{cu} \cdot b \cdot d^2} = 0.09 \Rightarrow \omega = 0.12$$

$$A_{s_{-ve}} = \omega \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d = 14 \# 25$$ علوي

④ T-section : $M_{+ve} = 539.35$ t.m



$$B = \min \begin{cases} 16(25) + 40 = 440 \text{ cm} \\ \phi - \phi_{plan} = 275 \text{ cm} \\ \frac{L'}{5} + b = \frac{0.8 * 1400}{5} + 40 = 264 \end{cases}$$

$\therefore$ (Continous one end)
$\therefore L' = 0.8L$

$\therefore B_{min} = 275$ cm

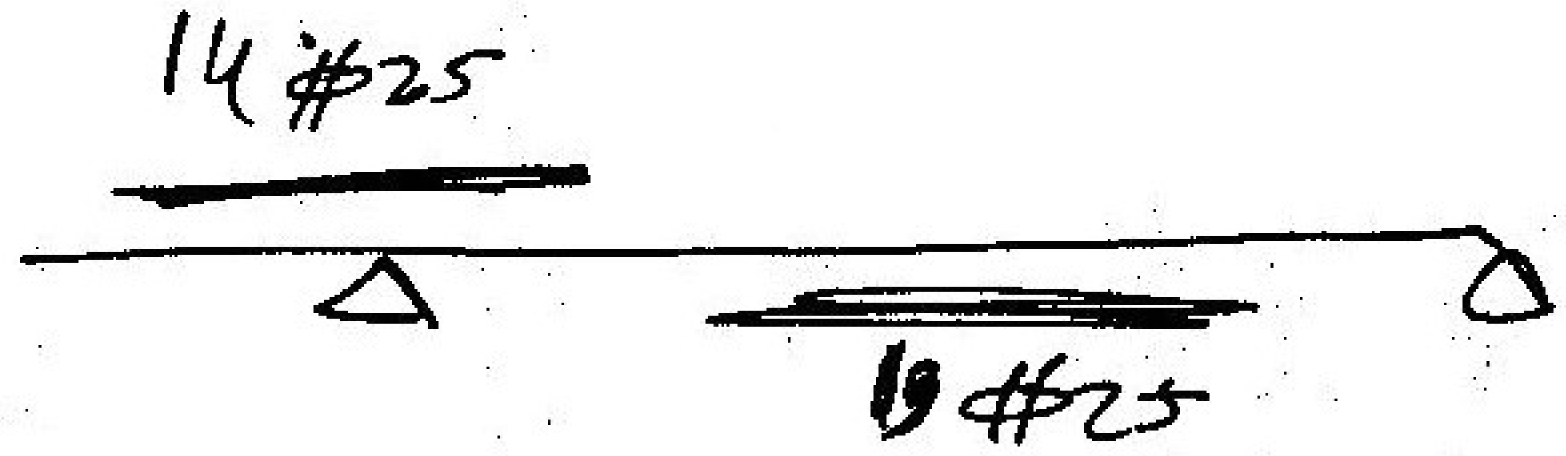
$$\therefore R_1 = \frac{M_u}{f_{cu} \cdot B \cdot d^2} = \frac{539.35 * 10^5}{250 * 275 * 195^2} = 0.021$$

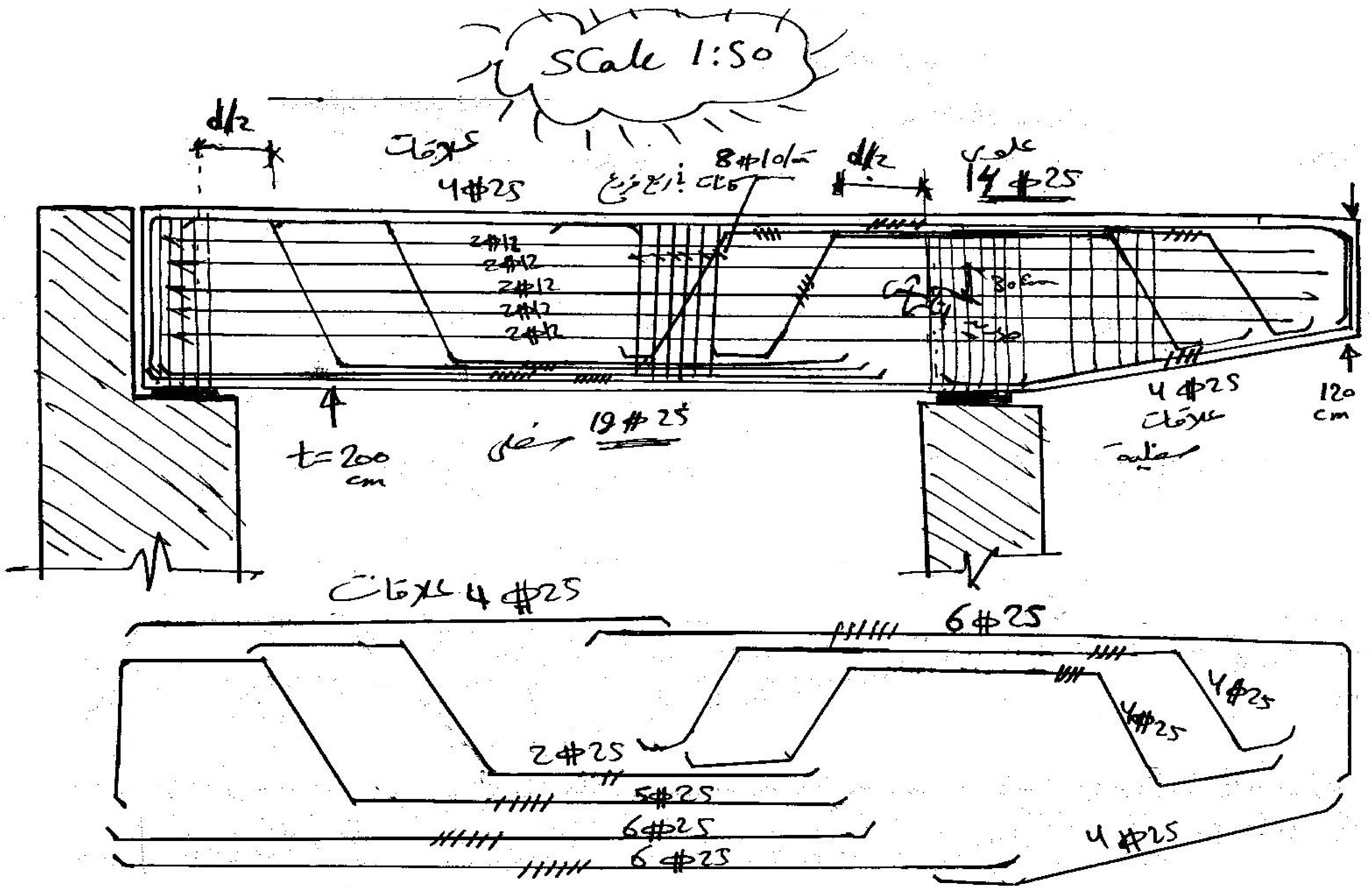
$\therefore \omega = 0.025$

$$A_{s_{+ve}} = 0.025 * \frac{250}{3600} * 275 * 195 = 89.3 \text{ cm}^2$$

(B)

$= 19 \# 25$ سفلي

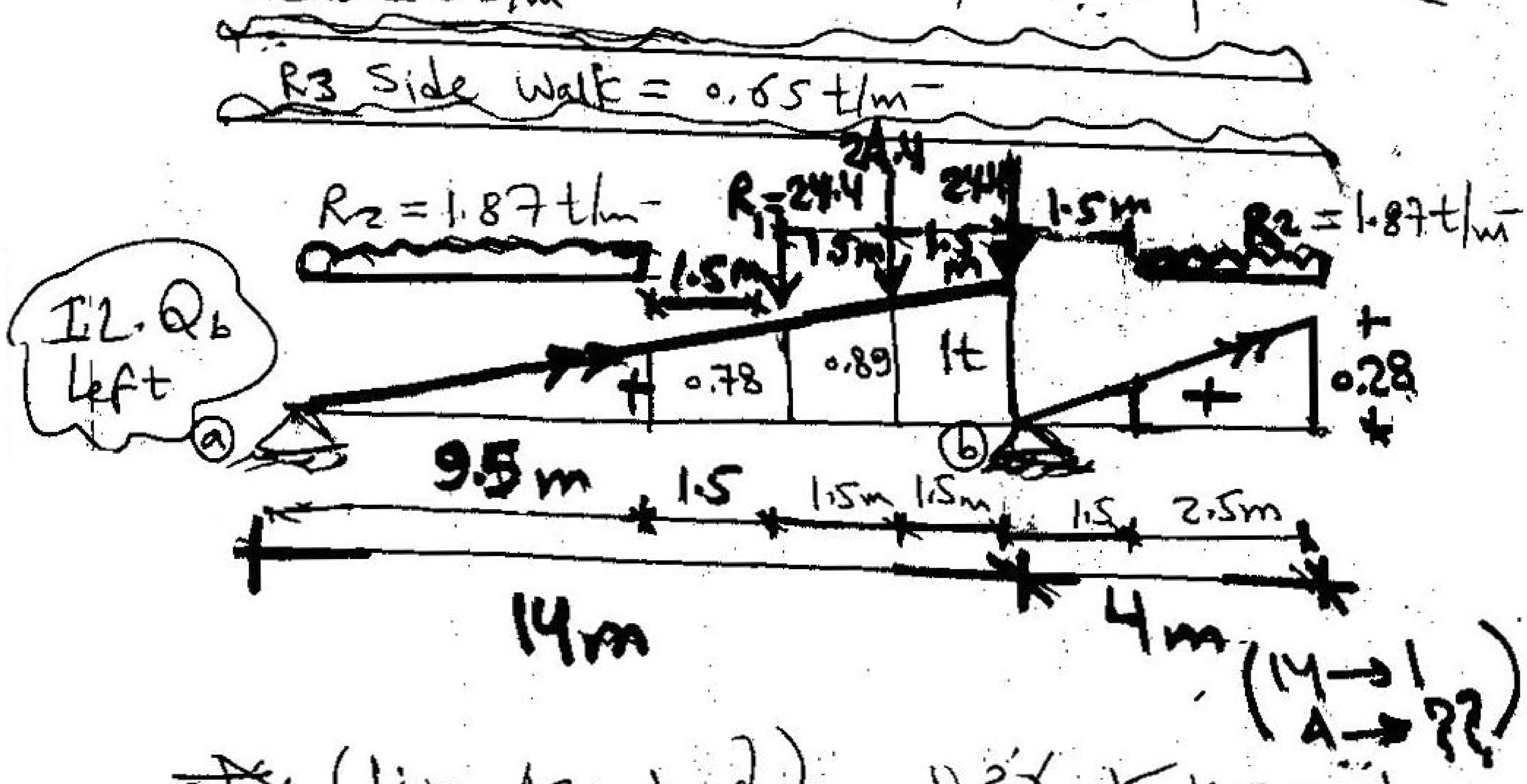



Scale 1:50
d/2
4Φ25
8Φ10/m
d/2
14Φ25
2Φ12
2Φ12
2Φ12
2Φ12
2Φ12
30 cm
4Φ25
120 cm
19Φ25
t=200 cm
4Φ25
6Φ25
4Φ25
4Φ25
2Φ25
5Φ25
6Φ25
6Φ25
4Φ25

check shar

* دائماً أقصى shear للكمرات المتصلة تكون عند الركيزة الوسطى.

$w_{dead} = 5 t/m$



* نضع هنا كل الأحمال (live & dead)

للحصول على أقصى shear

$\therefore Q_{max} = \checkmark$
(dead + live)

$Q_u = (Q_{max} \cdot 1.5)$

$Q_{critical} = Q_u - w\left(\frac{c+d}{2}\right)$

$\simeq 0.85\, Q_u = \checkmark$

$q_u = \frac{Q_{critical}}{b \cdot d} \times 10^3 > 0.75 \sqrt{\frac{f_{cu}}{\gamma_c}}$

unsafe

$\therefore$ use stirrups 8 ϕ 10/m

(28)

٥٠,-

Nour center

الخرسانه المسلحه

الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

"28"

أفكار حل الكمرات الرئيسية للكبارى الخرسانية المسلحة

Main Girders For Bridges

Faculty of Eng.
Structural Eng. Deprt.
4th year – Civil

Final term EX.
Time 3.0 h   2006-2007
Reinforced concrete (3)

Q2 : (25 %) It is required to make a complete design with all reinforcement for main girder (A) **only** for the shown R.C. bridge shown in Fig. (2), spacing of cross girders is 3.5 m.

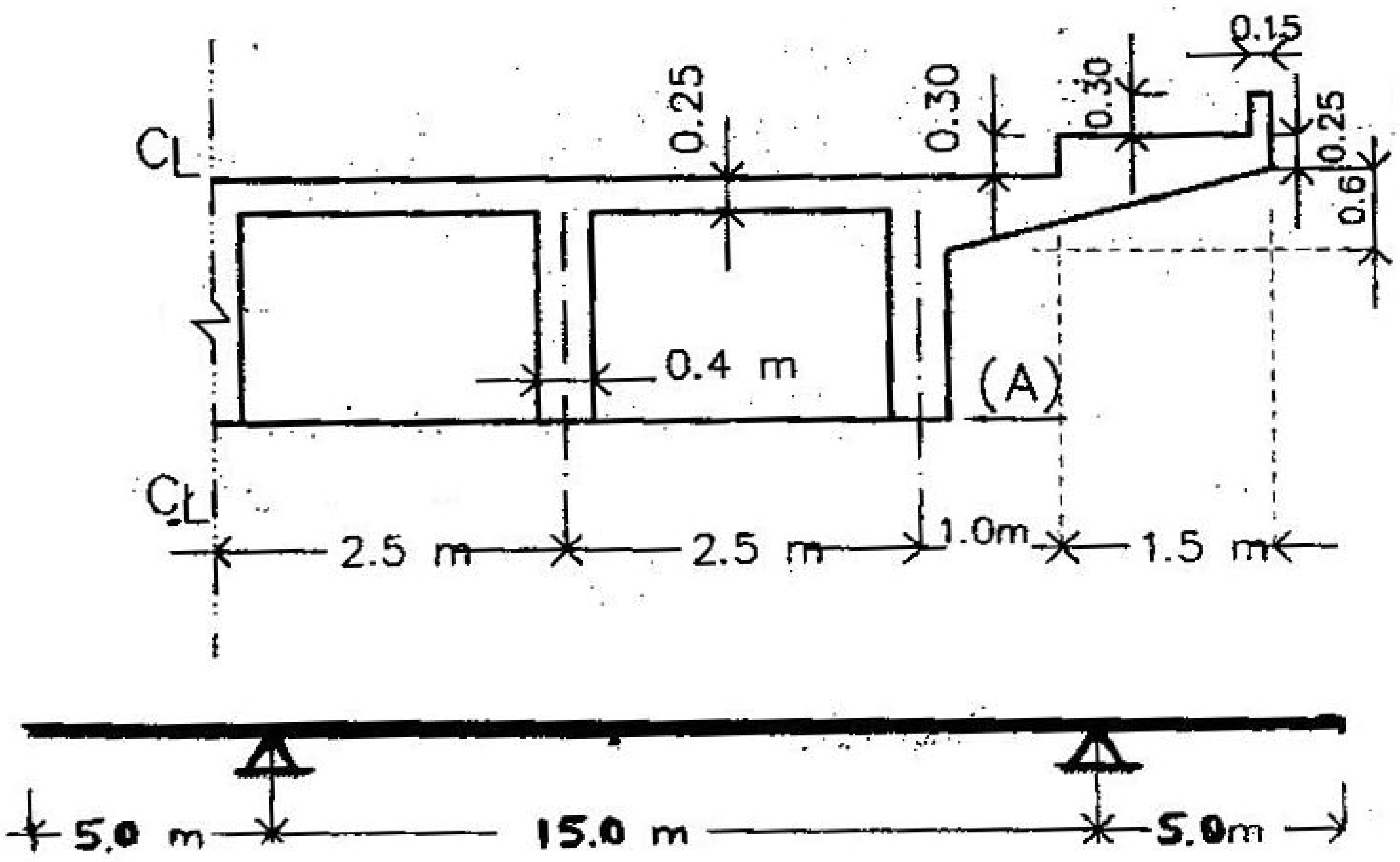


Fig.(2)

* الخطوات :

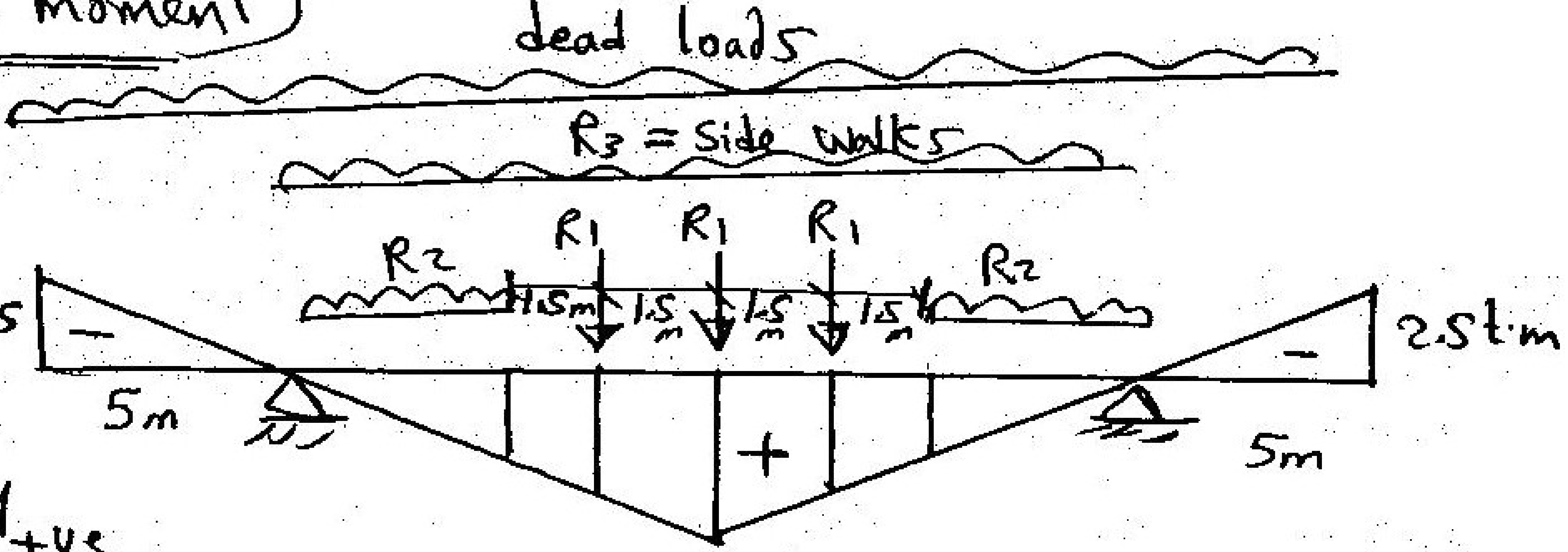
← نقوم بحساب قيم (R1 & R2 & R3) ع الكمرة (A)

R3 → Side walk.
R2 → Uniform loads (300, 500)
R1 → Trucks (60t, 30t)

← ونحسب الـ (dead load) ع الـ M.G

← ثم نضع الأحمال ع I.L M-ve & I.L M+ve

+ve moment



I.L. M_{+ve}

$$M = \frac{L}{4} = \frac{15}{4} = 3.75 \text{ t.m}$$

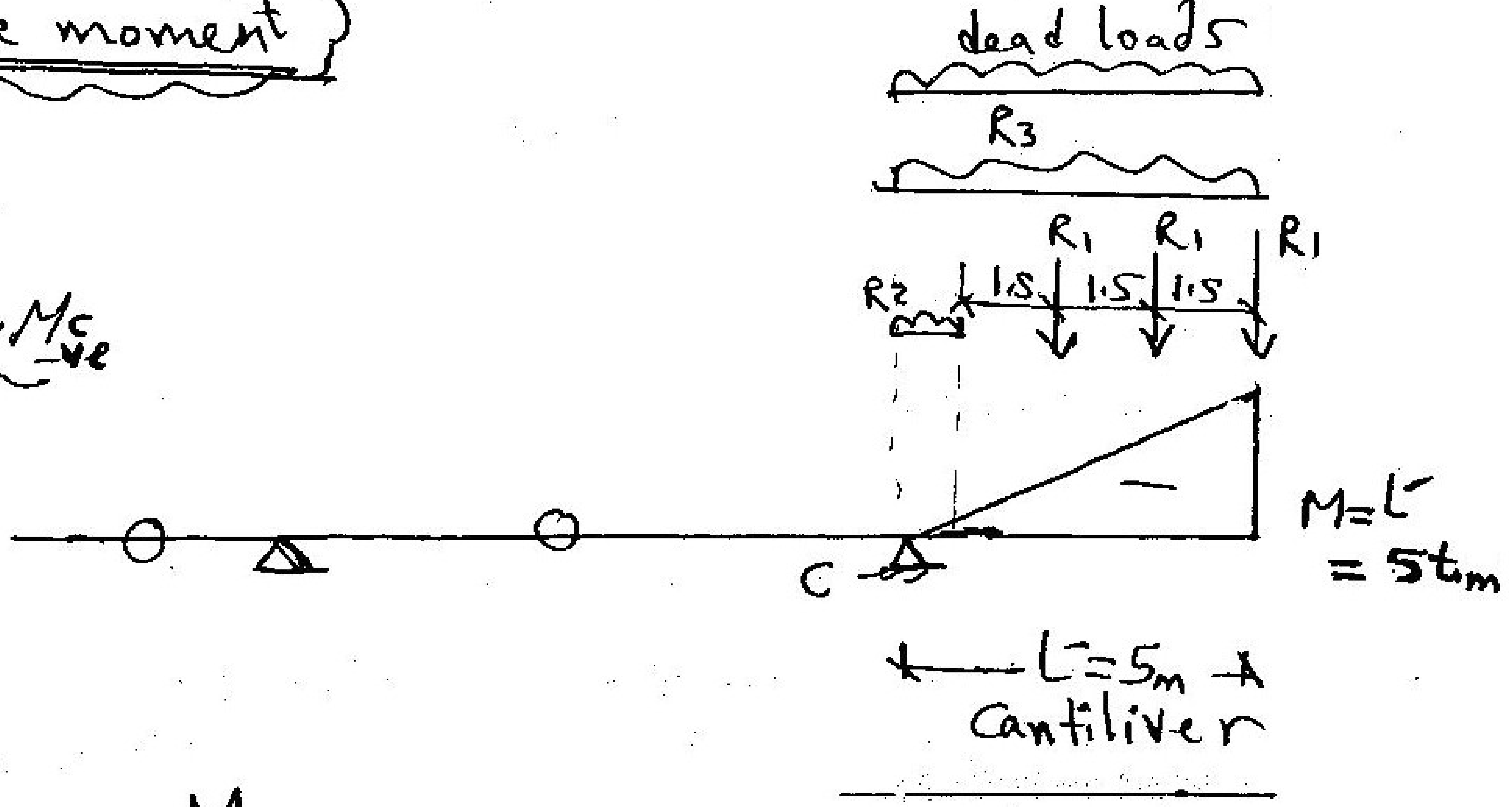
$$M_{+ve} = \checkmark$$

$$\Rightarrow M_{u_{+ve}} = 1.5\, M_{+ve} = \checkmark$$

(B) ⟸ T-section وتصمم ع أنه قطاع

-ve moment

I.L. M^{c}_{-ve}



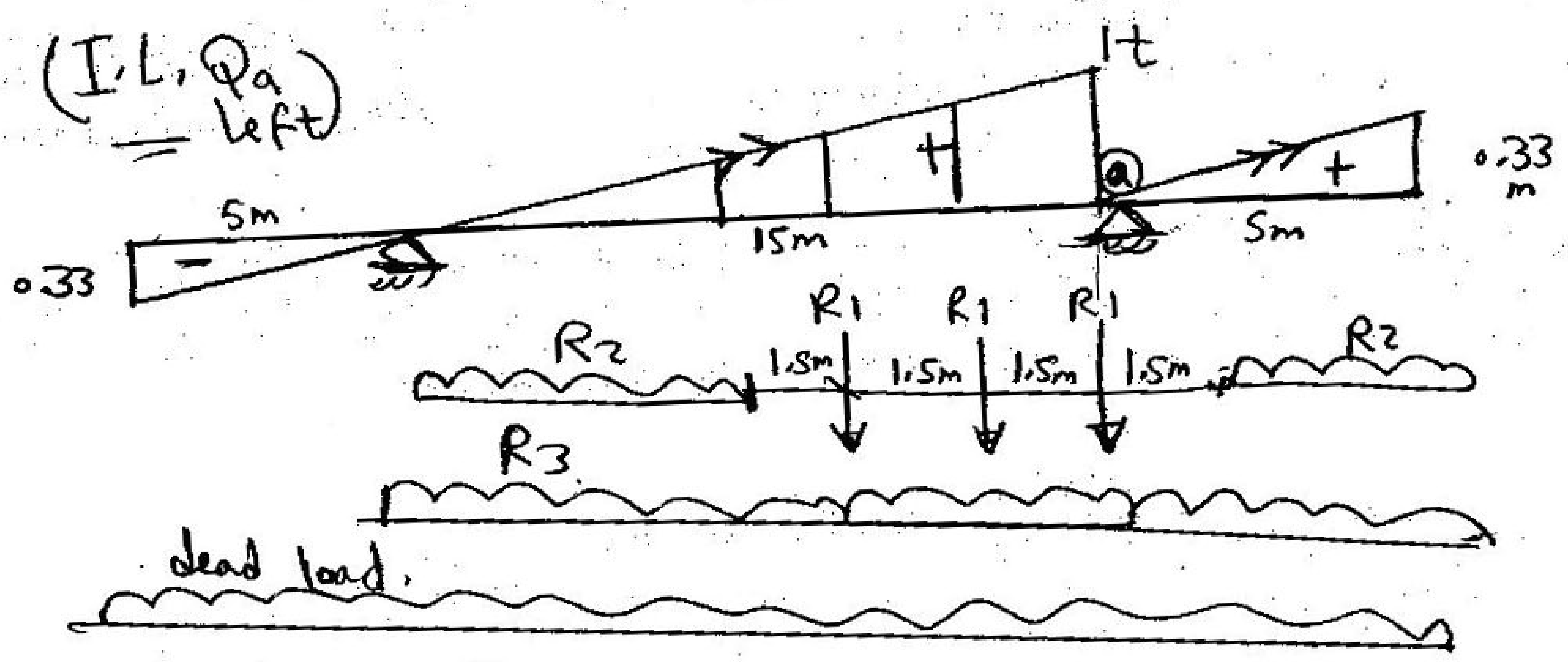
$$\Rightarrow M_{-ve} = \checkmark$$

$$\Rightarrow M_{u_{-ve}} = 1.5\, M_{-ve} = \checkmark$$

(b) ⟸ R-section وتصمم ع أنه قطاع

* to get shear :

أقصى (shear) يكون عند الركيزة داخل البحر الكبير .

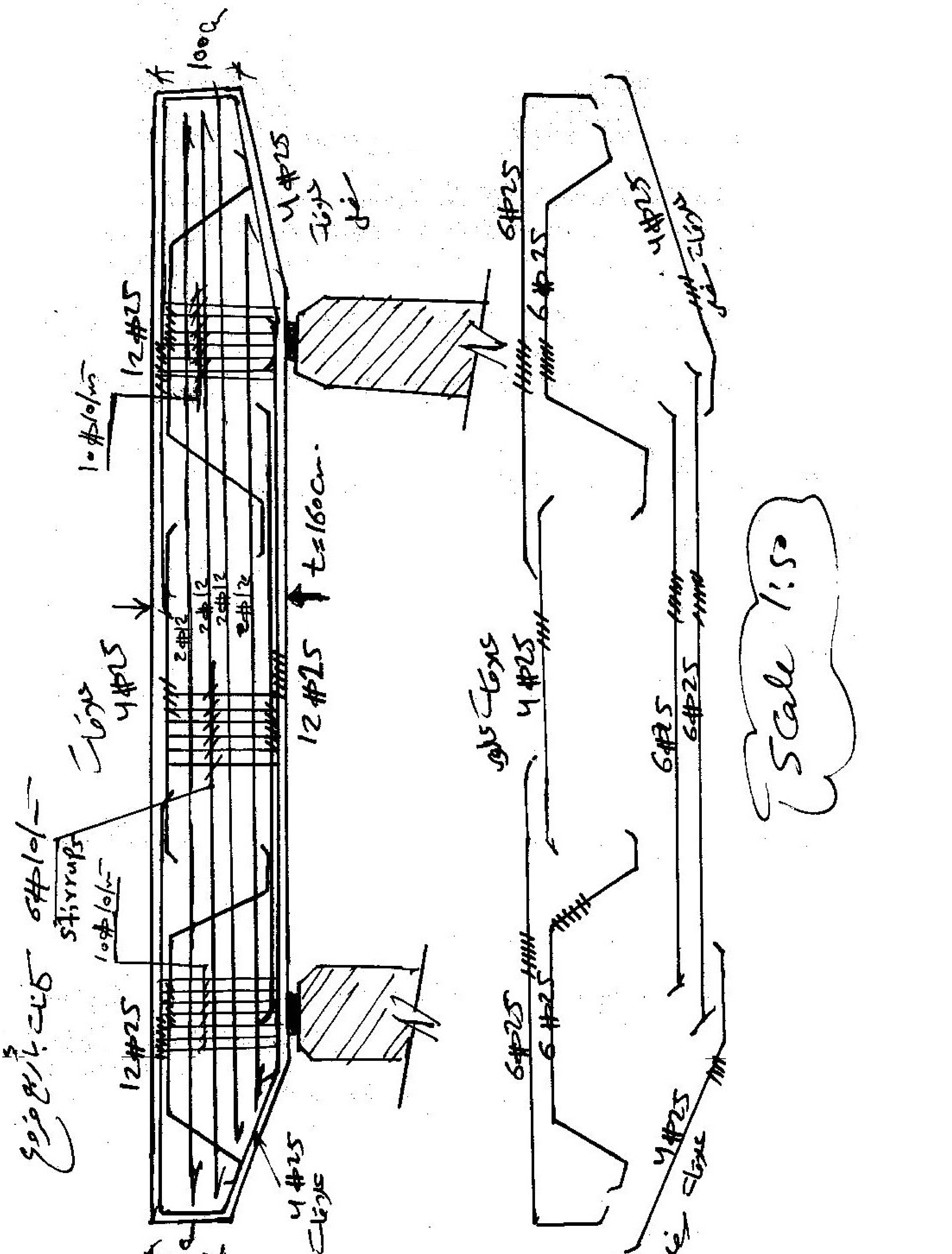


$\therefore Q = \searrow$

$\therefore Q_u = 1.5 * Q = \searrow$

$$q_u = \frac{Q_u * 10^3}{b \cdot d}$$

check shear ثم نكمل



100cm
12#25
4#25
6#25
2#12
10#10/m
6#10/m
stirrups
t=160cm
Scale 1:50

(30)

Nour center

الخرسانه المسلحه

Final Revision

الفرقة الرابعه مدنى

اسم يتردد ..... فكر يتجدد

Final exam 2009

"30"

ملحق
٣١-

Q(1): 50% of max grade

It is required to complete analysis and design for all elements (walls, floors, beams and ties) and give complete reinforcement details for the elevated rectangular tank shown in figures (1-a), (1-b) and (1-c).

Q(2): 30% of max grade

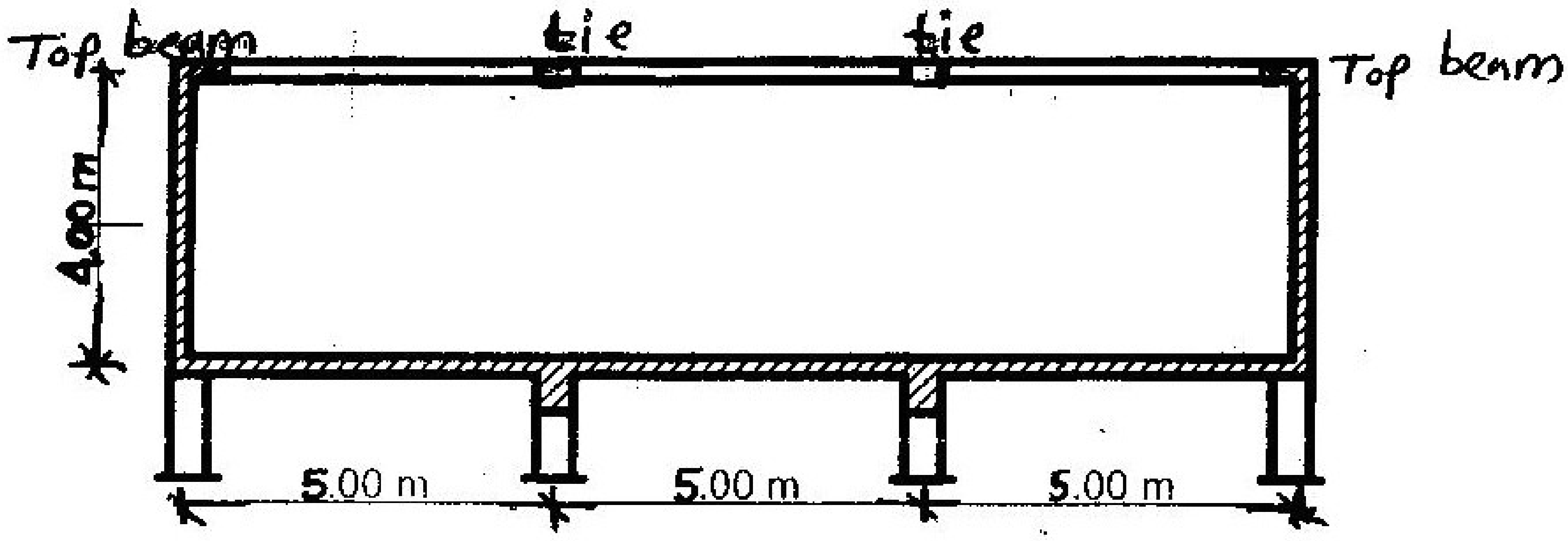
a) Find the horizontal forces in **y-direction** for the building with plan shown in figure (2) with area $(20*32m^2)$ and height (64 m) located in north coat due to wind loads **(q= 90 kg/m2)**

b) Using **approximate method for distribution of lateral loads** to distribute a total force Fy=200 ton in **y-direction** to the shear walls (W1,W2,.. Wn) .

