ص ٣٢٥

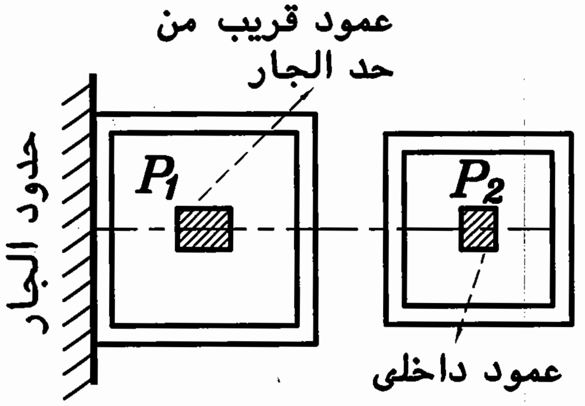
4th Year Civil
Public Works Department
Foundation Engineering
2012 - 2013

فونديشن
رابعة اشغال
٤
م/محمود فوزى

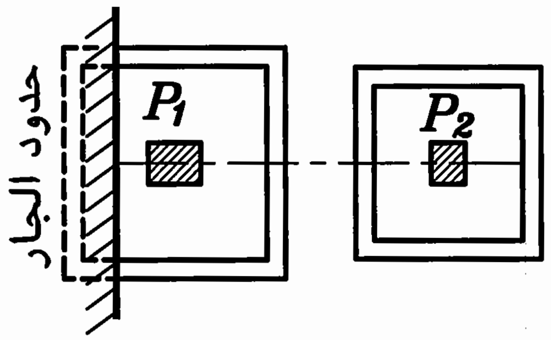
4

Shallow Foundations
Strap Beam

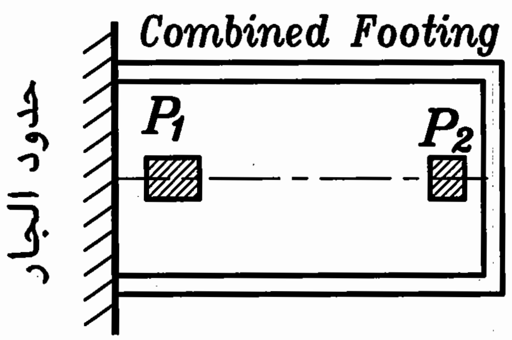
Design of strap beam

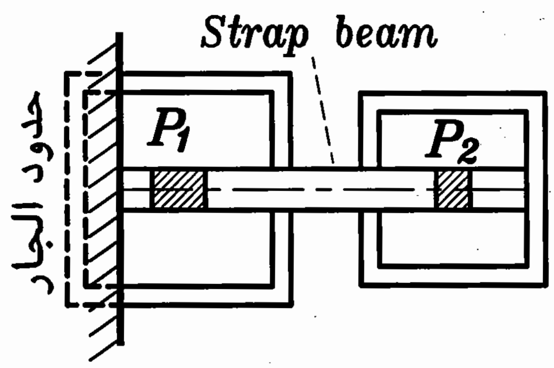


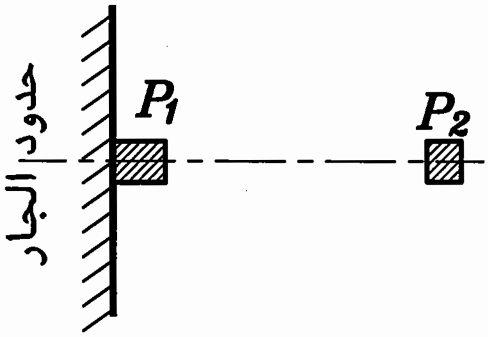
- عند وجود عمود قريب من حد الجار نحاول أولا أن نعمل قاعده منفصله بأبعاد خاصه بحيث لا تدخل القاعده العاديه فى حدود الجار.



و لكن اذا زادت أبعاد القاعده و تعدت حدود الجار فيتم ربط عمود الجار بعمود داخلى مجاور اما عن طريق قاعده مشتركه
Combined Footing
أو كمره تحزيم (شداد)
Strap beam







- عند وجود عمود عند حد الجار مباشره يتم ربط عمود الجار بعمود داخلى مجاور له بنفس الطريقة السابقة ونستبعد حل القاعدة المنفصلة .

و يتوقف اختيار نوع القاعده التى سوف تربط عمود حد الجار بالعمود الداخلى على :

١ ـ المسافه بين عمود حد الجار و العمود الداخلى المجاور . C_1 , C_2

٢ ـ قيمه الاحمال الواقعه على العمودين . P_1 , P_2

٣ ـ أكبر اجهاد تتحمله التربه *Bearing capacity of soil*

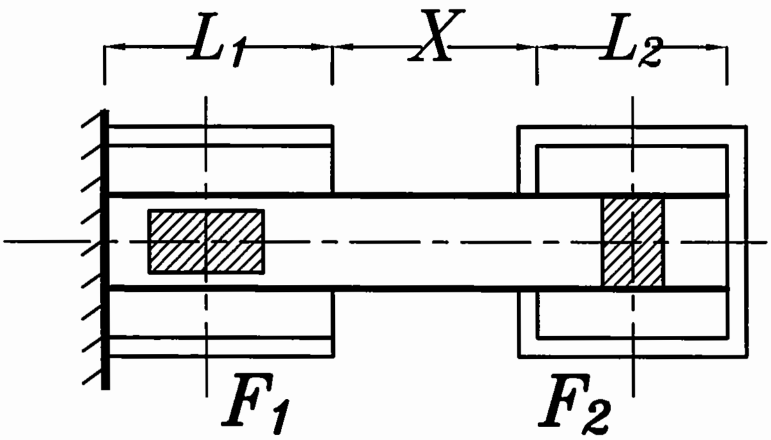
اذا لم ينفع حل القواعد المنفصله يتم التفكير اولا فى استخدام *Strap Beam*

و لتحديد اذا كانت الـ *Strap Beam* تنفع أم لا فيتم حساب أبعاد القواعد المنفصله F_1 , F_2

اذا حدث تداخل فى القواعد لن تنفع الـ *Strap Beam* و نعمل *Combined Footing*

اذا كانت المسافه بين القواعد المسلحه X أصغر من $\frac{L_2}{2}$ or $\frac{L_1}{2}$

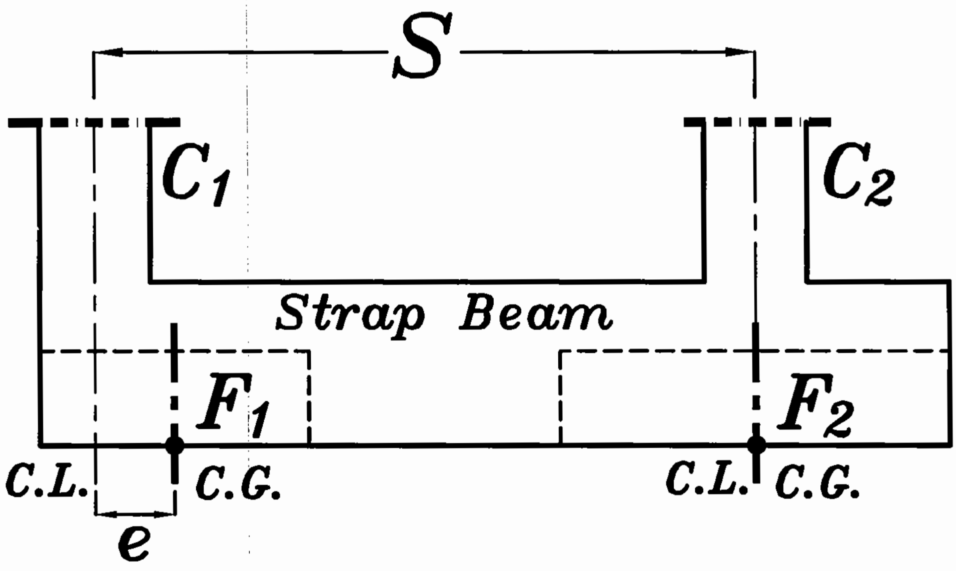
لن تنفع *Strap Beam*



IF $X \geqslant \frac{L_1}{2}$ or $\frac{L_2}{2}$ أيهما أصغر

use strap beam

الفكرة الاساسية



١- مركز القاعده F_2 أسفل العمود الداخلى يكون أسفل محور العمود مباشره.

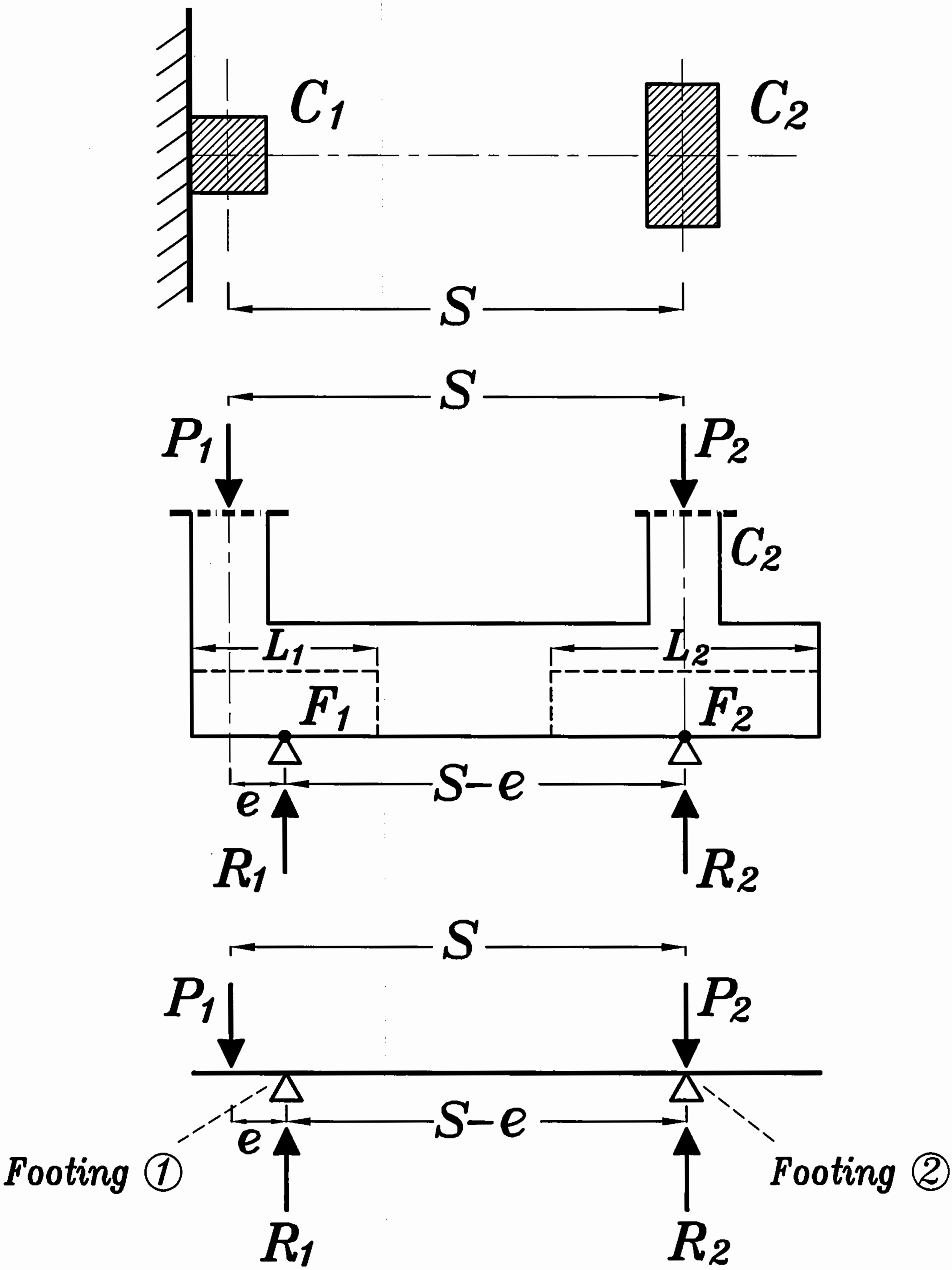
$C.G.$ القاعده F_2 تكون منطبقه مع $C.L.$ العمود C_2 .

