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Subject PRC I

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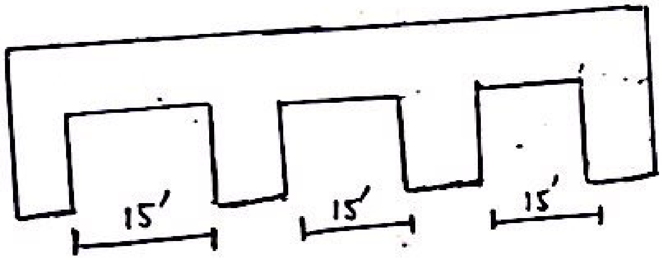
FINAL TERM PAPER

Question (1) (1)

GIVEN DATA

- → 3 equal spans concrete slab
- → clear span b/w supports = 15 ft
- → Factored live load = 160 lb/ft²
- → service floor finish load = 20 lb/ft²
- → $f'c = 4000$ psi
- → $fy = 40$ ksi

SOLUTION:-



→ STEP #1

→ By using formula

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

As $fy \rightarrow 40$ ksi

So multiply this factor with this thickness.

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

$$= \left(0.4 + \frac{40}{100}\right) = \boxed{0.8}$$

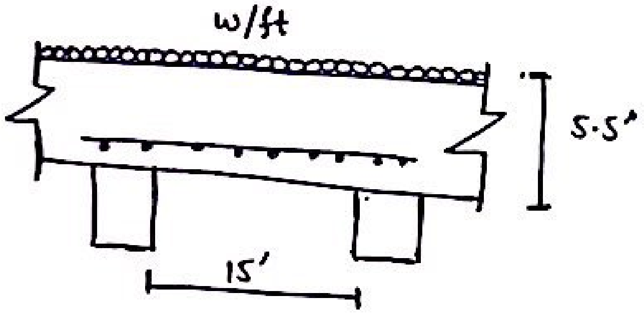
Hence minimum thickness will be

$$6.5 \times 0.8$$

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

STEP# 02 (2)

Effective depth



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

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

$d \cong 4.5''$

Step #03:-

self weight of slab

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

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

Step #04:-

Total factored load

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

So factored Dead load will be

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

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

$= 106.5 + 160$

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

$= \boxed{0.266 \text{ k/ft}^2}$

Step# 05

ULTTIMATE MOMENT

$$M_u = \frac{W_u \times L^2}{8} = \frac{0.266 \times (15)^2}{8} \times 12$$

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

Step #06

Area of steel for main bars
By Trial and Repeat method.

Trial #01

Let the depth of compression block

$$a = 0.2 \times t$$
$$= 0.2 \times 5.5 = 1.1''$$

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

Trial #02

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{A_{st} \times 40}{0.85 \times 4 \times 6}$$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.62}{2})}$$

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

Trial #03:-

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

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

So we will use

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

STEP#07 :- (Area of steel for distribution Reinforcement)

By formula

$$A_{smin} = 0.002 \times b \times t \rightarrow \text{For Grade 40 steel}$$

$$= 0.002 \times 12 \times 5.5 = \boxed{0.132 \ in^2/ft}$$

Step#08 :- (Spacing for Main Bars)

By formula of spacing.

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

we are using #5 bar

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

$$S = \frac{0.31}{0.59} \times 12 = 6.31 \approx \boxed{6.0''}$$

Hence 6.0" c/c

Step # 9 :- (Spacing for distribution Bars)

Also by using formula.

