Q No. 1 (1) 7809

A reinforced concrete slab is built integrally with its supports and consists of three equal spans, each with clear span of 15ft. The factored live load is 160 psf and service floor finished load is 20psf. Design slab using $f'_c = 4000psi$ and $f_y = 40ksi$ Draw sketch of your final diagram.

Solution :=

=> Three equal span concrete slab

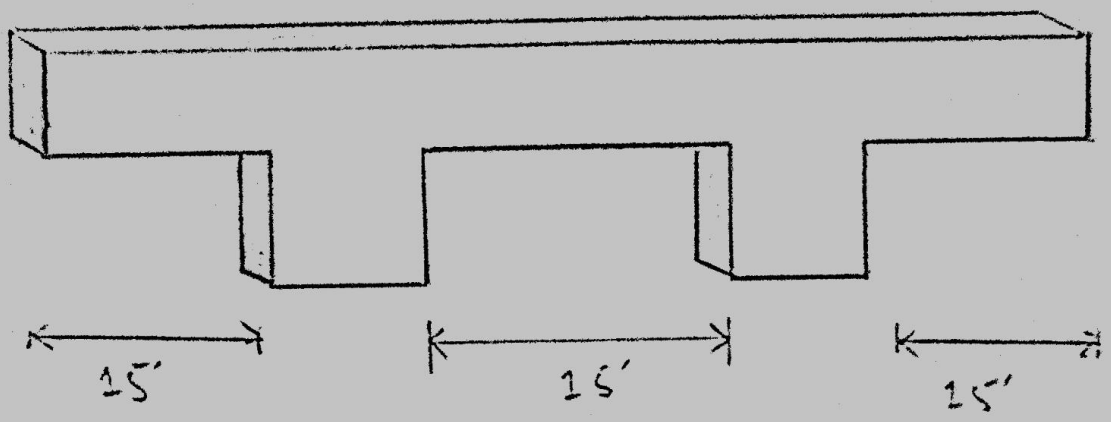
=> Clear Span = 15ft .

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

=> Service floor finished load = $\pm 20psf$

$\Rightarrow f'c = 4000 \text{ psi}$

$\Rightarrow fy = 40 \text{ ksi}$



STEP NO #1:-

Minimum Thickness

The minimum thickness formula is $t_{min} = \frac{L}{28} = \frac{15}{29} = 6.4 \approx 6.5''$

