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Section " 'A'

Subject " PRCD-1

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Semester " 6th

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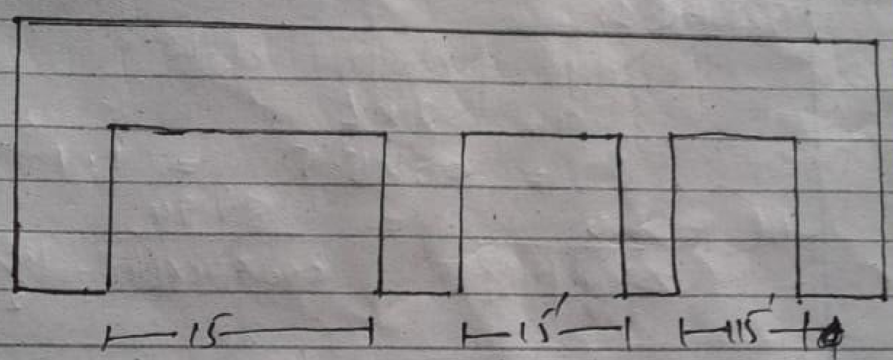
Q No 1

Given data :-

- ⇒ 3 equal spans concrete slab
- ⇒ clear span b/w support = 15 ft
- ⇒ Factor live load = 1600 lb/ft³
- ⇒ Service Floor finish load = 20 lb/ft³
- ⇒ F'_c = 4000 Psi
- ⇒ F_y = 40 ksi

Solution :-



Step No # 01

by using formula.

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

As $F_y \rightarrow 40$ ksi

So we will multiply a factor with this thickness

$$\text{Factor} = (0.4 + F_y/100)$$

$$= (0.4 + 40/100) = 0.8$$

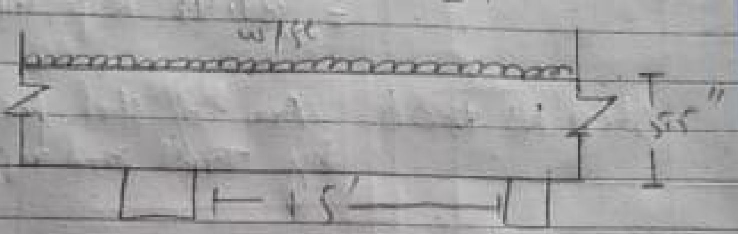
(2)

Hence the minimum thickness will be

6.5×0.8

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

Step No #02 :- (Effect Depth)



By formula:

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

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

$d \cong 4.5''$

Step No #03

By formula

$t/12 \times \gamma_{concrete}$

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

Step No #04

Factor of live load $= 160\ lb/ft^2$

so that D.L

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

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

$\text{''} = 106.5 + 160$

$\text{''} = 266.5\ lb/ft^2 = 0.2665\ K/ft^2$

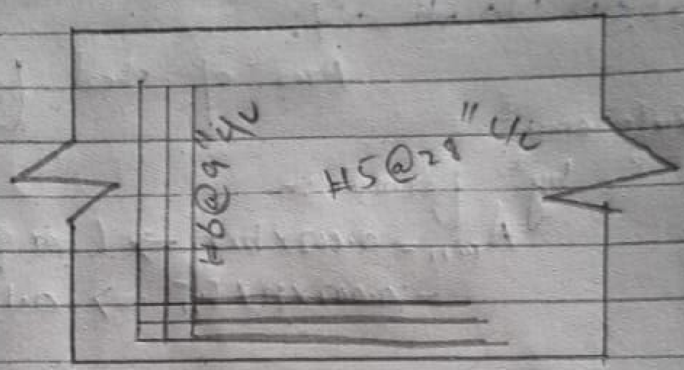
(5)

