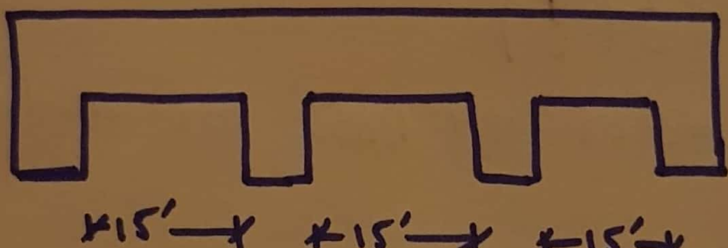
Name:- Malhaar
ID :- 7789
Semester:- 6th
Section :- A.

Question No:- 2

Given Data:-

Clear span = 15ft (b/w supports)
Factored live load = 160lb/ft²
Service ~~floor~~ fininish load = 20lb/ft².
$f_c' = 4000Psi \Rightarrow 4ksi$
$f_y = 40,000Psi \Rightarrow 40ksi$

Solution :-



Step#1. Finding Minimum Thickness of slab

$$\text{thickness (min)} = \frac{L}{28} \Rightarrow \frac{15}{28} = 6.4 \approx 6.5''.$$

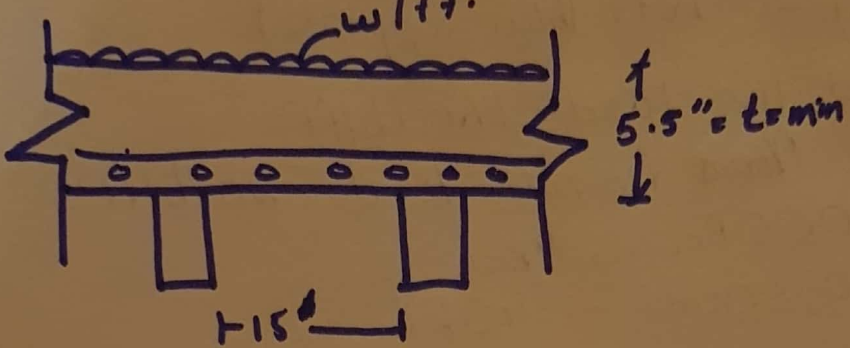
Now xing a factor with this thickness

$$\text{Factor} = \left(0.4 + \frac{f_y}{100}\right) \Rightarrow \left(0.4 + \frac{40ksi}{100}\right)$$

$$= \boxed{0.8}$$

So; $\Rightarrow 6.5 \times 0.8 \Rightarrow t_{min} = 5.2 \approx \boxed{5.5''}$

Step NO#2 :- Finding the effective depth (distance from top of slab to centre of main bars).



d = thickness − clear cover − $\frac{1}{2}$ (dia of main bar)

$= 5.5 - 0.75 - \frac{1}{2}\left(\frac{4}{8}\right)$

We can use #3 or #4 bars for reinforcement in slab.

$\boxed{d \cong 4.5''}$

Step #3. Self weight of slab :-

$\Rightarrow \frac{t}{12} \times \gamma_{concrete}$

$\therefore \boxed{\gamma_{concrete} = 150\ lb/ft^3}$

$= \frac{5.5}{12} \times 150 = \boxed{68.75\ lb/ft^3}$

Step #4 Total Factored Load :-

$\cancel{W_u = 1.2 D.L + 1.6 L.L}$

$= \cancel{1.2(20 + 68.75) + 1.6}$

Given Factored live load = 160 lb/ft²

$D.L = 1.2\,(20 + 68.75)$

$D.L = 106.5\ lb/ft^2$

Total factored ~~load~~ $= D.L + L.L$

$= 106.5 + 160$

$= 226.5\ lb/ft$

$= \boxed{0.2665\ k/ft^2}$

Step No:- 5#

Finding Ultimate Moment.

