Final Examination

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Section A

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subject PRCD -I

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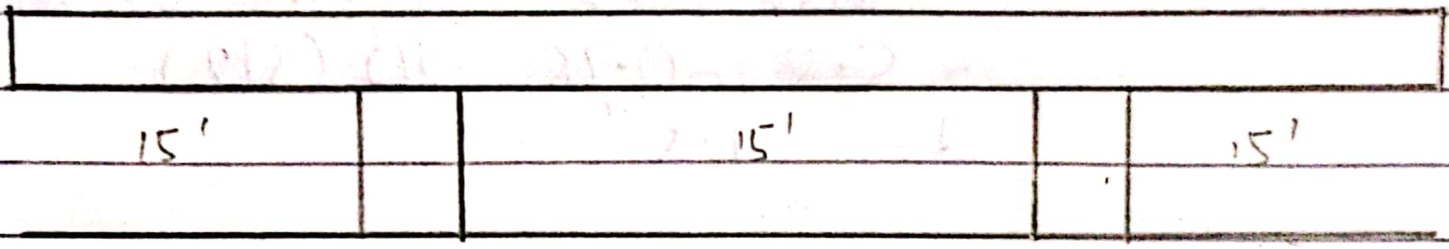
Q # 1

→ Factored live load = 160 lb/ft²
Servic floor finish load = 20 lb/ft²
$F_c' = 4000$ psi , $F_y = 40$ ksi
3 sequel span concrete slab
clear span b/w support = 1 sq.ft.



→ Step 01 (Minimum thickness)
Using formula
$t_{min} = L/28 = 15/28 = 6.4 \approx 6.5''$
As $F_y = 40$ ksi

We multiply a factor with this thickness

Facter = $(0.4 \times F_y/100)$
$= (0.4 \times 40/100) = 0.8$

Hence the minimum thickness will be
6.5×0.8
$\therefore t_{min} = 5.2 \approx 5.5''$

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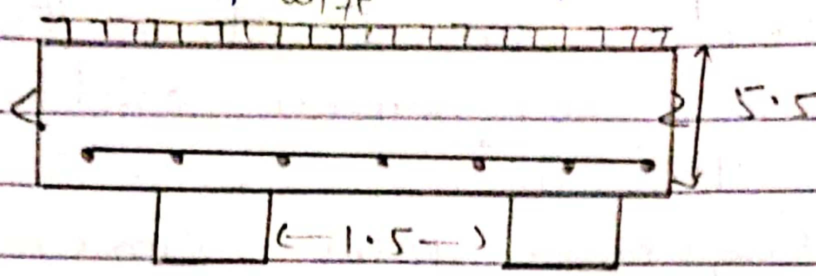
→ Step 02 (Effective depth).



By formula we have

$d = t -$ clear cover $- 1/2$ (dia of m.b)

$= 5.5 - 0.75 - 1/2\,(5/8)$

$d = 4.5''$

→ Step 03 (Self weight of slab)

$t/12 + \gamma_{concrete}$

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

→ Step 04 (Total factored load)

Factored live load = 160 lb/ft^2

The factored dead load will be

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

T.F.L = D.L + L.L

= 106.5 + 160

= 266.5 lb/ft^2 = 0.2665 k/ft^2

→ Step 05 (Ultimate moment)

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

$$= 89.94 \text{ kip / inch.}$$

→ Step 06 (Area of steel for M.B by trial and repeat method)

Trial #1

let depth of compression block = $a = 0.2 \times t$

$= 0.2 \times 5.5$

$a = 1.1'$

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

Trial #2

$$a = \frac{0.63 \times 40}{0.85 \times 4 \times 12} \qquad a = 0.62 \text{ in}^2$$

$$A_{st} = \frac{M_u}{\phi \times f_y (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.62}{2})}$$

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

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Trial # 3

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

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

So we will use $Ast = 0.59 \text{ in}^2$

→ Step 07 (Area of steel for distribution reinforcement).

