Final term paper

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Section: 'A'

Semester: 6th

Subject: PRCD – I

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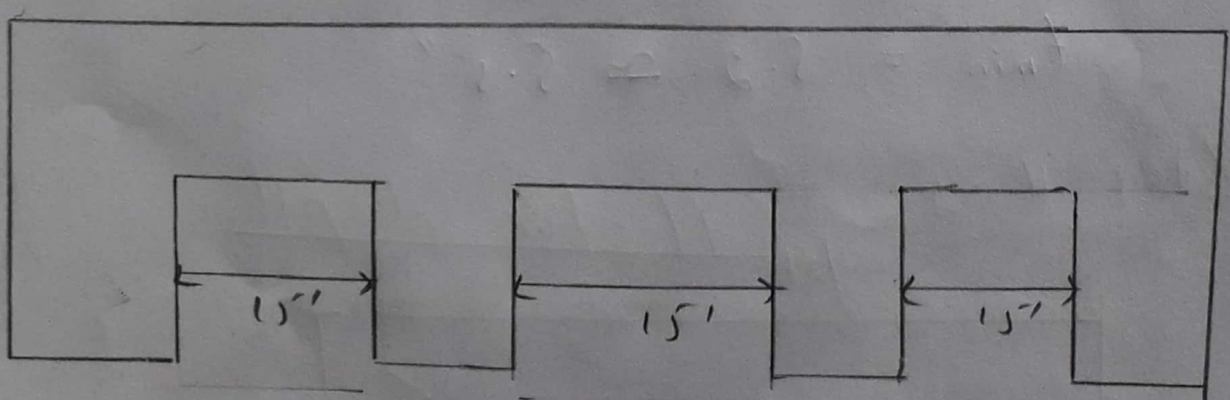
Question : No: 1

Given data:-

- Clear Span b/w Supports = 15 ft
- Factored Live load Live load = 160 lb/ft²
- 3 equal spans concrete slab.
- Service floor finish load = 20 lb/ft²
- f'_c = 4000psi
- F_y = 40ksi

Solution:-



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Step # 01 :- Minimum Thickness :-

We know that

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

As $f_y = 40ksi$

Multiply factor with thickness

$$Factor = 0.4 + \frac{f_y}{100}$$

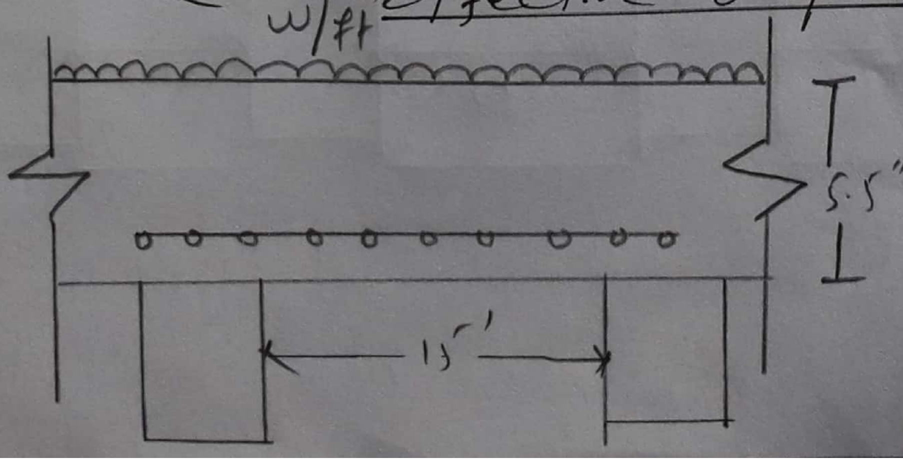
$$= 0.4 + \frac{40}{100} = 0.8$$

So the minimum thickness will

$$6.5 \times 0.8$$

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

Step # 02 :- Effective depth



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

$= 5.5 - 0.75 - \frac{1}{2}(3/8) = 4.56$

$d \cong 4.6''$

Step # 03:- Self wt of slab:

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

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

Step # 04:. Total factored load:-

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

So factored dead load will

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

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

$= 106.5 + 160$

$= 266.5 \ lb/ft^2 \Rightarrow 0.266 \ k/ft^2$

Step #05:- Ultimate Moment:-

$$M_U = \frac{W_U \times L^2}{8} \times 12 = \frac{0.266 \times (16)^2}{8} \times 12$$

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

Step #06:- Area of Steel for main Bars By Trail and Repeat method.

