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Section A

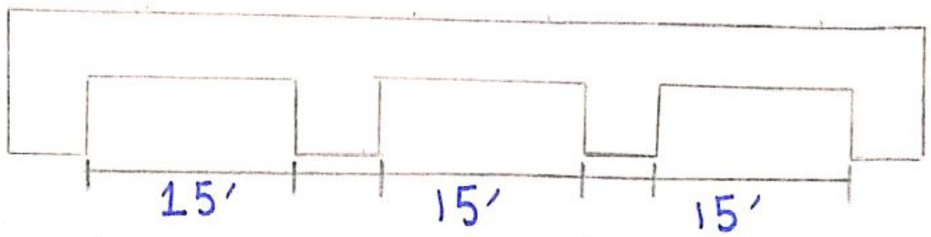
Semester 6th.

Subject PRC 1

Q 1

Given Data:-

Clear span between supports = 15 ft.
3 equal spans concrete slab.
Factored live load = 160 lb/ft^2
Service Floor finish load = 20 lb/ft^2
$f_c' = 4000$ psi
$f_y = 40$ ksi



Step 1 (Minimum Thickness)

Using formula

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

As $f_y \rightarrow 40$ ksi

We have to multiply a factor with this thickness.

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

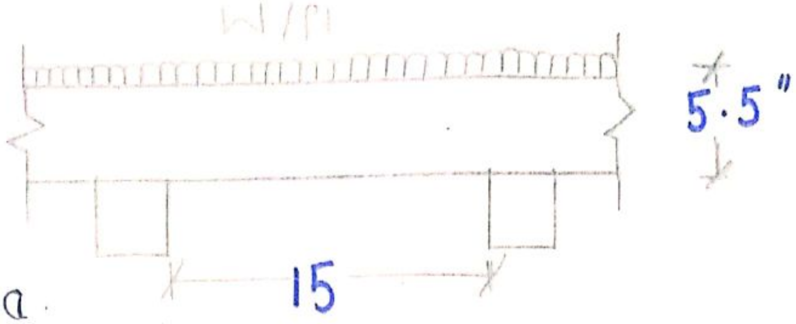
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

The minimum thickness will be

$$6.5 \times 0.8$$

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

Step 2 (Effective Depth)



Using formula.

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

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

$= 45''$

Step 3 (Self weight of slab)

Using formula.

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

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

Step 4 (Total Factored Load)

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

So factored dead load will be.

Dead load $= 1.2(20 + 68.75)$

$= 106.5 \text{ lb/ft}^2$.

Now

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

$= 106.5 + 160$

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

$= 0.2665 \text{ k/ft}^2$.

Step 5 (Ultimate Moment)

Using formula.

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

$= 89.94$ kips-inch.

Step 6

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

Trial : 1

Let depth of compression block.

$a = 0.2 \times t$

$= 0.2 \times 5.5 = 1.1''$

$$A_{st} = \frac{M_u}{\emptyset \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times \left(45 - \frac{1.1}{2}\right)}$$

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

Trial 2

$$a = \frac{A_{st} \times f_y}{0.55 \times f_c' \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} = 0.62 \, in^2$$

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

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

Trial 3

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

$$A_{st} = \frac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{0.57}{2}\right)}$$

$= 0.59 \, in^2$

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

Step 7

Area of steel for distibution reinforcemen

Using formula.

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

$= 0.002 \times 12 \times 5.5 = 0.132 \, in^2$

Step 8

Spacing for main bars.

Using formula.

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

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

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

Step 9

Spacing for distribution bars.

$Spacing = \frac{A_b}{A_{st}}$

We use #5 bars so.

dia $= (5/8)''$

Area $= \pi/4 \ (5/8)^2 = 0.31 \ in^2$.

$Spacing = \frac{0.31}{0.132} \times 12$

$= 2.81 \approx 28''$ c/c

Step 10 Find sketch.

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

Main steel #6 at 9" c/c.

Distibution steel #5 at 28" c/c.