$\Rightarrow M_u = \dfrac{W_u \times l^2}{8}$

$M_u = \dfrac{0.2665 \times (15)^2}{8} \times 12$

$\boxed{M_u = 89.94\ kip\text{-}inch}$

Step No:- 6# Finding Area of Steel for Main Bars.

Trial #1 :-

$a = 0.2 \times t$ $\quad \because a =$ depth of compression block.

$= 0.2 \times 5.5$

$\boxed{a = 1.1''}$

$\Rightarrow A_{st} = \dfrac{M_u}{\phi \times f_y \times (d - a/2)} = \dfrac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{1.1}{2}\right)}$

$\boxed{A_{st} = 0.632}$

Trial 2#

$$a = \frac{As \times fy}{0.85 \times fc' \times b}$$

$$a = \frac{0.632 \times 40}{0.85 \times 4 \times 12''}$$

$$\boxed{a = 0.619''}$$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{89.94}{0.90 \times 40\left(4.5 - \frac{0.619}{2}\right)}$$

$$\boxed{Ast = 0.596}$$

Trial 3# :-

$$\boxed{a = 0.584}$$

$$Ast = \frac{89.94}{0.90 \times 40\left(4.5 - \frac{0.584}{2}\right)}$$

$$\boxed{Ast = 0.59 \, in^2/ft}$$ same

Step 7#:- Area of Steel For Distribution Reinforcement :-

since $fy = 40ksi$

$$As(min) = 0.0018 \times bxt$$

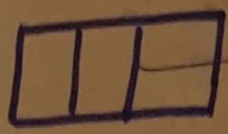
Taking $b = 12'' \Rightarrow 1ft$ of the total thickness.

$$As(min) = 0.0018 \times 12'' \times 5.5''$$

$$\boxed{As(min) = 0.1188 \, in^2/ft}$$

Step 8# :- Spacing for Main Bars.

#4 is used



$$S = \frac{A_b}{A_s} \times 12''$$

$$\because d = \left(\frac{4}{8}\right) = 0.5$$

$$S = \frac{0.196}{0.59} \times 12''$$

$$A_b = \frac{\pi (0.5)^2}{4}$$

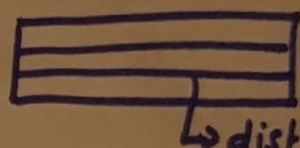
$$\boxed{A_b = 0.196}$$

$$S = 3.98 \approx \boxed{3.5'' \text{ C/C.}}$$

Step 9# :- Spacing for Distribution Bars :-

#4 is used

$$S = \frac{A_b}{A_s} \times 12''$$



$$S = \frac{0.196}{0.1188} \times 12''$$

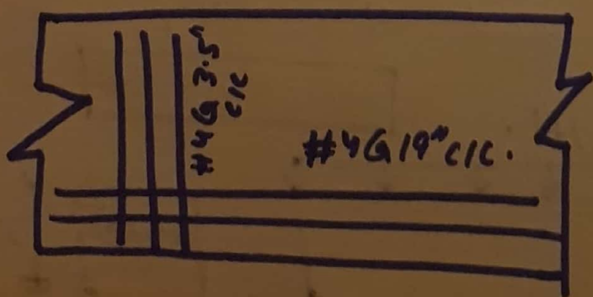
$$S = 19.79 \approx \boxed{19'' \text{ C/C}}$$

Step 10 # Final Summary.

$f_c' = 4$ ksi $f_y = 40$ksi $t = 5.5''$

Main steel = #4 at 3.5" C/C.

Distribution steel = #4 at 19" C/C.



Question No#2 :-

$b_w = 16"$
$d = 22"$ (effective depth)
Factored load $W_u = 9.4\,kip/ft$.
clear span = 20'
$f_c = 4\,ksi$
$f_y = 60\,ksi$
U stirrups = #3

Solution :-

Finding self weight of beam.

Formula;

W = breath x thickness x unit weight of concrete.

