Bearing Capacity Of Soil

Definitions:

Bearing Capacity:

أقصي ضغط يمكن أن يضغط به المنشأ علي التربة بدون حدوث انهيار للتربة بالقص أو حدوث هبوط زائد.

Ultimate bearing capacity (q_{ult}):

أقل ضغط كلى عند قاعدة الأساس تنهار عنده التربة بالقص.

Net ultimate bearing capacity (q_{un}):

أقل ضغط صافي يسبب انهيار للتربة بالقص.

$q_{un} = q_{ult} - \gamma * D_F$

Net safe bearing capacity (q_{ns}):

It is the ultimate bearing capacity over a factor of safety (F).

$q_{ns} = \frac{\mathbf{qun}}{\mathbf{F.O.S}}$

لو لم يعطي F.O.S = 3

Safe bearing capacity (q_s):

أقصى إجهاد (ضغط) يمكن أن تتحمله التربة بأمان من حدوث انهيار للتربة بالقص.

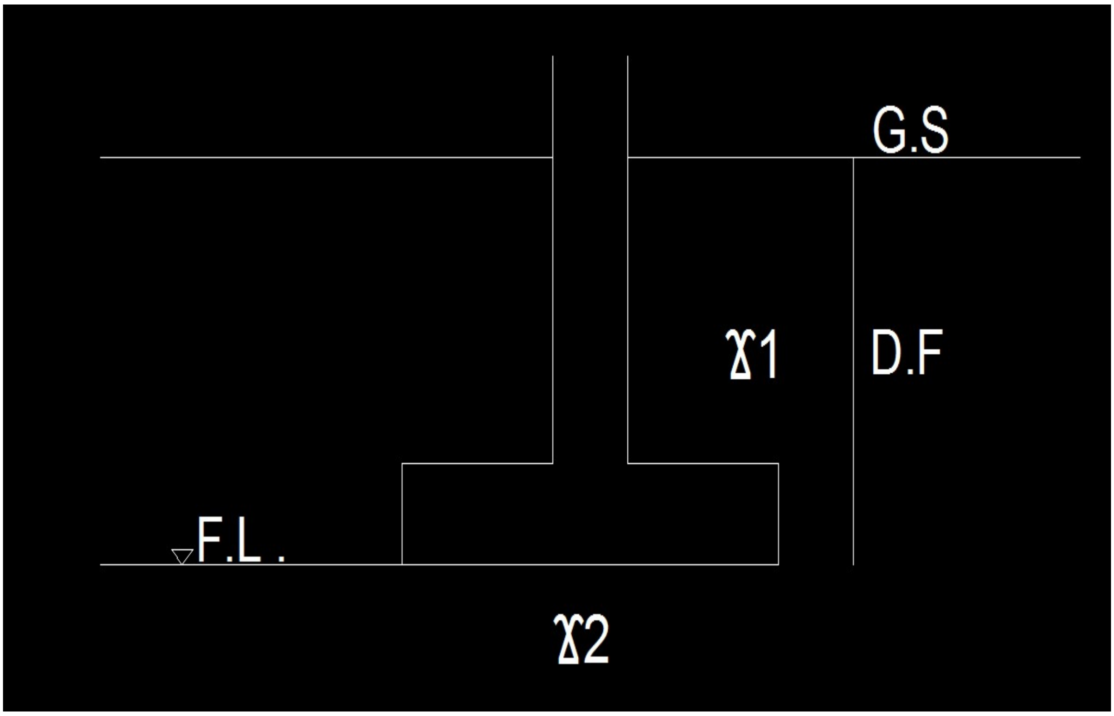
$q_S = q_{ns} + \gamma * D_F$

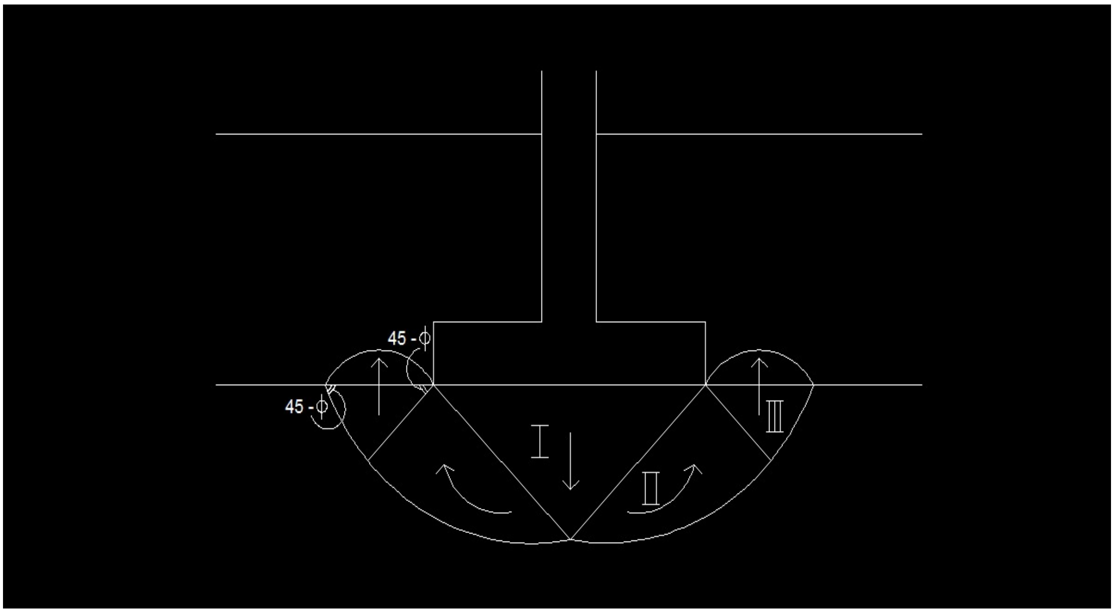
Allowable bearing capacity (q_{all}):

أقصى أجهاد (ضغط) آمن للتربة من حدوث انهيار بالقص أو هبوط زائد.

$P_{all} = q_s * B * L$

Terzaghi bearing capacity equation:





$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q + k_3\, \gamma_2\, B\, N_\gamma$

حيث أن:

k_1 , k_2 , k_3 shape factor from table

shape	k_1	k_2	k_3
Strip Footing قاعدة شرطية	1	1	0.5
Rectangular Footing قاعدة مستطيلة	$1+0.3\frac{B}{L}$	1	$1-0.6\frac{B}{L}$
Square Footing قاعدة مربعة	1.3	1	0.4
Circular Footing قاعدة دائرية	1.3	1	0.3

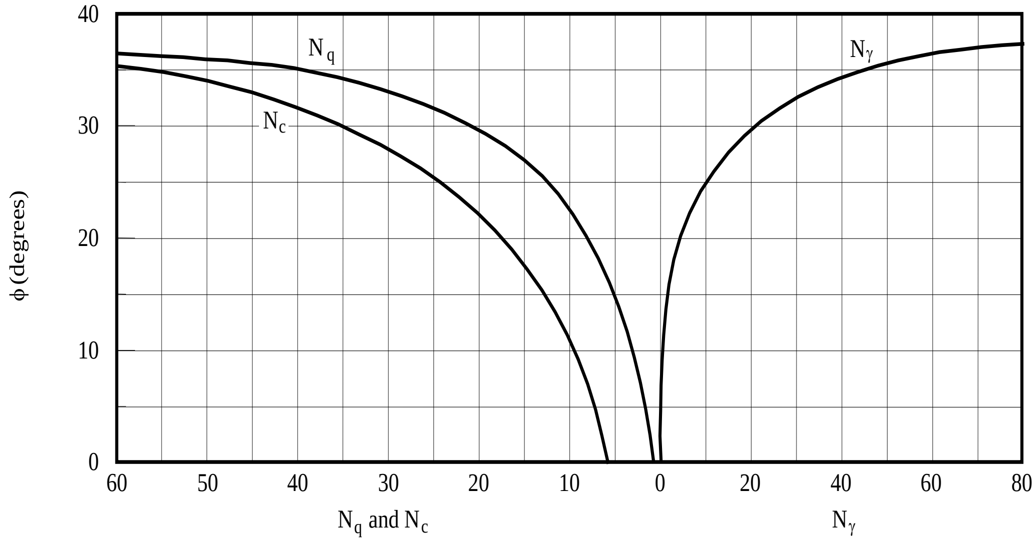
C	Cohesion	التماسك بين الحبيبات
B	Foundation Width	عرض الأساس (البعد الأصغر)
L	Foundation Length	طول الأساس (البعد الأكبر)
γ_1	Soil intensity above F.L	كثافة التربة اعلي منسوب التأسيس
γ_2	Soil intensity under F.L	كثافة التربة أسفل منسوب التأسيس
D_F	Foundation Depth	عمق التأسيس
F.L	Foundation Level	منسوب التأسيس
N_C	B/C Factors	من الجدول ندخل بقيمة ν نوجد قيمة N_C
N_q	B/C Factors	من الجدول ندخل بقيمة ν نوجد قيمة N_q
N_γ	B/C Factors	من الجدول ندخل بقيمة ν نوجد قيمة N_γ

يوجد 3 طرق لإيجاد قيمة N_C , N_q , N_γ

الطريقة الأولي: من الجدول ندخل بقيمة ν نوجد قيمة N_q , N_C , N_γ

Angle of Internal Friction (ν)	N_C	N_q	N_γ
0	5	1	-
5	6.5	1.5	-
10	8.5	2.5	0.5
15	11	4	1
20	15	6.5	2
22.5	17.5	8	3
25	20.5	10.5	4.5
27.5	25	14	7
30	30	18	10
32.5	37	25	15
35	46	33	23
37.5	58	46	34
40	75	64	53
42.5	99	92	83

الطريقة الثانية:



الطريقة الثالثة: من المعادلات

$$N_q = e^{\pi \tan \phi} * \tan^2 (45 + \varphi/2)$$

$$N_C = (N_q - 1) \cot \phi$$

$$N_\gamma = (N_q - 1) \tan \varphi$$

$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q + k_3\, \gamma_2\, B\, N_\gamma$

Cohesion term (c) $\rightarrow k_1 c\, N_c$

Foundation Depth term $\rightarrow k_2\, \gamma_1\, D_F\, N_q$

Dimension and Foundation Soil term (ϕ) $\rightarrow k_3\, \gamma_2\, B\, N_\gamma$

For cohesive soil (clay) : (c - soil)

$c =$ ☑ , $\phi = 0$

في هذه الحالة الجزء الثالث = صفر

$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q + k_3\, \cancel{\gamma_2\, B}\, N_\gamma$

$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q + 0$

For cohesion less soil (sand) : (ϕ - soil)

$c = 0$, $\phi =$☑

في هذه الحالة الجزء الأول = صفر

$q_{ult} = k_1 \cancel{c}\, N_c + k_2\, \gamma_1\, D_F\, N_q + k_3\, \gamma_2\, B\, N_\gamma$

$q_{ult} = 0 + k_2\, \gamma_1\, D_F\, N_q + k_3\, \gamma_2\, B\, N_\gamma$

لو c لم يعطي يتم حسابه بالمعادلة

$$C = \frac{\mathbf{qu}}{\mathbf{2}}$$

Effect of Ground water table on B/c :

لأخذ تأثير المياه الجوفية في الاعتبار يضاف معاملين w_q , w_γ إلي معادلة B/C لتقليل B/C

$$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q\, w_q + k_3\, \gamma_2\, B\, N_\gamma\, w_\gamma$$

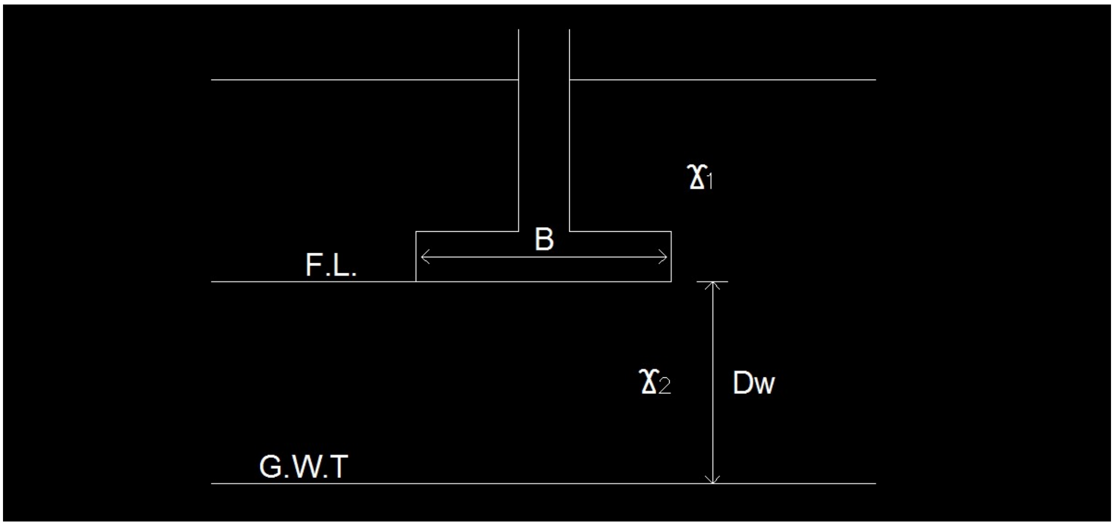
ملاحظة :

w_q , $w_\gamma \leq 1$

هناك 4 حالات لوجود G.W.T في تربة التأسيس:

Case 1 :

1- في حالة وجود المياه علي عمق كبير من منسوب التأسيس.



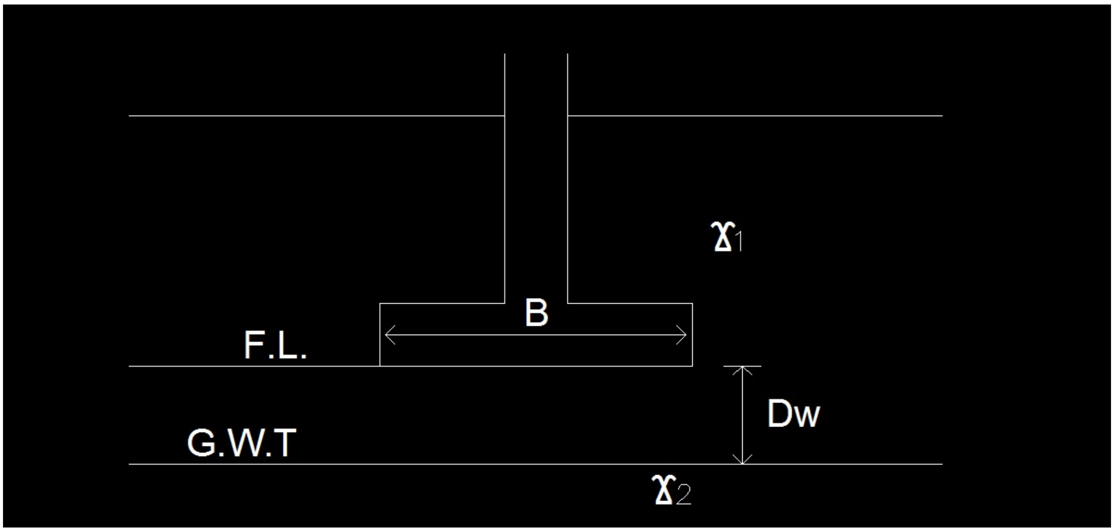
$D_w \geq B$

∴ المياه الجوفية لا تؤثر علي B/C

$\therefore w_q = w_\gamma = 1$

Case 2 :

2- في حالة وجود المياه علي عمق صغير من منسوب التأسيس.



$D_w < B$

المياه الجوفية تؤثر علي الجزء الثالث من المعادلة ولا تؤثر علي الجزء الثاني من المعادلة.

$\therefore\ w_q = 1$

$$w_\gamma = 0.5+\frac{\mathbf{Dw}}{\mathbf{B}}*0.5 \not> 1$$

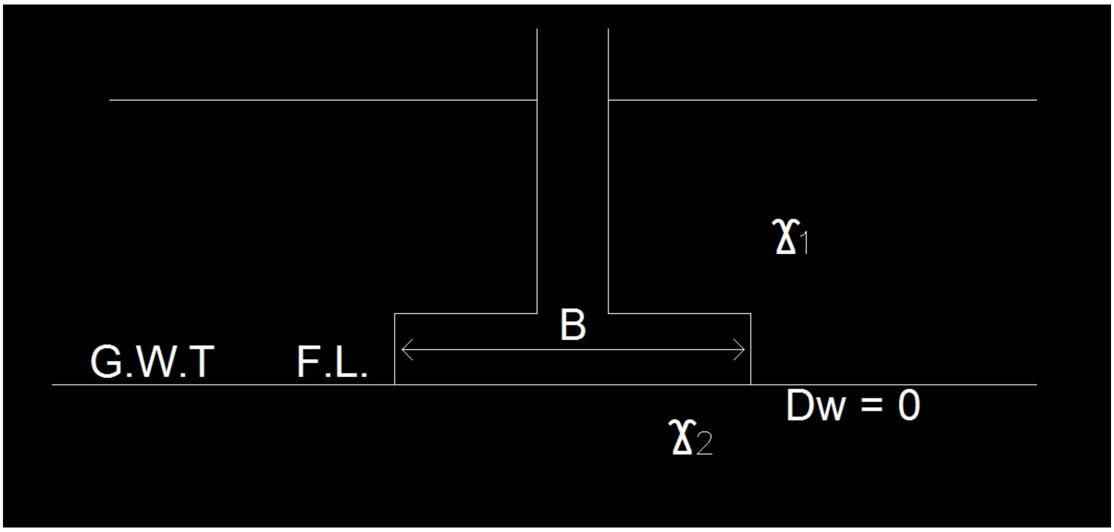
حيث أن :

D_w → عمق المياه من أسفل القاعدة

B → عرض الأساس

Case 3 :

3-في حالة وجود المياه عند منسوب التأسيس.



$D_w=0$

$\therefore\ w_q = 1$

$$w_\gamma = 0.5+\frac{\mathbf{Dw}}{\mathbf{B}}*0.5 = 0.5+\frac{\mathbf{0}}{\mathbf{B}}*0.5 = 0.5$$

Take γ_2 submerged

$$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q\, w_q + k_3\, \gamma_{2sub}\, B\, N_\gamma\, w_\gamma$$

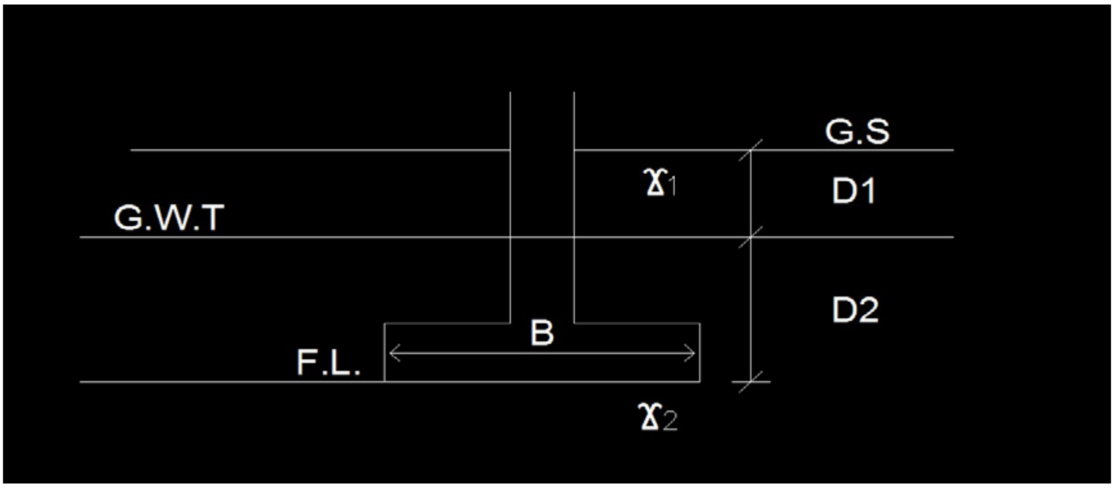
$$\gamma_{sub} = \gamma_{sat} - \gamma_w$$

حيث أن:

$\gamma_w = 1$

Case 4 :

4- في حالة وجود المياه بين منسوب التأسيس وسطح الأرض.



المياه الجوفية تؤثر علي الجزء الثاني والثالث من المعادلة.

$\therefore w_\gamma = 1$

$W_q = 0.5+\frac{D1}{D2}*0.5$

Take γ_2 submerged

$q_{ult} = k_1 c\, N_c + (\gamma_{1bulk\ or\ saturated} * D_1 + \gamma_{1sub} * D2)\, N_q\, w_q + k_3\, \gamma_{2sub}\, B\, N_\gamma\, w_\gamma$

حيث أن:

المسافة من سطح الأرض حتى G.W.T $\rightarrow$ D1

المسافة بين منسوب التأسيس و G.W.T $\rightarrow$ D2

Example: 1

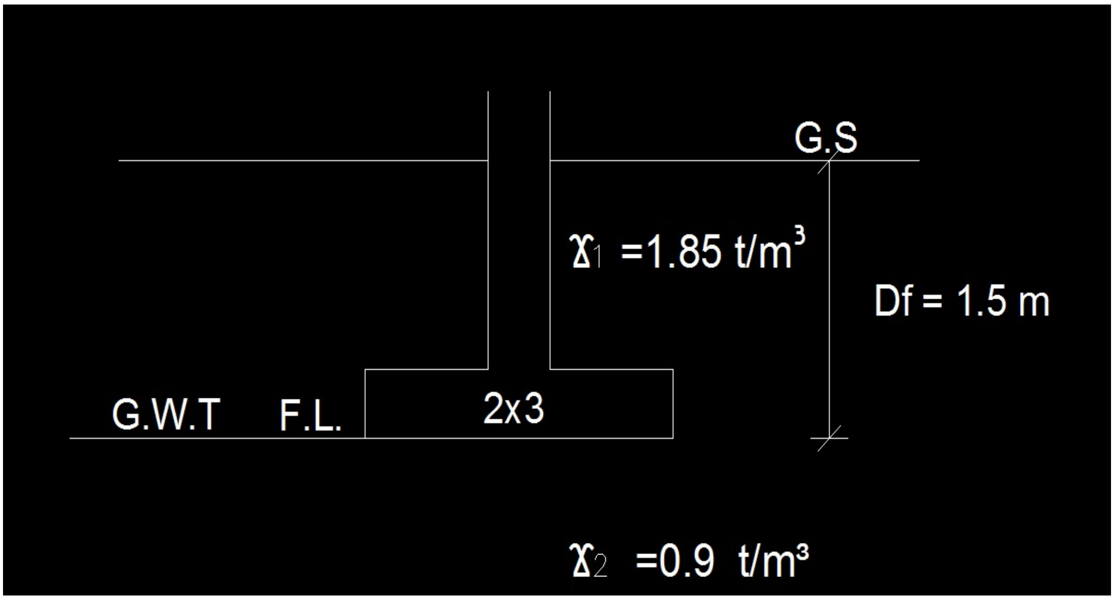
Determine the allowable load on a rectangular footing (2x3) m at depth 1.5 m below the ground surface if a fill $\gamma = 1.85\ t/m^3$ used above F.L. and the soil under footing has $\gamma_{sat} = 1.9\ t/m^3$, $c = 3\ t/m^2$, $\nu = 22''$, G.W.T was find at foundation level.

Solution

rectangular footing $\longrightarrow$ B = 2 m , L = 3 m

$\gamma_1 = 1.85 t/m^3$, $\gamma_{sub} = \gamma_{sat} - \gamma_w = 1.9 - 1 = 0.9\ t/m^3$

$c = 3$, $\nu = 22''$, $D_f = 1.5$ m , G.W.T was find at foundation level



For $\nu = 22''$

$N_q = e^{\pi \tan \phi} * \tan^2 (45 + \varphi/2)$

$N_q = e^{\pi \tan 22} * \tan^2 (45 + 22/2) = 3.56 * 2.2$
$= 7.82$

$N_C = (N_q - 1) \cot \phi$

$N_C = (7.82 - 1) \cot 22 = 6.82*2.4 = 16.88$

$N_\gamma = (N_q - 1) \tan \varphi$

$N_\gamma = (7.82 - 1) \tan 22 = 6.82 * 0.4 = 2.76$

For rectangular footing

$k_1 = 1+0.3\frac{B}{L} = 1+0.3\frac{2}{3} = 1.2$

$k_2 = 1$

$k_3 = 1-0.6\frac{B}{L} = 1-0.6\frac{2}{3} = 0.6$

∵ G.W.T was find at foundation level

∴ Case 3

$w_q = 1$

$w_\gamma = 0.5+\frac{Dw}{B}*0.5 = 0.5+\frac{0}{2}*0.5 = 0.5$

Take γ_2 submerged

$$q_{ult} = k_1 c\, N_c + k_2\, \gamma_1\, D_F\, N_q\, w_q + k_3\, \gamma_{2sub}\, B\, N_\gamma\, w_\gamma$$

q_{ult} =(1.2*3*16.88)+(1*1.85*1.5*7.82*1)+(0.6*0.9*2*2.76*0.5)

= 60.77 + 21.7 + 1.49 = 83.96 t/m^2

$q_{un} = q_{ult} - \gamma_1 * D_F$ = 83.96-(1.85*1.5)=81.19 t/m^2

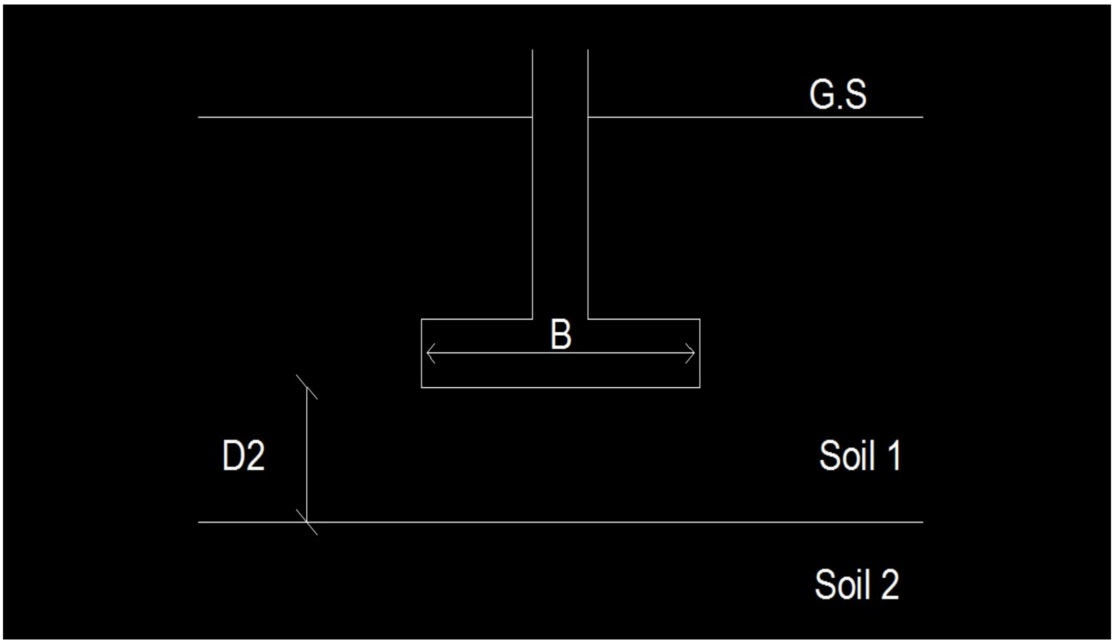
$$q_{ns} = \frac{\mathbf{qun}}{\mathbf{F.O.S}} = \frac{\mathbf{81.19}}{\mathbf{3}} = 27.06\ t/m^2$$

$q_S = q_{ns} + \gamma_1 * D_F$ = 27.06 + (1.85*1.5)=29.84 t/m^2

$P_{all} = q_s * B * L$ = 29.84*2*3=179 ton

In case of stratified soil

في حاله وجود طبقات مختلفة من التربة:



If $D_2 > 2B$

في حاله وجود الطبقة الثانية علي عمق أكبر من مرتين عرض الأساس يهمل تأثير الطبقة الثانية ونأخذ B/C للطبقة الأولى.

If $D_2 < 2B$

في حاله وجود الطبقة الثانية علي عمق أقل من مرتين عرض الأساس نوجد B/C للطبقتين الأولى والثانية ونأخذ B/C الأقل.

How to choose Foundation type:

Type of foundation:

Isolated footing

Raft footing

Deep foundation (piles)

For sand soil:

$c = 0$, $\phi =$☑

P_{col} = load of floor / No. of floors

load of floor → حمل الدور الواحد

No. of floors → عدد الأدوار

Area of footing = $\frac{p}{qall}$

If Area of footing < 70% for loaded Area

Use Isolated footing

حيث أن:

loaded Area = L*B

loaded Area → المساحة المحملة

If Area of footing ≥ 70% for loaded Area

Use Raft footing

If Area of footing > 100% for loaded Area

Use Deep foundation

OR

Area of Building = $\sum \mathbf{pcol}$

Area of foundation = $\frac{\sum \mathbf{pcol}}{\mathbf{qall}}$

If Area of foundation < 70% for Building Area

Use Isolated footing

If Area of foundation $\geq$ 70% for Building Area

Use Raft footing

If Area of foundation >100% for Building Area

Use Deep foundation

For clay soil:

c = ☑ , ϕ = 0

Calculate the Settlement:

S = C_c /1+e *H * Log $\frac{\sigma 0+\Delta\sigma}{\sigma 0}$

OR

S = m_v * H * $\Delta\sigma$

حيث أن:

e → void ratio of compressible layer (clay layer).

H → Height of compressible layer (clay layer).

σo → effective overburden stress at Midle of clay layer.

$$\boldsymbol{\sigma o} = \sum \mathcal{X}\, h$$

$$\Delta\sigma = \frac{\mathrm{qs*L*B}}{\mathrm{(L+Z)(B+Z)}}$$

L , B → Loaded area

Z = H / 2 + height to F.L

C_c = 0.009(L.L% - 10)

$m_v \longrightarrow$ coeff of volume change

If the Settlement 0 $\longrightarrow$ 3 Use Isolated footing

If the Settlement 3 $\longrightarrow$ 10 Use Raft footing

ملاحظة:

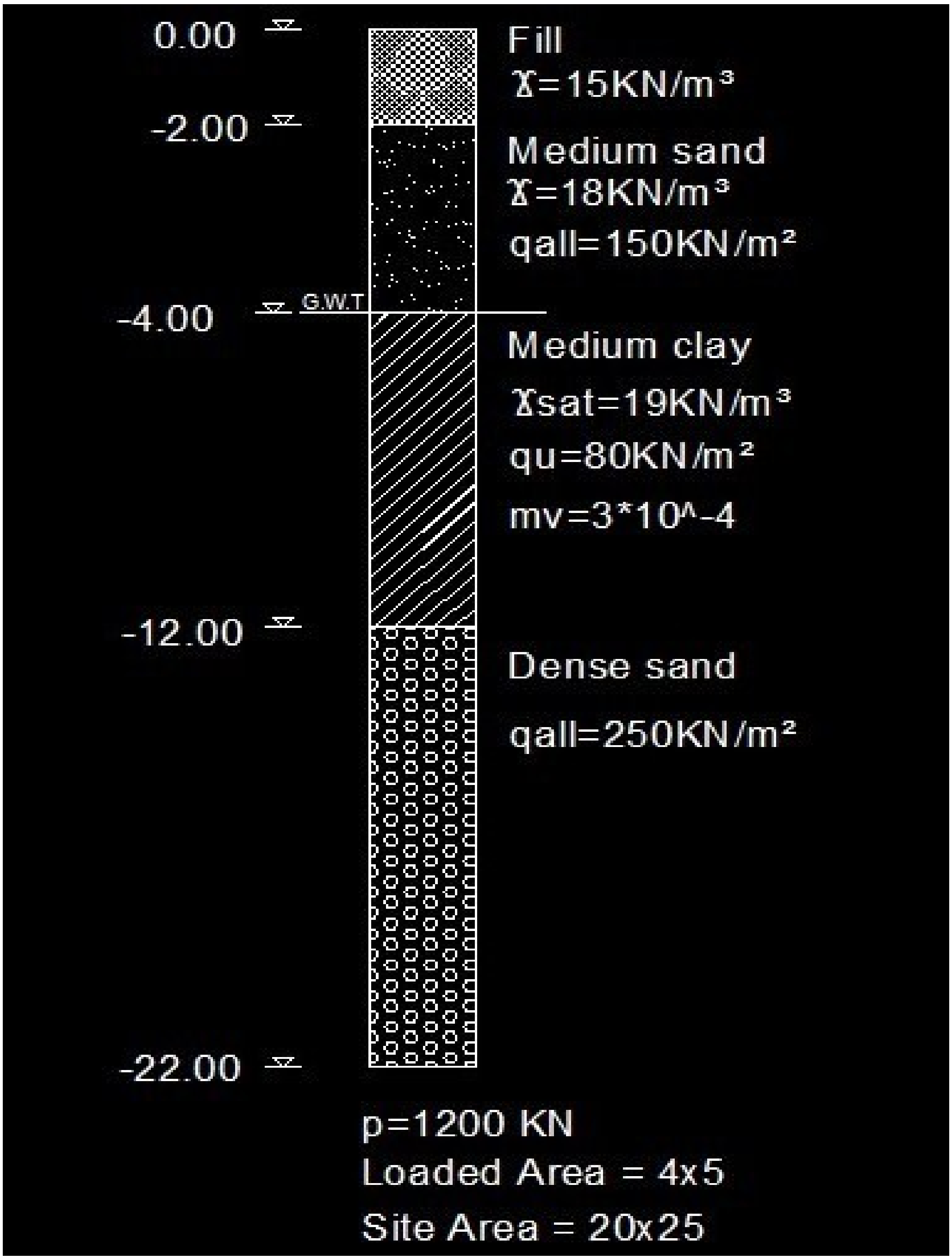
في حاله عدم الحصول علي الهبوط المسموح به نعوض في المعادلة بالهبوط المسموح به و أوجد q_s

S = C_c /1+e *H * Log $\frac{\sigma 0+\Delta\sigma}{\sigma 0}$

$$\Delta\sigma = \frac{qs * L * B}{(L + Z)(B + Z)}$$

Example: 2

Calculate the net safe B/C for the shown soil formation for a rectangular footing (4x5) m and choose Foundation type foundation level at -2.00 , $\nu = 0$".



Solution

rectangular footing $\longrightarrow$ B = 4 m , L = 5 m

For $\nu = 0^{"}$

$N_q = 5$, $N_C = 1$, $N_\gamma = 0$

For rectangular footing

$k_1 = 1+0.3\frac{B}{L} = 1+0.3\frac{4}{5} = 1.24$

$k_2 = 1$

$k_3 = 1-0.6\frac{B}{L} = 1-0.6\frac{4}{5} = 0.52$

$w_q = 1$, $w_\gamma = 0.5$

D < 2B

2 < 2*4

2 < 8

$\therefore$Calculate q_{all} for Medium clay

$C = \frac{qu}{2} = \frac{80}{2} = 40\ KN/m^2$

$q_{ult} = k_1 c\ N_c + k_2\ (\gamma_1\ D_F + \gamma_2\ D_F)\ N_q\ w_q$

qult =(1.24*40*5)+(1*(15*2)+(18*2)*1*1)

= 248+ 66 = 314 KN/m^2

$q_{un} = q_{ult} - (\gamma_1 D_F + \gamma_2 D_F)$

$= 314-((15*2)+(18*2))=248\ KN/m^2$

$q_{ns} = \frac{qun}{F.O.S} = \frac{248}{3} = 82.67\ KN/m^2$

$q_{all\ 2} = q_S = q_{ns} + (\gamma_1 D_F + \gamma_2 D_F)$

$= 82.67 + ((15*2)+(18*2)) = 148.67\ KN/m^2$

$q_{all\ 2} < q_{all\ 1}$

148.67 < 150

∴ take $q_{all} = q_{all\ 2} = 148.67\ KN/m^2 = 149\ KN/m^2$

Area of footing = $\frac{p}{qall} = \frac{1200}{149} = 8\ m^2$

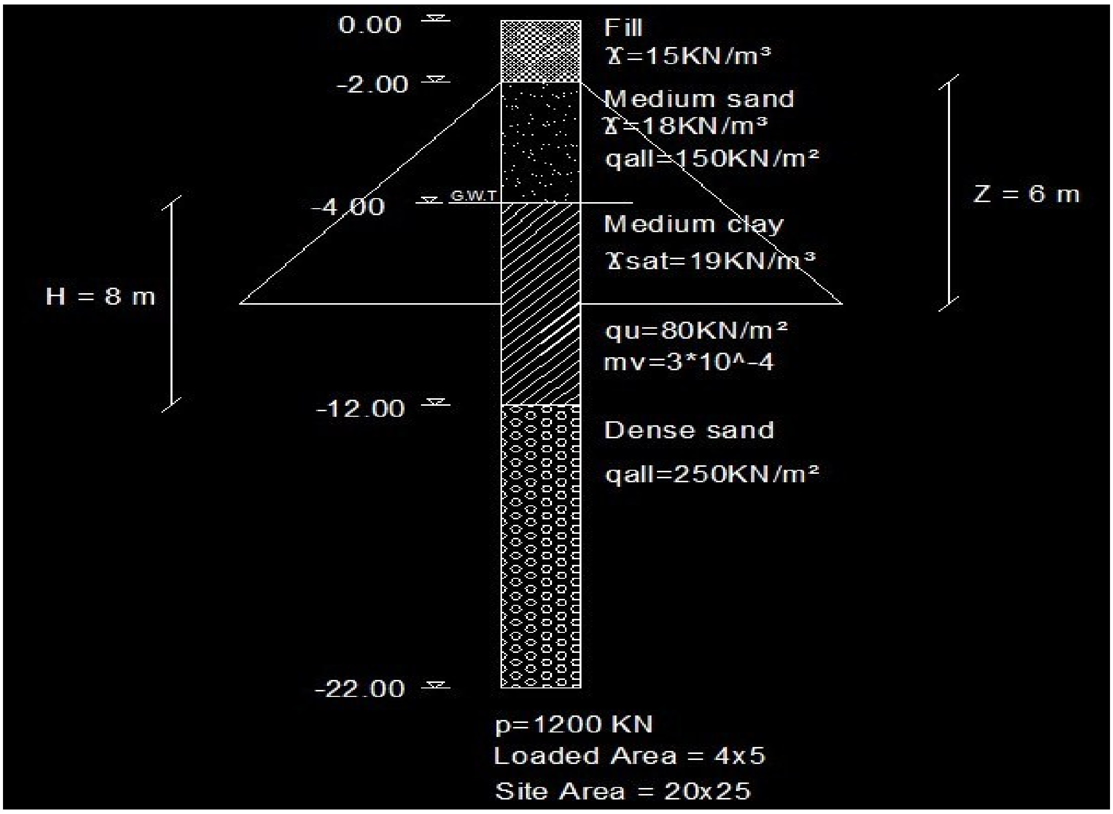
If Area of footing < 70% for loaded Area

8 < 70/100*4*5

$8\ m^2 < 14\ m^2$

∴ Use Isolated footing

Check Settlement for clay layer



S = m_v * H * $\Delta\sigma$

$$\Delta\sigma = \frac{qs * L * B}{(L+Z)(B+Z)}$$

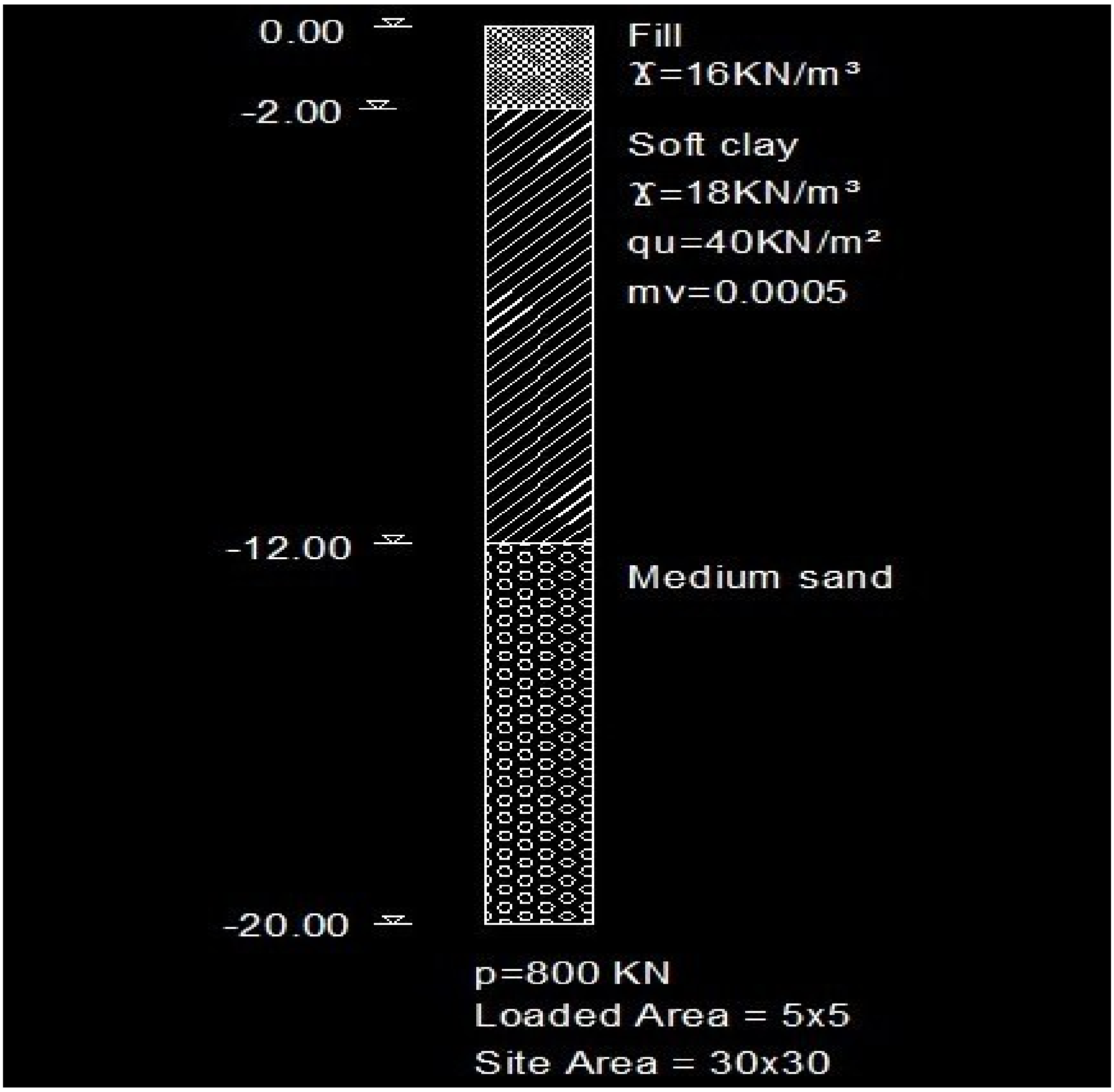
$$\Delta\sigma = \frac{149*5*4}{(5+6)*(4+6)}$$ = 27.1 KN/m^2

S = $\mathbf{3} * \mathbf{10^{-4}}$ * 27.1* 8 = 0.065 m = 6.5 cm

the Settlement is = 6.5 Use Raft footing

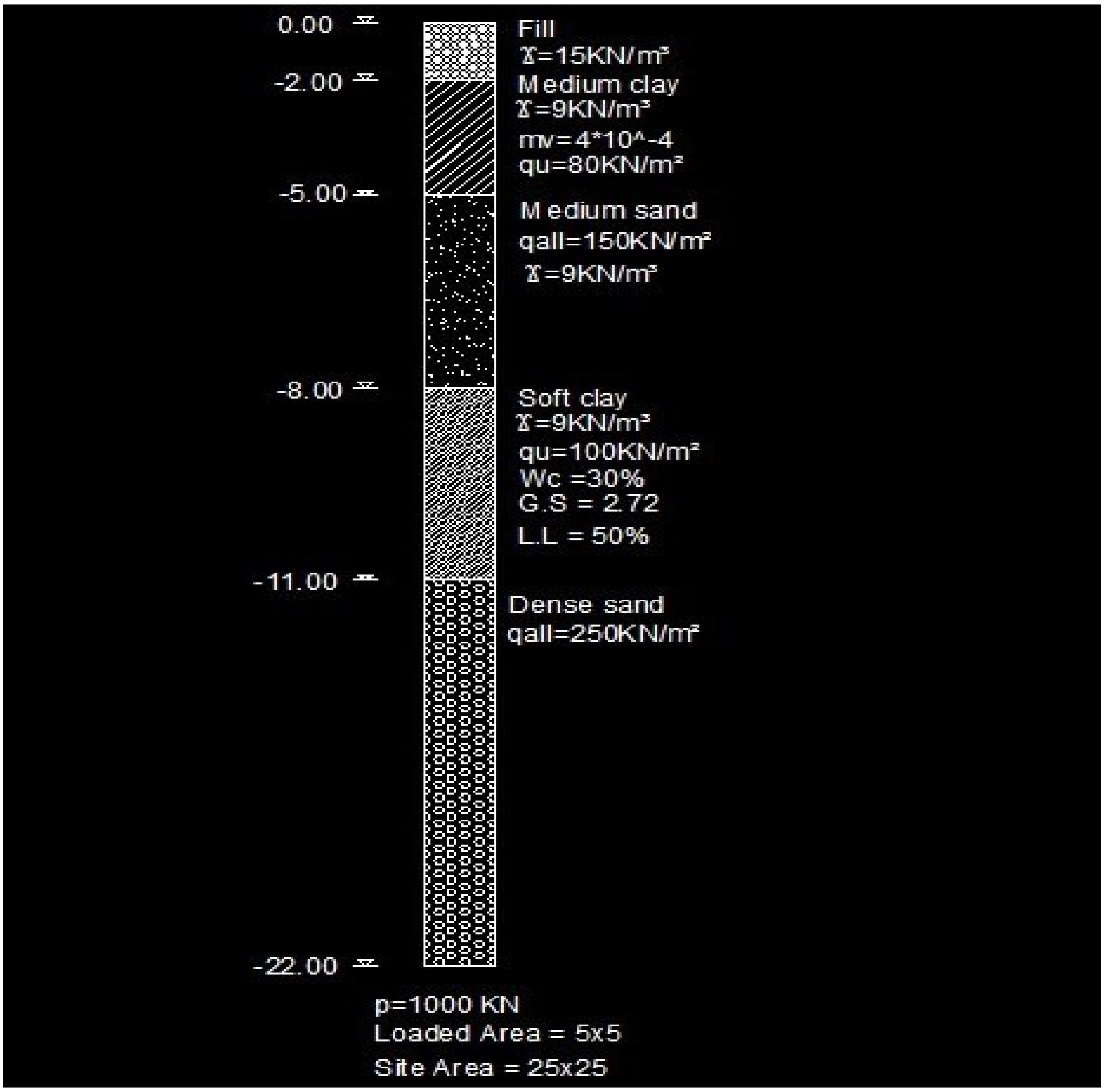
Example: 3

Calculate the net safe B/C for the shown soil formation for a rectangular footing (5x5) m and choose Foundation type , foundation level at -2.00 and G.W.T was find at Ground surface , $\nu = 0$".



Example: 4

Calculate the net safe B/C for the shown soil formation for a rectangular footing (5x5) m and choose Foundation type , foundation level at -2.00 and G.W.T was find at Ground surface , $\nu = 0^{"}$.



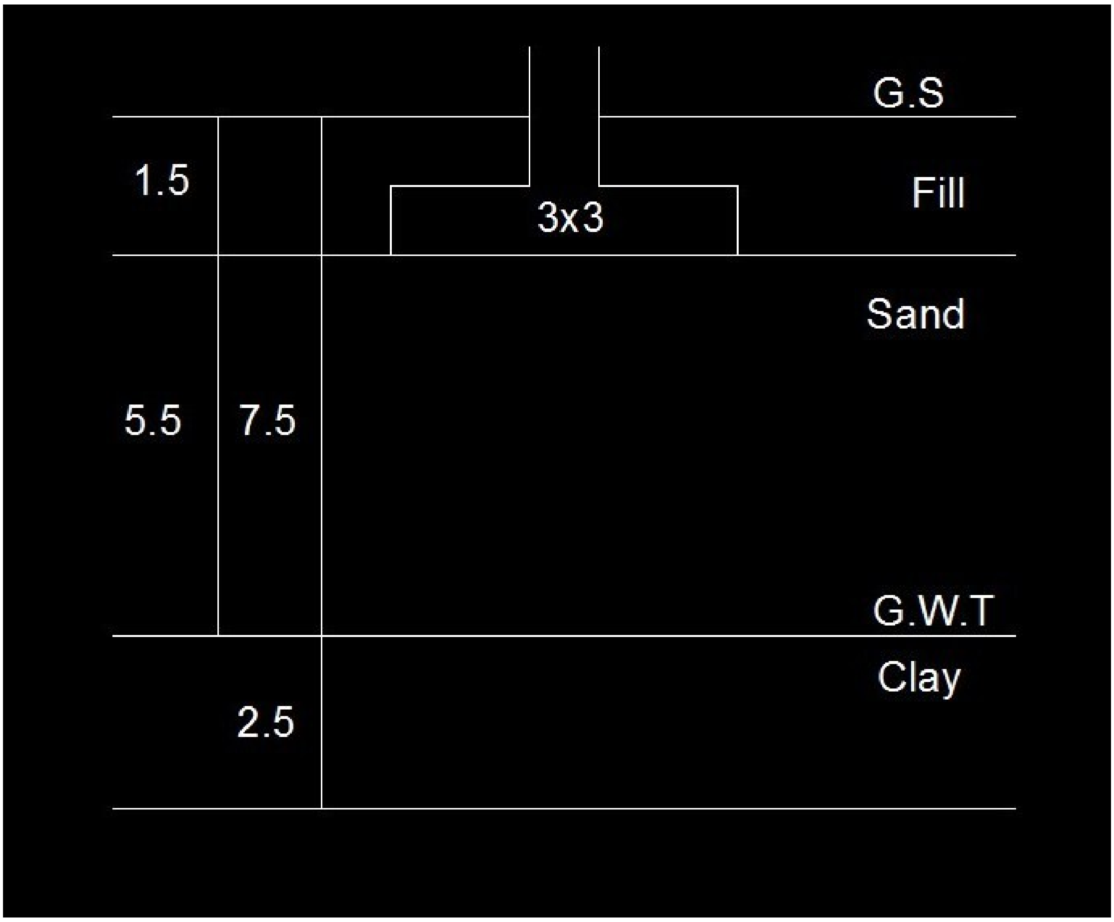
Example: 5

Fill : $\gamma = 1.45\ t / m^3$

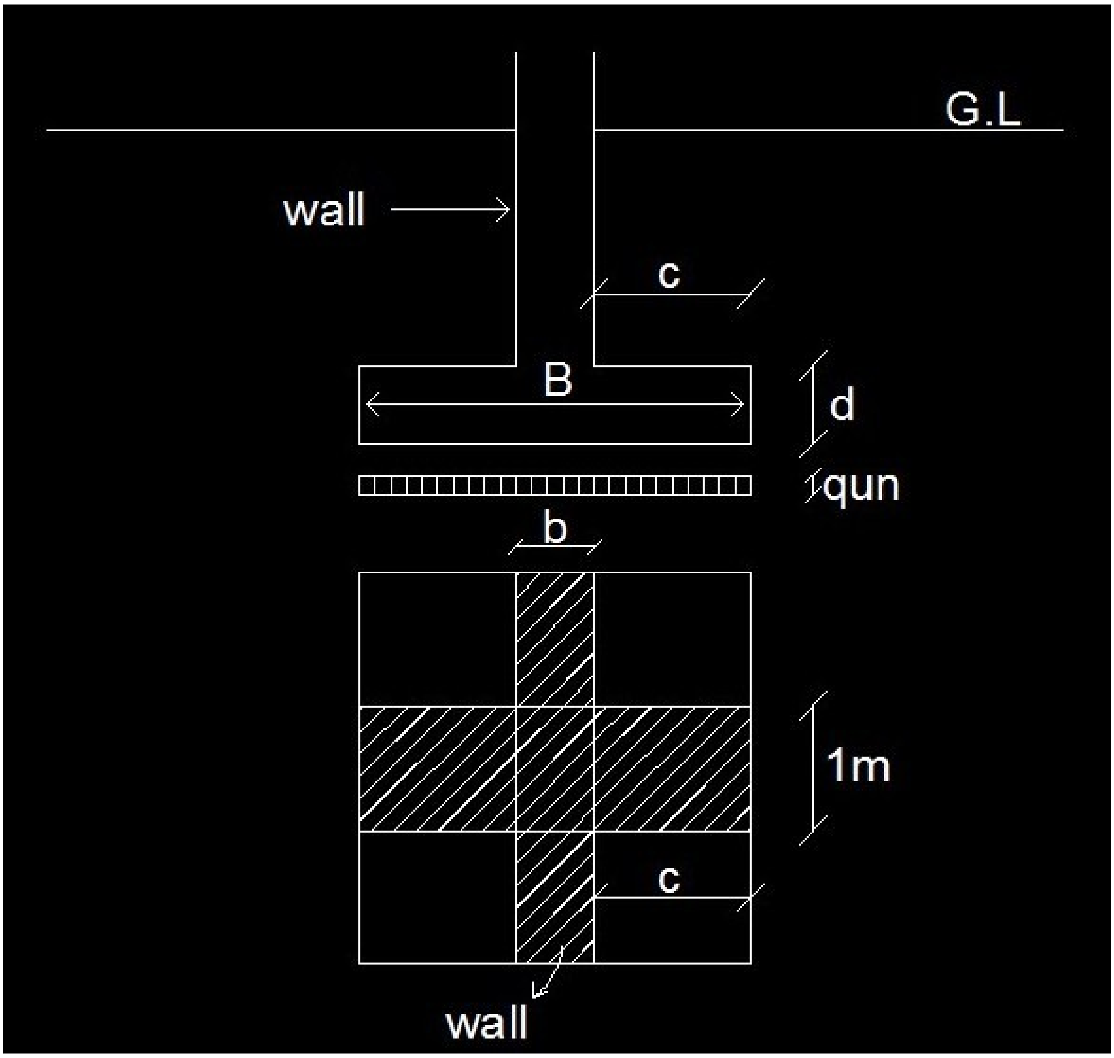
Sand : $\gamma = 1.81\ t / m^3$, $\nu = 30''$, F.O.S = 3

Clay : $\gamma_{sat} = 2.1\ t / m^3$, $m_v = 0.038\ cm^2 / kg$

The allowable Settlement = 2.5 cm



Strip Footing: القاعدة الشريطية:



الأبعاد ب working load

السمك و الحديد ب Ultimate load

للتحويل من ال working to Ultimate * 1.5

Procedure of Design:

Plain Concrete: الخرسانة العادية:

If $t_{p.c} > 20$ cm	If $t_{p.c} \leq 20$ cm
Consider p.c in design	Neglect فرشه نظافة فقط in design
$P_t = P_w * 1.1$	$P_t = P_w * 1.1$
$A_{p.c} = P_t / q_{all} = 1 * B_{p.c}$	$A_{R.c} = P_t / q_{all} = 1 * B_{R.c}$
$B_{R.c} = B_{p.c} - 2t_{p.c}$ to the nearest 5cm	$B_{R.c}$ = to the nearest 5cm

$t_{p.c}$ is assumed 10 $\rightarrow$ 40 cm

فرشه نظافة و لا تؤخذ في حسابات التصميم

$t_{p.c} = 10 \rightarrow 20$ cm

تعتبر قاعدة عادية و تؤخذ في حسابات التصميم

$t_{p.c} = 20 \rightarrow 40$ cm

Minimum dimensions of R.C. Footing:

$B_{R.c.} = 80$ cm

$t_{R.C.} = 40$ cm

$d_{R.C} = 33$ cm

If $t_{p.c}$ not given take $t_{p.c} = 20$ cm

$q_{ult} = 1.5 * p_w / B_{R.c} * 1$

$M_{ult} = q_{ult} * c^2 / 2$

$C = B_{R.c} - b_w / 2$

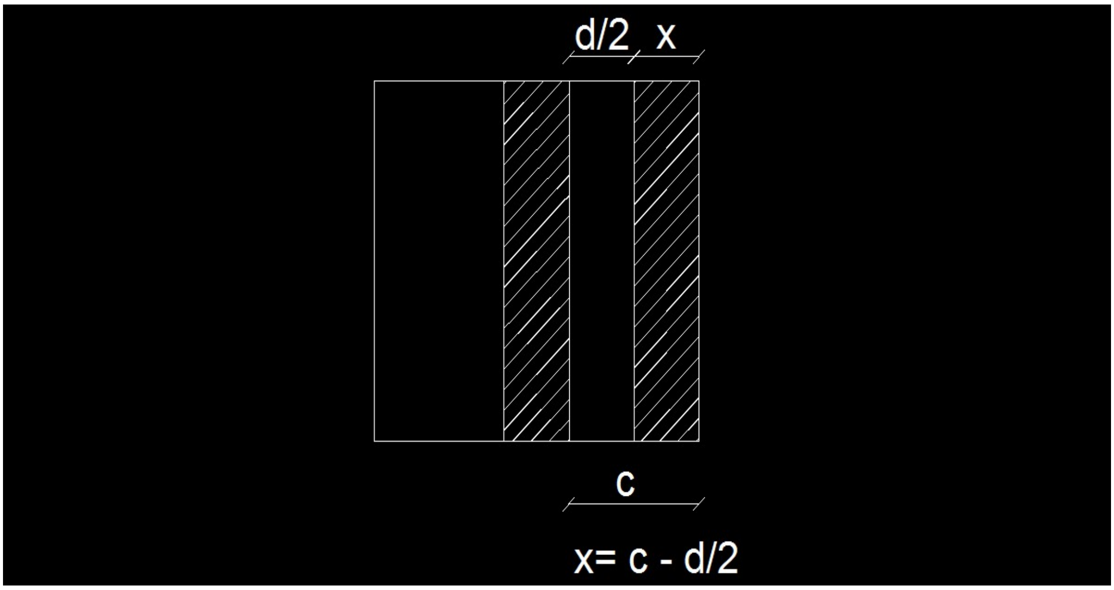
$d = c_1 \sqrt{\frac{\mathbf{Mult}}{\mathbf{Fcu * B}}} \cong$ to the nearest 5cm

If F_{cu} not given take $F_{cu} = 250$ kg / cm^2

$C_1 = 5$, B = 100 cm

p.c	Plain concrete	الخرسانة العادية
R.c	Reinforced concrete	الخرسانة المسلحة
P_w	wall load	حمل الحائط
$t_{p.c}$	Thickness of Plain concrete	سمك الخرسانة العادية
$A_{p.c}$	Area of Plain concrete	مساحة الخرسانة العادية
$A_{R.c}$	Area of Reinforced concrete	مساحة الخرسانة المسلحة
$B_{p.c}$	Plain concrete thickness	عرض الخرسانة العادية
$B_{R.c}$	Reinforced concrete thickness	عرض الخرسانة المسلحة
b_w	Wall thickness	عرض الحائط
q_{sh}	Actual shear stress	اجهادات ال shear
q_{cu}	Allowable shear stress	مقاومة الخرسانة لل shear
La	Available length	طول السيخ
ν	Diameter of bars	قطر السيخ

Check shear:



القطاع الحرج علي مسافة d/2 من وش الحائط.

Critical section

$Q_{sh} = q_{ult} (c - d/2)$

$q_{sh} = Q_{sh} / B*d$

$q_{cu} = 0.4 \sqrt{\mathbf{fcu}}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / q_{cu} *b$

t = d + cover ≅ to the nearest 5cm

cover = (5 to 10 cm)

Reinforcement of the footing:

Min 5 y 12 / m

Max 10 y ?? / m

$A_s = M_{ult} / J*d*f_y$ - - - - - - - - - -(1)

$A_{s\ min}$ = 5 y 12 / m - - - - - - - - - -(2)

$A_{s\ min} = (0.15 / 100) * B * d$ - - - - - - - - - -(3)

نأخذ القيمة الأكبر في القيم 1,2,3

If $A_s \geq A_{s\ min} \rightarrow$ ok

If $A_s < A_{s\ min} \rightarrow$ take $A_s = A_{s\ min}$

Check Bond:

$Ld = \alpha * \beta * \mu * (f_y / \boldsymbol{\gamma s}) * (\nu /4\ q_{ub})$

حيث أن:

$\alpha = 1$ → plan bars سيخ أملس

$\alpha = 0.75$ → H.G.S سيخ مشرشر

$\beta = 1$

$\mu = 1$

$\boldsymbol{\gamma s} = 1.15$

$F_y = 3600\ kg / cm^2$

$q_{ub} = 0.87 \sqrt{\frac{Fcu}{\gamma c}}$

$\gamma c = 1.5$

$Ld \leq La$

Example: 1

Given : f_{cu} = 200 kg/cm^2 , P_w= 180 kN / m^2 ,

b_w = 0.5 m , fy =3600 kg/cm^2 , $t_{p,c}$ = 20 cm , B/C (q_{all} = 100 kN / m^2

Req : Design of strip footing that carry the given line load.

Solution

100 kN / m^2 = 10 t / m^2 = 1 kg / cm^2

$\because t_{p.c} \leq 20$ cm

$\therefore$ Neglect in design

$A_{R.c} = 1.1 * P_w / q_{all} = 1.1 * 180 / 100 = 1.98$ m^2

$= 1 * B_{R.c} = 1 * 1.98 = 1.98 \cong 2$ m^2

End of working load

$q_{ult} = 1.5 * p_w / B_{R.c} * 1 = (1.5 * 18)/(2*1) = 13.5$ t /m^2

$C = B_{R.c} - b_w / 2 = (2-0.5)/ 2 = 0.75$ m

$M_{ult} = q_{ult} * c^2 / 2 = (13.5*(0.75)^2)/2 = 3.8$ t.m

$$d = c_1 \sqrt{\frac{\mathbf{Mult}}{\mathbf{Fcu * B}}} = 5 \sqrt{\frac{\mathbf{3.8 * 10^5}}{\mathbf{200 * 100}}} = 21.8 \text{ cm} \cong 25\text{cm}$$

$t = d + cover = 25+10 = 35$ cm

Check shear:

$Q_{sh} = q_{ult} (c - d/2) = 13.5*(0.75-(0.25/2)) = 8.4$ton

$q_{sh} = Q_{sh} / B*d = \frac{8.4*10^3}{100*25} = 3.3$ kg / cm^2

$q_{cu} = 0.4 \sqrt{\mathbf{fcu}} = 0.4 \sqrt{\mathbf{200}} = 5.66$kg / cm^2

$q_{sh} < q_{cu}$ ok safe

3.3 < 5.66 safe

Reinforcement:

$A_{s1} = M_{ult} / J*d*f_y = \frac{3.8*10^5}{0.826*25*3600} = 5.11$ cm^2 / m'

$A_{s\ min2} = 5$ y 12 /m = 5.65 cm^2 / m'

$A_{s\ min3} = \frac{0.15}{100}*B*d = \frac{0.15}{100}*100*25 = 3.75$cm^2/ m'

take $A_s = 5.65$cm^2/ m'

use 5 y 12 /m

Check Bond:

$$L_d = \alpha * \beta * \mu * (f_y / \gamma_s) * (\nu / 4\, q_{ub})$$

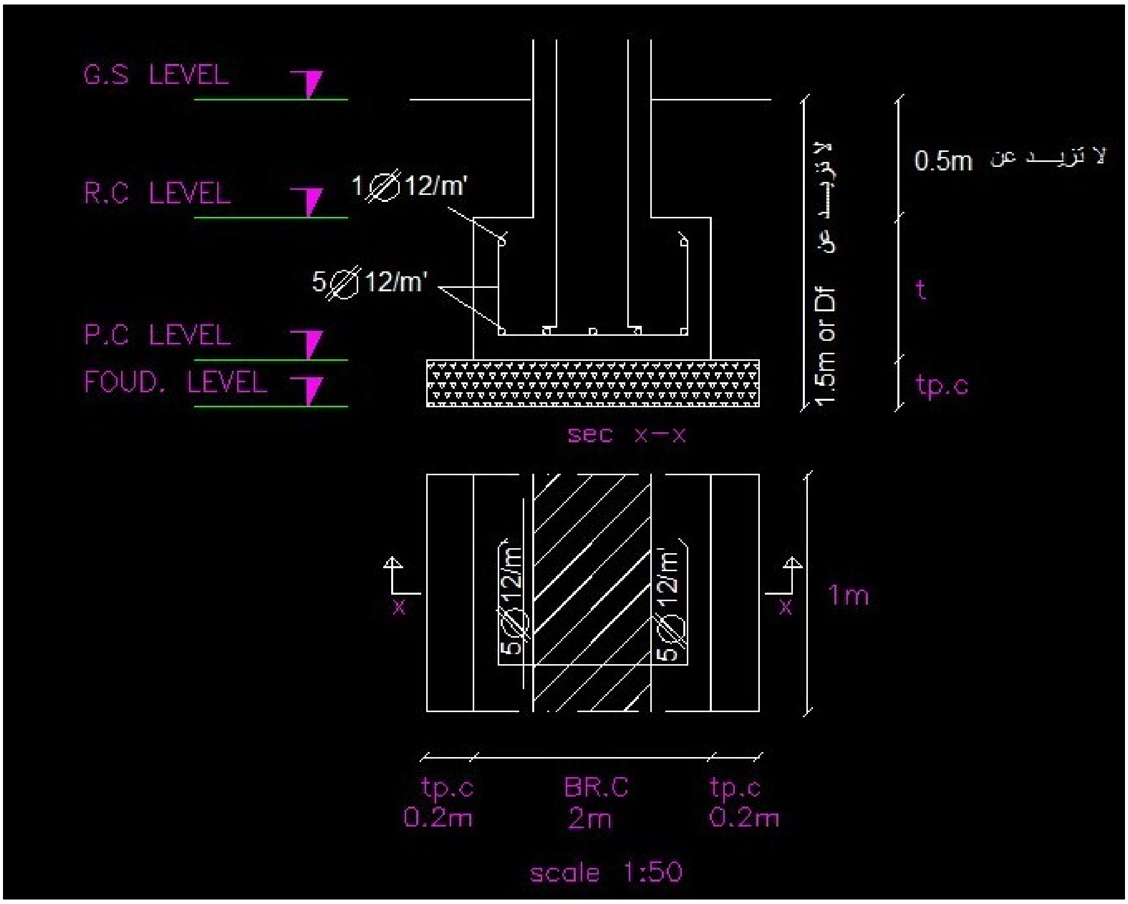
$$q_{ub} = 0.87 \sqrt{\frac{F_{cu}}{\gamma_c}} = 0.87 \sqrt{\frac{200}{1.5}} = 10\ kg/cm^2$$

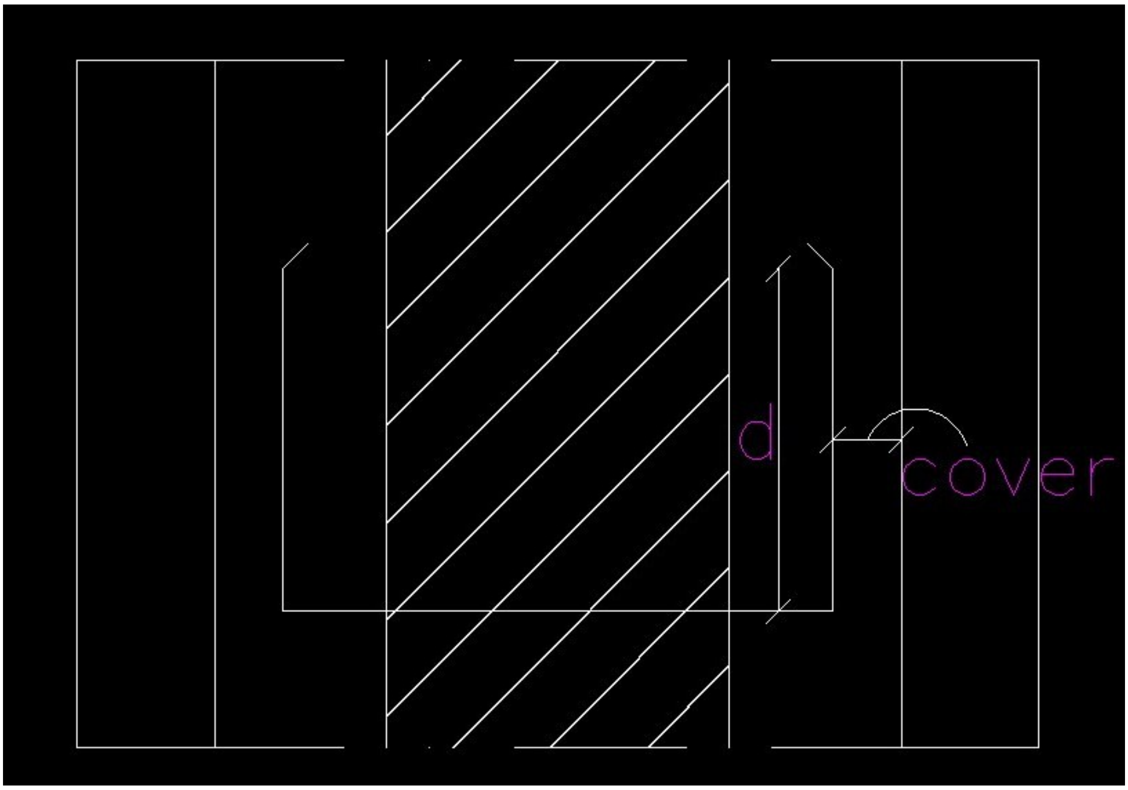
$$L_d = 0.75*1*1*(3600/1.15)*(1.2/(4*10))$$

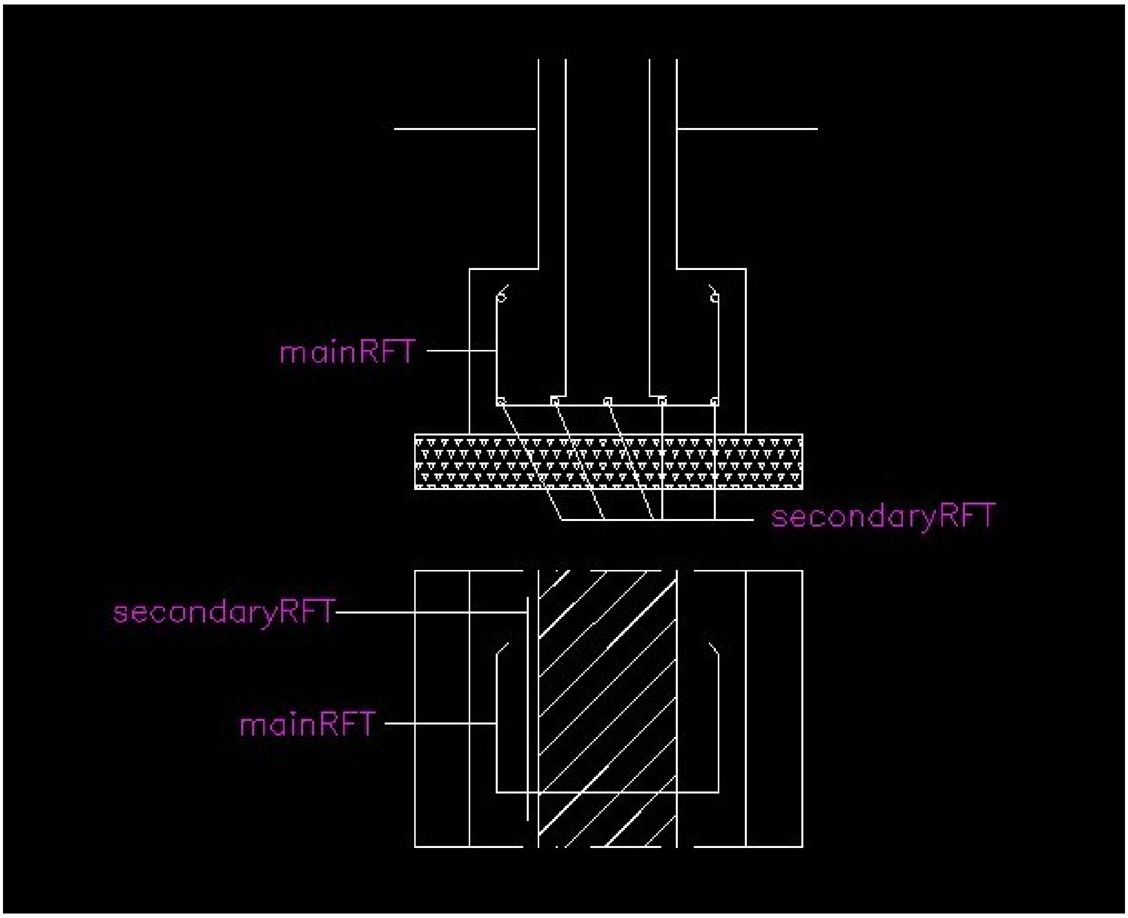
$$= 70.4\ cm \rightarrow 0.704\ m$$

$$L_d \leq L_a$$

$$0.704 \leq 2 \quad ok$$




d
cover


mainRFT
secondaryRFT
secondaryRFT
mainRFT

Isolated footing:

Squared Isolated footing .

تستخدم في حالة:

1- عمود مربع.

2- عمود دائري.

3- يمكن مع الأعمدة المستطيلة لكنة غير مفضل.

Hunched Squared Isolated footing .

Rectangular Isolated footing .

تستخدم في حالة:

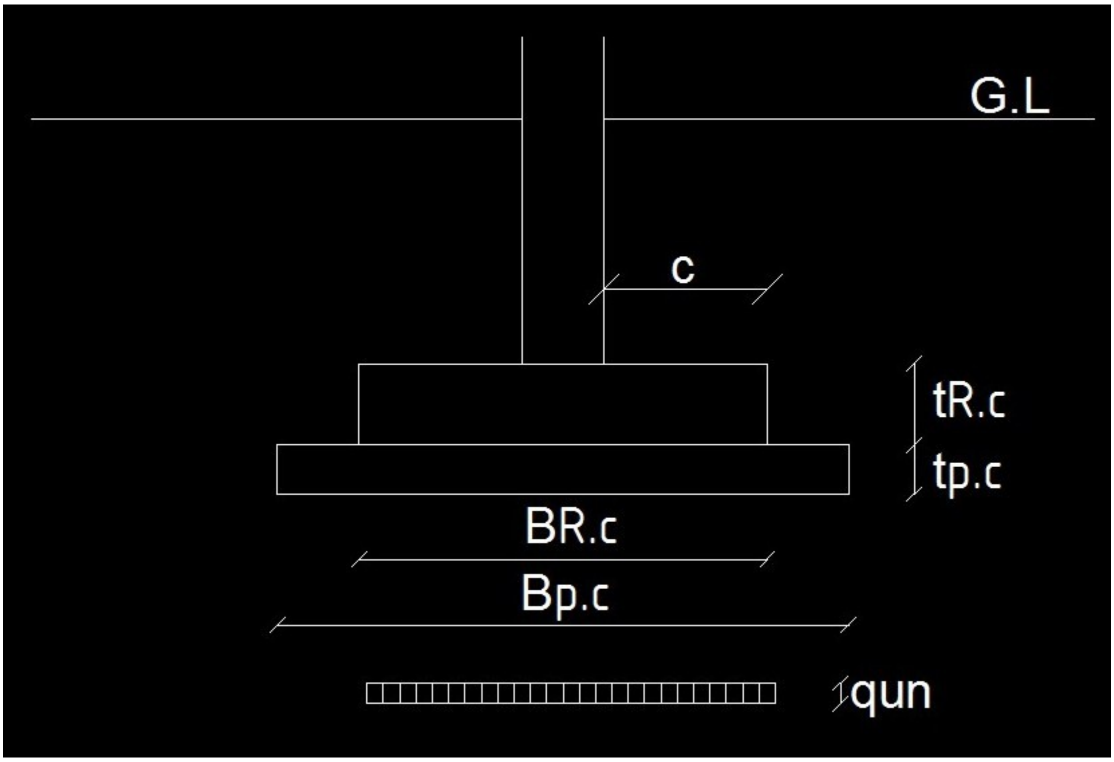
1- الأعمدة المستطيلة.

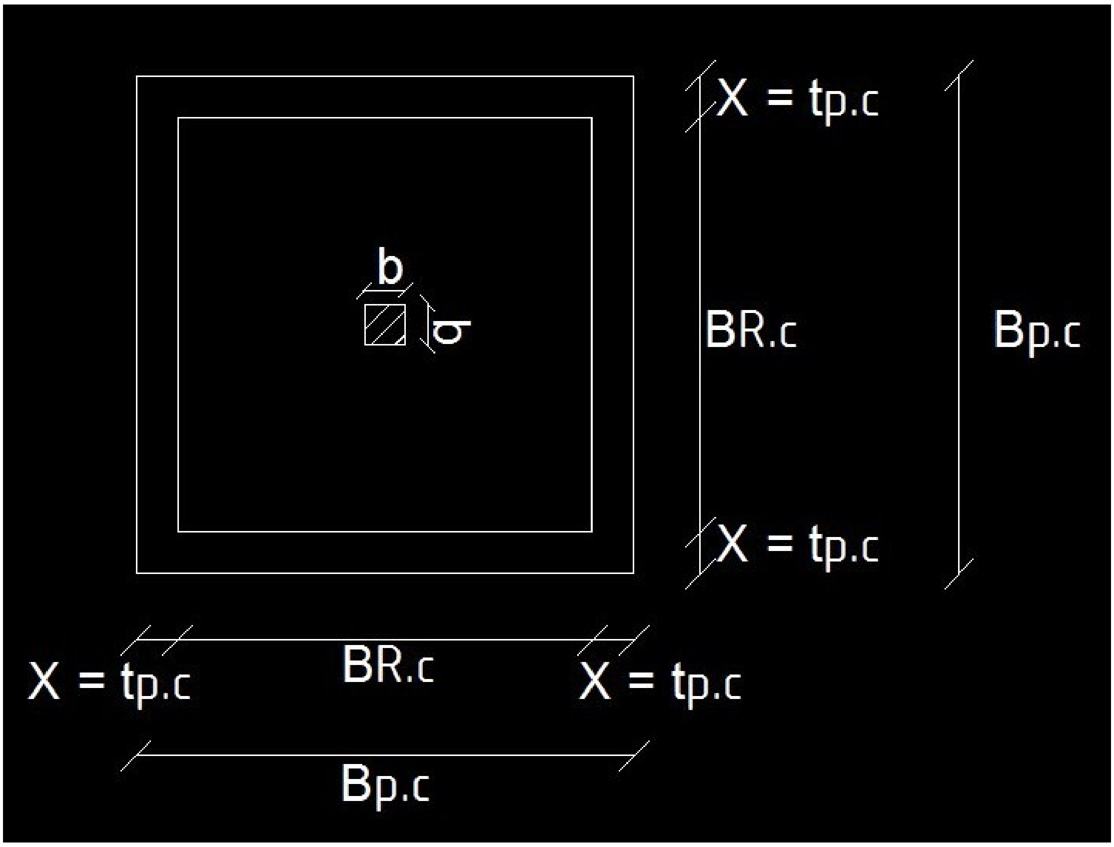
2- يمكن مع الأعمدة المربعة لكنة غير مفضل.

Circular Isolated footing .

تستخدم فقط مع الأعمدة الدائرية.

