مراجعه
فونديشن رابعه
أشغال
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(٨)

أشغال عامة - ٢٠١٣

Foundations

8

Midterm Revision

❋❋ Useful Informations ❋❋

❋ Some of the important functions in calculator Fx-570ES:

1 The function "Table":

- Steps (as an example):

1. Press MODE button.
2. Select TABLE (Choice No. 7).
3. f(x) = 2X + 2 (for example)

Hint: To write the equation, as follows:

2	ALPHA)	+	2
2	X	+	2

4. Press [=]

5. Calculator Screen:

   Start?
   1

6. Type 0

   0
   1

   , then [=]

7. End?
   5

8. Type 10

   10
   5

   , then [=]

9. | step? 1 |

10. Type 1 | 1 1 | , then [=]

11.

no. of trials	X	F(x)
1	0	2
2	1	4
3	2	6
4	3	8
⋮	⋮	⋮

This is the table for the equation f(x) = 2X + 2 when (x) varies from (0 to 10) with step of (1)

2 The function "Calc":

What if we want to calculate different values of X (not in a pattern form) like fraction values, i.e. 1, 1.5, and 3.

1. Write down the equation 2X + 2 (as before)
2. Press [Calc.]
3. | X? 10 |
4. Type 1.5 | 1.5 10 | , then [=]
5. The result should be = 5
6. Repeat steps 2, 3, and 4 for calculating different values of (X)

3 The function "Solve": (Very......... Very useful function)

If we have an unknown value in one equation, and we want to calculate this unknown value.

Example:

Try to calculate the value of X in the following equation:

$$\frac{(X^2)^{3/2} + 5X^{0.65}}{\sqrt{(X+1)^2 + 1}} = 3 \longrightarrow \text{Good Luck}$$ ☺ !

Solution:

1. Write down the equation.

Hint: To write the mark "=", as follows:

[ALPHA] [CALC] → =

2. Press [SHIFT] [CALC] → Solve

3. Solve for X

   1.5

4. Press any number but zero, then [=]

5. X should be = 1.1765

Question No. (1):-

The foundation of a structure is defined as the part of the structure in direct contact with the ground and which transmits the load of the structure to the ground. Explain the requirements that must be considered during foundation design to realize the above statement.

Answer:-

1. Stress under footing should not exceed the allowable bearing capacity of soil foundation.
2. Rigidity of footing should be achieved considering suitable dimesnions and big thickness.
3. Plain concrete footing should be considered if $t_{P.C} \ngtr$ 20cm.
4. The R.C. footing should be safe [depth] for moments, shear, and punching.
5. R.F.T. should be satisfied to the designed moments.

Question No. (2):-

Explain the role of tie beams.

Answer:-

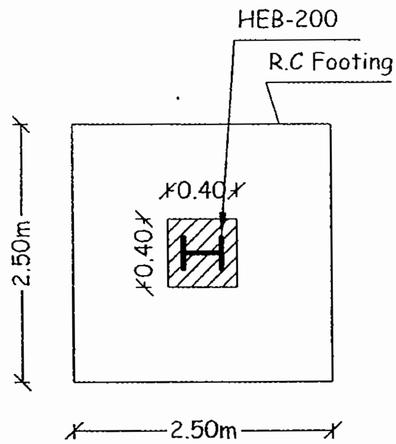
1. Supporting the walls of basement.
2. Connecting the footing to resist the differential settlement.

Example No. (1):-

A square R.C. isolated footing is proposed to support a square column of a composite section (as shown in figure). The column carries an axial compression load of 2000 KN. The concrete dimensions of the column cross section are 0.4 * 0.4m. The proposed dimensions of the R.C. footing are 2.5 * 2.5m, and its thickness is 0.5m as estimated from a preliminary design. It is required to check the safety of the proposed footing thickness only for punching shear. If the given footing thickness is unsafe, then estimate the footing thickness that will be safe in punching shear (no further calculations or checks are required).

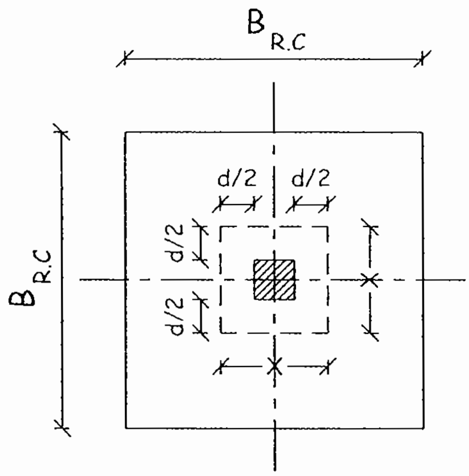
Given:-

- Column's dimensions = 0.4 * 0.4m
- R.C. footing thickness = 0.50 m
- f_{cu} = 30 N/mm^2



Solution:-

Check Punching Shear :-



$$Q_{p_u} = 1.5 * P_w - q_u (X * X)$$

$$= 1.5 * 2000 - 480 * (0.83)^2$$

$$= 2669.33 \text{ KN}$$

$$q_{p_u} = \frac{2669.33 * 10^3}{430 * (830) * 4}$$

$$= 1.87 \text{ N/mm}^2$$

$X = 0.4 + 0.43 = 0.83 \text{ m}$

$$q_u = \frac{1.5 * 2000}{2.5 * 2.5}$$

$$= 480 \text{ KN/m}^2$$

$$q_{p_{cu}} = 0.316 * \left(0.5 + \frac{0.4}{0.4}\right) \sqrt{\frac{30}{1.5}}$$

$\frac{0.4}{0.4} = 1 \Rightarrow$ take it $= 0.5$

$$= 1.413 \text{ N/mm}^2$$

$\because q_{p_u} > q_{p_{cu}} \Rightarrow \therefore$ UNSAFE

$\therefore$ Increase d

take d = 530 mm

$$Q_{p_u} = 1.5 * 2000 - 480 * (0.93)^2$$

$$= 2584.85 \text{ KN}$$

$$q_{p_u} = \frac{2584.85 * 10^3}{530 * (930) * 4}$$

$$= 1.311 \text{ N/mm}^2$$

$\because q_{p_u} < q_{p_{cu}} \Rightarrow \therefore$ SAFE

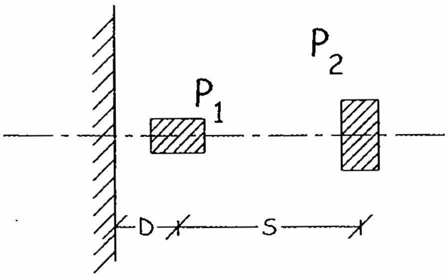
$d_{final} = 530$ mm

$t_{final} = 530 + 70$ (cover) $= 600$ mm

Choosing a foundation system near the property line: (As in lecture)

To choose a suitable foundation system for the property line, we shall try the solutions in the following two cases:-

(1) Case of the outer column has a distance "D":-



اختصارا لخطوات المسألة وتوفيرا لوقت الامتحان يتم اتباع الحلول الاتية بالترتيب لاختيار القاعدة المناسبة.

يتم البدأ بالقاعدة المنفصلة وفى حالة فشلها نحدد اذا كانت المسافة بين العمودين اصغر أو يساوى أو اكبر من 5.0 m لتحديد اى نوع من القواعد سنلجأ لها كالاتى :-

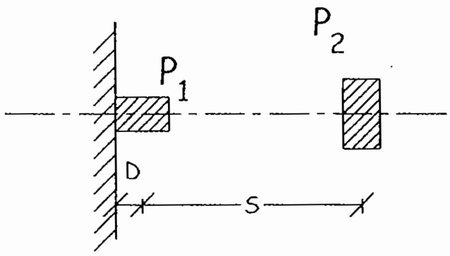
1 - Isolated. $\frac{1}{2}\sqrt{\frac{P_{col.}}{q_{all.}}} \not> D$

2- $P_1 < P_2$

- $S \leq 5.0$ m → Combined Rectangular.
- $S > 5.0$ m → Strap Beam

فى حالة فشل ال Strap Beam → Combined Rectangular.

(2) Case of the outer column is adjacent to the property line:-



1- $P_1 < P_2$

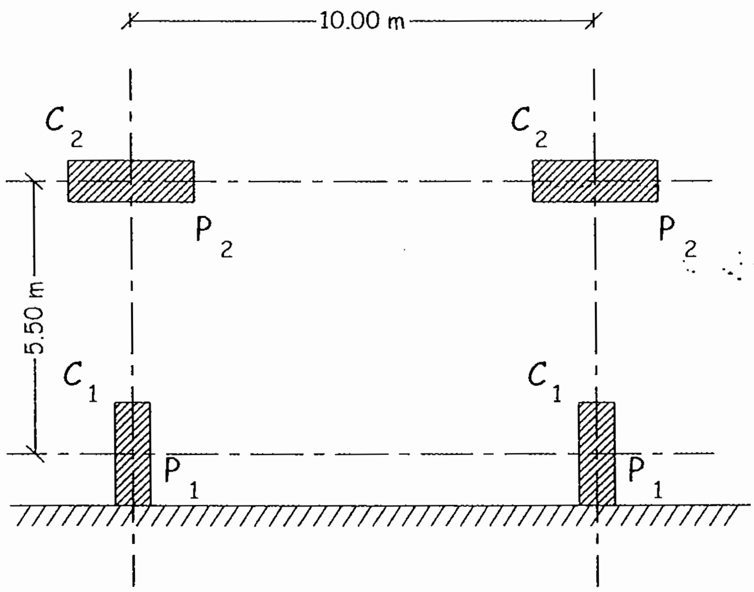
$S \leq 5.0$ m → Combined Rectangular.

$S > 5.0$ m → Strap Beam

فى حالة فشل Strap Beam ال → Combined Rectangular.

