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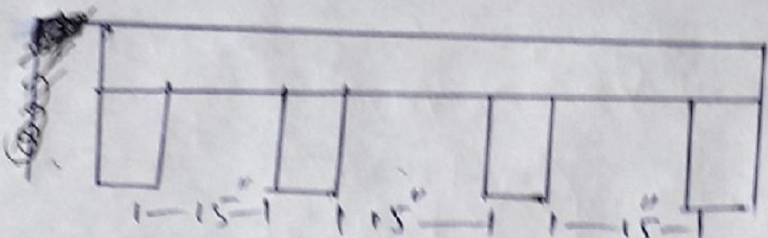
Q#01

Given data:

→ 3 equal spans concrete slab
→ Clear span b/w supports = 15ft
→ factored live load = 160 lb/ft
→ service floor finish load = 20 lb/ft^2
→ $f_c' = 4000$ psi
→ $f_y = 40$ ksi

Solution:



Step#01

Minimum Thickness

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

As $f_y \rightarrow 40$ ksi

So multiply this factor with thickness

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

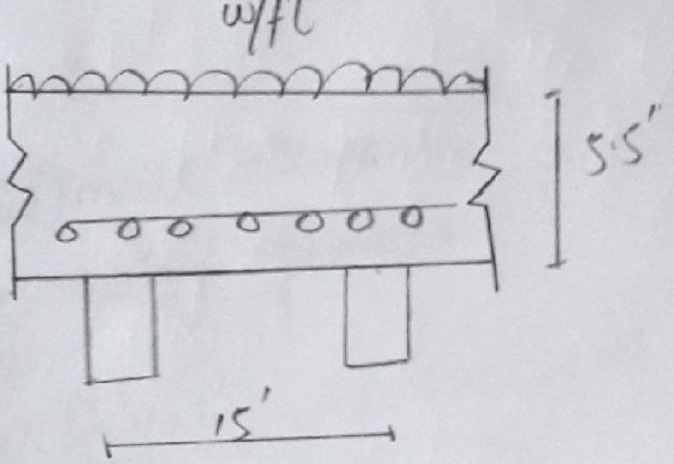
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be

6.5×0.8

$T_{min} = 5.2 \simeq 5.5''$

Step#02



By formula

$d = T -$ clear cover $- 1/2$ (dia of main bars)

$= 5.5 - 0.75 - 1/2\,(5/8) \simeq 4.5''$

Step#03 ~~ste~~ Self weight of slab

By formula

$= T/12 \times \gamma_{concrete}$

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

Step#04 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 = $D.L + L.L$

$= 106.5 + 160 = 266.5\ lb/ft^2$

or

$\Rightarrow$ $0.2665\ k/ft^2$

Step#05

Ultimate Moment

By using formula.

$$M_u = \frac{W_u \times L^2}{8} = \frac{0.2265 \times 15^2}{8} \times 12 = 89.94\ kip\text{-}inch.$$

Step#06

Area of Steel for main Bars By Trial & Repeat method.

* Trial #01

  Let depth of Compression block

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

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{1.1}{2})} = 0.63\ in^2$$

* Trial #02

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b} = \frac{40}{0.85 \times 4 \times 12} = 0.62\ in^2$$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - 0.6/2)}$$

$$A_{ST} = 0.59 \, in^2$$

* Trail # 03:

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

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

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

Step# 07 Area of Steel for distribution Reinforcement

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

$= 0.002 \times 12 \times 5.5 = 1.32 \, in^2$

Step# 08: Spacing of Main bars

Spacing $A_b / A_{st} \times 12$

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

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

Step#9

Spacing for distribution bars.

Spacing = A_b/A_{st}

we use #5 bar so

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

Spacing = $\frac{0.31}{0.132} \times 12 = 27.48'' \approx 28''\ c/c$

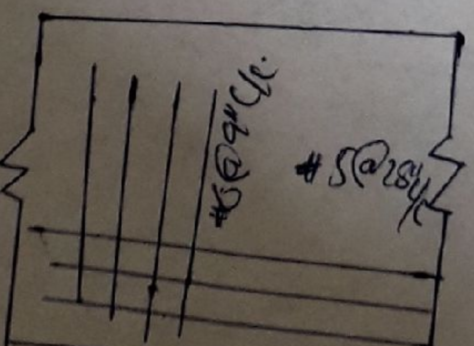
Step#10

Find Sketch

$f_c' = 4\,ksi$, $f_y = 40\,ksi$

Main steel #6 at 9" c/c

distribution steel #5 at 28" c/c



Q#02: A simply supported (7) - - -
- - - - - diagram.

