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Q No 2 A simply supported rectangular beam 16" wide ... ... Draw a sketch of your final diagram.

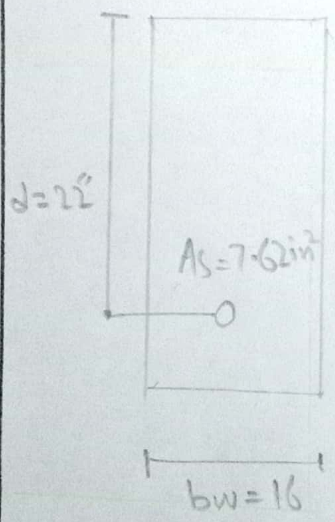
Sol First of all find the unit load of beam

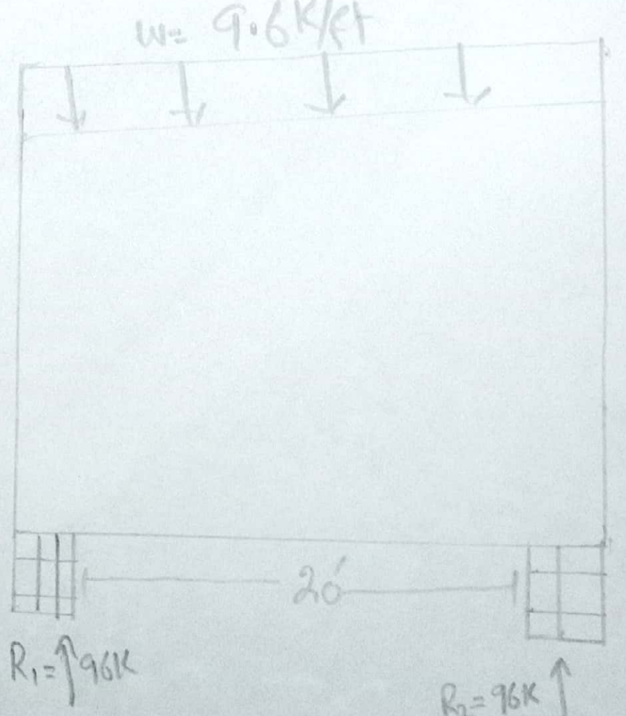
So $b \times \gamma_c$

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

So total factor load $= 9.4 + 0.2$

$= 9.6K/ft$



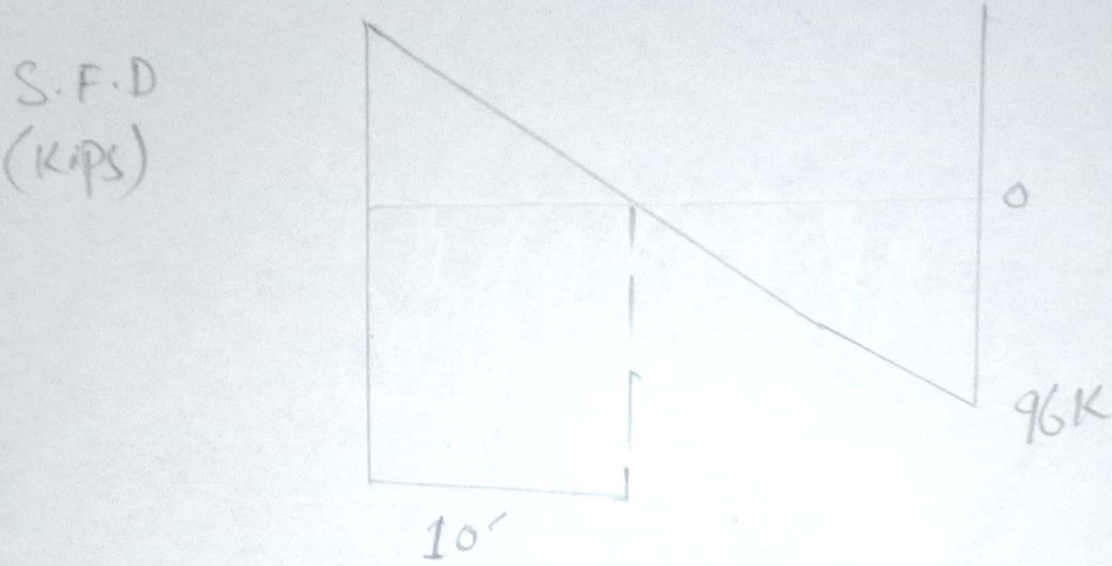


Step#01

Find the value of R_1 and R_2

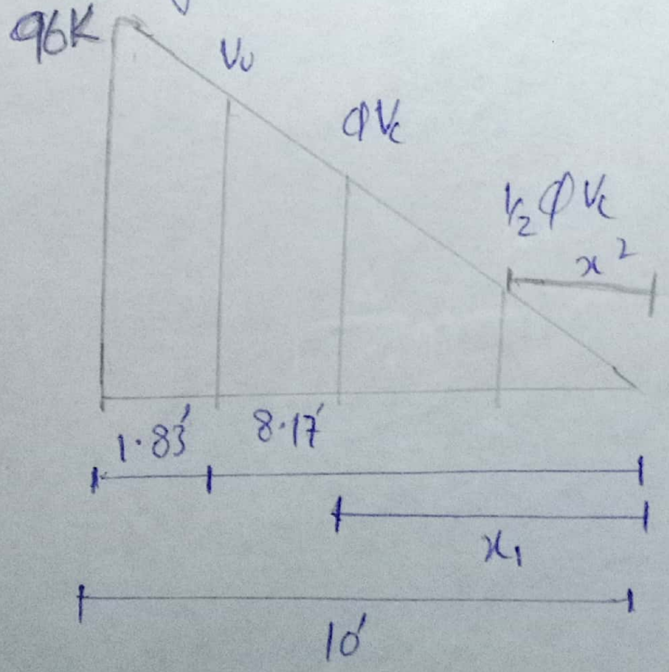
Total load $= 9.6 \times \frac{20}{2} = 96K$

Step #2 Draw its shear force diagram.



Step # 3 Find the value of critical stress "V_u" and its location.

As we know that 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



From similar Δ's

$$\frac{96}{10} = \frac{V_u}{8.17}$$

$$\boxed{V_u = 78.43K}$$

Step # 4 Find the value of "ϕV_c" {$\frac{1}{2}\phi V_c$"}
also its distance from zero shear to right side

$$\phi V_c = \phi \times 2 \times \sqrt{f'c} \times bw \times d \Rightarrow \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$$

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

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

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

Step#5 Value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

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

$\phi V_s = 78.43 - 33.40$

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

Step#16 check on section adequacy

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

$$= 133.57K$$

As $\phi \times 8 \times \sqrt{f'_c} \times bw \times d > \phi V_s$ → It means section is adequate

Step#07 Check on min spacing for stirrups.

$$\phi \times 4 \times \sqrt{f'_c} \times bw \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79K$$

As $\phi 4 \sqrt{f'_c}\, bwd > \phi V_s = 45.03K$

Thus max spacing will be selected from the following four condition

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

(2) $\frac{d}{2} = \frac{22}{2} = 11''$

(3) $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'_c} \times bw}$

$$A_v = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$$

$$= 17.40''$$

$A_v = 0.11 \times 2$

$A_v = 0.22$

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

$$= \frac{0.22 \times 60000}{50 \times 16}$$

$$= 16.50$$

From the above four condition least value of spacing from #3, U shaped will be selected

