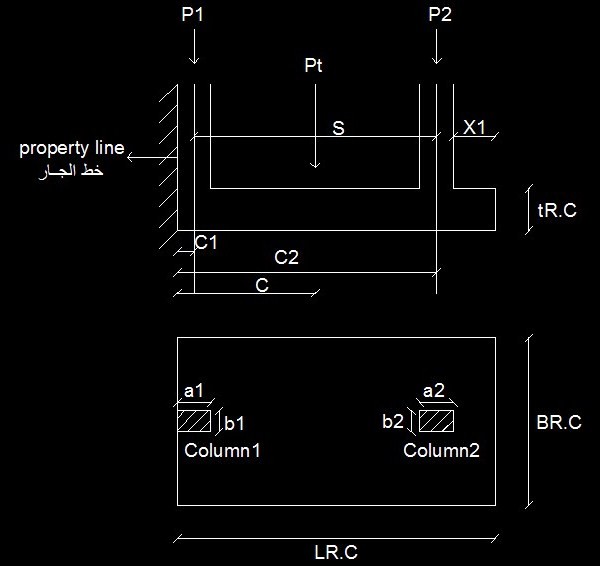
Combined Footing:

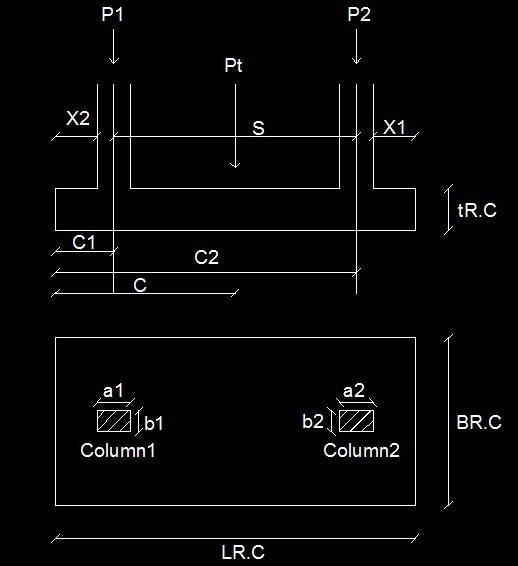
Types of Combined Footing:

1. قاعدة بعمود داخلي مع عمود جار:



البروز من ناحية واحدة فقط.

1. عمودان داخليان:



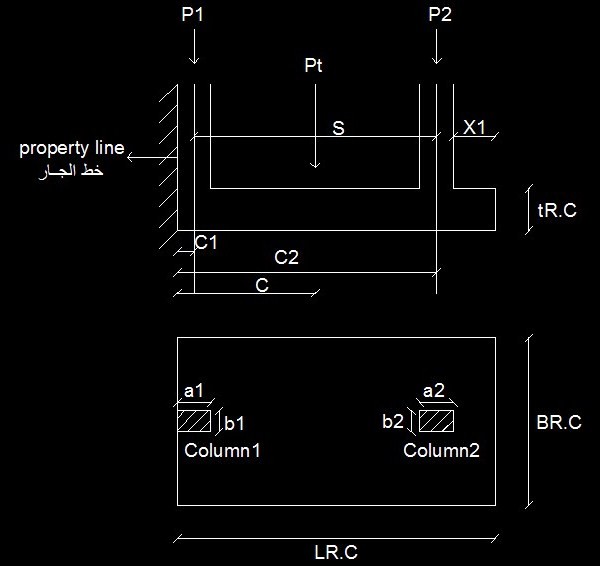
البروز من ناحيتين.

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 ):



Pt = (P1+P2 ) \* 1.1 = … Ton

حيث أن (P1+P2 )→ Working Loads

Working Loads to ultimate Loads \* 1.5

Ultimate Loads to Working Loads / 1.5

Area of Footing (AR.C ) = = L \* B = m2

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

من خط الجار إلي نص العمود Take C1 =

C2 = C1 + S = … m

C = = … m

حيث أن:

مكان تأثير → C

محصله القوي → Pt

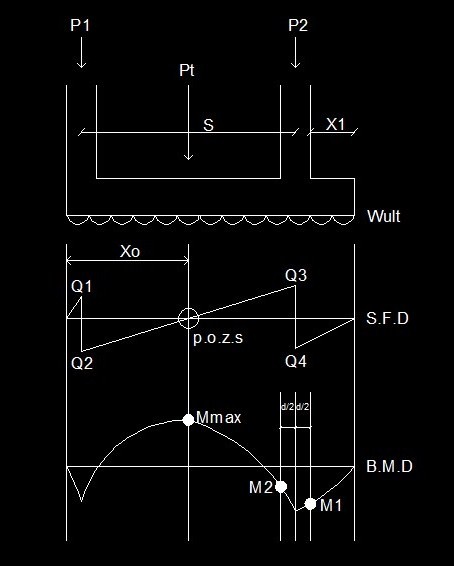
حتى تكون المحصلة في نصف القاعدة

LR.C = 2\* C = … m to nearest 5 cm

BR.C = = … m to nearest 5 cm

End of Working Loads

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



qult = = … t/m2

Wult = qult \* BR.C = … t/m'

Q1 = Wult \* C1  = … Ton

Q2 = Q1 – P1u  = … Ton

Q3 = Wult \* C2 – P1u = … Ton

Q4 = Q3 – P2u = … Ton

Moment يحسب عند وش العمود M1 , M2

Max Moment at point of zero shear

At p.o.z.s

Xo = = … m

X1 = LR.C – (C2 + ) = … m

*حيث أن:*

*مسافة من خط الجار إلي* point of zero shear

point of zero shear*→* p.o.z.s

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* →

M1 = Wu \* = … mt

M2 = Wu \* – P2u \* = … mt

حيث أن:

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* →

Mmax = P1u \*(Xo – C1) – (Wu \*) = … mt

3) Calculation the Depth:

d = c1

حيث أن:

c1 → 5

Mu → Max Moment

4) Check shear:

من وش العمود Critical section at

Qsh = QMax – Wu ( + ) = … Ton

حيث أن:

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* → و حسب QMax

QMax  → Max of Q1 , Q2 , Q3 , Q4

qsh = = … kg/cm2

qcu = 0.4 \* = … kg/cm2

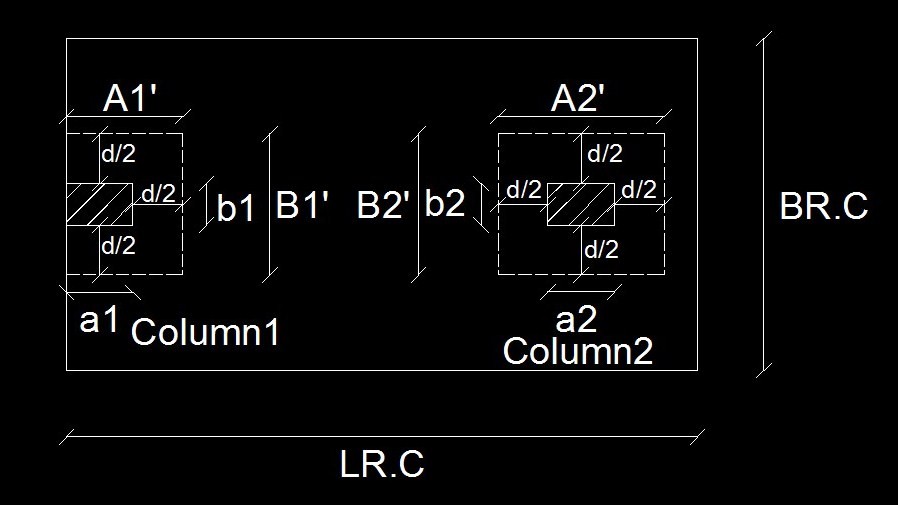
If qcu > qsh  ok safe

If qcu < qsh  un safe increase depth

Take d = Qsh / (qcu \* BR.c ) = … cm

5) Check Punching:

*الحالة الأولي:*



For Column 1:

QP1 = Pu1 – qU (A1' \*B1') = … Ton

*حيث أن :*

A1' = (a1 + ) = … m

B1' = (b1 + d) = … m

For Column 2:

QP2 = Pu2 – qU (A2' \*B2') = … Ton

*حيث أن :*

A2' = (a2 + d ) = … m

B2' = (b2 + d) = … m

qp =  = … kg/cm2

*حيث أن:*

QpMax = Max of QP1 & QP2

If QpMax → QP1 Take A1' , B1'

If QpMax → QP2 Take A2' , B2'

qpcu = (0.5 + ) = … kg/cm2

*حسب أن:*

If QpMax → QP1 Take b1 , b2

If QpMax → QP2 Take a1 , a2

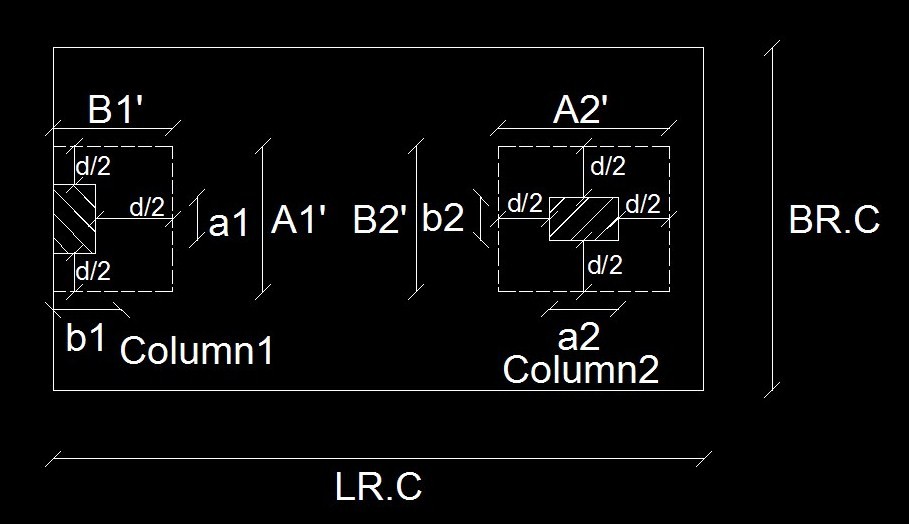
If qpcu > qp  ok safe

If qpcu < qp  un safe → increase depth

t = d + cover

cover = (5 to 10 cm)

*الحالة الثانية:*

**

For Column 1:

QP1 = Pu1 – qU (A1' \*B1') = … Ton

*حيث أن :*

A1' = (a1 + d) = … m

B1' = (b1 + ) = … m

*والباقي نفس الشئ*

6) Reinforcement of the footing:

in Long Direction:

As Top = = … cm2 /BR.C  = … cm2 /m'

As min = 0.15 \* d = … cm2 /m'