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

$= 0.002 \times 12 \times 5.5 = 0.132 \text{ in}^2$

→ Step 08 (Spacing for M.B)

$$\text{Spacing } \frac{Ab}{Ast} \times 12$$

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

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

→ Step 09 (Spacing for distribution bars)

we use #5 bar dia (5/8)''

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

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

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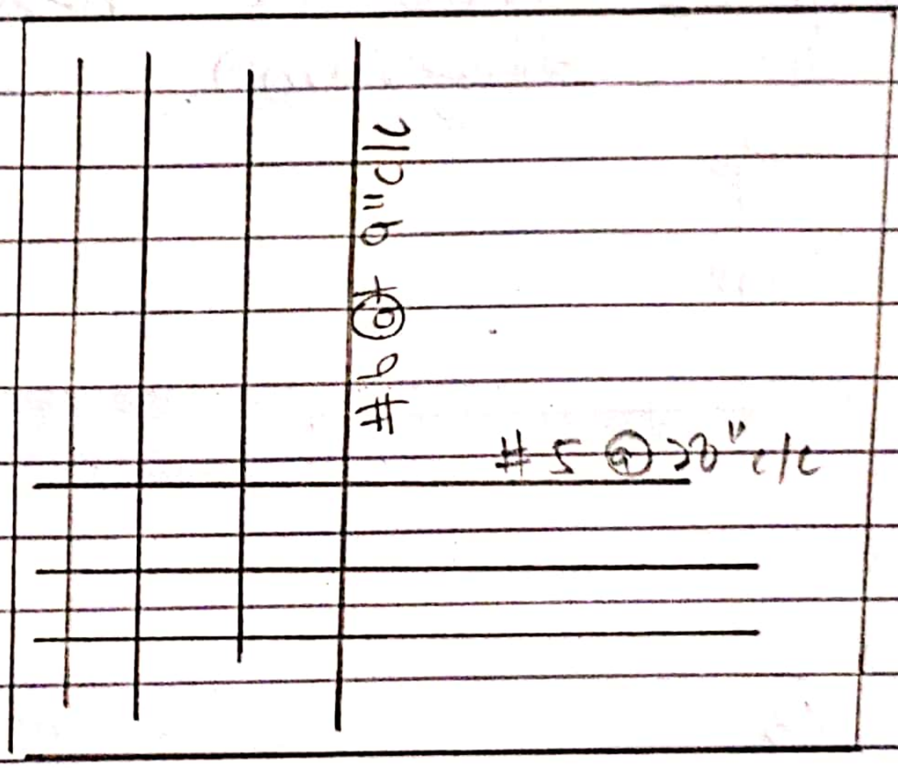
→ Step 10 (Final sketch).

F'C = 4 ksi Fy = 40 ksi
Mainsteel #6 at 9" c/c, Distribution steel #5 22" c/c.



Q#2

→ Solution :-

Find unit load of beam

b × γc

16/12 × 150 = 200 lb/ft = 0.2 k/ft.

T.F.L = 0.2 + 9.4

= 9.6 k/ft.

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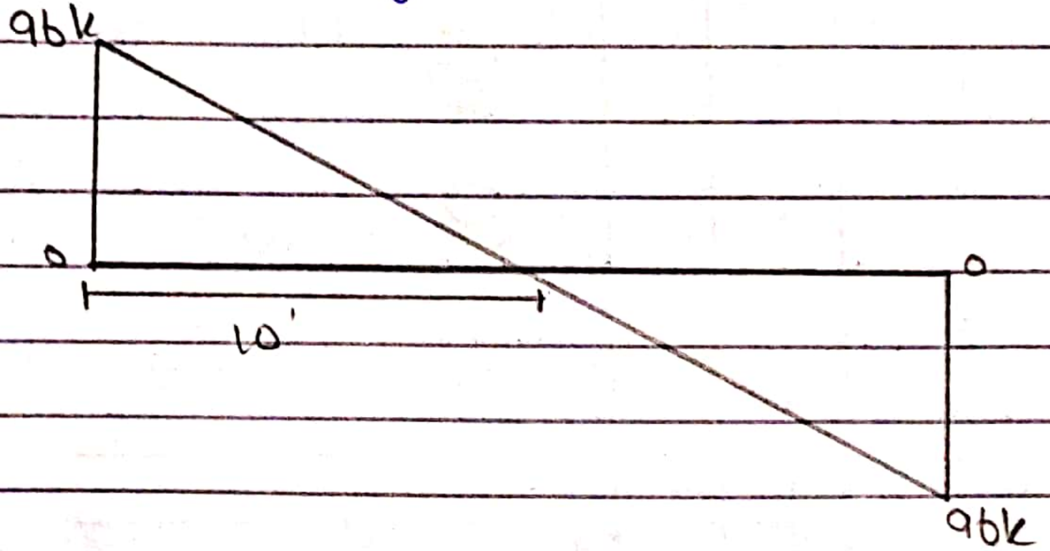
→ Step 01

Find value of R_1 and R_2

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

→ Step 02 (Draw its shear force diagram).



