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Section : B

Semester : 6^{th}

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Subject : PRCD – I

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Question No 1 7856

Given Data.

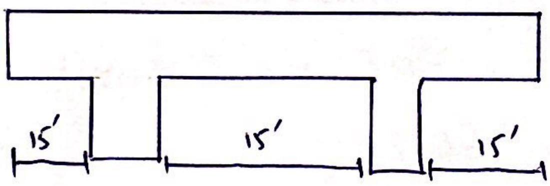
Factored live load = 160 lb/ft^2

Service floor finish load = 20 lb/ft^2

$F_c' = 4000$ Psi , $F_y = 40$ksi

3 equal Span Concrete slab

Clear span b/w Support = 15ft.



Step # 1 (Minimum thickness)

Using Formula

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

As $F_y = 40$ksi

we multiply a factor thickness

$$\text{Factor} = \left(0.4 \times \frac{F_y}{100}\right)$$

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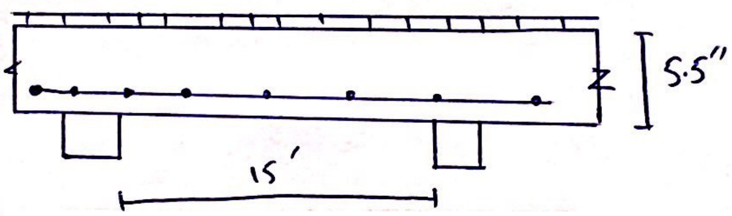
$$\text{Factor} = \left[0.4 + \frac{40}{100}\right] = 0.8$$

Hence the minimum thickness will be

$$6.5 \times 0.8$$

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

Step # 2 [Effective Depth].



By formula we have.

$$d = t - \text{clear cover} - \frac{1}{2}(\text{dia of m.b})$$

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

$$d = 4.5''$$

Step # 3 Self weight of Slab.

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

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

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Step # 4 Total Factored Load.

Factored live load = 160 lb/ft^2

The factored dead load will be $DL = 1.2\,(20+68.7)$

$= 106.5\ lb/ft^2$

$T.F.L = D.L + L.L$

$= 106.5 + 160$

$= 266.5\ lb/ft^2 = 0.2665\ K/ft^2$

Step # 05 (Ultimate Moment).

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

$= 89.94$ kip-inch.

Step # 06 Area of steel for M.B By trail & Repeat Method.

Trail 01:

Let depth of Compression block

$a = 0.2 \times t \Rightarrow 0.2 \times 5.5$

$a = 1.1$

$$A_{st} = \frac{M_u}{0 \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{1.1}{2})}.$$

Trail # 2.

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12}$$

$a = 0.62 in^2$

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

$Ast = 0.59 in^2$

Trial #03

$$a = \frac{0.59 \times 40}{0.35 \times 4 \times 12} = 0.57''$$

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

So we will ~~to~~ use $Ast = 0.59 in^2$

Step # 07.

Area of steel for distribution reinforcement

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

$A_{min} = 0.002 \times 1.2 \times 5.5 \Rightarrow 0.132 in^2$

Step # 8 Spacing for M.B

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

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

Step#9

Spacing for distribution. bars.

Spacing $\frac{A_b}{A_{st}}$ we use #5 bar.

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

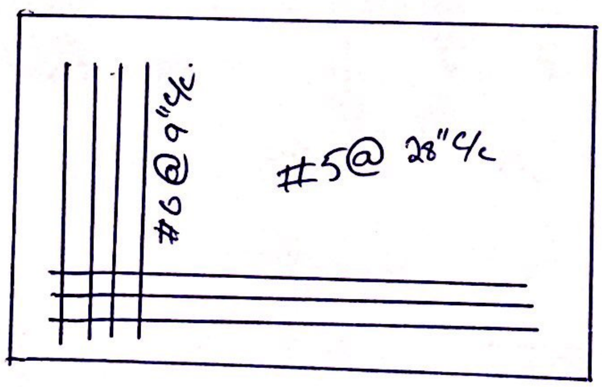
$$\text{Spacing} = \frac{0.31}{0.132} \times 12 = 28.1 \approx 28.\ c/c.$$

Step # 10 Final sketch.

