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Section # A

Semster # 6th

Paper # PRCD

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Ans (1)

Given data:-

$f_c' = 4000$ psi

$f_y = 40$ksi

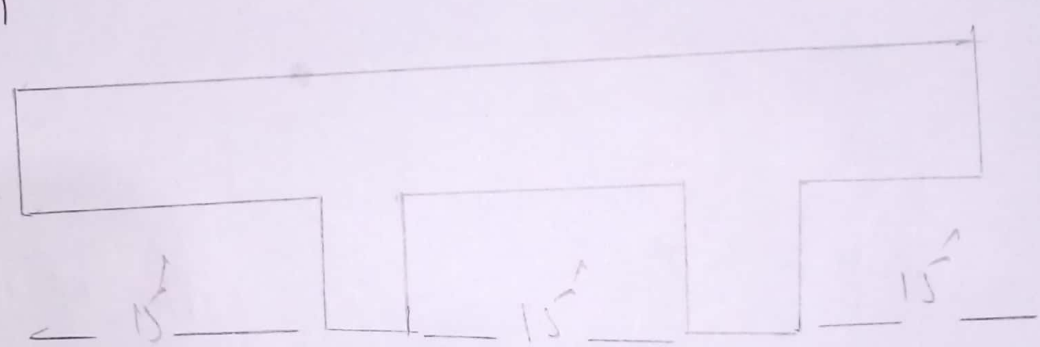
3 equal spans concrete slap

clear span between support = 15ft

factored live load = 160lb/ft²

service load finish load = 20 lb/ft².

Solution



step # 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.

$factor = (0.4 \pm f_y/100)$

$= (0.4 + 40/100)$

$= 0.8$

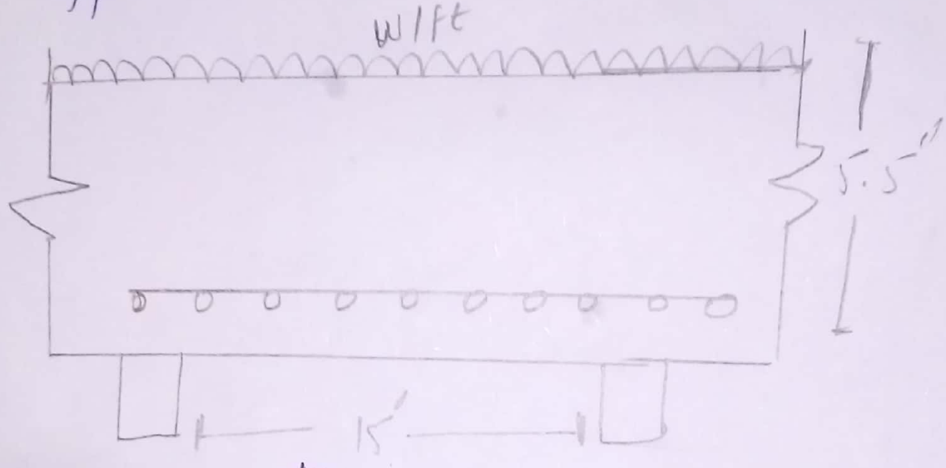
Hence the minimum thickness will be

6.5×0.8

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

Step # 2

Effective depth.



using formula

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

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

$d \cong 4.5''$

Step # 3

Self weight of slab

using formula

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

$= \frac{5.5}{12} \times 150$

$= 68.75 \text{ lb/ft}$

Step # 4
Total factored load

factored live load = 160 lb/ft^2

Hence the minimum thickness will be 6.5 x 0.8

t_{min} = 5.2 ≈ 5.5"

So the factored dead load will be = D.L = 1.2 (20 + 68.75)

Total factored load = D.L + L.L
= 106.5 + 160
= 266.5 lb/ft^2
= 0.2665 k/ft^2.

