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Question No 1

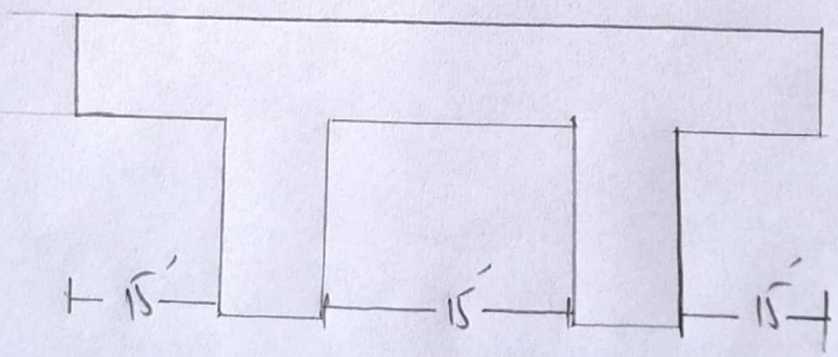
Given data:

- 3 equal span concrete slab
- Clear span b/w supports = 15 ft
- factorized line load = 160 lb/ft^2
- Service floor finish load = 20 lb/ft^2

f'_c = 4000 psi

f_y = 40 ksi

Solution:



Step # 1 (Minimum thickness)

By the help of formula

$t_{min} = l/28 = 15/28 = 6.4 \simeq 6.5$

As $f_y \rightarrow 40$ ksi

So we will multiply a factor with this thickness factor $(0.4 + f_y/100)$

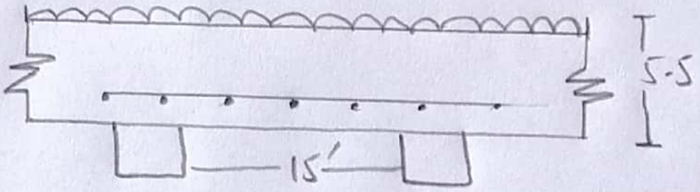
$= (0.4 + 40/100) = 0.8$

Hence the minimum thickness will be

6.5×0.8

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

Step #2 (Effective depth)



By formula we have

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

$= 5.5 - 0.75 - 1/2\,(4/8) \rightarrow (\text{use 4 no. bar})$

$d = 4.5'$

Step #3 (Self wt of slab)

we know that

$t/12 + \gamma_{concrete}$

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

Step #4 (Total factor load)

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

so the factored Dead load will be

$D.L = 1.2(70 + 68.75) = 106.5 \ lb/ft^2$

Total factored load = D.L + L.L

$= 106.5 + 160$

$= 266.5 \ lb/ft^2$

$= 0.2665 \ k/ft^2$

Step #5 (ultimate moment)

we know that

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

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

$= 89.94$ kip-inches.

Step #6 Area of steel for main bars by trial & Repeat method.

- Trial # 1

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

$$Ast = \frac{Mu}{0 \times fy \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.62}{2})}$$

$$\boxed{Ast = 0.59 \ in^2/ft}$$

Trial #03:

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

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

∴ we use only $ast = 0.59 in^2$

Step #07 (Area of steel for distribution reinforcement)

$As \ min = 0.002 \times b \times T$ → for grade 40 steel.

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

Step #08 (spacing for main bar)

By formula of spacing

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

we are using # 5 bar

dia = $(4/8)''$, Area $= \frac{\pi}{4}(4/8)^2 = 0.19\ in^2$

$S = \frac{0.19}{0.59} \times 12 = 3.86 \approx 4.0''$

Hence 4'' c/c

Step # 09 (spacing for Distribution bars)