If As Top As min → ok

If As Top < As min  → take As Top = As min

As Bot = = … cm2 /BR.C  = … cm2 /m'

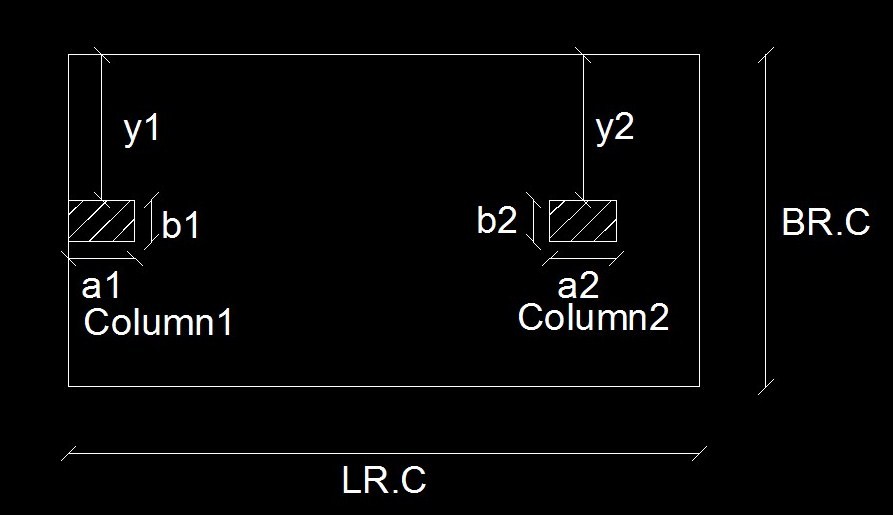
Take Max Moment of M1 & M2

As min = 0.15 \* d = … cm2 /m'

If As Bot As min → ok

If As Bot < As min  → take As Bot = As min

In Short Direction:

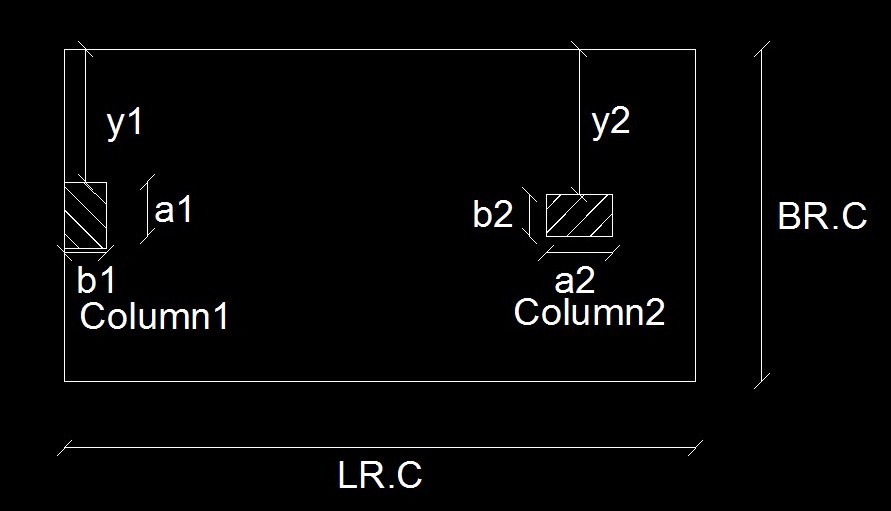


Mu = qult \* = … mt

Take y Max of y1 & y2

Y1 = = … m

Y2 = = … m



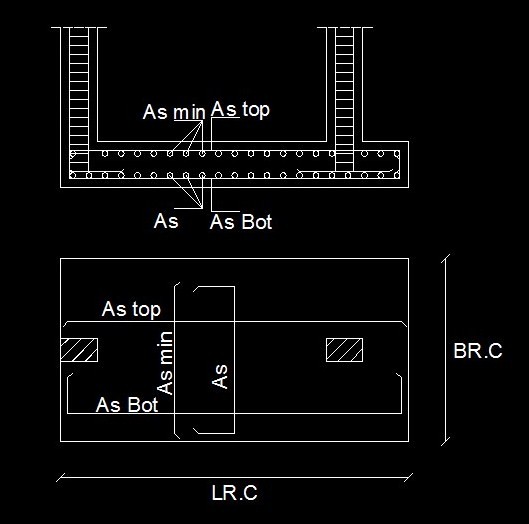
Y1 = = … m

Y2 = = … m

As = = … cm2 /m'

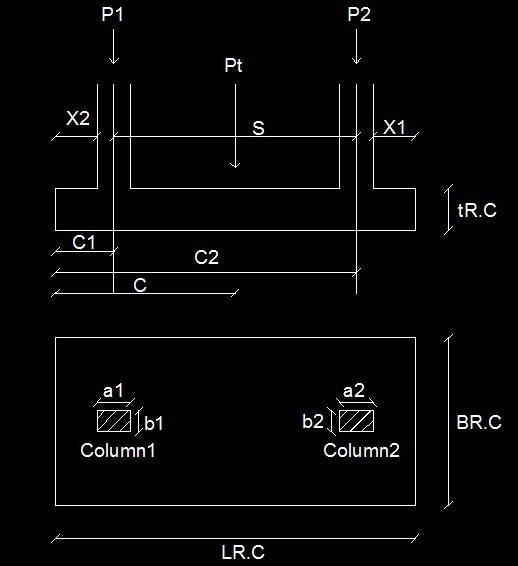
If As As min → ok

If As < As min  → take As = As min



Steps of Design:

1) Dimension of Footing ( working Loads ):



Pt = (P1+P2 ) \* 1.1 = … Ton

حيث أن (P1+P2 )→ Working Loads

Working Loads to ultimate Loads \* 1.5

Ultimate Loads to Working Loads / 1.5

Area of Footing (AR.C ) = = L \* B = m2

Take C1 = 1 m if not given.

