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Section	A
Semester	6th
Subject	PRCD-1
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Date	26/06/2020
	Final paper.

Date: ____________

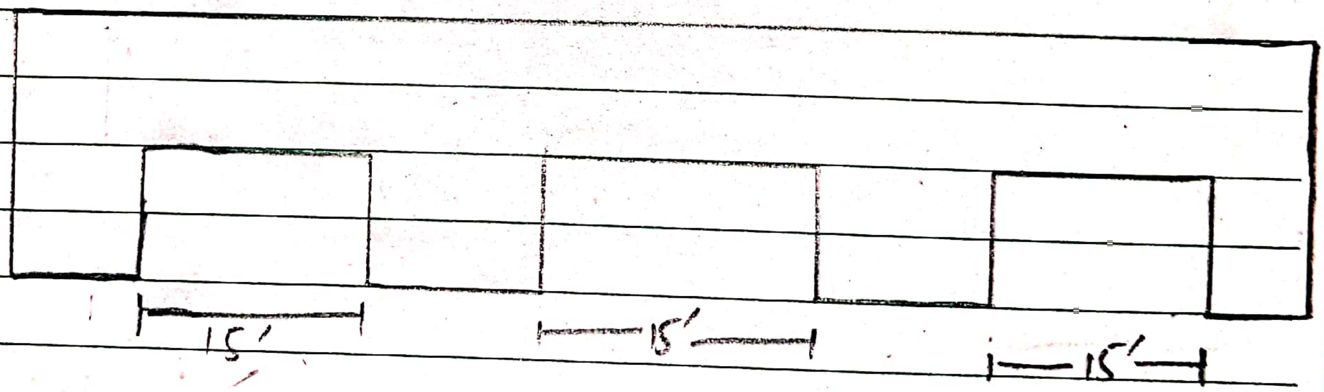
Q. No 1

A reinforced concrete slab is built.......
Draw sketch of your final design.

Given :-

f'_c = 4000 psi
f_y = 40 ksi
clear span btw supports = 15 ft
Factored live load = 160 lb/ft2
3 equal spans concrete slab
Service Floor finish load = 20 lb/ft2

Sol:-



Step #01: Minimum thickness

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

$F_y \rightarrow 40$ ksi

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Date: ____________

will multiply a factor with this thickness. Factor

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

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

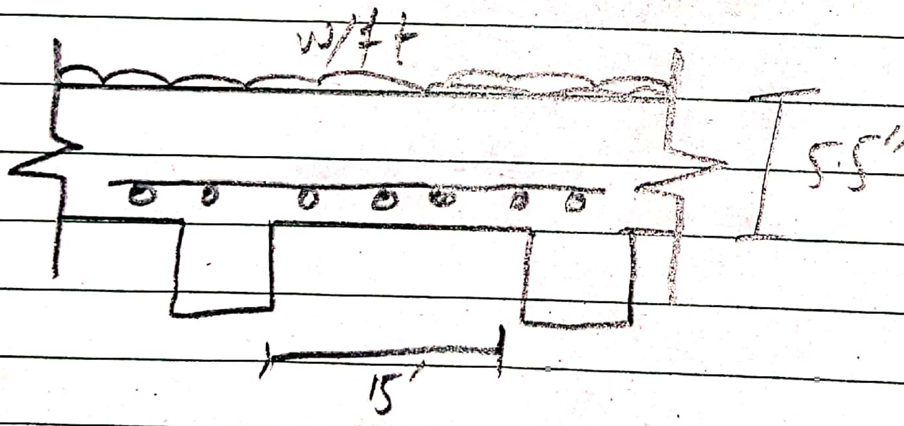
$$= 0.8$$

The minimum thickness will be

6.5×0.8

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

Step #02 :- (Effective depth)