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



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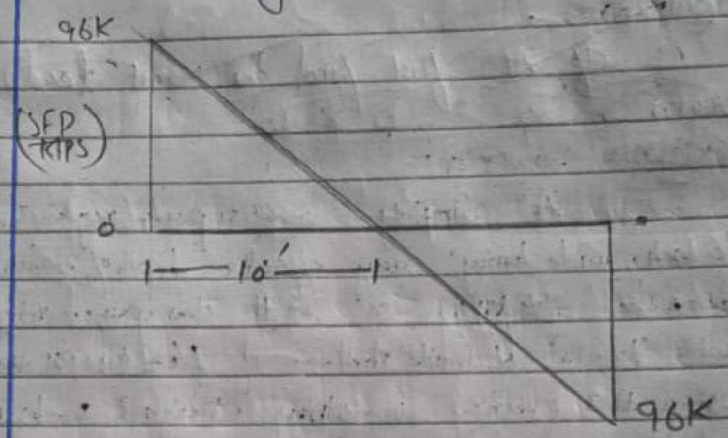
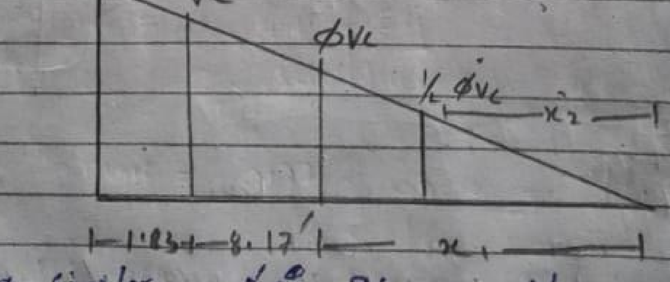
Step No # 02 :- Draw the shear force diagram



Step No # 03 :-

Find the value of critical stress "V_u" & its location

As we know that critical location is located distance "d" from face of support $d = 22'' = 1.83'$ value of critical shear at distance "d" by similarity triangles.



For similar Δs $\frac{96}{10} = \frac{V_u}{8.17}$

$V_u = 78.43K$

Step No # 08

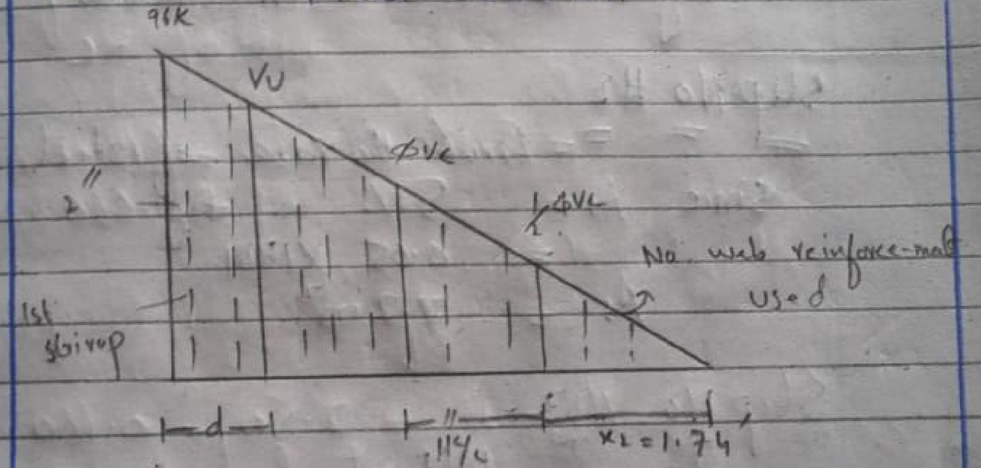
"Spacing of stirrup from at critical section."

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

$$S = 4.84 \approx 5'' \ c/c$$

Step No # 09

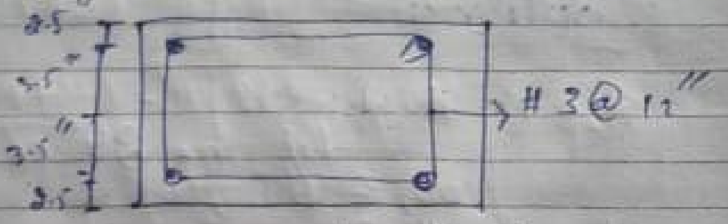
"Final sketch"



We know that first stirrup from face of support $= 5/2 = 2.5 \approx 2''$

(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.

