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Subject:→ PRCD-I
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Semester:→ 6th
Department:→ civil engineering
exame:→ final term
Date:→ 26th June 2020

Q1:→ ~~Reinfor~~

Given Data

3 equal spains concrete slab

clear span b/w supports = 15 ft

factor live load = 160 lb/ft^2

service floor finish load = 20 lb/ft^2

$f_c' = 4000$ psi

$f_y = 40$ ksi

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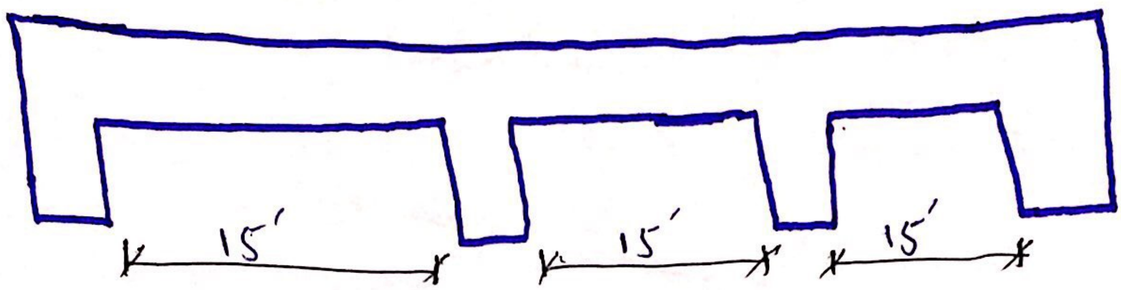
Sol:→



Step #01

Minimum thickness

$t_{min} = L/28$

$t_{min} = \frac{15}{28}$

$t_{min} = 6.4 \approx 6.5$

We will multiply a factor with this thickness

$factor = (0.4 + fy/100)$

$= (0.4 + 40/100)$

$factor = 0.8$

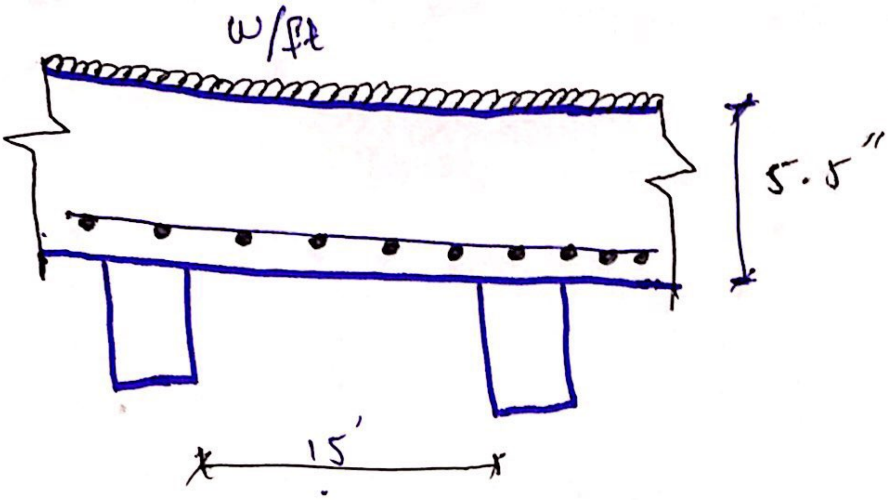
the minimum thikness will be

6.5×0.8

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

Step #02

effective depth



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

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

$d \cong 4.5''$

Step #03

self wt of slab

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

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

$= 68.75\ lb/ft^2$

Step # 04

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Total factor load.

Factor live load = 160 lb/ft^2

factor Dead load = 1.2(20+68.75)

D.L = 106.5 lb/ft^2

Total factored load = D.L + L.L

= 106.5 + 160

Total factored load = 266.5 lb/ft^2 => 0.2665 K/ft^3

Step # 05

Ultimate moment

$$Mu = \frac{W_u \times L^2}{8}$$

$$Mu = \frac{0.2665 \times (15)^2}{8} \times 12$$

Mu = 89.94 kip-inches

Step #06:→

Area of steel for main bars by trail and repeat method.