C2 = C1 + S = … m

C = = … m

حيث أن:

مكان تأثير → C

محصله القوي → Pt

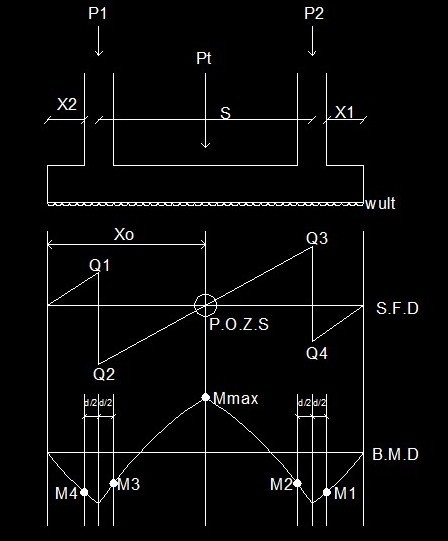
حتى تكون المحصلة في نصف القاعدة

LR.C = 2\* C = … m to nearest 5 cm

BR.C = = … m to nearest 5 cm

End of Working Loads

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



qult = = … t/m2

Wult = qult \* BR.C = … t/m'

Q1 = Wult \* C1  = … Ton

Q2 = Q1 – P1u  = … Ton

Q3 = Wult \* C2 – P1u = … Ton

Q4 = Q3 – P2u = … Ton

Moment يحسب عند وش العمود M1 , M2

Max Moment at point of zero shear

At p.o.z.s

Xo = = … m

X1 = LR.C – (C2 + ) = … m

X2 = C1 – = … m

*حيث أن:*

*مسافة من خط الجار إلي* point of zero shear

point of zero shear*→* p.o.z.s

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* →

M1 = Wu \* = … mt

M2 = Wu \* – P2u \* = … mt

M4 = Wu \* = … mt

M3 = Wu \* – P1u \* = … mt

حيث أن:

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* →

Mmax = P1u \*(Xo – C1) – (Wu \* )= … mt

3) Calculation the Depth:

d = c1

حيث أن:

c1 → 5

Mu → Max Moment

4) Check shear:

من وش العمود Critical section at

Qsh = QMax – Wu ( + ) = … Ton

حيث أن:

*طول العمود* a→

*عرض العمود* b→

*حسب اتجاه العمود* → و حسب QMax

QMax  → Max of Q1 , Q2 , Q3 , Q4

qsh = = … kg/cm2

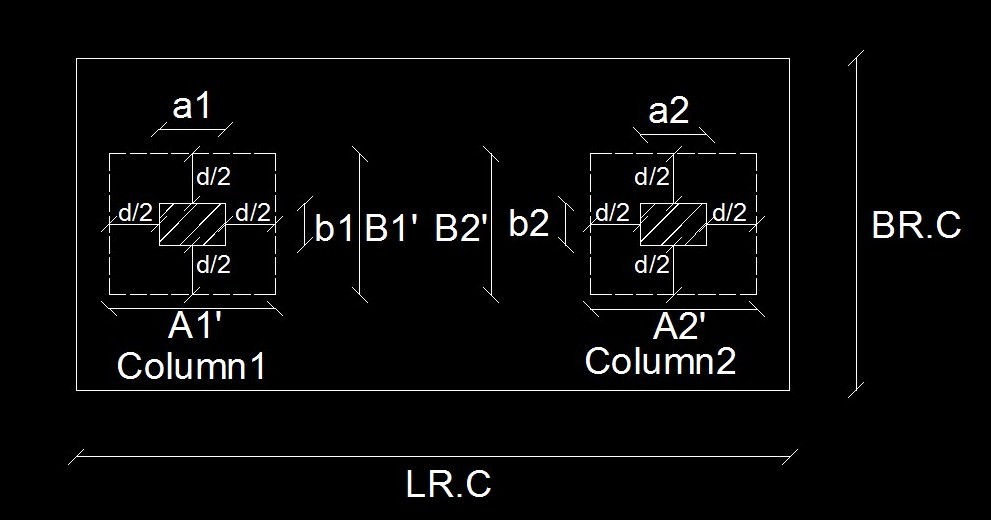
qcu = 0.4 \* = … kg/cm2

If qcu > qsh  ok safe

If qcu < qsh  un safe increase depth

Take d = Qsh / (qcu \* BR.c ) = … cm

5) Check Punching:



For Column 1:

QP1 = Pu1 – qU (A1' \*B1') = … Ton

*حيث أن :*

A1' = (a1 + d ) = … m

B1' = (b1 + d) = … m

For Column 2:

QP2 = Pu2 – qU (A2' \*B2') = … Ton

*حيث أن :*

A2' = (a2 + d ) = … m

B2' = (b2 + d) = … m

qp =  = … kg/cm2

*حيث أن:*

QpMax = Max of QP1 & QP2

If QpMax → QP1 Take A1' , B1'

If QpMax → QP2 Take A2' , B2'

qpcu = (0.5 + ) = … kg/cm2

*حسب أن:*

If QpMax → QP1 Take b1 , b2

If QpMax → QP2 Take a1 , a2

If qpcu > qp  ok safe

If qpcu < qp  un safe → increase depth

t = d + cover

cover = (5 to 10 cm)