Trial #01:-

Let depth of compression block

$$a = 0.2 \times t$$

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

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

$$A_{st} =$$

Trail #02:-

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

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$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40(4.6 - \frac{0.62}{2})}$$

$$= \frac{89.94}{36(4.29)} = \frac{89.94}{154.44} = 0.58$$

$$A_{st} = 0.58 \, in^2/ft$$

Trial no: 3 :-

$$a = \frac{0.58 \times 40}{0.85 \times 4 \times 12} = \frac{23.2}{40.8} = 0.56 \, in$$

$$A_{st} = \frac{89.94}{0.90 \times 40 \times (4.6 - \frac{0.56}{2})} = \frac{89.94}{155.52} = 0.58 \, in^2/ft$$

We will use $0.58 \, in^2$

$$A_{st} = 0.58 \, in^2$$

Step #07 :- Area of steel for distribution Reinforcement:

$A_{s\,min} = 0.002 \times b \times t$ ⇒ G40 Steel

$= 0.002 \times 12 \times 5.5 = 0.132 \, in^2/ft$

Step # 08 :-

From Spacing formula

$$\text{Spacing} = \frac{\text{Area of one bar}}{\text{Area of Steel}} \times 12$$

we are using # 3 bar

dia = 3/8 , Area = $\frac{\pi}{4}(3/8)^2 = 0.11 in^2$

$$S = \frac{0.11}{0.58} \times 12 = 2.275''$$

$S = 2'' c/c$

Step # 09 :- Spacing for distribution bar

$$\text{Spacing} = \frac{\text{Area of one bar}}{\text{Area of Steel}}$$

used # 3 Bar

dia 3/8 , Area = $0.11 in^2$

$$\frac{0.11}{0.132} \times 12 = 9.99 \cong 10''$$

So $10'' c/c$

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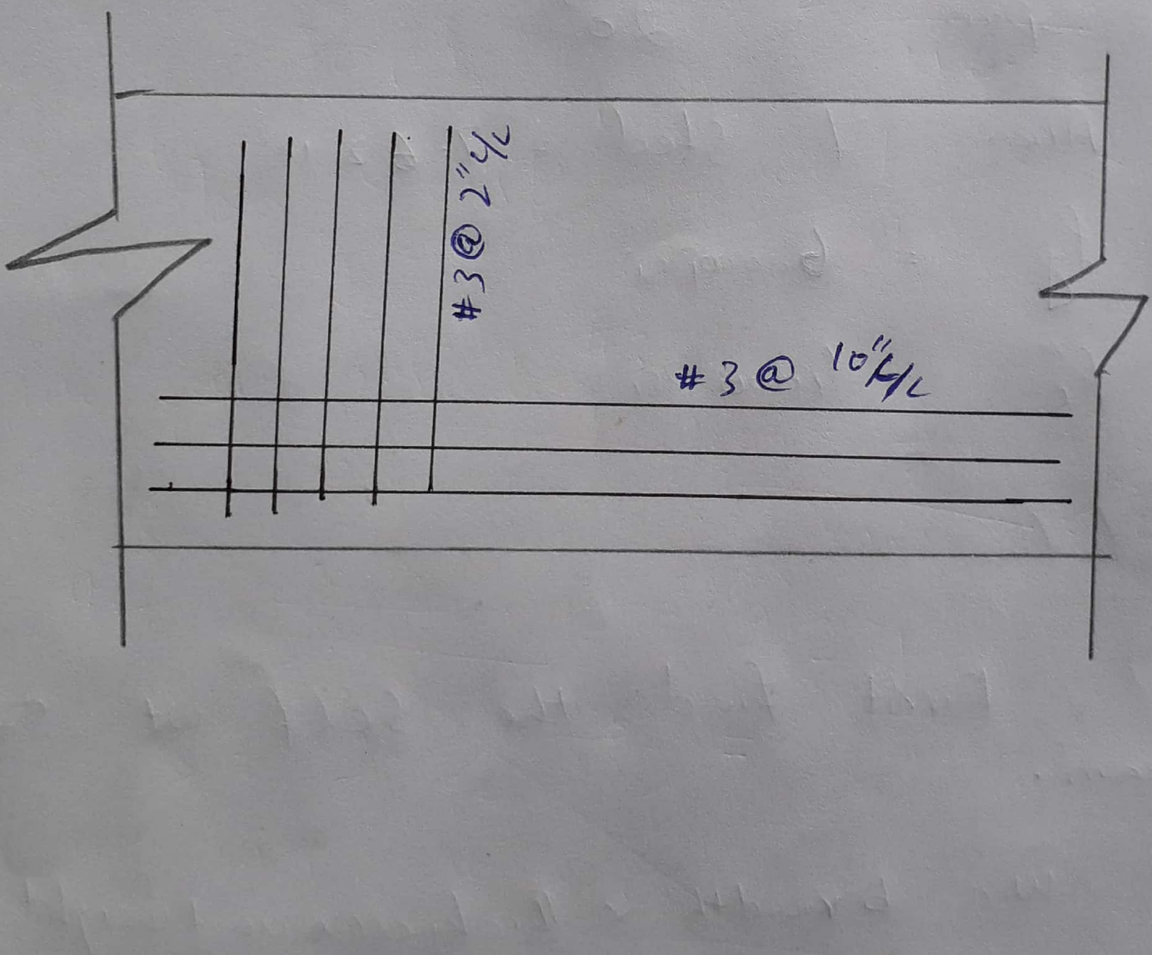
Step # 10