Wall No.	b	h	$b*h^3/12$	$h*b^3/12$
1	0.25	4	1.3333	0.005
2	0.25	4	1.3333	0.005
3	0.25	7.07	7.3624	0.0092
4	0.25	4	1.3333	0.005
5	0.25	5	2.6042	0.006
6	0.25	7.07	7.3624	0.009
7	0.25	3.75	1.0986	0.0049
8	0.25	3.75	1.0986	0.0049
WH. Core	0.25	6	4.5	0.0078
WV. core	0.25	2	0.1667	0.0026

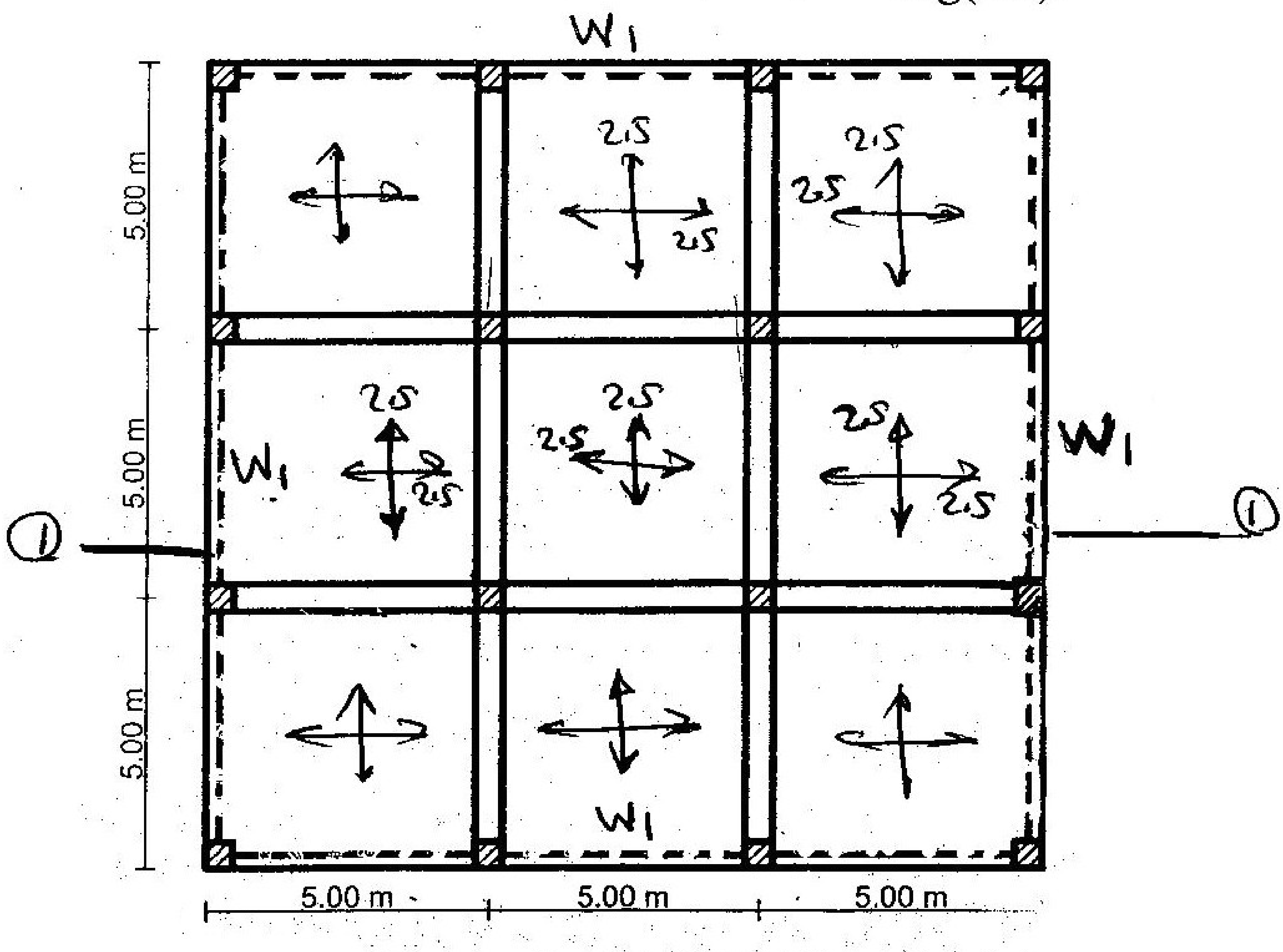
QUESTION NO. (3) (20% OF MAX GRADE)

It is required to make a complete design with all rft details for the shown R.C Bridge, (deck slab , Main Girder , Cross Girder) shown in fig (3)
Span of Girder (A) = 15.0 ms
Fcu = 250 kg / cm^2 Fy = 3600 kg / cm^2



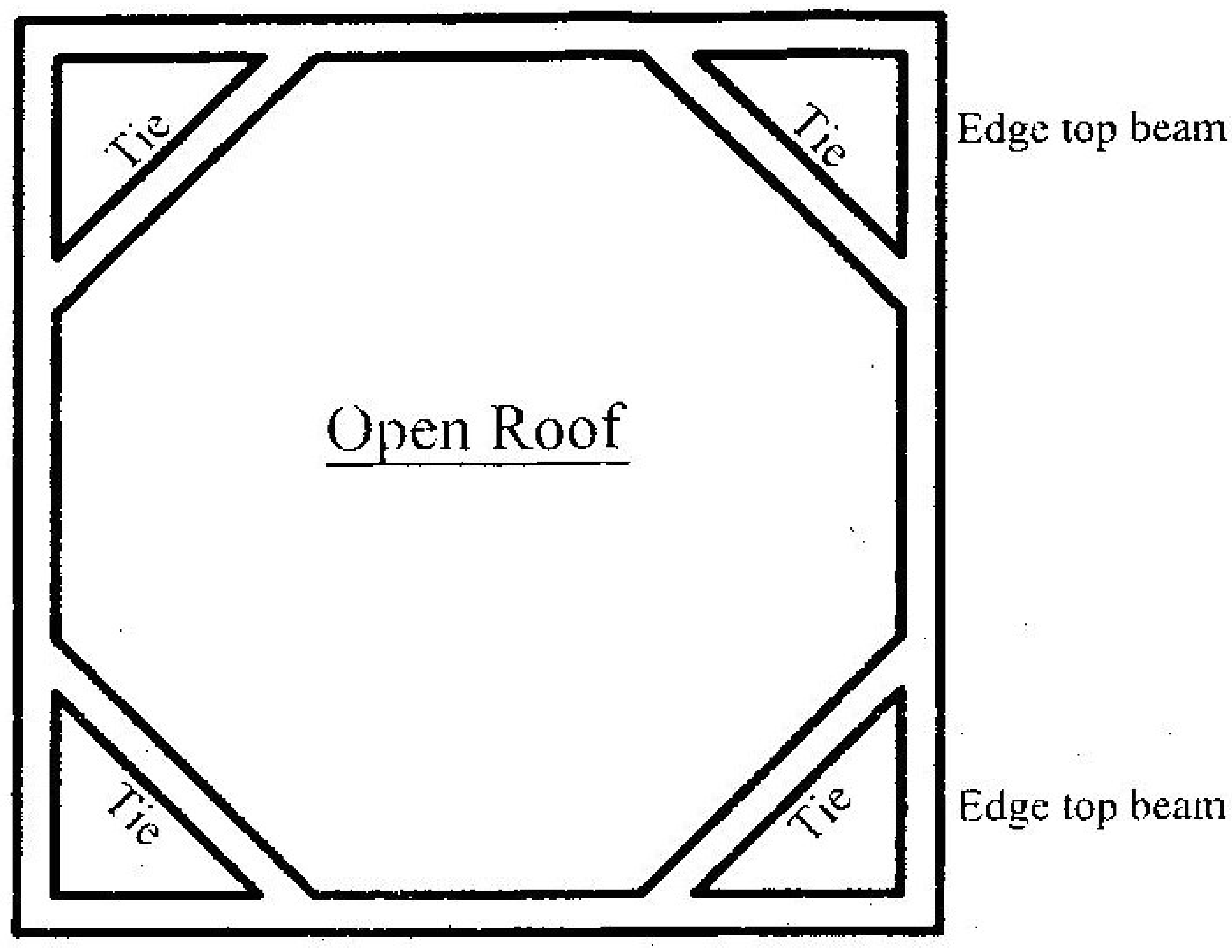
SEC. ELEVATION

Fig(1-a).



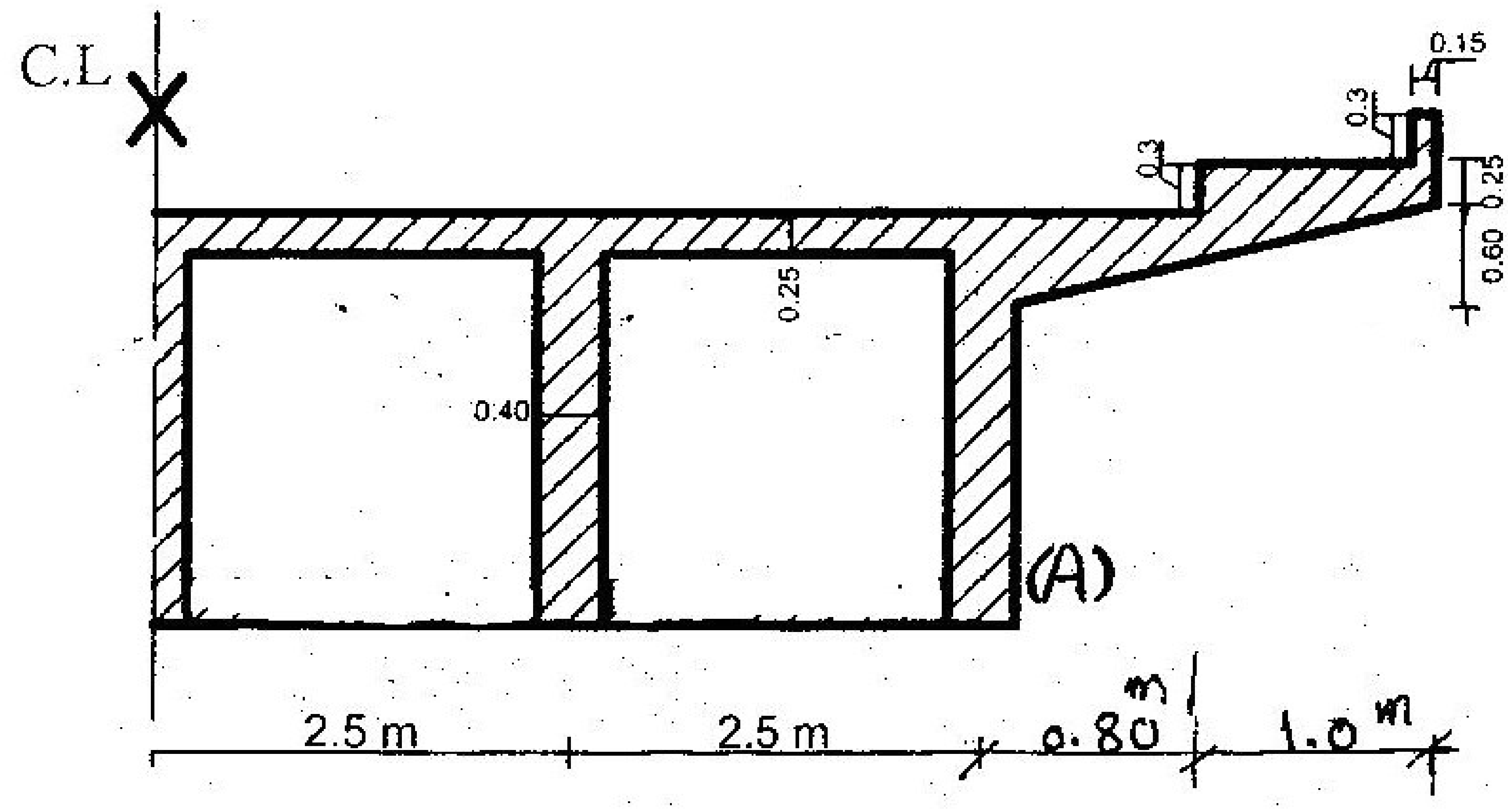
Structure System of Floor Plan

Fig(1-b)

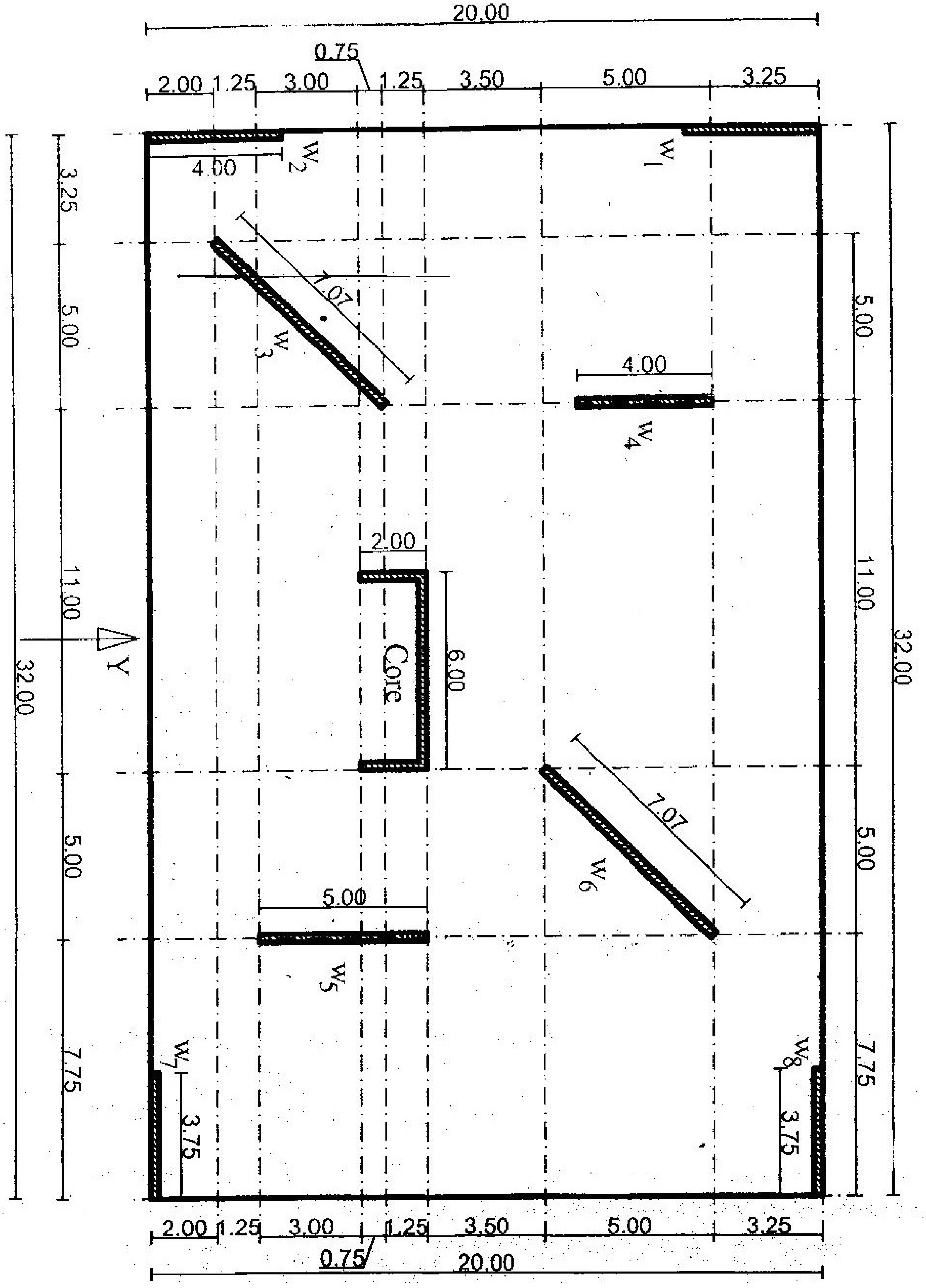


Open Roof with Ties

Fig(1-[illegible])



Fig(3).



20.00
0.75
2.00 1.25 3.00 1.25 3.50 5.00 3.25
W_2
W_1
4.00
3.25
5.00
11.00
5.00
7.75
32.00
W_3
7.07
4.00
W_4
2.00
Core
6.00
Y
7.07
W_6
5.00
W_5
W_7
3.75
W_8
3.75

Fig. (ج)

Q(.1)

Solution :

Elevated rectangular Tank

① Loads:

walls : $P = \gamma . H = 4\ t/m^2$

base : $W_{base} = t_{base} . \gamma_{R.C} + \gamma . H_{water}$

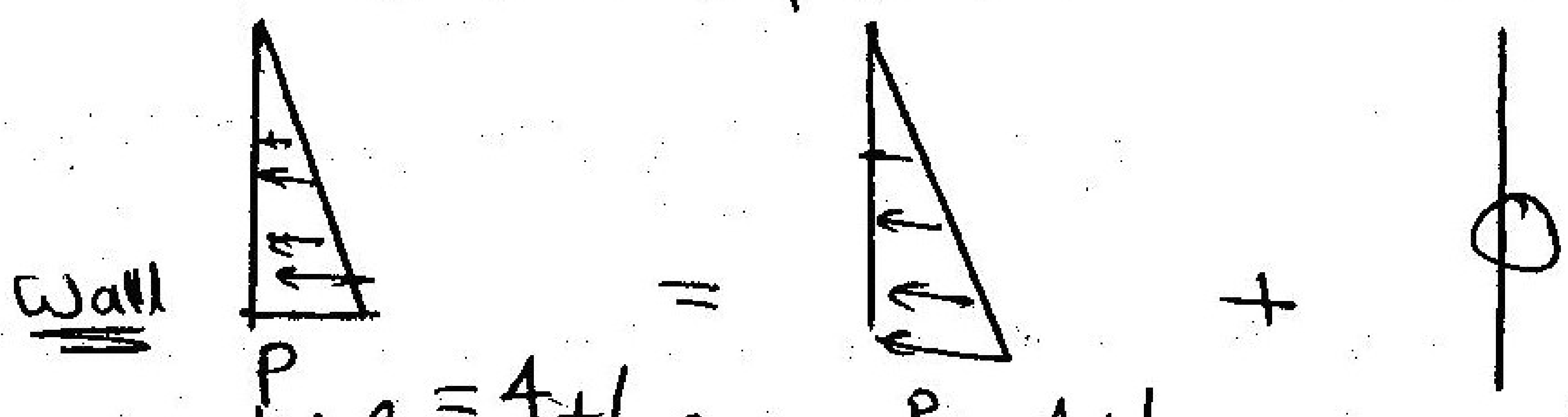
$= (0.4 * 2.5) + (1 * 4) = 5\ t/m^2$

② load distribution ;

for walls : $L_{Plan} = 15m$, $H = 5m$

$\because \frac{L}{H} = \frac{15}{5} > 2 \Rightarrow$ shallow

(VL) كل الأحمال تنقل بواسطة ¹ ² رأسي

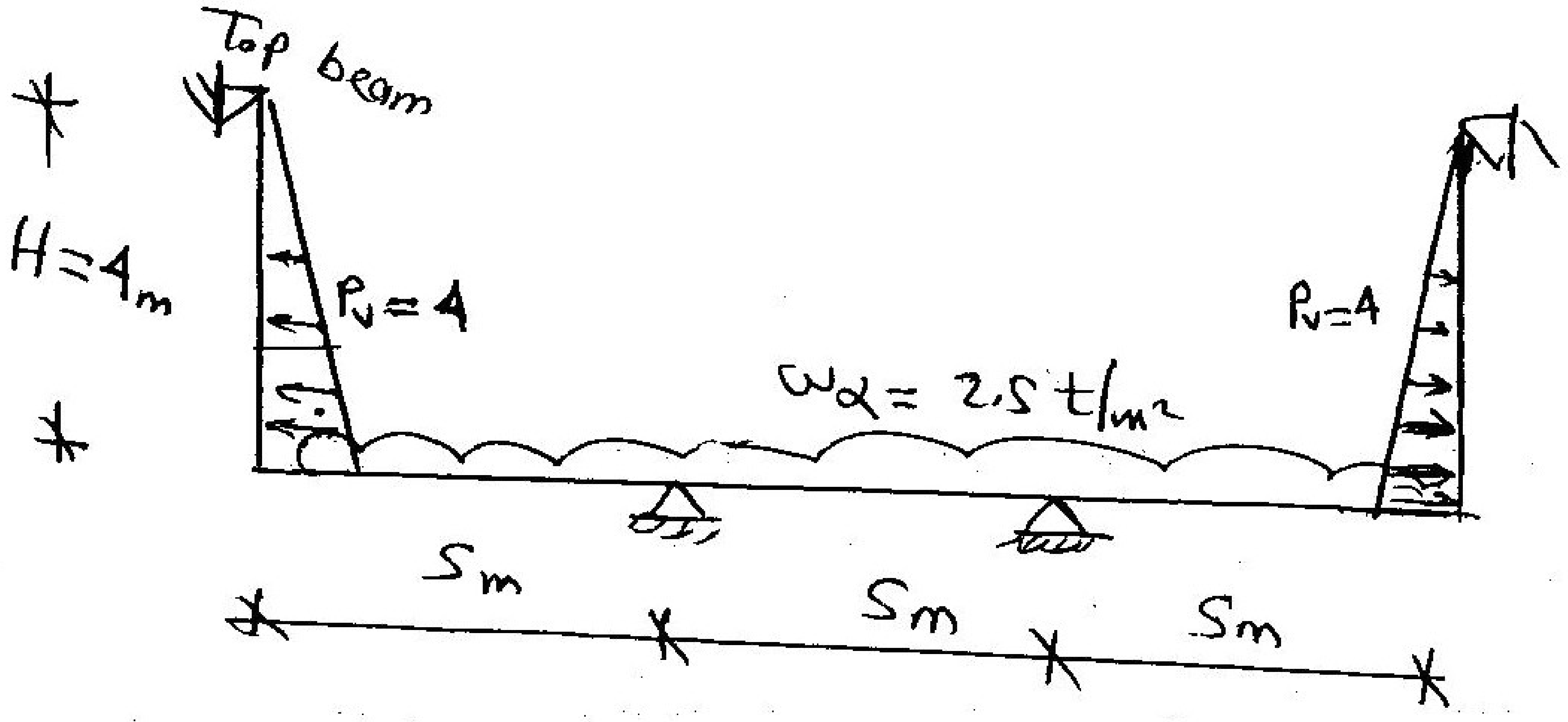


$P_{total} = 4\ t/m^2$ $\quad P_V = 4\ t/m^2$ VL. $\quad P_H = 0$ HL

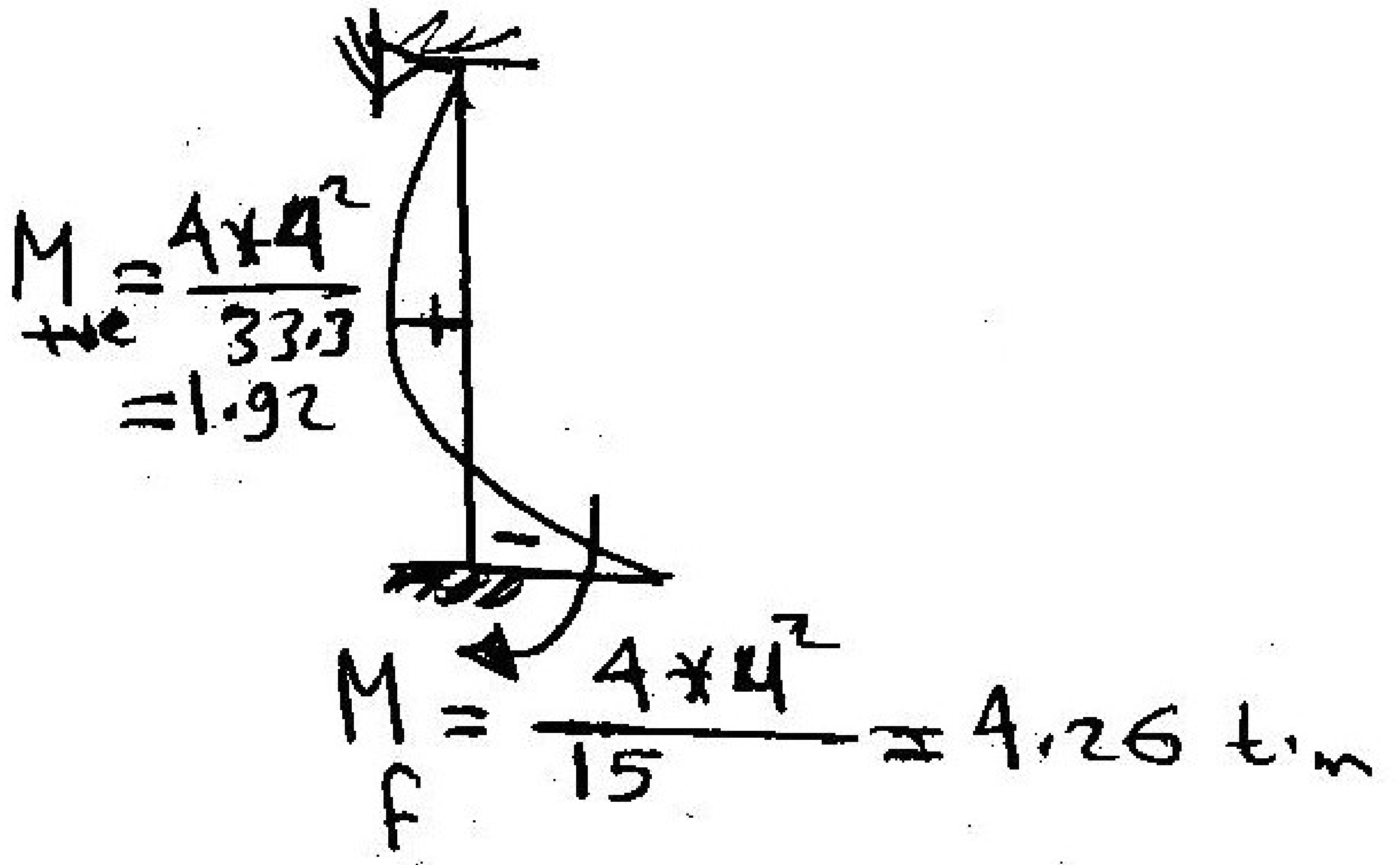
for base : $r = \frac{5}{5} = 1 \Rightarrow \alpha = \beta = 0.5$

$w_\alpha = w_\beta = 0.5 * W_{base} = 2.5\ t/m^2$

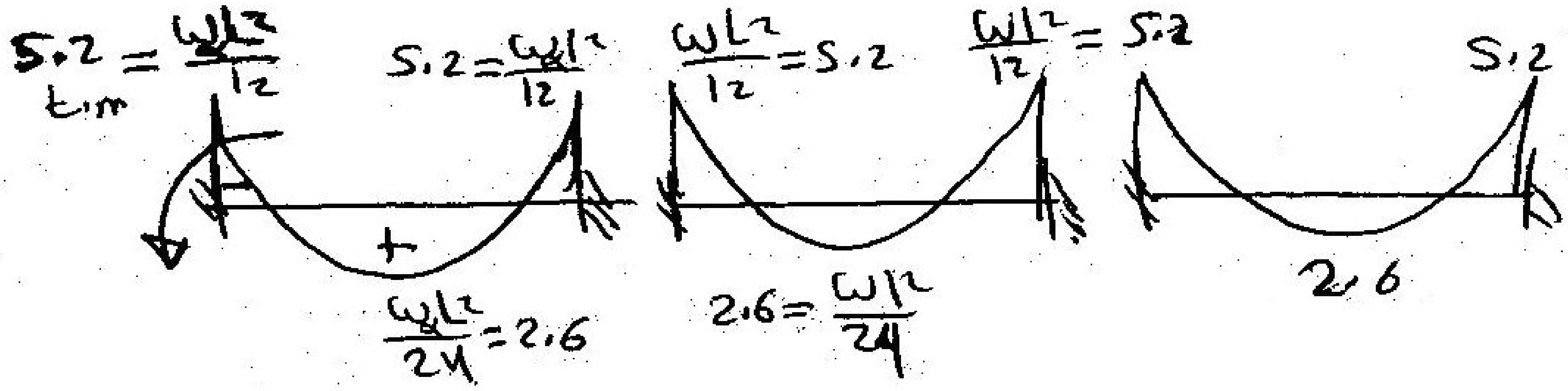
VI. Strip (1-1)



Top beam
H=4m
$P_v = 4$
$P_v = 4$
$\omega_\ell = 2.5\ t/m^2$
5m
5m
5m



$M_{+ve} = \frac{4 \times 4^2}{33.3} = 1.92$
$M_f = \frac{4 \times 4^2}{15} = 4.26\ t.m$



$5.2\ t.m = \frac{\omega l^2}{12}$
$5.2 = \frac{\omega_\ell l^2}{12}$
$\frac{\omega l^2}{12} = 5.2$
$\frac{\omega l^2}{12} = 5.2$
5.2
$\frac{\omega_\ell l^2}{24} = 2.6$
$2.6 = \frac{\omega l^2}{24}$
2.6

:- العزوم غير متزنة

∴ **Use Moment distribution**

* for Wall : $\left(\frac{3}{4}\frac{I}{H}\right) = \frac{3}{4} * \frac{1}{4} = 0.1875$

* for base : $\frac{I}{L} = \left(\frac{1}{5}\right) = 0.2$

∴ $Df_{wall} = \frac{0.1875}{(0.1875 + 0.2)} = 0.48$

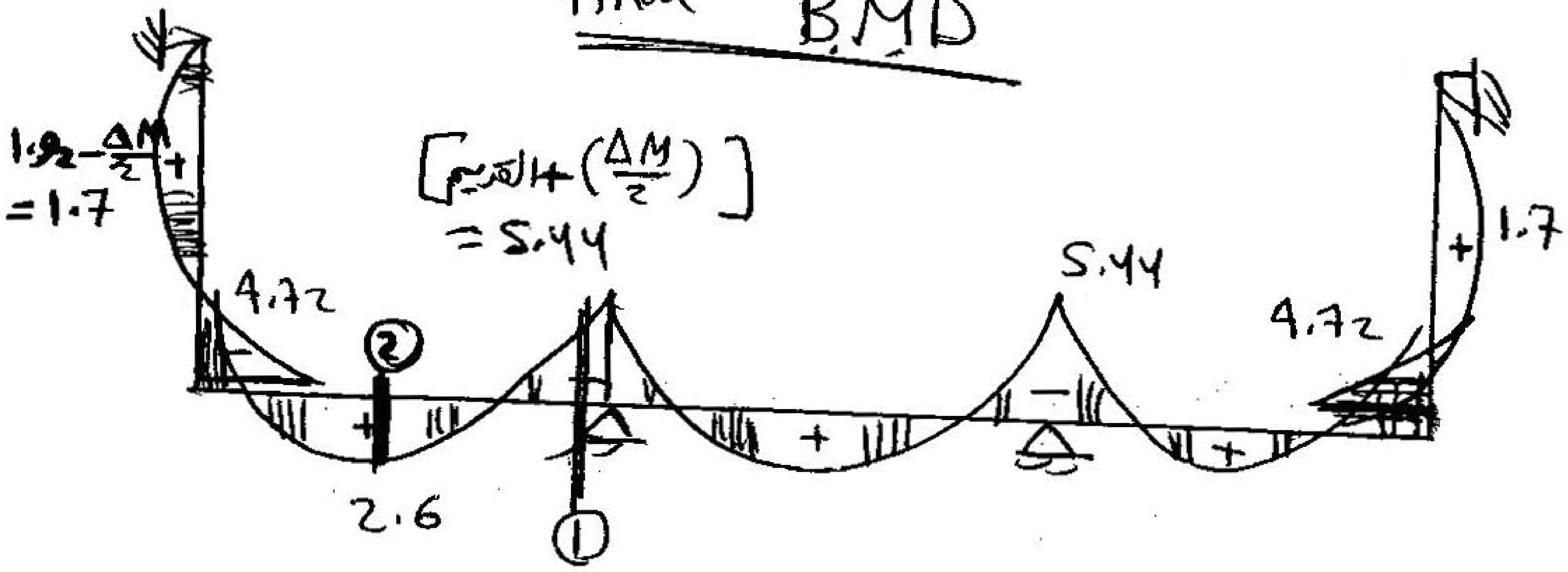
∴ $Df_{base} = (1 - 0.48) = 0.52$

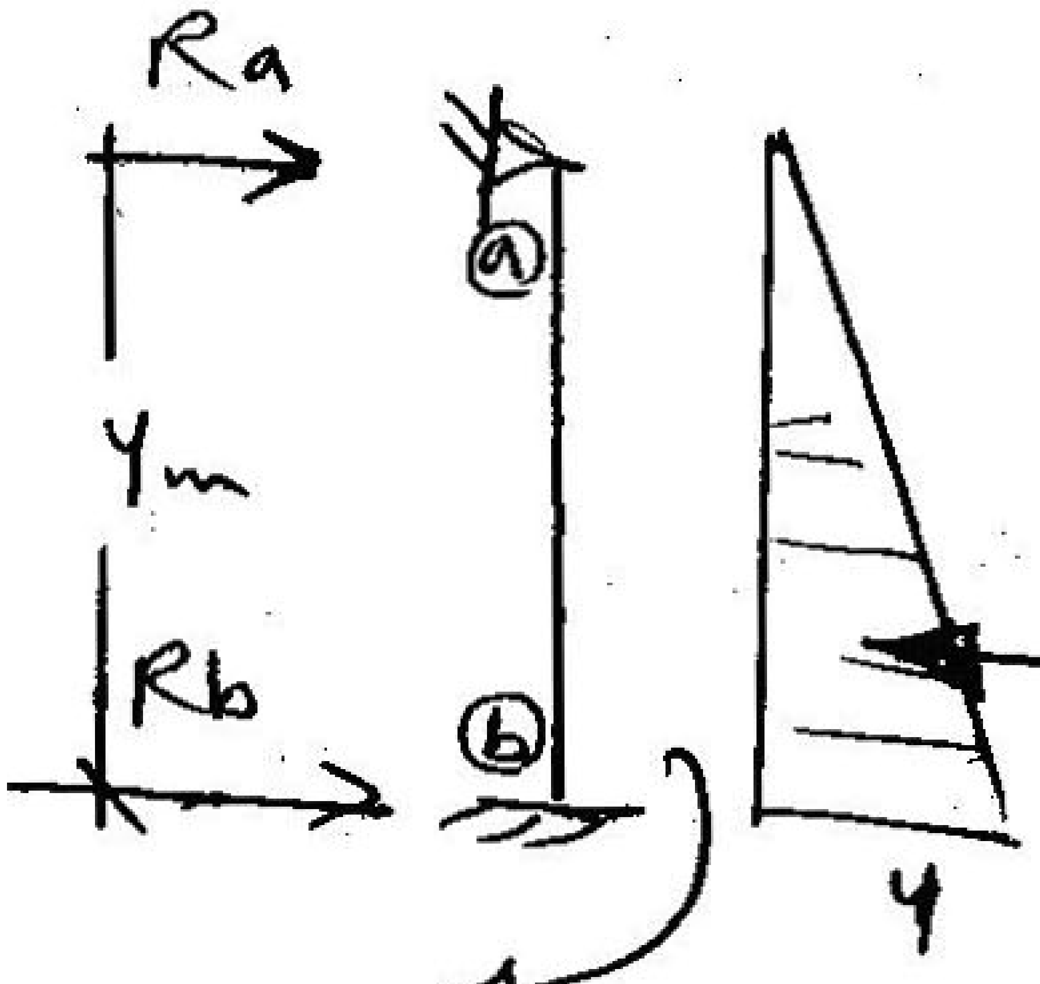
موجب لو مع عقارب الساعة +

	Df = 0.48	Df = 0.52
Moments	Wall	Base
Fixed Moment	+ 4.26	− 5.2
D.M	+ 0.45	+ 0.48
final	+ 4.72	−4.72

* ولو كنت اخدت ال Average كان هيطلع نفس النتيجة لكن اعمل اتزان العزوم (عليها درجات)

Final B.M.D





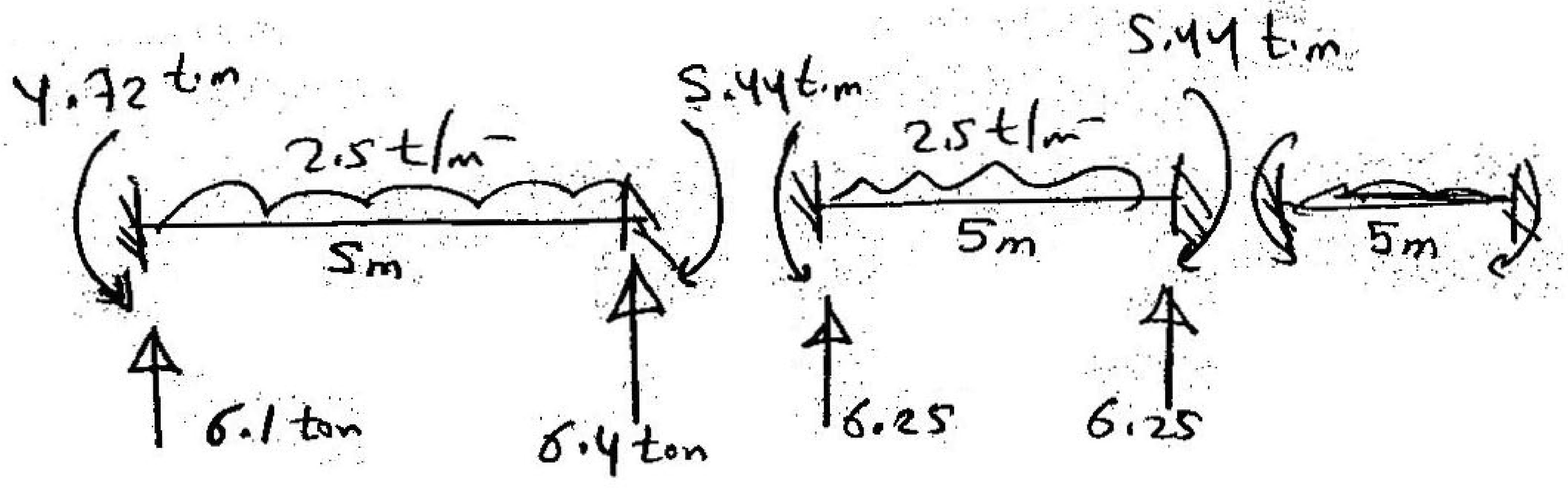
$F = \frac{1}{2} * 4 * 4 = 8$ ton

$\left(\frac{4}{3}\right) = 1.33$ m.

