ID: 7379

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Subject: PRCD - I

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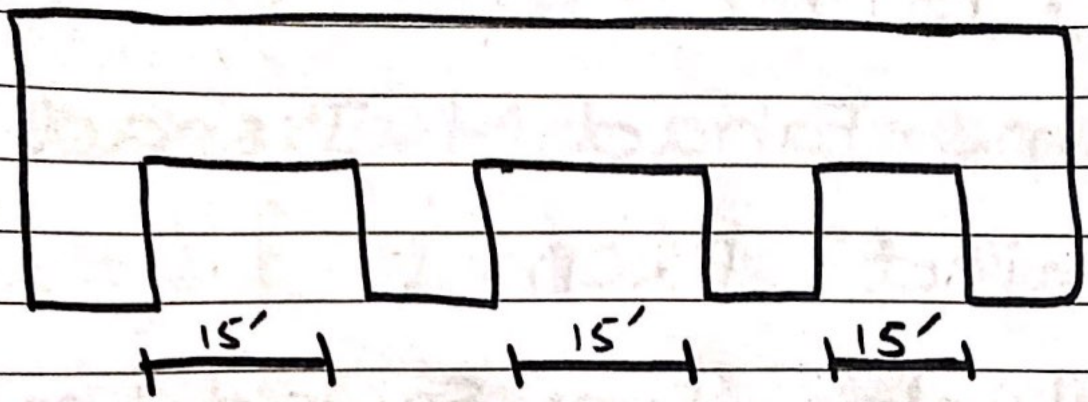
FINAL TERM.

Q1: A reinforced concrete slab is built integrally with its support and consists - - - - - - - - . . . . .
Draw sketch of your final design.

Given Data:

- ⇒ 3 equal spans concrete slab.
- ⇒ Clear span b/w supports = 15ft.
- ⇒ Factored live load = 160 lb/ft^2
- ⇒ Service floor finish load = 20 lb/ft^2
- ⇒ f'_c = 4000 psi
- ⇒ f_y = 40 ksi.

Solution:-



STEP #1 (Minimum Thickness)

By using formula

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

As $f_y \rightarrow 40$ ksi

So we will multiply a factor with this thickness.

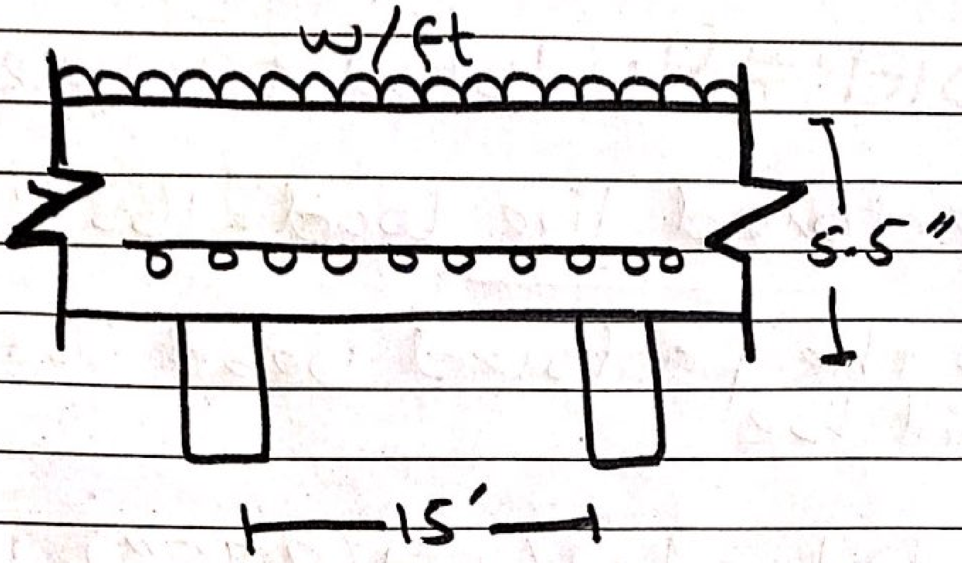
$$\text{factor} = \left(0.4 + \frac{f_y}{100}\right)$$

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

Hence the minimum thickness will be 6.5×0.8.

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

STEP # 2: (Effective Depth)



By formula

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

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

$d \cong 4.5"$

STEP # 3 (Self wt. of slab)

By formula

$\frac{t}{12} + \gamma\ \text{Concrete}$

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

STEP # 4: (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 # 5: (Ultimate Moment)

By using formula

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

$= 89.94$ Kip-inches

STEP#6: Area of steel for main Bar By Trial and Repeat Method.

