Final Term

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Subject : PRCD-1

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Section : B

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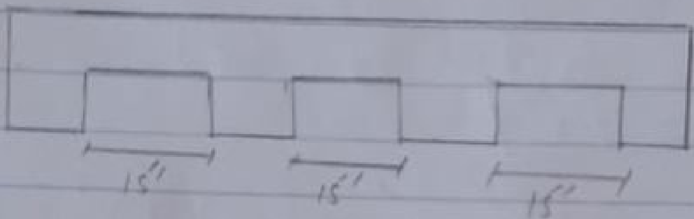
Q 1

Ans

Given data:-

-> 3 equal spans concrete slab
-> Clear span b/w supports = 15 ft
-> factored live load = 160 Lb/ft^2
-> Service floor finish load = 20 Lb/ft^2
-> $f'c$ = 4000 psi
-> Fy = 40 ksi

Solution:-



Step # 01 (Minimum thickness):-

By using formula:-

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

As Fy -> 40 ksi

So we will multiply a factor with this thickness.

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

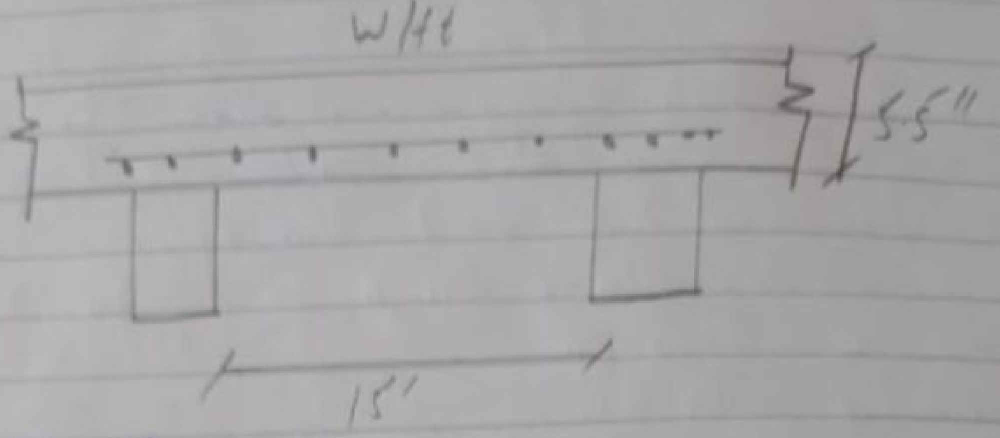
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be

6.5×0.8

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

Step#02:. (Effective depth):.



By formula

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

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

$\boxed{d \simeq 4.5''}$

Step#03:. (Self wt. of slab):-

By formula

$t/12 \times \gamma$ 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 formula

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

$= 89.94$ kip-inches.

Step # 06:- → (Area of steel for main Bars by trail and Repeat method).

Trail # 01:- Let depth of Compression block.

$a = 0.2 \times t$

$= 0.2 \times 5.5$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{1.1}{2})} = \boxed{0.63\ in^2}$$

Trail # 02:-

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} = \boxed{0.62\ in^2}$$

$$Ast = \frac{Mu}{\phi \times fy \times (d - \frac{a}{2})} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.6}{2})}$$

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

Trail # 03:-

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

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

Step #07:-(Area of steel for distribution reinforcement)

By formula:

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

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

Step #08:-(Spacing for main bars.)