Design Isolated Squared footing:





Procedure of Design:

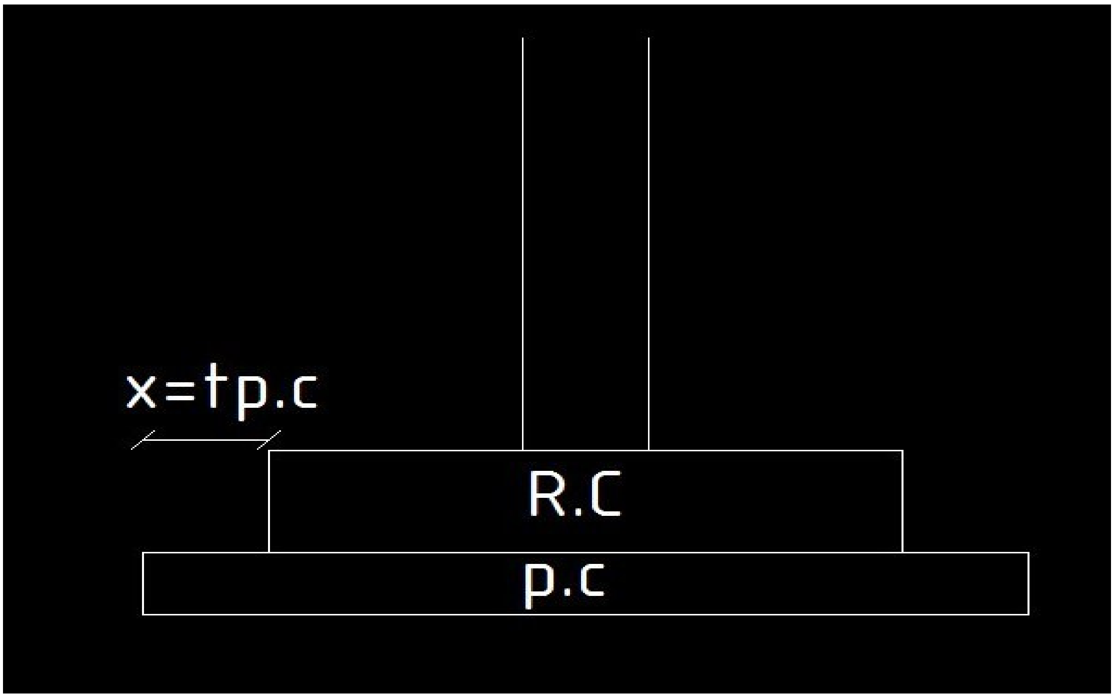
Plain concrete:

If $t_{p.c} > 20$ cm	If $t_{p.c} \leq 20$ cm
Consider p.c in design	Neglect فرشه نظافة فقط in design
$P_t = P_w * 1.1$	$P_t = P_w * 1.1$
$A_{p.c} = P_t / q_{all} = B_{p.c}^2$	$A_{R.c} = P_t / q_{all} = B_{R.c}^2$
$B_{p.c} = \sqrt{Ap.c}$	$B_{R.c} = \sqrt{AR.c}$
$B_{R.c} = B_{p.c} - 2t_{p.c}$ $\cong$ to the nearest 5cm	$B_{p.c} = B_{R.c} + 2t_{p.c}$ $\cong$ to the nearest 5cm

في حالة العمود المربع:

Check stresses on plain concrete:

عند أخذ القاعدة العادية في الحسابات:



$q_{ult} = 1.5 * p_w / B_{p.c}^2$

$M_{ult} = (q_{ult} * (X^2)) / 2$

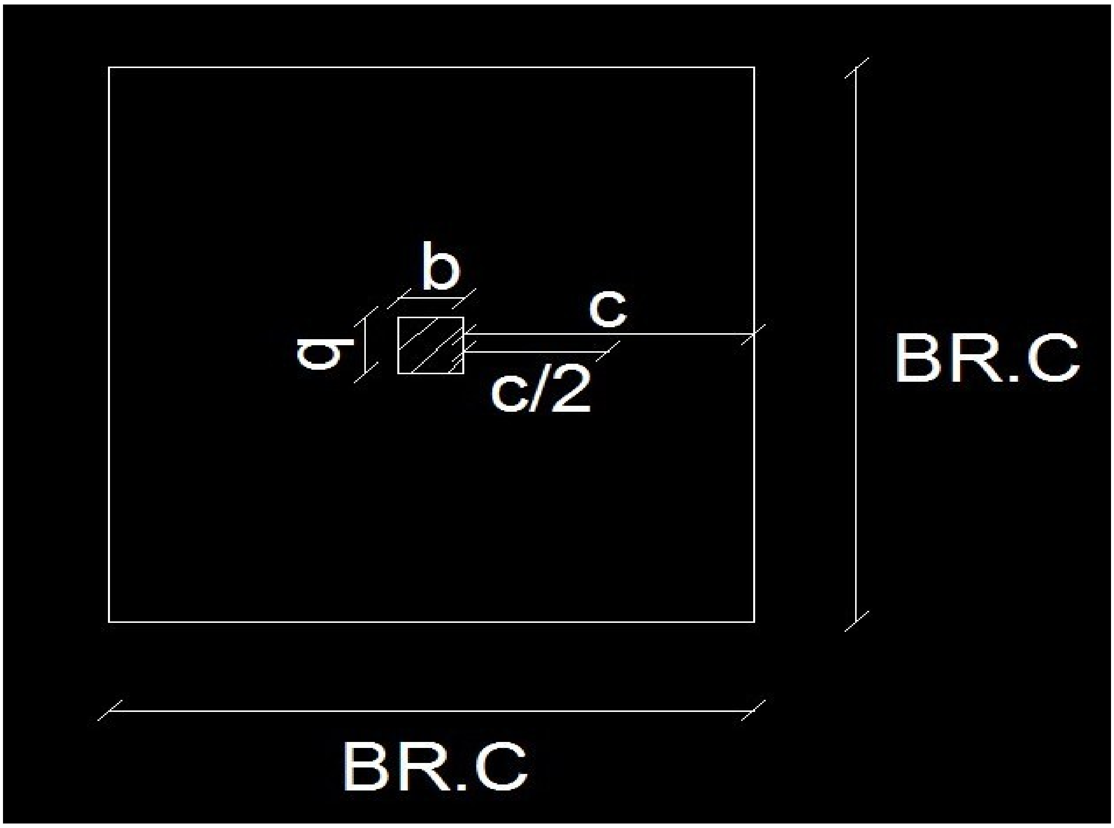
$F_t = 6 * M_{ult} / 100 * (t_{p.c})^2$

$F_{tcu} = (0.75 * (fcu)^{2/3}) / 1.5$

If $F_t < F_{tcu}$ ok safe

If $F_t > F_{tcu}$ not safe (X) نقلل بروز الخرسانة العادية

$q_{ult} = 1.5*p_w / B_{R.c}^2$



$M_{ult} = q_{ult} *(B_{R.c}*c)*(c / 2)$

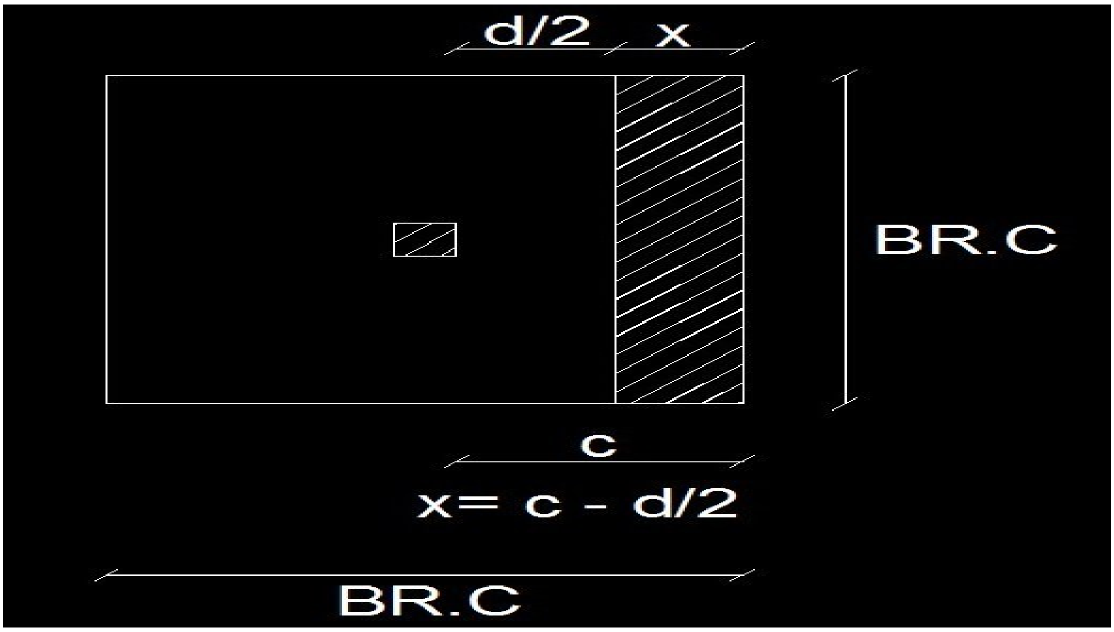
$C = (B_{R.c} - b / 2)$

$d = c_1 \sqrt{\frac{\textbf{Mult}}{\textbf{Fcu}*\textbf{BR.c}}} \cong$ to the nearest 5cm

$t = d + cover \cong$ to the nearest 5cm

cover = (5 to 10 cm)

Check shear:



القطاع الحرج علي مسافة d/2 من وش العمود.

Critical section

$Q_{sh} = q_{ult} (B_{R.c} * (c - d/2))$

$q_{sh} = Q_{sh} /(B_{R.c} * d)$

$q_{cu} = 0.4 \sqrt{fcu}$

if $q_{sh} < q_{cu}$ ok safe

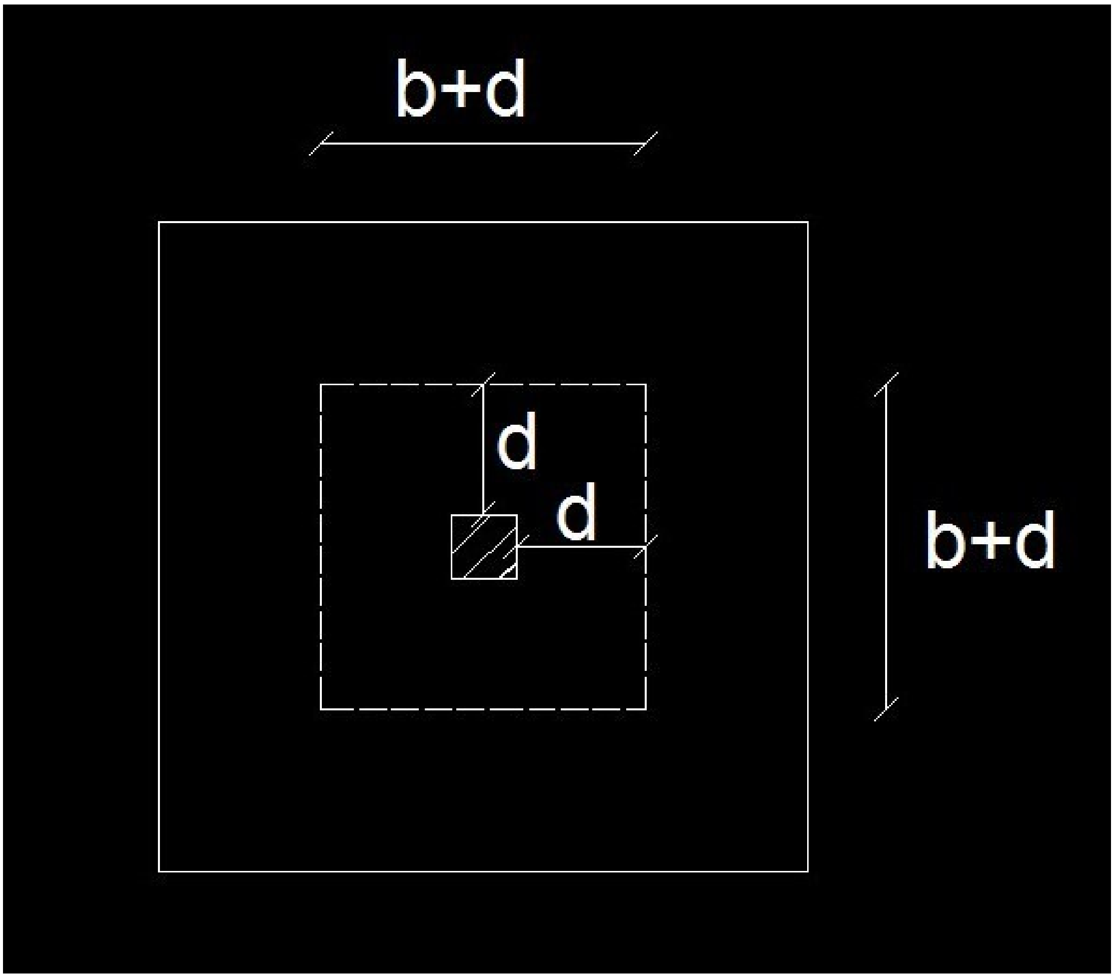
if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / (q_{cu} * B_{R.c})$

t = d + cover

cover = (5 to10 cm)

Check punching:



$Q_p = p_u - q_{ult}\,(b+d)^2$

$q_p = Q_p\,/\,(4(b+d)d)$

$q_{pcu} = \sqrt{\dfrac{fcu}{\gamma c}}$

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe $\longrightarrow$ increase depth

Reinforcement of the footing:

Min 5 y 12 / m

Max 10 y ?? / m

$A_s = M_{ult} / J*d*f_y / B_{R.c}$ - - - - - - - - - -(1)

$A_{s\ min} = 5$ y $12 / m$ - - - - - - - - - -(2)

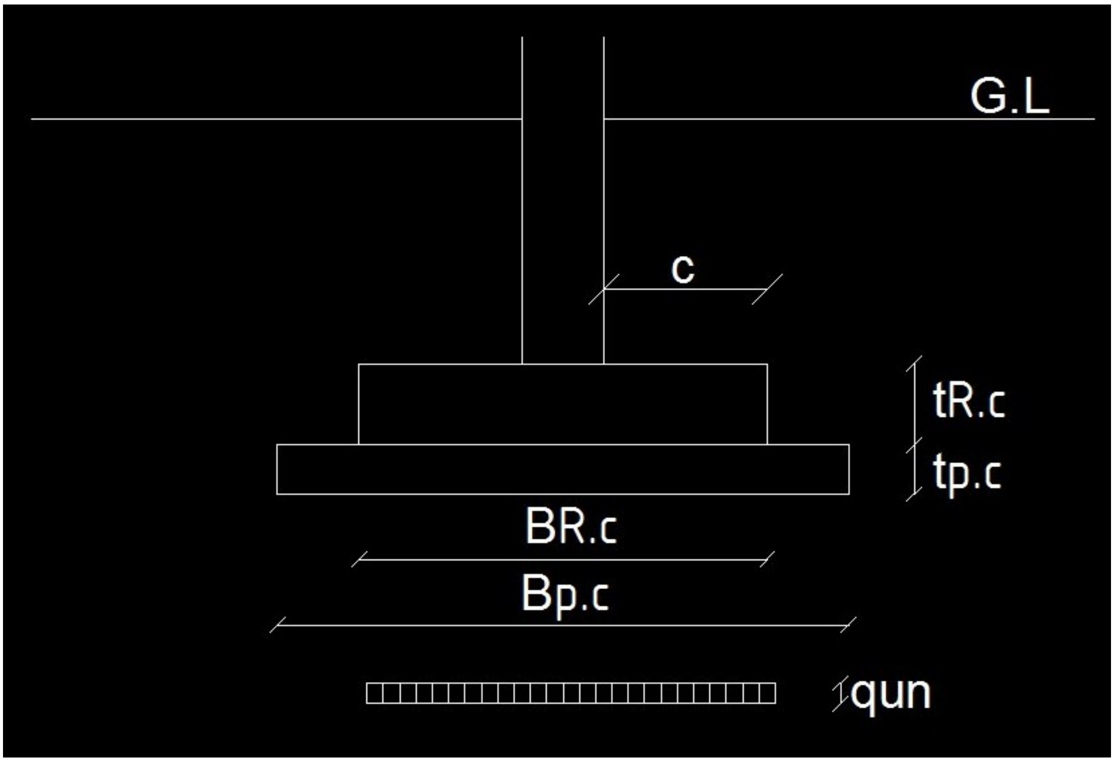
$A_{s\ min} = (0.15 / 100) * B * d$ - - - - - - - - - -(3)

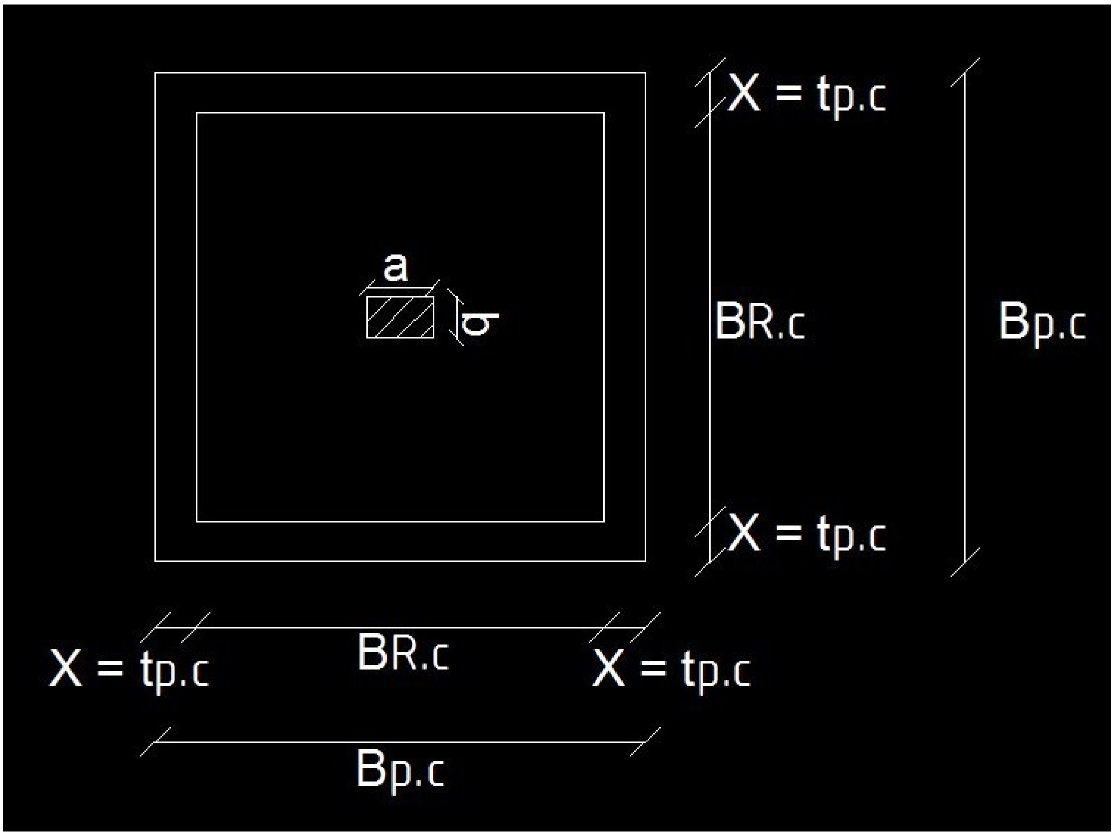
نأخذ القيمة الأكبر في القيم 1,2,3

If $A_s \geq A_{s\ min} \rightarrow$ ok

If $A_s < A_{s\ min} \rightarrow$ take $A_s = A_{s\ min}$

Design Isolated Squared footing:





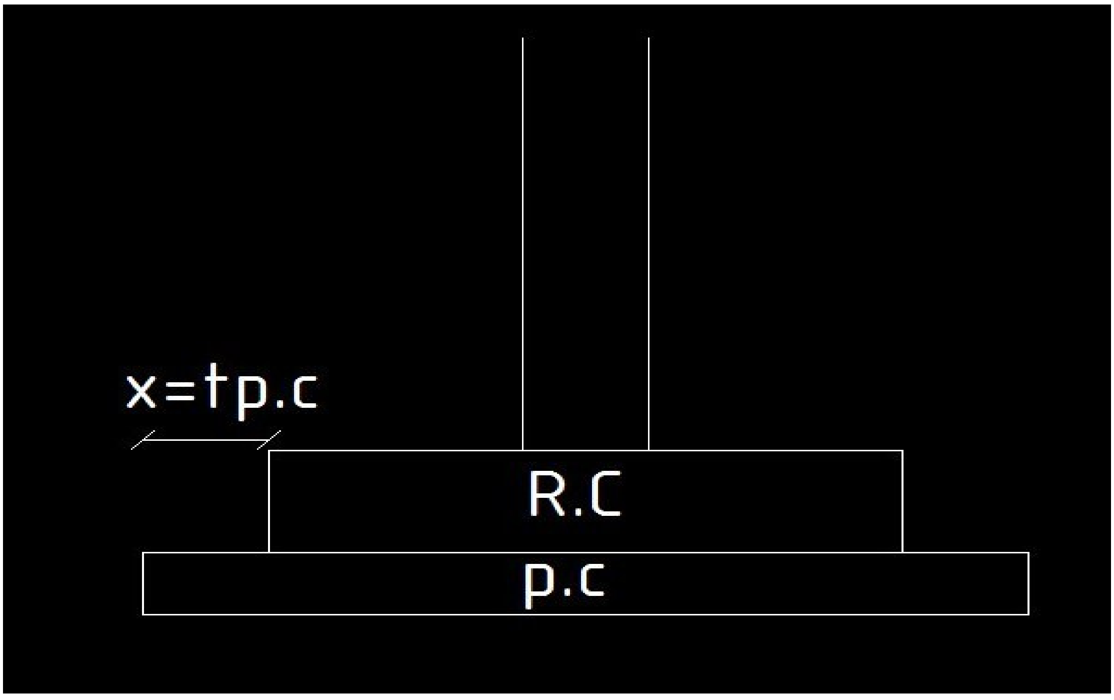
Procedure of Design:

If $t_{p.c} > 20$ cm	If $t_{p.c} \leq 20$ cm
Consider p.c in design	Neglect فرشه نظافة فقط in design
$P_t = P_w * 1.1$	$P_t = P_w * 1.1$
$A_{p.c} = P_t / q_{all} = B_{p.c}^2$	$A_{R.c} = P_t / q_{all} = B_{R.c}^2$
$B_{p.c} = \sqrt{Ap.c}$	$B_{R.c} = \sqrt{AR.c}$
$B_{R.c} = B_{p.c} - 2t_{p.c}$ to the nearest 5cm	$B_{p.c} = B_{R.c} + 2t_{p.c}$ to the nearest 5cm

في حالة العمود المستطيل:

Check stresses on plain concrete:

عند أخذ القاعدة العادية في الحسابات:



$q_{ult} = 1.5*p_w / B_{p.c}^2$

$M_{ult} = (q_{ult} *(X^2)) /2$

$F_t = 6* M_{ult} / 100*(t_{p.c})^2$

$F_{tcu} = (0.75*(fcu)^{2/3})/1.5$

If $F_t < F_{tcu}$ ok safe

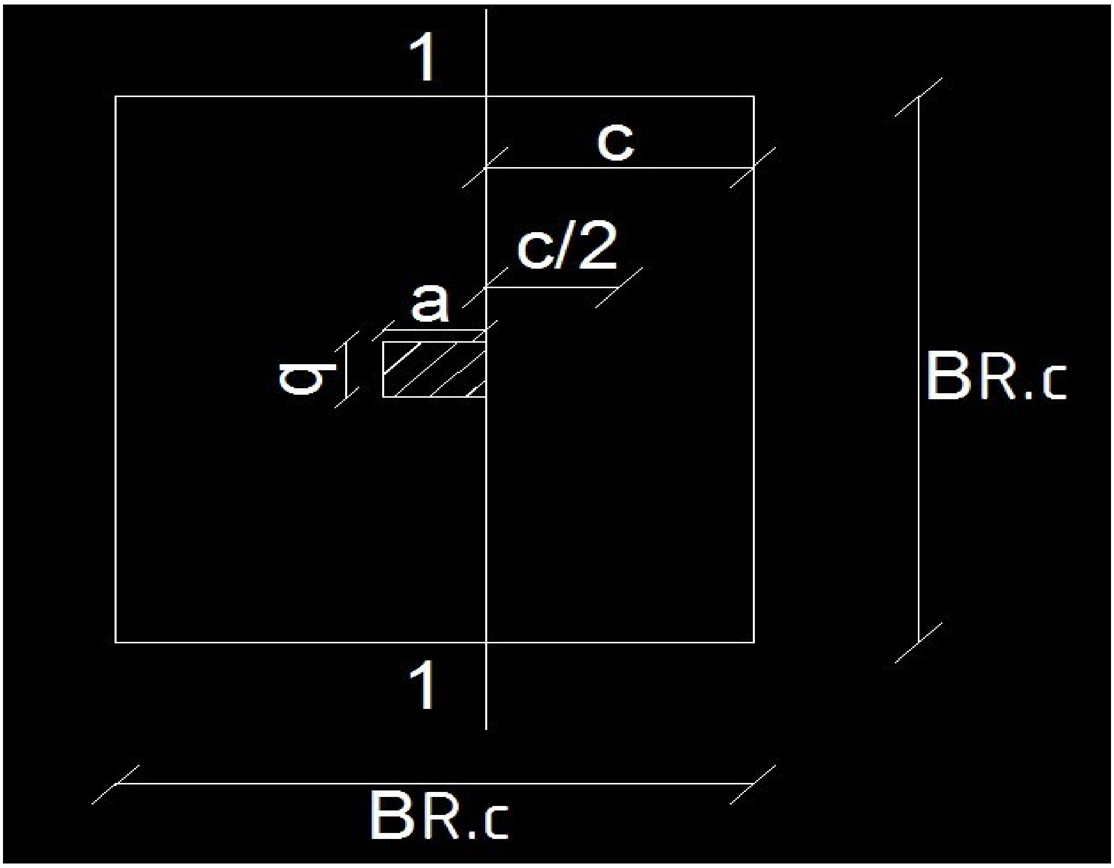
If $F_t > F_{tcu}$ not safe (X) نقلل بروز الخرسانة العادية

$q_{ult} = 1.5 * p_w / B_{R.c}^2$

نأخذ القطاعات الحرجة للعزوم علي وش العمود من الجهتين

Critical section of bending at R.C Footing .

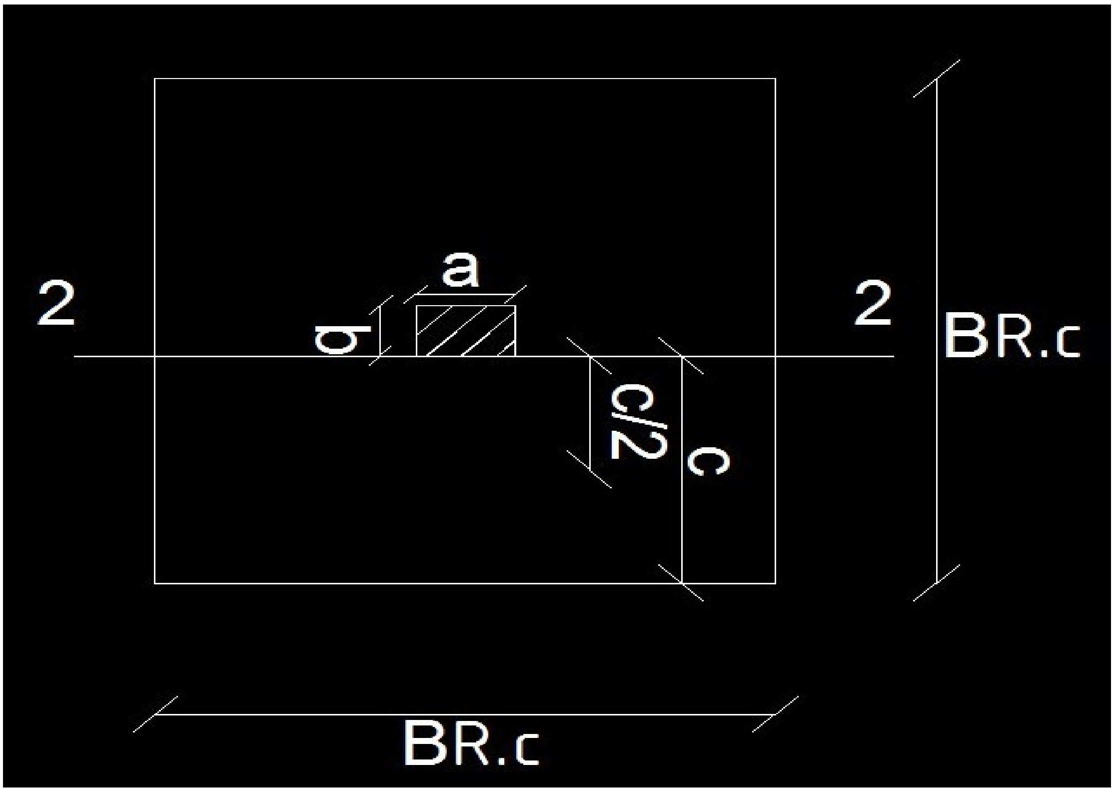
Direction 1:



$C_1 = (B_{R.c} - a / 2)$

$M_{ult\,1} = q_{ult} * (B_{R.c} * c_1) * (c_1 / 2)$

Direction 2:



$C_2 = (B_{R.c} - b / 2)$

$M_{ult\ 2} = q_{ult} *(B_{R.c}*c_2)*(c_2 / 2)$

يتم التصميم علي العزم الكبر من $M_{ult\ 1}$, $M_{ult\ 2}$

$d = c_1 \sqrt{\frac{\mathbf{Mult}}{\mathbf{Fcu*BR.c}}}$ ≅ to the nearest 5cm

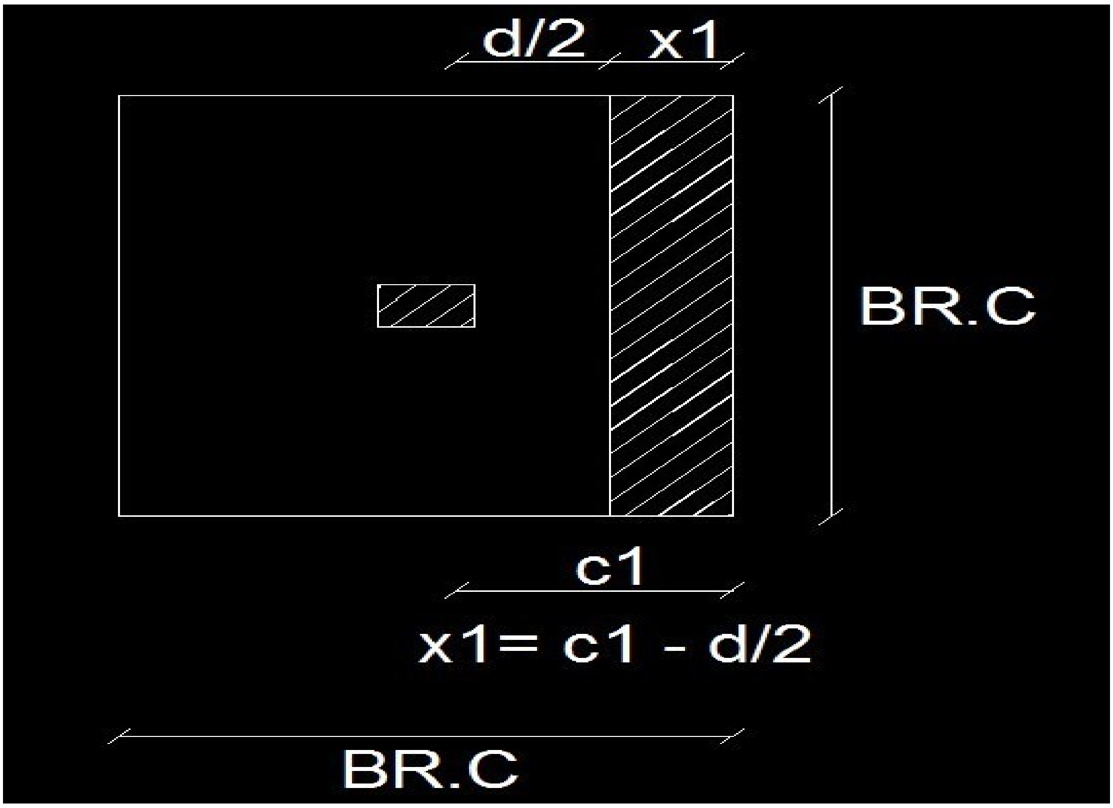
t = d + cover ≅ to the nearest 5cm

cover = (5 to 10 cm)

Check shear:

القطاع الحرج علي مسافة d/2 من وش العمود.

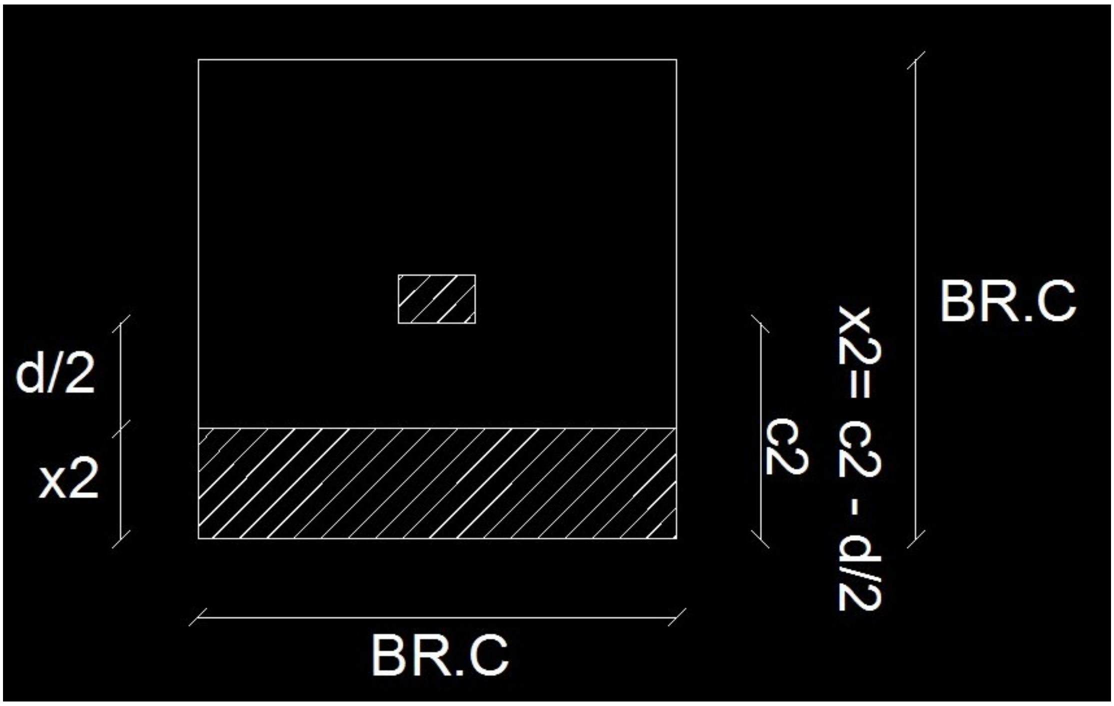
Critical section



$Q_{sh1} = q_{ult} (B_{R.c} * (c_1 - d/2))$

$q_{sh1} = Q_{sh1} /(B_{R.c} * d)$

$q_{cu} = 0.4 \sqrt{fcu}$



$Q_{sh2} = q_{ult} (B_{R.c} * (c_2 - d/2))$

$q_{sh2} = Q_{sh2} /(B_{R.c} * d)$

$q_{cu} = 0.4 \sqrt{fcu}$

Take the bigger of Q_{sh1} , Q_{sh2} and q_{sh1} , q_{sh2}

if $q_{sh} < q_{cu}$ ok safe

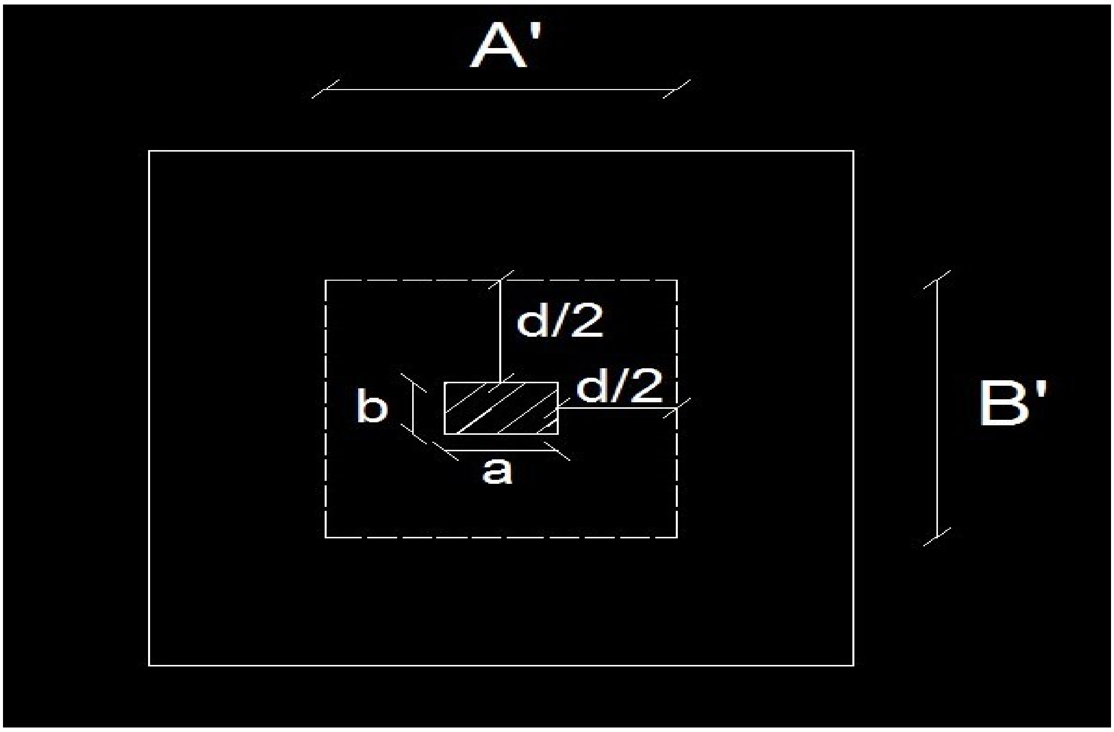
if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / (q_{cu} * B_{R.c})$

t = d + cover

cover = (5 to 10 cm)

Check punching:



$Q_p = p_u - q_{ult} (A'+B')$

$A' = a + d$, $B' = b + d$

a → طول العمود , b → عرض العمود

$q_p = Q_p / (2(A'+B')d)$

$q_{pcu} = (0.5 + \frac{b}{a}) \sqrt{\frac{fcu}{\gamma c}}$

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

Reinforcement of the footing:

Min 5 y 12 / m

Max 10 y ?? / m

$A_s = M_{ult} / J*d*f_y / B_{R.c}$ - - - - - - - - - -(1)

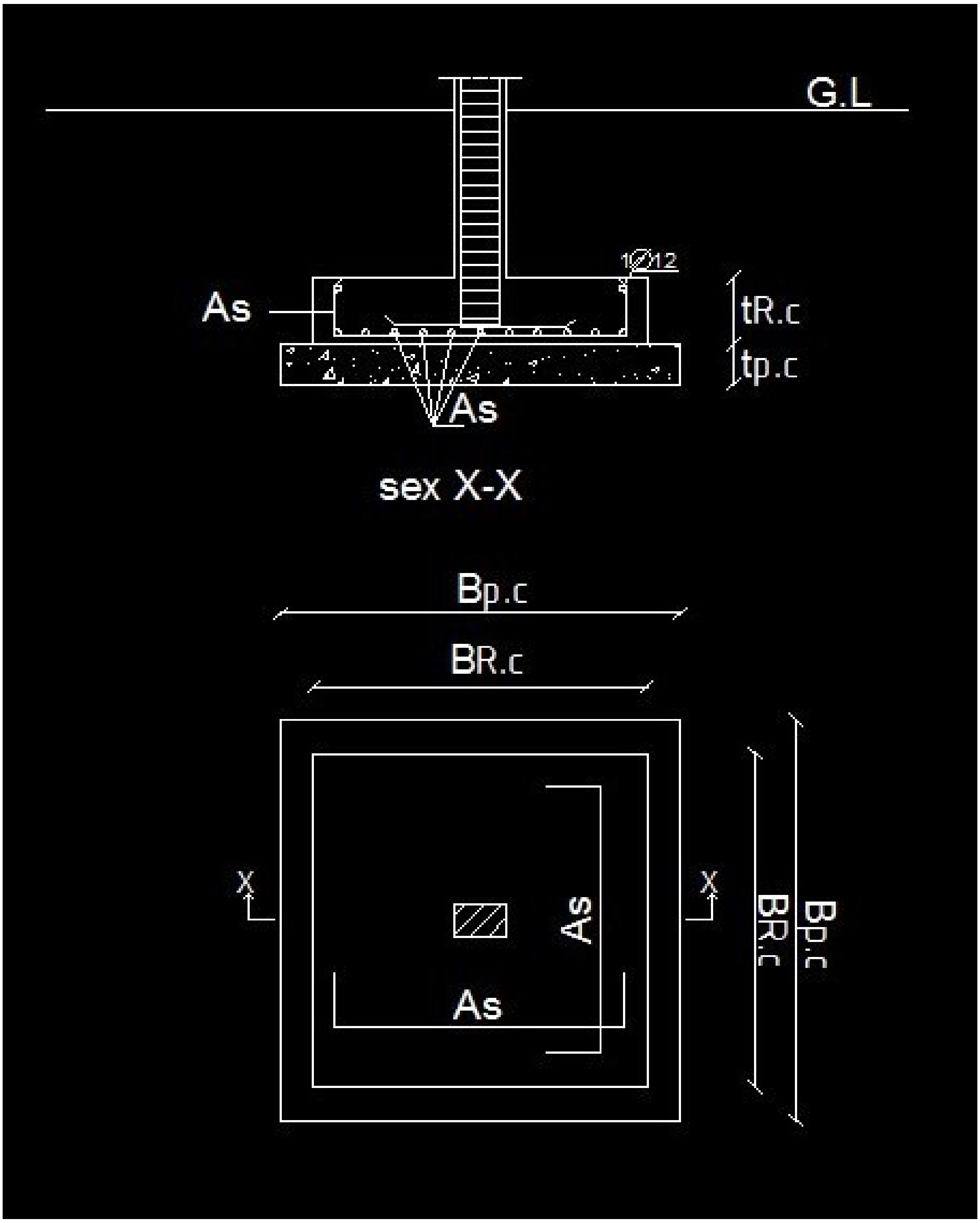
$A_{s\ min} = 5$ y 12 / m - - - - - - - - - -(2)

$A_{s\ min} = (0.15 / 100) * B * d$ - - - - - - - - - -(3)

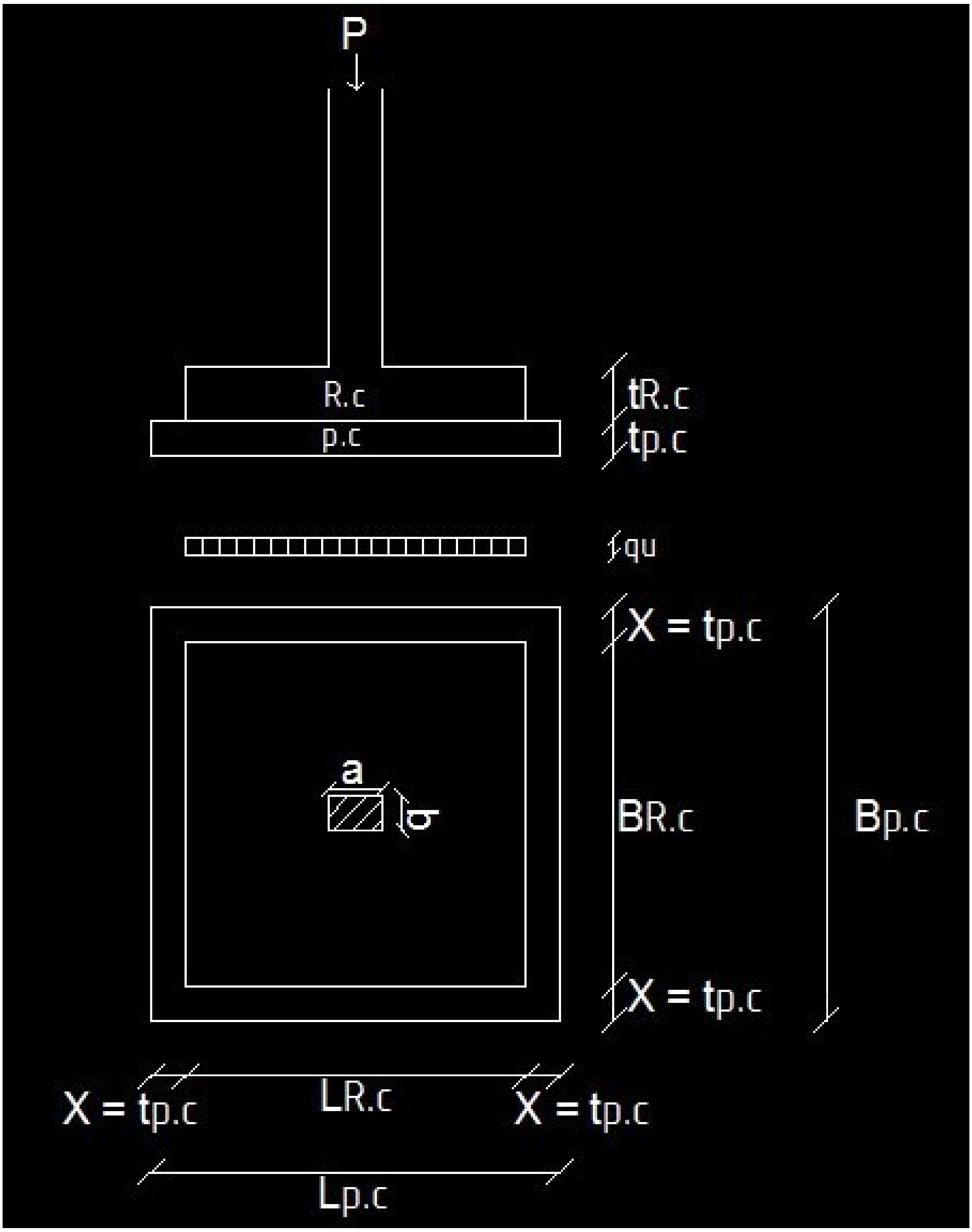
نأخذ القيمة الأكبر في القيم 1,2,3

If $A_s \geq A_{s\ min} \rightarrow$ ok

If $A_s < A_{s\ min} \rightarrow$ take $A_s = A_{s\ min}$


G.L
1∅12
As
tR.c
tp.c
As
sex X-X
Bp.c
BR.c
X
X
As
As
BR.c
Bp.c

Design of Isolated Rectangular footing:



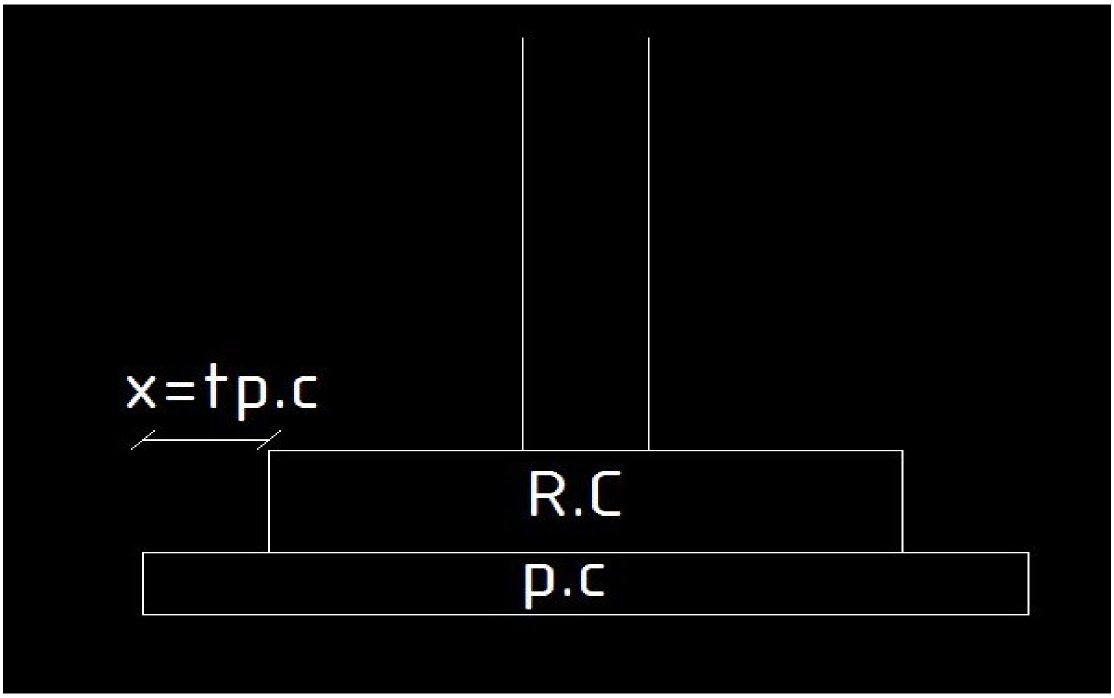
Procedure of Design:

Plain concrete:

If $t_{p.c} > 20$ cm	If $t_{p.c} \leq 20$ cm
Consider p.c in design	Neglect فرشه نظافة فقط in design
$P_t = P_w * 1.1$	$P_t = P_w * 1.1$
$A_{p.c} = P_t / q_{all} = B_{p.c} \times L_{p.c}$	$A_{R.c} = P_t / q_{all} = B_{R.c} \times L_{R.c}$
$B_{p.c} = \sqrt{Ap.c}$	$B_{R.c} = \sqrt{AR.c}$
نأخذ الفرق بين أبعاد القاعدة = الفرق بين أبعاد العمود $L_{p.c} + B_{p.c} = a\text{-}b$	نأخذ الفرق بين أبعاد القاعدة = الفرق بين أبعاد العمود $L_{R.c} + B_{R.c} = a\text{-}b$
$B_{R.c} = B_{p.c} - 2t_{p.c}$ $L_{R.c} = L_{p.c} - 2t_{p.c}$ $\cong$ to the nearest 5cm	$B_{p.c} = B_{R.c} + 2t_{p.c}$ $\cong$ to the nearest 5cm

Check stresses on plain concrete:

عند أخذ القاعدة العادية في الحسابات:



$q_{ult} = 1.5*p_w / (B_{p.c} * L_{p.c})$

$M_{ult} = (q_{ult} *(X^2)) /2$

$F_t = 6* M_{ult} / 100*(t_{p.c})^2$

$F_{tcu} = (0.75*(fcu)^{2/3})/1.5$

If $F_t < F_{tcu}$ ok safe

If $F_t > F_{tcu}$ not safe (X) نقلل بروز الخرسانة العادية

$q_{ult} = 1.5*p_w / (B_{p.c} * L_{p.c})$

القطاعات الحرجة للعزوم:

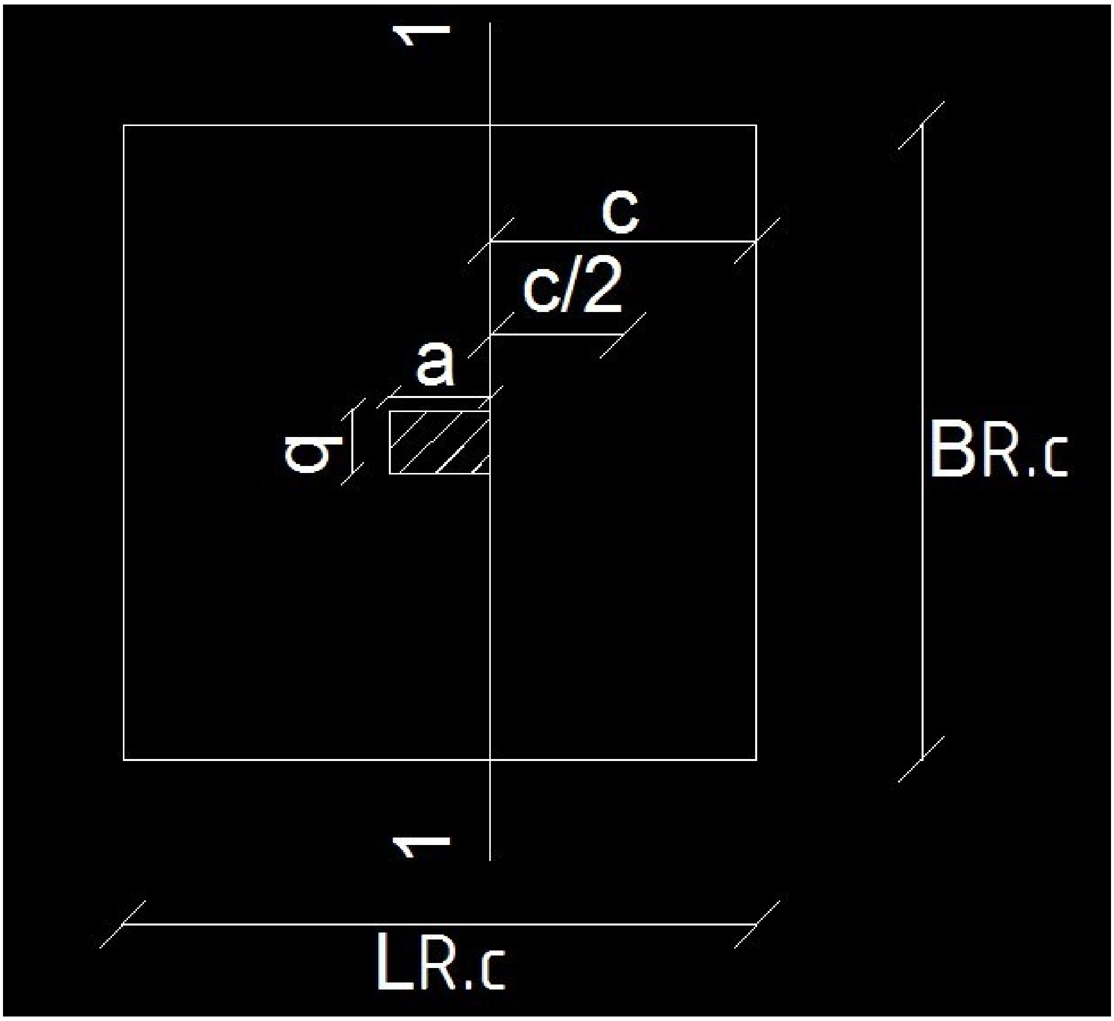
هنالك طريقتين لحساب M_{ult}

الطريقة الأولي:

نأخذ القطاعات الحرجة للعزوم علي وش العمود من الجهتين

Critical section of bending at R.C Footing .

Direction 1:



$C_1 = (L_{R.c} - a / 2)$

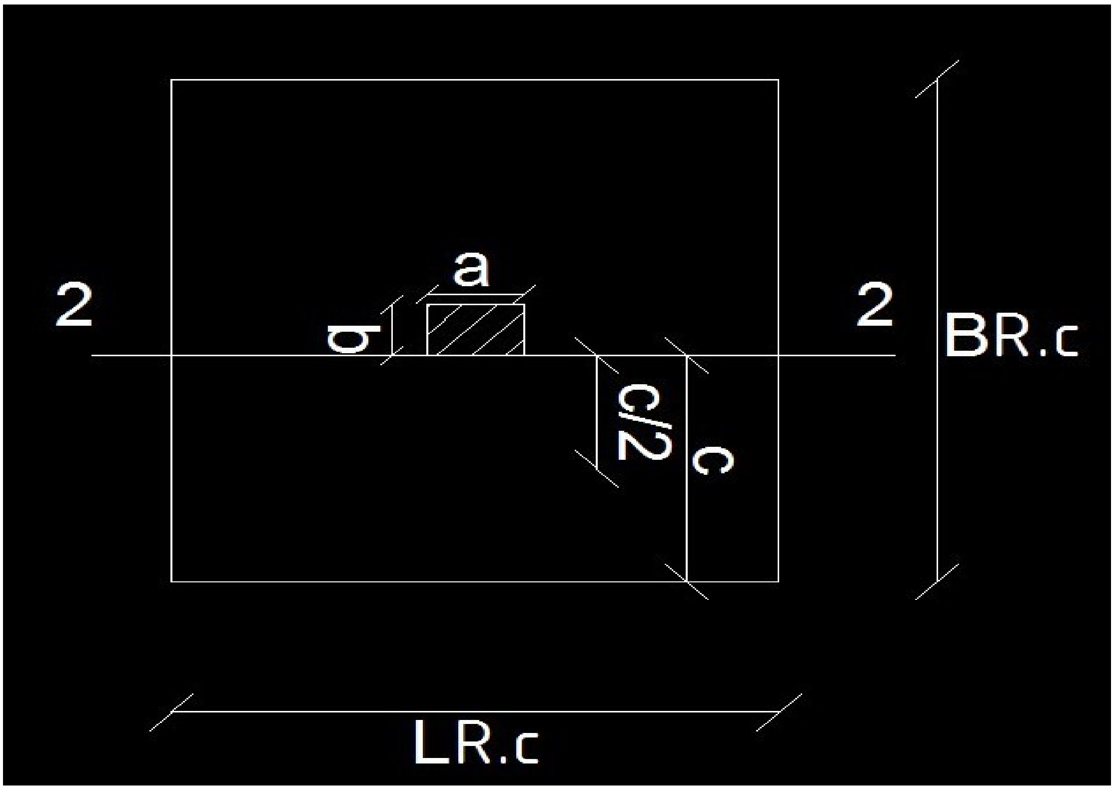
$M_{ult\ 1} = q_{ult} *(B_{R.c} * c_1)*(c_1 / 2)$

$d_1 = c_1 \sqrt{\frac{Mult1}{Fcu * BR.c}} \cong$ to the nearest 5cm

$t_{1R.C} = d_1 + cover \cong$ to the nearest 5cm

cover = (5 to 10 cm)

Direction 2:



$C_2 = (B_{R.c} - b / 2)$

$M_{ult\ 2} = q_{ult} *(L_{R.c} * c_2)*(c_2 / 2)$

$d_2 = c_1 \sqrt{\frac{\mathbf{Mult2}}{\mathbf{Fcu*LR.c}}} \cong$ to the nearest 5cm

$t_{2R.C} = d_2 +$ cover $\cong$ to the nearest 5cm

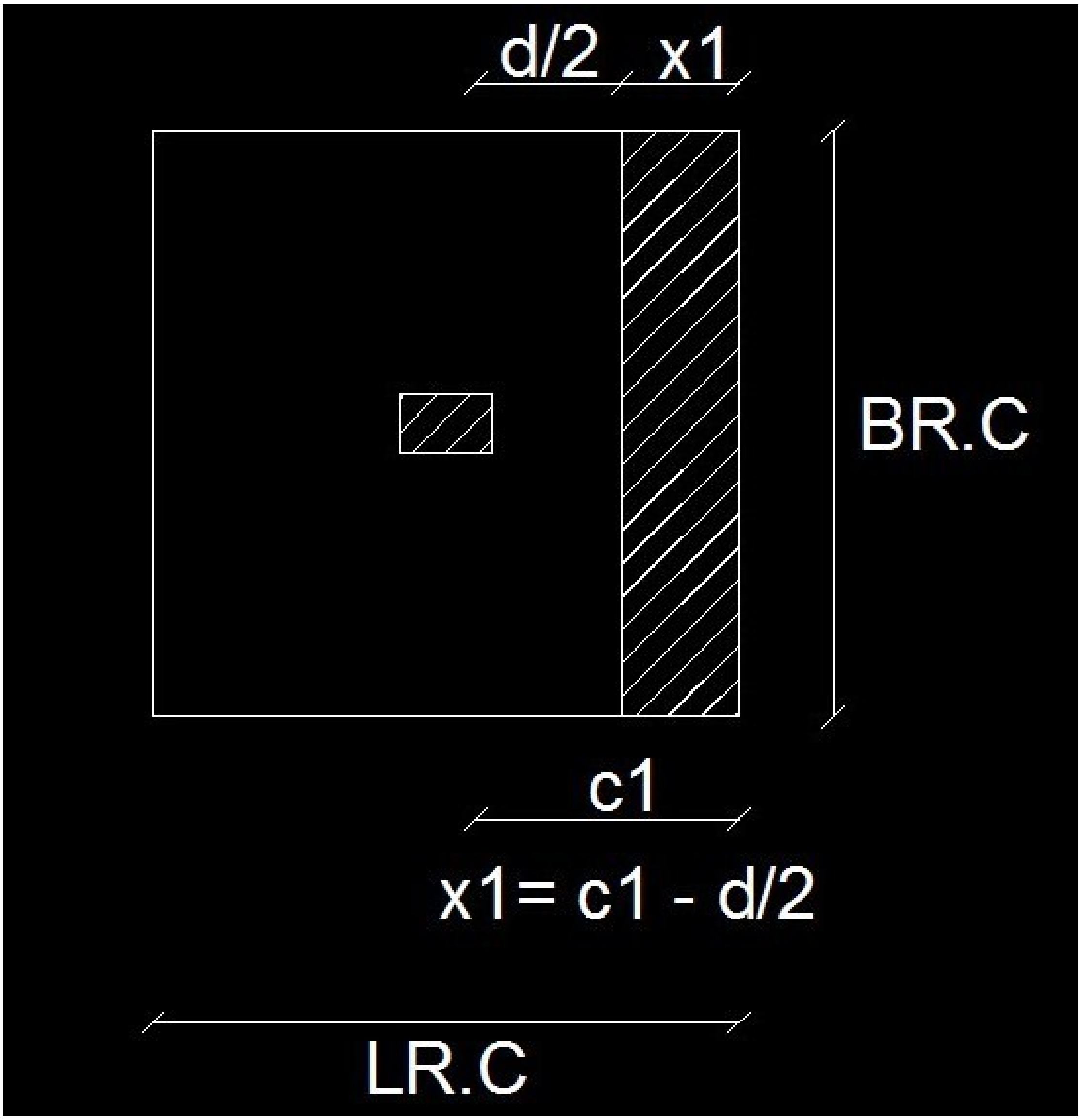
cover = (5 to 10 cm)

Take the bigger of $t_{1R.C}$, $t_{2R.C} \rightarrow t_{R.C}$

Check shear:

القطاع الحرج علي مسافة d/2 من وش العمود.

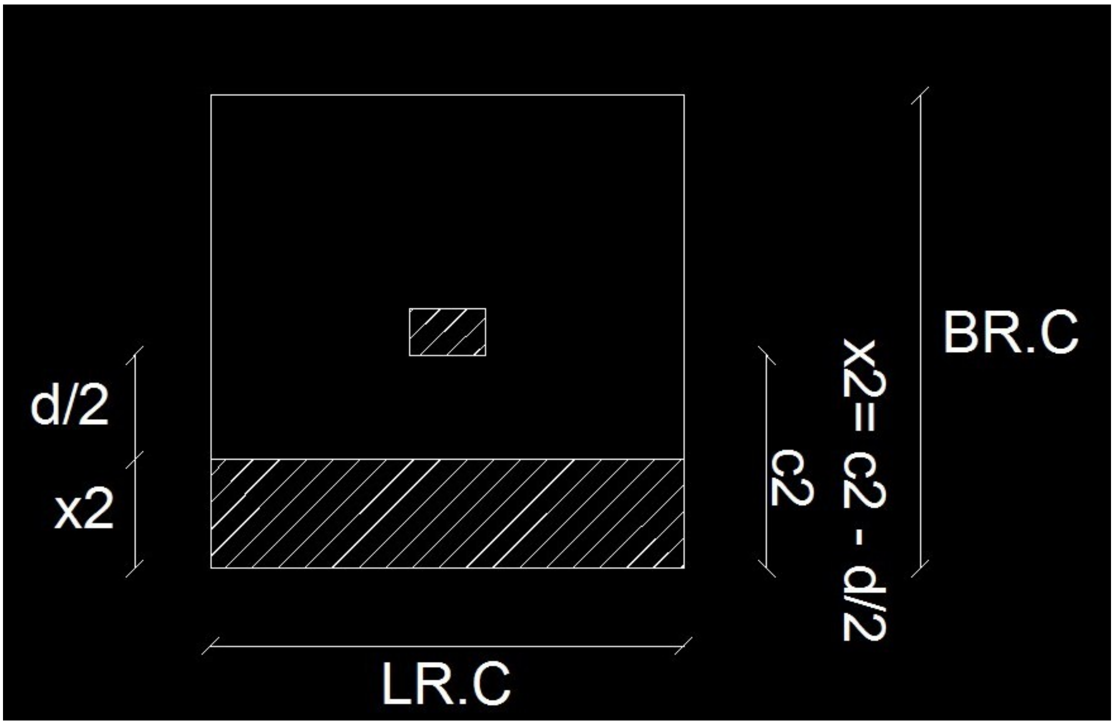
Critical section



$Q_{sh1} = q_{ult} (B_{R.c} * (c_1 - d/2))$

$q_{sh1} = Q_{sh1} /(B_{R.c} * d)$

$q_{cu} = 0.4 \sqrt{\mathbf{fcu}}$



$Q_{sh2} = q_{ult} \, (L_{R.c} * (c_2 - d/2))$

$q_{sh2} = Q_{sh2} /(L_{R.c} * d)$

$q_{cu} = 0.4 \sqrt{fcu}$

Take the bigger of Q_{sh1} , Q_{sh2} and q_{sh1} , q_{sh2}

if $q_{sh} < q_{cu}$ ok safe

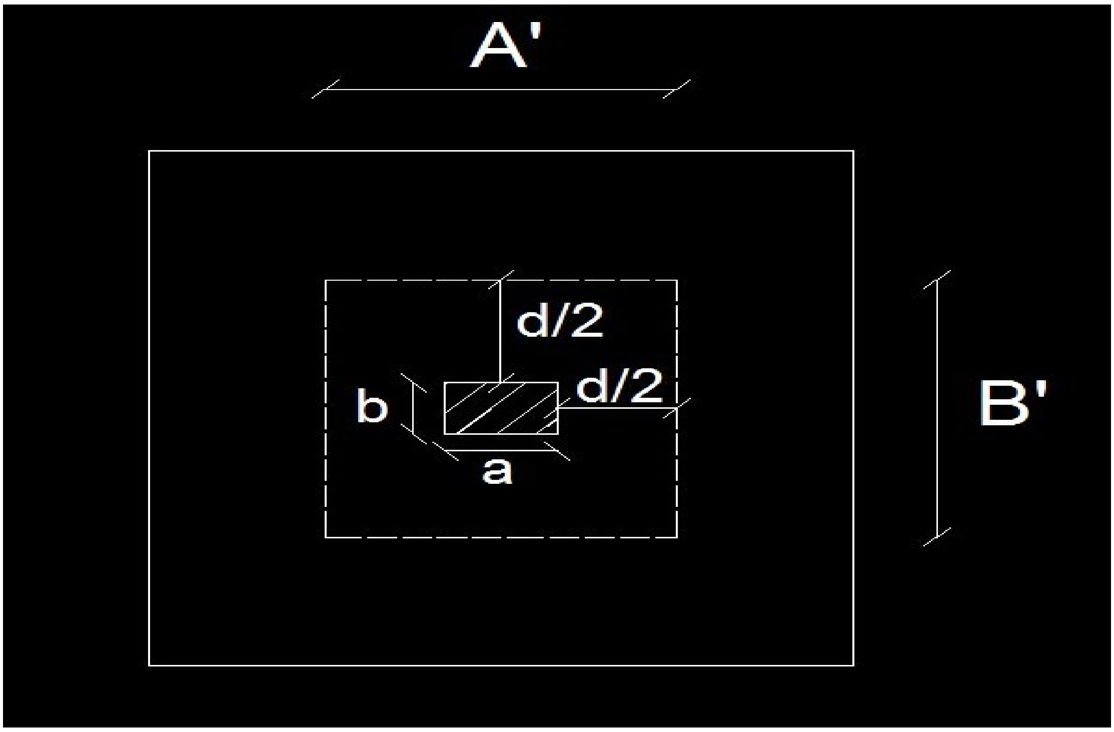
if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / (q_{cu} * B_{R.c}$ OR $L_{R.c})$

t = d + cover

cover = (5 to 10 cm)

Check punching:



$Q_p = p_u - q_{ult} (A'+B')$

$A' = a + d$, $B' = b + d$

a → طول العمود , b → عرض العمود

$q_p = Q_p / (2(A'+B')d)$

$q_{pcu} = (0.5 + \frac{b}{a}) \sqrt{\frac{fcu}{\gamma c}}$

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

Reinforcement of the footing:

Min 5 y 12 / m

Max 10 y ?? / m

$A_{s1} = M_{ult1} / J*d*f_y / B_{R.c}$ - - - - - - - - - -(1)

$A_{s2} = M_{ult2} / J*d*f_y / L_{R.c}$ - - - - - - - - - -(1)

$A_{s\,min}$ = 5 y 12 / m - - - - - - - - - -(2)

$A_{s\,min} = (0.15 / 100) * B * d$ - - - - - - - - - -(3)

نأخذ القيمة الأكبر في القيم 1,2,3

If $A_s \geq A_{s\,min} \rightarrow$ ok

If $A_s < A_{s\,min} \rightarrow$ take $A_s = A_{s\,min}$

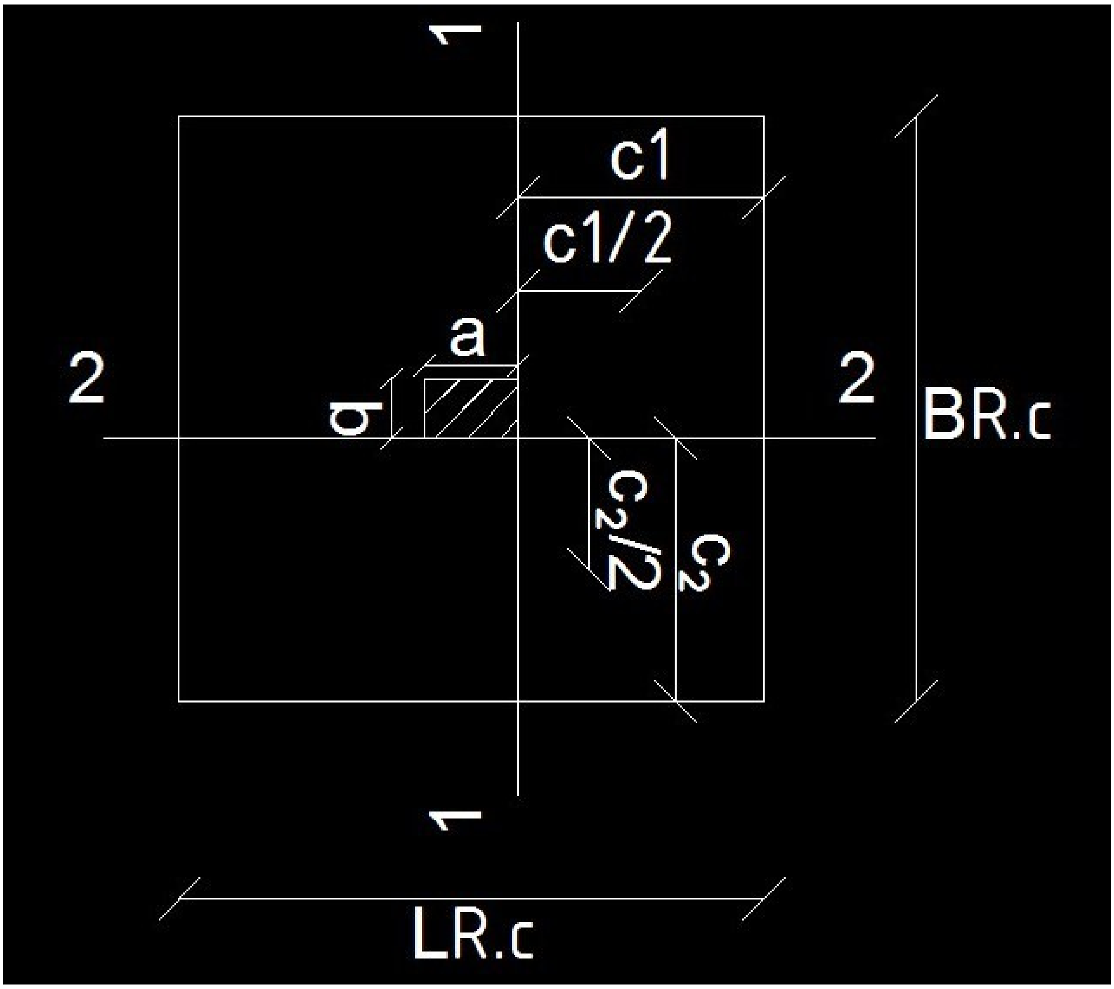
الطريقة الثانية:

نأخذ القطاعات الحرجة للعزوم علي وش العمود في اتجاه واحد فقط ولكن لابد من تحقق الشرط

$L_{p.c} - B_{P.C} = a - b$

فيكون $c_1 = c_2$ وبالتالي سيكون $M_{ult\ 1} = M_{ult\ 2}$ و من ثم سيكون $d_1 = d_2$

$q_{ult} = 1.5*p_w / (B_{p.c} * L_{p.c}) = ... \ t/m^2$



$C = C_1 = C_2 = (L_{R.c} - a / 2)$ OR $(B_{R.c} - b / 2)$

$M_{ult1}=M_{ult2}= q_{ult} * C^2 /2 =.....$ m t/m'

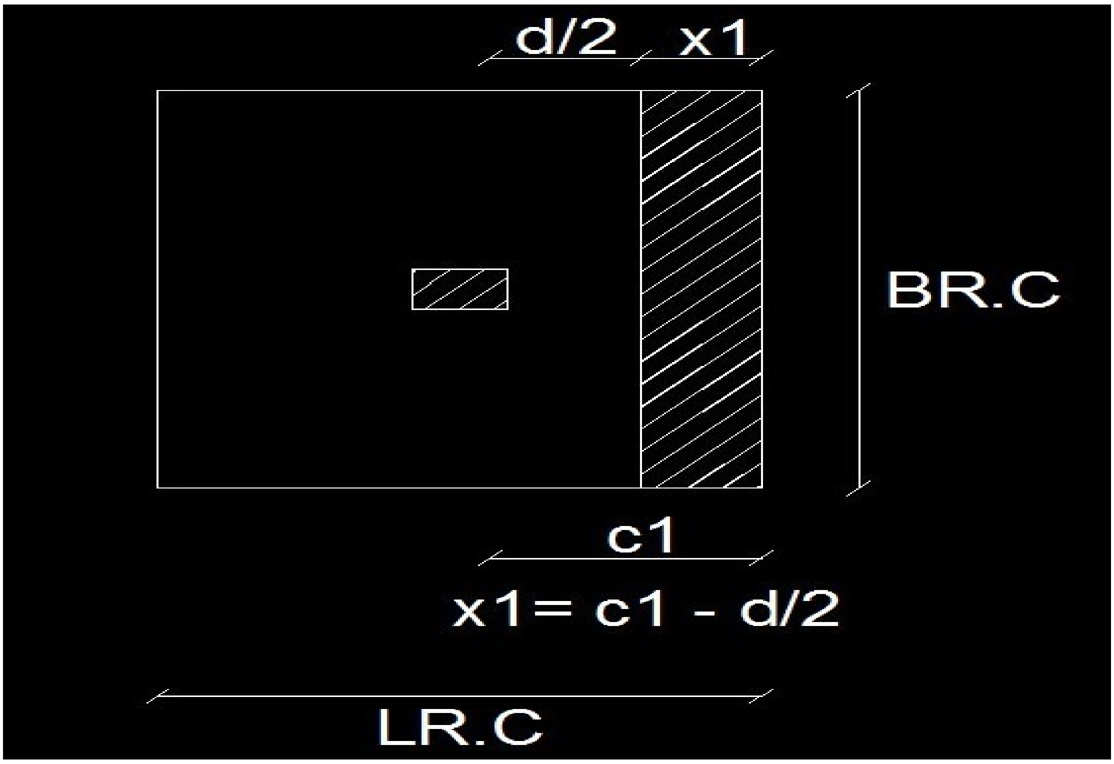
$d=c_1 \sqrt{\frac{\mathbf{Mult1or2}}{\mathbf{Fcu*b}}} \cong$ to the nearest 5cm =... cm

b= 100 cm شريحة

Check shear:

القطاع الحرج علي مسافة d/2 من وش العمود.

Critical section



$Q_{sh} = q_{ult} (c_1 - d/2) = ...$ ton

$q_{sh} = Q_{sh} /(b*d) = ...$ Kg/cm^2

$q_{cu} = 0.4 \sqrt{\mathbf{fcu}}$

if $q_{sh} < q_{cu}$ ok safe

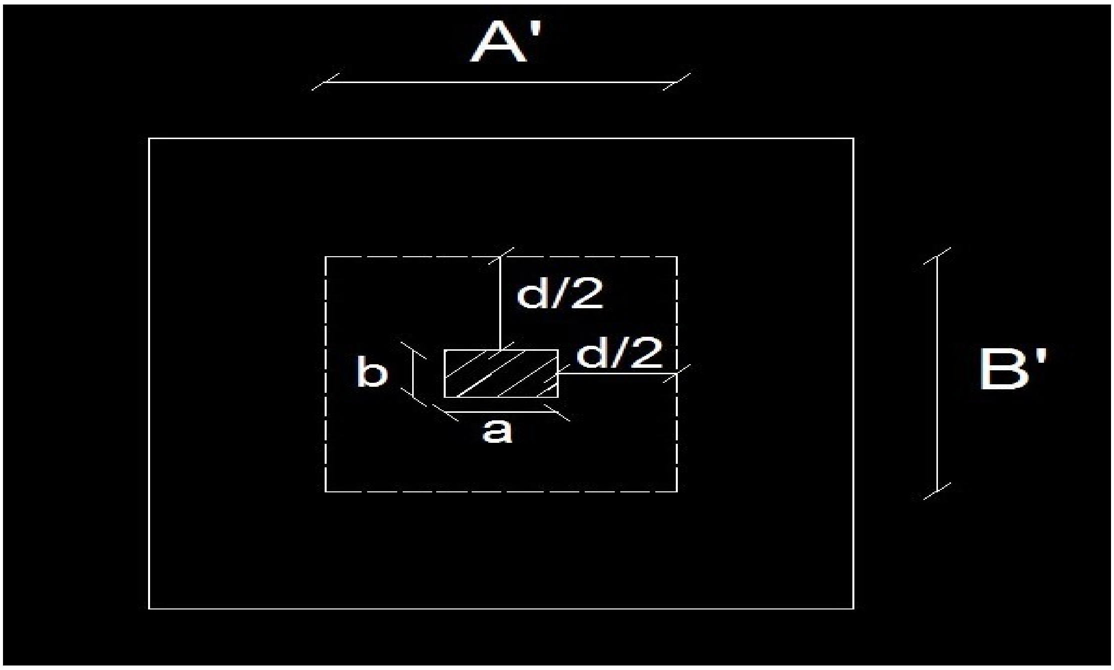
if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / (q_{cu} * b)$

t = d + cover

cover = (5 to 10 cm)

Check punching:



$Q_p = p_u - q_{ult} (A'+B') =$ ..... ton

$A' = a + d$, $B' = b + d$

a → طول العمود , b → عرض العمود

$q_p = Q_p / (2(A'+B')d) =$ .... Kg/cm^2

$q_{pcu} = (0.5 + \frac{b}{a}) \sqrt{\frac{fcu}{\gamma c}} =$ .... Kg/cm^2

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

t = d + cover

cover = (5 to 10 cm)

Reinforcement of the footing:

Min 5 y 12 / m

Max 10 y ?? / m

$A_{s1} = A_{s2} = M_{ult} / J*d*f_y =$...$cm^2/m'$ - - - - - - - - - -(1)

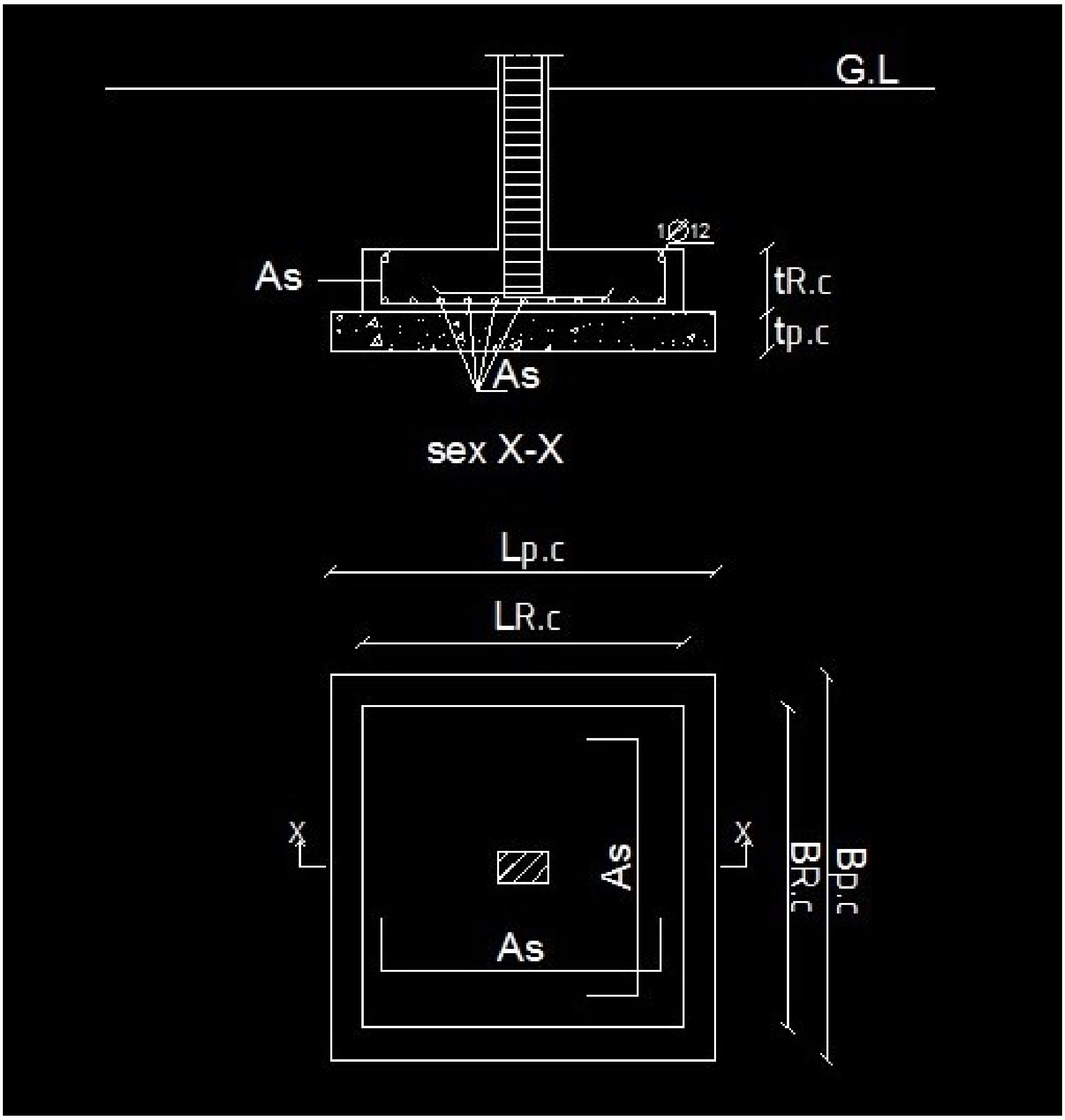
$A_{s\ min} = 5$ y 12/m' - - - - - - - - - -(2)

$A_{s\ min} = (0.15/100)*b*d =$..$cm^2/m'$ - - - - - - - - - -(3)

نأخذ القيمة الأكبر في القيم 1,2,3

If $A_s \geq A_{s\,min} \longrightarrow$ ok

If $A_s < A_{s\,min} \longrightarrow$ take $A_s = A_{s\,min}$



Example: 1

Given : f_{cu} = 250 kg/cm^2 , P_{ult}= 1800 kN,

Col 30x70 cm , fy =3600 kg/cm^2 , $t_{p,c}$ = 50 cm , B/C (q_{all} = 150 kN / m^2

Req : Design of strip footing that carry the given line load.