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

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

$d \cong 4.5''$

Step #03:- self wt of slab

$\frac{t}{12} + \gamma_{concrete}$

$\frac{5.5 \times 15}{12}$

$= 68.75\ lb/ft^2$

Step #04:- Total Factored Load

Factored live load $= 160\ lb/ft^2$

The Factored live load will

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

$= 106.5\ lb/ft^2$

Total Factored Load $= D.L + L.L$

$= 106.5 + 160$

$= 266.5\ lb/ft^2$

$= 0.2665\ K/ft^2$

Step # 5 :- Ultimate Moment

$$M_u = \frac{W_r \times l^2}{8}$$

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

$$= 89.94 \text{ Kip-inches}$$

Step # 6 :- Area of steel for main bars by Trial & Repeat Method

Trial # 01

depth of compression-block

$$a = 0.2 \times t$$

$$= 0.2 \times 5.5$$

$$= 1.1''$$

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

Trial # 02 :-

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12}$$

$$= 0.62 \text{ in}^2$$

Date: ____________

Trial #03:-

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

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

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

Step #07:-

Area of steel for distribution reinforcement.

$$A_{min} = 0.002 \times b \times t \quad \text{(for Grade 40 steel)}$$
$$= 0.002 \times 12 \times 5.5$$
$$= 0.132 in^2$$

Step #08:-

Spacing for main bar

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

We use # 6 bar dia = $(6/8)''$

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

Date: ____________

Step #09:-

spacing for distribution bars.