6) Reinforcement of the footing:

in Long Direction:

As Top = = … cm2 /BR.C  = … cm2 /m'

As min = 0.15 \* d

If As Top As min → ok

If As Top < As min  → take As Top = As min

As Bot= =..cm2/BR.C =.. cm2 /m'

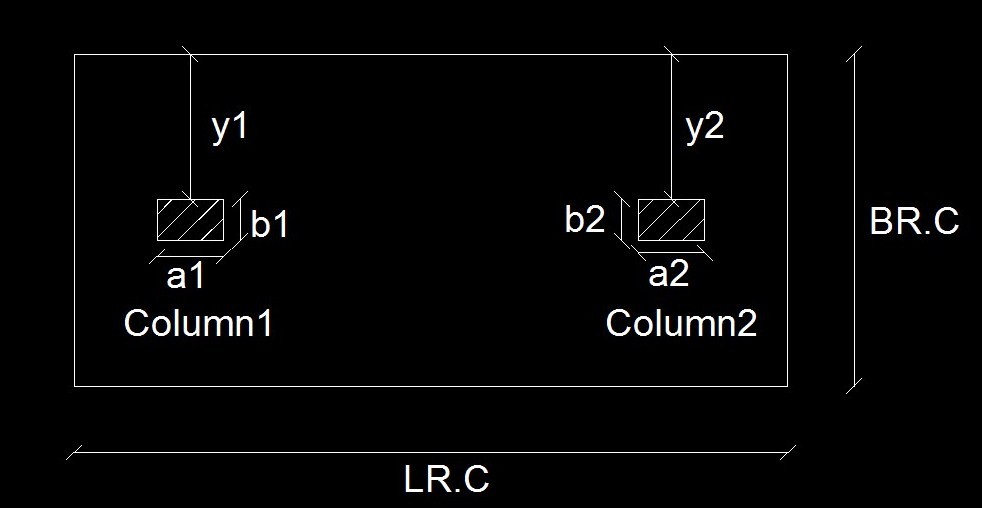
Take Max Moment of M1 & M2 & M3 & M4

As min = 0.15 \* d

If As Bot As min → ok

If As Bot < As min  → take As Bot = As min

In Short Direction:



Mu = qult \* = … mt

Take y Max of y1 & y2

Y1 = = … m

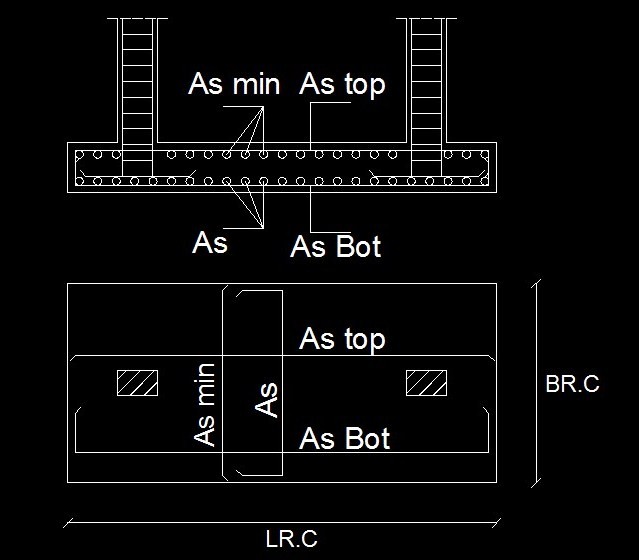
Y2 = = … m

As = = … cm2 /m'

As min = 0.15 \* d

If As As min → ok

If As < As min  → take As = As min



Example: 1

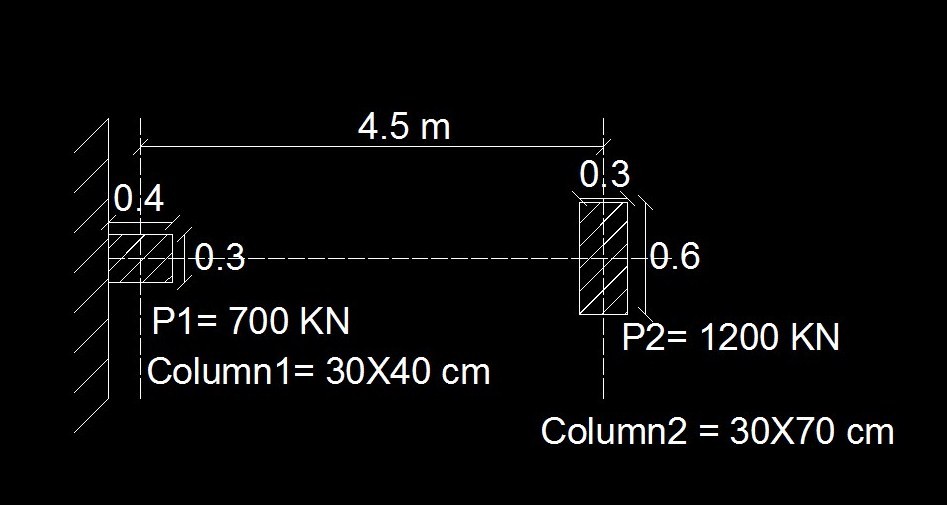
The two column shown in fig are to be supported en a combined footing with the given Dimension.