Trial #01

Let depth of compression block

$$a = 0.2 \times t$$

$$a = 0.2 \times 5.5$$

$$a = 1.1''$$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)}$$

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - 1.1/2)}$$

$$Ast = 0.63 \text{ in}^2$$

Trail #02

$$a = \frac{Ast \times fy}{0.55 \times f'c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} = 0.62 \text{ in}^2$$

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

$$Ast = 0.59 \text{ in}^2$$

Trail # 03 :→

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

$$a = 0.57''$$

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

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

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

Step # 07

Area of steel for distribution reinforcement

$$A_{min} = 0.002 \times b \times t$$

$$A_{min} = 0.002 \times 12 \times 5.5$$

$$A_{min} = 0.132 \, in^2$$

Step # 08

Spacing for main bars

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

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

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

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Step # 09

Spacing for distribution bars

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

we use # 5 bars so,

dia = (5/8)"

$$Area = \frac{\pi}{4}(5/8)^2$$

Area = 0.31 in²

$$Spacing = \frac{0.31}{0.132} \times 12$$

spacing = 28.1" ≈ 28" c/c

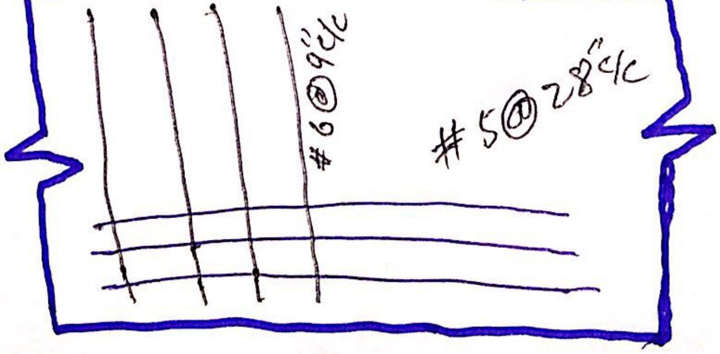
Step # 10 :→

Final sketch

fc' = 4ksi , fy = 40ksi

main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c



Q2:→

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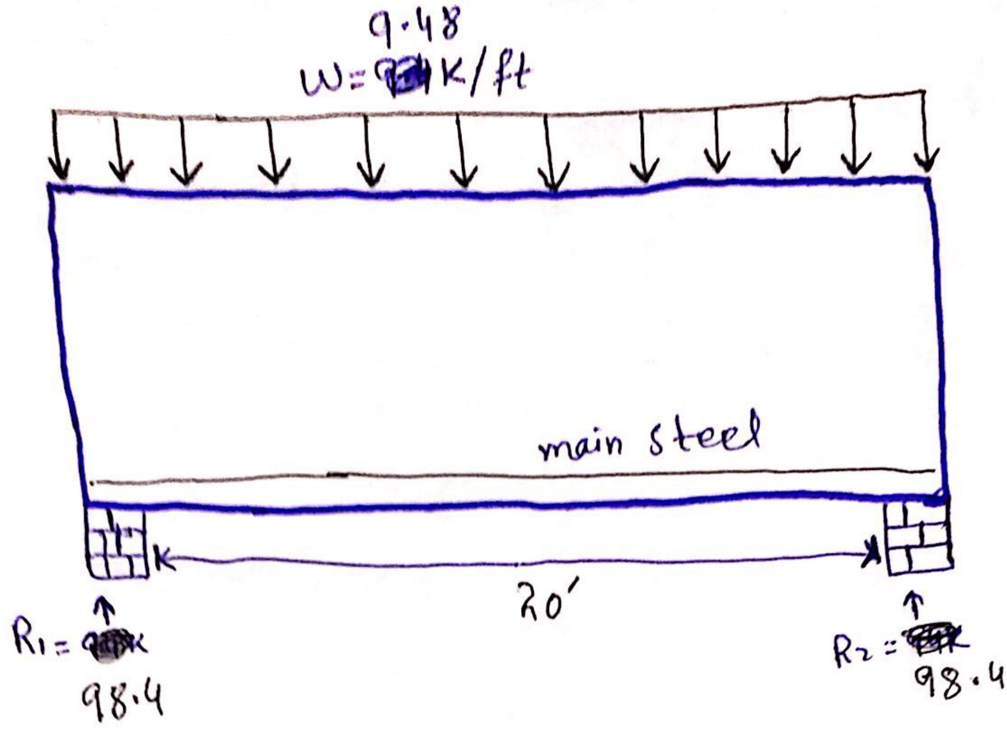
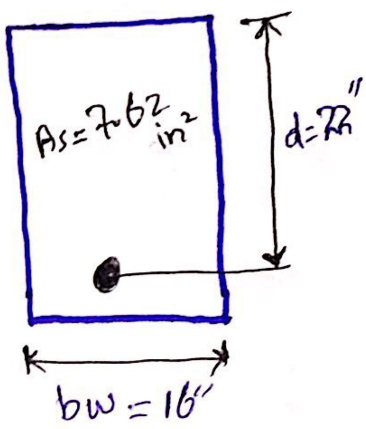
Sol:→