Final Sketch:-

Fy = 40 ksi, Fc' = 4 ksi

Main steel = #3 bar



Question no 9

Given data:

Effective depth = 29"

Breadth = b = 16"

Total factored load = 9.4 kips/ft

Span = 20'

Area of steel = 7.62 in²

f_y = 60000 psi

f'_c = 4000 psi

Solution:-

First find the self wt of beam.

w = breadth × thickness × unit weight of concrete

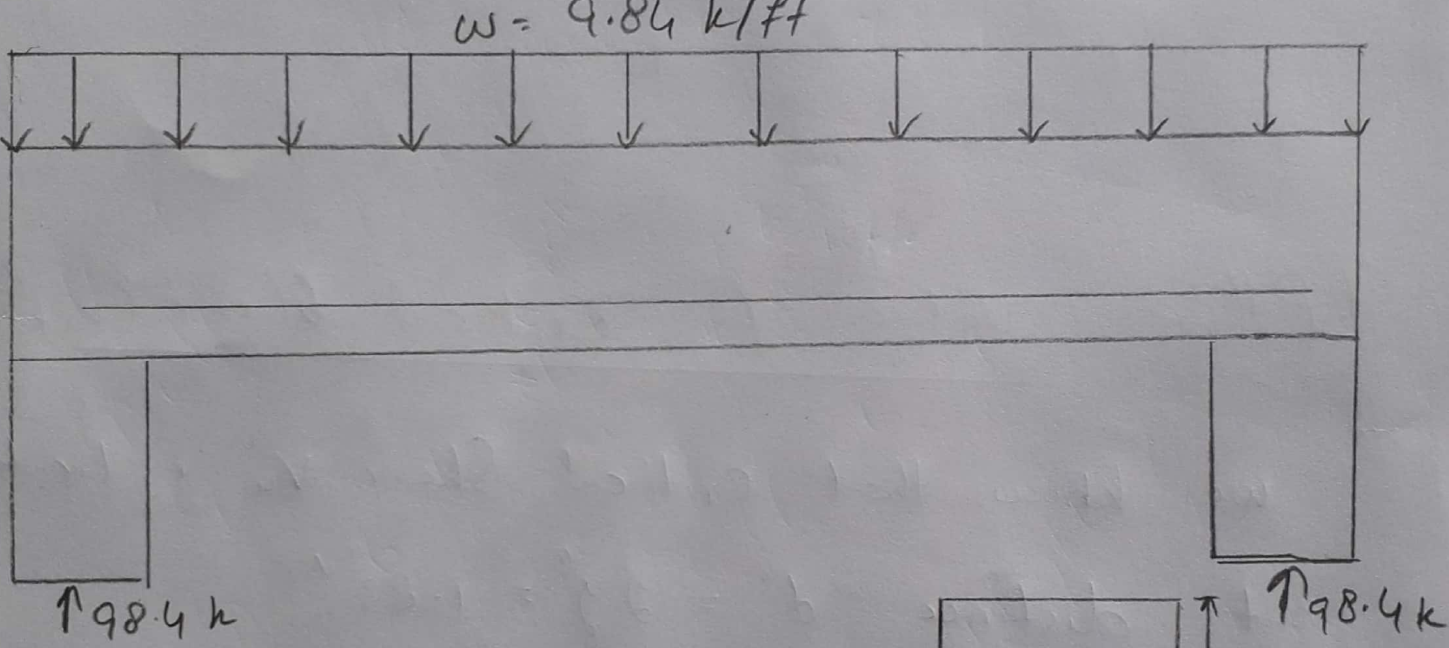
= b × t × 150 lb/ft³