Example No. (2):-

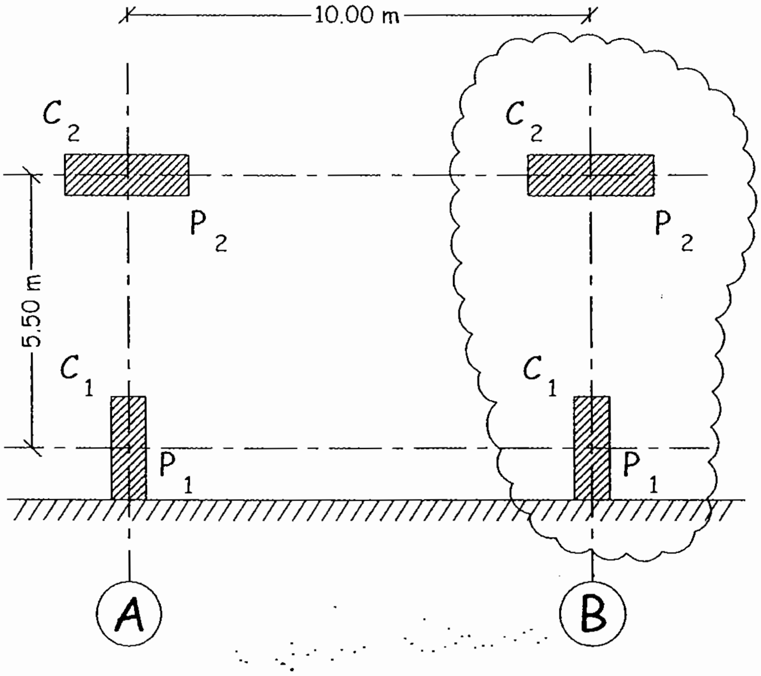
It is required to design suitable and economic foundation system (s) to support the given columns in the part plan shown in the figure. Also, draw sketches illustrating the details of the foundations for both concrete dimensions and reinforcement.



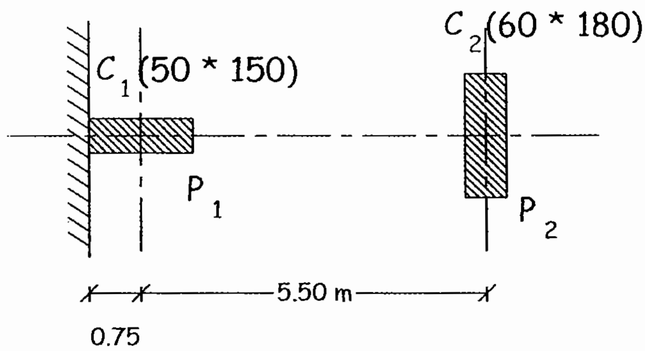
Given:-

- $t_{P.C}$ = 40 cm
- $q_{all.}$ = 150 Kpa
- f_{cu} = 30 N/mm^2
- f_y = 360 N/mm^2
- C_1 (0.5 * 1.5)m , P_1 = 4500 KN
- C_2 (0.6 * 1.8)m , P_2 = 6500 KN

Solution:-



For the two columns C_1, C_2 (Axis A or B), we shall design a strap beam footing as a foundation system.



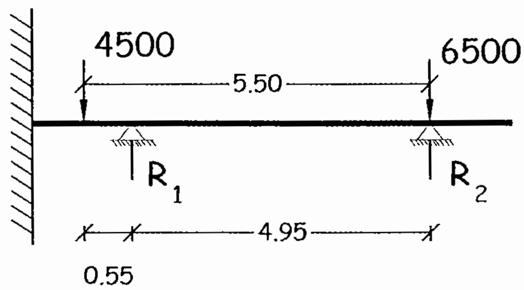
assume $e = (0.1 \longrightarrow 0.2) * 5.50$

$e = 0.55$ m

$$\therefore R_1 = \frac{4500 * 5.50}{4.95} = 5000 \text{ KN}$$

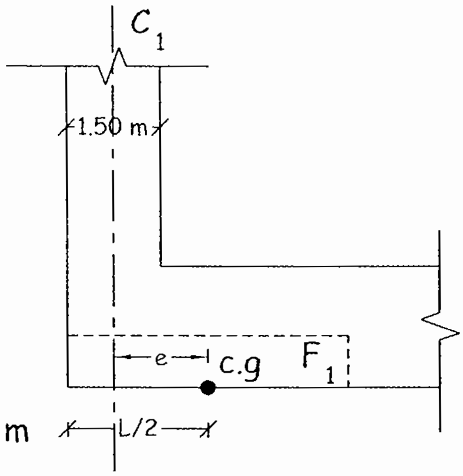
$$\therefore R_2 = [4500 + 6500] - 5000$$

$$= 6000 \text{ KN}$$



① Calculate the footing area :-

For [F_1]



$\because\ t_{P.C} = 40\ cm > 20\ cm$

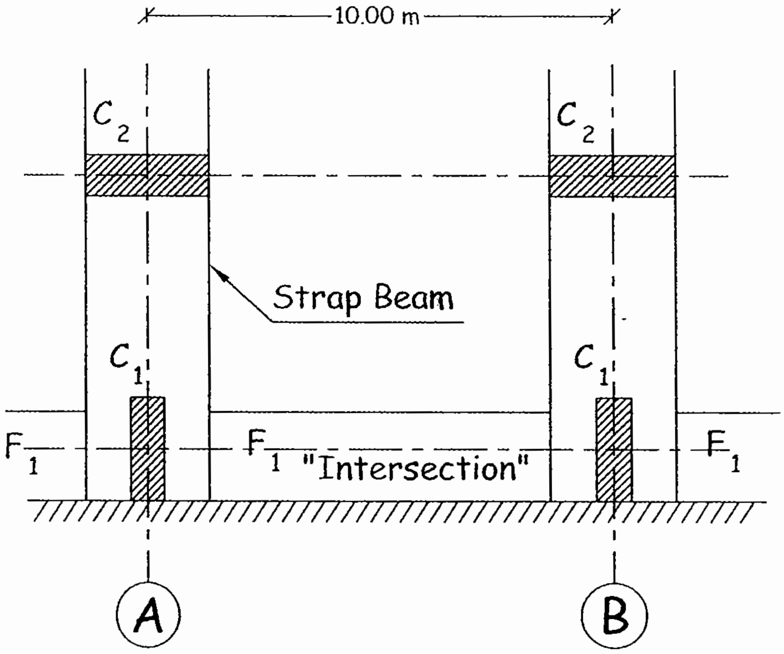
$$\therefore\ A_{P.C} = \frac{R_1}{q_{all.}} = \frac{5000}{150} = 33.33\ m^2$$

$$L_{P.C} = 2\left[e + \frac{C}{2}\right] = 2\left[0.55 + \frac{1.5}{2}\right] = 2.60\ m$$

$$\therefore\ B_{P.C} = \frac{A_{P.C}}{L_{P.C}} = \frac{33.33}{2.60} = 12.82\ m$$

Since the distance between Axis A & B = 10.00 m

∴ سيحدث تداخل بين القاعدتين F_1 على محور A & B

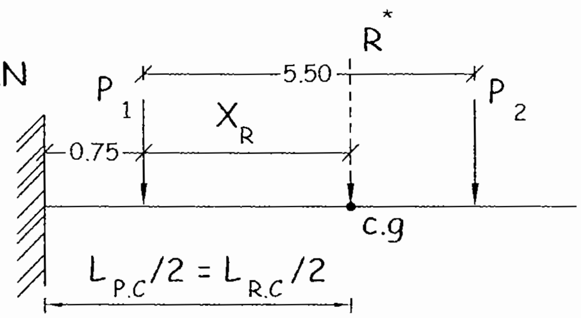


∴ We can't use strap beam

∴ Use combined footing ⟹ $\because\ P_1 < P_2$ ⟹ ∴ Use rectangular combined

$R^* = P_1 + P_2 = 4500 + 6500 = 11000$ KN

$X_R = \frac{6500 * 5.50}{11000} = 3.25$ m



① **Calculate the footing area :-**

$\frac{L_{P.C}}{2} = X_R + D = 3.25 + 0.75 = 4.00$ m

$L_{P.C} = 2 * 4.00 = 8.00$ m

$L_{P.C} = L_{R.C} = 8.00$ m

$\because t_{P.C} = 40$ cm $>$ 20 cm

$\therefore A_{P.C} = \frac{R^*}{q_{all.}} = \frac{11000}{150} = 73.33\ m^2 = B_{P.C} * 8.00$

$\therefore B_{P.C} = \frac{A_{P.C}}{L_{P.C}} = \frac{73.33}{8.00} = 9.20$ m $<$ 10.00 m $\Rightarrow \therefore$ O.K.