By formula:

$$\text{spacing} = \frac{A_b}{A_{st}} \times 12$$

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

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

Step #09 (Spacing for distribution bars)

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

We use # 5 bars so dia $= (5/8)$

$$\text{Area} = \frac{\pi}{4}(5/8)^2 = 0.31\ in^2$$

$$\text{spacing} = \frac{0.31}{0.132} \times 12 = 2.81'' \approx 28''\ c/c$$

Step #10 (Find sketch)

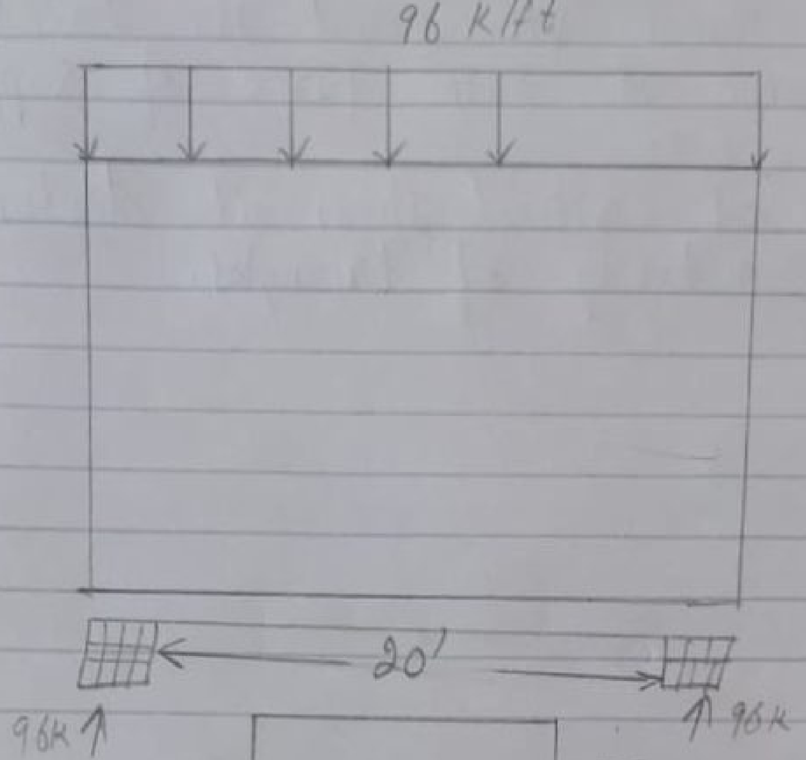
$f'c = 4\,ksi$, $fy = 40\,ksi$

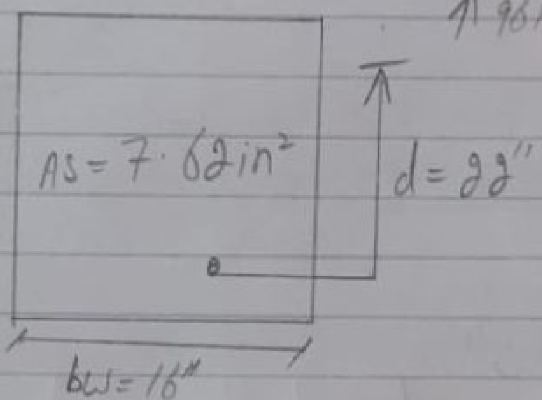
Main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c