Solution

100 kN / m^2 = 10 t / m^2 = 1 kg / cm^2

P_{ult} = 1800 KN ⟶ 180 ton

q_{all} = 150 KN/m^2 ⟶ 15 t/m^2

$t_{p.c}$ > 20 cm

50 > 20 cm ⟶ Consider p.c in design

$P_w = \frac{pult}{1.5} = \frac{180}{1.5}$ = 120 Ton

$P_t = P_w$ *1.1 = 120 * 1.1 = 132 ton

$A_{p.c} = P_t / q_{all}$= 132/15 = 8.8 m^2

هنالك طريقتين لإيجاد قيمة أبعاد القاعدة العادية:

الطريقة الأولي أسهل و أسرع من الطريقة الثانية والنتيجة نفسها.

الطريقة الأولي:

$a - b = 0.7 - 0.3 = 0.4$ m

$L_{p.c} = \sqrt{Ap.c} + (a - b / 2)$

$B_{p.c} = \sqrt{Ap.c} - (a - b / 2)$

$\sqrt{Ap.c} = \sqrt{8.8} = 2.97 \cong 3m$

$L_{p.c} = 3 + 0.2 = 3.2$ m

$B_{p.c} = 3 - 0.2 = 2.8$ m

الطريقة الثانية:

$A_{p.c} = P_t / q_{all} = 132/15 = 8.8\ m^2 = L_{p.c} * B_{p.c}$

$L_{p.c} * B_{p.c} = 8.8$

$L_{p.c} = 8.8 / B_{p.c}$ 1

$L_{p.c} - B_{p.c} = a - b$

$L_{p.c} - B_{p.c} = 0.7 - 0.3 = 0.4$

$L_{p.c} = B_{p.c} + 0.4$ 2

بالتعويض عن $L_{p.c}$ في المعادلة رقم 1

$8.8 / B_{p.c} - B_{p.c} = 0.4$

بالضرب في $B_{p.c}$

$8.8 - (B_{p.c})^2 = 0.4\ B_{p.c}$

$B_{p.c}^2 + 0.4\ B_{p.c} - 8.8 = 0$

$ax^2 + bx + c = 0$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$B_{p.c}^2 + 0.4\ B_{p.c} - 8.8 = 0$

$$Bp.c = \frac{-0.4 \pm \sqrt{(0.4)^2 - (4 * 1 * (-8.8))}}{2 * 1}$$

$B_{p.c} = 2.77\ m \cong 2.8\ m$

في التعويض بالمعادلة مرة بالسالب ومرة بالموجب والناتج السالب مرفوض.

بالتعويض بالمعادلة رقم 2 بقيمه $B_{p.c}$ لإيجاد $L_{p.c}$

$L_{p.c} = B_{p.c} + 0.4$

$L_{p.c} = 2.8 + 0.4 = 3.2\ m$

Check stresses on plain concrete:

$q_{ult}=1.5*p_w/(B_{p.c}*L_{p.c})=\frac{180}{3.2*2.8}=20\ t/m^2$

$M_{ult}=(q_{ult}*(X^2))/2=\frac{20*(0.5)^2}{2}=2.5\ mt$

$F_t=6*M_{ult}/100*(t_{p.c})^2=\frac{6*(2.5*10^5)}{100*(50)^2}=6\ kg/cm^2$

$F_{tcu}=\frac{0.75*(fcu)^{\frac{2}{3}}}{1.5}=\frac{0.75*(250)^{\frac{2}{3}}}{1.5}=19.8\ kg/cm^2$

$F_t < F_{tcu}$

6 < 19.8 ok safe

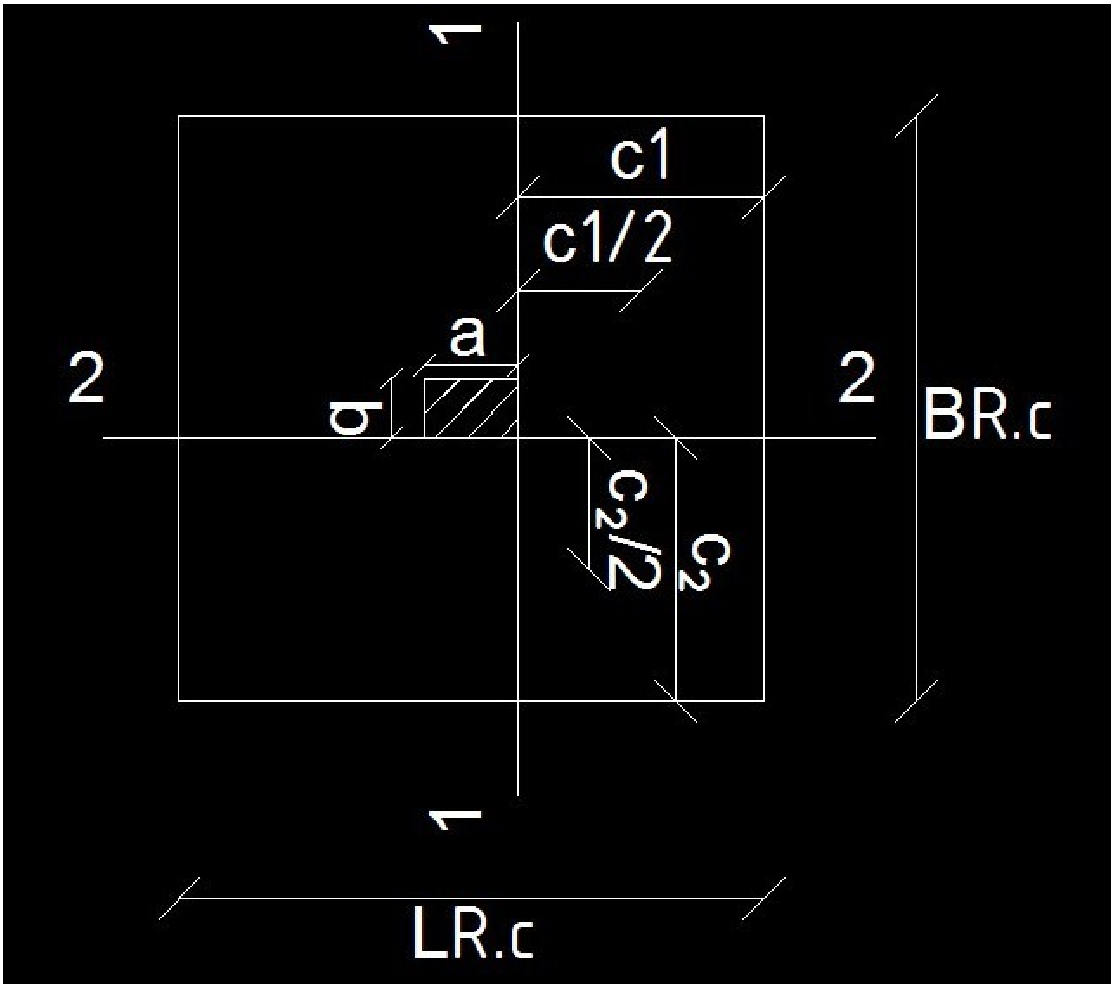
ملاحظة:

لإيجاد قيمة $L_{R.C}$ و $B_{R.C}$ يمكن إيجادها قبل Check stresses on plain concrete و لكن يتم إيجادها بعد علشان $L_{R.C}$ و $B_{R.C}$ يعتمد علي $t_{p.c}$ لو ال check طلع un safe يتم نقلل بروز الخرسانة العادية ($t_{p.c}$)

$L_{R.C}=L_{p.c}-2\ t_{p.c}=3.2-(2*0.5)=2.2m$

$B_{R.C}=B_{p.c}-2\ t_{p.c}=2.8-(2*0.5)=1.8m$

q_{ult}=1.5*p_w/($B_{R.c}$*$L_{R.c}$)= $\frac{180}{2.2*1.8}$ = 45.5 t / m^2



C =($L_{R.c}$ - a / 2) = $\frac{2.2-0.7}{2}$ = 0.75

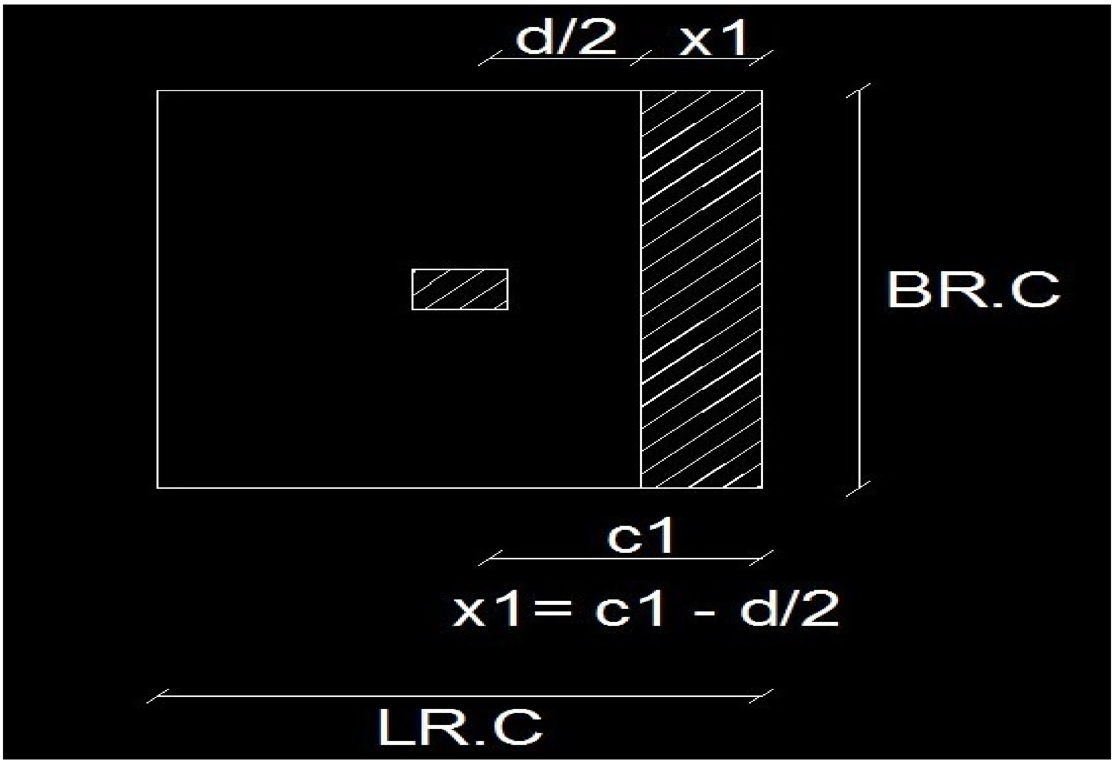
M_{ult} = q_{ult} * C^2 /2 =$\frac{45.5*(0.75)^2}{2}$=12.8 m t/m'

d=$c_1\sqrt{\frac{\mathbf{Mult}}{\mathbf{Fcu*b}}}$ = 5 $\sqrt{\frac{\mathbf{12.8*10^5}}{\mathbf{250*100}}}$ =35.7cm≅40cm

Check shear:

القطاع الحرج علي مسافة d/2 من وش العمود.

Critical section



$Q_{sh} = q_{ult}(c - d/2) = 45.5(0.75-0.4/2) = 25$ ton

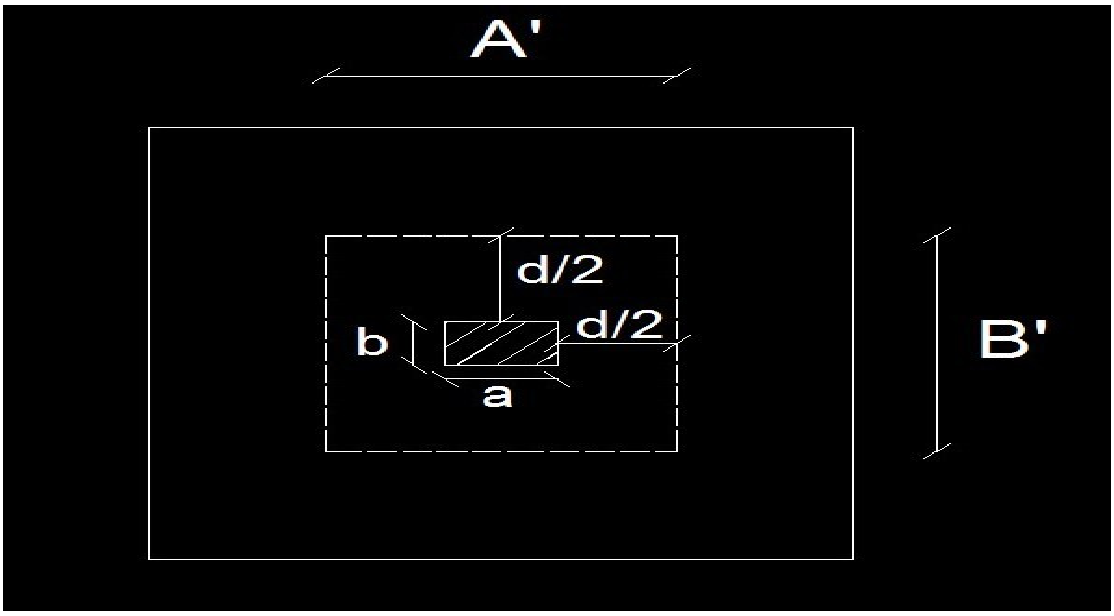
$q_{sh} = Q_{sh}/(b*d) = \frac{25*10^3}{100*40} = 6.25$ Kg/cm^2

$q_{cu} = 0.4\sqrt{\mathbf{fcu}} = 0.4\sqrt{\mathbf{250}} = 6.3$ Kg/cm^2

$q_{sh} < q_{cu}$

6.25 < 6.3 ok safe

Check punching:



$Q_p = p_u - q_{ult}$ (A'+B') =

A' = a + d= 0.7+0.4= 1.1 m

B' = b + d= 0.3+0.4= 0.7 m

$Q_p = p_u - q_{ult}$(A'+B')=180-45.5(1.1*0.7)=145 ton

$q_p = Q_p /(2(A'+B')d) = \frac{145*10^3}{(2(110+70)*40)}$ = 10 Kg/cm^2

$q_{pcu} = (0.5 + \frac{b}{a})\sqrt{\frac{fcu}{\gamma c}} = (0.5+\frac{0.3}{0.7})\sqrt{\frac{250}{1.5}}$ =12 Kg/cm^2

$q_{pcu} > q_p$

12 > 10 ok safe

t = d + cover = 40+10= 50 cm

Reinforcement of the footing:

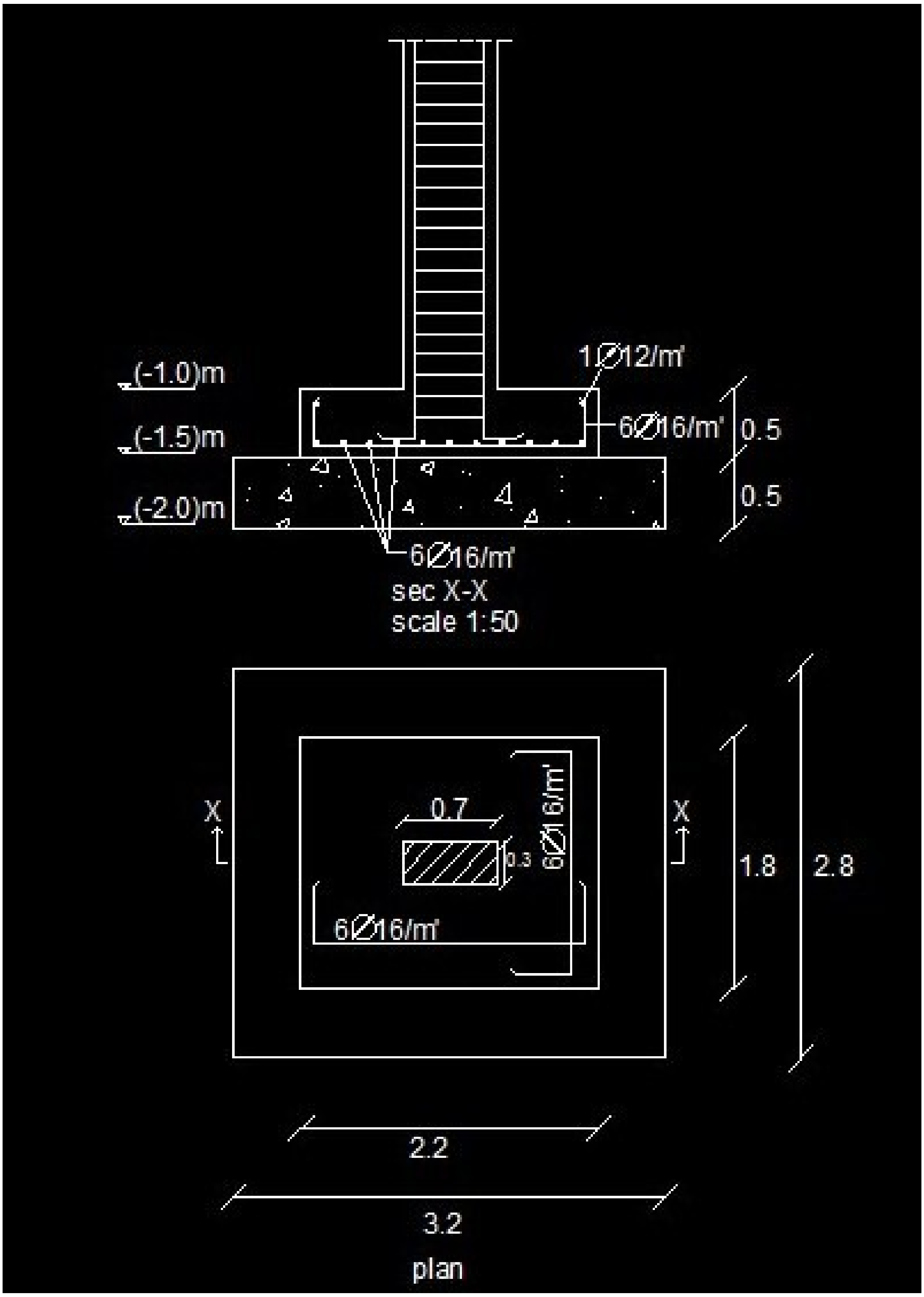
A_{s1}=A_{s2}= $\frac{Mult}{J*d*fy}$= $\frac{12.8*10^5}{0.826*40*3600}$ =10.76 cm^2/m'

$A_{s\ min}$ = 5y12/m = 5.65 cm^2 / m'

$A_{s\ min}$=$\frac{0.15}{100}$*b*d=$\frac{0.15}{100}$*100*40 = 6 cm^2/m'

take A_s = 10.76 cm^2/m'

use 6 y 16 /m

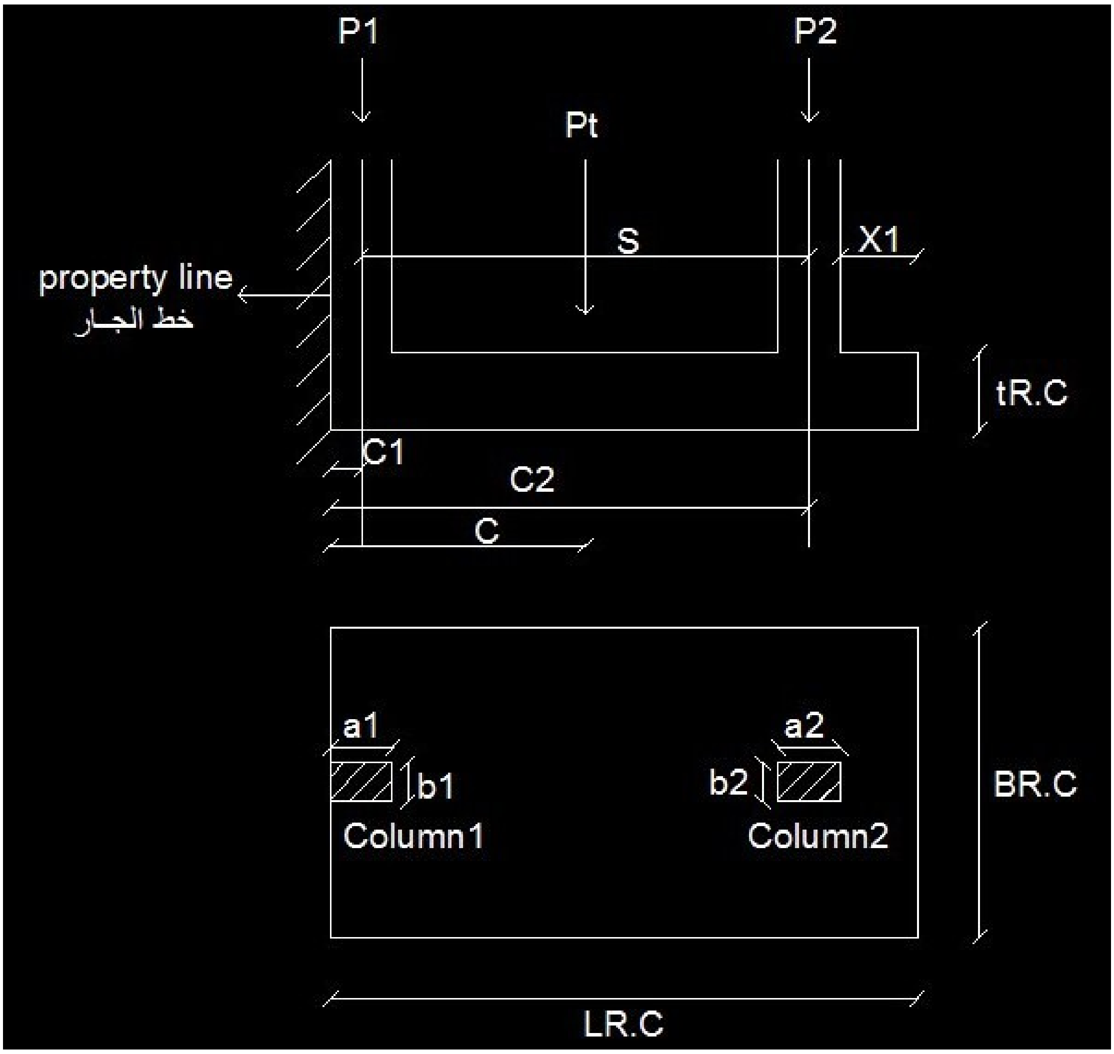


(-1.0)m
(-1.5)m
(-2.0)m
1∅12/m'
6∅16/m'
0.5
0.5
6∅16/m'
sec X-X
scale 1:50
X
X
0.7
0.3
6∅16/m'
6∅16/m'
1.8
2.8
2.2
3.2
plan

Combined Footing:

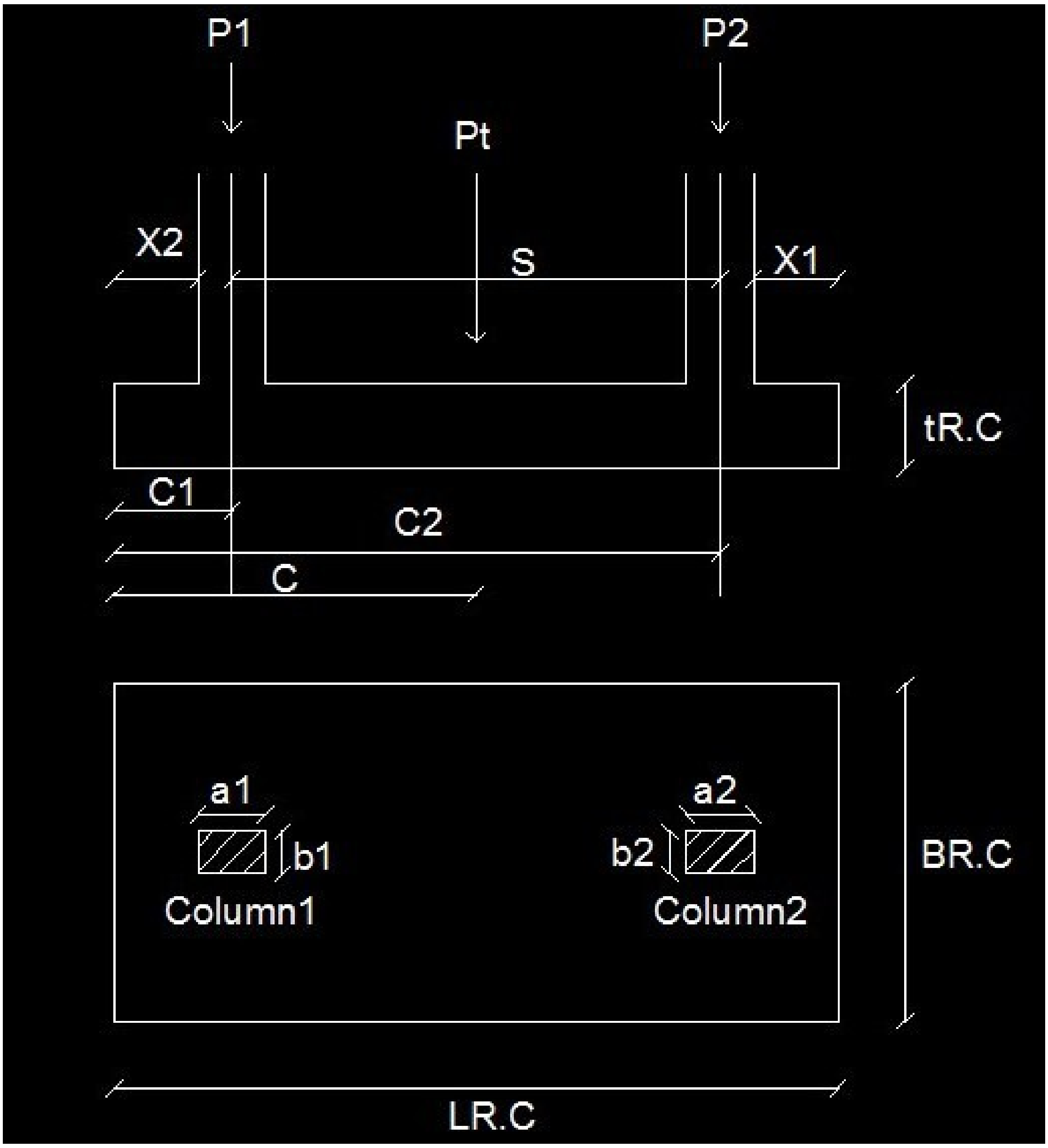
Types of Combined Footing:

1-قاعدة بعمود داخلي مع عمود جار:



البروز من ناحية واحدة فقط.

2- عمودان داخليان:



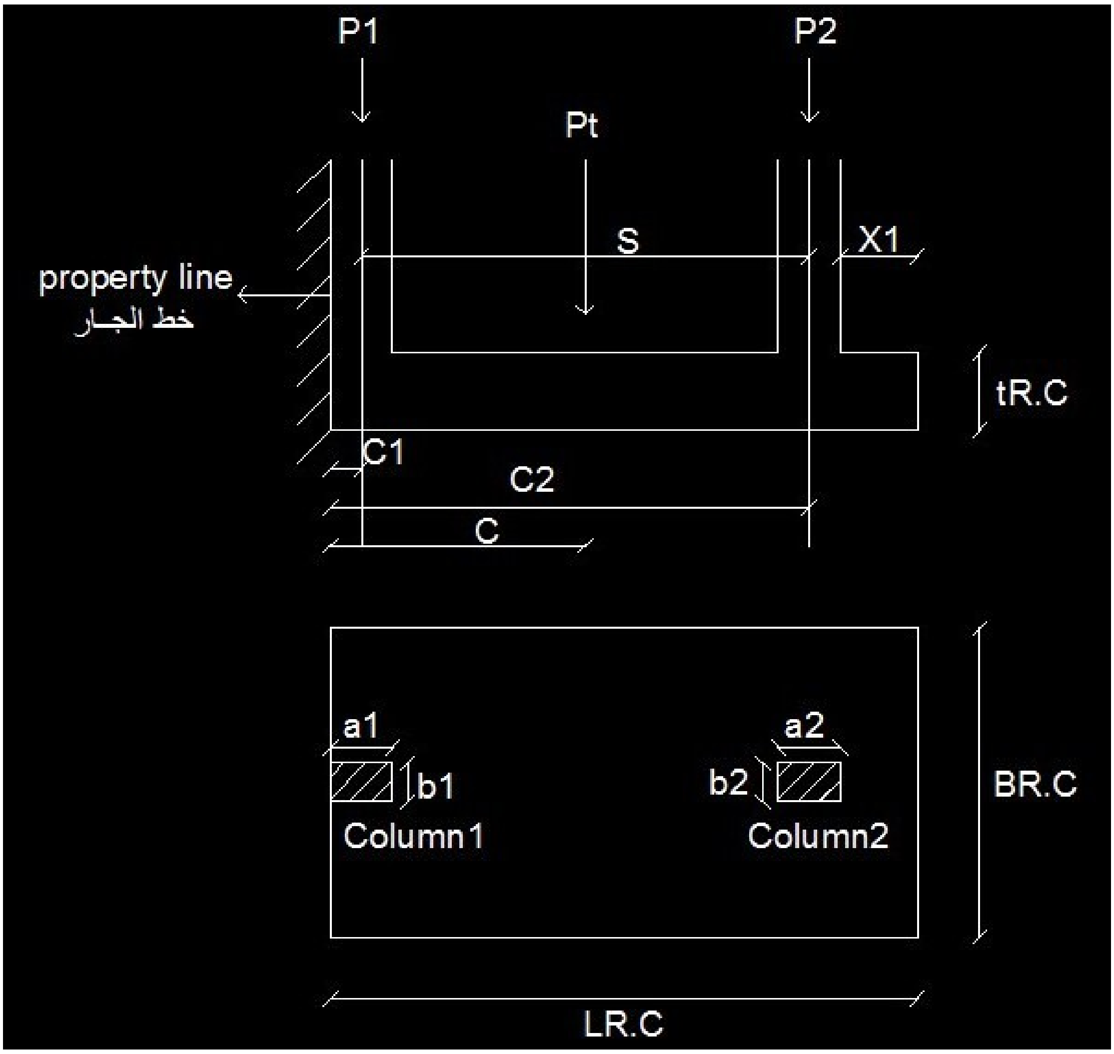
البروز من ناحيتين.

نأخذ C1 من ناحية العمود الأقل بالحمل $P1 < P2$

Take C1 = 1 m if not given.

Steps of Design:

1) Dimension of Footing (working Loads):



$P_t = (P_1+P_2) * 1.1 = \ldots$ Ton

حيث أن $(P_1+P_2) \rightarrow$ Working Loads

Working Loads to ultimate Loads * 1.5

Ultimate Loads to Working Loads / 1.5

Area of Footing $(A_{R.C}) = \frac{Pt}{qall} = L * B = m^2$

لا تدخل الخرسانة العادية في الحسابات في حالة الجار لعدم وجود سماح ببروز من ناحية الجار.

Take C_1 = من خط الجار إلي نص العمود

$C_2 = C_1 + S = \ldots$ m

$C = \frac{(c1*p1)+(c2*p2)}{pt} = \ldots$ m

حيث أن:

مكان تأثير → C

محصله القوي → P_t

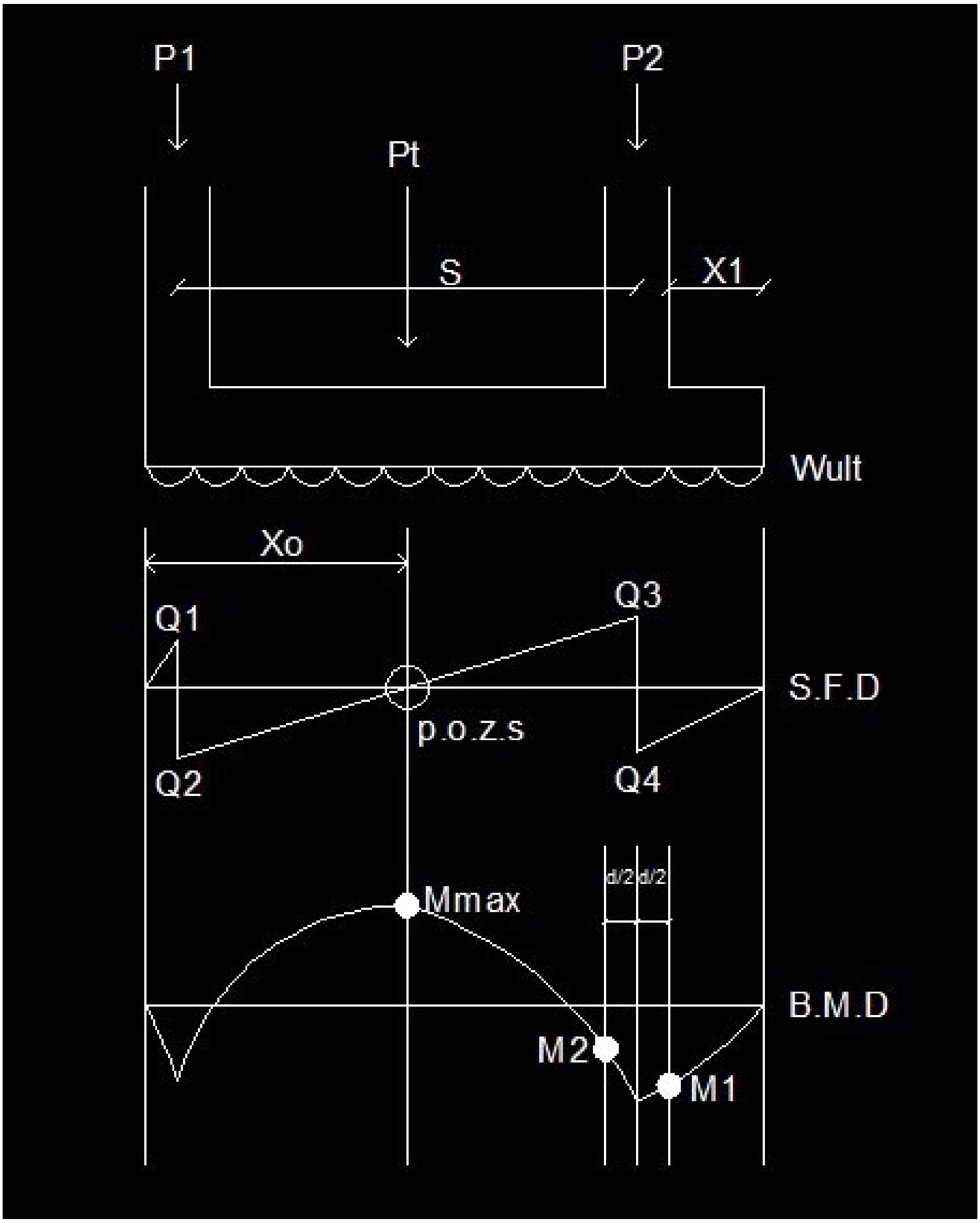
حتى تكون المحصلة في نصف القاعدة

$L_{R.C} = 2* C = \ldots$ m ≅ to nearest 5 cm

$B_{R.C} = \frac{AR.C}{LR.C} = \ldots$ m ≅ to nearest 5 cm

End of Working Loads

2) Ultimate stress & Draw B.M.D & S.F.D:



$$q_{ult} = \frac{(p1+p2)*1.5}{LR.C*BR.C} = \dots\ t/m^2$$

$$W_{ult} = q_{ult} * B_{R.C} = \dots\ t/m'$$

$Q_1 = W_{ult} * C_1 = \ldots$ Ton

$Q_2 = Q_1 - P_{1u} = \ldots$ Ton

$Q_3 = W_{ult} * C_2 - P_{1u} = \ldots$ Ton

$Q_4 = Q_3 - P_{2u} = \ldots$ Ton

Moment يحسب عند وش العمود M_1 , M_2

Max Moment at point of zero shear

At p.o.z.s

$X_o = \frac{P1u}{Wu} = \ldots$ m

$X_1 = L_{R.C} - (C_2 + \frac{b2 \text{ or } a2}{2}) = \ldots$ m

حيث أن:

مسافة من خط الجار إلي point of zero shear

p.o.z.s →point of zero shear

طول العمود ←a

عرض العمود ←b

حسب اتجاه العمود ←b2 or a2

$M_1 = W_u * \frac{(X1)^2}{2} = \ldots$ mt

$M_2 = W_u * \frac{(X1 + a2 \text{ or } b2)^2}{2} - P_{2u} * \frac{a2 \text{ or } b2}{2} = \ldots$ mt

حيث أن:

a→ طول العمود

b→ عرض العمود

b2 or a2→ حسب اتجاه العمود

$M_{max} = P_{1u} * (X_o - C_1) - (W_u * \frac{(Xo)^2}{2}) = \ldots$ mt

3) Calculation the Depth:

$$d = c1 \sqrt{\frac{Mu}{Fcu * BR.C}}$$

حيث أن:

c1 → 5

M_u → Max Moment

4) Check shear:

Critical section at $\frac{d}{2}$ من وش العمود

$Q_{sh} = Q_{Max} - W_u \left(\frac{d}{2} + \frac{a1 or a2 \text{ or } b1 or b2}{2}\right) = \ldots$ Ton

حيث أن:

طول العمود →a

عرض العمود →b

حسب اتجاه العمود →$b2 \text{ or } a2$ و حسب Q_{Max}

$Q_{Max} \rightarrow$ Max of Q_1 , Q_2 , Q_3 , Q_4

$q_{sh} = \frac{Qsh}{BR.C * d} = \ldots$ kg/cm^2

$q_{cu} = 0.4 * \sqrt{Fcu} = \ldots$ kg/cm^2

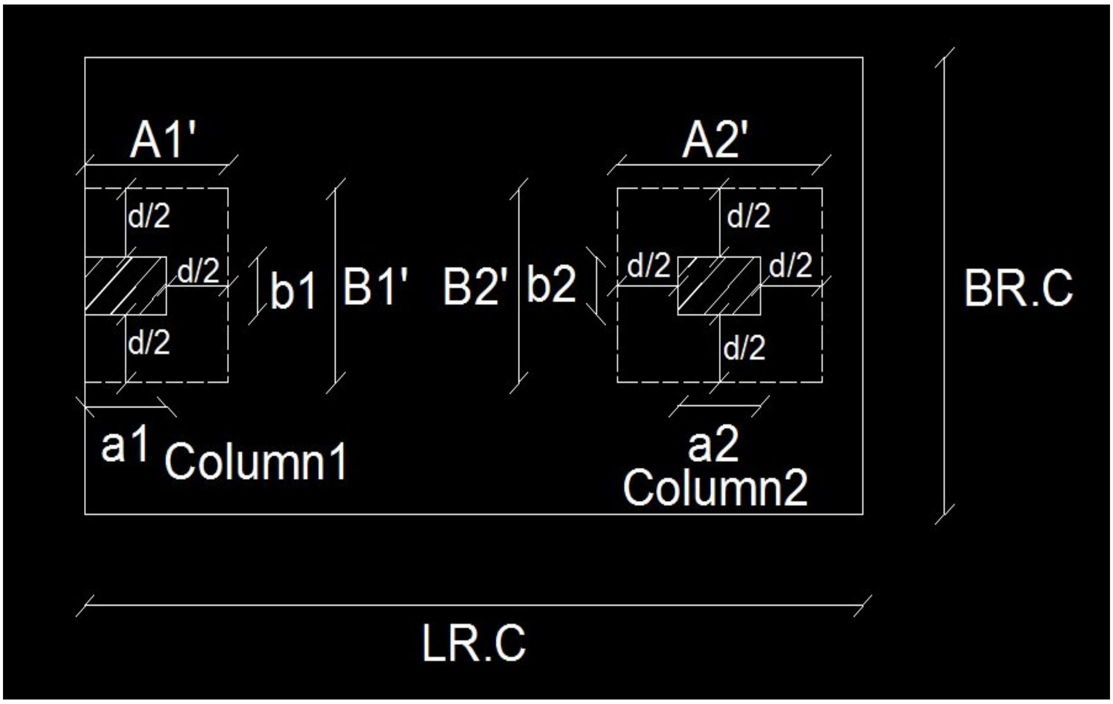
If $q_{cu} > q_{sh}$ ok safe

If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B_{R.c}) = \ldots$ cm

5) Check Punching:

الحالة الأولي:



For Column 1:

$Q_{P1} = P_{u1} - q_U (A_1' * B_1') = \ldots$ Ton

حيث أن :

$A_1' = (a_1 + \frac{d}{2}) = \ldots$ m

$B_1' = (b_1 + d) = \ldots$ m

For Column 2:

$Q_{P2} = P_{u2} - q_U (A_2' * B_2') = \ldots$ Ton

حيث أن :

$A_2' = (a_2 + d) = \ldots$ m

$B_2' = (b_2 + d) = \ldots$ m

$$q_p = \frac{\mathrm{QpMax}}{2*(\mathrm{A1or2'}+\mathrm{B1or2'})*\mathrm{d}} = \ldots \ \mathrm{kg/cm^2}$$

حيث أن:

Q_{pMax} = Max of Q_{P1} & Q_{P2}

If $Q_{pMax} \rightarrow Q_{P1}$ Take A_1' , B_1'

If $Q_{pMax} \rightarrow Q_{P2}$ Take A_2' , B_2'

$$q_{pcu} = \left(0.5 + \frac{\mathrm{b1or2}}{\mathrm{a1or2}}\right) \sqrt{\frac{Fcu}{\gamma c}} = \ldots \ \mathrm{kg/cm^2}$$

حسب أن:

If $Q_{pMax} \rightarrow Q_{P1}$ Take b_1 , b_2

If $Q_{pMax} \rightarrow Q_{P2}$ Take a_1 , a_2

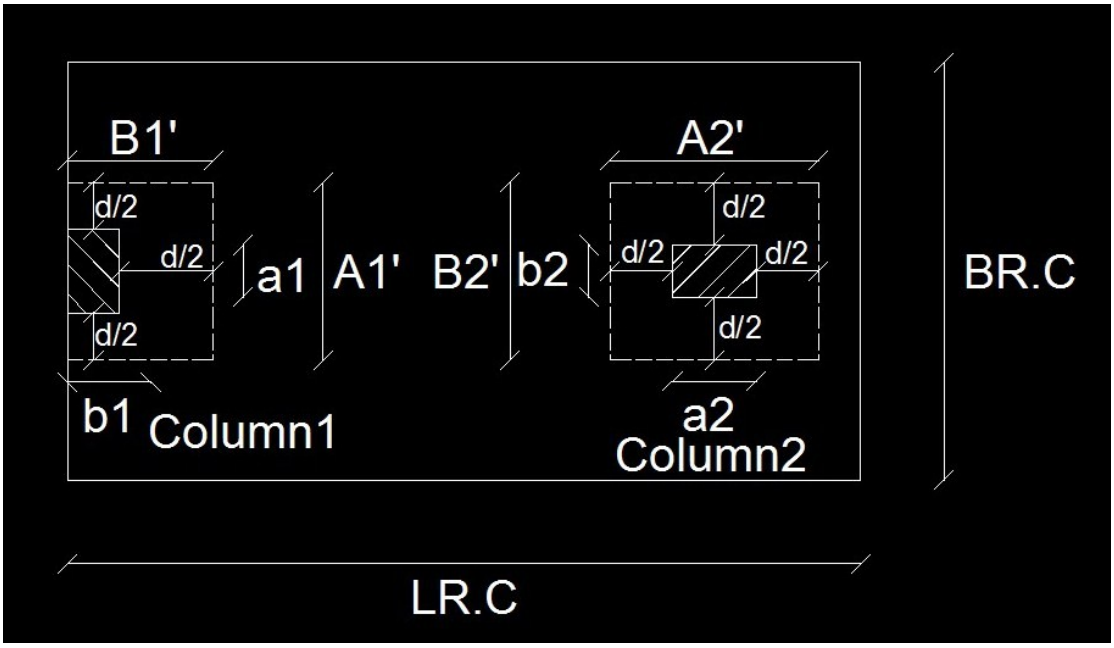
If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe $\rightarrow$ increase depth

t = d + cover

cover = (5 to 10 cm)

الحالة الثانية:



For Column 1:

$Q_{P1} = P_{u1} - q_U\,(A_1' * B_1') = \dots$ Ton

حيث أن :

$A_1' = (a_1 + d) = \dots$ m

$B_1' = (b_1 + \frac{d}{2}) = \dots$ m

والباقي نفس الشئ

6) Reinforcement of the footing:

in Long Direction:

$A_{s\ Top} = \frac{Mmax}{J*d*Fy}$ = ... $cm^2/B_{R.C}$ = ... cm^2/m'

$A_{s\ min}$ = 0.15 * d = ... cm^2/m'

If $A_{s\ Top} \geq A_{s\ min} \rightarrow$ ok

If $A_{s\ Top} < A_{s\ min} \rightarrow$ take $A_{s\ Top} = A_{s\ min}$

$A_{s\ Bot} = \frac{M1orM2}{J*d*Fy}$ = ... $cm^2/B_{R.C}$ = ... cm^2/m'

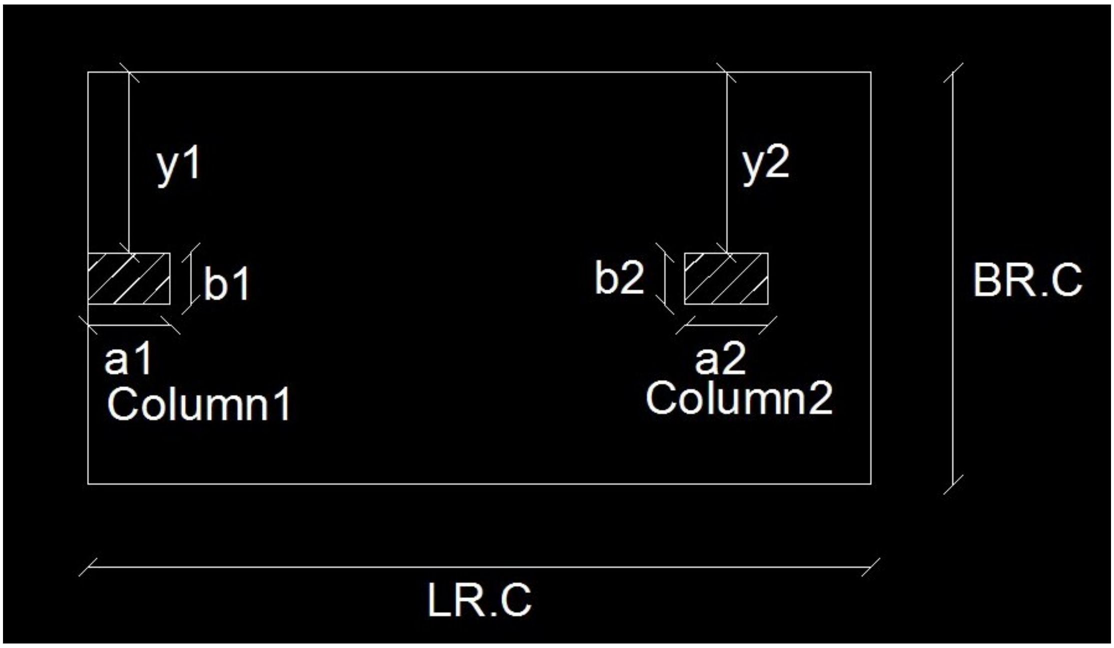
Take Max Moment of M_1 & M_2

$A_{s\ min}$ = 0.15 * d = ... cm^2/m'

If $A_{s\ Bot} \geq A_{s\ min} \rightarrow$ ok

If $A_{s\ Bot} < A_{s\ min} \rightarrow$ take $A_{s\ Bot} = A_{s\ min}$

In Short Direction:

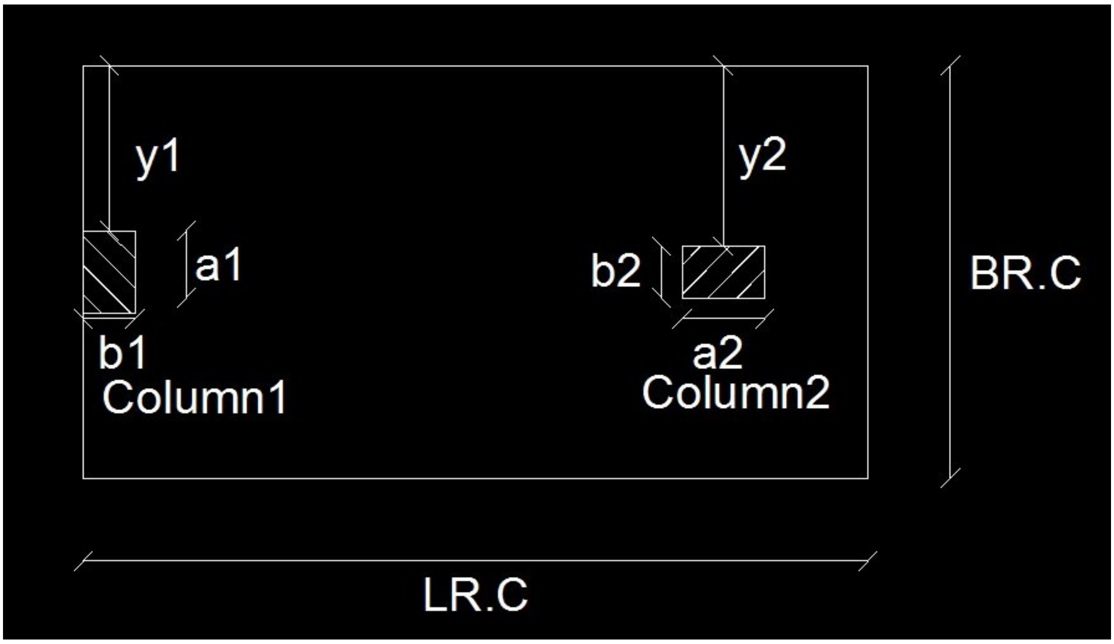


$M_u = q_{ult} * \frac{(y1or2)^2}{2} = \ldots$ mt

Take y Max of y_1 & y_2

$Y_1 = \frac{BR.C - b1}{2} = \ldots$ m

$Y_2 = \frac{BR.C - b2}{2} = \ldots$ m



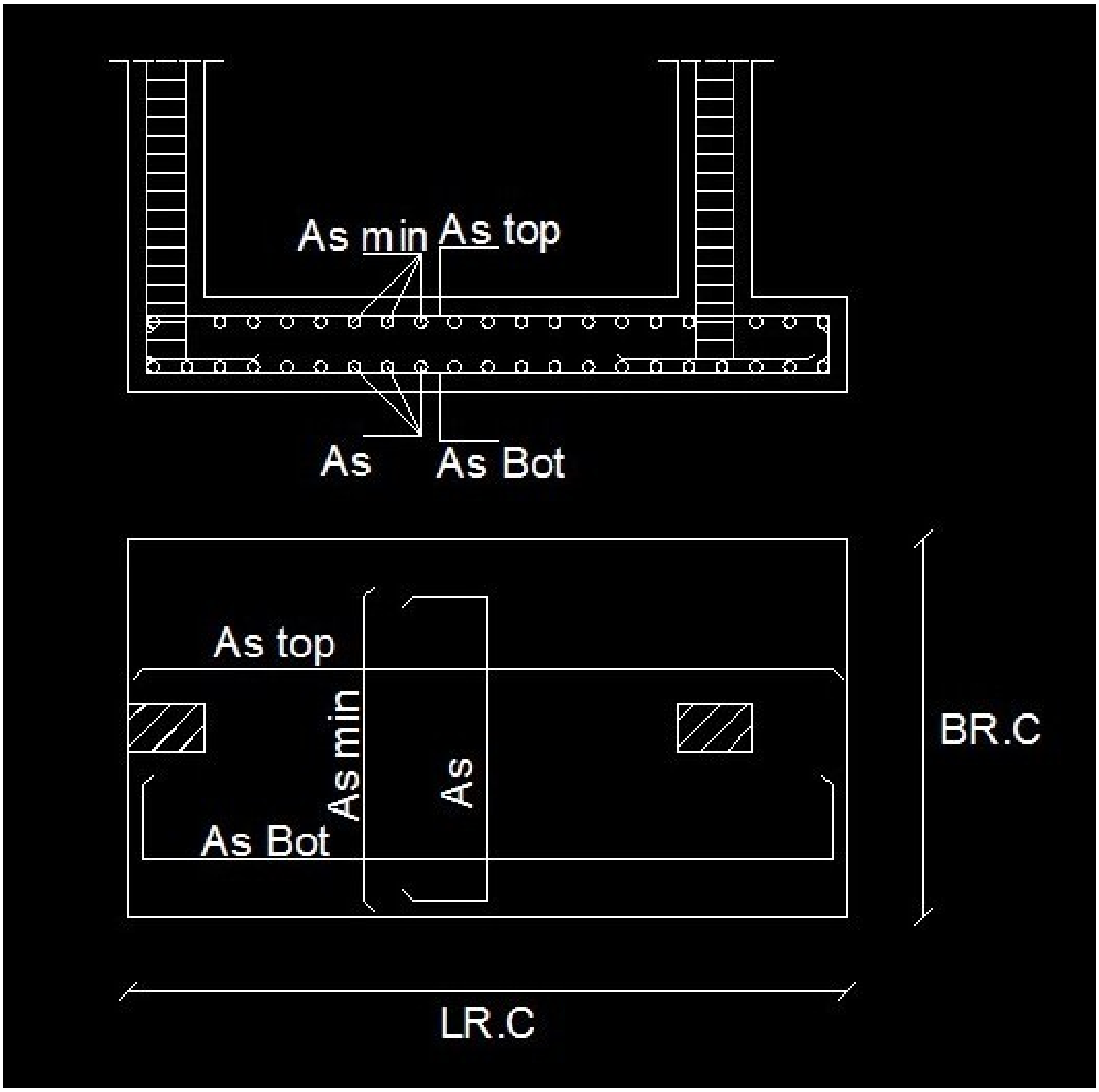
$$Y_1 = \frac{BR.C - a1}{2} = \ldots \text{ m}$$

$$Y_2 = \frac{BR.C - b2}{2} = \ldots \text{ m}$$

$$A_s = \frac{Mu}{J * d * Fy} = \ldots \text{ cm}^2 / \text{m}'$$

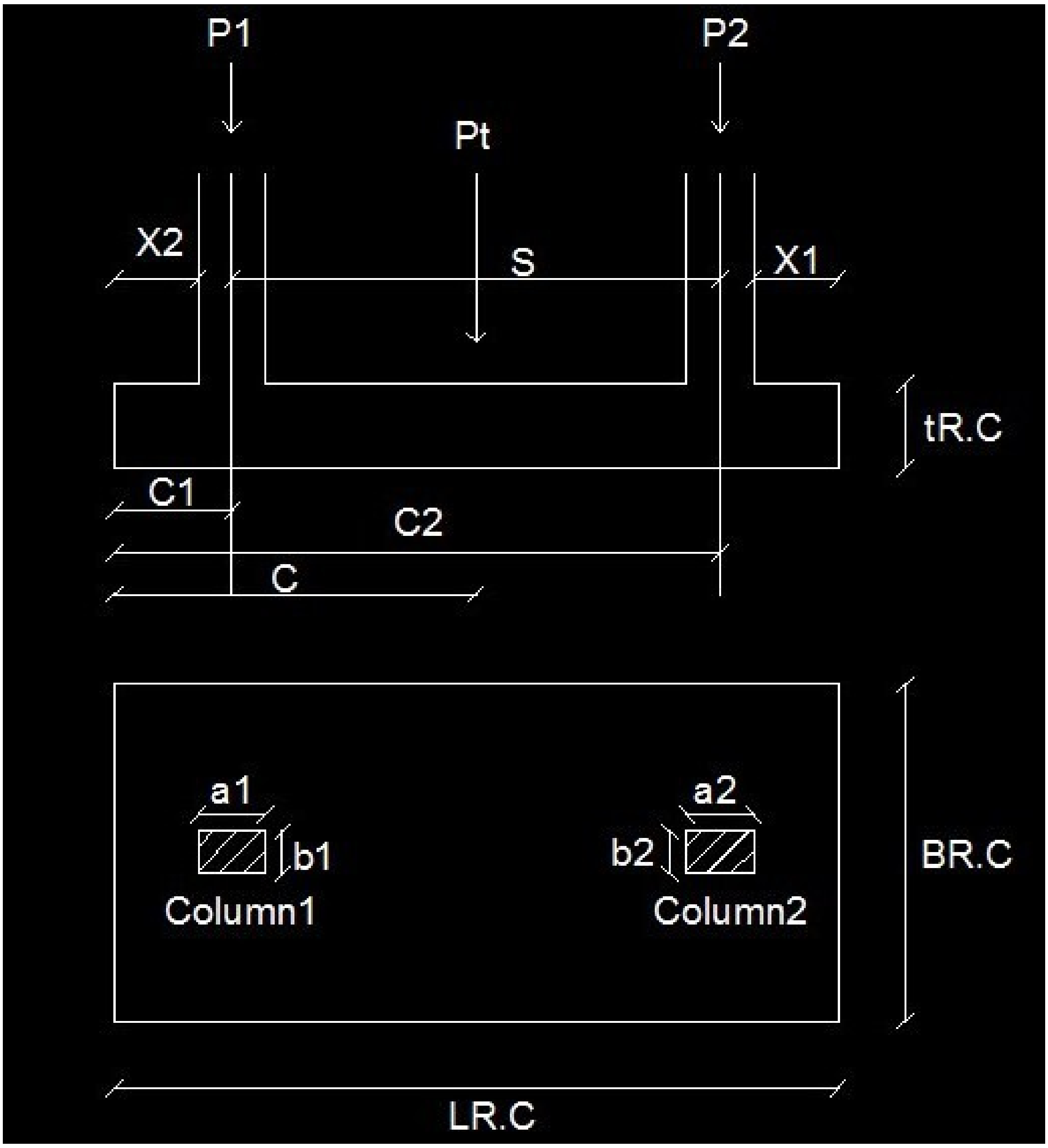
If $A_s \geq A_{s\,min} \longrightarrow$ ok

If $A_s < A_{s\,min} \longrightarrow$ take $A_s = A_{s\,min}$


As min
As top
As
As Bot
As top
As min
As
As Bot
BR.C
LR.C

Steps of Design:

1) Dimension of Footing (working Loads):



$P_t = (P_1+P_2) * 1.1 = ...$ Ton

حيث أن $(P_1+P_2) \rightarrow$ Working Loads

Working Loads to ultimate Loads * 1.5

Ultimate Loads to Working Loads / 1.5

Area of Footing ($A_{R.C}$) = $\frac{Pt}{qall}$ = L * B = m^2

Take C_1 = 1 m if not given.

$C_2 = C_1 + S$ = … m

$$C = \frac{(c1*p1)+(c2*p2)}{pt} = \dots m$$

حيث أن:

C → مكان تأثير

P_t → محصله القوي

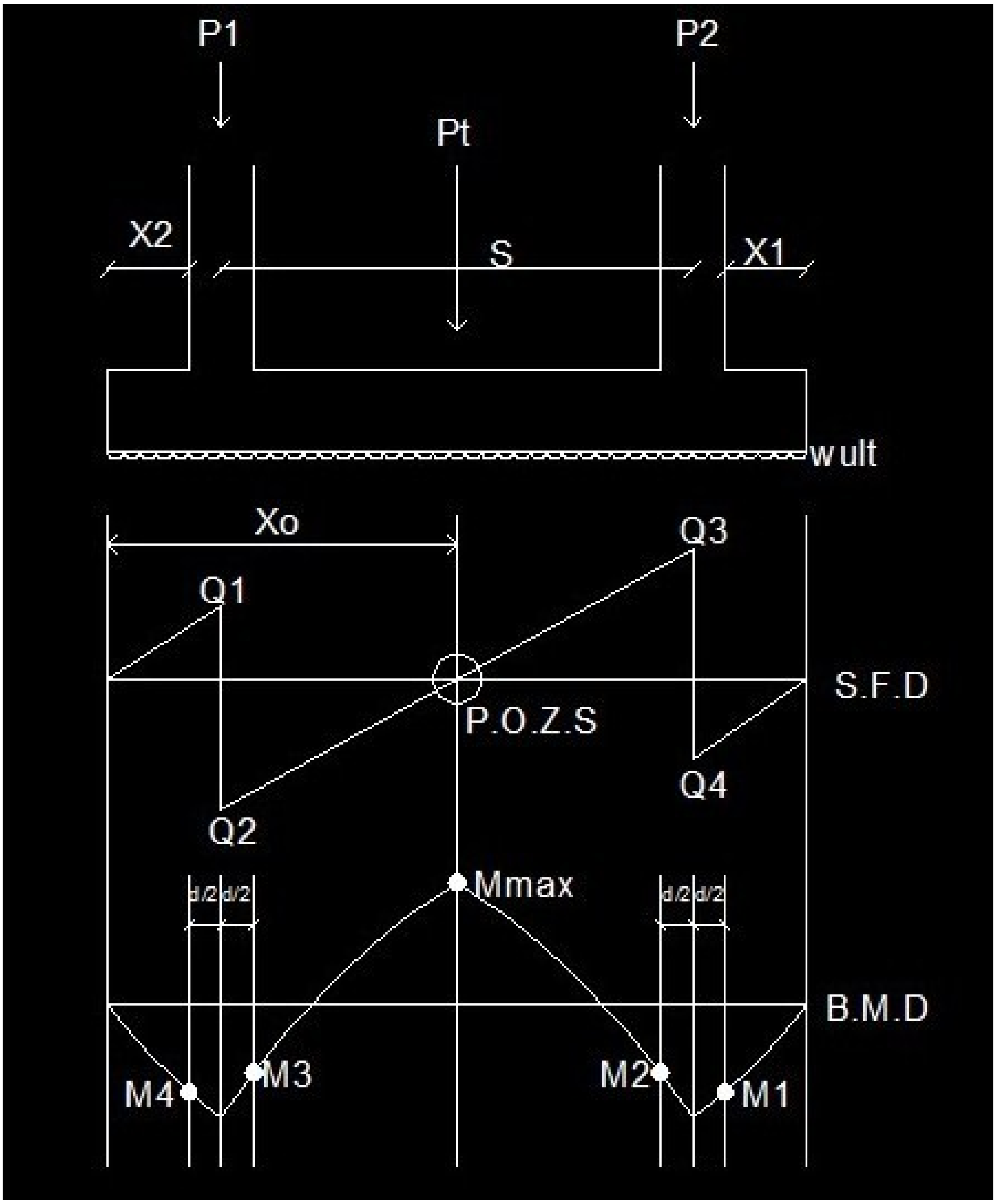
حتى تكون المحصلة في نصف القاعدة

$L_{R.C}$ = 2* C = … m ≅ to nearest 5 cm

$B_{R.C} = \frac{AR.C}{LR.C}$ = … m ≅ to nearest 5 cm

End of Working Loads

2) Ultimate stress & Draw B.M.D & S.F.D:



$$q_{ult} = \frac{(p1+p2)*1.5}{LR.C*BR.C} = \ldots\ t/m^2$$

$$W_{ult} = q_{ult} * B_{R.C} = \ldots\ t/m'$$

$Q_1 = W_{ult} * C_1 = \dots$ Ton

$Q_2 = Q_1 - P_{1u} = \dots$ Ton

$Q_3 = W_{ult} * C_2 - P_{1u} = \dots$ Ton

$Q_4 = Q_3 - P_{2u} = \dots$ Ton

Moment يحسب عند وش العمود M_1, M_2

Max Moment at point of zero shear

At p.o.z.s

$X_o = \frac{P1u}{Wu} = \dots$ m

$X_1 = L_{R.C} - (C_2 + \frac{b2 \text{ or } a2}{2}) = \dots$ m

$X_2 = C_1 - \frac{b1 \text{ or } a1}{2} = \dots$ m

حيث أن:

مسافة من خط الجار إلي point of zero shear

p.o.z.s →point of zero shear

طول العمود →a

عرض العمود →b

حسب اتجاه العمود →b2 or a2

$$M_1 = W_u * \frac{(X1)^2}{2} = \dots \text{ mt}$$

$$M_2 = W_u * \frac{(\text{X1+a2 or b2})^2}{2} - P_{2u} * \frac{\text{a2 or b2}}{2} = \dots \text{ mt}$$

$$M_4 = W_u * \frac{(X2)^2}{2} = \dots \text{ mt}$$

$$M_3 = W_u * \frac{(\text{X2+a1 or b1})^2}{2} - P_{1u} * \frac{\text{a1 or b1}}{2} = \dots \text{ mt}$$

حيث أن:

a→ طول العمود

b→ عرض العمود

b2 or a2→ حسب اتجاه العمود

$$M_{max} = P_{1u} *(X_o - C_1) - (W_u *\frac{(\text{Xo})^2}{2}) = \dots \text{ mt}$$

3) Calculation the Depth:

$$d = c1 \sqrt{\frac{\text{Mu}}{\text{Fcu}*\text{BR.C}}}$$

حيث أن:

c1 → 5

M_u → Max Moment

4) Check shear:

Critical section at $\frac{d}{2}$ من وش العمود

$Q_{sh} = Q_{Max} – W_u (\frac{d}{2} + \frac{a1ora2 \text{ or } b1orb2}{2}) = \ldots$ Ton

حيث أن:

طول العمود →a

عرض العمود →b

حسب اتجاه العمود →b2 or a2 و حسب Q_{Max}

$Q_{Max} \rightarrow$ Max of Q_1 , Q_2 , Q_3 , Q_4

$q_{sh} = \frac{Qsh}{BR.C*d} = \ldots$ kg/cm^2

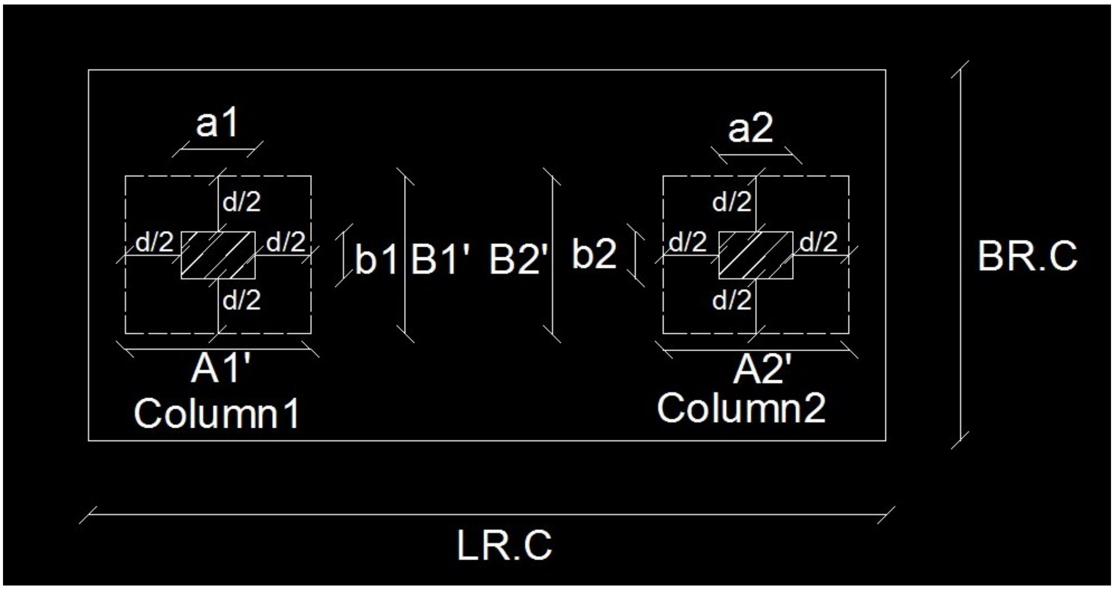
$q_{cu} = 0.4 * \sqrt{Fcu} = \ldots$ kg/cm^2

If $q_{cu} > q_{sh}$ ok safe

If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B_{R.c}) = \ldots$ cm

5) Check Punching:



For Column 1:

$Q_{P1} = P_{u1} - q_U (A_1' * B_1') = \ldots$ Ton

حيث أن :

$A_1' = (a_1 + d) = \ldots$ m

$B_1' = (b_1 + d) = \ldots$ m

For Column 2:

$Q_{P2} = P_{u2} - q_U (A_2' * B_2') = \ldots$ Ton

حيث أن :

$A_2' = (a_2 + d) = \ldots$ m

$B_2' = (b_2 + d) = \ldots m$

$q_p = \frac{QpMax}{2*(A1or2'+B1or2')*d} = \ldots kg/cm^2$

حيث أن:

Q_{pMax} = Max of Q_{P1} & Q_{P2}

If $Q_{pMax} \rightarrow Q_{P1}$ Take A_1' , B_1'

If $Q_{pMax} \rightarrow Q_{P2}$ Take A_2' , B_2'

$q_{pcu} = (0.5 + \frac{b1or2}{a1or2}) \sqrt{\frac{Fcu}{\gamma c}} = \ldots kg/cm^2$

حسب أن:

If $Q_{pMax} \rightarrow Q_{P1}$ Take b_1 , b_2

If $Q_{pMax} \rightarrow Q_{P2}$ Take a_1 , a_2

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe $\rightarrow$ increase depth

t = d + cover

cover = (5 to 10 cm)

6) Reinforcement of the footing:

in Long Direction:

$A_{s\,Top} = \frac{Mmax}{J*d*Fy}$ = … cm^2 /$B_{R.C}$ = … cm^2 /m'

$A_{s\,min}$ = 0.15 * d

If $A_{s\,Top} \geq A_{s\,min} \rightarrow$ ok

If $A_{s\,Top} < A_{s\,min} \rightarrow$ take $A_{s\,Top} = A_{s\,min}$

$A_{s\,Bot} = \frac{M1orM2orM3orM3}{J*d*Fy}$=..$cm^2$/$B_{R.C}$ =.. cm^2 /m'

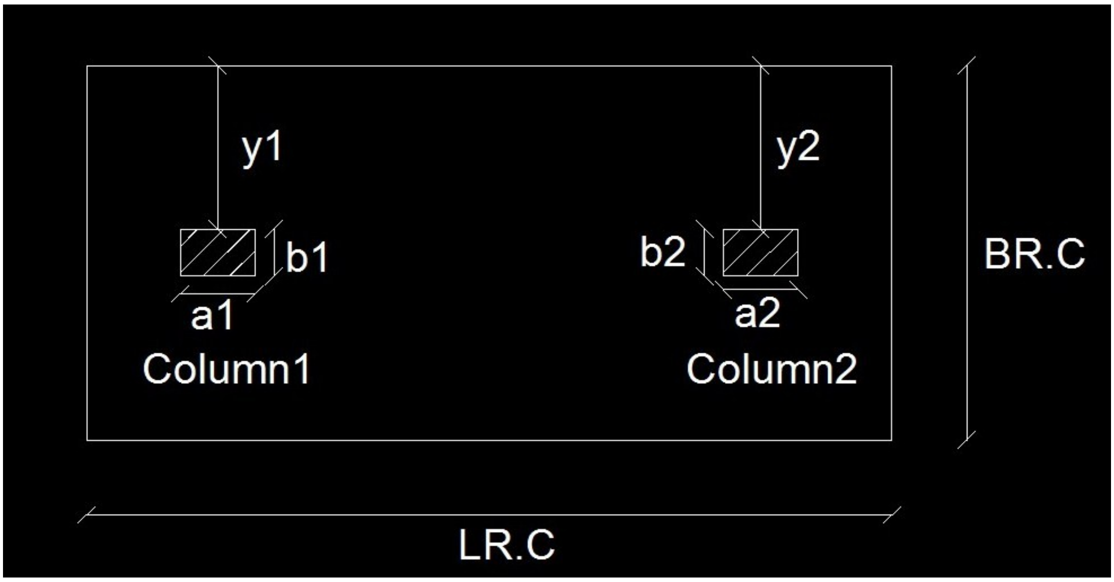
Take Max Moment of M_1 & M_2 & M_3 & M_4

$A_{s\,min}$ = 0.15 * d

If $A_{s\,Bot} \geq A_{s\,min} \rightarrow$ ok

If $A_{s\,Bot} < A_{s\,min} \rightarrow$ take $A_{s\,Bot} = A_{s\,min}$

In Short Direction:



$$M_u = q_{ult} * \frac{(y1 or 2)^2}{2} = \dots \ mt$$

Take y Max of y_1 & y_2

$$Y_1 = \frac{BR.C - b1 or a1}{2} = \dots \ m$$

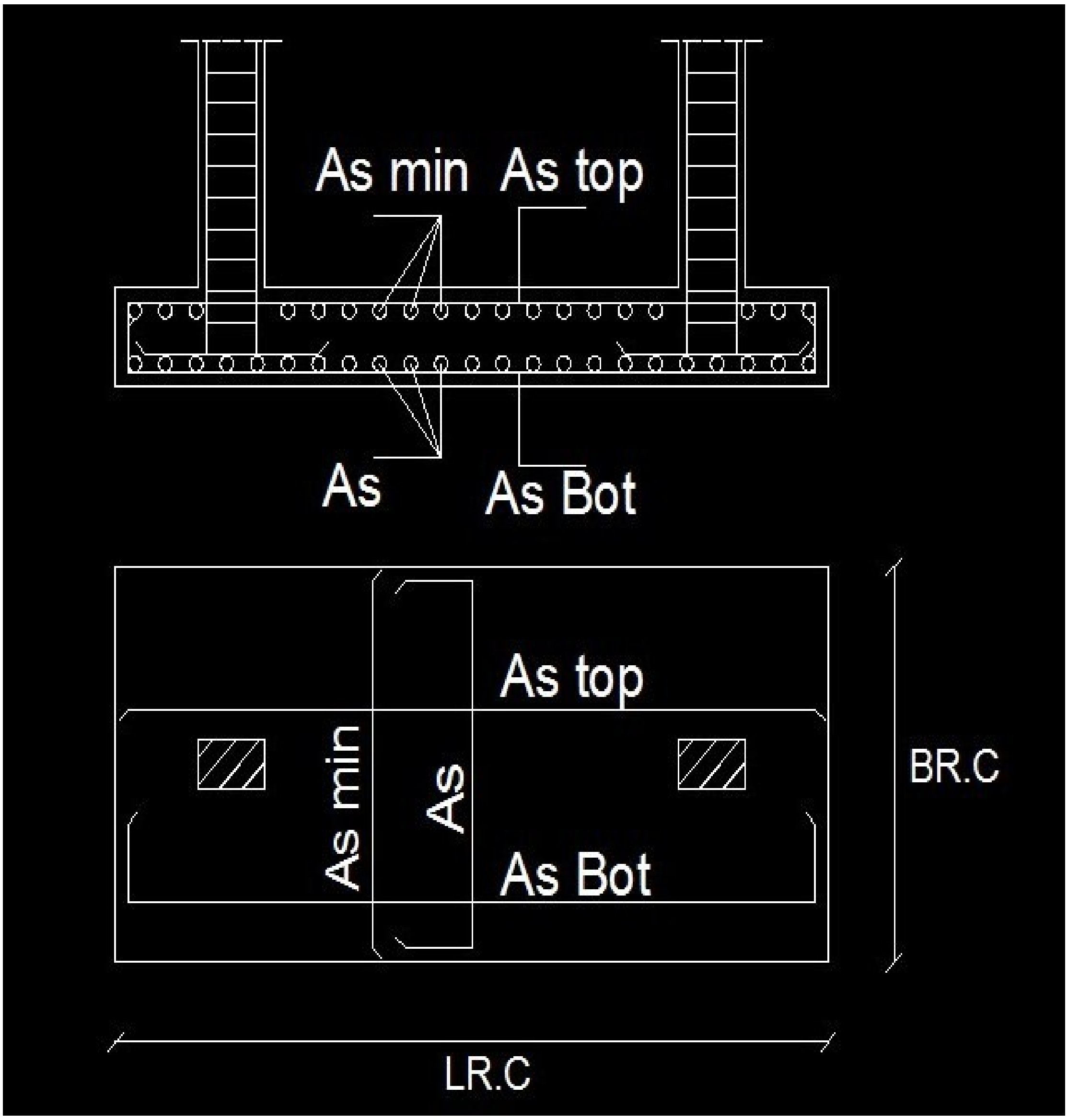
$$Y_2 = \frac{BR.C - b2 or a2}{2} = \dots \ m$$

$$A_s = \frac{Mu}{J * d * Fy} = \dots \ cm^2 / m'$$

$A_{s\ min} = 0.15 * d$

If $A_s \geq A_{s\ min} \rightarrow$ ok

If $A_s < A_{s\ min} \rightarrow$ take $A_s = A_{s\ min}$


As min
As top
As
As Bot
As top
As min
As
As Bot
BR.C
LR.C

Example: 1

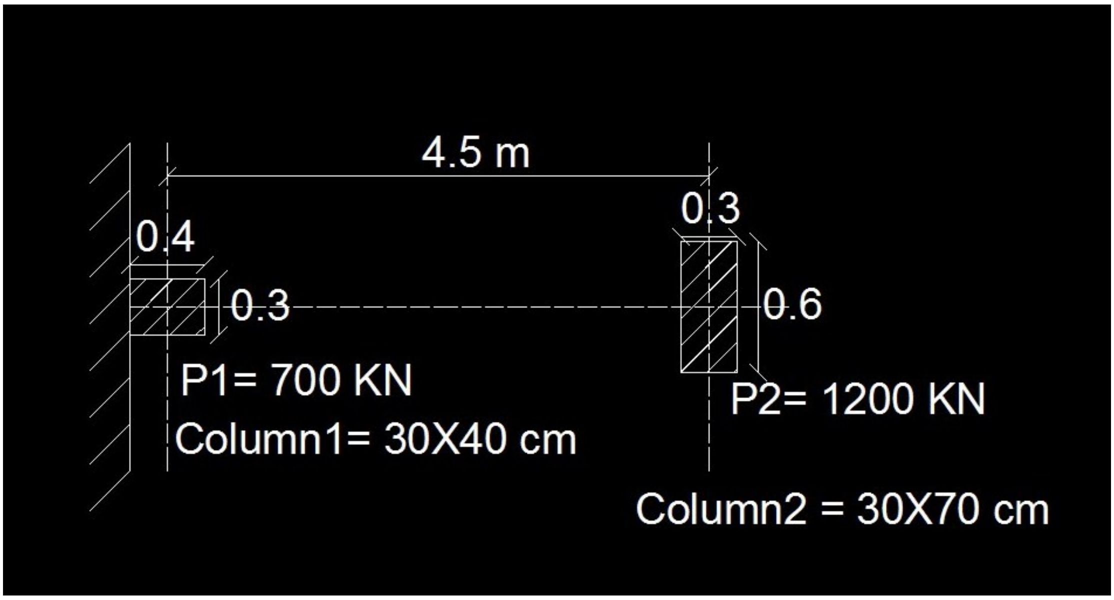
The two column shown in fig are to be supported en a combined footing with the given Dimension.

