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SECTION = A

SEMESTER = 6

Date = 26/06/2020

QUESTION # 1

GIVEN DATA:-

3 Equal spans concrete slab

clear span b/w supports = 15 ft

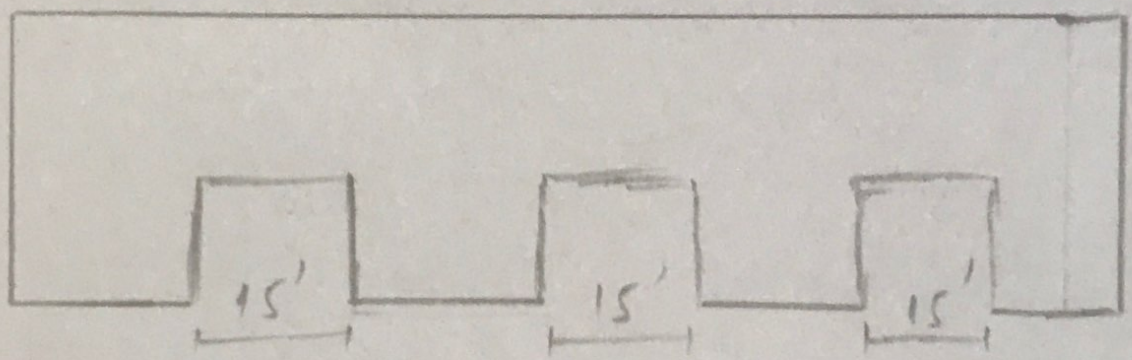
Factored lived load = 180 lb/ft^2

Service floor finish load = 20 lb/ft^2

$f'_c = 4000$ psi

$f_y = 40$ ksi

SOLUTION:-



STEP # 1 Minimum Thickness

By using formula

$t_{min} = l/28 = 15/28 = 6.4 \simeq 6.5''$

As fy → 40 ksi
We will multiply a factor with this thickness.

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

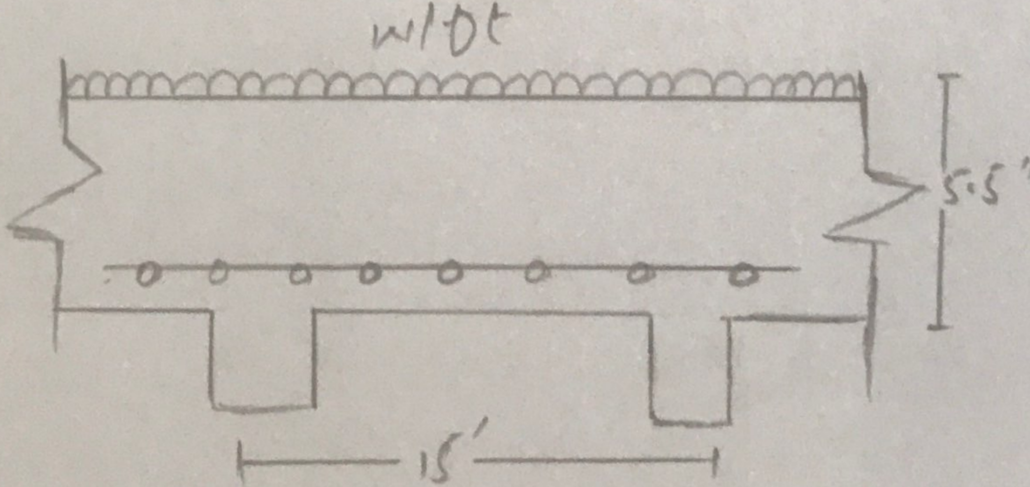
$$\text{Factor} = \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be

$6.5 \times 0.8 \Rightarrow 5.2$

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

STEP # 02:- Effective depth



By formula

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

$d = 5.5 - 0.75 - 1/2\,(5/8)$

$d \simeq 4.5''$

STEP # 3:- Self weight of slab:-

By formula

$t/12 \times \gamma$ (concrete)

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

$\Rightarrow 68.75\ lb/ft^2$

STEP # 4 Total factor load:-

Factor live load = 160 lb/ft^2

The ~~factor~~ factor dead load will be

$D.L = 1.2\,(20 + 68.75) \Rightarrow 1.2\,(88.75)$

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

Total factored load = D.L + L.L

$= 106.5 + 160 \Rightarrow 266.5\, lb/ft^2$

Total factored load = $0.2665\, K/ft^2$

STEP#5 Ultimate Moment:-

BY using the formula

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

$$= \frac{0.2665 \times 225}{8} \times 12 \Rightarrow \frac{59.9625}{8} \times 12$$