∴ t = b + 2 = 16

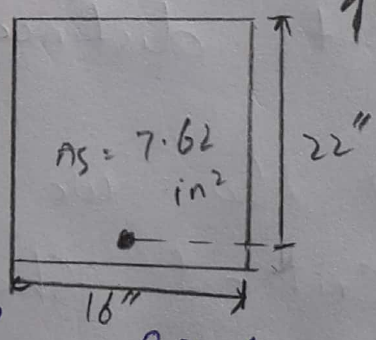
= $\frac{16}{12} \times \frac{22}{12} \times 15$ = 366.67 lb/ft factored load will

$= 1.2(0.366) = 0.44$ kip/ft

So The total applied factored load will be $9.4 + 0.44 = 9.84$ kip/ft



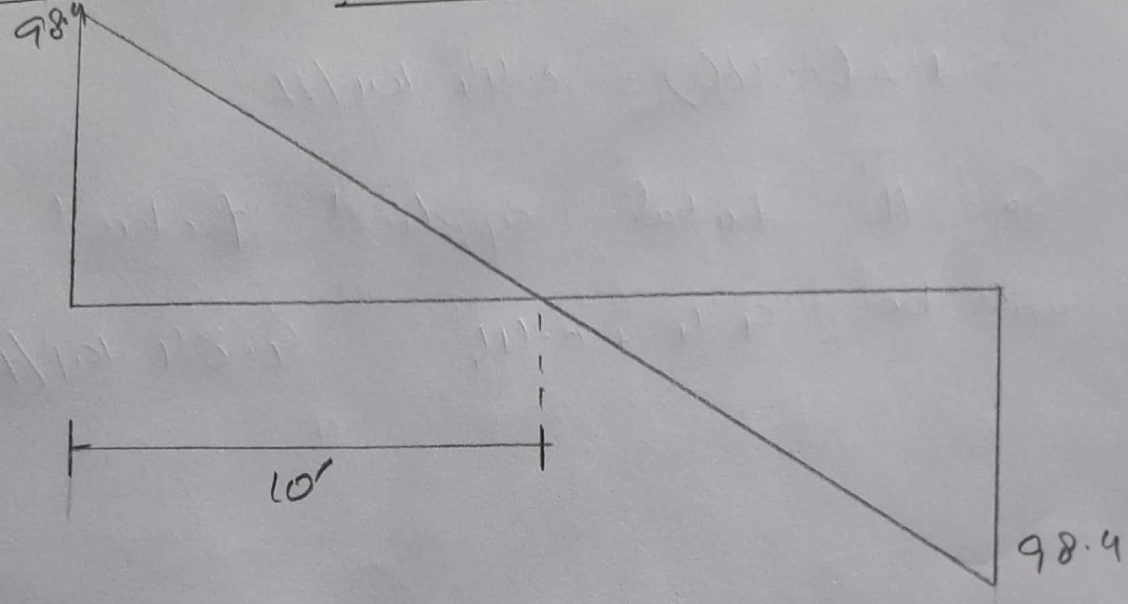
Step # 1:



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

So both support have 98.4 kips load.