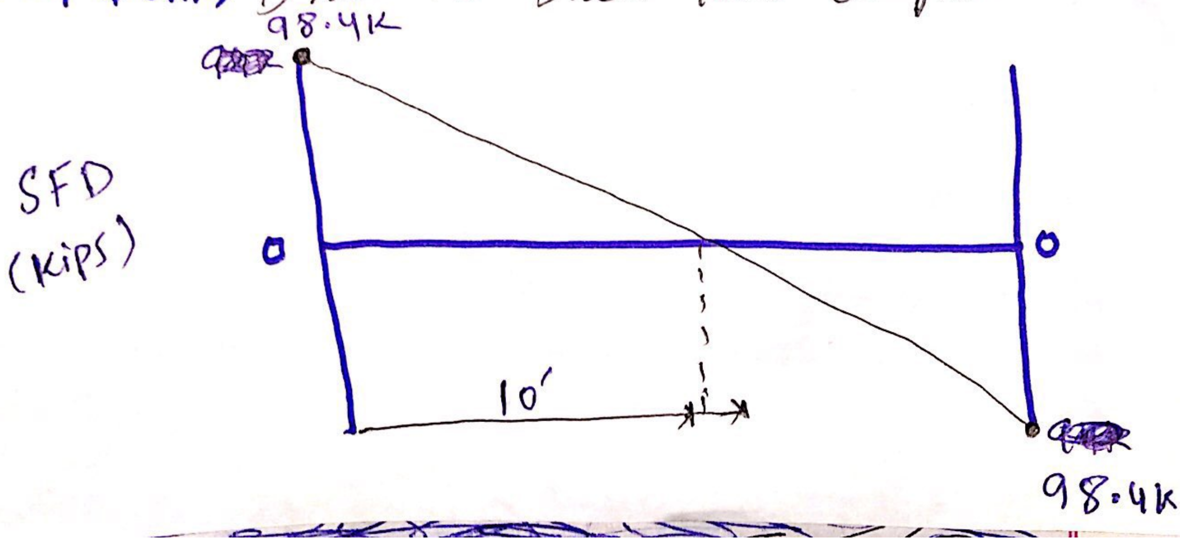




Step # 01:→ Find values of R_1 and R_2

total load = $9.4 \times 20 = \frac{188}{2} = 94K$

step #02:→ Draw its shear force diagram



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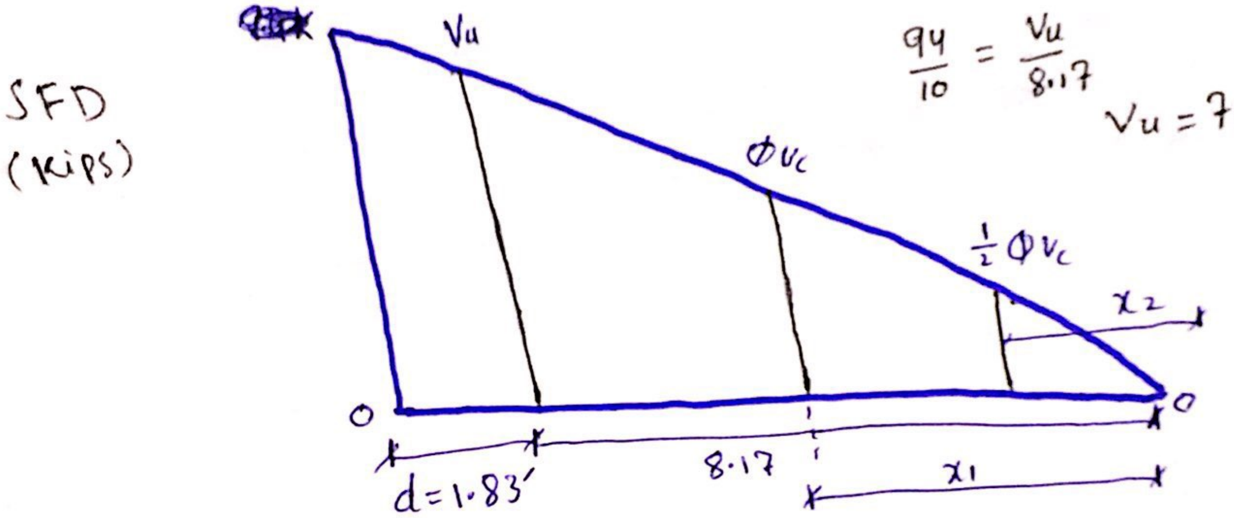
Step # 03:→ Find value of critical shear "Vu" and its location