Also by using formula

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

we are using # 4 bar , so

dia = $(4/8)''$, Area = $0.19\ in^2$

$$\text{Spacing} = \frac{0.19}{0.132} \times 12 = 17.27$$

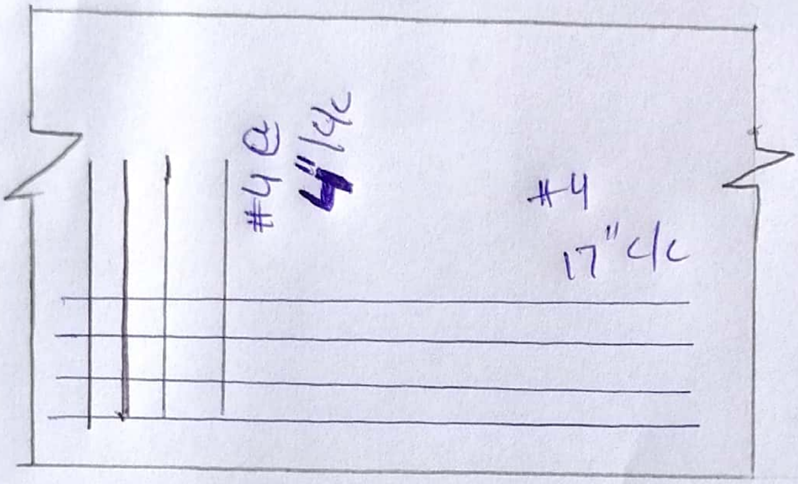
So 17'' c/c

Step#10

Final sketch

fc' = 4ksi   fy = 40ksi

Main steel bar = #4 at



(Question No 2)

Given data:

Breadth (b) = 16"

effective depth = 22"

Total factored load = 9.4 kips/ft

span = 20'

area of steel = 7.62 in²

fc' = 4000 = 7.62 in²

fy = 60000 psi

Solution:

To find the self-weight of beam

w = b × thickness × unit weight of concrete

$= b \times t \times 150\ lb/ft^3$ $t = b \times 12$ $= 16$

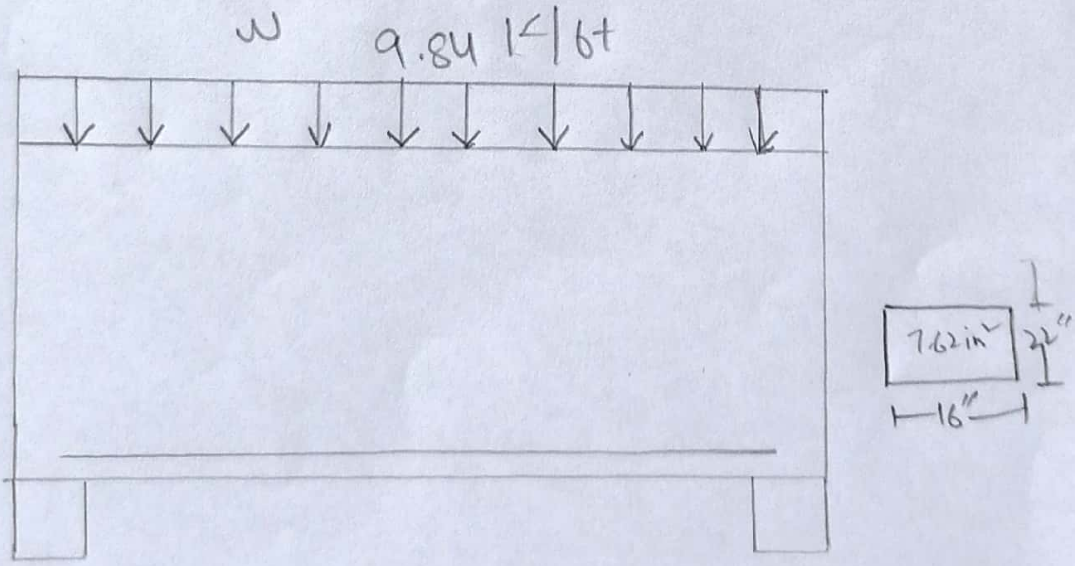
$= \frac{16}{12} \times \frac{22}{12} \times 150 = 366.6\ lb/ft$

• factor load will be

$= 1.2(0.366) = 0.44\ kips/ft$

Now the total applied factored load will be

$9.4 + 0.44 = 9.84\ kips/ft$

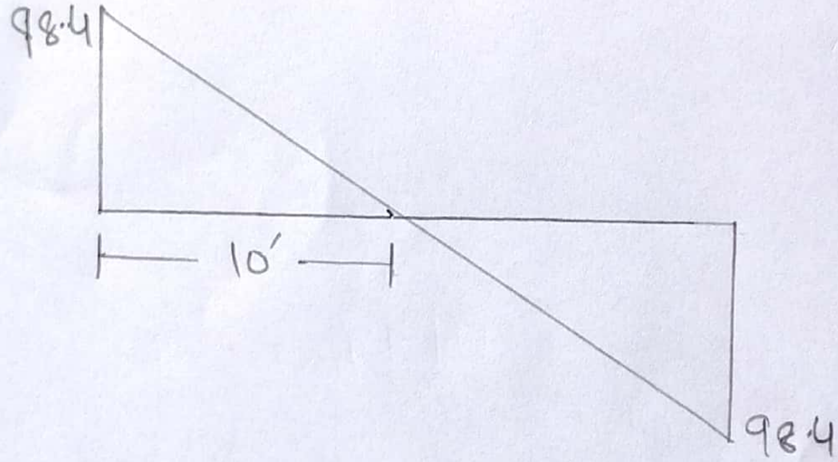


Step#1 (Reaction values)

$$\text{total Load} = \frac{9.84 \times 20}{2} = 98.4 \text{ kips}$$

so its clear that both supports have same load 98.4 kips.