Q 2

Ans **Solution:-**

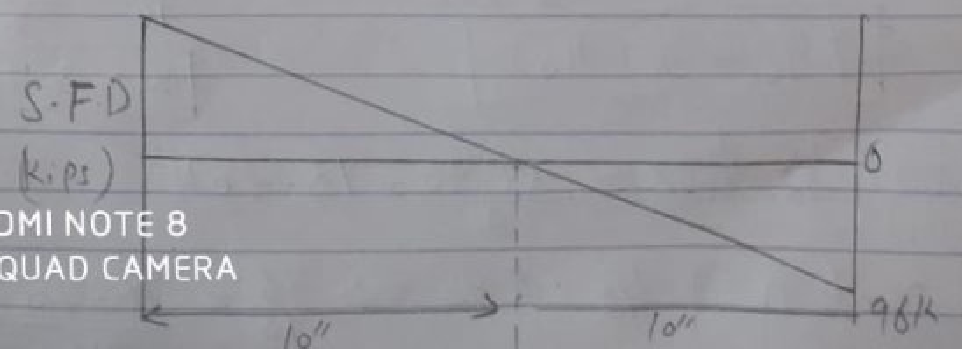




Step#01:- Find the values of R_1 & R_2

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

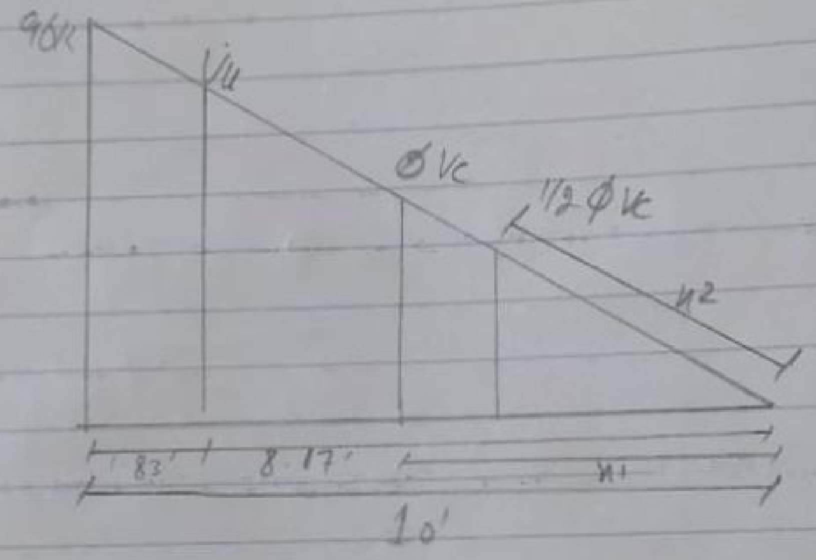
Step#02:- Draw It shear force diagram.



Step # 03:- Find the Value of Critical stress "Vu" and Its location at distance "d" from force of support

$d = 22'' = 1.83'$

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



Step # 04:- Find the value of "ØVc" & "1/2Vc" & also Its distance from zero shear to right side.

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

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

$$\boxed{\phi V_c = 33.40\,k}$$

∴ Location of ØVc by similarity of Δs.

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

$$\boxed{x_1 = 3.48'}$$

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

∴ Location of 1/2 ØVc $\Rightarrow \frac{96}{10} = \frac{16.70}{x_2}$

$$\boxed{V_2 = 1.74}$$

Step # 05 :- Value of ϕVs $(Uv = \phi Vs + \phi Vc)$

So, $\phi Vs = Vu - \phi Vc$

$\phi Vs = 78.43 - 33.40$

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

Step # 06 :- Check on section adequacy.

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

$$= 133.57$$

As $\phi \times 8 \sqrt{f'c} \times bw \times d > \phi Vs \rightarrow$ It means section is adequate.

Step # 07 :- Check on min spacing for stirrups.

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

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

Thus max spacing will be selected from the following four condition.

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

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

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

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$\because Av = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$ $Av = 0.11 \times 2$
$Av = 0.22$