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

STEP#6 Area of Steel for main bar BY Trial and Repeat Method

Trial#01:-

Depth of compression block

$a = 0.2 \times t$

$= 0.2 \times 5.5 = 1.1''$

$$\boxed{a = 1.1''}$$

Scanned with CamScanner

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{1.1}{2})}$$

$$\boxed{Ast = 0.63 in^2}$$

Trial#2:-

$$a = \frac{As \times fy}{0.85 \times f'c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} \Rightarrow 0.62 in^2$$

$$\boxed{a = 0.62 in^2}$$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)}$$

$$= \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.62}{2})}$$

$$\boxed{Ast = 0.59 in^2}$$

Trial:-3:-

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

$$\boxed{a = 0.57 in^2}$$

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

$Ast = 0.59 in^2$

We will use $Ast = 0.59 in^2$

STEP # 7 Area of steel for distribution Reinforcement:-

By formula

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

$= 0.002 \times 12 \times 5.5 \Rightarrow 0.132 in^2$

STEP # 8 Spacing for Main bar

By formula

spacing $\frac{Ab}{Ast} \times 12$

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

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

STEP#9:- Spacing for distribution bars

Spacing = Ab/Ast

we will use #5 bars so

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

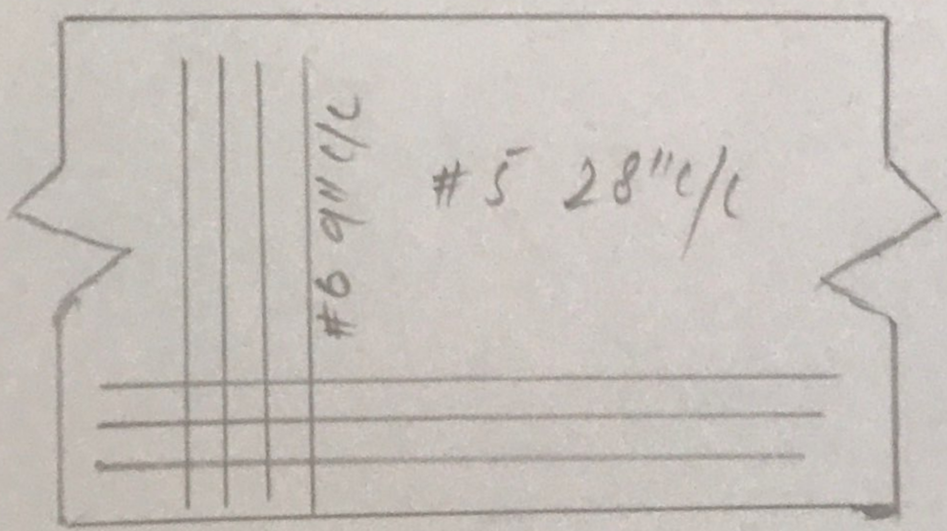
spacing $= \frac{0.31}{0.132} \times 12 \Rightarrow 28.1'' \approx 28''$ c/c