Q 2

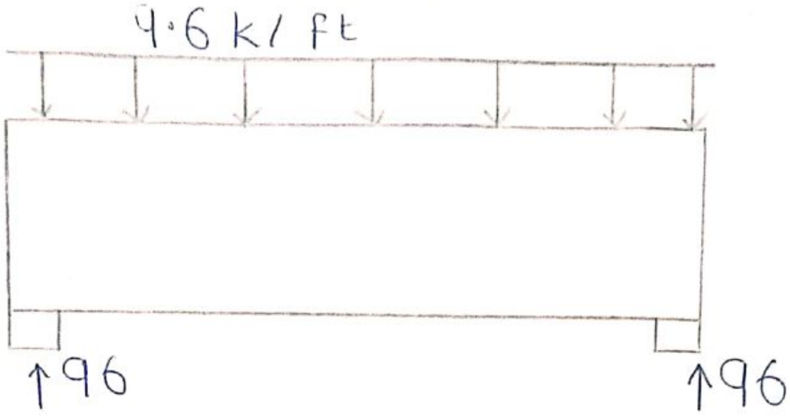
Sol:-

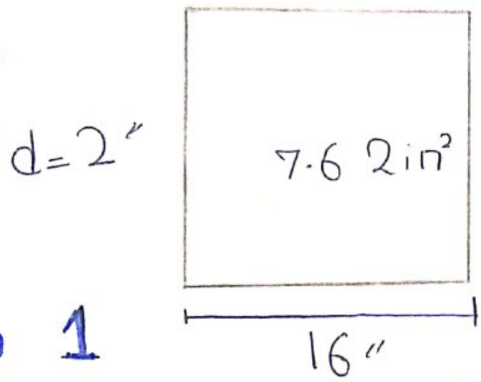
First we have to find unit load of beam

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

Total factored load $= 9.4 + 0.2$

$= 9.6\ k/ft.$





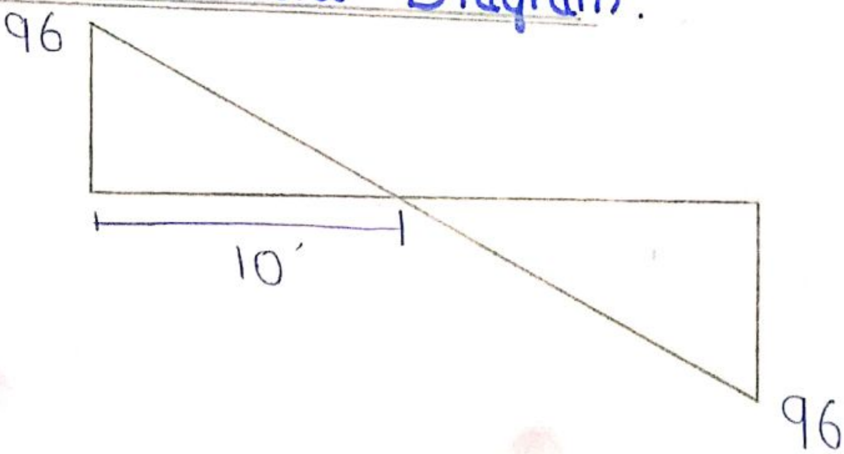
Step 1

Find value of R_1 & R_2

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

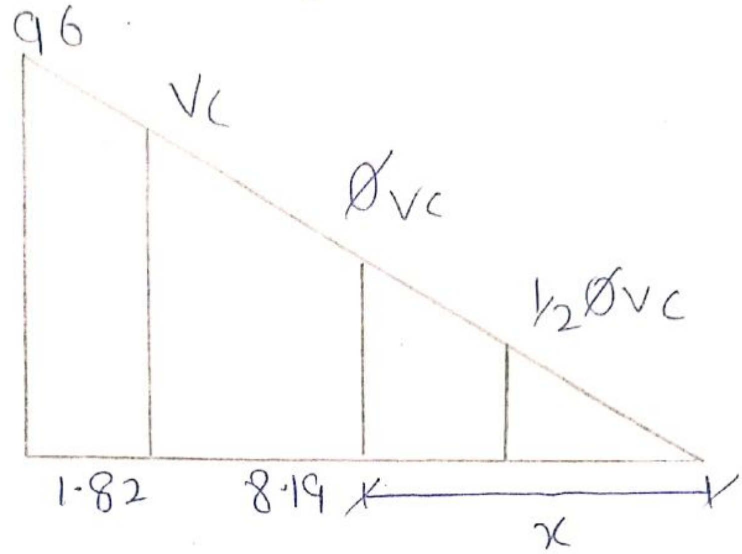
$= 96k$

Step 2 Shear Force Diagram.