$= 133.57\ K$

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

Step No # 7

check mini spacing for stirrups

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

$= 66.79K > \phi V_S = 44.93K$

Thus max spacing will be selected from the following 4 condition

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

(2) $d/2 = 22/2 = 11''$

(3) $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$\because A_v = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 \therefore A_v = 0.11 \times 2 = 0.22$

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

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

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

From above 4 condition least value of spacing from #3 U shaped will be selected so $S_{max} = 11''$ c/c

Q No # 04

Solution :-

Step No # 01 :
let $h = 24''$

Step No # 02:
Total weight = wt of soil + wt of RC

$= 3 \times 120 + 2 \times 150 = 660$ Psf
$= 0.660$ Ksf

Step No # 03 :-
effective bearing capacity

$q_e = q_a - w = 2.50 - 0.660$

$q_e = 1.84$ Ksf

Step No # 04
Required area of foundation

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

$Area = 119.57 ft^2$

Step No # 05 :-
Since foundation is square.

Q No 3

Solution

Step No #1 = Find grass area of concrete

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

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

Step No #2 = Find the area of steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2 \, in^2$

Step No #03 = Ultimate load carrying capacity

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

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

$P_u = 486.50 \, K$

Step No #04 = Sketch & design of ties (c/c)

From the below value we chose the last value of all these

1) $16 \times$ dia of long bar $= 16 \times 9/8$
$= 18''$

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

$A_{req} = b \times b = 116.57 \Rightarrow B \cong 11'$

Step No # 06

upward bearing capacity of Soil

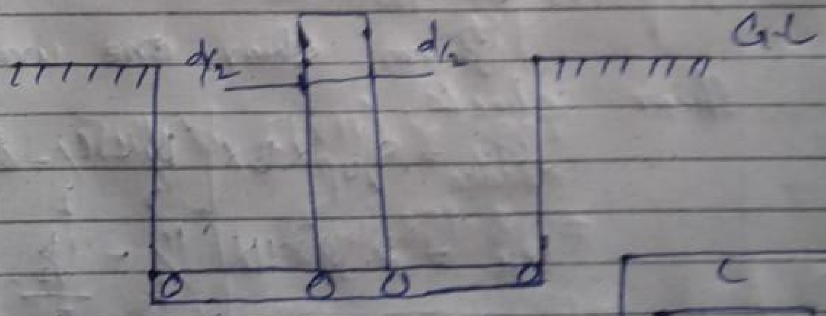
$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{(11)^2}$$

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

Step No # 07

Punching shear.

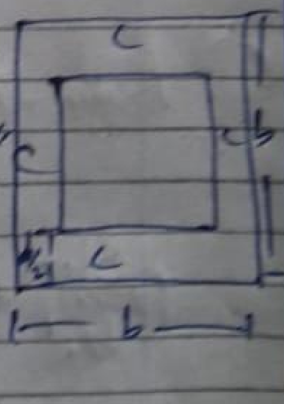
$b_o = 4 \times (c + d)$



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

∴ take # 8 bar dia = 8/8 = 1"

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



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

Trail No # 03

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

$$A_s = \frac{3877.33}{0.90 \times 60\left(11 - \frac{1.28}{2}\right)} = 7.1\,in^2$$

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

Step No # 4
check the main reinforcement by the follow 3 method.

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

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

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

$= 8.58\,in^2$

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

$= 7.05\,in^2$

from above value greater value will be selected thus A_s min $= 8.58\,in^2$

~~Step No~~

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

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

$= 110.04\ K > V_u \Rightarrow O.K$

Step #12 ultimate moment.

$M_u = \frac{q_{up} \times B}{8} \times (B - C)^2 = \frac{2.58 \times 11 \times (11 - \frac{16}{12})^2}{8}$

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

Step # No. 13:-

Area of steel for main bar by trail, sq root method.

