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Subject : PRCD-1
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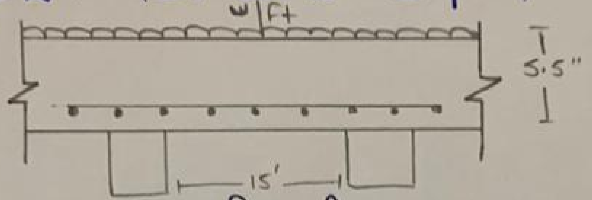
Exam : Final Term

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

Step 2 :- (Effective Depth)



By formula

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

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

$d \cong 4.5''$

Step 3 :- (Self wt. of Slab)

By Formula

$t/12 + \gamma_{concrete}$

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

Step 4 :- (The Total Factored Load)

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

So the factored Dead load will be

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

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

$= 106.5 + 160$

$= 266.5\ lb/ft^2$

$= 0.2665\ k/ft^2$

Step # 5 (Ultimate Moment)

By using formula

$$M_u = \frac{w_u \times L^2}{8}$$

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

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

Step 6 Area of Steel for Main Bars By Trail & Repeat Method.

Trail # 01

Let depth of compression block

$$a = 0.2 \times t$$

$$= 0.2 \times 5.5 \qquad = 1.1$$

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

Trail # 02

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} \Rightarrow 0.62 \text{ in}^2$$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{89.94}{0.9 \times 40 \times (4.5 - \frac{0.6}{2})}$$

$$A_{st} = 0.59 \text{ in}^2$$

Trail # 3

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

As $f_y \rightarrow 40$ ksi

So we will multilply a factor with this thickness.

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

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

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Question 1:- A reinforced concrete slab is built integrally with its support and consists of three equal spans each with ....?

Given Data:-

3 equal spans concrete slab.

clear span b/w supports = 15ft.

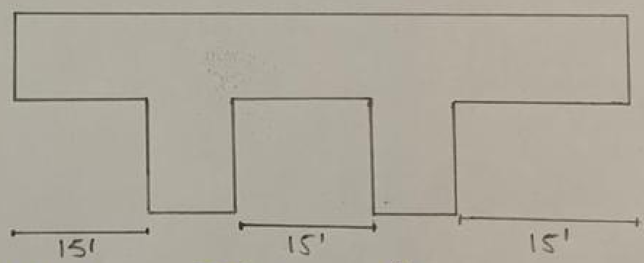
Factored line load = 160 lb/ft^2

Service floor finish load = 20 lb/ft^2

$f'c$ = 4000 Psi

fy = 40 ksi

Solution:-



Step#1 (Minimum Thickness)

By using formula

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

As $fy \rightarrow 40$ ksi

So we will multiply a factor with this thickness

factor $= (0.4 + fy/100)$

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

Hence the minimum thickness will be
6.5×0.8

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Hense the minimum thickness will be

6.5×0.8

$t_{min} = 5.2 \approx 5.5$

Step # 7 Area of Steel for distribution reinforcement

By Formula

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

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

Step # 8 spacing for main bars.

By formula

spacing $\frac{A_o}{A_{si}} \times 12$

we use #6 bars dia $(6/8)''$

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

Step #9 spacing for distribution bars.

spacing $= A_o / A_{si}$

we use #5 bars so

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

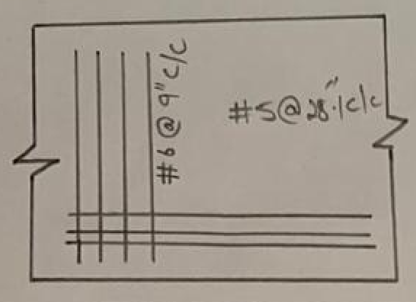
spacing $= \frac{0.31}{0.132} \times 12 = 2.81'' \approx 28''$ c/c

Step #10 Find Sketch

$f'_c = 4ksi$, $f_y = 40ksi$

Main Steel #6 at 9" c/c

Distribution steel #5 at 28.1" c/c.



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Step:5

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

So we have

$\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

$\phi V_s = 45.03k$

Step : 6 Check section Adequacy.

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

$= 1333.57k$

1333.57 ϕV_s (mean section is adequacy)

Step : 7 Check mini spacing for Stirrups

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

$= 66.79k > \phi V_s = 44.03k$

thus max spacing will be selected from the following 4 conditions.