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

we are using # 5 bar, so

dia = (5/8)", Area = 0.31 in^2

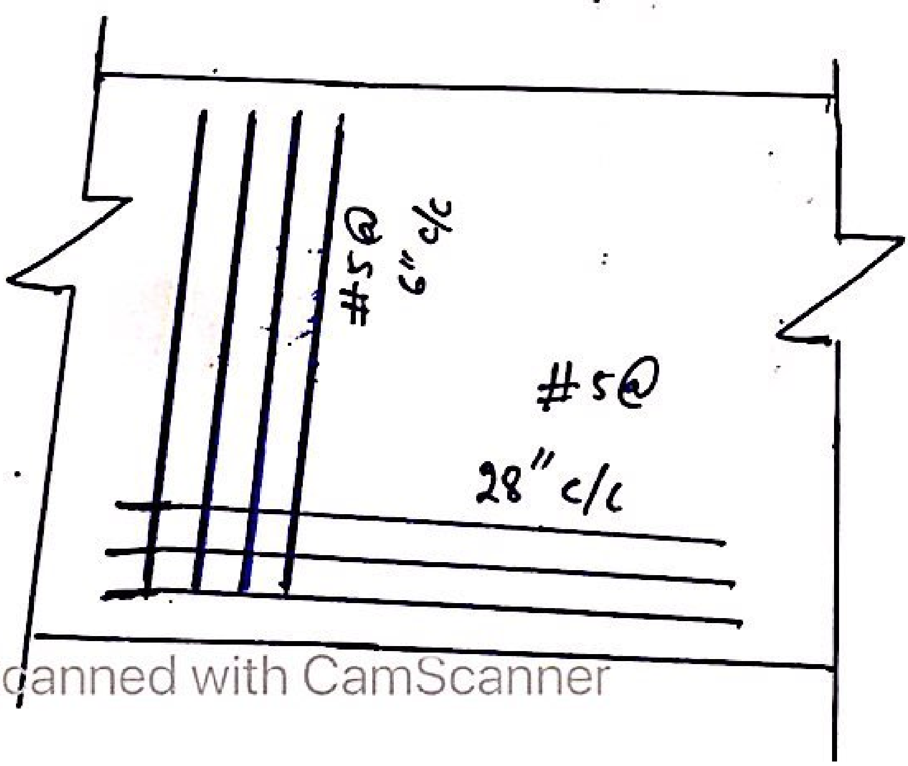
$$\text{Spacing} = \frac{0.31}{0.132} \times 12 = 28.1 \approx 28''$$

So 28" c/c

Step #10 (Final sketch)

$f'c$ = 4 ksi f_y = 40 ksi

Main steel = #5 at.