Step # 5
ultimate moment

using formula

$$MU = \frac{WU \times L^2}{8} = \frac{0.2665 \times 15^2}{8} \times 12$$

MU = 89.94 kip - inch

Step # 6
Area of steel for main bars

Trial # 1
let depth of compression block

a = 0.2 x t
= 0.2 x 5.5
= 1.1"

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

Trial 02:-

$$a = \frac{Ast \times fy}{0.85 \times fc' \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12}$$

$$Ast = 0.62 \, in^2$$

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

$$Ast = 0.59 \, in^2$$

Trial 03 :-

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

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.57}{2})}$$

$$= 0.59 \, in^2$$

So we will use $Ast = 0.59 \, in^2$

Step # 7

Area of steel for distribution reinforcement

using formula

$A_{min} = 0.002 \times b \times t$ → (for grade 60 steel)

$= 0.002 \times 12 \times 5.5$

$= 0.132 \ in^2$

Step # 8

Spacing for main bar using formula.

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

we use # 6 bar dia $= \left(\frac{6}{8}\right)''$

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

Step # 9

Spacing for distribution bars

Spacing $= \frac{Ab}{Ast}$

we use # 5 bars

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

(9)

$$\text{Spacing} = \frac{0.31}{0.132} \times 12 = 28.11'' \approx 28'' \text{ c/c}$$