Finding value of critical stress & its location

As we know critical section is located at distance "d" from face of $d = 22'' = 1.83'$ value of critical Shear. at distance "d" by similarity triangles



Step 4

Find values of 'ØVc' and '1/2 ØVc" and also distance from zero shear to right side.

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

$$= \frac{0.75 \times 2\sqrt{4000} \times 16 \times 22}{1000}$$

$$\phi V_c = 33.40k$$

Location of ØVc by similarity of 'Δs'

$$\frac{94}{10} = \frac{33.40}{x_1}$$

$$x_1 = 3.55'$$

Now

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

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{94}{10} = \frac{16.70}{x_2}$

$$x_2 = 1.78.$$

Step 5 (Finding value of $\emptyset V_s$)

$$V_u = \emptyset V_s + \emptyset V_c$$

So

$$\emptyset V_s = V_u - \emptyset V_c$$
$$= 76.80 - 33.40$$
$$= 43.40k.$$

Step 6

Check on Section adequacy

$$\emptyset \times 8 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$
$$= 133.57k.$$

133.57

Step 7

Check ~~minimum~~ max spacing for stirrups

$$\emptyset \times 4 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$$
$$= 66.79k > \emptyset V_s.$$

So maximum spacing will be selected from following 4 conditions.

1) $S_{max} = 24''$
2) $d/2 = 22/2 = 11''$
3) $S_{max} = \dfrac{0.22 \times 60000}{0.75\sqrt{4000} \times 16}$
   $= 17.40.$
4) $S_{max} = \dfrac{0.22 \times 60{,}000}{50 \times 16}$
   $= 16.50''$

From above 4 conditions Least value of spacing for # 3, 2 legged stirrup will be selected so