It is required to:

1) Determine the Foundation thickness required to satisfy Max bending Moment and shear.

2) Determine the reinforcement steel in both direction.

3) Draw net sketch a section elevation and a plan showing concrete dimension and steel details.



Solution

Given: $f_{cu} = 250\ kg/cm^2$, $q_{all} = 150\ kN / m^2$,

$F_y = 3600\ kg/cm^2$, Foundation depth = 2m

$P_1 = 700$ KN = 70 Ton

$P_2 = 1200$ KN = 120 Ton

$P_t = 190$ Ton

$P_{1u} = 70*1.5 = 105$ Ton

$P_{2u} = 120*1.5 = 180$ Ton

$q_{all} = 150\ kN/m^2 = 15\ t/m^2$

1) Dimension of Footing:

$P_t = (P_1+P_2) * 1.1 = (70 + 120)*1.1 = 209$ Ton

$A_{R.C} = \frac{Pt}{qall} = \frac{209}{15} = 13.93\ m^2$

$C_1 = 0.2$ m

$C_2 = C_1 + S = 0.2 + 4.5 = 4.7$ m

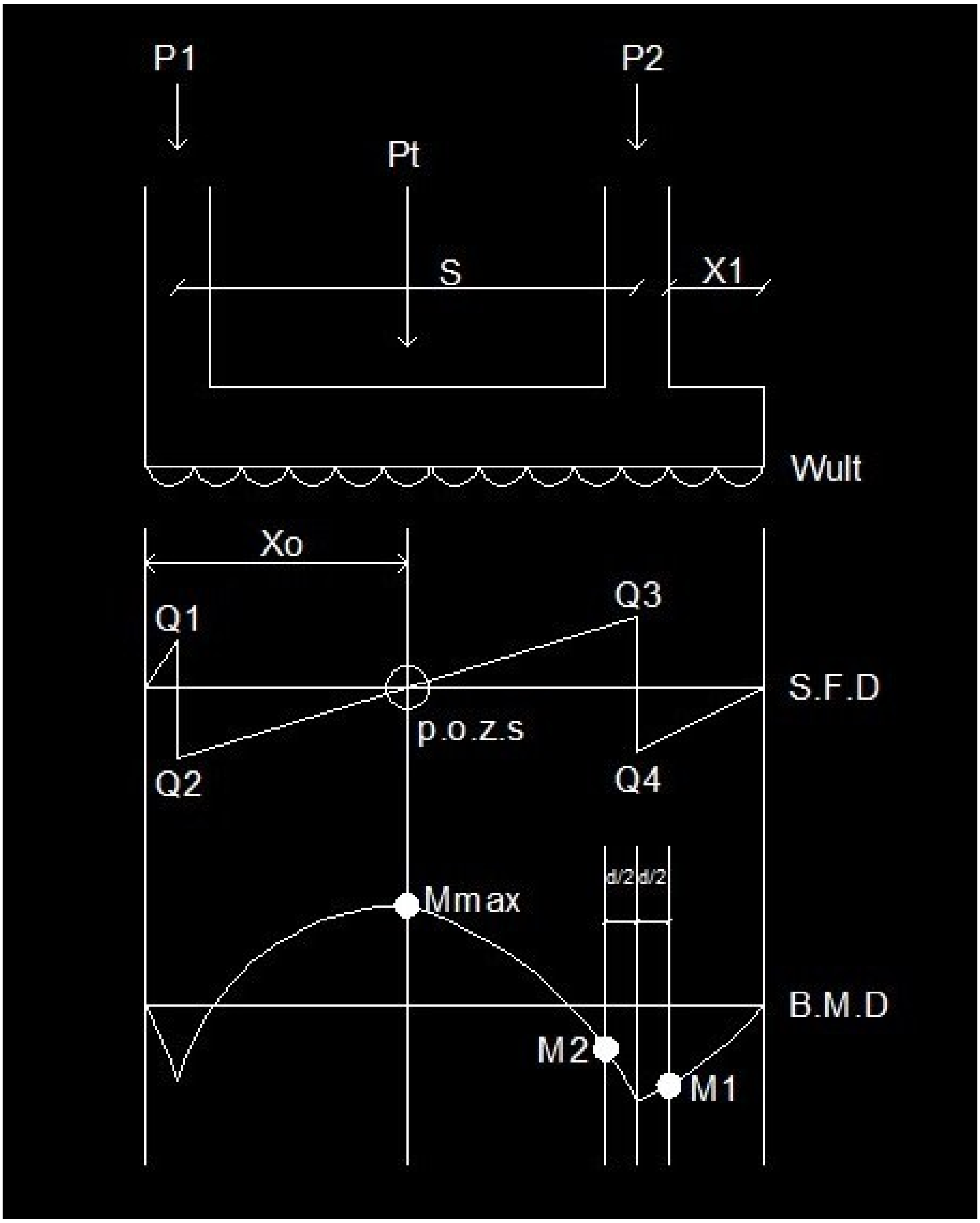
$C = \frac{(c1*p1)+(c2*p2)}{pt} = \frac{(0.2*70)+(4.7*120)}{190} = 3m$

$L_{R.C} = 2* C = 2* 3 = 6$ m

$B_{R.C} = \frac{AR.C}{LR.C} = \frac{13.93}{6} = 2.32m \cong 2.35$ m

End of Working Loads

2) Ultimate stress & Draw B.M.D & S.F.D:



$$q_{ult} = \frac{(p1+p2)*1.5}{LR.C*BR.C} = \frac{(70+120)*1.5}{6*2.35} = 20.21\ t/m^2$$

$$W_{ult} = q_{ult} * B_{R.C} = 20.21 * 2.35 = 47.5 t/m'$$

$Q_1 = W_{ult} * C_1 = 47.5 * 0.2 = 9.5$ Ton

$Q_2 = Q_1 – P_{1u} = 9.5 – 105 = 95.5$ Ton

$Q_3 = W_{ult} * C_2 – P_{1u} = 47.5*4.7–105 = 118.25$ Ton

$Q_4 = Q_3 – P_{2u} = 118.25 – 180 = 61.75$ Ton

$X_1 = L_{R.C} – (C_2 + \frac{b2}{2}) = 6– (4.7 + \frac{0.3}{2}) = 1.15$ m

$M_1 = W_u * \frac{(X1)^2}{2} = 47.5* \frac{(1.15)^2}{2} = 31.4$ mt

$M_2 = W_u * \frac{(X1+b2)^2}{2} – P_{2u} * \frac{b2}{2} = 47.5* \frac{(1.15+0.3)^2}{2}$

$–180* \frac{0.3}{2} = 23$ mt

At p.o.z.s

$X_o = \frac{P1u}{Wu} = \frac{105}{47.5} = 2.2$ m

$M_{max} = P_{1u}*(X_o– C_1)– (W_u*\frac{(Xo)^2}{2}) = 105*(2.2–0.2)$

$– (47.5 *\frac{(2.2)^2}{2}) = 95.1$ mt

3) Calculation the Depth:

$$d = c1\sqrt{\frac{Mu}{Fcu*BR.C}} = 5\sqrt{\frac{95.1*10^5}{250*235}} = 63.6cm \cong 70cm$$

4) Check shear:

$$Q_{sh} = Q_{Max} - W_u\left(\frac{d}{2} + \frac{b2}{2}\right) = 118.25 - 47.5\left(\frac{0.7}{2} + \frac{0.3}{2}\right)$$

$$= 94.5 \text{ Ton}$$

$$q_{sh} = \frac{Qsh}{BR.C*d} = \frac{94.5*10^3}{235*70} = 5.7 kg/cm^2$$

$$q_{cu} = 0.4 * \sqrt{Fcu} = 0.4 * \sqrt{250} = 6.3 \ kg/cm^2$$

$q_{cu} > q_{sh}$

6.3 > 5.7 ok safe

5) Check Punching:

For Column 1:

$Q_{P1} = P_{u1} - q_U (A_1' * B_1')$

$A_1' = (a_1 + \frac{d}{2}) = (0.4 + \frac{0.7}{2}) = 0.75$ m

$B_1' = (b_1 + d) = (0.3 + 0.7) = 1$ m

QP1 =105–20.21(0.75*1)= 90 Ton

For Column 2:

$Q_{P2} = P_{u2} - q_U (A_2' * B_2')$

$A_2' = (a_2 + d) = (0.6 + 0.7) = 1.3$ m

$B_2' = (b_2 + d) = (0.3 + 0.7) = 1$ m

$Q_{P2} = 180 - 20.21 (1.3 * 1) = 154$ Ton

$q_p = \frac{Qp2}{2*(A2'+B2')*d} = \frac{154*10^3}{2*(130+100)*70} = 4.8 \text{ kg/cm}^2$

$q_{pcu} = (0.5 + \frac{b2}{a2}) \sqrt{\frac{Fcu}{\chi c}}$

$= (0.5 + \frac{0.3}{0.6}) \sqrt{\frac{250}{1.5}} = 12.9 \text{ kg/cm}^2$

$q_{pcu} > q_p$

12.9 > 4.8 ok safe

t = d + cover = 70 + 10 = 80 cm

6) Reinforcement of the footing:

in Long Direction:

$A_{s\ Top} = \frac{Mmax}{J*d*Fy}$ = … $cm^2/B_{R.C}$ = cm^2/m'

$= \frac{95.1*10^5}{0.826*70*3600}$=45.7/2.35=19.4$cm^2$/m'

$A_{s\ min}$ = 0.15 * d = 0.15 * 70 = 10.5 cm^2/m'

$A_{s\ Top} \geq A_{s\ min} \rightarrow$ ok

Take $A_{s\ Top}$ = 19.4 cm^2/m'

Use 6y22/m'

$A_{s\ Bot} = \frac{M1}{J*d*Fy}$ = … $cm^2/B_{R.C}$ = … cm^2/m'

$= \frac{31.4*10^5}{0.826*70*3600}$ = 15.1/2.35 = 6.4cm^2/m'

$A_{s\ min}$ = 0.15 * d = 0.15 * 70 = 10.5 cm^2/m'

$A_{s\ Bot} < A_{s\ min} \rightarrow$ take $A_{s\ Bot} = A_{s\ min}$

take $A_{s\ Bot}$ = 10.5 cm^2/m'

Use 6y16/m'

In Short Direction:

$$M_u = q_{ult} * \frac{(y1)^2}{2} = \ldots \text{ mt}$$

$$Y_1 = \frac{BR.C-b1}{2} = \frac{2.35-0.3}{2} = 1.025 \text{ m}$$

$$Y_2 = \frac{BR.C-a2}{2} = \frac{2.35-0.6}{2} = 0.875 \text{ m}$$

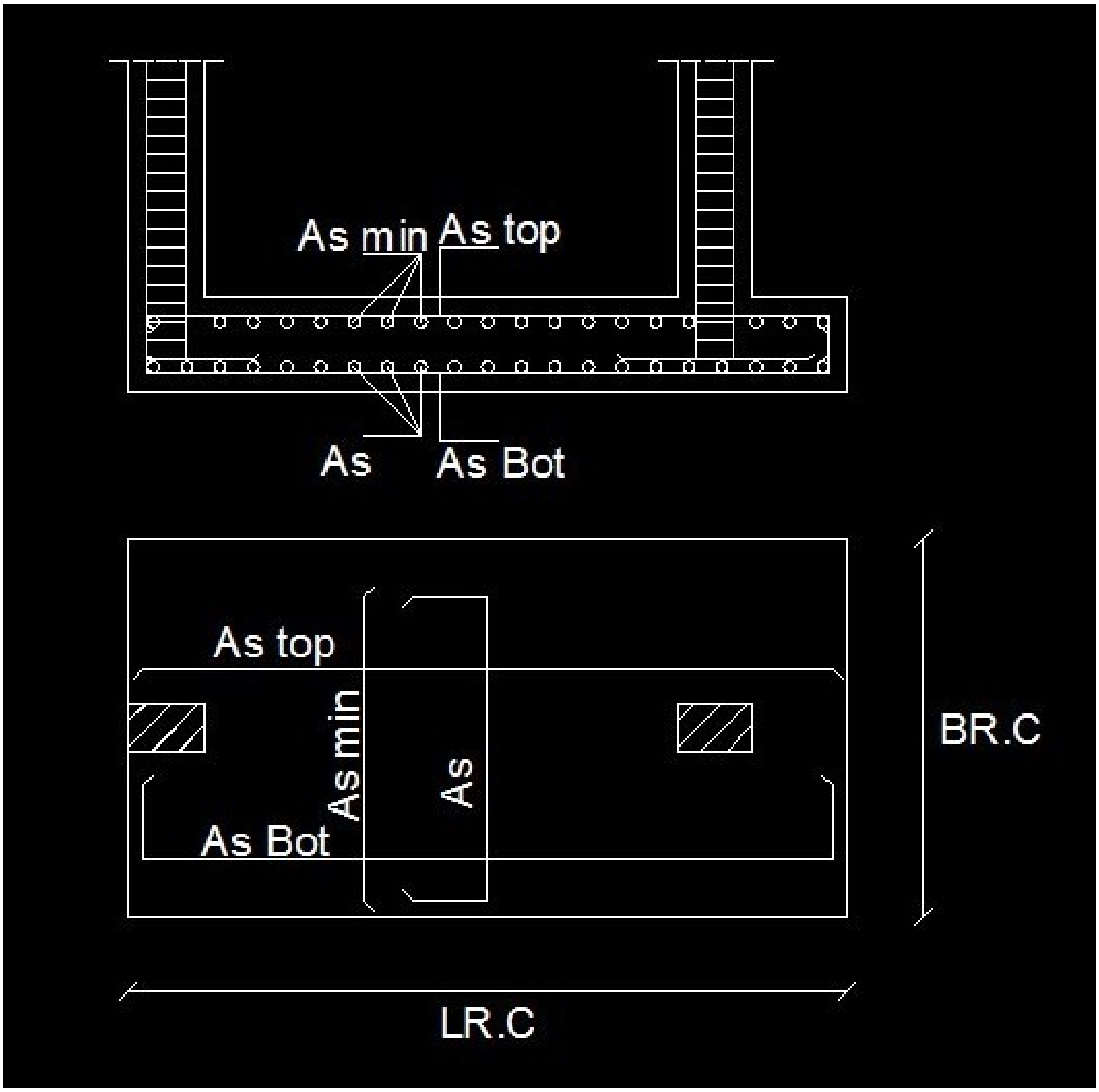
$$M_u = q_{ult} * \frac{(y1)^2}{2} = 20.21 * \frac{(1.025)^2}{2} = 10.62 \text{ mt}$$

$$A_s = \frac{Mu}{J*d*Fy} = \frac{10.62*10^5}{0.826*70*3600} = 5.1 \text{ cm}^2/\text{m'}$$

$A_s < A_{s\ min} \longrightarrow$ take $A_s = A_{s\ min}$

take A_s =10.5 cm^2/m'

Use 6y16/m'



As min
As top
As
As Bot
As top
As min
As
As Bot
BR.C
LR.C

Example: 2

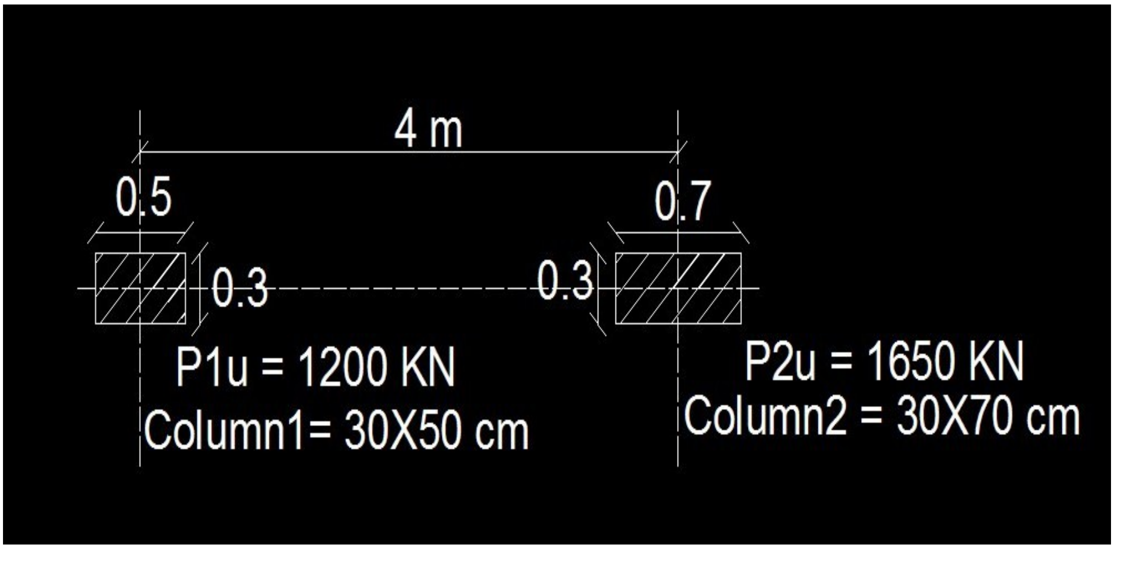
The two interior column shown in fig are to be supported en a combined footing with the given Dimension.

It is required to:

1) Determine the Foundation thickness required to satisfy Max bending Moment and shear.

2) Determine the reinforcement steel in both direction.

3) Draw net sketch a section elevation and a plan showing concrete dimension and steel details.



Solution

Given: f_{cu} = 200 kg/cm^2 , q_{all} = 120 kN / m^2 ,

F_y = 3600 kg/cm^2 , Foundation depth = 2m

$P_{1u} = 1200\ KN = 120\ Ton$

$P_{2u} = 1650\ KN = 165\ Ton$

$P_{t\,u} = 285\ Ton$

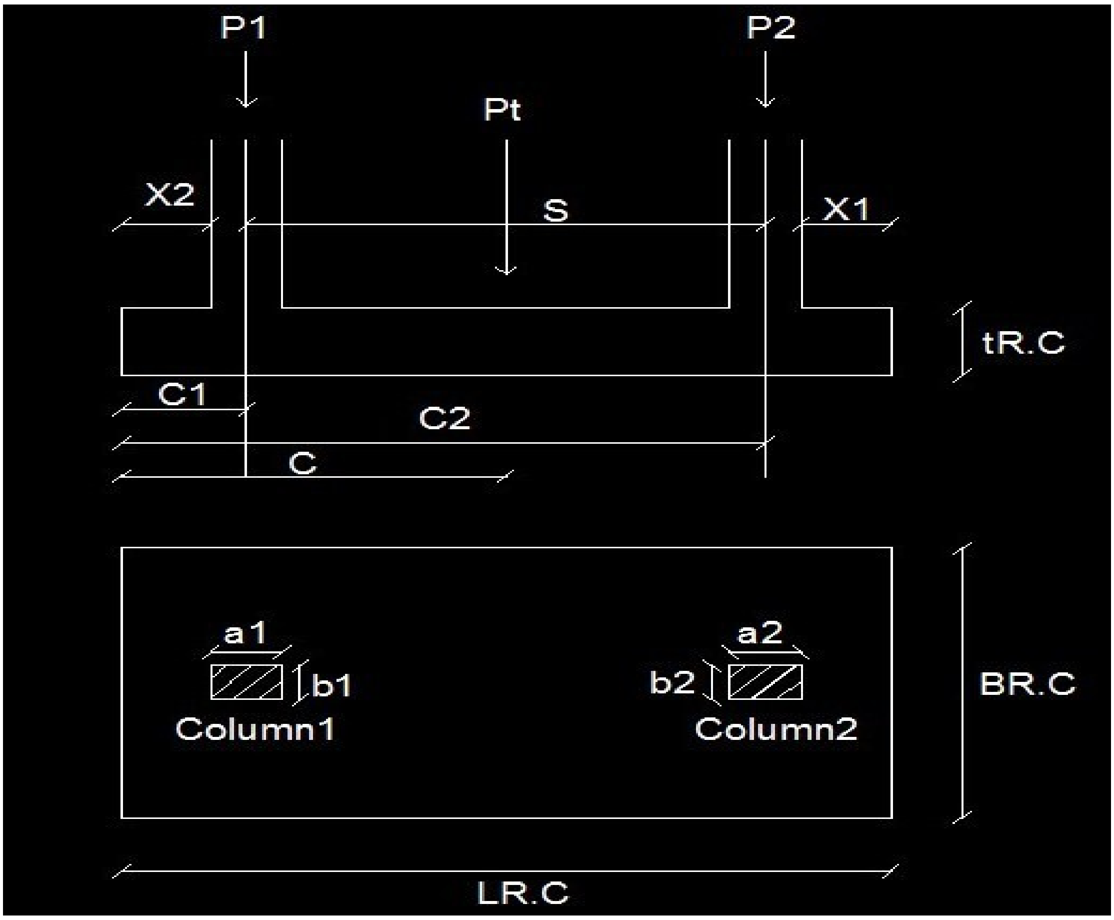
$P_{1w} = \frac{P1u}{1.5} = \frac{120}{1.5} = 80\ Ton$

$P_{2w} = \frac{P2u}{1.5} = \frac{165}{1.5} = 110\ Ton$

$P_{t\,w} = 80 + 110 = 190\ Ton$

$q_{all} = 120\ kN/m^2 = 12\ t/m^2$

1) Dimension of Footing (working Loads):



P_t =(P_1+P_2)*1.1=(80+110)*1.1=209 Ton

$A_{R.C} = \frac{Pt}{qall} = \frac{209}{12} = 17.4\ m^2$

Take C_1 = 1 m

$C_2 = C_1 + S = 1 + 4 = 5$ m

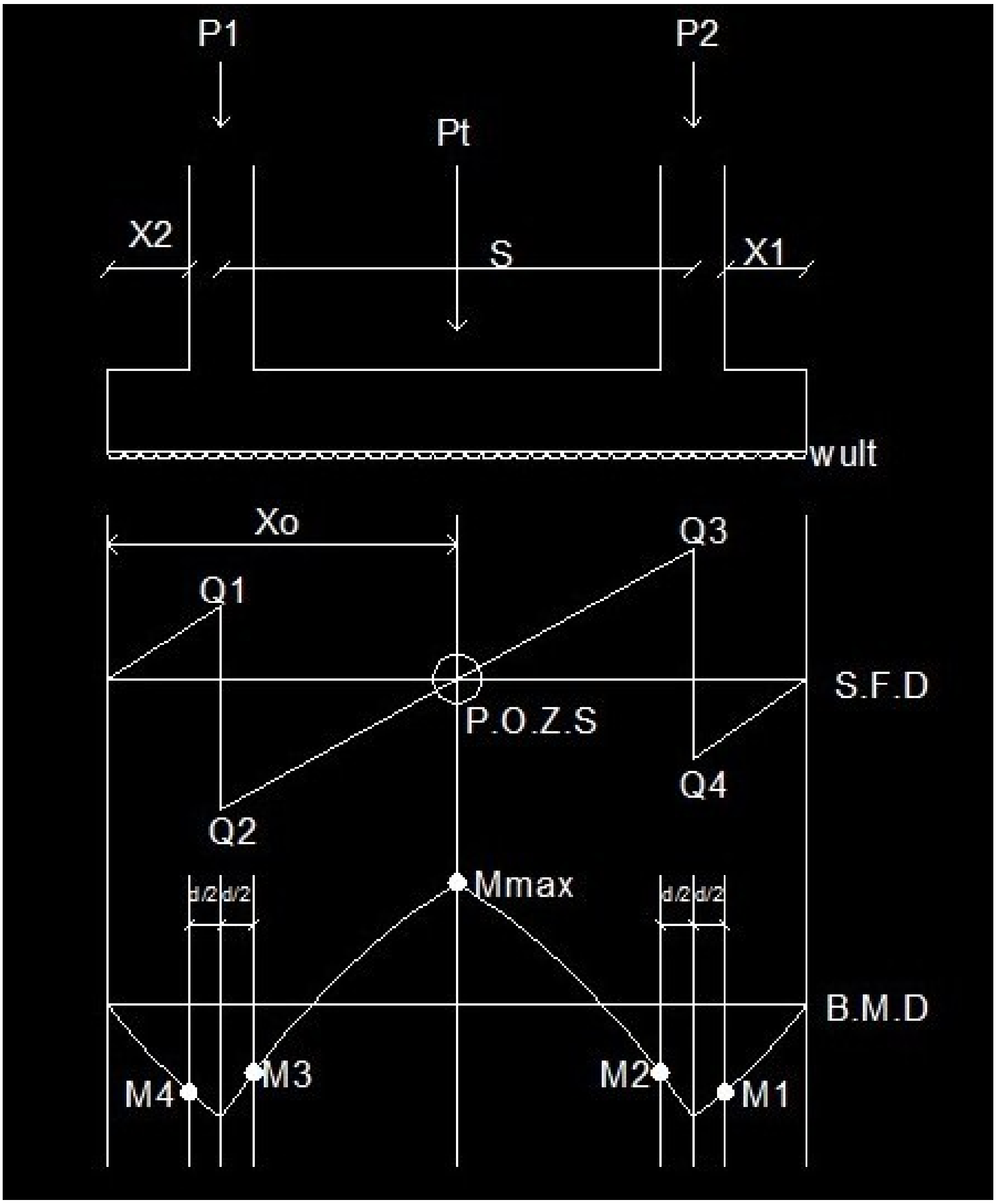
$C = \frac{(c1*p1)+(c2*p2)}{pt} = \frac{(1*80)+(5*110)}{190} = 3.3$ m

$L_{R.C} = 2*C = 2*3.3 = 6.6$ m

$B_{R.C} = \frac{AR.C}{LR.C} = \frac{17.4}{6.6} = 2.64m \cong 2.7m$

End of Working Loads

2) Ultimate stress & Draw B.M.D & S.F.D:



$$q_{ult} = \frac{(p1+p2)}{LR.C*BR.C} = \frac{(120+165)}{6.6*2.7} = 16 \text{ t/m}^2$$

$$W_{ult} = q_{ult} * B_{R.C} = 16 * 2.7 = 43.2 \text{ t/m'}$$

$Q_1 = W_{ult} * C_1 = 43.2 * 1 = 43.3$ Ton

$Q_2 = Q_1 – P_{1u} = 43.2 – 120 = 76.8$ Ton

$Q_3 = W_{ult} * C_2 – P_{1u} = 43.2 * 5 – 120 = 96$ Ton

$Q_4 = Q_3 – P_{2u} = 96 – 165 = 69$ Ton

$X_1 = L_{R.C} – (C_2 + \frac{a2}{2}) = 6.6 – (5 + \frac{0.7}{2}) = 1.25$ m

$X_2 = C_1 – \frac{a1}{2} = 1 – \frac{0.5}{2} = 0.75$ m

$M_1 = W_u * \frac{(X1)^2}{2} = 43.2 * \frac{(1.25)^2}{2} = 33.75$ mt

$M_2 = W_u * \frac{(X1+a2)^2}{2} – P_{2u} * \frac{a2}{2}$

$= 43.2 * \frac{(1.25+0.7)^2}{2} – 165 * \frac{0.7}{2} = 24.38$ mt

$M_4 = W_u * \frac{(X2)^2}{2} = 43.2 * \frac{(0.75)^2}{2} = 12.15$ mt

$M_3 = W_u * \frac{(X2+a1)^2}{2} – P_{1u} * \frac{a1}{2}$

$= 43.2 * \frac{(0.75+0.5)^2}{2} – 120 * \frac{0.5}{2} = 3.75$ mt

At p.o.z.s

$X_o = \frac{P1u}{Wu} = \frac{120}{43.2} = 2.78$ m

$M_{max} = P_{1u} * (X_o - C_1) - (W_u * \frac{(Xo)^2}{2}) = \dots$ mt

$= 120 * (2.78 - 1) - (43.2 * \frac{(2.78)^2}{2}) = 46.7$ mt

3) Calculation the Depth:

$d = c1 \sqrt{\frac{Mu}{Fcu * BR.C}} = 5 \sqrt{\frac{46.7 * 10^5}{200 * 270}} = 46.5 \cong 50cm$

4) Check shear:

$Q_{sh} = Q_{Max} - W_u (\frac{d}{2} + \frac{a2}{2}) = \dots$ Ton

$= 96 - 43.2 (\frac{0.5}{2} + \frac{0.7}{2}) = 70$ Ton

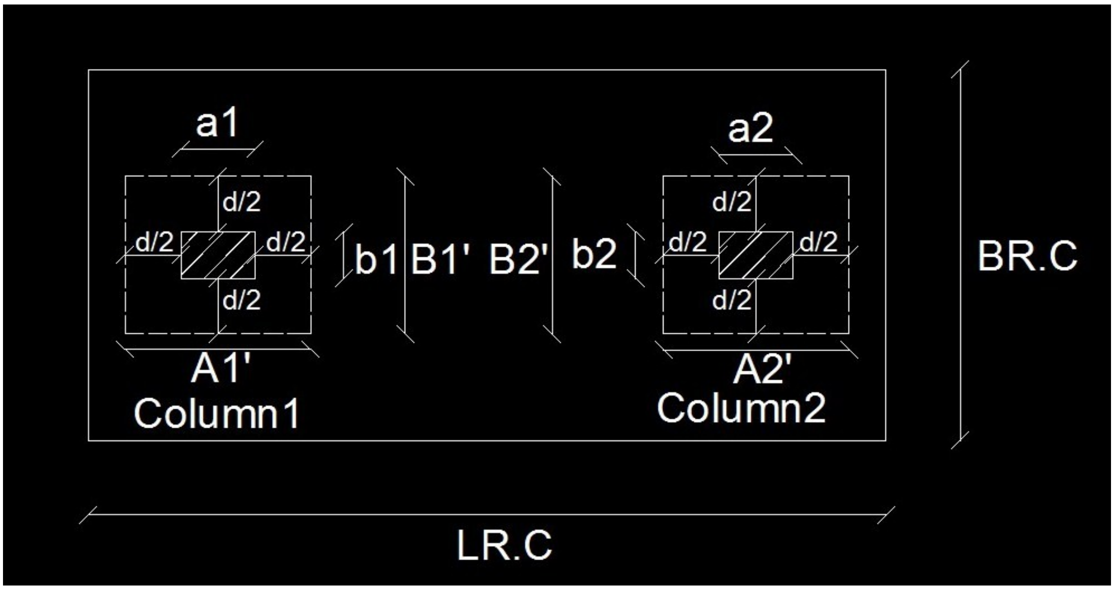
$q_{sh} = \frac{Qsh}{BR.C * d} = \frac{70 * 10^3}{270 * 50} = 5.18 \ kg/cm^2$

$q_{cu} = 0.4 * \sqrt{Fcu} = 0.4 * \sqrt{200} = 5.66 \ kg/cm^2$

$q_{cu} > q_{sh}$

5.66 > 5.18 ok safe

5) Check Punching:



For Column 1:

$Q_{P1} = P_{u1} - q_U (A_1' * B_1')$

$A_1' = (a_1 + d) = (0.5+0.5) = 1$ m

$B_1' = (b_1 + d) = (0.3 + 0.5) = 0.8$ m

$Q_{P1} = 120 - 16(1*0.8) = 107.2$Ton

For Column 2:

$Q_{P2} = P_{u2} - q_U (A_2' * B_2')$

$A_2' = (a_2 + d) = (0.7 + 0.5) = 1.2$ m

$B_2' = (b_2 + d) = (0.3 + 0.5) = 0.8$ m

$Q_{P2} = 165 - 16\,(1.2 * 0.8) = 149.64$ Ton

$$q_p = \frac{Qp2}{2*(A2'+B2')*d} = \frac{149.64*10^3}{2*(120+80)*50} = 7.48 \text{kg/cm}^2$$

$$q_{pcu} = \left(0.5 + \frac{b2}{a2}\right)\sqrt{\frac{Fcu}{\gamma c}}$$

$$= \left(0.5 + \frac{0.3}{0.7}\right)\sqrt{\frac{200}{1.5}} = 10.7 \text{ kg/cm}^2$$

$q_{pcu} > q_p$

10.7 > 7.48 ok safe

t = d + cover = 50+10 = 60 cm

6) Reinforcement of the footing:

in Long Direction:

$A_{s\,Top} = \frac{Mmax}{J*d*Fy} = \ldots\ cm^2/B_{R.C} = \ldots\ cm^2/m'$

$= \frac{46.7*10^5}{0.826*50*3600} = 31.41/2.7 = 11.63\ cm^2/m'$

$A_{s\,min} = 0.15 * d = 0.15 * 50 = 7.5\ cm^2/m'$

$A_{s\,Top} \geq A_{s\,min} \rightarrow$ ok

take $A_{s\,Top} = 11.63\ cm^2/m'$

Use 6y 16 / m'

$A_{s\,Bot} = \frac{M1}{J*d*Fy} = ..cm^2/B_{R.C} = ..\ cm^2/m'$

$= \frac{33.75*10^5}{0.826*50*3600} = 23cm^2/2.7 = 8.5\ cm^2/m'$

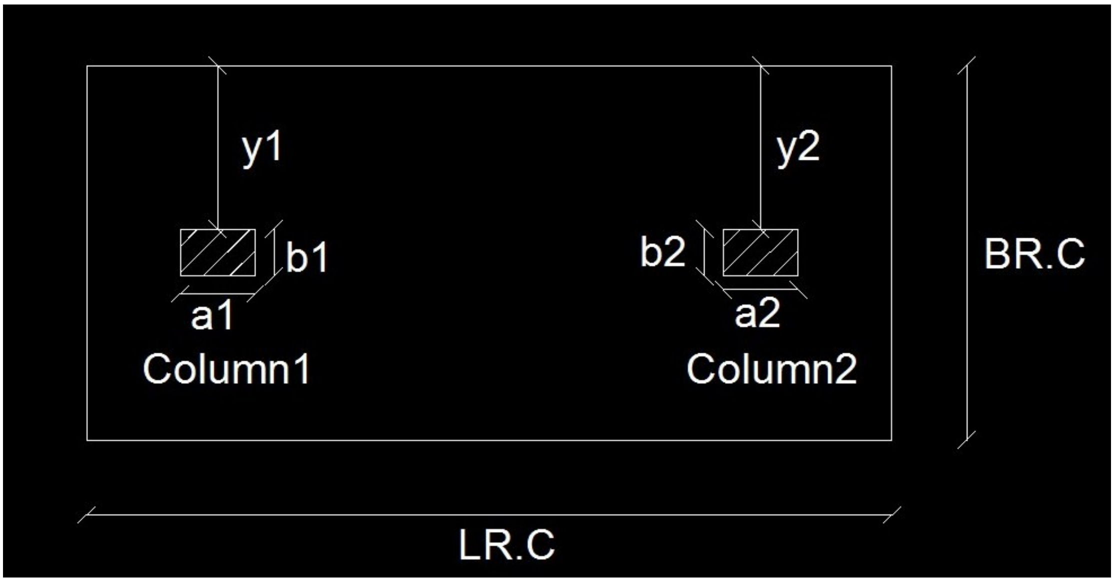
$A_{s\,min} = 0.15 * d = 0.15 * 50 = 7.5\ cm^2/m'$

$A_{s\,Bot} \geq A_{s\,min} \rightarrow$ ok

take $A_{s\,Bot} = 8.5\ cm^2/m'$

Use 8y 12 / m'

In Short Direction:



$M_u = q_{ult} * \frac{(y1or2)^2}{2}$

$Y_1 = \frac{BR.C-b1}{2} = \frac{2.7-0.3}{2} = 1.2$ m

$Y_2 = \frac{BR.C-b2}{2} = \frac{2.7-0.3}{2} = 1.2$ m

$M_u = 16 * \frac{(1.2)^2}{2} = 11.52$ mt

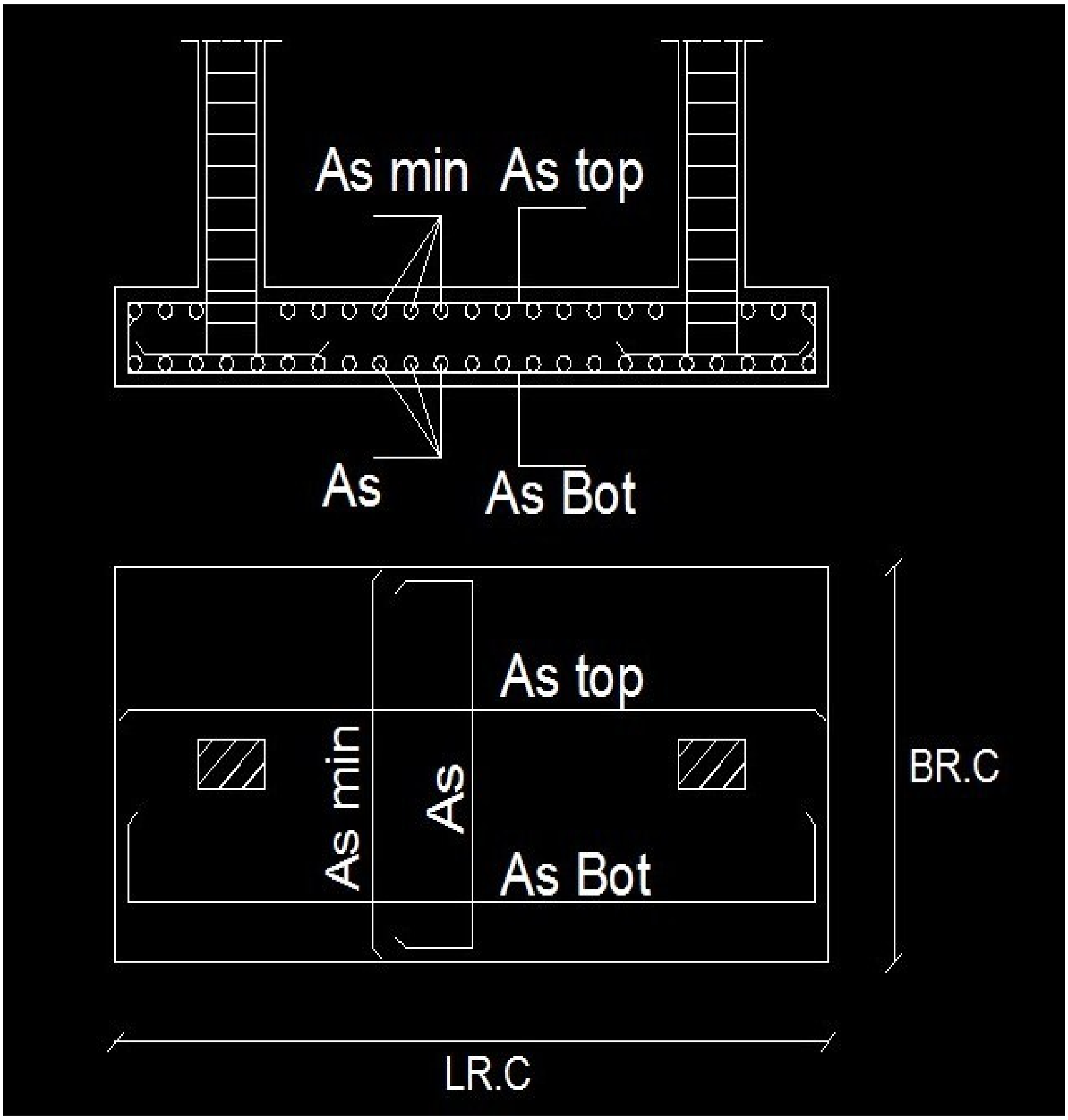
$A_s = \frac{Mu}{J*d*Fy} = \frac{11.52*10^5}{0.826*50*3600} = 7.75 cm^2/m'$

$A_{s\ min} = 0.15 * d = 0.15 * 50 = 7.5\ cm^2/m'$

$A_s \geq A_{s\ min} \rightarrow$ ok

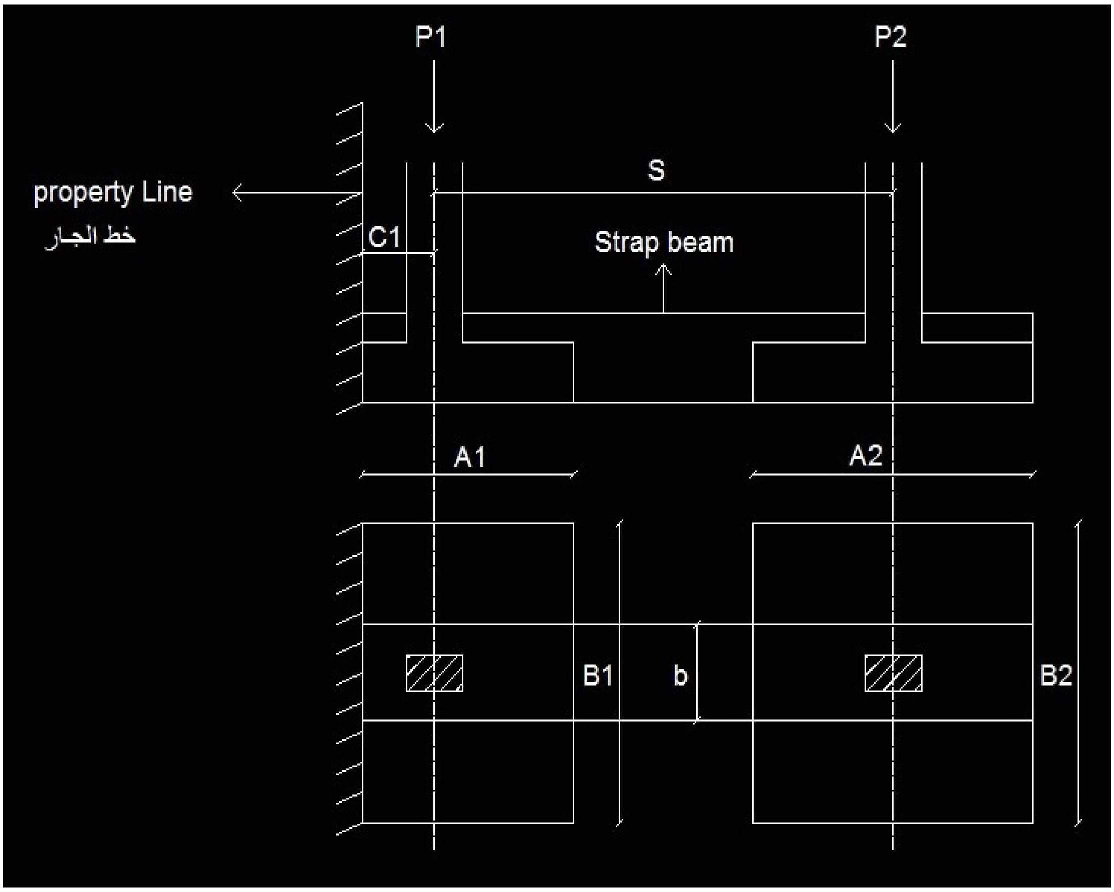
take $A_s = 7.75 cm^2/m'$

Use 8y 12 / m'


As min
As top
As
As Bot
As top
As min
As
As Bot
BR.C
LR.C

Steps of Design:

1) Dimension of Footing:



$P_{t1} = 1.2*P_1 = ...ton$

$P_{t2} = P_2 = ...ton$

حيث أن:

P_2 و $P_1 \rightarrow$ Working Loads

Take $t_{p.c} = 30$ cm

Area of Footing (1):

$A_{f1} = \frac{Pt1}{qall} = \ldots\ m^2 \longrightarrow A_1, B_1$

حيث أن:

$A_1 \longrightarrow$ (البعد الأصغر) العرض

$B_1 \longrightarrow$ (البعد الأكبر) الطول

Area of Footing (2):

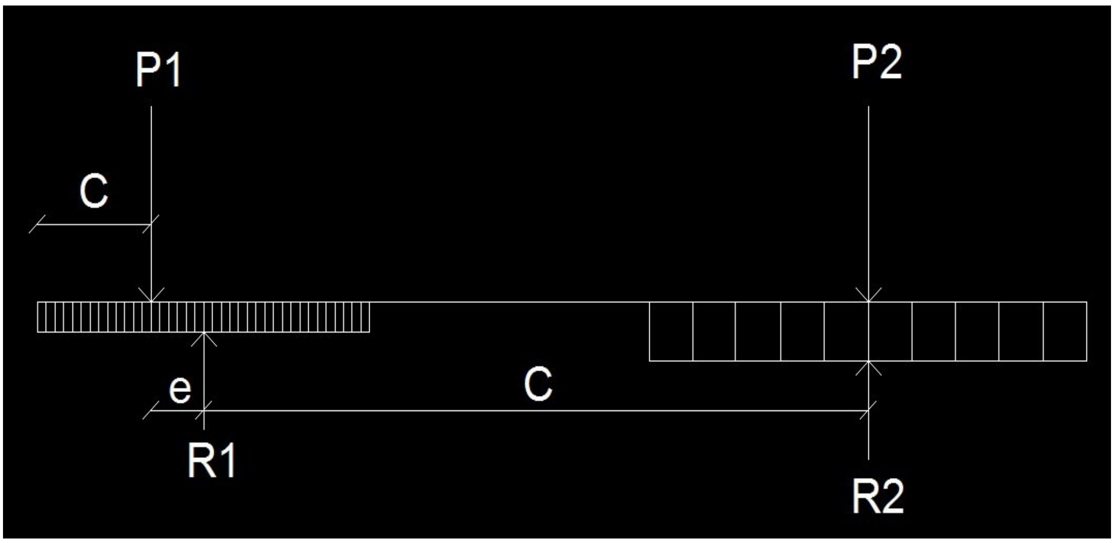
$A_{f2} = \frac{Pt2}{qall} = \ldots\ m^2 \longrightarrow A_2, B_2$

حيث أن:

$A_2 \longrightarrow$ العرض أو الطول حسب وضع العمود

$B_2 \longrightarrow$ العرض أو الطول حسب وضع العمود

2) Determination of eccentricity:



نلاحظ أن:

القاعدة الثانية مرتكزة مع العمود فتكون محصلة إجهاد التربة في نفس مكان تأثير حمل العمود.

القاعدة الأولي غير مرتكزة مع العمود ويوجد ترحيل بين P_1 و R_1 .

$e = \frac{A1}{2} - C_1 = \ldots$ m

$C = s - e = \ldots$ m

3) Check Area:

$R_{1u} = P_1 + P_1 * \frac{e}{C} = \ldots$ ton

$R_2 = P_2 - P_1 * \frac{e}{C} = \ldots$ ton

$q_1 = \frac{Rt1*1.1}{A1*B1} = \ldots\ t/m^2 \ngtr q_{all}$

$q_2 = \frac{Rt2*1.1}{A2*B2} = \ldots\ t/m^2 \ngtr q_{all}$

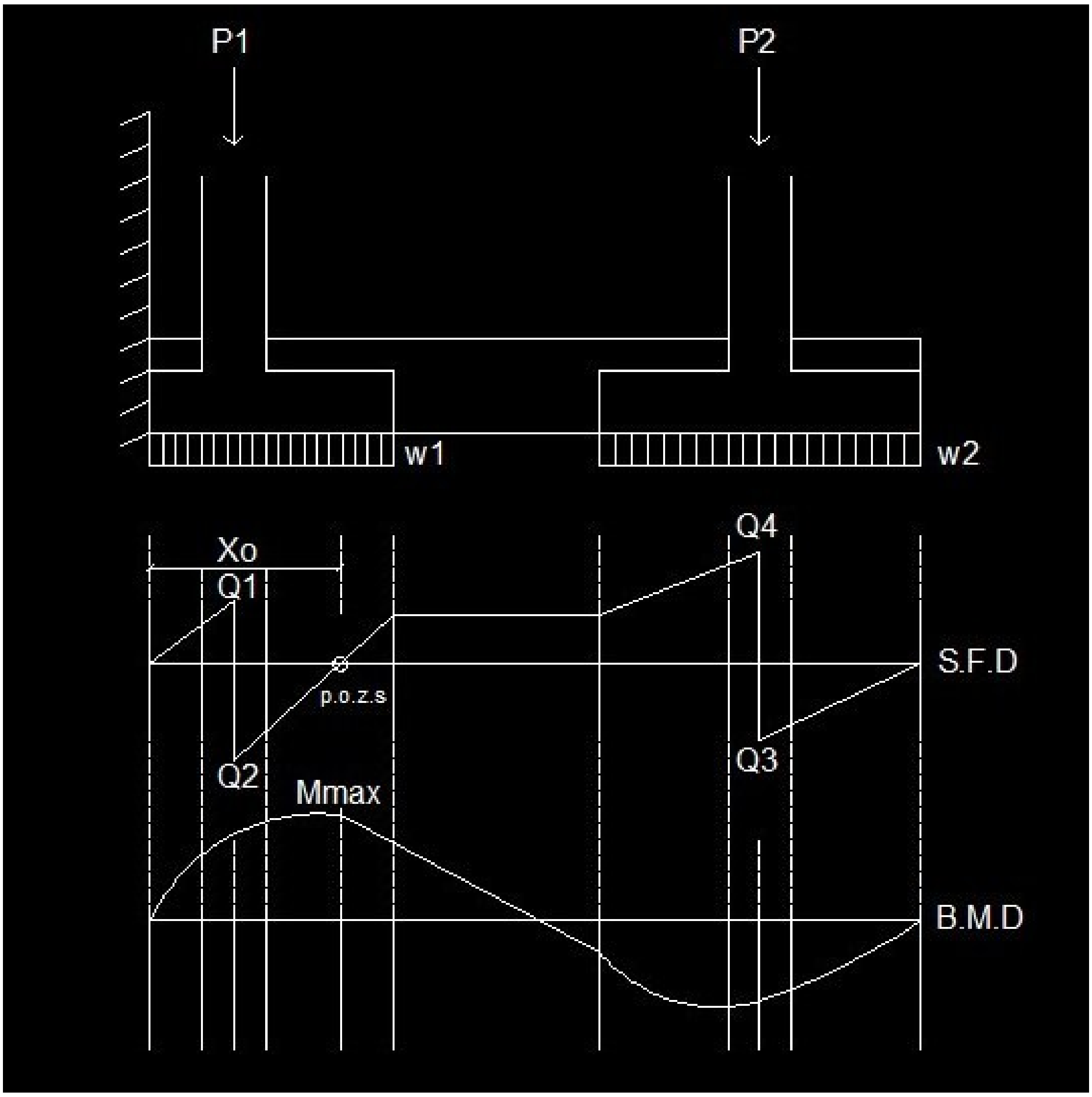
If $q_1 > q_{all}$ increase B_1

If $q_2 > q_{all}$ increase B_2

End of Working Loads .

4) Design of Strap Beam:

Calculation of Moment and Shear for Strap Beam:



$P_{1u} = 1.5\ P_1 = \ldots$ ton

$P_{2u} = 1.5\ P_2 = \ldots$ ton

$R_{1u} = 1.5\ R_1 = \ldots$ ton

$R_{2u} = 1.5\ R_2 = \ldots$ ton

$W_1 = \frac{R1u}{A1} = \ldots$ t/m'

$W_2 = \frac{R2u}{A2} = \ldots$ t/m'

Point of Zero Shear

At distance X_o

$X_o = \frac{p1u}{w1} = \ldots$ m

$M_{max} = P_{1u}\ (X_o - C_1) - W_1 * \left(\frac{(Xo)^2}{2}\right) = \ldots$ mt

$$d = c_1 \sqrt{\frac{Mult}{Fcu*b}} = \dots \text{ cm}$$

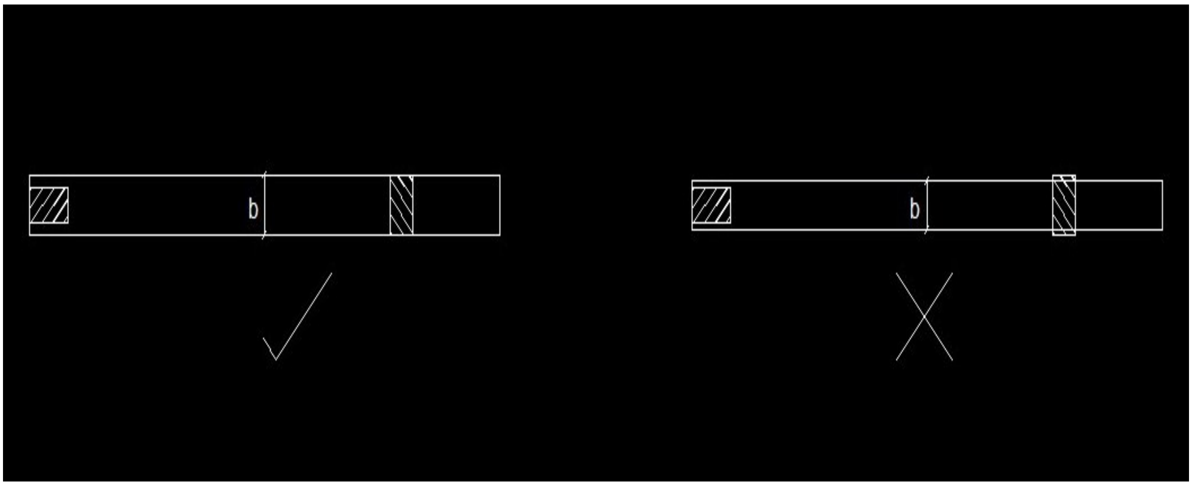
حيث أن:

$c_1 = 4 \rightarrow$ beam

$b \rightarrow$ strap beam عرض

$b = 40 \rightarrow 80$ cm

strap beam ولا تقل عن بعد العمود في اتجاه



5) Check Shear:

$Q_1 = W_1 * C_1 = ...$ t

$Q_2 = Q_1 - P_{1u} = ...$ t

$Q_3 = W_2 * \frac{A2}{2} = ...$ t

$Q_4 = Q_3 - P_{2u} = ...$ t

$Q_{sh1} = Q_1 \text{ or } Q_2 - W_1 * (\frac{d}{2} + \frac{a1 \text{ or } b1}{2}) = ...$ ton

حيث أن:

Take the bigger of Q_1 or Q_2

a→ طول العمود

b→ عرض العمود

b1 or a1→ حسب اتجاه العمود

$Q_{sh2} = Q_3 \text{ or } Q_4 - W_2 * (\frac{d}{2} + \frac{a2 \text{ or } b2}{2}) = ...$ ton

حيث أن:

Take the bigger of Q_3 or Q_4

a→ طول العمود

b→ عرض العمود

b2 or a2→ حسب اتجاه العمود

$q_{sh} = \frac{Qsh1or2}{b*d}$ = … kg/cm^2

حيث أن:

Take the bigger of Q_{sh1} or Q_{sh2}

b→ strap beam عرض

q_{cu} = $0.75*\sqrt{\frac{Fcu}{\gamma c}}$ (for beam) = … kg/cm^2

حيث أن:

$\gamma c = 1.5$

If $q_{cu} > q_{sh}$ ok (use min stirrups 5y8/m')

If $q_{cu} < q_{sh}$ (use min stirrups 7y10/m')

t = d + cover

cover =(5 to 10 cm)

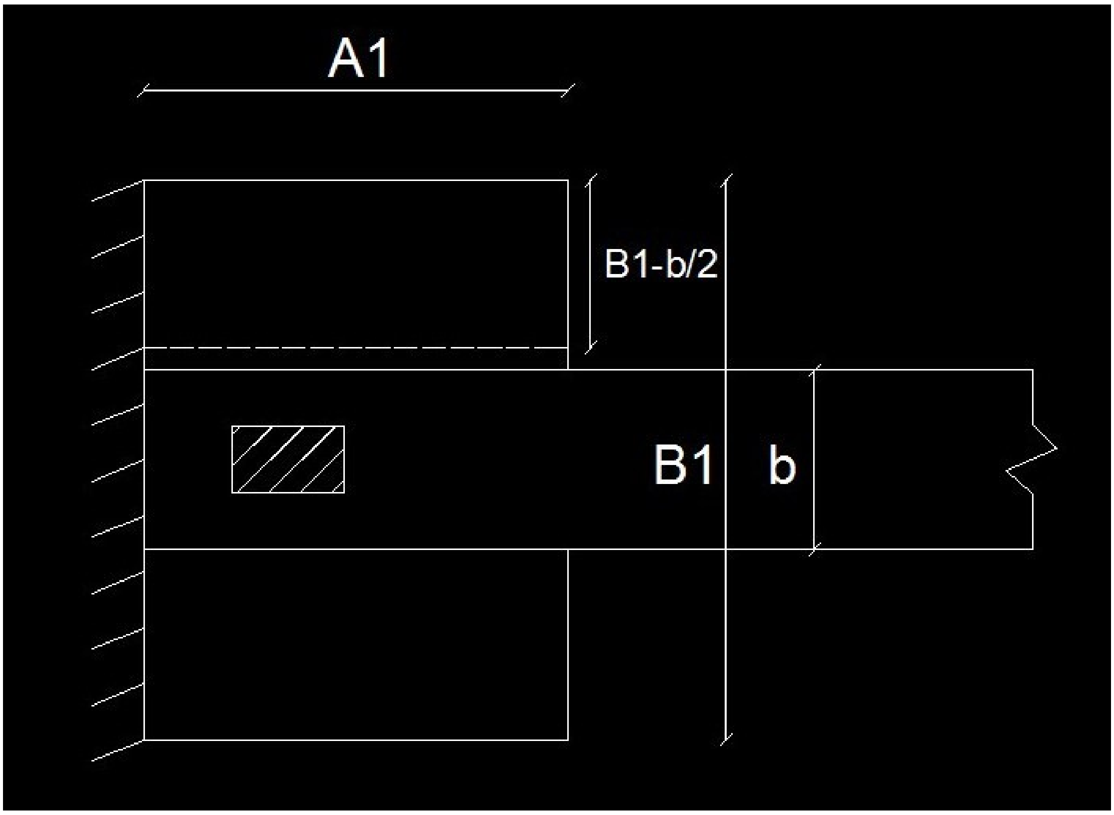
Reinforcement of the Strap beam:

$A_{s\ top} = \frac{Mmax}{J*d*fy}$ = … cm^2

$A_{S\ bott}$ = 20 % $A_{s\ top}$ = … cm^2

6) Design of Footing:

Footing 1 (F_1):



$$q_{u1} = \frac{R1u}{A1 * B1} = \dots \; t/m^2$$

$$M_1 = q_{u1} * \frac{\left(\frac{B1-b}{2}\right)^2}{2} = \dots \; mt$$

$$d_1 = c_1 \sqrt{\frac{M1ult}{Fcu * B}} = \dots \; cm$$

حيث أن:

B = 100 cm , c_1 = 5 for Footing

Check Shear:

$Q_{sh} = q_{u1} *(\frac{d}{2} + \frac{B1-b}{2}) =$ … ton

$q_{sh} = \frac{Qsh}{B*d1} =$ … kg/cm^2

حيث أن:

B = 100 cm

$q_{cu} = 0.4*\sqrt{Fcu} =$ … kg/cm^2

If $q_{cu} > q_{sh}$ ok safe

If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B) =$ … cm

t = d + cover

cover =(5 to 10 cm)

Reinforcement of the footing (1):

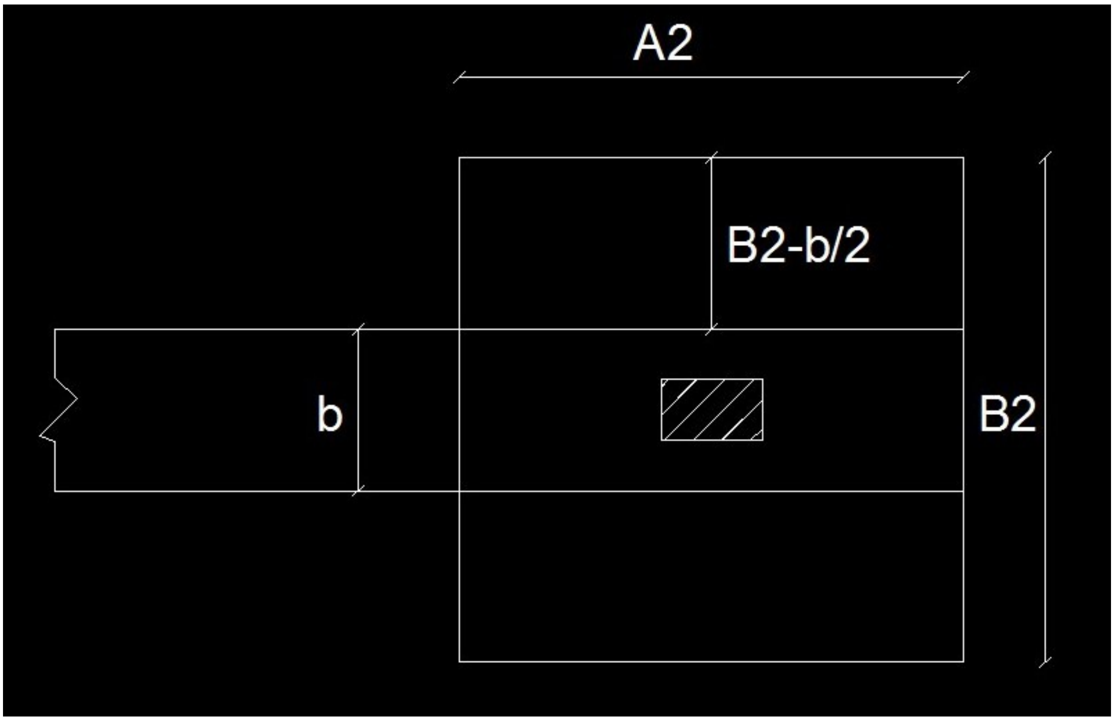
$A_{s1} = \frac{M1}{J*d1*Fy} =$ … cm^2 /m'

$A_{s\ min}$ = 5y12/m' = … cm^2 /m'

If $A_{s1} \geq A_{s\ min} \rightarrow$ ok

If $A_{s1} < A_{s\ min} \rightarrow$ take $A_{s1} = A_{s\ min}$

Footing 2 (F_2):



$$q_{u2} = \frac{R2u}{A2*B2} = \dots \ t/m^2$$

$$M_2 = q_{u2} * \frac{\left(\frac{B2-b}{2}\right)^2}{2} = \dots \ mt$$

$$d_2 = c_1\sqrt{\frac{M2ult}{Fcu*B}} = \dots \ cm$$

حيث أن:

B = 100 cm , c_1 = 5 for Footing

Check Shear:

$$Q_{sh} = q_{u2} *\left(\frac{d}{2} + \frac{B2-b}{2}\right) = \dots \ ton$$

$q_{sh} = \frac{Qsh}{B*d2} = \ldots\ kg/cm^2$

حيث أن:

B = 100 cm

$q_{cu} = 0.4*\sqrt{Fcu} = \ldots\ kg/cm^2$

If $q_{cu} > q_{sh}$ ok safe

If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B) = \ldots$ cm

t = d + cover

cover =(5 to 10 cm)

Reinforcement of the footing (2):

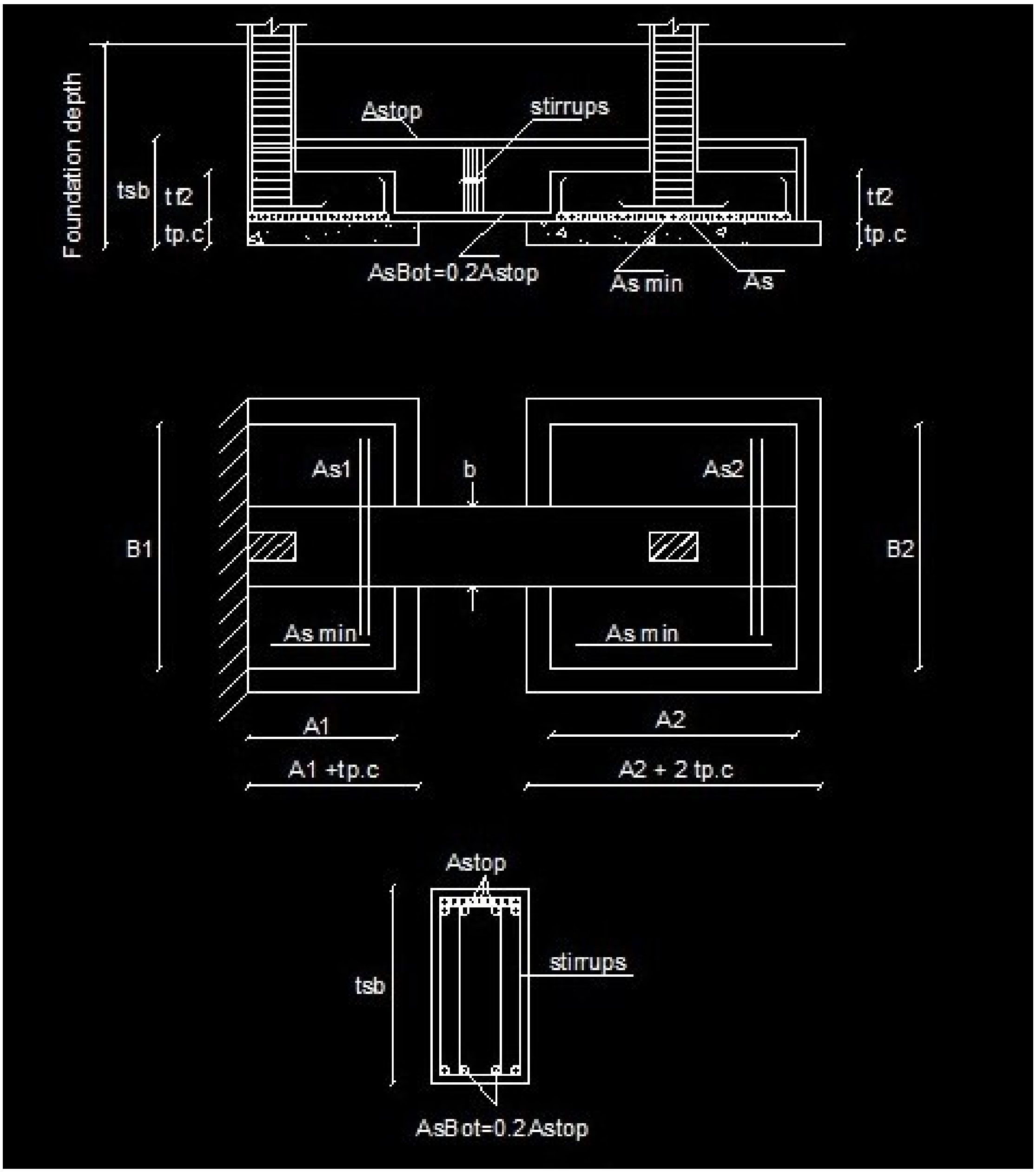
$A_{s2} = \frac{M2}{J*d2*Fy} = \ldots\ cm^2/m'$

$A_{s\,min} = 5y12/m' = \ldots\ cm^2/m'$

If $A_{s2} \geq A_{s\,min} \rightarrow$ ok

If $A_{s2} < A_{s\,min} \rightarrow$ take $A_{s2} = A_{s\,min}$

Details of Reinforcement:



Example: 1

The two column shown in fig are supported to be connected with a strap beam passing through the outer face of footing (1) to the outer face of

footing (2)

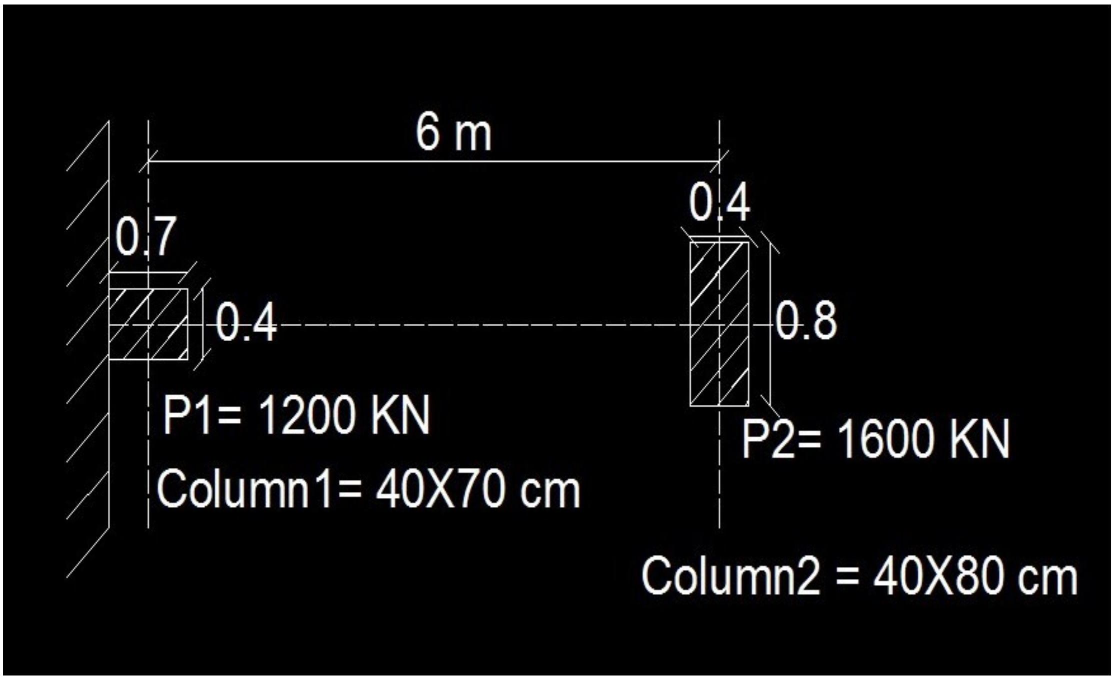
It is required to:

1) Determine the footing Area.

2) Draw bending Moment and shear of the strap beam.

3) Determine the depth & reinforcement steel of the strap beam wish satisfy bending Moment and shear .

4) Draw clear sketch showing dimensions of strap beam and steel details.



Solution

Given: $f_{cu} = 250$ kg/cm^2, $q_{all} = 175$ kN / m^2,

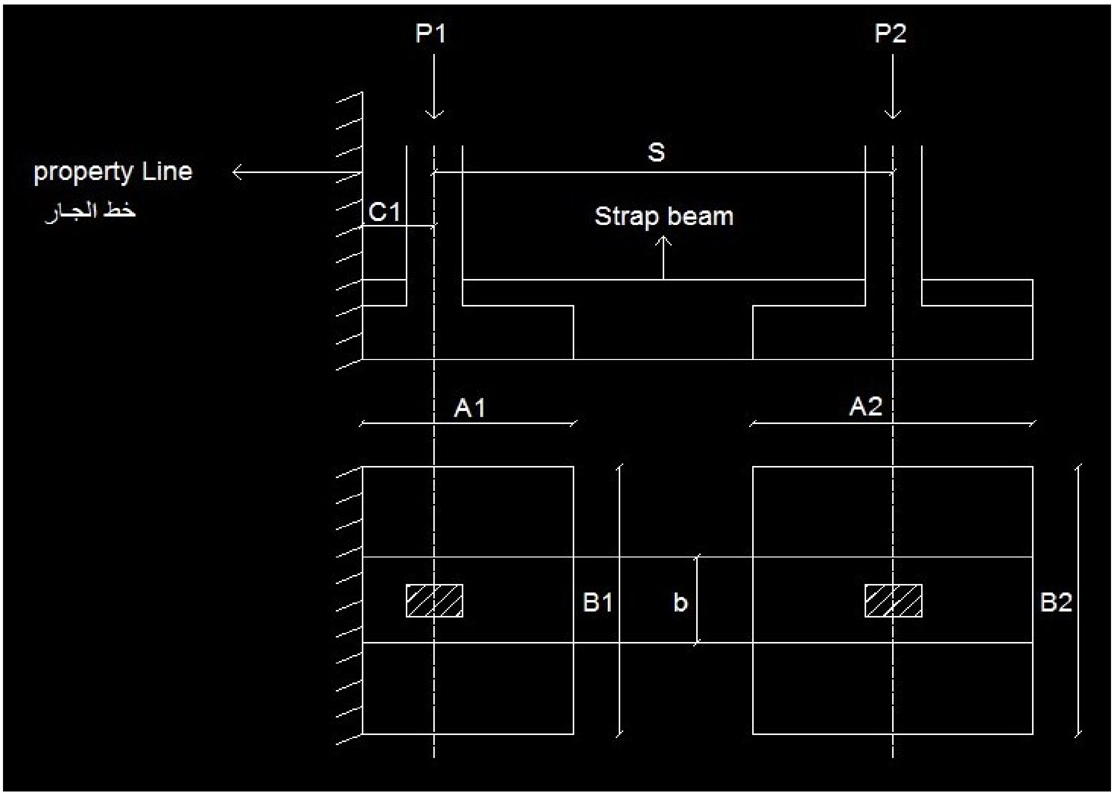
$F_y = 3600$ kg/cm^2, Foundation depth = 2m

$P_1 = 1200$ KN = 120 Ton

$P_2 = 1600$ KN = 160 Ton

$q_{all} = 175$ kN /m^2 = 17.5 t / m^2

1) Dimension of Footing:



$P_{t1} = 1.2*P_1 = 1.2*120 = 144$ ton

$P_{t2} = P_2 = 160$ ton

Take $t_{p.c} = 30$ cm

Area of Footing (1):

$A_{f1} = \frac{Pt1}{qall} = \frac{144}{17.5} = 8.3\ m^2 \longrightarrow A_1, B_1$

$B_1 = 3.2$ m

$A_1 = 2.6$ m

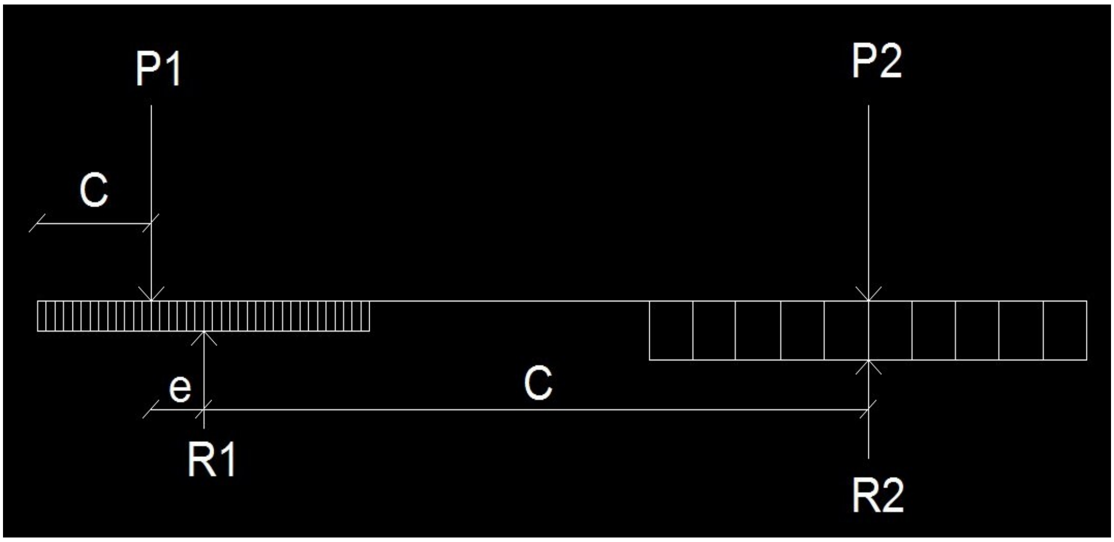
Area of Footing (2):

$A_{f2} = \frac{Pt2}{qall} = \frac{160}{17.5} = 9.15\ m^2 \longrightarrow A_2, B_2$

$B_2 = 3.3$ m

$A_2 = 2.8$ m

2) Determination of eccentricity:



$e = \frac{A1}{2} - C_1 = \frac{2.6}{2} - 0.35 = 0.95$ m

C = s – e = 6 – 0.95 = 5.05 m

3) Check Area:

$R_{1u} = P_1 + P_1 * \frac{e}{C} = 120 + 120 * \frac{0.95}{5.05} = 142.6$ ton

$R_2 = P_2 - P_1 * \frac{e}{C} = 160 - 120 * \frac{0.95}{5.05} = 137.4$ ton

$q_1 = \frac{Rt1*1.1}{A1*B1} = \frac{142.6*1.1}{2.6*3.2} = 18.85\ t/m^2$

$q_1 > q_{all}$

18.85 > 17.5 increase B_1

$q_1 = \frac{Rt1*1.1}{A1*B1}$

$17.5 = \frac{142.6*1.1}{2.6*B1}$

$17.5 * 2.6\ B_1 = 142.6 * 1.1$

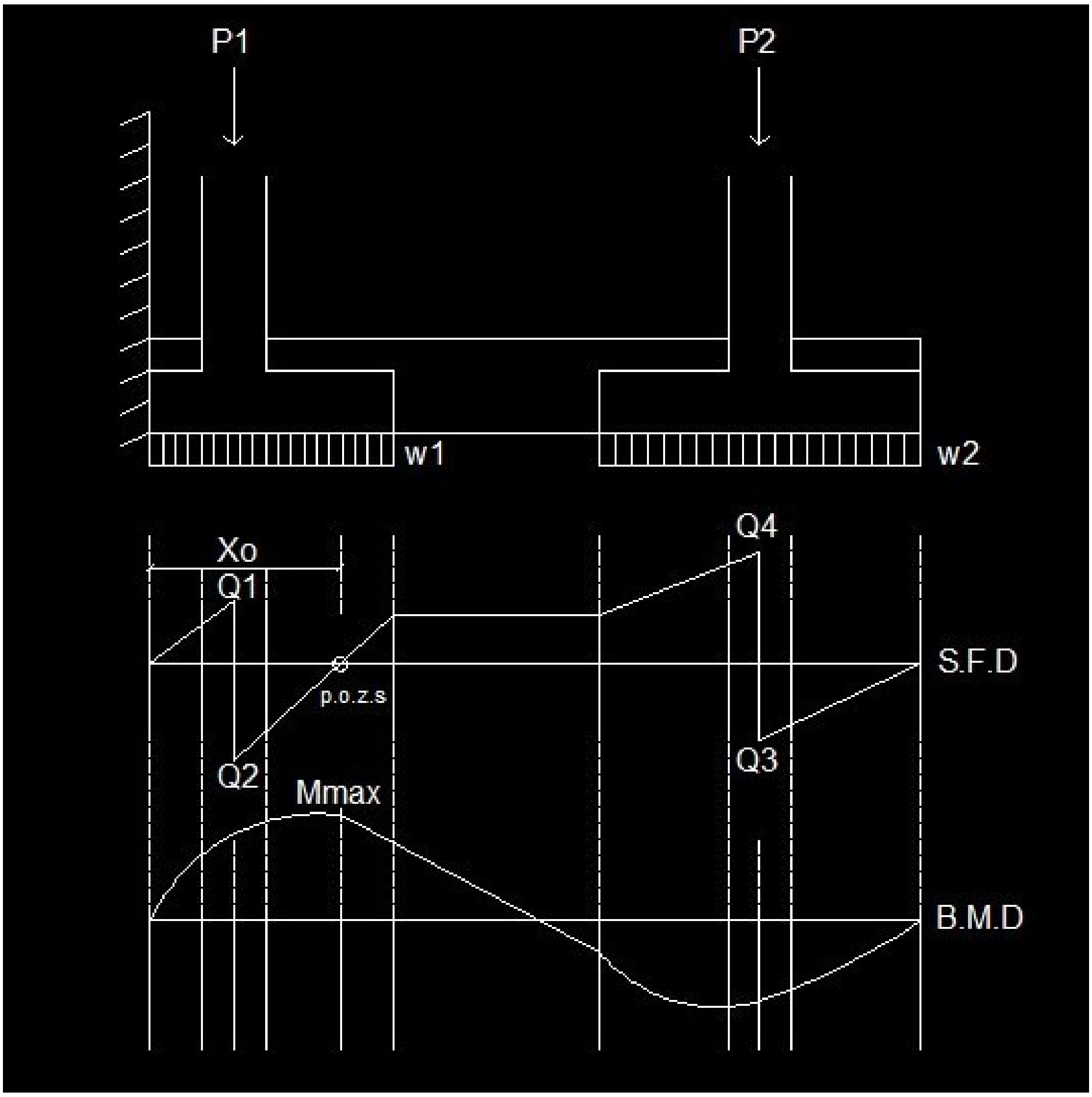
$B_1 = 3.5$ m

$q_2 = \frac{Rt2*1.1}{A2*B2} = \frac{137.4*1.1}{2.8*3.3} = 16.3\ t/m^2 > q_{all}$ ok

End of Working Loads .