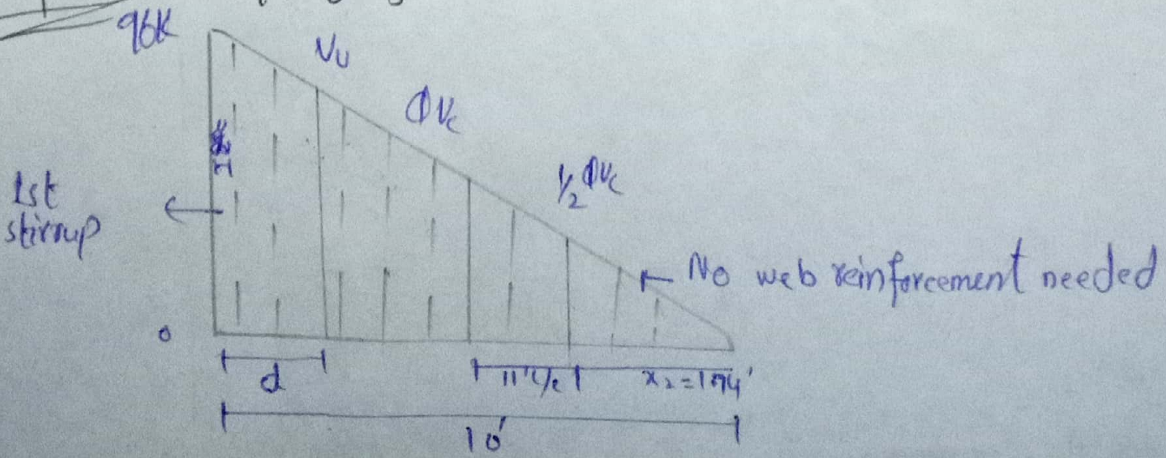
So $S_{max} = 11''$ c/c

step#08 Spacing of stirrup from/at critical section

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

$$= 48.4'' \approx 5''\ c/c$$

step#9 Find sketch



→ As we know that first stirrup from face of support.

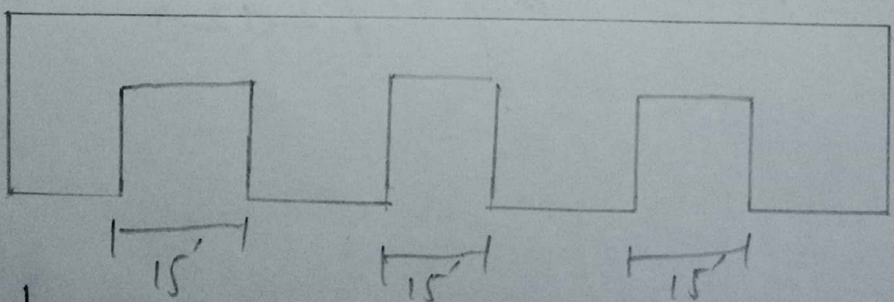
$\rightarrow \frac{5}{2} = 2.5 \approx 2''$

Q No 1 A reinforcement concreate slab is ——
—— Draw sketch of your final design.

Given Data

- → Clear span b/w support = 15′
- → Factored live load = 160 lb/ft^2
- → Server floor finish load = 20 lb/ft^2
- → f'_c = 4000 psi
- f_y = 40 ksi

Sol



Step#01 Minimum thickness
By using formula

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

As $f_y \rightarrow 40ksi$

So we will multiply a factor with this thickness

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

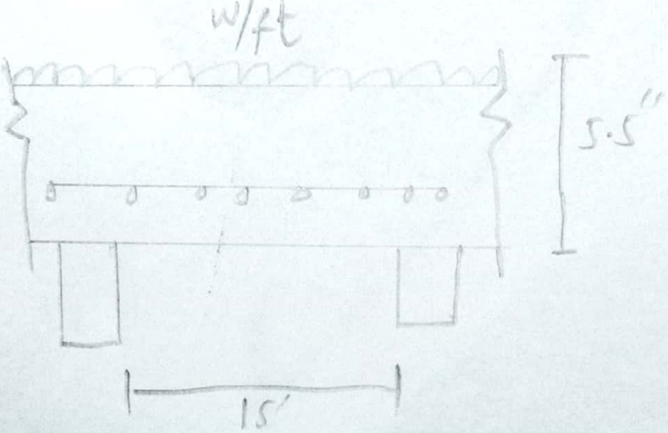
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be

$$6.5 \times 0.8$$

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

Step # 2 :- Effective Depth.