$= b \times t \times 150\,lb/ft^3$

For R.C.C.

$$W = \frac{16}{12} \times \frac{22}{12} \times 150$$

$W = 366.67\,lb/ft$

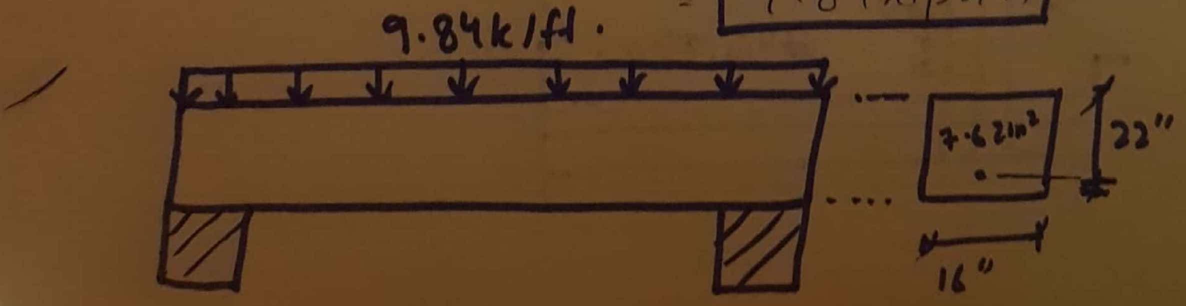
$$\boxed{W = 0.3666\,k/ft.}$$

So, factored load becomes.

$= 1.2(0.366) \Rightarrow 0.44\,kips/ft.$

Total factored load $= 9.4 + 0.44$

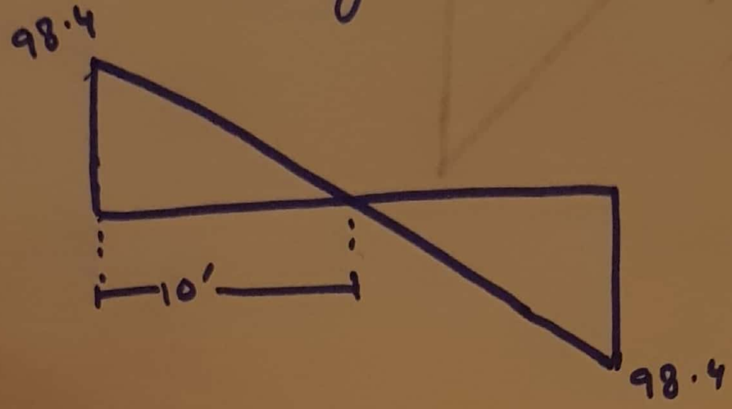
$= \boxed{9.84\,kips/ft}$



~~Rea~~ Step 1# Reaction Values.

Total load $= \frac{9.84 \times 20}{2} = \boxed{98.4 \text{ kips.}}$

Step No 2# Draw Shear Force Diagram.

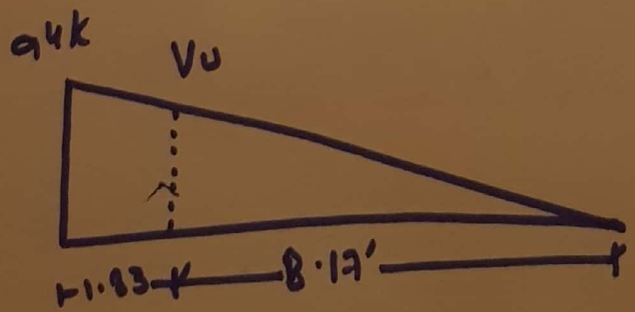


Step No:-3 Finding the Values of Critical Shear.