$F_c' = 4ksi$ $f_y = 40ksi$

Main steel # 6' at 9" c/c.

Distribution steel # 5 at 28" c/c



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Solution:

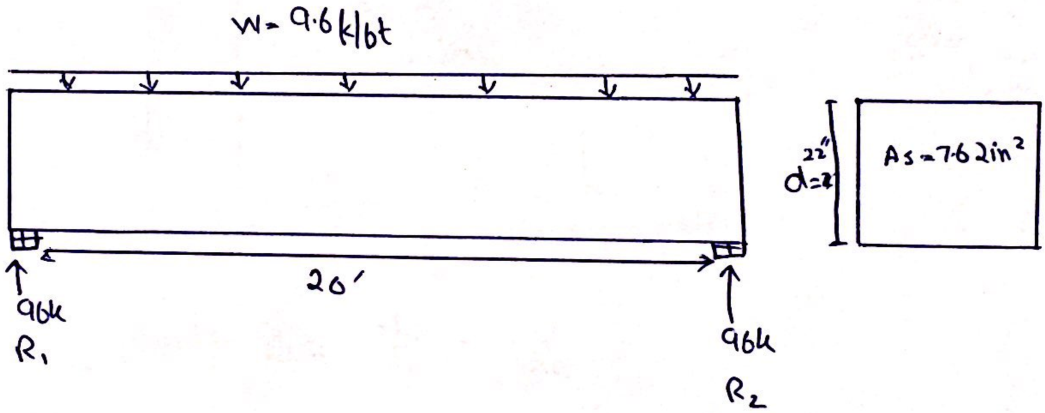
At first find the unit load of beam

So $b \times r_c$

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

Total factored load $= 9.4 + 0.2$

$= 9.6\,k/ft.$



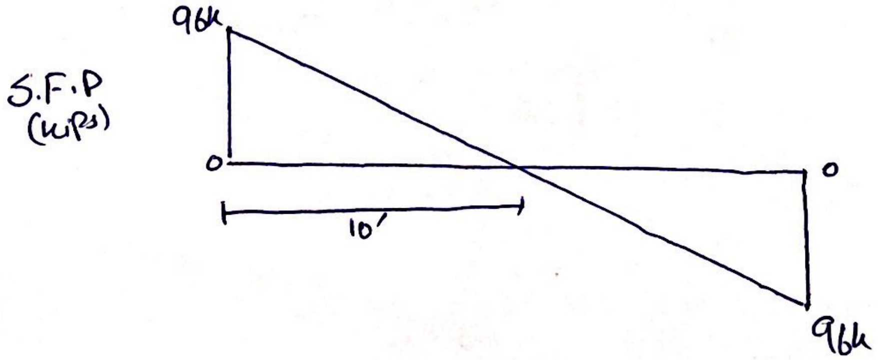
Step#01:

Find value of "R_1" & "R_2"

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

Step#02

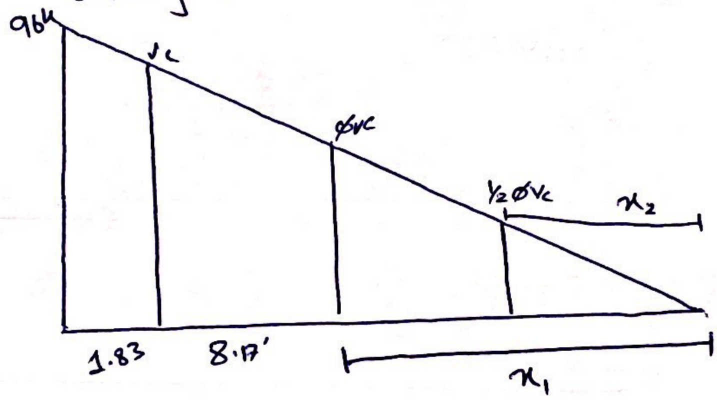
Draw Its shear force diagram.



