Name :- Abdus Rahman

ID :- 7826

Sec :- A

Subject :- PRCD 1

Submitted to :- Eng Fawad

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Final Term exam.

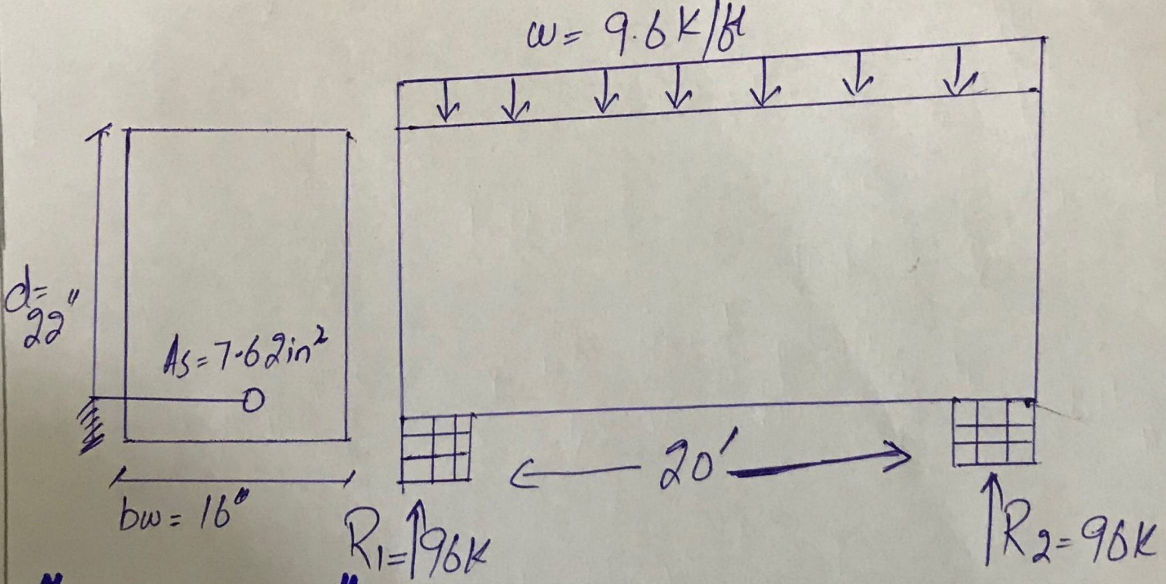
2) A Simply supported rectangular beam 16" wide ...
.... Draw a sketch of your final diagram.

Sol: First of all find the unit load of beam.

So $b \times \gamma_c$

$= \frac{16 \times 150}{12} \Rightarrow 200\ lb/ft = 0.2\ K/ft$

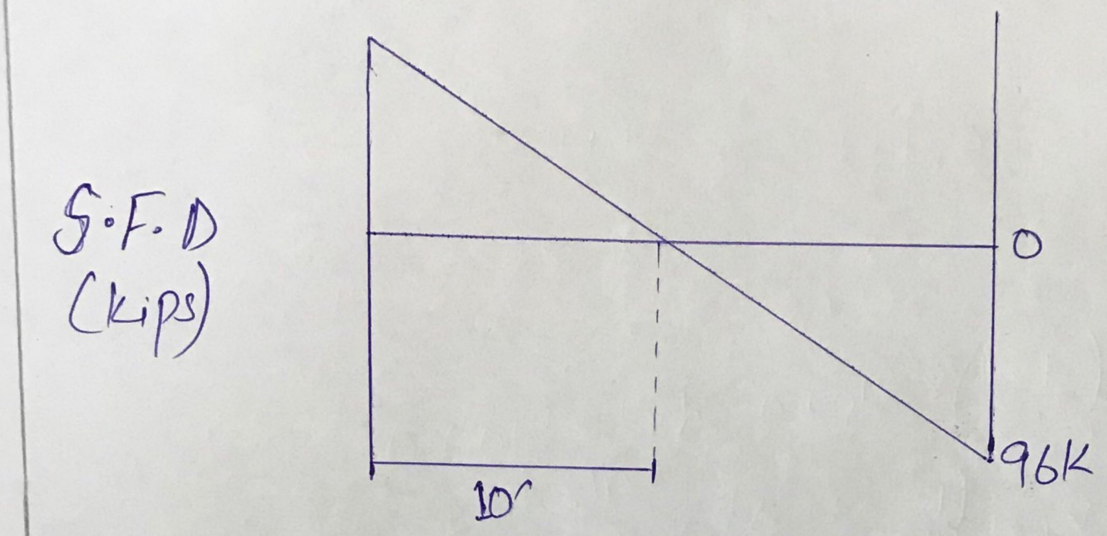
So total factored load = 9.4 + 0.2
= 9.6 K/ft