4) Design of Strap Beam:

Calculation of Moment and Shear for Strap Beam:



P_{1u} =1.5 P_1 = 120*1.5 = 180 Ton

P_{2u} = 1.5 P_2 = 160*1.5 = 240 Ton

R_{1u} = 1.5 R_1 = 1.5 *142.6 = 213.9 Ton

R_{2u} = 1.5 R_2 = 1.5 *137.4 = 206 Ton

$W_1 = \frac{R1u}{A1} = \frac{213.9}{2.6} = 82$ t/m'

$W_2 = \frac{R2u}{A2} = \frac{206}{2.8} = 73.6$ t/m'

Point of Zero Shear

At distance X_o

$X_o = \frac{p1u}{w1} = \frac{180}{82} = 2.195$ m

M_{max}=180(2.195 –0.35)– 82*($\frac{(2.195\ )^2}{2}$)= 135 mt

$d = c_1 \sqrt{\frac{Mult}{Fcu*b}}$

Take b = 80 cm

$d = 4 \sqrt{\frac{135*10^5}{250*80}}$ = 104 ≅ 110 cm

5) Check Shear:

$Q_1 = W_1 * C_1$ = 82* 0.35 = 28.7 t

$Q_2 = Q_1 - P_{1u}$ = 28.7–180 = 151.3 t

$Q_3 = W_2 * \frac{A2}{2} = 73.6 * \frac{2.8}{2}$ = 103 t

$Q_4 = Q_3 - P_{2u}$ = 103 – 240 = 137 t

$Q_{sh1}=Q_2-W_1*(\frac{d}{2} + \frac{a1}{2})$

= 151.3 – 82 * ($\frac{1.1}{2} + \frac{0.7}{2}$) = 77.5 ton

$Q_{sh2} = Q_4 - W_2 * (\frac{d}{2} + \frac{b2}{2})$

$= 137 - 73.6 * (\frac{1.1}{2} + \frac{0.4}{2}) = 81.8$ ton

$q_{sh} = \frac{Qsh2}{b*d} = \frac{81.8*10^3}{80*110} = 9.2$ kg/cm^2

$q_{cu} = 0.75 * \sqrt{\frac{Fcu}{\gamma c}} = 0.75 * \sqrt{\frac{250}{1.5}} = 9.68$ kg/cm^2

If $q_{cu} > q_{sh}$ ok use min stirrups 5y8/m'

t = d + cover = 110 + 10 = 120 cm

Reinforcement of the Strap beam:

$A_{s\ top} = \frac{Mmax}{J*d*fy} = \frac{135*10^5}{0.826*110*3600} = 41.3$ cm^2

Use 11 y 22

$A_{S\ bott}$ = 20 % $A_{s\ top}$ = 0.2 * 41.3 = 8.3 cm^2

Use 5 y 16

6) Design of Footing:

Footing 1 (F_1):

$q_{u1} = \frac{R1u}{A1*B1} = \frac{213.9}{2.6*3.5} = 23.5$ t/m^2

$M_1 = q_{u1} * \frac{\left(\frac{B1-b}{2}\right)^2}{2} = 23.5*\frac{\left(\frac{3.5-0.8}{2}\right)^2}{2} = 21.4$ mt

$d_1 = c_1 \sqrt{\frac{M1ult}{Fcu*B}} = 5 \sqrt{\frac{21.4*10^5}{250*100}} = 46.26 \cong 50$ cm

Check Shear:

$Q_{sh} = q_{u1}*(\frac{d}{2} + \frac{B1-b}{2})$

$= 23.5*(\frac{0.5}{2} + \frac{3.5-0.8}{2}) = 37.6$ ton

$q_{sh} = \frac{Qsh}{B*d1} = \frac{37.6*10^3}{100*50} = 7.52$ kg/cm^2

$q_{cu} = 0.4*\sqrt{Fcu} = 0.4*\sqrt{250} = 6.32$ kg/cm^2

$q_{cu} < q_{sh}$

6.32 < 7.52 un safe increase depth

Take $d_1 = Q_{sh} /(q_{cu}*B)$

$d_1 = \frac{37.6*10^3}{100*6.32} = 59.49 \cong 65$ cm

$t_1 = d + cover = 65 + 10 = 75$ cm

Reinforcement of the footing (1):

$$A_{s1} = \frac{M1}{J*d1*Fy} = \frac{21.4*10^5}{0.826*65*3600} = 11.07 \text{ cm}^2/\text{m}'$$

Use 6 y 16

$A_{s\ min}$ = 5y12/m' = 5.65 cm^2/m'

take A_{s1}=11.07 cm^2/m'

Use 6 y 16

Footing 2 (F_2):

$$q_{u2} = \frac{R2u}{A2*B2} = \frac{206}{2.8*3.3} = 22.3 \ \ t/m^2$$

$$M_2 = q_{u2} * \frac{\left(\frac{B2-b}{2}\right)^2}{2} = 22.3*\frac{\left(\frac{3.3-0.8}{2}\right)^2}{2} = 17.4 \text{ mt}$$

$$d_2 = c_1\sqrt{\frac{M2ult}{Fcu*B}} = 5\sqrt{\frac{17.4*10^5}{250*100}} = 41.71 \cong 50 \text{ cm}$$

Check Shear:

$$Q_{sh} = q_{u2}*\left(\frac{d}{2} + \frac{B2-b}{2}\right)$$

$$=22.3*\left(\frac{0.5}{2} + \frac{3.3-0.8}{2}\right) = 33.45 \text{ ton}$$

$q_{sh} = \frac{Qsh}{B*d2} = \frac{33.45*10^3}{100*50} = 6.69\ kg/cm^2$

$q_{cu} = 0.4*\sqrt{Fcu} = 0.4*\sqrt{250} = 6.32\ kg/cm^2$

$q_{cu} < q_{sh}$

6.32 < 6.69 un safe increase depth

Take $d_2 = Q_{sh} /(q_{cu}*B)$

$d_2 = \frac{33.45*10^3}{100*6.32} = 52.92 \cong 60$ cm

$t_2 = d_2 + cover = 60 + 10 = 70$ cm

Reinforcement of the footing (1):

$A_{s2} = \frac{M2}{J*d2*Fy} = \frac{17.4*10^5}{0.826*60*3600} = 9.75\ cm^2/m'$

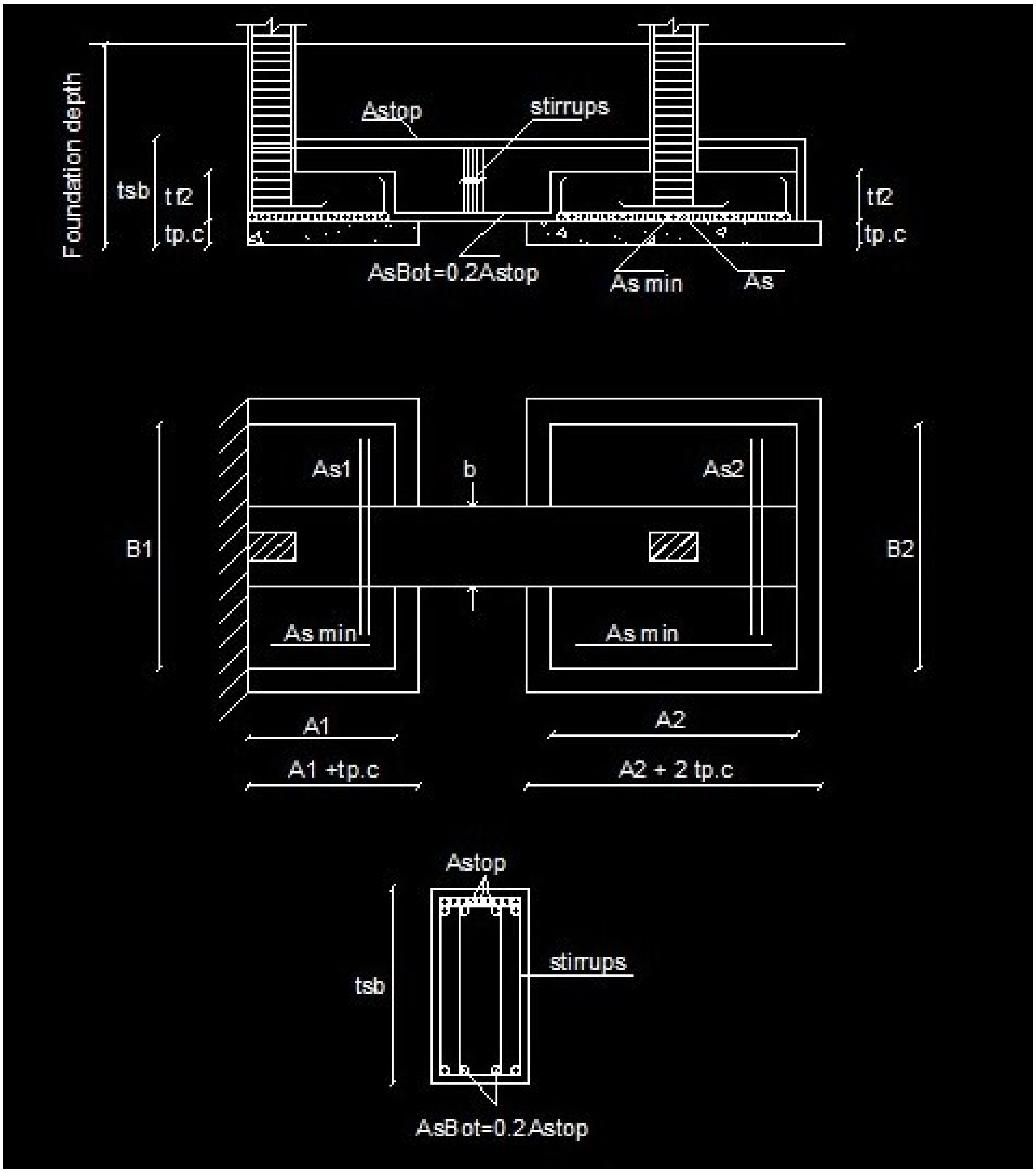
Use 6 y 16

$A_{s\ min} = 5y12/m' = 5.65\ cm^2/m'$

take $A_{s1}=9.75\ cm^2/m'$

Use 6 y 16

Details of Reinforcement:



Raft Footing:

Calculation of soil pressure under Raft:

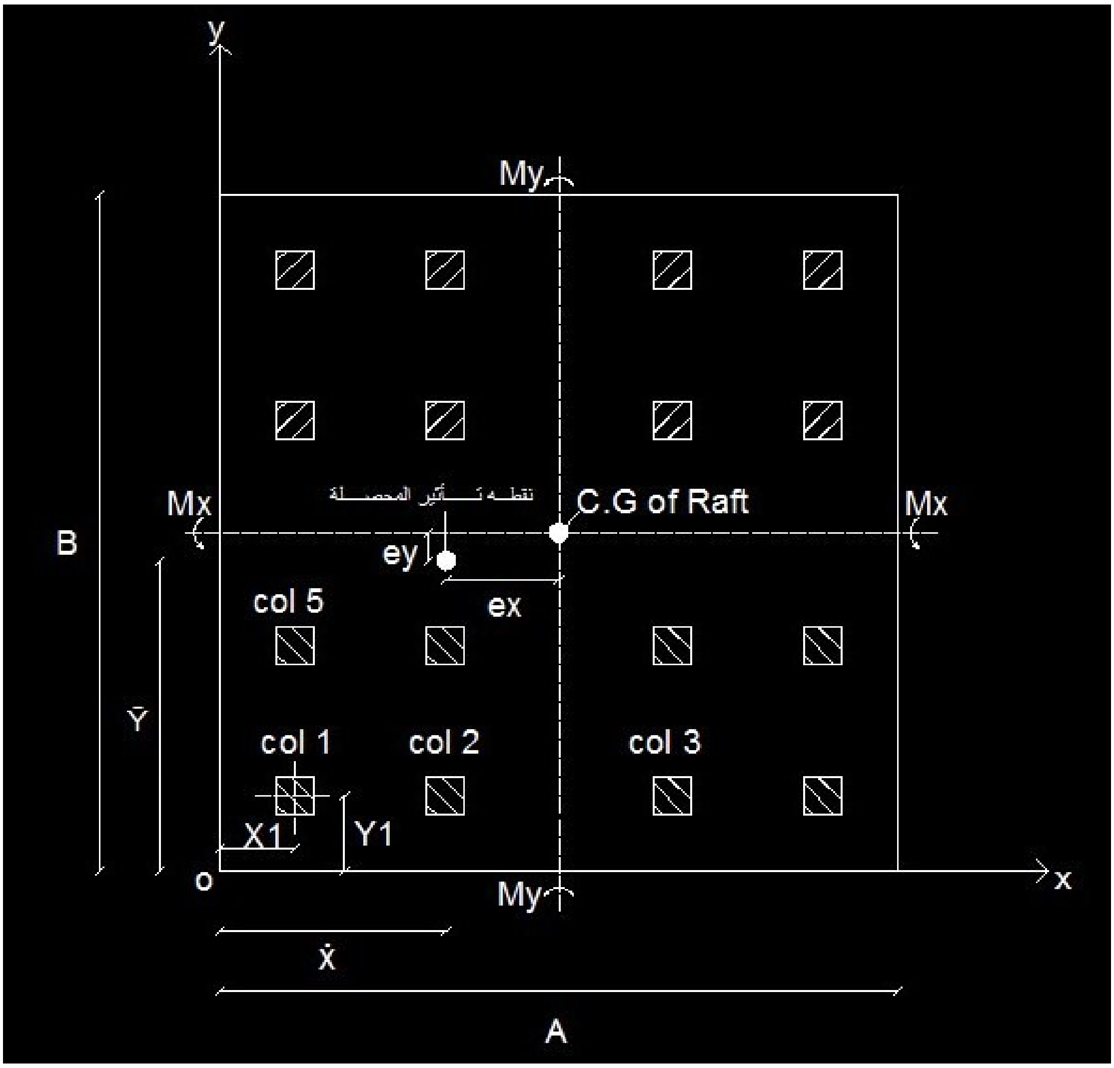
Steps of Calculation:

1) Determination of C.G of Raft:

تحديد C.G للبشة.

2) Determination of Resultant Load and its point of application:

تحديد محصلة القوي (أحمال الأعمدة) ونقطة تأثيرها.


y
My
نقطه تأثير المحصلة
C.G of Raft
Mx
Mx
B
ey
ex
col 5
Ȳ
col 1
col 2
col 3
X1
Y1
o
My
x
Ẋ
A


My
+My
- My
+My
+My
Mx
- My
- My
- My
+My

يتم عمل جدول:

Col No.	Load (p)	X	Y	P*X	P*Y
1	P1	X1	Y1	P1* X1	P1* Y1
2	P2	X2	Y2	P2* X2	P2* Y2
3	P3	X3	Y3	P3* X3	P3* Y3
4	P4	X4	Y4	P4* X4	P4* Y4
5	P5	X5	Y5	P5* X5	P5* Y5
6	P6	X6	Y6	P6* X6	P6* Y6
	$\sum P$			$\sum P * X$	$\sum P * Y$

$$\overline{X} = \frac{\sum P*X}{\sum P} = \dots \text{ m}$$

$$\overline{Y} = \frac{\sum P*Y}{\sum P} = \dots \text{ m}$$

3) Determination the value and direction determined:

تحديد قيمة واتجاه العزم:

$$e_x = \frac{A}{2} - \overline{X} = \dots \text{ m}$$

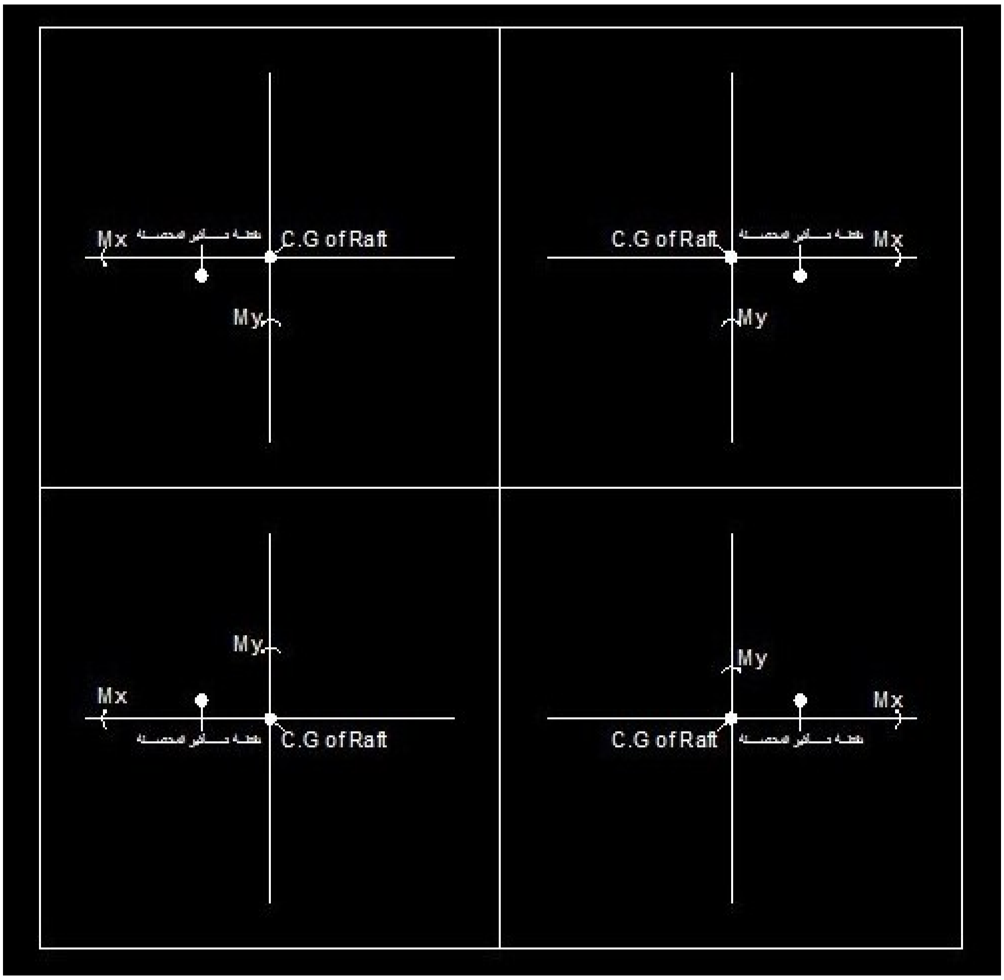
$$e_y = \frac{B}{2} - \overline{Y} = \dots \text{ m}$$

حيث أن:

مكان C.G للبشة $\rightarrow \frac{A}{2}$

مكان C.G للبشة $\rightarrow \frac{B}{2}$

اتجاه العزم في الحالات المختلفة:



$M_x = \sum P * e_y = \ldots$ KN.m

$M_y = \sum P * e_x = \ldots$ KN.m

4) Calculate the soil pressure at the points required:

$$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x = \ldots KN/m^2$$

حيث أن:

$N \rightarrow \sum P$

إذا كانت النقطة ناحية رأس سهم العزم ← سالب (ضغط)

إذا كانت النقطة ناحية ذيل سهم العزم ← موجب (شد)

$A \rightarrow$ Area of Raft

Area of Raft (A) = (A*B) = … m^2

$$Ix = \frac{A*(B)^3}{12} = \ldots m^4 \quad Ix = \frac{\text{الموازي}*(\text{العمودي})^3}{12} = \ldots m^4$$

حيث أن:

الموازي ← البعد الموازي للمحور (X)

$$Iy = \frac{B*(A)^3}{12} = \ldots m \quad Ix = \frac{\text{الموازي}*(\text{العمودي})^3}{12} = \ldots m^4$$

حيث أن:

الموازي ← البعد الموازي للمحور (Y)

البعد الأفقي والرأسي من C.G of Raft للنقطة المراد

حساب soil pressure عندها (دائما موجب) ← X ,Y

5) If required to Draw the soil pressure on Nutural axies:

خطوات الرسم :

نوجد مكان Nutural axies (N.A)

أ- نعوض عن $\sigma = 0$, $x = 0$ ونوجد y = ✓

$$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x$$

$$0 = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * 0$$

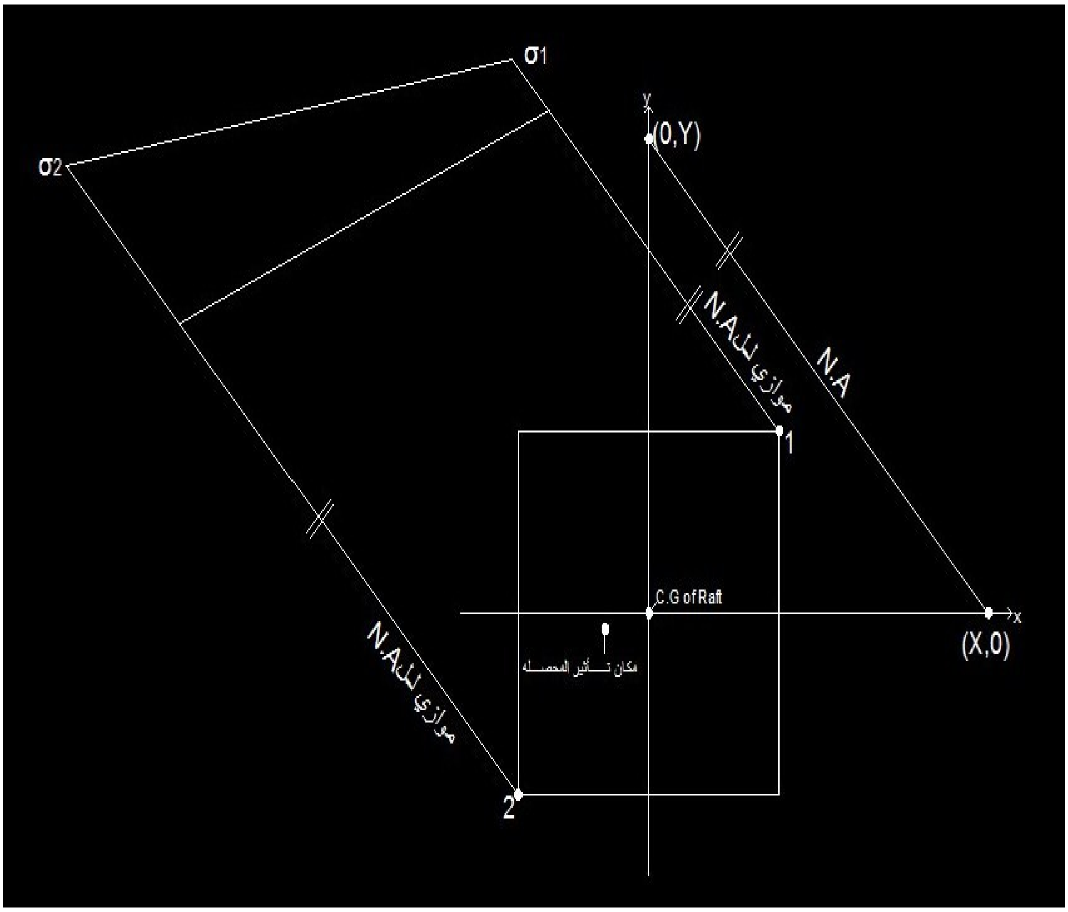
ب- نعوض عن $\sigma = 0$, $y = 0$ ونوجد x = ✓

$$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x$$

$$0 = \frac{-N}{A} \pm \frac{Mx}{Ix} * 0 \pm \frac{My}{Iy} * x$$

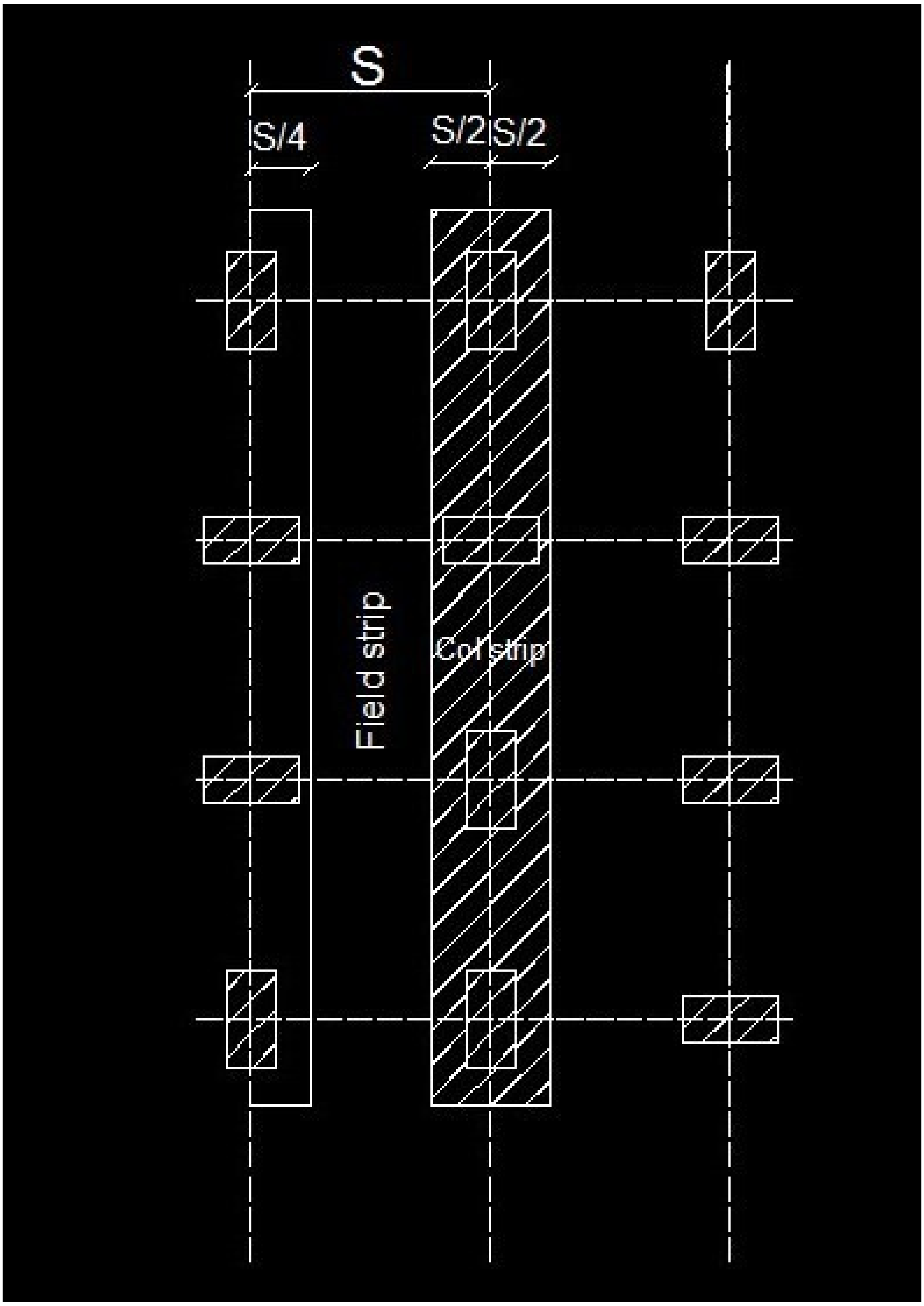
ملاحظة:

N.A ← يظهر خارج حدود اللبشه ويظهر ناحية المربع المقابل لمربع المحصلة.



σ1
σ2
(0,Y)
y
N.A
موازي للN.A
1
C.G of Raft
x
(X,0)
مكان تـــأثير المحصـــله
موازي للN.A
2

6)Raft Foundation Design:



Method (1):

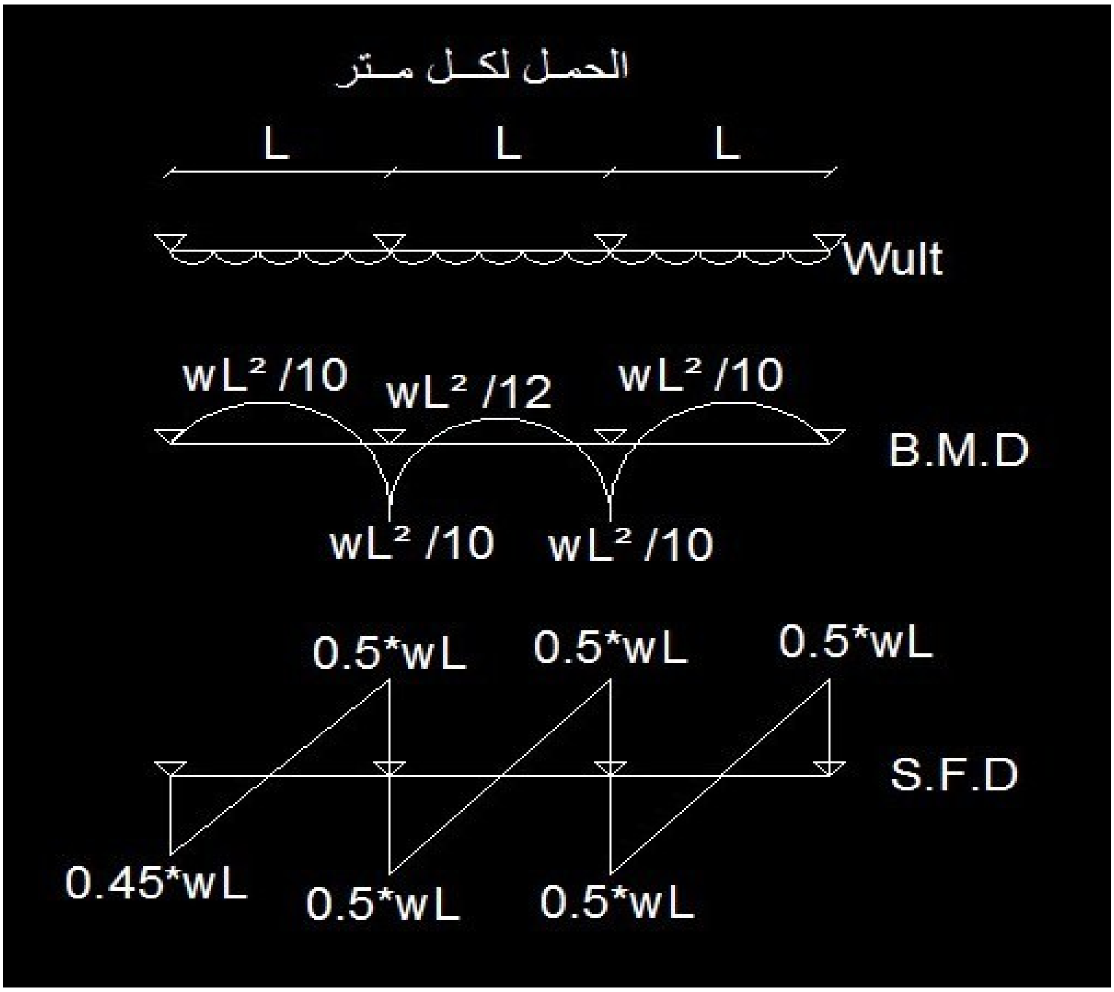
If not given Col strip width take:

Col strip width = $\frac{S}{2}$ عرض الشريحة للأعمدة الداخلية

Col strip width = $\frac{S}{4}$ عرض الشريحة للأعمدة الجار

$q_{un} = \frac{\sum \text{Pult}}{\text{Area}}$

$w_{ult} = q_{un} * B = \ldots$ t/m'



M_{max} = take the bigger Moment from B.M.D

Q_{max} = take the bigger Shear from S.F.D

$$d = C_1 \sqrt{\frac{Mult}{Fcu * B}} = \dots \text{ cm}$$

حيث أن:

$c_1 = 5$

B= 100 cm

Check Shear:

$$Q_{sh} = Q_{max} - (\frac{d}{2}) * w_{ult} = \dots \text{ ton}$$

$$q_{sh} = \frac{Qsh}{B * d} = \dots \text{ kg/cm}^2$$

حيث أن:

B = 100 cm

$$q_{cu} = 0.4 * \sqrt{Fcu} = \dots \text{ kg/cm}^2$$

If $q_{cu} > q_{sh}$ ok safe

If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B) = \dots$ cm

t = d + cover

cover =(5 to 10 cm)

Check Punching:

$Q_P = P_u - q_U (A' * B') = ...$ Ton

حيث أن :

أعلي حمل عمود في الشريحة $\rightarrow P_u$

$A' = (a_1 + d) = ...$ m

$B' = (b_1 + d) = ...$ m

عرض العمود $\rightarrow$ b , طول العمود $\rightarrow$ a

$q_p = \frac{Qp}{2*(A'+B')*d} = ...$ kg/cm^2

$q_{pcu} = (0.5 + \frac{b}{a}) \sqrt{\frac{Fcu}{\gamma c}} = ...$ kg/cm^2

حيث أن:

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe $\rightarrow$ increase depth

t = d + cover

cover = (5 to 10 cm)

7) Reinforcement of the footing:

$A_{s\ Top} = \frac{Mutop}{J*d*Fy} = \ldots\ cm^2/m'$

$A_{s\ Bot} = \frac{Mubot}{J*d*Fy} = \ldots\ cm^2/m'$

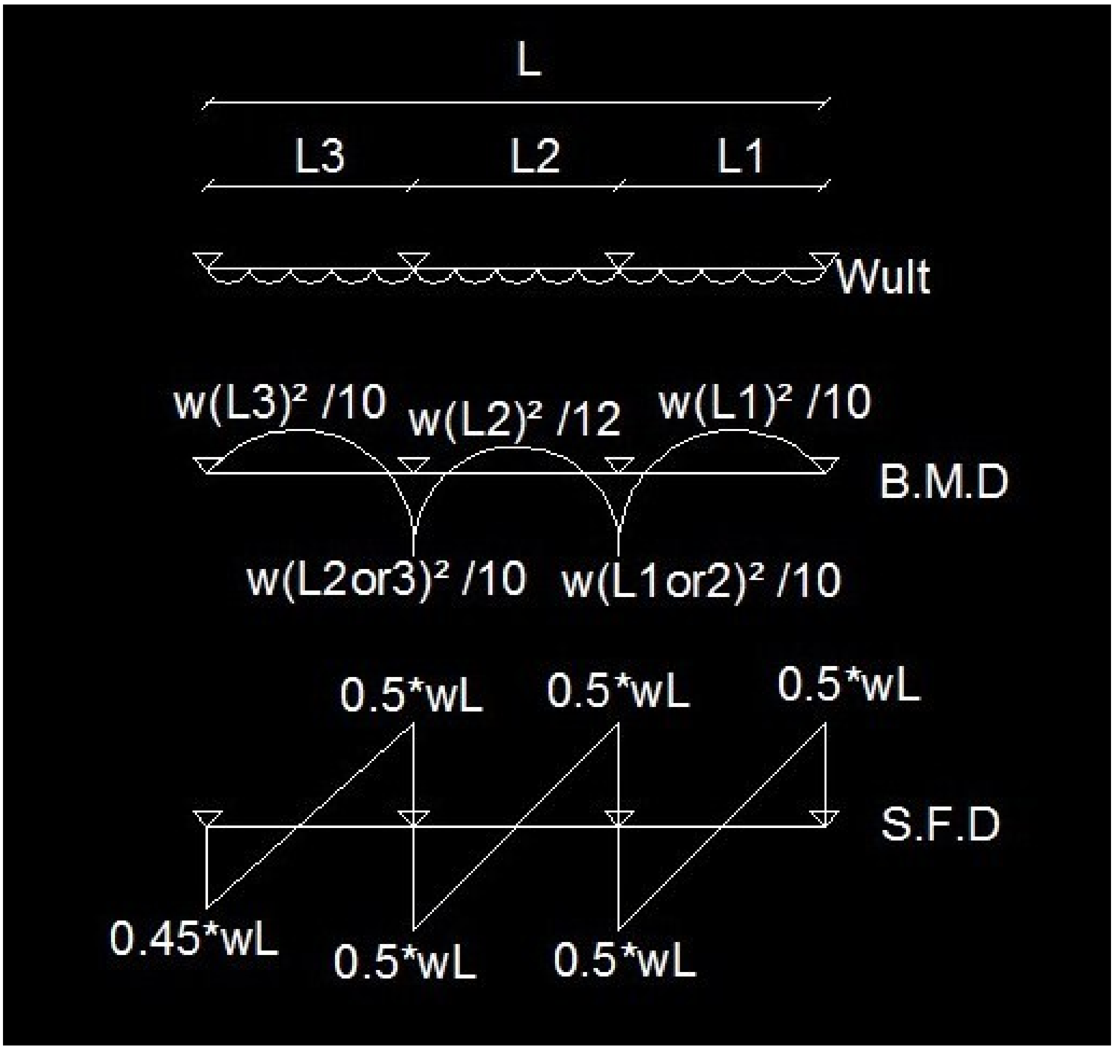
حيث أن:

أعلي عزم علوي ← Mutop

أعلي عزم سفلي ← Mubot

Method (2):

$W = \frac{\sum Pw}{L}$ = … KN/B



حيث أن:

مجموع أحمال أعمدة Col strip فقط ← $\sum P w$

عرض شريحة ال Col strip ← B

طول شريحة ال Col strip ← L

$W_U = W * 1.5$

M_{max} = take the bigger Moment from B.M.D

Q_{max} = take the bigger Shear from S.F.D

$d = C_1 \sqrt{\frac{Mult}{Fcu*B}}$ = … cm

حيث أن:

$c_1 = 5$

B ← Col strip عرض شريحة ال

Check Shear:

$Q_{sh} = Q_{max} - (\frac{d}{2}) * w_{ult}$ = … ton

$q_{sh} = \frac{Qsh}{B*d}$ = … kg/cm^2

حيث أن:

B ← Col strip عرض شريحة ال

$q_{cu} = 0.4*\sqrt{Fcu}$ = … kg/cm^2

If $q_{cu} > q_{sh}$ ok safe

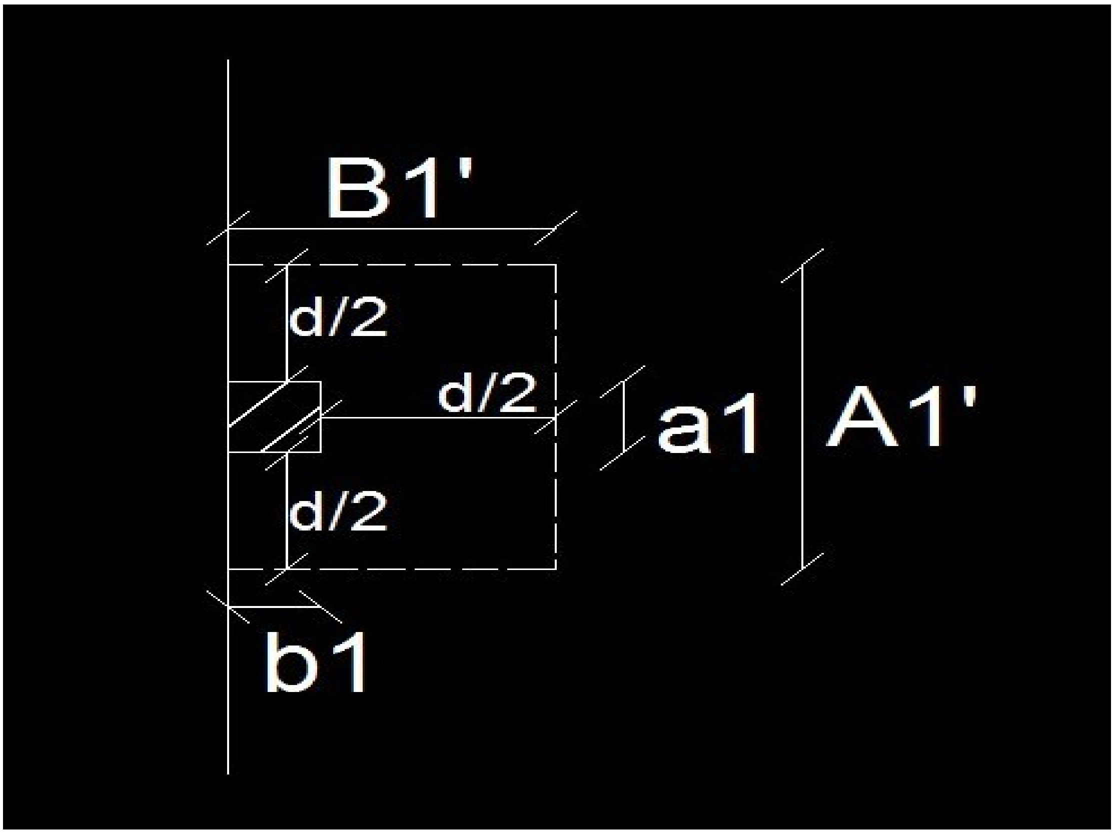
If $q_{cu} < q_{sh}$ un safe increase depth

Take $d = Q_{sh} / (q_{cu} * B)$ = … cm

t = d + cover

cover =(5 to 10 cm)

Check Punching:



$q_{un} = \frac{\sum \text{Pult}}{\text{Area}}$ = ... KN/m^2

$Q_P = P_u - q_U (A' * B')$ = ... Ton

حيث أن :

أعلي حمل عمود في الشريحة بوحدة ton → P_u

$A' = (a_1 + d)$ = ... m

$B' = (b_1 + d)$ = ... m

عرض العمود → b , طول العمود → a

$q_p = \frac{Qp}{2*(A'+B')*d} = \ldots kg/cm^2$

حيث أن:

$q_{pcu} = (0.5 + \frac{b}{a}) \sqrt{\frac{Fcu}{\gamma c}} = \ldots kg/cm^2$

حيث أن:

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe $\rightarrow$ increase depth

t = d + cover

cover = (5 to 10 cm)

Reinforcement of the footing:

$A_{s\ Top1} = \frac{Mutop}{J*d*Fy} = \ldots cm^2$ /B'= /m'

$A_{s\ Top2} = \frac{Mutop}{J*d*Fy} = \ldots cm^2$ /B'= /m'

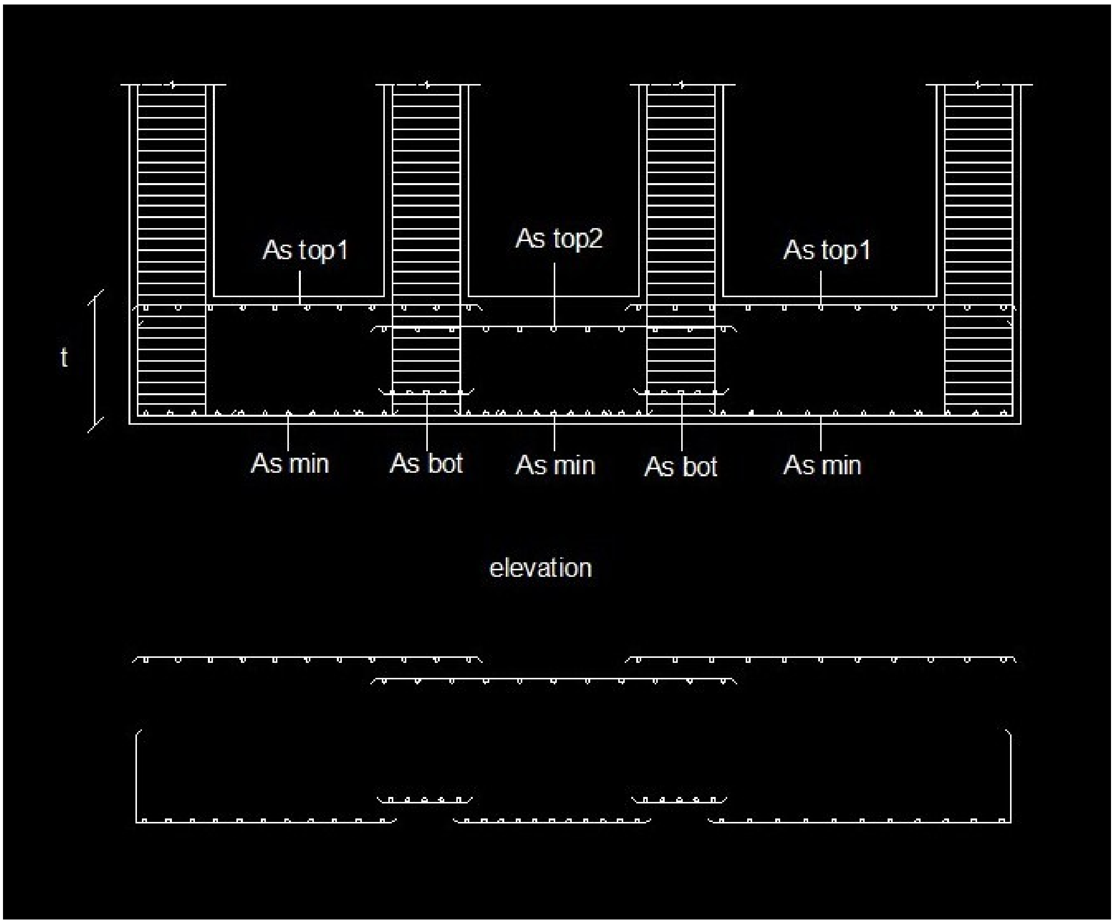
$A_{s\ Bot} = \frac{Mubot}{J*d*Fy} = \ldots cm^2$ /B'= /m'

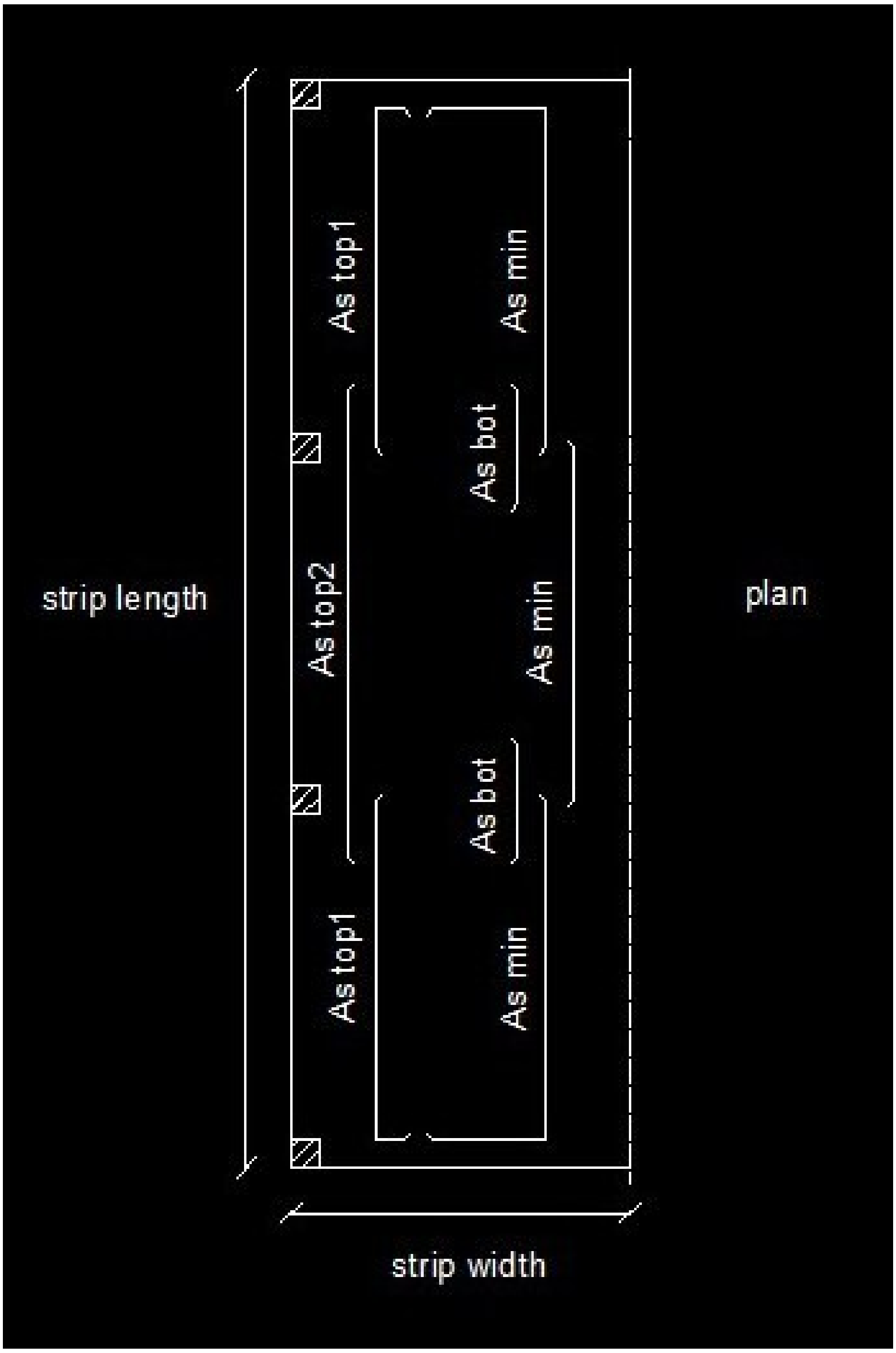
حيث أن:

أعلي عزم علوي ← Mutop

أعلي عزم سفلي ← Mubot

Details of Reinforcement:





As top1
As min
As bot
strip length
As top2
As min
plan
As bot
As top1
As min
strip width

Example: 1

The Raft footing shown in fig all columns 40 X 40 cm .

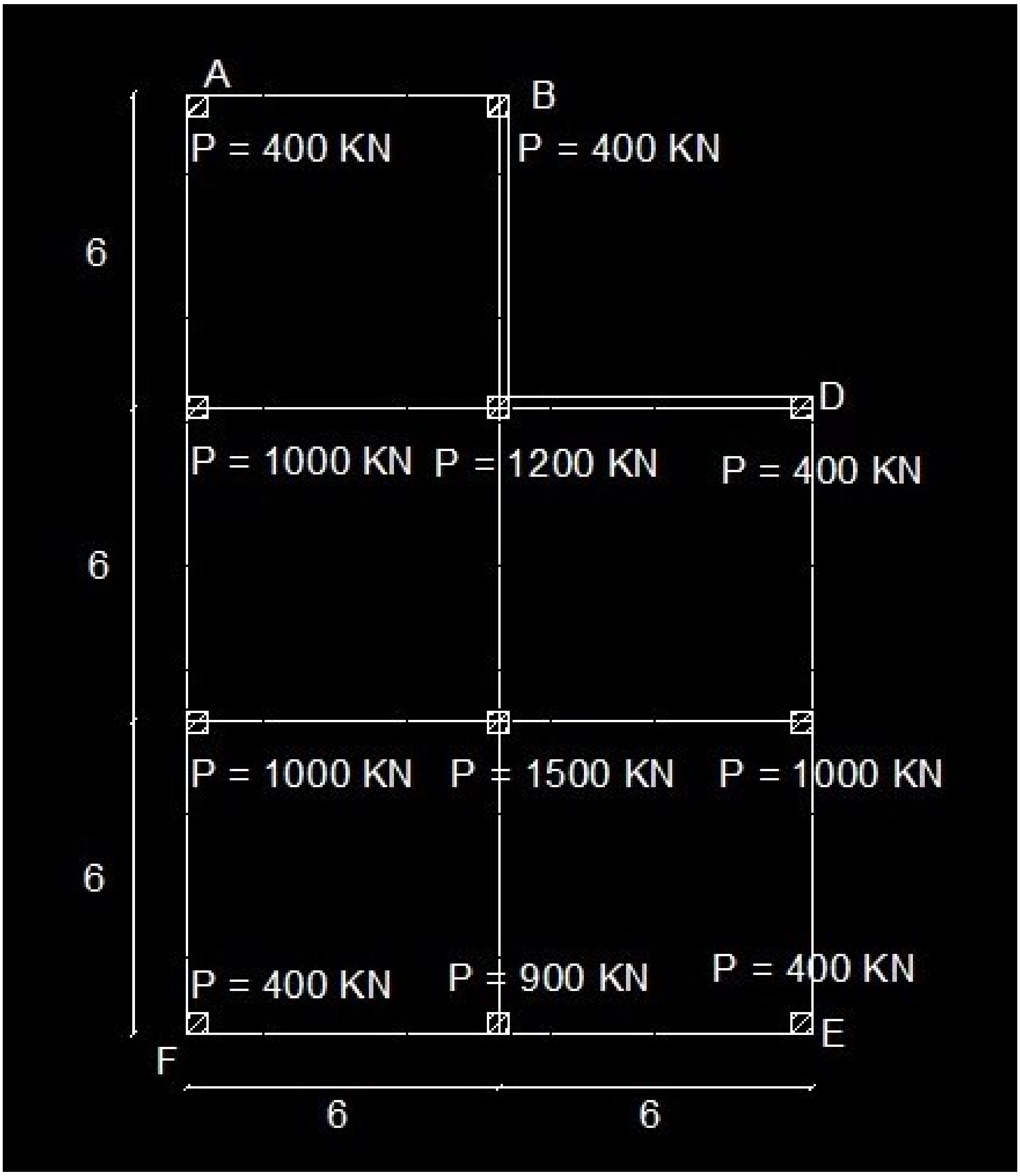
It is required to:

1) Determine the soil pressure under the corners of the given Raft.

2) Make Full design for strip AF take strip width=3m.

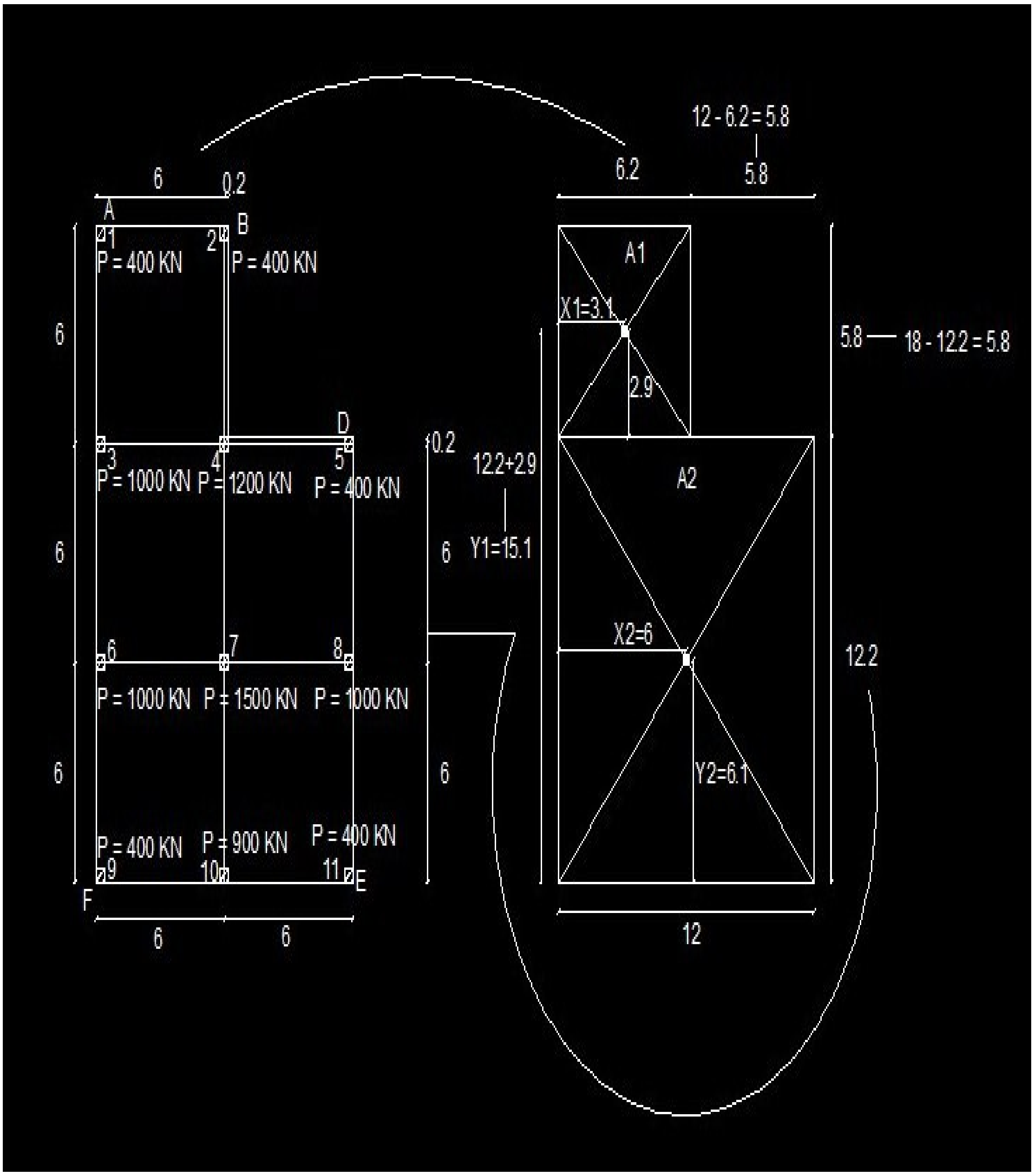
3) Determine the reinforcement steel of the Raft footing .

4) Draw net sketch showing dimensions of Raft footing and steel details.



Solution

Given: f_{cu} = 250 kg/cm^2 , F_y = 3600 kg/cm^2



نلاحظ أن الشكل غير متماثل فيتم تقسيم الشكل

$A_1 = 6.2 * 5.8 = 35.96\ m^2$

$A_2 = 12.2 * 12 = 146.4\ m^2$

Area	X	Y	A*X	A*Y
35.96	3.1	15.1	111.5	543
146.40	6	6.1	878.4	893
182.36			989.9	1436
Σ Area			Σ A*X	Σ A*Y

1) Determination of C.G of Raft:

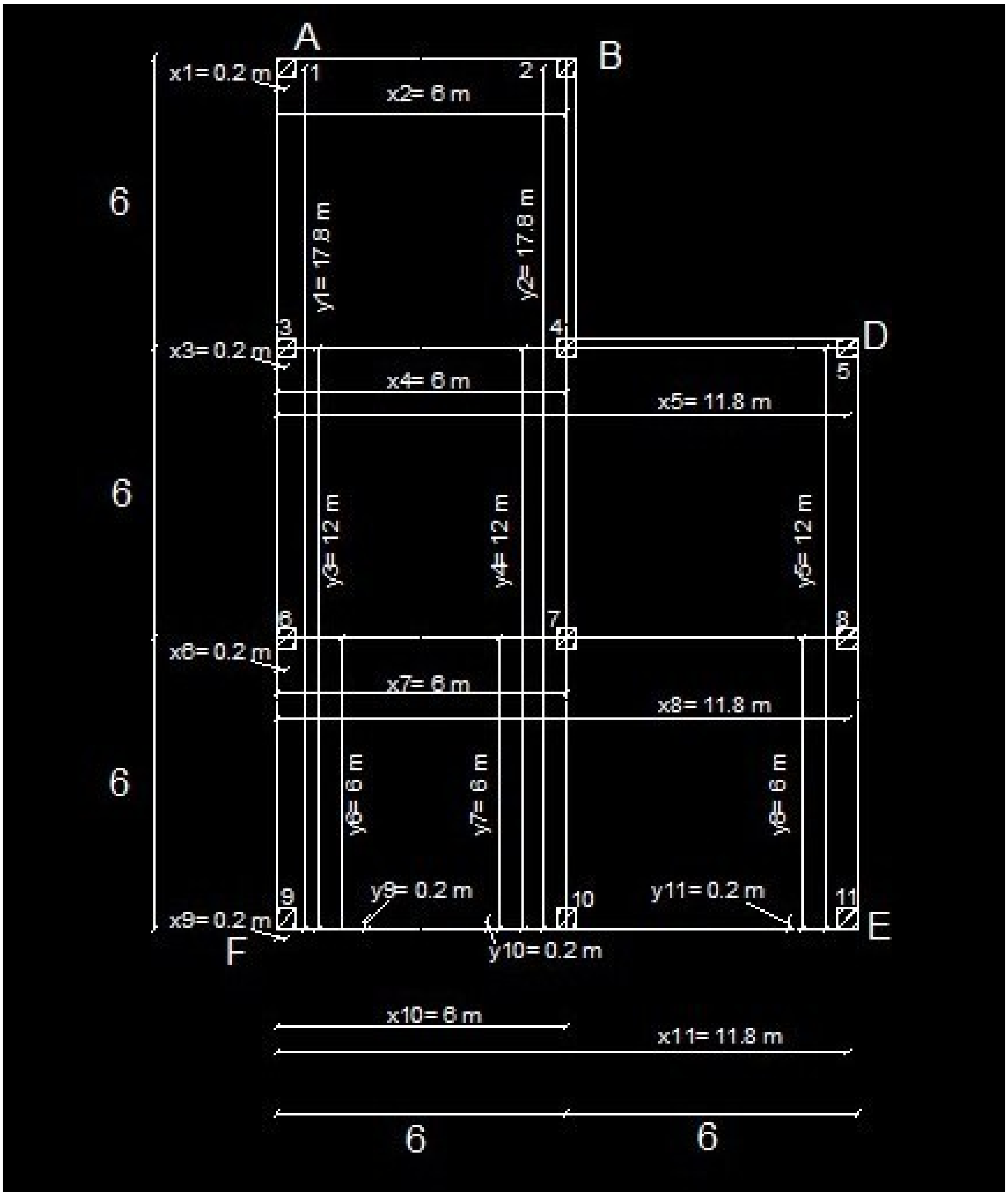
تحديد C.G للبشة.

$$X_{C.G} = \frac{\sum A*X}{\sum Area} = \frac{989.9}{182.36} = 5.4 \text{ m}$$

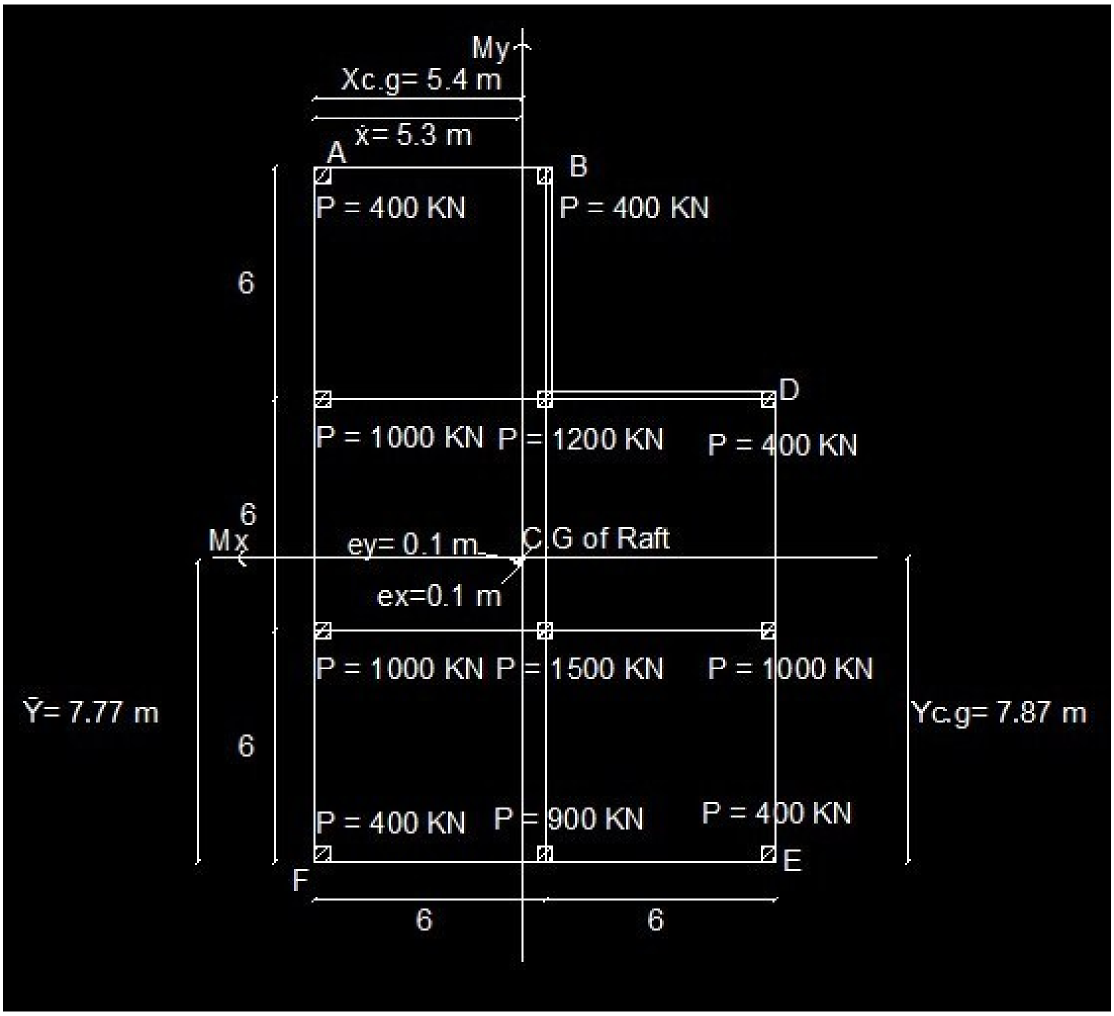
$$Y_{C.G} = \frac{\sum A*Y}{\sum Area} = \frac{1436}{182.36} = 7.87 \text{ m}$$

2) Determination of Resultant Load and its point of application:

تحديد محصلة القوي (أحمال الأعمدة) ونقطة تأثيرها.



A
B
D
E
F
1
2
3
4
5
6
7
8
9
10
11
x1= 0.2 m
x2= 6 m
y1= 17.8 m
y2= 17.8 m
x3= 0.2 m
x4= 6 m
x5= 11.8 m
y3= 12 m
y4= 12 m
y5= 12 m
x6= 0.2 m
x7= 6 m
x8= 11.8 m
y6= 6 m
y7= 6 m
y8= 6 m
x9= 0.2 m
y9= 0.2 m
y10= 0.2 m
y11= 0.2 m
x10= 6 m
x11= 11.8 m
6
6
6
6
6



My
Xc.g= 5.4 m
x̄= 5.3 m
A
B
P = 400 KN
P = 400 KN
6
D
P = 1000 KN
P = 1200 KN
P = 400 KN
6
Mx
ey= 0.1 m
C.G of Raft
ex=0.1 m
P = 1000 KN
P = 1500 KN
P = 1000 KN
Ȳ= 7.77 m
Yc.g= 7.87 m
6
P = 400 KN
P = 900 KN
P = 400 KN
F
E
6
6

Col N.o	P (KN)	X	Y	P*X	P*y
1	400	0.2	17.8	80	7120
2	400	6	17.8	2400	7120
3	1000	0.2	12	200	12000
4	1200	6	12	7200	14400
5	400	11.8	12	4720	4800
6	1000	0.2	6	200	6000
7	1500	6	6	9000	9000
8	1000	11.8	6	11800	6000
9	400	0.2	0.2	80	80
10	900	6	0.2	5400	180
11	400	11.8	0.2	4720	80
	8600			45800	66780
	ΣP			ΣP*X	ΣP*Y

$$\overline{X} = \frac{\sum P*X}{\sum P} = \frac{45800}{8600} = 5.3 \text{ m}$$

$$\overline{Y} = \frac{\sum P*Y}{\sum P} = \frac{66780}{8600} = 7.77 \text{ m}$$

3) Determination the value and direction determined:

تحديد قيمة واتجاه العزم:

$e_x = X_{C.G} - \overline{X} = 5.4 - 5.3 = 0.1$ m

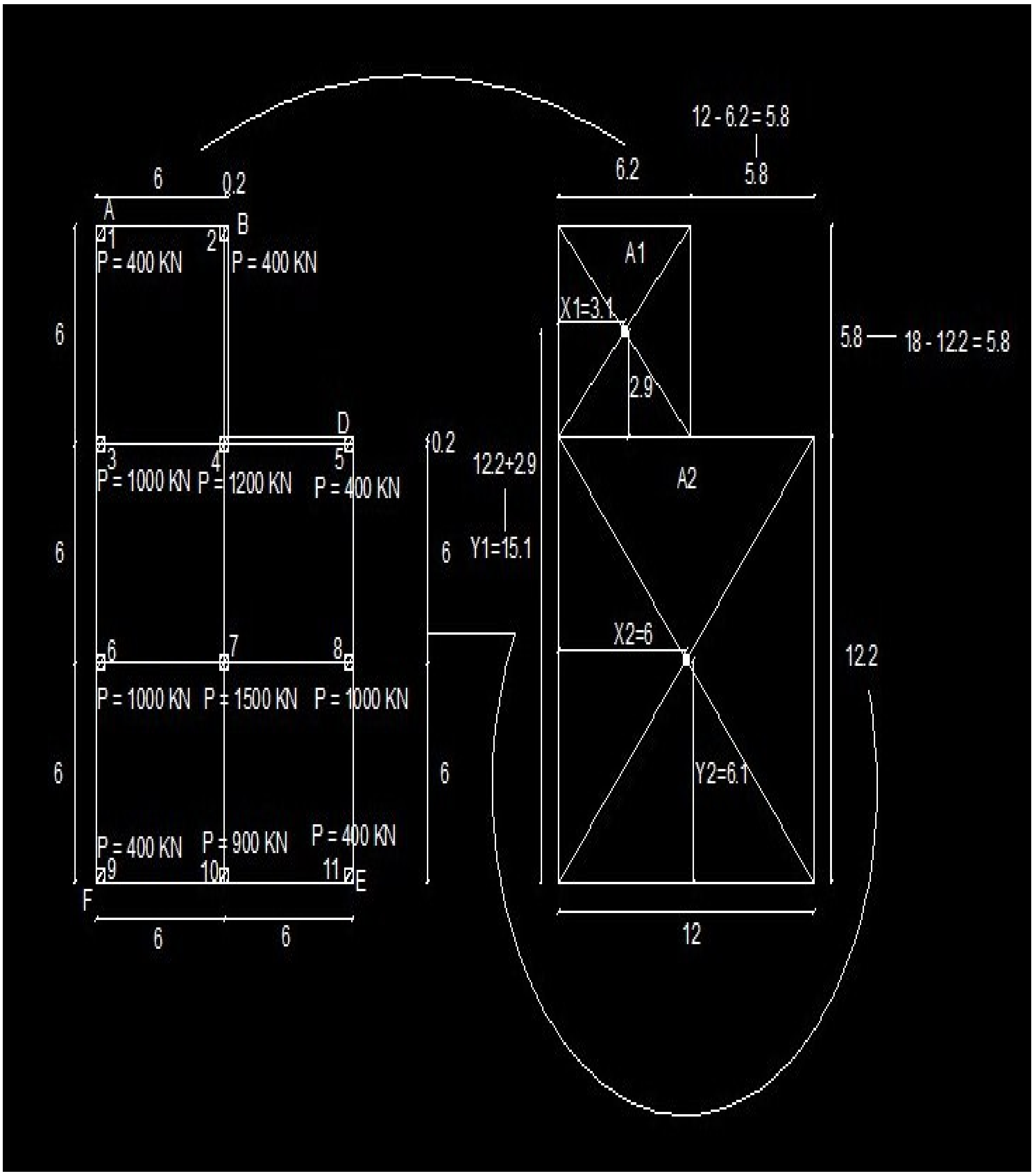
$e_y = Y_{C.G} - \overline{Y} = 7.87 - 7.77 = 0.1$ m

$M_x = \sum P * e_y = 8600 * 0.1 = 860$ KN.m

$M_y = \sum P * e_x = 8600 * 0.1 = 860$ KN.m

4) Calculate the soil pressure at the points required:

$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x = \ldots$ KN/m^2



نلاحظ أن الشكل غير متماثل فيتم تقسيم الشكل

$A_1 = 6.2 * 5.8 = 35.96\ m^2$

$A_2 = 12.2 * 12 = 146.4\ m^2$

Area of Raft (A) = $\sum \text{Area}$ = 182.36 m^2

For A_1 :

$A_1 = 6.2$, $B_1=5.8$, $Y_{C.GA1} = 15.1$, $Y_{C.G}=7.87$

For A_2 :

$A_2 = 12$, $B_2=12.2$, $Y_{C.GA2} = 6.1$, $Y_{C.G}=7.87$

$$Ix = \left\{ \frac{A1*(B1)^3}{12} + A_1 *(Y_{C.GA1} - Y_{C.G})^2 \right\} + \left\{ \frac{A2*(B2)^3}{12} + A_2 *(Y_{C.GA2} - Y_{C.G})^2 = \ldots\ m^4 \right.$$

$$Ix = \left\{ \frac{6.2*(5.8)^3}{12} + 35.96*(15.1 - 7.87)^2 \right\} + \left\{ \frac{12*(12.2)^3}{12} + 146.4*(6.1 - 7.87)^2 \right.$$

$= (100.81 + 1879.73) + (1815.85 + 458.66)$

$= 4255 m^4$

For A_1 :

$A_1 = 5.8$, $B_1=6.2$, $X_{C.GA1} = 3.1$, $X_{C.G}=5.4$

For A_2 :

$A_2 = 12.2$, $B_2=12$, $X_{C.GA2} = 6$, $X_{C.G}=5.4$

$$Iy = \{ \frac{A1*(B1)^3}{12} + A_1 *(X_{C.GA1} - X_{C.G})^2 \} + \{ \frac{A2*(B2)^3}{12} + A_2 *(X_{C.GA2} - X_{C.G})^2 = \ldots m^4$$

$$Iy = \{ \frac{5.8*(6.2)^3}{12} + 35.96*(3.1-5.4)^2 \} + \{ \frac{12.2*(12)^3}{12} + 146.4*(6-5.4)^2$$

$=(115.19 +190.23)+(1756.8+52.7)$

$= 2115\ m^4$

$$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x = \ldots KN/m^2$$

$$\sigma A = \frac{-8600}{182.36} + \frac{860}{4255}*(18-7.87) - \frac{860}{2115}*5.4$$

$=-47.3\ KN/m^2$

$$\sigma D = \frac{-8600}{182.36} + \frac{860}{4255}*(12.2-7.87) + \frac{860}{2115}*(12-5.4)$$

$= -43.6\ KN/m^2$

$$\sigma F = \frac{-8600}{182.36} - \frac{860}{4255}*(7.87) - \frac{860}{2115}*(5.4)$$

$= -51 \text{ KN/ } m^2$

$$\sigma E = \frac{-8600}{182.36} - \frac{860}{4255} * (7.87) + \frac{860}{2115} * (12-5.4)$$

$= -46 \text{ KN/ } m^2$

6)Raft Foundation Design:

For strip AF

strip width=3m

Method (2):

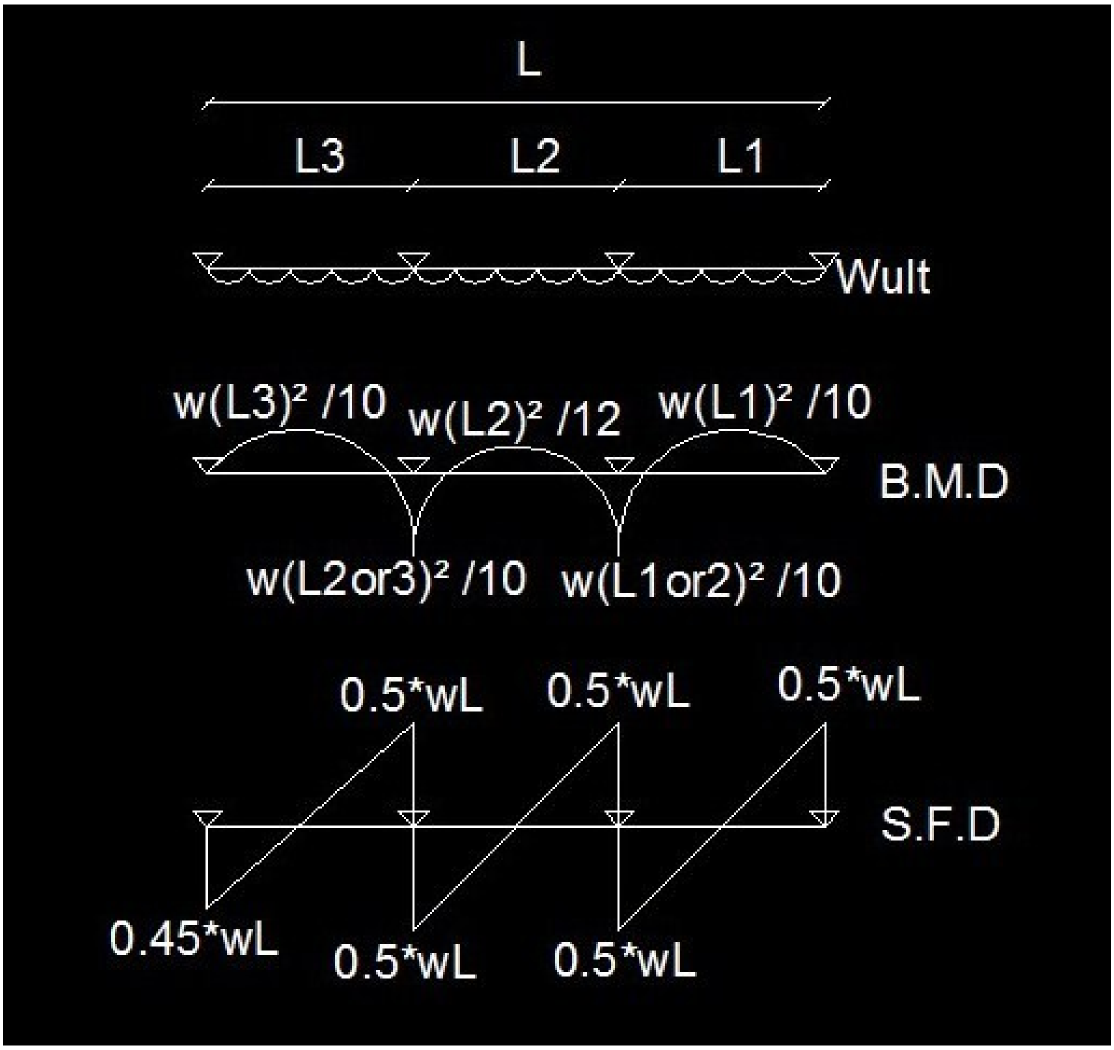
$\sum P w$ = 400+1000+1000+400 = 2800 KN