Step # 03

Find value of critical stress "Vu" & 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.



From Similarity Δ's $\frac{96}{10} = \frac{VU}{8.17}$

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

Step No 4.

Finding value of "ØVc" & "½ ØVc" & its distance from zero shear to right side.

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

$$\boxed{ØVc = 33.40k}$$

location of ϕV_c by simlarity of Δ's

$$\frac{96}{100} = \frac{33.40}{x_1}$$

$$\boxed{x_1 = 3.48}$$

Now

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

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

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

Step # 05

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

So we have

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

$$\phi V_s = 78.43 - 33.40$$

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

Step # 06.

Check Section Adaquacy.

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

$$\boxed{= 133.57k}$$

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Step # 07

Check mini Spacing for stirrups.

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

$$= 66.794 > \phi V_s = 44.03k.$$

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

① $S_{max} = 24''$

② $\frac{d}{2} = \frac{22}{2} = 11''$

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

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

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

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 the above 4 conditions, least value of spacing for #3 stirrups will be selected

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

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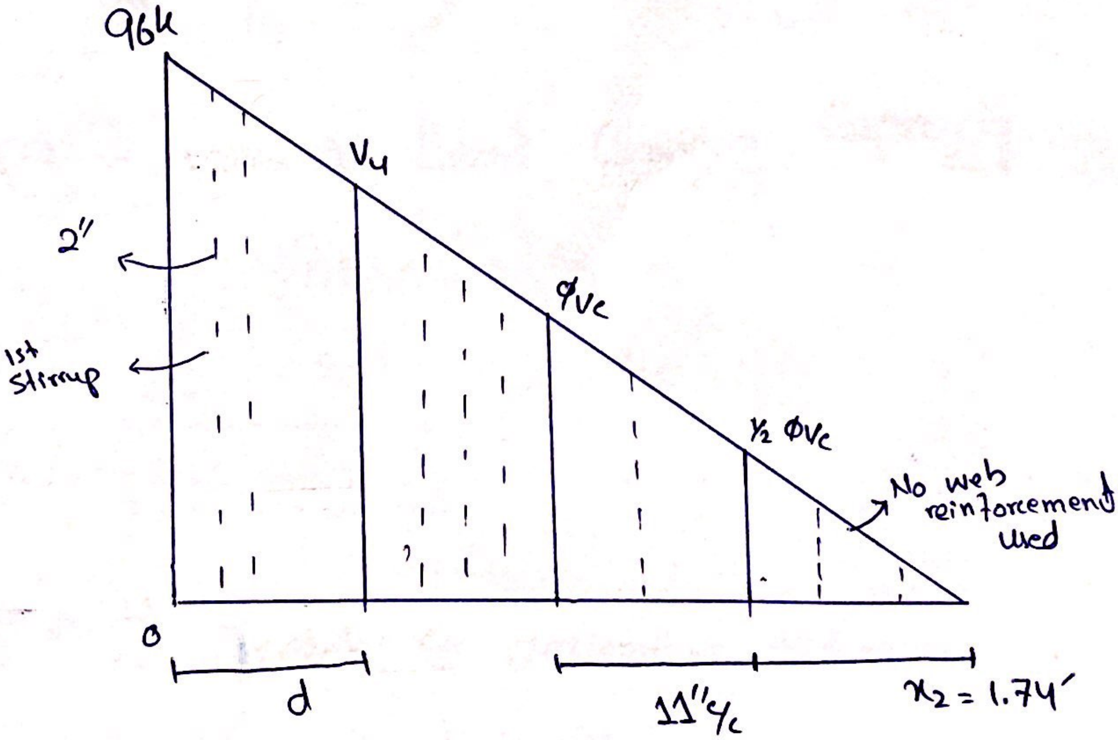
Step # 08

Spaing of stirrup from at critical Section.