As we Know that

$fy = 40 \text{ ksi}$

So multiply a factor with this thickness

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

$$\text{Factor} = \left(0.4 + \frac{400}{100}\right)$$

$$\text{Factor} = 0.8$$

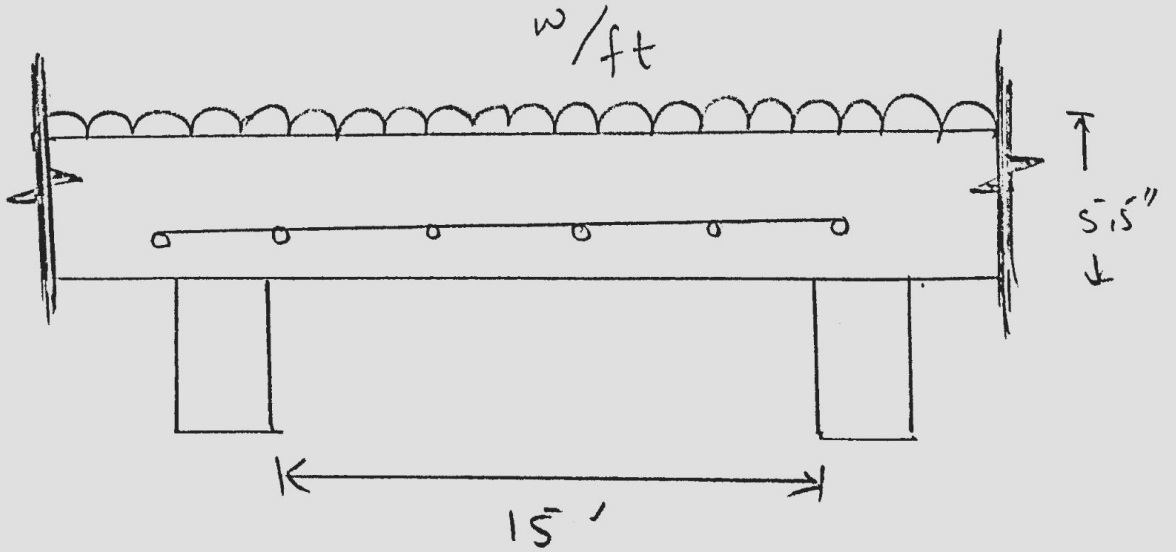
So minimum thickness will be

6.5×0.8

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

STEP No # 2 :-

Effective Depth.



By Formula.

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

~~d = t - cle~~

$$d = 5.5 - 0.75 - \frac{1}{2}\left(\frac{5}{8}\right)$$

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

STEP NO # 3 :-

Self weight of Slab

we have formula

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

$$\frac{5.5}{12} \times 150 \Rightarrow \boxed{68.7\ lb/ft^2}$$

STEP No# 4:-

Total Factored Load.

factored live load = 160 lb/ft²

So

factored dead load = 1.2(20 + 68.75)

= 106.5 lb/ft²

Tototal Factored load = DL + LL

= 106.5 + 160

= 266.5 lb/ft²

Total Factored load = 0.2605 k/ft²

STEP No#5:-

Ultimate moment

As we Know that

$$Mu = \frac{Wu \times L^2}{8} \times 12$$

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

Mu = 89.94 kip-inches

STEP No #6:-

Main Bar steel Area.

Trail No#1

let depth of Compression block

$$a = 0.2 \times t$$

$$a = 0.2 \times 5.5$$

$$a = 1.1''$$

$$Ast = \frac{M_u}{\phi \times fy \times \left(d - \frac{a}{2}\right)}$$

$$Ast = \frac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{1.1}{2}\right)}$$

$$Ast = 0.63 in^2$$

Traid #2

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

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$$a = \frac{Ase \times fy}{0.55 \times f'c \times b}$$

$$a = \frac{0.63 \times 40}{0.85 \times 4 \times 12}$$

$$a = 0.62 in^2$$

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

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.6}{2})}$$

$$Ast = 0.59 in^2$$

Trail #3

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

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - 0.57/2)}$$

$A_{st} = 0.59 in^2$

So we will use ~~A_{st}~~

$A_{st} = 0.59 in^2$

STEP No # 7 :-

Area of steel for distribution reinforcement

$A_{min} = 0.002 \times b \times t$

$= 0.002 \times 12 \times 5.5$

$A_{min} = 0.132 in^2$

↳ For Grade 40 steel.

STEP No # 8 :-

Spacing for main bar.

$$\text{Spacing} = \frac{A_b}{A_s} \times 12$$

Use #6 bar dia $= \left(\frac{6}{8}\right)''$

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

$$\text{Area} = 0.442 \text{ in}^2$$

STEP No# 9 :-

Spacing for distribution bars.

$$\text{Spacing} = \frac{Ab}{Ast}$$

Use #5 bars so

$$\text{dia} = \left(\frac{5}{8}\right)''$$

$$\text{Area} = \frac{\pi}{4}(5/8)^2$$

$$\text{Area} = 0.31\ in^2$$

$$\text{Spacing} = \frac{0.31}{0.132} \times 12$$

$$\text{Spacing} = 28.1'' \approx 28'' \text{ c/c}$$

STEP No# 10 :-

Sketch.