$B_{R.C} = 9.20 - 2 * 0.40 = 8.40$ m

② **Design in long direction:-**

$P_{1u} = 1.5 * 4500 = 6750$ KN

$P_{2u} = 1.5 * 6500 = 9750$ KN

$R^*_u = 1.5 * 11000 = 16500$ KN

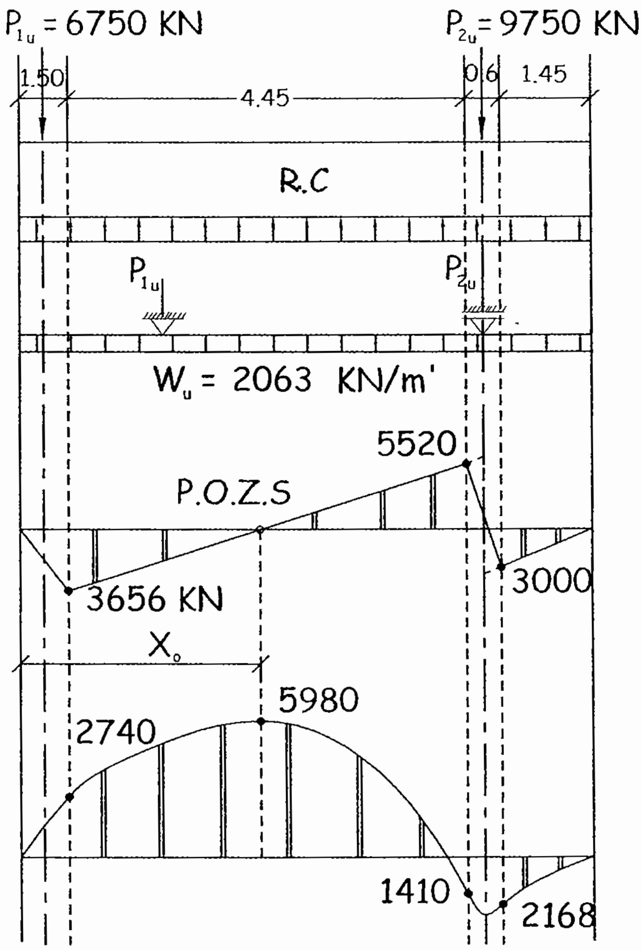
$W_u = \frac{16500}{8.00} = 2063\ KN/m'$

$q_u = \frac{16500}{8.00 * 8.40} = 246\ KN/m^2$

* **get the point of zero shear:-**

$6750 = 2063 * X_o \Rightarrow X_o = 3.27$ m

$M_{max.} = 2063 * \frac{3.27^2}{2} - 6750\,[3.27 - 0.75] = -5980$ KN.m



$$\therefore d = 5\sqrt{\frac{M_{max.} * 10^6}{f_{cu} * B_{R.C}(mm)}} = 5\sqrt{\frac{5980 * 10^6}{30 * 8400}} = 793.4 \text{ mm}$$

take d = 830 mm

③ Check Shear :-

$Q_{max.} = 5520$ KN

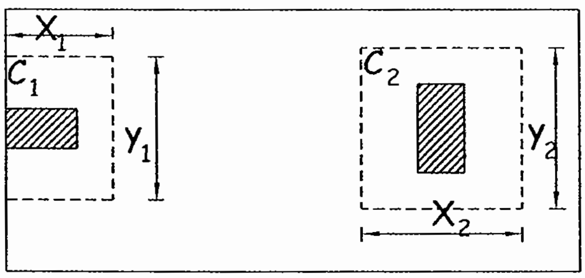
$$Q_{su} = Q_{max.} - W * \frac{d}{2} = 5520 - 2063 * \frac{0.83}{2} = 4663.86 \text{ KN}$$

$$q_{su} = \frac{Q_{su} * 10^3}{d * B} = \frac{4663.86 * 10^3}{830 * 8400} = 0.669 \text{ N/mm}^2$$

$$q_{scu} = 0.16\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.16\sqrt{\frac{30}{1.5}} = 0.72 \text{ N/mm}^2$$

$\because q_{su} < q_{scu} \Rightarrow \therefore$ SAFE

④ Check Punching Shear :-



For C_1

$$X_1 = 1.5 + \frac{0.83}{2} = 1.915 \text{ m}$$

$$Y_1 = 0.5 + 0.83 = 1.33 \text{ m}$$

$$Q_{p_1} = 6750 - 246 * (1.915 * 1.33)$$

$$= 6123.45 \text{ KN}$$

For C_2

For C_1

$$q_{p_1} = \frac{6123.45 * 10^3}{830 * [2 * 1915 + 1330]} = 1.43 \ N/mm^2$$

$$q_{p_{cu_1}} = 0.316 \ (0.5 + \frac{0.5}{1.5})\sqrt{\frac{30}{1.5}}$$

$$= 1.18 \ N/mm^2$$

$$\because q_{p_1} > q_{p_{cu_1}} \Rightarrow \therefore \text{UNSAFE}$$

take d = 930 mm

$$X_1 = 1.5 + \frac{0.93}{2} = 1.965 \ m$$

$$Y_1 = 0.5 + 0.93 = 1.43 \ m$$

$$Q_{p_1} = 6750 - 246 * (1.965 * 1.43)$$

$$= 6058.8 \ KN$$

$$q_{p_1} = \frac{6058.8 * 10^3}{930 * [2 * 1965 + 1430]} = 1.22 \ N/mm^2$$

$$\because q_{p_1} > q_{p_{cu_1}} \Rightarrow \therefore \text{UNSAFE}$$

take d = 980 mm

$$X_1 = 1.5 + \frac{0.98}{2} = 1.99 \ m$$

$$Y_1 = 0.5 + 0.98 = 1.48 \ m$$

$$Q_{p_1} = 6750 - 246 * (1.99 * 1.48)$$

$$= 5972 \ KN$$

$$q_{p_1} = \frac{5972 * 10^3}{980 * [2 * 1990 + 1480]} = 1.12 \ N/mm^2$$

$$\because q_{p_1} < q_{p_{cu_1}} \Rightarrow \therefore \text{SAFE}$$

For C_2

$$X_2 = 1.8 + 0.98 = 2.78 \ m$$

$$Y_2 = 0.6 + 0.98 = 1.58 \ m$$

$$Q_{p_2} = 9750 - 246 * (2.78 * 1.58)$$

$$= 8670 \ KN$$

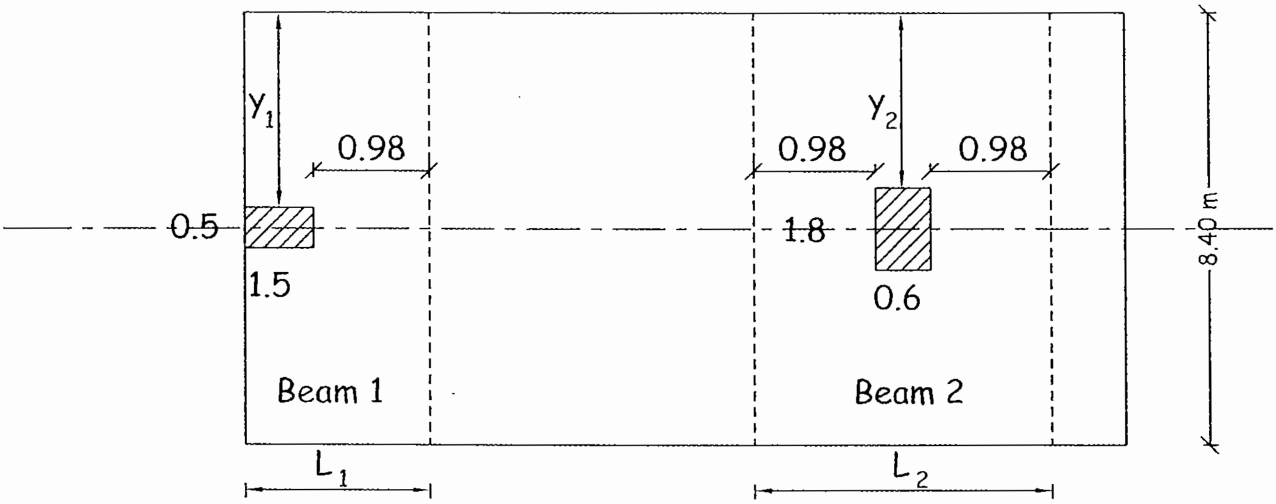
$$q_{p_2} = \frac{8670 * 10^3}{980 * [2780 + 1580] * 2} = 1.014 \ N/mm^2$$

$$q_{p_{cu_2}} = 0.316 * (0.5 + \frac{0.6}{1.8})\sqrt{\frac{30}{1.5}}$$

$$= 1.18 \ N/mm^2$$

$$\because q_{p_2} < q_{p_{cu_2}} \Rightarrow \therefore \text{SAFE}$$

⑤ Design in short direction:-



For Beam 1

$L_1 = 1.5 + 0.98 = 2.48$ m

$\therefore\ q_{u_1} = \dfrac{6750}{8.40 * 2.48} = 334.8\ KN/m^2$

$\therefore\ Y_1 = \dfrac{8.40 - 0.50}{2} = 3.95$ m

$\therefore\ M_1 = 334.8 * \dfrac{3.95^2}{2} * 1m$

$= 2611.9\ KN.m/m'$

For Beam 2

$L_2 = 0.6 + 2 * 0.98 = 2.56$ m

$\therefore\ q_{u_2} = \dfrac{9750}{8.40 * 2.56} = 453.4\ KN/m^2$

$\therefore\ Y_2 = \dfrac{8.40 - 1.80}{2} = 3.30$ m

$\therefore\ M_2 = 453.4 * \dfrac{3.30^2}{2} * 1m$

$= 2468.76\ KN.m/m'$

$$M_{bigger} = M_1 = 2611.9\ KN.m/m'$$

$$\therefore\ d = 980 = C_1 \sqrt{\frac{2611.9 * 10^6}{30 * 1000}} \Rightarrow C_1 = 3.32 > 2.8 \quad \therefore\ SAFE$$

⑥ Final Thickness :-

$d_{final} = 980$ mm

$t_{final} = 980 + 70\ (cover) = 1050$ mm

⑦ R.F.T :-

$$A_{s_{min.}} = \begin{cases} 1.5 * d_{mm} = 1.5 * 980 = 1470 \ mm^2/m' \\ 5 \phi 12/m' = 565 \ mm^2/m' \end{cases}$$

8 ϕ 16/m'

In Long direction:-

$$A_{s_{Top}} = \frac{M_{u_{top}} * 10^6 / B}{F_y * J * d} = \frac{5980 * 10^6 / 8.40}{360 * 0.826 * 980} = 2442.9 \ mm^2/m'$$

7 ϕ 22/m'

$$A_{s_{Bottom}} = \frac{M_{u_{bot.}} * 10^6 / B}{F_y * J * d} = \frac{2168 * 10^6 / 8.40}{360 * 0.826 * 980} = 890 \ mm^2/m' < A_{s_{min.}}$$

use $A_{s_{min.}}$ **8 ϕ 16/m'**

In Short direction:-

$$A_{s_1} = \frac{M_{u_1} * 10^6}{F_y * J * d} = \frac{2611.9 * 10^6}{360 * 0.77 * 980} = 9615 \ mm^2/m'$$