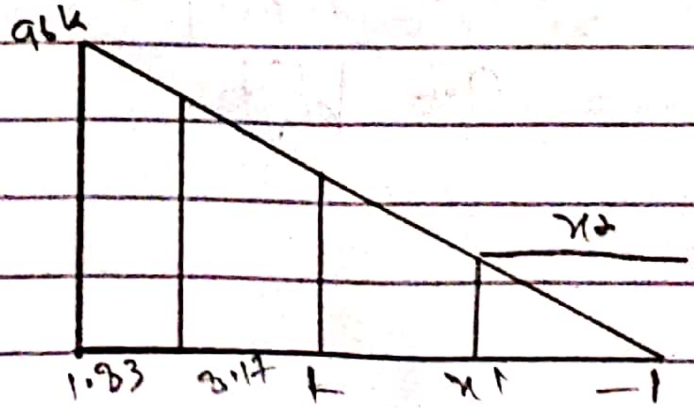
Step 03

Find critical stress and its location.

As we know it is located at distance d from force of support d = 22

= 1.83'

Value by similarity triangle.



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From similarity Δ's $\frac{96}{10} = \frac{V4}{8.17}$

$VU = 78.43\ k$

→ Step 04

Finding value of ϕV_C and $1/2\ \phi V_C$ and its distance from zero shear to right side

$\phi V_C = \phi \times 2 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 33.40\ k$

location $= \frac{96}{100} = \frac{33.40}{x_1}$

$x_1 = 3.48$

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

location of $\frac{1}{2} \phi V_C$ $\frac{96}{10} = \frac{16.70}{x_2}$

$x_2 = 1.74$

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Step 05 (Find value of ϕV_s ($V_u = \phi V_s + \phi V_c$))

So we have

$$\phi V_s = V_u - \phi V_c$$
$$= 78.43 - 33.40$$
$$\phi V_c = 45.03\ k.$$

Step 06 (Check section adaquacy).

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

Step 07 (Check mini spacing for stirrups)

$$\phi \times 4 \times \sqrt{f_c} \times b_w \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$$
$$66.79\ k > \phi V_s = 44.03\ k$$

Thus max spacing will be selected from the following:-

① $S_{max} = 24''$ ② $d/2 = \frac{22}{2} = 11''$

③ $S_{max} = \frac{A_v \times f_y}{0.75\sqrt{f_c} \times b_w \times d}$ $\therefore A_v = 0.22$

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

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

$= \dfrac{0.22 \times 60\,000}{50 \times 16} = 16.50$

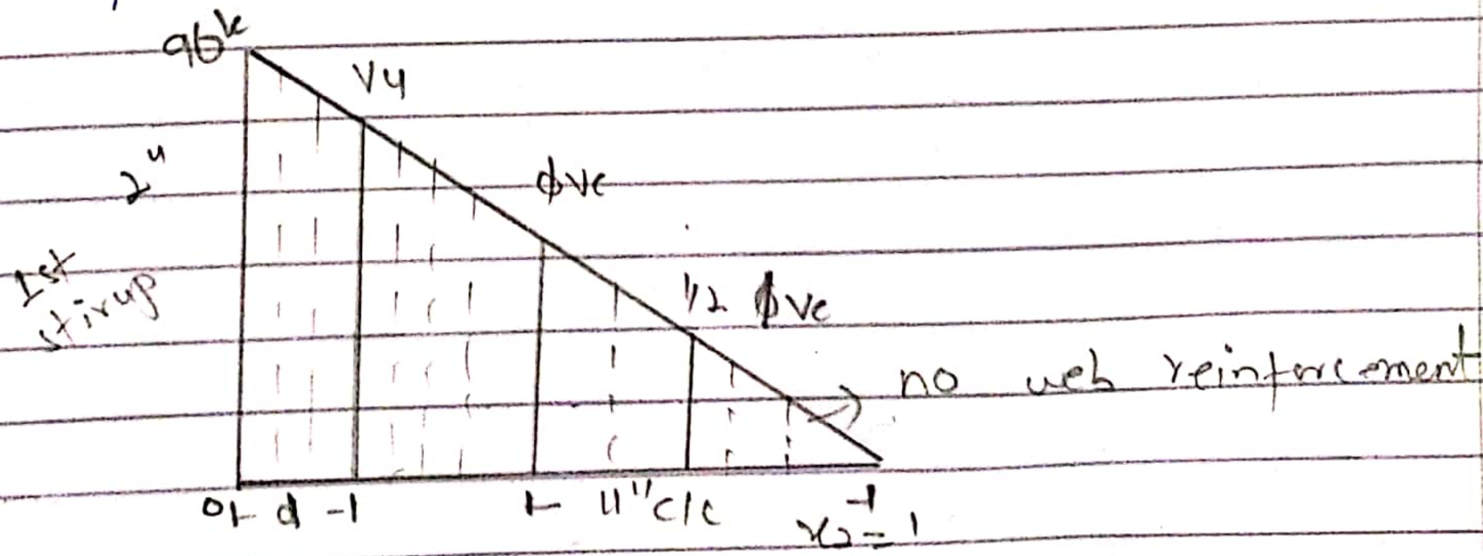
From the above 4 conditions least value of spacing for #3 striped will be selected so $S_{max} = 4''$ c/c.