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

use #5 bars

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

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

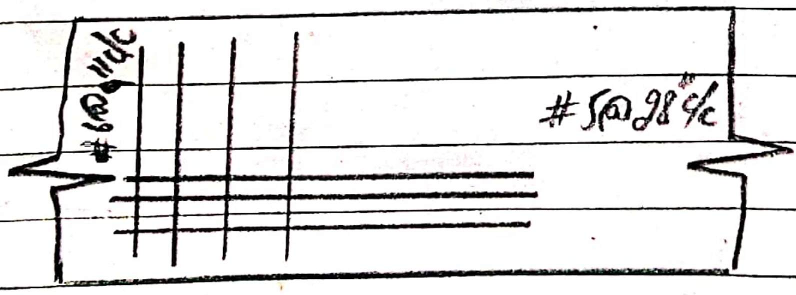
Step #10:-

Sketch

$f'_c = 4\text{ksi}$, $f_y = 40\text{ksi}$

Main steel #6 at 9" c/c

distribution steel #5 at 28" c/c



Date: ________

Q No 2

Sol:-

First of all Find the unit load of beam

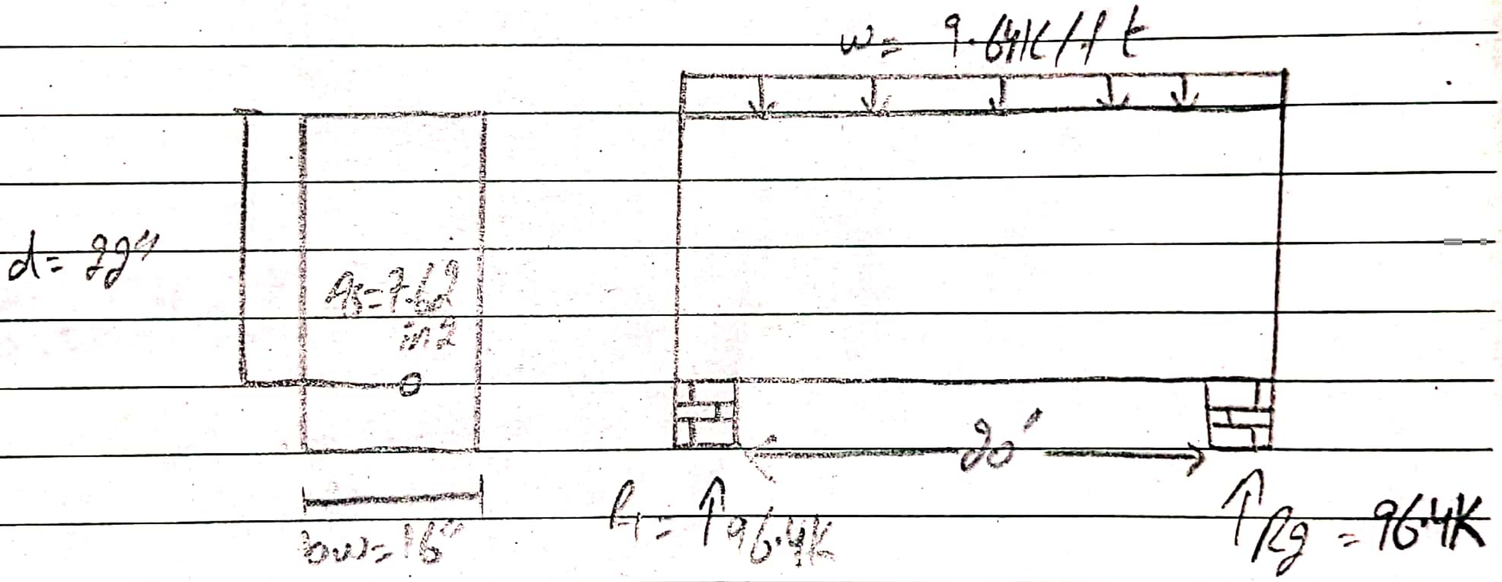
So $b \times \gamma_c$

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

Now $1.2 \times 0.2 = 0.24$

So total factored load $= 9.4 + 0.24$

$= 9.64K/ft$



Step # 01:-

Find values of R_1 & R_2

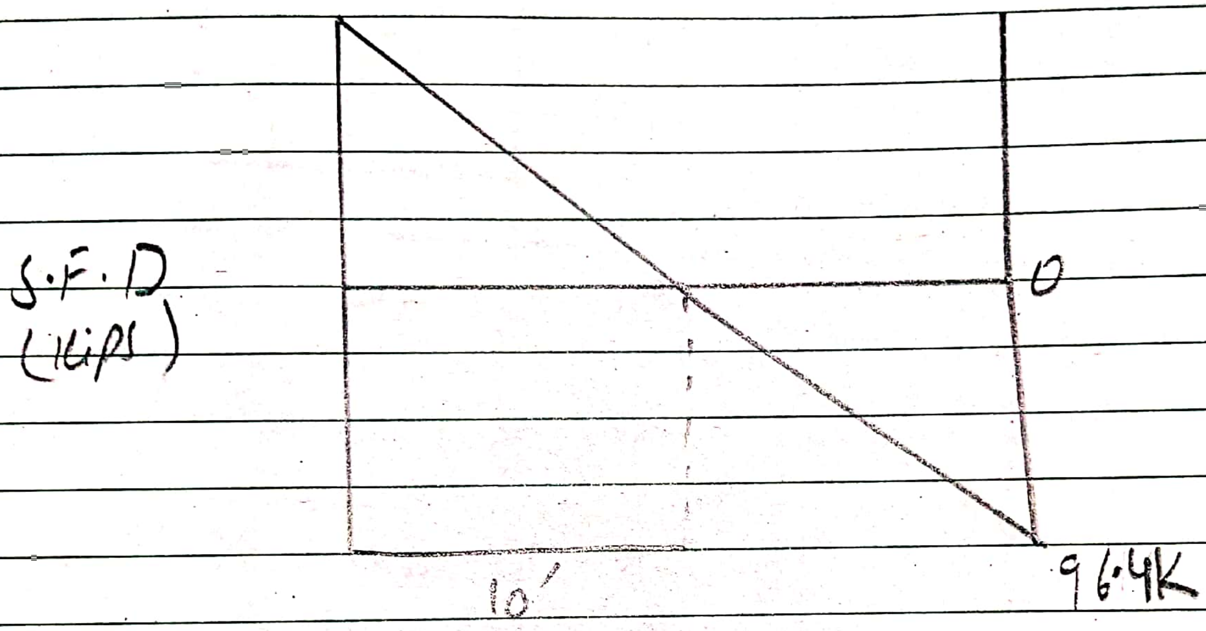
Total load $= 9.64 \times \frac{20}{2}$

$= 96.4K$

Date:

Step #02:-

Draw its shear force diagram



Step #03:-

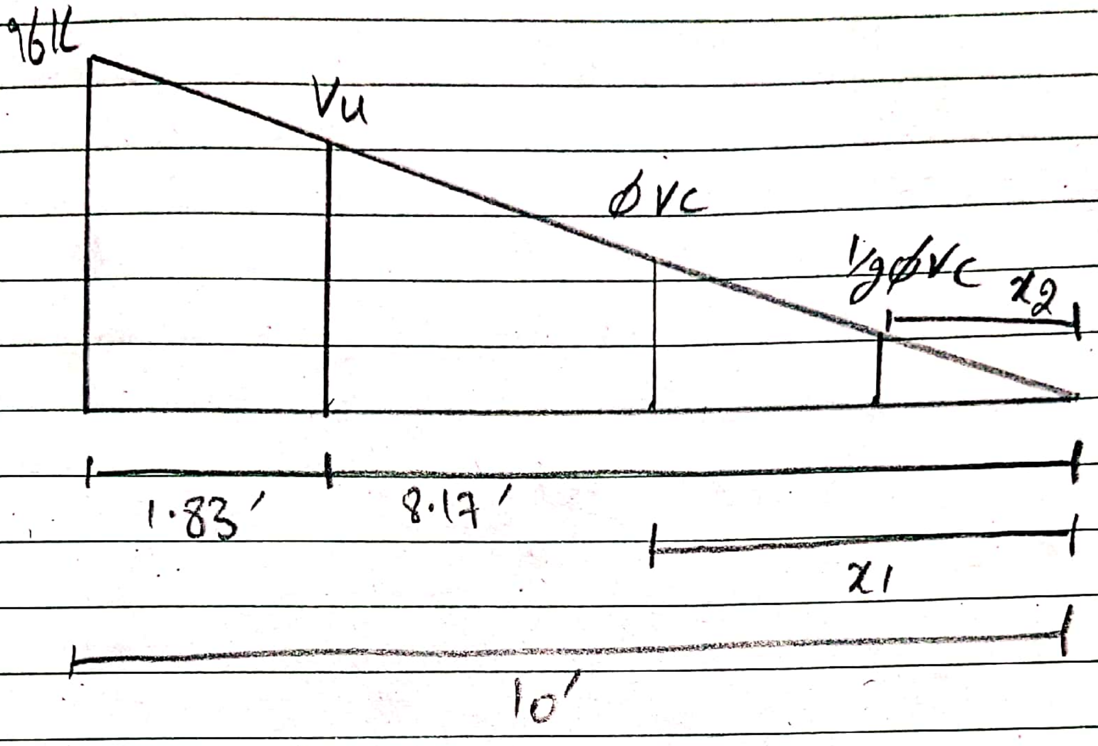
Find the value of critical stress 'Vu' & its location -

we know that critical section is located at distance 'd' from face support

d = 22" = 1.83'

value of critical shear at distance 'd' by similarity of triangles.