14 ϕ 32/m'

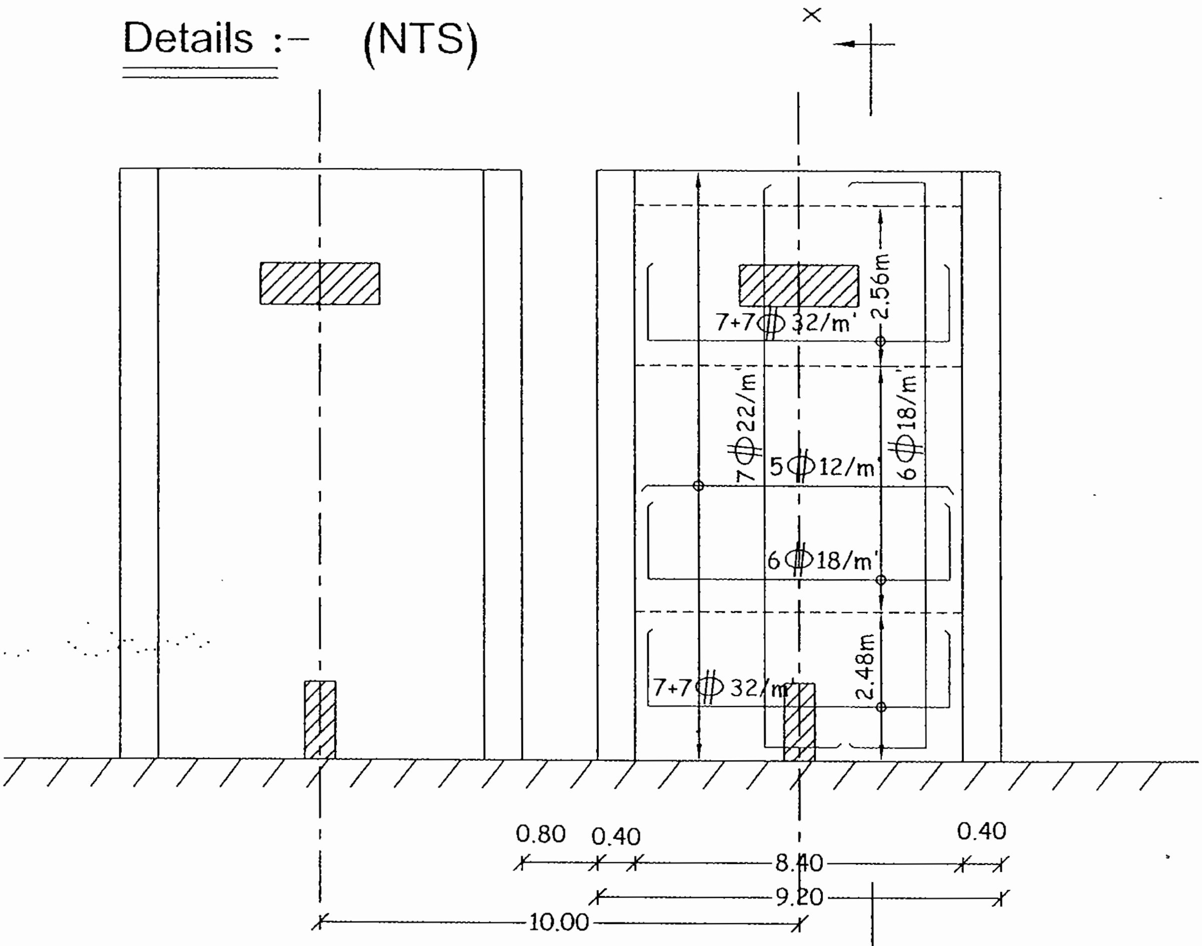
on two rows

$$A_{s_2} = \frac{M_{u_2} * 10^6}{F_y * J * d} = \frac{2468.8 * 10^6}{360 * 0.77 * 980} = 9088 \ mm^2/m'$$

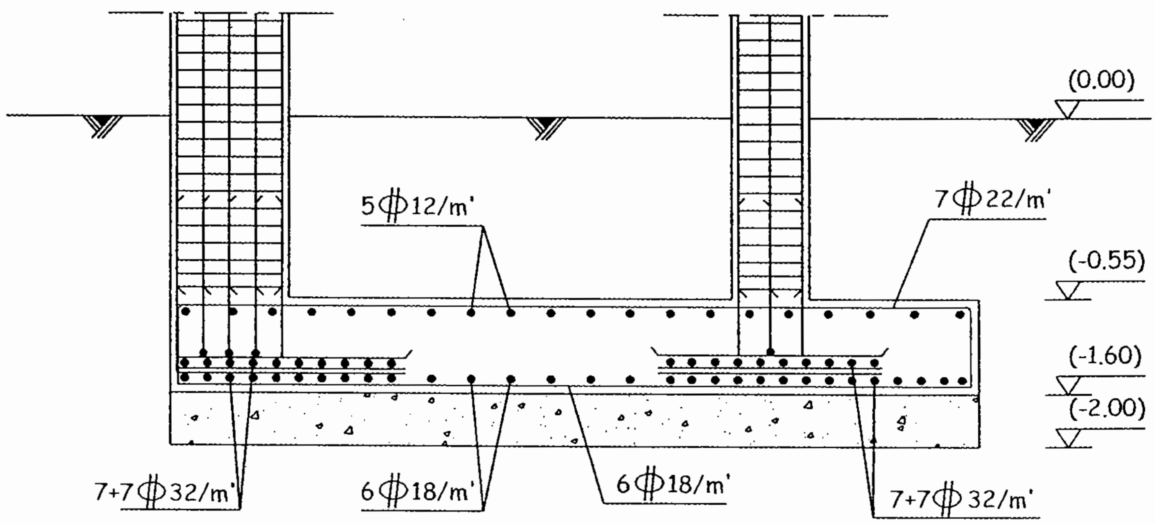
14 ϕ 32/m'

on two rows

Details :- (NTS)



PLAN



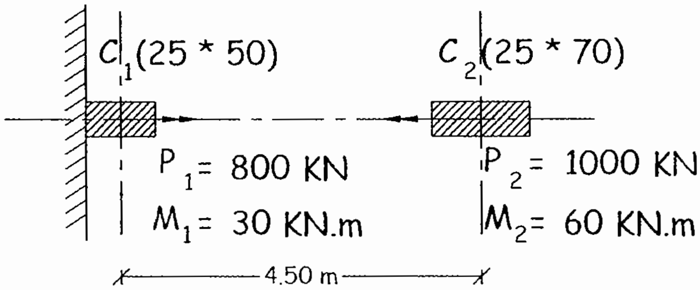
SEC. (X-X)

Example No. (3):-

For the shown two columns beside the property line of a building, it is required to design a suitable foundation system to support the two columns under the given loads (normal loads and moments on the columns are considered), full detail (scale 1:50) in plan and elevation are required.

Given:-

- $t_{P.C}$ = 40 cm
- $q_{all.}$ = 150 Kpa
- f_{cu} = 30 N/mm^2
- f_y = 360 N/mm^2



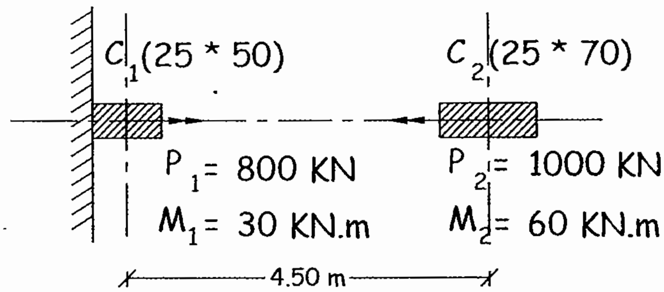
Solution:-

∵ C_1 ملاصق لحد الجار

∴ لا يصلح حل ال Isolated footing

∵ S = 4.50 m

∴ Try Combined Rect.

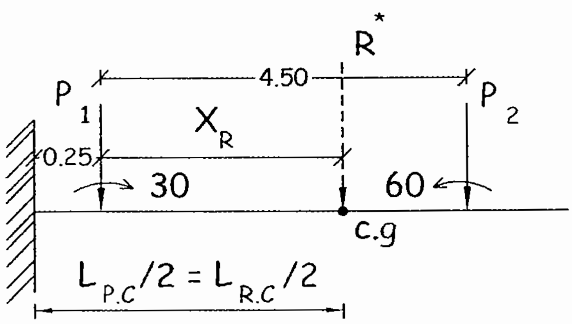


$R^* = P_1 + P_2 = 800 + 1000 = 1800$ KN

$\Sigma M_{C_1} =$ Zero

∴ $1000 * 4.50 + 30 - 60 = X_R * 1800$

$X_R = 2.48$ m



1) Calculate the footing area :-

$$\frac{L_{P.C}}{2} = X_R + D = 2.48 + 0.25 = 2.73 \text{ m} \approx 2.75 \text{ m}$$

$$L_{P.C} = 2 * 2.75 = 5.50 \text{ m}$$

$$L_{P.C} = L_{R.C} = 5.50 \text{ m}$$

$$\because t_{P.C} = 40 \text{ cm} > 20 \text{ cm}$$

$$\therefore A_{P.C} = \frac{R^*}{q_{all.}} = \frac{1800}{150} = 12 \text{ m}^2 = B_{P.C} * 5.50$$

$$\therefore B_{P.C} = \frac{A_{P.C}}{L_{P.C}} = \frac{12}{5.50} = 2.18 \text{ m} \approx 2.20 \text{ m}$$