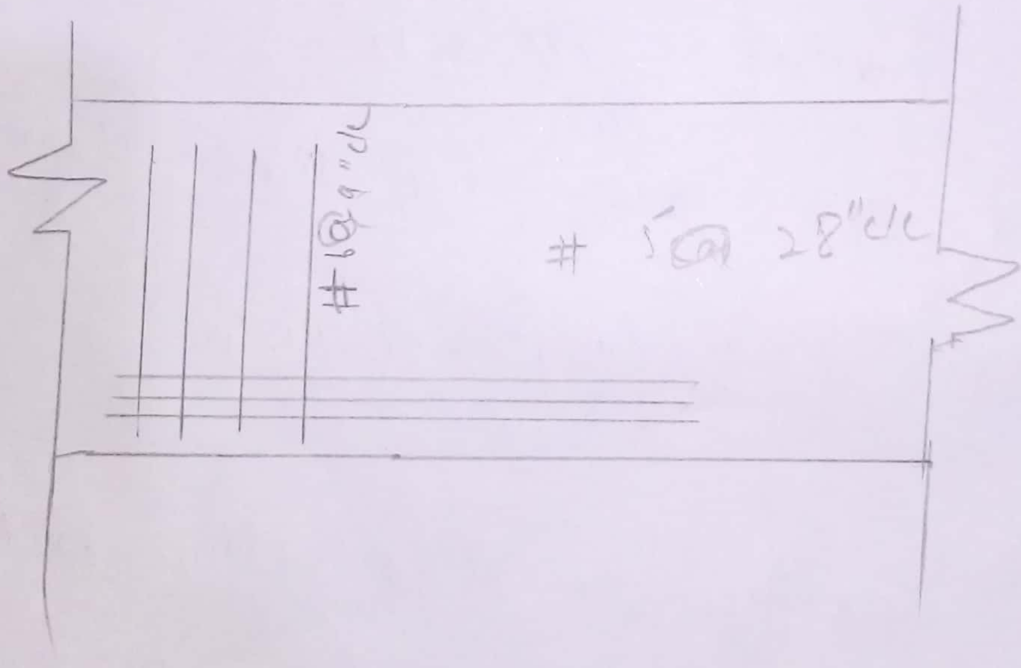
Step # 10

find sketch

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

Main Steel #6 at 9" c/c

Distribution Steel #5 at 28" c/c



Q2) Givens

let find the unit load of beam

$b \times \gamma_c$

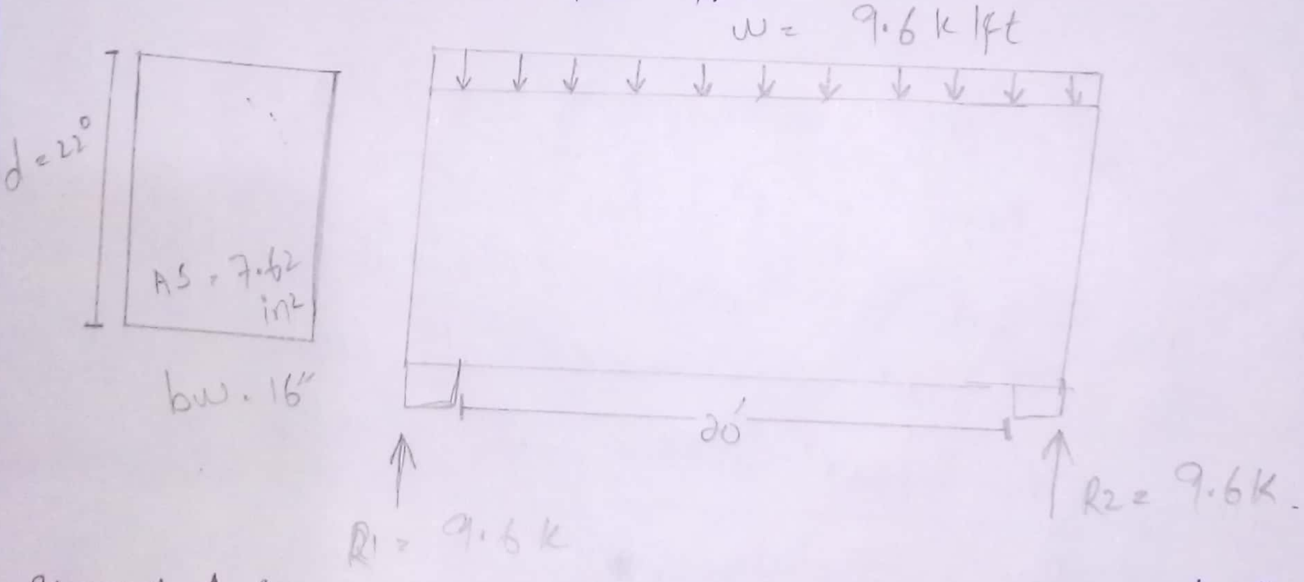
$= \frac{16}{12} \times 150$

$= 200 lb/ft = 0.2 K/ft$

so total factored load

$= 9.4 + 0.2$

$= 9.6 K/ft$



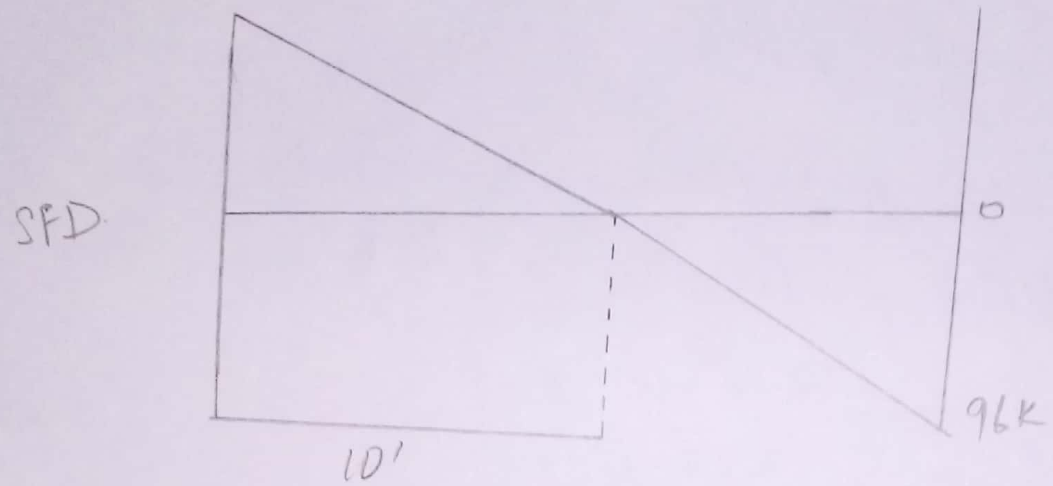
Step# 1 :-

find the values of R1 and R2

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

$= 9.6 \ k.$

Step # 2
Draw it Shear force diagram



Step # 3
Find the value of critical stress "Vu" and its location.
As we know that critical section is located at distance "d" from face of support = a = 22" = 1.83'

