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Section : A

Subject : PRCD1

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Given Data:-

-> 3 equal spans concrete slab

-> Clear span b/w supports = 15ft

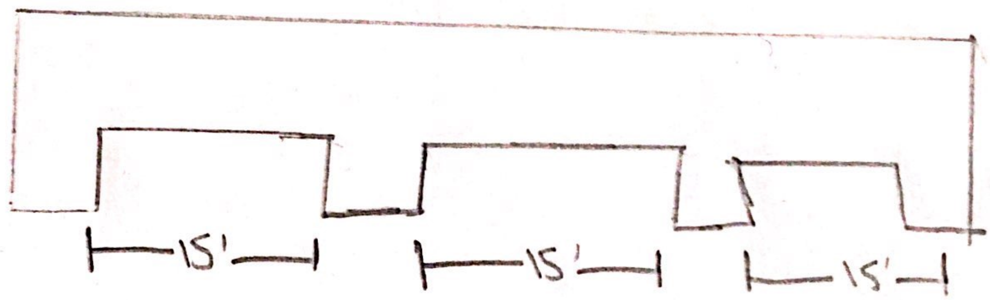
-> Factored live load = 160 Lb/Ft²

-> service Floor Finish load = 20Lb/Ft²

-> $F'_c = 4000 Psi$

-> $F_y = 40 ksi$

Solution:-



Step 1:-

Using Formula

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

As $f_y = 40 ksi$

We multiply a Factor with this thickness

$$Factor = \left(0.4 \times \frac{F_y}{100}\right)$$

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

Hence the minimum thickness will be

6.5×0.8

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

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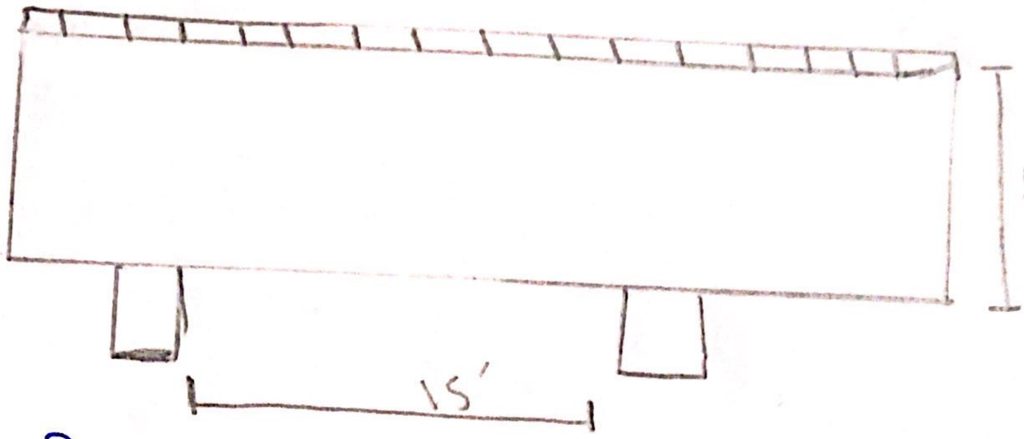
Step 2:- (Effective depth)



By Formula we have

$d = t - \text{clear cover} - \frac{1}{2}(\text{dia of m.b})$

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

$d = 4.5''$

Step # 3 Self weight of slab

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

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

Step # 4 (Total Factored load).

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

the Factor 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 # 5 (Ultimate moment)

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

$= 89.94$ kip-inch

Step # 6

Area of steel For main Bars By Trail and Repeat Method.

Trail # 01

Let depth of compression black

$a = 0.2 \times t$

$= 0.2 \times 5.5 = 1.1''$

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

Trail # 2

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

Trail # 3 .

$$a = \frac{0.59 \times 40}{0.35 \times 4 \times 12} = 0.57''$$

$$A_{st} = \frac{89.94}{0.90 \times 4 \times (4.5 - \frac{0.57}{2})} = 0.59 \text{ in}^2$$

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

Step # 7 Area of steel for distribution reinforcements

$A_{min} = 0.002 * b * t$ (For grade 4 steel)

$A_{min} = 0.002 * 12 * 5.5 \Rightarrow 0.132 in^2$

Step # 8 spacing for M.B

Spacing $\frac{A_b}{A_{st}} * 12$

we use # 6 bar dia = (6/8)"