SOLUTION:

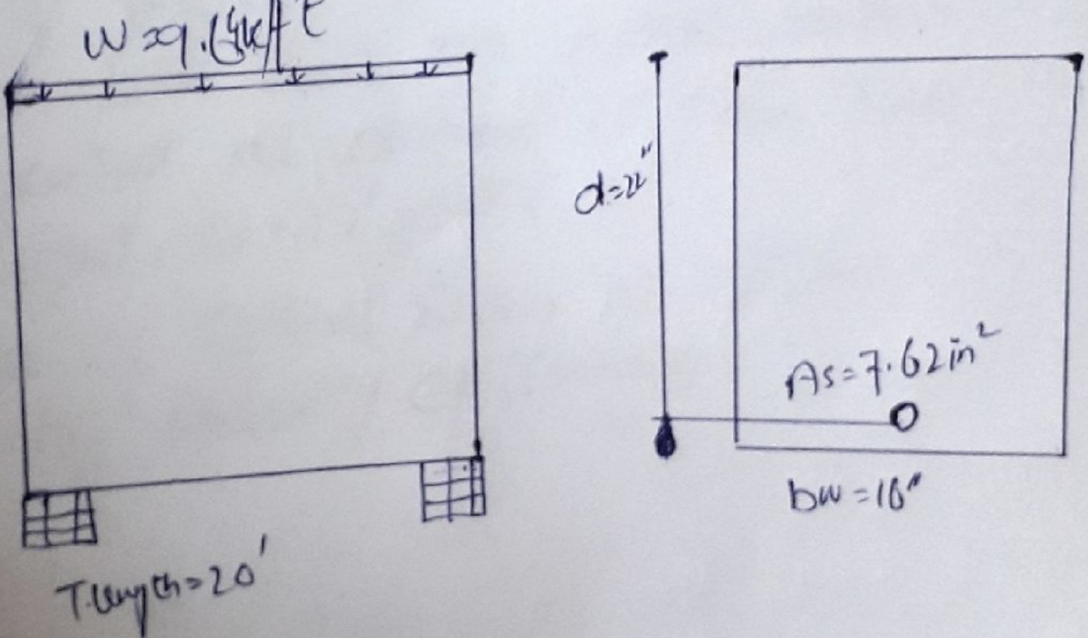
first of all find the unit load of beam.

So $b \times \gamma_c$

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

→ Now, $1.2 \times 0.2 = 0.24$

→ Total factored load $= 9.4 + 0.24 = 9.64\ k/ft$



Step#01

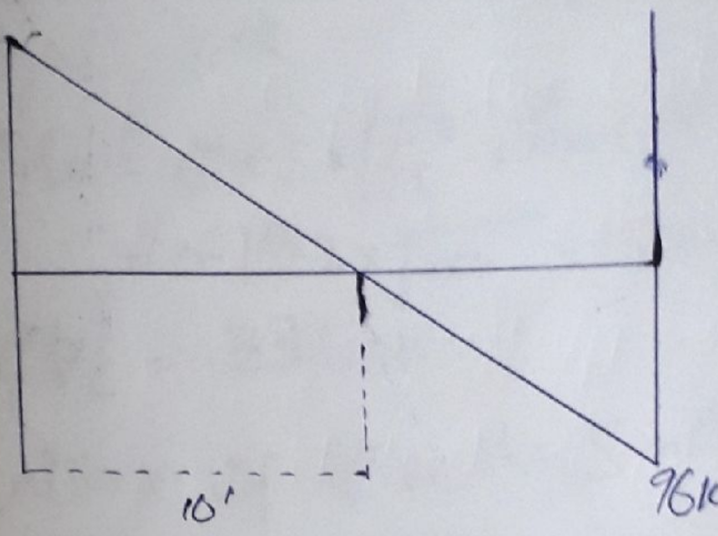
find value of R_1 and R_2

Total load $= 9.64 \times 20/2 = 96k$

Step#02

Draw The shear force diagram.