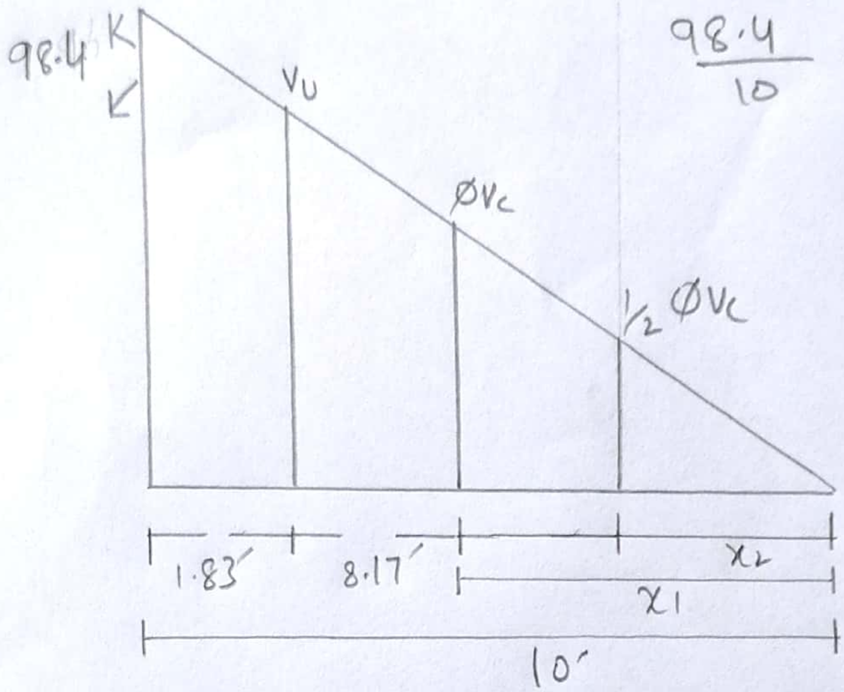
Step # 2 (Shear force Diagram)



Step # 3 (value of critical shear (Vu))

As critical shear (Vu) is Located at distance 'd' = 22″ = 1.83′

so by the help of similar triangles we will find the value of critical.



From similar Δs,

$$\frac{98.4}{10} = \frac{V_u}{8.17}$$

$V_u = 80.39$ kips

Step # 04 (Value of ϕV_c and $\frac{1}{2}\phi V_c$)

By using the help of formula

we know that

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

$$= \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000} = 33.40 \text{ kips.}$$

so

$$\frac{98.4}{10} = \frac{33.40}{x_1} \Rightarrow x_1 = 3.39'$$

Now

By using formula

$$\frac{1}{2}\phi V_c = \phi V_c / 2$$

$$= 33.40/2 = 16.70 \text{ kips}$$

Location of $\frac{1}{2} \phi V_c$

By similar triangles

$$\frac{98.4}{10} = \frac{16.70}{x_2} = x_2 = 1.69'$$

Step # 5 (value of ϕV_s)

As

$$V_u = \phi V_s + \phi V_c$$

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

$$= 80.39 - 33.40$$

$$\phi V_s = 46.99 \text{ kips}$$

Step # 06 (check on section adequacy)

By formula

$$\phi \times 8 \times \sqrt{f_c'} \times b_w \times d$$

$$= \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 32}{1000} = 133.57 \text{ kips}$$

As $133.57 > \phi V_s$

so the section is adequate!

Step # 07 (Mixmum spacing for stissups)

$$= \phi \times 4 \times \sqrt{f'c} \times bw \times d$$

$$= \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 66.79 \text{ kips}$$

As $\phi 4 \sqrt{f'c}\ bwd > \phi V_s$

so it shows the maximum spacing will be selected from the following 4 conditions.