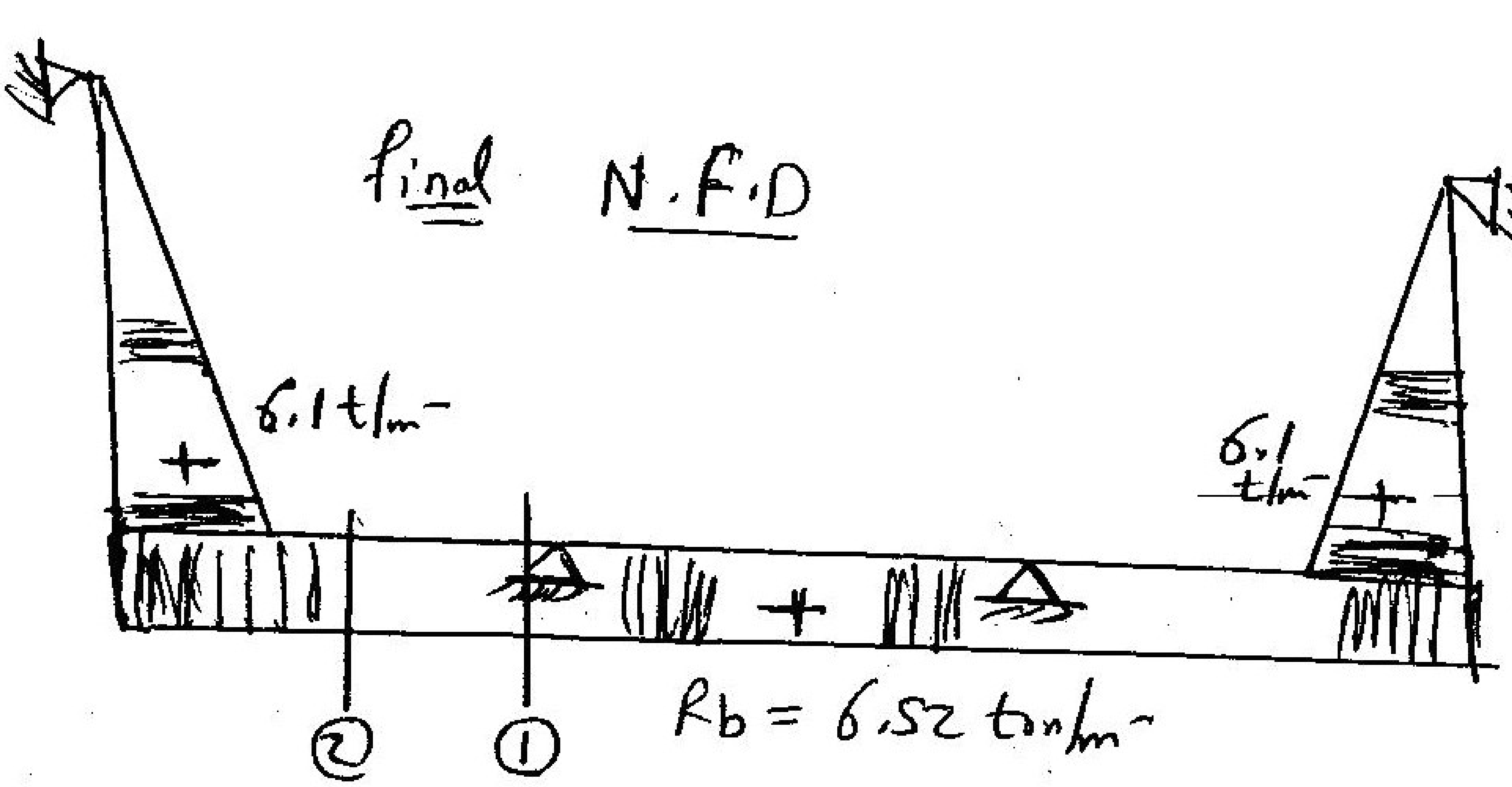
$M_f = 4.72$

$\Sigma M_b = 0 \Rightarrow R_a = 1.48$ ton/m

$\Sigma F_x = 0 \Rightarrow R_b = 6.52$ ton/m



final N.F.D



Design of sections:

Sec ① $M_{\text{water side}} = 5.44 \text{ t.m}$, $T = 6.52 \text{ t/m}$

stage Ⓘ $t = \sqrt{\dfrac{M \times 10^5}{\psi . B}} + 5 = 50 \text{ cm}$

(B) = 100 cm

stage Ⓘⅰ ultimate

$T_u = 1.5$

$M_u = 1.5\, M$

$e = \dfrac{M_u}{T_u}$

$e/t > 0.5 \rightarrow$ big ecc

$e_s = e - \frac{t}{2} + (0.05)$

$M_{us} = T_u . e_s$

$R_1 = \dfrac{M_{us} \times 10^5}{f_{cu} . B . d^2} \Rightarrow$

$\omega =$

$\therefore A_s = \left[\dfrac{\omega . f_{cu}}{f_y} B . d + \dfrac{T_u \times 10^3}{(f_y / \gamma_s)} \right] = 7 \# 12/m$ crack up

Sec ② $M_{air\ side} = 2.6$ t.m/m , $T = 6.52$ ton/m

use $t = 25$ cm ← يمكن تصغيرها (قاعدة)

(ويمكن تركها كبيرة كما هي 50 cm)

⇓

$d = 20$ cm

air side مباشرة Stage (II) ultimate ⟹

$M_u = 1.5\,M$

$T_u = 1.5\,T$

• $e = \frac{M_u}{T_u}$, $e/t \geq 0.5$

∴ $e_s = e - \frac{t}{2} + (0.05)$

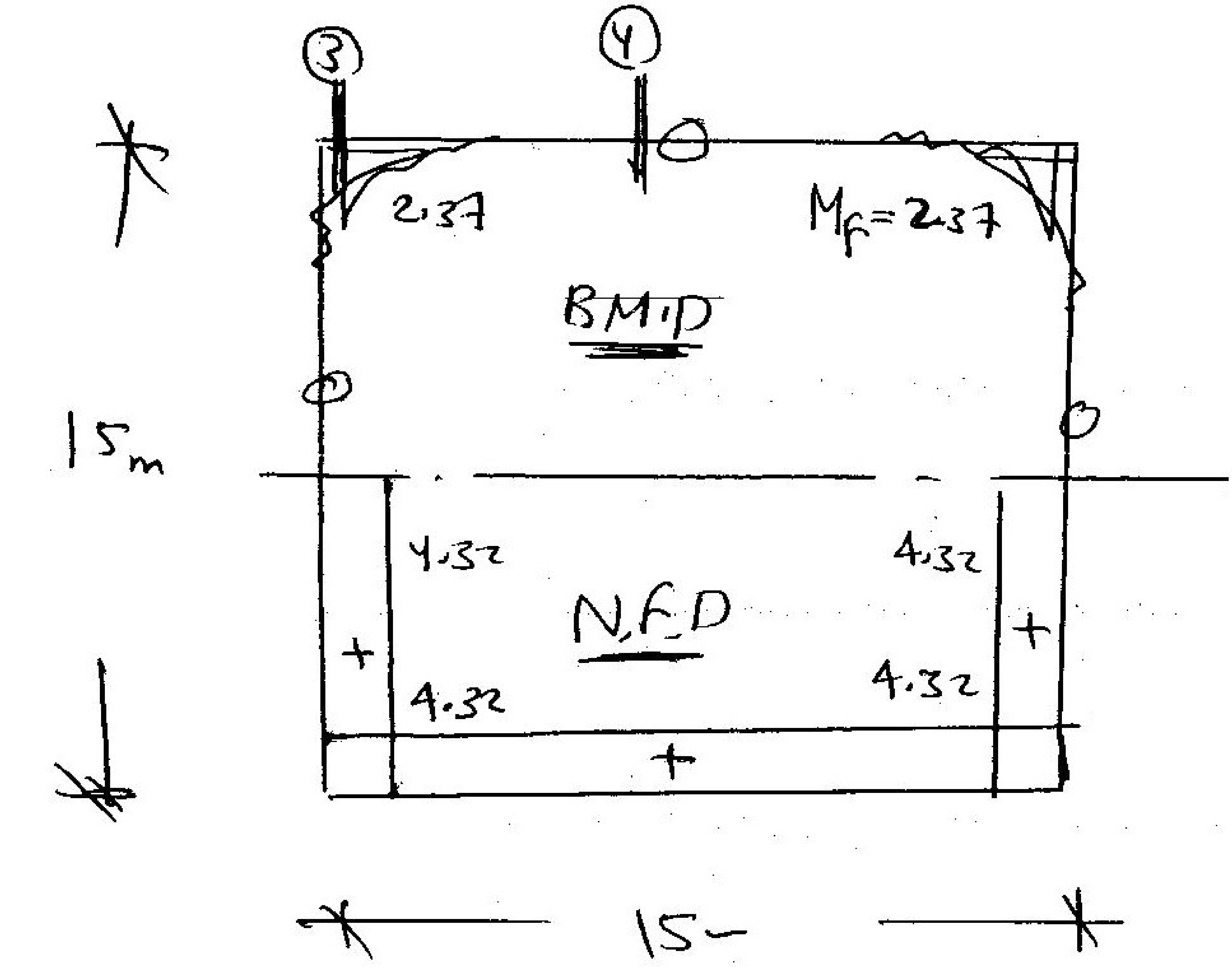
∴ $M_{us} = T_u \cdot e_s$

∴ $R_1 = \frac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} \rightarrow \omega =$

∴ $A_s = \frac{\omega \cdot f_{cu}}{f_y} \cdot B \cdot d + \frac{T_u * 10^3}{(f_y/\gamma_s)}$

$= 7\,\Phi\,12$/m خلفي

(Hl. Strip)



(Hl. Strip) حيث تعوض ان أصل ع

$\therefore M_f = \left(\frac{\gamma H^3}{27}\right) = \frac{1 \times 4^3}{27} = 2.37 \ t.m/m'$

water side

$\therefore$ Normal force $= (0.27 \gamma H^2) = .27 * 1 * 4^2$

= reactions $= 4.32 \ t/m'$

<u>Design of sections:</u>

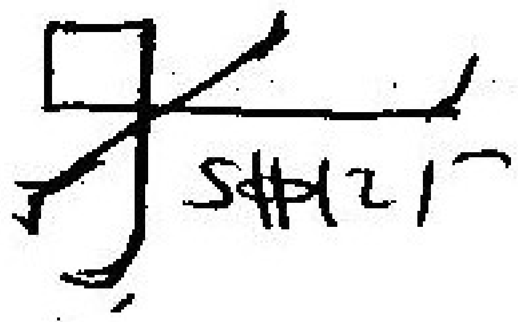
Sec (3) $M_{\text{water side}} = 2.37 \text{ t.m/m}$ $T = 4.32 \text{ t/m}$

Stage (I) $t = \sqrt{\dfrac{M \times 10^5}{\psi \cdot B}} + 5 = 35 \text{ cm}$

Stage (II) ultimate

$\therefore A_s = 5\Phi 12/m$

صح داخل



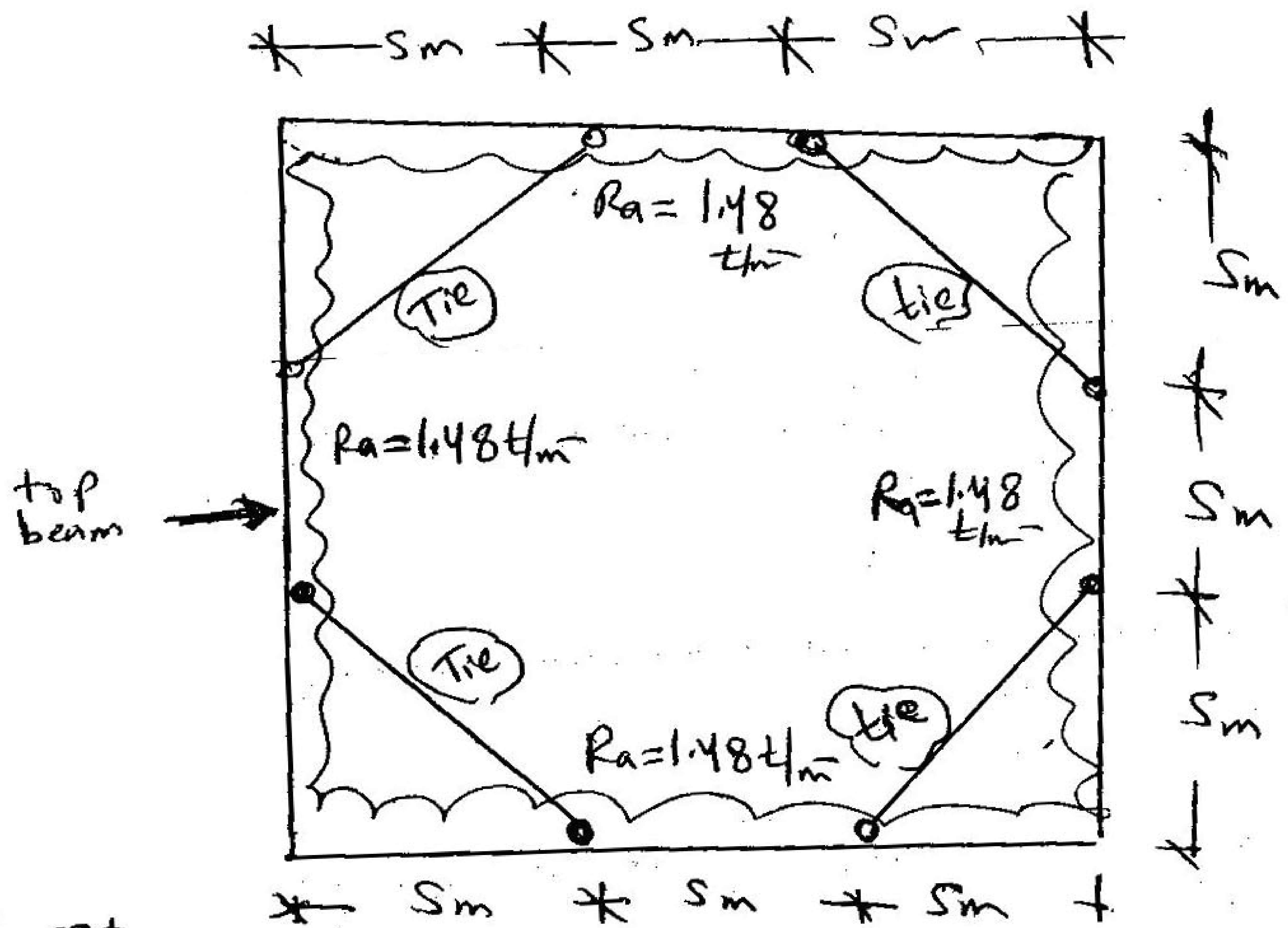
Sec (4) $T_{only} = 4.32 \text{ t/m}$

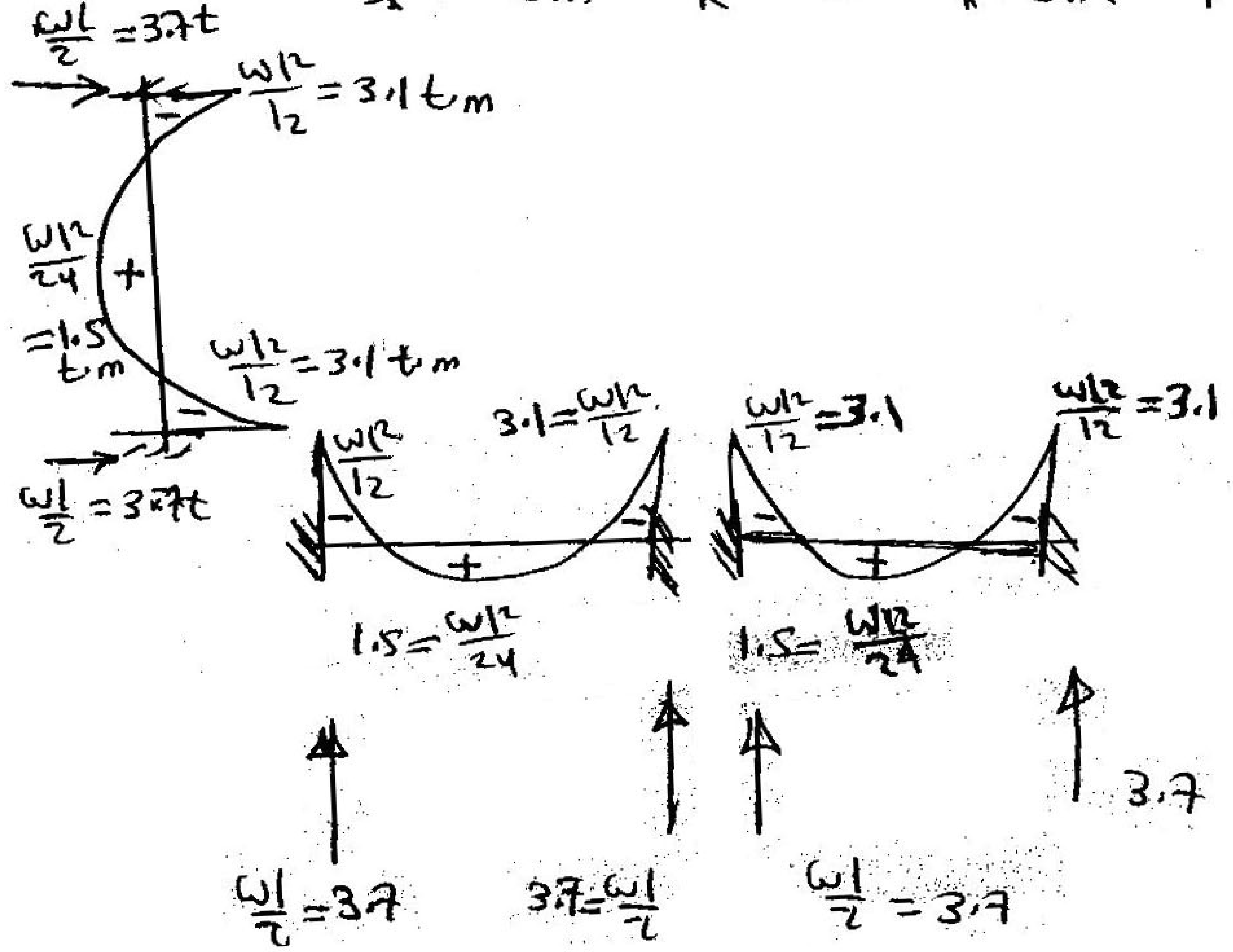
Stage (I) $t = \rho \cdot T$ = صغيرة جداً cm

$\rho = 0.6$, $T = 4.32 \text{ ton}$ $\Rightarrow$ use $t = 25 \text{ cm}$

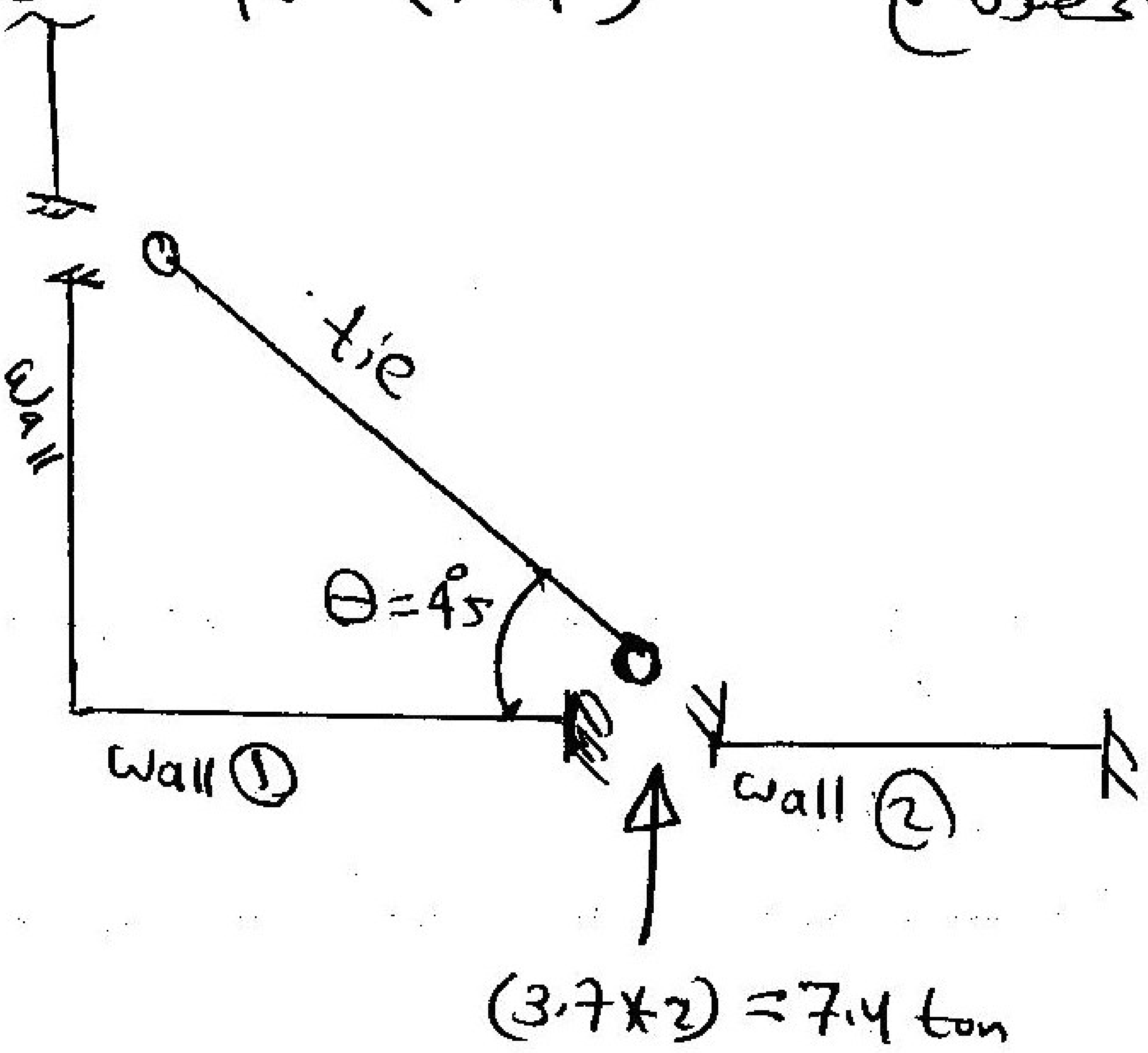
Stage (II) $A_s = \dfrac{T_u \times 10^3}{2\left(\dfrac{f_y}{\gamma_s}\right)}$ = min $5\Phi 10/m$ each side

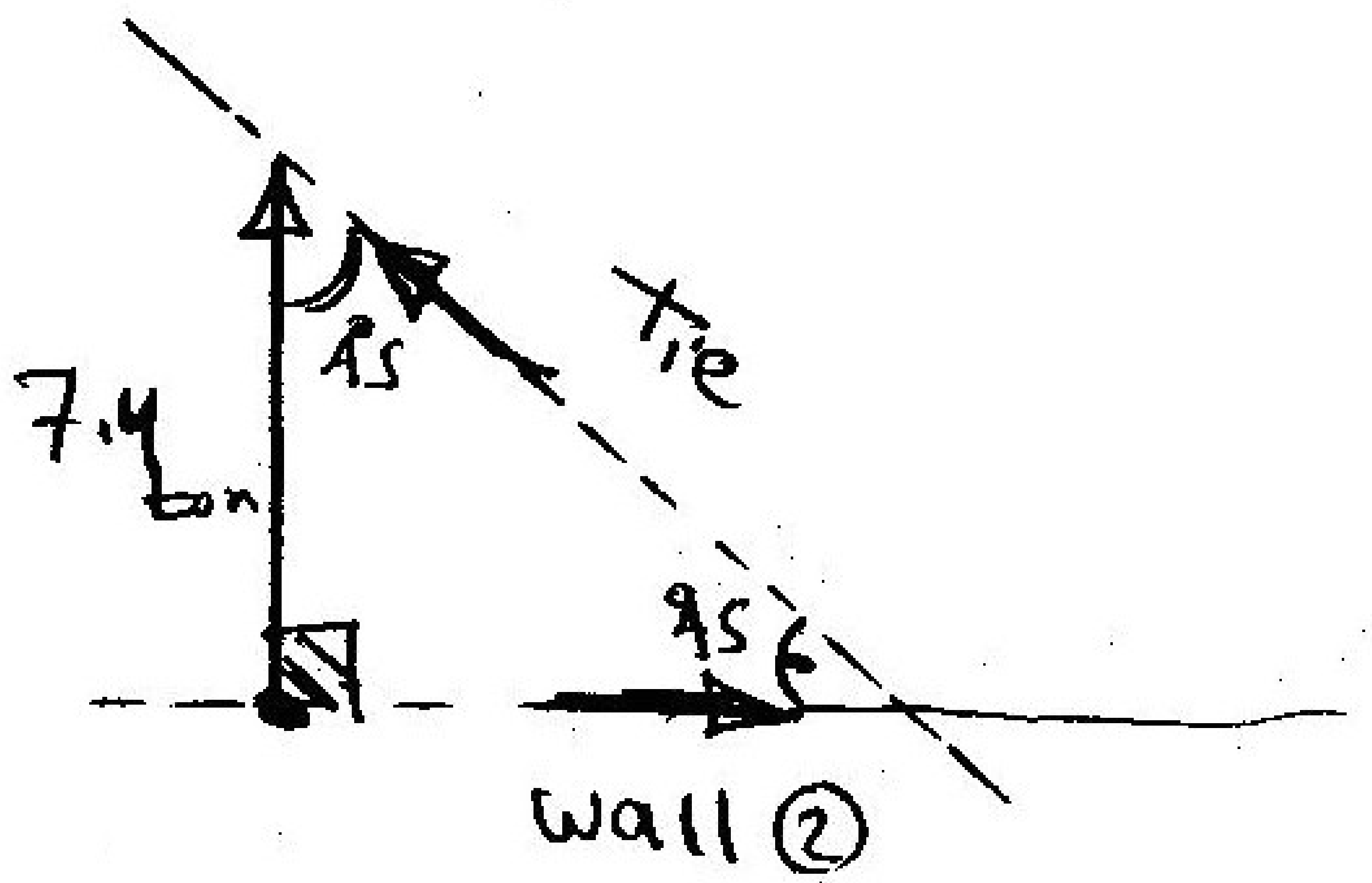
Design of Top beams:





(tie) قوة (N.f) للمعمل



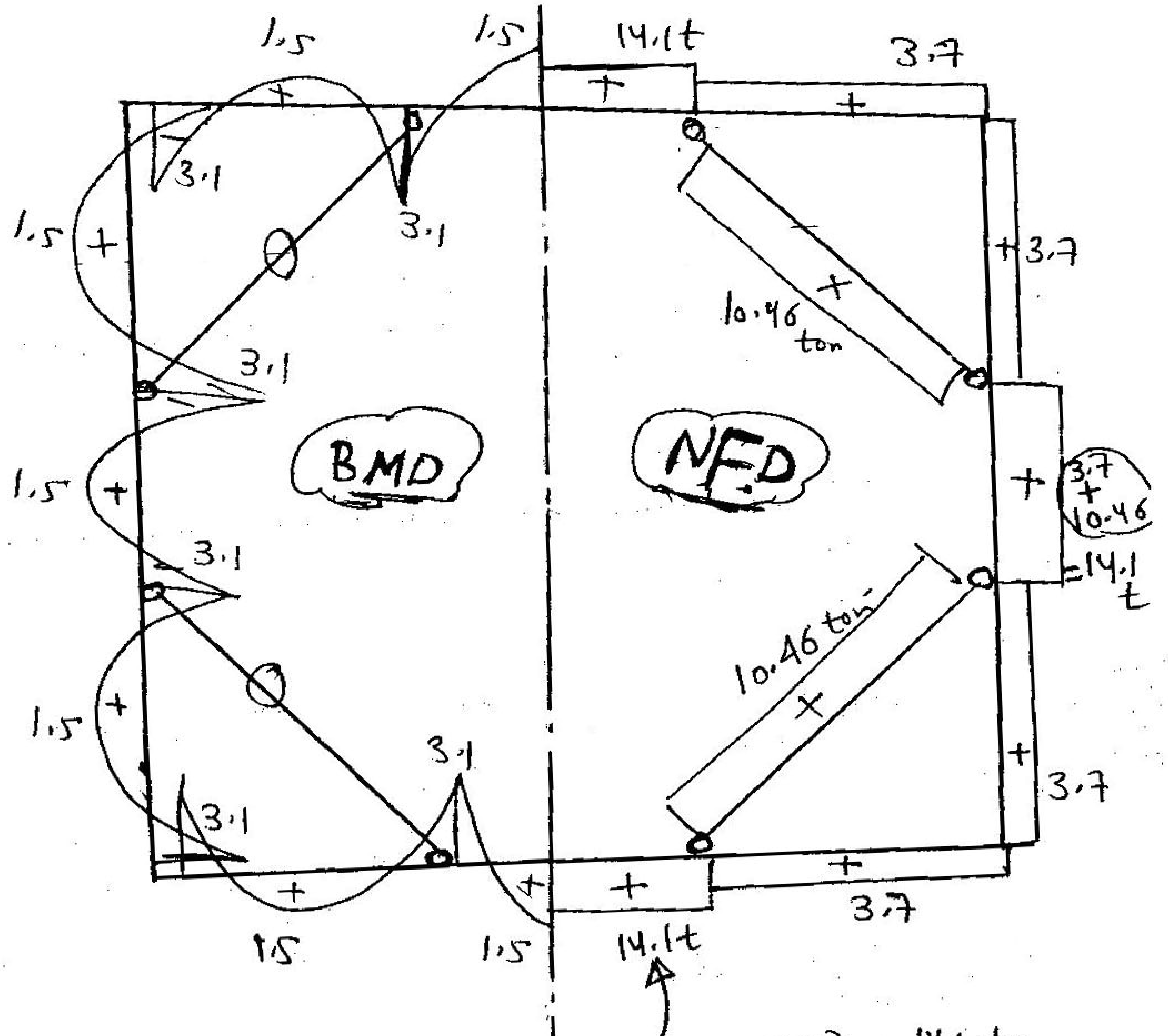


$\therefore$ Tension in tie $= \left(\frac{7.4}{\cos 45}\right) = 10.46$ ton

$\therefore$ tension in wall ② $= \frac{7.4}{\sin 45} = 10.46$ ton.

إضافة ضغط على الحائط ②

* Top beam Moments, Normal force



(10.46+3.7) = 14.1 ton.

Design of sections for (top beam), (ties)

Top beam $M_{max} = 3.1$ t.m , $T = 14.1$ ton
water side

stage (I) use $b = 30$ cm

$$t = \sqrt{\frac{M \times 10^5}{\psi \cdot b}} + 5 = 65 \text{ cm}$$

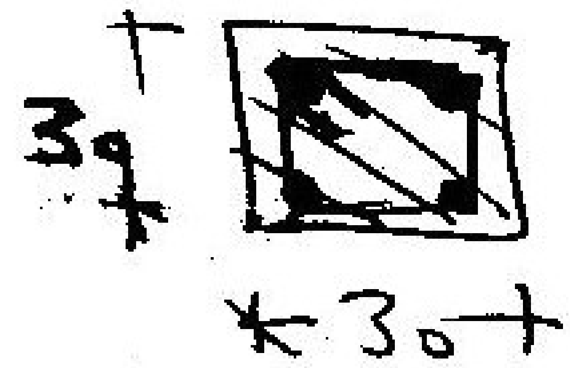
stage (II) ultimate $\Rightarrow M_u, T_u, \Rightarrow e, e/t \Rightarrow e_s$
(R_1, ω)

$A_s = 5\Phi16$

---

tie use $b \times t = (30 \times 30)$ cm

$$A_s = \frac{T_u \times 10^3}{(f_y/\gamma_s)}$$



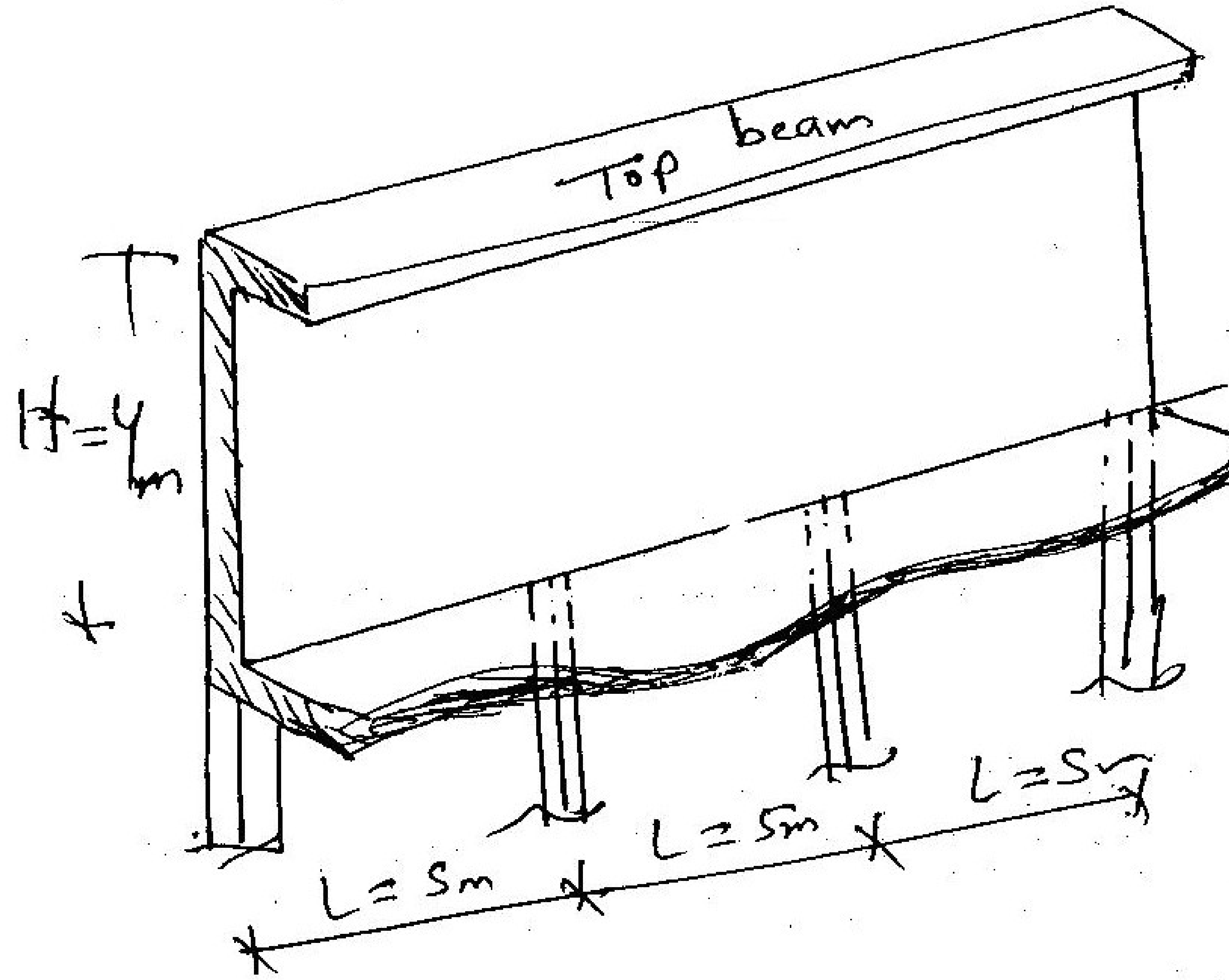
ultimate

$$= \frac{1.5 \times 10.46 \times 10^3}{(3600/1.15)} = 5 \text{ cm}^2$$

$$= 4\Phi16$$

design of wall as beam;

(Continous) $\frac{H}{L} = \frac{4}{5} = 0.8 > 0.4$ $\Rightarrow$ deep beam



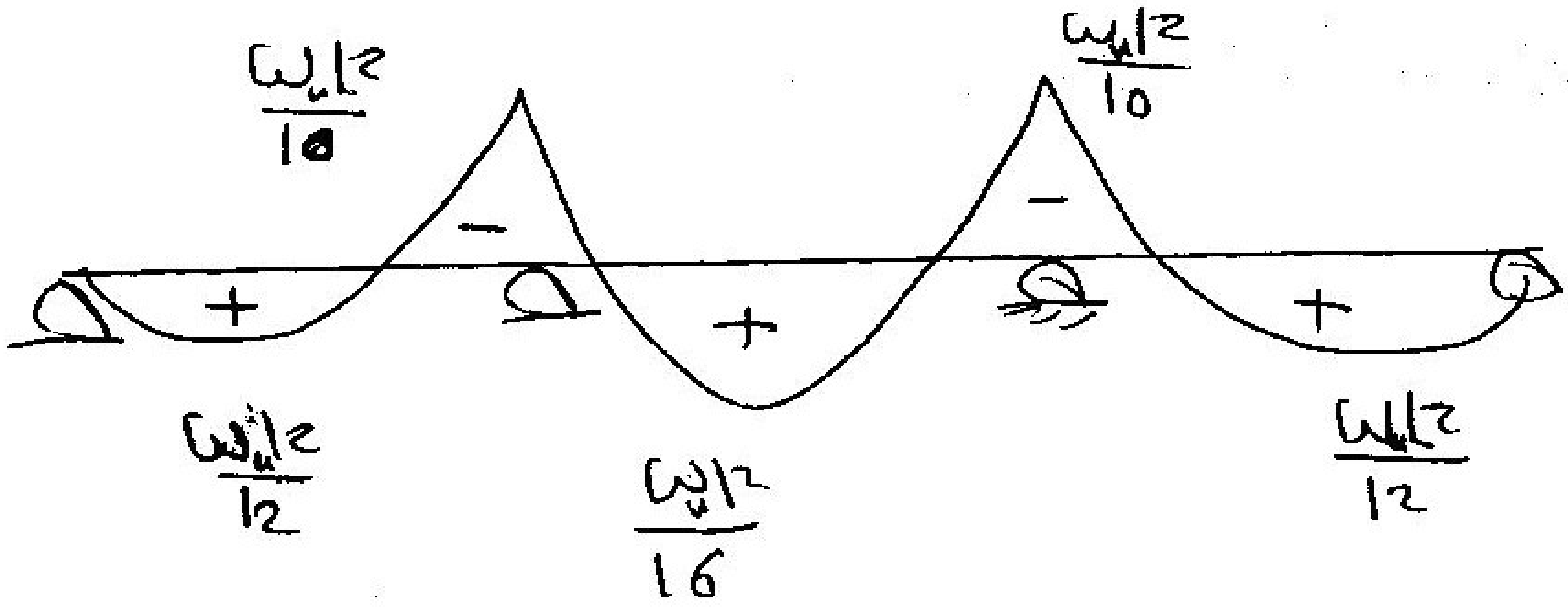
$$W_{\text{deep beam}} = (\text{own wt of Top beam}) + (R_{slab}) + (\text{own wt of wall})$$

(own wt of Top beam) ⇓ $(b \cdot t \cdot \gamma_{R.C})$; (own wt of wall) ⇓ $(t_{wall} \cdot H \cdot \gamma_{R.C})$

$$= (0.3 * 0.65 * 2.5) + 6.1 + (0.25 * 4 * 2.5)$$

$$= 9.1 \ t/m$$

$$\therefore W_{u \ (\text{ultimate})} = 1.5\, W = 13.6 \ t/m$$



$$\therefore M_{u\,max\,-ve} = \frac{W_u l^2}{10} = \frac{13.6 * (5)^2}{10} = 34 \text{ t.m}$$

$$\therefore M_{max\,+ve} = \frac{W_u . L^2}{12} = \frac{13.6 * (5)^2}{12} = 28.33 \text{ t.m}$$

Design

$M_{u\,-ve} = 34$ t.m

علوى

$y_{ct} = 0.37 L$

$= 0.37 * 5 = 1.85$ m

$\therefore T_u = \frac{M_u}{y_{ct}} = \frac{34}{1.85} = 18.4$ ton

$\therefore A_s = \frac{T_u * 10^3}{f_y / \gamma_s} = 6 \text{ cm}^2$

علوى

$= 3 \# 16$

كانات ع (0.6 H) من الداخل ⇐

$M_{u\,+ve} = 28.33$ t.m

سفلى

$y_{ct} = 0.43 L$

$= 0.43 * 5 = 2.15$ m

$\therefore T_u = \frac{M_u}{y_{ct}} = \frac{28.33}{2.15} = 13.2$

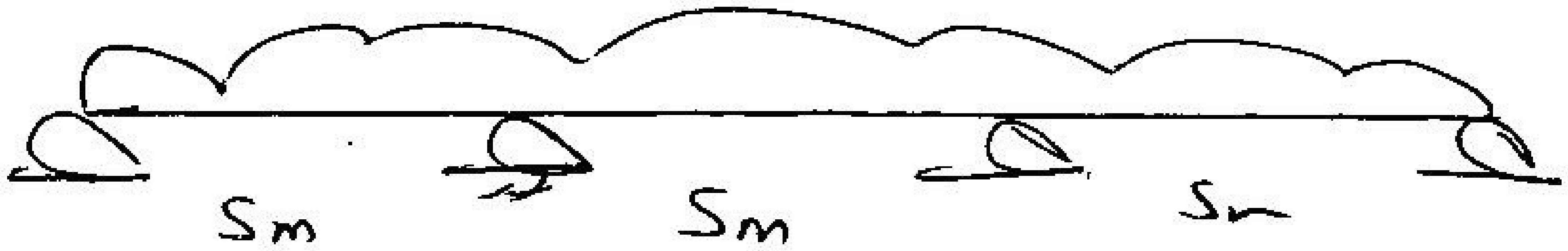
$\therefore A_s = \frac{T_u * 10^3}{(f_y / \gamma_s)} = 4.2$

سفلى

$= 3 \# 16$

design of base beams:

$\omega = $ (own wt of base beam) + R_{slabs}



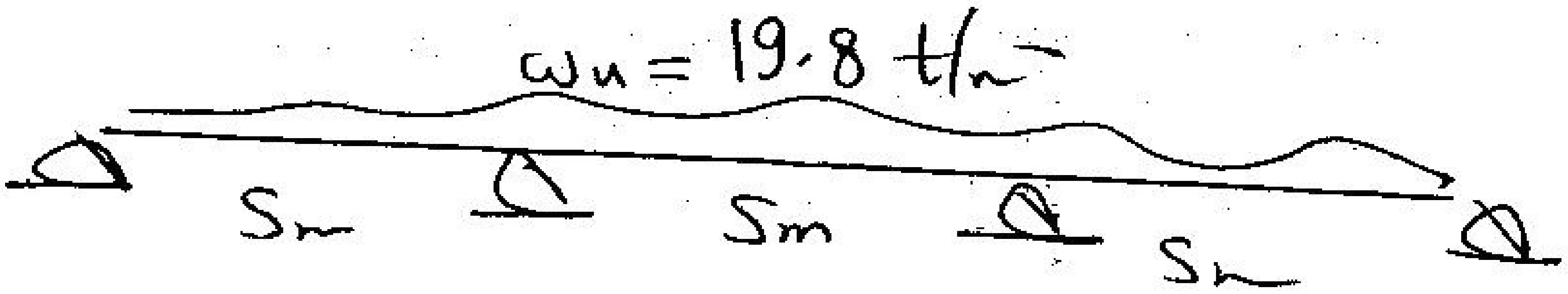
b . t . $\gamma_{R.c}$

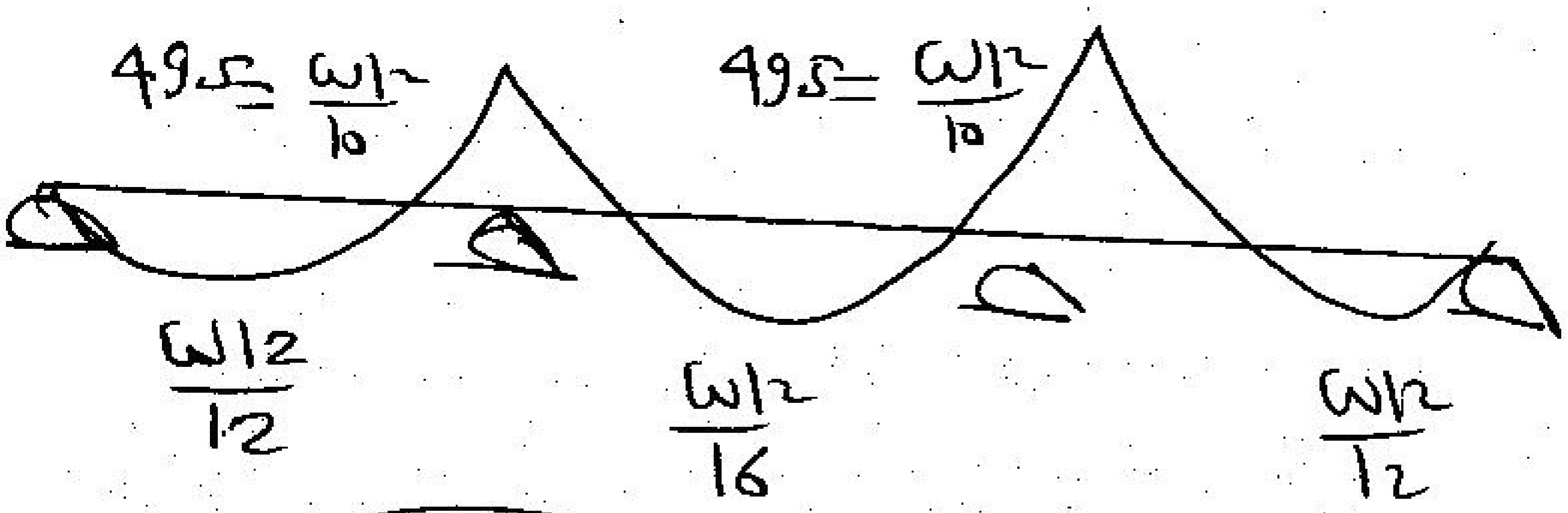
$\therefore \omega = (0.4 \times 0.8 \times 2.5) + (6.4 + 6.25)$

فرض

$\therefore \omega = 13.25$ t/m

$\Rightarrow \omega_u = 1.5\omega = 19.8$ t/m





$M_u = \frac{\omega l^2}{10} = 49.5$ t.m (نصمم أقصى عزم)

water side

stage (I) working

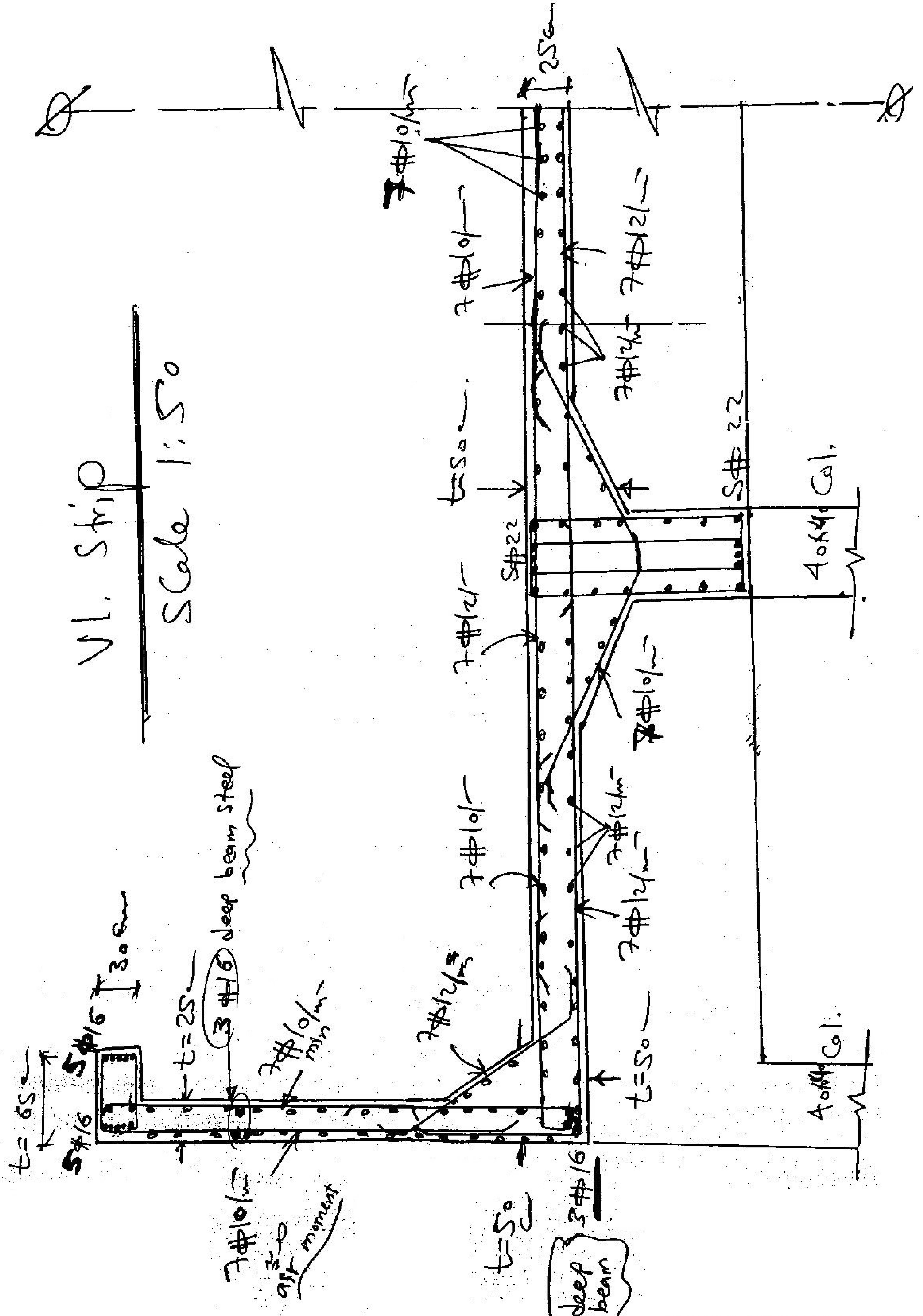
$t = \sqrt{\frac{M \times 10^5}{\psi \cdot b}} + 5 = 160$

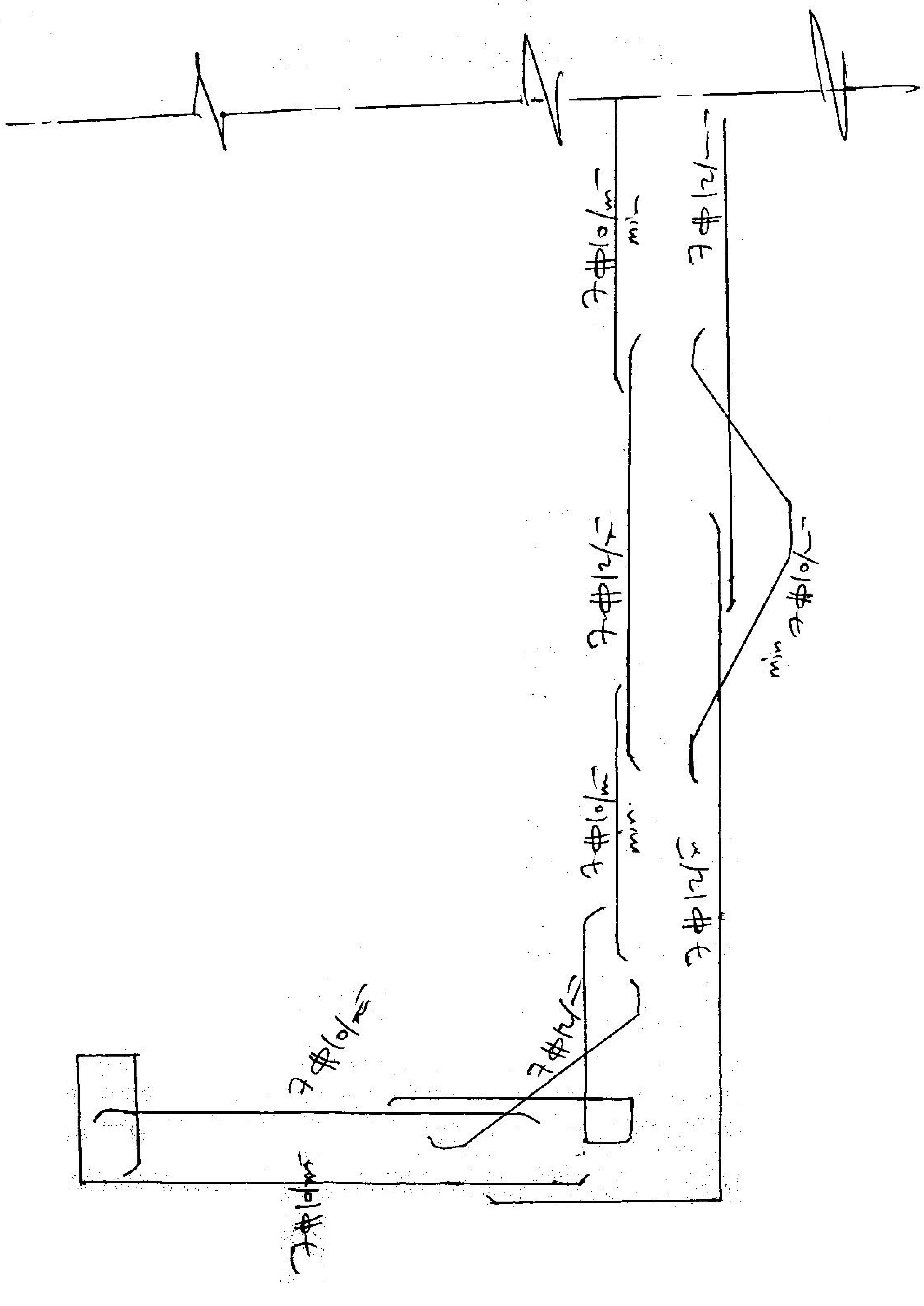
$M = \left(\frac{49.5}{1.5}\right) = 33$

40

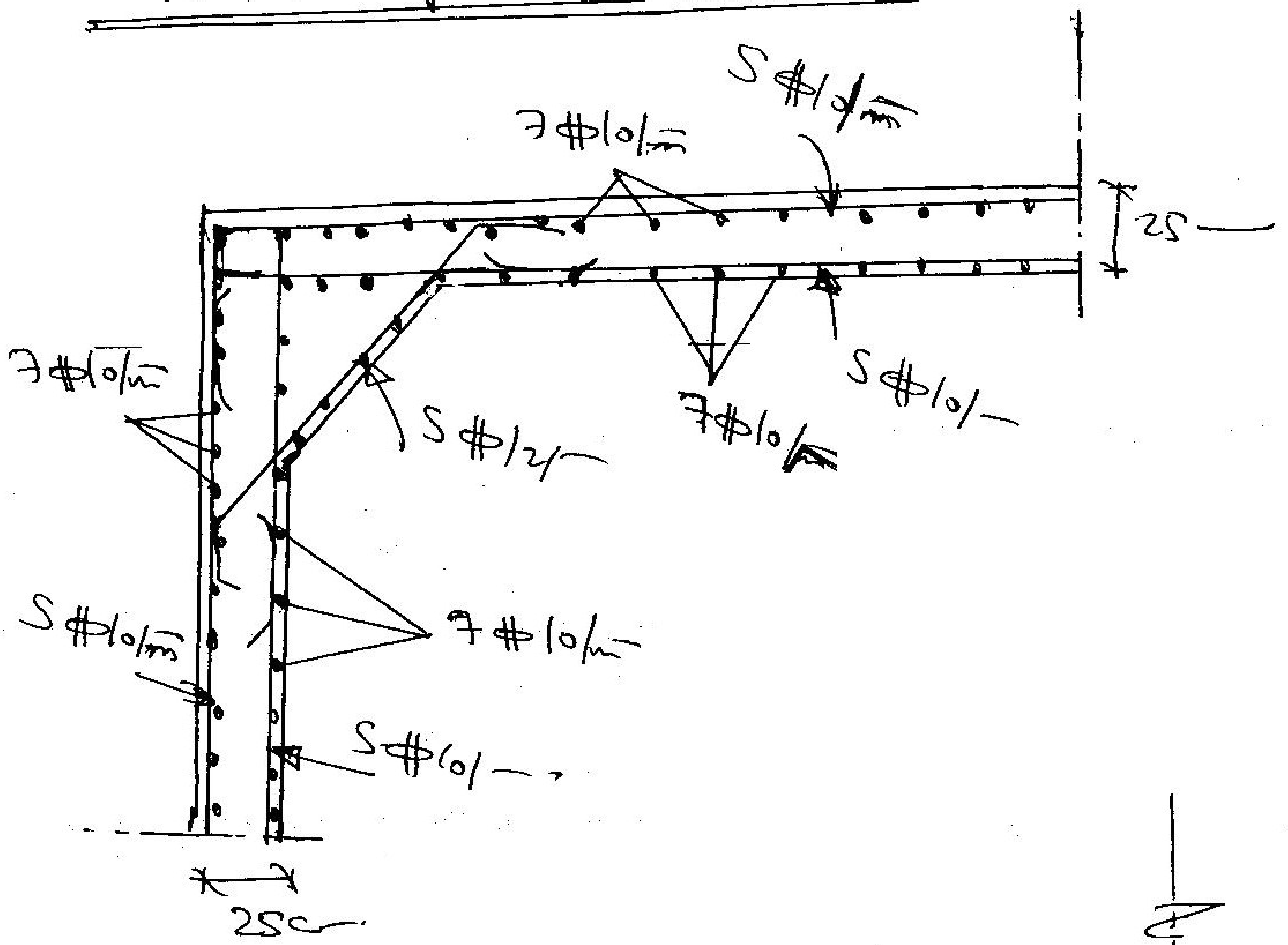
Stage (II) ultimate.

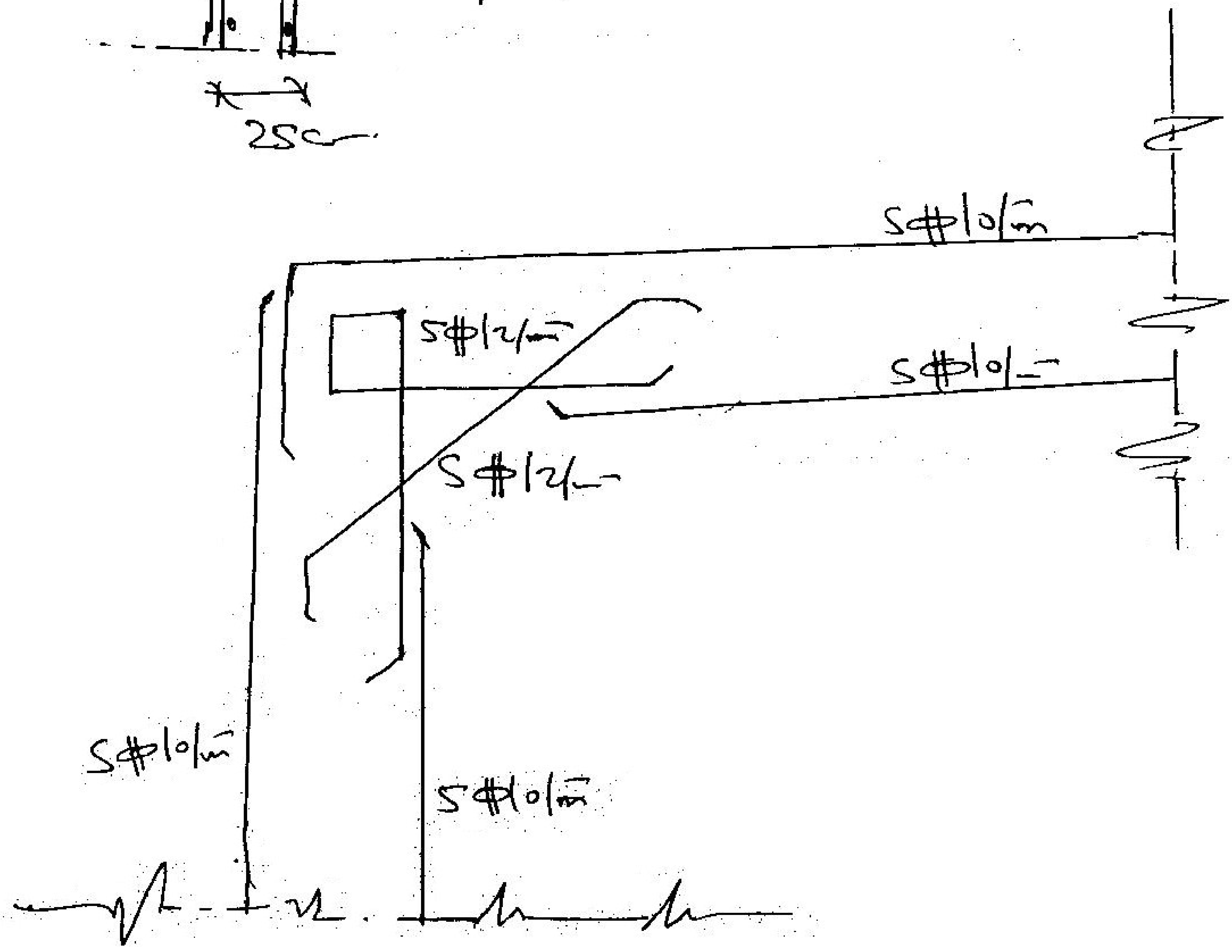
$A_s = \frac{11}{f_y} \cdot b \cdot d = 20\ cm^2 = 5 \# 22$


Vl. Strip
Scale 1:50
deep beam steel
deep beam
t=50
t=25
t=65
air moment



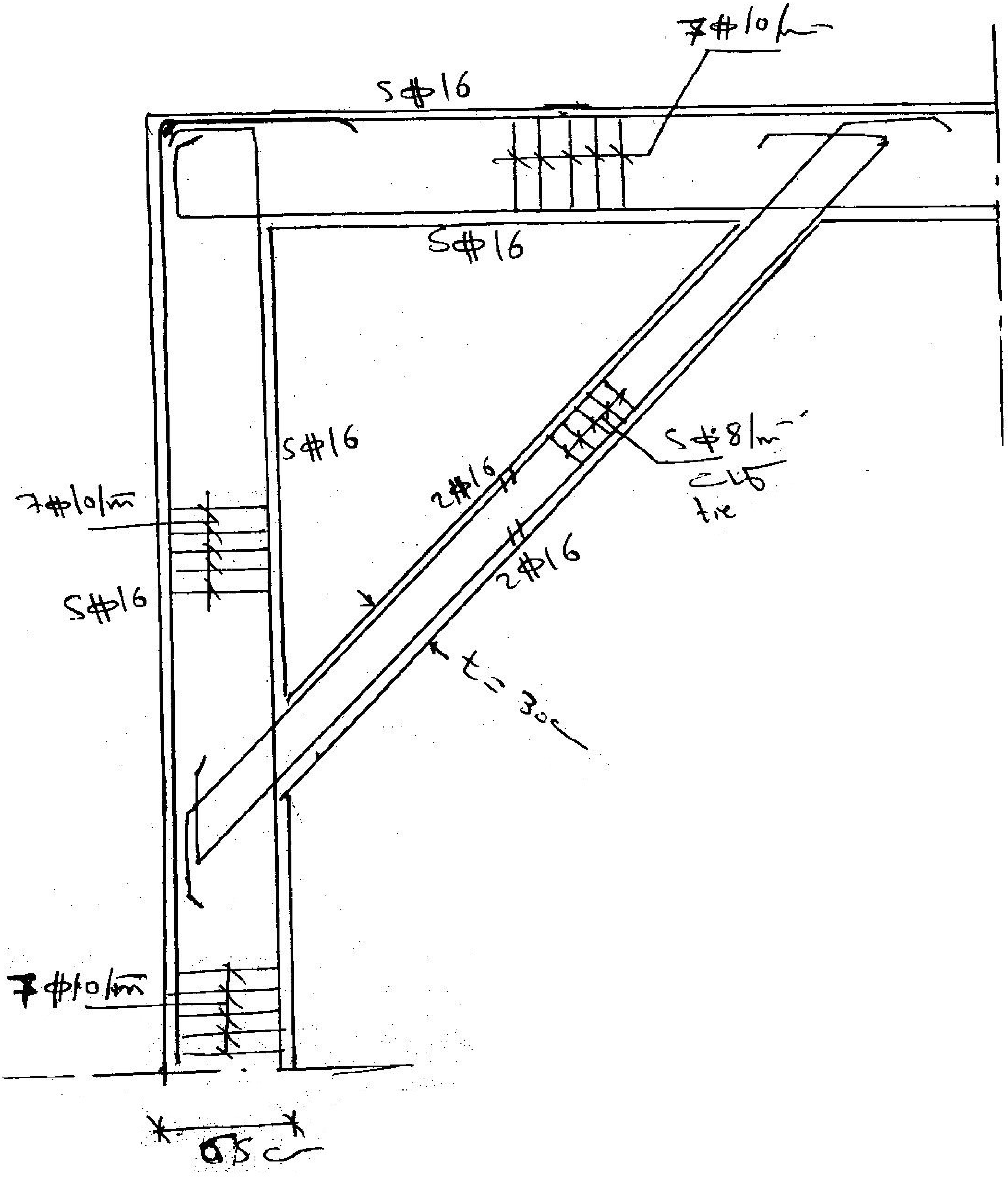
HL. Strip scale (1:50)

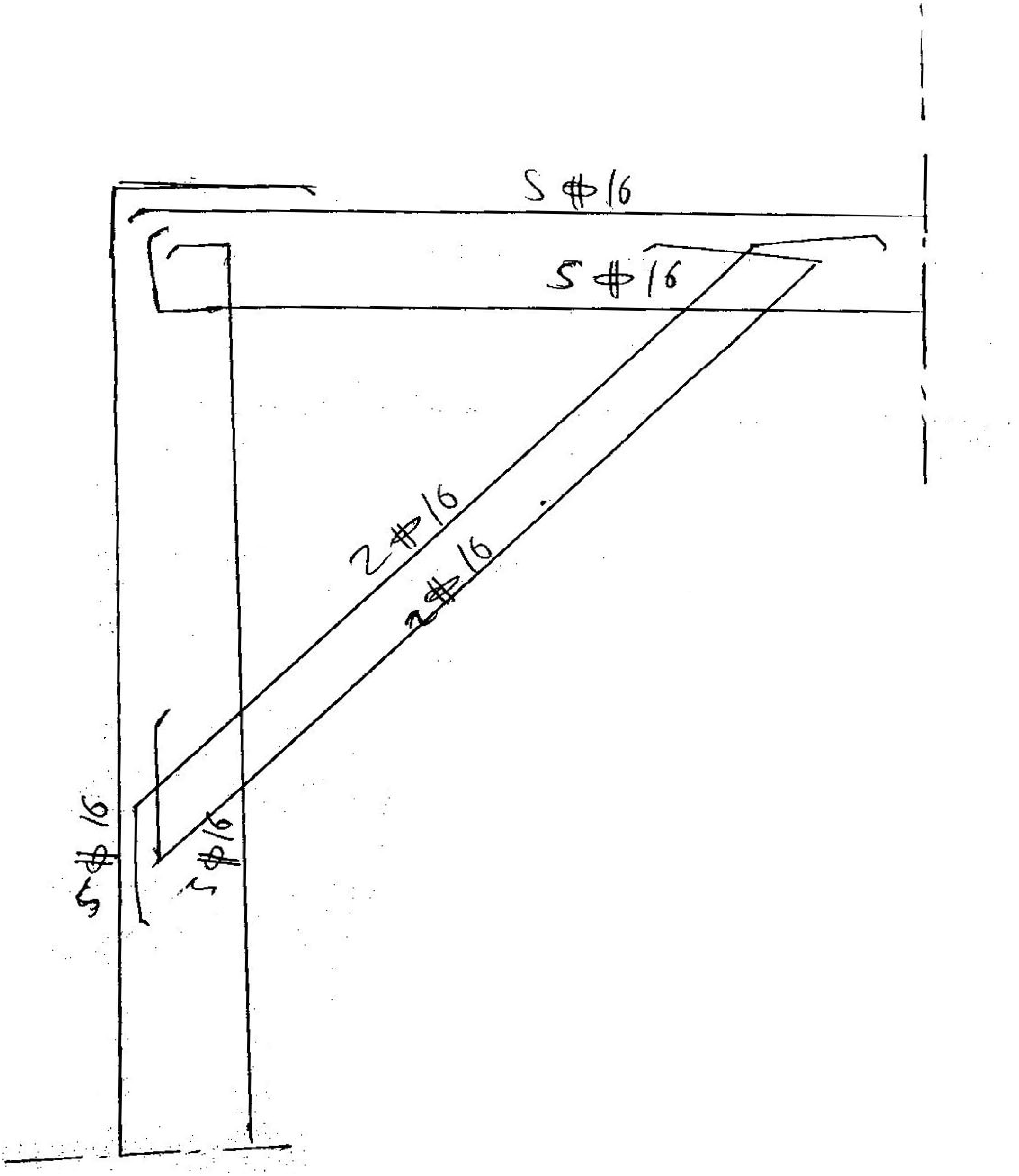




Ties, top beam

Scale (1:50)



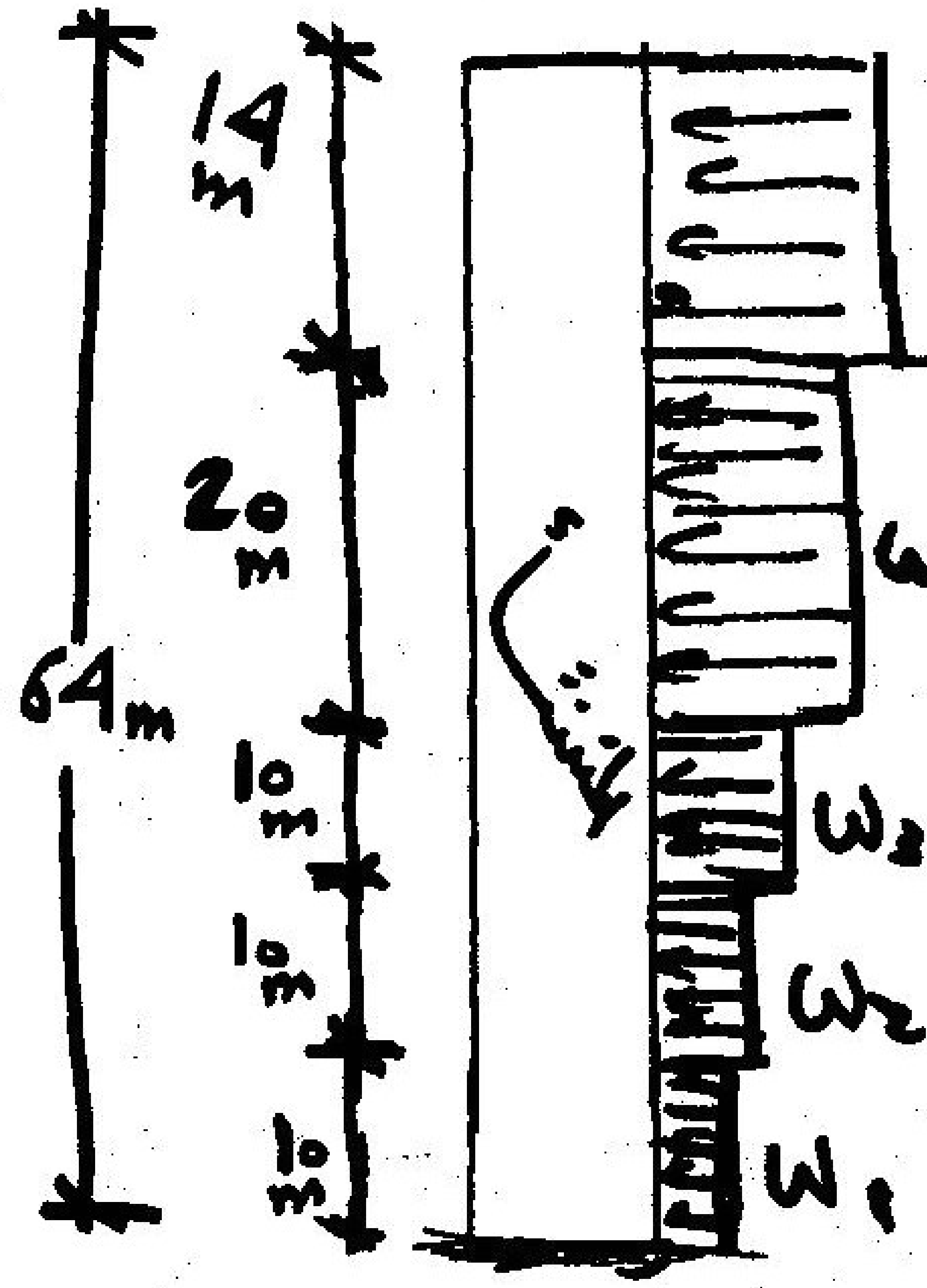

5 ϕ16
5 ϕ16
2 ϕ16
2 ϕ16
5 ϕ16
5 ϕ16

Q (2) Lateral loads

Solution:

(a) حساب قوة الرياح الكلية

$F_{y\,wind}$



$w_5 = 1.3 * 1.7 * 0.09 * 32 = 6.36\ t/m$

$w_4 = 1.3 * 1.5 * 0.09 * 32 = 5.6\ t/m$

$w_3 = 1.3 * 1.3 * 0.09 * 32 = 4.8\ t/m$

$w_2 = 1.3 * 1.1 * 0.09 * 32 = 4.11\ t/m$

$w_1 = 1.3 * 1 * 0.09 * 32 = 3.74\ t/m$

عرض الواجهة العمودية على القوة

$w_{wind} = C_f \cdot K \cdot q * (\text{width of building})$

$= [1.3 * K * 0.09 * 32]\ t/m$

حسب الارتفاع من الكود مذكرة رقم (22)

$\therefore \text{Total force} = (6.36 * 14) + (5.6 * 20) + (4.8 * 10) + (4.11 * 10) + (3.7 * 10)$

$\Rightarrow \text{total } F_{y\,wind} = \ldots\ ton$

المطلوب الثاني ← **(B)** لتوزيع القوة $F_y = 200\,ton$ رياح

---

* نضع كل الحوائط في جدول.

* نلاحظ اننا قسمنا الـ (Core) الى مجموعة حوائط خرسانية مسلحة أفقية (HL) ورأسية (VL)

قطعتين ← WV

قطعة واحدة ← WH

*

---

* وحيث ان القوى المعطاة قوة رياح [تؤثر في منتصف الواجهة]

∴ لا يلزم حساب الـ **Center of mass**

∴ نحسب الـ **Rigidity Center** (Cr) فقط

$$x_r = \frac{\sum I_x \cdot x_i}{\sum I_x} = \frac{181}{14.299} = 12.67\,m$$

$$y_r = \frac{\sum I_y \cdot y_i}{\sum I_y} = \frac{128}{14.06} = 9.073\,m$$

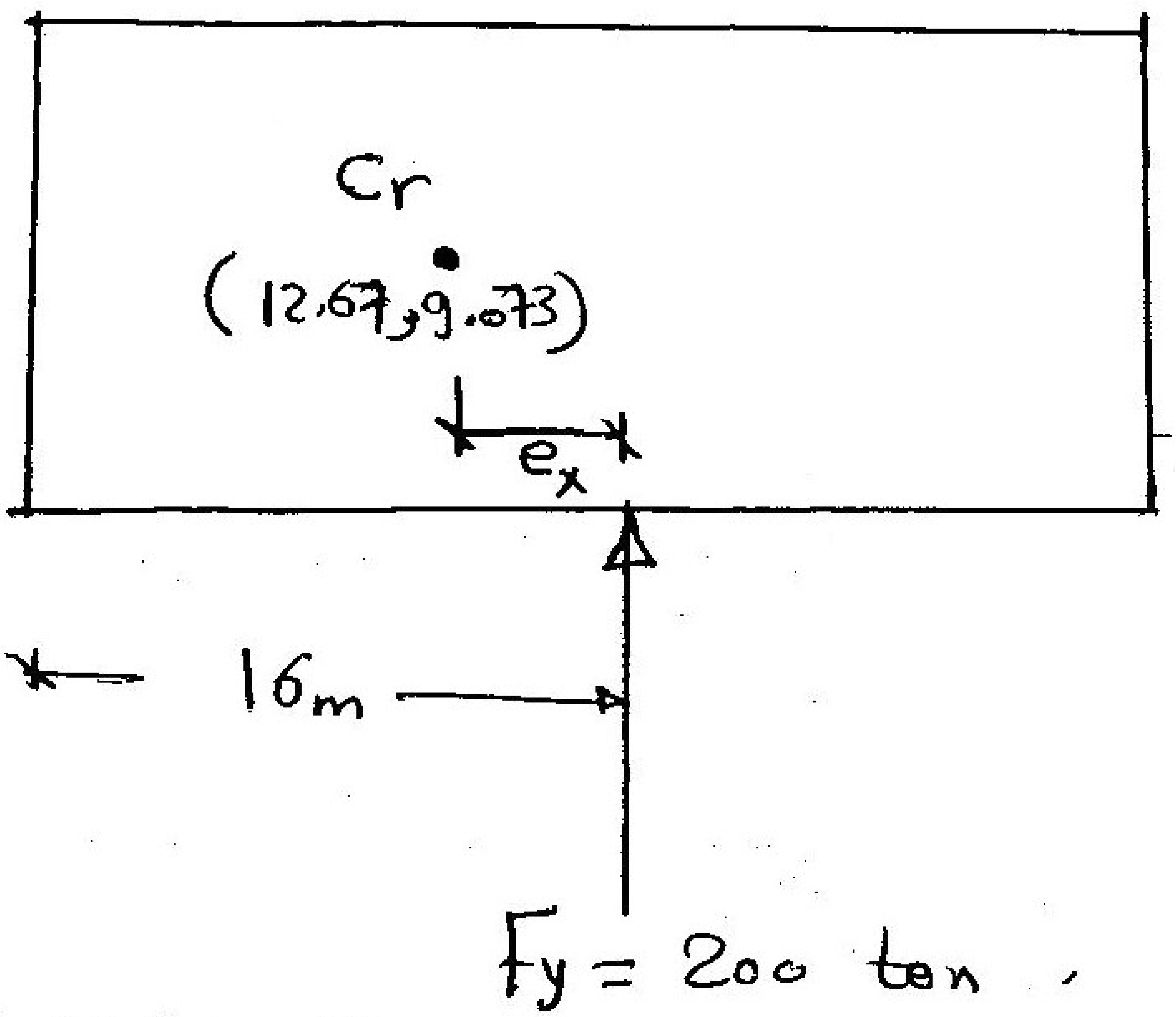
---

* **Note**

$$\underset{\text{للعنصر المائل}}{I_x} = \underset{\text{الكبيرة } \frac{b \cdot h^3}{12}}{I} * \sin^2\theta = 7.07 * (\sin 45)^2 = 3.6812\,m^4$$

$$\underset{\text{للعنصر المائل}}{I_y} = \underset{\text{الكبيرة } \frac{b \cdot h^3}{12}}{I} * \cos^2\theta = 7.07 * (\cos 45)^2 = 3.6812\,m^4$$

											Forces due to torsion		Direct force
Wall	IX	Iy	xi	yi	Ix*xi	Iy*yi	x'=xi-xr	y'=yi-yr	Ix*x'^2	Iy*y'^2	fxt	fyt	fyi
1	1.3333	0	0.125	18	0.17	0	12.54	8.93	209.7	0	0.00	6.64	18.65
2	1.3333	0	0.125	2	0.17	0	12.54	7.07	209.7	0	0.00	6.64	18.65
3	3.6812	3.6812	5.75	4.5	21.2	16.6	6.92	4.57	176.1	77	6.69	10.12	51.49
4	1.3333	0	8.25	14.75	11	0	4.42	5.68	26.01	0	0.00	2.34	18.65
5	2.6042	0	24.25	5.75	63.2	0	11.58	3.32	349.4	0	0.00	11.99	36.42
6	3.6812	3.6812	21.75	14.25	80.1	52.5	9.08	5.18	303.7	98.7	7.57	13.29	51.49
7	0	1.0986	30.125	0.125	0	0.14	17.46	8.95	0	88	3.91	0.00	0.00
8	0	1.0986	30.125	19.875	0	21.8	17.46	10.80	0	128	4.72	0.00	0.00
WH core	0	4.5	16.25	8.125	0	36.6	3.58	0.95	0	4.04	1.69	0.00	0.00
WV core 1	0.1667	0	13.375	7.25	2.23	0	0.71	1.82	0.084	0	0.00	0.05	2.33
WV core 2	0.1667	0	19.125	7.25	3.19	0	6.46	1.82	6.953	0	0.00	0.43	2.33
slab	-------	-------	16	10	----	----	---------	---------	----	----	---------	---------	---------
Summation	14.2999	14.06			181	128			1282	396			



قوة رياح من نصف الواجهة.

