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Subject : PRC I
Semester : 10th
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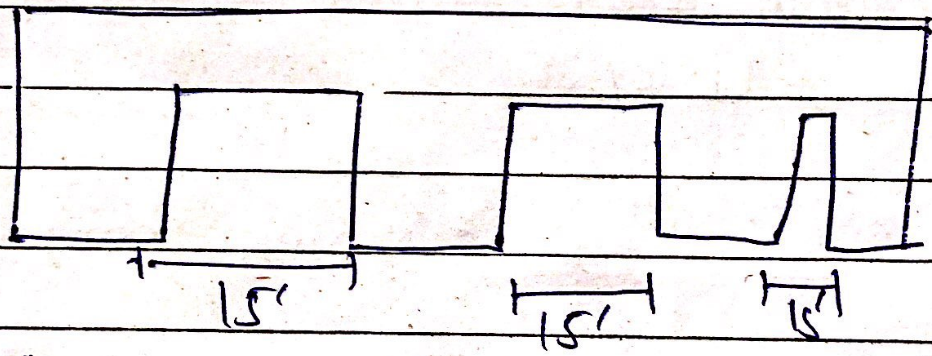
Q1 A reinforcement ···· your final design.

Given data:

- Clear span b/w support = 15'
- Factored live load = 160 lb/ft²
- Service floor finish load = 20 lb/ft²
- $f'_c = 4000$ Psi
- $f_y = 40$ ksi

Sol:



Step no 1: Minimum thickness

By using formula

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

As $f_y \rightarrow 40$ ksi

So we will multiply a factor with this thickness

$$\text{Factor} = (0.4 + f_y/100)$$

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

Date:

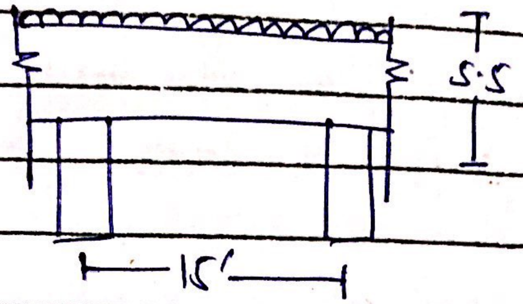
Day: M T W T F S S

Hence the minimum thickness will be

6.5×0.8

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

Step no 2: effective Depth



By formula

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

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

$d = 4.5''$

Step no 3: Self weight of Slab

By formula

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

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

Step no 4: Total factored load

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

so the factored load will be

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

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

$= 106.5 + 160$

$= 266.5\ lb/ft^2 \Rightarrow 0.2665\ k/ft^2$

Day: M T W T F S S

Step no 5: Ultimate moment

By using formula

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

$$\boxed{M_u = 89.94 \text{ kips-inches}}$$

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

"Trail no 01:

let depth of compression block

$a = 0.2 \times t$

$= 0.2 \times 5.5 \Rightarrow 1.1$

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

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

Trail # 02

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

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

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

Trail # 03

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

$$A_{st} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.57}{2})} = 0.59 \text{ in}^2$$

so we will use $A_{st} = 0.59 \text{ in}^2$

Day: M T W T F S S

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

$\text{Spacing} = \frac{A_b}{A_{ST}} \times 12$

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

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

Step no 9 : Spacing for distribution bars

$\text{spacing} = \frac{A_b}{A_{ST}}$

we use # 5 bars so

$\text{dia} = (5/8)''$, $\text{Area} = \frac{\pi}{4}\left(5/8\right)^2 = 0.31\ in^2$

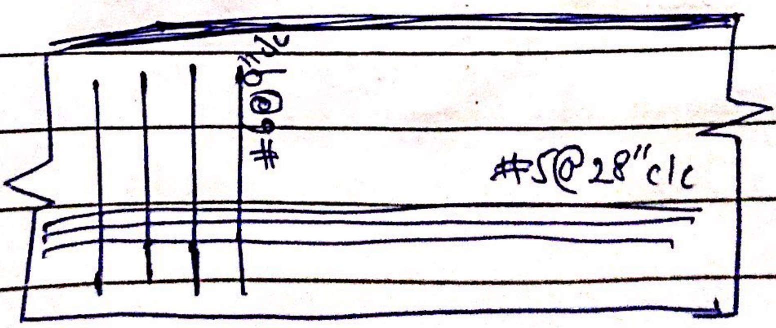
$\text{Spacing} = \frac{0.31}{0.132} \times 12 = 28.1'' \approx 28''\ c/c$