"Step # 01:" Find the values of R_1 & R_2

Total load = $9.6 \times \frac{20}{2} = 96K$

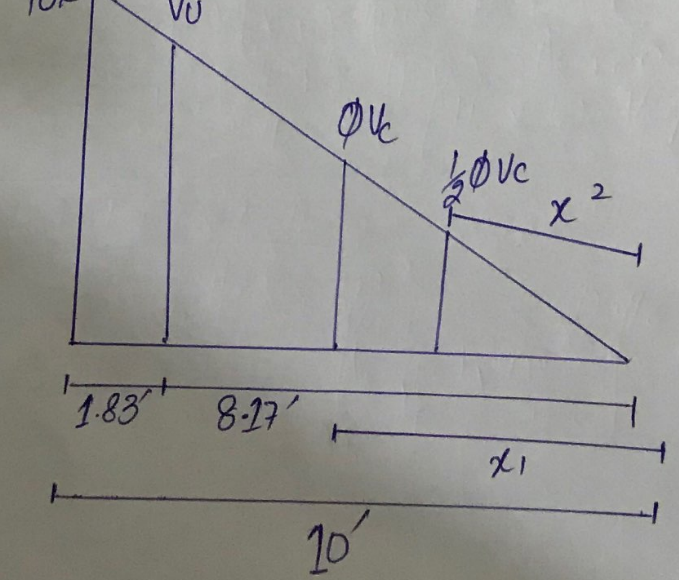
"Step#02:-" Draw its Shear force diagram.



"Step#03:-" Find the value of critical stress "V_u" and its location.

As we know that critical section is located at distance "d" from face of support = d = 22" = 1.83'

Value of critical shear at distance "d" by similarity of triangles.



From similar Δ's

$$\frac{96}{10} = \frac{V_u}{8.17}$$

$$\boxed{V_u = 78.43k}$$

"Step#04:- "Find the value of "ϕV_c" & "$\frac{1}{2}\phi V_c$" & also its distance from zero shear to right side.

$$\phi V_c = \phi \times 2 \times \sqrt{f'c} \times b_w \times d \Rightarrow \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$\boxed{\phi V_c = 33.40K}$$

Location of ϕV_c by similarity of Δ's.

$$\frac{96}{10} = \frac{33.40}{x_1}$$

$$\boxed{x_1 = 3.48'}$$

Now:

$$\frac{1}{2}\phi V_c = \frac{33.40}{2} = 16.70K$$

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{96}{10} = \frac{16.70}{x_2}$

$$\boxed{x_2 = 1.74'}$$

"Step #05:-" Value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

So $\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

$\boxed{\phi V_s = 45.03K}$

"Step #06:-" Check on section adequacy.

$\Rightarrow \phi \times 8 \times \sqrt{f'c} \times b_w \times d = \dfrac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 133.57\ K$

As $\phi \times 8\sqrt{f'c} \times b_w \times d > \phi V_s$ → It means section is adequate.

"Step #07:-" Check on min spacing for stirrups.

$\phi \times 4 \times \sqrt{f'c} \times b_w \times d = \dfrac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79K$

As $\phi 4\sqrt{f'c}\, b_w d > \phi V_s = 45.03K$

Thus max spacing will be selected from the following four condition

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

2) $\dfrac{d}{2} = \dfrac{22}{2} = 11''$

3) $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'c} \times b_w}$ $\dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16} = 17.40$

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$\therefore A_v = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$ $A_v = 0.11 \times 2$