L = 3*6 =18 m

$$W = \frac{\sum Pw}{L} = \frac{2800}{18} = 155.56 \text{ KN/B}$$

$= 15.56$ t/B

W_U = W * 1.5 = 15.56 *1.5 = 23 .33 t/B



$M_{ult} = \frac{w(L)^2}{10} = \frac{23.33(6)^2}{10} = 84$ mt

$M_{ult} = \frac{w(L)^2}{12} = \frac{23.33(6)^2}{12} = 70$ mt

$M_{max} = 84$ mt

Q = 0.45*wL = 0.45*23.33*6 = 63 t

Q = 0.5*wL = 0.5*23.33*6 = 70 t

$Q_{max} = 70$ t

$$d = C_1 \sqrt{\frac{Mult}{Fcu*B}} = 5 \sqrt{\frac{84*10^5}{250*300}} = 53 \text{ cm} \cong 60 \text{ cm}$$

Check Shear:

$$Q_{sh}=Q_{max} - (\frac{d}{2})*w_{ult} = 70-(\frac{0.6}{2})* 23.33= 63 \text{ ton}$$

$$q_{sh} = \frac{Qsh}{B*d} = \frac{63*10^3}{300*60} = 3.5 \text{ kg/cm}^2$$

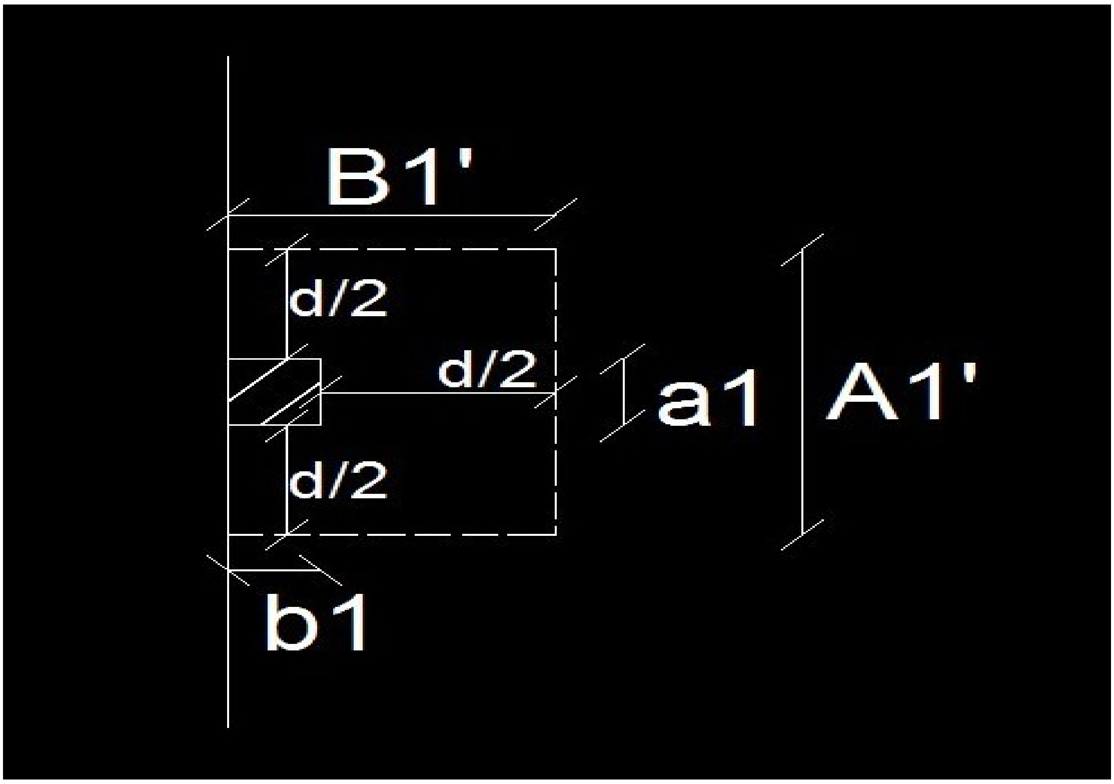
$$q_{cu} = 0.4*\sqrt{Fcu} = 0.4*\sqrt{250} = 6.3 \text{ kg/cm}^2$$

$q_{cu} > q_{sh}$

6.3 > 3.5 ok safe

t = d + cover = 60 + 10 = 70 cm

Check Punching:



$q_{un} = \frac{\sum \text{Pult}}{\text{Area}} = \frac{8600}{182.36} = 47.2\ \text{KN/m}^2 \cong 4.72\ \text{t/m'}$

$Q_P = P_u - q_U\,(A' * B') = \ldots$ Ton

$A' = (a_1 + d) = 0.4 + 0.6 = 1$ m

$B' = (b_1 + \frac{d}{2}) = (0.4 + \frac{0.6}{2}) = 0.7$ m

$Q_P = 100 - 4.72\,(1 * 0.7) = 96.7$ Ton

$q_p = \frac{Qp}{2*(A'+B')*d} = \frac{96.7*10^3}{2*(100+70)*60} = 4.74\ \text{kg/cm}^2$

$q_{pcu} = (0.5 + \frac{b}{a})\sqrt{\frac{Fcu}{\gamma c}} = (0.5 + \frac{0.4}{0.4})\sqrt{\frac{250}{1.5}}$

$=19.36\ kg/cm^2$

$q_{pcu} > q_p$

19.36 > 4.74 ok safe

t = d + cover = 60 + 10 = 70 cm

Reinforcement of the footing:

$A_{s\ Top1} = \frac{Mutop}{J*d*Fy}$ =… cm^2 /B'= /m'

$= \frac{84*10^5}{0.826*60*3600}$ = 47cm^2 /3= 15.6cm^2/m'

Use 8Y 16 /m'

$A_{s\ Top2} = \frac{Mutop}{J*d*Fy}$ = … cm^2 /B'= cm^2/m'

$= \frac{70*10^5}{0.826*60*3600}$ = 39 cm^2 /3= 13 cm^2/m'

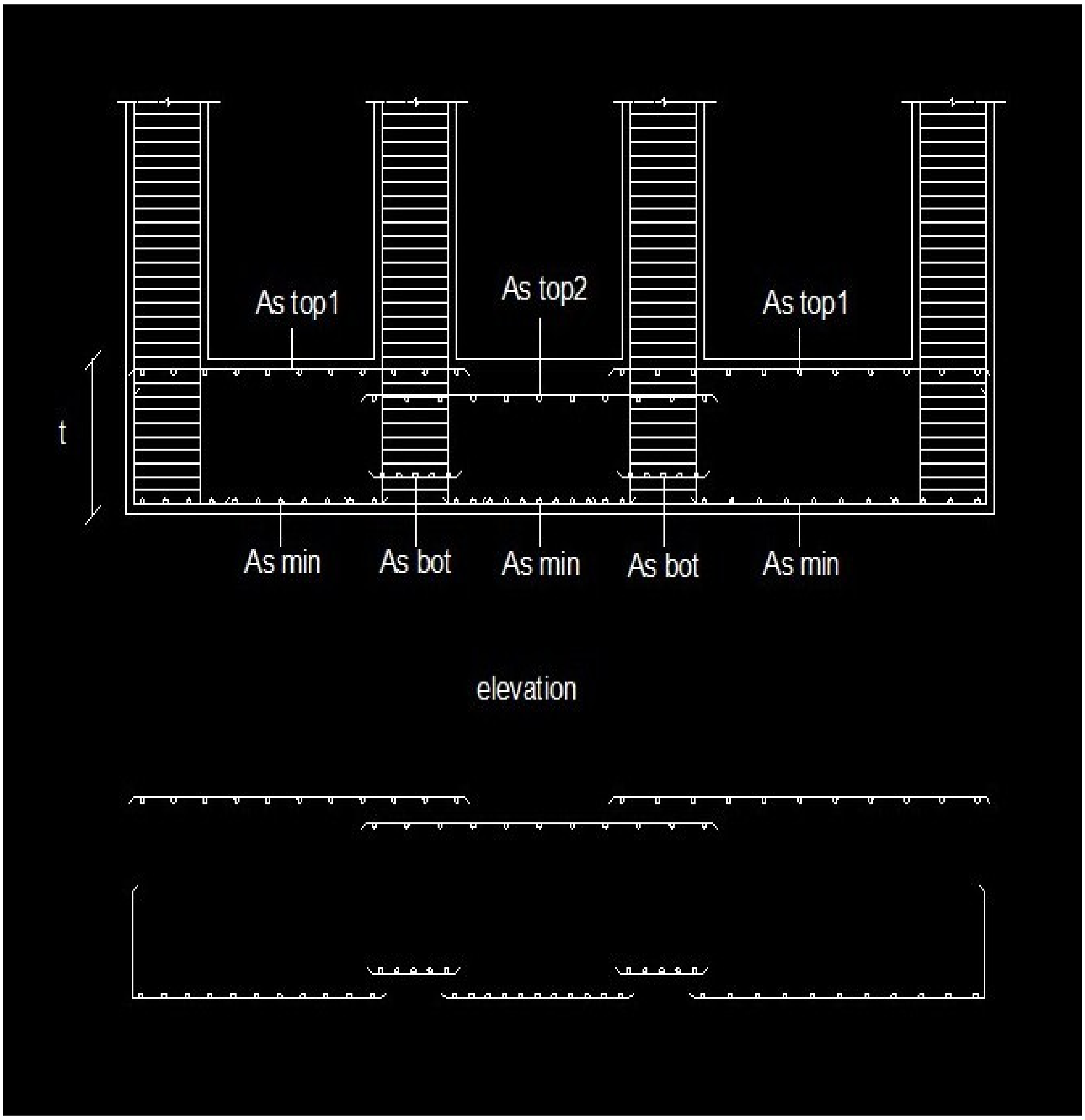
Use 7Y 16 /m'

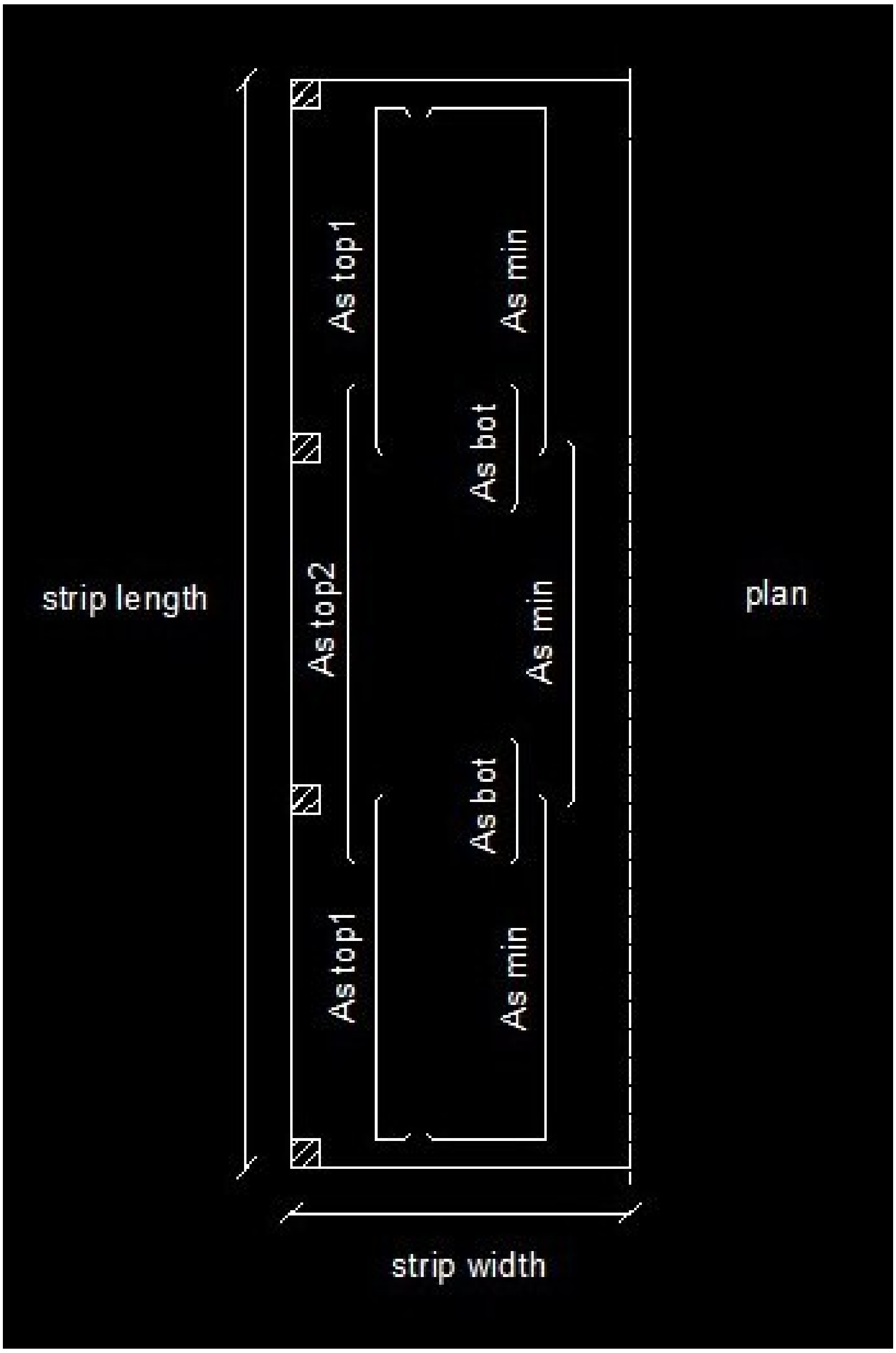
$A_{s\ Bot} = \frac{Mubot}{J*d*Fy}$ = … cm^2 /B'= cm^2/m'

$= \frac{84*10^5}{0.826*60*3600}$ = 47 cm^2 /3= 15.6 cm^2/m'

Use 8Y 16 /m'

Details of Reinforcement:





strip length
As top1
As min
As bot
As top2
As min
As bot
As top1
As min
plan
strip width

Example: 2

The Raft footing shown in fig all columns 50 X 50 cm .

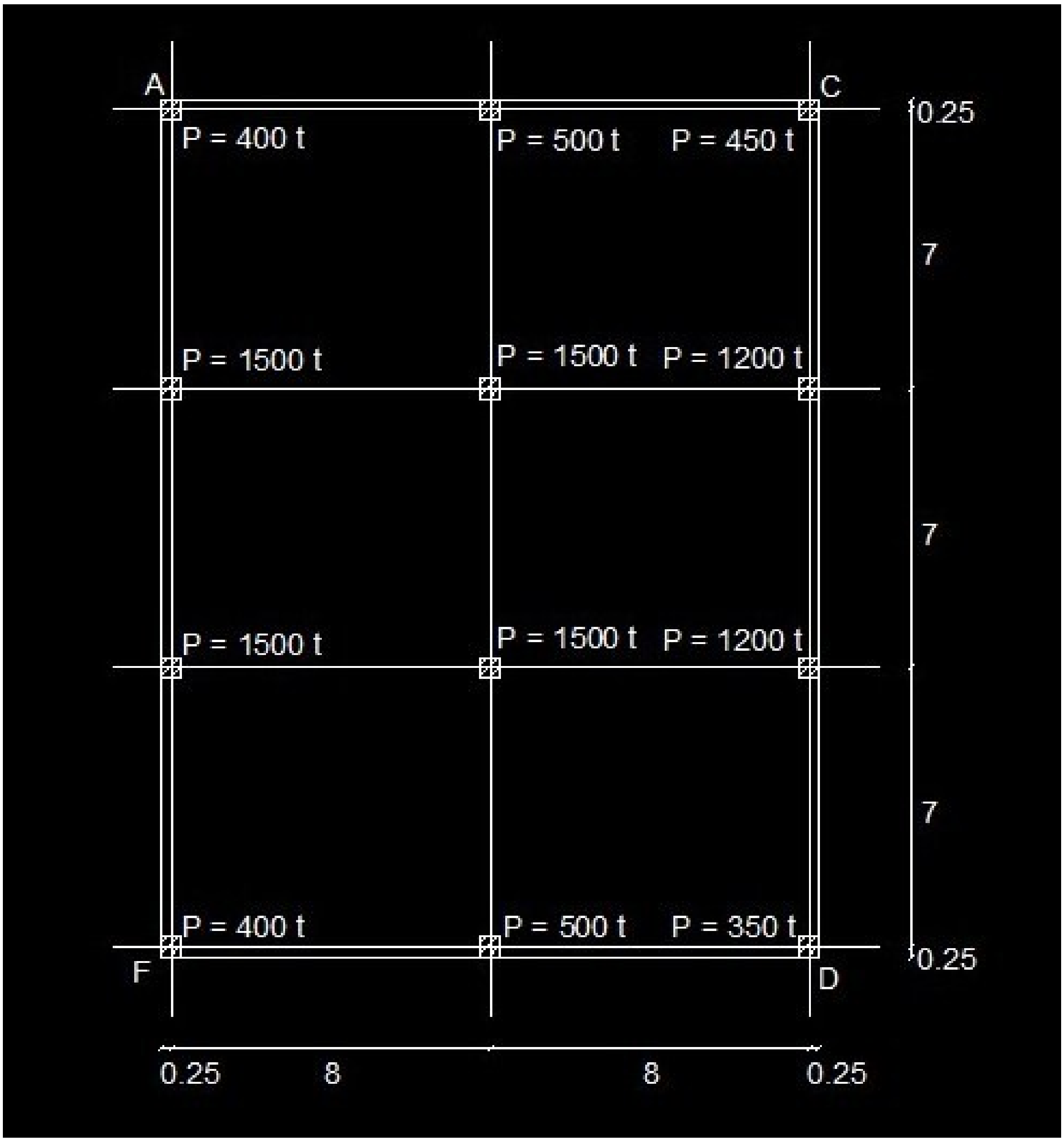
It is required to:

1) Determine the soil pressure under the corners of the given Raft.

2) Make Full design for strip width=3m.

3) Determine the reinforcement steel of the Raft footing .

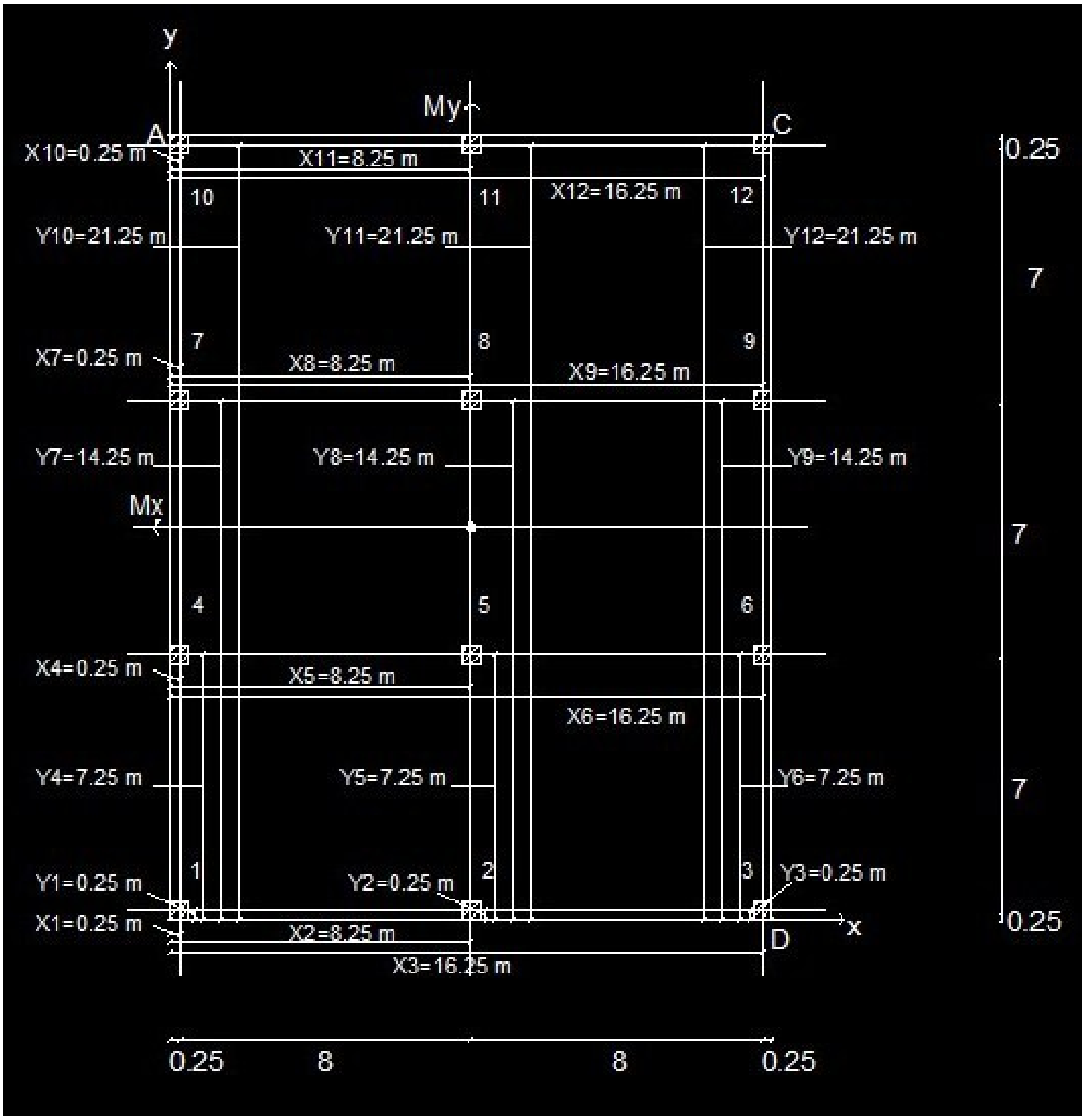
4) Draw net sketch showing dimensions of Raft footing and steel details.



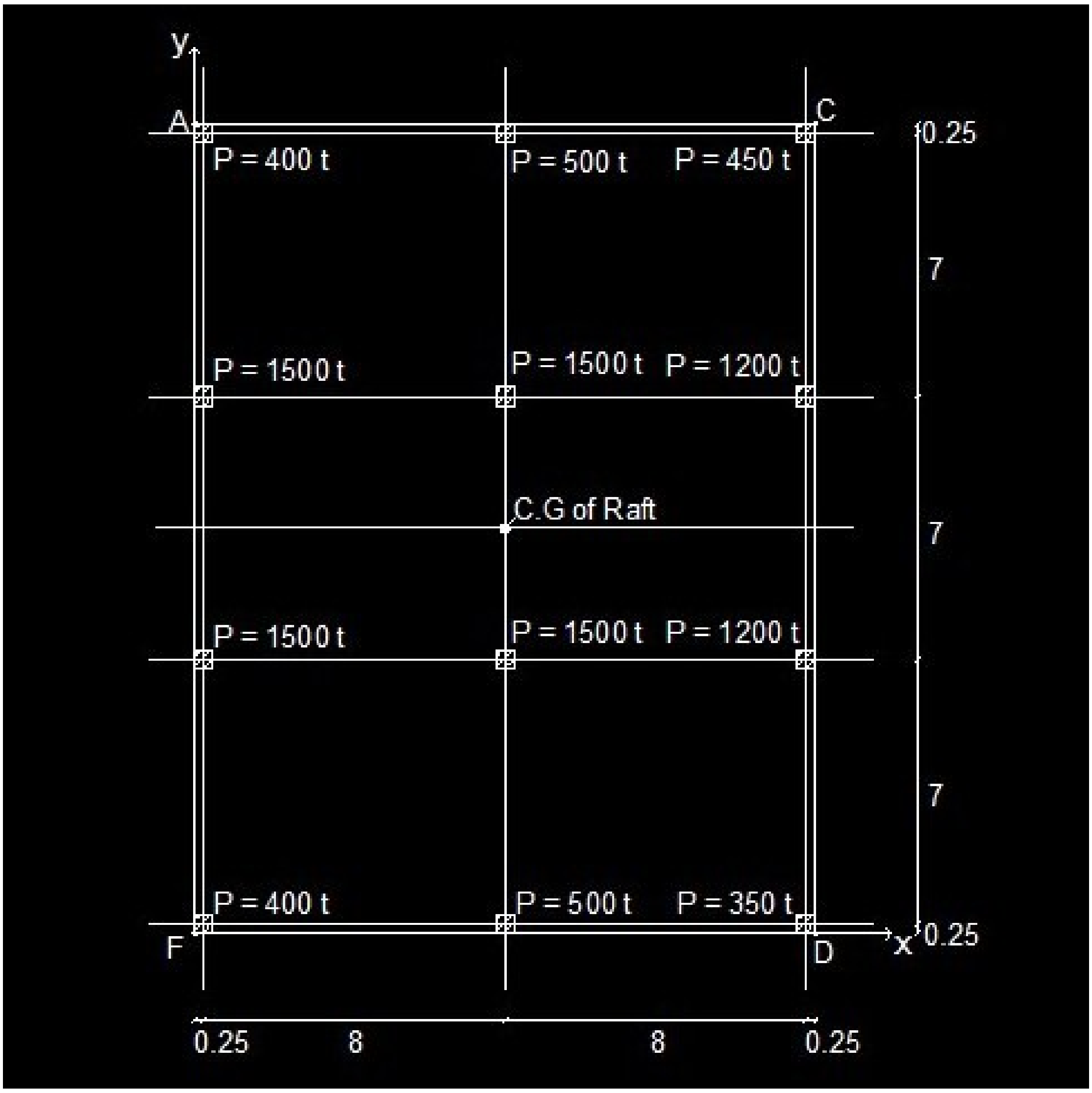
Solution

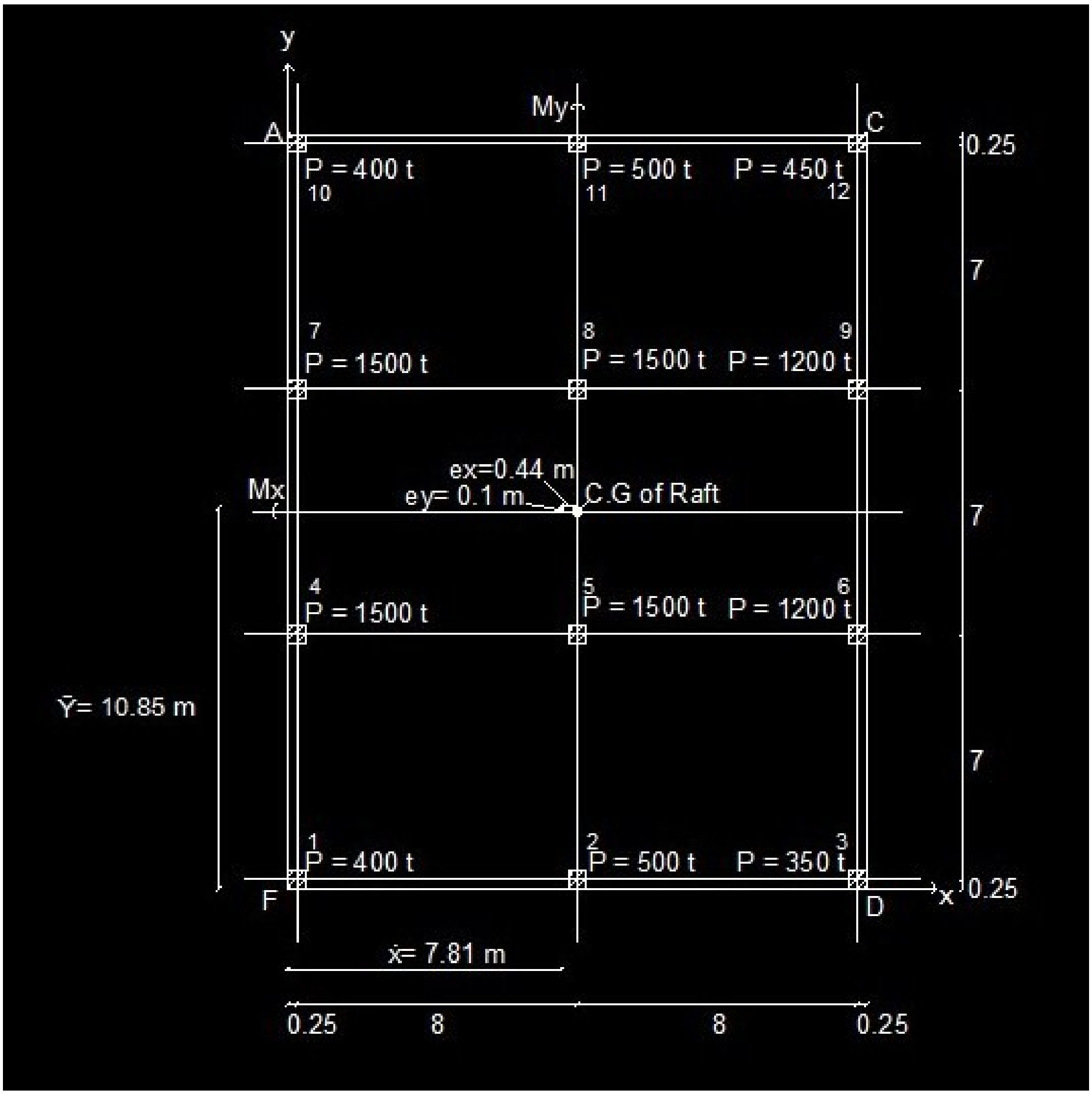
Given: $f_{cu} = 250\ kg/cm^2$, $F_y = 3600\ kg/cm^2$

, $q_{all} = 60\ KN/m^2$



y
My
A
C
X10=0.25 m
X11=8.25 m
X12=16.25 m
10
11
12
Y10=21.25 m
Y11=21.25 m
Y12=21.25 m
7
8
9
X7=0.25 m
X8=8.25 m
X9=16.25 m
Y7=14.25 m
Y8=14.25 m
Y9=14.25 m
Mx
4
5
6
X4=0.25 m
X5=8.25 m
X6=16.25 m
Y4=7.25 m
Y5=7.25 m
Y6=7.25 m
1
2
3
Y1=0.25 m
Y2=0.25 m
Y3=0.25 m
X1=0.25 m
X2=8.25 m
X3=16.25 m
x
D
0.25
8
8
0.25
0.25
7
7
7
0.25


y
A
C
P = 400 t
P = 500 t
P = 450 t
0.25
7
P = 1500 t
P = 1500 t
P = 1200 t
C.G of Raft
7
P = 1500 t
P = 1500 t
P = 1200 t
7
P = 400 t
P = 500 t
P = 350 t
0.25
F
D
x
0.25
8
8
0.25



1) Determination of C.G of Raft:

تحديد C.G للبشة.

2) Determination of Resultant Load and its point of application:

تحديد محصلة القوي (أحمال الأعمدة) ونقطة تأثيرها.

Col N.o	P (KN)	X	Y	P*X	P*y
1	400	0.25	0.25	100	100
2	500	8.25	0.25	4125	125
3	350	16.25	0.25	5687.5	87.5
4	1500	0.25	7.25	375	10875
5	1500	8.25	7.25	12375	10875
6	1200	16.25	7.25	19500	8700
7	1500	0.25	14.25	375	21375
8	1500	8.25	14.25	12375	21375
9	1200	16.25	14.25	19500	17100
10	400	0.25	21.25	100	8500
11	500	8.25	21.25	4125	10625
12	450	16.25	21.25	7312.5	9562.5

	11000			85950	119300
	ΣP			ΣP*X	ΣP*Y

$$\overline{X} = \frac{\sum P*X}{\sum P} = \frac{85950}{11000} = 7.81 \text{ m}$$

$$\overline{Y} = \frac{\sum P*Y}{\sum P} = \frac{110300}{11000} = 10.85 \text{ m}$$

3) Determination the value and direction determined:

تحديد قيمة واتجاه العزم:

$$e_x = \frac{A}{2} - \overline{X} = \frac{16.5}{2} - 7.81 = 0.44 \text{ m}$$

$$e_y = \frac{B}{2} - \overline{Y} = \frac{21.5}{2} - 10.85 = 0.1 \text{ m}$$

$$M_x = \sum P * e_y = 11000 * 0.1 = 1100 \text{ KN.m}$$

$$M_y = \sum P * e_x = 11000 * 0.44 = 4840 \text{ KN.m}$$

4) Calculate the soil pressure at the points required:

$$\sigma = \frac{-N}{A} \pm \frac{Mx}{Ix} * y \pm \frac{My}{Iy} * x = \ldots \text{ KN/m}^2$$

Area of Raft (A) = (A*B)=16.5*21.5= 354.75 m^2

$Ix = \frac{A*(B)^3}{12} = \frac{16.5*(21.5)^3}{12}$ = 13665 m^4

$Iy = \frac{B*(A)^3}{12} = \frac{21.5*(16.5)^3}{12}$ = 8048 m

الباقي نفس الشئ

Example: 3

The Raft footing shown in fig all columns 50 X 50 cm .

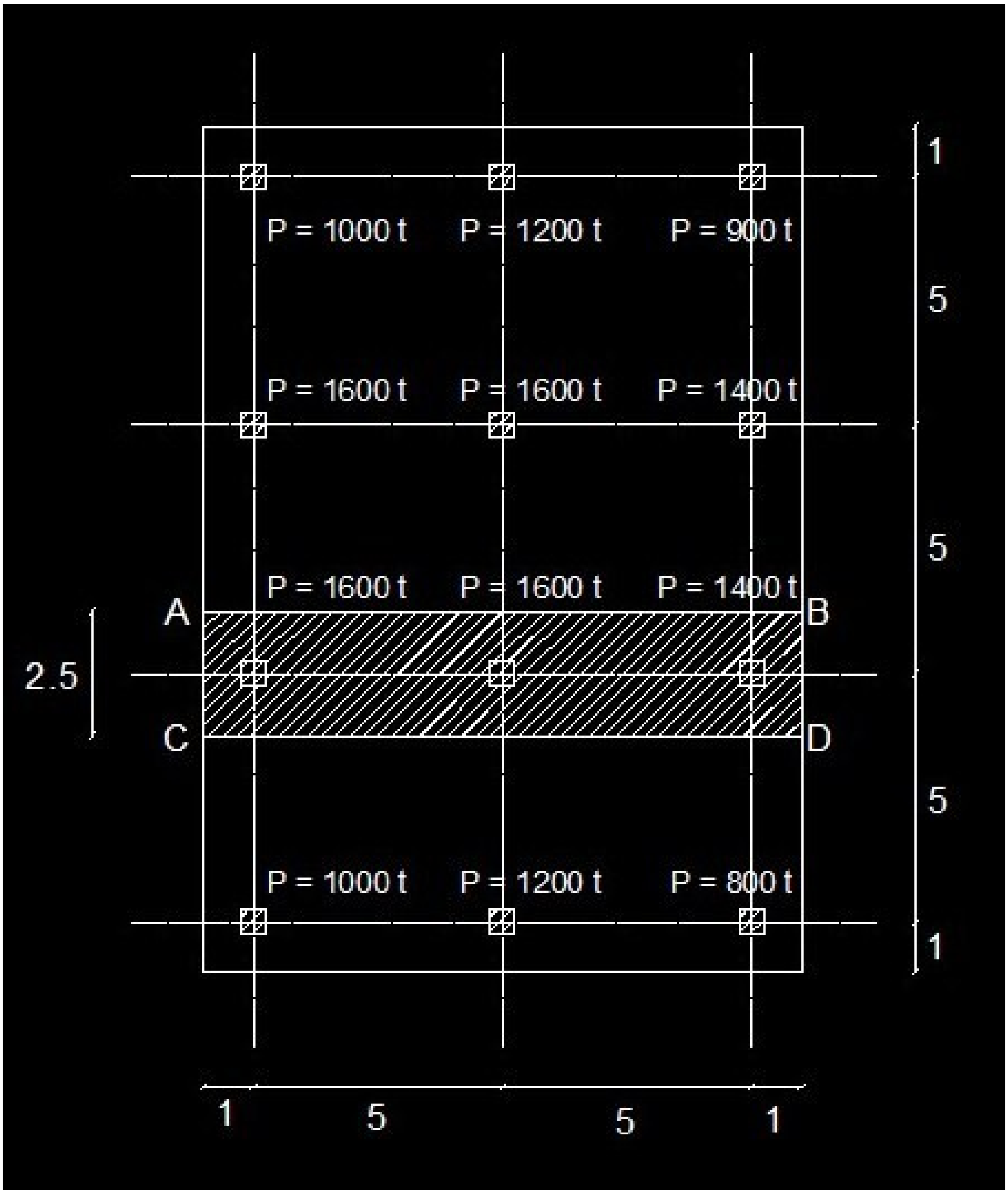
It is required to:

1) Determine the soil pressure under the corners of the given Raft.

2) Make Full design for strip ABDC strip width=2.5m.

3) Determine the reinforcement steel of the Raft footing .

4) Draw net sketch showing dimensions of Raft footing and steel details.



Solution

Given: $f_{cu} = 250\ kg/cm^2$, $F_y = 3600\ kg/cm^2$

Example: 4

The Raft footing shown in fig all columns 40 X 40 cm .

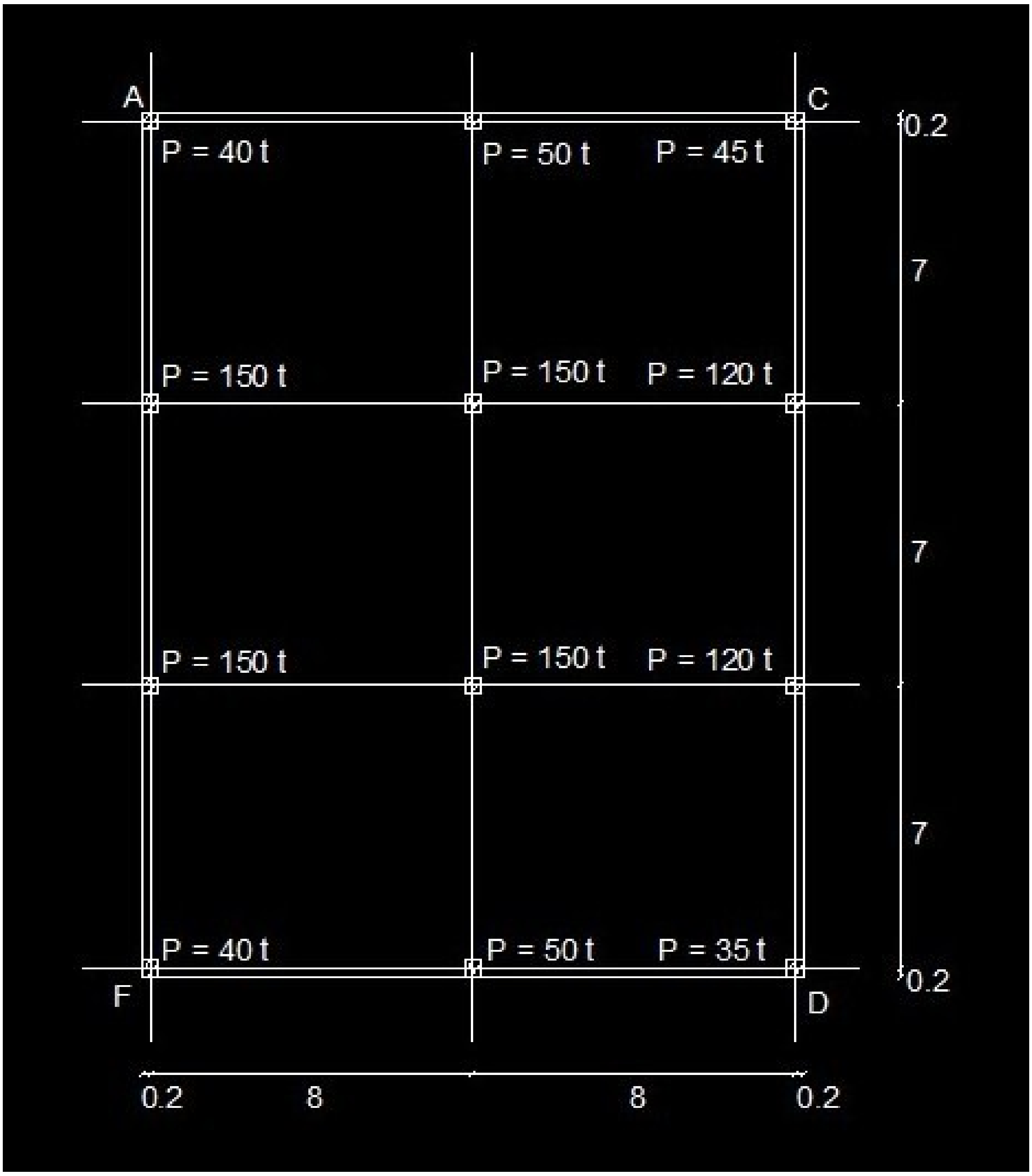
It is required to:

1) Determine the soil pressure under the corners of the given Raft.

2) Make Full design for strip width=2.5m.

3) Determine the reinforcement steel of the Raft footing .

4) Draw net sketch showing dimensions of Raft footing and steel details.



Solution

Given: f_{cu} = 250 kg/cm^2 , F_y = 3600 kg/cm^2

Piles:

1) Design of piles:

2) Bearing Capacity of piles:

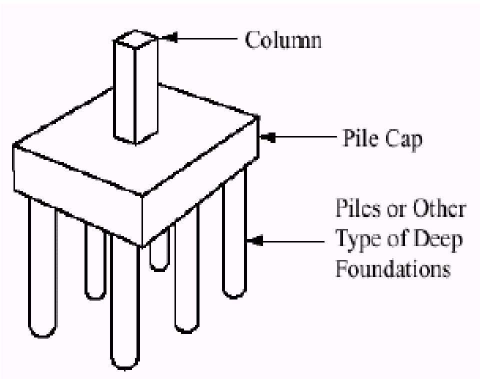
3) Determination settlement:

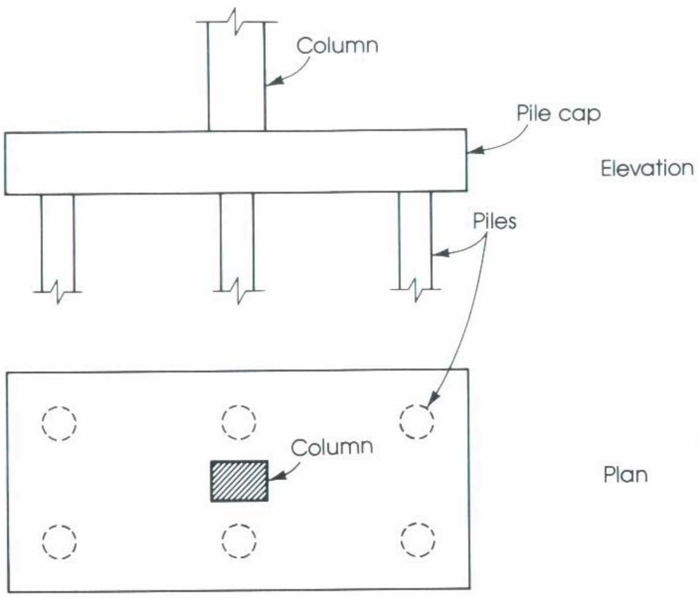
4) Short and Long pile:

5) Design of piles cap:

6) Design of steel sheet piles:

Piles:





Main reasons For use piles:

1) In case of the top layers are as weak that they could not bear the structure , the piles transfer loads to a good layer at reasonable depth.

عندما تكون الطبقات السطحية ضعيفة بحيث لا تستطيع تحمل أحمال المنشأ تقوم الخوازيق بنقل الحمل إلي الطبقات العميقة الأقوى.

2) In order to resist uplift pressure.

3) In case of structure in water.

في حالات المنشآت المائية.

4) In order to densify the soil as in case of short stone piles.

Types of piles:

1)With respect to the method of transform loads:

A) End Bearing piles.

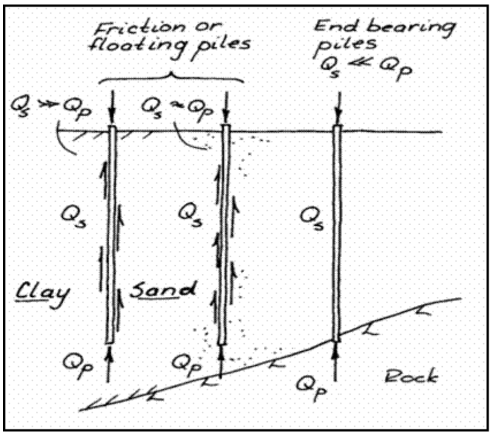
خوازيق ارتكاز: وهذا النوع ينقل الحمل إلى التربة بالمقاومة المتولدة عند نقطة ارتكازه أو قاعدته (Qb).

B) Friction piles.

خوازيق احتكاك: وهذا النوع ينقل الحمل أساسا بمقاومة الاحتكاك على سطحه (Qs).

C) End Bearing + Friction piles.

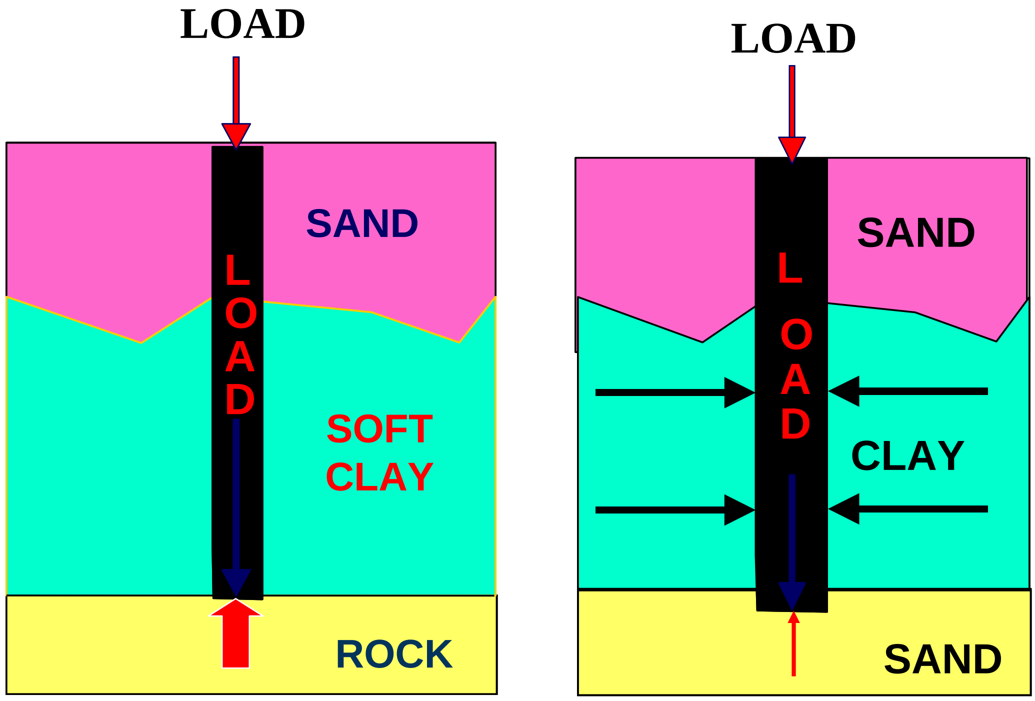
وهذا النوع ينقل الحمل جزئيا بواسطة الاحتكاك على سطحه وجزئيا بمقاومة الارتكاز عند قاعدته (Qb+Qs).



End bearing piles

Friction piles

END BEARING PILE **FRICTION PILE**

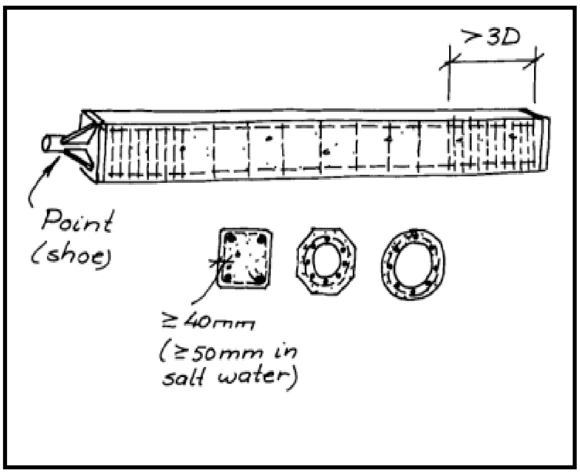


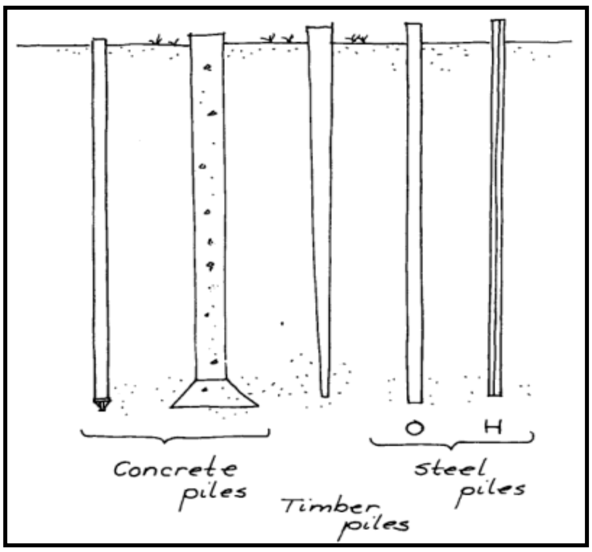
End bearing - Friction

2) With respect to Material:

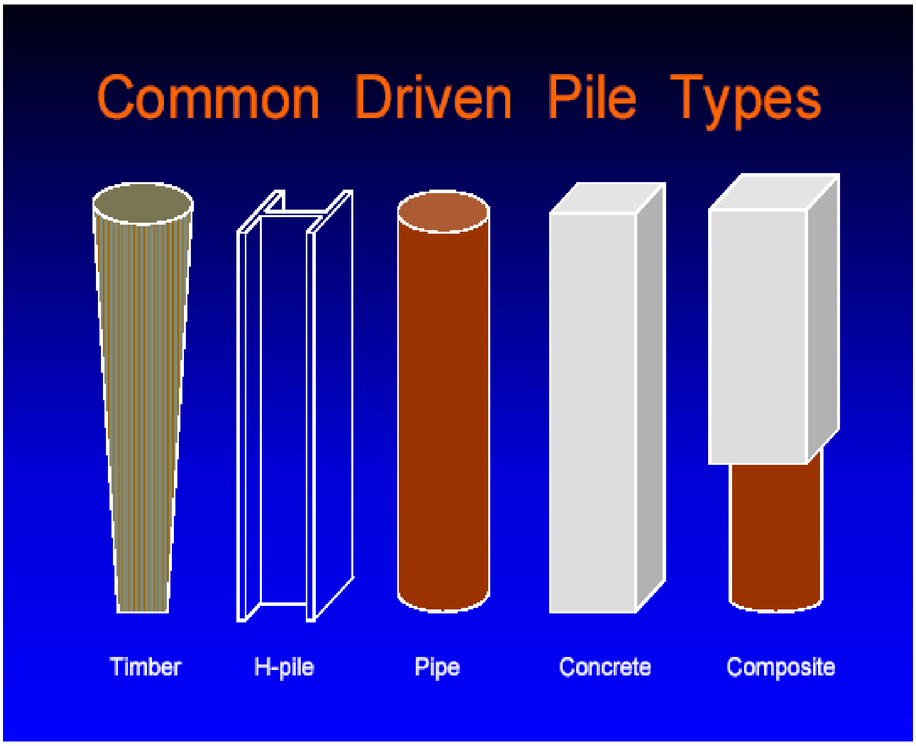
تصنع الخوازيق من الخرسانة أو الحديد أو الخشب أو أكثر من مادة من هذه المواد.

The main types of materials used for piles are wood, steel and concrete.





Materials used for piles

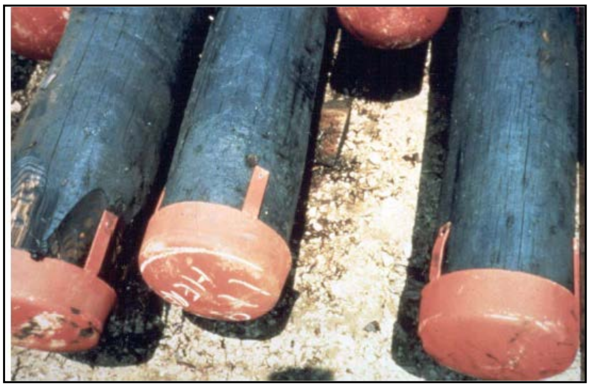


A) Timber piles:

خوازيق خشب:

تستخدم في الأعمال المؤقتة.

Use in temporary works.



Length: 9 → 15 m

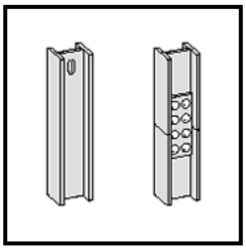
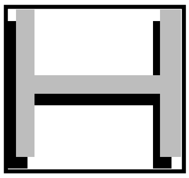
Max load: 45 Ton

B) Steel piles:

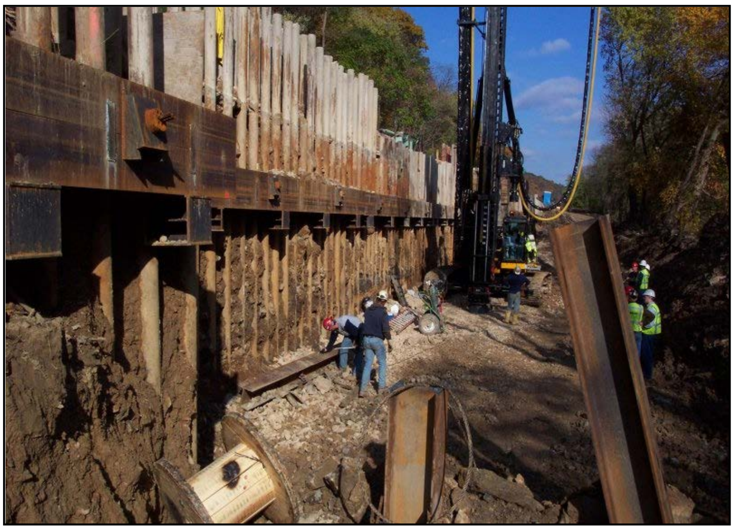
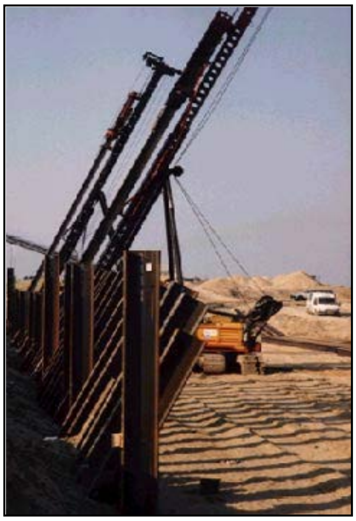
خوازيق حديد:

تستخدم عندما يخترق الخازوق طبقات قوية.

Use when the pile cross hard layers.

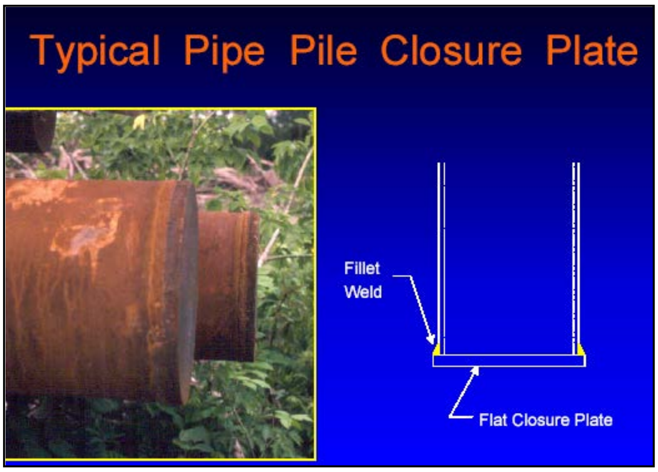




Steel Pile – H piles:

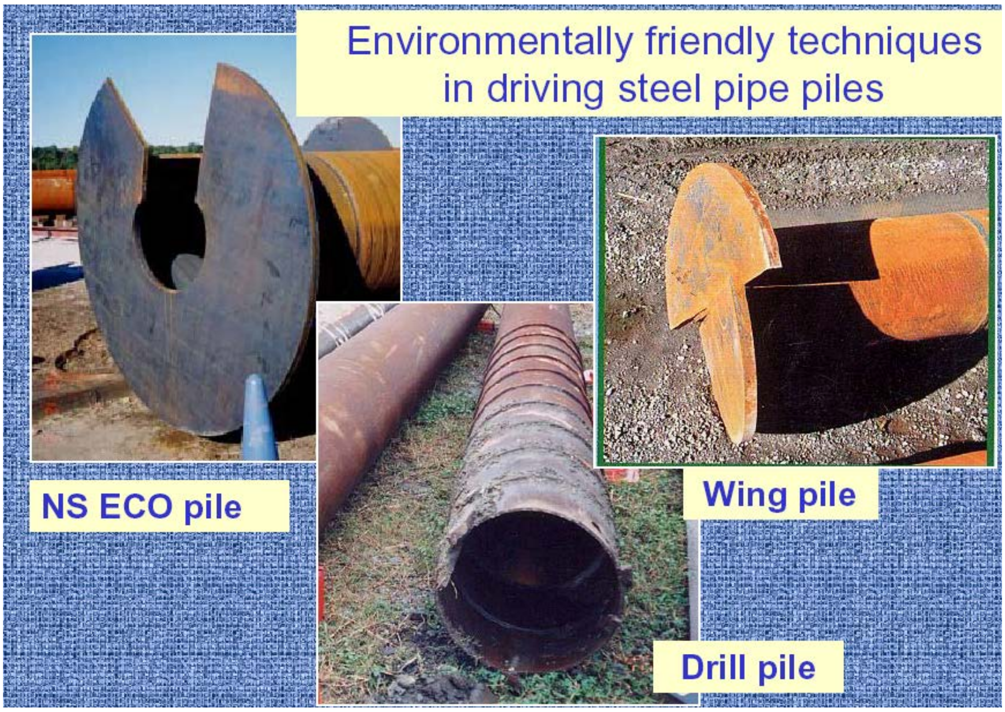




Steel Pipe Pile (Tube piles)

Steel Pipe Pile



Steel Pipe Pile



Steel Pipe Pile

NS ECO pile has a one-round spiral wing at the end of the pile of which diameter is 1.5 to 2.0 times of its shaft diameter, i.e. the shaft diameter is 1200mm, then the spiral wing diameter is 2400mm so that its end bearing area is quite large and effective to increase its bearing capacity.

Length: 12 → 50 m

Max load: 35 → 100 Ton

C) Concrete piles:

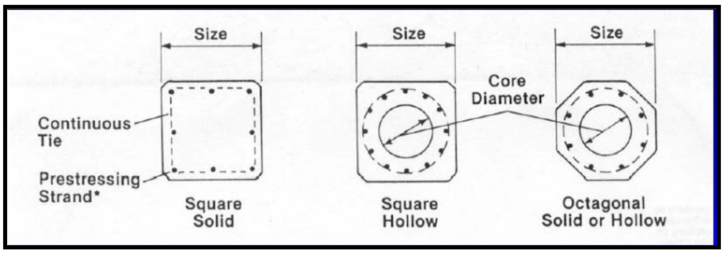
خوازيق خرسانة:

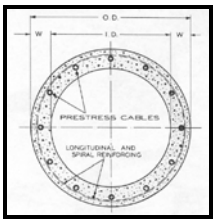
C-1) Pre cast: Driven

سابقة الصب: بالدق

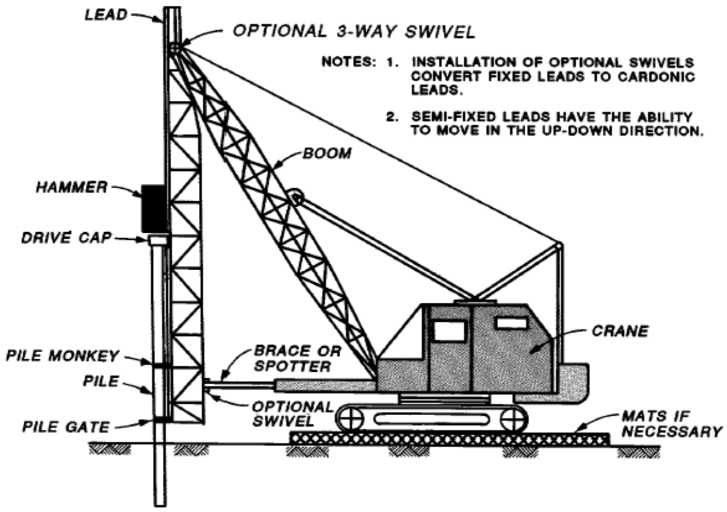
C-2) Cast in place: Driven , Bored

مصبوب في الموقع :بالحفر والصب



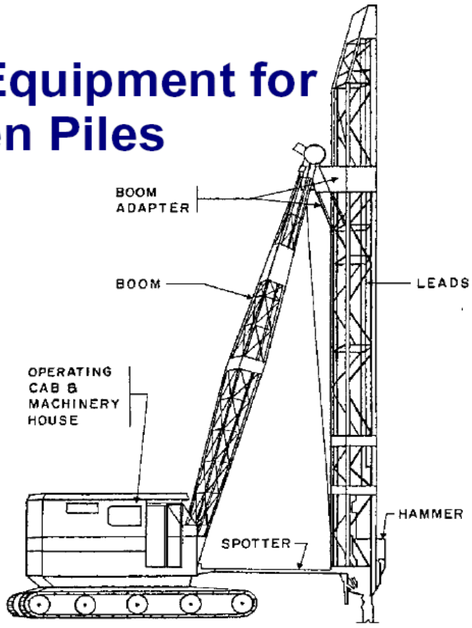


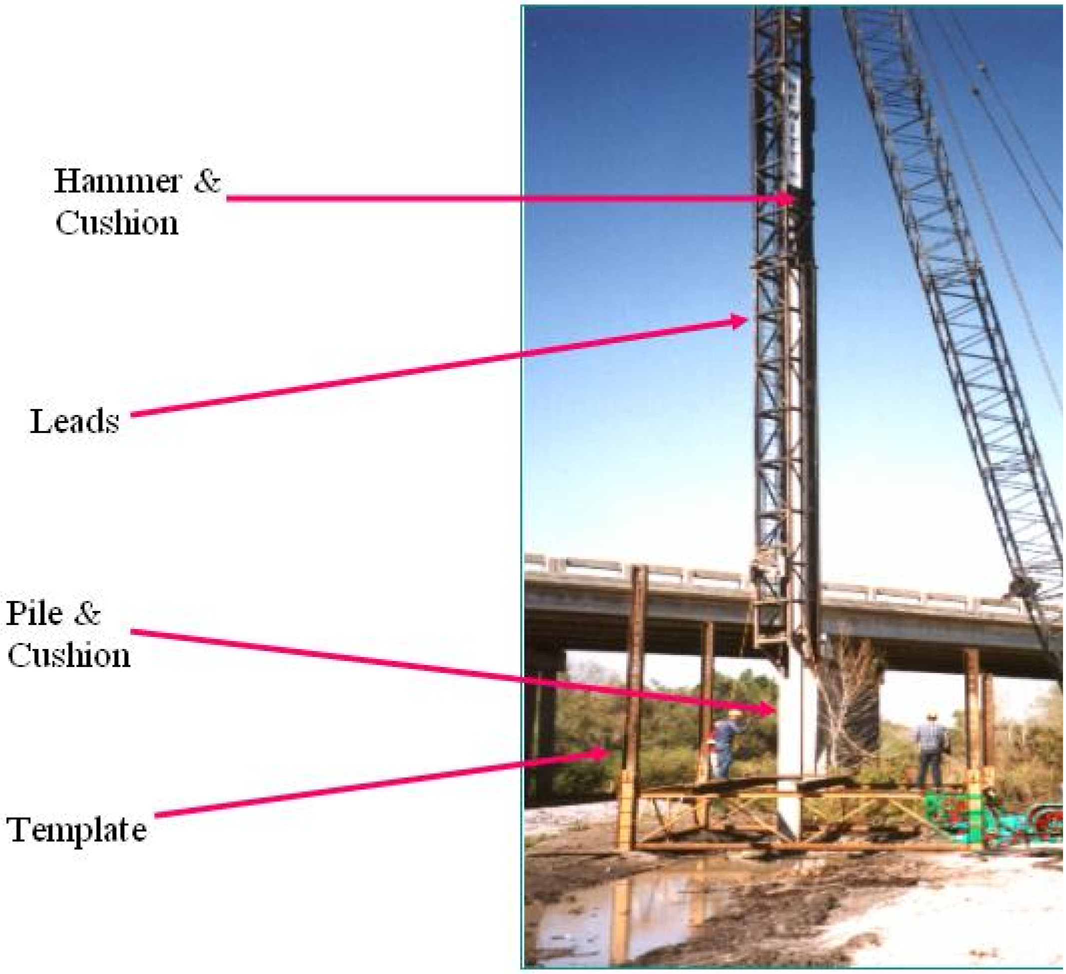


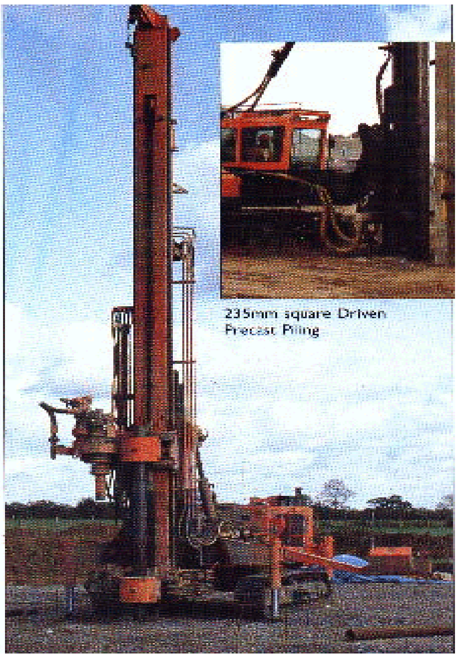



Installation Equipment for Driven Piles

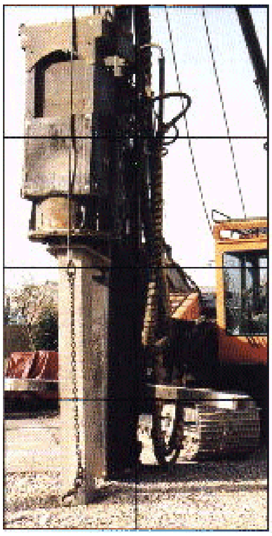
- Pile Driving Rigs
- Pile Hammers
- Hammer Accessories
  - Leaders
  - Cushion Material
- Predrilling, Jetting and Spudding

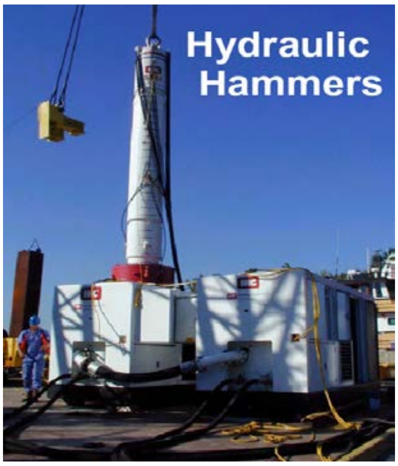



Hammer &
Cushion
Leads
Pile &
Cushion
Template



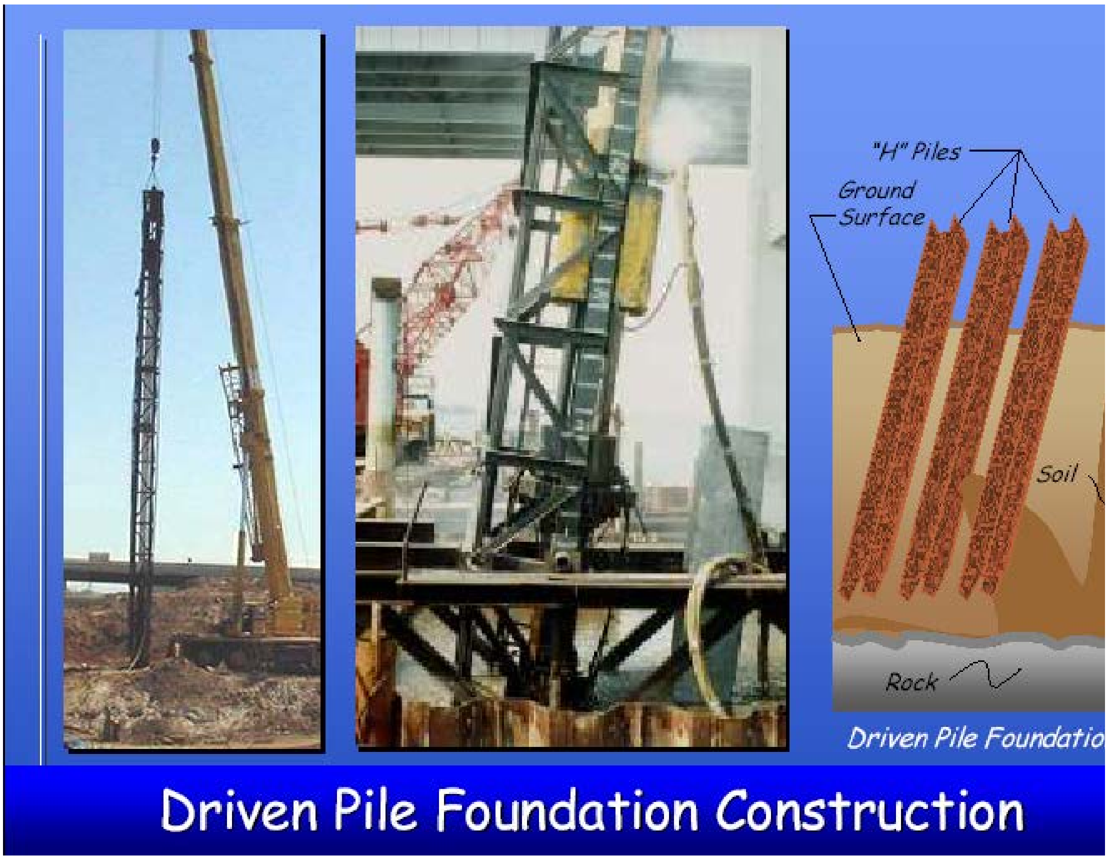
235mm square Driven Precast Piling




Hydraulic
Hammers


3100

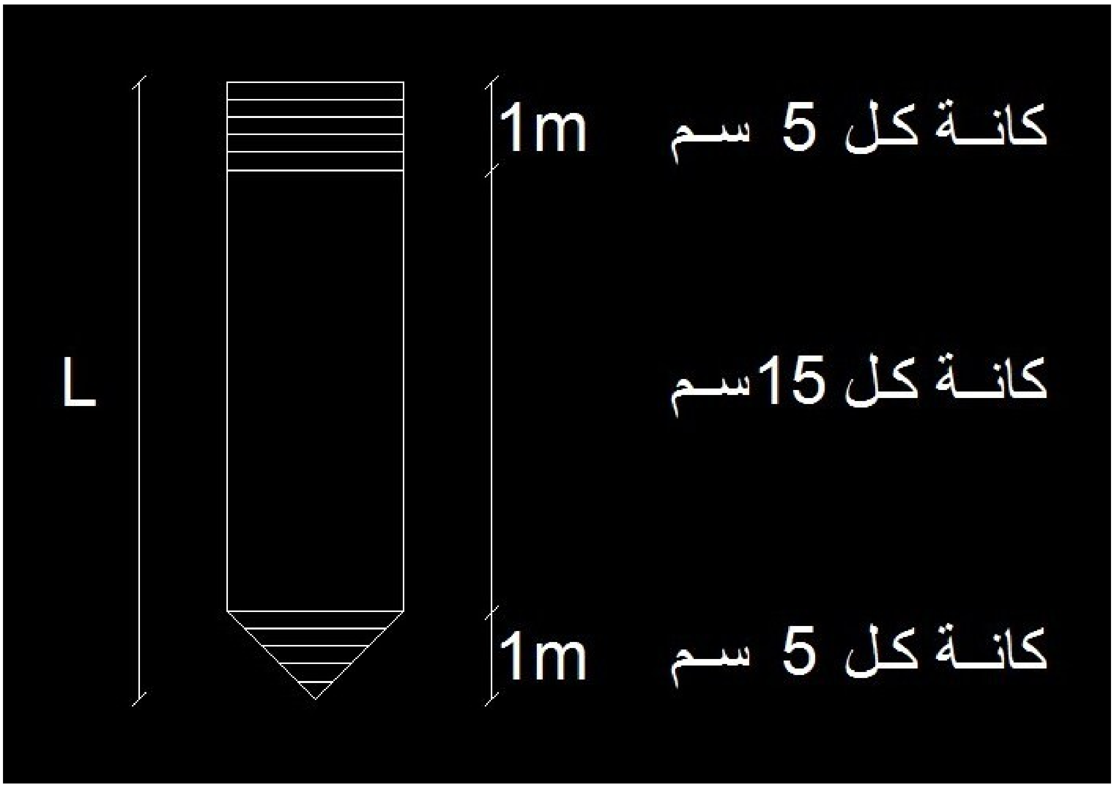

Boulanger


"H" Piles
Ground Surface
Soil
Rock
Driven Pile Foundatio
Driven Pile Foundation Construction

C-1) Pre cast:

يتطلب تسليح الأجهادات الناتجة عن المناولة والنقل.

Handling stresses.



If $\frac{L}{D} \leq 30 \rightarrow A_S = 1.25\ \%\ A_C$

If $30 < \frac{L}{D} < 40 \rightarrow A_S = 1.5\ \%\ A_C$

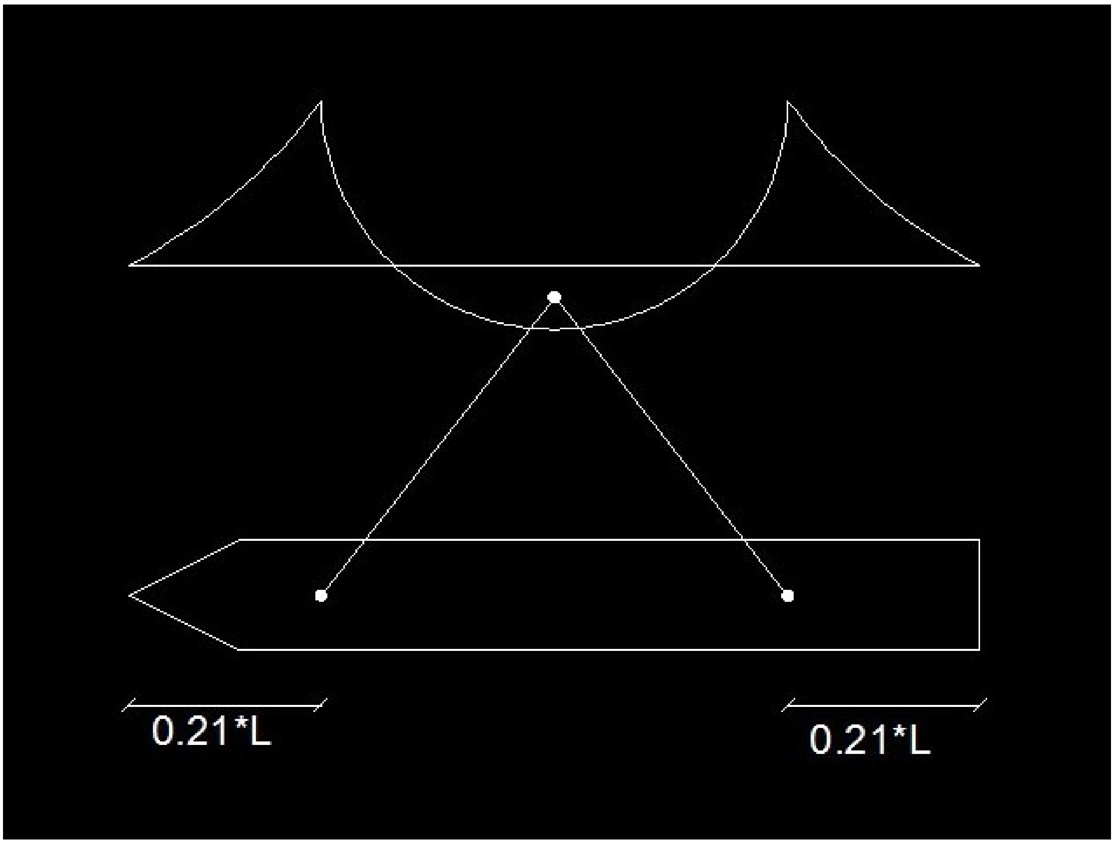
If $\frac{L}{D} > 40 \rightarrow A_S = 2\ \%\ A_C$

حيث أن:

L ⟶ طول الخازوق

D ⟶ قطر الخازوق

عملية رفع الخازوق:



C-2) Cast in place:

Types of Cast in place pile:

C-2-1) Simplex piles. , C-2-2) Frankie piles.

C-2-3) Vibro piles. , C-2-4) Raymod piles.

C-2-5) Strausse piles.

1) Design of piles:

هناك طريقتين:

1- استخدام اختبار الاختراق القياسي:

Use standard penetration test (S.P.T):

2- استخدام اختبار المخروط الإستاتيكى:

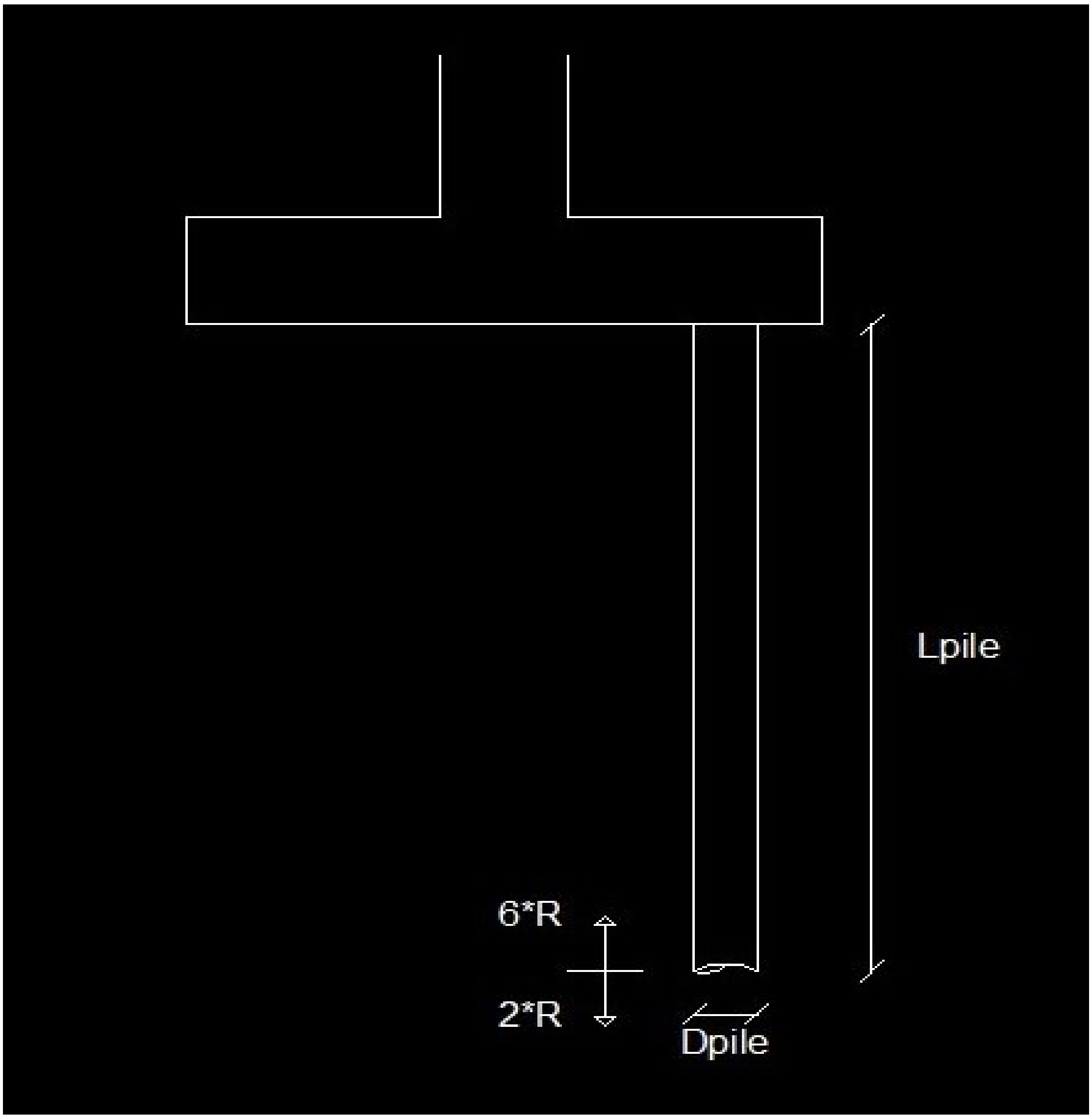
Use cone penetration test (C.P.T):

سيتم دراسة الطريقة الأولي فقط

3- استخدام اختبار الاختراق القياسي:

Use standard penetration test (S.P.T):

حيث أن:



Assume:

D_{pile} = … cm

L_{pile} = … m

$Q_{all} = 45*N*\frac{\pi(Dpile)^2}{4} + \frac{\bar{N}}{3} *\pi *D_{pile} *L_{pile}$ = … KN

حيث أن:

$Q_{all} \rightarrow$ حمل تشغل الخازوق.