$f'c = 4ksi$

$fy = 40ksi$

Main steel #6 at 9" c/c

Distrubition steel #5 at 28" c/c

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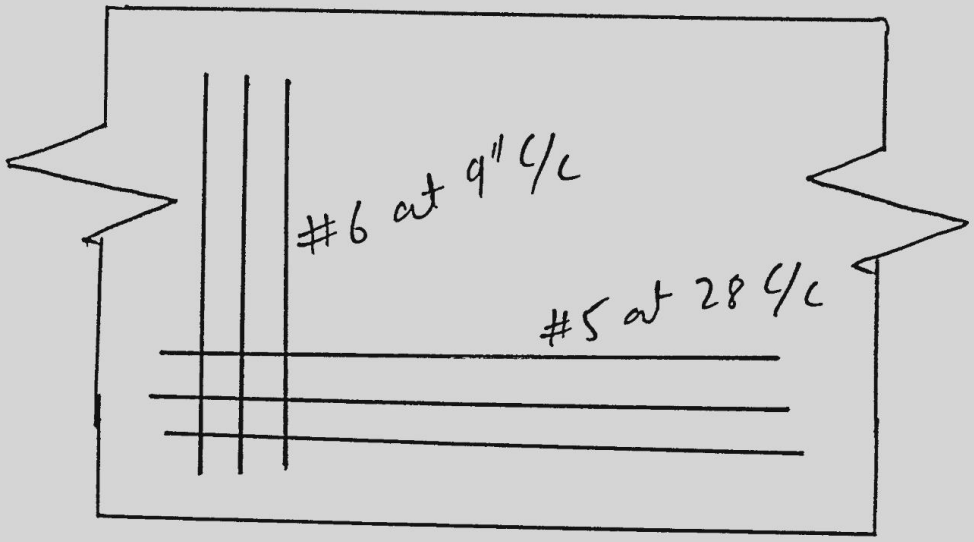

Diagram.

Q No. 2 (13)

A Simply Supporte rectangular beam 16 inch wide having an effective depth of 22 inches carries a total factored load of 9.4 Kips/ft. (excluding self weight of beam) on a 20-ft. clear span. It is reinforced with $7.62 in^2$ of tensile steel which continues uninterrupted into the support If $f'c = 4000$ psi and $fy = 600000$ psi. using #3 verticle - U Stirrup. Design the web reinforcement. Draw a sketch of your final diagram.

Solution :-

P.T.O

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Given Data :-

Width of beam = 16"

Effective depth = 22"