Question 2:-

ANSWER:-

A simply supported rectangular beam 16" wide

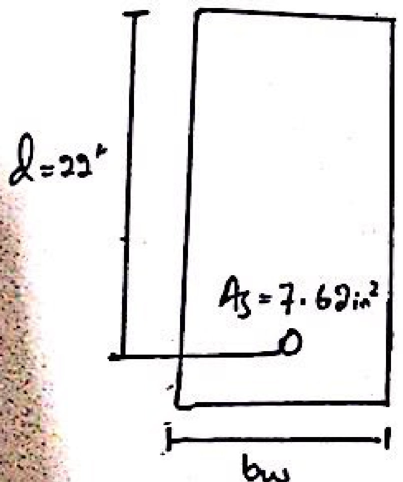
SOLUTION:-

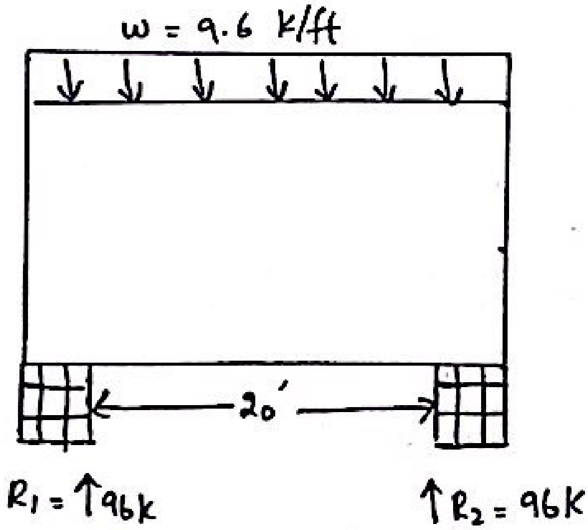
First we have to find the unit of beam

So $b \times \gamma_c$

$= 16/12 \times 150 = 800\ lb/ft = 0.2\ k/ft$

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



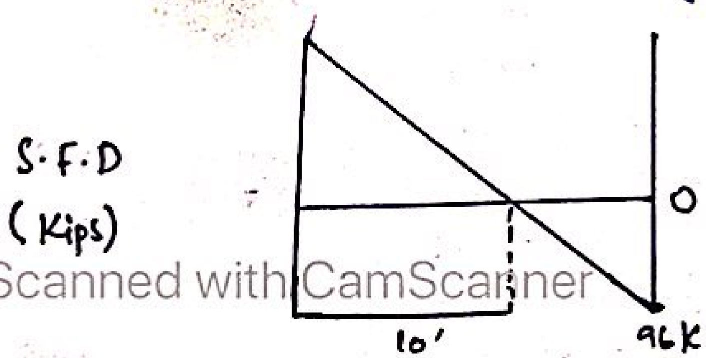


STEP #01:-

Find the value of R_1 & R_2

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

STEP# 2:- Draw shear force diagram:-

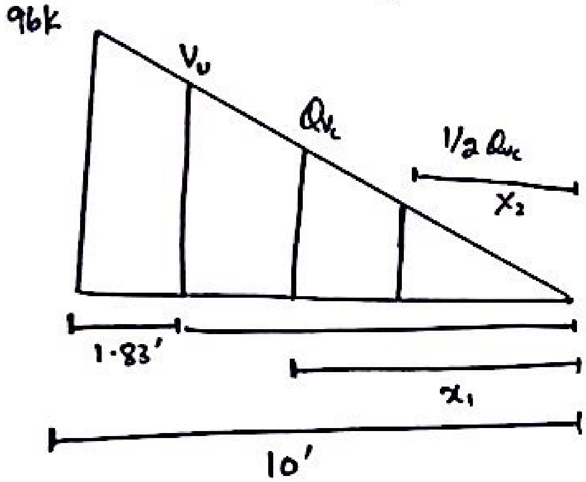


Step #03:-

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

→ As critical section is located at distance "d" from face of support $= a = 22'' = 1.83'$

→ Value of critical shear of distance "d" by similarity of triangles.



From similar triangles $96/10 = \dfrac{V_u}{8.17} = 78.432$ kips

STEP#04:-

Find the value of (ϕV_c) and $1/2\,\phi V_c$ and also its distences from zero shear to right side.

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

$$\Rightarrow \boxed{33.40\ k}$$

Location of ϕV_c by similar Δ's.

$$96/10 = \frac{33.40}{x_1} = 3.47' \qquad \boxed{x_1 = 3.47'}$$

Now

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

Location of $\frac{1}{2}\phi V_c = 96/10 = 16.70/x_2$ = $\boxed{x_2 = 1.73'}$

Step #05

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

$\phi V_s = V_u - \phi V_c = 76.80 - 33.40$

$\boxed{\Rightarrow 43.40\,k}$

Step #06

Check on section adequency.

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

$\boxed{\Rightarrow 133.57\,k}$

As $\phi V_s < \phi \times 8 \times \sqrt{f'_c} \times b_w \times d \Rightarrow$ It means section is adequate

Step #07:-

Check on maximum spacing for stirrups

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

$\Rightarrow \boxed{66.79 \text{ kips}}$

As $\phi 4 \sqrt{f'_c}\, b_w d > \phi V_s = 49.40k$

So maximum spacing will be selected from following 4 conditions:

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

2) $d/2 = 22/2 = \boxed{11''}$

(3) $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w} = \boxed{17.40''}$

(4) $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w} = \boxed{16.50''}$

From above four conditions - least value of spacing for #3, 2 legged stirrups will be selected.