$N \rightarrow$ number of average blows from S.P.T. tests through depth of 3D above and below pile tip.

القيمة المتوسطة لعدد الدقات في تجربة الاختراق القياسي في طبقة التربة المؤثرة علي حمل الارتكاز و الممتدة لمسافة (2R) أسفل قاعدة الخازوق و (6R) أعلا نقطة الارتكاز.

$\overline{N} \rightarrow$ average number of blows from S.P.T. tests throughout the pile length subjected to shear.

متوسط عدد الدقات في تجربة الاختراق القياسي علي طول الخازوق داخل الطبقة أو الطبقات غير متماسكة الحبيبات.

$D_{pile} \rightarrow$ pile diameter.

قطر الخازوق.

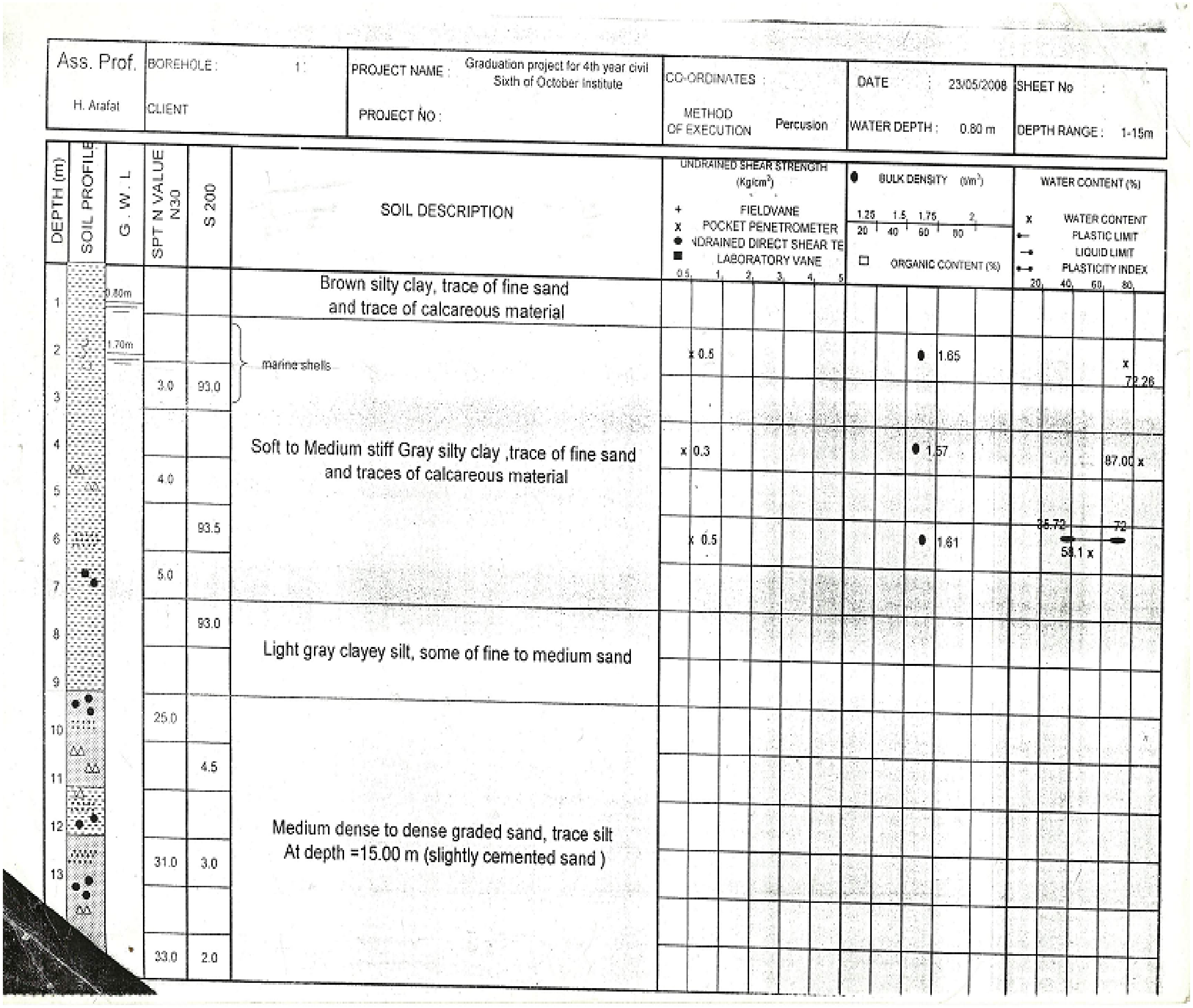
$L_{pile} \rightarrow$ pile length.

طول الخازوق.

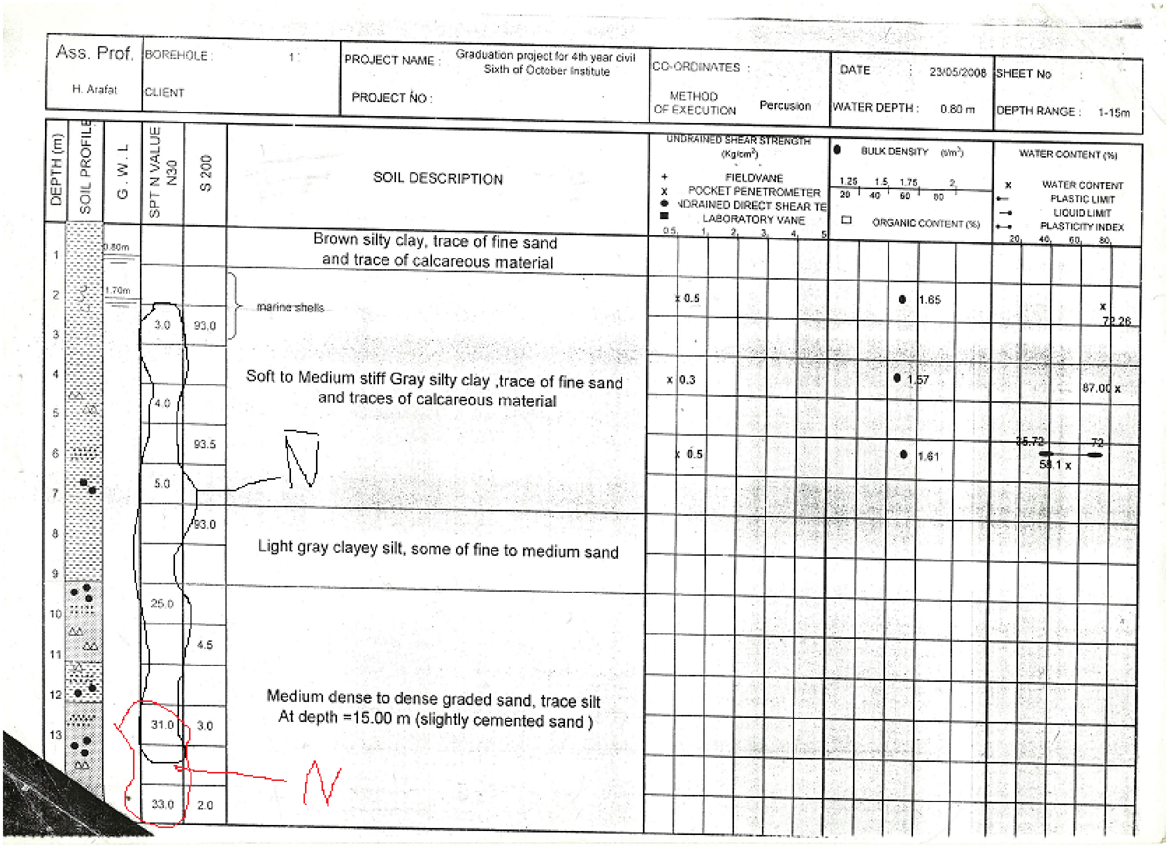
Example: 1

For the inspection of soil Design of piles

Use standard penetration test (S.P.T)



Solution



Assume:

$D_{pile} = 40$ cm

$L_{pile} = 12$ m

$$Q_{all} = 45 * N * \frac{\pi(Dpile)^2}{4} + \frac{\bar{N}}{3} * \pi * D_{pile} * L_{pile}$$

$$N = \frac{31+33}{2} = 32$$

$$\bar{N} = \frac{3+4+5+25+31}{5} = 13.6$$

$$Q_{all} = 45 * 32 * \frac{\pi(0.4)^2}{4} + \frac{13.6}{3} * \pi * 0.4 * 12 = 249.4 \text{ KN}$$

$Q_{all} = 25$ T

2) Bearing Capacity of piles:

Methods of Calculation Bearing Capacity of piles:

1) Static formula.

2) Dynamic formula.

3) Field tests.

4) Pile loading test.

سيتم دراسة الطريقة الأولي فقط.

1) Static formula:

For pure clay:

1) Compression:

الخوازيق المعرضة لأحمال ضغط:

$Q_{ult} = C * N_C * \frac{\pi(D)^2}{4} + C_a * \pi * d * L$

$Q_{all} = \frac{Qult}{F.O.S}$

End Bearing = $C * N_C * \frac{\pi(D)^2}{4}$

Friction = $C_a * \pi * d * L$

حيث أن:

$Q_{ult} \rightarrow$

قدرة تحمل الخازوق.

$Q_{all} \rightarrow$

حمل الآمان للخازوق.

C →Cohesion of soil at pile tip.

متوسط تماسك التربة حول الطرف السفلي للخازوق.

d → pile diameter.

قطر الحازوق.

L → pile length.

طول الخازوق.

F.O.S → Factor of Safety.

معامل الأمان.

F.O.S = 3 if (D.L+L.L)

F.O.S = 2.5 if (D.L+L.L+WIND+EAETHQUAKE)

$N_C \rightarrow$ Bearing capacity factor (6→9)

معامل قدرة التحميل.

N_C = 6 if d > 100 cm

N_C = 7 if 50 < d < 100 cm

N_C = 9 if d < 50 cm

$C_a \rightarrow$ adhesion

متوسط إلتصاق التربة علي سطح الخازوق.

$C_a = \frac{2}{3} * C$

OR

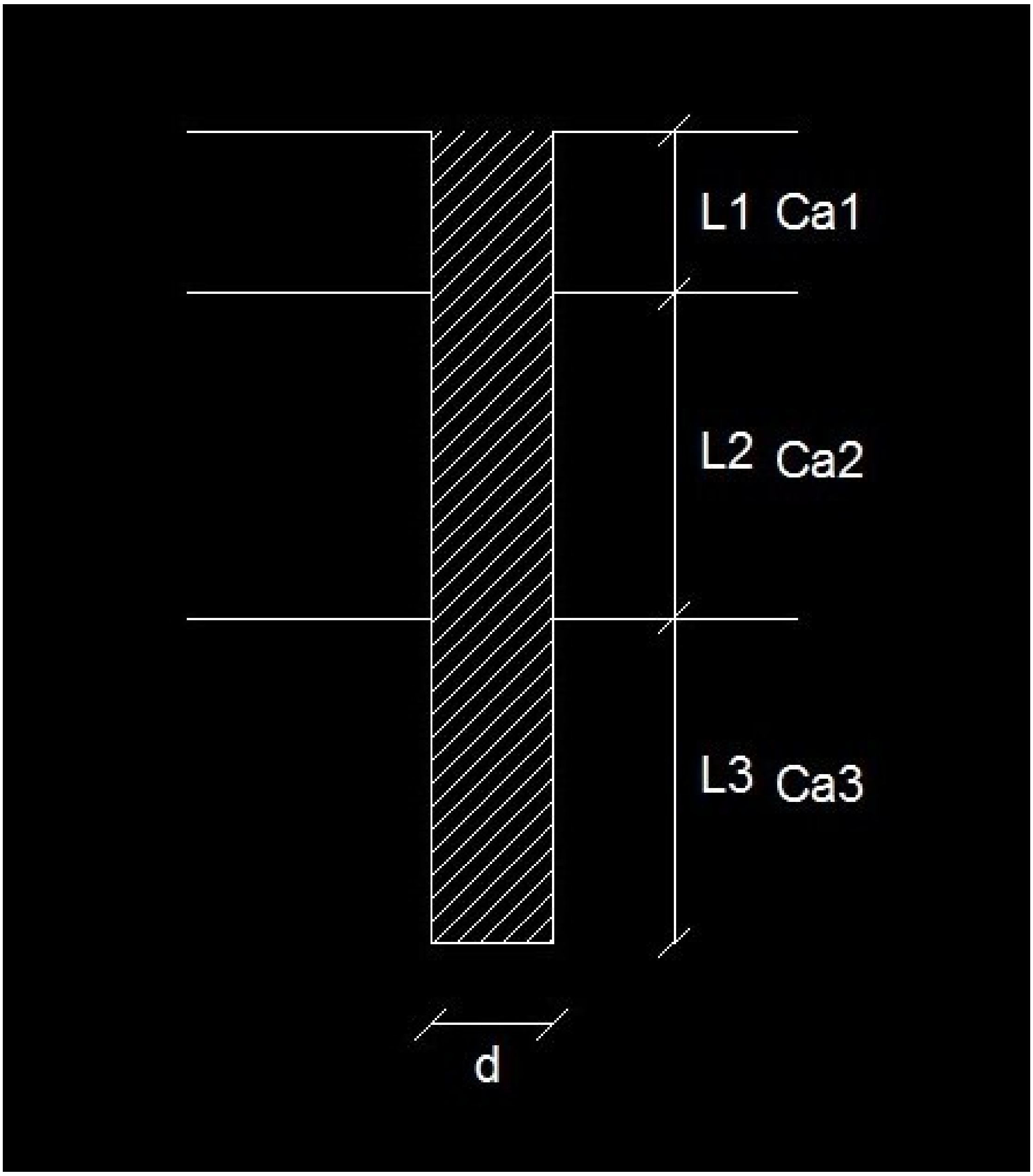
C_a = 0.3 – 0.4 (C_u) Cu ≤ 100 kPa For bored piles.

C_a = 0.6 – 0.8 (C_u) For driven piles.

OR

For driven Piles Ca could be directly taken as mentioned in the following table:

Pile Type	Cohesion C_u (kN/m^2)	Adhesion Ca (kN/m2)
Timber or concrete	0-12.5	0-12.5
	12.5-25	12.5-24
	25-50	24-37.5
	50-100	37.5-47.5
	100-200	47.5-65
Steel	0-12.5	0-12.5
	12.5-25	12.5-23
	25-50	23-35
	50-100	35-36



في حالة وجود عدد من الطبقات نضرب C_a لكل طبقة *
طول الخازوق في هذه الطبقة:

$C_{a1} * L_1 + C_{a2} * L_2 + C_{a3} * L_3$

2) Tension:

الخوازيق المعرضة لأحمال الشد:

$T_{ult} = C_a * \pi * d * L + W_p$

$T_{all} = \frac{tult}{F.O.S}$

حيث أن:

$T_{ult} \rightarrow$

أقصي حمل شد يتحمله الخازوق.

$T_{all} \rightarrow$

حمل الشد الآمان الذي يتحمله للخازوق.

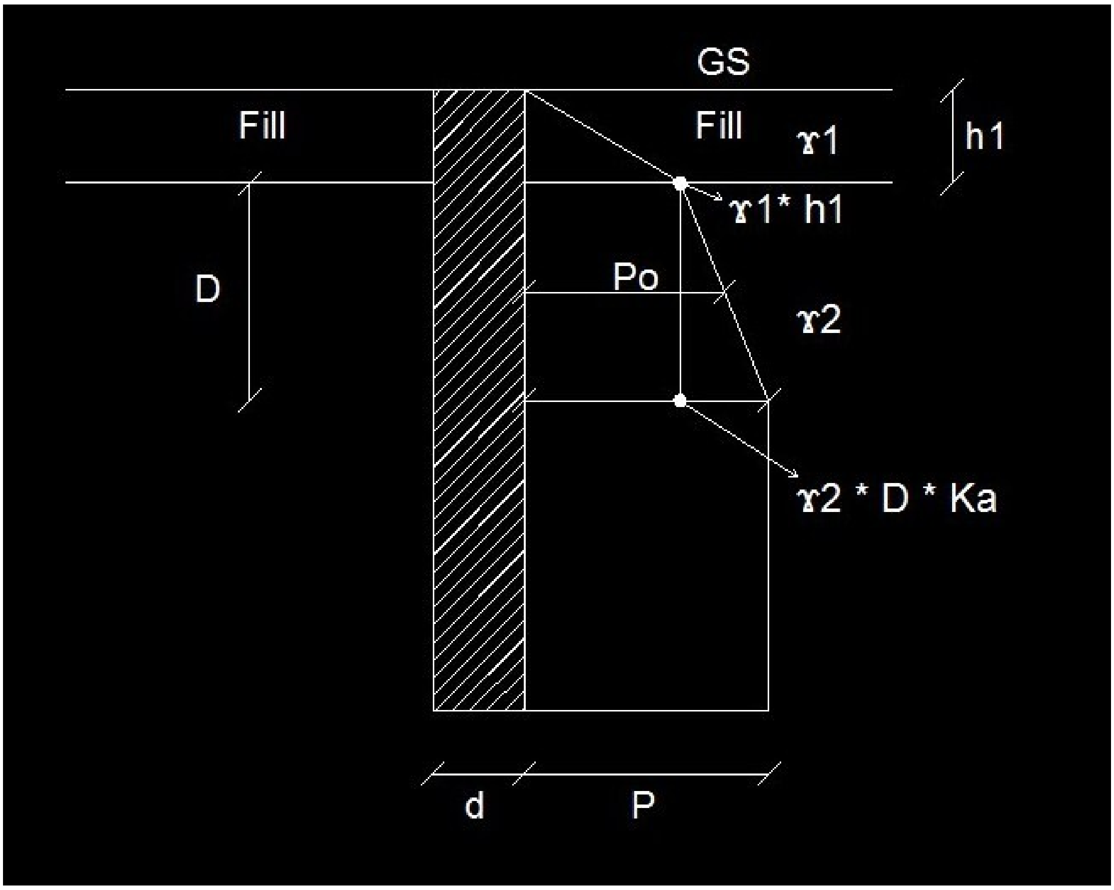
$W_p \rightarrow$ Weight of pile.

وزن الخازوق.

$W_p = \frac{\pi * (d^2)}{4} * L * Ɣ_c$

$Ɣ_c = 2.5$

For Cohesion Less Soil (Sand):



1) Compression:

الخوازيق المعرضة لأحمال ضغط:

$Q_{ult} = P * N_q * \frac{\pi * (d^2)}{4} + K_{HC} * P_o * \tan\delta * \pi * d * L$

$Q_{all} = \frac{Qult}{F.O.S}$

End Bearing = $P * N_q * \frac{\pi * (d^2)}{4}$

Friction = $K_{HC} * P_o * \tan\delta * \pi * d * L$

حيث أن:

$D = 20*d$

العمق الذي يظل بعده الضغط الجانبي ثابت ولا يزيد.

$P = \gamma_1 * h_1 + \gamma_2 * h_2$

$P \rightarrow$

الضغط الجانبي علي عمق D من سطح طبقة الرمل.

$K_a = \frac{1-\sin\emptyset}{1+\sin\emptyset}$

$N_q \rightarrow$ Bearing capacity factor function of ν

معامل قدرة التحميل.

To get N_q from table:

ν	25	30	35	40	
Displacement pile	15	30	75	150	Nq
Bored pile	7	15	37	75	

If $\nu = 0$, $N_q = 0$

$\nu^* = \nu - 3^o$ (For bored piles)

$\nu^* = \frac{\nu + 40^o}{2}$ (For driven piles)

$K_{HC} \rightarrow$ Coefficient of lateral pressure.

$K_{HC} = 0.7 \rightarrow 1.5$ (For bored piles) Take = 1

K_{HC} = 1→ 1.5 (For driven piles) Take = 1.5

قيم المعاملات (K_{HC}) & (K_{Ht}) طبقا للكود المصرى :

K_{Ht}	K_{HC}	نوع الخازوق
0.50 – 0.30	1.0 - 0.50	خازوق ذو قطاع H
1.0 – 0.6	1.5 - 1.0	خازوق إزاحة
1.3 – 1.0	2.0 – 1.5	خازوق إزاحة متغير القطاع
0.6 – 0.3	0.9 – 0.4	خازوق إزاحة باستخدام النفاثات
1.0 – 0.4	1.5 – 0.7	خازوق تثقيب اعتيادى (قطر أقل من 0.60 متر)

P_o →

متوسط قيمة الضغط الجانبي خلال الطول.

δ → Pile-Soil friction angle

زاوية الاحتكاك بين الخازوق و التربة.

$\delta = \frac{3}{4} * \nu$ (for concrete and timber pile).

$\delta = 20^{o}$ (for steel pile).

2) Tension:

الخوازيق المعرضة لأحمال الشد:

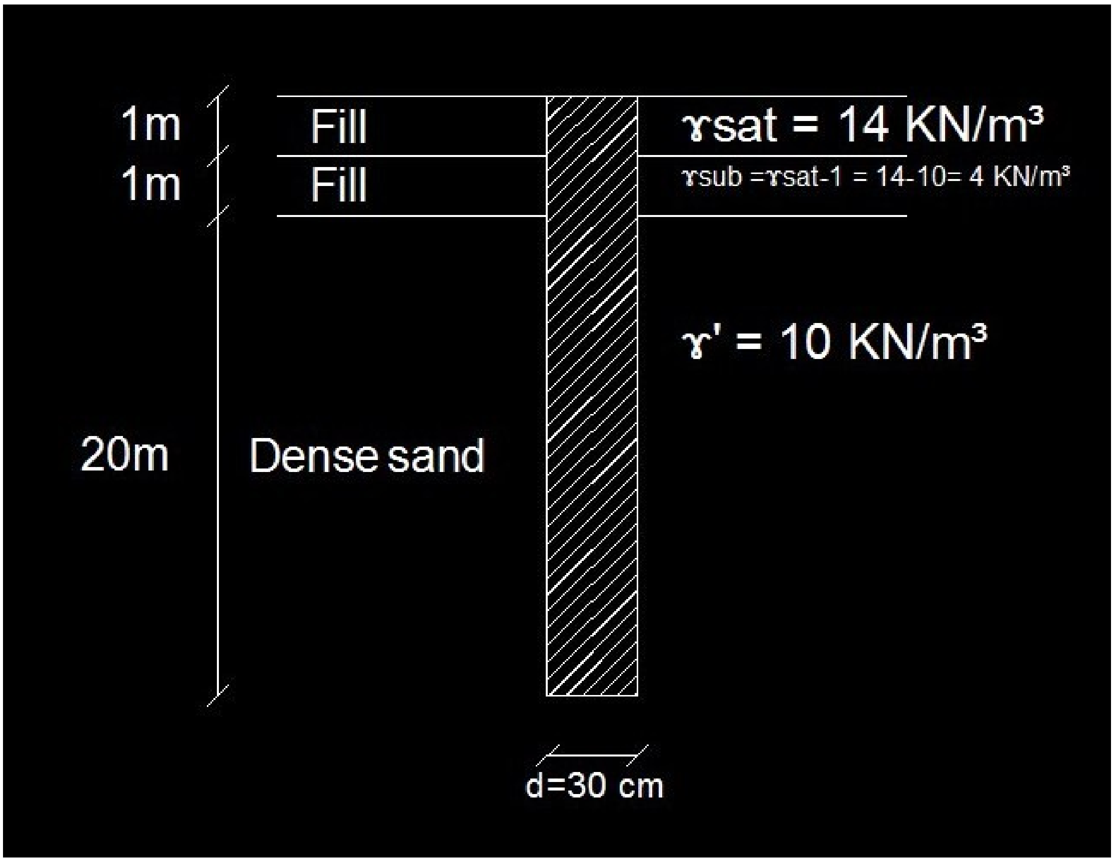
$T_{ult} = K_{Ht} * P_o * \tan\delta * \pi * d + W_p$

$T_{all} = \frac{tult}{F.O.S}$

Example: 2

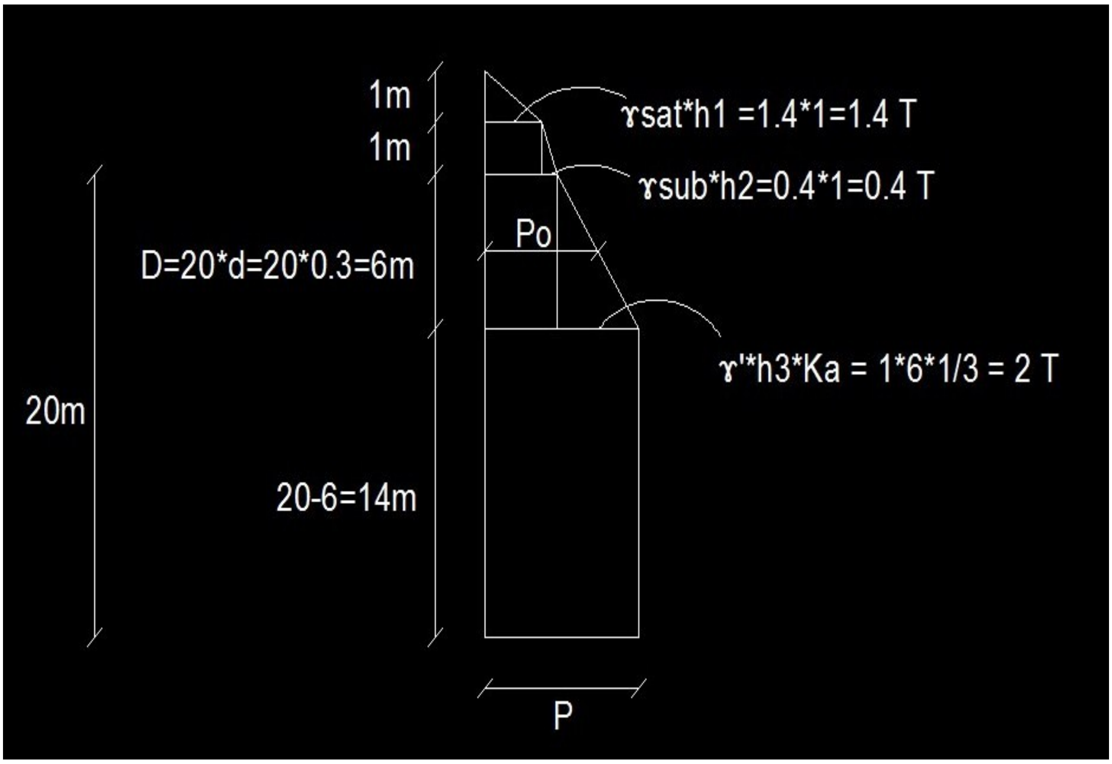
Given : $\nu = 30^{o}$, d= 30 cm , $K_{Ht} = 1$, $K_{Hc} = 1.5$, F.O.S = 3

Req : Determine the allowable Max Load for Driven pile shown in case of Compression & Tension .



Solution

$$100\ kN / m^2 = 10\ t / m^2 = 1\ kg / cm^2$$



For Cohesion Less Soil (Sand):

D = L*d = 20*0.3 = 6 m

1) Compression:

$Q_{ult} = P*N_q*\frac{\pi*(d^2)}{4} + K_{HC}*P_o*\tan\delta * \pi * d * L$

$K_a = \frac{1-\sin\emptyset}{1+\sin\emptyset} = \frac{1-\sin 30}{1+\sin 30} = 0.33$

$\delta = \frac{3}{4} * \nu = \frac{3}{4} * 30 = 22.5$

$\nu = 30^o \rightarrow N_q = 30$ from table

P = 1.4 + 0.4 + 2 = 3.8 T

$P_{o1} = (\frac{1.4 + 0.4 + 3.8}{2}) * 6 = 16.8$ T

$P_{o2} = 3.8*14 = 47.6$ T

$P_{To} = 47.6 + 16.8 = 64.4$ T

تم ضرب قيمة ال P_o في الطول L لكل جزء فلا يتم وضع قيمة الطول L في المعادلة.

$Q_{ult} = 3.8*30*\frac{\pi*(0.3)^2}{4} + 1.5*64.4*\tan 22.5*\pi*0.3$

$= 45.77$ Ton

$Q_{all} = \frac{Qult}{F.O.S} = \frac{45.77}{3} = 15.26$ Ton

2) Tension:

$T_{ult} = K_{Ht} * P_o * \tan\delta * \pi * d + W_p$

$= 1*64.4**\tan 22.5*\pi*0.3 + 3.89 = 29$ Ton

$K_{Ht} = 1$, $L = 22$

$W_p = \frac{\pi*(d^2)}{4} * L * \gamma_c$

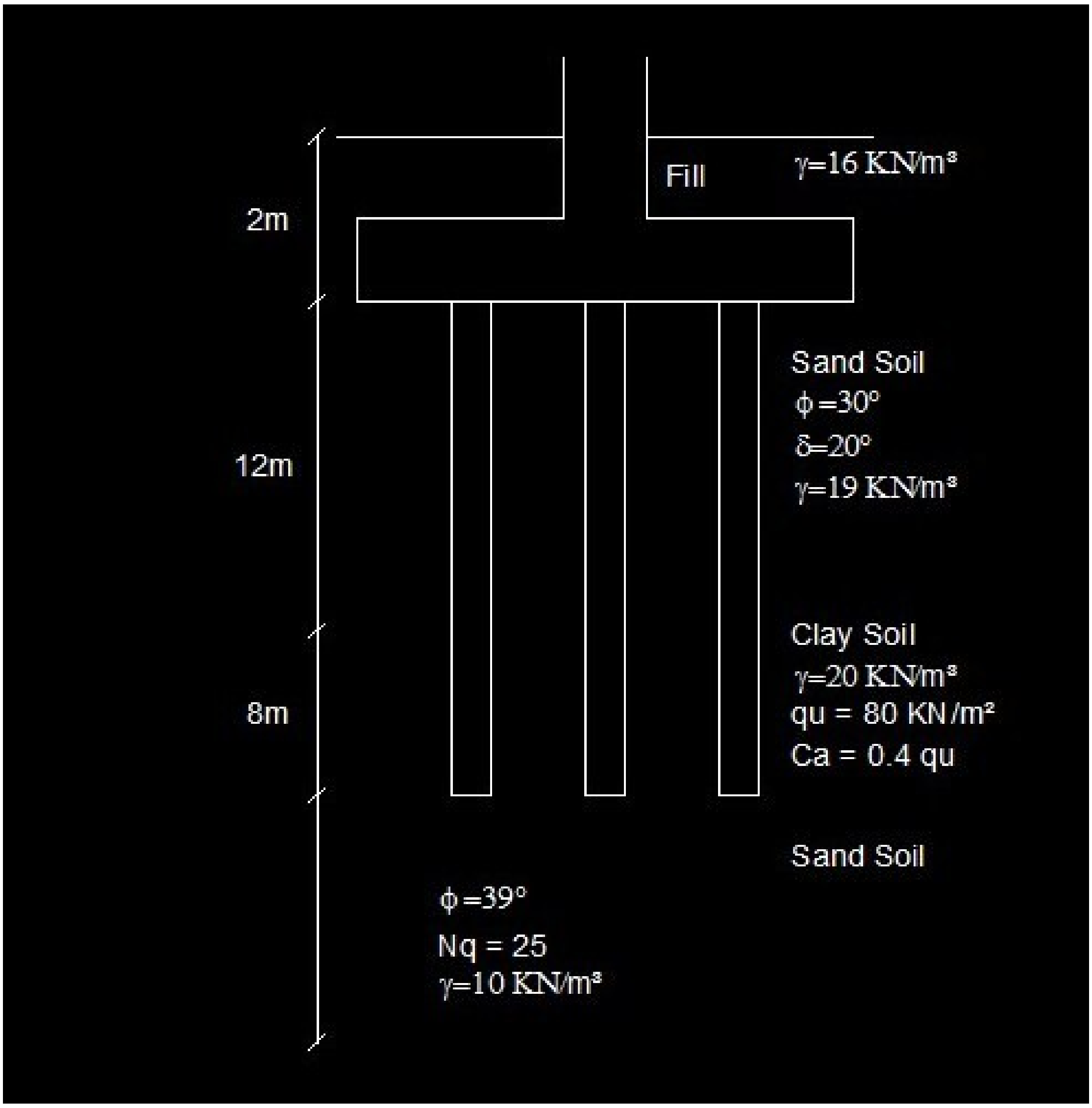
$W_p = \frac{\pi*(0.3)^2}{4} * 22 * 2.5 = 3.89$

$T_{all} = \frac{tult}{F.O.S} = \frac{29}{3} = 9.67$ Ton

Example: 3

Given : d= 40 cm , K_{Ht} = 1 , K_{Hc} = 1 , F.O.S = 3 , No. of piles = 12

Req : Determine the safe Load capacity of the pile group.



Solution

For Clay Soil:

∵ Pile Rested on Sand Soil:

∴ end Bearing = 0

$Q_{ult(1)} = C_a * \pi * d*L$

$C_a = 0.4* q_u = 0.4 * 80 = 32\ KN/m^2$

$Q_{ult(1)} = 32* \pi * 0.4*8 = 321.7\ KN$

For Sand Soil:

Sand (1):

طبقة الرمل العلوية:

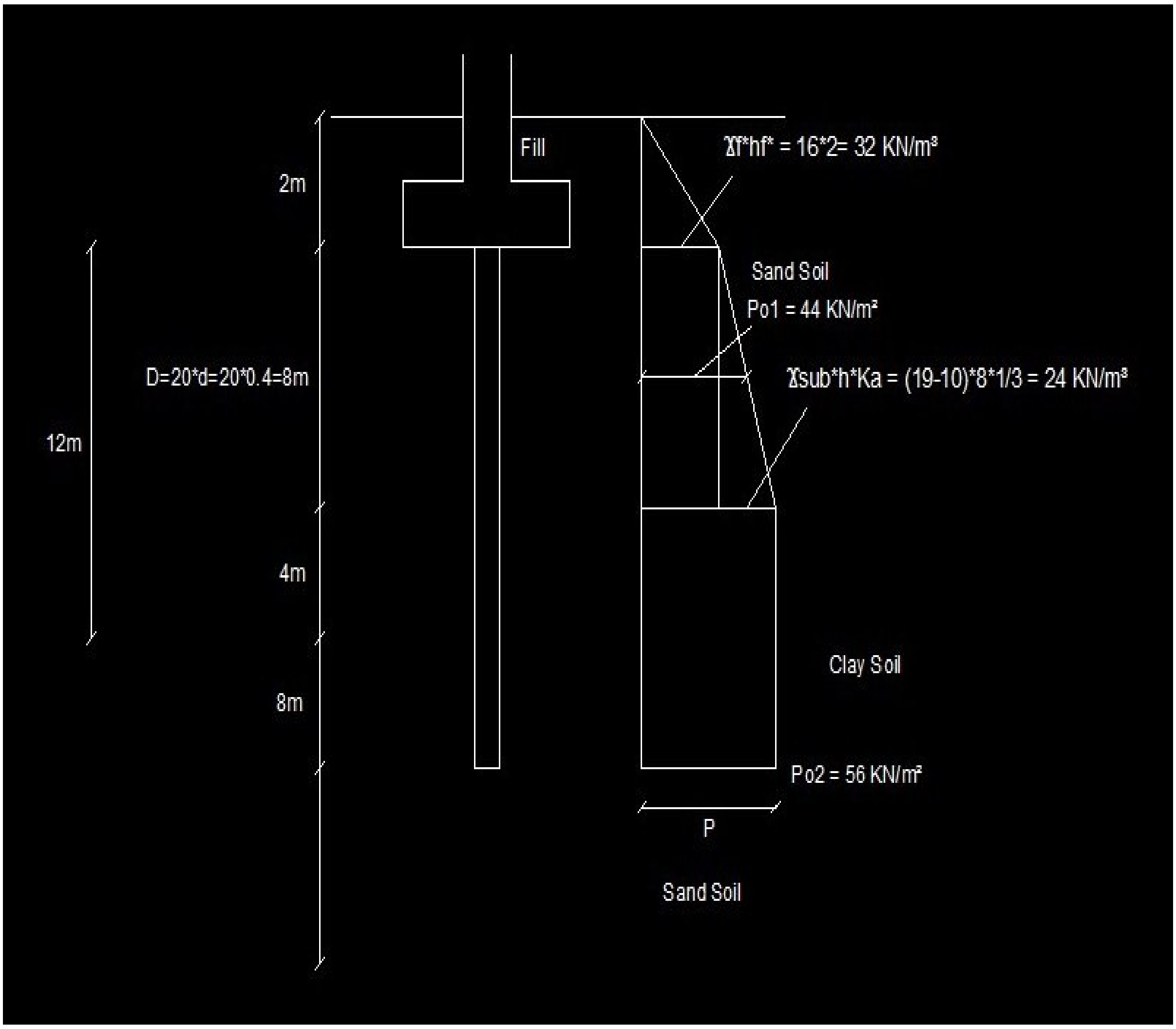
Friction only:

D = L*d = 20*0.4 = 8 m

$Q_{ult} = K_{HC} *P_o *\tan\delta * \pi * d * L$

$K_a = \frac{1-\sin \emptyset}{1+\sin \emptyset} = \frac{1-\sin 30}{1+\sin 30} = 0.33 = 1/3$

$\gamma_{sub} = \gamma - \gamma_w = 19 - 10 = 9\ KN/m^3$



$P_{o1} = \frac{32+56}{2} = 44\ KN/m^2$

$P_{o2} = 56\ KN/m^2$

$Q_{ult(2)} = 1*\{(8*44)+(4*56)\}*\tan 20*\pi*0.4$

$= 263.45\ KN$

Sand (2):

طبقة الرمل السفلية:

End Bearing only:

$Q_{ult(3)} = P*N_q*\frac{\pi*(d^2)}{4}$

$Q_{ult(3)} = 56*25*\frac{\pi*(0.4)^2}{4} = 176\ KN$

$Q_{ult(TOTAL)} = Q_{ult(1)} + Q_{ult(2)} + Q_{ult(3)}$

$=321.7 + 263.45 + 176 =761.15\ KN$

$Q_{all} = \frac{Qult}{F.O.S} = \frac{761.15}{3} = 253.72\ KN$

$Q_{all(group)} =$ No. of piles * $Q_{all} = 12*253.72$

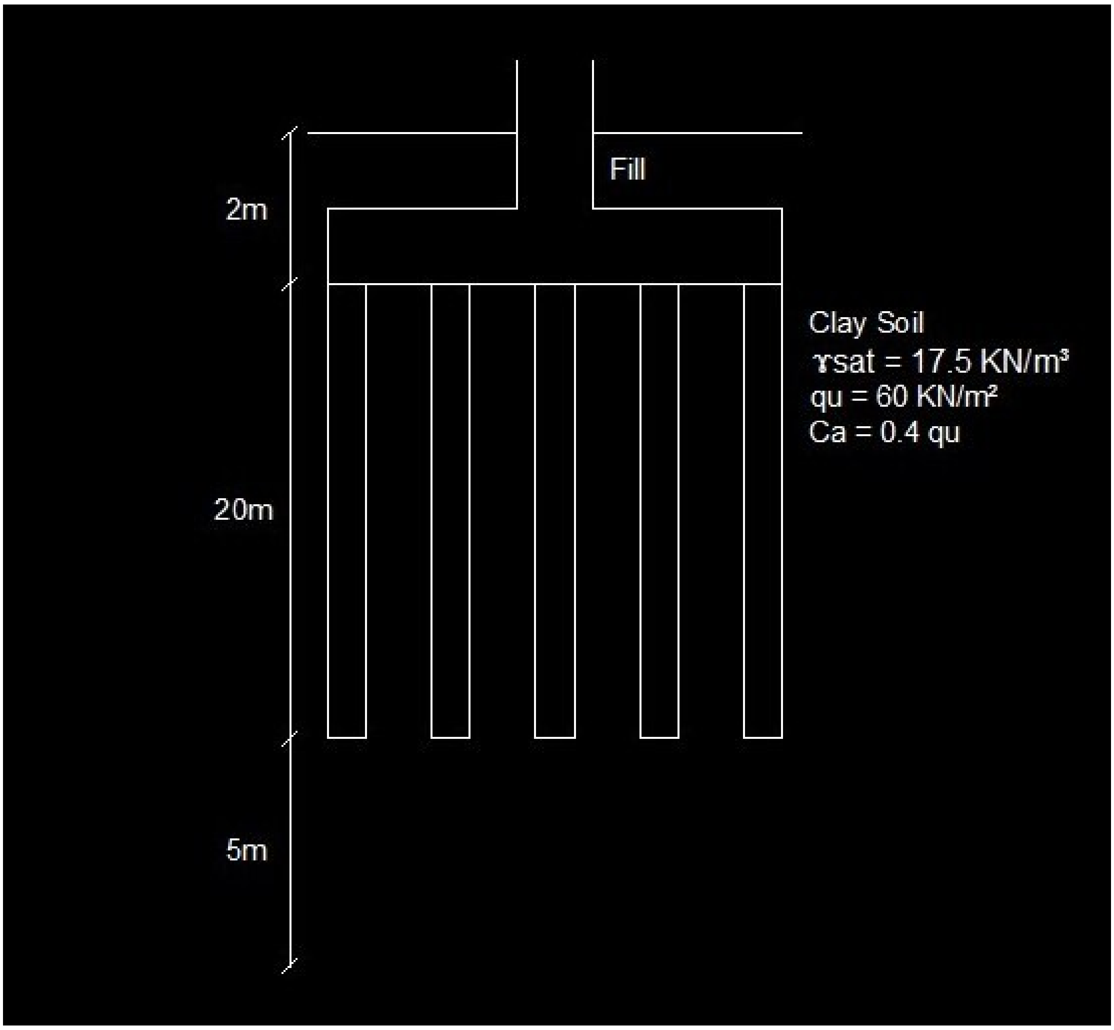
$= 3044.64\ KN = 304.46\ Ton$

Example: 4

Given : d= 40 cm , F.O.S = 3 , No. of piles = 16 ,

Friction pile.

Req : Determine the safe Load capacity of the pile group.



Solution

For Clay Soil:

∵ Pile Friction:

∴ end Bearing = 0

$Q_{ult(F)} = C_a * \pi * d*L$

$C_a = 0.4* q_u = 0.4 * 60 = 24\ KN/m^2$

$Q_{ult(F)} = 24* \pi *0.4*20 = 603.2\ KN = 60.3\ Ton$

$Q_{all} = \frac{Qult}{F.O.S} = \frac{603.2}{3} = 201.1\ KN$

$Q_{all(group)} = \text{No. of piles} * Q_{all} = 16*201.1$

$= 3217.1\ KN = 321.7\ Ton$

3) Determination piles settlement:

For settlement of a single pile is considered to be the sum of three components:

هبوط الخازوق المفرد: يتم حسابه باعتبار هبوط الخازوق عند طرفة العلوي هو حاصل جمع ثلاثة مقادير هي:

1. The elastic compression of pile shaft (S_s):

   الهبوط نتيجة لانفعال جذع الخازوق تحت إجهادات التحميل:

2. The settlement caused by load transferred at the pile tip (S_{pp}):

   الهبوط نتيجة لإنتقال حمل الارتكاز Q_b إلي التربة S_{pp}.

3. The settlement caused by load transferred along the pile shaft (S_{ps}):

   هبوط الخازوق نتيجة لإنتقال حمل الاحتكاك Q_f من جذع الخازوق إلي التربة S_{ps}.

The total settlement is then equal to:

$$S_o = S_s + S_{pp} + S_{ps}$$

1.The elastic compression of pile shaft (Ss) :

$$S_s = (Q_b + \alpha_f * Q_f) * \frac{L}{A * Ep}$$

In which:

حيث أن:

Qb → Bearing load at pile tip.

حمل الإرتكاز المنقول للتربة عند طرف الخازوق السفلي.

Qf → Friction load transmitted by pile shaft.

حمل الإحتكاك المنقول للتربة عن طريقة جهود الإحتكاك علي سطح جذع الخازوق.

L →Pile length.

طول الخازوق.

A → Pile cross-sectional area.

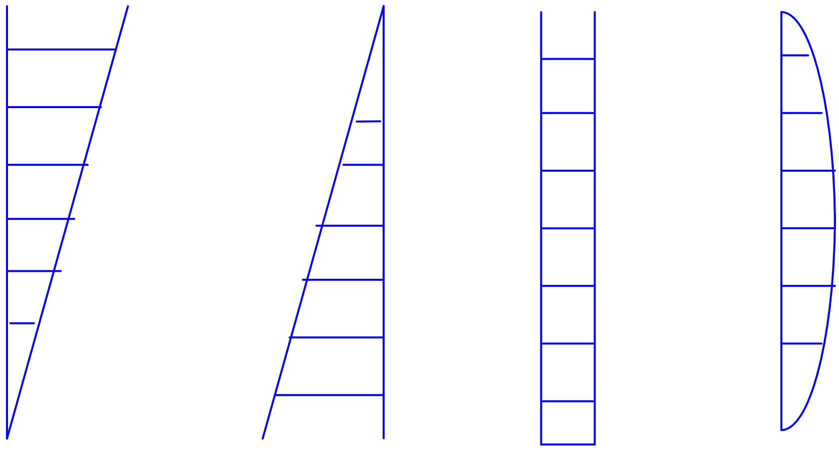
مساحة مقطع الخازوق.

E_p → Elastic modulus for pile material.

معامل المرونة لمادة الخازوق.

α_f → Skin friction distribution coefficient.

معامل يتوقف علي منحني توزيع جهود الإحتكاك علي إمتداد طول الخازوق.



$\alpha_f = 0.33$ $\alpha_f = 0.67$ $\alpha_f = 0.5$ $\alpha_f = 0.5$

Skin friction distribution Coefficient (α_f)

2- Settlement caused by load transferred at the pile tip (S_{pp}):

$$S_{pp} = \frac{C_b Q_b}{d.q}$$

In which:

C_b ⟶ Factor according to table 9.1.

معامل يعتمد علي نوعية التربة وعلي أسلوب تنفيذ الخازوق.

Q_b ⟶ Bearing load at pile tip.

حمل الإرتكاز المنقول للتربة عند طرف الخازوق السفلي.

d → pile diameter.

قطر الخازوق.

q → Ultimate end bearing capacity.

الجهد الأقصى لسعة التحميل عند نهاية الخازوق.

Bearing stratum under pile tip assumed to extend at least 10 pile diameters below tip and soil below tip is of comparable or higher stiffness.

ويشترط أن تكون طبقة ارتكاز الخازوق ممتدة تحت طرف الخازوق لمسافة تساوى عشرة أمثال قطره على الأقل وأن تكون الطبقات التى تليها ذات مقاومة تتساوى مع أو تزيد عن مقاومة الطبقات المنشأة بها الخوازيق.

Table 9.1 Values of C_b:

Soil Type	Driven piles	Bored Piles
Loose to dense sand	0.02-0.04	0.09-0.18
Soft to stiff clay	0.02-0.03	0.03-0.06
Loose to dense silt	0.03-0.05	0.09-0.12

3- Settlement caused by load transferred along the pile shaft (S_{ps}):

$$S_{ps} = \frac{C_s \, Q_f}{L_o \, . \, q}$$

In which:

حيث أن:

C_s → Factor from the following relation:

معامل.

$$C_s = (0.93 + 0.16\sqrt{\frac{L_o}{d}}).C_b$$

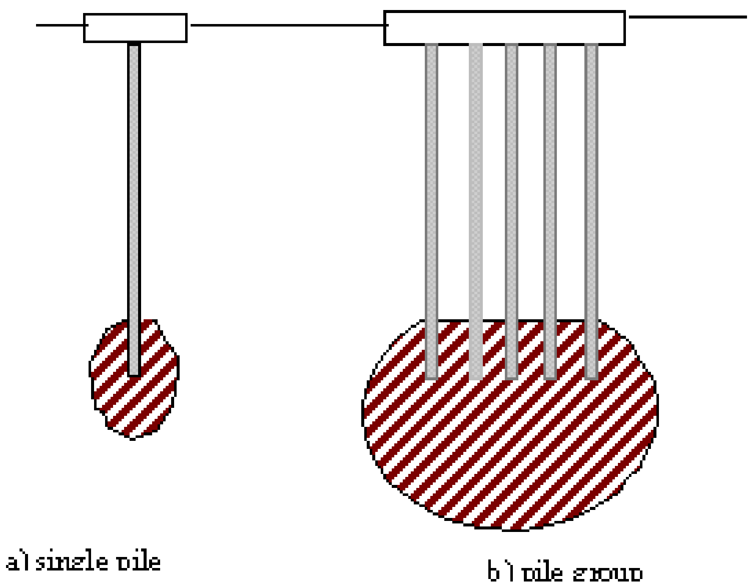
Lo → Embedded pile length.

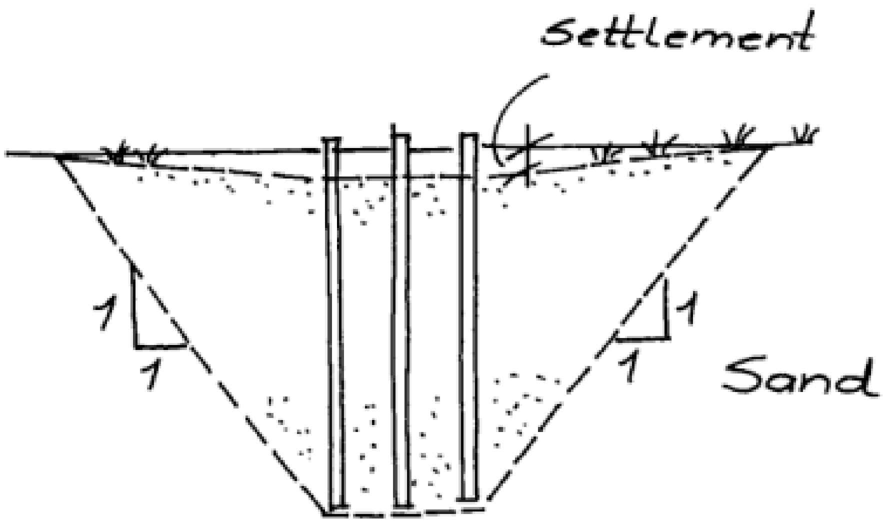
طول جذع الخازوق المدفون بالتربة.

q → Ultimate end bearing capacity.

الجهد الأقصى لسعة التحميل عند نهاية الخازوق.

Settlement of pile groups:





Settlement of pile groups according to Egyptian code:

$$S_g = S_o * \sqrt{\frac{b}{d}}$$

In which:

حيث أن:

b → pile group width.

المقياس الأدنى (الطول الأصغر) لمجموعة الخوازيق بالمسقط الأفقي.

d → pile diameter.

قطر الخازوق.

So → Single pile settlement estimated or determined from load tests.

مقدار هبوط الخازوق المفرد مقدر من الصيغة السابق ذكرها أو المحددة من تجارب التحميل.

Example: 5

Given : d= 80 cm , L= 25 m , Qall = 200 Ton ,

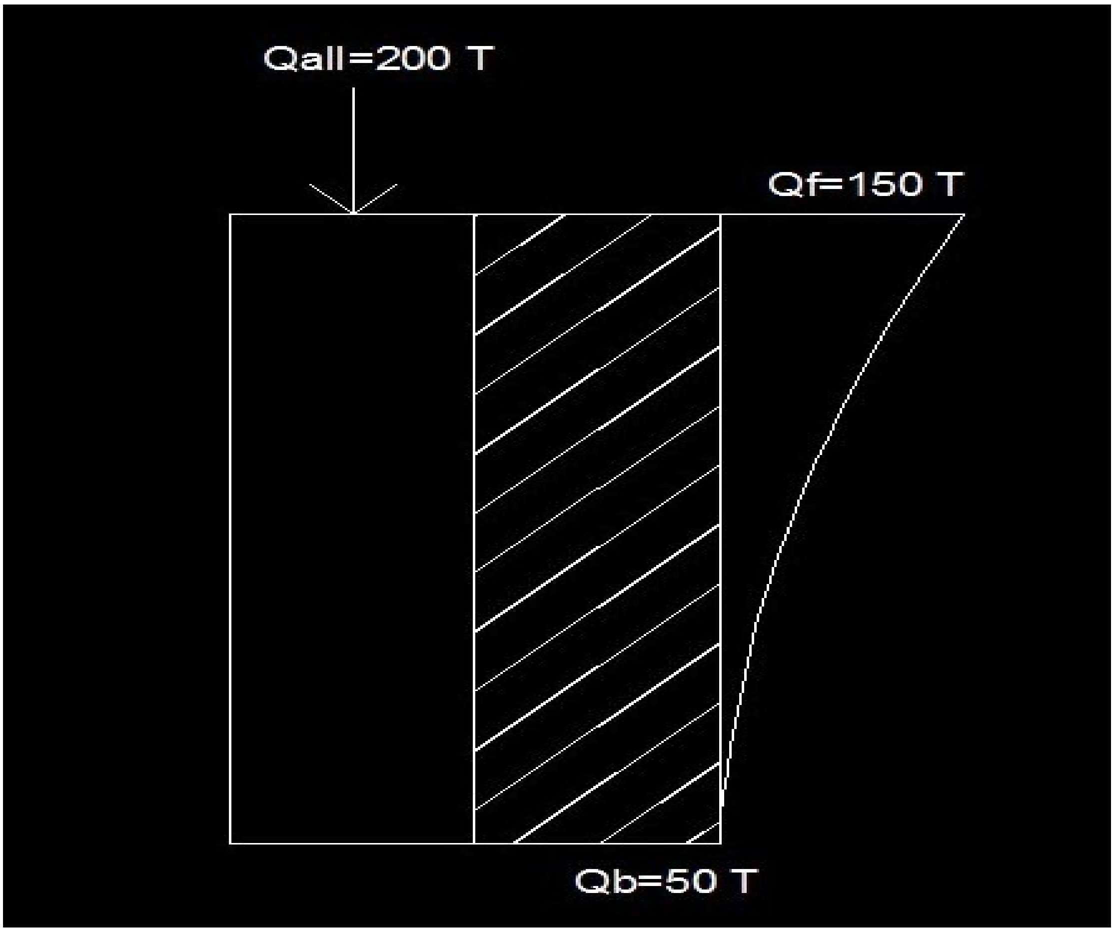
E_p = 2000000 t/m^2 , b = 5.6 m , Soil Type is Loose to dense sand , Bored Piles

Req : Determine the settlement of a single pile & the Settlement of pile groups.

Solution

For settlement of a single pile:

$$S_o = S_s + S_{pp} + S_{ps}$$



$S_s = (Q_b + \alpha_f * Q_f) * \frac{L}{A * Ep}$

$A = \frac{\pi * (d)^2}{4} = \frac{\pi * (0.8)^2}{4} = 0.5$ m

$\alpha_f = 0.5$ from chart

$S_s = (50 + 0.5 * 150) * \frac{25}{0.5 * 2000000} = 0.00313$ m

$S_{pp} = \frac{Cb * Qb}{d * q}$

d = 0.8 m , $Q_b = 0$ T

$C_b = 0.09$ From table

$q = \frac{Qb}{A} = \frac{0}{0.5} = 0$

$S_{pp} = \frac{0.09 * 0}{0.8 * 0} = 0$

$S_{ps} = \frac{Cs * Qf}{Lo * q}$

$C_s = (0.93 + 0.16 \sqrt{\frac{Lo}{d}}) * C_b$

$L_o = 18$ m , d = 0.8 , $C_b = 0.09$, q = 300

$C_s = (0.93 + 0.16 * \sqrt{\frac{18}{0.8}}) * 0.09 = 0.15$

$S_{ps} = \frac{0.15*150}{18*300} = 0.0042$ m

$S_o = S_s + S_{pp} + S_{ps}$

$= 0.00313 + 0 + 0.0042 = 0.0073$ m

For Settlement of pile groups:

$S_G = S_o \sqrt{\frac{b}{d}} = 0.0073 * \sqrt{\frac{5.6}{0.8}} = 0.02$ m

4) Short and Long pile:

Elastic versus rigid behavior:

$$T = \sqrt[5]{\frac{E*I}{\eta}}$$

حيث أن:

T ⟶ relative stiffness factor

E ⟶ modulus of elasticity of pile

I ⟶ pile inertia

$$I = \frac{\pi*(D)^4}{64}$$

η for clayey or silty soil:

q_{un} (KN/m^2)	25	50	100
η(KN/m^3)	600	1600	3700

η for sand soil:

Relative Density (Dr)	35	65	85	100
η(KN/m^3)	4300	12300	18000	22200

For submerged soil ''η'' is reduced to half the above values. Besides, ''η'' must be reduced to 0.25 the above values if pile spacing in the direction of loading is three times the pile diameter (3D), no reduced if spacing = 8D, values for another spacing values shall be calculated by interpolation.

If $\frac{L}{T} < 2 \rightarrow$ the pile is considered short rigid pile

If $\frac{L}{T} > 4 \rightarrow$ the pile is considered long flexible pile

حيث أن:

L → pile length (embedded length)

For Short Rigid Piles:

1) Fixed headed piles:

1.1.) Piles in sandy soil:

$P_u = 1.5*\gamma*L^2*D*K_P$

حيث أن:

γ → effective unit weight

$\gamma = \gamma_{sub}$ under water

L → pile length

D → pile diameter

K_P → passive coefficient

To get K_P from chart

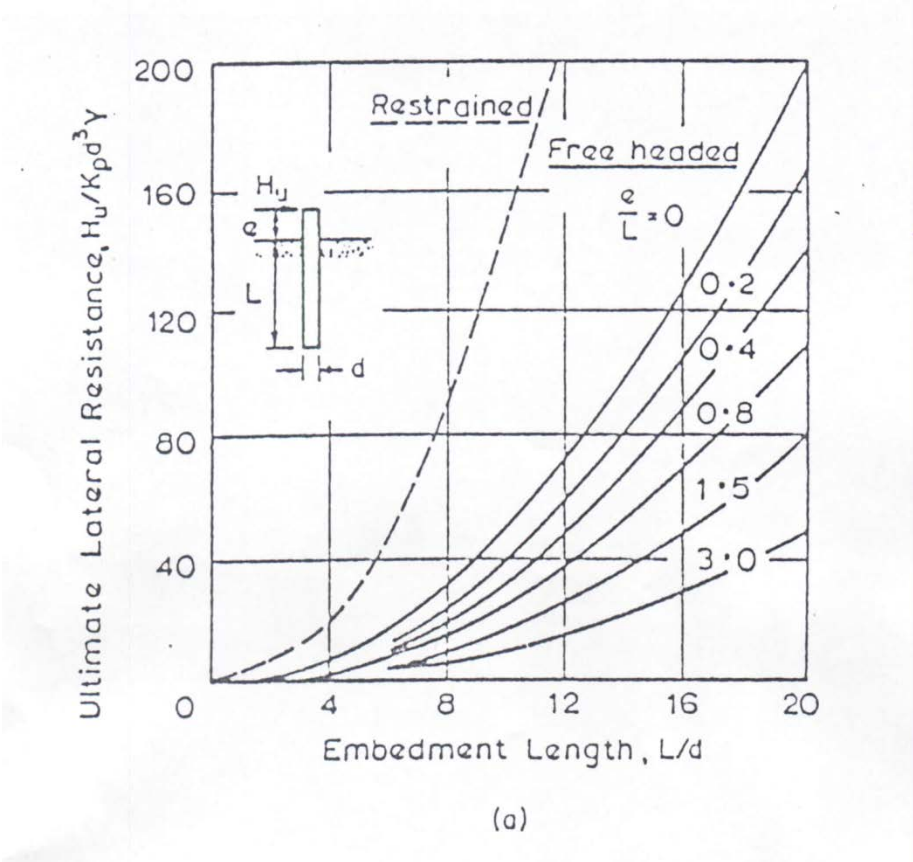


Fig. (2-a) Ultimate lateral resistance of short piles in cohesionless soils (after Broms, 1964)

1.2.) piles in clay soil:

$P_u = 9*c_u*D*(L-1.5*D)$

حيث أن:

c_u → undrained shear strength of soil

2) Free headed piles:

2.1.) Piles in sandy soil:

$$P_u = \frac{0.5*D*(L)^3*Kp*\gamma}{H+L}$$

حيث أن:

L ⟶ is the embedded length of pile

H ⟶

سمك الردم

Take H=2m

2.2.) piles in clay soil:

$$P_u = \frac{(Lo)^2-2*L'*Lo+(0.5*(L')^2)}{L+H+(1.5*D)} * 9 * Cu * D$$

حيث أن:

$L' = L - 1.5*D$

$$L_o = \frac{(H+\frac{2}{3}*L)}{2*H+L} * L$$

For Long Flexible Pile

1) Fixed headed piles:

1.1.) Piles in sandy soil:

$$P_u = \frac{2*\text{Mult resisting}}{H+\{0.54*\left(\frac{Pu}{(Ɣ'*D*Kp)}\right)\}}$$

حيث أن:

M_{ult} → is the moment of resisting of the pile section including its reinforcement.

1.2.) piles in cohesive soil:

$$P_u = \frac{2*\text{Mult resisting}}{H+\{1.5*\left(\frac{Pu}{(9*Cu*D)}\right)\}}$$

The maximum induced ultimate moment in pile = $0.85*P_u*\eta$

The maximum deflection at pile top

$$= 0.88*P_{service} * \frac{(T)^3}{E*I}$$

2) Free headed piles:

2.1.) Piles in sandy soil:

$P_u = \frac{\text{Mult resisting}}{H+\{0.54*\left(\frac{Pu}{(\gamma' * D * Kp)}\right)\}}$

حيث أن:

$M_{ult} \rightarrow$ is the moment of resisting of the pile section including its reinforcement.

2.2.) piles in cohesive soil:

$P_u = \frac{\text{Mult resisting}}{H+\{1.5*\left(\frac{Pu}{(9*Cu*D)}\right)\}}$

The maximum induced ultimate moment in pile = 0.77*(P_u *η+M_{OU})

The maximum deflection at pile top

$= 2.4*\frac{\text{Pservice}*(\eta)^3}{E*I} + \frac{1.55*Mo*(\eta)^2}{E*I}$

حيث أن:

$M_o \rightarrow$ is any induced acting moment on the free pile head

$P_u = \frac{\text{Rection}}{\text{no.of pile}}$

Reaction = $\sqrt{(Fx)^2 + (Fy)^2}$

From INTERACTION Diagrams:

K = $\frac{\mathrm{Mu}}{\mathrm{Fcu}*(\mathrm{R})^3}$

Get ρ

A_s = $\boldsymbol{\rho} * (fcu * 10^{-4}) * \pi * (R)^2$

حيث أن:

R $\rightarrow$

نصف قطر الخازوق

Example: 5

Given : D= 80 cm , L= 25 m , E_p = 2000000 t/m^2 , piles in clay soil , q_{un} = 50 KN/m^2 , C_u = 5 t/m^2 , F_x = 327.7 ,

F_y = 73.34 , No. of piles = 11 ,

F_{cu} = 30 N/mm^2 , Pile Rested in cohesive soil

Req : Determine the pile is Short or Long pile.

Solution

$$T = \sqrt[5]{\frac{E*I}{\eta}}$$

$$I = \frac{\pi*(D)^4}{64} = \frac{\pi*(0.8)^4}{64} = 0.02 \text{ m}^4$$

for clayey soil:

$$\eta = 1600 = 1600/2 = 800 \text{ KN/m}^3 = 80 \text{ t/m}^3$$

$$T = \sqrt[5]{\frac{2000000*0.03}{80}} = 3.47 \text{ m}$$

$$L = 25 - 2 = 23 \text{ m}$$

$$\frac{L}{T} = \frac{23}{3.47} = 6.63 > 4$$

∴ the pile is considered long flexible pile

For long flexible pile (Fixed headed)

$P_u = \frac{2*\text{Mult resisting}}{H+\{1.5*\left(\frac{Pu}{(9*Cu*D)}\right)\}}$

Take H = 3

$C_u = 5\ t/m^2$

$P_u = \frac{\text{Rection}}{\text{no.of pile}}$

Reaction = $\sqrt{(Fx)^2 + (Fy)^2}$

$= \sqrt{(327.7)^2 + (73.34)^2}$ = 336 T

$P_u = \frac{336}{11}$ = 30.55 T

$30.55 = \frac{2*\text{Mult}}{3+\{1.5*\left(\frac{30.55}{(9*5*0.8)}\right)\}}$

$2M_{ult}$ = 130.54

M_{ult} = 65.27 m.t

From INTERACTION Diagrams:

$K = \frac{Mu}{Fcu*(R)^3} = \frac{65.27*10^7}{30*(400)^3}$ = 0.34

ρ = 4

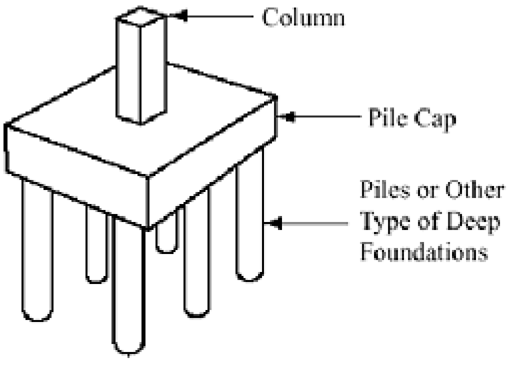
A_s = $\boldsymbol{\rho} * (fcu * 10^{-4})*\pi*(R)^2$

= $\mathbf{4} * (30 * 10^{-4})*\pi *(40)^2$

= 60.32 cm

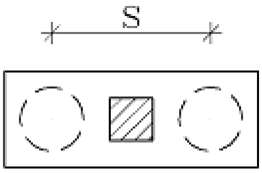
Use 20 y 25

5) Design of piles cap:

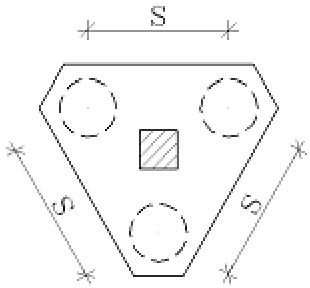


Pile caps are thick slabs used to tie a group of piles together to support and transmit column loads to the piles.

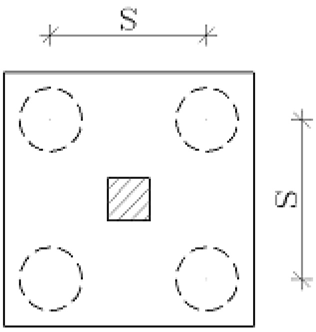
Typical Arrangement of Piles:



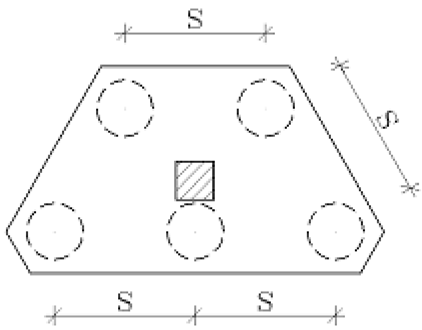
2 Piles



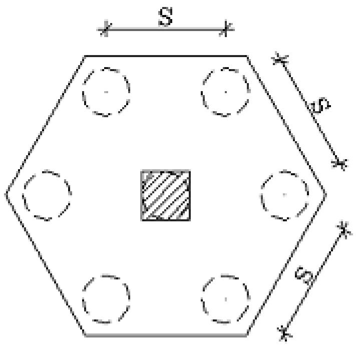
3 Piles

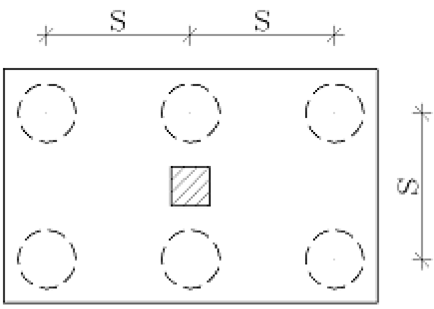


4 Piles

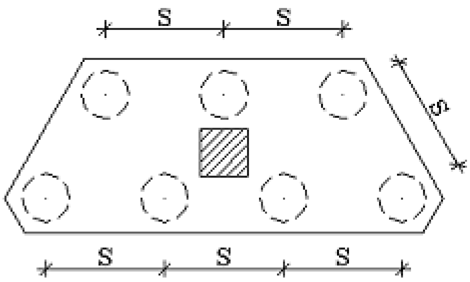


5 Piles

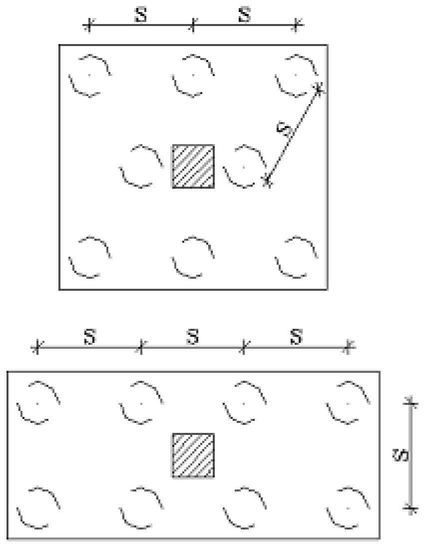




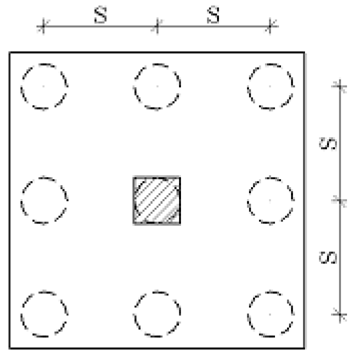
6 Piles



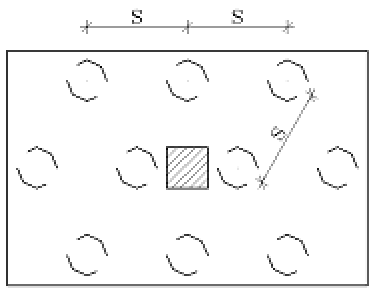
7 Piles



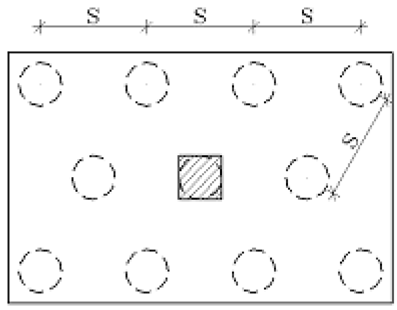
8 Piles



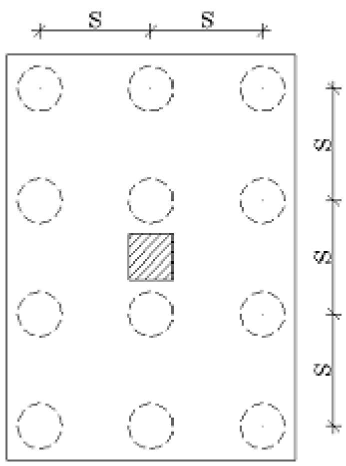
9 Piles



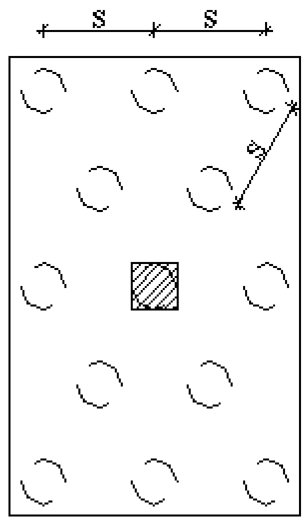
10 Piles



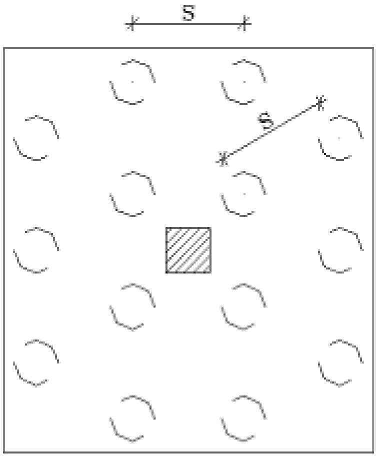
11 Piles



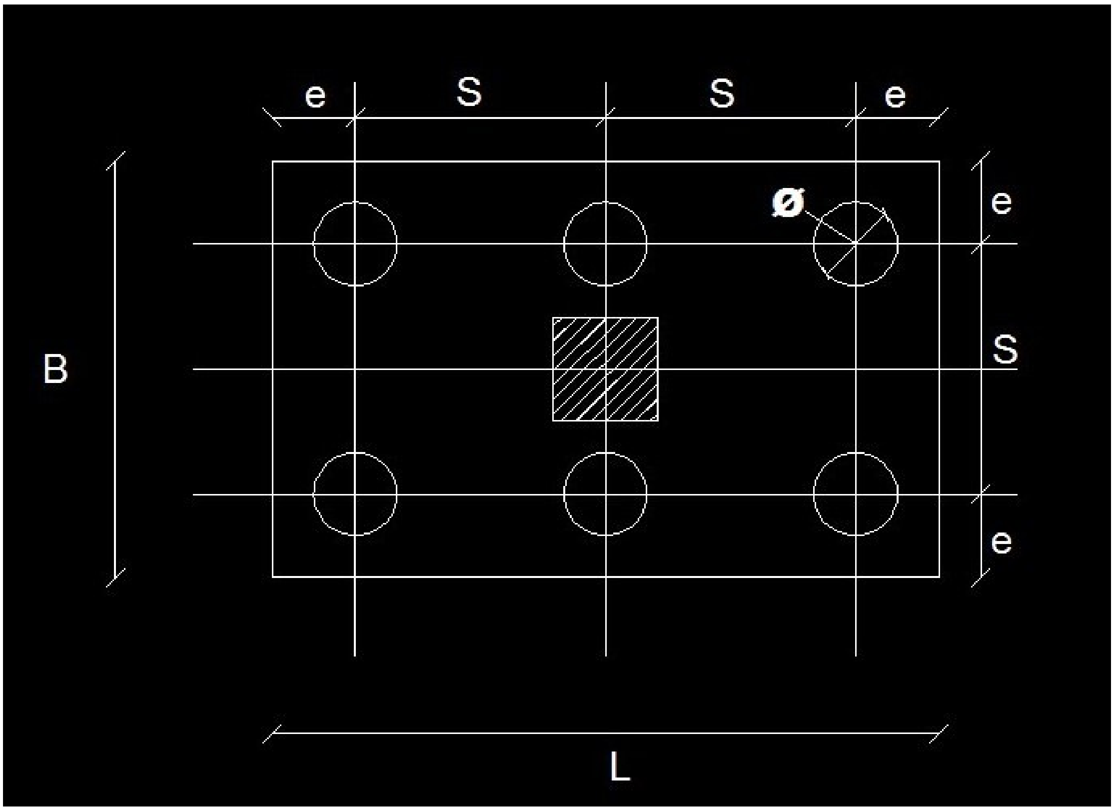
12 Piles



13 Pilcs



14 Piles



يراعي أن يكون العمود في C.G of pile cap

حتي تكون القاعدة مرتكزة علي العمود

Steps of Design:

1) No.of.pile= $\frac{1.15*p}{Qall} + (1 \rightarrow 2)$
   approximated to the nearesr bigger no → min 2 piles
2) Draw pile cap and get Dimention:

Thickness of PC = 10 cm

S_{min} = 3*ν → for friction piles

S_{min} = 2.5*ν → for bearing piles

S_{max} = 6*ν

e =(1→1.5)*ν

$P_{pile} = \frac{1.1P}{no.of\ piles}$

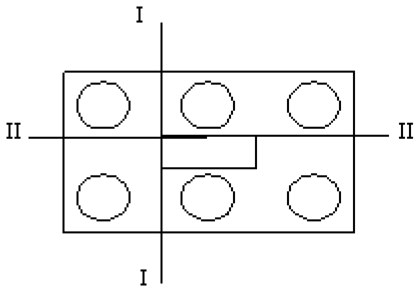
P_u = 1.5* P_{pile}

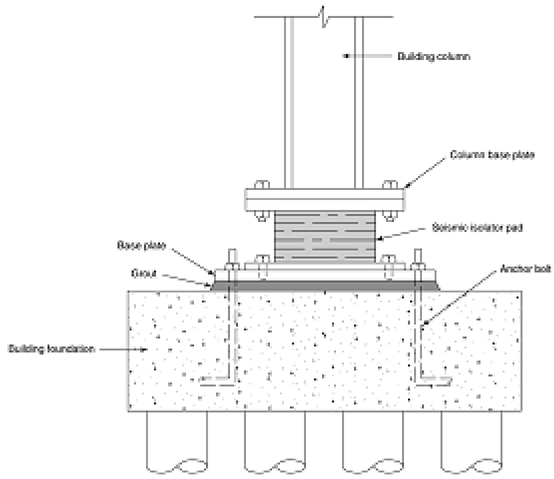
حيث أن:

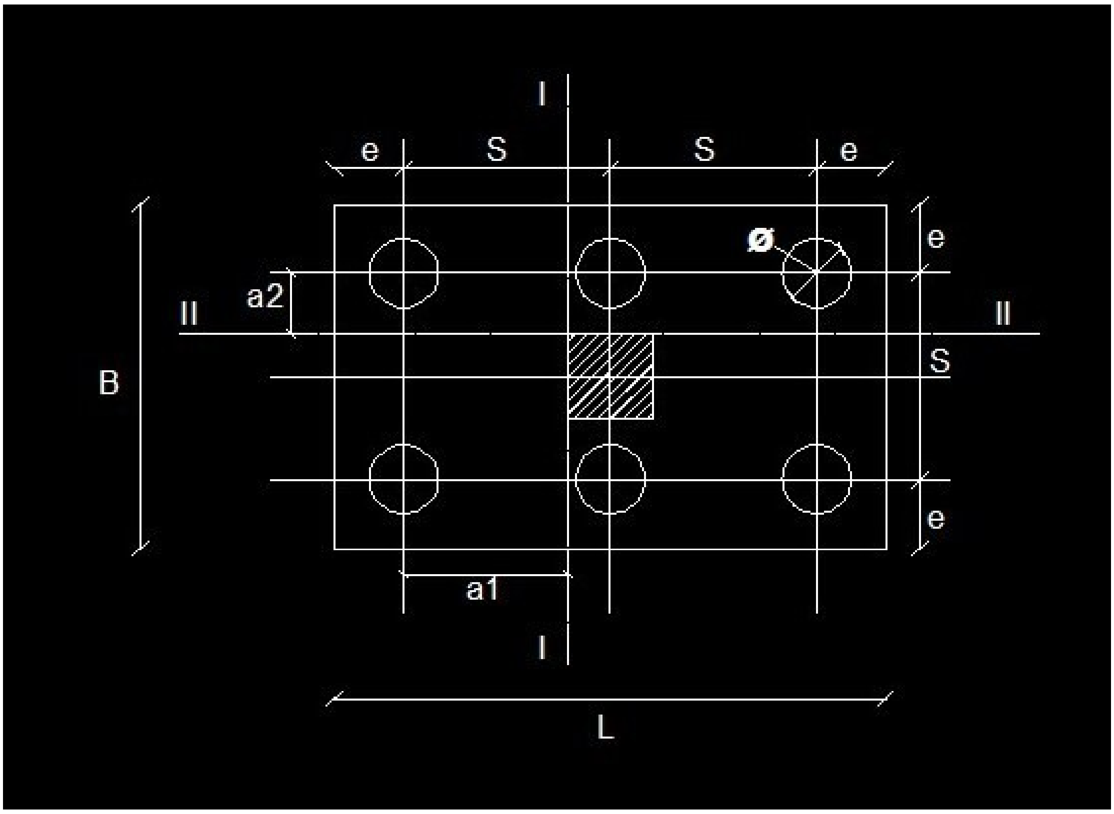
ν → pile diameter

3)Design for moment:

The critical section for moment is taken at the column face.