Total Factored load = 9.4 kips/ft

clear span = 20ft

f'c = 4000 psi

fy = 60000 psi

Solution :-

unit load of beam is $= b \times \gamma_c$

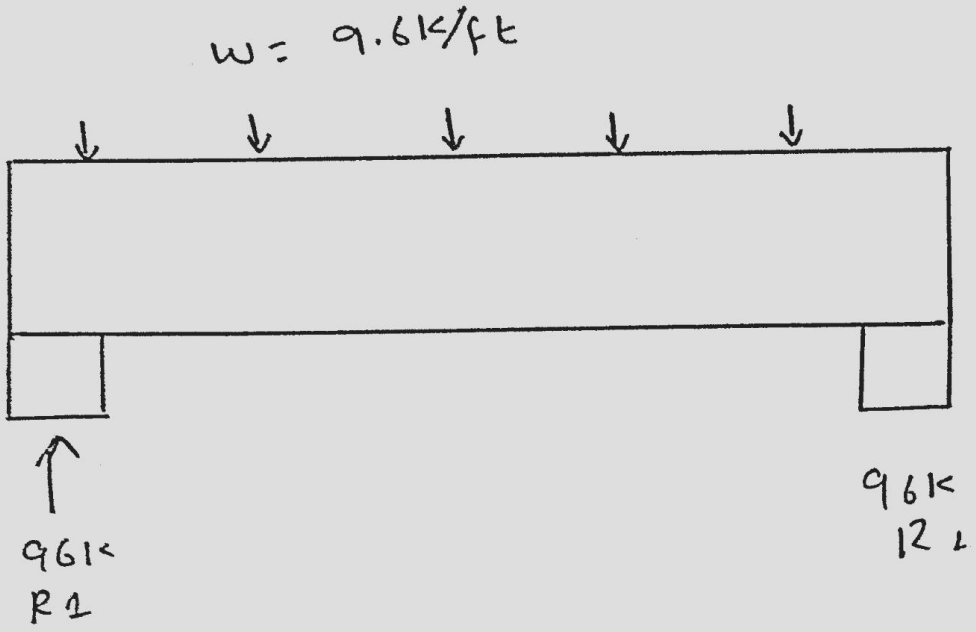
$= \frac{16}{12} \times 150$

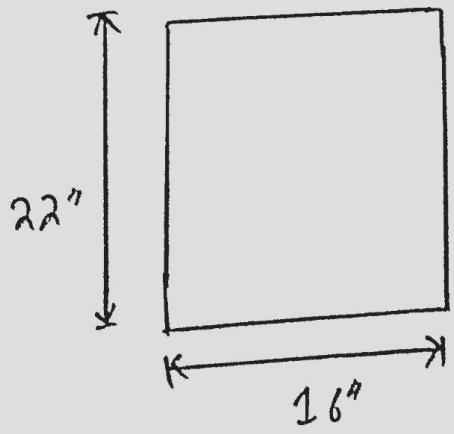
$= 200 lb/ft$

$= 0.2 K/ft$

Total Factored load = 9.4 + 0.2

= 9.61k/ft.





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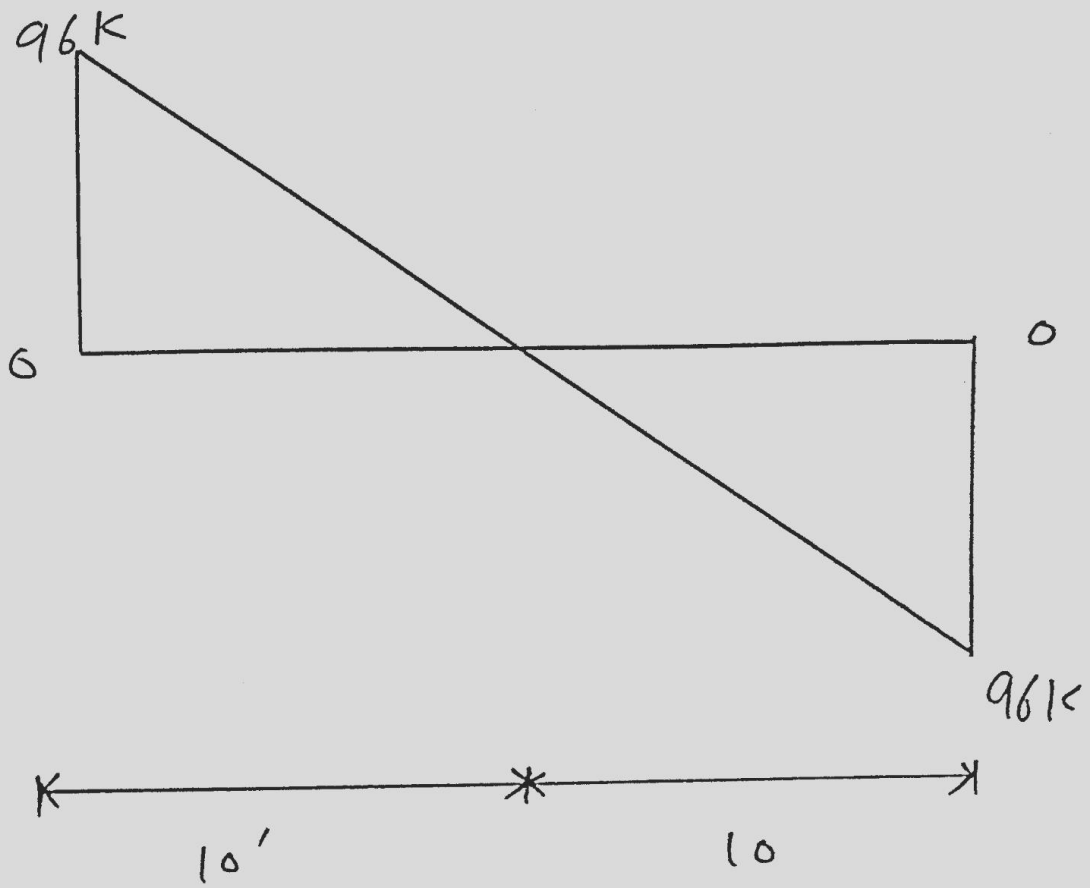
STEP No # 1 :-