$\therefore e_x = 16 - 12.67 = 3.33m$

الإزاحة للحمل عن Cr

$$\therefore M_{Torsion} = F_y \cdot e_x$$

$$= 200 * 3.33$$

$$= 666.61 \text{ ton.m}$$

---

* ثم نقوم بحساب قيمة ⟸ (X^{-}, y^{-}) في الجدول.

$$X^{-} = (X_i - X_r)$$ (X_i للحوائط)

$$y^{-} = (y_i - y_r)$$ (y_i للحوائط)

$$J_r = \Sigma(I_x \cdot \bar{x}^2) + \Sigma(I_y \cdot \bar{y}^2)$$

∴ $J_r = 1677.57\ m^6$ ⟸ بالآلة الحاسبة مباشرة

---

* ثم نقوم بتوزيع الحمل ($f_y = 200t$) والـ (Torsion) على الحوائط المطلوبة.

direct force

⊛ $f_y = \bar{f_y} * \left(\dfrac{I_x}{\Sigma I_x}\right)$

$= 200 * \dfrac{(I_x)\ \text{لكل}}{14.2999}$

forces from Torsion

⊛ $f_{xt} = \dfrac{M_T * I_y \cdot \bar{y}}{J_r}$

$= \dfrac{666.6 * (I_y * \bar{y})\ \text{لكل حائط}}{1677.57}$

⊛ $f_{yt} = \dfrac{M_T * I_x \cdot \bar{x}}{J_r}$

$= \dfrac{666.6 * (I_x \cdot \bar{x})\ \text{لكل حائط}}{1677.57}$

ملحوظة :

من حالة اعطاء القوة (Y) نوعها زلازل

يلزم حساب مركز تأثيرها هو mass Center (Cm)

$$X_m = \frac{\sum w_i \cdot x_i}{\sum w_i}$$

$$y_m = \frac{\sum w_i \cdot y_i}{\sum w_i}$$

حيث : (w_i) هو وزن كل حائط أو بلاطة سقف

(X_i) هو مركز الحائط أو البلاطة من إحداثيات (X)

(Y_i) هو مركز الحائط أو البلاطة في اتجاه (Y)

Wall	Wi	xi	yi	wi*xi	wi*yi
1	7.5	0.125	18	0.938	135
2	7.5	0.125	2	0.938	15
3	13.26	5.75	4.5	76.22	59.65
4	7.5	8.25	14.75	61.88	110.6
5	9.375	24.25	5.75	227.3	53.91
6	13.26	21.75	14.25	288.3	188.9
7	7.031	30.125	0.125	211.8	0.879
8	7.031	30.125	19.875	211.8	139.7
WH core	11.25	16.25	8.125	182.8	91.41
WV core 1	3.75	13.375	7.25	50.16	27.19
WV core 2	3.75	19.125	7.25	71.72	27.19
slab	544	16	10	8704	5440
Summation	635.2			10088	6289

وفي حالة إعطاء أشكال

⇐ نعمل جدول ونضع فيه كل الحوائط ونلاحظ أن الـ (Core) له ثلاث حوائط (2VL.) و (1HL.)

Weights of walls :

$$W_1 = b * t * \gamma_{R.C} * H_{floor}$$

↓

إرتفاع الدور وليكن مثلاً (3m) يفرض إذا لم يعطى

$$W_1 = 0.25 * 4 * 2.5 * 3 = 7.5 \text{ ton}$$

$$W_2 = 0.25 * 4 * 2.5 * 3 = 7.5 \text{ ton}$$

$$W_3 = 0.25 * 7.07 * 2.5 * 3 = 13.256 \text{ ton}$$

$$W_4 = 0.25 * 4 * 2.5 * 3 = 7.5 \text{ ton}$$

وهكذا لبقية الحوائط .

* بالنسبة للسقف (floor)

$$W_{floor} \text{ (slab)} = W_s * \text{Area}$$

$$= (t_s . \gamma_{R.C} + \text{Covering} + \text{Walls}) * \text{Area}$$

$$= (0.2 * 2.5 + 0.15 + 0.2) * 32 * 20$$

تفرض (Covering) — تفرض (Partitions)

$$W_{slab} = 544 \text{ ton}$$

* للحصول ع مركز الكتلة (Center of mass) $\underline{C_m}$

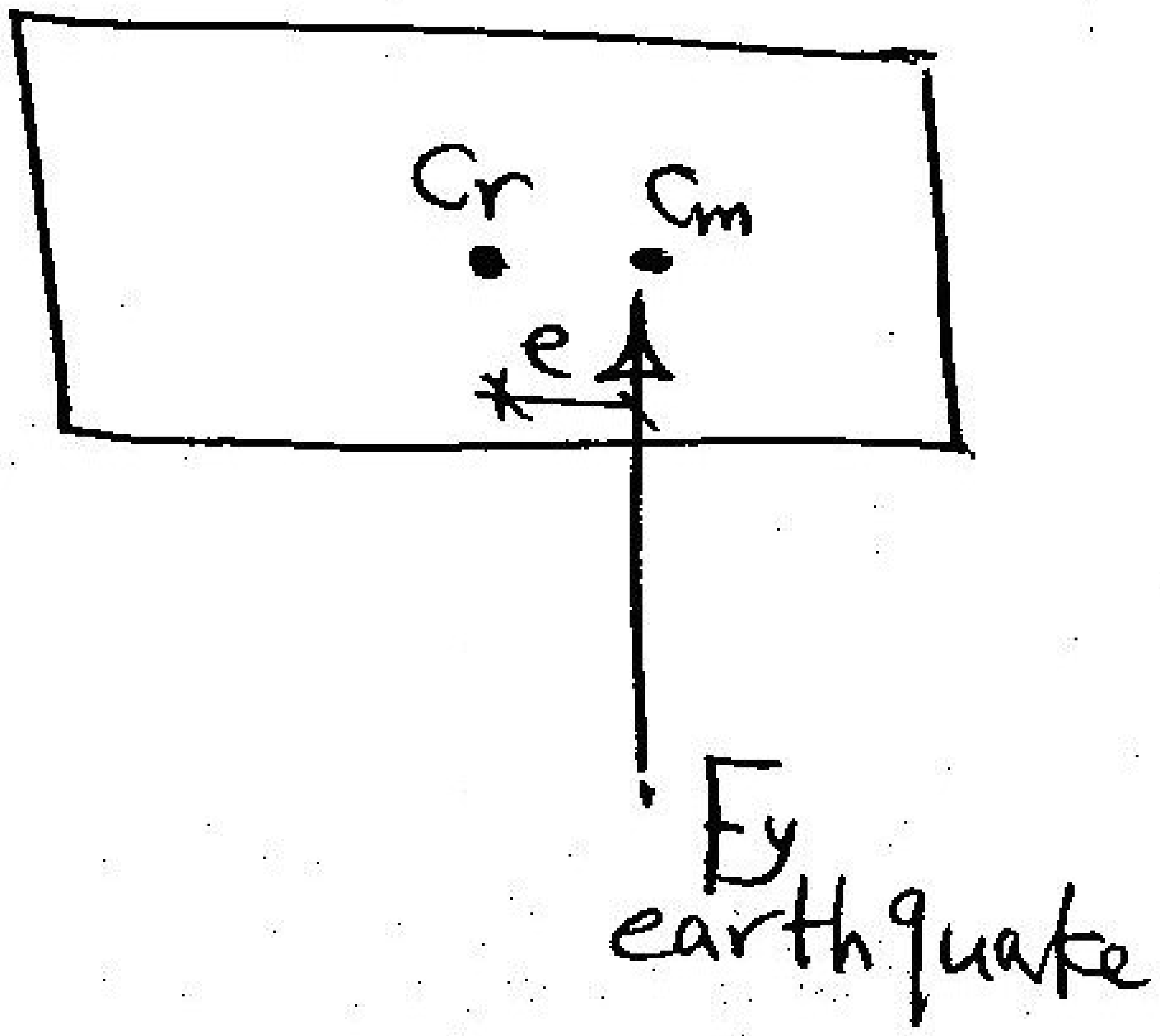
$$X_m = \frac{\sum w_i \cdot x_i}{\sum w_i} = 15.88 \text{ m}$$

$$y_m = \frac{\sum w_i \cdot y_i}{\sum w_i} = 9.902 \text{ m}$$

$$\therefore \quad e = X_m - X_r$$

$$= 15.88 - 12.67$$

$$= 3.21 \text{ m}$$



$$\therefore \quad M_{Torsion} = F_{y\,earthquake} * e$$

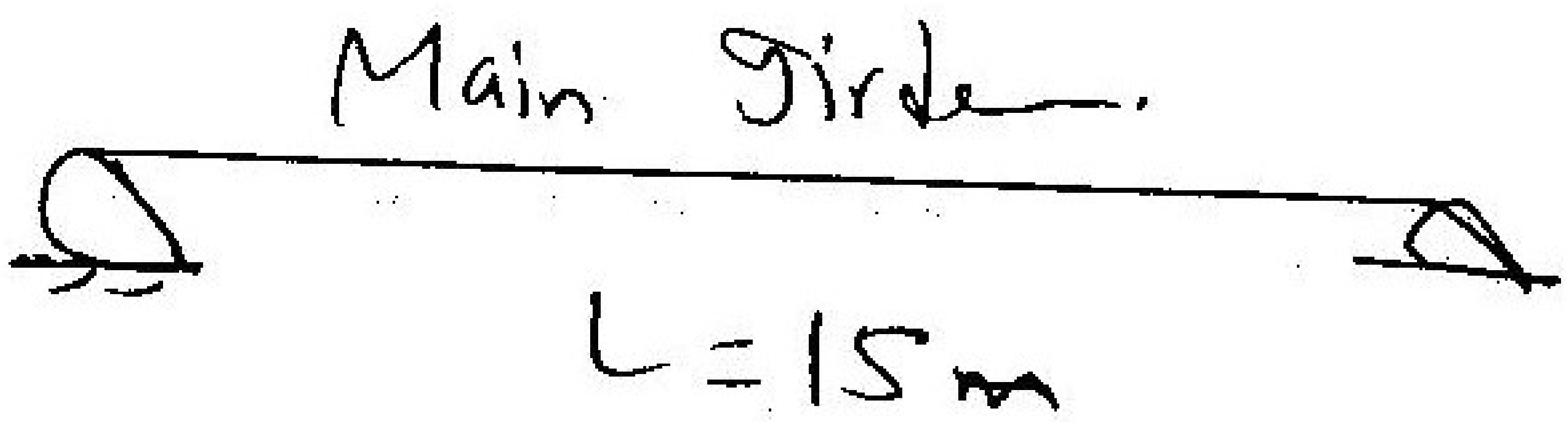
ثم نوزع القوة المباشرة (Fy) ونوزع الـ (Torsion)

١٥ ـــ على الكمرات

(P3)

"Bridge" الكوبري

* يفضل البدء بحل الـ (Main girder)
حيث لها درجة أكبر من
(side walk , deck slab)
وهي مسألة محلولة من قبل مع تغيير الأرقام.



(Simple beam) ✓

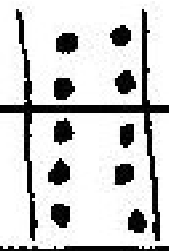
design of sections in Tanks

T

stage I :- working design :-

$t_{cm} = \xi * T_{ton} \geq 20$ cm   (ξ = 0,6)

stage II :- ultimate :-



$T_u = 1,5 * T$

$A_s = \dfrac{T_u * 10^3}{2 \; \dfrac{f_y}{\gamma_s}}$ على الجانبين   (f_y = 3600 (36/52), γ_s = 1,15)

$A_{s\,min} = \dfrac{0,15}{100} B \cdot d$ ($\#$) or $\dfrac{0,25}{100} B \cdot d$ (ϕ)   (B = 100, d = t − 5)

5 $\#$ 10 / m'

M

water side: stage I & II ← M → air side II: use t = 25 cm, d = 20

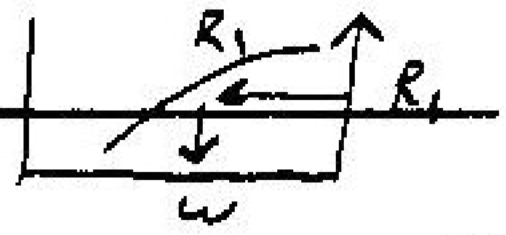
stage I :- working :-

$t = \sqrt{\dfrac{M * 10^5}{\psi * B}}$ (ψ = 3,2; B = 100 شريحة)

stage II :- ultimate :-

$M_u = 1,5 * M$ $d = t - 5$

$R_1 = \dfrac{M_u * 10^5}{f_{cu} * B * d^2}$ (f_{cu} = 250, B = 100)



$R_1 \xrightarrow{curve} \omega = 1,3 \, R_1$

$A_s = \omega * \dfrac{f_{cu}}{f_y} \cdot B \cdot d$ ناحية الشد   (f_{cu} = 250, f_y = 3600, B = 100)

M, T

water side I & II ← M, T → air side II: t = 25, d = 20

stage I :-

$t = \sqrt{\dfrac{M * 10^5}{\psi * B}} + 5$ cm   (ψ = 3,2; B = 100)

check :- Tension stress $f_t = \dfrac{6M * 10^5}{B * t^2} + \dfrac{T * 10^3}{B * t} \ngtr f_{ct}$ [illegible] (f_{ct} = 18)

stage II :-

$M_u = 1,5\,M$ $T_u = 1,5\,T$ $d = t - 5$ $e = M_u / T_u$

$e/t \geq 0,5$ [big eccentricity]	$e/t < 0,5$ [small eccentricity]
ناحية العزم — As (Mu)	As 1, As 2 (Mu)
$e_s = e - \dfrac{t}{2}$ + cover (0,05)	
$M_{us} = T_u * e_s$	$A_{s1} = \dfrac{T_u * 10^3}{f_y / \gamma_s} * \dfrac{\frac{d-d'}{2} + e}{d - d'}$
$R_1 = \dfrac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} \longrightarrow \omega$ (f_{cu} = 250, B = 100)	
$A_s = \omega \cdot \dfrac{f_{cu}}{f_y} \cdot B \cdot d + \dfrac{T_u * 10^3}{F_y / \gamma_s}$	$A_{s2} = \dfrac{T_u * 10^3}{f_y / \gamma_s} * \dfrac{\frac{d-d'}{2} - e}{d - d'}$

M, N

Moment + compression

neglect N ⟹ design on M

N comp only

$A_{s\,min}$ 5 $\#$ 10 / m'   [illegible]

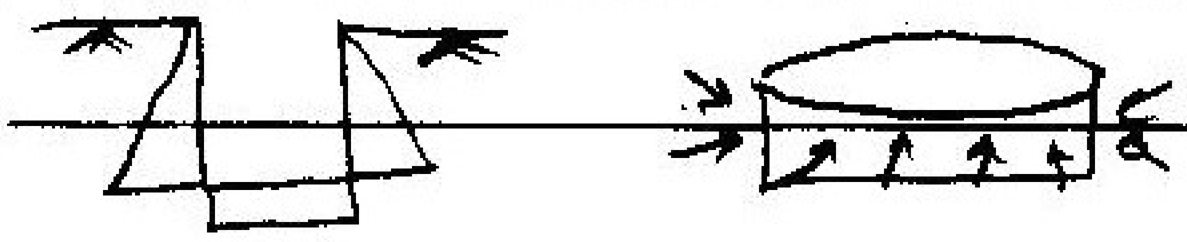
t_{min} = 20 cm

Circular Tanks

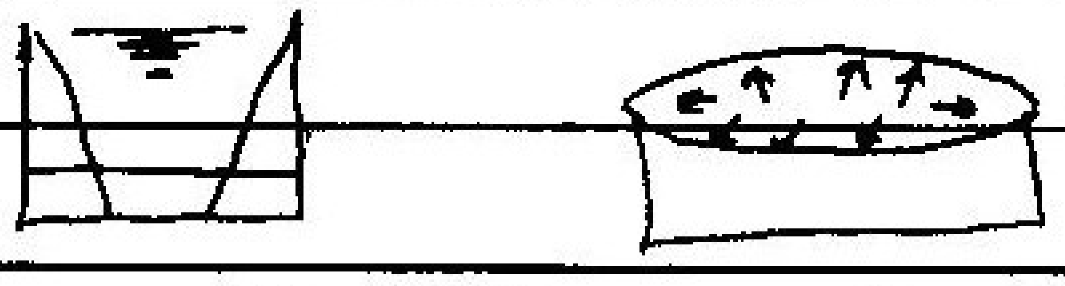
walls

Loads on walls

external soil pressure	Internal water pressure



الحوائط عليها ضغط



الحوائط عليها شد

$P = K_a \cdot \gamma_{soil} \cdot H$

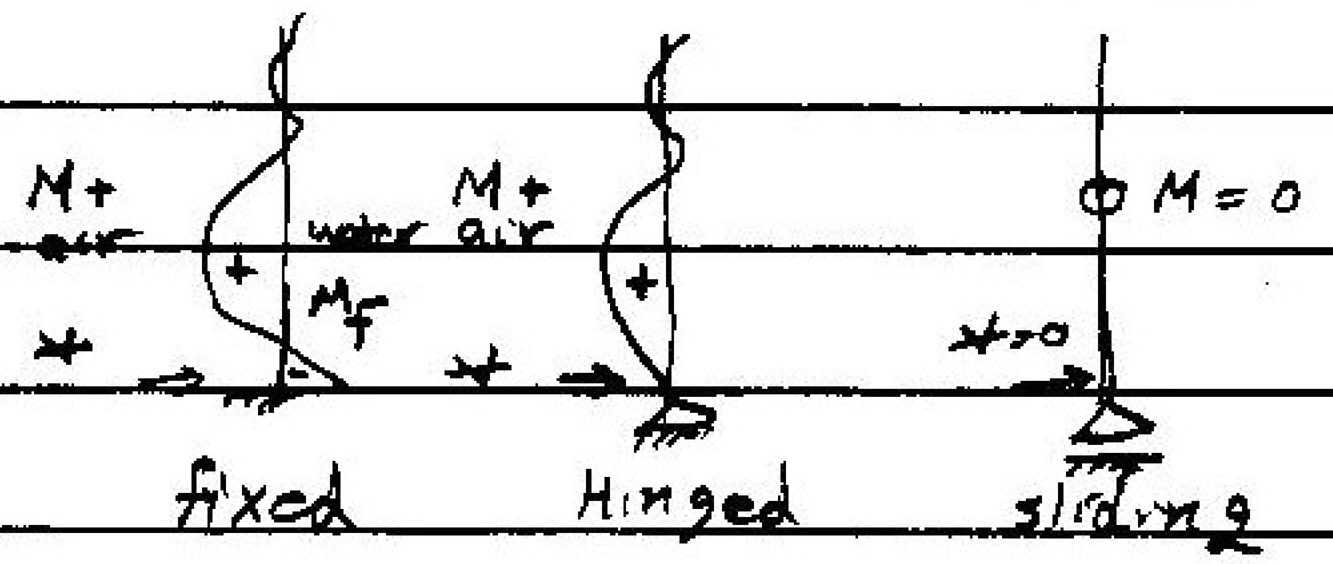
$K_a = 0.33 = \frac{1-\sin\phi}{1+\sin\phi}$

$P = \gamma_{water} * H$

↙ 1

straining actions on walls

vertical direction



Ring direction

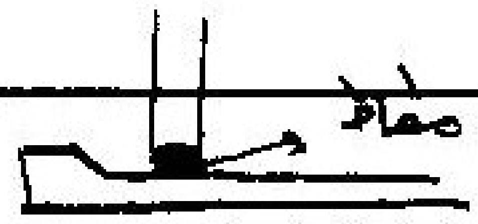
★ شد افقي (حلقات افقيه)

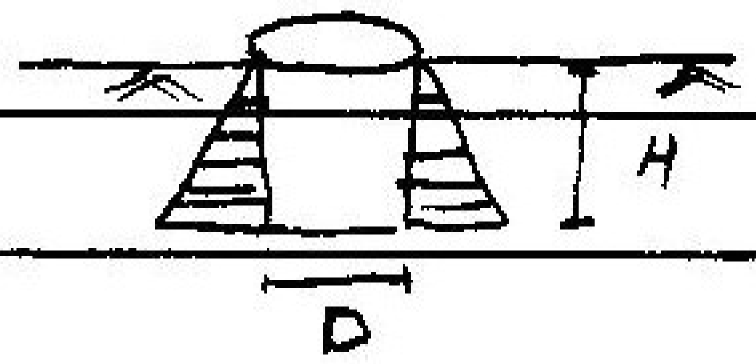
نتيجه ← ضغط المياه الداخلي

★ ضغط افقي (حلقات افقيه)

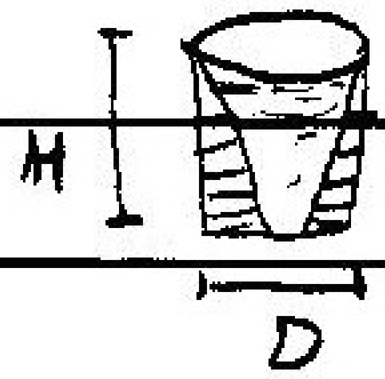
نتيجه ← ضغط التربه الخارجي

sliding wall [Special Method]





ضغط $N_{max\ ring} = K_a \cdot \gamma_{soil} \cdot H \cdot r$

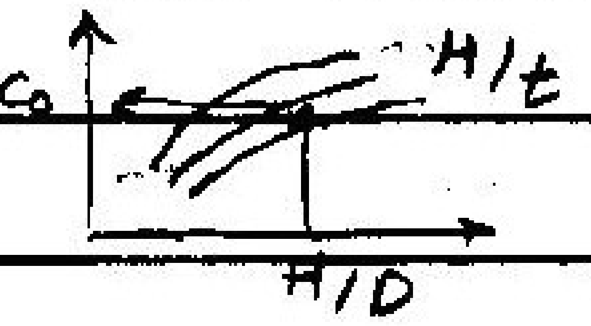
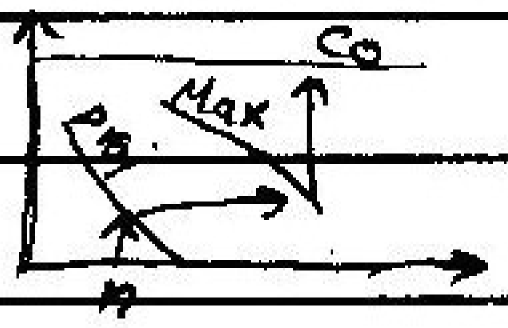


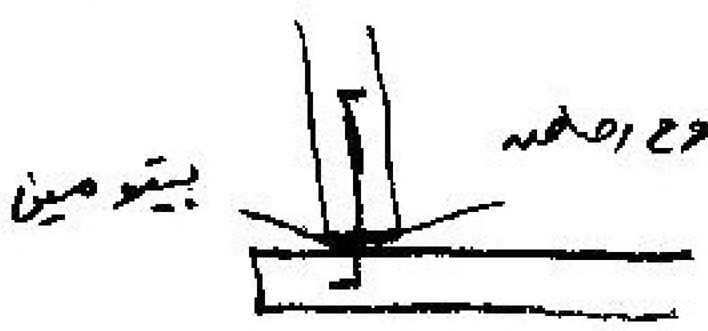
$T_{max\ ring} = \gamma_{water} * H * r$

(γ_{water} = 1, r = نص القطر $\frac{D}{2}$)

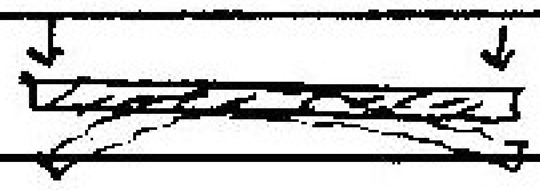
h	$T = K_a \cdot \gamma \cdot H \cdot r$	As = √J
2		
4		
6		

fixed wall

Reissner P (3-1)	simplified P (3-2)	P.C.A P.(3-4)→(3-16)	Approximate
Kg, cm وحدات	ton, m وحدات	ton, m وحدات	deep $\frac{H}{R^2} \geq 0.25$
$-n = 0.5 + 0.25\sqrt{\frac{f_{ct}\cdot H}{R^2\cdot \gamma}}$	- from $\frac{H}{R^2}$ get $C_1 - C_2 - C_3$	ass $t = 25cm = 0.25$ $H^2/D.t$ = ✓✓	$T_{ring} = 0.65\cdot\gamma\cdot H\cdot R$ t_{wall} → Reissner
$\gamma = 0.001$ kg/cm³	H/R² : C_1, C_2, C_3		$M_f = \frac{\gamma\cdot H\cdot D\cdot t}{7.5}$
H = ارتفاع الخزان بالـ م		- Table 1 ② → C_o	$M_{+ve} = M_f/5$
R = نصف قطر الخزان بالـ م		$H^2/D.t$: 1, 5, 16 → C_o	$V_{shear} = 0.25\cdot\gamma\cdot H$
$f_{ct} = 20$ kg/cm²	-t wall at base (cm) $= C_3\cdot\gamma\cdot H\cdot R$		medium
-t wall at base (cm) $= \frac{1.73\, H^2}{R\cdot n^2}$	- get C_o from curve 	أكبر C_o موجب في العمق $T_{ring} = C_o\cdot\gamma\cdot H\cdot R$	$0.025 < \frac{H}{R^2} < 0.25$ $T_{ring} = 0.5\,\gamma\cdot H\cdot R$ t_{wall} → reissner
ton, m وحدات		② - Table 7	$M_f = \frac{\gamma\cdot H\cdot D\cdot t}{9}$
- get C_o from curve 	$T_{ring} = C_o\cdot\gamma\cdot H\cdot R$	أكبر C_o موجب وسالب	$M_{+ve} = M_f/5$
	$-M_f = \frac{\gamma\cdot H\cdot D\cdot t_{wall}}{C_1}$	$M_f = C_o\,\gamma\, H^3$ ⊗ C- $M_{+ve} = C_o\cdot\gamma\cdot H^3$ C+	$V_{shear} = 0.3\cdot\gamma\cdot H$
$T_{ring} = C_o\cdot\gamma\cdot H\cdot R$	$-M_{+ve} = M_f/5$	⑫	shallow $\frac{H}{R^2} \leq 0.025$
$-M_f = \frac{\gamma\cdot R^2 t^2\cdot n(n-1)}{6H}$	$-V_{shear} = C_2\cdot\frac{\gamma H^2}{2}$	- Table 12 ← (hinged) fixed - Triangular → C_o = ✓✓	$T_{ring} = 0.2\,\gamma\cdot H\cdot R$ $M_f = \frac{\gamma\cdot H^3}{6}$
$-M_{+ve} = M_f/5$			$V_{shear} = \frac{\gamma\cdot H^2}{2}$
$-V_{shear} = \frac{\gamma\cdot R^2\cdot t^2\cdot n^2(2n-1)}{6H^2}$		$V_{shear} = C_o\cdot\gamma\cdot H^2$ ⇓ Hinged walls	



Base for fixed Tanks

weak soil	medium soil	rocky soil
الـ B/C ضعيفة جداً	sand - clay - sandy clay	صخر $B/C \geq 3\ kg/cm^2$
استخدام خوازيق	يحدث تشكل well deformation	لا يحدث تشكل - لا يتولد عزوم
يتعامل على انه elevated	يتولد عزوم سـ يجب دراستها	تكون عزوم الحائط ترتد على القاعدة
		لمسافة L ثم تموت

+ يتم نقل Q ليعمل شد في القاعدة

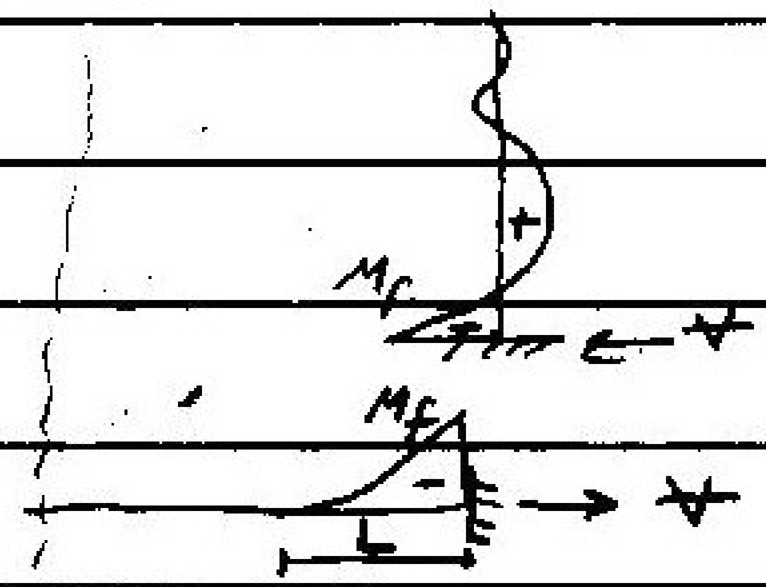
fixed tank - Rocky soil

* wall ⟹ $M_f = \checkmark\checkmark$ $M_{+ve} = \checkmark\checkmark$ $Q_{shear} = \checkmark\checkmark$ $T_{ring\ max} = \checkmark\checkmark$

* Base $w = t_{base} \cdot \gamma_{R.C} + \gamma_{water} \cdot H$

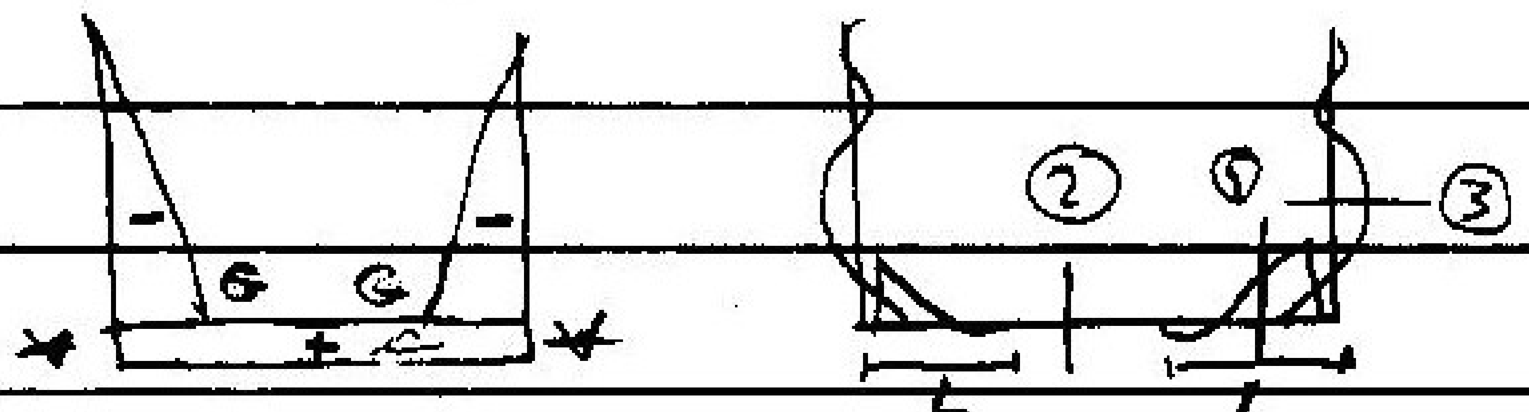
($t_{base} = 0.40$, $\gamma_{R.C} = 2.5$, $\gamma_{water} = 1$)

$$L = 2\sqrt{\frac{M_f}{w}}$$



* Total B.M.D , N.F.D

وزن الحائط $G = t_{wall} \cdot H \cdot \gamma_{R.C}$



* design of sections :-

1) Ring direction :- $T_{ring\ max}$

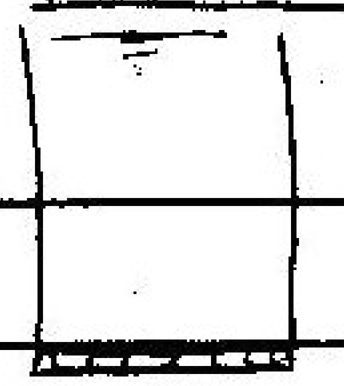
2) VL. direction :- sec (1) $M_{water\ side} + T$

sec (2) T only

sec (3) $M_{air\ side} + N_{compression}$

fixed base - medium soil

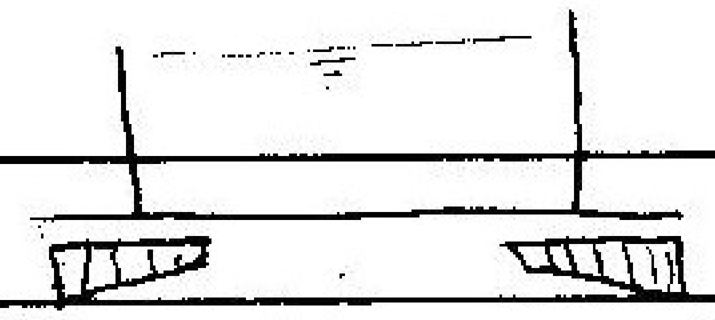
$\frac{D}{H} \leq 1.5$



⇓

plate نأخذ القاعده كلها ونحلها

$\frac{D}{H} > 1.5$



نأخذ جزء من القاعده مع الحائط ونحلهم wedge

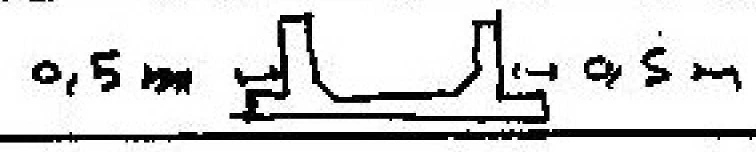
★ wall ⇒ $M_f = \checkmark\checkmark$ $M_{+ve} = \checkmark\checkmark$ $Q_{shear} = \checkmark\checkmark$ $T_{ring\ max} = \checkmark\checkmark$

★ Base

check stress on soil :- $\delta_{soil} = \gamma_{water} \cdot h_{water} + t_{base} \cdot \gamma_{R.C} + G \cdot \frac{2\pi R}{\pi R^2}$

(zero = empty tank; t_{base} = 0.3; $\gamma_{R.C}$ = 2.5; G = $t_{wall} \cdot h_{wall} \cdot \gamma_{R.C}$ (0.2); $2\pi R$ = محيط القاعده; πR^2 = مساحة القاعده)

$\delta_{soil} \not> B/C$ if not safe

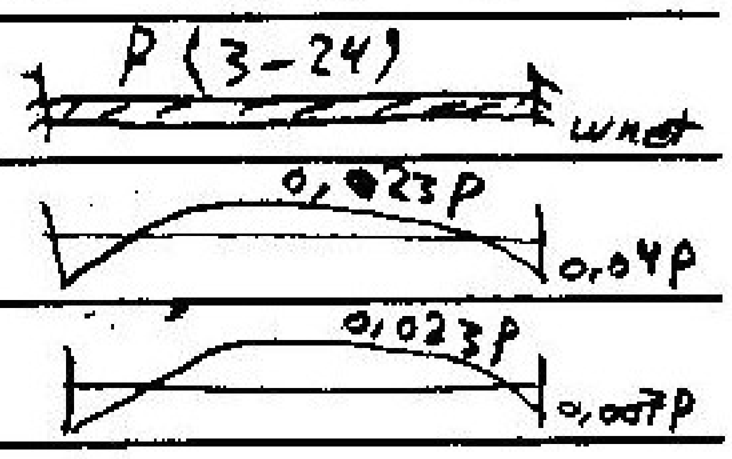


Moments on base :-

نحسب الحمل العامل الذي يعمل moment وهو الناتج من رد فعل الحوائط فقط

$w_{net} = G * \frac{2\pi R}{\pi R^2} = G * \frac{2}{R}$

تركيز الحمل $P = w_{net} * (\pi R^2)$



العزم M_{radial} يتزن مع العزم M_f للحائط

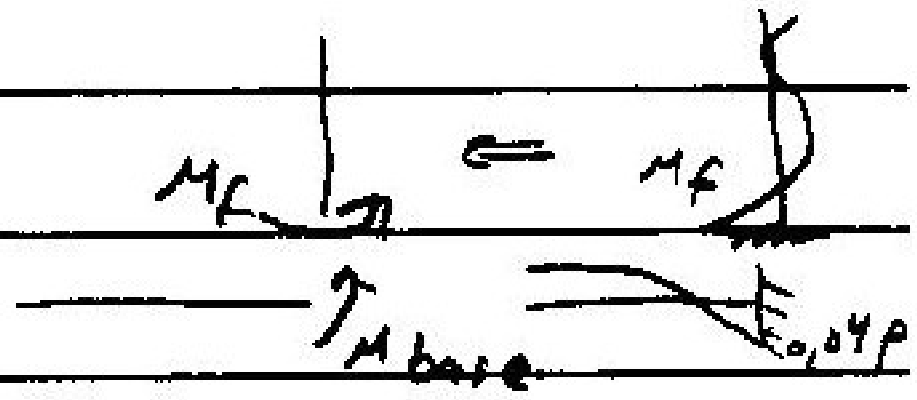
العزم M_{tang} يحتاج حديد على هيئة دوائر في القاعده

moment distribution :- P (3-19)