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

Step # 8:-

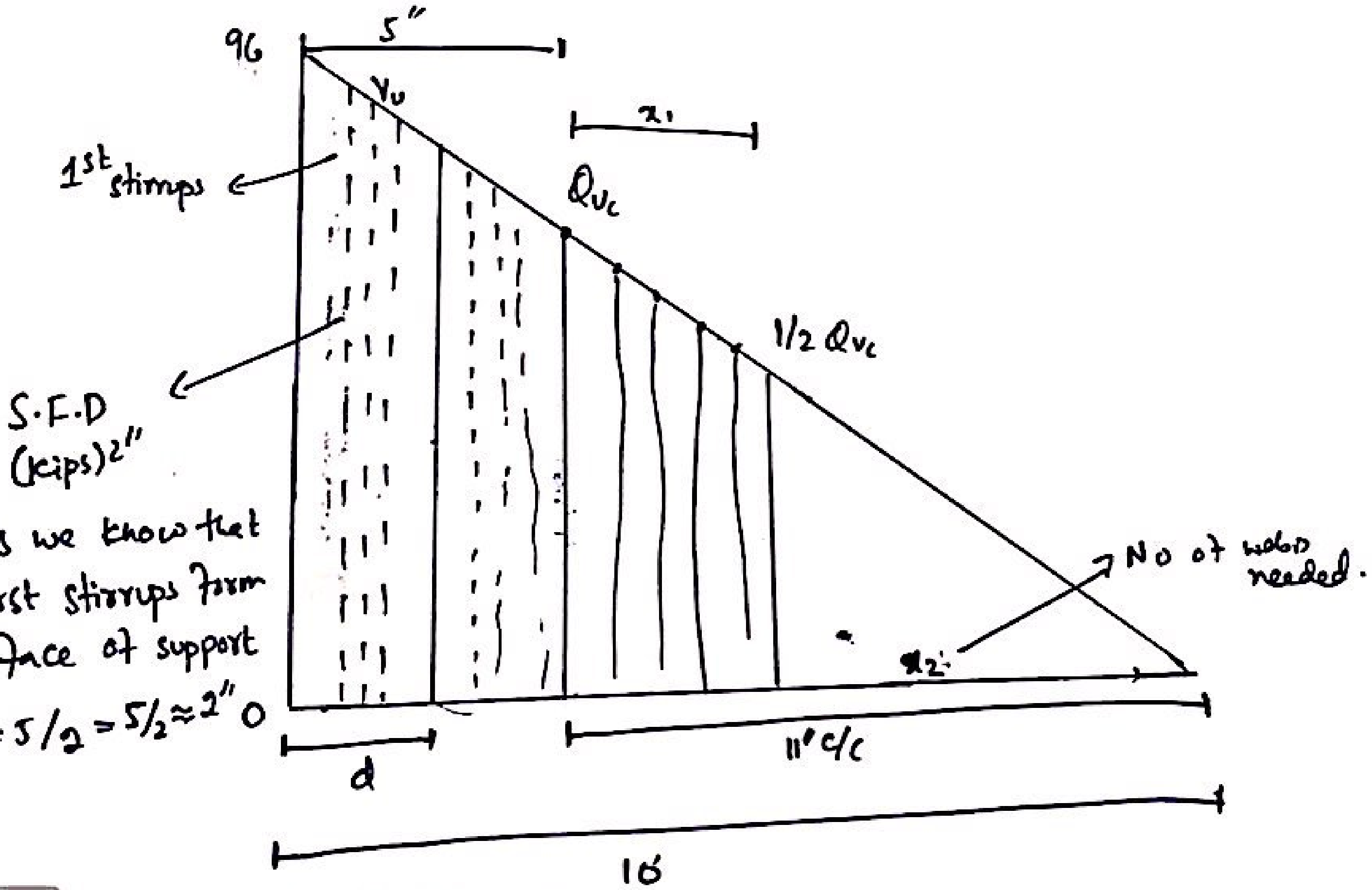
Spacing of Stirrups from at critical section.

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{76.80 - 33.44}$$

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

Step # 9

Final sketch



As we know that first stirrups from face of support $= 5/2 = 5/2 \approx 2''$ O

Q.No =(3)

calculate the axial ....

Solution

Step # 1:-

Find gross area of concrete

$A_g = b \times b$ (square column so)

$A_g = 12 \times 12 = $ **144 in² 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.

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

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

$P_u = 466.50 K$

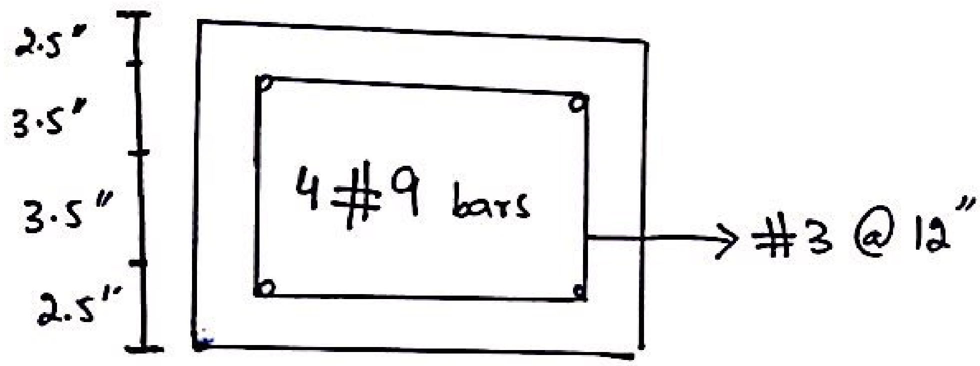
Step #(4):- Sketch & design of Ties (c/c to distance)

The least value should be selected

from the below values.