Trail # 01

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

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

Trail # 02

$a = \frac{A_s \times f_y}{0.85 \times f'_c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.55''$

$A_s = \frac{3977.93}{0.90 \times 60 \times (11 - \frac{1.55}{2})} = 7.197\ in^2$

Step No #08

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

$$V_{u_2} = 2.58 \left[11^2 - \left(\frac{16+19.5}{12} \right)^2 \right]$$

$$V_{u_2} = 289.60\ K$$

Step No #09:-

$$\phi V_{cp} = \phi \times 4 \times \sqrt{f'_c} \times b \times d$$

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

$$\phi V_c = 525.38$$

Step No # 10

Beam shear one way Shear check.

$$V_u = q_{up} \times B \times \left[\frac{B}{2} - \frac{C}{2} - d \right]$$

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

$$V_u = 90.95K$$

Step No #11

Self shear capacity.

Step No # 4

Find the value "ϕV_u" & $\frac{1}{2} \phi V_u$ & its distance from zero shear to right side

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

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

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 $\frac{1}{2} \phi V_c \Rightarrow \frac{9.6}{10} = \frac{16.70}{x_2}$

$x_2 = 1.74'$

Step No # 05

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

so we have

$\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

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

Step No # 06

Check Section Adequacy

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

Step # 15

using # 8 bar

$A_b = 0.785\ in^2$

No. of bars $= A_s / A_b = 8.58 / 0.785$

$= 10.92 \approx$ 11 bars in each direc

(3)

Step #05:

by using formula

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

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

Step No #06 Area of steel for main bars by Trail and repeat method

Trail #No 1:

Let depth of compress block

$$a = 0.2 \times L$$

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

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

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

Trail # 02

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

$$Ast = \frac{Mu}{\phi fy (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.6}{2})}$$

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

Trail No #03:-

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

(6)

Q No # 02

~~Solution:- At first find the unit load of beam b × γc~~

Q No Given data:-

A Simply supported rectangular beam 16 inch. wide having any effective depth of 22 inch ... total factor load 9.4 kip/ft on 20 ft clear span ... reinforcement with 7.62 in² of tensile steel ... if $f'c = 4000$ psi and $fy = 60000$ psi using # 3 vertical U-stirrups. Design the web reinforcement draw the sketch.

Solution

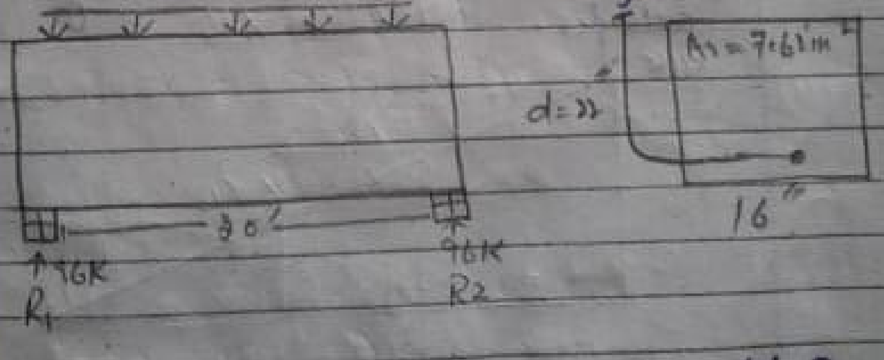
At first find the unit load of beam

So b × γc

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

total factor load = 9.4 + 0.2

= 9.6 K/ft



Step No # 1 Find the value of "R1" & R2

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

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

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

Step No # 07:-

Area of steel for distribution reinforcement.

by formula:-

$$A_{min} = 0.002 \times b \times t \rightarrow (\text{For grade 40 steel})$$

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

Step No # 08

Spacing for main bars.

by formula.

$$\text{spacing } A_b / A_{st} \times 12$$

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

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

Step No # 09:-

spacing for distribution bars

$$\text{Spacing} = A_b / A_{st}$$

we use # 5 bars so

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

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

$$= 28.1'' \approx 28'' c/c$$