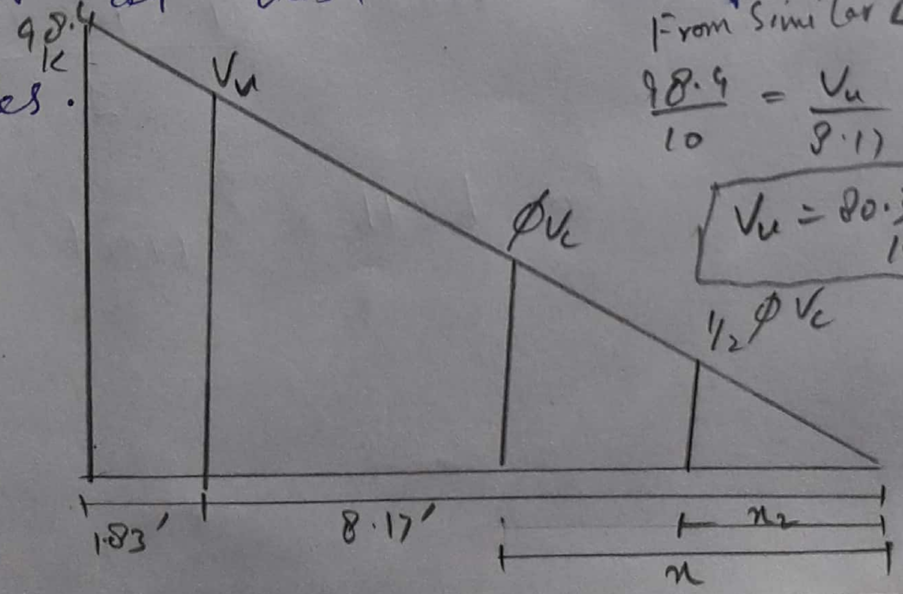
Step # 02 :- Shear force diagram:



Step # 03 :- Value of Critical Shear (V_u)

we know that critical shear 'V_u' is located at distance 'd' = 22" = 1.83'

=> So we will find the value of critical shear at distance "d" by similar triangles.



From similar Δ_s

$$\frac{98.4}{10} = \frac{V_u}{8.17}$$

$V_u = 80.39$ kips

Step # 4/ Value of ϕV_c and $\frac{1}{2}\phi V_c$

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

$$= \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000} = 33.40 \text{ kips}$$

Location by Similar triangles

$$\frac{98.4}{10} = \frac{33.40}{x_1} \Rightarrow \boxed{x_1 = 3.39'}$$

Now

$$\frac{1}{2}\phi V_c = \phi V_c / 2$$

$$= 33.4/2 = 16.70 \text{ kips.}$$

Location of $1/2\ \phi V_c$

By Similar triangless

$$\frac{98.4}{10} = \frac{16.70}{x_2} \Rightarrow \boxed{x_2 = 1.69'}$$

Step #5:-

A_s

$V_u = \phi V_s + \phi V_c$

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

$= 80.39 - 33.40$

$\phi V_s = 46.99$ kips.

Step # 6:- Check on Section adequency:-

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

$= \dfrac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000} = 133.57$ kips

As $133.57 > \phi V_s$

It mean Section is adequate.

Step #07:- Maximum Spacing for Stirrups:

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

$= \dfrac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79$ kips

As $\phi 4 \sqrt{f'_c}\, b_w d > \phi V_s$

then maximum spacing will be selected from the following 4 conditions.

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

2 - $d/2 = 22/2 = 11''$

3 - $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$= \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$

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

$= \dfrac{0.22 \times 60000}{50 \times 16} = 16.50''$

As we are using #3 U-stirrup which has dia of 3/8" while area = $0.11 in^2$
For 2 legged multiply by 2.
0.11×2
$= 0.22 in^2$