By formula

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

$$= 5.5 - 0.75 - \tfrac{1}{2}\left(\tfrac{5}{8}\right)$$

$$d = 4.5''$$

Step # 03 Self weight of slab

By formula

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

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

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 $= D.L + L.L$

$= 106.5 + 160$

$= 266.5 \, lb/ft^2$

$= 0.2665 \, k/ft^2$

Step # 05 Ultimate moment

By using formula

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

Mu = 89.94 Kips-inches

Step#6 Area of steel for main bars by Trail and repeat method.

Trail #01

let depth of compression block

$a = 0.2 \times t$

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

~~Ast = 0.63 in²~~

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

$A_{st} = 0.63\,in^2$

Trail #02

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

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

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

Trail #03

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

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

So we will use $Ast = 0.59\,in^2$

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#08 Spacing for main bars

By formula

$$\text{Spacing } \frac{Ab}{Ast} \times 12$$

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

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

step#09 spacing for distribution bars

$$\text{spacing} = \frac{Ab}{Ast}$$

We use #5 bar so

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

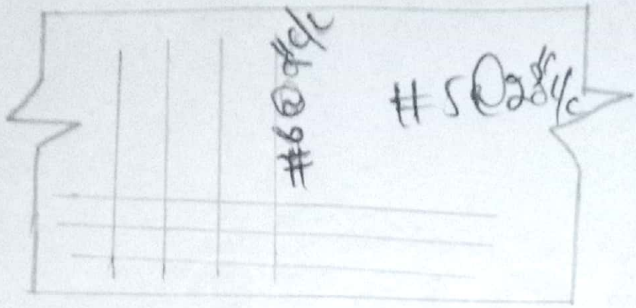
$$\text{Spacing} = \frac{0.31}{0.132} \times 12 = 28.1'' \approx 28''\, c/c$$

step#10 Find Sketch

$f'c = 4ksi$, $fy = 40ksi$

Main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c



Q No 3 Calculate the axial ultimate — design necessary spirals

Step #01 Find gross area of concrete

$Ag = b \times b$ (since it is squave tied column)

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

Step #02 Find the area of steel

Since $As = 5\%$ of Ag

$= 0.05 \times 144$

$As = 7.2 in^2$

Step #03 Ultimate load carrying capacity

$Pu = \phi \times 0.80 \times \{0.85 \times f'c \times (Ag - As) + As \times fy)$

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

$Pu = 466.50 K$

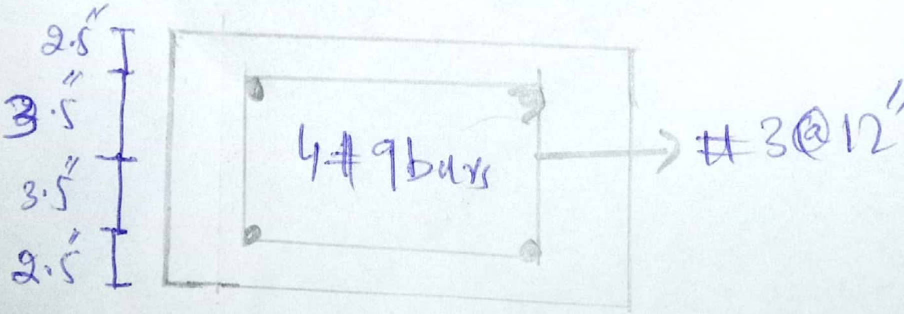
Step#04 sketch and design of Ties (c/c to distance)

From the below value we choose the least 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"



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.

Q4 Design a square footing ------ sketch of your final design.

Step #01

let $h = 24''$

Step #02

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

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

$= 660 psf = 0.660 ksf$

Step #03, Effective bearing capacity.