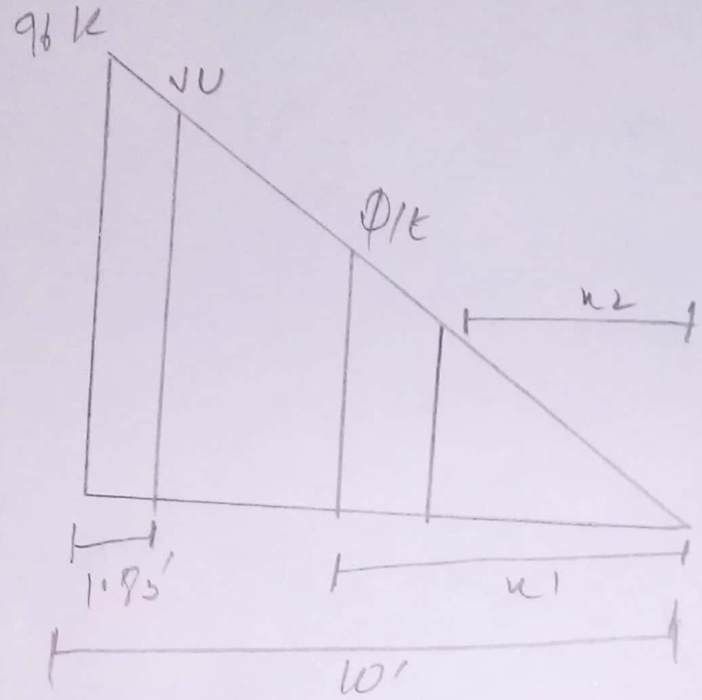
$\phi v_c = 33.40K$

location of ϕv_c by Similarity △'s

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

$x_1 = 3.48'$

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



from Similar Δ's

$$\frac{96}{10} = \frac{VU}{8.17}$$

$$VU = 78.43\,K$$

Step # 4
Fin the value of ϕV_C & $\frac{1}{2}\phi V_C$ and also its distance from zero sher to right side.

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

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

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

$= 16.70\,K$

location of $\frac{1}{2}\phi V_c$.

$\Rightarrow \frac{96}{10} = \frac{16.70}{x_2}$

$x_2 = 1.74'$

Step # 5 value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

So $\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

$\phi V_s = 45.03\,K$

Step # 6 check on section adequacy.

$\Rightarrow \phi \times 8 \times \sqrt{f'_c} \times b_w \times d$

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

$= 133.57\,K$

As $\phi \times \sqrt{f'_c} \times b_w \times d > \phi V_s$

it mean section is adequate.