→ Step 08 (Spacing of stirup from at critical condition).

$S = \dfrac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \dfrac{0.75 \times 0.22 \times 60 \times 22}{78.2 - 33.40}$

$S = 4.84 \simeq 5''$ c/c.

→ Step 09 (Final sketch).



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We know that first stirrup from face of support = 5/2

= 2.5 ≈ 2"

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Date:

Q#3

Solution,

→ Step 1, Find gross area of concrete

$A_g = b \times b$ (since its squaretied column)

$A_g = 12 \times 12 = 144 \text{ in}^2$ (Actual)

→ Step 2, Find the area of steel,

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

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

→ Step 3, Ultimate load carrying capacity

$P_u = \phi \times 0.8 [0.85 \times f'c \times (A_g - A_s) + A_s \times f_y]$

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

$P_u = 466.50 k$

→ step 4: Sketch and design of ties (c/c to distance)

From the below value we choose least value of all these

① 16 x dia of long bar = $16 \times 9/8 = 18''$

② 16 x dia of pie bar = $48 \times 3/8 = 18''$

③ Least column dimension = 12''

So c/c distance b/w ties = 12''

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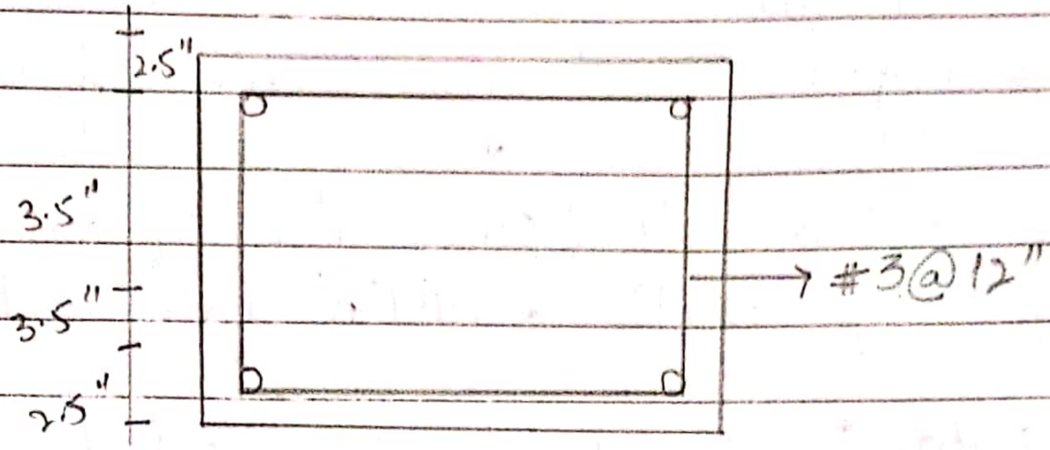

Since it is a died square column so there is no spiral stirrup used. the Stirrup used is of rectangular shape due to the specification of the structure thus we will use tie stirrup instead.