$= 17.40''$

(4) $S_{max} = \frac{Av \times fy}{50 \times bw}$

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

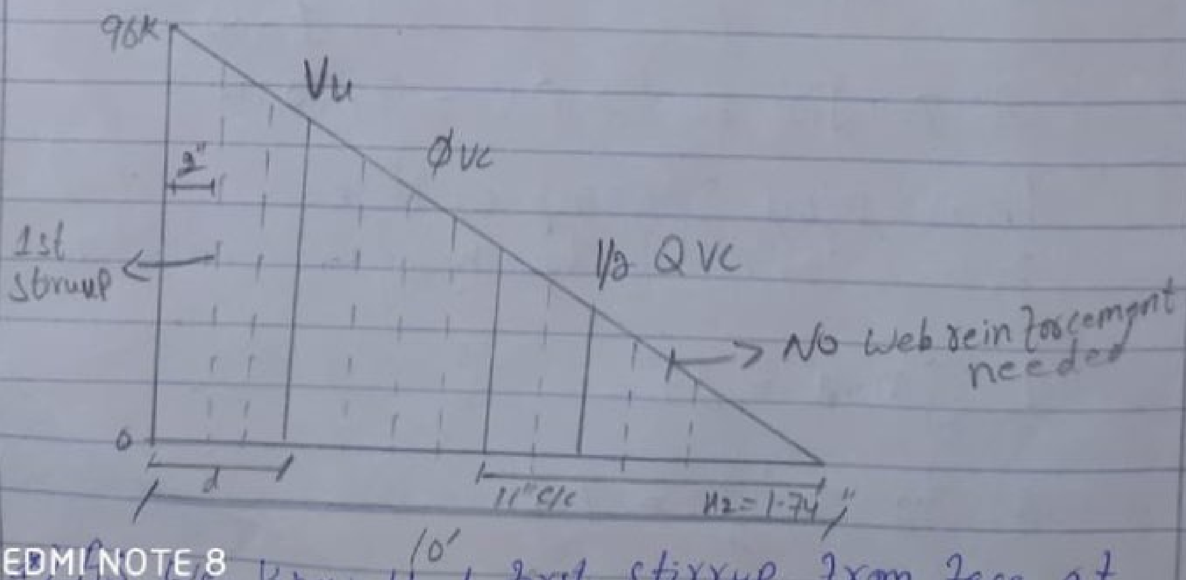
From the above four conditions, least value of spacing from #3, U shaped will be selected so $S_{max} = 11''$ c/c.

Step#08: Spacing of Stirrup from/at critical section.

$S = \frac{\phi \times Av \times fy \times d}{Vu - \phi Vc} = \frac{0.75 \times 0.22 \times 60 \times 22}{78.403 - 33.40}$

$= 4.84'' \approx 5''$ c/c

Step#09: Find sketch:



As we know that first stirrup from face of support $= 5/2 = 2.5 \approx 2''$

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Q 3
Ans

Solution:

Step#01:(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#02:- (Find the area of steel)

Since, $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2 in^2$

Step#03:- (Ultimate load Carrying Capacity)

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

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

$\boxed{P_u = 466.50k}$

Step#04:-

Sketch & design of ties (c/c 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 the tie bar = 48 x 3/8 = 18"

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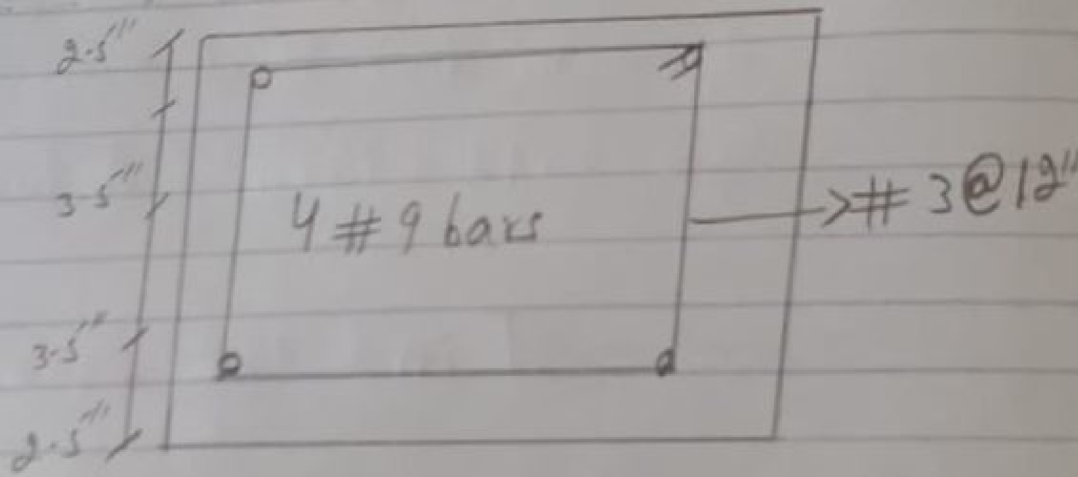
3) Least Column dimension = 12"

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.