Step #7

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

(3) $\frac{AU \times fy}{0.75 \times \sqrt{f'c} \times bw}$

$AU = \frac{\pi}{4}\; 0.11 \times 2$

$AU = 0.22.$

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

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

$= 16.50$

from the above four condition least value of spacing from # 3

U-Shaped will be Selected so max
= 11" c/c

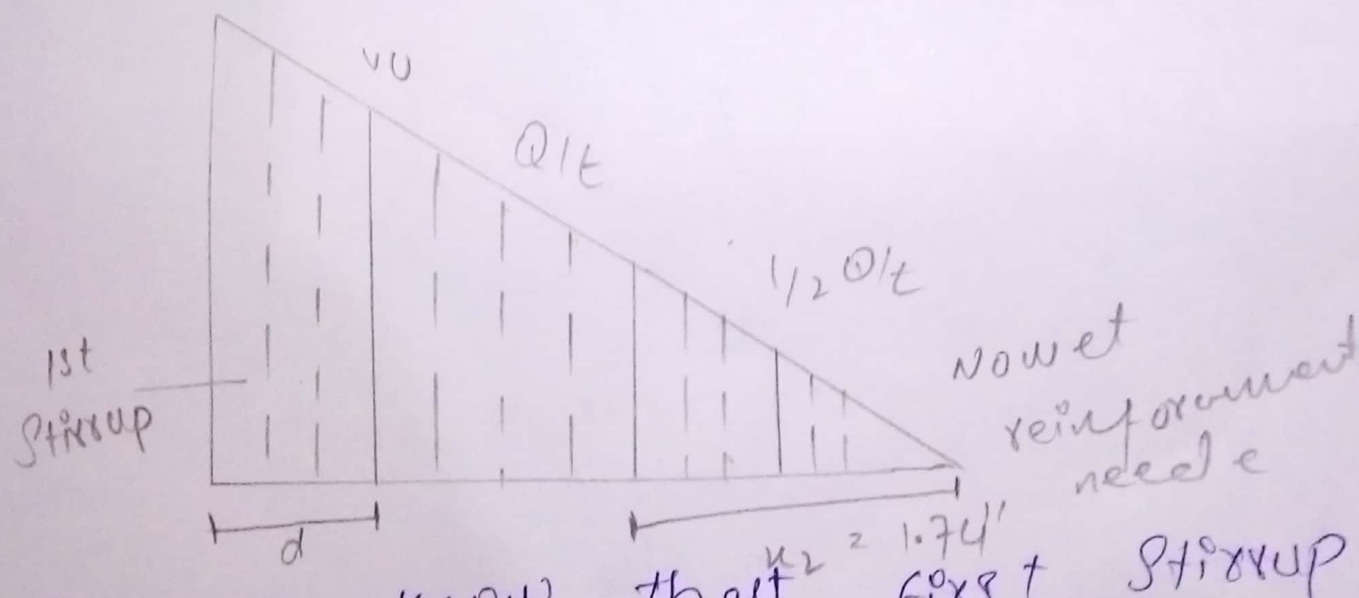
Step # 8
Spacing of Stirrup from at critical Section

$$S = \frac{\phi \times Av \times fy \times d}{Vu - \phi Vc}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40}$$

$$= 48.44'' \approx 5'' c/c$$

Step # 9
Find Sketches.



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

Q3

Step # 1

find gross area of concrete.

Ag = bxd (since its squairedfied column

Ag = 12 x 12 = 144 in^2 (Actual)

Step # 2

find the area of steel

Since

As = 5% of Ag

0.05 x 144

= ~~7.2~~ in^2

= 7.2 in^2

Step # 3 ultimate load carrying capacity

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

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

Pu = 466.50k

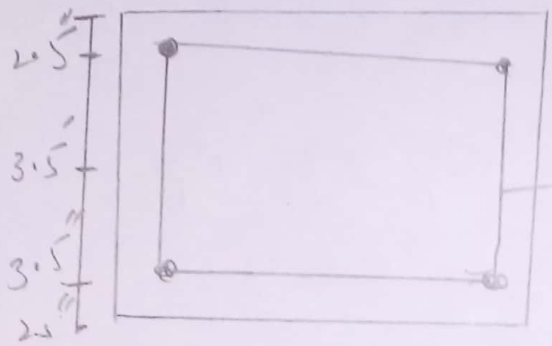
Step # 4 from the below value we choose the cost value of all this

(1) 16 x dia of long bar = 16 x 9/8
= 18"

(2) 48 x dia of tie bar = 45 x 3/8
= 18"

(3) least column dimension = 12"

so c/c distance b/w ties = 12"



Since its 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 the tie stirrups instead.