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

Step # 9 Spacing for distribution bars

Spacing $\frac{A_b}{A_{st}}$ we use # 5 bar

dia = (5/8)", Area $\frac{\pi}{4}(\frac{5}{8})^2 = 0.3 in^2$

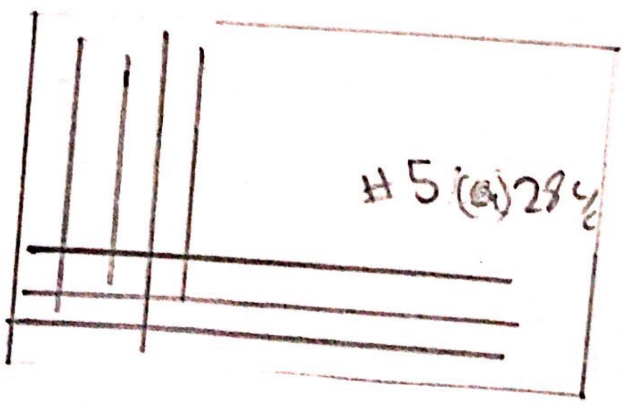
spacing = $\frac{0.31 * 12}{0.132}$ = 28.1 ≈ 28.1 ≈ 28" c/c

Step # 10 Final sketch

Fc' = 4 ksi Fy = 40 ks

Mainsteel # 6 at 9" c/c

Distribution steel # 5 at 28" c/c



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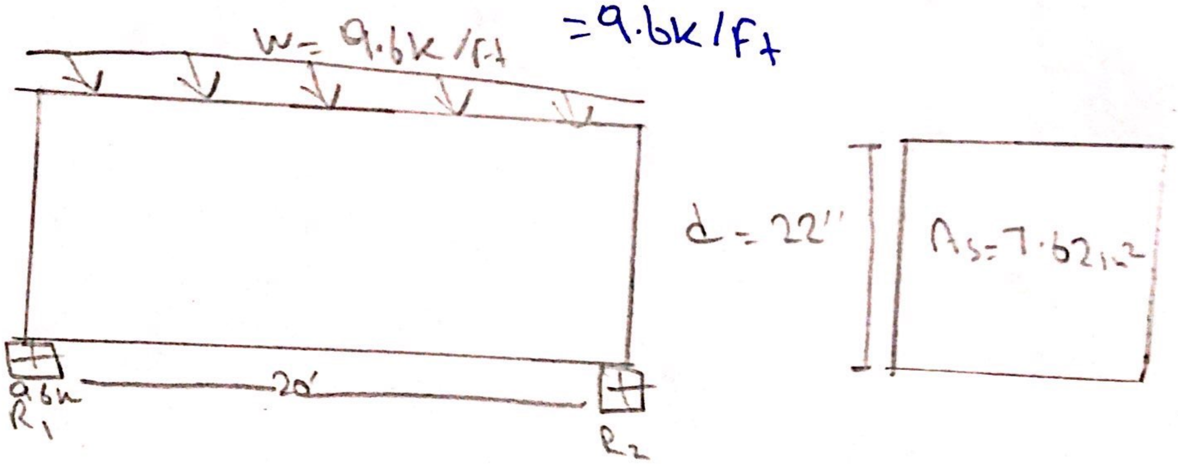
Solution:-