٢- مركز القاعده F_1 أسفل عمود الجار C_1 يكون على بعد مسافه (e) من محور العمود .

$$e = (0.1 - 0.2)\ S$$

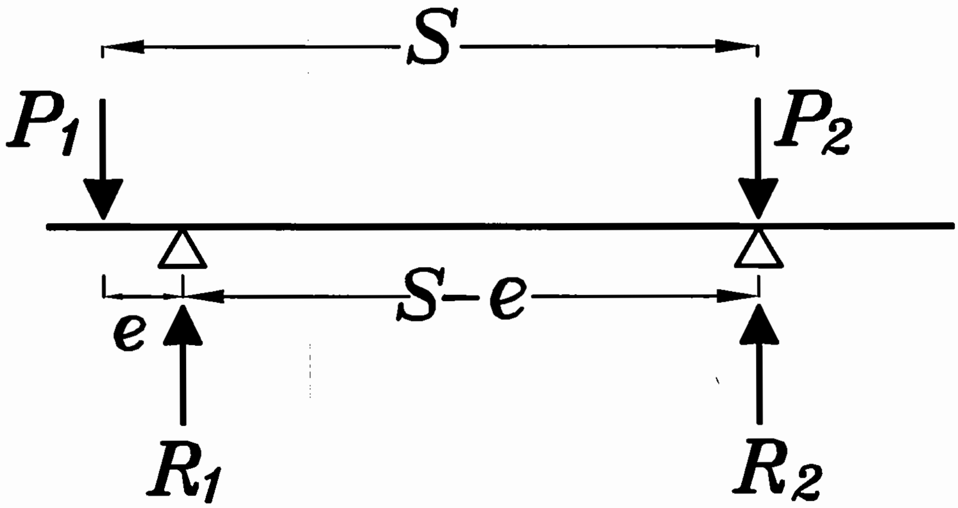
و ذلك حتى لا تدخل القاعده F_1 فى منطقه الجار .

Design steps of strap beam footing system :



1– Calculate the Footing area. (Width & Length of R.C. Footings.)

- Take $e = (0.1 \rightarrow 0.2)\, S$
- Calculate the reactions on Footings R_1, R_2



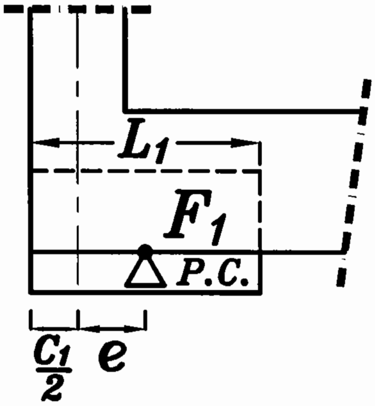
$$P_1 * S = R_1 * (S-e)$$

$$R_1 = \frac{P_1 * S}{S-e}$$

$$P_1 + P_2 = R_1 + R_2 \longrightarrow R_2 = P_1 + P_2 - R_1$$

Footing F_1

IF $t_{P.C.} > 20\ cm$



$$L_{1P.C.} = L_{1R.C.}$$

$$L_{1R.C.} = 2\left(e + \frac{C_1}{2}\right)$$

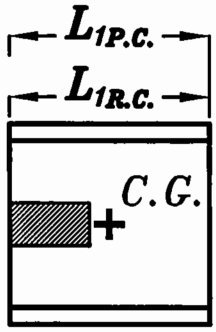
$$A_{P.C.} = \frac{R_1}{q_{all}} = \checkmark\checkmark\ m^2$$

$$A_{P.C.} = B_{1P.C.} * L_{1P.C.} \longrightarrow B_{1P.C.} = \checkmark$$

بعد حساب $B_{1P.C.}$ تقرب لاقرب ٥٠ مم بالزياده

$$B_{1R.C.} = B_{1P.C.} - 2\ t_{P.C.}$$

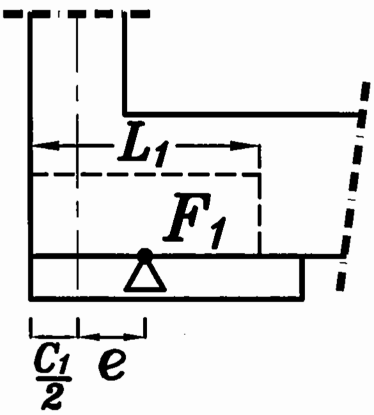
$$L_{1R.C.} = L_{1P.C.}$$



فى هذة الحالة يجب ان يكون الـ .C.G للقاعده العاديه و المسلحه منطبقان لان القاعدة العادية تنقل الاجهادات وليست مجرد فرشة نضافة لذلك لا يتم عمل رفرفة فى هذا الاتجاة .

IF $t_{P.C.} \leq 20\ cm$

$$L_{1R.C.} = 2\left(e + \frac{C_1}{2}\right)$$

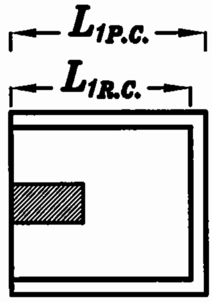


Get $B_{1R.C.}$ From $A_{R.C.} = \frac{R_1}{q_{all}} = \checkmark\checkmark\ m^2$

$$A_{R.C.} = B_{1R.C.} * L_{1R.C.} \longrightarrow B_{1R.C.} = \checkmark$$

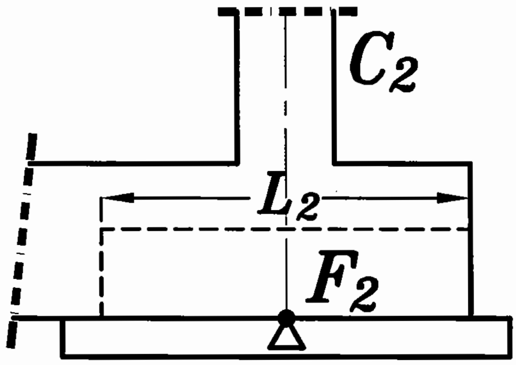
$$B_{1P.C.} = B_{1R.C.} + 2\ t_{P.C.}$$

$$L_{1P.C.} = L_{1R.C.} + t_{P.C.}$$



بروز من ناحيه واحده لان الناحيه الاخرى عندها حد الجار لا يهم فى هذه الحاله أن ينطبق .C.G للقاعده العاديه و المسلحه لان القاعده العاديه فى هذه الحاله فرشه نظافه .

Footing F_2



IF $t_{P.C.} > 20\ cm$

(Square footing)

$$A_{P.C.} = \frac{R_2}{q_{all}} = \checkmark\checkmark\ m^2 = (B_{2\,P.C.})^2 \quad \text{------} (1)$$

بعد حساب $B_{2\,P.C.}$ تقرب لاقرب ٥٠ مم بالزياده

$$\boxed{B_{2\,R.C.} = B_{2\,P.C.} - 2\ t_{P.C.}}$$

IF $t_{P.C.} \leqslant 20\ cm$

(Square footing)

$$A_{R.C.} = \frac{R_2}{q_{all}} = \checkmark\checkmark\ m^2 = (B_{2\,R.C.})^2 \quad \text{------} (1)$$

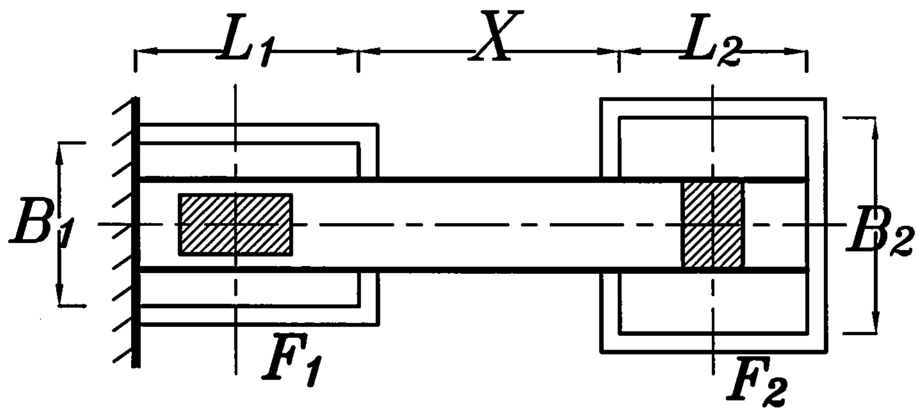
بعد حساب $B_{2\,R.C.}$ تقرب لاقرب ٥٠ مم بالزياده

$$\boxed{B_{2\,P.C.} = B_{2\,R.C.} + 2\ t_{P.C.}}$$

2- Check the validity of using Strap Beam .

نتأكد من سماحيه عمل Strap Beam أم لا .

نرسم sketch للقاعدتين F_2 , F_1 و نحدد عليه أبعاد كل قاعده .



شروط استخدام ال Strap Beam :

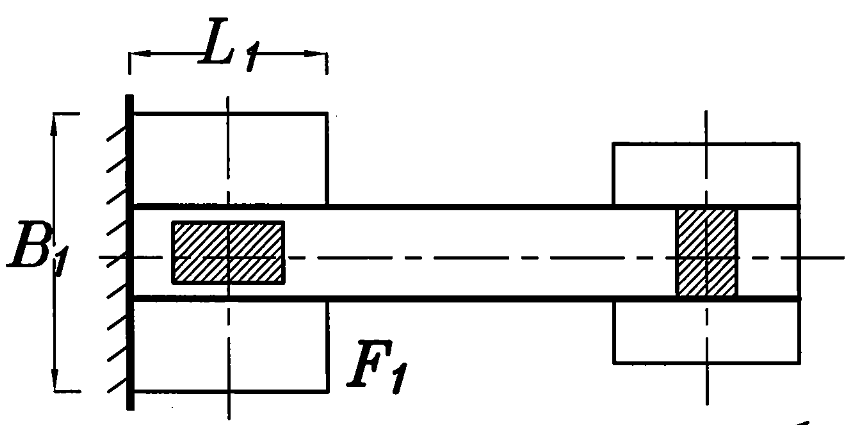
١- عدم حدوث تداخل بين القاعدتين F_1 , F_2

٢- أن لا تقل المسافه X عن الاصغر من $\frac{L_2}{2}$ and $\frac{L_1}{2}$

٣- أن لا يزيد عرض القاعدة F_1 عن مرة و نصف طولها .