Trial#1:

Let depth of compression block

$$a = 0.2 \times t$$
$$= 0.2 \times 5.5 = 1.1''$$

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

$$A_{ST} = 0.63 \text{ in}^2$$

Trial#2:

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

$$= 0.62 \text{ in}^2$$

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

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

Trial # 3:

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

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

So we will be $A_{ST} = 0.59 \, in^2$

STEP # 7: Area of steel for distribution reinforcement

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

$= 0.002 \times 12 \times 5.5$

$= 0.132 \, in^2$

STEP: 8: Spacing for main bar

By formula

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

We use # 6 bar dia = $\left(6/8\right)^4$

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

STEP#9: Spacing for distribution bars.

$$Spacing = \frac{A_b}{A_{ST}}$$

we use # 5 bars so

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

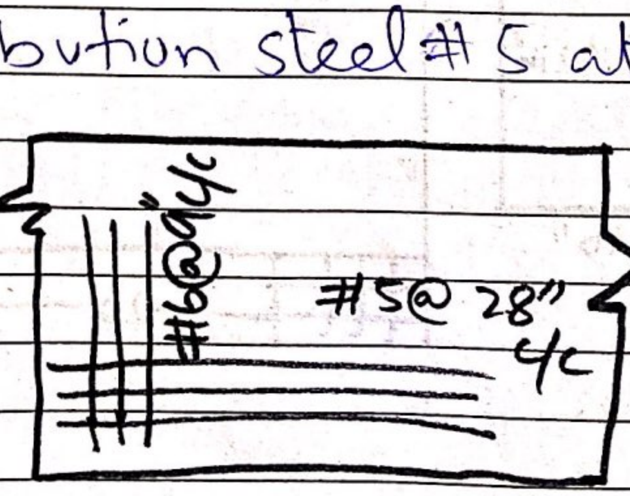
$$spacing = \frac{0.31}{0.132} \times 12 = 28.1'' \approx 28$$

STEP#10: Find Sketch.

$f_c' = 4\,ksi$, $f_y = 40\,ksi$

main steel # 6 at 9'' c/c

Distribution steel # 5 at 28'' c/c



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A simply supported rectangular beam 16" wide .... Draw a sketch of your final diagram.

Solution:

First of all find the unit Load of beam

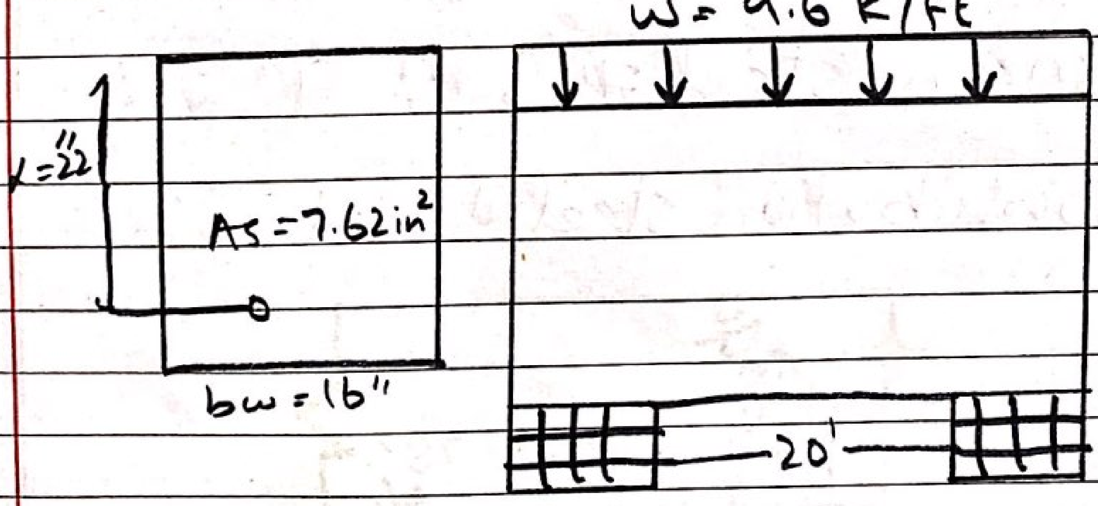
so $b \times \gamma_c$

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

$0.2\ K/ft$

So total factored load $= 9.4 + 0.2$

$= 9.6\ K/ft$

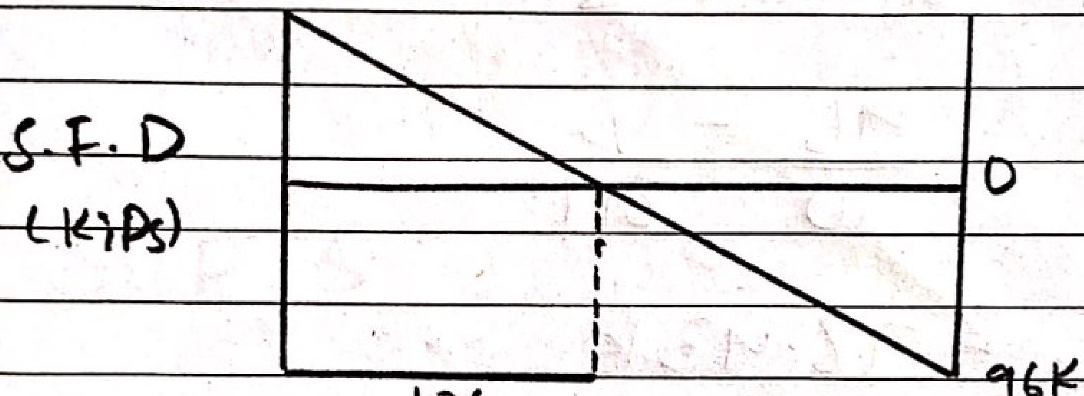


STEP # 1

find the value of R_1 & R_2

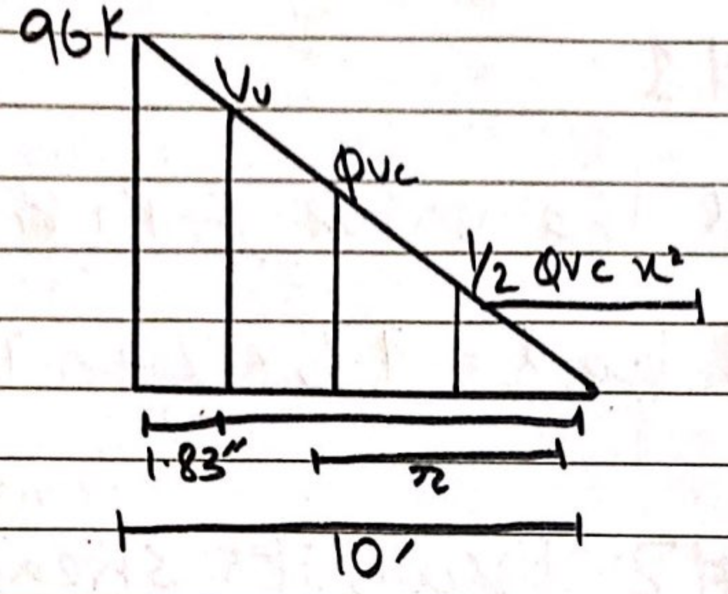
Total Load $= 9.6 \times \frac{20}{2} = 96K.$

STEP # 2 Draw its shear force diagram.



STEP # 3: Find the value of critical stress "vu" and its location.

As we know that critical reaction is located at distance "d" from face of support $a = 22'' = 1.83'$ value of critical shear at distance "d" by similarity of triangles.



from similar Δ's

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

$V_u = 78.43K$

STEP: 4: Find the value of ΦVc {1/2ΦVc"} Also its distance from zero shear of right side.

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

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

$\Phi V_c = 33.40K$

Location of ΦVc by similarity of Δs'

$$\frac{96}{10} = \frac{33.40}{x'}$$

$$x_1 = 3.48'$$

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

Location of $\frac{1}{2} \phi V_c \Rightarrow \frac{96}{10} = \frac{16.70}{x^2}$

$$x_2 = 1.74'$$

STEP: 5: Value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

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

$$\phi V_s = 78.43 - 33.40$$

$$\phi V_s = 45.03K$$

STEP: 6: Check on section Adaway.

$\Rightarrow \phi \times 8 \times \sqrt{f'c} \times bw \times d =$

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

$= 133.57k$

As $\phi \times 8\sqrt{f'c} \times bw \times d > \phi Vs \rightarrow$

It means section is adequate.

STEP: 7: Check on min spacing for stirrups.