Step no 10 : Sketch

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

Main steel # 6 at 9" c/c

Distribution Steel # 5 at 28" c/c



Q2

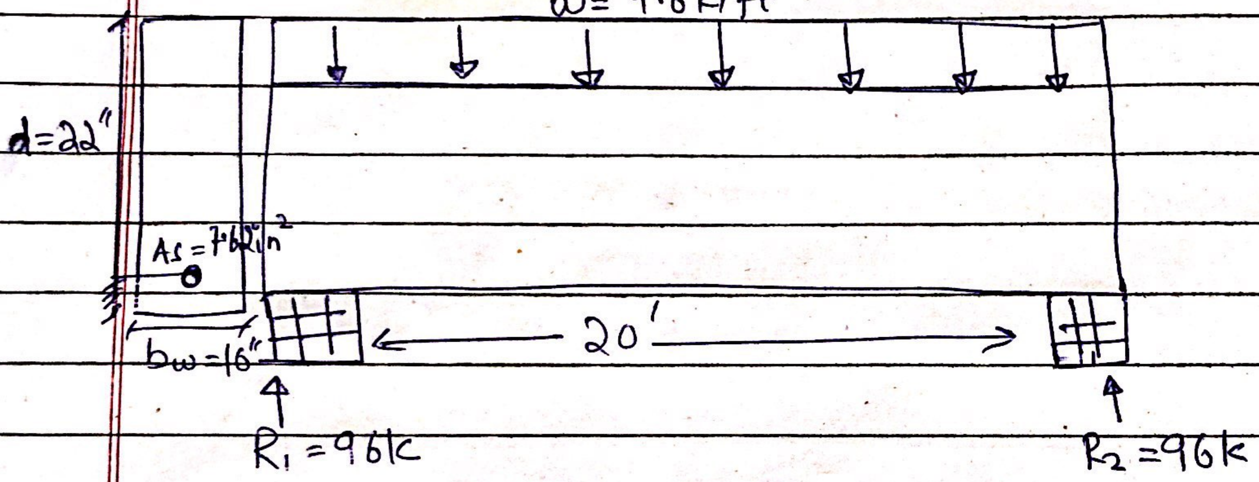
Ans: Solution: First of all find the unit load of beam

So $b \times \gamma_c$

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

So total factored load $= 9.4 + 0.2$

$= 9.6\ k/ft$

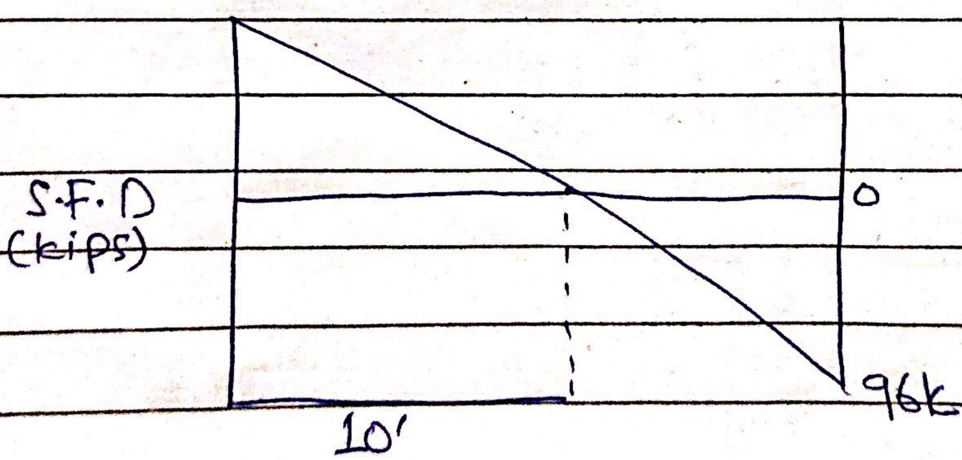


Step no 1

find value of R_1 & R_2

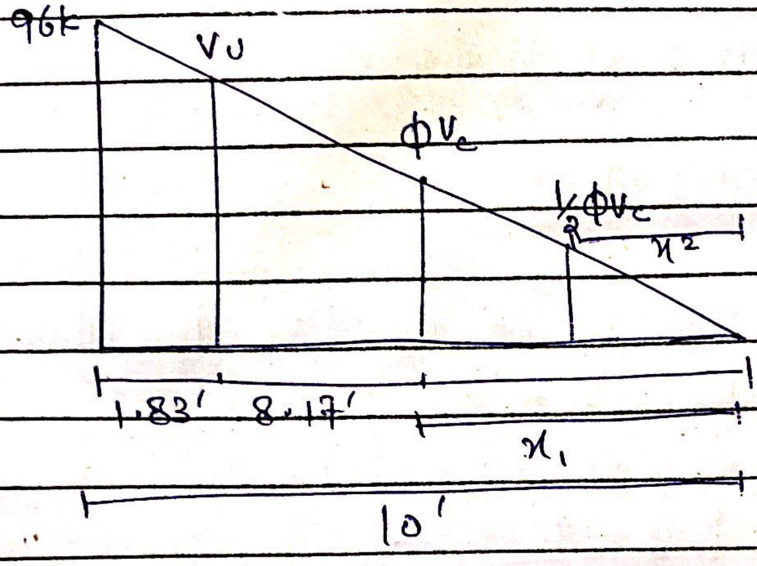
Total load $= 9.6 \times \frac{20}{2} = 96k$