S.F.D (kips)



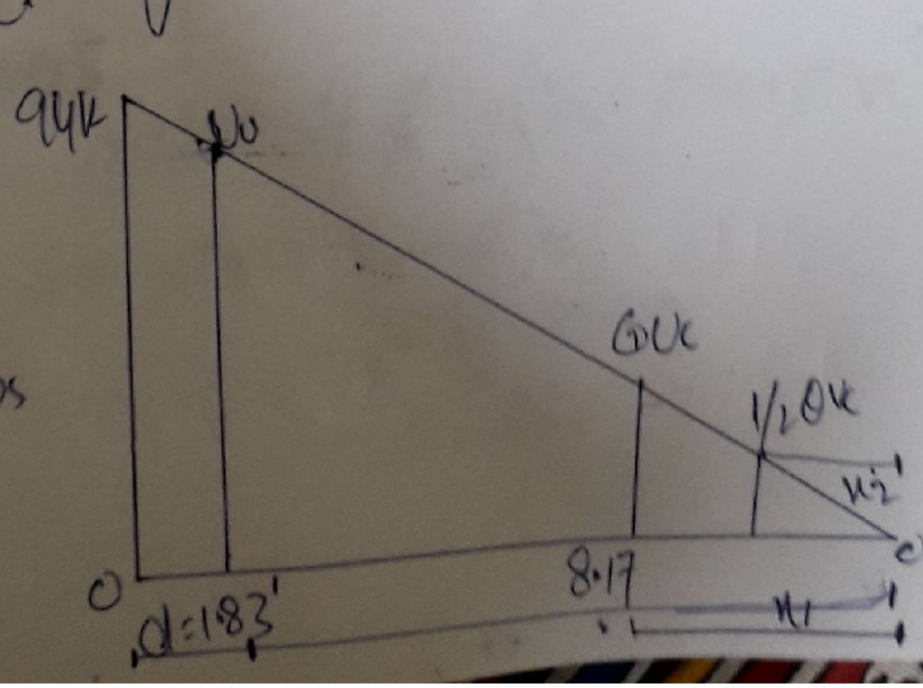
Step#03

find The value of Critical Stress "Vu" and its location.

→ we know that, the critical section is located at distance "d" from face of support. $d = 22'' = 1.83'$

value of Critical Shear at distance 'd' by Similarity of Triangles.

SFD kips



Step#4

find value of 'ϕV_c' and '$1/2 \phi V_c$' and also it distances from zero shear to Right side.

$$\phi V_c = \phi * 2 \times \sqrt{F_c'} \times b_w \times d$$

$$= 0.75 \times 2 \times \sqrt{4000} \times 16 \times 22$$

$$\phi V_c = 33.40k$$

location of ϕV_c by Similarity of Δ's

$$\frac{96}{10} = \frac{33.40}{x_1} = 3.48'$$

Now

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

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

$$\Rightarrow x_2 = 1.74'$$

Step#05 value of ϕV_s $(V_u = \phi V_s + \phi V_c)$

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

$$= 78.43 - 33.40$$

$$= 45.03k$$

Step# 06

Check on section adequacy

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

$$= 133.57k$$

As $\phi V_s < \phi 8 \sqrt{f_c'} b_w d$

Its means section is adequate.

Step# 7

Check on Section adequacy

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

$= 66.79 \text{ ksip}$

As, $\phi 4 \sqrt{f_c'} \, b_w \, d > \phi V_s = 43.40k$

So, max-Spacing will be selected from following four Conditions

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

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

3) $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$

4) $S_{max} = \frac{A_v \times f_y}{50 \times b_w} = \frac{0.22 \times 60000}{50 \times 16} = 16.50''$

from above four Conditions, least value of Spacing from #3. 2 legged Stirrup will be selected.