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

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

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

: $A_v = \pi/4 \, (3/8)^2$ ∵ $A_v = 0.11 \times 2 = 0.22$

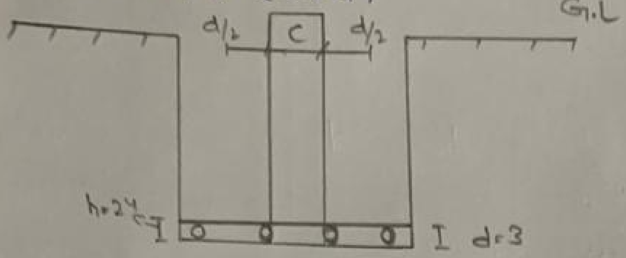
$S_{max} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$

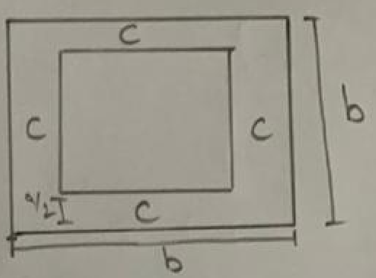
4) $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

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

Step 7 Punching shear

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





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

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

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

Take #8 bar
dia $= 8/8'' = 1''$

Step 8:-

$V_{v2} = q_{up} \times [B^2 (c+d)^2]$

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

$V_{v2} = 289.60k$

Step 9:-

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

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

$V_{c/p} = 525.38$

Step 10:-

Beam shear / one way shear check

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

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

$V_{u1} = 90.95k$

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Step #14 Check the min reinforcement by the following 03 method.

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

b) $A_{smin} = \frac{200}{f_y} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$
$= 8.58 in^2$

c) $A_{smin} = \frac{3\sqrt{f_c'}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000} \times (11 \times 12) \times 19.5}{60000}$
$= 7.05 in^2$

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

Step # 15

Using #8 bar

$A_b = 0.785 in^2$

No of bars $= \frac{A_s}{A_b} = \frac{8.58}{0.785} = 10.92 \approx 11$ bars in each direction

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Step 11 :- Self Shear Capacity

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

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

$$= 110.04 > V_{u1} \Rightarrow 0.12$$

Step 12 :- Ultimate momovent

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

$$M_u = 331.49\, k' \approx 3977.93\, k''$$

Step 13 :- Area of main bars by Trail & Repeat Method.

Trail = 1

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

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

Trail = 2

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

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

Trail = 3

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

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

So that area = 7.1 m

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Q4) Design a square single footing to support a 16 inches tied concentrically loaded column.........?

Solution:-

Step 1

$h = 24$

Step 2

total weight = wt of soil + wt of R.C

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

$= 660$ Psf $= 0.660$ ksf

Step 3

Effective bearing Capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84$ ksf

Step 4

Required Area for foundation

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

$= 119.57\ ft^2$

Step 5 Since foundation is square

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

Step 6 upward bearing Capacity of Soil

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

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

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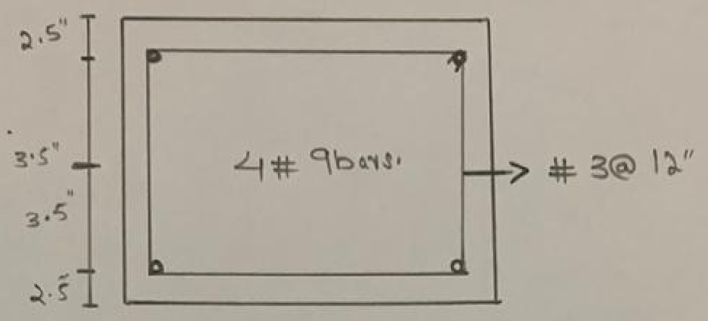

★ Since it is a tied square column so there is no spiral stirrup used, the stirrup used of rectangular shape due to the specification of the structure thus we will use to tie stirrups instead.

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Q3) Calculate the axial ultimate design ......?

Ans:- Step 1

To Find gross area of Concrete

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

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

Step 2

Find the area of Steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2 in^2$

Step 3

Ultimate load Carrying Capacity

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

$= 0.65 \times 0.80 [0.85 \times 4 [1.44 - 7.2] + 7.2 \times 60]$

$P_u = 466.50 k$

Step 4

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

From the below value we choose the last 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"

From the above 4 conditions. least value of Spacing for #3 U stupeel will be Selected

So S_{max} = 11" c/c.