STEP# FINAL SKETCH

f'_c = 4ksi, f_y = 40ksi

Main steel #6 at 9'' c/c

Distribution steel #5 at 28'' c/c



QUESTION # 02

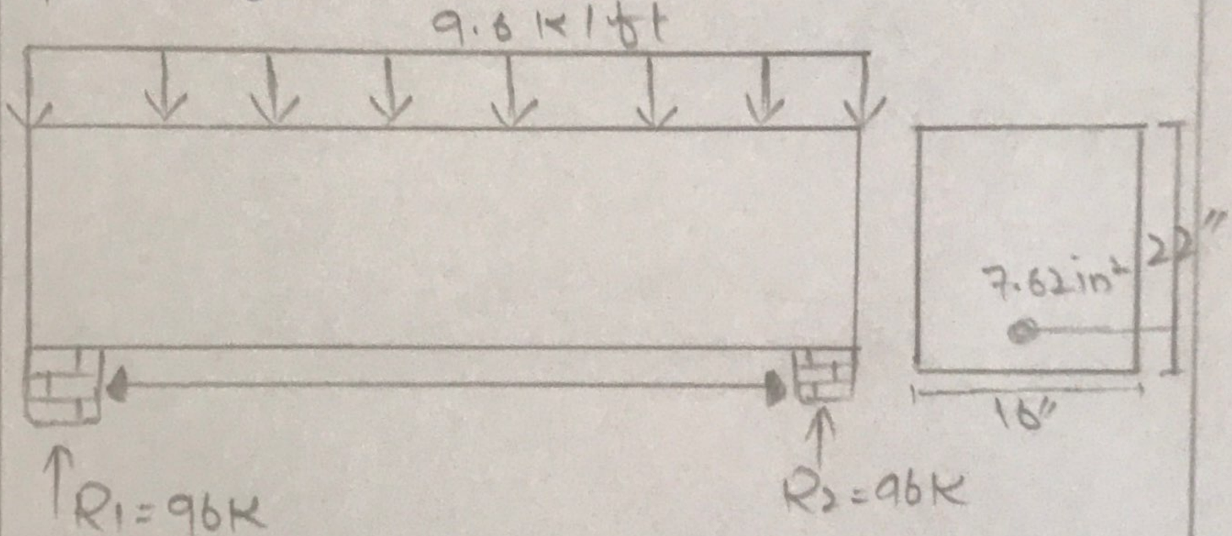
SOLUTION:-

First of all find the unit load of beam.