M_I = no. of pile*P_u *a_1

No. of piles $\rightarrow$

عدد الخوازيق المقابل لل I

M_{II} = no. of pile*P_u *a_2

No. of piles $\rightarrow$

عدد الخوازيق المقابل لل II

$$d_I = C_1 \sqrt{\frac{MuI}{Fcu*B}}$$

$$d_{II} = C_1 \sqrt{\frac{MuII}{Fcu*L}}$$

حيث أن:

$C_1 = 5$

Take the bigger of d_I , d_{II}

$d_{min} = \{(1.5*\nu)+10cm\}$

حيث أن:

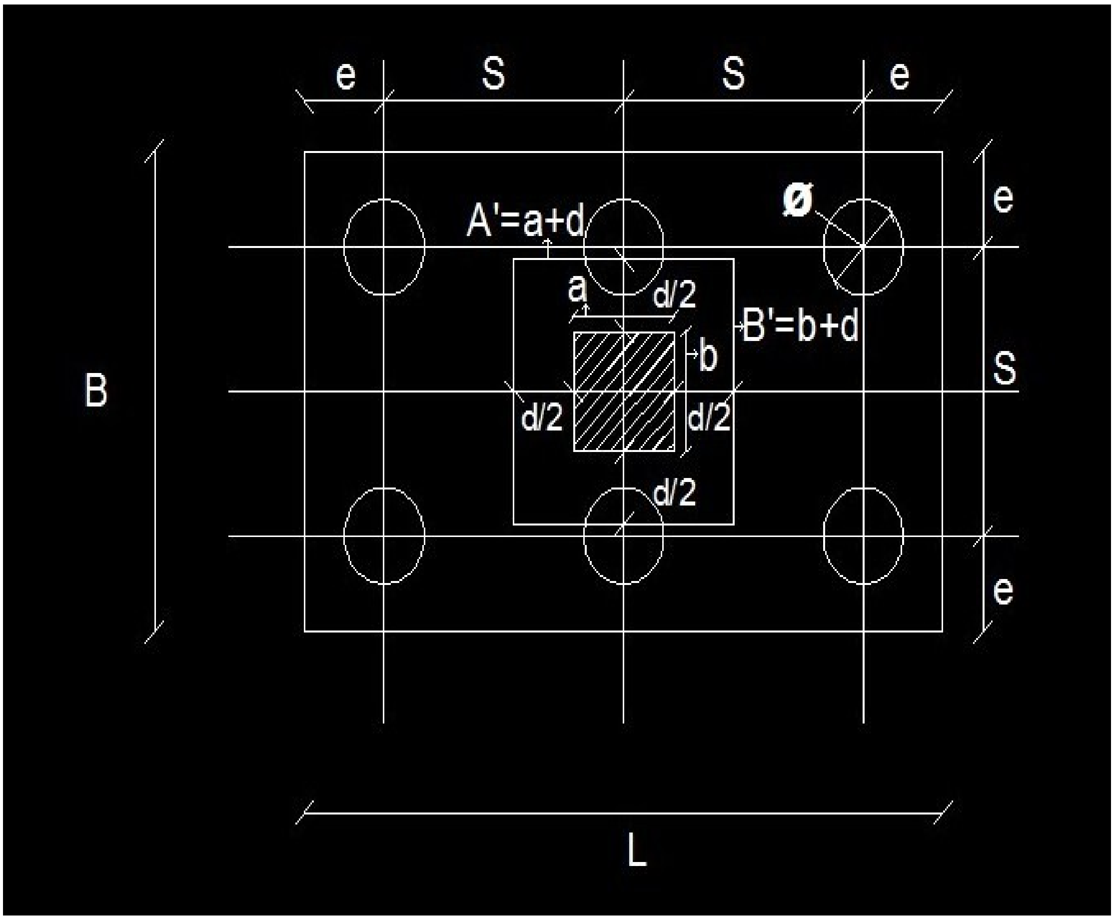
$\nu \rightarrow$ pile diameter

d_I , d_{II} , $d_{min} \rightarrow$ depth of pile cap

t = d + cover

cover = (10 to 15 cm)

Check Punching:



$Q_p = p_u - p_{upile}$

$A' = (a + d) = \ldots m$

$B' = (b + d) = \ldots m$

حيث أن:

a → طول العمود , b → عرض العمود

d → depth of pile cap

p_{upile} → *parts of the piles inside the column , critical section at d/2 from the column as in shallow footing*

$\gamma_c = 1.5$

$q_p = \frac{Qp}{2*(A'+B')*d}$ = … kg/cm^2

$q_{pcu} = \sqrt{\frac{Fcu}{\gamma c}}$ = … kg/cm^2

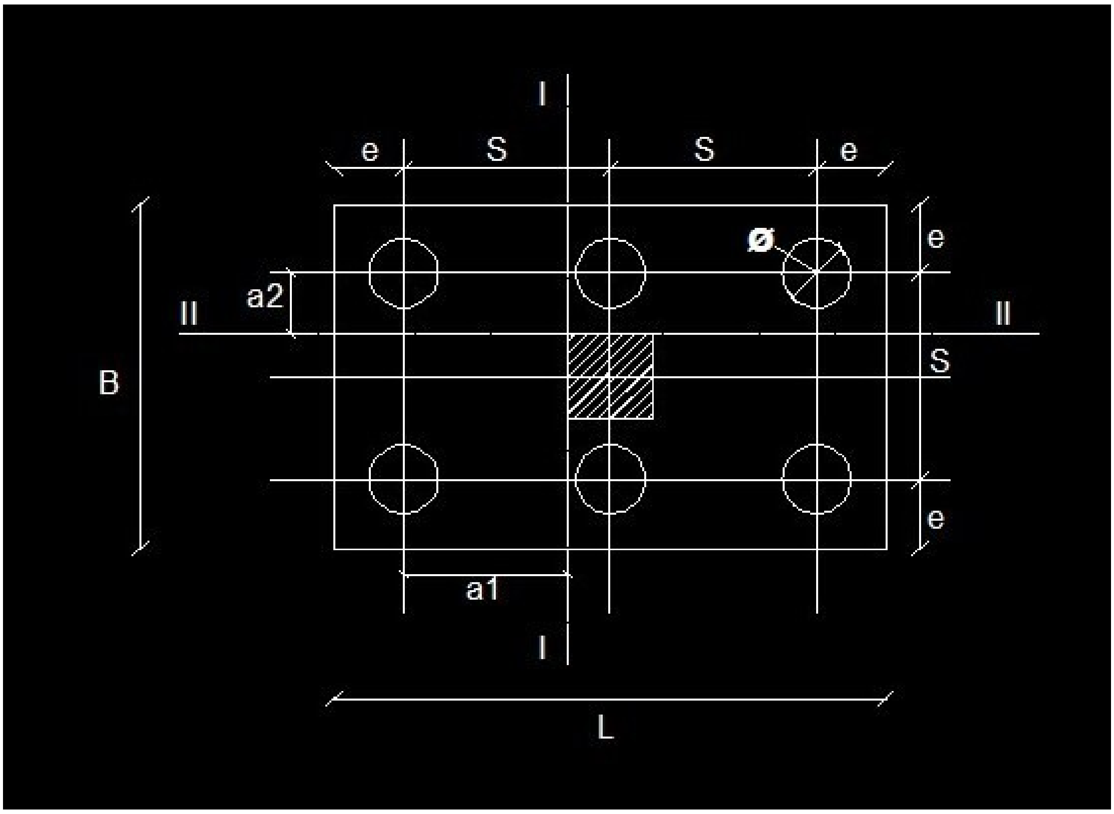
If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

t = d + cover

cover = (10 to 15 cm)

Check Shear:



Q_{sh1}= sum no. of piles

No. of piles $\rightarrow$

مجموع حمل الخوازيق المقابل لل I

$q_{sh1} = \frac{Qsh1}{B*d}$

$q_{cu} = 0.4 * \sqrt{Fcu}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh1} / (q_{cu} * B)$

$t = d + cover$

cover = (10 to 15 cm)

Q_{sh2}= sum no. of piles

No. of piles →

مجموع حمل الخوازيق المقابل لل II

$q_{sh2} = \frac{Qsh1}{L*d}$

$q_{cu} = 0.4 * \sqrt{Fcu}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh1} / (q_{cu} * L)$

$t = d + cover$

cover = (10 to 15 cm)

Reinforcement of the Cap Pile:

$A_{s1} = M_{ultI} / J*d_I*f_y / B$ - - - - - - - - - -(1)

$A_{s2} = M_{ultII} / J*d_{II}*f_y / L$ - - - - - - - - - -(1)

$A_{s\,min} = (0.15 / 100) * B * d$ - - - - - - - - - -(2)

نأخذ القيمة الأكبر في القيم 1,2

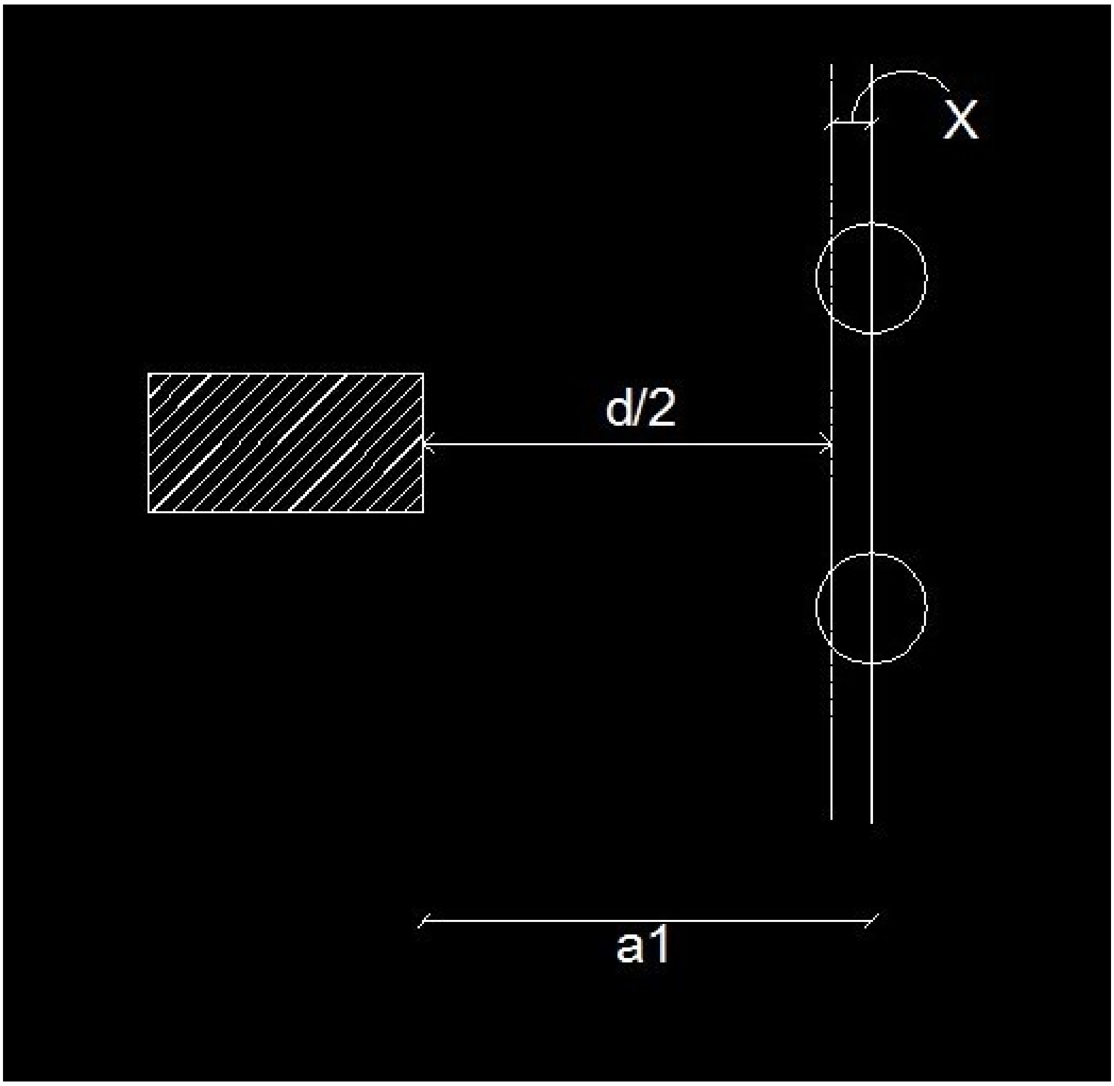
If $A_s \geq A_{s\,min} \rightarrow$ ok

If $A_s < A_{s\,min} \rightarrow$ take $A_s = A_{s\,min}$

في حالة تساوي أبعاد القاعدة B=L والشكل يكون متماثل:

Check Punching:

$$Q_p = \frac{Pu*(X+\frac{\nu}{2})}{\nu}$$



حيث أن:

$\nu \rightarrow$ pile diameter

$A' = (a + d) = \dots m$

$B' = (b + d) = \dots m$

حيث أن:

a → طول العمود , b → عرض العمود

d → depth of pile cap

$\gamma_c = 1.5$

$q_p = \frac{Qp}{2*(A'+B')*d} = \dots kg/cm^2$

$q_{pcu} = \sqrt{\frac{Fcu}{\gamma c}} = \dots kg/cm^2$

If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

t = d + cover

cover = (10 to 15 cm)

Check Shear:

$Q_{sh} = Q_P$ * No. of piles

No. of piles →

عدد الخوازيق المقابل لل II أو I

$q_{sh} = \frac{Qsh}{B*d}$

$q_{cu} = 0.4 * \sqrt{Fcu}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh} / (q_{cu} * B)$

t = d + cover

cover = (10 to 15 cm)

Reinforcement of the Cap Pile:

$A_s = M_{ult} / J*d*f_y$ - - - - - - - - - -(1)

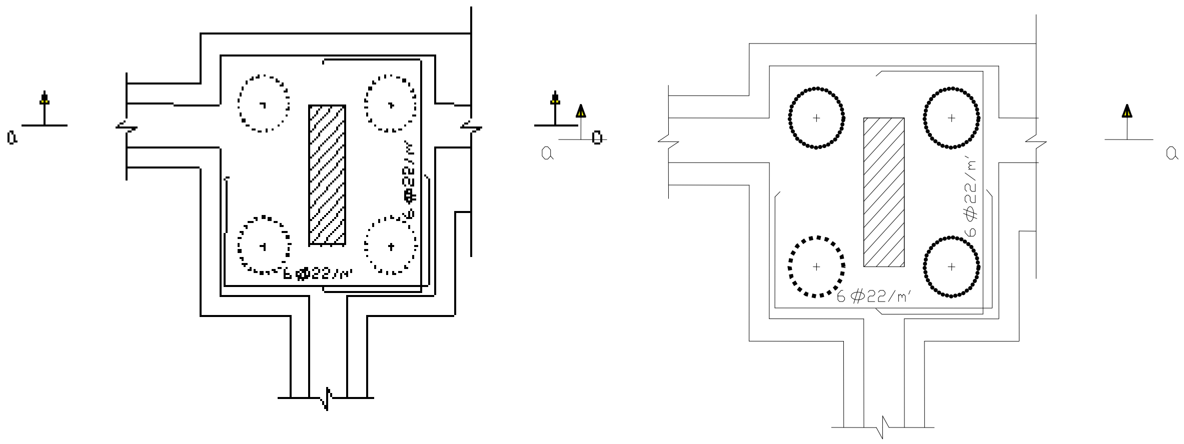
$A_{s\ min} = (0.15 / 100) * B * d$ - - - - - - - - - -(2)

نأخذ القيمة الأكبر في القيم 1,2

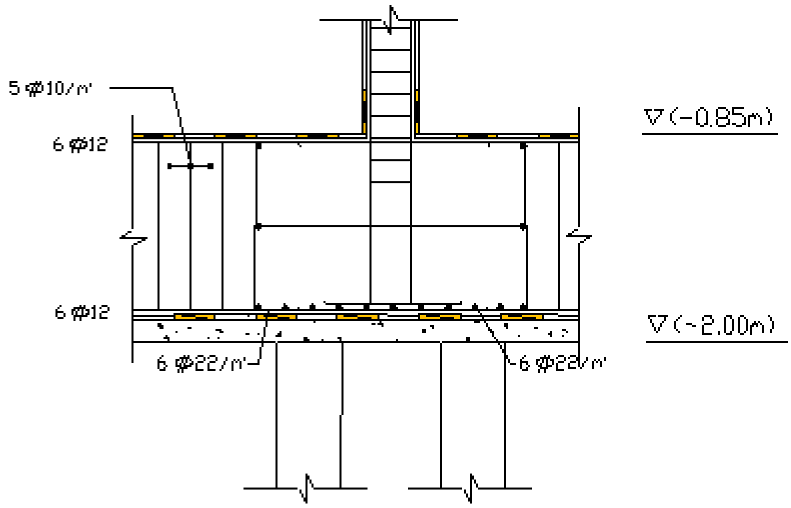
If $A_s \geq A_{s\ min} \rightarrow$ ok

If $A_s < A_{s\ min} \rightarrow$ take $A_s = A_{s\ min}$

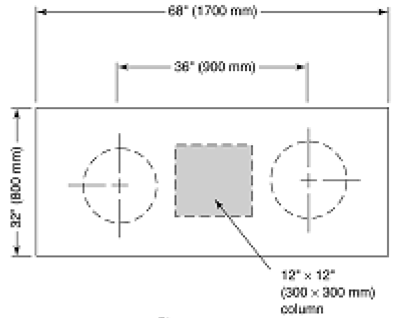
Details of reinforcement:



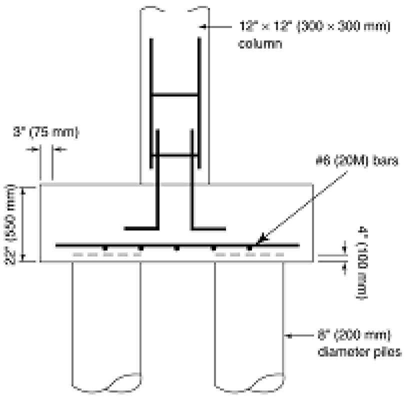
Plane



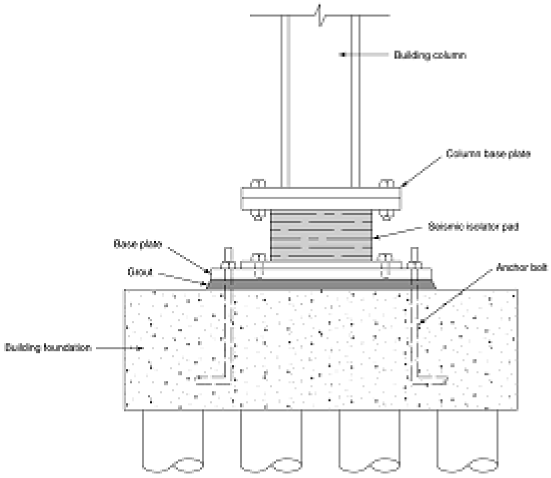
Sec a-a

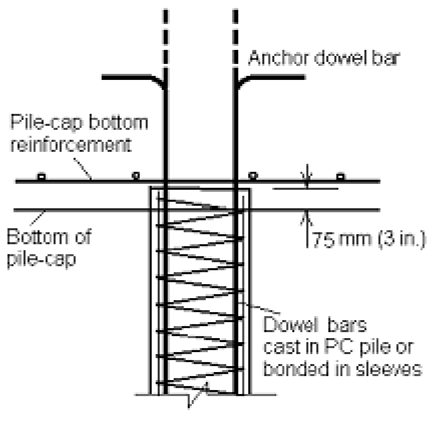


Plan



Elevation





Example: 6

Given : Pile Diameter = 40 cm , Q_{all} = 50 T,

F_{cu} = 200 Kg/cm^2 , Fy = 3600 Kg/cm^2 ,

Column Caring =200 T , Column Dimension =60x60 cm

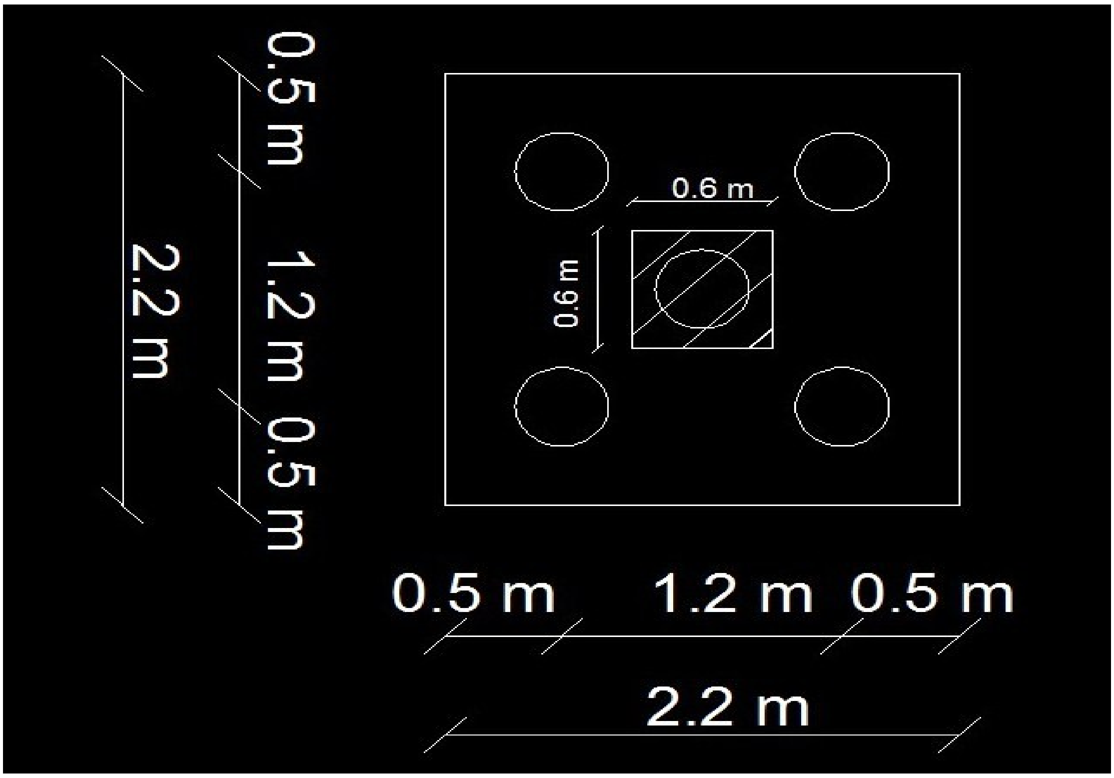
Req : Design Pile Cap.

Solution

$$\text{No.of.pile} = \frac{1.15 * p}{\text{Qall}} = \frac{1.15 * 200}{50} = 4.6 \cong 5 \text{ piles}$$

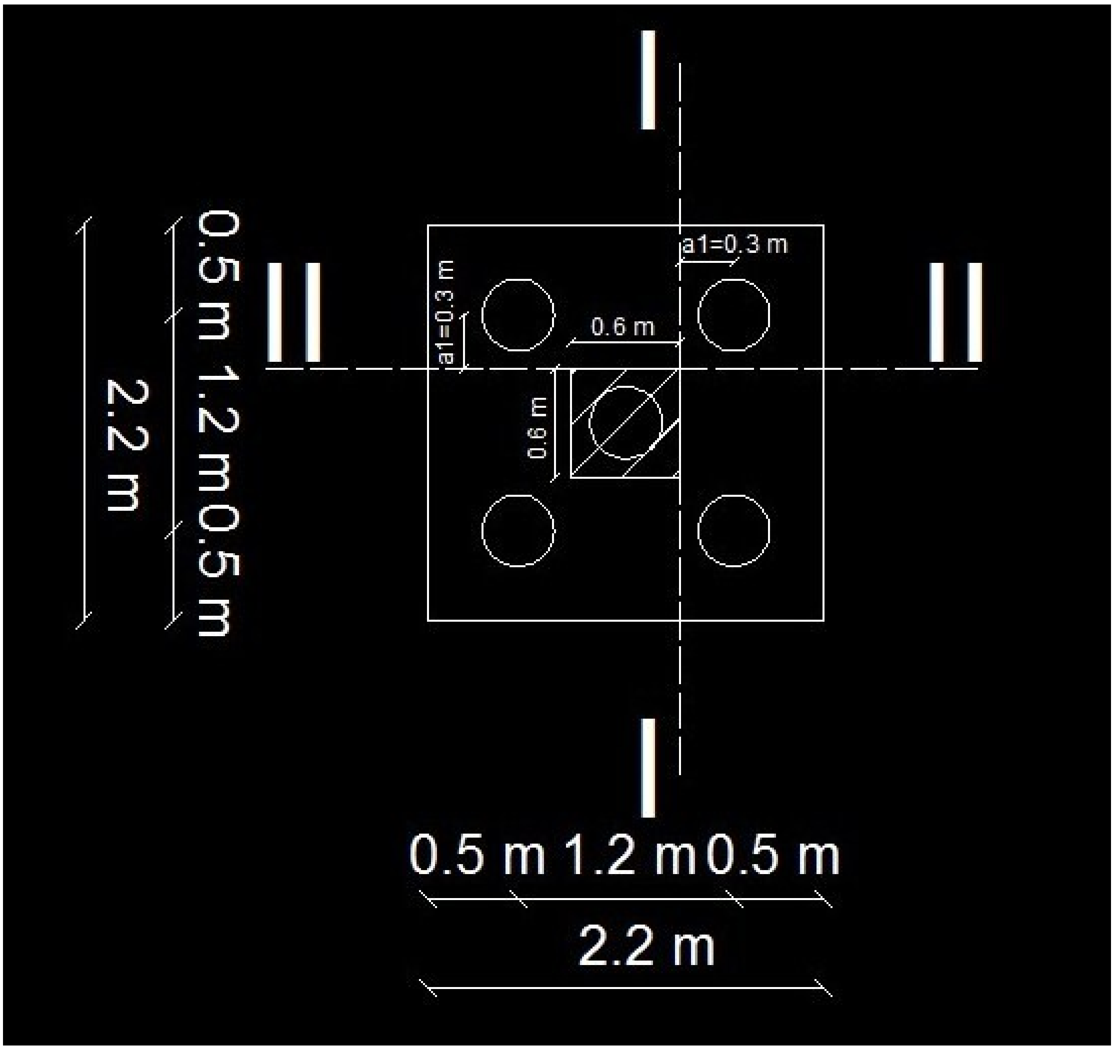
S = 3*ν = 3*0.4 = 1.2 m

e = 1.25 * ν =1.25* 0.4 = 0.5 m



$P_{pile} = \frac{1.1*P}{\text{no.of piles}} = \frac{1.1*200}{5} = 44$

$P_u = 1.5* P_{pile} = 1.5 * 44 = 66\ T$



$M_{uI-I} = M_{uII-II}$

M_u = no. of pile*P_u *a =2*66 *0.3 = 39.6 m.t

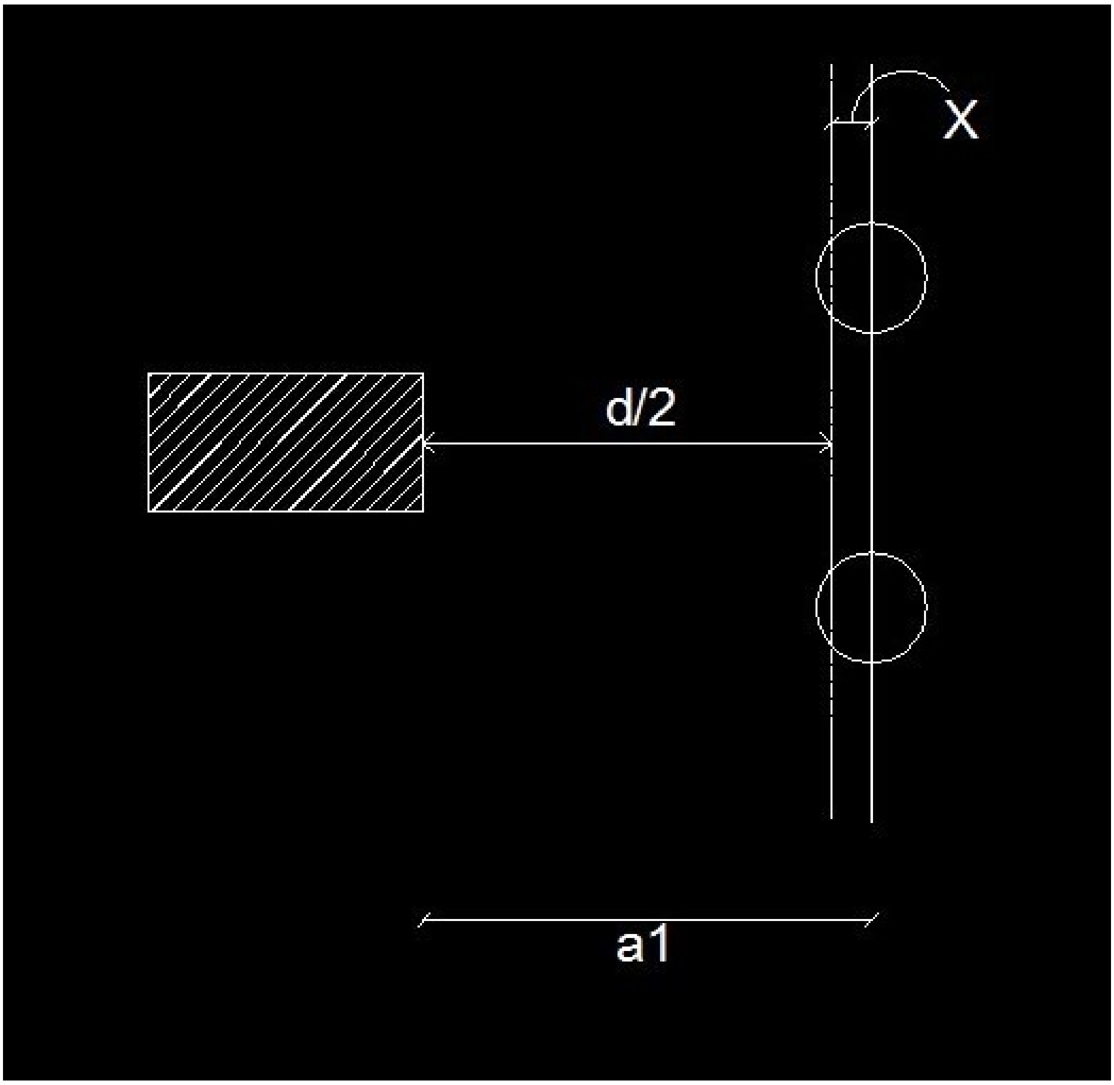
$d = C_1 \sqrt{\frac{Mu}{Fcu*B}} = 5 \sqrt{\frac{39.6*10^5}{200*220}} = 47.43\ cm \cong 50\ cm$

d_{min} = {(1.5*ν)+10cm}= {(1.5*40)+10} = 70 cm

take d = 70 cm

Check Punching:

$$Q_p = \frac{Pu*(X+\frac{\nu}{2})}{\nu} = \frac{66*(0.05+\frac{0.4}{2})}{0.4} = 41.25\ t$$



$A' = (a + d) = (0.6 + 0.7) = 1.3$ m

$B' = (b + d) = (0.6 + 0.7) = 1.3$ m

$q_p = \frac{Qp}{2*(A'+B')*d} = \frac{41.25*10^3}{2*(130+130)*70} = 1.13$ kg/cm^2

$q_{pcu} = \sqrt{\frac{Fcu}{\gamma c}} = \sqrt{\frac{200}{1.5}} = 11.55$ kg/cm^2

$q_{pcu} > q_p$

11.55 > 1.13 ok safe

t = d + cover = 70 + 10 = 80 cm

Check Shear:

$Q_{sh} = Q_P$ * No. of piles = 41.25* 2 = 82.5

$q_{sh} = \frac{Qsh}{B*d} = \frac{82.5*10^3}{220*70} = 5.36$ kg/cm^2

$q_{cu} = 0.4* \sqrt{Fcu} = 0.4* \sqrt{200} = 5.66$ kg/cm^2

$q_{sh} < q_{cu}$

5.36 < 5.66 ok safe

t = d + cover = 70 + 10 = 80 cm

Reinforcement of the Cap Pile:

$$A_s = \frac{Mult}{J * d * Fy} = \frac{39.6 * 10^5}{0.826 * 70 * 3600} = 19.02 \text{ cm}^2$$

$$A_{s\ min} = \frac{0.15}{100} * B * d = \frac{0.15}{100} * 220 * 70 = 23.1 \text{ cm}^2$$

$A_s < A_{s\ min}$

take $A_s = A_{s\ min} = 23.1$ cm^2

Use 10 y 18

يتم رسم التسليح كما في الشرح.

If columns subjected to P & M

"Permanent ":

Steps of Design:

1) No.of.pile= $\frac{1.15*p}{Qall} + (1 \rightarrow 2)$

   approximated to the nearesr bigger no → min 2 piles

2) Draw pile cap and get Dimention:

Thickness of PC = 10 cm

S_{min} = 3*ν → for friction piles

S_{min} = 2.5*ν → for bearing piles

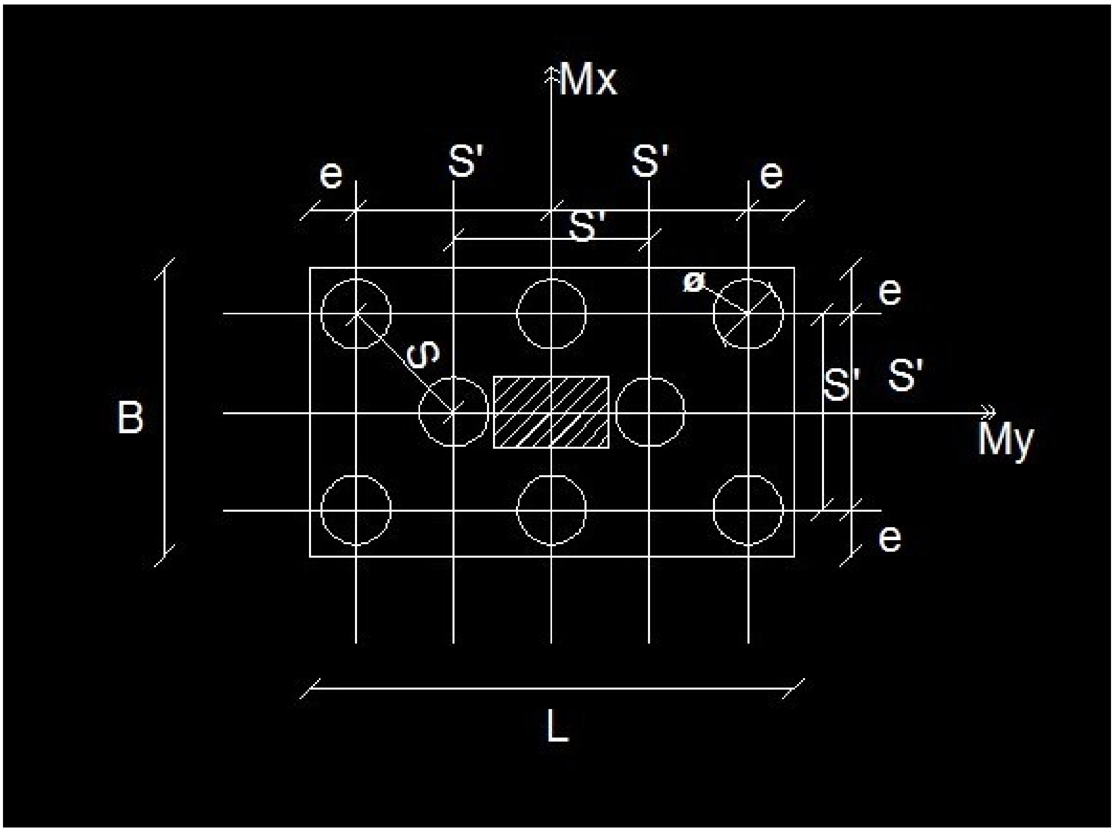
S_{max} = 6*ν

e =(1→1.5)*ν

$S' = \sqrt{(S)^2 + (S)^2}$

حيث أن:

ν → pile diameter



Case of My:

$$P_i = P_{max\,,\,min} = \frac{1.15*P}{\text{no.of pile}} \pm \frac{My}{\sum X^2} *X \pm \frac{Mx}{\sum Y^2} *Y$$

$$P_{max} < \frac{Pall}{pile}$$

P_{min} > zero ⟶ if P_{min} (-ve) < T_{all} (friction)

If unsafe:

Increace no. of pile

OR

Increace S

OR

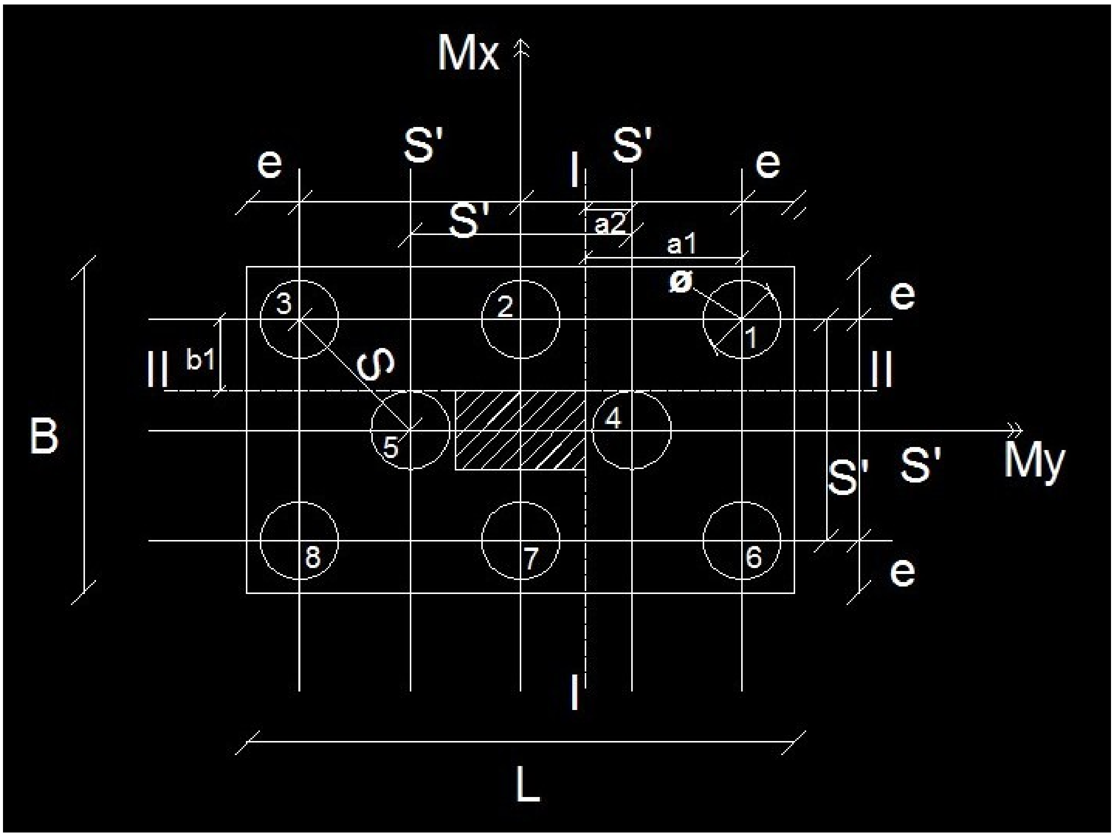
Increace length of piles

يتم عمل جدول كلاتي:

No. of pile	Y	Y^2	X	X^2	Pi
1	Y1	$(Y1)^2$	X1	$(X1)^2$	Form eq
2	Y2	$(Y2)^2$	X2	$(X2)^2$	Form eq
3	Y3	$(Y3)^2$	X3	$(X3)^2$	Form eq
4	Y4	$(Y4)^2$	X4	$(X4)^2$	Form eq
5	Y5	$(Y5)^2$	X5	$(X5)^2$	Form eq
...	...	...	...	...	...
...	...	...	...	...	...
		$\sum Y^2$		$\sum X^2$	

Design for moment:

The critical section for moment is taken at the column face.



$M_I = (P_1 + P_6) * a_1 + (p_4) * a_2$

$P_1 , P_6 , P_4 \longrightarrow$

عدد الخوازيق المقابل لل I

$M_{II} = (P_1 + P_2 + P_3) * b_1$

$P_1 + P_2 + P_3 \longrightarrow$

عدد الخوازيق المقابل لل II

$$d_I = C_1 \sqrt{\frac{MuI}{Fcu * B}}$$

$$d_{II} = C_1 \sqrt{\frac{MuII}{Fcu * L}}$$

حيث أن:

$C_1 = 5$

Take the bigger of d_I , d_{II}

$d_{min} = \{(1.5*\nu)+10cm\}$

حيث أن:

$\nu \rightarrow$ pile diameter

d_I , d_{II} , $d_{min} \rightarrow$ depth of pile cap

t = d + cover

cover = (10 to 15 cm)

Check Punching:

$Q_p = p_u - p_{upile}$

A' = (a+ d) = … m

B' = (b + d) = … m

حيث أن:

a $\rightarrow$ طول العمود , b $\rightarrow$ عرض العمود

d $\rightarrow$ depth of pile cap

p_{upile} → *parts of the piles inside the column , critical section at d/2 from the column as in shallow footing*

$\gamma_c = 1.5$

$q_p = \frac{Qp}{2*(A'+B')*d}$ = … kg/cm^2

$q_{pcu} = \sqrt{\frac{Fcu}{\gamma c}}$ = … kg/cm^2

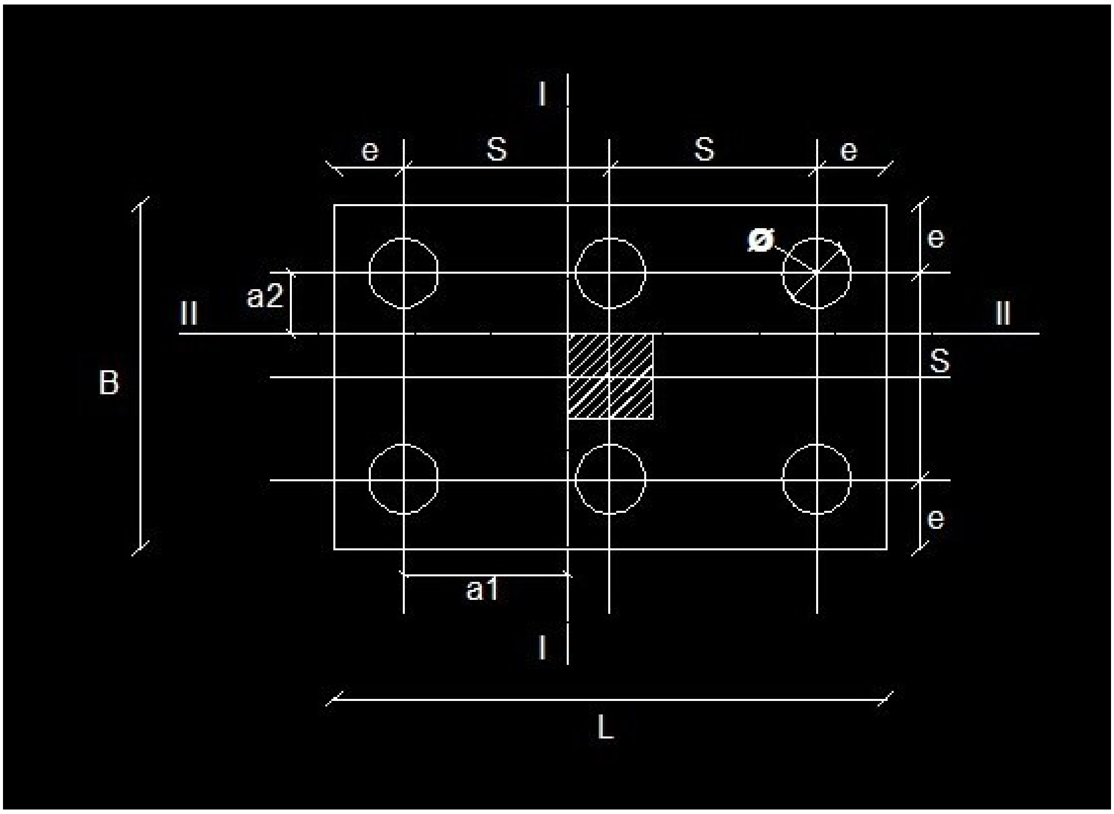
If $q_{pcu} > q_p$ ok safe

If $q_{pcu} < q_p$ un safe → increase depth

t = d + cover

cover = (10 to 15 cm)

Check Shear:



Q_{sh1}= sum no. of piles

No. of piles →

مجموع حمل الخوازيق المقابل لل I

$q_{sh1} = \frac{Qsh1}{B*d}$

$q_{cu} = 0.4 * \sqrt{Fcu}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh1} / (q_{cu} * B)$

$t = d + cover$

cover = (10 to 15 cm)

Q_{sh2}= sum no. of piles

No. of piles $\rightarrow$

مجموع حمل الخوازيق المقابل لل II

$q_{sh2} = \frac{Qsh1}{L*d}$

$q_{cu} = 0.4 * \sqrt{Fcu}$

if $q_{sh} < q_{cu}$ ok safe

if $q_{sh} > q_{cu}$ not safe increase depth

$d = Q_{sh1} / (q_{cu} * L)$

$t = d + cover$

cover = (10 to 15 cm)

Reinforcement of the Cap Pile:

$A_{s1} = M_{ultI} / J*d_I*f_y / B$ - - - - - - - - - -(1)

$A_{s2} = M_{ultII} / J*d_{II}*f_y / L$ - - - - - - - - - -(1)

$A_{s\,min} = (0.15 / 100) * B * d$ - - - - - - - - - -(2)

نأخذ القيمة الأكبر في القيم 1,2

If $A_s \geq A_{s\,min} \rightarrow$ ok

If $A_s < A_{s\,min} \rightarrow$ take $A_s = A_{s\,min}$

Example: 7

Given : Pile Diameter = 80 cm ,Q_{all} = 192 T, Q_{ult} = 200 T

F_{cu} = 350 Kg/cm^2 , Fy = 3600 Kg/cm^2 ,M_x = 290.22 m.t

M_y = 55.71 m.t , Column Caring =1020 T

Column Dimension =250x120 cm

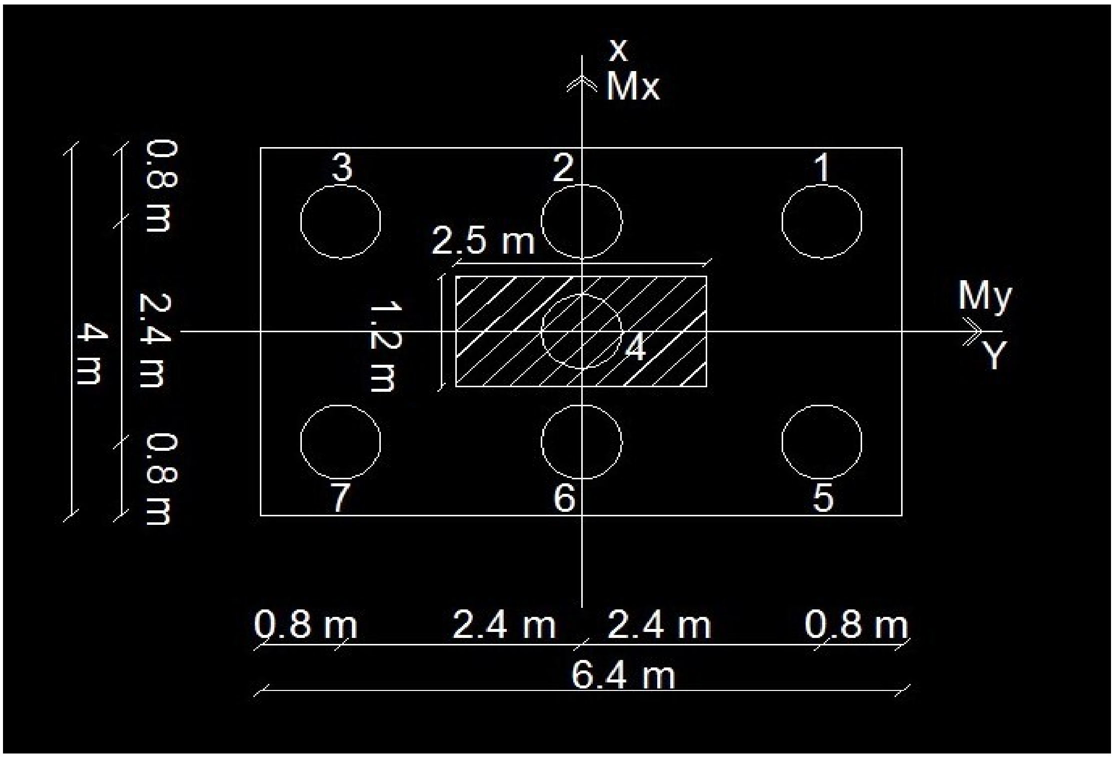
Req : Design Pile Cap.

Solution

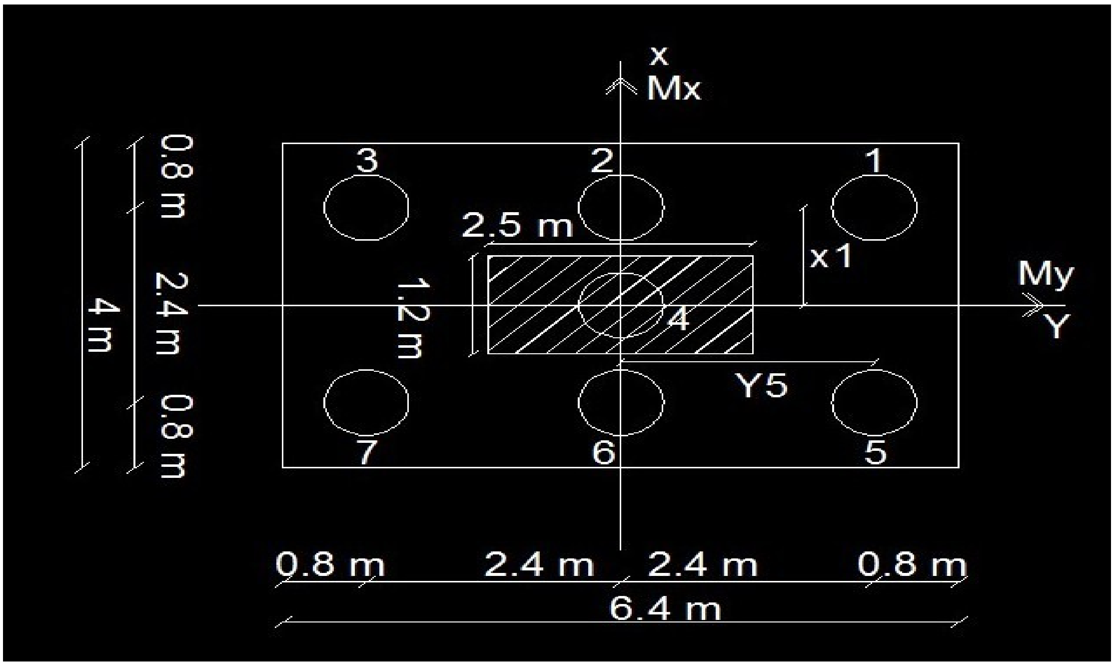
No.of.pile= $\frac{1.1*p}{Qall} = \frac{1.15*1020}{192}$ = 6.11 ≅ 7 piles

S = 3*ν = 3*0.8 = 2.4 m

e = 1* ν =1* 0.8 = 0.8 m



يتم عمل جدول:



No. of pile	Y	Y^2	X	X^2	P_i
1	2.4	5.76	1.2	1.44	-205.55
2	0	0	1.2	1.44	-159.83
3	2.4	5.76	1.2	1.44	-190.07
4	0	0	0	0	-167.57
5	2.4	5.76	1.2	1.44	-190.07
6	0	0	1.2	1.44	-159.83
7	2.4	5.76	1.2	1.44	-129.59
		$\sum 23.04$		$\sum 8.64$	

$$P_i = \frac{1.15*P}{\text{no.of pile}} \pm \frac{Mx}{\sum Y^2} *y \pm \frac{My}{\sum X^2} *x$$

$\frac{1.15*P}{no.of\ pile} = \frac{1.15*1020}{7} = 167.57$

$\frac{My}{\sum X^2} = \frac{55.71}{8.64} = 6.45$

$\frac{Mx}{\sum Y^2} = \frac{290.22}{23.04} = 12.6$

$P_{i(1)}$ =-167.57–(12.6*2.4)–(6.45*1.2)= -205.55

$P_{i(2)}$ =-167.57– 0 + (6.45*1.2) = -159.83

$P_{i(3)}$ =-167.57+(12.6*2.4)+(6.45*1.2)= -190.07

$P_{i(4)}$ =-167.57 – 0 – 0 = -167.57

$P_{i(5)}$ =-167.57–(12.6*2.4)+(6.45*1.2)= -190.07

$P_{i(6)}$ =-167.57– 0 +(6.45*1.2) = -159.83

$P_{i(7)}$ =-167.57+(12.6*2.4)+(6.45*1.2)= -129.59

$P_{i(1)} > Q_{ult}$

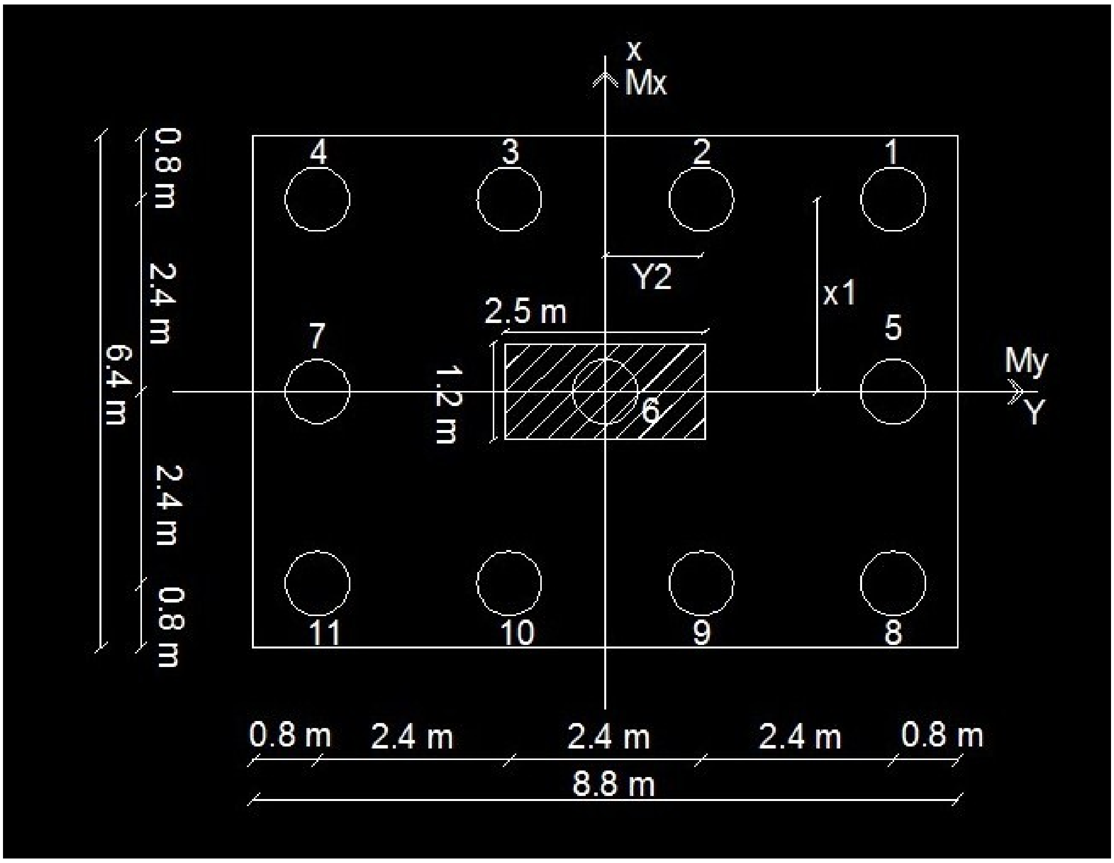
205.55 > 200 unsafe

Increace no. of pile

Taken 8 piles

يتم زيادة عدد الخوازيق بزيادة 1 وكل مرة نشوف الشرط انا قمت بزبادة عدد الخوازيق والشرط لم يتحقق الا لم تم أخذ 11 خوازيق.

Taken no. of pile = 11 piles



يتم عمل جدول:

No. of pile	Y	Y^2	X	X^2	P_i
1	3.6	12.96	2.4	5.76	-122.04
2	1.2	1.44	2.4	5.76	-113.71
3	1.2	1.44	2.4	5.76	-105.38
4	3.6	12.96	2.4	5.76	-97.05
5	3.6	12.96	0	0	-119.13
6	0	0	0	0	-106.64
7	3.6	12.96	0	0	-94.15
8	3.6	12.96	2.4	5.76	-116.23
9	1.2	1.44	2.4	5.76	-107.9
10	1.2	1.44	2.4	5.76	-99.58
11	3.6	12.96	2.4	5.76	-91.25
		$\sum 83.52$		$\sum 46.08$	

$$P_i = \frac{1.15*P}{\text{no.of pile}} \pm \frac{Mx}{\sum Y^2} *y \pm \frac{My}{\sum X^2} *x$$

$$\frac{1.15*P}{\text{no.of pile}} = \frac{1.15*1020}{11} = 106.64$$

$$\frac{My}{\sum X^2} = \frac{55.71}{46.08} = 1.21$$

$$\frac{Mx}{\sum Y^2} = \frac{290.22}{83.52} = 3.47$$

$P_{i(1)}$ =-106.64–(3.47*3.6)–(1.21*2.4)= -122.04

$P_{i(2)} = -106.64 - (3.47*1.2) - (1.21*2.4) = -113.71$

$P_{i(3)} = -106.64 + (3.47*1.2) - (1.21*2.4) = -105.38$

$P_{i(4)} = -106.64 + (3.47*3.6) - (1.21*2.4) = -97.05$

$P_{i(5)} = -106.64 - (3.47*3.6) - 0 = -119.13$

$P_{i(6)} = -106.64 - 0 - 0 = -106.64$

$P_{i(7)} = -106.64 + (3.47*3.6) - 0 = -94.15$

$P_{i(8)} = -106.64 - (3.47*3.6) + (1.21*2.4) = -116.23$

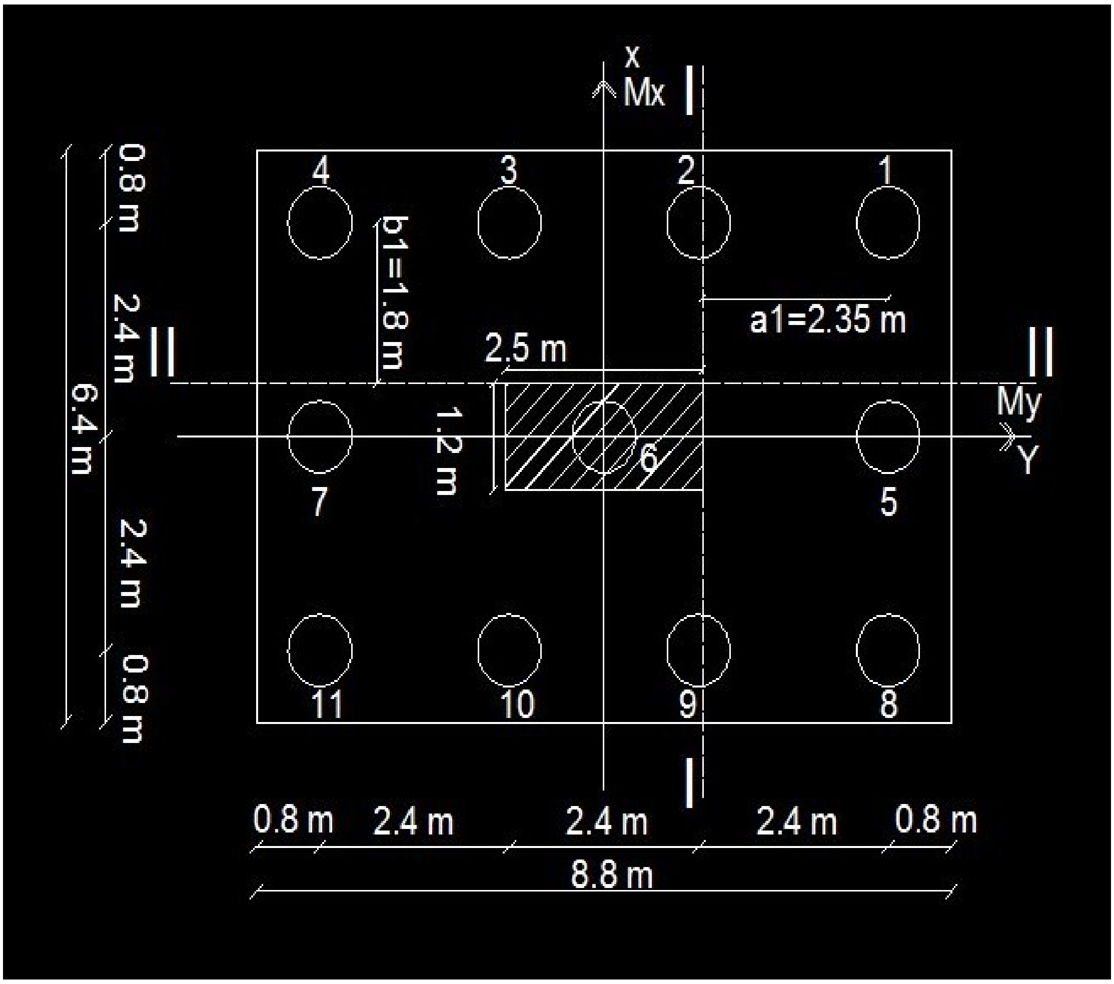
$P_{i(9)} = -106.64 - (3.47*1.2) + (1.21*2.4) = -107.9$

$P_{i(10)} = -106.64 + (3.47*1.2) + (1.21*2.4) = -99.58$

$P_{i(11)} = -106.64 + (3.47*3.6) + (1.21*2.4) = -91.25$

$P_{i(1)} < Q_{ult}$

122.04 < 200   safe



$M_I = (P_{i(1)} + P_{i(5)} + P_{i(8)})*a_1$

$= (122.04+119.13+116.23)*2.35 = 839.89$ m.t

$M_{II} = (P_{i(1)} + P_{i(2)} + P_{i(3)} + P_{i(4)})*b_1$

$= (122.04 + 113.71 + 105.38 + 97.05)*1.8$

$= 788.72$ m.t

$$d_I = C_1 \sqrt{\frac{MuI}{Fcu*B}}$$

$$= 5\sqrt{\frac{839.89*10^5}{350*640}} = 96.82 \text{ cm} \cong 100 \text{ cm}$$

$$d_{II} = C_1 \sqrt{\frac{MuII}{Fcu*L}}$$

$$= 5\sqrt{\frac{788.72*10^5}{350*880}} = 80 \text{ cm} \cong 85 \text{ cm}$$

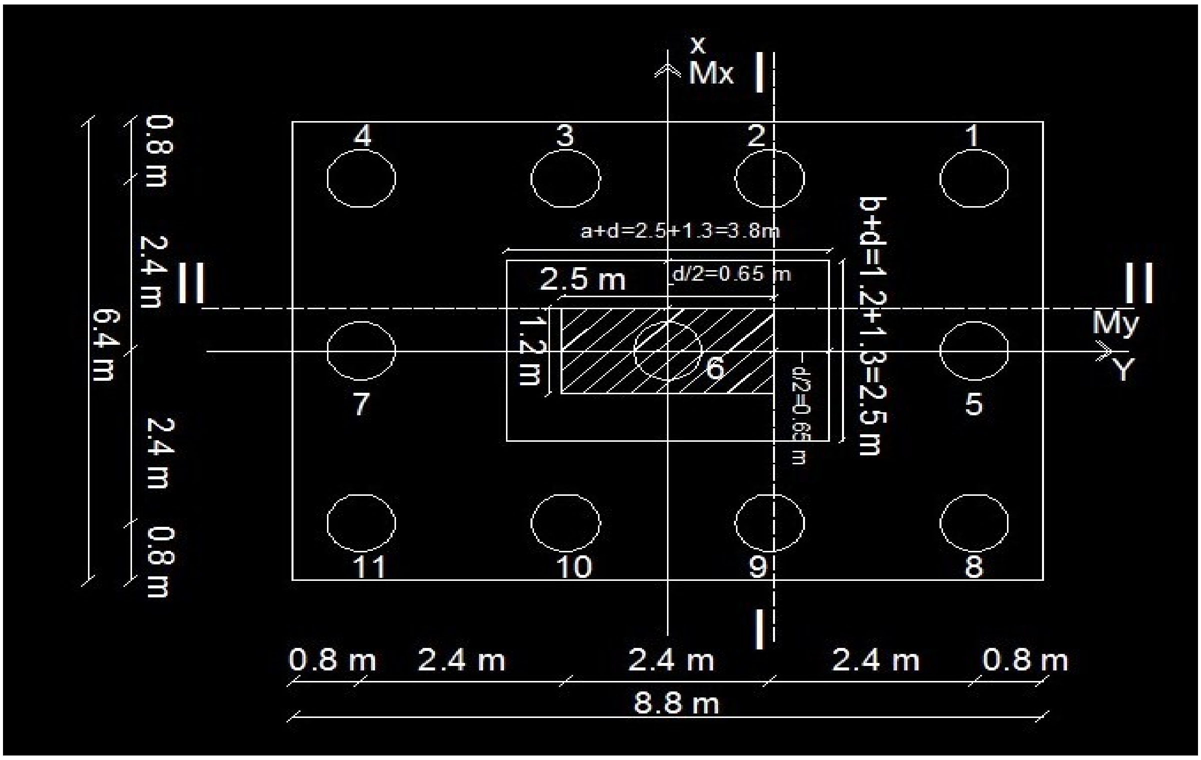
$d_{min} = \{(1.5*\nu)+10cm\}$

$=\{(1.5*80)+10\} = 130$ cm

Take d = 130 cm

t = d + cover = 130 + 10 = 140 cm

Check Punching:



$Q_p = p_{col} - p_{i(6)} = 1020 - 106.64 = 913.36$ T

$A' = (a + d) = (2.5 + 1.3) = 3.8$ m

$B' = (b + d) = (1.2 + 1.3) = 2.5$ m

$q_p = \frac{Qp}{2*(A'+B')*d} = \frac{913.36*10^3}{2*(380+250)*130} = 5.58$ kg/cm^2

$q_{pcu} = \sqrt{\frac{Fcu}{\gamma c}} = \sqrt{\frac{350}{1.5}} = 15.28$ kg/cm^2

$q_{pcu} > q_p$

15.28 > 5.58 ok safe

t = d + cover = 130 + 10 = 140 cm

Check Shear:

Q_{sh1}= ($P_{i(1)}$ +$P_{i(5)}$ +$P_{i(8)}$)

=(122.04+119.13+116.23) =357.4 T

$q_{sh1} = \frac{Qsh1}{B*d} = \frac{357.4*10^3}{640*130}$ = 4.3 kg/cm^2

q_{cu} = 0.4 * $\sqrt{Fcu}$ = 0.4 * $\sqrt{350}$=7.48 kg/cm^2 $q_{sh1} < q_{cu}$

4.3 < 7.48 ok safe

t = d + cover = 130 + 10 = 140 cm

Q_{sh2}=($P_{i(1)}$ +$P_{i(2)}$ + $P_{i(3)}$ + $P_{i(4))}$)

= (122.04 + 113.71 + 105.38 + 97.05)

= 438.18 T

$q_{sh2} = \frac{Qsh1}{L*d} = \frac{438.18*10^3}{880*130}$ = 3.83 kg/cm^2

q_{cu} = 0.4 * $\sqrt{Fcu}$ = 0.4 * $\sqrt{350}$=7.48 kg/cm^2

$q_{sh2} < q_{cu}$

3.83 < 7.48 ok safe

t = d + cover = 130 + 10 = 140 cm

Reinforcement of the Cap Pile:

$A_{sI} = \frac{\text{Mult I}}{J*d*Fy} = \frac{839.89*10^5}{0.826*130*3600}$

$= 217.27\ cm^2 / B = 217.27 / 6.4 = 34\ cm^2$

Use 9 y 22

$A_{sII} = \frac{\text{Mult II}}{J*d*Fy} = \frac{788.72*10^5}{0.826*130*3600}$

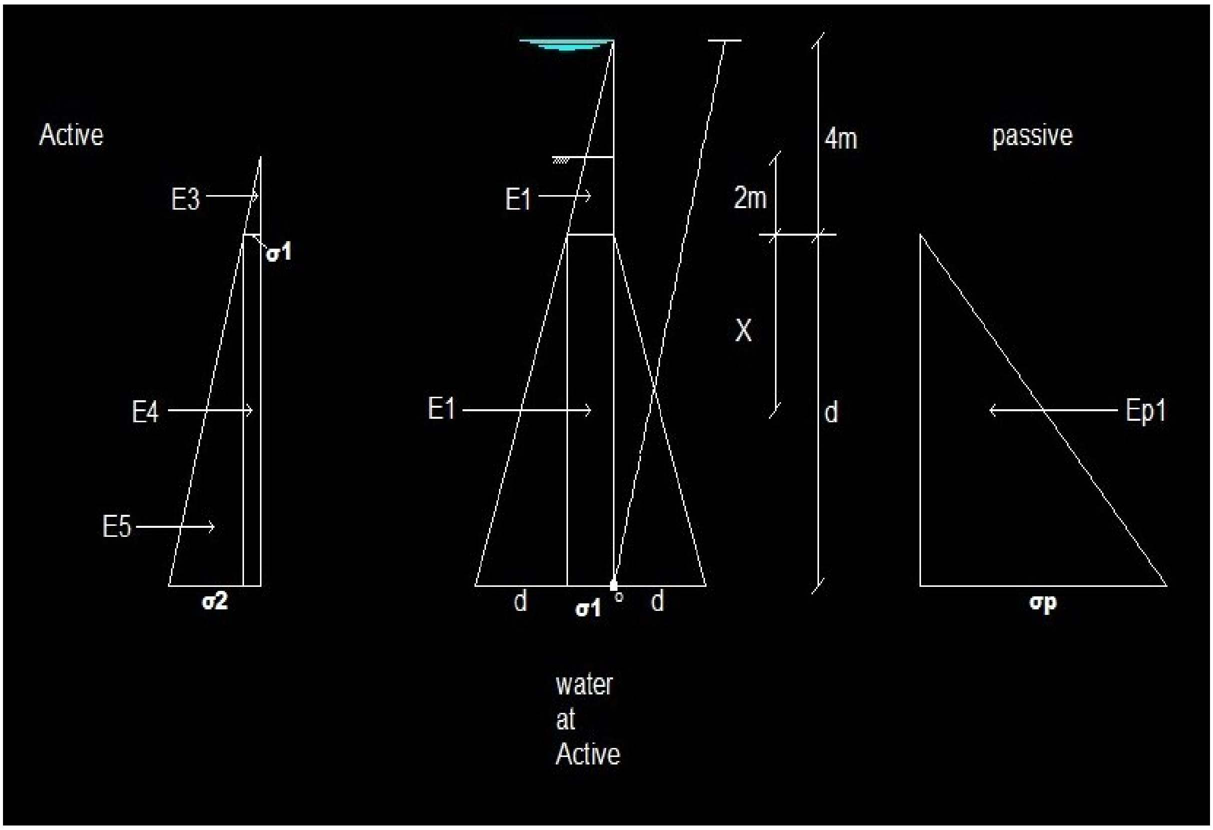
$= 204.03\ cm^2 / L = 204.03 / 8.8 = 23.19\ cm^2$

Use 7 y 22

$A_{s\ min} = \frac{0.15}{100} * B * d = \frac{0.15}{100} * 100 * 130 = 19.5 cm^2$

يتم رسم التسليح كما في الشرح.

6) Design of steel sheet piles:

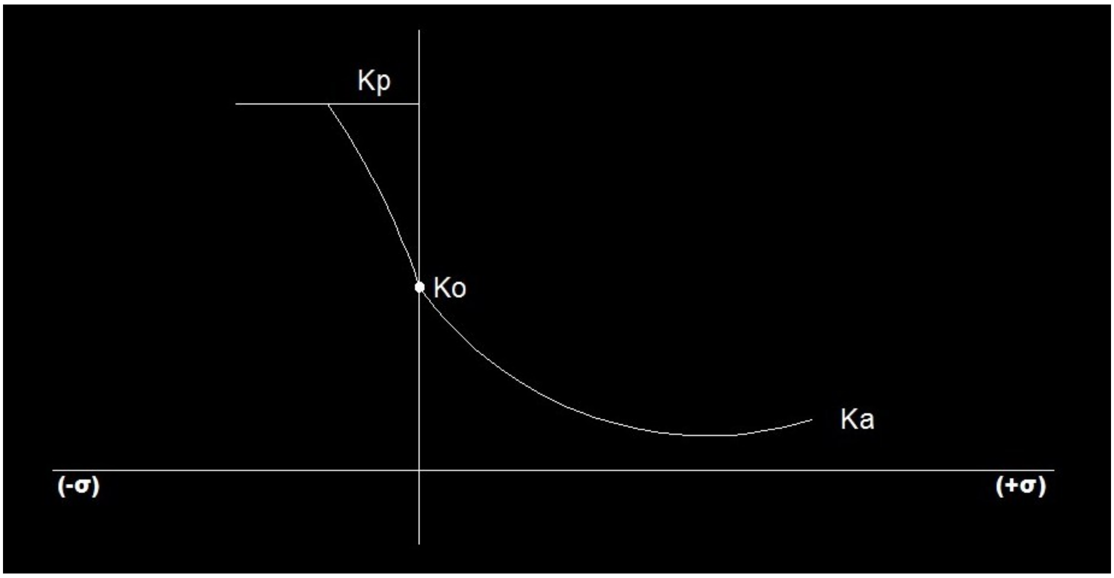


Water press = $\gamma_w * h_w$

$\sigma_1 = 1*4 = 4$ t/m'

$\sigma_2 = (1*d)+4 = (4+d)$ t/m'

Take $\nu = 30$



$$K_a = \frac{1-\sin\nu}{1+\sin\nu} = \frac{1-\sin 30}{1+\sin 30} = 0.333$$

$$K_a = \frac{1+\sin\nu}{1-\sin\nu} = \frac{1+\sin 30}{1-\sin 30} = 3$$

$$K_o = 1\text{-}\sin\nu = 1\text{-}\sin 30 = 0.5$$

$$\sigma_{@(1)} = \gamma * H * K_a = 0.8*2*0.333 = 0.533 \text{ t/m'}$$

$$\sigma_{@(2)} = \sigma_{@(1)} + \gamma * d * K_a$$

$$= 0.533+(0.8*d*0.333)$$

$$=0.533+0.266d$$

$$\sigma_p = \gamma * d * K_a = 0.8*d*3 = 2.4d$$

Force	Distance From Point O	Moment
$E_{@1}$=0.5*4*4=8	$d+\frac{4}{3}$	8d+10.666
$E_{@2}$=4d	0.5d	$2d^2$
$E_{@3}$=0.5*2*0.533=0.533	$\frac{2}{3}+d$	0.35+0.533d
$E_{@4}$=0.533d	0.5d	$0.267d^2$
$E_{@5}$=0.5d*0.266d=0.133d	$\frac{1}{3}d$	$0.0444d^3$
$E_{p1}=0.5*2.4d*d=-1.2d^2$	$\frac{1}{3}d$	$-0.4d^3$

$\sum \text{Moment}$

$-0.355d^3+2.267d^2+8.533d+11.016 = 0$

نقسم المعادلة علي 0.355-

$d^3 - 6.3859\, d^2 - 24.03d - 31.031 = 0$

d = 9.7 m

$(9.7)^3 - 6.3859 * (9.7)^2 - 24.03*9.7 - 31.031$

= 47.7

L_1 = F.o.s *d = 1.2*9.7 = 11.64

L = 11.64 +4 = 15.64 ≅ 16 m

Max moment at point of zero shear:

$8+(4X)+0.533+0.533X+0.133X^2 - 1.2X^2 = 0$

$1.0667X^2 - 4.533X - 8.533 = 0$

نقسم المعادلة علي 1.0667

$X^2 - 4.25X - 8 = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

b = - 4.25 , a= 1 , c = 8

$$x = \frac{4.25 + \sqrt{(4.25)^2 - (4*1*8)}}{(2*1)} = 5.66 \text{ m}$$

$M_{max} = -0.355*(5.66)^3 + 2.267*(5.66)^2$

$+8.533*5.66 + 11.016 = 67.47 \cong 69$ m.t/m'

$F = \frac{M}{Zx}$

F = 2.1 at steel 52

$2.1 = \frac{69*100}{Zx}$

$Z_x = 3385.71 \text{ cm}^3/\text{m}'$

Take sec VI from table

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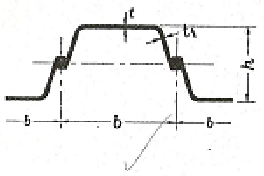
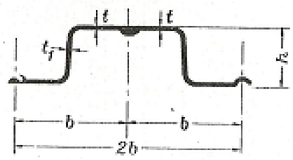
I.10. Properties of Steel Sheet Piles

a) LARCEN - TYPE



Profile Section	Dimensions mm b	h	t	t_1	Weight g Unit kg/m	G Wall kg/m²	for 1m wall W_x cm³	A cm²	U cm
I	400	220	7.5	6.3	35.6	89	600	113	260
II	400	270	9.5	7.5	48.8	122	1100	156	301
III	400	290	13	8.5	62.0	155	1600	198	309
IV	400	360	14.8	10.0	74.0	185	2200	236	330
V	420	360	20.5	12.0	100.0	238	3000	305	330
VI	420	440	22	14.0	121.8	290	4200	370	368
VII	460	460	26	14.0	142.6	310	5000	394	370

b) HOESCH - TYPE



Profile Section	b	h	t	t_1	g kg/m	G kg/m²	W_x cm³	A cm²	U cm
I	425	160	7	7	37.8	89	600	113	252
II	425	160	8	8	42.5	100	700	127	254
III	425	170	10.5	10.5	51.9	122	850	155	246
IV	425	200	9.50	8.5	51.9	122	1100	155	278
V	400	230	12	9.5	62	155	1600	197	291
VI	400	267	14	10.5	74	185	2200	236	306
VII	425	290	18	12	101.2	238	3000	303	327

profile section	Dimensions (mm)				Weigh	
	b	h	t	t1	g(kg/m)unit	G(kg/m3 wall
VI	420	440	22	14	121.8	290