$K_{wall} = C_o \cdot \frac{E t^3}{H} = \checkmark E$

$H^2/D.t$		
C_o		

$K_{base} = \frac{0.104 \cdot E \cdot t^3_{base}}{R} = \checkmark E$

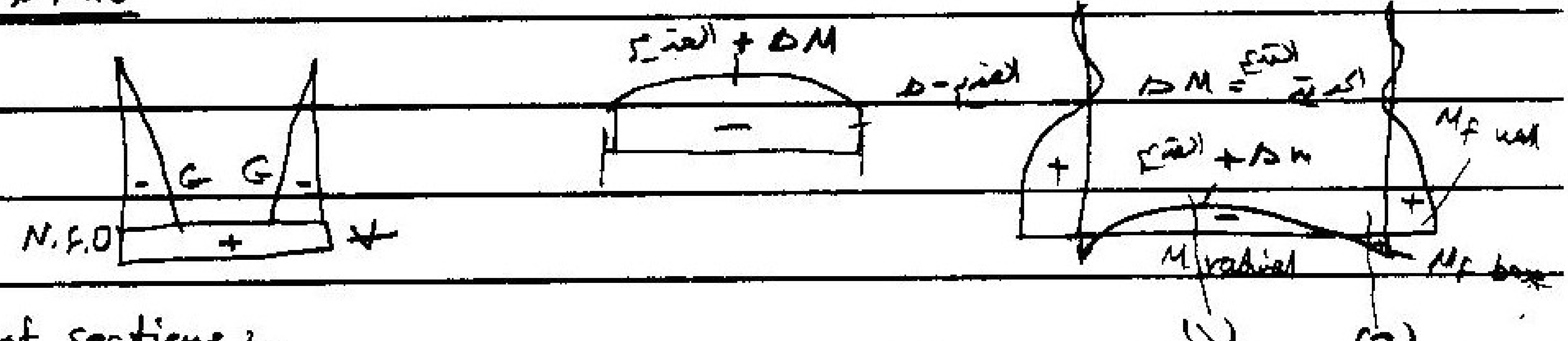


$D.f_{wall} = \frac{K_{wall}}{K_{base} + K_{wall}} = \checkmark\checkmark$

$D.f_{base} = 1 - D.f_{wall} = \checkmark\checkmark$

	wall	base
M_{fixed}	+ —	+ —
$D.M = D.f * \Sigma M_{fixed}$	- —	- —
final Σ	- ///	+ ///

final B.M.D



design of sections :-

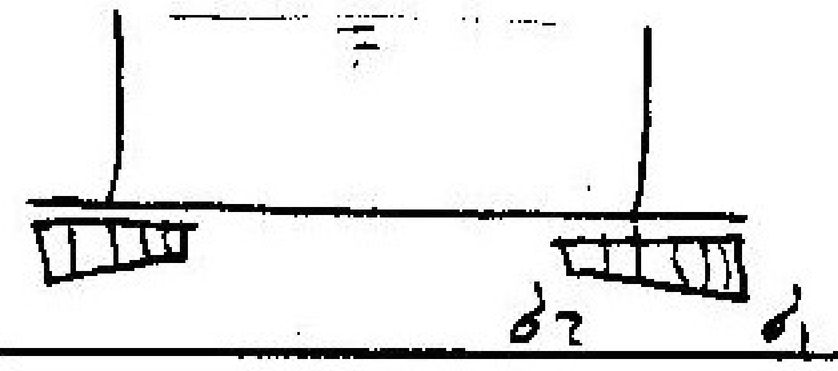
(1) Ring direction $T_{ring\ max}$

(2) VL direction   sec (1) $M_{water\ side} + T$

sec (2) $M_{air\ side} + T$

[6] $\frac{D}{H} > 1,5$

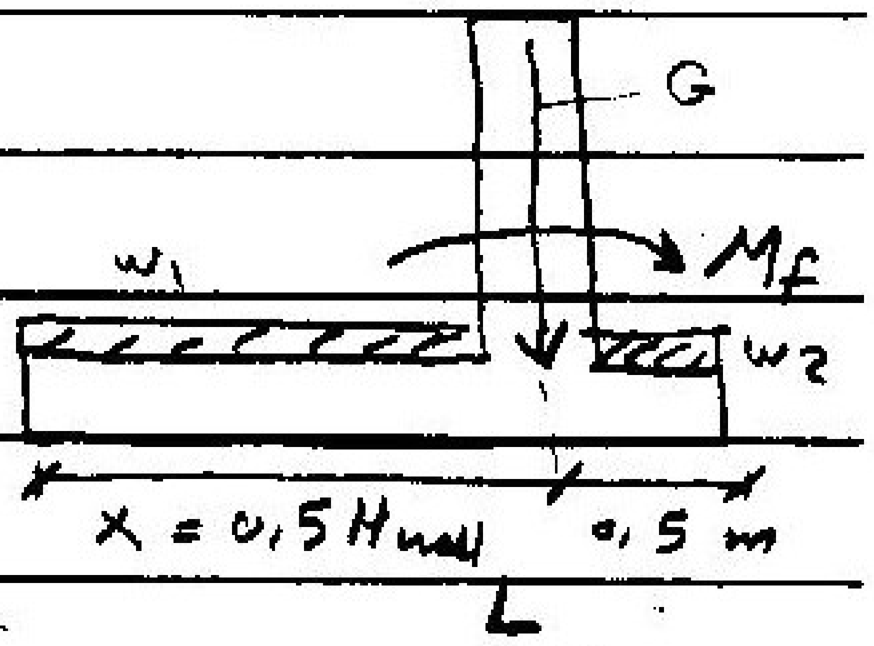
لا يوجد من القاعده بتتحمل الاجهاد الناتج من المائع



* wall ⟹ $M_f = \checkmark\checkmark$ $M_{+ve} = \checkmark\checkmark$ $Q_{shear} = \checkmark\checkmark$ $T_{ring\ max} = \checkmark\checkmark$

* **Base**

check of soil stress under base



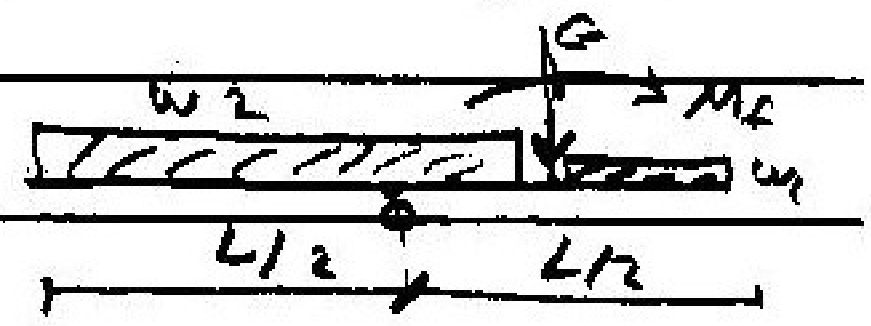
$G = t_{wall} * H_{wall} * \gamma_{R.C}$

$w_1 =$ وزن المياه + وزن القاعده $= \gamma_{\underset{1}{}} \cdot H + t_{\underset{0,3}{base}} \cdot \gamma_{\underset{2,5}{R.C}}$

$w_2 =$ وزن القاعده $= t_{base} * \gamma_{R.C} = 0,3 * 2,5$

$\Sigma M_o =$ جمع العزوم يمين وشمال $= \checkmark\checkmark\ [w_1 + w_2 + G + M_f]$

Normal force $N = \checkmark\checkmark\ [w_1 + w_2 + G]$

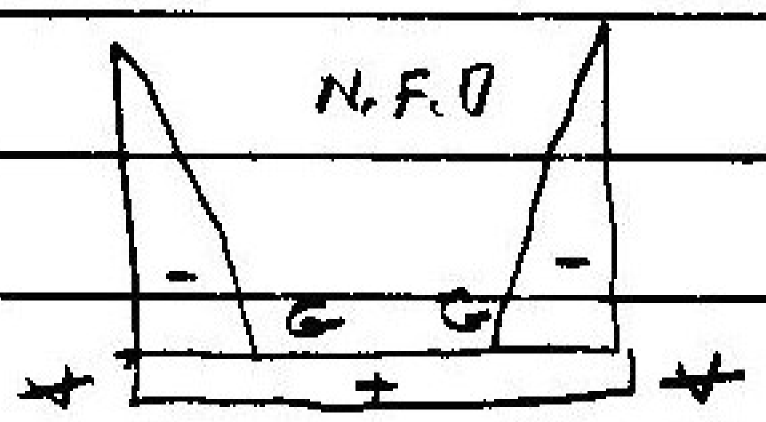


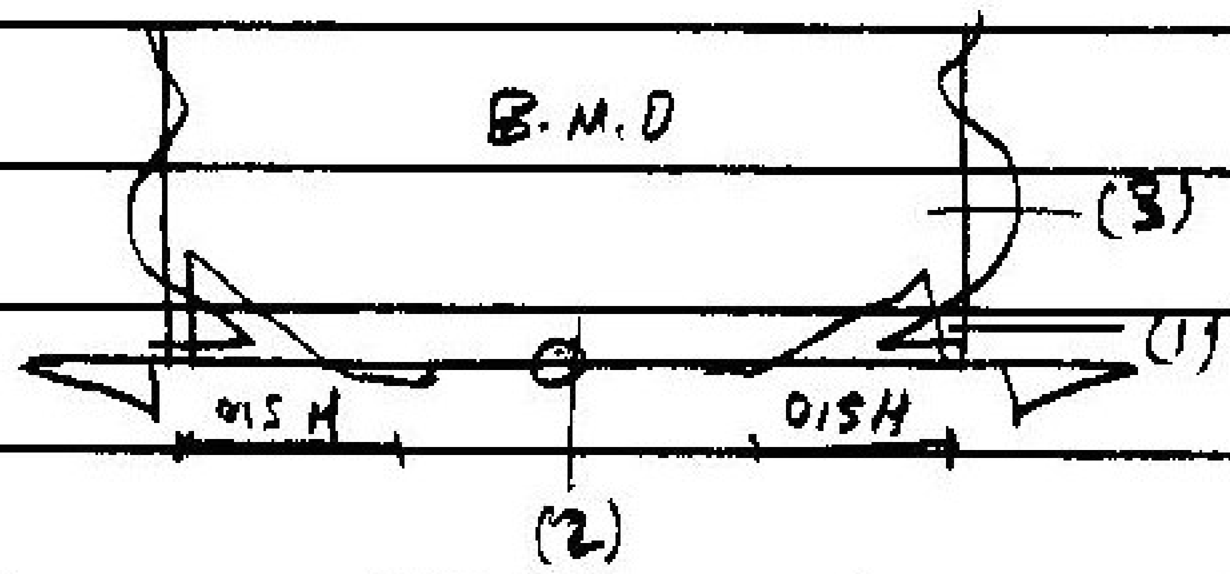
$\delta_{soil\ 1,2} = \pm \frac{6\ M_o}{B\ L^2} + \frac{N}{B \cdot L}$

$\delta_1 \ngtr B/c$ $\delta_2 \ngtr B/c$

Moments on wedge :- عزوم المائع لم تتغير عن الحالات الاولى M_+ , M_f

find B.M.D :-





design of sections :-

(1) Ring direction :- $T_{max\ ring}$

(2) VL direction :- sec (1) M water side , N compression neglect

sec (2) M = 0 , T only

sec (3) M air side , N compression neglect

Base for hinged Tanks

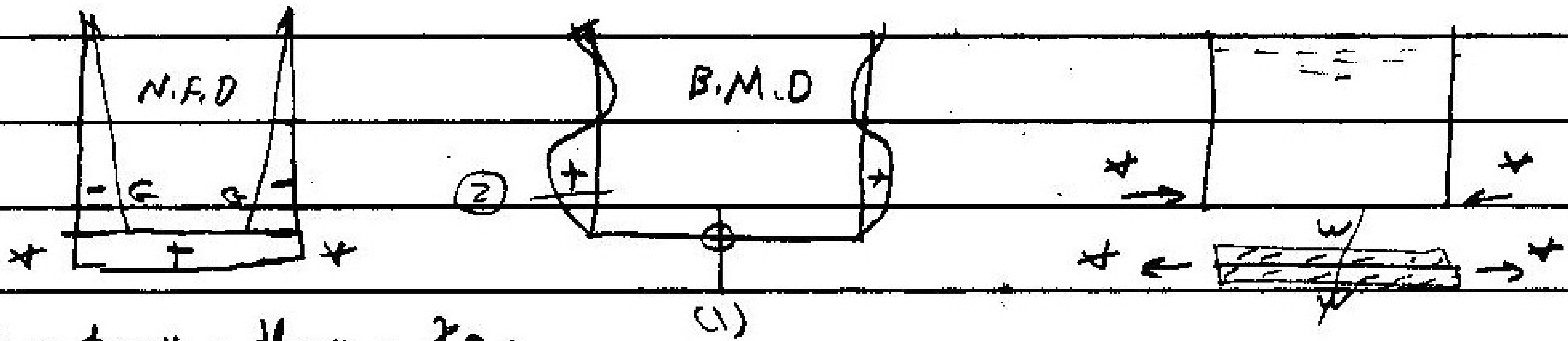
Hinged Tank - Rocky soil

* wall :- ⟶ P.C.A Method

T_{max} ring = ٧٧ M_{+ve} = ٧٧ V_{shear} = ٧٢

* Base:-

Rock soil ⟶ كل الا حمال المركزه والموزعه ترتد على نفسها ولا تعمل عزوم



$G = t_{wall} \cdot H_{wall} \cdot \gamma_{R.C}$ (t_{wall} = 0,25, $\gamma_{R.C}$ = 2,5)

* design of section:-

(1) Ring dorection T_{max} ring

(2) VL direction sec (1) T only

sec (2) $M_{air\ side}$ + N_{comp} neglect

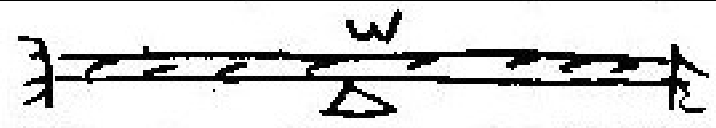
8

fixed base - weak soil
elevated Tank

★ wall: ⟹ $M_f = \checkmark\checkmark$ $M_{+ve} = \checkmark\checkmark$ $\tau_{shear} = \checkmark\checkmark$ Tring norm = ✓✓

★ Base:-

$w = t_{base} \cdot \gamma_{RC} + \gamma_{water} \cdot H$ (0.4, 2.5, 1) → $w = \checkmark\checkmark$



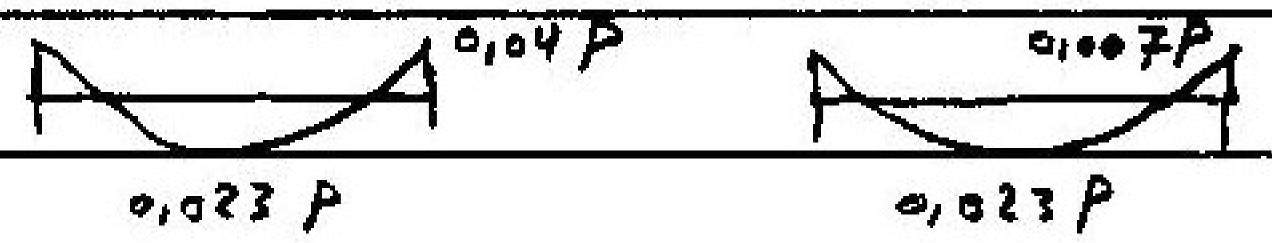
P (3-17)

تركيز الحمل $P = w * Area = w \cdot \pi R^2$

C → قطر الخازوم D → قطر الخزان $C/D = \checkmark\checkmark$

P (3-24)

Radial moment Tangential Moment



C/D	Co			
Radial 0.1	اول سالب	اكبر موجب	آخر سالب	
Tang 0.1	ثاني سالب	اكبر موجب	آخر سالب	

Moment = $Co \cdot w \cdot R^2$

equilibrium of Base & wall :- P (3-19) equilibrium

$K_{wall} = Co\, E\, t^3_{wall} / H$ ($H^2/D.t$ | Co)

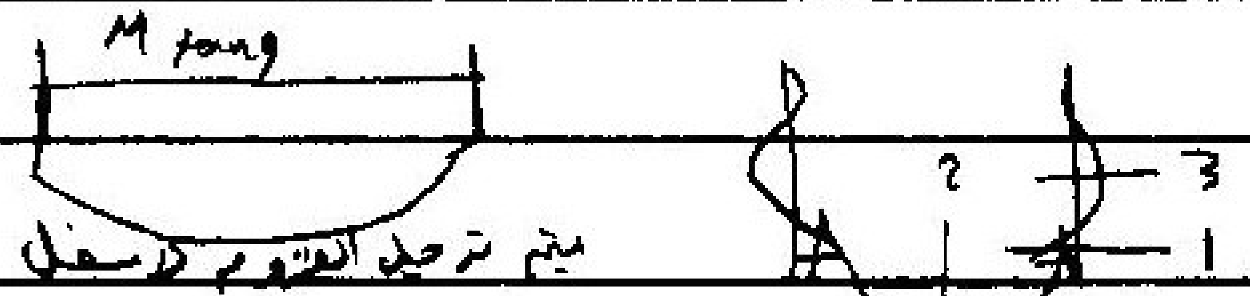
$K_{base} = 0.104\, E\, t^3_{base} / R$

$D.F_{wall} = K_{wall} / [K_{wall} + K_{base}]$

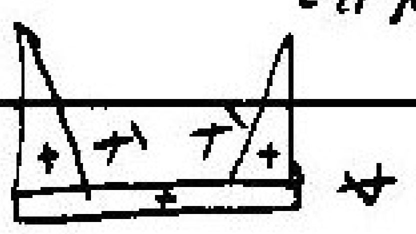
$D.F_{base} = 1 - D.F_{wall}$

	wall	base
M fixed	+	+
D.M = D.F × Σ M fixed	−	−
final Σ	−	+

final B.M.D :-



$T^1 = w * \frac{مساحة}{طول} = w * \frac{\pi R^2}{2\pi R} = w * \frac{R}{2}$ $T^1 = w * \frac{مساحة}{محيط} = \frac{\frac{\pi}{4}(D^2 - 4^2)}{2\pi R}$



★ design of sections :-

(1) Ring direction T max ring

(2) V.L direction sec (1) M water + T
sec (2) M air + T
sec (3) M=0 T

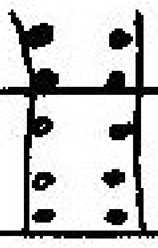
design of sections in Tanks

T

stage I :- working :

$t_{cm} = \xi * T_{ton} \geq 20$ cm (ξ = 0,6)

stage II :- ultimate :



$T_u = 1,5 * T$

$A_s = \dfrac{T_u * 10^3}{2 \, \dfrac{f_y}{\gamma_s}}$ على الجهتين (f_y — 3600, γ_s — 1.15) (36/52)

$A_{s\,min} = \dfrac{0,15}{100} B \cdot d$ or $\dfrac{0,25}{100} B \cdot d$ (# / ϕ; B = 100, d = t − 5)

5 ϕ 10 /m`

M

water side: stage I & II ← M → air side → II; use t = 25 cm, d = 20

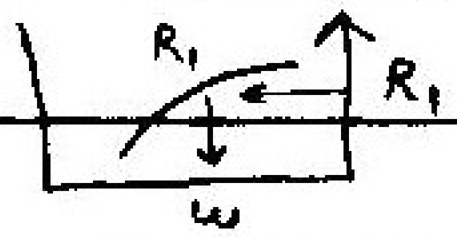
stage I :- working :

$t = \sqrt{\dfrac{M * 10^5}{\psi * B}}$ (ψ = 3,2; B — 100 شريحة)

stage II :- ultimate :

$M_u = 1,5 * M$ $d = t - 5$

$R_1 = \dfrac{M_u * 10^5}{f_{cu} * B * d^2}$ (f_{cu} = 250, B = 100)



$R_1 \xrightarrow{curve} \omega = 1,3 R_1$

$A_s = \omega * \dfrac{f_{cu}}{f_y} \cdot B \cdot d$ ناحية الشد (f_{cu} — 250, f_y — 3600, B — 100)

M , T

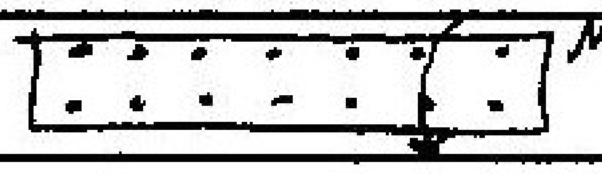
water side I & II ← M , T → air side II t = 25 d = 20

stage I :- $t = \sqrt{\dfrac{M * 10^5}{\psi * B}} + 5$ cm (ψ = 3,2; B = 100)

checks: Tension stress $\delta_t = \dfrac{6 M * 10^5}{B * t^2} + \dfrac{T * 10^3}{B * t} \not> f_{ct} = 18$ مقاومة الخرسانة للشد

stage II :-

$M_u = 1,5 M$ $T_u = 1,5 * T$ $d = t - 5$ $e = M_u / T_u$

$e/t \geq 0,5$ [big eccentricity]	$e/t < 0,5$ [small eccentricity]
ناحية العزم As 	As_1, As_2 
$e_s = e - \dfrac{t}{2}$ + cover (0,05)	
$M_{us} = T_u * e_s$	$As_1 = \dfrac{T_u * 10^3}{f_y / \gamma_s} * \dfrac{\frac{d-d'}{2} + e}{d - d'}$
$R_1 = \dfrac{M_{us} * 10^5}{f_{cu} \cdot B \cdot d^2} \longrightarrow \omega$ (f_{cu} = 250, B = 100)	
$A_s = \omega \cdot \dfrac{f_{cu}}{f_y} \cdot B \cdot d + \dfrac{T_u * 10^3}{f_y / \gamma_s}$ (f_{cu} — 250, f_y — 3600, B = 100, d = t − 5, γ_s — 1,15)	$As_2 = \dfrac{T_u * 10^3}{f_y / \gamma_s} * \dfrac{\frac{d-d'}{2} - e}{d - d'}$

M , N	N
neglect N (compression)	t_{min} = 20 cm
design on M (moment)	As_{min} = 5 ϕ 10 /m`

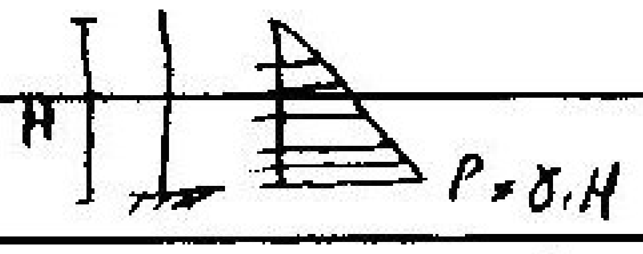
مهندس هشام

Rectangular Tanks

walls

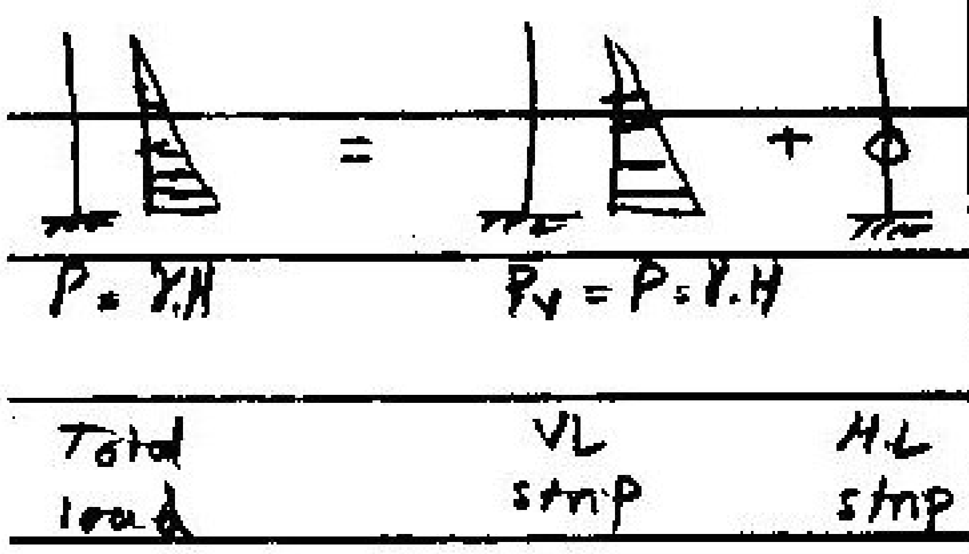
Loads on walls

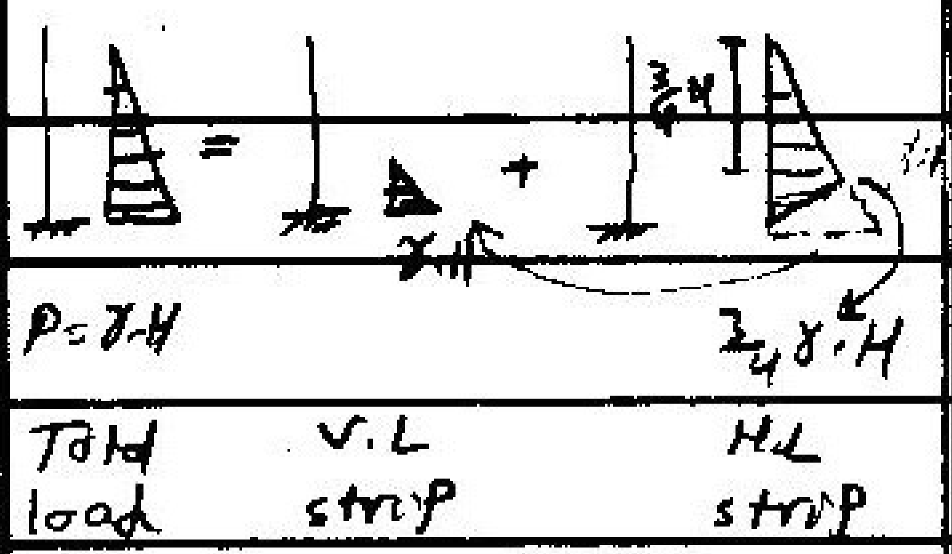
external soil pressure	Internal water pressure
$P = K_a \cdot \gamma_{soil} \cdot H$	$P = \gamma_{water} * H$
$K_a = 0.33 = \frac{1-\sin\phi}{1+\sin\phi}$	1

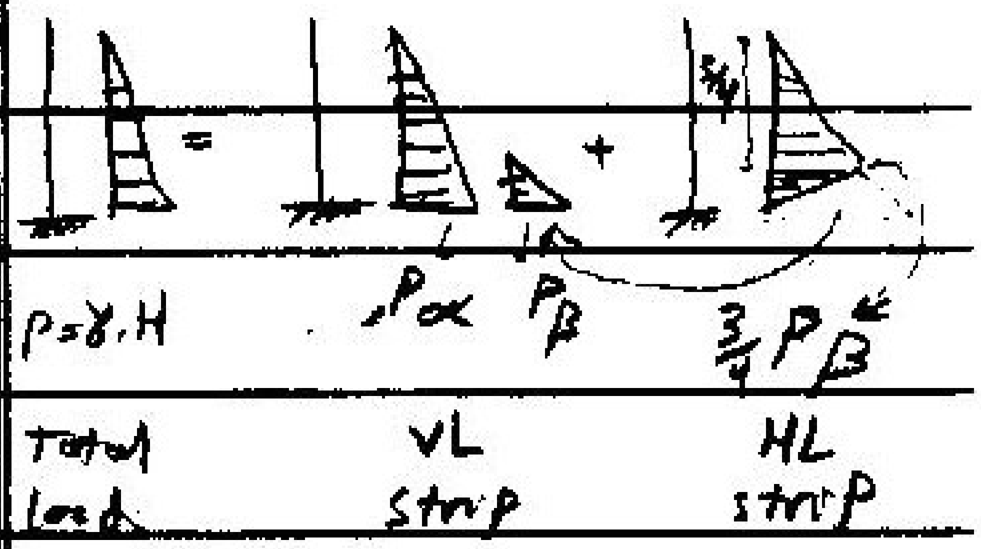


load distribution on walls

$\frac{L}{H} \geq 2$ shallow	$\frac{L}{H} \leq 0.5$ deep	$0.5 < \frac{L}{H} < 2$ medium
كل الاحمال تنتقل في الاتجاه الراسي	معظم الاحمال تنتقل في الاتجاه الافقي	الاحمال تتوزع على شرائح VL & HL







$r = \frac{Long}{Short} \longrightarrow$ grashof (1-12)

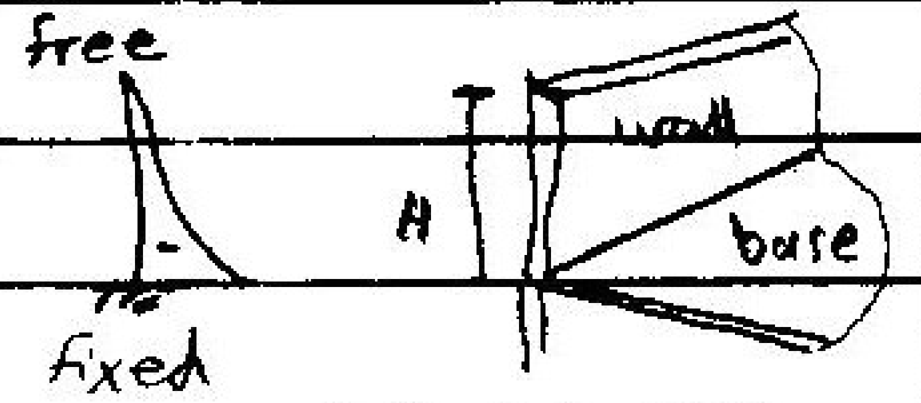
$P_\alpha = \alpha \cdot (\gamma \cdot H)$ للاتجاه القصير

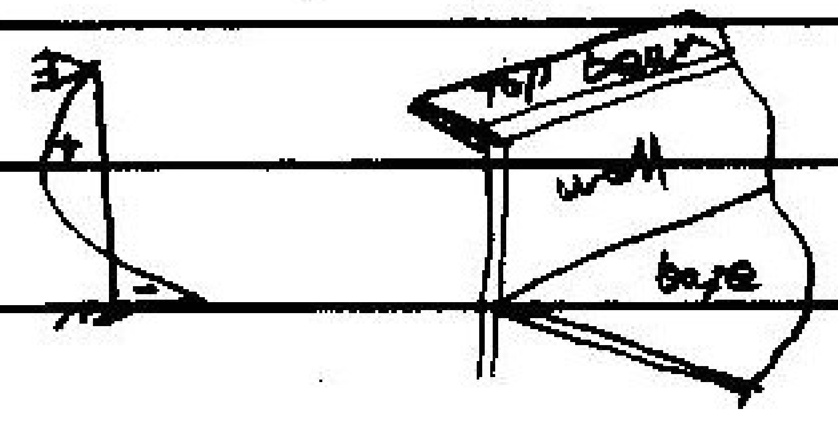
$P_\beta = \beta \cdot (\gamma \cdot H)$ للاتجاه الطويل

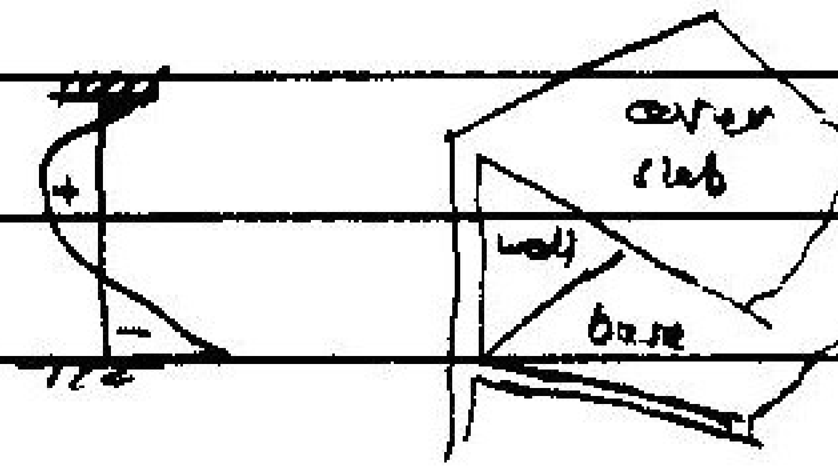
زي الاخر → طويل L قصير H

Top support

free at top	Top beam	cover slab
$H \leq 3.5\ m$	$H > 3.5\ m$	

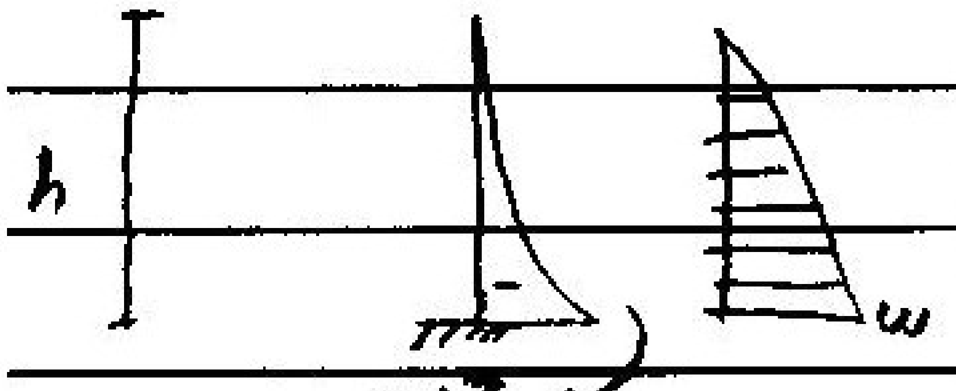
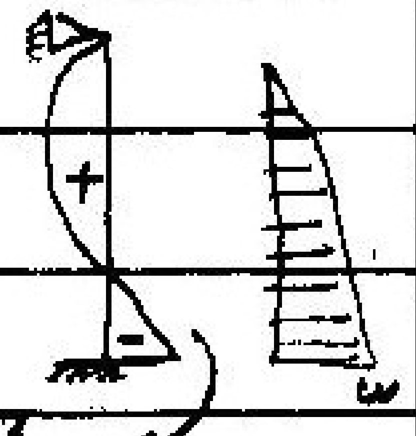
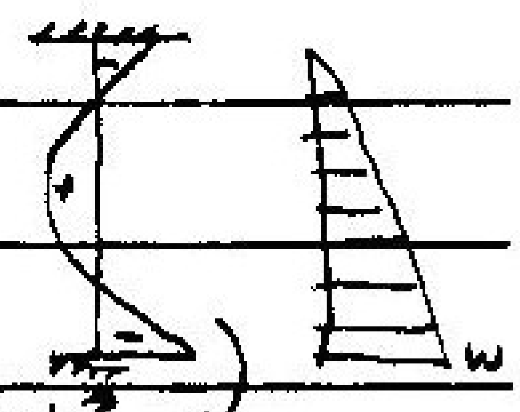
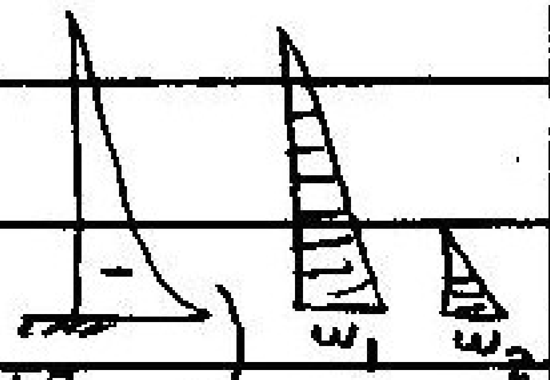
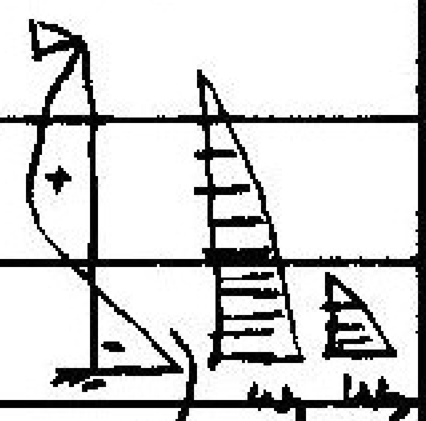
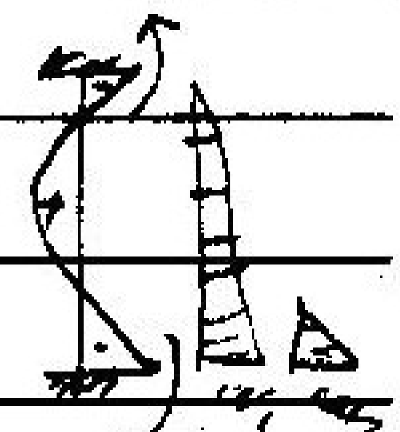
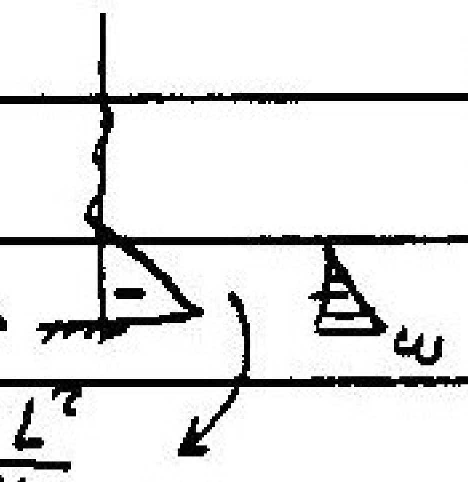
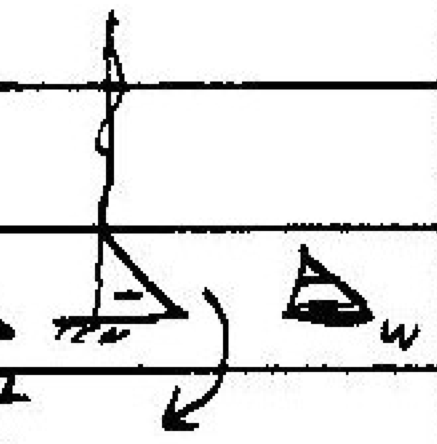
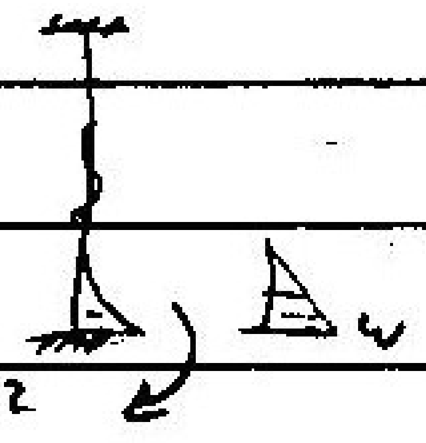






11

Moments on vertical strips

fixed - free	fixed - Hinged	fixed - fixed
 $\frac{wh^2}{6}$	$\frac{wh^2}{33,5}$  $\frac{wh^2}{15}$	$\frac{wh^2}{46,6}$  $\frac{wh^2}{20}$
 $\frac{w_1 h^2}{6} + \frac{w_2 h^2}{96}$	$\frac{w_1 h^2}{33,5} + \frac{w_2 h^2}{800}$  $\frac{w_1 h^2}{15} + \frac{w_2 h^2}{117}$	$\frac{w_1 h^2}{30} + \frac{w_2 h^2}{960}$ $\frac{w_1 h^2}{46,6} + \frac{w_2 h^2}{500}$  $\frac{w_1 h^2}{20} + \frac{w_2 h^2}{124}$
$R = 0,3\, wL \rightarrow$  $\frac{wL^2}{24}$	$R = 0,3\, wL \rightarrow$  $\frac{wL^2}{24}$	$R = 0,3\, wL \rightarrow$  $\frac{wL^2}{24}$