1) 16 x dia of length 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"



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

(11)

Question (4)

SOLUTION:-

Step # 01:-

let $h = 24''$

Step # 02:-

Total weight = wt of soil + wt of Rc

$3 \times 120 + 2 \times 150 = 660$ psf $\Rightarrow 0.660$

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.

$$\text{Area} = \frac{S.L}{q_c} = \frac{100 + 120}{1.84} \Rightarrow \text{Area} = 119.56\, ft^2$$

Step # 5:-

Since foundation is square

$\text{Area} = B \times B = 119.56$

$B \cong 119' - 56''$

Step #6:-

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

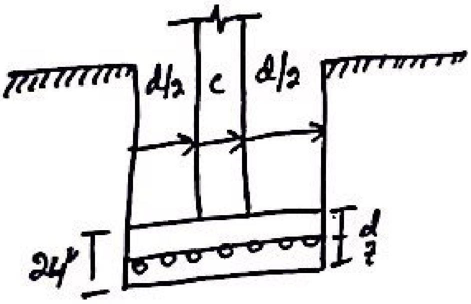
$$= \frac{1.2 \times 100 + 1.6 \times 120}{(119.56)^2}$$

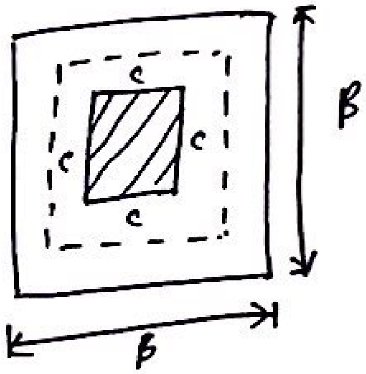
$$\boxed{q_{up} = 0.021\ k/ft^2}$$

Step # 7:-

Ponching shear

$b_o = 4 + (c+d)$





$d = h - \text{clear cover} - \text{dia of bar} - \frac{1}{2} \times d_b$

$d = 24 - 3 - 1 - \frac{1}{2} + 1 = 19.5''$

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

Step# 08:-

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

$$= 0.021 \left[(119.56)^2 - \left(\frac{16 + 19.5}{12} \right)^2 \right]$$

$$\boxed{V_{v_2} = 300}$$

Step # 09:-

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

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

$$\boxed{\phi V_{up} = 525.38}$$

Step # 10 :-

Beam Shear/one way shear check.

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

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

$$\boxed{V_{u_1} = 90.95\ K}$$

Step # 11 :- self shear capacity.

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

$$= \frac{0.75 \times 2\sqrt{4000} \times (115 \times 12 - 16)}{1000}$$

$$= 110.04\ K > V_{u_1} \Rightarrow O.K$$

Step # 12: Ultimate moment

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

$$M_u = 331.49\ K' = \boxed{3977.93\ K''}$$

Step 13:-

Area of steel for main bars by Trail and repeat method.

Trial #01:

Let $a = 0.2 \times 4 = 0.2 \times 24 = \boxed{4.8''}$

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

$$\boxed{= 8.56\ in^2}$$

Trial # 02:

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

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

Trial #03:

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

$$A_s = \frac{3977.93}{0.90 \times 60 (11 - \frac{1.28}{2})} = \boxed{7.14\ in^2}$$

Thus $\boxed{\text{Area} = 7.14\ in^2}$

Scanned with CamScanner

Step #14:

Check the min reinforcement by the following 03 methods.

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

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

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

$$\boxed{= 8.58 \text{ in}^2}$$

$$A_{s\,min} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times 11 \times 12 \times 19.5$$

$$\boxed{= 7.05 \text{ in}^2}$$

From the above values greater value will be selected.

Step #15

Using #8 Bars.

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

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

$= 10.92 \approx 11$ bars in each direction.

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