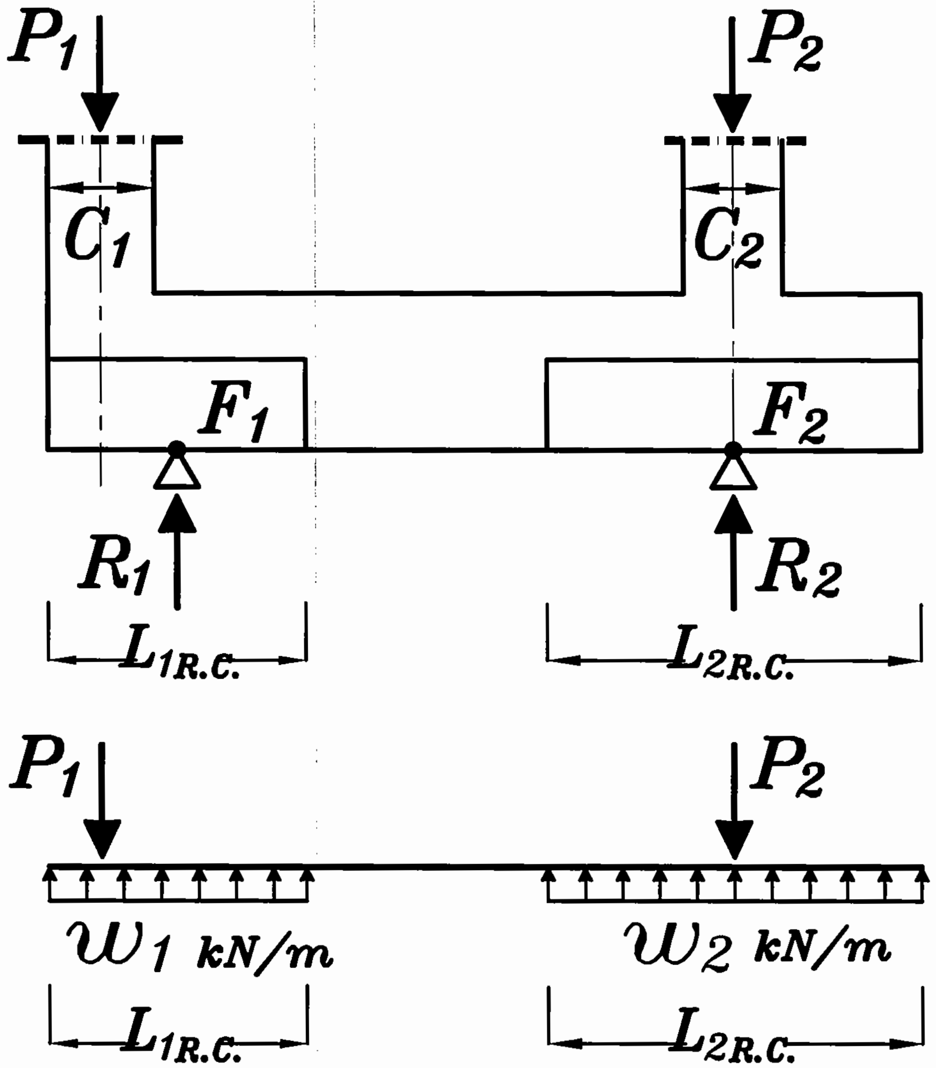
$$B_{1R.C.} \leqslant 1.5 \, L_{1R.C.}$$

اذا لم يتحقق أيا من الشروط السابقه نضطر لعمل **Combined Footing**



شكل غير مفضل
ولكن يمكن عملة فى الشغل خارج الكلية

3 – Dimensions of the Strap Beam. (Width & depth)

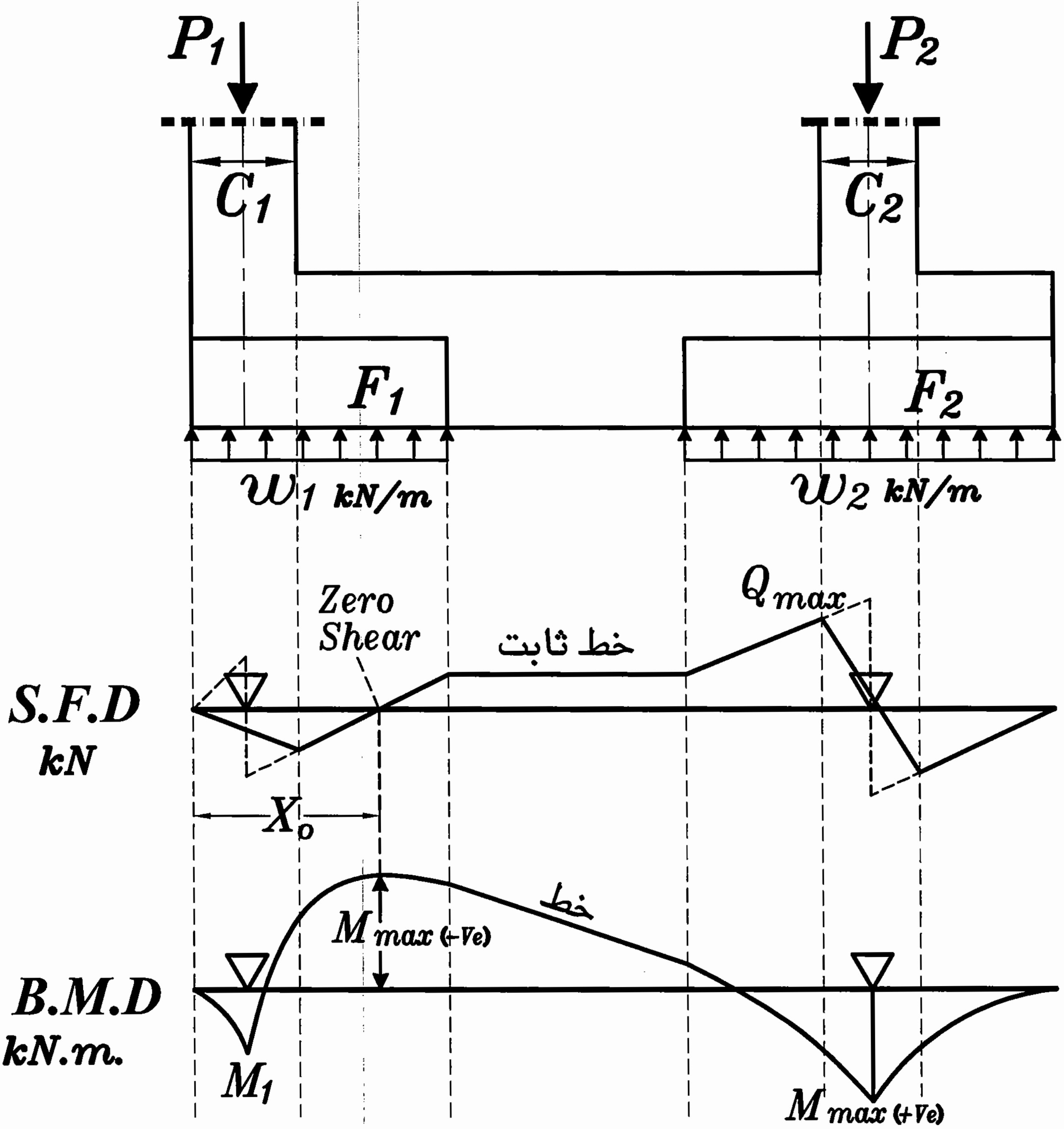


Stresses on Footings.

$$w_1 = \frac{R_{1\,(U.L.)}}{L_{1\,R.C.}} \quad (kN/m)$$

$$w_2 = \frac{R_{2\,(U.L.)}}{L_{2\,R.C.}} \quad (kN/m)$$

Drawing B.M.D. & S.F.D. For the Beam.



To Calculate the point of Zero Shear.

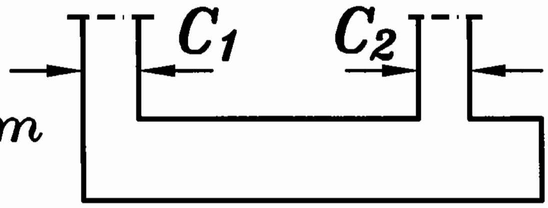
$$w_1 (X_o) = P_1 \longrightarrow X_o = \checkmark$$

To Calculate the max (-Ve) Moment.

$$M_{max\,(-Ve)} = P_1 \left(X_o - \frac{C_1}{2}\right) - w_1 \frac{(X_o)^2}{2}$$

M_{max} the bigger From $M_{max\,(-ve)}$ & $M_{max\,(+ve)}$

Choose $b = (400 \rightarrow 1000)$ mm



لا يقل عرض الكمره عن عرض العمود العمودى عليها

$$d_{(mm)} = C_1 \sqrt{\frac{M_{max\,(kN.m)} * 10^6}{F_{cu\,(N/mm^2)} * b_{(mm)}}}$$

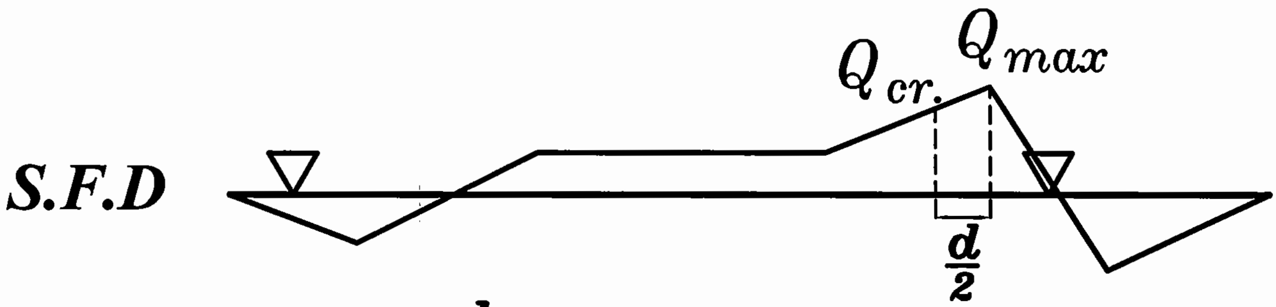
Choose $C_1 = (3.5 \rightarrow 5.0)$ — 5.0 recommended

Get $d = \checkmark\checkmark$ (mm)

Take cover = 70 mm

$t = d + cover\ (70\ mm)$ تقرب لاقرب ٥٠ مم بالزياده

4 – Check Shear For Strap Beam. as beams.



$Q_{cr.}$ على بعد $\frac{d}{2}$ من وش العمود

$$Q_{cr.} = Q_{max.} - w\left(\frac{d}{2}\right)$$

① Calculate Allowable Shear Stresses.

$$q_{scu} = 0.24 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

$$q_{scu\,max.} = 0.70 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

② Calculate Actual Shear Stress.

$$q_{su} = \frac{Q_{cr.}}{b\,d} \quad N\backslash mm^2$$

③ IF

IF q_U

- $q_{su} \leqslant q_{scu}$
  Use min. Stirrups.
  $5 \phi 10 \backslash m'$
  4 branches
- $q_{scu} < q_{su} \leqslant q_{scu\,max.}$
  We need Stirrups
  More Than $5 \phi 10 \backslash m'$
- $q_{su} > q_{scu\,max.}$
  Increase Dim.
  b or d

$* \; IF \;\; q_{scu} < q_{su} < q_{scu_{max.}}$

We need Stirrups more than $5 \phi 10 \backslash m'$

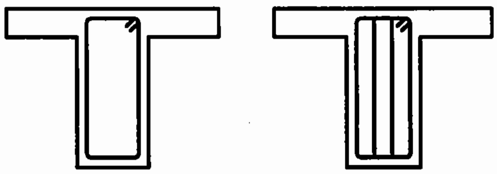
$$q_{su} - \frac{q_{scu}}{2} = \frac{n \, A_s \, (F_y/\gamma_s)}{b \; S}$$

Where :

q_{su} = *Actual Shear Stress.*

$\frac{q_{scu}}{2}$ = *Shear Stress Taken by Concrete only.*

– n = *No. of Branches.*



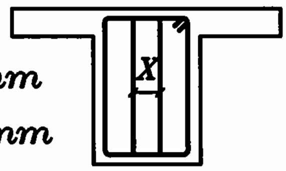
$n=2$ $\qquad$ $n=4$

IF $b \geqslant 400$ mm OR $b > t$ ملحوظه

Take $n=4$

$X \not< 50$ mm

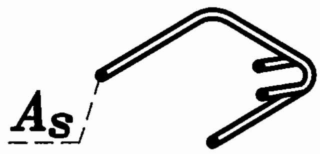
$X \not> 250$ mm



– A_s مساحه سطح السيخ الواحد من الكانه

IF using $\phi 8 \longrightarrow A_s = 50.3 \;\; mm^2$

IF using $\phi 10 \longrightarrow A_s = 78.5 \;\; mm^2$



– $F_y = 240 \quad N\backslash mm^2$ *Mild Steel*

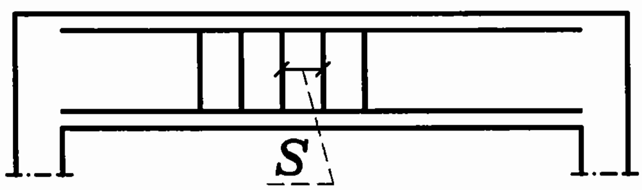
$F_y = 360 \quad N\backslash mm^2$ *H.T.Steel*