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{78.2 - 33.40}$$

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

Step # 9 Final sketch.



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

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Solution:-

Step 1: Find gross area of Concrete.

$A_g = b \times b$ (Since this squaredised 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

$P_u = \phi \times 0.8 \times [0.85 \times f'_c \times (A_g - A_s) + A_s \times f_y)$

$0.65 \times 0.80 [0.85 \times 4 [144 - 7.2] + 7.2 \times 60]$.

$\boxed{P_u = 466.50k}$

Step # 4. Sketch & design of ties (c/c to distance).

From the below value we choose least value of all the ties.

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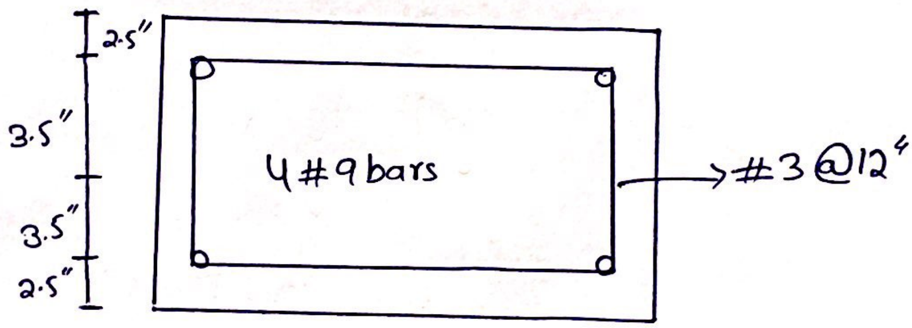
① $16 \times$ dia of long bar $= 16 \times 9/8 = 18''$

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

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.

Question No -4

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Solution:

Step No 1:

let $h = 24''$

Step # 02.

Total weight = wt of soil + wt of Rc

$= 3\times120 + 2\times150$

$= 660\,Psf = 0.660\,ksf.$

Step # 03

Effective bearing Capacity

$q_e = q_a - W$

$= 2.50 - 0.660$

$q_e = 1.84\,ksf.$

Step #4 Required Area for foundation.

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

$$= 119.57\,ft^2$$

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Step # 5.

Since foundation is square

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

Step # 6

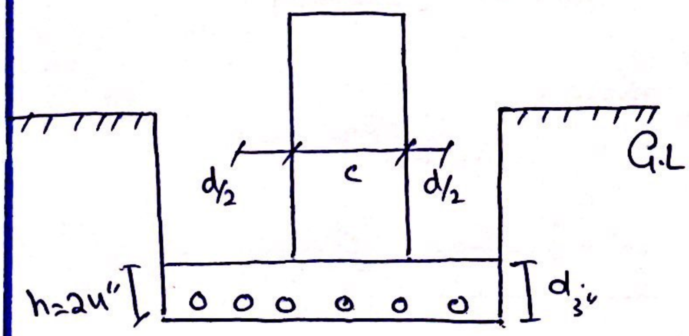
Upward bearing capasity of soil

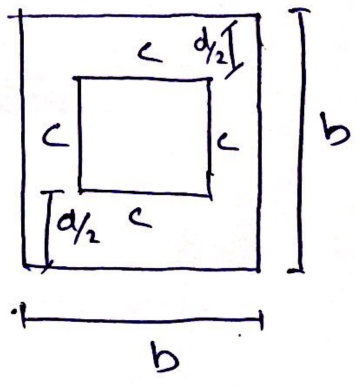
$$q_{up} = \frac{\text{Factored Load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