$S_{max} = 11'' \, C/C.$

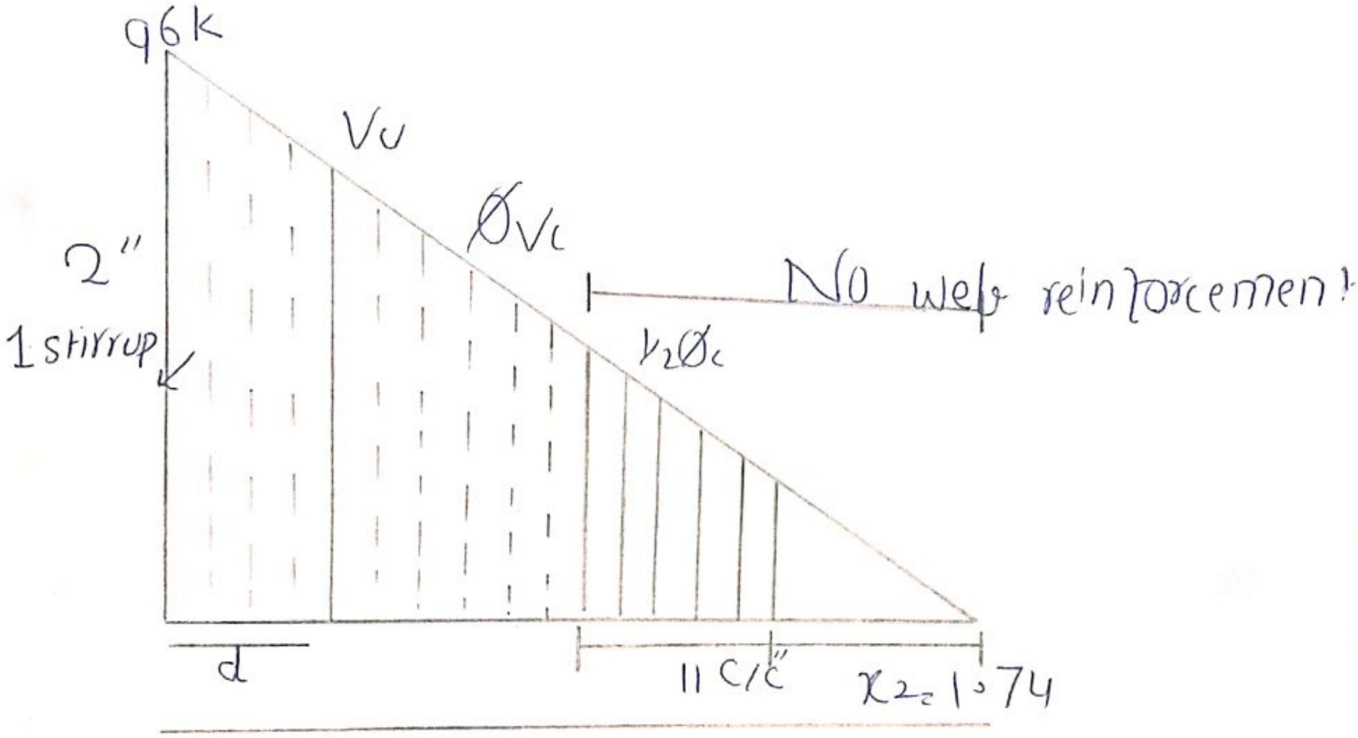
Step 8

Spacing of stirrup from/at Critical Section.

$$S = \frac{0.75 \times 0.22 \times 60 \times 22}{76.80 - 33.44}$$

$= 5'' \, C/C$

Step 9:-



As we know first stirrup from face of support

$$\frac{S}{2} = 5/2 = 2.5 \approx 2.$$

Q3

Step # 1

Find gross area of concrete

$A_g = b \times b$ (Since it is square tied column)

$A_g = 12 \times 12$

$= 144 in^2$ (Actual)

Step 2

Finding 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

$P_u = \emptyset \times 0.80 \times [0.85 \times f_c' \times (A_g - A_s) + A_s \times f_y]$

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

$P_u = 466.50 k$

Step 4 Sketch & design of Tiles (C/C distance)

From below value we choose least value.

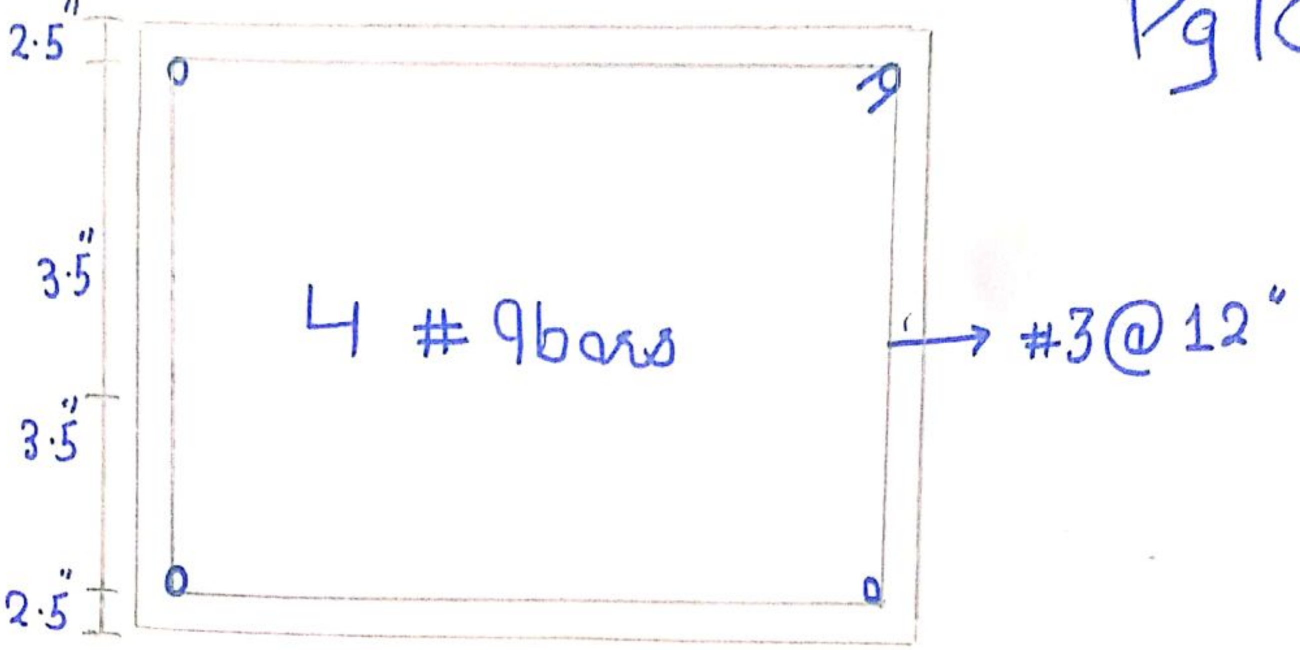
1) 16× dia of long bar $= 16 \times 9/8$

$= 18''$

2) 48 × dia of tie bar $= 48 \times 3/8 = 18''$

3) least column dimension $= 12''$

So C/C distance b/w ties $= 12''$



Since it a tied square column so there is no spiral stirrup used, the stirrup used is of rectangular shape due to specification of structure thus we have to use tie stirrup instead.