Finding value of R_1 and R_2

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

STEP No # 2 :-

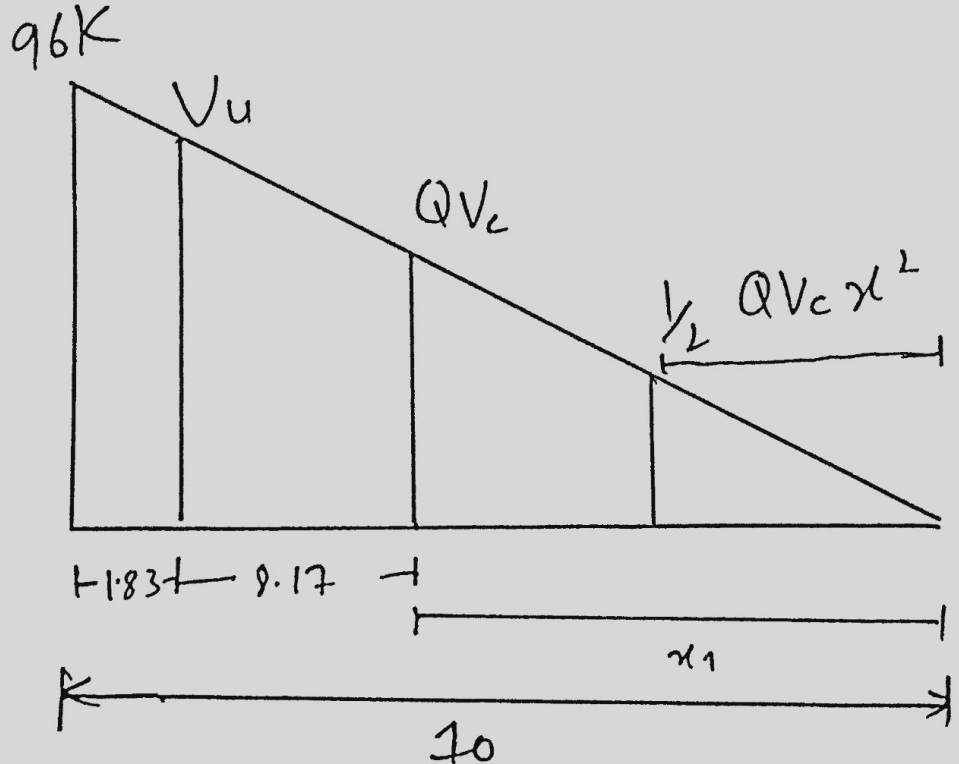
Shear Force diagram.



STEP No#3 :-

value of Criticle stresse and its location.

Critical location is located distance d from face of support d = 22" = 1.83'
value of criticle stress at distance 'd" by similarity traingle.



From Similar Δ's $\frac{96}{7_0} = \frac{V_u}{8.17}$

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

STEP NO#4 :-

Finding ϕV_c and $\frac{1}{2}\phi V_c$ and also finding its distance from zero shear to right side.

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

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

$$\phi V_c = 33.40k$$

⇒ Location of ϕV_c by Similarity of $\Delta s'$

$$\frac{96}{700} = \frac{33.40}{x_1}$$

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

Now

$$\Rightarrow \frac{1}{2}\phi V_c = \frac{33.40}{2} = \boxed{16.70^k}$$

Location of $1/2\,\phi V_c$

$$= \frac{96}{10} = \frac{16.70}{x_2}$$

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

STEP No # 5 :-

Finding values of ϕV_s [$V_u = \phi V_s + \phi V_c$]

So

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

$$\phi V_s = 78.43 - 33.40$$

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

STEP No # 6 :-

Check section Adequacy.