Q 4 Solution:.

Step # 01:-

Let $h = 24''$

Step # 02:-

Total Weight = Wt of Soil + Wt of Rc

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

$= 660 psf = 0.660 ksf$

Step # 03: (Effective bearing Capacity).

$q_e = q_a - W$

$= 2.50 - 0.660$

$q_a = 1.84 \ ksf$

Step # 04:- (Required Area for foundation)

$Area = \frac{Service \ Load}{q_a} = \frac{100 + 120}{1.84} = 119.57 \ ft^2$

Step # 05:- (Since foundation is square).

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

Step # 06:- (Upward bearing Capacity of soil)

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

$\boxed{q_{up} = 2.58 \ KIA^2}$

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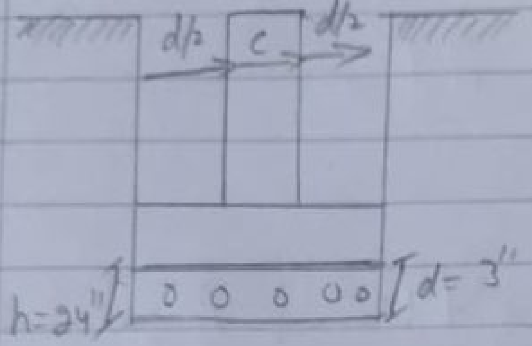
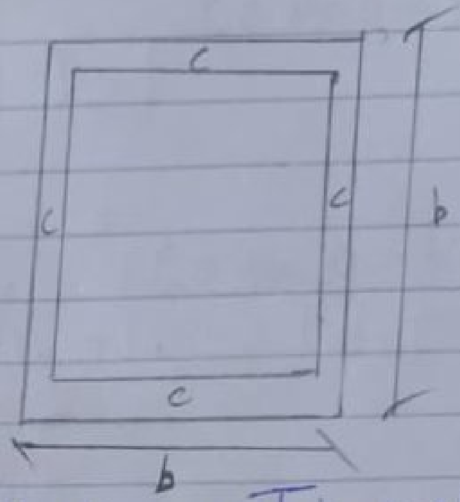
Step#07:·(Punching shear)·

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





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

$= 24 - 3 - 1 - 1/2(1) = 19.5"$

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

Step#08:·

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

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

$V_{u2} = 289.60\text{K}$

Step#09:·

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

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

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

Step#10 :- Beam shear/one way shear check

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

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

$$\boxed{V_{u1} = 90.95 k}$$

Step#11 :- Self shear Capacity:

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

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

$$= 110.04 k > V_{u1}$$

Step#12 :- (ultimate moment)

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

$$M_u = 331.49 k' = 3977.93 k''$$

Step#13 :- (Area of steel for main bars by trail and Repeat method)

Trail#01 :- Let, $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

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

$$= 8.56 m^2$$

Trail # 02 :- $a = \frac{As \times fy}{0.85 \times f'c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12}$

$= 1.53''$

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

Trail # 03 :-

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

$As = \frac{3977.93}{0.90 \times 60 (11 - \frac{12.8}{2})} = \boxed{7.1\ in^2}$

Thus, Area $= \boxed{7.1\ in^2}$

Step # 14 :- (check the min-reinforcement by the following 03 methods;)

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

$As_{min} = \boxed{5.70\ in^2}$

$As_{min} = \frac{200}{fy} \times B \times d$

$= \frac{200}{6000} \times (11 \times 12) \times 19.5$

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

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

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

From above values the greater value willbe selected thus:

$$A_s\,min = 8.58\,in^2$$

Step # 15: (Using # 8 Bars)

$$A_b = 0.785\,in^2$$

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

$$= 10.92 \approx \text{bars in}$$

each, direction.

$\leftarrow\!\!\longrightarrow$