– S = *Spacing between stirrups in the Long Direction.*

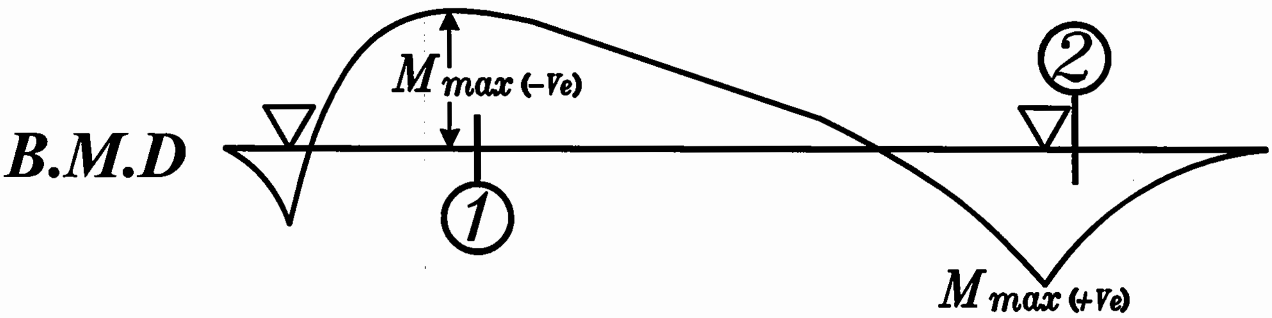
المسافات بين الكانات فى الإتجاه الطولى

$S_{min} = 100$ mm

$S_{max.} = 200$ mm



5 – Reinforcement of Strap Beam.



Sec. ①

$$d = C_1 \sqrt{\frac{M_{max\,(-Ve)}}{F_{cu} * b}} \longrightarrow C_1 \longrightarrow J$$

Get $$A_{S\,Top} = \frac{M_{max\,(-Ve)}}{J\, F_y\, d} \quad (mm^2)$$

Check $A_{S\,min} =$ الأكبر { الأقل { $\frac{1.1}{F_y} b\, d$, $1.3\, A_{s\,req.}$ } , $\frac{0.15}{100} b\, d$ }

Sec. ②

$$d = C_1 \sqrt{\frac{M_{max\,(+Ve)}}{F_{cu} * b}} \longrightarrow C_1 \longrightarrow J$$

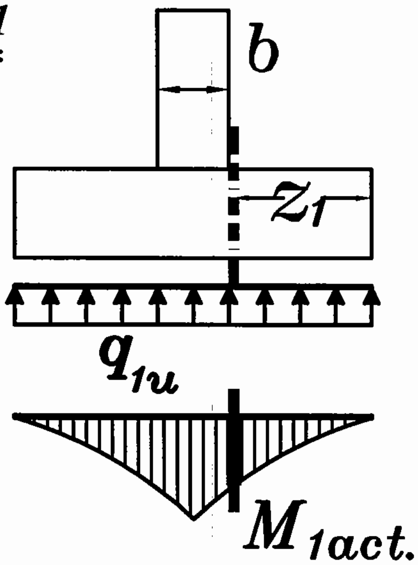
Get $$A_{S\,bott} = \frac{M_{max\,(+Ve)}}{J\, F_y\, d} \quad (mm^2)$$

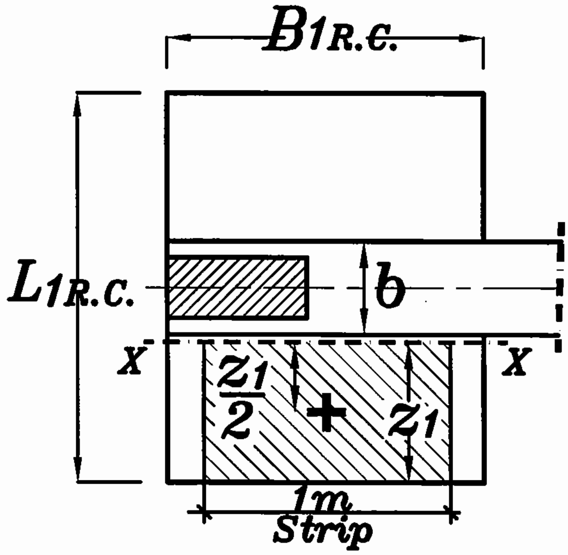
Check $A_{S\,min}$

6 – Design of Footings. *as a strip Footing.*

Footing. F_1

يتم الحساب
على شريحة
عرضها ١ متر





Footing. F_1

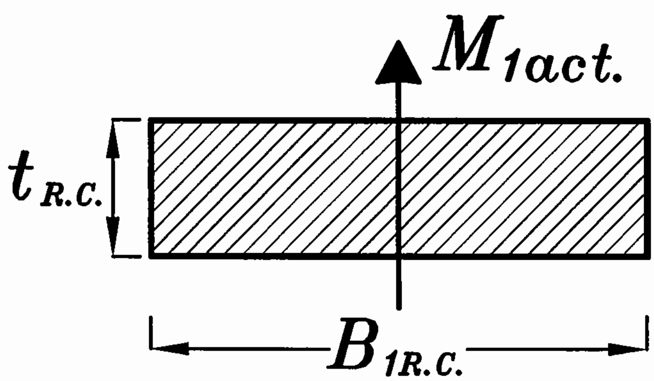
– Actual Normal stress on R.C. Footing (U.L.)

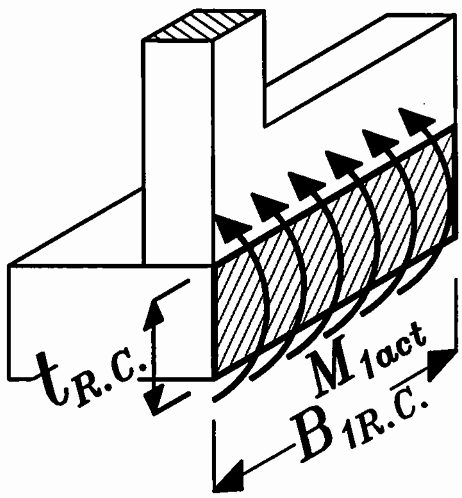
$$q_{1u} = \frac{R_{1U.L.}}{B_{1R.C.} * L_{1R.C.}} \quad (kN/m^2)$$

– Critical section of bending at R.C. Footing. $z_1 = \frac{L_{1R.C.} - b}{2}$ (m)

– moment = Force * Distance

$$M_{1act.} = (q_{1u} * z_1 * 1m)\frac{z_1}{2} \quad (kN.m/m')$$





$$d_1 = C_1 \sqrt{\frac{M_{1act.}}{F_{cu} * B}} \qquad B = 1000$$

Take $C_1 = (3.5 \rightarrow 5.0)$

Get $d_1 = \checkmark\checkmark$ (mm)

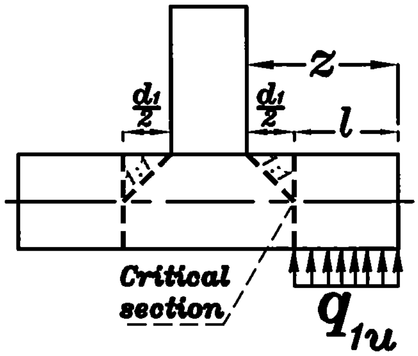
Take cover = 70 mm

$$t_{1\,R.C.} = d_1 + \text{cover } (70\text{ mm})$$

تقرب لاقرب ٥٠ مم بالزياده

Check Shear.

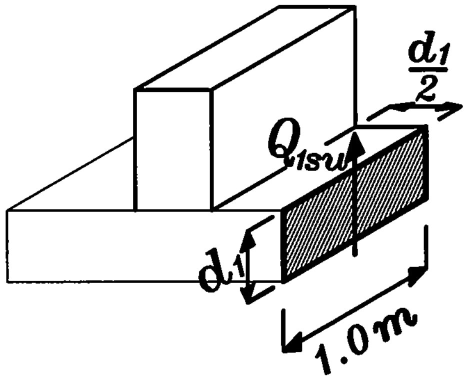
* Calculate $l_1 = z_1 - \frac{d_1}{2}$ (m)



* Calculate Actual shear Force.

$$Q_{1su} = q_{1u} * l_1 * 1.0\,m \quad (kN)$$

* Calculate Actual shear stress.



$$q_{1su} = \frac{Q_{1su}}{b * d_1} = \frac{Q_{1su}(kN) * 10^3}{1000 * d_1 (mm)}$$

* Calculate Allowable shear stress.

$$q_{scu} = 0.16 \sqrt{\frac{F_{cu}}{\gamma_c}}$$

* Compare between

Actual shear stress (q_{su}) & Allowable shear stress (q_{scu})

* IF $q_{1su} \leqslant q_{scu} \longrightarrow$ Safe shear stresses
  No need to increase dimensions.

* IF $q_{1su} > q_{scu} \longrightarrow$ UnSafe shear stresses
  We have to increase dimensions.

Reinforcement of the Footing.

From $C_1 \xrightarrow{Get} J$

Get $$A_{s1} = \frac{M_{1act.}}{J\ F_y\ d_1} \quad (mm^2/m')$$

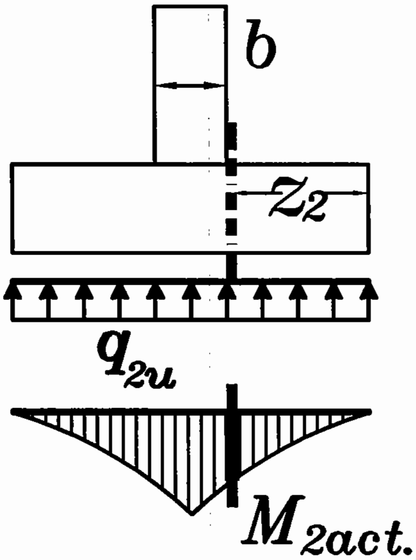
Check $$A_{s\,min}\ (mm^2/m) = \begin{Bmatrix} 1.5\,d\ (mm) \\ 5\phi 12/m' \end{Bmatrix}$$ الأكبر

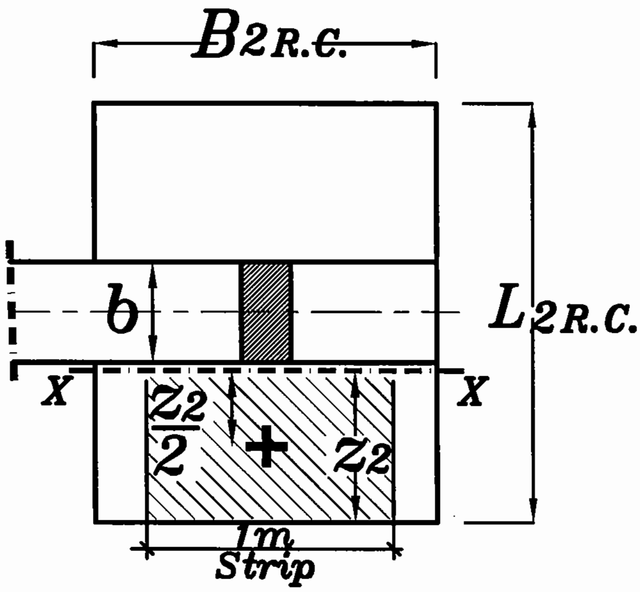
IF $A_{s1} \geqslant A_{s\,min} \longrightarrow o.k.$

IF $A_{s1} < A_{s\,min} \longrightarrow$ Take $A_{s1} = A_{s\,min}$

Footing. F_2

يتم الحساب
على شريحة
عرضها ١ متر





Footing. F_2

– Actual Normal stress on R.C. Footing (U.L.)