=> We know that critical section is located at a distance "d" from the face of the support

"d" = 22" = 1.83'

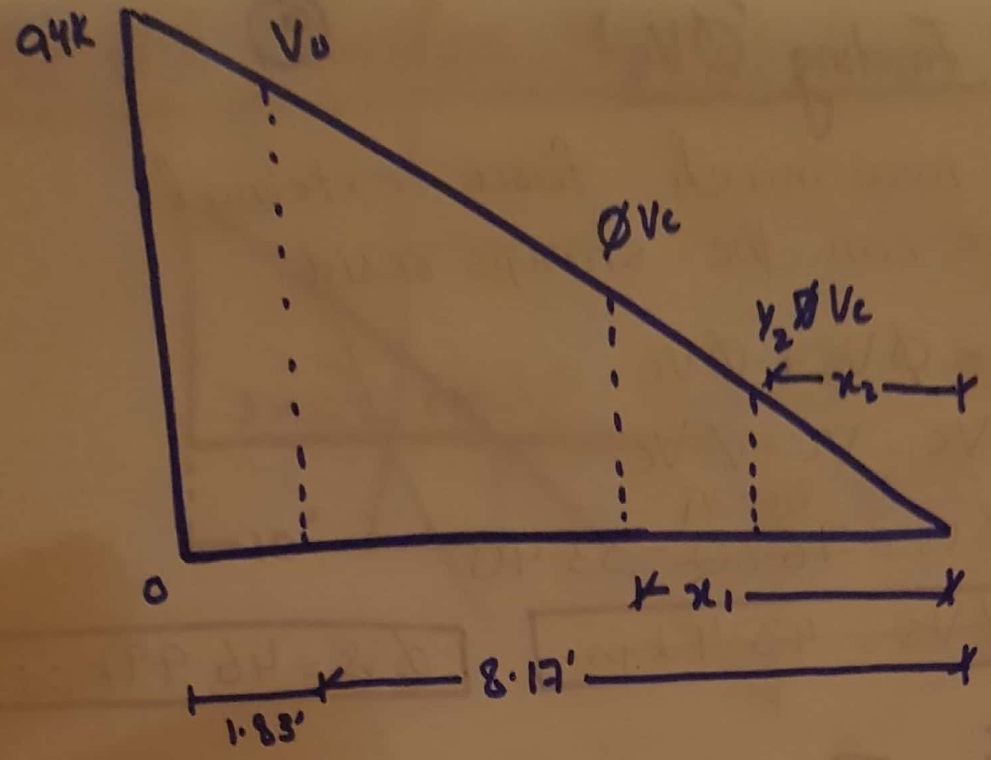
=> We have considered ~~the~~ left side of the triangle.



From similar Δs $\frac{98.4K}{10'} = \frac{V_u}{8.17}$ => $9.84 \times 8.17 = V_u$.

~~$\boxed{V_u = 76.80 \text{ kips}}$~~

$\boxed{V_u = 80.39 \text{ kips}}$



Step 4# Finding Values of ØVc & ½ØVc & Also its distance from zero shear to right side.

$$\phi V_c = \phi \times 2\sqrt{f_c'} \times b_w \times d$$

$$= \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$\boxed{\phi V_c = 33.40 \text{ kips.}}$$

Location of ØVc by similar Δs.

$$\frac{98.4}{10} = \frac{33.40}{x_1}$$

$$\boxed{x_1 = 3.39'}$$

From formula $\frac{1}{2}\phi V_c \Rightarrow \frac{\phi V_c}{2}$

$$= \frac{33.40}{2}$$

$$\boxed{\frac{1}{2}\phi V_c = 16.70 \text{kips}}$$

Step 5 # finding 'ØVs'

=> To know how much ~~force~~ external shear force can the stirrups resist

$$V_u = \phi V_s + \phi V_c$$

$$\text{or } \phi V_s = V_u - \phi V_c$$

$$\phi V_s = \cancel{76.80}^{\,80.39} - 33.40$$

$\cancel{\boxed{\phi V_s = 43.4 \text{ kips}}}$ $\boxed{\phi V_s = 46.99 \text{ kips}}$

Step No:- 6 To Check Adequacy As To how much shear force can the cross-section resist.

$$\phi \times 8 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 133.57k.$$

So, $\boxed{\phi V_s < \phi 8\sqrt{f_c'} b_w d}$

section is adequate i.e it can resist shear.