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

$$= 133.57 K$$

$133.57 K > \phi V_s$ (mean section is adequate)

STEP No# 7:-

Check mini Spacing for Stirrups.

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

$$= \boxed{66.79} > \phi Vs = 44.031c$$

Spacing will be selected from these four conditions.

① $S_{max} = 24''$

② $\frac{d}{2} = \frac{22}{2} = 11''$

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

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$$Au = \frac{\pi}{4}(3/8)^2 \quad \therefore Au = 0.11 \times 2 = 0.22$$

$$S_{max} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$$

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

$$= \frac{0.22 \times 600000}{50 \times 16}$$

$$= 16.50$$

From the above 4 Condition least value of spacing to #3 U stripped will be selected so

$S_{max} = 12''$ c/c

STEP No# 8:-

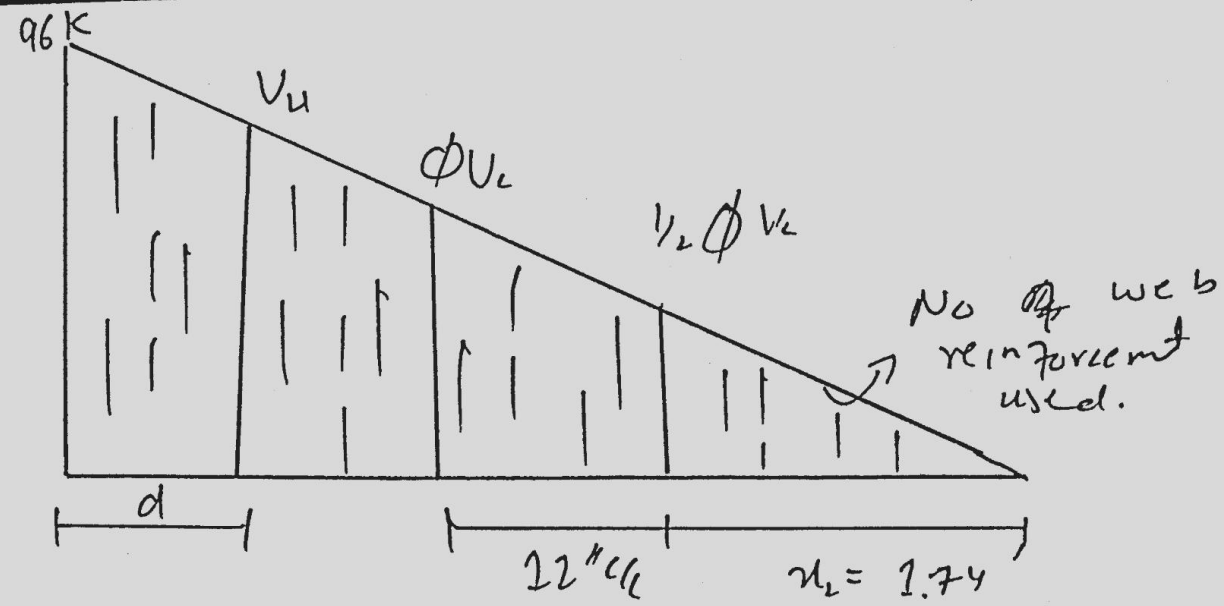
Spacing of stirrup from critical section:-

$$S = \frac{\phi \times A_{vx} \times f_y \times d}{V_u - \phi V_c}$$

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

$$S = 4.84 \approx 5'' \text{ c/c}$$

STEP No # 9:-



First Stirrup from face of Support $= \frac{S}{2} = 2.5 \approx 2''$

Q No. 3

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Calculate the axial ultimate load carrying capacity of a 12 inch. Square tied column reinforcement with 4 #9. Ties are #3 inches. use f'c = 4000psi and fy = 60ksi. Also design necessary spirals.