Step no 2: Draw its shear force diagram



Step no 3: Find the value of critical stress "V_u" and its location:

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 no 3: Find value of "ϕV_c" & "$\frac{1}{2}\phi V_c$" & also its distance from zero shear to right side.

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

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

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

$$\boxed{x_2 = 1.74}$$

Step no 05 : 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 no 6 : Check on section adequay.

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

$= 133.57k$

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

step no 7 : 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 $\phi 4\sqrt{f'c}\ bw\ d > \phi V_s = 45.03k$

Thus max spacing will be selected from the following four condition

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

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

3) $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$A_v = \dfrac{\pi}{4}\left(3/8\right)^2 = \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$ $\qquad A_v = 0.11 \times 2$

$A_v = 0.22$

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

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

$= 16.50$

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

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

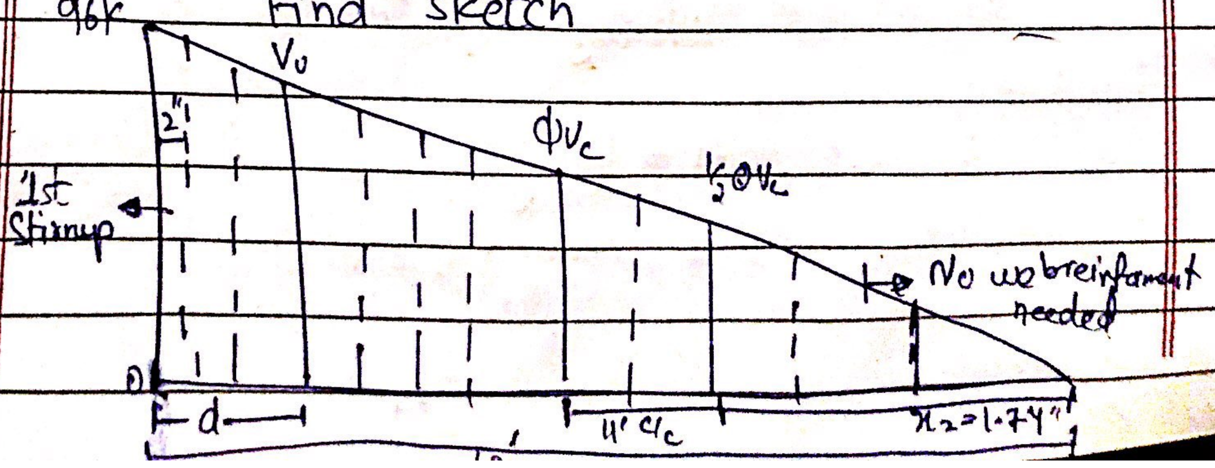
Step no 8: Spacing of stirrup from/at critical section

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

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

Step no 9

Find sketch

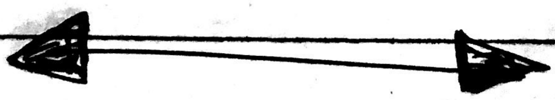


Date:______

Day: M T W T F S S

★ As we know that first stirrup from face of support

$\Rightarrow 5/2 = 2.5 \approx 2''$



Q3 : Calculate ...... necessary spirals

Solution: Solution:

Step no 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 no 2: Find the area of steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2\ in^2$

Step no 3: Ultimate load carrying capacity:

$P_U = \phi \times 0.80 \times [0.85 \times f'c \times (A_g - A_s) + A_s \times f_y)$

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

$P_U = 466.50\ k$

Step no 4: sketch & 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 $= 16 \times 9/8$