$$B_{R.C} = 2.20 - 2 * 0.40 = 1.40 \text{ m}$$

2) Design in long direction:-

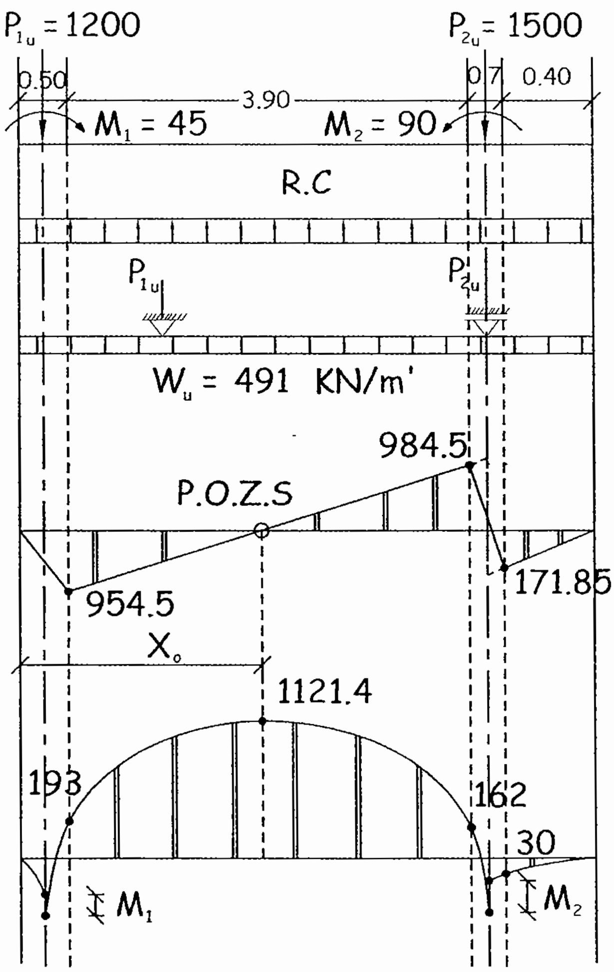
$$P_{1u} = 1.5 * 800 = 1200 \text{ KN}$$

$$P_{2u} = 1.5 * 1000 = 1500 \text{ KN}$$

$$R^*_u = 1.5 * 1800 = 2700 \text{ KN}$$

$$W_u = \frac{2700}{5.50} = 491 \text{ KN/m'}$$

$$q_u = \frac{2700}{5.50 * 1.40} = 350.65 \text{ KN/m}^2$$



* get the point of zero shear:-

$$1200 = 491 * X_o \Longrightarrow X_o = 2.44 \text{ m}$$

$$M_{max.} = 491 * \frac{2.44^2}{2} + 45$$

$$- 1200 [2.44 - 0.25]$$

$$= - 1121.4 \text{ KN.m}$$

$$\therefore d = 5\sqrt{\frac{M_{max.} * 10^6}{f_{cu} * B_{R.C}(mm)}} = 5\sqrt{\frac{1121.4 * 10^6}{30 * 1400}} = 817 \text{ mm}$$

take d = 830 mm

③ Check Shear :-

$Q_{max.} = 984.5$ KN

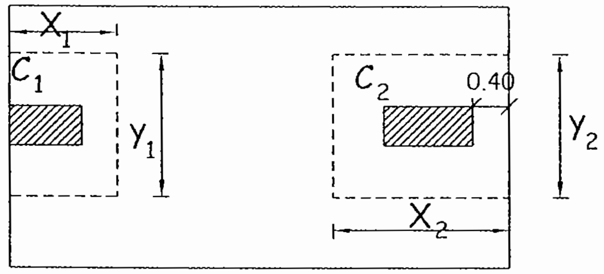
$$Q_{su} = Q_{max.} - W * \frac{d}{2} = 984.5 - 491 * \frac{0.83}{2} = 780.7 \text{ KN}$$

$$q_{su} = \frac{Q_{su} * 10^3}{d * B} = \frac{780.7 * 10^3}{830 * 1400} = 0.67 \quad N/mm^2$$

$$q_{scu} = 0.16\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.16\sqrt{\frac{30}{1.5}} = 0.72 \quad N/mm^2$$

$$\because q_{su} < q_{scu} \Rightarrow \therefore \text{SAFE}$$

④ Check Punching Shear :-



For C_1

$X_1 = 0.5 + \frac{0.83}{2} = 0.915$ m

$Y_1 = 0.25 + 0.83 = 1.08$ m

$Q_{p_1} = 1200 - 350.65 * (1.08 * 0.915)$

$= 853.5$ KN

$q_{p_1} = \frac{853.5 * 10^3}{830 * [2 * 915 + 1080]} = 0.35$ N/mm^2

$q_{p_{cu_1}} = 0.316 * (0.5 + \frac{0.25}{0.5}) \sqrt{\frac{30}{1.5}}$

$= 1.413$ N/mm^2

$\because q_{p_1} < q_{p_{cu_1}} \Rightarrow \therefore$ SAFE

For C_2

$X_2 = 0.7 + \frac{0.83}{2} + 0.40 = 1.515$ m

$Y_2 = 0.25 + 0.83 = 1.08$ m

$Q_{p_2} = 1500 - 350.65 * (1.515 * 1.08)$

$= 926.27$ KN

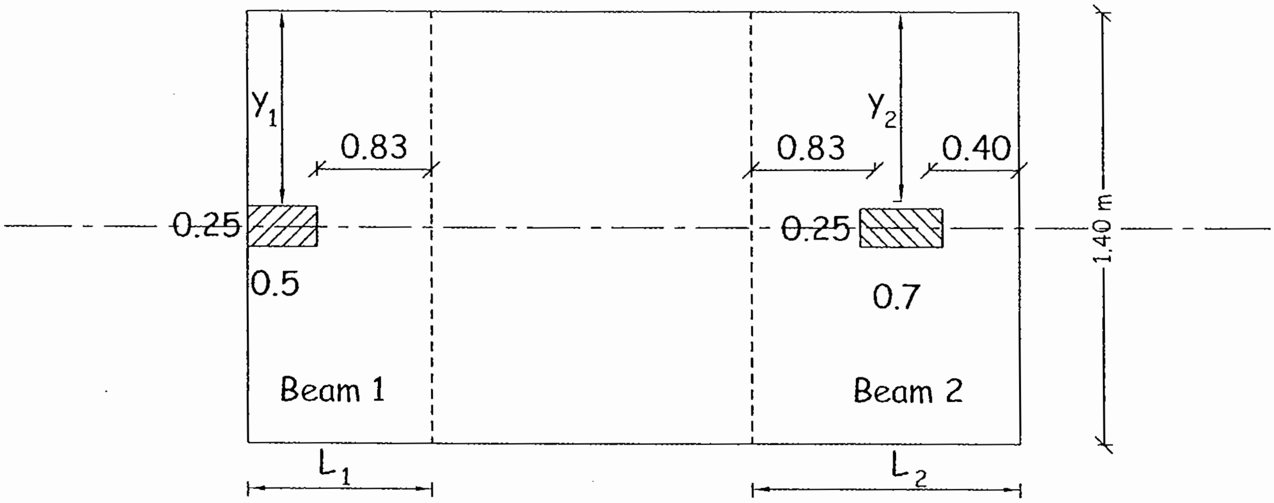
$q_{p_2} = \frac{926.27 * 10^3}{830 * [2 * 1515 + 1080]} = 0.27$ N/mm^2

$q_{p_{cu_2}} = 0.316 * (0.5 + \frac{0.25}{0.70}) \sqrt{\frac{30}{1.5}}$

$= 1.21$ N/mm^2

$\because q_{p_2} < q_{p_{cu_2}} \Rightarrow \therefore$ SAFE

(5) Design in short direction:-



For Beam 1

$L_1 = 0.5 + 0.83 = 1.33$ m

$\therefore q_{u_1} = \dfrac{1200}{1.40 * 1.33} = 644.5$ KN/m^2

$\therefore Y_1 = \dfrac{1.40 - 0.25}{2} = 0.575$ m

$\therefore M_1 = 644.5 * \dfrac{0.575^2}{2} * 1m$

$= 106.5$ KN.m/m'

For Beam 2

$L_2 = 0.7 + 0.83 + 0.40 = 1.93$ m

$\therefore q_{u_2} = \dfrac{1500}{1.40 * 1.93} = 555$ KN/m^2

$\therefore Y_2 = \dfrac{1.40 - 0.25}{2} = 0.575$ m

$\therefore M_2 = 555 * \dfrac{0.575^2}{2} * 1m$

$= 91.75$ KN.m/m'

$$M_{bigger} = M_1 = 106.5 \text{ KN.m/m'}$$

$$\therefore d = 830 = C_1 \sqrt{\frac{106.5 * 10^6}{30 * 1000}} \Rightarrow C_1 = 13.9 > 2.8 \quad \therefore \text{SAFE}$$

(6) Final Thickness :-

$d_{final} = 830$ mm

$t_{final} = 830 + 70$ (cover) $= 900$ mm

⑦ R.F.T :-

$$A_{s_{min.}} = \begin{cases} 1.5 * d_{mm} = 1.5 * 830 = 1245 \ mm^2/m' \\ 5 \phi 12/m' = 565 \ mm^2/m' \end{cases} \quad \boxed{7 \phi 16/m'}$$

