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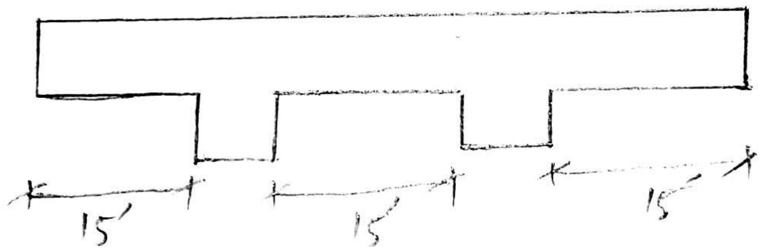
QNo 1:-
numerical:-

Given:-

- ⇒ 3 equal spans concrete slab
- ⇒ Clear span between supports = 15 ft
- ⇒ Factored live load = 160 lb/ft²
- ⇒ service floor finish load = 20 lb/ft²
- ⇒ f'_c = 4000 psi
- ⇒ f_y = 40 ksi

Sol:-



Step #1
minimum thickness

by using formula

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

As $f_y \rightarrow$ 40 ksi

so we will multiply a factor with this thickness

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

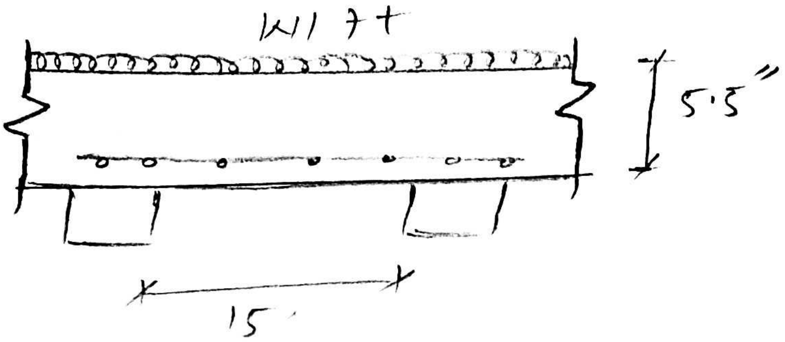
$$= \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be

$$6.5 \times 0.8$$

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

Step #2:- Effective depth



by formula

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

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

$d = 4.5''$

Step #3:- Self weight of slab

by formula

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

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

Step#4:- Total factored load

factored live load = 160 lb/ft²

so the factored dead load will be

$D.L = 1.2(20 + 68.75) = 106.5 \text{ lb/ft}^2$

Total factored ~~dead~~ load

$= D.L + L.L$

$106.5 + 160$

266.5 lb/ft^2

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

Step #5 (ultimate moment)

by formula

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

$$= \boxed{89.94 \text{ kip-inch}}$$

Step #6:-

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

Trial #1:-

let depth of compression block

$$a = 0.2 \times t$$

$$= 0.2 \times 5.5 = 1.1$$

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

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

Trail #2:-

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

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

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

Trial #3:-

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

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

so we will use $A_{ST} = 0.59 in^2$

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step # 7:-
Area of steel for distribution reinforcement

by formula
$A_{min} = 0.002 \times b \times t$ → (for grade 40 steel)
$= 0.002 \times 12 \times 5.5 \Rightarrow 0.132 in^2$

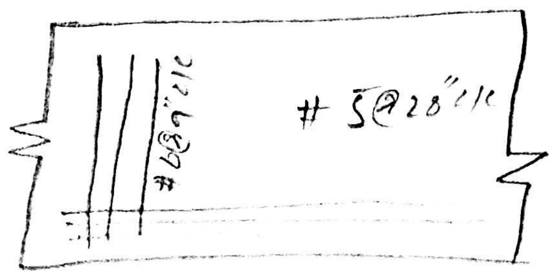
step # 8:-
spacing for main bar
we use #6 bars

by formula
$spacing = \frac{Ab}{As} \times 12 = \frac{0.442}{0.59} \times 12$
$= 8.98 \approx 9'' c/c$

step # 9
spacing for distribution bar
$s = \frac{Ab}{As} \times 12$ we use # 5 bars

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

step # 10
$f'c = 4ksi$, $fy = 40ksi$
main bar #6 at 9" c/c
distribution bar #5 at 28" c/c