So $b \times \gamma c$

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

Total factored load = $9.4 + 0.2 = 9.6 K/ft$



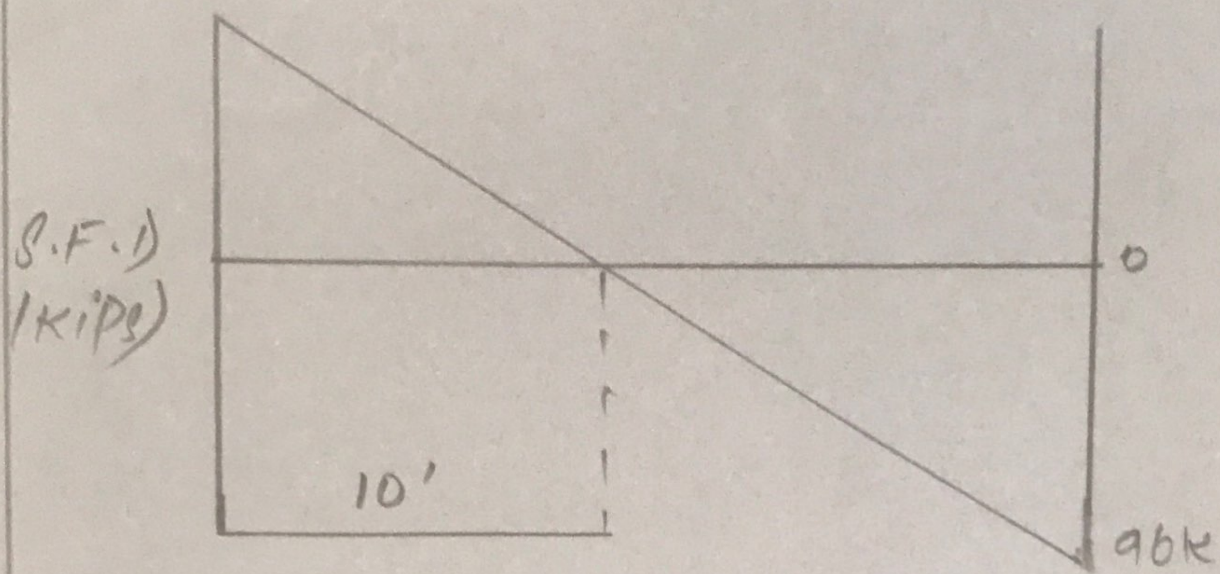
STEP# 01

Find the value of R_1 and R_2

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

STEP#02

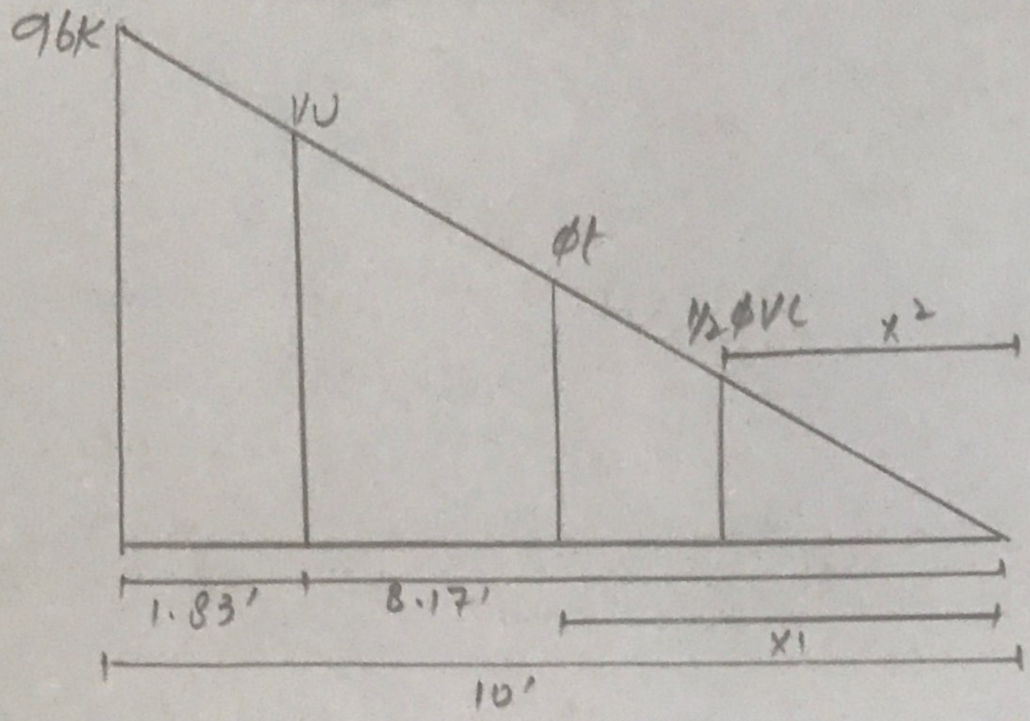
Shear force diagram



STEP#3 Find value of critical stress (vu) and it's location

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

value of critical shear at distance (d) by similarity and of triangles.



From Similar Δ's $\frac{96}{10} = \frac{Vu}{8.17}$

$Vu = 78.43K$

STEP#4 Find the value of (ϕvc) and (1/2ϕvc) and also its distance from Zero Shear to Right Side:-

$\phi Vc = \phi \times 2 \times \sqrt{f'c} \times b_{IN} \times d$

$\Rightarrow \frac{0.75 \times 2 \sqrt{1000} \times 16 \times 2}{1000}$

$\phi Vc = 33.40K$

location of ϕV_c by similarity of Δ's

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

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

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

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

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

STEP # 5:- 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 # 6:- Check on Section adequacy

$\Rightarrow \phi \times 8 \times \sqrt{f'_c} \times b_w \times d$

$\Rightarrow \frac{0.75 \times 8 \times \sqrt{1000} \times 16 \times 22}{1000}$

$$= \frac{0.75 \times 8 \times \sqrt{1000} \times 16 \times 22}{1000}$$

$= 133.57K$

As $\phi \times 8\sqrt{f'_c} \times bw \times d > \phi Vs$

$\Rightarrow$ (It means section is adequate)

STEP # 7:- Check on Main Spacing for Stirrups

$$\phi \times 4\sqrt{f'_c} \times bw \times d = \frac{0.75 \times 4\sqrt{4000} \times 16 \times 22}{1000}$$

$= 66.79K$

As $\phi 4\sqrt{f'_c}\, bw \times d > \phi Vs = 45.03K$

Thus max spacing will be selected from the following four condition

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

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

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

$$A_U = \frac{\pi}{4}(3/8)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$$