$= 17.40''$ $A_v = 0.22$

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

$= \frac{0.22 \times 60000}{50 \times 16}$

$= 16.50$

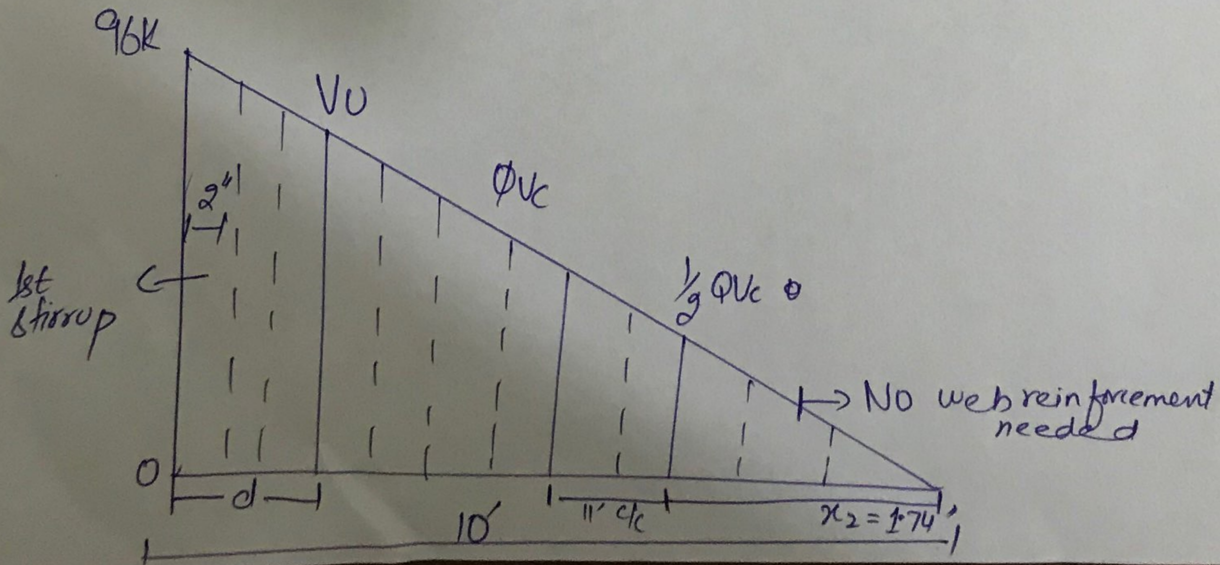
From the above four Condition, least value of spacing from # 3, U shaped will be selected so $S_{max} = 11'' c/c$

Step#08:- Spacing of stirrup from/at critical section.

$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40}$

$=$ ~~44.8''~~ $48.4'' \approx 5'' c/c$

Step# 9:- Find sketch.



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* As we know that first stirrup from face of support

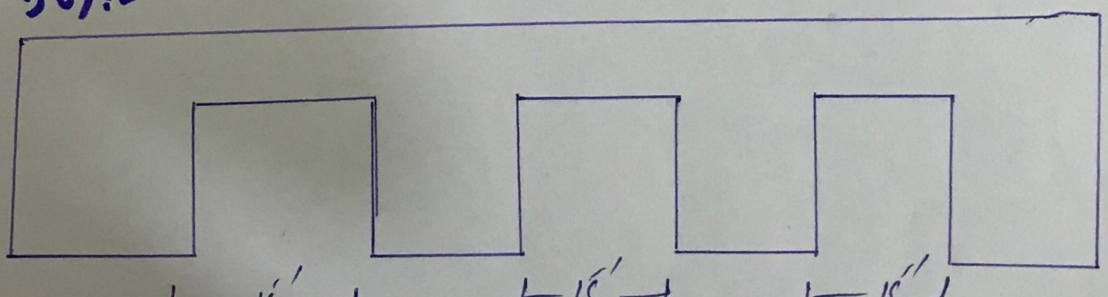
$$\Rightarrow \frac{S}{2} = 2.5 \approx 2''$$

Q2) A reinforcement Concrete slab is .....
...... Draw sketch of your final design.

Given data:-

- Clear span b/w support = 15'
- Factored live load = 160 lb/ft²
- Service floor finish load = 20 lb/ft²
- $f'c = 4000$ psi
- $fy = 40$ ksi

Sol:-



Step #01:- Minimum thickness:-

By using formula

$$t_{min} = L/28 = \frac{15}{28} = 6.4 \approx 6.5''$$

As $f_y \rightarrow 40ksi$

So we will multiply a factor with this thickness

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

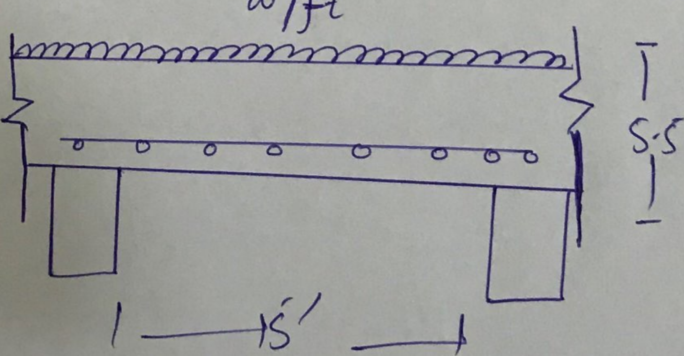
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hense the minimum thickness will be

6.5×0.8

$t_{min} = 5.2 \approx 5.5''$

"Step #2:-" effective Depth.