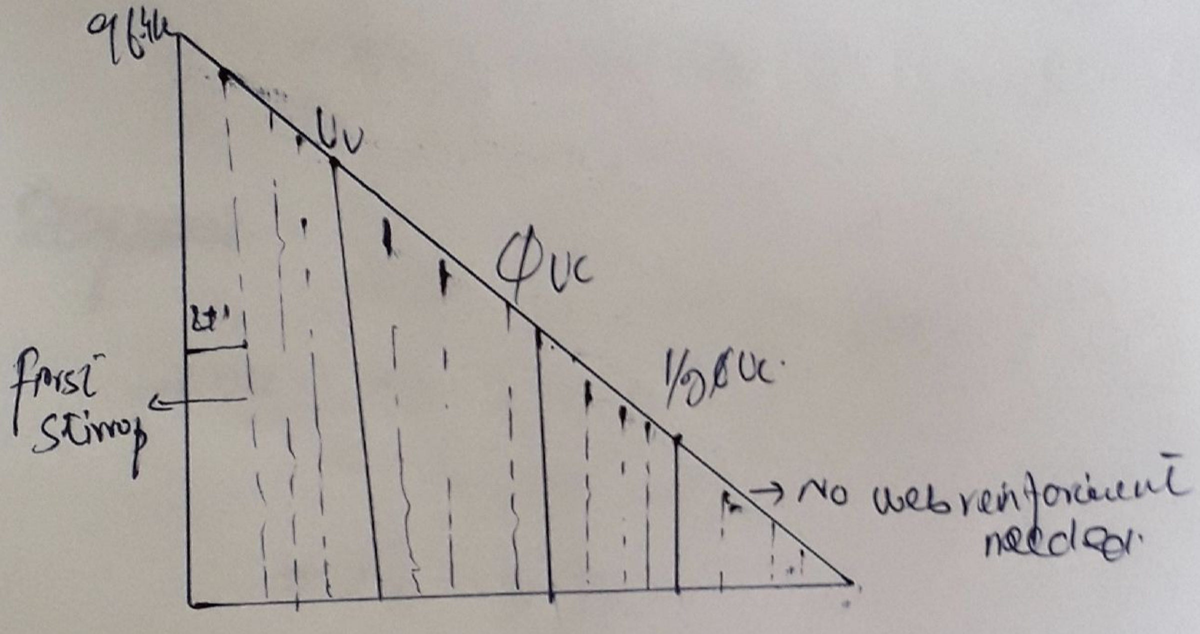
So $S_{max} = 11'' \, c/c$

Step# 08

Spacing of Stirrup from at Critical Section

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40} = 4.84'' \approx 5'' c/c$$

Step# 09



Q3:- Calculate (13) the Axial - - -

- - - - Spirals:

Step#01

Find gross Area Concrete.

$Ag = b \times b$ (Since it is squaretied column)

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

Step#02 Find the Area of Steel

Since $As = 5\%$ of Ag

$= 0.05 \times 144$

$\Rightarrow As = 7.2 in^2$

Step#03

Ultimate the load Carrying Capacity.

$Pu = \phi \times 0.80 \cdot [0.85 \times Fc' \times (Ag - As) + As \times fy]$

$= 0.65 + 0.80 [0.85 \times 4 (144.72) + 7.2 \times 60]$

$Pu = 466.50k$

Step#04:

Sketch & design of Ties (c/c To distance)

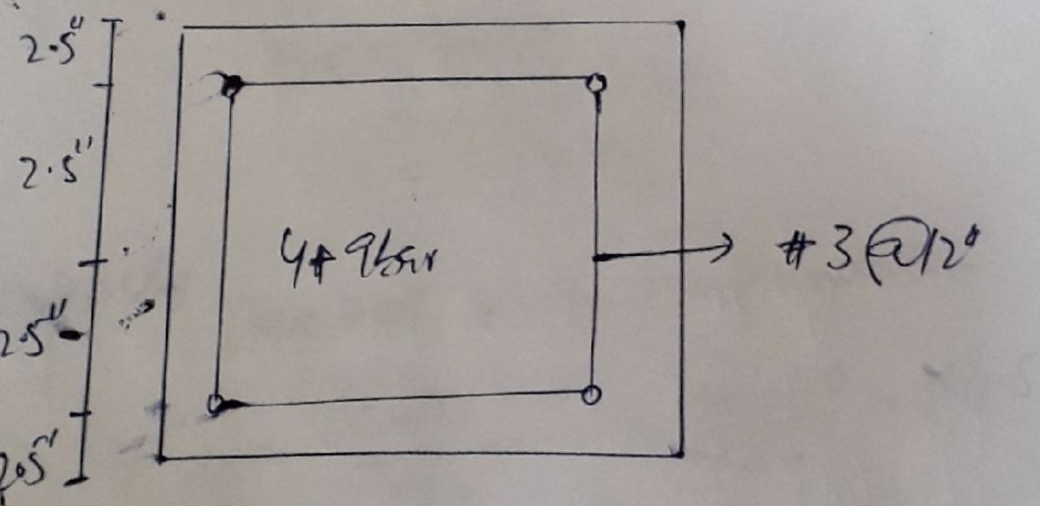
from The below value we choose The least value of All Thus

→ 16×dia of long bar = 16 × 9/8 = 18"

→ 48×dia of Tie bar = 48 × 3/8 = 18"

→ least Column dimension = 18"

So. c/c distance b/w Ties = 18"



→ Since it is a tied square column so there is no spiral stirrup used. The stirrup used is of rectangular shape due to specification of the structure Thus used will the tie stirrups instead.