Date:



from Similar Δ's

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

$Vu = 78.43K$

Step #04:- Finding value of 'ØVc' & '½ ØVc' & its distance from zero shear to right side.

$$ØVc = Ø \times 2 \times \sqrt{F'c} \times bw \times d$$

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

$ØVc = 33.40K$

Date: ____________

location of ϕV_c by similarity of Δ's

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

$$x_1 = 3.48'$$

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

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{96.4}{10} = \frac{16.70}{x_2}$

$$x_2 = 1.74'$$

Step #05:-

value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

$$\phi V_s = V_u - \phi V_c$$
$$\phi V_s = 78.43 - 33.40$$
$$= 45.03K$$

Step #06:-

Check on section adequacy

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

$$= 133.57K$$

$\phi \times 8\sqrt{f'c} \times b_w \times d > \phi V_s$

It means section is adequate.

Date:

step #07:-

Check on min spacing for stirrups.

$\phi \times 4 \times \sqrt{f'c} \times bw \times d$

$= \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 66.79K$

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

Max spacing will be selected from the following four condition.

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

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

3) $S_{max} = \frac{Au \times fy}{0.75 \times \sqrt{f'c} \times bw}$

$Au = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$

$Au = 0.11 \times 2$

$Au = 0.22$

4) $S_{max} = \frac{Au \times fy}{50 \times bw}$

$= \frac{0.22 \times 60000}{50 \times 16} = 16.50$

Date: ____________

From the above four condition, least value of spacing from #3, U shaped will be selected