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

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

3- $S_{max} = \frac{Au \times fy}{0.75 \times \sqrt{f'c} \times bw}$

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

∴ using #3 and dia is $3/8 = 0.11 in^2$
Now for 2 legged × by 2
0.11×2
$= 0.22 in^2$

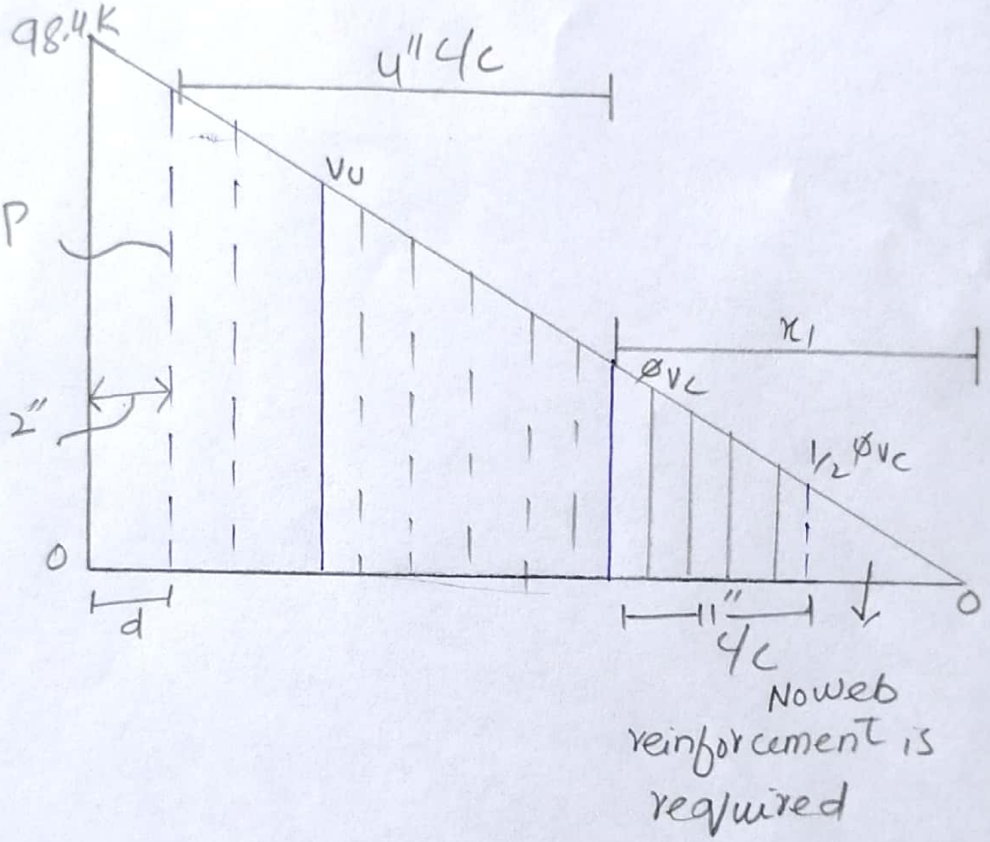
Now from above 4 conditions we use $S_{max} = 11''$ c/c

Step # 8 (spacing of stirup out at critical section)

By formula

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{80.39 - 33.40}$$

$\Rightarrow S = 4'' \, c/c = 4.6 \simeq 4$



First stirup

$= \frac{S}{2} = \frac{4}{2}$

$= 2''$

Question no 3

Solution:

Step # 01 (Find gross area of concrete)

we know that

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

$Ag = 12 \times 12 = 144 \text{ in}^2$ (actual)

Step # 02 (Find the area of steel.)

since $As = 5\%$ of Ag

$= 0.05 \times 144$

$As = 7.2 \text{ in}^2$

Step # 03 (Ultimate load carrying capacity)

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

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

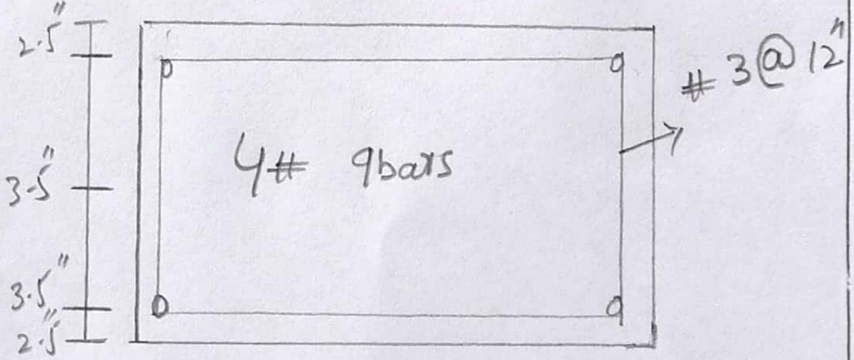
$Pu = 466.50K$

Step #4 (sketch & design of ties and center to center distance)

from the below value we choose the least value of all this.