$A_U = 0.11 \times 2$

$A_U = 0.22$

$$= 17.40''$$

4) $$S_{max} = \frac{A_U \times f_Y}{50 \times b_W}$$

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

$$= 16.50$$

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

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

STEP#8 **Spacing of Stirrups from/at critical Section:-**

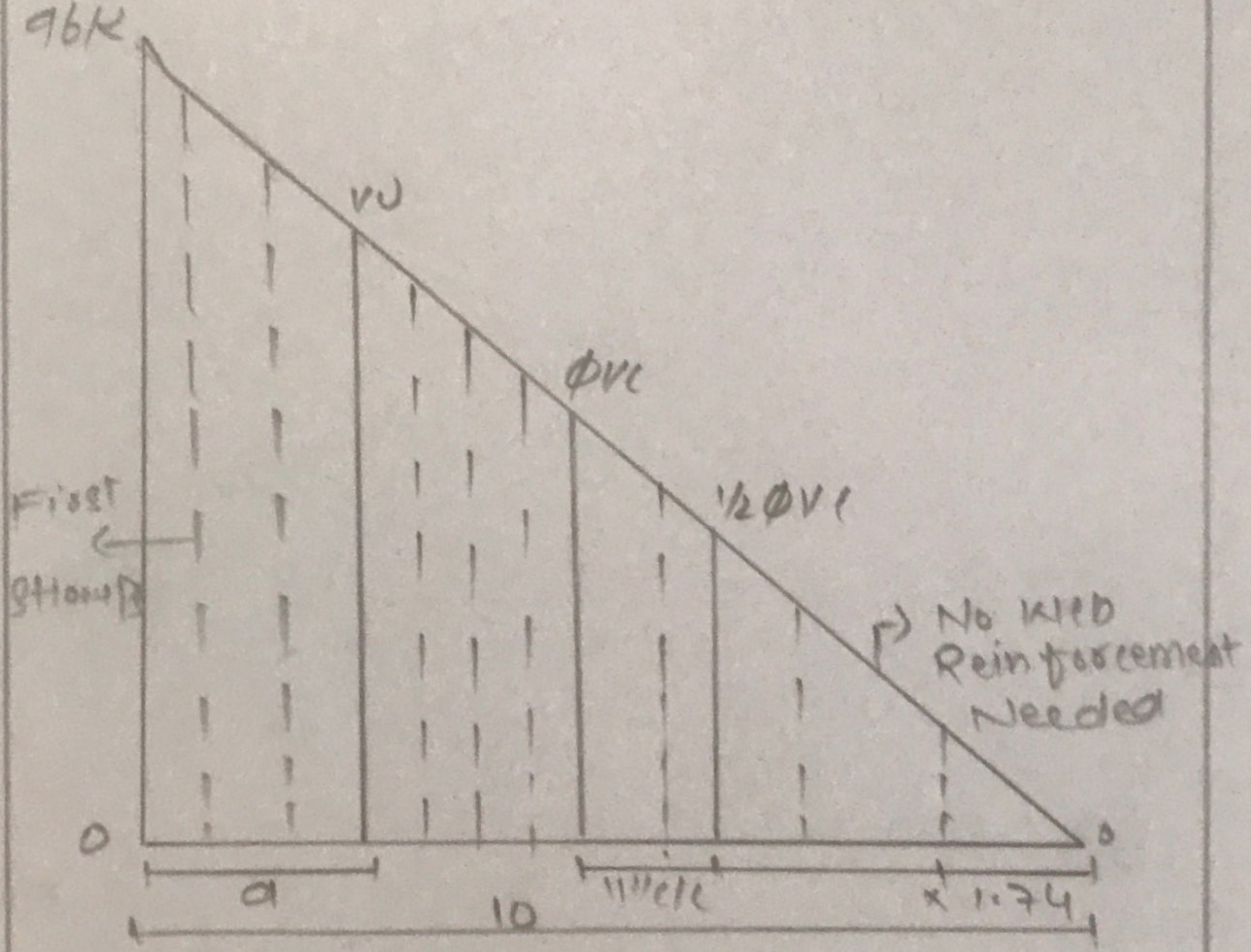
$$S = \frac{\phi \times A_U \times f_Y \times d}{V_U - \phi V_C}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40} = 48.4''$$

$= \boxed{48.4'' \approx 5'' c/c}$

STEP # 9

FINAL SKETCH



QUESTION #3

SOLUTION:-

STEP# 1:- Find Gross are of Concrete

$Ag = b \times b$ (Since it's square tied column)