Q No 3:-

Numerical:-

Given:-

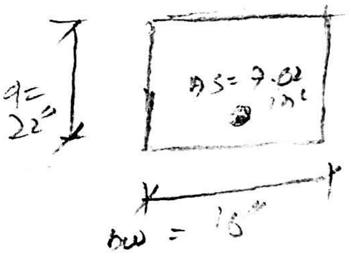
Breadth of web of beam (bw) = 16"
Effective depth (d) = 22"
Given load = 9.4 kips/ft
Steel area = $7.62 in^2$
f'_c = 4000 psi
f_y = 6000 psi

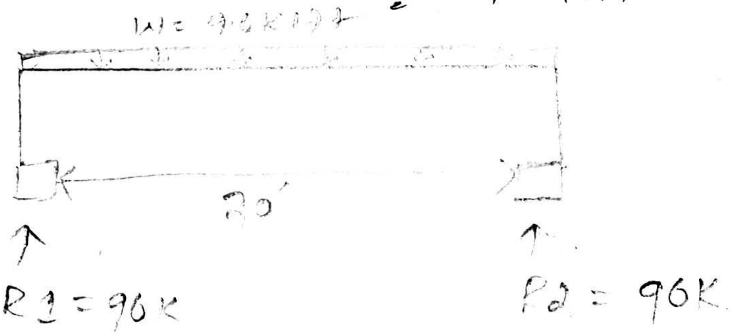
Sol:- As first of all find the unit load of beam