Solution :=

P.T.O

STEP No #1 :-

Gross area of concrete

$A_g = b \times b$ (since it is squarid column)

$A_g = 12 \times 12$

$A_g = 144 in^2$ (Actual)

STEP No# 2 :-

Area of steel.

$A_s = 5\%$ of A_g

$A_s = 0.05 \times 144$

$A_s = 7.2 in^2$

STEP NO#3:

Ultimate load Carrying Capacity.

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

$$P_u = 0.65 \times 0.80 [0.85 \times 4 [144 - 7.2] + 7.2 \times 6]$$

$$P_u = 466.50$$

STEP NO#4:

Sketch and design of ties

From the below value we will chose the least value in all values.

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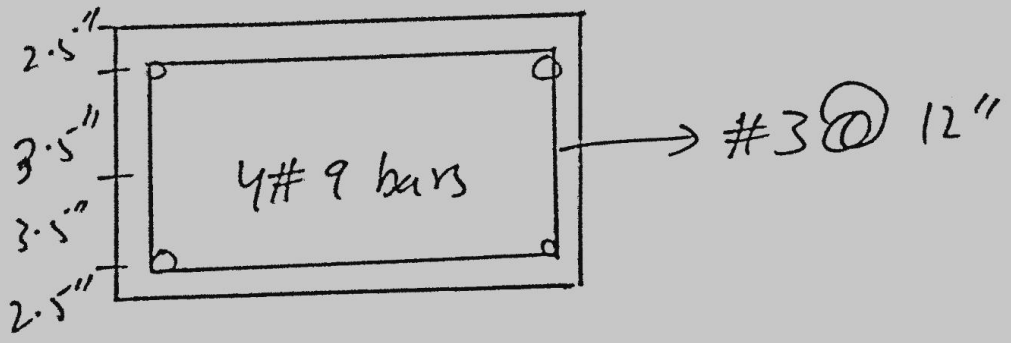
① 16 x dia of long ba = $16 \times 9/8 = 18''$

② 48 x dia of the bar = $48 \times 3/8 = 18''$

③ Least colum dimension = 12"

so c/c distance b/w ties = 12"



Sinice it is a tied square colum so there is no spiral stirrup used the stirruped use is of rectangular shape due to the specification of the structure thus we will use ties stirrups insted

Q No. 4

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Design a square footing to support a 16inches square tied concentrically loaded column. The column carries an un-factored axial D.L of 100 kips and an axial L.L of 120 kips. The base of footing is 5ft. below final grade and the allowable soil pressure is 2.50ksf. Use $f'c = 3$ksi, $fy = 60$ksi and $\gamma_{soil} = 120$ pcf. Draw sketch of your final diagram.

Solution:=

STEP No# 1 :-

h = 24"

STEP No#2 :-

Total weight = wt of soil + wt of RF

= 3 × 120 + 2 × 150

= 660 psf

Total weight = 0.660 ksf

STEP No# 3 :-

Effective bearing Capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84$ ksf

STEP No #4 :-

Area of Foundation

$A_{rq} = \frac{\text{service load}}{q_e} = \frac{100 + 120}{1.84} =$ 1.5 units

STEP No# 5

Since foundation is Square

$$\text{Area} = b \times b = 119.57 \Rightarrow B \cong 11'$$

STEP No# 6

Upward bearing Capacity of soil :

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

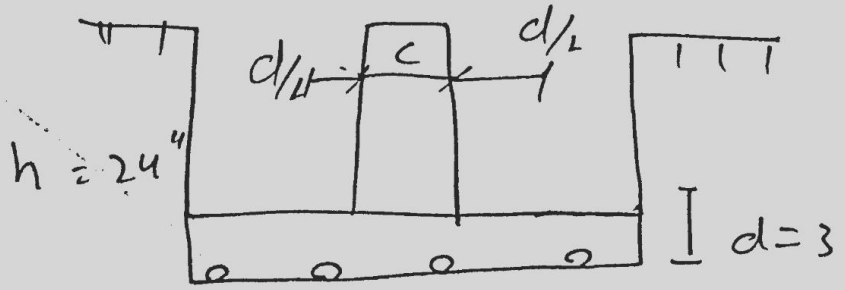
$$q_{up} = \frac{1.2 \times 100 + 5.6 \times 120}{11^2}$$