Step No:7 # Check Maximum stirrups spacing between ØVc & ½ Vc.

$$\phi 4\sqrt{f_c'} b_w d = \frac{0.75 \times 4\sqrt{4000} \times 16 \times 22}{1000}$$

$$= \boxed{66.79 \text{ kips}}.$$

As the value of;

$$\phi 4\sqrt{f_c'} b_w d > \phi V_s$$

So, maximum spacing will be selected from the following 4 condition.

1. $S_{max} = 24''$

2. $d/2 = \frac{22}{2} = 11''$

3. $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w}$

$= \frac{0.22 \times 60{,}000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$

∴ Using #3 U-stirrups.
So it has dia $(3/8)''$ & Area $0.11 in^2$
For 2 legged we multiply it by 2.
$= 0.11 \times 2$
$= 0.22 in^2$

4- $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

$= \frac{0.22 \times 60{,}000}{50 \times 16} = 16.50''$

Now from above 4 conditions we use $\boxed{S_{max} = 11'' C/C}$

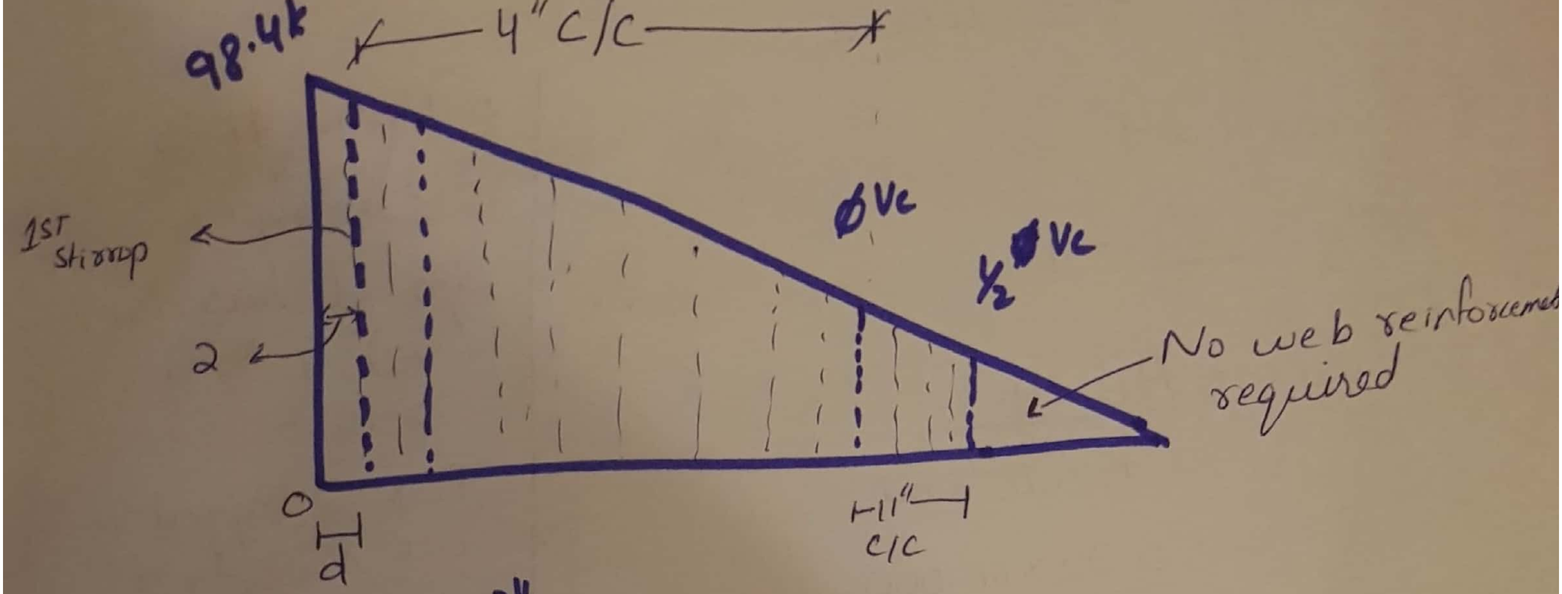
⇒ selecting least value we will use for #3 2 legged stirrups.