By formula

$d = t - \text{Clear cover} - \frac{1}{2}(\text{dia of main bars})$

$= 5.5 - 0.75 - \frac{1}{2}(5/8)$

$d = 4.5''$

"step #03:-" **Self weight of Slab.**

By formula

$\frac{t}{12} + \gamma$ Concrete

$= \frac{5.5}{12} \times 150 = 68.75\ lb/ft^2$

"step#04:-" **Total Factored load.**

Factored live load = 160 lb/ft²

So the factored dead load will be

$D.L = 1.2\,(20 + 68.75) = 106.5\ lb/ft^2$

Total factored load = D.L + L.L

$= 106.5 + 160$

$= 266.5\ lb/ft^2 \Rightarrow 0.2665\ k/ft^2$

"step#05:-" **Ultimate Moment**

By using formula

$Mu = \frac{Wu \times L^2}{8} = \frac{0.2665 \times (15)^2 \times 12}{8}$

Mu = 89.94 kips-inches

"Step #6:- Area of Steel for Main bars by Trail and repeat Method."

"Trail #01:-"

Let depth of Compression block

$a = 0.2 \times t$

$= 0.2 \times 5.5 \Rightarrow 1.1''$

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

$A_{ST} = 0.63 \text{ in}^2$

"Trail #02:-"

$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} \Rightarrow 0.62 \text{ in}^2$

$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.6}{2})}$

$A_{ST} = 0.59 \text{ in}^2$

"Trail #03:-"

$a = \frac{0.59 \times 40}{0.85 \times 4 \times 12} = 0.57''$

$$A_{ST} = \frac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{0.57}{2}\right)} = 0.59\,in^2$$

So we will use $A_{ST} = 0.59\,in^2$

"Step#07:-" Area of Steel for distribution reinforcement

By formula

$A_{min} = 0.002 \times b \times t \longrightarrow$ (For Grade 40 steel)

$= 0.002 \times 72 \times 5.5 \Rightarrow 0.132\ in^2$

"Step #08:-"

spacing for main bars.

By formula

$Spacing\ \frac{A_b}{A_{ST}} \times 12$

We use #6 bars dia $= \left(\frac{6}{8}\right)''$

$Area = \frac{\pi}{4}\left(\frac{6}{8}\right)^2 = 0.442\ in^2$

"Step#09:-" spacing for distribution bars

$Spacing = \frac{A_b}{A_{ST}}$

we use #5 bars so

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dia $= \left(\frac{5}{8}\right)''$, Area $= \frac{\pi}{4}\left(\frac{5}{8}\right)^2 = 0.31 \text{ in}^2$

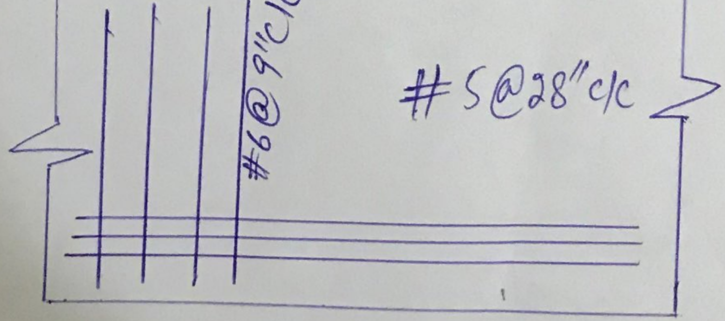
Spacing $= \frac{0.31}{0.132} \times 12 = 28.1'' \approx 28''$ c/c

"Step #10": Find Sketch

$f'_c = 4$ ksi , $f_y = 40$ ksi

Main Steel #6 at 9" c/c

Distribution steel #5 at 28" c/c



Q3) Calculate the axial ultimate .... design" necessary spirals.