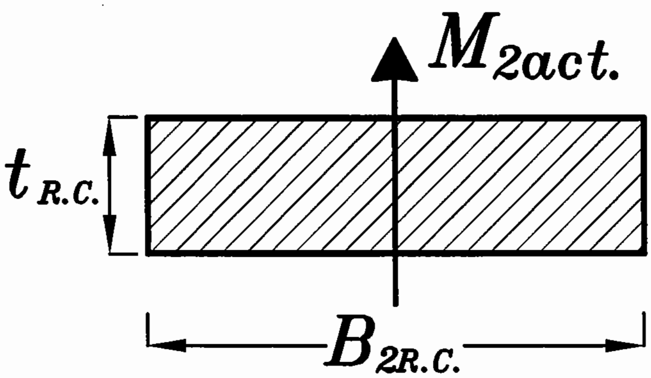
$$q_{2u} = \frac{R_{2U.L.}}{B_{2R.C.} * L_{2R.C.}} \quad (kN/m^2)$$

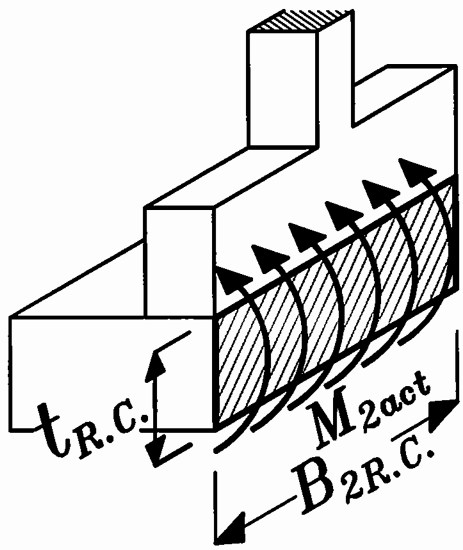
– Critical section of bending at R.C. Footing.

$$z_2 = \frac{L_{2R.C.} - b}{2} \quad (m)$$

– moment = Force * Distance

$$M_{2act.} = (\, q_{2u} * z_2 * 1m \,) \frac{z_2}{2} \quad (kN.m/m')$$





$$d_2 = C_1 \sqrt{\frac{M_{2act.}}{F_{cu} * \boxed{B}}}$$ Take $C_1 = (3.5 \rightarrow 5.0)$

B: 1000

Get $d_2 = \checkmark\checkmark$ (mm)

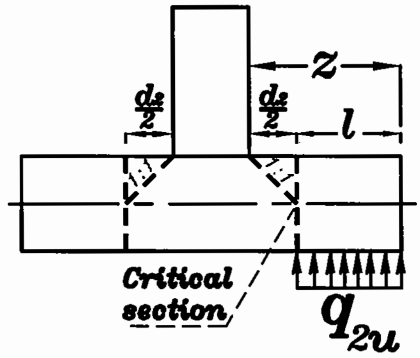
Take cover = 70 mm

$$t_{2\,R.C.} = d_2 + cover\ (70\ mm)$$

تقرب لاقرب ٥٠ مم بالزياده

Check Shear.

* Calculate $l_2 = Z_2 - \frac{d_1}{2}$ (m)

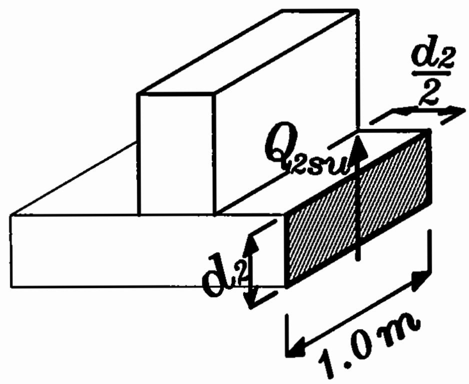


* Calculate Actual shear Force.

$$Q_{2su} = q_{2u} * l_2 * 1.0\,m \quad (kN)$$

* Calculate Actual shear stress.

$$q_{2su} = \frac{Q_{2su}}{b * d_2} = \frac{Q_{2su}(kN) * 10^3}{1000 * d_2(mm)}$$



* Calculate Allowable shear stress.

$$q_{scu} = 0.16 \sqrt{\frac{F_{cu}}{\gamma_c}}$$

* Compare between

Actual shear stress (q_{su}) & Allowable shear stress (q_{scu})

* IF $q_{2su} \leq q_{scu} \longrightarrow$ Safe shear stresses
No need to increase dimensions.

* IF $q_{2su} > q_{scu} \longrightarrow$ UnSafe shear stresses
We have to increase dimensions.

Reinforcement of the Footing.

From $C_1 \xrightarrow{Get} J$

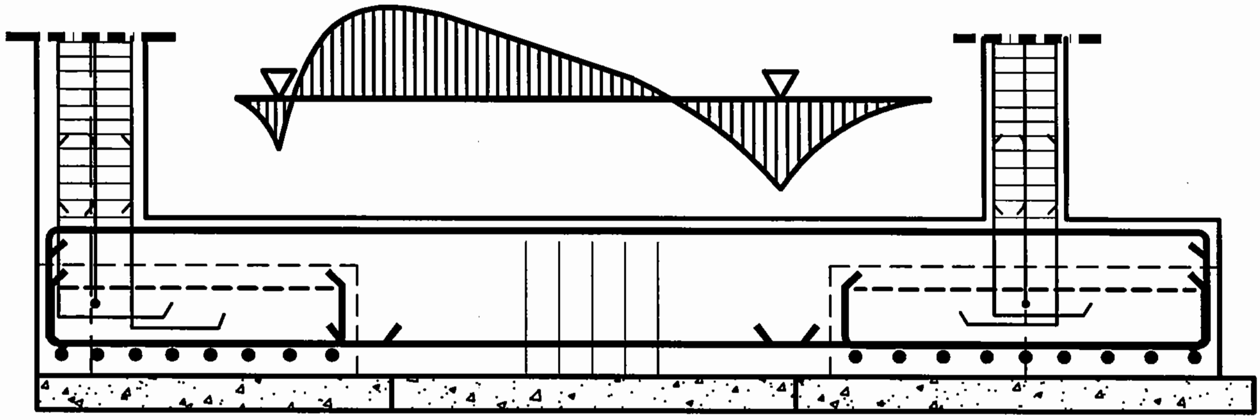
Get $$A_{s2} = \frac{M_{2act.}}{J\ F_y\ d_2} \quad (mm^2/m')$$

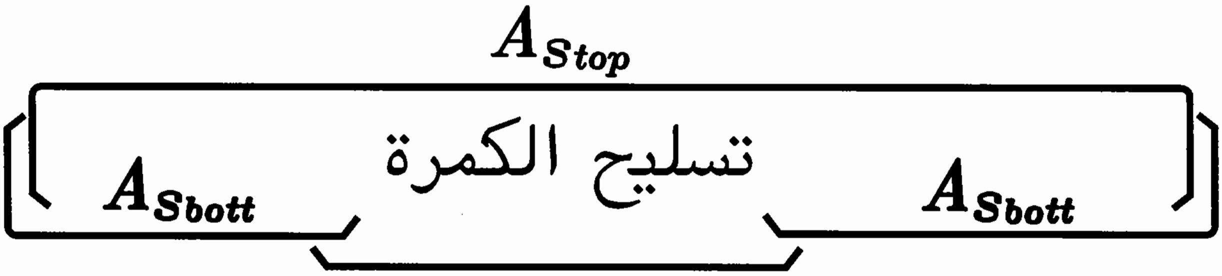
Check $$A_{s\,min}\ (mm^2/m) = \begin{cases} 1.5\,d\ (mm) \\ 5\phi 12/m' \end{cases} \text{الأكبر}$$

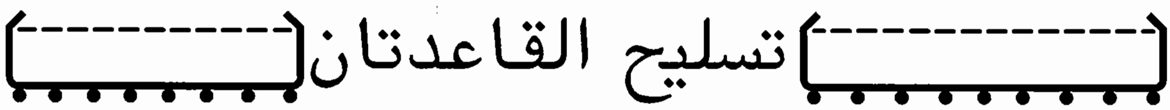
IF $A_{s2} \geqslant A_{s\,min} \longrightarrow o.k.$

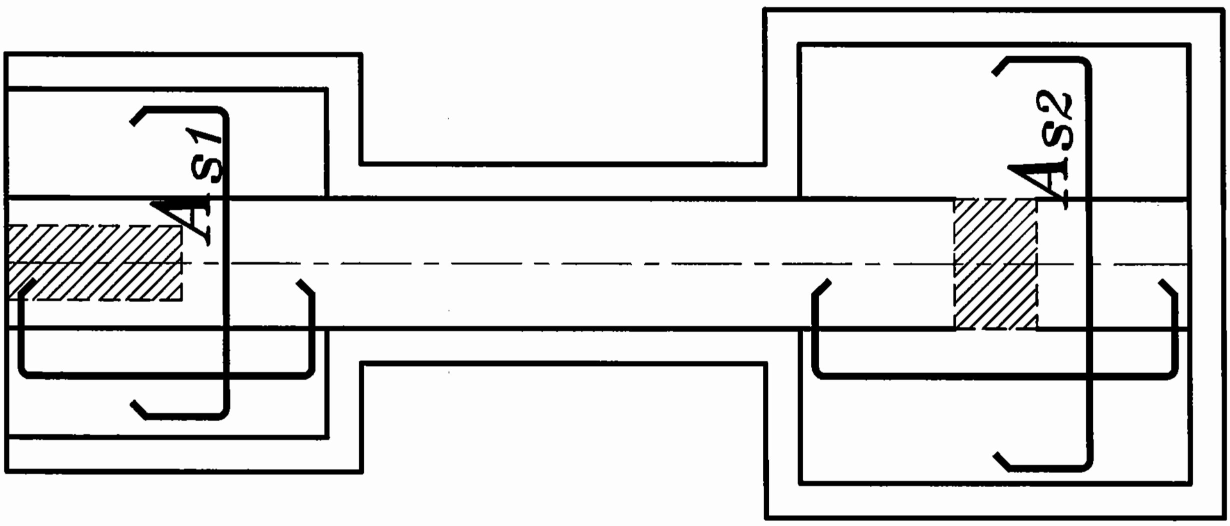
IF $A_{s2} < A_{s\,min} \longrightarrow$ Take $A_{s1} = A_{s\,min}$

7- Details of Reinforcement.



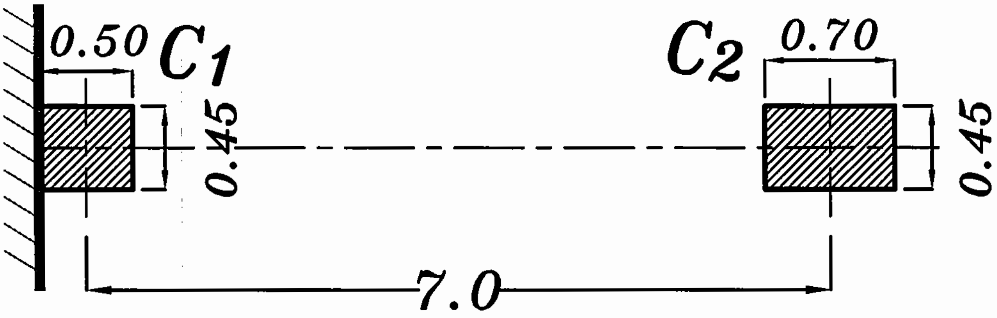






Example (1):

*It is required to design Footings to support a proterty line column C_1 (45 * 50) cm. and carrying working load 1000 kN and interior column C_2 (45 * 70) cm. and carrying working load 2200 kN the spacing between the C.L. of the two columns is 7.0 m as shown*



and the allowable net bearing capacity in the Footing site is 200 kN/m². (F_{cu} = 25 N/mm², F_y = 360 N/mm²).
and draw details of RFT. to scale 1:50

Solution.