so $b \times \gamma_c$

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

so total factored load $= 9.4 + 0.2$
$= 9.6\ k/ft$



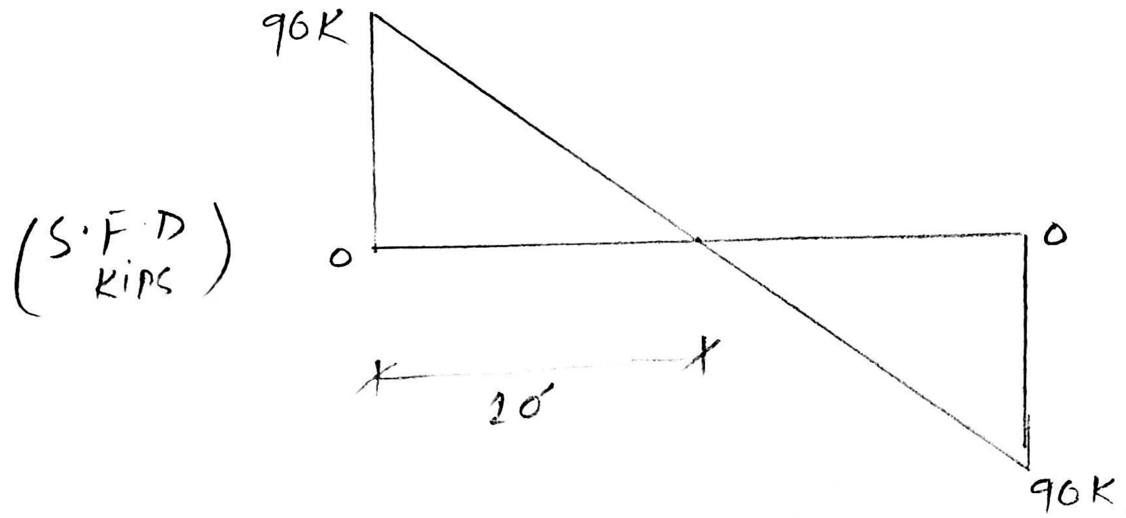


Step #1:-

find the value of R1 and R2

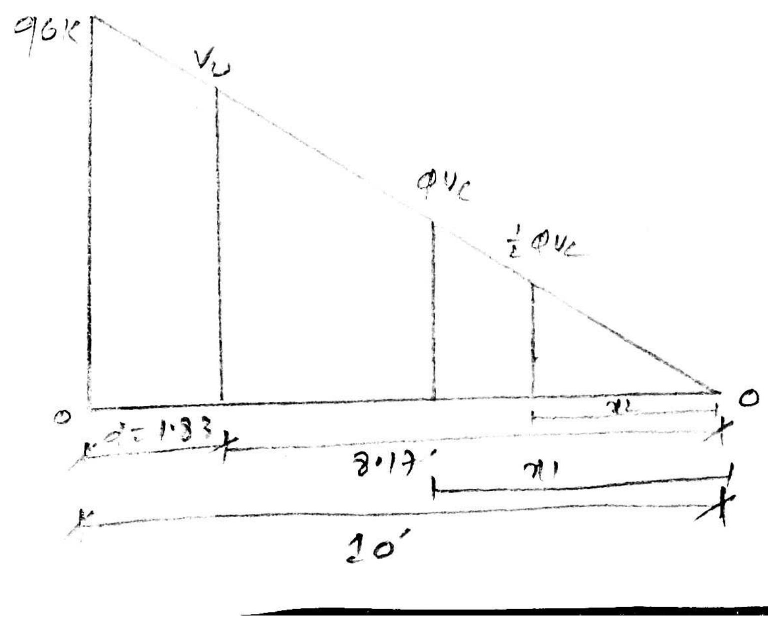
Total load $= 9.6 \times \frac{20}{2} = 96K$.

Step#2 Draw its shear Diagram



Step#3 Find the value of critical stress 'Vu' and its locations

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 Δs

$$\frac{96}{10} = \frac{Vu}{8.17} = \boxed{Vu = 78.43 \text{ kips}}$$

Step#4: Find the value of φVc and ½φVc and also its distance from zero shear to right side

$$\phi Vc = \phi \times 2 \times \sqrt{f'c} \times bw \times d$$

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

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

location of φVc by similarity of Δs

$$96/10 = \frac{33.40}{x1}$$

$$\boxed{x1 = 3.48'}$$

Now $\frac{1}{2}\phi Vc = \frac{33.40}{2} = 16.70K$

location of $\frac{1}{2}\phi Vc = \frac{96}{10} = \frac{16.70}{x2}$

$$\boxed{x2 = 1.74'}$$

Step#5 value of φVs (Vu = φVs + φVc)

so $\phi Vs = Vu - \phi Vc$

$= 78.43 - 33.40$

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

step #6 check on section adequacy

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

$$= \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$= 133.57\ K$

As $\phi \times 8 \times \sqrt{f_c} \times b_w \times d > \phi V_s \rightarrow$ it means section is adequate.

step #7
check on maximum spacing for Stirrups:-

$\phi \times 4 \times \sqrt{f_c} \times b_w \times d$

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

$=$ ~~133.57~~ 66.79 kips.

As $\phi\, 4 \sqrt{f_c'}\, b_w \times d > \phi V_s = 45.03\ K$

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

1 $S_{max} = 24''$

$\therefore A_v = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = 0.11 \times 2$

$A_v = 0.22$

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

3) $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w} = \frac{0.22 \times 6000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$

4) $S_{max} = \frac{A_v \times f_y}{50 \times b_w} = \frac{0.22 \times 6000}{50 \times 16}$