Now from above 4 conditions

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

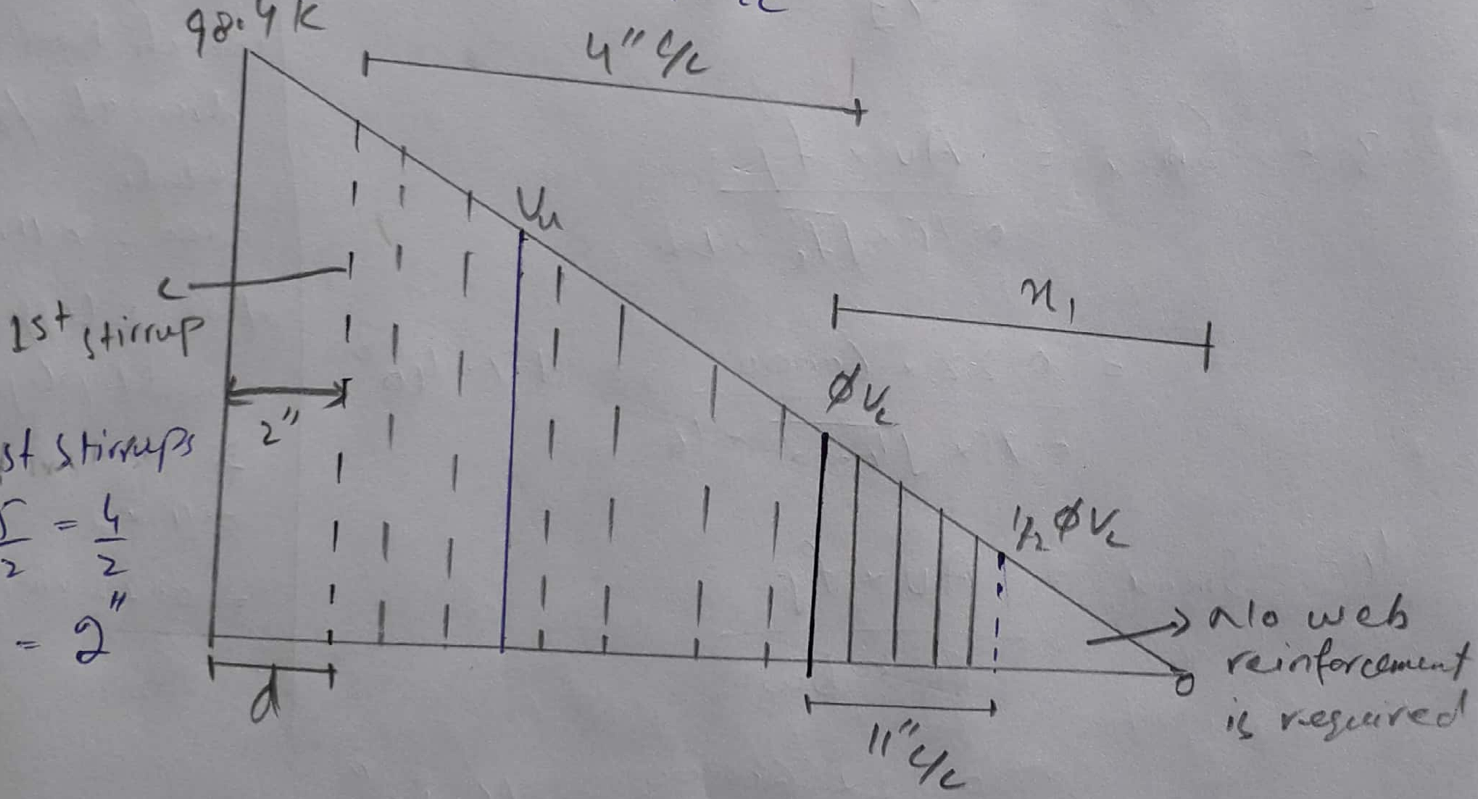
b/c it is the least value which we will use for #3 2 legged stirrups.

Step # 08:- Spacing of Stirrups at Critical Section:

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

$$= 4.6 \simeq 4''$$

$S = 4''$ c/c



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Question - 04

Given data :-

Column ⟶ Square of 16" x 16"

Live load = 120 kip

Dead load = 100 kip

Base of footing = 5'