Step #8:- Spacing of Stirrups at Critical Section i.e b/w V_u & ϕV_c.

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{80.39 - 33.40}$$

$S = 4.6'' \approx 4''$

$\boxed{S = 4'' C/C}$



$\Rightarrow \frac{5}{2} = \frac{4}{2} = 2''$

Question No:- 3.

Step 1 # Find Gross Area of Concrete

$A_g = b \times b$ (Since its square tied column)

$A_g = 12 \times 12 = 144 in^2$ (Actual).

Step 2 # Steel Area

$A_s = 5\%$ of $A_g \Rightarrow 0.05 \times 144$

$\boxed{A_s = 7.2 in^2}$

Step # 3 Ultimate Load Carrying Capacity.

$P_u = \phi \times 0.80 \times (0.85 \times f_c' \times (A_g - A_s) + A_s \times f_y)$

$= 0.65 \times 0.80 [0.85 \times 4 [144 - 7.2] + 7.2 \times 60]$

$\boxed{P_u = 466.50k}$

Step 4 # Sketch & Design of Ties.

16 x dia of bar $= 16 \times 9/8$

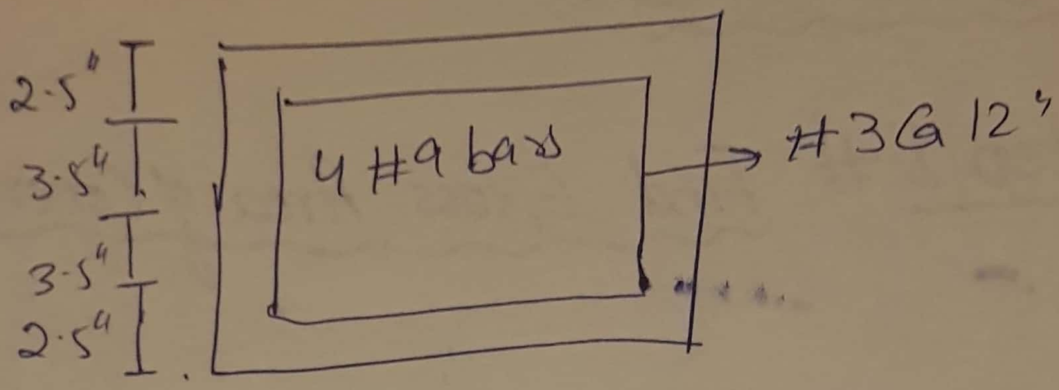
$= 18''$

48 x dia of tie bar $= 48 \times 3/8$

$= 18''$

Least column dimensions $= 12''$

C/C distance b/w ties $= 12''$



No spiral stirrup is used, the stirrup used is of rectangular shape due to its specification of structure so we use tie stirrups.

Question 4.

Given Data:-

Dimensions of column → Square column of 16" × 16"

D·L = 100 Kips L·L = 120 k.

Base of footing below ground = 5'