- 16 x dia of long bar = 16 x 9/8 = 18"
- 48 x dia of tie bar = 48 x 3/8 = 18"
- least column dimension = 12"

So the center to center distance between 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

Solution:

Step 1

• So $h = 24''$

Step #2

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

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

$= 660 \text{ psf} = 0.660 \text{ ksf}$

Step # 03 (Effective bearing capacity)

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84 \text{ ksf}$

Step # 04 (Required area of foundation)

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

$= 119.57 \text{ ft}$

Step # 05 (while foundation is square)

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

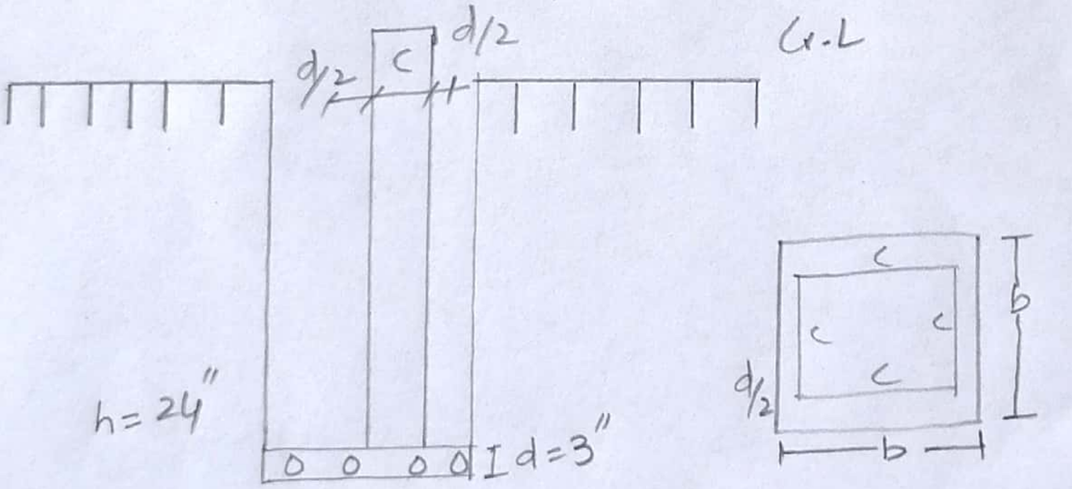
Step # 06 (upward bearing capacity of soil)

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

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

Step # 07 (punching shear)

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



∴ Take #8 bar

$$dia = \frac{8}{8} = 1$$

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

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

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

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Step 08 |

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

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

$$\boxed{V_{V2} = 289.60 \text{ kips}}$$

Step 9 (value of ϕV_{cp})

$$\phi = 4 \times \sqrt{f'c} \times b_a \times d$$

$$\frac{0.75 \times 4 \times \sqrt{3000} \times 142 \times 19.5}{1000} = 454.99K$$

Step 10 (Beam shear check)

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

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

$$V_{U1} = 91.05 \text{ kips}$$

Step 11 self shear capacity

By formula

$$= \frac{0.75 \times 2 \times \sqrt{3000} \times (11 \times 12) + 19.5}{1000}$$

$\phi V_c = 211.47 > V_{u1} \rightarrow$ ok!

Step 12 (Ultimate moment)

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

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

Step 13 Area of steel for main bars by trial & repeat method.

Trial 1

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

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

Trial 2

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

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

Trial 3

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

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

the area is $7.1 in^2$

Step 14

Check the min reinforcement by the following 3 Method.

a) $As_{min} = 0.0018 \times b \times h = 0.0018 \times (11 \times 12) \times 24$

$= 5.70 in^2$

b) $As_{min} = \frac{200}{f'y} \times b \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$

$\boxed{8.58 \ in^2}$

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

$= 7.05 in^2$

From the above value greater will be selected so Asmin $8.58 in^2$

Step #15 using # 8 bar

$Ab = 0.785 in^2$

No. of bars $= \frac{As}{Ab} = \frac{8.58}{0.783} = 10.92$

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