$H \rightarrow$ ارتفاع الحائط

$L \rightarrow$ العمودى على الشريحة

design of wall as beam

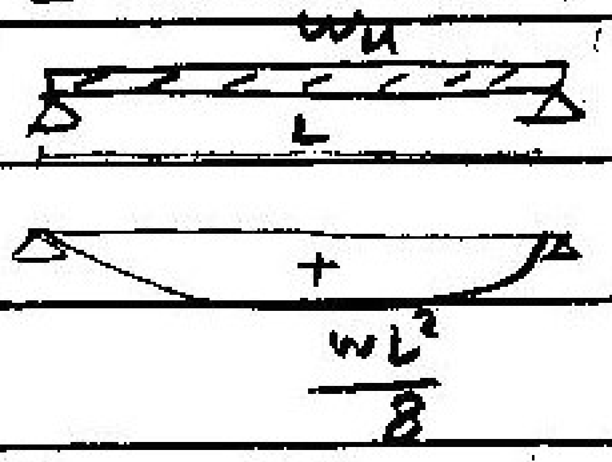
$w = R$ (من البلاطة على الحائط) $+$ own wt (وزن الحائط) $+$ top beam وزن الكمرة العلوية

own wt $= t_{wall} * H * \gamma_{R.C}$ ($t_{wall} = 0.25$, $\gamma_{R.C} = 2.5$)

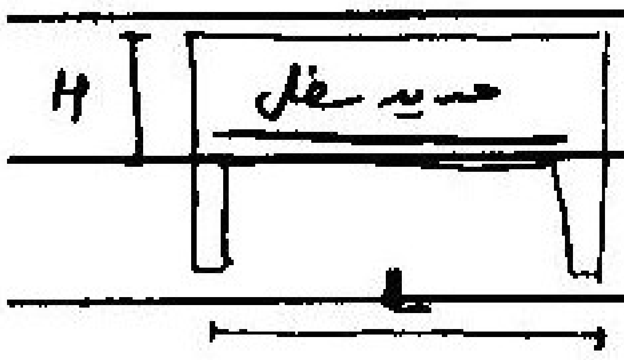
top beam $= b * t * \gamma_{R.C}$ ($b = 0.3$, $t = 0.6$, $\gamma_{R.C} = 2.5$)

$$w_u = 1.5 * w$$

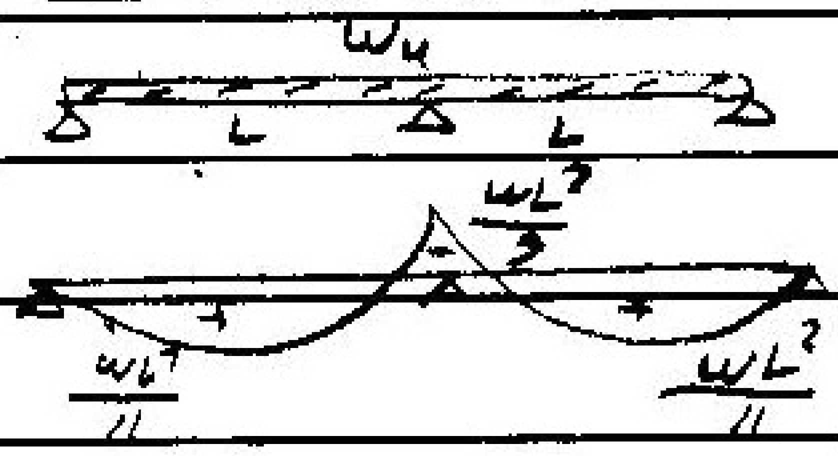
simple wall



deep beam	slender beam
$\frac{H}{L} > 0.8$	
$y_{ct} = 0.87 * H$ or L (الأصغر)	$R_1 = \frac{M_u * 10^5}{f_{cu} * b * d^2}$
$T_u = M_u / y_{ct}$	$w = 1.3\, R_1$
$A_s = \frac{T_u * 10^3}{f_y / \gamma_s}$ سفلي	$A_s = w \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d$



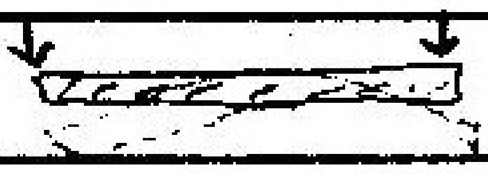
continous wall



deep beam	slender beam
$\frac{H}{L} > 0.4$	
- M+ve	$R_1 = \frac{M_u * 10^5}{f_{cu} * b * d^2}$
$y_{ct} = 0.43\, L$	$w = 1.3\, R_1$
$T_u = M_{+ve} / y_{ct}$	$A_s = w \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d$
$A_s = \frac{T_u * 10^3}{f_y / \gamma_s}$ سفلي	
- M-ve	
$y_{ct} = 0.37\, L$	
$T_u = M_{-ve} / y_{ct}$	
$A_s = \frac{T_u * 10^3}{f_y / \gamma_s}$ علوي	

Base

Loads on Base

weak soil	medium soil	rocky soil
- التربة ضعيفة جداً	sand - clay - sandy clay	صخر $B/c \geq 3\ kg/cm^2$
- استخدام خوازيق	يحدث تشكل deformation للقاعدة	لا يحدث تشكل - لا يتولد عزوم
{ elevated Tank }	يولد عزم ← يجب دراسته	لكنه عزوم الحائط ترتد على القاعدة
		لمسافة L ثم تموت

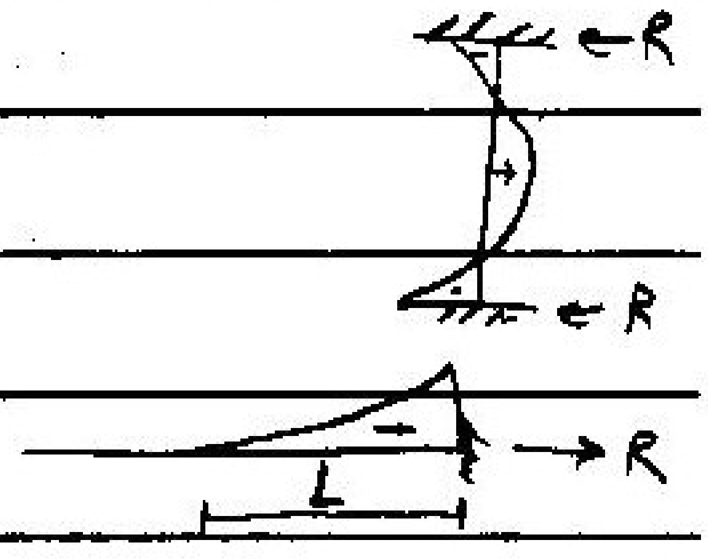
يتم تكبير R ليصل سند على القاعدة.

Rocky soil

★ wall: M_f , N

★ Base:

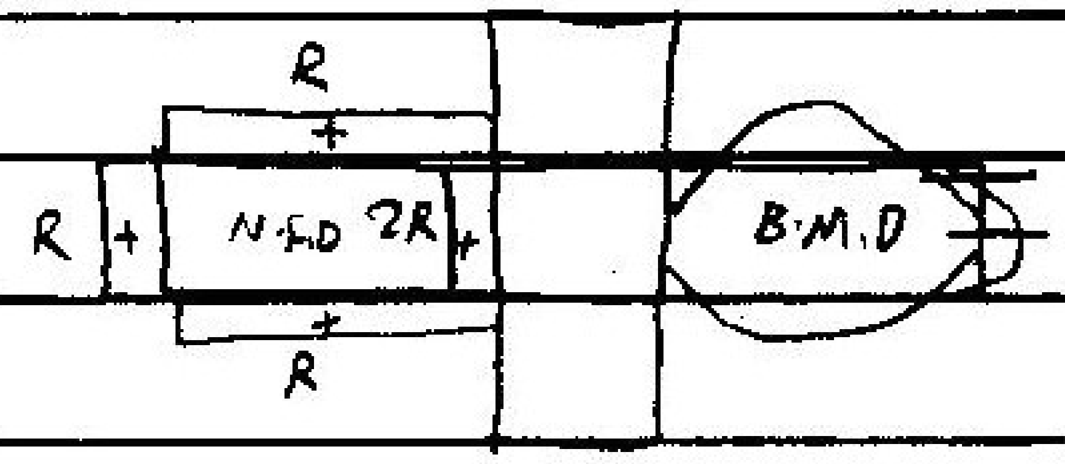
- loads on base: $w = t_{base} * \gamma_{R.C} + \gamma_{water} \cdot H$ (t_{base} = 0,4 ; $\gamma_{R.C}$ = 2,5 ; γ_{water} = 1)

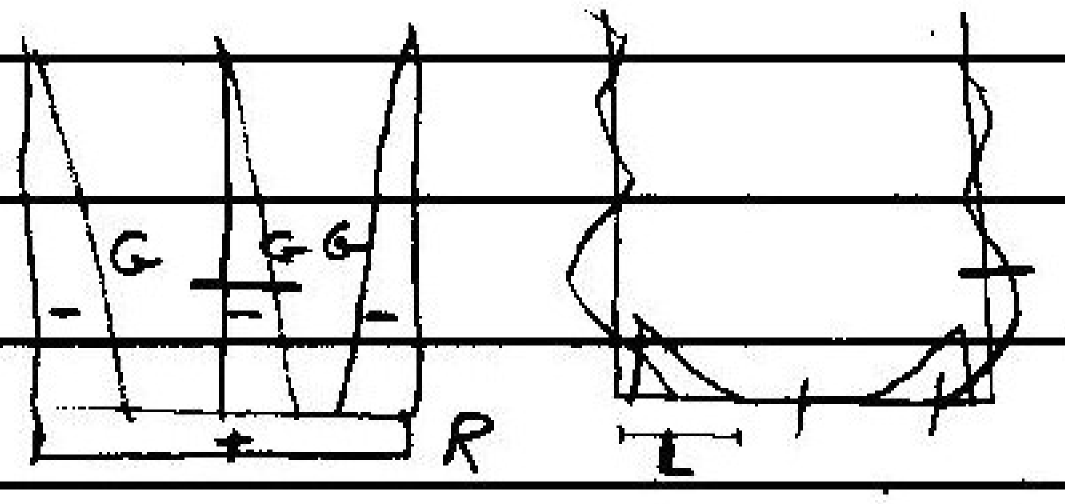


- load distribution: no calculation

$$L = 2\sqrt{\frac{M_f}{w_{base}}}$$

★ B.M.D & N.F.D وزن الحائط $G = t_{wall} * H * \gamma_{R.C}$ (t_{wall} = 0,25 ; $\gamma_{R.C}$ = 2,5)

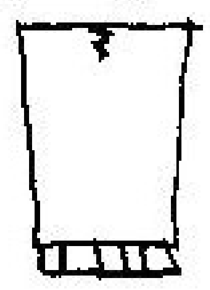




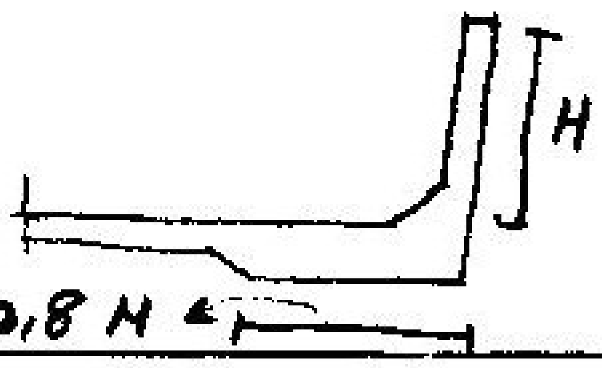
medium soil

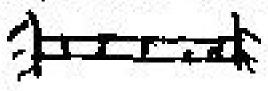
$\frac{L}{H} \leq 1.5$

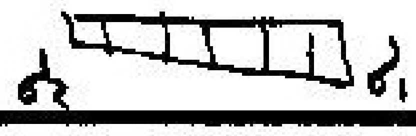
$L \rightarrow$ طول القطعة الواحدة للقاعدة
الطول العرضي للقاعدة



$\frac{L}{H} > 1.5$



uniform stress 

non-uniform stress 

★ wall : $M_f = \checkmark\checkmark$

★ Base : - check stress on soil

δ_{soil} = وزن القاعدة + وزن المياه + الحوائط + الكمرات + السقف + الاعمدة $\ngtr B/C$ H

وزن القاعدة = $t_{base} * \gamma_{R.C}$ (0.4) (2.5) وزن المياه = $\gamma_{water} * H$ (1)

الحوائط = $\frac{G * \text{محيط الحوائط}}{\text{مساحة الخزانة كلها}}$ ($t_{wall} \cdot H \cdot \gamma_{RC}$; 0.25, 2.5) الكمرات = $\frac{\text{وزن الكمرات} * \text{محيط الكمرات}}{\text{مساحة الخزانة كلها}}$ (30 * 80 cm) ($\times \gamma_{R.C}$)

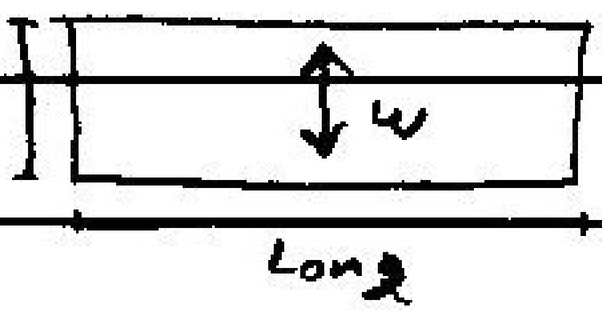
السقف = $w_{Live} + t_{roof} * \gamma_{RC}$ (0.5, 0.25, 2.5) الاعمدة = $\frac{\text{وزن العمود} * \text{عدد الاعمدة}}{\text{مساحة الخزانة كلها}}$

- **loads under base :** احمال مباشرة

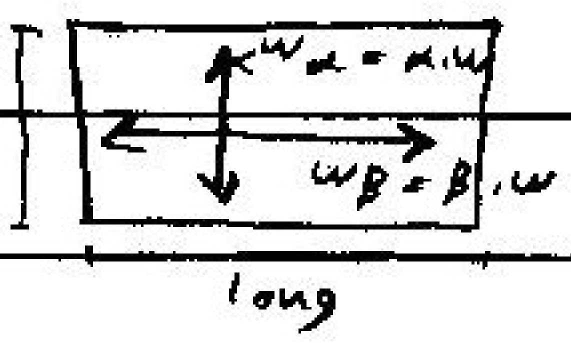
$W_{net} = \delta_{soil} - \{t_{base} \cdot \gamma_{R.C} + \gamma_{water} \cdot H\}$ الحمل الصافي الذي يرتد على القاعدة ليعمل عزم

- **load distribution** [grashof P(1-12)]

$\frac{Long}{Short} \geq 2$ {one way}



$\frac{Long}{Short} < 2$ [Two way]



α → short
β → long

elevated Tank

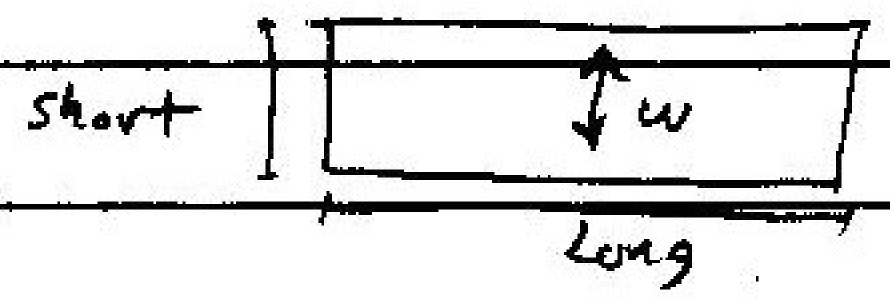
*** wall :** $M_f = W$

*** Base :**

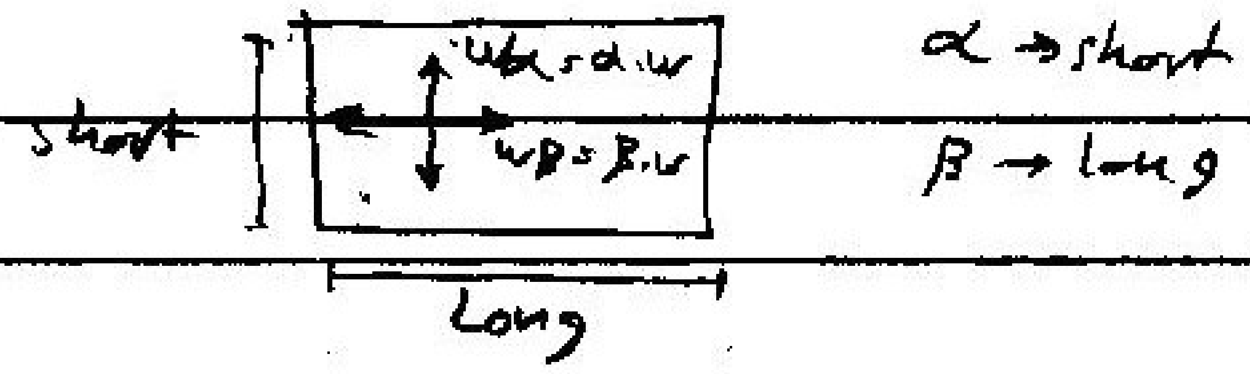
- **loads on base :-** $w = t_{base} * \gamma_{R.C} + \gamma_{water} \cdot H_w$ (t_{base} ≈ 0.4, $\gamma_{R.C}$ = 2.5, γ_{water} = 1)

- **load distribution :-** [grashof P(1-12)]

$\frac{long}{short} \geq 2$ {one way}

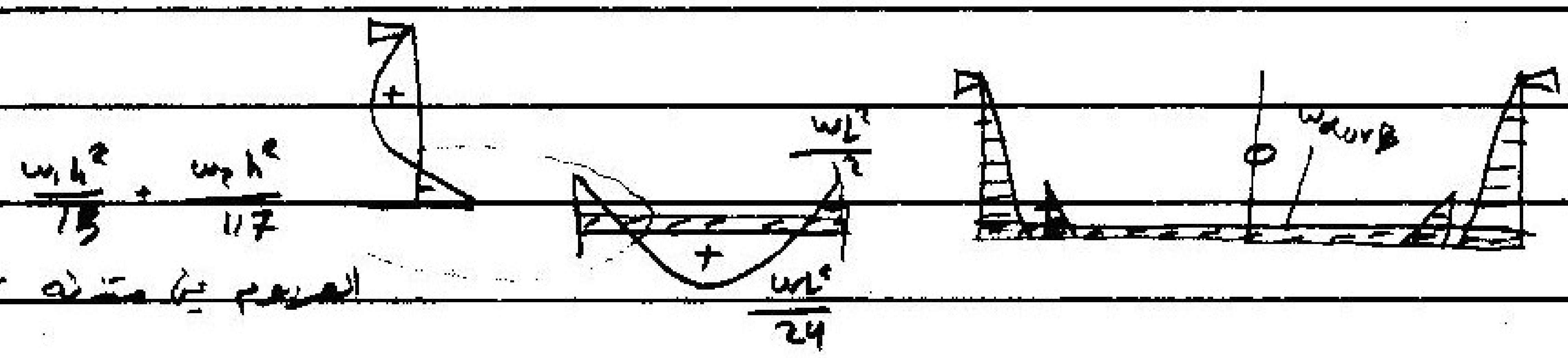


$\frac{Long}{Short} < 2$ [Two way]



*** strips :**

VL. strip

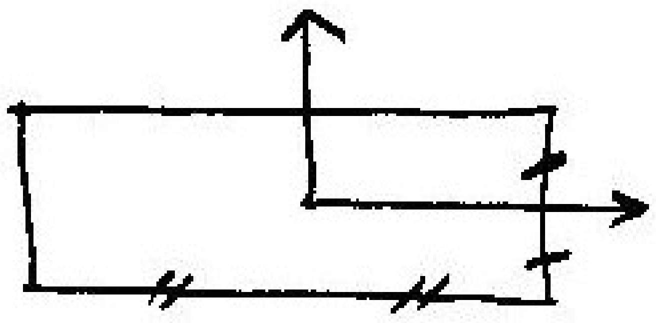


Maverage
or P(3-19) ← [illegible]

حل

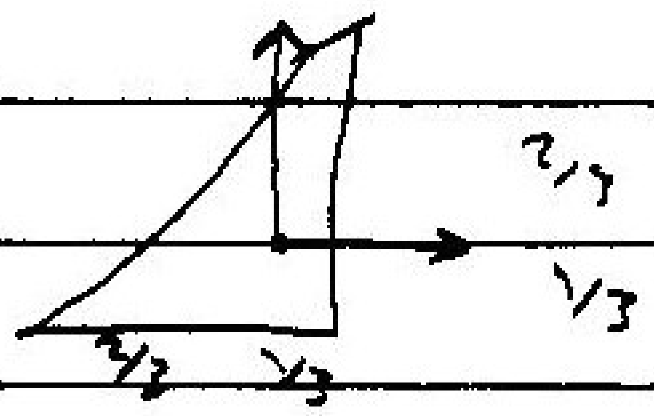
$$I_x = \frac{\text{موازي} \times \text{عمودي}^3}{12}$$

$$I_y = \frac{\text{موازي} \times \text{عمودي}^3}{12}$$



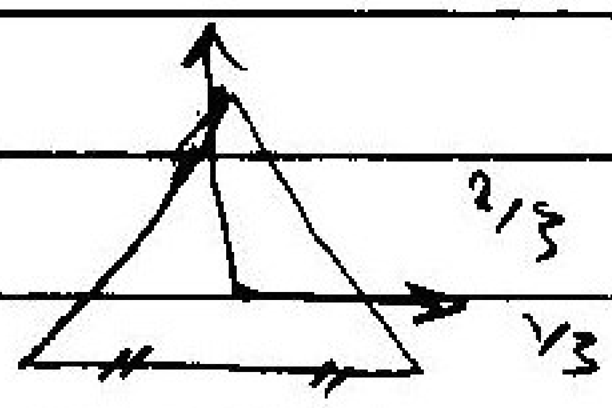
$$I_x = \frac{\text{موازي} \times \text{عمودي}^3}{36}$$

$$I_y = \frac{\text{موازي} \times \text{عمودي}^3}{36}$$

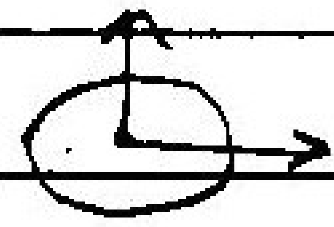


$$I_x = \frac{\text{موازي} \times \text{عمودي}^3}{36}$$

$$I_y = \frac{\text{موازي} \times \text{عمودي}^3}{48}$$

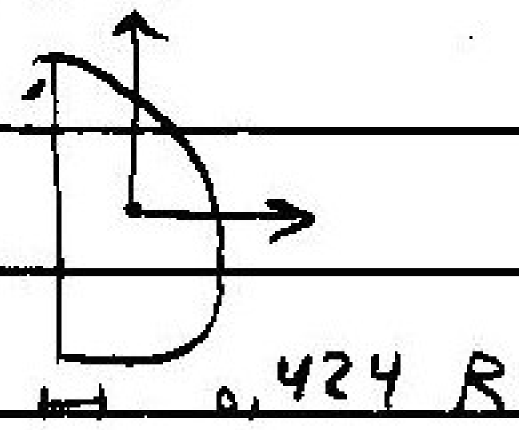


$$I_x = I_y = \frac{\pi}{64} D^4$$

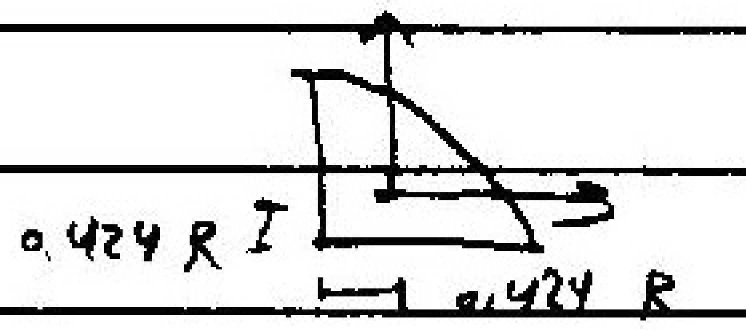


$$I_x = \frac{\pi}{8} r^4$$

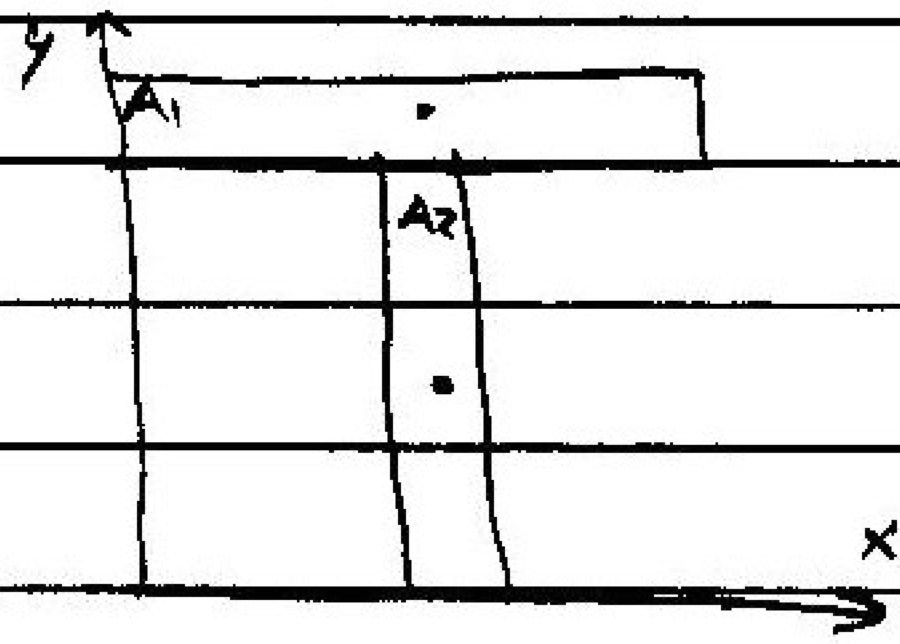
$$I_y = 0.11\ r^4$$



$$I_x = I_y = 0.055\ r^4$$



	A	x	y
A_1	/	/	/
A_2	/	/	/
A_{tot}	Σ /		



$$x_{cg} = \frac{A_1 \times x_1 + A_2 \times x_2}{A_{tot}}$$

$$y_{cg} = \frac{A_1 \cdot y_1 + A_2 \cdot y_2}{A_{tot}}$$

$$I_x = \text{——} + A(y)^2$$

$$I_y = \text{——} + A(x)^2$$

wall	weight	x_i	y_i	I_x	I_y	$\bar{X} =$	$\bar{y} =$
	$b.t.\gamma_{R.c}.H_{floor}$					$x_i - X_r$	$y_i - y_r$
A $b*t$	$b.t.\gamma_{Rc}.H$	بعد المركزين		$\frac{b\,t^3}{12}$	$\frac{t.b^3}{12}$	بدون إشارة	
B $b*t$		(0,0)					
c $b*t$		↙ أسفل شمال					
slab	$w_s * Area$ ↓	✓	✓	//////	//////	//////	//////
	$t_s.\gamma_{R.c}$ + cover						
	+ walls + live						
Σ	✓✓	//////	//////	✓✓	✓✓	//////	//////

* Center of mass :- مركز الكتلة

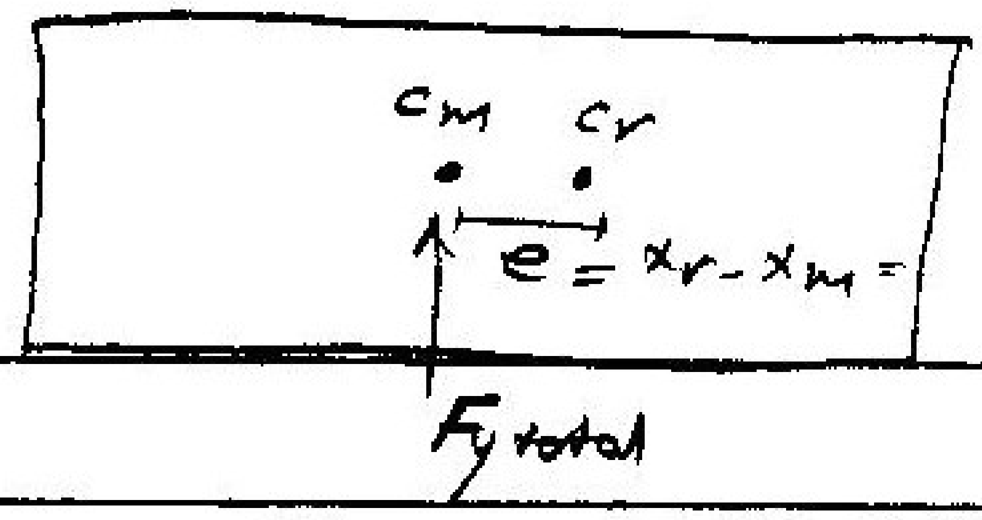
$$X_m = \frac{\Sigma\, w_i * x_i}{\Sigma w_i} = \frac{w_1 * x_1 + w_2 * x_2 + w_3 * x_3 + wall * x_4}{\Sigma\ weight}$$

$$y_m = \frac{\Sigma\, w_i * y_i}{\Sigma w_i}$$

* center of rigidity :- مركز الجساءة

$$x_r = \frac{\Sigma\, I_x . x_i}{\Sigma I_x} = \frac{I_{x1} * x_1 + I_{x2} . x_2 + I_{x3} . x_3}{\Sigma I_x}$$

$$y_r = \frac{\Sigma\, I_y . y_i}{\Sigma I_y}$$



بدون اشاره

$$M_{Total} = F_{total} * e$$

*** distribution of earthquake force to walls ***

قوه ناتجه من ال torsion	direct force
لها مركبتين	قوه في اتجاه قوه الزلزال فقط
$f_{x_t} = \frac{I_{y_i} * \bar{y}_i * M_T}{J_r}$	$f_y = \frac{I_{x_i}}{\Sigma I_x} * F_{y\,total}$
$f_{y_t} = \frac{I_{x_i} * \bar{x}_i * M_T}{J_r}$	or $f_x = \frac{I_{y_i}}{\Sigma I_y} * F_{x\,total}$

$$J_r = \Sigma I_{x_i} * \bar{x}_i^2 + \Sigma I_{y_i} * \bar{y}_i^2$$

direct force (→ f_y) — forces from torsion (→ f_{x_t}, f_{y_t})

wall	I_{x_i}	$\bar{x}_i$	I_{y_i}	$\bar{y}_i$	f_y	f_{x_t}	f_{y_t}
A	/	/	/	/			
B	/	/	/	/			
C	/	/	/	/			
.							
↓							
Σ	✓	//////	✓	//////	//////	//////	//////

earthquake loads

$$V = Z \cdot I \cdot K \cdot C \cdot S \cdot W$$

(0,2 ; 1,– ; 1,33 ; 1,3)

Z : Zone factor	Zone one	0,1
	Zone two	0,2 ✓
	Zone Three	0,3
I : Important factor	Important	1,25
	not-Important	1,– ✓
K : statically system	1,3 ✓	- النظام الصندوقي (حوائط قص)
	0,67	- اطارات ممطوليه
	0,80	- اطارات غير ممطوليه
	1,–	- اطارات + حوائط قص

$C = \frac{1}{15\sqrt{T}} \not> 0,12$

$T = \frac{2\pi}{w}$

$T = 0,1\ N$ — N عدد الادوار

✓✓ $T = \frac{0,09\ H}{\sqrt{B}}$ — H ارتفاع المبنى الكلي من الاساسات; B البعد الافقي الموازي لقوة الزلزال

S : soil factor	1,–	تربه متماسكه
	1,15	تربه متوسطه
	1,20	تربه ضعيفه

W : weight — وزن المبنى كله

L.L ≤ 500 — W = D.L

= Σ weight * عدد الادوار — L.L > 500 — W = D.L + 0,5 L.L

$F_{top} = 0,07 * T * V \not> 0,25\ V$ (T: الزمن)

لو الزمن اقل من ٧, - اليكون = صفر

$F = \frac{(V - F_{top}) * H}{H_1 + H_2 + H_3 \ldots}$ (H: ارتفاع الدور)

$F_i = (V - F_{top}) * \frac{W_i * H_i}{\Sigma W_i * H_i}$

Floor	H_i الارتفاع من منسوب الاساسات	W_i وزن كل دور	$W_i * H_i$	F_i
1	3	3571,6		
2	6	3571,6		
3	9			
Σ	//////	✓	✓	✓

wind loads

$$P_e = C_f * K * q$$

(C_f → ١،٣ ; q → 0,007)

q =	90	مرسى مطروح
	80	الاسكندرية - السلوم - الغردقة - ابو سويرة
	70 // = 0,07 t/m²	القاهرة - اسيوط - الزقازيق - المدن الساحلية
	60	سيوه - الداخلة
	50	الفيوم - المنيا - الاقصر - اسوان - الداخلة - المنصورة - دمنهور

K =	١،-	١٠ ← ٠
	١،١	٢٠ ← ١٠
	١،٢	٣٠ ← ٢٠
	١،٥	٥٠ ← ٣٠
	١،٧	٨٠ ← ٥٠
	١،٩	١٢٠ ← ٨٠
	٢،١	١٦٠ ← ١٢٠
	٢،٢	١٦٠ <

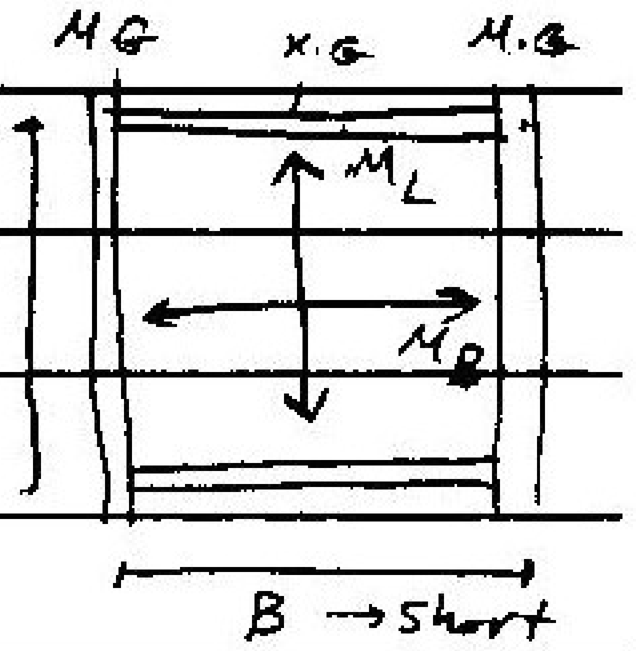
$C_f = 0,5 + 0,8 = ١،٣$

H start	H end	K	P_e
0	١٠	١،-	
١٠	20	١،١	
20	30	١،٢	
30	50	١،٥	

story	P تركيز (عند كل دور)	wind force (/1000) B = ٧٧٤٠	B = ٧٧١٥
١	$P_e * \Sigma \frac{2,5}{2,5}$	P * B	P * B
2			
3			
4			

R.c Bridge

deck slab



*** dead loads :-**

$w = t_{slab} * \gamma_{R.C} + t_{asphalt} * \gamma_{asphalt}$ L → long

(0,25) (2,5) (0,08) (2,2)

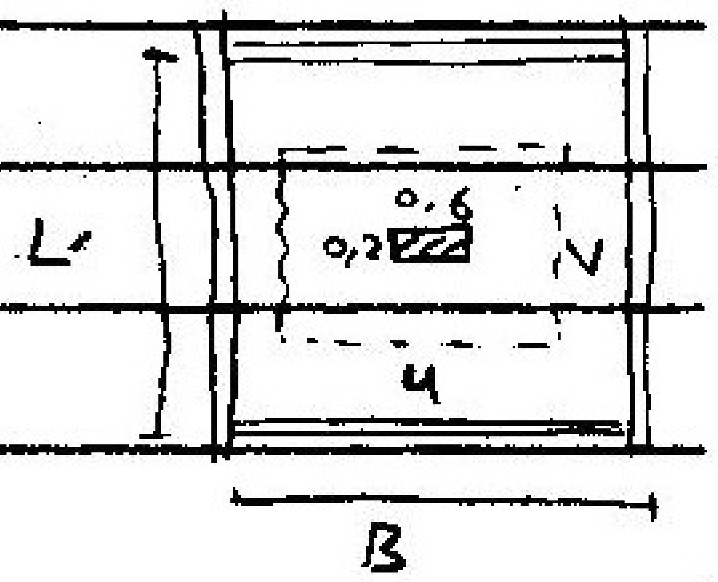
تركيز الحمل $P = w * \text{Area slab} - B * L$

$\because \frac{u}{B} = 1$ $\frac{v}{L} = 1$ ⟶ الحمل موزع على البلاطة كلها

$k = \frac{Long}{short} = √√$ ⟹ Page (4-6) ⟹ $m_1 = √√ * 10^{-2}$ $m_2 = √√ * 10^{-2}$

M_B short $= P(m_1 + 0,15\ m_2) = √√$

M_L long $= P(m_2 + 0,15\ m_1) = √√$



*** Live load :-**

Impact factor $I = 0,4 - 0,008\ B$

حمل عجلة واحدة $P = 10\ (1 + I)$

$u = 0,6 + 2\ t_{asphalt} = 0,6 + 2 * 0,08 = 0,76$

$V = 0,2 + 2\ t_{asphalt} = 0,2 + 2 * 0,08 = 0,36$

$\frac{u}{B} = \frac{0,76}{} = √√$ $\frac{V}{L} = \frac{0,36}{} = √√$

Page (4-6) ⟹ $m_1 = √√$ ⟹ $m_2 = √√$

M_B short $* M_L$ long $= P(1+I)(m_1 + 0,15\ m_2) = √√$

*** total Moment :**

معامل اتصال

$M_B = 0,8\ (\text{dead} + \text{Live})$ $M_L = 0,8\ (\text{dead} + \text{Live})$ take max

*** design :**

$M_u = 1,5\ M_{max}$

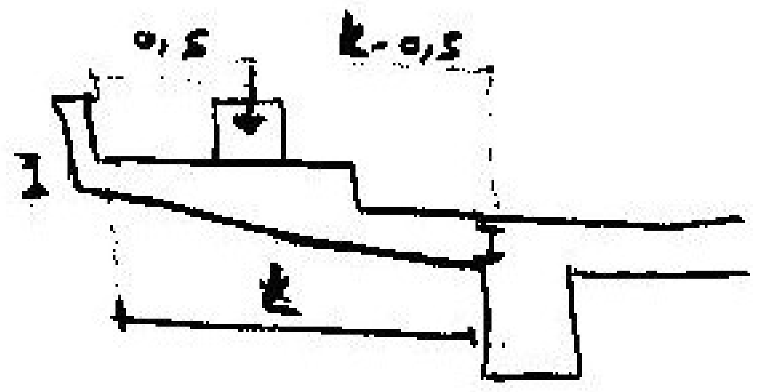
$R_1 = \frac{M_u * 10^5}{f_{cu} * B \cdot d^2}$ ⟹ $w = 0,033$