Q4

Step : 1

Let $h = 24''$

Step 2

Total weight = Wt of soil + Wt of RC

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

$= 660\,psi$

$= 0.660$

Step 3

Effective Bearing capacity

$q_e = q_a - W = 2.50 - 0.660$

$= 1.84\,ksf$

Step 4

Required area for foundation

$$Area = \frac{Service\ Load}{q_c}$$

$$= \frac{100 + 120}{1.84}$$

$= 119.56\,ft^2$

Step 5:-

Since foundation is square.

$Area = B \times B$

$= 119.56$

$B \Rightarrow$ ~~119' - 56''~~ 11

Step 6

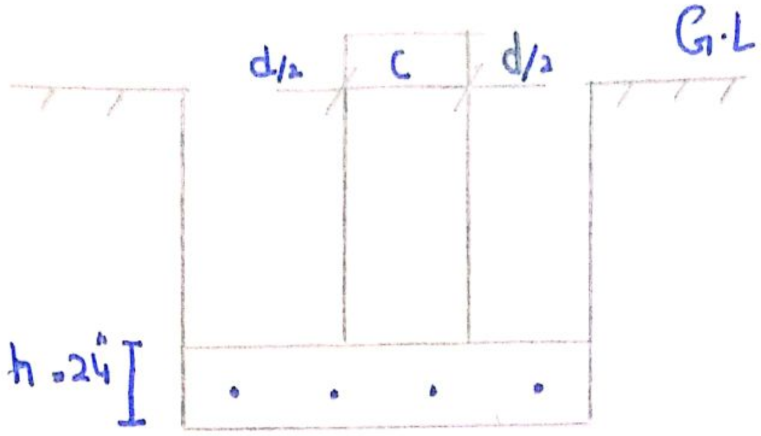
upward bearing capacity of soil

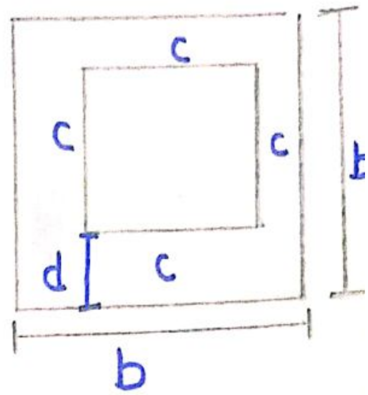
$$q_{up} = \frac{Factored\ Load}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{}$$

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

Step 7 Punching Shear

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





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

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

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

$= 142''$

Step 8

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

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

$V_{u2} = 289.60k.$

Step 9

$\varnothing V_c = \varnothing \times 4 \times \sqrt{f_c'} \times b \times d.$

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

$= 525.38.$

Step 10

Beam shear one way shear Check

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

$V_{u1} = 2.58 \times 11 \times [11/2 - \frac{16/2}{2} - 19.5]$

$= 90.95k.$

Step 11

Self Shear capacity

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

$= \frac{0.75 \times 2 \times \sqrt{4000}\ [11 \times 12.16]}{1000}$

$= 110.04\ k < V_{u1} \Rightarrow Ok.$

Step 12

Ultimate moment.

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

$= \frac{2.58 \times 11}{8} \times (11 - 16/12)^2$

$= 331.49k' \approx 3977.93k.$

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

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

$= 1.53''$

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

$$= 7.197\ in^2$$

Trial 3

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

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

So area $= 7.1\ in^2$

Step 14

Check min reinforcement by following 3 methods.

a) $A_{smin} = 0.0018 \times B \times h = 0.018 \times (11 \times 12) \times 24$

$= 5.70\ in^2$

b) $A_{smin} = \frac{200}{f_y} \times B \times h = \frac{200}{60000} (11 \times 12)\ 19.5$

$= 8.58\ in^2$

c) $A_{smin} = \frac{3\sqrt{f_c'}}{f_y} \times B \times d$

$$= \frac{3\sqrt{3000}}{60000} (11 \times 12)(19.5)$$

$= 7.05\ in^2$

From above value greater will be selected

$A_{smin} = 8.58\ in^2$

$A_b = 0.785\ in$

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