As, 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 traingles



From similar Δs

$$\frac{94}{10} = \frac{Vu}{8.17}$$

$Vu = 76.8$ Kips

Step #04:→ Find value of "ΦVc" and "½ ΦVc" and also distance from zero shear to right side.

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

$$\Rightarrow \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000} = 33.40K$$

Loction of ΦVc by Similarity of Δ's.

$$\frac{98.4}{10} = \frac{33.40}{x_1}$$

$$\Rightarrow x_1 = 3.39'$$

Now,

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

Loction of $\frac{1}{2}\phi V_c \Rightarrow \frac{98.4}{10} = \frac{16.70}{x_2} \Rightarrow x_2 = 1.69'$

Step#05:→

Value of ϕV_s.

$$V_u = \phi V_s + \phi V_c$$

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

$$\phi V_s = 80.39 - 33.40$$

$$\phi V_s = 46.99 \text{ kips}$$

Step#05:→

Check on section adequacy.

$$\phi \times 8 \times \sqrt{f_c'} \times b_w \times d = \frac{0.7 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 133.57k$$

As, $\phi V_s < \phi 8 \sqrt{f_c'} b_w d$ ⇒ means section is adequate.

Check on maximum spacing for stirrups.

$$\phi \times 4 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 66.79 \text{ kip}$$

As,

$$\phi 4 \sqrt{f_c'} b_w d > \phi V_s = 43.40 K$$

So, max spacing will be selected from following four conditions

1):→ $S_{max} = 24''$

2):→ $\frac{d}{2} = \frac{22}{2} = 11''$

3):→ $S_{max} \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w}$

$$S_{max} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16} = 17.40''$$

4):→ $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

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

$$S_{max} = 16.50''$$

From above four conditions, least value of spacing for #3, 2 legged stirrup will be selected

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

Step #08:→

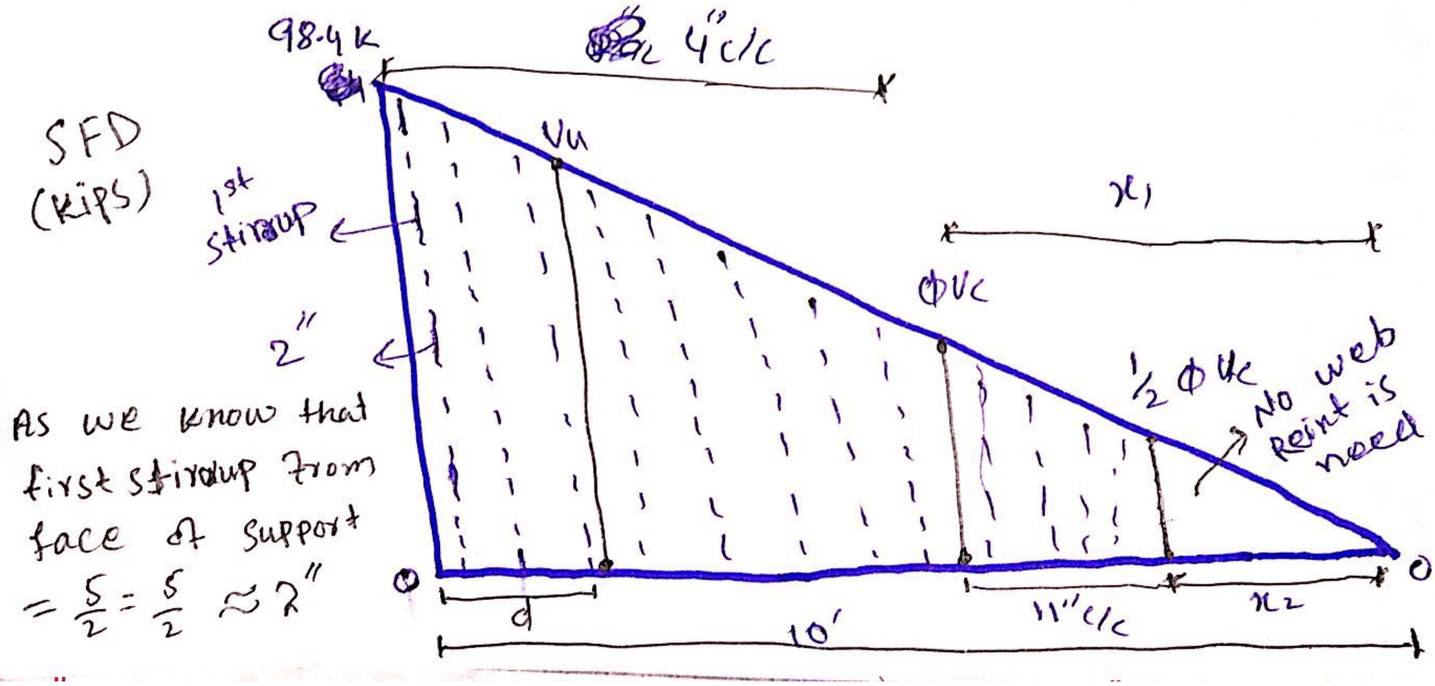
Spacing of stirrup from/at critical section