"Step#01:-"

Find gross area of Concrete

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

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

"Step#02:-"

Find the area of steel -

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2\,in^2$

"Step#03:-"

Ultimate load carrying capacity

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

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

$P_u = 466.50\,k$

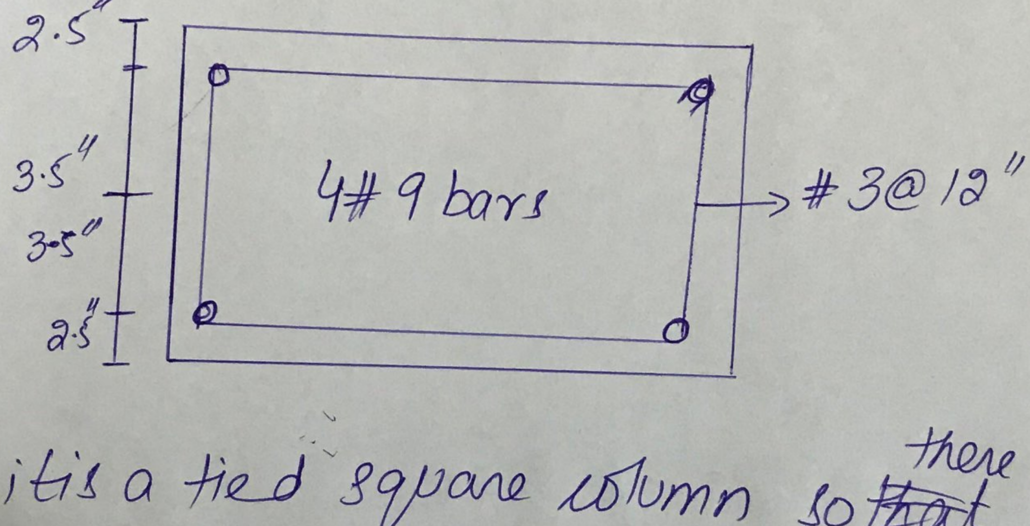
"Step#04:-" Sketch & design of Ties (c/c to distance)

From the below value we choose the least value of all thus;

1)- 16 x dia of long bar = 16 x 9/8
= 18"

2)- 48 x dia of Tie bar = 48 x 3/8
= 18"

3) least Column dimension = 12"
so c/c distance b/w ties = 12"



* Since it is a tied square column so there is no spiral stirrup used, the stirrup used is of rectangular shape due to the specification of the structure thus we will use tie stirrups instead-

Q4) Design a square footing .... Sketch of your final design.

"Step 01:-" let $h = 24''$

"Step # 02:-"

Total weight = Wt of soil + Wt of RC

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

$= 660\ psf = 0.660\ ksf$

"Step # 03:-" Effective bearing Capacity.

$q_e = q_a - W$

$= 2.50 - 0.660$

$q_e = 1.84\ ksf$

"Step # 04:-" Required Area for foundations

$A_{req} = \frac{\text{Service load}}{q_e} = \frac{100 + 120}{1.84}$

$= 119.57\ ft^2$

"Step # 05:-" Since foundation is square.

$A_{req} = b \times b = 119.57 \Rightarrow B \cong 11'$

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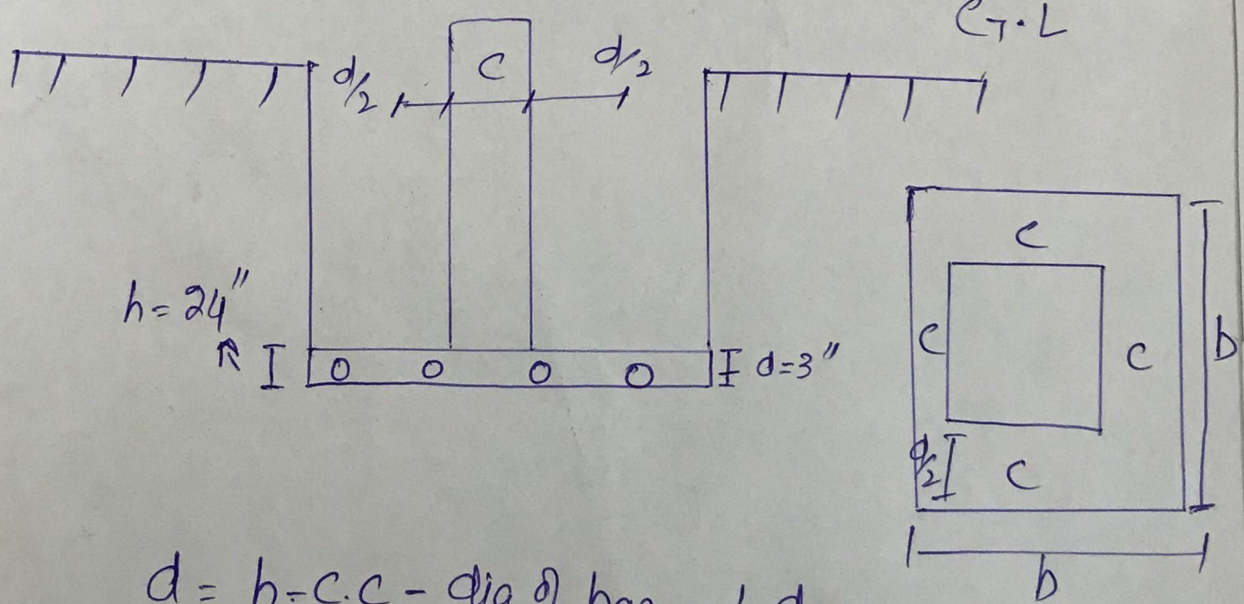
"Step# 6:" upward bearing Capacity of soil.