At First Find the unit load of beam so bxrc

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

total Factored load $= 9.4 + 0.2$

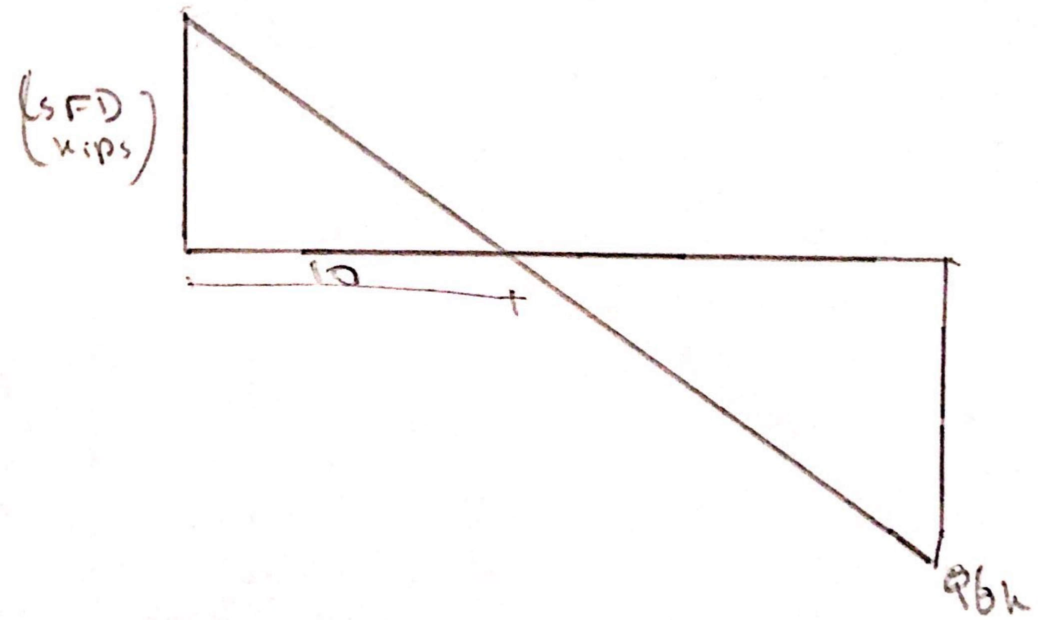
$= 9.6k/Ft$



Step #1 Finding value of R_1 and R_2

total load $= 9.6 + \frac{20}{2} = 96k$

Step #2



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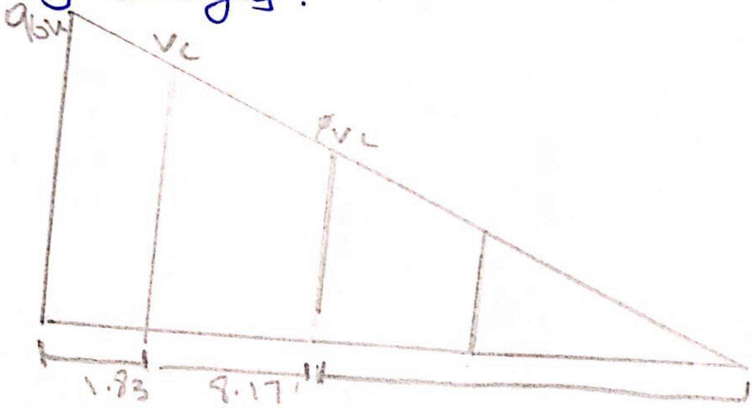
Step # 3 Finding value of critical stress "V_u" & its location.

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



From similar Δ'S $\frac{96}{10} = \frac{V_u}{8.17}$

$V_u = 78.43k$

Step # 4 Finding value of "ØVc" & ½ØVc" & its distance from zero shear to right side

$ØVc = Ø \times 2 \times \sqrt{F'c} \times b_w \times d = \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 2.2}{1000}$

$ØVc = 33.40k$

location of ØVc by similarity of Δ S'

$\frac{96}{100} = \frac{33.40}{K_1} = K_1 = 3.48'$

Now

$\frac{1}{2} ØVc = \frac{33.40}{2} = 16.70k$

Location for ½ ØVc ⇒ $\frac{96}{10} = \frac{16.70}{K_2}$

$K_2 = 1.74'$

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

So we have

$\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

$\phi V_s = 45.03k$

Step#6 Check section Adaquacy.

$\phi \times 8 \times \sqrt{F'_c} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 133.57k$

$133.57k > \phi V_s$ (mean Section is adaquate.)

Step#7 Check mini spacing For stirrups

$\phi \times 4 \times \sqrt{F'_c} \times b_w \times d \Rightarrow \frac{0.7 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 66.79k > \phi V_s = 44.03k$

thus max spacing will be selected from the following 4 conditions

① $S_{max} = 24''$

② $\frac{d}{2} = \frac{22}{2} = 11''$

③ $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{F'_c} \times 16}$

④ $S_{max} = \frac{0.22 \times 60000}{50 \times 16} = 16.50$

From the above 4 conditions least value of spacing For #3 U shaped will be selected