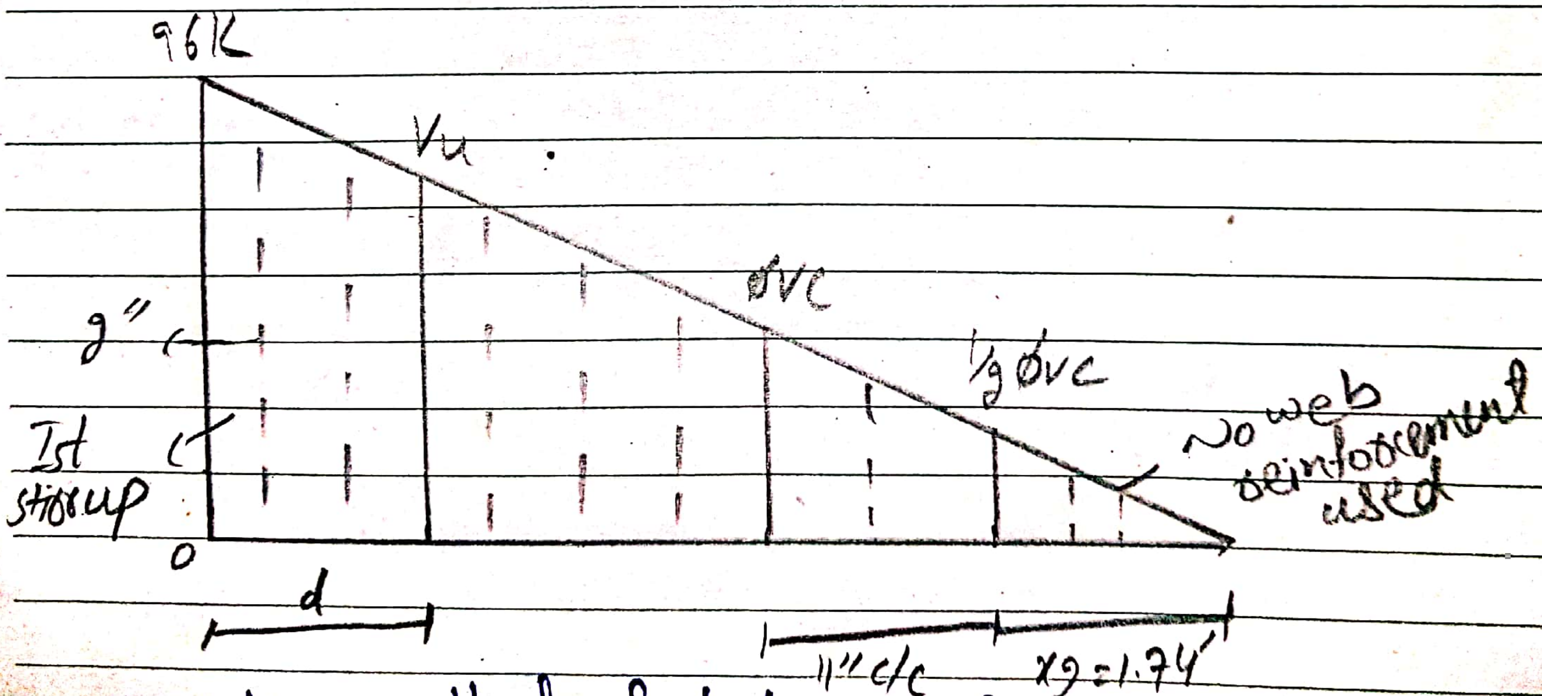
So $S_{max} = 11''$ c/c

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

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

$$= 4.84'' \simeq 5''$$

Step #09:- Final sketch



we know that first stirrup from face of support $= \frac{5}{2} = 2.5 \approx 2''$

Date: ____________

Q. No 3

Sol:-

Step #01:- Find gross Area of concrete

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

$A_g = 12 \times 12$

$= 144 in^2$ Total

Step #02: Find 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.

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

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

$P_u = 466.50 K$

Date: ____________

Step #04:-

Sketch & design of Ties (c/c to distance)

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

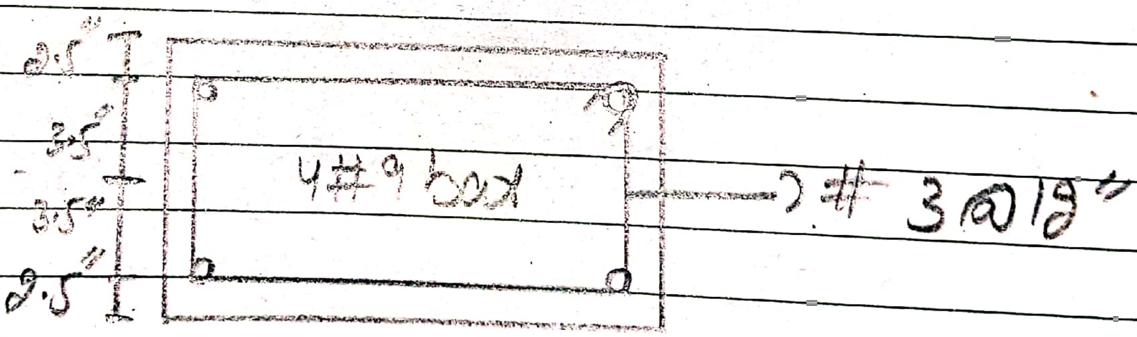
1) 16x dia of long bar = 16x 9/8
= 18"

2) 48xdia of Tie bar = 48x 3/8

= 18"

3) least column dimension = 12"

So c/c distance btw ties = 12"



It is a tied square column there is no spiral stirrup used, the stirrup used is a rectangular shape due to the specification of the structure thus we will tie stirrups instead.