Soil pressure = 2.50 k/ft^2

f_y = 60 ksi

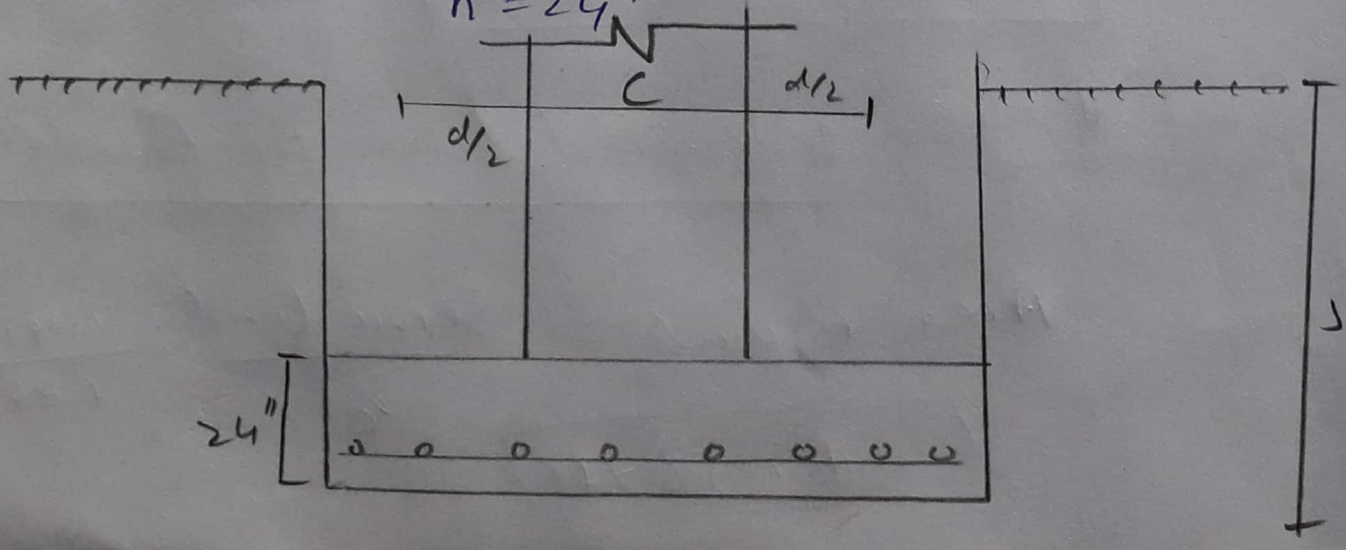
f'_c = 3 ksi

γ_{soil} = 120 lb/ft^3

Step # 1. Depth of foundation:-

Assuming depth

h = 24"



Step # 2 Total weight:

Total wt = wt of soil + wt of R.C.C

Total wt = (Depth of Soil × γ_{soil}) + (Depth of R.C.C × $\gamma_{concrete}$)

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

$= 660\ lb/ft^2$

$= 0.66\ k/ft^2$

Step # 3 Effective bearing capacity:

$q_{effect} = q_{allowable}$ − Total weight

$= ~~1.84~~\ 2.50 - 0.660$

$q_{effect} = 1.84\ k/ft^2$

Step # 04: Required area for foundation

Area required $= \dfrac{\text{Servic Load}}{q_e} = \dfrac{100+120}{1.84}$

$= 119.56\ ft^2$

Step # 05 Foundation dimension:-

Since foundation is square so,

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

$\Rightarrow B = 10.9'$ or $10'9''$

$B = 10.9'$ or $B = 11'$

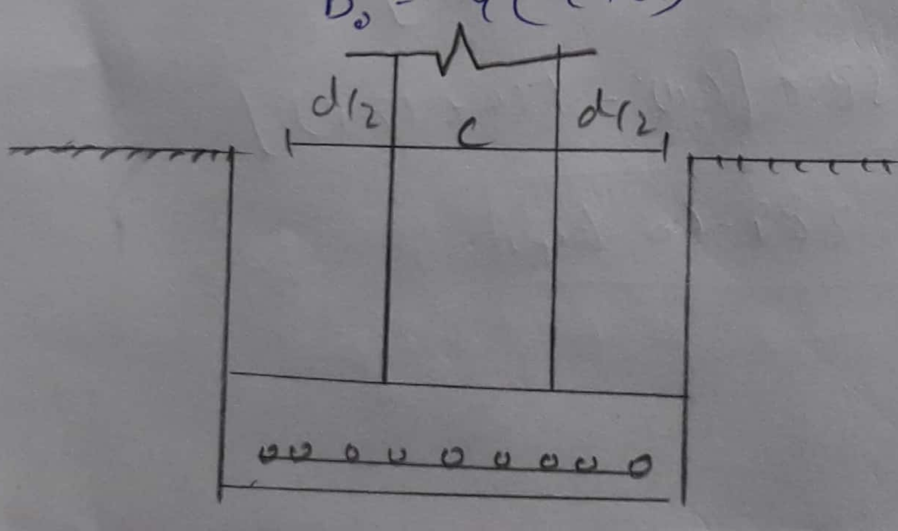
Step # 06 Upward Bearing Capacity:-

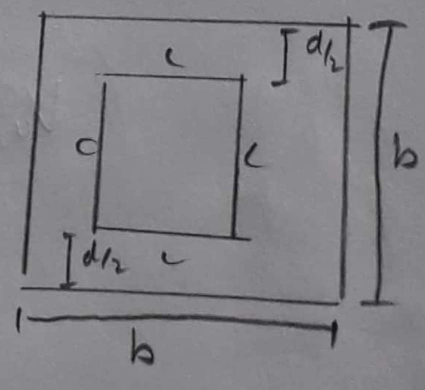
$q_{upward} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2(100) + 1.6(120)}{(11)^2}$

$= 2.58\ k/ft^2$

Step # 7 Punching Shear

$b_o = 4(c+d)$





Effective depth (d)

$d = h - \text{Clear Cover} - \text{dia of bottom bar} - \frac{1}{2}\text{ dia of top bar}$

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

$d = 19.5''$

So the punching Shear will be

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

$b_o = 142''$

we are using #8 bar
dia = 1"
Area = 0.785 in²

Step # 8 Value of V_{u_2}

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

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

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

Step #09/ Value of ϕv_{cp}

$\phi \times 4 \times \sqrt{f'_c} \times b_o \times d$

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

Step #10/ Beam Shear Check)

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

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

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

Step #11 Self-Shear Capacity:-

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

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

$$\phi V_c = 211.47 > V_{u_1}$$

So It is **OK**.