$= 1.650$

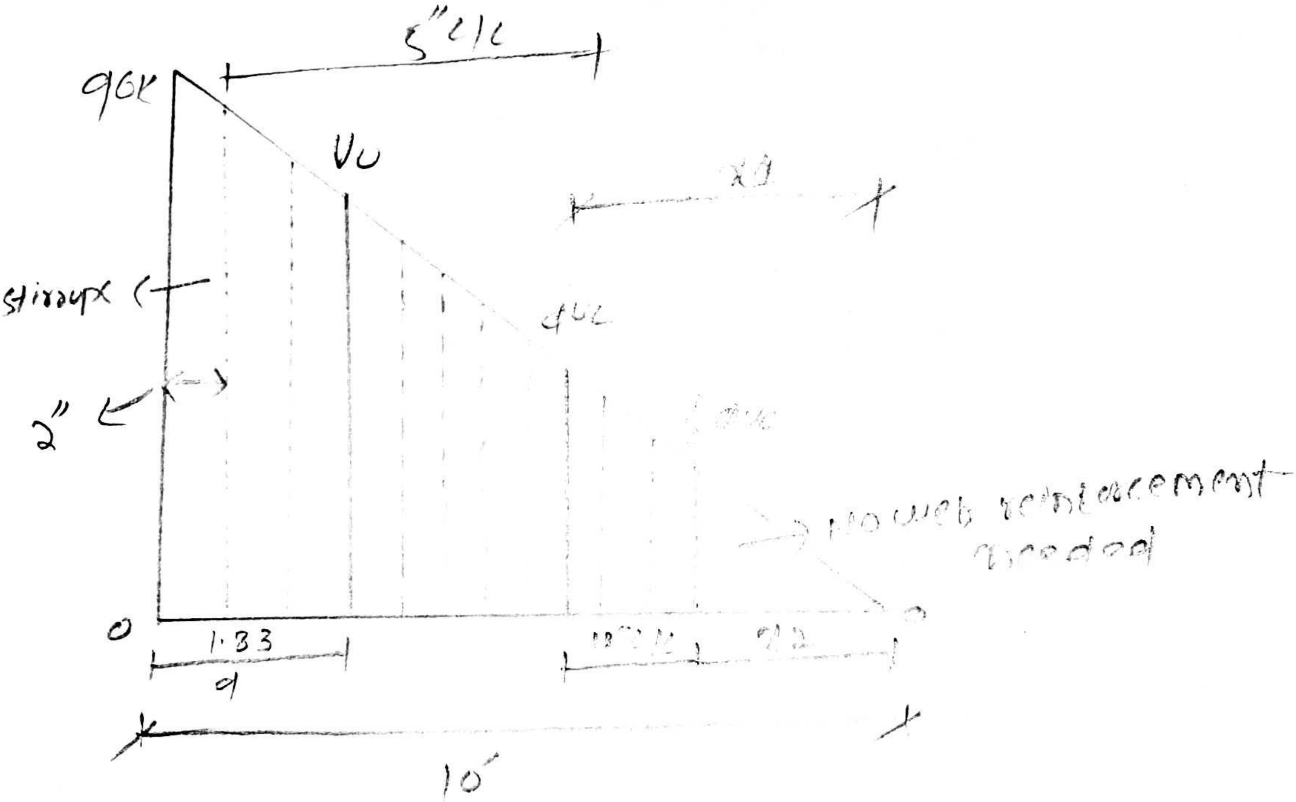
From the above four condition, least value of Spacing from #3, U-shaped will be selected so $S_{max} = 11'' \, c/c$.

Step #8 Spacing at stirrups at critical section:-

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

$$S = 4.8'' \approx 5'' \, c/c.$$

Step #9:- Final sketch



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QNO3:-
Numerical:-

Sol:- As
step #1 find gross area of concrete

$Ag = b \times b$ (since it is square tied column)
$Ag = 12 \times 12 = 144 in^2$ (Actual)

step #2:- find the area of steel

since $As = 5\%$ of Ag
$= 0.05 \times 144$
$As = 7.2 in^2$

step #3:- 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# 4:-
sketch and design of tie c/c to distance From the below value we choose the least value of all this.

1) $16 \times$ dia of long bar $= 16 \times 9/8 = 18''$
2) $48 \times$ dia of tie bar $= 48 \times 3/8 = 18''$
3) least column dimension $= 12''$
so c/c distance b/w ties $= 12''$.

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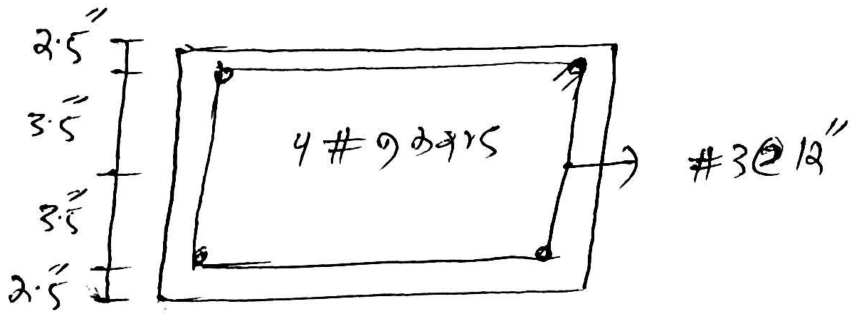

* since it is a tied square column, so there is no spiral stirrups is used, the stirrups used of rectangular shape due to the specification of the structure. thus we will use tie stirrups instead.