In Long direction:-

$$A_{s_{Top}} = \frac{M_{u_{top}} * 10^6 / B}{F_y * J * d} = \frac{1121.4 * 10^6 / 1.40}{360 * 0.826 * 830} = 3260 \ mm^2/m'$$

$$\boxed{9 \phi 22/m'}$$

$$A_{s_{Bottom}} = \frac{M_{u_{bot.}} * 10^6 / B}{F_y * J * d} = \frac{30 * 10^6 / 1.40}{360 * 0.826 * 830} = 86 \ mm^2/m' < A_{s_{min.}}$$

use $A_{s_{min.}}$ $\boxed{7 \phi 16/m'}$

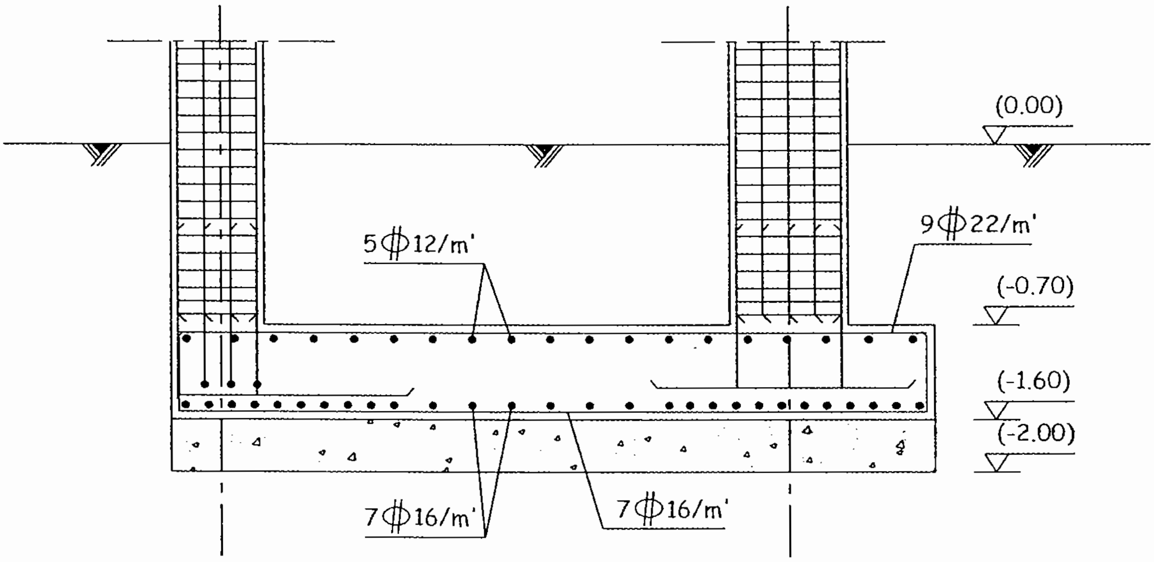
In Short direction:-

$$A_{s_1} = \frac{M_{u_1} * 10^6}{F_y * J * d} = \frac{106.5 * 10^6}{360 * 0.826 * 830} = 431 \ mm^2/m' < A_{s_{min.}}$$

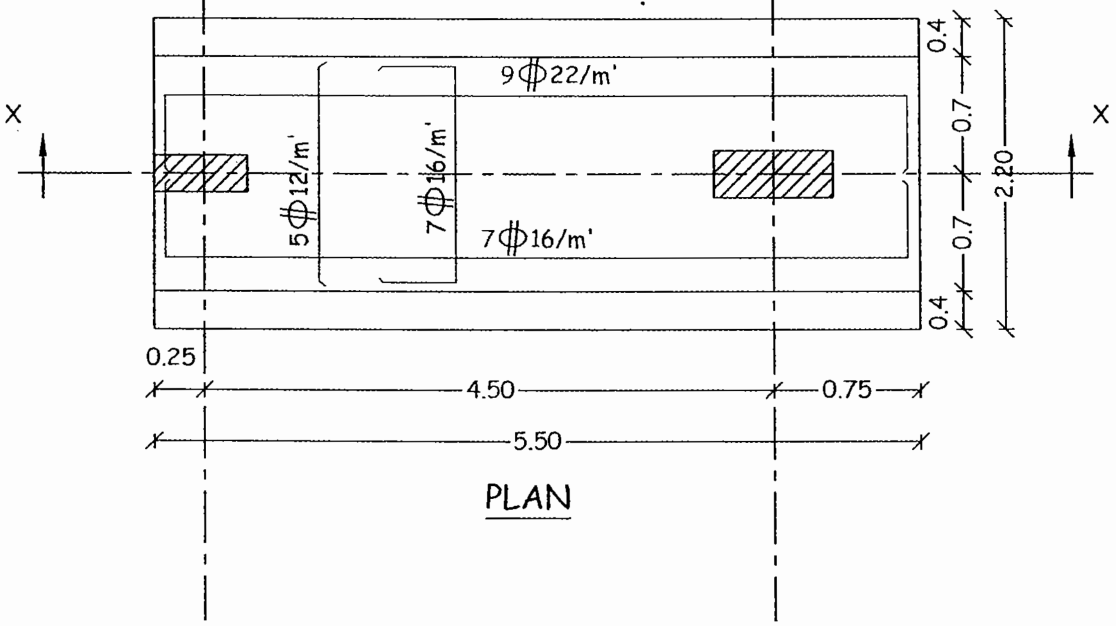
$$A_{s_2} = \frac{M_{u_2} * 10^6}{F_y * J * d} = \frac{94.2 * 10^6}{360 * 0.826 * 830} = 381 \ mm^2/m' < A_{s_{min.}}$$

use $A_{s_{min.}}$ $\boxed{7 \phi 16/m'}$

⑧ Details :-



SEC. (X-X)



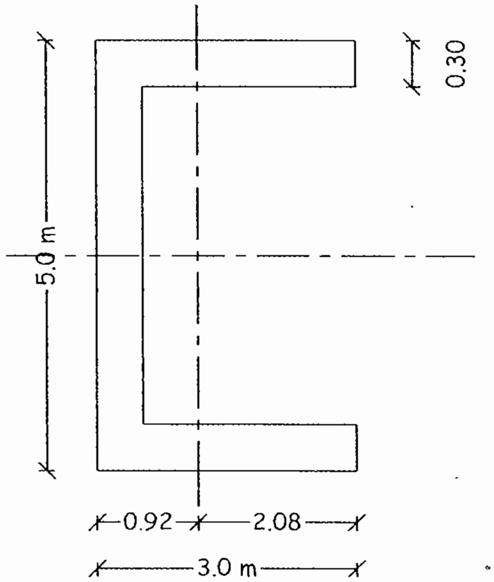
PLAN

Example No. (4):-

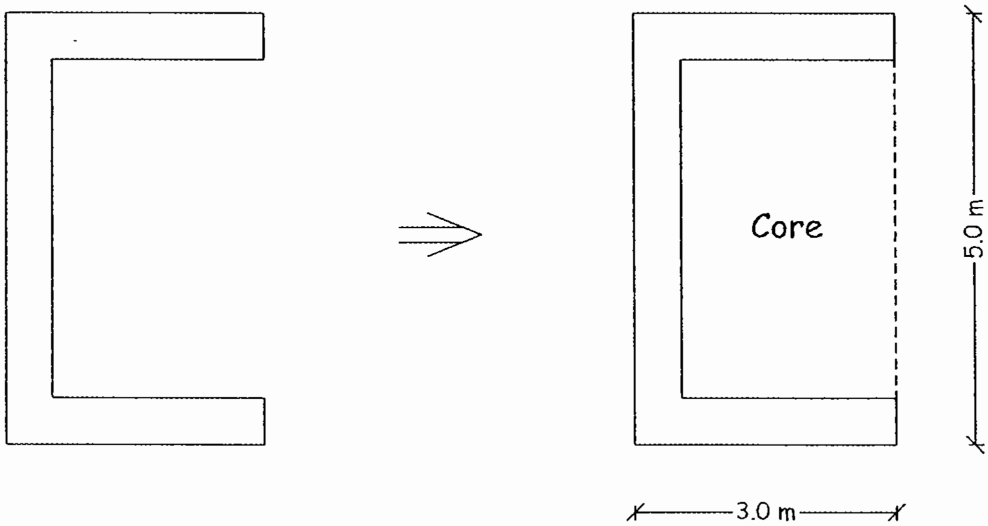
For the shown reinforced concrete core, design a suitable foundation assuming rigid footing. The core is carrying net working load of 1000 ton, the net bearing capacity of supporting soil is 20 t/m^2.

Given:-

- f_{cu} = 30 N/mm^2
- f_y = 400 N/mm^2



Solution:-



① Calculate the footing area :-

assume $t_{P.C} = 10$ cm < 20 cm

$$\therefore A_{R.C} = \frac{10000}{200} = 50 \quad m^2 = B_{R.C} * L_{R.C} \dashrightarrow ①$$

$$L_{R.C} - B_{R.C} = b - a$$

$$L_{R.C} - B_{R.C} = 5 - 3 = 2 \text{ m} \dashrightarrow ②$$

Solving ① & ② :-

$$50 = B_{R.C} * (2 + B_{R.C}) \Longrightarrow B_{R.C} = 6.14 \approx 6.15 \text{ m}$$