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

STEP#2 Area of Steel:-

Since $As = 5\%$ of Ag

$= 0.05 \times 144$

$As = 7.2 in^2$

STEP#3 Ultimate load carrying capacity

$Pu = \phi \times 0.80 \times [0.85 \times f'c \times (Ag - As) + As \times fy]$

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

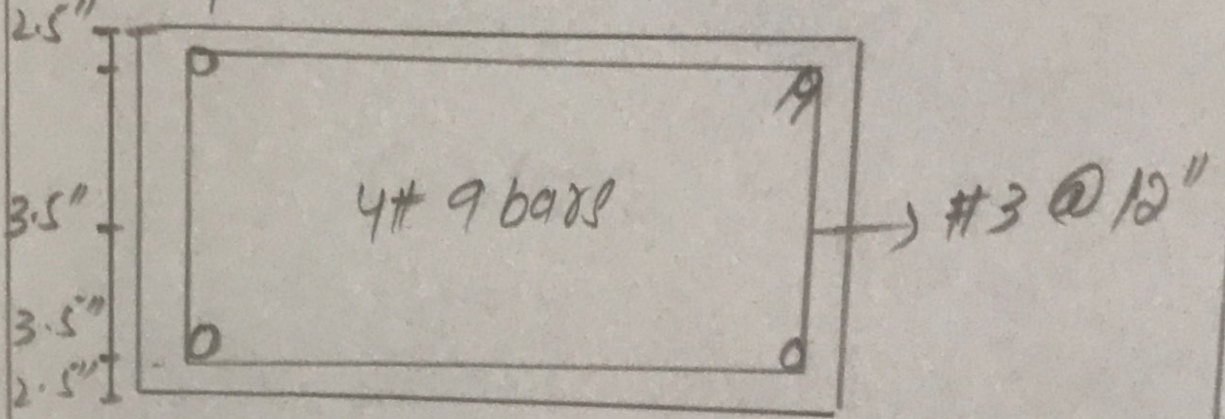
$Pu = 466.50k$

STEP # 4 Sketch [Design of ties (c/c dist

From the above 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"



It is a tied square column so there is no spiral stirrups used. The stirrups used is of Rectangular shape due to the specification of the structure. Thus we will use ties stirrups instead.

QUESTION # 04

SOLUTION

STEP # 01:-

$h = 24''$

STEP # 02:-

Total Weight = Wt of soil + Wt of Rc

$= 3 \times 120 + 2 \times 150 = 660\,psf$

Total weight = 0.660 ksf

STEP # 03:- Effective bearing capacity:-

$q_e = q_a - 1 \times 1$

$= 2.50 - 0.660 = 1.84\,ksf$

$q_e = 1.84\,ksf$

STEP # 04 Required Area for foundation

$$Area = \frac{\text{Service load}}{q_e} = \frac{100 + 120}{1.84} = \frac{220}{1.84}$$