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

$$S = \frac{0.75 \times 0.22 \times 60 \times 22}{80.39 - 33.40}$$

$S = 4'' c/c$

Step #09:→ Final sketch



CQ3:→

Sol:→

Step #01

Find gross area of concrete

$A_g = b \times b$

$A_g = 12 \times 12$

$A_g = 144 in^2$ (actual).

Step #02

Area of Steel

$A_s = 5\%$ of A_g

$A_s = 0.05 \times 144$

$A_s = 7.2 in^2$

Step #03

Ultimate Load carring capacity

$P_u = \phi \times 0.80 \times \left(0.85 \times f'_c \times (A_g - A_s) + A_s \times f_y\right)$

$P_u = 0.65 \times 0.80 \left(0.85 \times 4 \times (144 - 7.2) + 7.2 \times 60\right)$

$P_u = 466.50 K$

Step #04

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

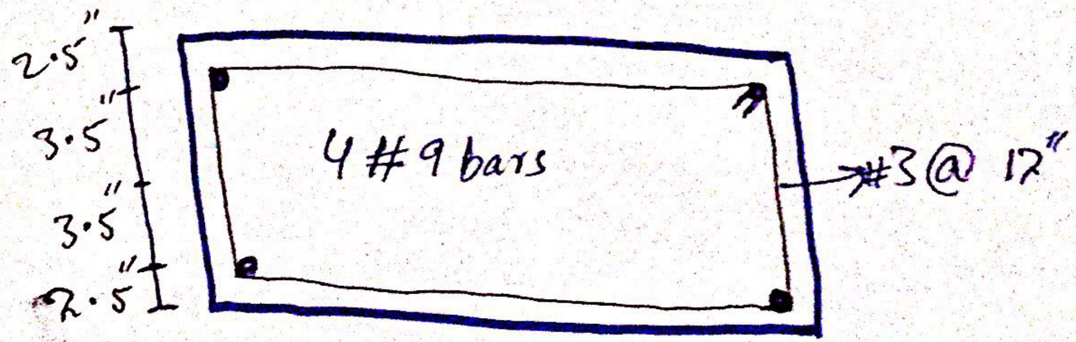
From the below value we choose the last value of all

i) 16 x dia of Long bar = 16 x 9/8 = 18"

ii):→ 48 x dia of tie bar = 48 x 3/8 = 18"

iii):→ Least column dimension = 12"

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



→ Since it is a tied square column so ~~there~~ 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 stirrups instead.

Q4:→

Sol:→

Step #01

$h = 24''$

Step #02 Total weight

Total weight = wt of soil + wt of Rc

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

$= 660 psf \Rightarrow 0.660 ksf$

Step #03 Effective bearing capacity

$q_e = q_a - w$

$q_e = 2.50 - 0.660$

$q_e = 1.84 ksf$

Step #04 Required area for foundation.