$$\boxed{q_{up} = 2.58\,k/ft^2}$$

Step 07. 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

$\text{dia} = 8/8'' = 1''$

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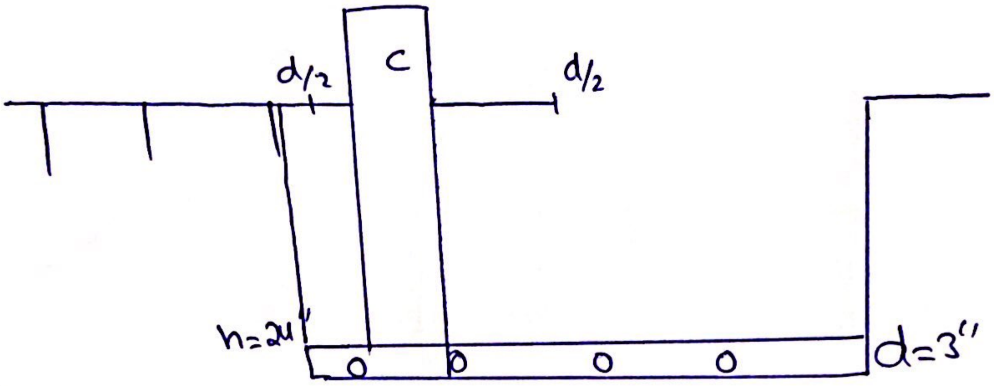
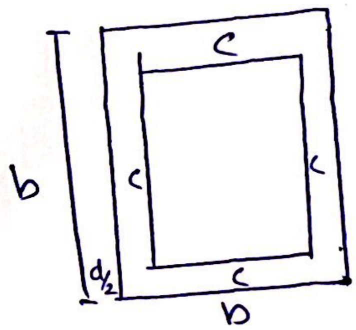


$d = h - cc - \text{dia of bar} - \tfrac{1}{2} d_b$

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

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



Step 8:

$V_{v_2} = q_{up} \times \left[B^2 - (c \times d)^2 \right]$

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

$V_{v_2} = 289.60k$

Step #9

$\phi V_{up} = \dfrac{\phi \times 4 \times \sqrt{f'_c} \times b \times d}{1000}$

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

$= 525.38k$

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Step # 10

Beam shear / one way shear check

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

$$V_{u_1} = 2.58 \times 11 \times \left[\frac{11}{2} - \frac{16/2}{2} - \frac{19.5}{2} \right]$$

$$V_{u_1} = 90.95k.$$

Step # 11

Self shear Capacity.

$$\varphi V_c = \varphi \times 2 \times \sqrt{f_c'} \times b \times d$$

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

$$= 110.04k > V_{u_1} \Rightarrow \text{ok}.$$

Step # 12'

Ultimate Moment

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

$$M_u = 331.49k' = 3977.93k''$$

Step # 13

Area of steel for main bars by trail & Repeed Method.

Trail # 1

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

$$A_s = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{3977.93}{0.9 \times 60 \times \left(11 - \frac{4.8}{2}\right)}$$

$$= 8.56 in^2.$$

Trail # 2

$$a = \frac{A_s \times f_y}{0.85 \times f_c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.58''$$

$$A_s = \frac{3977.93}{0.9 \times 60 \times \left(11 - \frac{1.53}{2}\right)} = 7.197 \ in^2$$

Trail # 3.

$$a = \frac{7.192 \times 60}{0.85 \times 3 \times 11 \times 12} \times 1.28''$$

$$A_s = \frac{3977.93}{0.9 \times 60 \times \left(11 - \frac{1.28}{2}\right)} = 7.1 in^2.$$

So this area is $7.1 in^2$

Step # 14

Check the main renitorcenend by the folloing as methods.

$$A_{s\,min} = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$$

$$A_{s\,min} = 5.70\, in^2.$$

$$A_{s\,min} = \frac{200}{f_y} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$$

$$A_{s\,min} = \frac{3 \times \sqrt{F'c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times 19.5$$

$$= 7.05\ in^2$$

From above values greater value will be selected thus $A_{s\,min} = 8.58\, in^2$

Step #15

Using #8 bars

$A_b = 0.785\, in^2$

$$\text{No of bars} = \frac{A_s}{A_b} = \frac{8.58}{0.785} = 10.92$$

$\approx$ 11 bars in each direction.