$\phi \times 4 \times \sqrt{f'c} \times bw \times d =$

$$\frac{0.75 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79k$$

As $\phi 4\sqrt{fc'} \times bwd > \phi vs = 45.03k$

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

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

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

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

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

$Av = 0.11 \times 2$

$Av = 0.22$

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4) $p = \frac{Au \times fy}{50 \times bw}$

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

$= 16.50$

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

so $S_{max} = 1.1'' c/c$

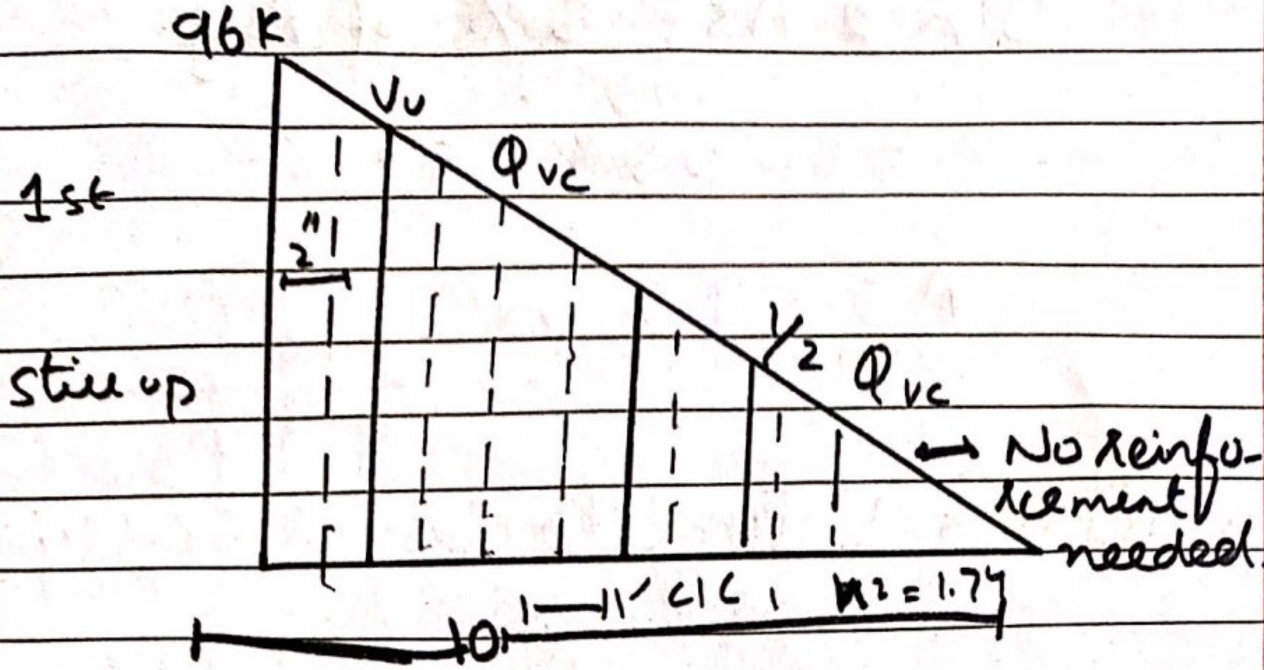
STEP # 8: Spacing of Stirr up from / at critical section.

$S = \frac{\phi \times Au \times fy \times d}{Vu - \phi Vc}$ = ~~0.75~~

$= \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.46}$

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

STEP # 9: Find Sketch.



As we know that first stirr up from face of support.

$\Rightarrow \frac{5}{2} = 2.5 \approx 2"$

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Q3: Calculate the axial ultimate .... design necessary spirals.

STEP: 1. Find gross area of concrete.

$A_g = b \times b$ (since it is squaretied column)

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

STEP: 2 Find the area of Steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2\ in^2$

STEP: 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: 4 Sketch & design of Ties