Ans[(4)] :-

Step # 1
let $h = 24''$

Step # 2
Total weight = wt of soil + wet of RL

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

$= 660 psi$

$= 0.660 ksi$

Step # 3
Effective bearing capacity

$q_e = q_a - w$

$= 250 - 0.660$

$= 1.84 ksi$

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×b = 119.57

$\Rightarrow B \cong 11'$

Step # 6 :-
upward bearing capacity of soil

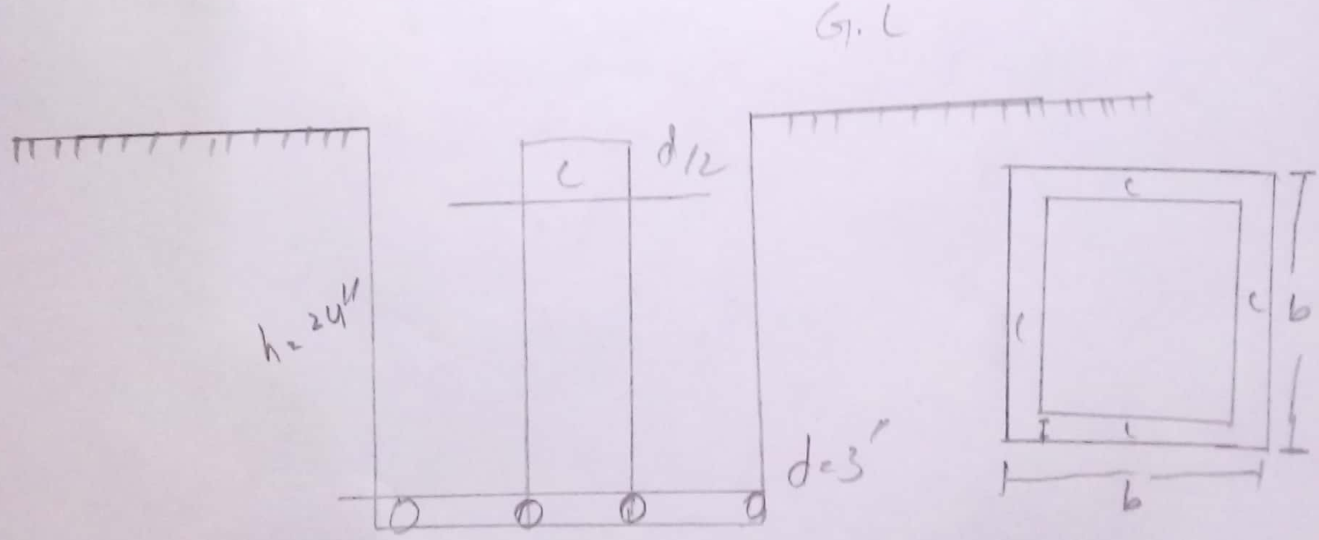
$q_{up} = \dfrac{\text{factored load}}{(B)^2}$

$= \dfrac{1.2 \times 100 \times 1.6 \times 120}{11^2}$

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

Step # 7 :
Punching Shear

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



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

Take # 8 bar dia = 1"

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

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

Step # 8

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

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

$V_{u2} = 289.60\,k$

Step # 9

$\phi V_{cp} = \phi \times 4 \times \sqrt{f'c} \times b \times d$

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

$\phi K/p = 525.38$

Step # 10 on way shear check.

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

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

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

Step # 11

Self Shear capacity

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

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

$110.04k > V_{u1}$

$\Rightarrow$ ok

Step # 12

Ultimate moment

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

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

$M_U = 331.49k' \approx 3977.93\ k$

Step #13

Area of steel for main bars by trial and repeat method

Trial #01

let $a = 0.2 \times h$

$= 0.2 \times 2.4$

$= 4.8''$

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

$= 8.56\ in^2$

Trial # 2

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

$$AS = \frac{39787.93}{0.90 \times 60\left(11 - \frac{1.28}{2}\right)}$$

$$\boxed{Ared = 7.1 in^2}$$

Step # 14

Check the min reinforcement by the following 03 method.

(a) $AS_{min} = 0.0018 \times B \times h$

$= 0.0018 \times (11 \times 12) \times 24$

$= 5.70 \ in^2$

(b) $AS_{min} = \frac{200}{fy} \times b \times d$

$= \frac{200}{60000} \times (11 \times 12) \times 19.5$

$= 8.58 in^2$

(c) $As_{min} = \frac{3 \times \sqrt{f'y}}{fy} \times B \times d$

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

$= 7.05 \, in^2$

from above greater value will be selected thus $As_{min} = 8.58 \, in^2$

Step #15

$Ab = 0.785 \, in^2$

No of bars $= \frac{As}{Ab} = \frac{8.58}{0.785}$

$= 10.92 \cong 11$ bars in each direction.

$\longleftrightarrow$