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

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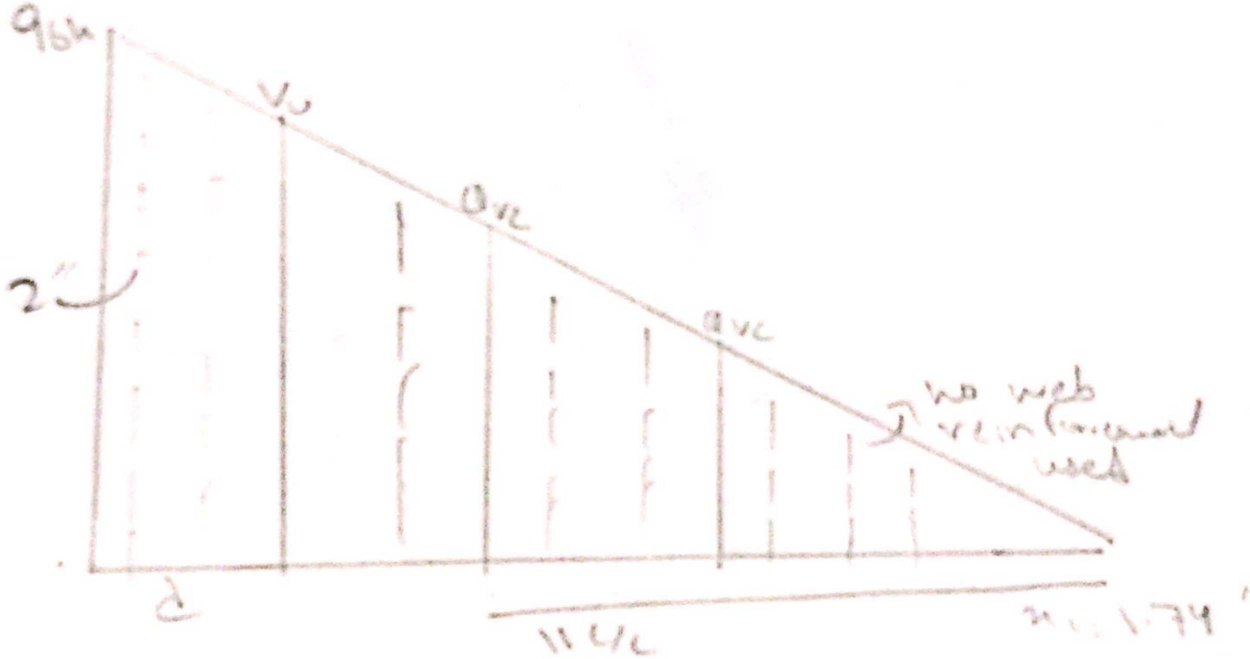
Step #8 Spacing of stirrup from at critical section

$$s = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{79.43 - 33.40}$$

$s = 4.94 \approx 5'' c/c$

Step #9 Final section



we know that first stirrup from face of support $= 5/2 = 2.5 \approx 2''$

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Solution:-

Step # 01:-

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 # 02

Find the area of steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2 in^2$

Step # 03

ultimate load carrying capacity

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

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

$P_u = 466.50 k$

Step # 04

Sketch and design of Ties (c/c to distance)

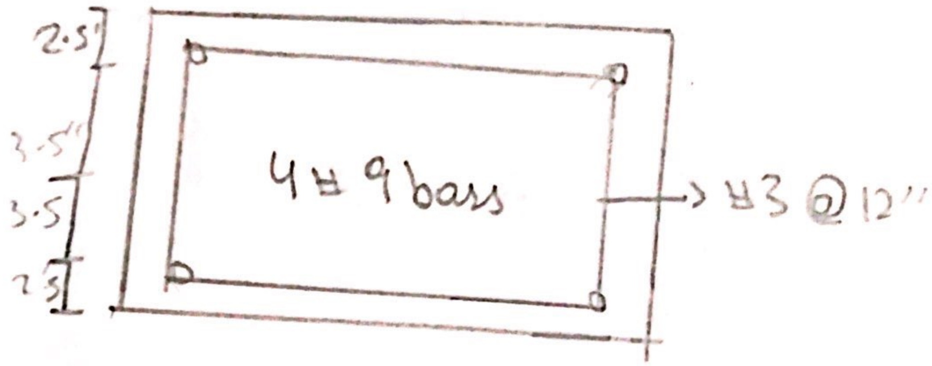
From the below value choose the least value of all thus

1) 16 × dia of long bar = $16 \times 9/8$

$= 18''$

2) 48 × dia of Tie bar = 48 × 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 tie stirrups instead.

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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

$q_e = q_a \mp w$

$= 2.50 - 0.660$

$q_e = 1.84 \, ksf$

Step # 4

Required Area for foundation.

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

$= 119.57 \, ft^2$

Step # 5

Since foundation is square.