$Area = 119.57\,ft$

STEP#5 Foundation is square

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

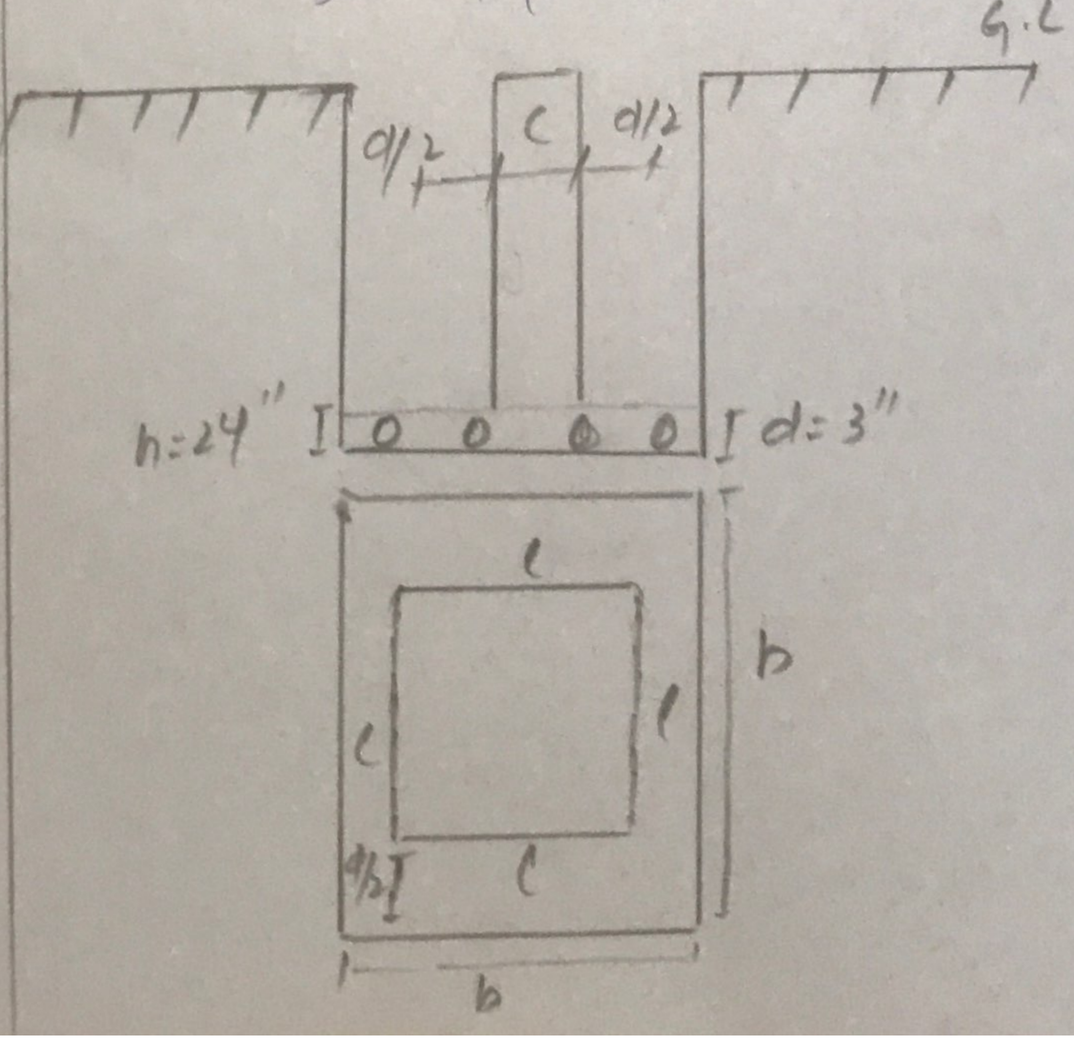
STEP#6 upward bearing capacity of soil:-

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

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

STEP #7 PUNCHING SHEAR

$b_o = 4(c+d)$



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

$= 24 - 3 - 1 - 1/2(1) = 19.5''$ Take #8 bar dia $= 8/8'' = 1''$

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

STEP#8

$V_{U2} = q_{UP} \times [B^2 - (c+d)^2]$

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

$V_{U2} = 289.60k$

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

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

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

$$\boxed{V_{U1} = 90.95K}$$

STEP#11 SELF weight capacity

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

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

$$\Rightarrow 110.04K > V_{U1} \Rightarrow (O.K!)$$

STEP#12 Ultimate moment

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

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

STEP#13 Area of Steel for Main bar by Trial and Repeat method

Trial#01

let $a = 0.2 \times h \Rightarrow 0.2 \times 2.4 = 4.8''$

$$AS = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{3977.93}{0.90 \times 60 (11 - 4.8/2)} = 8.56 in^2$$

$$\boxed{AS = 8.56 in^2}$$

Trial#2

$$a = \frac{AS \times fy}{0.85 \times f'c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.53''$$

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

$$\boxed{AS = 7.197 in^2}$$

Trial#03:-

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

$$As = \frac{3977.93}{0.90 \times 60 (11 - \frac{1.28}{2})} = \boxed{7.11 in^2}$$

So That area = $7.1 m^2$

STE# 14 Cheack Reinforcement by the following 3 Methods:

a) $As_{min} = 0.0018 \times b \times h = 0.0018 \times (11 \times 12) \times 24$
$= 5.70 in^2$

b) $As_{min} = 200/fy \times b \times d = 200/60000 (11 \times 12) \times 19.5$
$= 8.58 in^2$

c) $As_{min} = 3 \times \sqrt{fc}/fy \times b \times d = 3\sqrt{3000}/60000 \times (11 \times 12)$
$\Rightarrow 19.5 \Rightarrow \boxed{7.05 in^2}$

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

STEP# 15 using #8 bar

$Ab = 0.785 in^2$

No. of bars $= \frac{As}{Ab} = \frac{8.58}{0.783} = 10.92 \approx$

(11 bars in each direction)