$= 18''$

2) 48 x 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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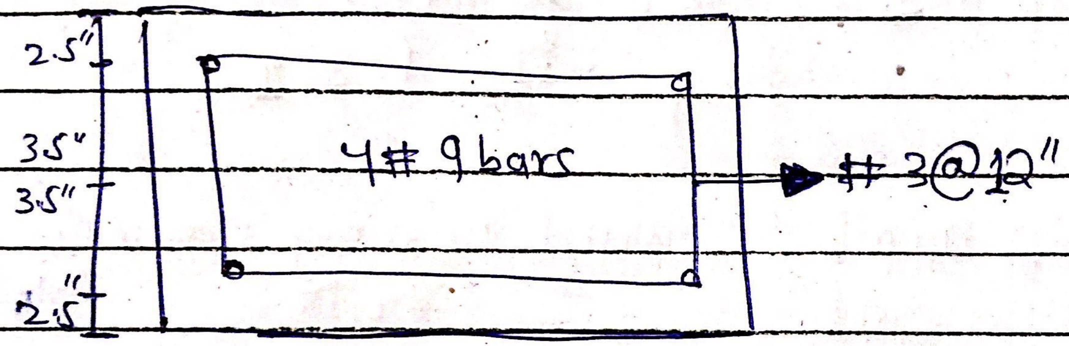
Date:

Day: M T W T F S S



* it is a tied square column so no spiral stirrup, the stirrup that is used in rectangular shape because of specification of the structure thus we will use tie stirrups instead.

Ques# Design a square .... final design

Step no 1 :

let $h = 24''$

Step no 2 : Total weight = wt of soil + wt of Rc

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

$= 660$ Psf $= 0.660$ ksf

Step no 3 : Effective bearing capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84$ ksf

Step no 4 : Required Area for foundation

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

$= 119.57 \, ft^2$

Step no 5: Since foundation is square

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

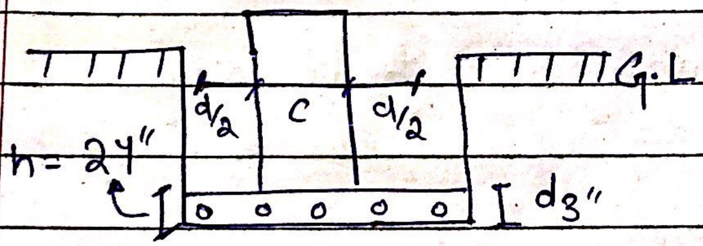
Step no 6: upward bearing capacity of soil

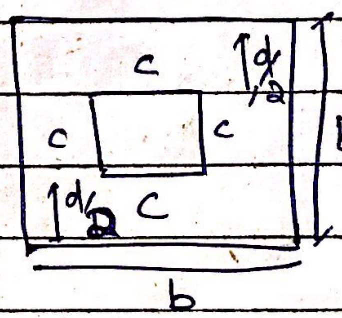
$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$

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

Step no 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 no 8:

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

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

$V_{u2} = 289.60\ k$

Date:
Day: M T W T F S S

Step no 9

$$\phi V_{up} = \frac{\phi \times 4 \times \sqrt{f'_c} \times \quad \times b_o d}{1000}$$

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

$$= 525.38K$$

Step no 10

Beam shear / one way shear check

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

$$V_{u1} = 2.58 \times 11 \times \left[11/2 - \frac{16/12}{2} - \frac{19.5}{12} \right]$$

$$V_{u1} = 90.95K$$

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

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

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

Day: M T W T F S S

Step 13 : Area of steel for mainbars by Trial & repeat method.

Trail 1: $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

$$A_s = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{3977.93}{0.9 \times 60 \times (11 - \frac{4.8}{2})}$$

$$= 8.56 \, in^2$$

Trail no 2;

$$a = \frac{A_s \times f_y}{0.85 \times f_c \times b} = \frac{8.56 \times 6}{0.85 \times 3 \times 11 \times 12} = 1.53''$$

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

Trail no 3;

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

$$A_s = \frac{3977.93}{0.90 \times 60 (11 - \frac{1.28}{2})} = ~~7 in^2~~ \; 7.1 \, in^2$$

So thus area is ; $7.1 \, in^2$

Step no 14: Check the min reinforcement by the following as methods;

$A_{s\,min} = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$

$A_{s\,min} = 5.70 \, in^2$

Date:

Day: M T W T F S

$$A_{s\,min} = \frac{200}{f_y} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$$

$$= 8.58\,in^2$$

$$A_{s\,min} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times 19.5$$

$$= 7.05\,in^2$$

From above values greater value will be selected thus $A_{s\,min} = 8.58\,in^2$

Step 15 : Using #8 bars

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

$$\text{No. of bars} = \frac{A_s}{A_b} = \frac{8.58}{0.785} = 10.92$$

≈ 11 bars in each direction