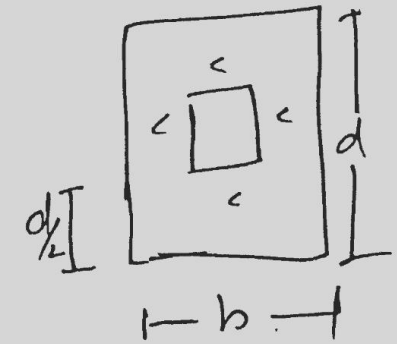
$$\boxed{q_{up} = 2.58 \text{ K/ft}^2}$$

STEP No # 7

Punching Shear.

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





Take #8 bar

$d = h' - c.c - d_{,o}$ of bar $- \frac{1}{2} d_b$

$= 24 - 3.1 - \frac{1}{2}(1) = 19.5"$

$b_o = 4 \times (16 + 9.5)$

$b_{.o} = 142"$

STEP No # 9

$V_{uL} = q_{up} \times [13^2 - (c+d)^2]$

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

$V_{uL} = 289.60k$

STEP No# 9

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

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

$$\boxed{\phi V_{up} = 525.39\ k}$$

STEP No# 10

Beam shear one way

Shear check

$$V_{u1} = q_{up} \times B \times \left(B/2 - 9/2 - d \right)$$

$$V_{u1} = 2.58 \times 11 \times \left[11/2 - \frac{16/12}{2} - 19.3 \right]$$

$$V_{u1} = 90.95\ k$$

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STEP No# 11

Self shear Capacity

$$\phi V_c = \frac{\phi \times 2 \times \sqrt{4000} \times [11 \times 12 \times 1.6)}{1000}$$

$$= 110.04 K > V_{u_1}$$

$$= \cancel{\phi} K \quad \text{ok!}$$

STEP # 12

Ultimate moment

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

$$= \frac{2.58 \times 11}{8}$$

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

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$M_u = 331.49 K' \approx 3971.93 k$

STEP No # 13

Area of steel for main bar by trial and repeat method.

Trial # 1

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

$$A_s = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})}$$

$$A_s = \frac{3977.93}{0.90 \times 60 \times (11 - \frac{4.8}{2})}$$

$$A_s = 8.56 \text{ in}^2$$

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Trial N2#2

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

$$a = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12}$$

$$a = 1.53''$$

$$As = \frac{3977.93}{0.90 \times 60 \times \left(11 - \frac{1.53}{2}\right)}$$

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

Trail #3

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

$$Ast = \frac{3977.93}{0.90 \times 60 \left(11 - \frac{1.28}{2}\right)}$$

$$Ast = 7.1 in^2$$

So that area $= 7.1 in^2$

STEP No# 14

Check Minimum reinforcemet by the following 3 method.

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(a)

$$A_{smin} = 0.0018 \times B \times h$$

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

$$A_{smin} = 5.70 \text{ in}^2$$

(b) $$A_{smin} = \frac{200}{f_y} \times B \times d$$

$$A_{sim} = \frac{200}{60000} \times (11 \times 12) \times 19.5$$

$$= 9.58 \text{ in}^2$$

(c)

$$A_{sim} = \frac{3 \times \sqrt{f'c}}{f_y} \times B \times d$$

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

$$A_{smin} = 7.05 \text{ in}^2$$

From the above value (58) 7809
will be select greather
in all

$A_{smin} = 8.58 \text{ in}^2$

STEP NO #15

$A_b = 0.785 \text{ in}^2$

$$\text{No of bars} = \frac{A_s}{A_b} = \frac{8.58}{0.783}$$

$$= 10.92 \simeq 11 \text{ bars}$$

in each direction.

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SECTION → A

ID → 7809

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