Q#04 (15)

Design - - - - final design

Solution:

Step#01

let $h = 24"$

Step#02

Total weight = Wt of soil + wt of RC

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

$= 660 psf = 0.660 ksf$

Step#03 effective Bearing Capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$= 1.84 ksf$

Step#04 Required Area for foundation

$A_{req} = \frac{\text{Service load}}{q_e} = \frac{100+120}{1.84} = 119.57 ft^2$

Step#05 Since foundation is Square.

Area $= b \times b = 119.57 \approx 11'$

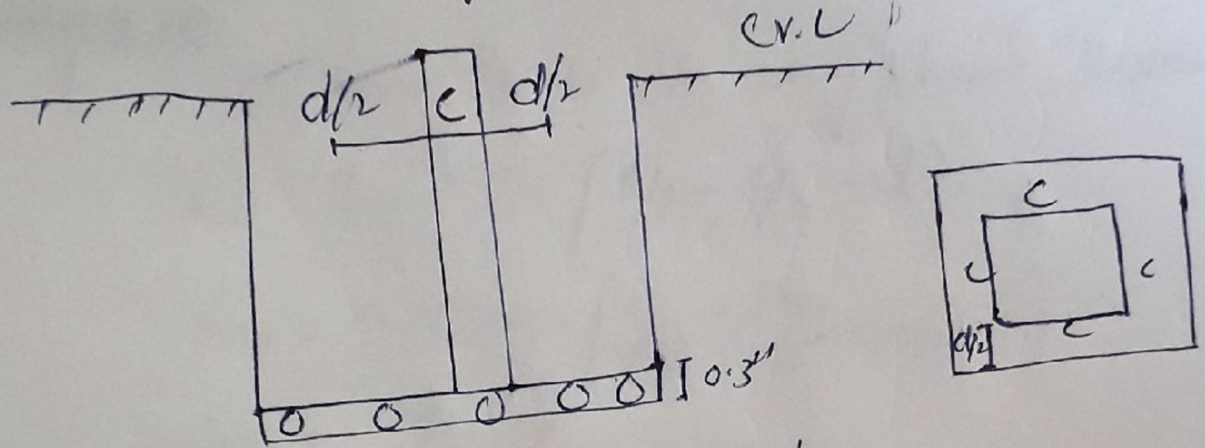
Step#06: Upward bearing Capacity of Soil.

$$q_{up} = \frac{\text{factored load}}{B^2} = \frac{1.2\times100 + 1.6\times120}{4^2}$$

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

Step#07: punching Shear

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



$d = h - c.c - \text{dia of bar} - \frac{1}{2} d_b$ ∴ #8 bar,

$= 24 - 3 - 1 - \frac{1}{2}(1) = 19.5''$ dia $= 8/8 = 1''$

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

Step#08:

$$V_{u2} = q_{up}\left[B^2 - (c+d)^2\right]$$

$$= 2.58\left[4^2 - \left(\frac{16+19.5}{12}\right)^2\right]$$

$$= 289.60k$$

Step# 09

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

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

$$= 525.38$$

Step# 10 Beam Shear on way shear Check

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

$$V_{u1} = 7.58 \times 11 \times \left[11/2 - \frac{16/12}{2} - 19.5 \right]$$

$$V_{u1} = 90.95k$$

Step# 11 Self Shear capacity.

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

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

$$= 110.04\ k > V_{u1} \Rightarrow \text{Okay}$$

Step# 12 ultimate moment.

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

$$= \frac{2.58 \times 11}{8} \times \left(11 - 16/12\right)^2 = 331.49 \Leftarrow 3977.93k''$$

Step#13

Area of Steel for main bars by Trail & Repeat method.

Trail#01

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

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

Trail#02

$$\Rightarrow a = \frac{A_s \times F_y}{0.85 \times f_c' \times b} = 1.53''$$

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

Trail#03

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

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

So their Area = $7.1 \, in^2$

Step#14: Check The min Reinforcement

a) $A_{smin} = 0.0018 \times B \times h = 0.0018\,(11\times12)\times 24$
$= 5.70\,in^2$

b) $A_{smin} = \frac{200}{fy} \times B \times H$
$= \frac{200}{60000}(11\times12)\,19.5$
$= 8.58\,in^2$

c) $A_{smin} = \frac{3\times\sqrt{fc'}}{Fy} \times B \times d = \frac{3\sqrt{3000}\times(11\times12)\times19.5}{60000}$
$= 7.05\,in^2$

→ From above value greater value will be Selected $A_{smin} = 8.58\,in^2$.

Step#15:

Using #8 bare
we get
$A_b = 0.785\,in^2$

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