$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

$$q_{up} = 2.58\ K/ft^2$$

"Step# 7:" Punching shear

$$b_o = 4 \times (C+d)$$



$$d = h - c.c - \text{dia of bar} - \frac{1}{2} d_b$$

∴ Take #8 bar
dia = 8/8" = 1"

$$d = 24 - 3 - 1 - \frac{1}{2}(1) = 19.5"$$

$$b_o = 4 \times (16 + 19.5) = 142"$$

"Step# 08:-"

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

$$= 2.58 \times \left[11^2 - \left(\frac{16 + 19.5}{12}\right)^2\right]$$

$V_{U_2} = 289.60K$

"Step#09 :-"

$\phi V_{c/p} = \phi \times 4 \times \sqrt{f'c} \times b \times d$

$= \frac{0.75 \times 4 \times \sqrt{4000} \times 142 \times 19.5}{1000}$

$\phi V_{c/p} = 525.38$

Step# 10 :-" Beam/one way shear check (shear)

$V_{U1} = q_{up} \times B \times \left[B/2 - C/2 - d \right]$

$V_{U1} = 2.58 \times 11 \times \left[11/2 - \frac{16/12}{2} - 19.5 \right]$

$V_{U1} = 90.95K$

Step#11:-"

Self Shear Capacity.

$\phi V_c = \phi \times 2 \times \sqrt{f'c} \times b \times d$

$= \frac{0.75 \times 2 \times \sqrt{4000} \times [11 \times 12 - 16]}{1000}$

$= 110.04 K > V_{U1} \Rightarrow O.K$

Step # 12 Ultimate moment

$$M_U = \frac{q_{up} \times B}{8} \times (B-c)^2 = \frac{2.58 \times 11}{8} \times \left(11 - \frac{16}{12}\right)^2$$

$$M_U = 331.49 K' = 3977.93 K''$$

Step # 13 Area of steel for main bars by Trail & Repeat method

Trail # 01:-

let $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

$$A_s = \frac{M_U}{\phi \times f_y \times (d - a/2)} = \frac{3977.93}{0.90 \times 60 \times \left(11 - \frac{4.8}{2}\right)} = 8.56 \text{ in}^2$$

Trail # 02:-

$$a = \frac{A_s \times f_y}{0.85 \times f_c' \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.53''$$

$$A_s = \frac{3977.93}{0.90 \times 60 \times \left(11 - \frac{1.53}{2}\right)} = 7.197 \text{ in}^2$$

"Trail # 03:-"

$$a = \frac{7.197 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.28''$$

$$A_s = \frac{3977.93}{0.90 \times 60 \left(11 - \frac{1.28}{2}\right)} = 7.1 \text{ in}^2$$

So that area = 7.1 in^2

Step 14:-

Check the min reinforcement by the following 03 method:

a) $A_{s\,min} = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$
$= 5.70 \; in^2$

b) $A_{s\,min} = \frac{200}{f_y} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$

$= 8.58 \; in^2$

c) $A_{s\,min} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times 19.5$
$= 7.05 \; in^2$

From above value greater value will be selected. Thus $A_{s\,min} = 8.58 \; in^2$

Step#15: using #8 bar

$A_b = 0.785 \; in^2$

No. of bars $= \frac{A_s}{A_b} = \frac{8.58}{0.785} = 10.92 \approx 11$ bars in each direction.