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 = $48 \times 3/8 = 18''$

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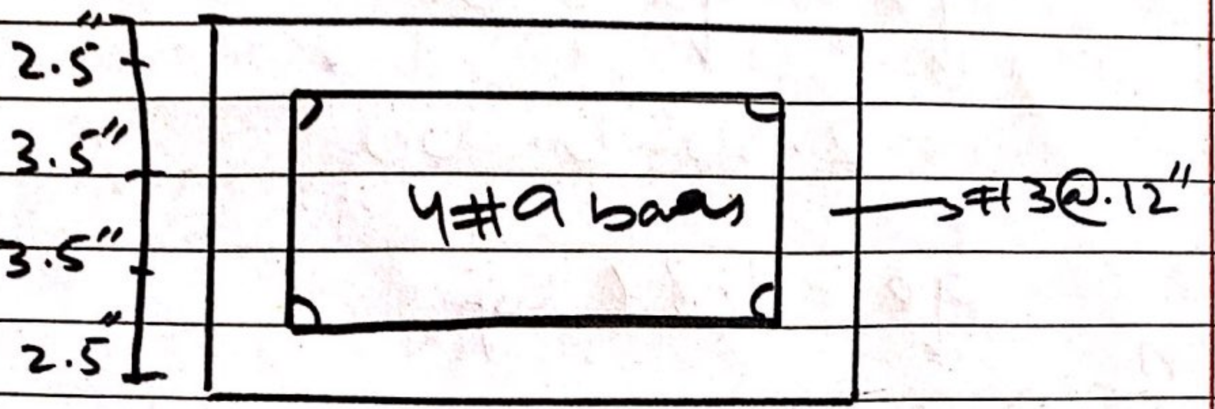
3) least column dimension = 12"

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 the stirrup instead.

——x——x——x——x——

Q4:

Design a square footing ------sketch of your final design.

STEP: 1.

Let $h = 24"$

STEP:2. Effective bearing capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84$ ksf

STEP:3 Required Area for foundation.

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

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

STEP:4 Since foundation is square.

$\text{Area} = b \times b = 119.57 \Rightarrow B \cong 11'$

STEP:5 Upward bearing capacity of soil".

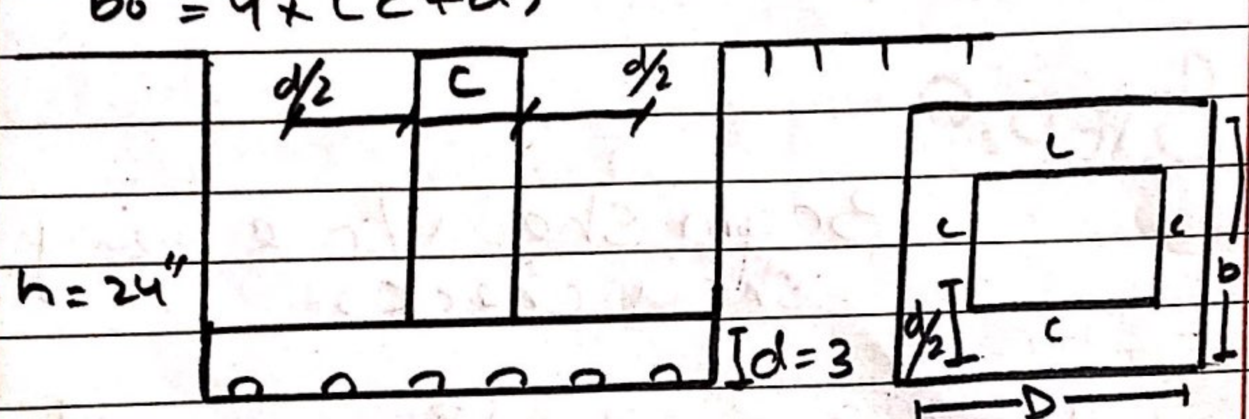
$q_{up} = \frac{\text{factored load}}{(B)^2}$

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

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

STEP: 6 Punching shear

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



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

∴ Take #8 bar dia = $\frac{8''}{8} = 1''$

$= 24 - 3.1 - \frac{1}{2}(1) = 19.5''$

$b_o = 4 \times (16 + 9.5) = 142''$

STEP: 7

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

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

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$V_{u2} = 289.60K$

STEP : 8

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

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

$\phi_{up} = 525.38K$

STEP: 9

Beam shear / one way shear check :-

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

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

$V_{u1} = 90.95K$

"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: 11 Ultimate moment

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

$$M_u = 331.49K' = 3977.93K''$$

STEP: 12

Area of steel for main bars by trial & Repeat method.

trial # 1

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

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

$= 8.56 \, in^2$

trial #2

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

$$= 1.53''$$

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

trial #3

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

$$As = \frac{3977.93}{0.90 \times 60 (11 - 1.28/2)} = 7.1 \, in^2$$

So thus area $= 7.1 \, in^2$

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Step # 14.

Check the min reinforcement by the following as method,

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

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

$$As_{min} = \frac{200}{fy} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$$

$$= 8.58\ in^2$$

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

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

$= 7.05 \, in^2$

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

STEP : 15

Using #8 bars.

$A_b = 0.785 \, in^2$

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

$\approx$ 11 bars in each direction.

THE END.