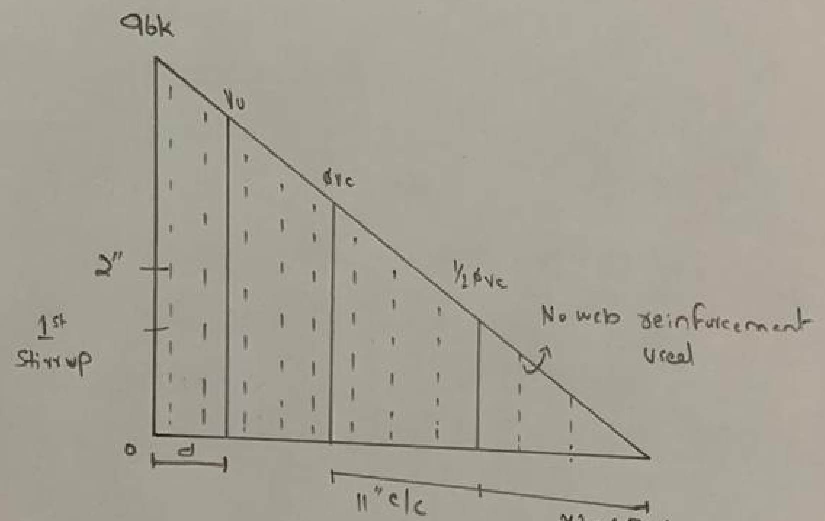
Step 8 :-

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

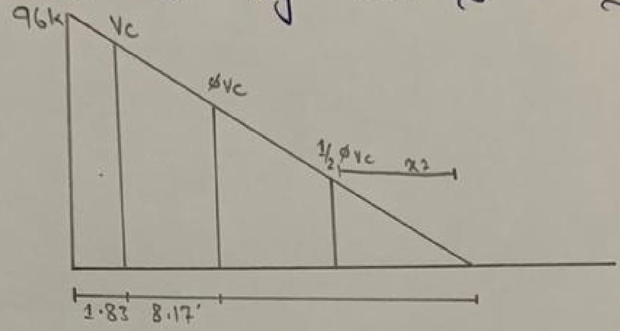
Step 9 :-



we know that first Stirrup from face of Support = 5/2 = 2.5 ≈ 2"

Step # 3 Finding value of critical Stress "Vu" & its location.

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



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

$VU = 78.43K.$

Step # 4 Finding value of "ØVc" & "1/2 ØVc" & its distance from zero shear to right side.

$ØVc = Ø \times 2 \times \sqrt{F'c} \times bw \times d = \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$

$ØVc = 33.40K$

location of ØVc by similarity of Δs'

$\frac{96}{109} = \frac{33.40}{x1}$

$x10 = 3.48'$

Now:- $1/2\ ØVc = \frac{33.40}{2} = 16.70K$

Location of 1/2 ØVc ⇛ $96/10 = \frac{16.70}{x2}$

$x_2 = 1.74'$

Q#2: A simply supported rectangular beam 16 inch wide having an effective depth 22 inches caries a total . . . . ?

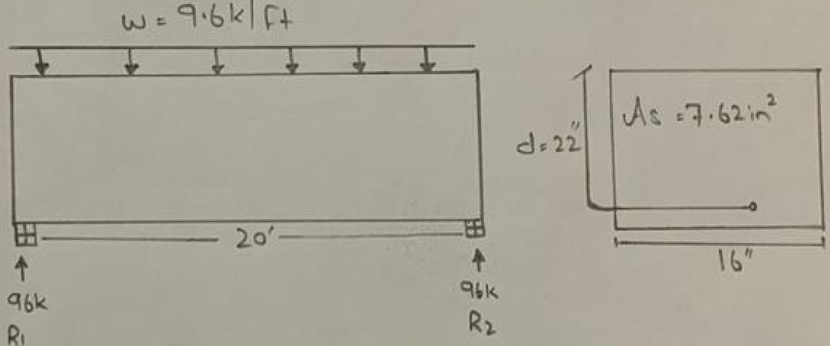
Solution:-

At first find the unit load of beam

So $b \times \gamma_c$

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

total factored load $= 9.4 + 0.2$
$= 9.6k/ft$



Step 1:- Find value of "R1" & "R2"
total load $= 9.6 \times 20/2 = 96K$

Step 2:- Draw a shear force diagram