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: fcu = 250 kg/cm2 , qall = 150 kN / m2 ,

Fy = 3600 kg/cm2 , Foundation depth = 2m

P1 = 700 KN = 70 Ton

P2 = 1200 KN = 120 Ton

Pt = 190 Ton

P1u = 70\*1.5 = 105 Ton

P2u = 120\*1.5 = 180 Ton

qall = 150 kN /m2 = 15 t / m2

1) Dimension of Footing:

Pt = (P1+P2 ) \* 1.1 =(70 + 120)\*1.1=209 Ton

AR.C  = = =13.93 m2

C1 = 0.2 m

C2 = C1 + S = 0.2 + 4.5= 4.7 m

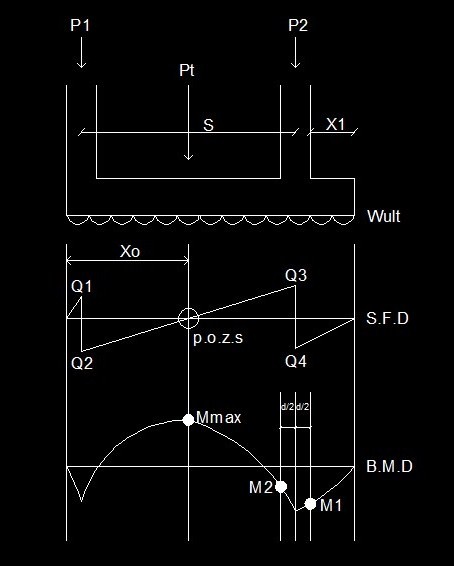
C = = = 3m

LR.C = 2\* C = 2\* 3=6 m

BR.C = == 2.32m 2.35 m

End of Working Loads

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



qult = = = 20.21 t/m2

Wult = qult \* BR.C = 20.21\* 2.35= 47.5t/m'

Q1 = Wult \* C1  = 47.5\* 0.2= 9.5 Ton

Q2 = Q1 – P1u  = 9.5– 105= 95.5 Ton

Q3 = Wult \* C2 – P1u=47.5\*4.7–105=118.25 Ton

Q4 = Q3 – P2u = 118.25– 180 = 61.75 Ton

X1 = LR.C – (C2 + ) = 6– (4.7+ )=1.15 m

M1 = Wu \* = 47.5\* = 31.4 mt

M2 =Wu\* –P2u\* = 47.5\*

–180\* = 23 mt

At p.o.z.s

Xo = = =2.2 m

Mmax =P1u\*(Xo– C1)– (Wu\* )=105\*(2.2–0.2) – (47.5\* ) =95.1 mt

3) Calculation the Depth:

d =c1 =5 =63.6cm 70cm

4) Check shear:

Qsh =QMax–Wu ( + )= 118.25–47.5( + ) =94.5 Ton

qsh = = = 5.7kg/cm2

qcu = 0.4 \* = 0.4 \* = 6.3 kg/cm2

qcu > qsh

6.3 > 5.7 ok safe

5) Check Punching:

For Column 1:

QP1 = Pu1 – qU (A1' \*B1')

A1'=(a1 + )= (0.4+ )= 0.75 m

B1'=(b1 + d)= (0.3+ 0.7)= 1 m

QP1 =105–20.21(0.75\*1)= 90 Ton

For Column 2:

QP2 = Pu2 – qU (A2' \*B2')

A2' = (a2 + d ) = (0.6+ 0.7 ) =1.3 m

B2' = (b2 + d) = (0.3+ 0.7) = 1 m

QP2 = 180– 20.21(1.3 \*1)= 154 Ton

qp =  =  =4.8 kg/cm2

qpcu = (0.5 + )

=(0.5 + ) = 12.9 kg/cm2

qpcu > qp

12.9 > 4.8 ok safe

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

6) Reinforcement of the footing:

in Long Direction:

As Top = = … cm2 /BR.C = cm2 /m'

= =45.7/2.35=19.4cm2 /m'

As min = 0.15 \* d = 0.15 \* 70 = 10.5 cm2 /m'

As Top As min → ok

Take As Top = 19.4 cm2 /m'

Use 6y22/m'

As Bot = = … cm2 /BR.C  = … cm2 /m'

= = 15.1/2.35 = 6.4cm2 /m'

As min = 0.15 \* d = 0.15 \* 70 = 10.5 cm2 /m'

As Bot < As min  → take As Bot = As min

take As Bot = 10.5 cm2 /m'

Use 6y16/m'

In Short Direction:

Mu = qult \* = … mt

Y1 = = = 1.025 m

Y2 = = =0.875 m

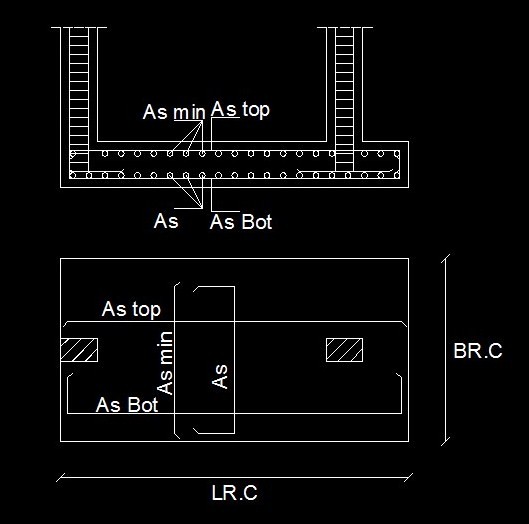
Mu = qult \* = 20.21\* =10.62 mt

As = = =5.1 cm2 /m'