(250) (100) (25 - 2)

$A_s = w \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$

فرش وغطاء

5t عجلة



Side walk

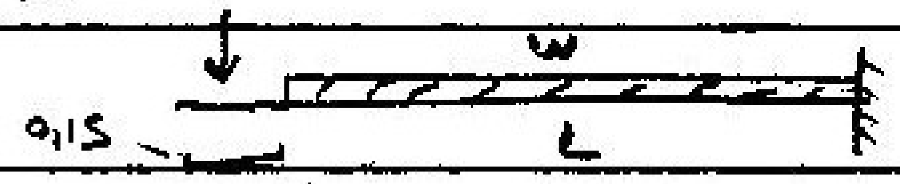
*** dead load :**

$$t_{avg} = \frac{t_1 + t_2}{2} = \frac{0.5 + 0.3}{2} = 0.4$$

$$w = t_{avg} * \gamma_{R.C} * cover$$

0.4 , 2.5 , 0.2 فرش

0.2 سور



$$M_{dead} = w \cdot L \cdot \frac{L}{2} + \underset{سور}{0.2} * \left(L + \frac{0.15}{2}\right) = \checkmark\checkmark$$

*** Live load :**

نفرض حمل عجلة (5t) بدون Impact على الحافة

$$B_e = \underset{0.2}{\text{عرض العجلة}} + \underset{factor}{1.2}\,(L - 0.5)$$

$$M_{Live} = \frac{\overset{5}{\text{حمل العجلة } P} * (L - 0.5)}{B_e}$$

*** total Moment :**

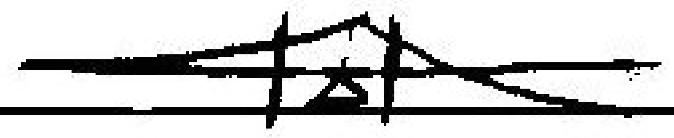
$$M_{total} = M_{dead} + M_{Live}$$

$$M_u = 1.5 * M_{total}$$

*** design :**

نصمم القطاع الاخطر وهو البلاطة المجاورة للكابولي
حيث انه له نفس العزم عند الاتصال ولكن تخانته اقل

$t = 25$ cm $\quad d = 23$ cm



$$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2}$$

$f_{cu} = 250$, $B = 100$, $d = 23$

$w = 0.13$

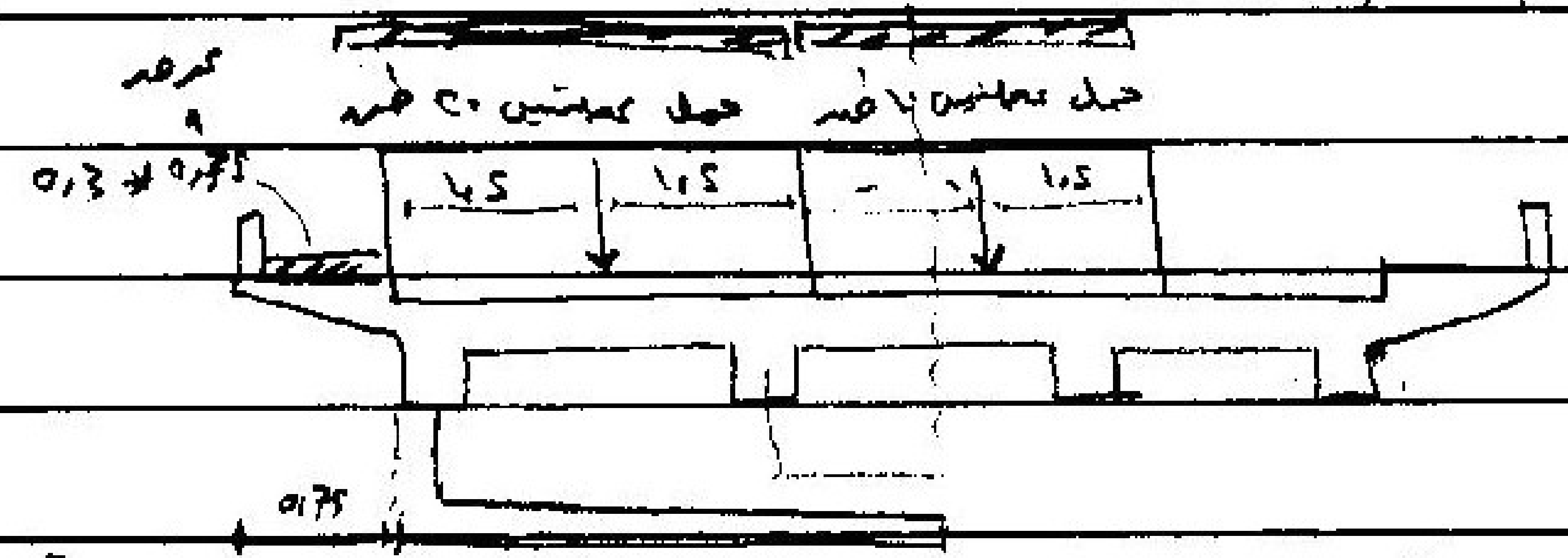
$$A_s = w \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$$

$f_{cu} = 250$, $f_y = 3600$, $B = 100$, $d = 23$

Main Girder

0,3	0,5	0,3
	60 t car	30 t car
	0,5	0,3

عرض 0,5 * 3   عرض 0,3 * 3



$R_i = \frac{P}{N}\left(1 + \frac{N \cdot e \cdot L_i}{\Sigma L^2}\right)$ الحمل على الكمره

$P \longrightarrow$ 20 , 10 , 0,5 _ 0,3 _ 0,3   الحمل المدروس

$N \longrightarrow$ 4   عدد ال M.G

$e \longrightarrow$ بعد الحمل المدروس عن محور الكوبرى < + ناحيه الكمره المدروسه / - الناحيه الثانيه

$L_i \longrightarrow$ بعد الكمره المدروسه عن محور الكوبرى

$\Sigma L^2 \longrightarrow$ مجموع بعد جميع الكمرات عن محور الكوبرى

Impact factor $I = 0,4 - 0,008 * L_{span\ main\ Girder} \Longrightarrow 20 - 0,5$

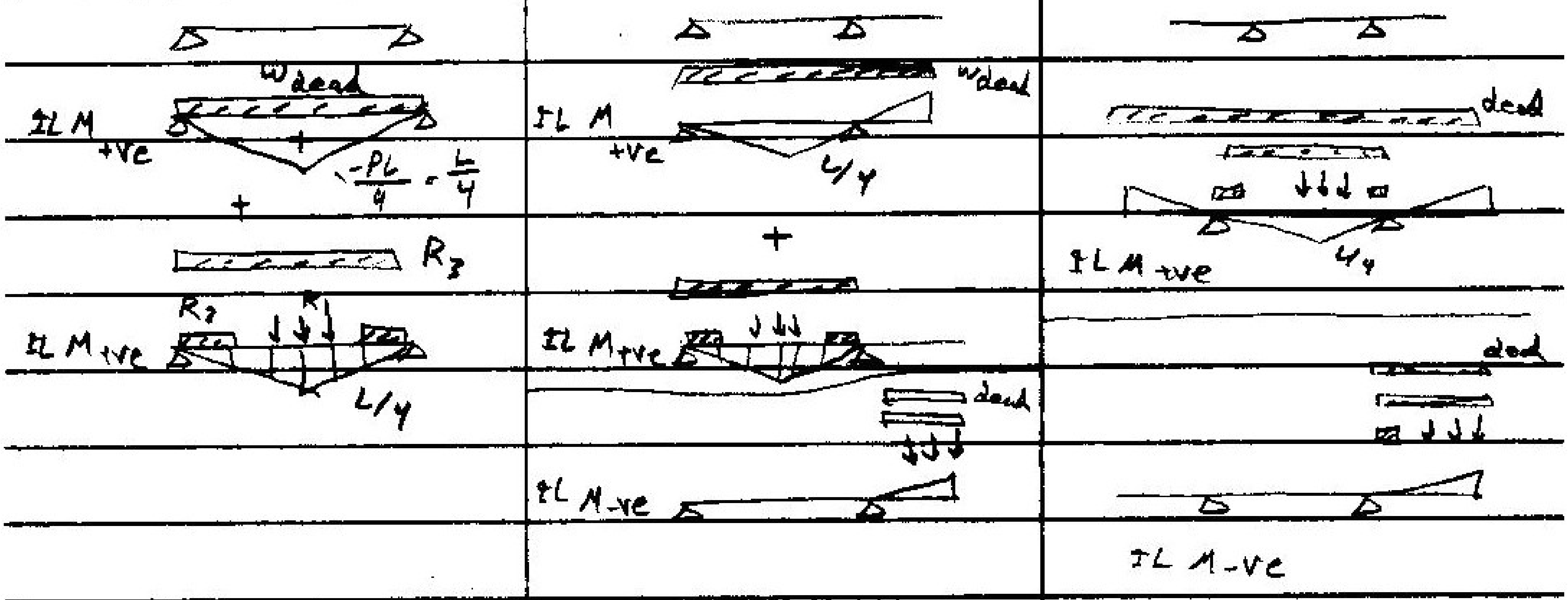
$R_1 \rightarrow$ Tracks $R_2 \rightarrow$ Live load $R_3 \rightarrow$ side walk

*** dead load**   ass $t_{main\ girder} = \frac{span}{10}$

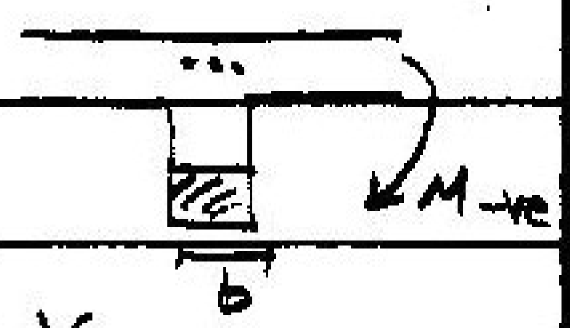
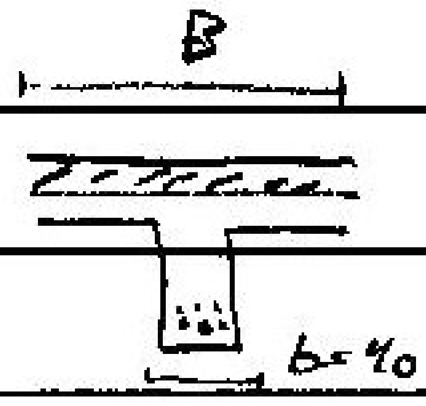
w_{dead} = M.G own wt + w_s dead *   عرض الكوبرى كله بالكامل / عدد ال M.G

M.G own wt $\rightarrow b \cdot t \cdot \gamma_{R.C}$

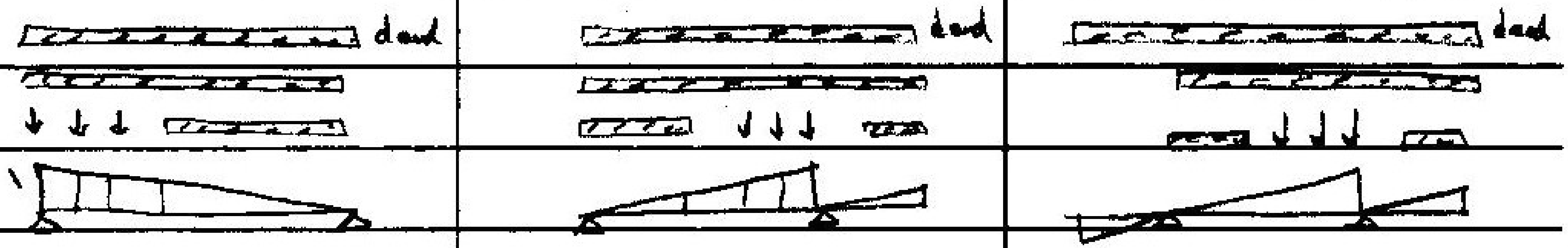
*** Max moment**



M total = M dead + M Live M +ve = N M+ve = Mu = 1,5 * M+ve	Mu = 1,5 * M	Mu = 1,5 * M

M -ve 	M +ve 
Rec-section	T-section
$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot b \cdot d^2} \ngtr 0,16$	B min: $16\, t_s + b$; $\phi - \phi$ main Gurder ; $\frac{L'}{5} + b$ (simple $L' = L$)
or increase $t = 200$ cm, $d = 195$ cm	
$\Longrightarrow w = 0,12$	$R_1 = \frac{M_u * 10^5}{f_{cu} \cdot B \cdot d^2} \Longrightarrow w = 0,033$
$A_{s\,-ve} = w \cdot \frac{f_{cu}}{f_y} \cdot b \cdot d$	
	$A_s = w \cdot \frac{f_{cu}}{f_y} \cdot B \cdot d$

* shear :-



$Q = \sum V$

$Q_u = 1,5 * Q$

$Q_{critical} = Q_u - w_u \left(\frac{c + d}{2}\right) = 0,85\ Q_u$

q_u shear stress $= \frac{Q_{cr} * 10^3}{b \cdot d} \ngtr q_{allow}$ concrete $= 0,75 \sqrt{\frac{f_{cu}}{\gamma_c - 1,5}}$

$q_{steel} = q_u - \frac{q_{allow}}{2}$

Cross girder

$b_{X.G} = \left(\frac{3}{4}\right) t_{M.G} = 120$

$A_{s\,min} = \frac{11}{3600} \cdot b \cdot d$ (b = 40, d = 115) علوى وسفلى

ZAGAZIG UNIVERSITY FACULTY OF ENGINEERING

4th year Civil Engineering Bachelor – TERM - WORK April 2011 Second TERM

REINFORCED CONCRETE STRUCTURE (3) TIME 1.25 HOURS

** Neat drawings and logical arrangement of calculation steps are* very important.

*** Any data not given is to be reasonably assumed.* Hand book are allowed

برجاء قراءة كل سؤال بعناية والإجابة علي المطلوب فقط !

Question: No: 1

For the open circular tank resting on rocky soil.
The tank height = 5.2 m, diameter = 8.0 m,
It is required to make analysis for wall considering:
The tank totally full of water for the following cases:

A– wall statically system hinged with base and free at top.
Using (p.c.a method). (10.0 % from total).

B – wall statically system fixed with base and free at top.
Using (ressiner method). (10.0 % from total).

Question: No: 2

For the shown rectangular tank consists of three vents as shown in figure (1), the tank resting on soil with bearing capacity equals to = 1.50 kg /cm^2. It is required to make complete analysis, design and give complete reinforcement details. Using suitable scale.

F_{cu} = 250 kg /cm^2. F_y = 3600 kg /cm^2.

Soil type and loads distribution. (13 % from total).
Analysis of vertical section, design critical sections. (25 % from total).
Horizontal section, design critical sections. (12 % from total).
Reinforcement details:
Vertical section. (20 % from total).
Horizontal section. (10 % from total).

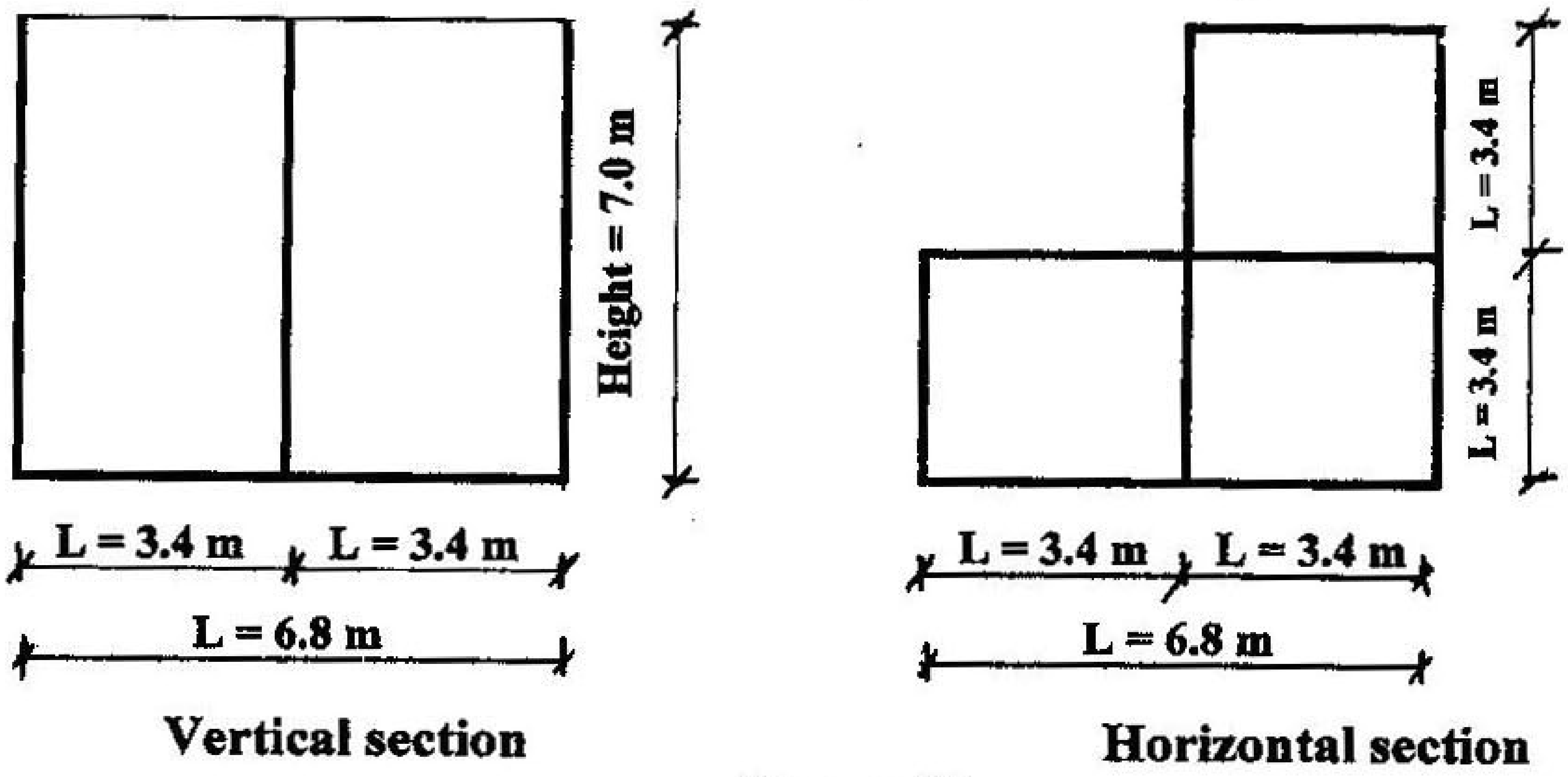


Figure (1)

مع أطيب التمنيات بالنجاح والتوفيق

ZAGAZIG UNIVERSITY | **FACULTY OF ENGINEERING**

4th year Civil Engineering Bachelor – Term Work | **May 2011 second term**

REINFORCED CONCRETE STRUCTURE (3) | **TIME: 2 HOURS**

*** Neat drawing and logical arrangement of calculation steps are very important.**

**** Any data not given is to be reasonably assumed.**

For the plan shown figure, consider the wind in directions shown in fig. , The building consists of 15 floors with a story height 3.0 meters, Total wind force ⊥ long side can be assumed = 200 tons.

Concrete grade (Fcu) = 300 kg / cm2 , steel grade (Fy) = 3600 kg / cm2

Question No: (1) (25 % of max degree)

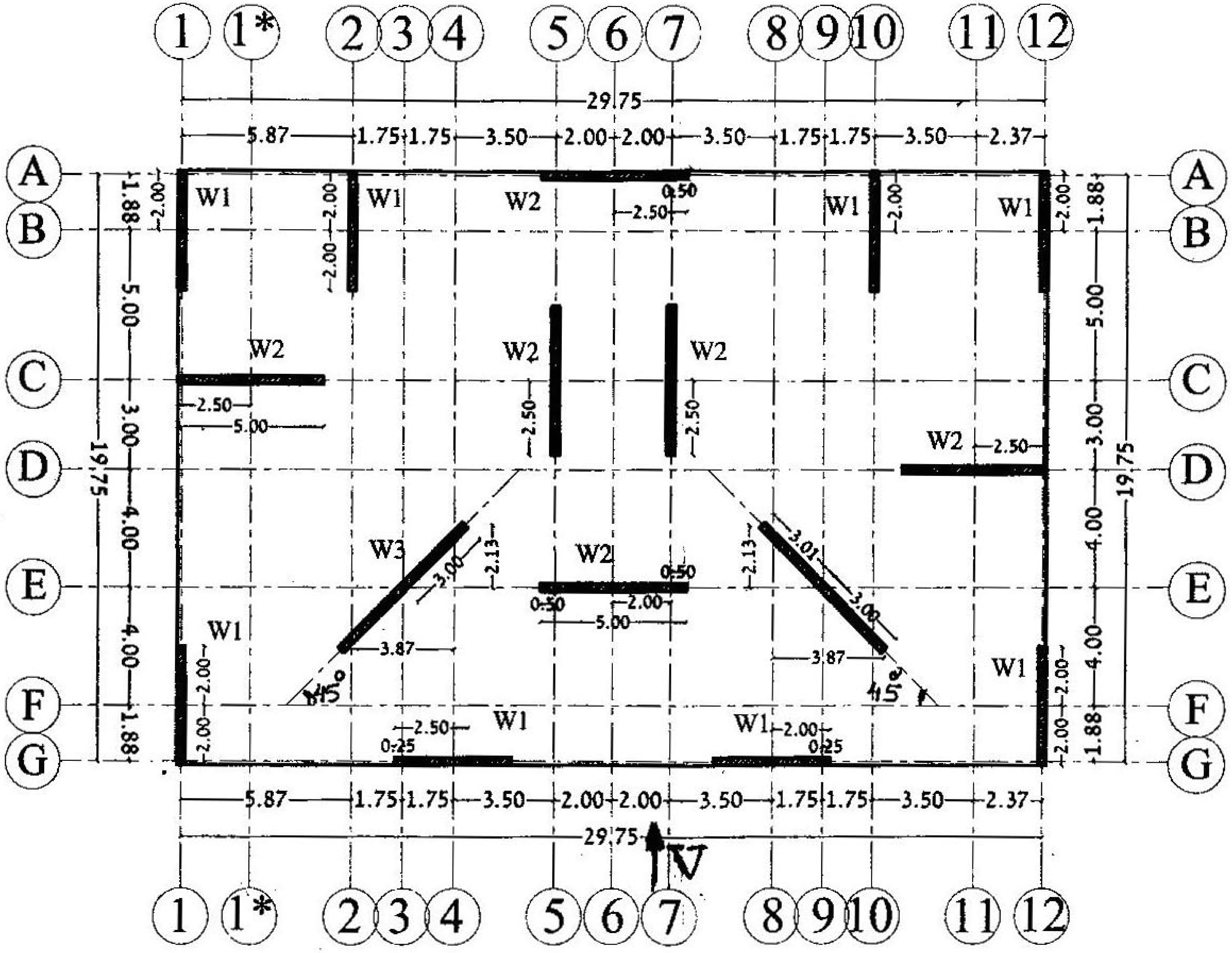
By approximate method find the location of center of mass and center of rigidity.

Question No: (2) (50 % of max degree)

This building subjected to vertical load which can be calculated and horizontal load from wind.
Load equal 200 tons affected on mass center and ⊥ long side. Find shear at base and moments with assumption wind pressure with equal intensity on all height of the building.

Question No: (3) (25 % of max degree)

From first principle design cross section of wall at intersection of two axes (6/E) .



All Wall Same As The Following Data :.

W1 (0.25 * 4.00) m

W2 (0.25 * 5.00) m

W3 (0.25 * 6.00) m

Zagazig University
Faculty of Eng

Final 2nd term EX. 2010-2011
Structural Eng. Deprt
R.C. (3) Time 3.0 h
4th year – Civil

- Answer the following three questions (2-pages)
- Any missing data may be assumed properly
- Tables and charts (hand books) only are allowed
- F_{cu}= 300 kg/cm^2, and steel grade =36/52

Q-I (45%) It is required to make a complete **analysis and design** with all reinforcement Details for all structural elements (Walls , floor, edge beams and ties) of the shown elevated water tank in Fig (1).

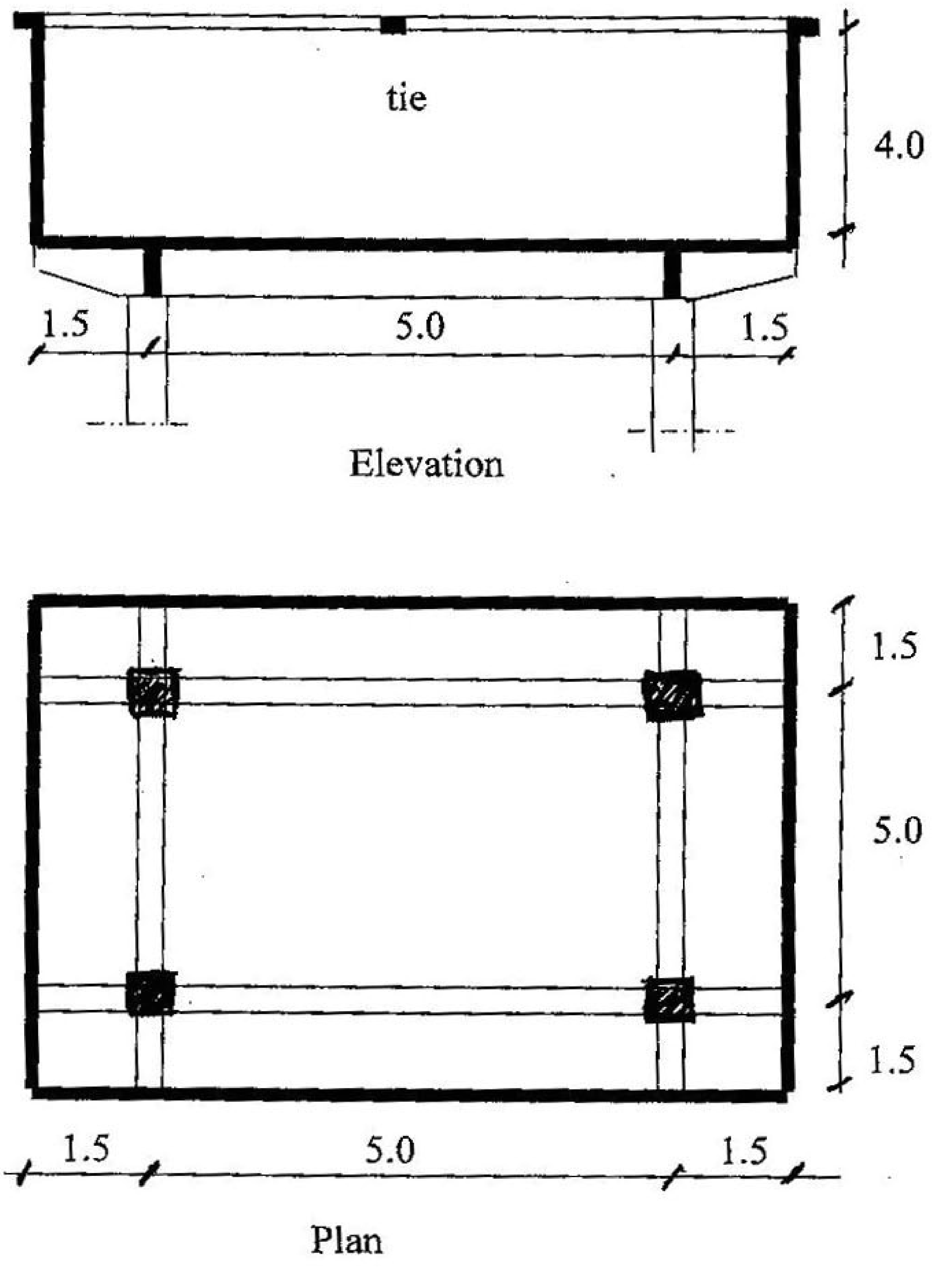
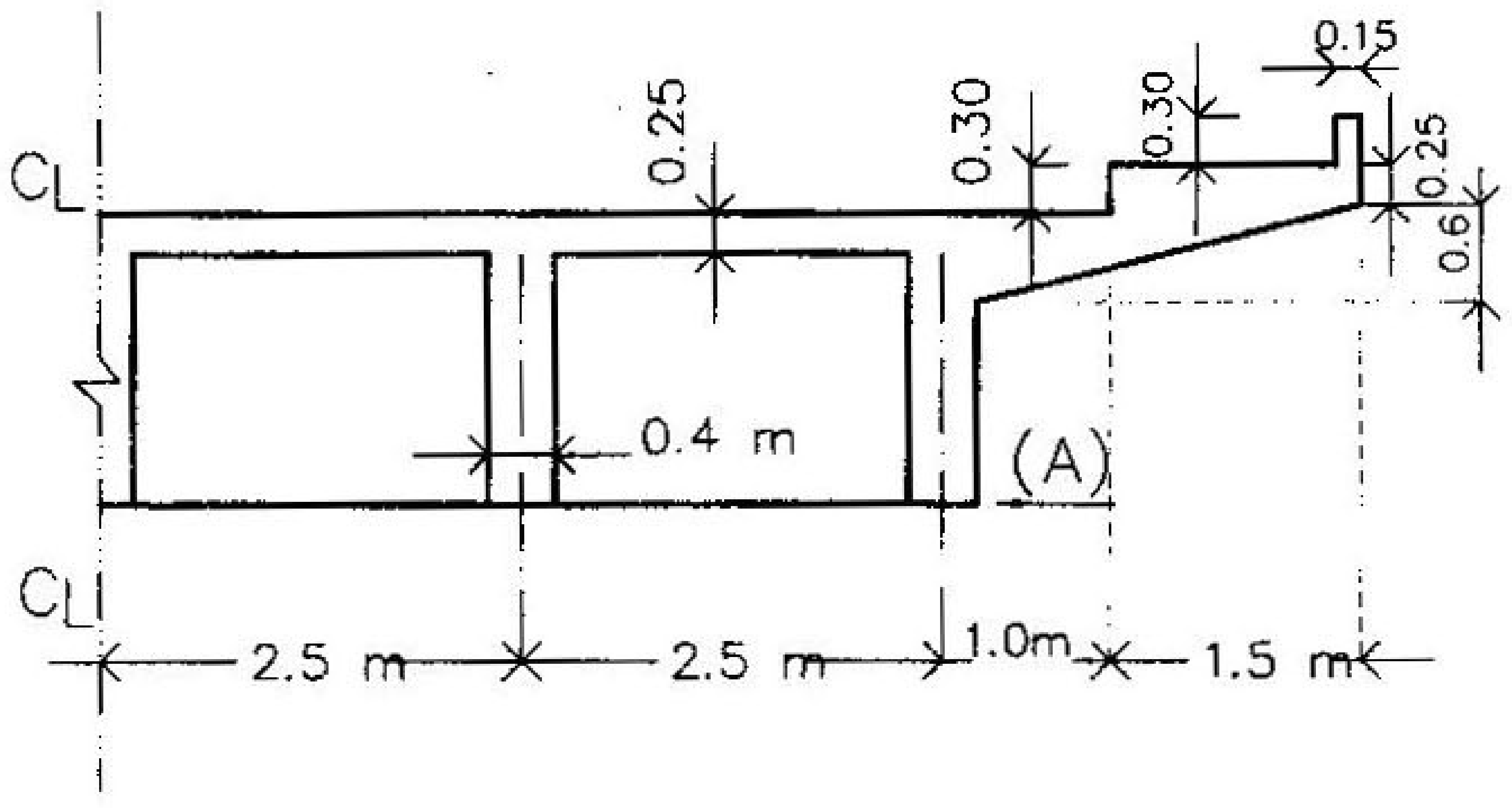
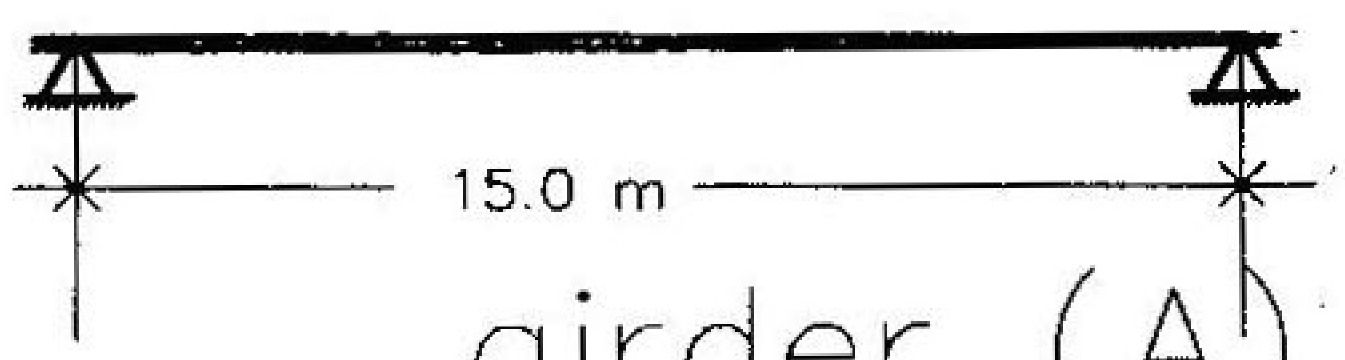


Fig. (1)

Q2 : (20 %) It is required to make a complete design with all reinforcement for R.C. bridge with 15.0 m simply supported span shown in Fig. (2), **(main girders, and cross girders)** spacing of cross girders is 3.0 m.





Fig(2)

girder (A)

QUESTION NO. (3) (35% OF MAX GRADE)

For the plan shown in Fig.(3) consider the wind load in vertical direction effect at center of mass , the building consists of 20 floors with story height 3.0 meters . Total wind force ⊥ long side can be assumed 250 tons .
Concrete grade (fcu) = 300 kg\cm^2
Steel grade (fy) = 3600 kg\cm^2

It is required:-

- **By approximate method find the location of center of mass and center of rigidity.**
- **Find shear at base and moment for all vertical element resisted Ha⊥ force of this direction**
- **From first principle design cross section of wall at intersection of two axes (B/3)**
- **W1 (0.25 * 3.00) , W2 (0.25 * 4.00) , W3 (0.25 * 5.00) , B1 (0.25 * 0.60) ,**

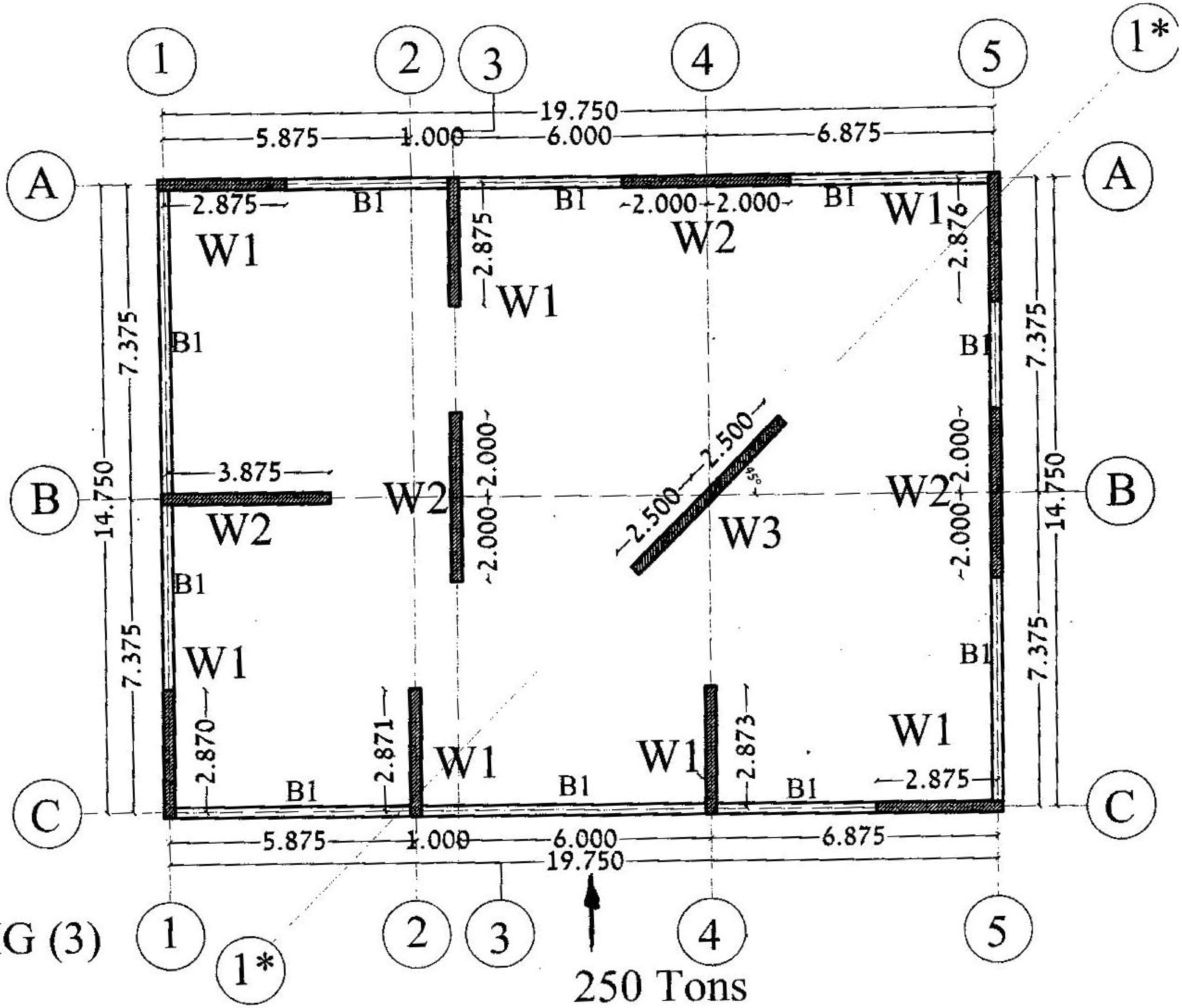

A
B
C
1
2
3
4
5
1*
19.750
5.875
1.000
6.000
6.875
14.750
7.375
2.875
2.876
2.870
2.871
2.873
3.875
2.000
2.500
B1
W1
W2
W3
250 Tons

FIG (3)