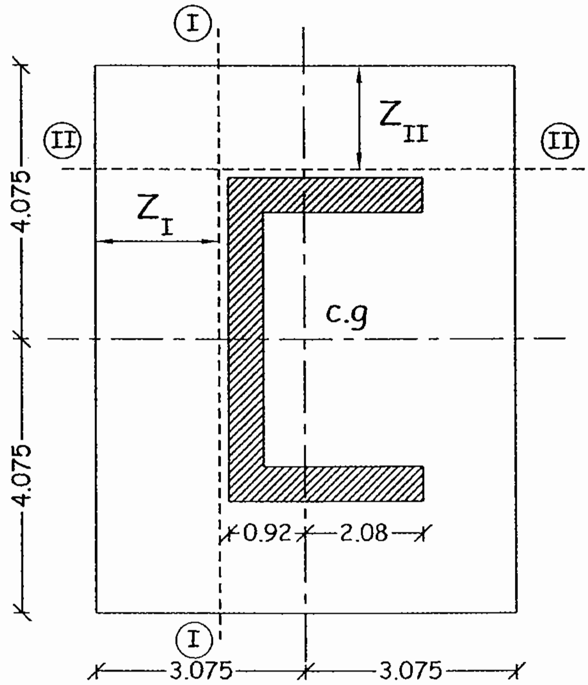
$$L_{R.C} = 2 + B_{R.C} = 2 + 6.15 = 8.15 \text{ m}$$

$$L_{P.C} = 8.15 + 2 * 0.10 = 8.35 \text{ m}$$

$$B_{P.C} = 6.15 + 2 * 0.10 = 6.35 \text{ m}$$

② Ultimate loads :-

$$q_u = \frac{1.5 * 10000}{8.15 * 6.15} = 299.3 \text{ KN/m}^2$$



③ Critical section for moment (M) :-

** For sec (I-I)

$$Z_I = \frac{1}{2}(8.15 - 5) = 1.575 \text{ m}$$

$$\therefore M_{u_I} = 299.3 * \frac{1.575^2}{2} * 1 \text{ m}$$

$$= 371.22 \quad KN.m/m'$$

** For sec (II-II)

$$Z_{II} = 3.075 - 0.92 = 2.155 \text{ m}$$

$$\therefore M_{u_{II}} = 299.3 * \frac{2.155^2}{2} * 1 \text{ m}$$

$$= 695 \quad KN.m/m'$$

$$M_{bigger} = M_{u_{II}} = 695 \quad KN.m/m'$$

$$d_{II} = 5\sqrt{\frac{695 * 10^6}{30 * 1000}} = 761 \text{ mm} \simeq 780 \text{ mm}$$

④ Check Shear :-

$$\ell = Z_{II} - \frac{d}{2} = 2.155 - \frac{0.78}{2} = 1.765 \text{ m}$$

$$Q_{su} = q_u * \ell * 1m = 299.3 * 1.765 * 1m = 528.3 \quad KN/m'$$

$$q_{su} = \frac{Q_{su} * 10^3}{d * B} = \frac{528.3 * 10^3}{780 * 1000} = 0.677 \quad N/mm^2$$

$$q_{scu} = 0.16\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.16\sqrt{\frac{30}{1.5}} = 0.715 \quad N/mm^2$$

$$\because q_{su} < q_{scu} \Rightarrow \therefore \text{SAFE}$$

⑤ Check Punching Shear :-

The given column works as a core (acts as a wall), therefore no punching shear check shall be calculated.

⑥ Final Thickness :-

$$d_{final} = 780 \text{ mm}$$

$$t_{final} = 780 + 70 \text{ (cover)} = 850 \text{ mm}$$

⑦ R.F.T :-

$$A_{s_{min.}} = \begin{cases} 1.5 * d_{mm} = 1.5 * 780 = 1170 \text{ mm}^2/\text{m}' \\ 5 \phi 12/\text{m}' = 565 \text{ mm}^2/\text{m}' \end{cases}$$

6 ɸ 16/m'

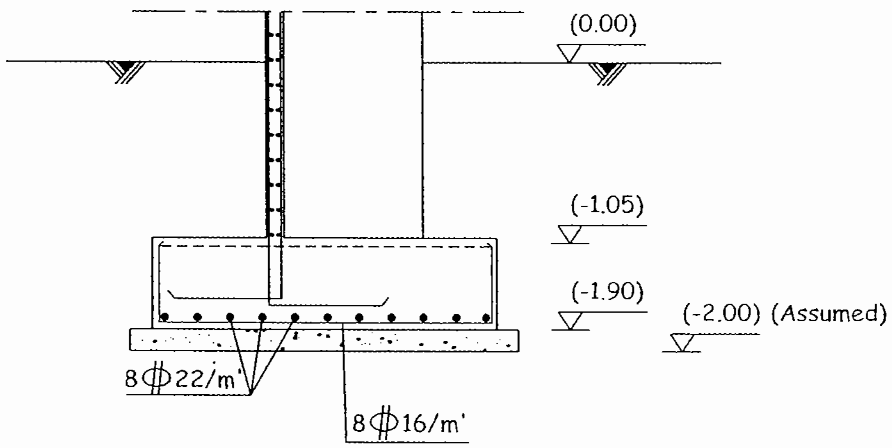
$$A_{s_I} = \frac{M_{u_I} * 10^6}{F_y * J * d} = \frac{371.22 * 10^6}{400 * 0.826 * 780} = 1440 \text{ mm}^2/\text{m}'$$

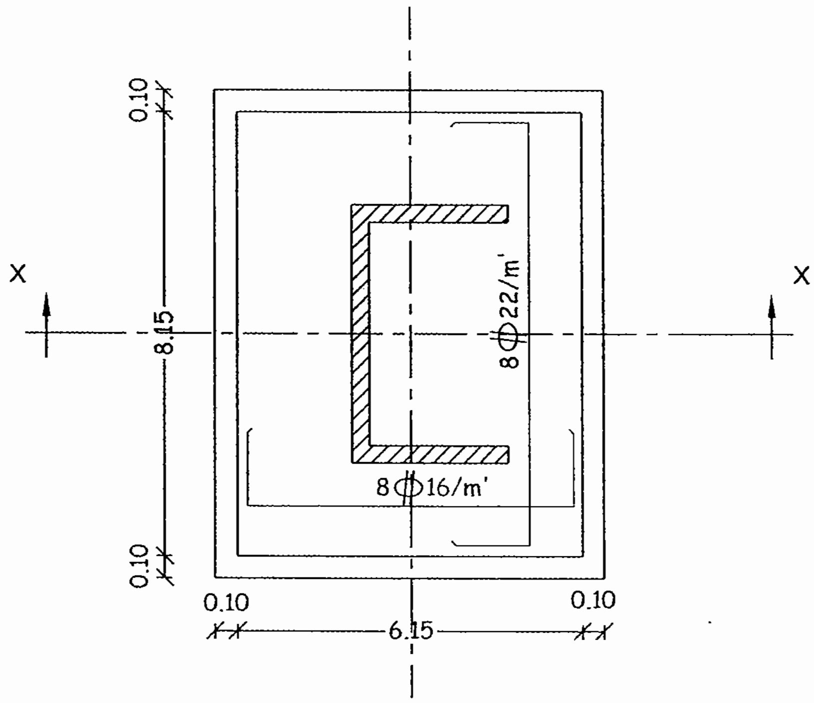
8 ɸ 16/m'

$$A_{s_{II}} = \frac{M_{u_{II}} * 10^6}{F_y * J * d} = \frac{695 * 10^6}{400 * 0.826 * 780} = 2696.8 \text{ mm}^2/\text{m}'$$

8 ɸ 22/m'

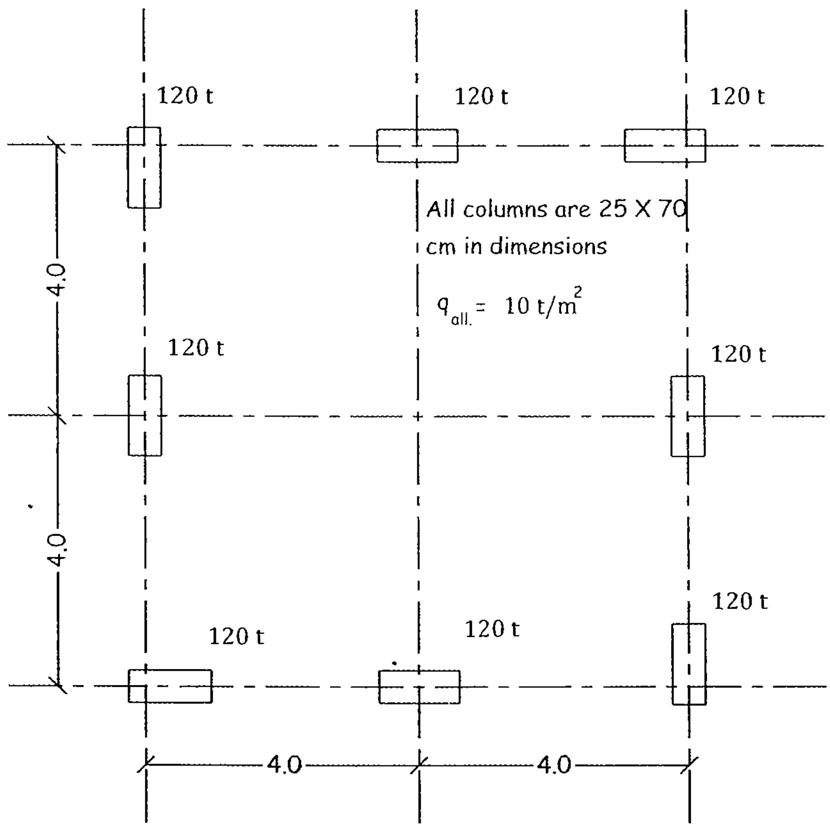
⑧ Details :-


(0.00)
(-1.05)
(-1.90)
(-2.00) (Assumed)
8Φ22/m'
8Φ16/m'


X
X
0.10
8.15
0.10
8Φ22/m'
8Φ16/m'
0.10
6.15
0.10

Example No. (5):-

For the group of columns shown in figure, suggest a suitable type of foundation and calculate the are required in each case. Without design, sketch concrete dimensions and reinforcement details.