Data given:

Column C_1 dimensions (450 * 500) mm

P_1 (working) = 1000 kN $\qquad$ P_1 (U.L.) = 1000 * 1.5 = 1500 kN

Column C_2 dimensions (450 * 700) mm

P_2 (working) = 2200 kN $\qquad$ P_2 (U.L.) = 2200 * 1.5 = 3300 kN

R (working) = $P_1 + P_2$ = 3200 kN

R (U.L.) = 1.5 * 3200 = 4800 kN

Bearing capacity of the soil = q_{all} = 200 kN/m²

F_{cu} = 25 N/mm² $\qquad$ F_y = 360 N/mm²

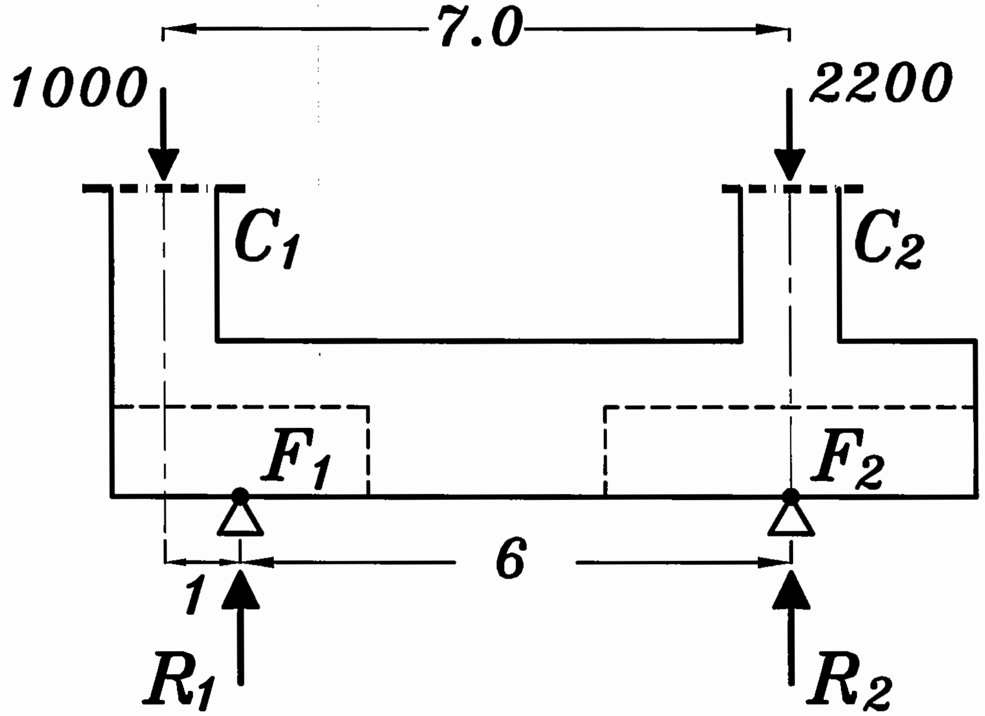
For property line use
Strap Beam or Combined Footing.

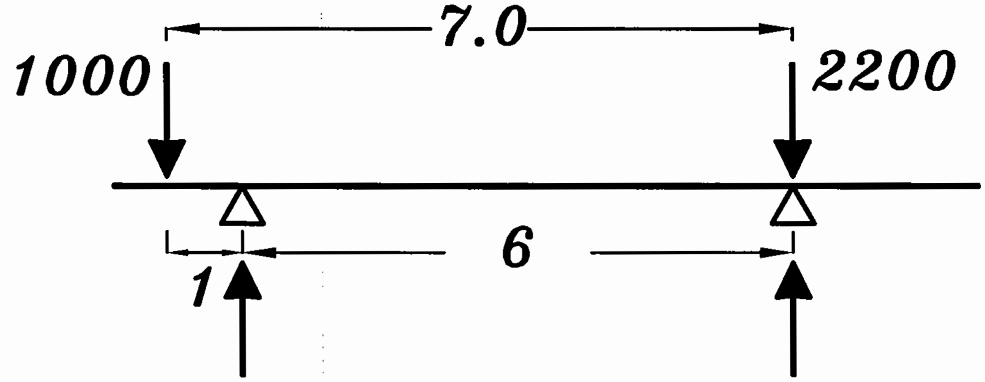
Start with Strap Beam.

1– Calculate the Footing area. (Width & Length of R.C. Footings.)

Take $e = (0.1 - 0.2)\, S = (0.1 - 0.2)\, 7 = 0.7 \rightarrow 1.4$

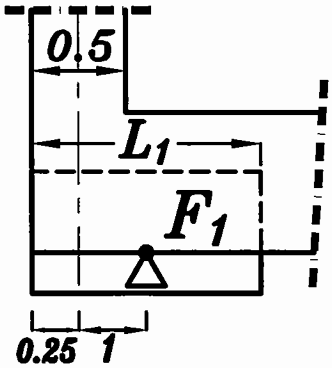
Take $e = 1$ m





$R_1 = 1166.7$ kN $\qquad R_2 = 2033.3$ kN

Footing F_1



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

$L_{1\,P.C.} = 2\left(e + \frac{C_1}{2}\right) = 2(1 + 0.25) = 2.5\ m$

get $B_{1\,P.C.}$ From $A_{P.C.} = \frac{R_1}{q_{all}} = A_{P.C.} = B_{1P.C.} * L_{1\,P.C.}$

$A_{P.C.} = \frac{1166.7}{200} = B_{1P.C.} * 2.50 \longrightarrow B_{1P.C.} = 2.33\ m$

$B_{1P.C.} = 2.35\ m$

$L_{1P.C.} = 2.50\ m$

$B_{1R.C.} = 1.75\ m$

$L_{1R.C.} = 2.50\ m$

Footing F_2

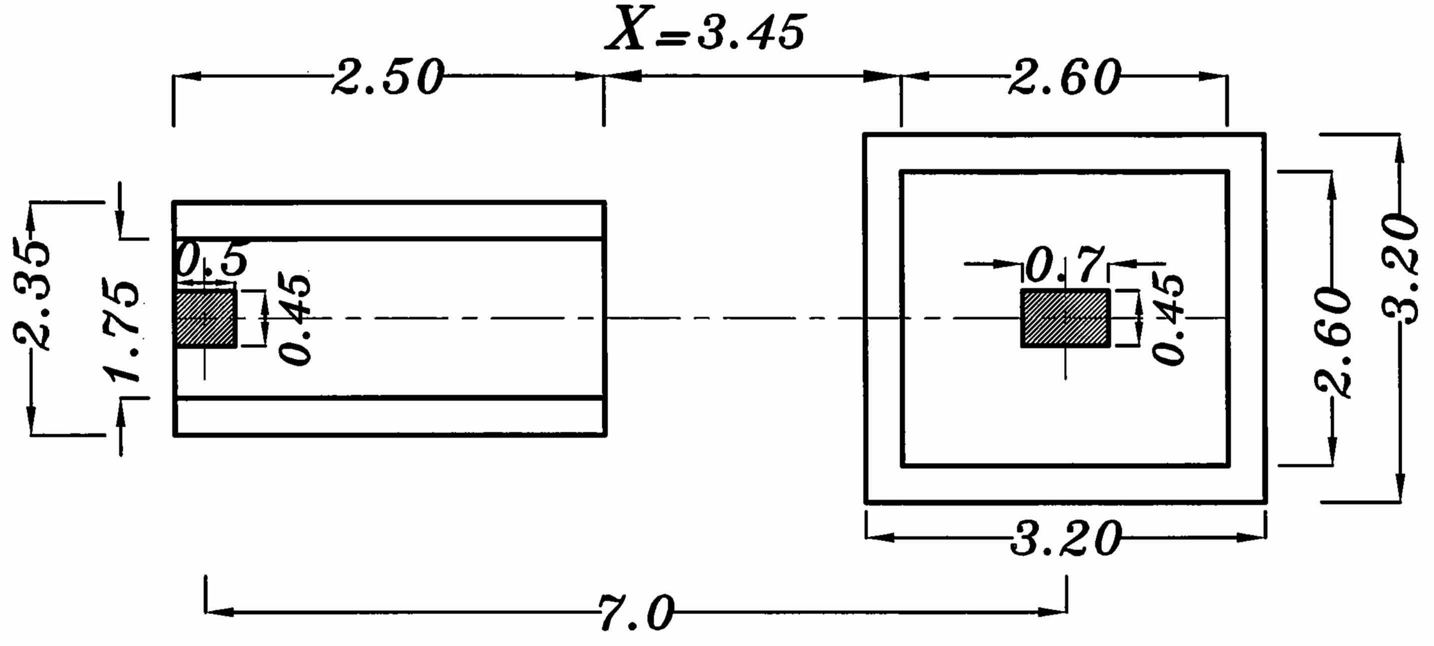
$A_{2P.C.} = \frac{R_2}{q_{all}} = \frac{2033.3\ (kN)}{200\ \ (kN/m^2)} = 10.2\ \ m^2$

$A_{2P.C.} = (B_{2P.C.})^2 = 10.2\ m^2$

$B_{2P.C.} = 3.19\ m$

$B_{2P.C.} = 3.20m$

$B_{2R.C.} = 2.60\ m$



$$X > \frac{L_{min}}{2}$$ $\therefore$ **use Strap Beam.**

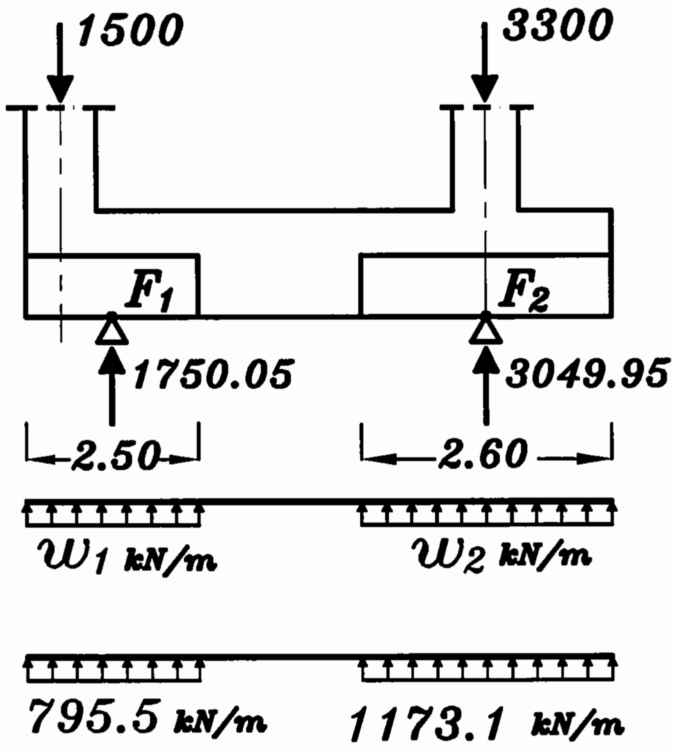
3 – Dimensions of the Strap Beam. (Width & depth)