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Q # 04

Solution,

Step 1;

let $h = 24''$

Step 2;

Total weight = Wt of soil + Wt of Rc

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

$= 660$ 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 of foundation

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

$= 119.57 \text{ ft}^2.$

Step 5;

Since foundation is square

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

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Step 6;

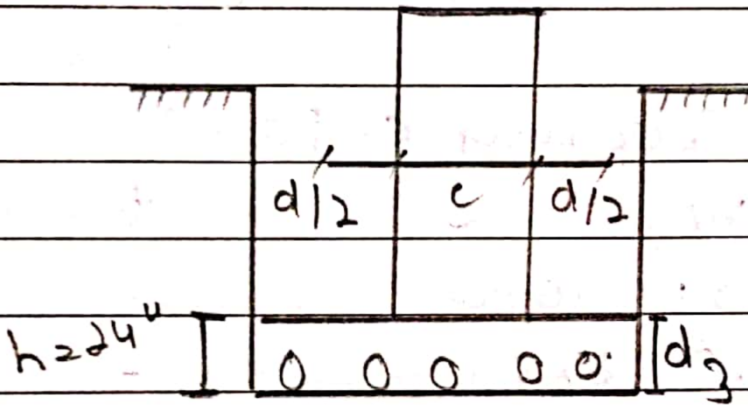
$$q_{ue} = \frac{\text{upward bearing capacity of soil}}{\text{Factored load} \; (B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

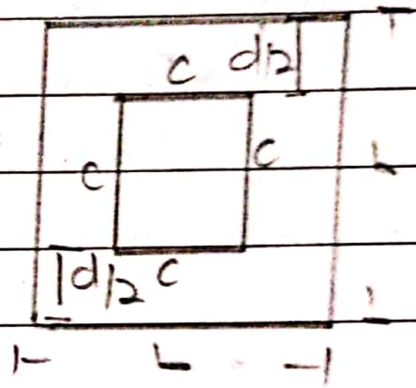
$q_{up} = 2.58 k/ft^2$

Step 7;

Punching shear

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





d = h - C.C - dia of bar - 1/2 db

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

Take #8 bar dia 8/8 = 1"

d = h - CC - dia of bar - 1/2 db

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

b_o = 4 (16 + 19.5) = 142"

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→ Step 08

$V_{v2} = q_{up} [B^2 - (c+d)^2]$

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

$= 289.60 k$

→ Step 09

$\phi V_{up} = \phi \times 4 \times \sqrt{f_c'} \times b \times d$

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

$= 525.38 k$

→ Step 10

Beam sheer / One way sheer check

$V_{v1} = q_{up} \times B \times [B/2 - C/2 - d]$

$V_{v1} = 2.58 \times 11 [11/2 - 16/2 - \frac{19.5}{2}]$

$V_{v1} = 90.95 k$

→ Step 11 (Soil) sheer capacity

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

$= \frac{0.75 \times 2 \times \sqrt{4000} \times (11 \times 12 - 6)}{1000}$

$= 110.04 k > V_{v1} \rightarrow Ok$

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→ Step 12 (Ultimate moment)

$$M_o = \frac{q_u p \times 13}{8} \times (B - c)^2 - \frac{2.58 \times 4}{8} \times \left(11 - \frac{16}{12}\right)^2$$

$M_u = 331.49k = 3977.93k$.

→ Step 13 (Area of steel Ly mainbars with trial and repeat method).

Trial # 1

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

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

$= 8.56\ in^2$

Trial # 2

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

$= 1.58''$

$$A_s = \frac{3977.93}{0.9 \times 60 \left(11 - \frac{1.53}{2}\right)} = 7.197\ in^2$$

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Trial #3

$$a = \frac{7.192 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.28 \text{ in}^2$$

$$A_s = \frac{3977.93}{0.9 \times 60 \left(11 - \frac{1.28}{2}\right)} = 7.1 \text{ in}^2$$

→ So this area is 7.1 in^2

→ Step 14 (Check the main reinforce-ments by the following methods)

- $A_s min = 0.0018 \times B \times h = 0.0018 (11 \times 12) 24$
$= 5.70 \text{ in}^2$

- $A_s min = \frac{200 \times B \times d}{f_y} = \frac{200}{60000} \times (11 \times 12) 19.5$

$A_s min = \frac{3 \times \sqrt{f_c'} \times B \times d}{f_y} = \frac{3 \times \sqrt{3000} \times (11 \times 12) \times 19.5}{60,000}$

$= 7.05 \text{ in}$

From the above values greater value will be selected thus

A_s min = 8.58 in²

→ Step 15

Using #8 bars

$A_b = 0.785 \text{ in}^2$

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

≃ 11 bars in each direction.

The End.

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