Solution:-

- ALL columns are 25 * 70 cm
- P = 120 ton ⟶ for each column
- $q_{all.} = 10 \quad t/m^2$

① Calculate the footing area :-

assume $t_{P.C} = 30 \text{ cm} > 20 \text{ cm}$

$$\therefore A_{P.C} = \frac{120}{10} = 12 \quad m^2 = B_{P.C} * L_{P.C} \quad \text{-------}\rightarrow ①$$

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

$$L_{P.C} - B_{P.C} = 0.7 - 0.25 = 0.45 \text{ m} \quad \text{-------}\rightarrow ②$$

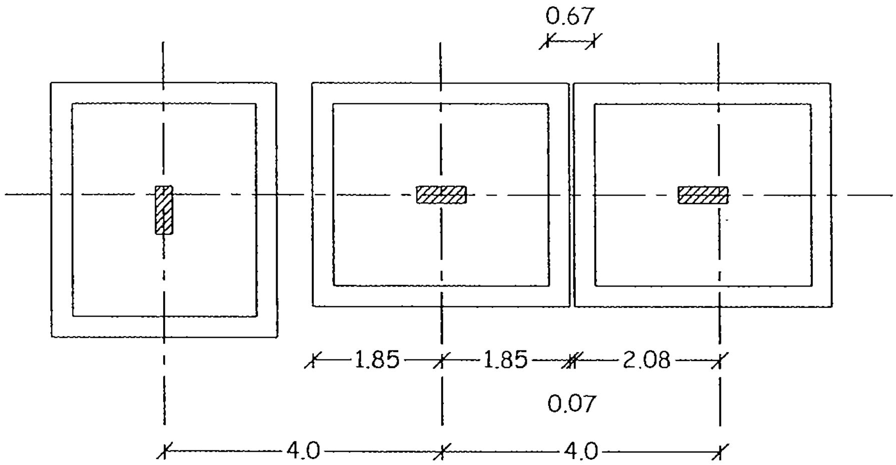
Solving ① & ② :-

$$12 = B_{P.C} * (0.45 + B_{P.C}) \Longrightarrow B_{P.C} = 3.24 \approx 3.25 \text{ m}$$

$$L_{P.C} = 0.45 + B_{P.C} = 0.45 + 3.25 = 3.70 \text{ m}$$

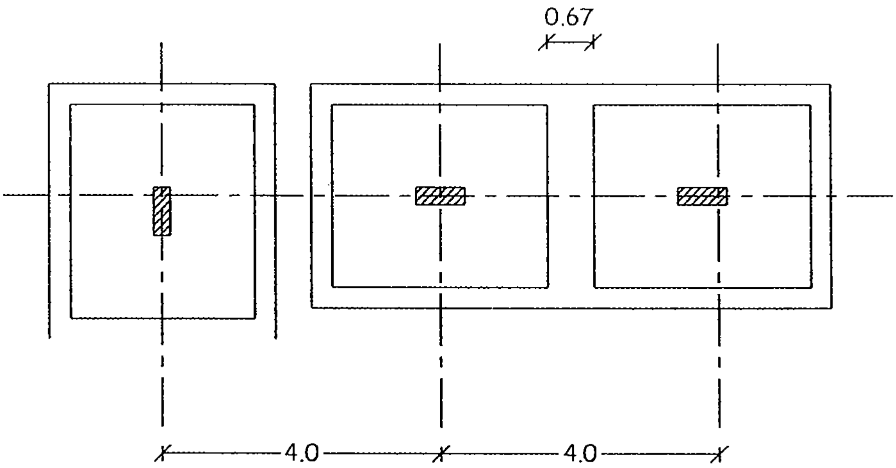
$$L_{R.C} = 3.70 - 2 * 0.30 = 3.10 \text{ m}$$

$$B_{R.C} = 3.25 - 2 * 0.30 = 2.65 \text{ m}$$



أقل مسافة بين القواعد العادية من الرسم هى 7.0 cm وهى مسافة صغيرة لا تمكنا من عمل الشدات الخشبية .

يمكن دمج القواعد العادية سويا مع ملاحظة ان القواعد المسلحة تبعد عن بعضها البعض مسافة 67 cm وهى مسافة كافية بين القاعدتين المسلحتين لتوزيع اجهاد كلا منهما على التربة .

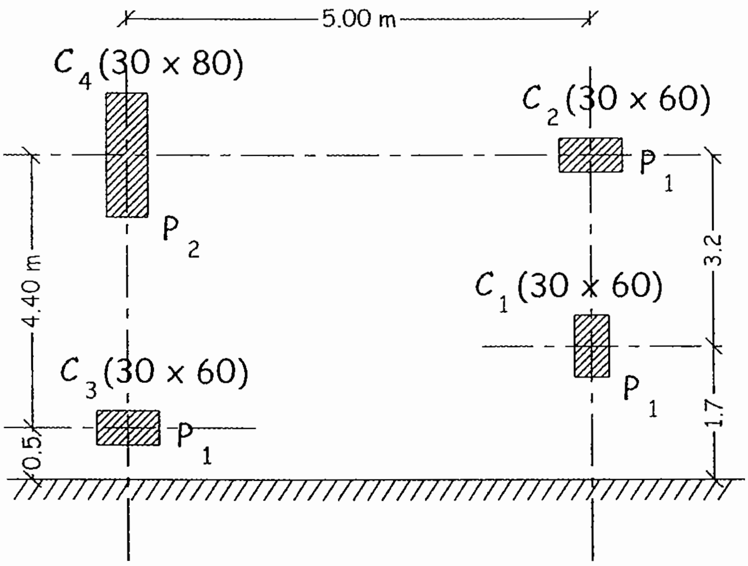


Example No. (6):-

For the four columns, shown in the part plan in figure (1), it is required to:

a) Suggest the most suitable and economic foundation type for the four columns, and then calculate the required footings concrete horizontal dimensions if the thickness of P.C. is 30 cm, and $q_{all.} = 20\ t/m^2$.

b) Draw a plan with scale 1:50, showing the foundations dimensions.



Given:-

P_1 = 1000 KN

P_2 = 1300 KN

Solution: -

(a) C_1, C_2, and C_3 have same dimensions and loads, but different geometry.

Try isolated footing

Calculate the footing area :-

$$\because \; t_{P.C} = 30 \text{ cm} > 20 \text{ cm}$$

$$\therefore \; A_{P.C} = \frac{1000}{200} = 5 \; m^2 = B_{P.C} * L_{P.C} \quad \text{------} \rightarrow (1)$$

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

$$L_{P.C} - B_{P.C} = 0.6 - 0.30 = 0.30 \text{ m} \quad \text{------} \rightarrow (2)$$

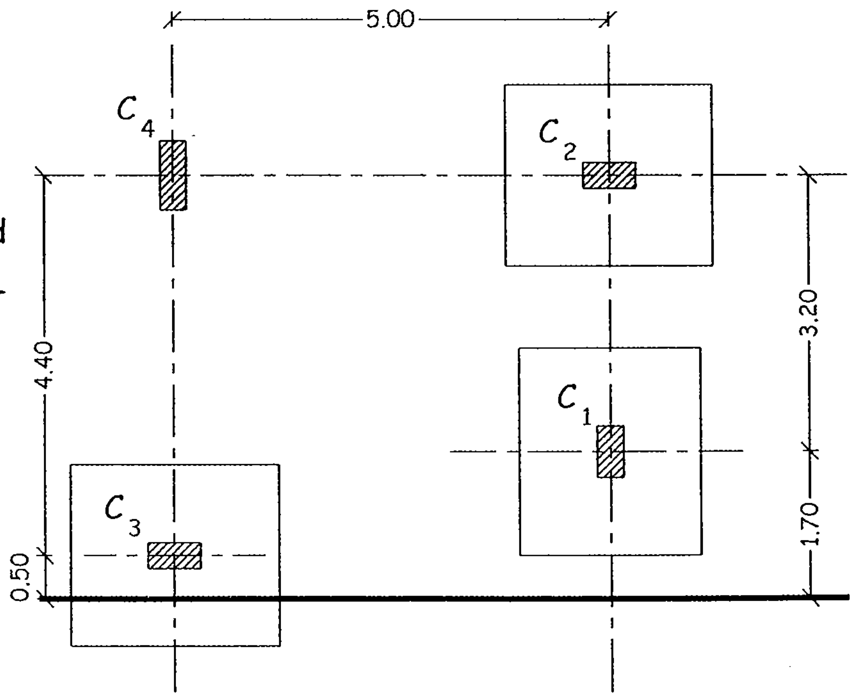
Solving (1) & (2) :-

$$5 = B_{P.C} * (0.30 + B_{P.C}) \Longrightarrow B_{P.C} = 2.09 \approx 2.10 \text{ m}$$

$$L_{P.C} = 0.30 + B_{P.C} = 0.30 + 2.10 = 2.40 \text{ m}$$

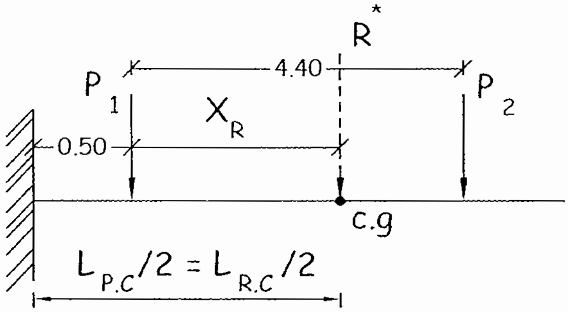
We can use isolated footings for C_1 & C_2, but not for C_3.

For C_3 & C_4, combined rectangular footing, as S = 4.40 m.



$R^* = P_1 + P_2 = 1000 + 1300 = 2400$ KN

$$X_R = \frac{1300 * 4.40}{2400} = 2.38 \text{ m}$$



① Calculate the footing area :-

$$\frac{L_{P.C}}{2} = X_R + D = 2.38 + 0.50 = 2.88 \text{ m} \approx 2.90 \text{ m}$$

$$L_{P.C} = 2 * 2.90 = 5.80 \text{ m}$$

$$L_{P.C} = L_{R.C} = 5.80 \text{ m}$$

$$\because \; t_{P.C} = 30 \text{ cm} > 20 \text{ cm}$$

$$\therefore \; A_{P.C} = \frac{R^*}{q_{all.}} = \frac{2400}{200} = 12 \text{ m}^2 = B_{P.C} * 5.80$$

$$\therefore \; B_{P.C} = \frac{A_{P.C}}{L_{P.C}} = \frac{12}{5.80} = 2.06 \text{ m} \approx 2.10 \text{ m}$$

$$B_{R.C} = 2.10 - 2 * 0.30 = 1.50 \text{ m}$$

(b)