As < As min  → take As = As min

take As =10.5 cm2 /m'

Use 6y16/m'



Example: 2

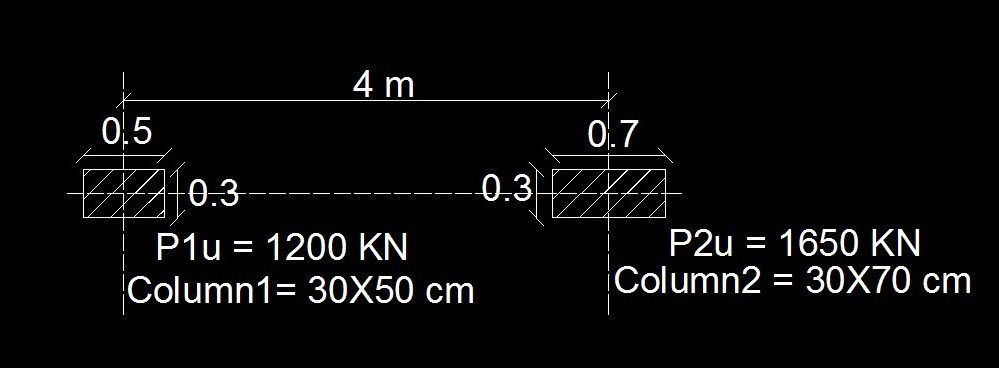
The two interior column shown in fig are to be supported en a combined footing with the given Dimension.

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: fcu = 200 kg/cm2 , qall = 120 kN / m2 ,

Fy = 3600 kg/cm2 , Foundation depth = 2m

P1u = 1200 KN = 120 Ton

P2u = 1650 KN = 165 Ton

Pt u = 285 Ton

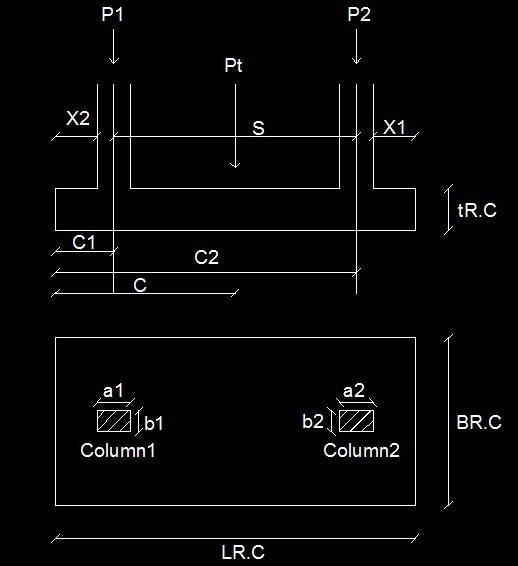
P1w = = = 80 Ton

P2w = = = 110 Ton

Pt w = 80 + 110 = 190 Ton

qall = 120 kN /m2 = 12 t / m2

1) Dimension of Footing ( working Loads ):



Pt =(P1+P2)\*1.1=(80+110)\*1.1=209 Ton

AR.C = = = 17.4 m2

Take C1 = 1 m

C2 = C1 + S = 1 + 4 = 5 m

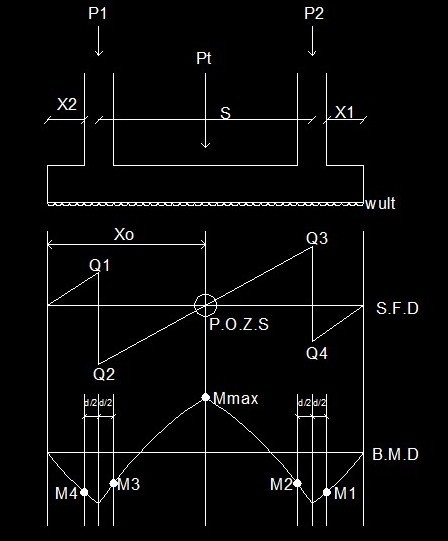
C = = = 3.3 m

LR.C = 2\* C = 2\*3.3 = 6.6 m

BR.C = = = 2.64m 2.7m

End of Working Loads

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



qult = = = 16 t/m2

Wult = qult \* BR.C = 16\* 2.7= 43.2 t/m'

Q1 = Wult \* C1  = 43.2\* 1 = 43.3 Ton

Q2 = Q1 – P1u  = 43.2 – 120 =76.8 Ton

Q3 = Wult \* C2 – P1u = 43.2\* 5– 120= 96 Ton

Q4 = Q3 – P2u = 96– 165= 69 Ton

X1 = LR.C – (C2 + ) = 6.6– (5+ ) = 1.25 m

X2 = C1 – = 1– = 0.75 m

M1 = Wu \* = 43.2\* = 33.75 mt

M2 =Wu\* –P2u\*

=43.2\* –165\* =24.38 mt

M4 = Wu \* = 43.2\* =12.15 mt

M3 =Wu\* –P1u\*

=43.2\* –120\* = 3.75 mt

At p.o.z.s

Xo = = = 2.78 m

Mmax = P1u \*(Xo – C1) – (Wu \* )= … mt

=120\*(2.78–1)– (43.2\* )= 46.7 mt

3) Calculation the Depth:

d = c1 =5 = 46.5 50cm

4) Check shear:

Qsh = QMax – Wu ( + )= … Ton

= 96– 43.2( + )= 70 Ton

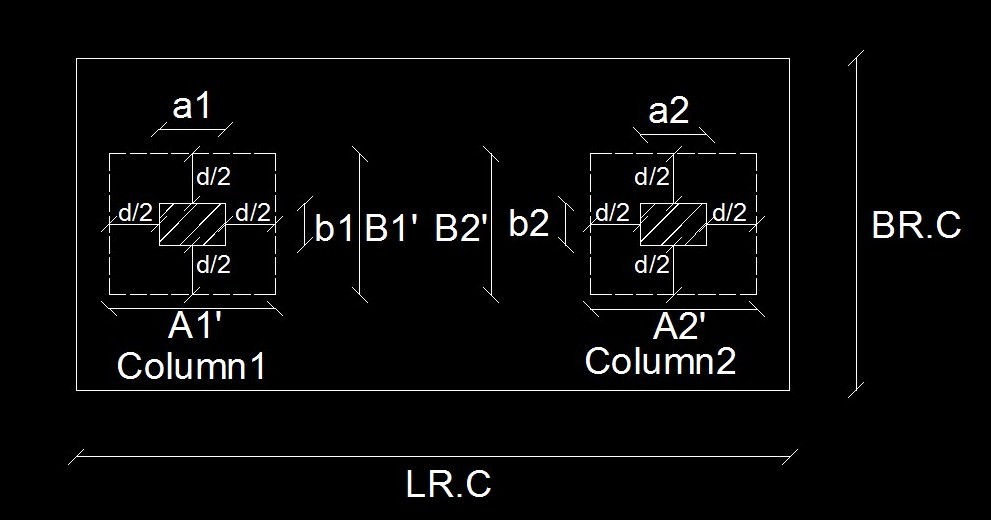
qsh = = = 5.18 kg/cm2

qcu = 0.4 \* = 0.4 \* = 5.66 kg/cm2

qcu > qsh

5.66> 5.18 ok safe

5) Check Punching:



For Column 1:

QP1 = Pu1 – qU (A1' \*B1')

A1' =(a1+d)= (0.5+0.5)= 1 m

B1' =(b1+ d)= (0.3+ 0.5) = 0.8 m

QP1 =120–16(1\*0.8)=107.2Ton

For Column 2:

QP2 = Pu2 – qU (A2' \*B2')

A2' = (a2 + d ) = (0.7+ 0.5 ) = 1.2 m

B2' = (b2 + d) = (0.3+ 0.5) =0.8 m

QP2 = 165– 16(1.2 \*0.8) = 149.64 Ton

qp =  = = 7.48kg/cm2

qpcu = (0.5 + )

=(0.5 + ) = 10.7 kg/cm2

qpcu > qp

10.7 > 7.48 ok safe

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

6) Reinforcement of the footing:

in Long Direction:

As Top = = … cm2 /BR.C  = … cm2 /m'

= =31.41/2.7=11.63 cm2 /m'

As min = 0.15 \* d= 0.15 \* 50 = 7.5 cm2 /m'

As Top As min → ok

take As Top = 11.63 cm2 /m'

Use 6y 16 / m'

As Bot= =..cm2/BR.C =.. cm2 /m'

= =23cm2/2.7=8.5 cm2 /m'

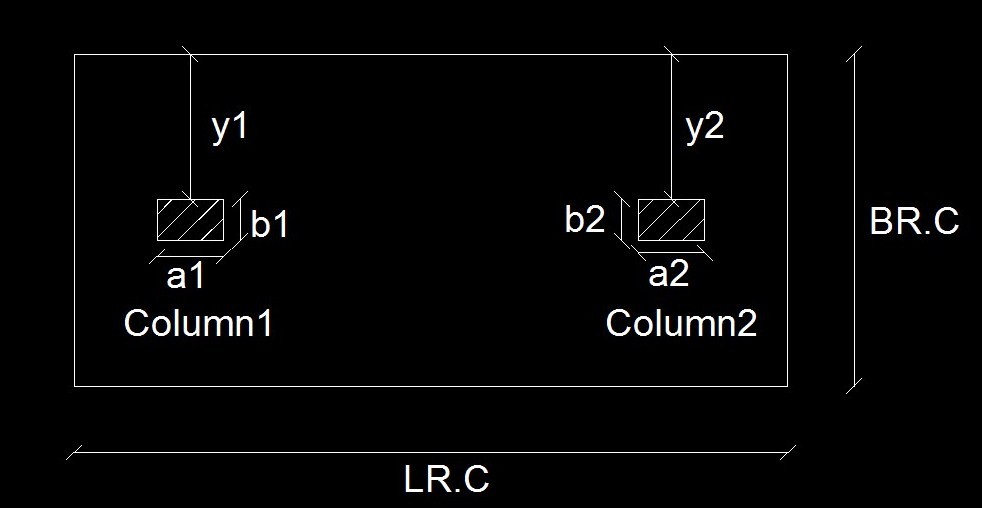
As min = 0.15 \* d = 0.15 \* 50 = 7.5 cm2 /m'

As Bot As min → ok

take As Bot = 8.5 cm2 /m'

Use 8y 12 / m'

In Short Direction:



Mu = qult \*

Y1 = = = 1.2 m

Y2 = = = 1.2 m

Mu = 16\* = 11.52 mt

As = = = 7.75cm2 /m'

As min = 0.15 \* d = 0.15 \* 50 = 7.5 cm2 /m'

As As min → ok

take As = 7.75cm2 /m'

Use 8y 12 / m'