Step # 12 **Ultimate moment:-**

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

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

$$= 331.49\, k.ft = 3377.88 \text{ kip-inch}$$

Step # 13:- Area of Steel for main Bars

Trial # 01 Let $a = 0.2 \times h$

$$= 0.2 \times 24 = 4.8''$$

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

$$a = 0.76''$$

Trial # 02

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

$$a = 0.76''$$

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

Trial # 31

$a = 0.68''$

$A_{st} = 3.85 in^2$

Step # 14: Check mini Reinforcement.

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

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

$= 3.168\ in^2$

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 = $A_{s\,min} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d$

$= \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times (19.5)$

$= 7.04\ in^2$

The greater value is $A_{s\,min} = 8.58\ in^2$

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Step # 15 No: of Bars

Using # 8 bars.

Area = 0.785 in²

No: of Bar $\frac{A_{st}}{A_b} = \frac{8.58}{0.785} = 10.9$

So 11 bars in each direction.

Question: 3:-

Solution:-

Step # 01:- Gross area of Concrete

Gross area (A_g) = b×b

(b×b because it is Square tied column

$A_g = 12 \times 12 = 144 m^2$

$144 m^2 \longrightarrow$ Actual Area.

Step # 2/ Area of steel:-

As

$A_{st} = 5\%$ of Gross Area

$= \frac{5}{100} \times 144$

$A_{st} = 7.2 \text{ in}^2$

Step # 3:- Ultimate Load Carrying Capacity

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

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

$P_u = 466.50 \text{ k}$

Step # 04/ Sketch of ties:-

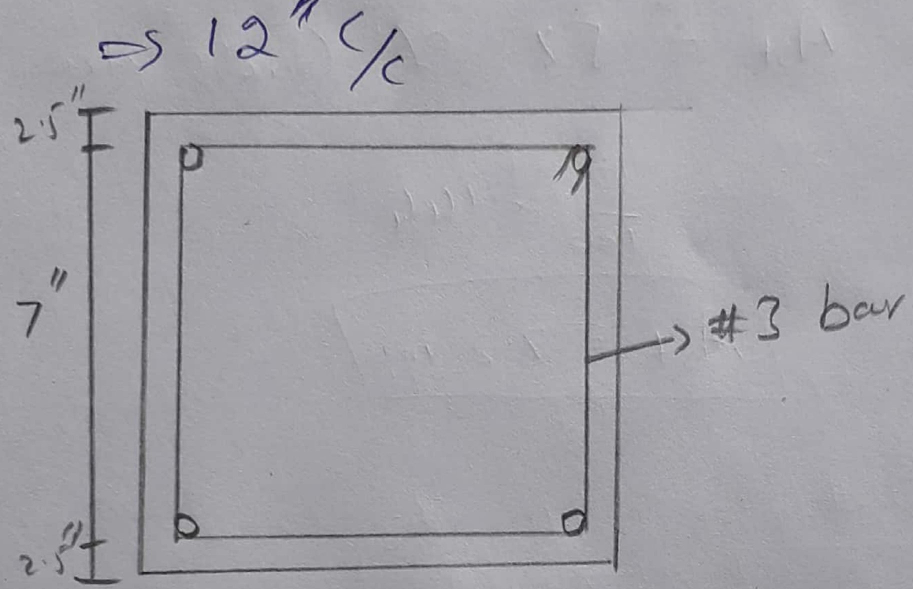
We have to choose the least value from the following below formulas.

1 - 16 (dia of long bars) $= 16 \times 9/8$
$= 18''$

2 - 48 (dia of Tie bar) $48 \times 3/8$
$= 18''$

3- Least Column dimension = 12"

So the least value is 12"



⇒ No Spiral designing is used/required in the above case b/c it is a Square tied Column, So rectangular or Square Shaped Stirrups/ties are used in this case.

End