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

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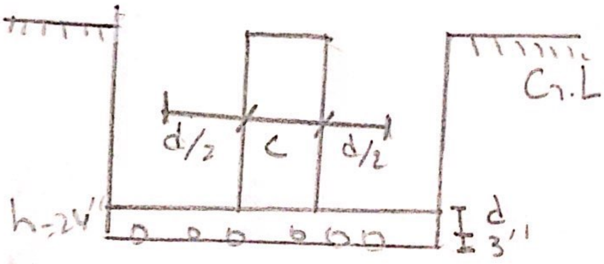
Step # 06:- upward bearing capacity of soil

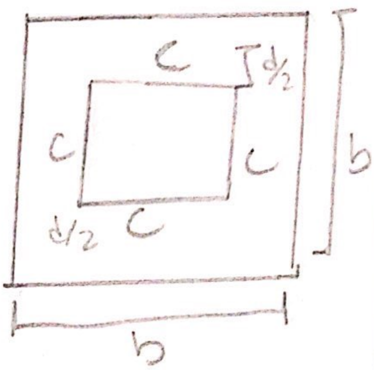
$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

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

Step # 07 Punching shear

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





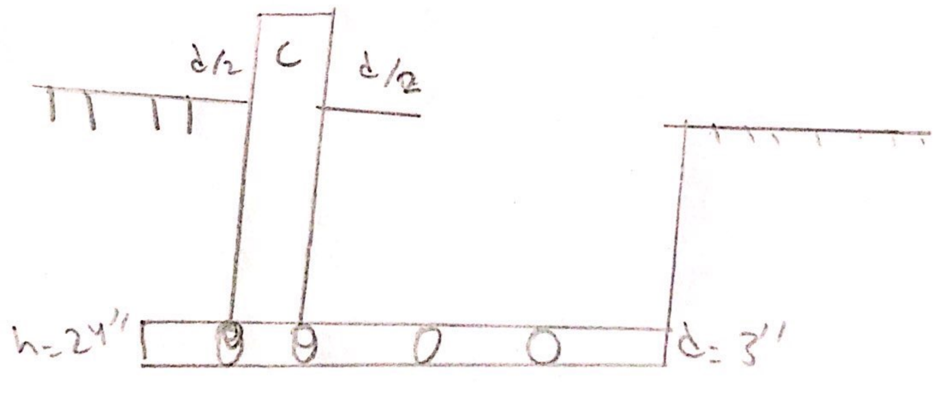
$d = h - cc - \text{dia of bar} - \frac{1}{2} d_b$

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

∴ Take #8 bar

dia $= 8/8'' = 1''$

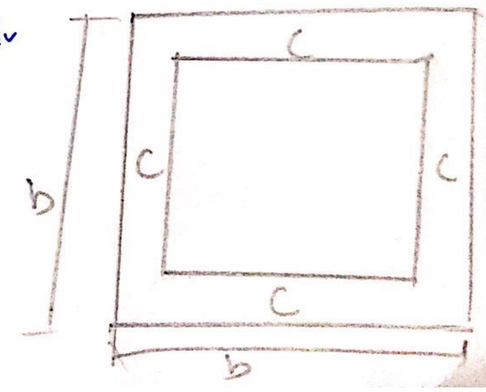
$b_o = 4 \times (16 + 19.5) = 142''$



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

$= 24 - 3 - 1 - \frac{1}{2}(1) = 195''$

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



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Step # 8:-

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

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

$$V_{u2} = 289.60k$$

Step # 9

$$\phi V_{up} = \frac{\phi \times 4 \times \sqrt{F'c} \times b \times d}{1000}$$

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

$$= 525.38k$$

Step 10:- Beam shear/one way shear check.

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

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

$$V_{u1} = 90.95k$$

Step 11 # Self shear capacity

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

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

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

Step 12:- Ultimate Moment 7817

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

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

Step 13:- Area of steel for mainbars by trail & repeat Method

Trail 1:-

Let $a = 0.2 \times h = 0.2 \times 24 = 4.8$

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

$= 8.56 \text{ in}^2$

Trail 2:-

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

$$A_s = \frac{3977.93}{0.90 \times 60 \times (11 - \frac{1.53}{2})} = 7.97 \text{ in}^2$$

Trail 3:-

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

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

So thus Area $= 7.1 \text{ in}^2$

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

Step 15 #

using #8 bars

$Ab = 0.785$

$\text{No. of Bars} = \frac{As}{Ab} = \frac{8.58}{0.785} = 10.92$

$\simeq 11$ bars in Each direction