Date: ____________

Q.No 4

Sol:-

Step # 01:-

$h = 24''$

Step # 02

Total weight = wt of soil + wt of R.C
= 3x120 + 2x150
= 660 psi = 0.660 ksi

Step # 03:-

Effective bearing Capacity

$q_e = q_a - w$
$= 2.50 - 0.660$
$q_e = 1.84 ksi$

Step # 4:-

Required area for foundation

$$Area = \frac{Service\ load}{q_e}$$

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

$= 119.57 ft^2$

Date: ____________

Step #05:-
Since Foundation is square:-

$$Area = b \times b = 119.57$$
$$B \cong 11'$$

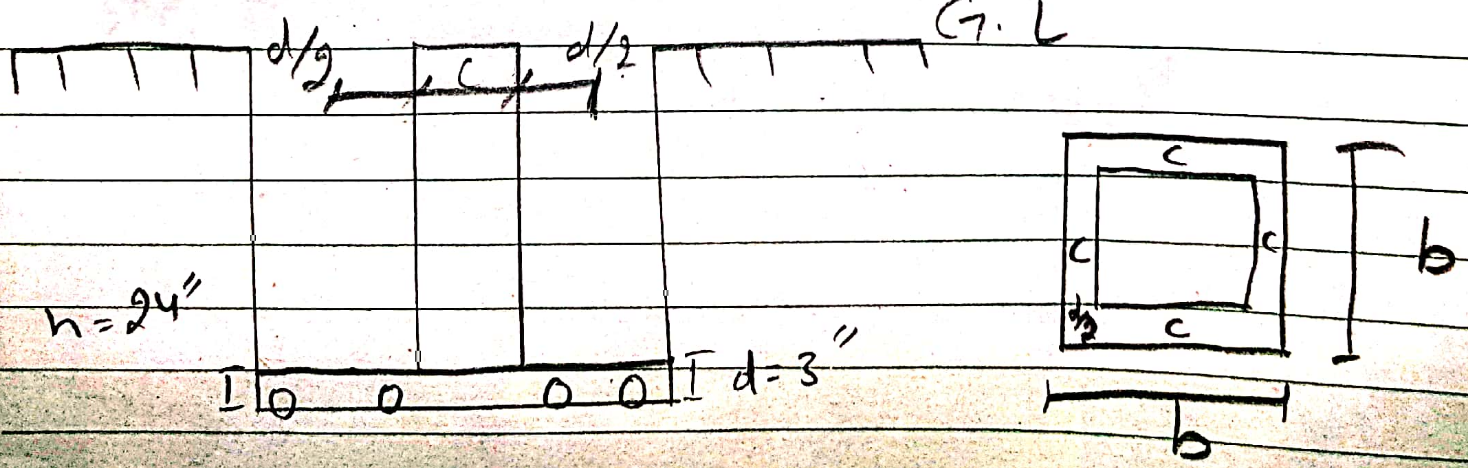
Step #06:-
Upward bearing capacity of soil

$$q_{up} = \frac{\text{Factored load}}{(B)^2}$$

$$= \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

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

Step # 07:-
Punching shear



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

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

∵ Take #8 bar
dia $= 8/8'' = 1''$

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

Step # 8:-

$V_{u2} = q_{up} \times [B^2 - (c+d)^2]$

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

$V_{u2} = 289.60k$

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 shear one way shear check

$V_{u1} = q_{up} \times B \times [B/2 - c/2 - d]$

Date: ________

$$V_{u1} = 2.58 \times 11 \times \left[\frac{11}{2} - \frac{\frac{16}{12}}{2} - 19.5 \right]$$

$$V_{u1} = 90.95K$$

Step # 11 :- Self shear capacity

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

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

$$= 110.04K > V_{u1} = O.K.$$

Step # 12 :- Ultimate moment

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

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

$$M_u = 331.49K' \approx 3977.93K''$$

Date:

Step #13:-

Area of steel for main bars by Trial & Repeat method.

Trial #01 :-

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

$$A_s = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{3977.93}{0.90 \times 60 \times (11 - \frac{4.8}{2})}$$

$$= 8.56 \, in^2$$

Trial #02 :-

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

$$= 1.53''$$

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

Trial #03 :-

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

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

So, area $= 7.1 \, in^2$

Date: ______________

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

$= 8.58 in^2$

c) $A_{s min} = 3 \times \frac{\sqrt{f'c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times 19.5$

$= 7.05 in^2$

From above value greater value will be selected thus $A_{min} = 8.58 in^2$

Step #15:- Using #8 bar

$A_b = 0.785 in^2$

No. of bars $= \frac{A_s}{A_b} = \frac{8.58}{0.785} = 10.92$

$\simeq$ 11 bars in each direction.

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