Allowable soil pressure = 2.50 k/ft²

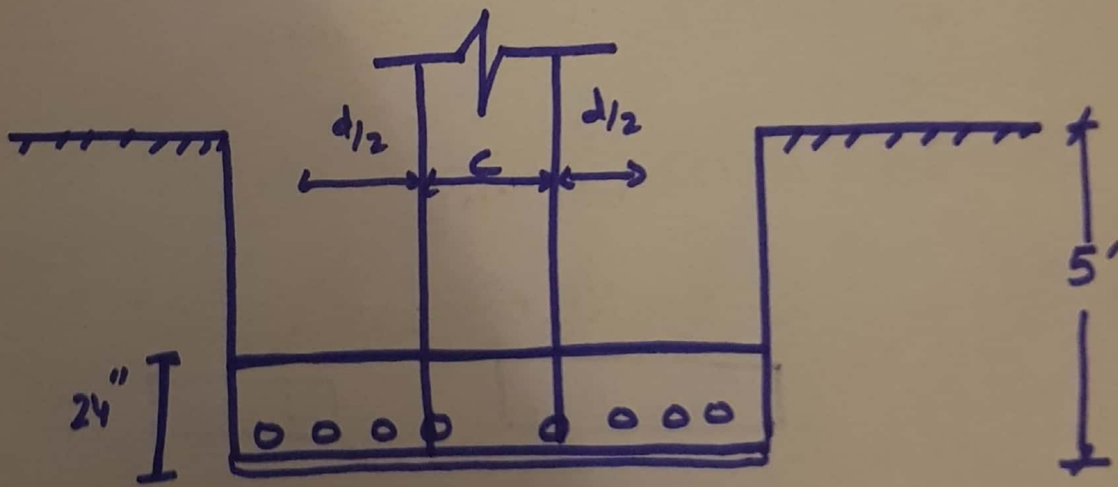
fc' = 3 ksi fy = 60 ksi

Unit weight of soil (γ_s) = 120 lb/ft³.

Step #1 Finding Depth of Foundation.

Assuming depth of foundation as;

h = 24".



Step #2 (Total Weight)

Total weight = wt. of soil + wt. of reinforcement concrete

= (depth of soil) + (depth of R C × γ_{conc})

$= (3 \times 120) + (2 \times 150)$

$= 660 lb/ft^2 \Rightarrow 0.660 K/ft^2$

Step #3 Effective Bearing Capacity.

$q_{effective} = q_{allowable} - \text{Total weight}$

$= 2.50 - 0.660$

$\boxed{q_e = 1.84 K/ft^2}$

Step #4 Required Area for foundation:

$$Area_{(required)} = \frac{\text{Service Load}}{q_e}$$

$$= \frac{100 + 120}{1.84}$$

$$= 119.56 ft^2$$

Step #5 Foundation Dimensions

We know that it is square foundation,

$A_{required} = B \times B = \sqrt{119.56}$

$B = 10.9'$ or $10' - 9''$

$\boxed{B = 10.9'}$ or $\boxed{B = 11''}$

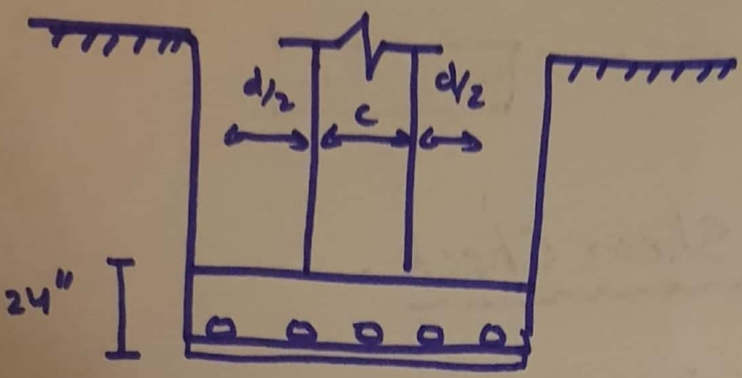
Step #6 Upward Bearing Capacity

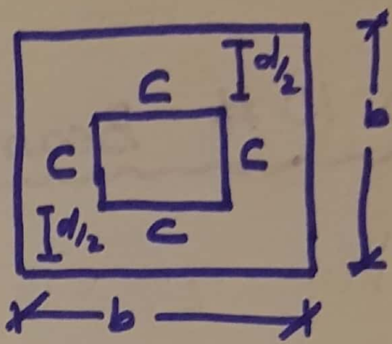
$$q_{upward} = \frac{\text{Factored Load}}{(B)^2}$$

$$= \frac{1.2(100) + 1.6(120)}{(11)^2} \Rightarrow 2.58 K/ft^2$$

Step # 7 :- Punching Shear :-

$b_o = 4(c+d)$.