QNo4:-
Numericals

Sol:- As
Step # 1:-
let $h = 24''$

Step #2
Total weigh = wt of soil + wt of RCC
$= 3 \times 120 + 2 \times 150$
$= 660 psf = 0.660 ksf$

Step # 3:- Effective bearing capacity:-

$q_e = q_a - W$
$= 2.50 - 0.660$
$q_e = 1.84 \ ksf$

Step #4:- Required area for foundation

$$Area = \frac{service\ load}{q_e} = \frac{100 + 120}{1.84}$$
$$= 119.57 \ ft^2$$

Step #5 since foundation is square

$Area = b \times b = 119.57 \Rightarrow B \cong 11'$.

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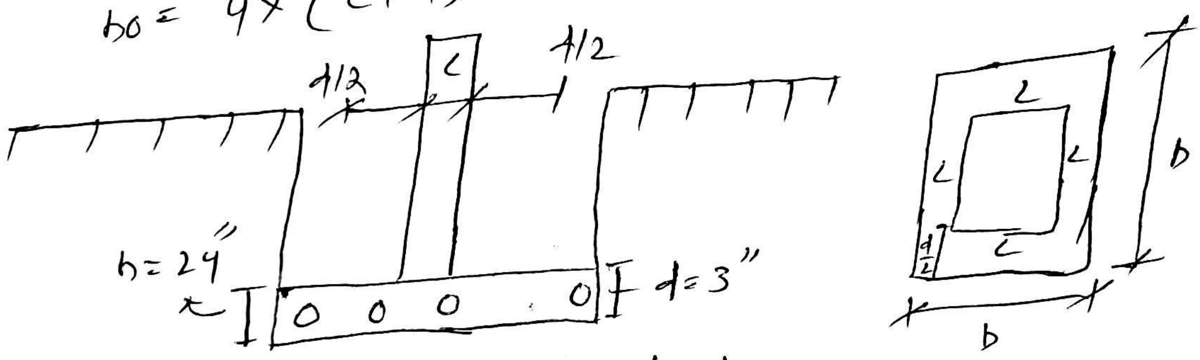
Step # 06:- upward bearing capacity of soil

$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2\times100+1.6\times120}{(11)^2}$$

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

Step # 7 punching shear

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



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

∴ Take # 8 bars

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

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

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

Step # 08

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

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

$V_{u2} = 289.60k$.

Step # 09:-

$$\phi V_{c/p} = \phi\times4\times\sqrt{f'c}\times b\times d$$

$$= 0.75\times4\times\sqrt{4000}\times142\times19.5/1000$$

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

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Step # 10

Beam shear / one way shear check

$V_{U1} = q_{up} \times B \times [B/2 - C/2 - d]$

$V_{U1} = 2.58 \times 11 \times [\frac{11}{2} - \frac{16/12}{2} - 19.5]$

$\boxed{V_{U1} = 90.95K}$

Step # 11

self shear capacity

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

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

$= 110.04K > V_{U1} \Rightarrow O.K$

Step # 12

ultimate moment

$M_U = \frac{q_{up} \times B}{8} \times (B - C)^2 = \frac{2.58 \times 14}{8} \times (11 - \frac{16}{12})^2$

$M_U = 331.49 K' \simeq 3977.93 K''$

Step # 13

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

Trial # 1 let $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

$A_{st} = \frac{M_U}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{3977.93}{0.90 \times 60(11 - \frac{4.8}{2})} = 8.56 in^2.$

Trial # 2

$a = \frac{A_{st} \times f_y}{0.85 \times f'c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.53''$

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

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Trial #3

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

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

so that area $= 7.1\,in^2$.

Step #14 check the min reinforcement by the following 03 method.

$\Rightarrow A_{smin} = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$
$= 5.70\,in^2$

$\Rightarrow A_{smin} = \frac{200}{f_y} \times b \times d = \frac{200}{60000} (12 \times 11) \times 19.5$
$= 8.858\,in^2.$

$\Rightarrow A_{smin} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d = \frac{3\sqrt{3000}}{60000} (11 \times 12)(19.5)$
$= 7.05\,in^2$

From above value greater value will be selected

Thus $A_{smin} = 8.58\,in^2.$

Step #15:-

$A_b = 0.785\,in^2$

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