$$w_1 = \frac{R_{1\,(U.L.)}}{L_{1\,R.C.}}$$

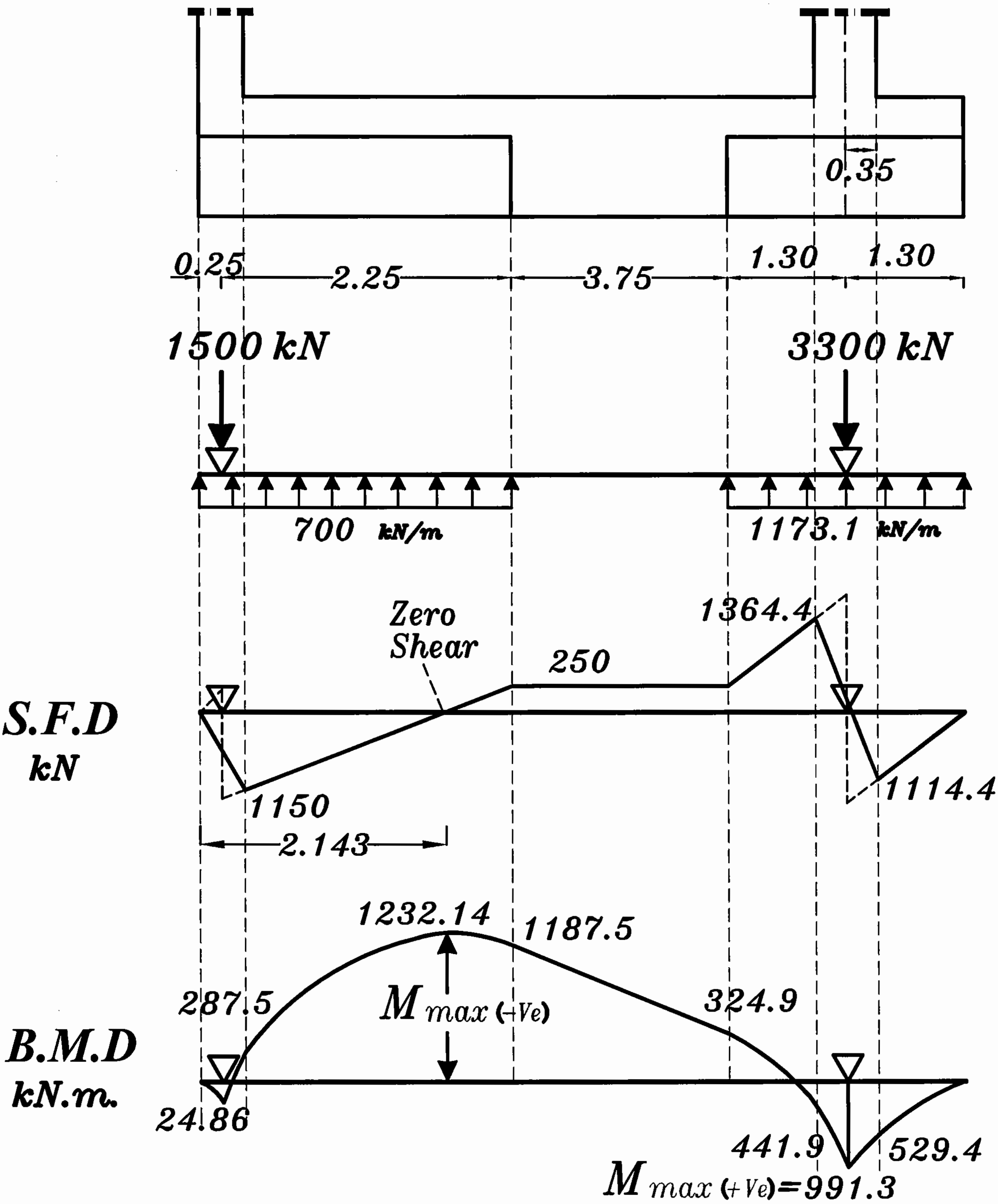
$$w_1 = \frac{1.5 * 1166.7}{2.50} = 700 \quad (kN/m)$$

$$w_2 = \frac{R_{2\,(U.L.)}}{B_{2\,R.C.}}$$

$$w_2 = \frac{1.5 * 2033.3}{2.60} = 1173.1 \quad (kN/m)$$



Drawing B.M.D. & S.F.D. For the Beam.



$$\text{Point of Zero Shear } (X_o) = \frac{1500}{700} = 2.143\,m$$

Take $b \nless C_1$ or C_2 or $0.4m$ Take $\boxed{b = 0.45m}$

$$\because d = C_1 \sqrt{\frac{M_{max}}{F_{cu} * b}} \qquad \text{Choose } C_1 = 4.5$$

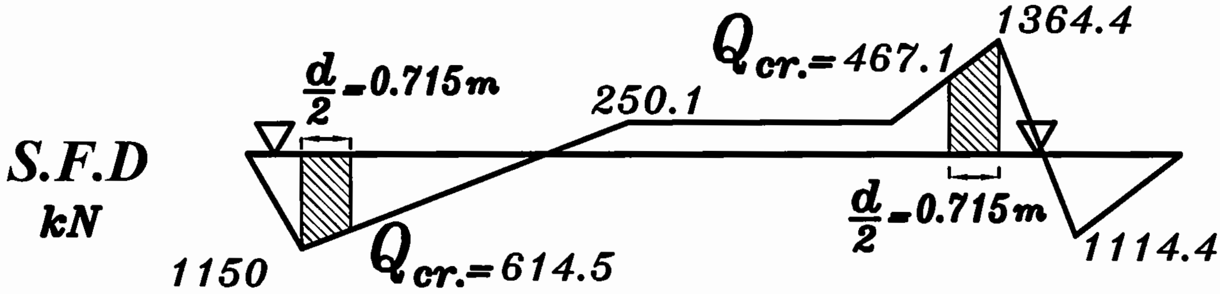
$$\therefore d = 4.5 \sqrt{\frac{1232.1 * 10^6}{25 * 450}} = 1489 \text{ mm}$$

$$t_{R.C.} = d + 70 \text{ mm} = 1489 + 70 = 1559 \text{ mm}$$

$\boxed{t_{R.C.} = 1600 \text{ mm}}$ $\boxed{d = 1530 \text{ mm}}$

---

4 – Check Shear For Strap Beam. as beams.



$$Q_{cr.} = Q_{max.} - w\left(\frac{d}{2}\right) = 1150 - 700.00\left(\frac{1.53}{2}\right) = 614.5 \text{ kN}$$

$$Q_{cr.} = Q_{max.} - w\left(\frac{d}{2}\right) = 1364.40 - 1173.1\left(\frac{1.53}{2}\right) = 467.1 \text{ kN}$$

– Actual Shear Stress.

$$q_{su} = \frac{Q_{cr.}}{b * d} = \frac{614.5 * 10^3}{450 * 1530} = 0.892 \text{ kN/m}^2$$

– Allowable shear stress.

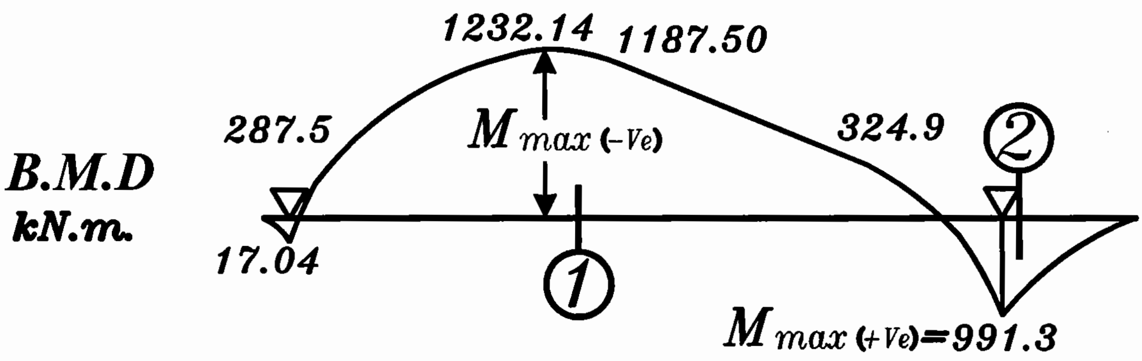
$$- q_{scu} = 0.24 \sqrt{\frac{F_{cu}}{\gamma_c}} = 0.24 \sqrt{\frac{25}{1.5}} = 0.98 \text{ N}\backslash\text{mm}^2$$

$$- q_{scu\,max} = 0.7 \sqrt{\frac{F_{cu}}{\gamma_c}} = 0.7 \sqrt{\frac{25}{1.5}} = 2.85 \text{ N}\backslash\text{mm}^2$$

$\therefore q_{su} < q_{scu} \longrightarrow$ use min. stirrups

Use Stirrups $\boxed{5\phi 10\backslash m}$ 4 branches

5 – *Reinforcement of Strap Beam.*



Sec. ① $M_{max\,(-Ve)} = 1232.14$ kN.m.

$$1430 = C_1 \sqrt{\frac{1232.14 * 10^6}{25 * 450}} \longrightarrow C_1 = 4.60 \longrightarrow J = 0.818$$

$$A_S = \frac{M}{J\,F_y\,d} = \frac{1232.14 * 10^6}{0.818 * 360 * 1430} = 2467.78\ mm^2$$

Check $A_{s_{min}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}\,(450)\,(1430) = 1966.25\ mm^2$

$\therefore A_s > A_{s_{min}}$ $\therefore A_S = 2467.78\ mm^2$ **7 Ø 22**

Sec. ② $M_{max\,(+Ve)} = 991.3$ kN.m.

$$1430 = C_1 \sqrt{\frac{991.3 * 10^6}{25 * 450}} \longrightarrow C_1 = 4.8 \longrightarrow J = 0.824$$

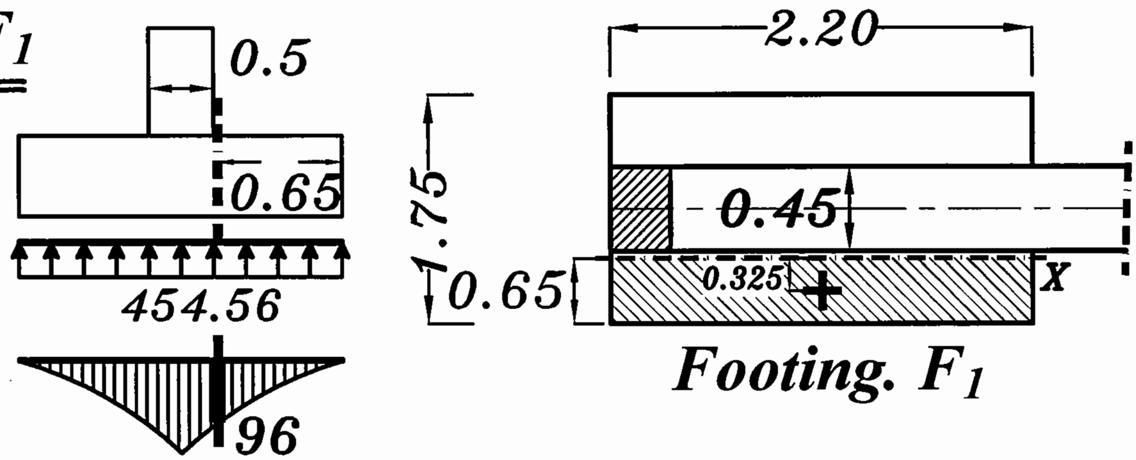
$$A_S = \frac{M}{J\,F_y\,d} = \frac{991.3 * 10^6}{0.824 * 360 * 1430} = 2337\ mm^2$$

Check $A_{s_{min}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}\,(450)\,(1430) = 1966.25\ mm^2$

$\therefore A_s > A_{s_{min}}$ $\therefore A_S = 2337\ mm^2$ **7 Ø 22**

6 – Design of Footings. as a strip Footing.