effective depth (d)

$d = h -$ clear cover $-$ dia of bottom bar $- \frac{1}{2}$ dia of top bar

$= 24 - 3 - (1) - \frac{1}{2}(1)$

$\boxed{d = 19.5''}$

So, punching shear will be;

$b_o = 4(16'' + 19.5'')$

$b_o = 142''$

#8 is used

$d = (8/8)'' = 1''$

Area $= 0.785 in^2$

Step #8:- Value of V_{u_2}

$V_{u_2} = q_{up} \times [B^2 - (c+d)^2]$

$= 2.58 \times [(11)^2 - (16+19.5)^2]$

$\boxed{V_{u_2} = 289.60 \text{kips}}$

Step #9: (Value of $\phi V_{c/p}$)

$\phi \times 4 \times \sqrt{f_c'} \times b_o \times d$

$\frac{0.75 \times 4 \times \sqrt{3000} \times 142 \times 19.5}{1000} = \boxed{454.99k}$

Step 10 # Beam Shear Check.

$V_{u_1} = q_{up} \times B \times \left[\frac{B}{2} - \frac{c}{2} - d\right]$

$= 2.58 \times 11 \times \left[\frac{11}{2} - \frac{16/2}{2} - \frac{19.5}{12}\right]$

$\boxed{V_{u_1} = 91.05\text{ kips.}}$

Step #11 Self Shear Capacity

$\phi V_c = \phi \times 2 \times \sqrt{f_c'} \times B \times d$

$= \frac{0.75 \times 2 \times \sqrt{3000} \times (11 \times 12) + 19.5}{1000}$

$\phi V_c = 211.47 > V_{u_1} \rightarrow$ ok!

Step #12 Ultimate Moment

$M_u = \frac{q_{up} \times B}{8} \times (B-C)^2$

$= \frac{2.58 \times 11}{8} \times \left(11 - \frac{16}{12}\right)^2$

$= 331.49k\cdot ft \Rightarrow \boxed{3977.88\text{ kip-inch}}$

Step 13 # Area of Steel for main bars

Trial #01:-

Let $a = 0.2 \times h$

$= 0.2 \times 24$

$\boxed{a = 4.8''}$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} \Rightarrow \frac{3977.88}{0.90 \times 60 \times (19.5 - \frac{4.8}{2})}$$

$\boxed{A_{st} = 4.31 in^2}$

Trial #2:-

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times B} = \frac{4.31 \times 60}{0.85 \times 3 \times (11 \times 12)}$$

$\boxed{a = 0.76''}$

$\boxed{A_{st} = 3.85 in^2}$

Trial #3:

$a = 0.68''$

$\boxed{A_{st} = 3.85 in^2}$

Step # 14 Check Minimum Reinforcement.

a) $\Rightarrow A_{st\,min} = 0.0018 \times B \times h$

$= 0.0018 \times (11 \times 12) \times 24$

$= 3.168 in^2$

b=) $As_{min} = \frac{200}{fy} \times B \times d$

$= \frac{200}{60,000} (11 \times 12) \times 19.5$

$= 8.58 in^2$

c=) $As_{min} = \frac{3 \times \sqrt{fc'}}{fy} \times B \times d$

$= \frac{3 \times \sqrt{3000}}{60,000} \times (11 \times 12) \times (19.5)$

$= 7.04 in^2$

Greater value $\boxed{As_{min} = 8.58 in^2}$

Step 15# No. of Bars.

Using # 8 bars.

No. of bars $= \frac{Ast}{Ab} = \frac{8.58}{0.785}$

$= 10 \approx 11$ bars → in each direction.