$q_e = q_a - w$

$q_e = 2.50 - 0.660$

$q_e = 1.84 ksf$

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

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

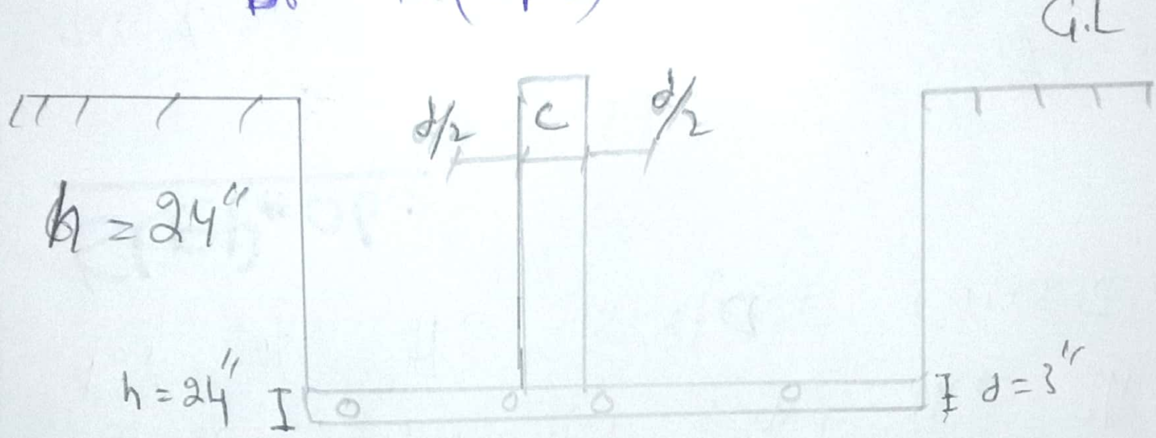
Step #6 upward bearing capacity of soil

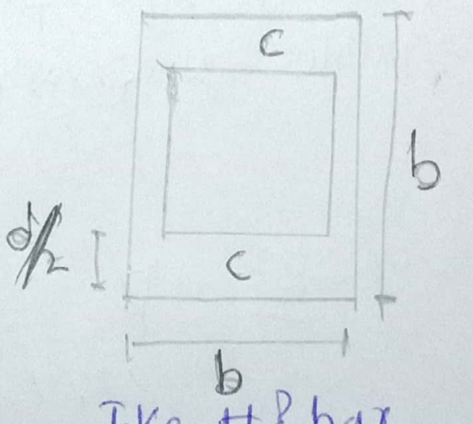
$$q_{up} = \frac{\text{factored load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

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

Step #7 Punching shear

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





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

Take #8 bar

dia = 8/8" = 1"

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

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

Step#08

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

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

$$V_{u_2} = 289.60K$$

Step#09

$$\phi V_{c/p} = \phi \times 4 \times \sqrt{f'_c} \times b \times d$$

$$= \frac{0.75 \times 4 \times \sqrt{4000} \times 149 \times 19.5}{1000}$$

$$\phi V_{c/p} = 525.38$$

Step#10 Beam shear/one way shear check

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

$$V_{u_1} = 2.58 \times 11 \times \left[11/2 - \frac{16}{12}/2 - 19.5\right]$$

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

Step#11 Self shear capacity

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

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

$= 10.04K > Vu_1 \Rightarrow O.K$

Step# 12 Ultimate moment

$$Mu = \frac{q_u P \times B}{8} \times (B - C)^2 = \frac{2.58 \times 11}{8} \times \left(11 - \frac{16}{12}\right)^2$$

$$Mu = 331.49 K' \approx 3977.93 K''$$

Step# 13 Area of steel for main bars by trial and Repeat method.

Trial #01

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

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

Trial #02

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

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

Trial #03

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

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

So that area $= 7.1 m^2$

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

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

(b) $As_{min} = \frac{200}{fy} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5 = 8.58 in^2$

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

$= 7.05 in^2$

From the above value greater value will be selected thus $As_{min} = 8.58 in^2$

Step # 15 using # 8 bar

$Ab = 0.785 in$

Ab of bars $= \frac{As}{Ab} = \frac{8.58}{0.785} = 10.92 = 11$ bars in each direction