$A_{req} = \frac{\text{Service Load}}{q_e} = \frac{100 + 120}{1.84}$

$A_{req} = 119.57 ft^2$

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Step #05 :→

Since foundation is square

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

Step #06

Upward bearing capacity of soil

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

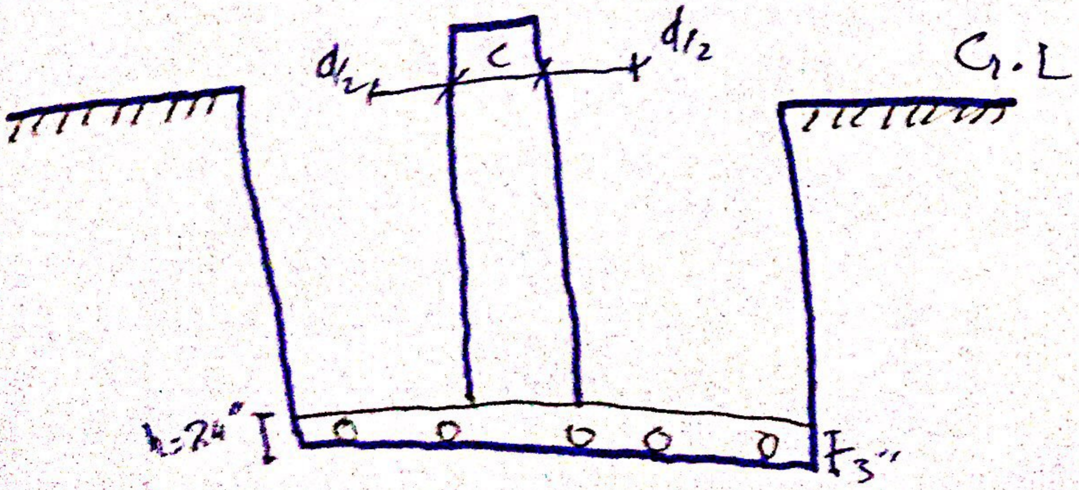
$$q_{up} = \frac{1.2 \times 100 + 1.6 \times 120}{(11)^2}$$

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

Step #07

Punching shear

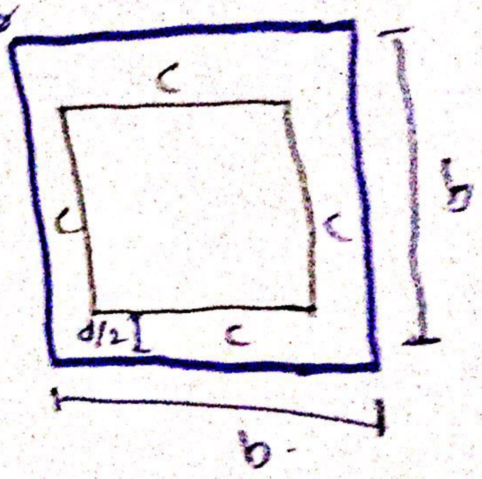
$b_o = 4 \times (c + d)$



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

$= 24 - 3 - 1 - \frac{1}{2}(1) = 19.5$ ∴ Take #8 bar dia $\frac{8}{8} = 1$

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



Step #08

$V_{u_2} = q_{up} \times [B^2 - (\frac{c+d}{12})^2]$

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

$V_{u_2} = 289.60K$

Step #09:→

$\phi V_{c/p} = \phi \times 4 \times \sqrt{f'_c} \times b \times d$

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

$\phi V_{c/p} = 525.38$

Step #10

Beam shear / one way shear check

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

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

$V_{u1} = 90.95K$

Scanned with CamScanner

Step #11

Self Shear capacity

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

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

$$= 110.04 > V_{u1} \quad OK$$

Step # 12

Ultimate moment

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

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

$$M_u = 331.49K' \approx 3977.93K''$$

Step #13

Area of steel for main bars by Trail and Repeat method.

Trial #01

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

$$A_{st} = \frac{M_u}{\phi f_y (d - a/2)} = \frac{3977.93}{0.90 \times 60 (11 - \frac{4.8}{2})} = 8.56 in^2$$

Trail # 02

$$a = \frac{As \times fy}{0.85 \times fc \times b} = \frac{8.56 \times 60}{0.90 \times 60 (11 - \frac{4.8}{2})} = 1.53''$$

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

Trail # 03

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

~~As = 3977.93 / 0.85 x 3 x 1~~

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

So that area = 7.1 m^2

Step #14

check the min reinforcement by the following 03 method

a):→ $A_{s\,min} = 0.0018 \times B \times h = 0.0018(11 \times 12) \times 2$

$= 5.70\,in^2$

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

$= 8.58\,in^2$

c):→ $A_{s\,min} = \frac{3 \times \sqrt{f_c'}}{f_y} \times B \times d = \frac{3 \times \sqrt{300} \times (11 \times 12) \times 19.5}{60000}$

$= 7.05\,in^2$