Footing. F_1

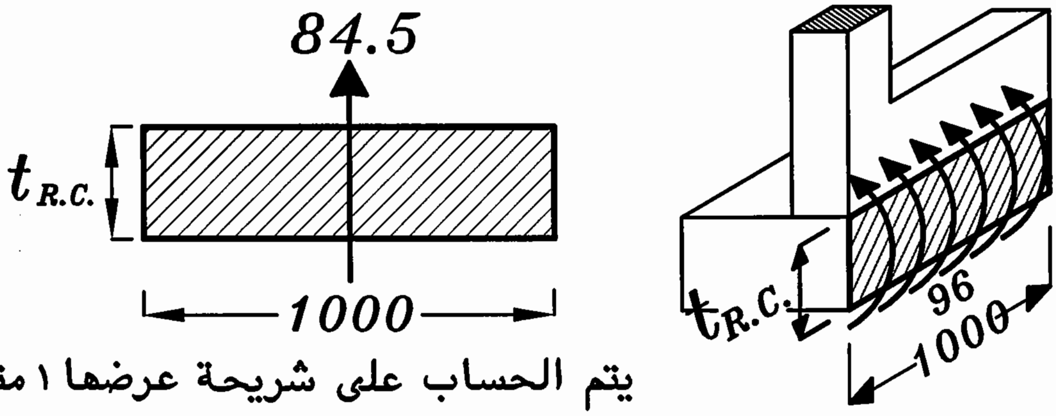


– Actual Normal stress on R.C. Footing (U.L.)

$$q_{1u} = \frac{R_{1U.L.}}{B_{1R.C.} * L_{1R.C.}} = \frac{1750.05}{1.75 * 2.50} = 400.01\, kN/m^2$$

– moment = Force * Distance

$$M_{1act.} = 400.01 * 0.65 * 1m * 0.325 = 84.5\, kN.m/m'$$



يتم الحساب على شريحة عرضها ١ متر

$$\because d = C_1 \sqrt{\frac{M_{act.}}{F_{cu} * b}}$$

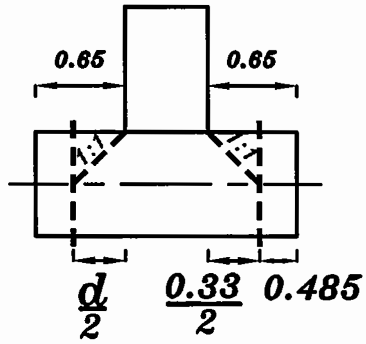
Choose $C_1 = 5.0$

$$\therefore d = 5.0 \sqrt{\frac{84.5 * 10^6}{25 * 1000}} = 290.7\ mm < 330\ mm$$

$$t_{R.C.} = d + 70\ mm = 330 + 70 = 400\ mm$$

$t_{R.C.} = 400\ mm$ **$d = 330\ mm$**

Check Shear.



$$Q_{su} = q_{1u} * l * 1.0\,m$$

$$= 454.56 * 0.485 * 1.0\,m = 220.46\,kN$$

* Calculate Actual shear stress. (q_{su})

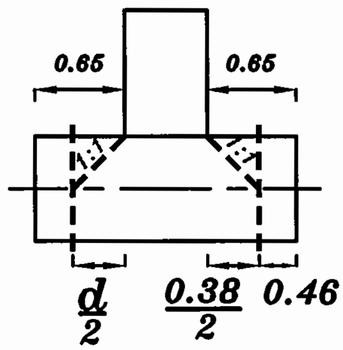
$$q_{su} = \frac{Q_{su}}{b*d} = \frac{220.46*10^3}{1000*330} = 0.668 \quad N/mm^2$$

* Allowable shear stress. (q_{scu})

$$q_{su} = 0.16\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.16\sqrt{\frac{25}{1.5}} = 0.653 \quad N/mm^2$$

$q_{su} > q_{scu}$ → un safe shear stresses
We need to increase dimensions.

take **d=380mm** , **t=450mm**



$$Q_{su} = 454.56 * 0.46 * 1.0\,m = 209.1\,kN$$

$$q_{su} = \frac{209.1 * 10^3}{1000*380} = 0.55 \quad N/mm^2 < q_{scu}$$

safe shear stresses

Reinforcement of the Footing.

$$J = 0.826$$

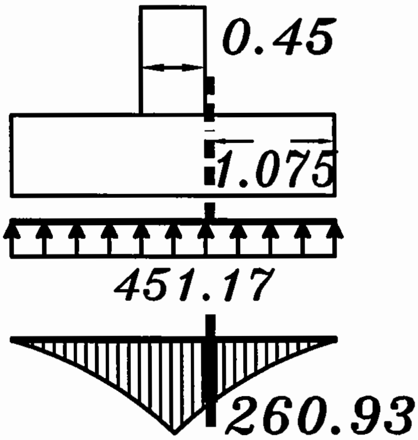
$$A_S = \frac{M_{1act.}}{J\,F_y\,d} = \frac{96 * 10^6}{0.826*360*380} = 849.58\ mm^2/m'$$

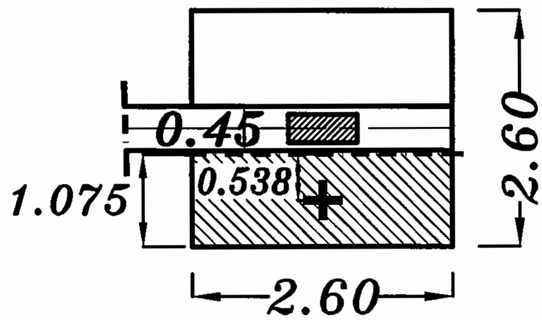
Check $A_{s_{min}} = \begin{cases} 1.5\,d = 1.5*380 = 570 \\ 5\phi 12/m' = 565 \end{cases} 570\,mm^2$

$\therefore A_s > A_{s_{min}} \longrightarrow A_s = 849.58\ mm^2/m'$

$5\phi 16/m'$

Footing. F_2





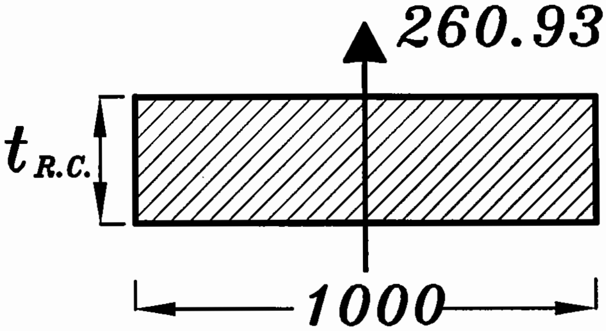
Footing. F_2

- Actual Normal stress on R.C. Footing (U.L.)

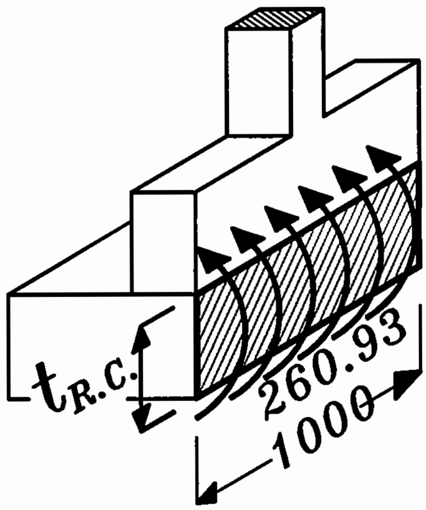
$$= \frac{R_{2U.L.}}{B_{2R.C.} * L_{2R.C.}} = \frac{3049.95}{2.60 * 2.60} = 451.17\,kN/m^2$$

- moment = Force * Distance

$$M_{2act.} = 451.17 * 1.075 * 1m * 0.538 = 260.93\,kN.m/m'$$



يتم الحساب على شريحة عرضها ١ متر



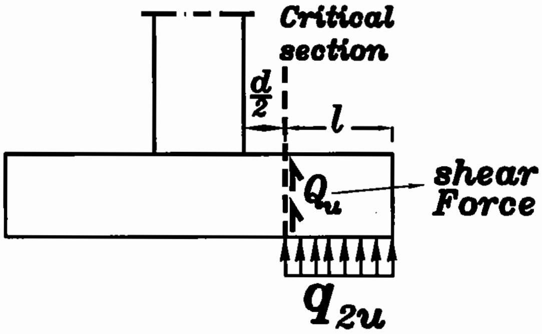
$$\because\ d = C_1 \sqrt{\frac{M_{act.}}{F_{cu} * b}} \qquad \text{Choose } C_1 = 5.0$$

$$\therefore\ d = 5.0 \sqrt{\frac{260.93 * 10^6}{25 * 1000}} = 510.8 \text{ mm}$$

$$t_{R.C.} = d + 70 \text{ mm} = 510.8 + 70 = 580.8 \text{ mm}$$

$$\boxed{t_{R.C.} = 600 \text{ mm}} \qquad \boxed{d = 530 \text{ mm}}$$

Check Shear.



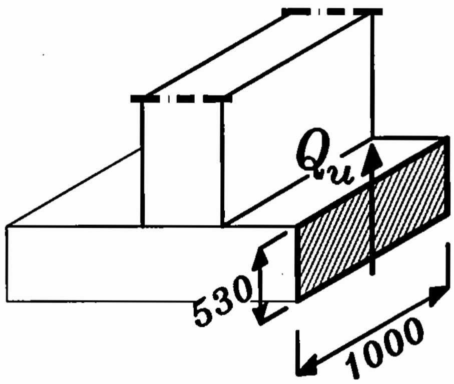
*Critical section For Shear.

$$l = z - \frac{d}{2}$$

$$l = 1.075 - \frac{0.53}{2} = 0.81 \text{ m}$$

* Actual shear Force. (Q_{su})

$$Q_{su} = q_{2u} * l * 1.0 \text{ m} = 451.17 * 0.81 * 1.0 = 365.45 \text{ kN}$$



* Actual shear stress. (q_{su})

$$q_{su} = \frac{Q_{su}}{b * d} = \frac{365.45 * 10^3}{1000 * 530} = 0.689 \text{ N/mm}^2$$

* Allowable shear stress. (q_{su})

$$q_{su} = 0.16 \sqrt{\frac{F_{cu}}{\gamma_c}} = 0.16 \sqrt{\frac{25}{1.5}} = 0.653 \text{ N/mm}^2$$

$\boxed{q_{su} > q_{scu}}$ ⟶ un safe shear stresses

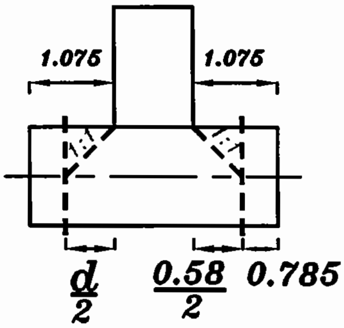
We need to increase dimensions.

take $\boxed{d = 580mm}$, $\boxed{t = 650mm}$

$Q_{su} = 451.17 * 0.785 * 1.0\ m = 354.2\ kN$

$q_{su} = \frac{354.2 * 10^3}{1000 * 580} = 0.61\ N/mm^2 < q_{scu}$

safe shear stresses



Reinforcement of the Footing.

$$A_S = \frac{M_{2act.}}{J\ F_y\ d} = \frac{260.93 * 10^6}{0.826 * 360 * 580} = 1512.91 mm^2/m'$$

$$\text{Check}\quad A_{S\,min} = \begin{cases} 1.5\,d = 1.5 * 580 = 870 \\ 5\phi 12/m' = 565 \end{cases} 870 mm^2$$

$$\therefore\ A_S > A_{S\,min} \longrightarrow A_S = 1512.91\ mm^2/m'$$

$\boxed{8\phi 16/m'}$

7 – Details of Reinforcement.