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section	A
paper	PRCD - 1
Date	26-06-20

Qno2) A simply suppuled rectangular beam 16" . . .

Ans2) . . . . of your final diagram.

Sol;. First of all find the unit load of beam

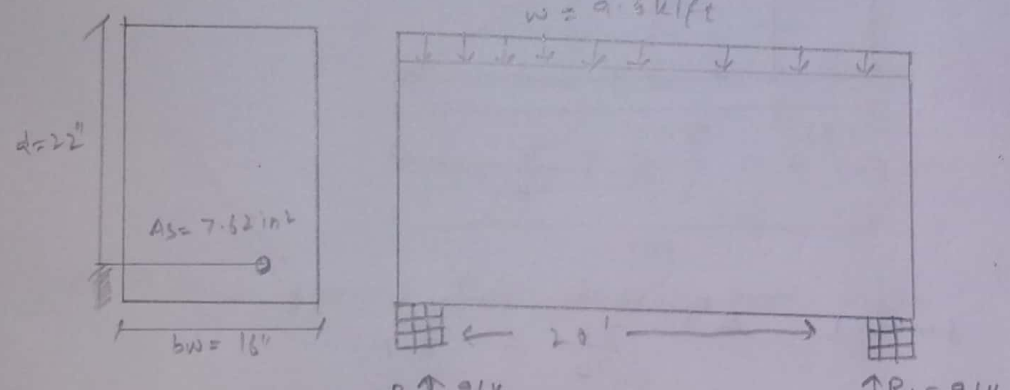
So $b \times \gamma_c$

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

so total factored load $= 9.4 + 0.2$

$= 9.6 \ k/ft$

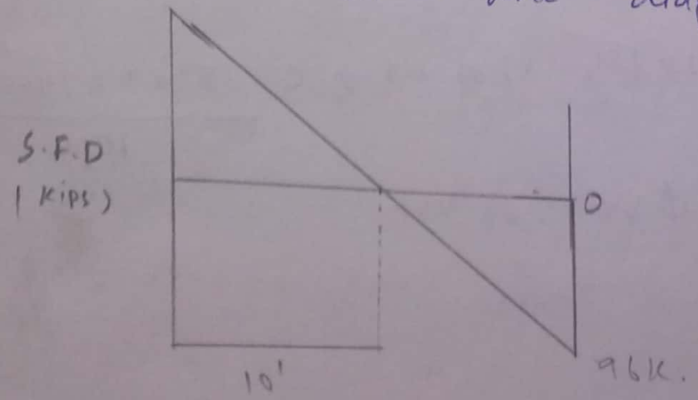
$w = 9.6$



Step 1;- Find the values of R_1 & R_2

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

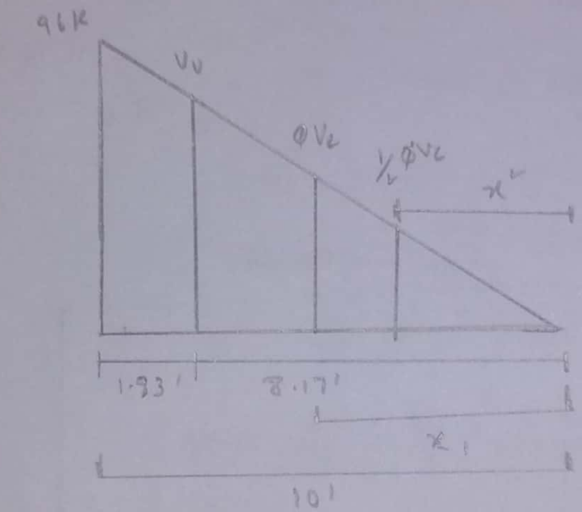
Step 2;- Draw it shear force diagram.



Step 3:- Find the value of critical stress "V_u" & its location.

As we know that critical section is located at distance "d" from face of support = 9-22" = 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 ϕV_c & $\frac{1}{2}\phi V_c$ & $\frac{1}{2}\phi V_c$ & also its distance from zero shear to right side.

$\phi V_c = \phi \times 2 \times \sqrt{f'c} \times b_w \times d \Rightarrow \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$

$\phi V_c = 33.40K$

Location of ϕV_c by similarity of $\Delta s'$

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

$$\boxed{x_1 = 3.48'}$$

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

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

$$\boxed{x_2 = 1.74'}$$

Step 5:-

Value of V_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 adequency

$\Rightarrow \phi \times 8 \times \sqrt{f'c} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$

$= 133.57K$

As $\phi \times 8\sqrt{f'c} \times b_w \times d > \phi V_s \rightarrow$ At mean section is adequate.

Step 7:- Check on min spacing for stirrup:-

$\phi \times 4 \times \sqrt{f'c} \times b_w \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79K$

As $\phi 4 \sqrt{f'c}\ b_w d > \phi V_s = 45.03k$

Thus max spacing will be selected from the following for condition

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

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

3) $S_{max} = \frac{A_u \times f_y}{0.75 \times \sqrt{f'c} \times b_w}$

$\because A_u = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$ $A_U = 0.11 \times 2$, $A_U = 0.22$

$= 17.40''$

4) $S_{max} = \frac{A_u \times f_y}{50 \times b_w}$

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

$= 16.50$

From the above four condition, least value of spacing from #3, Ushaped will selected

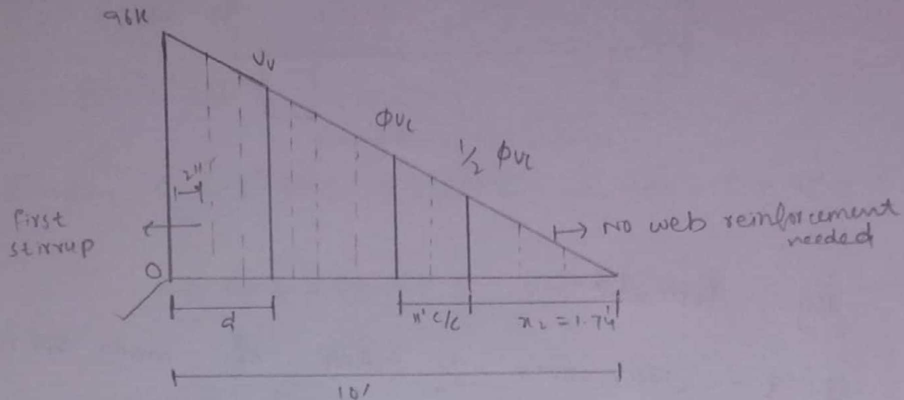
so $S_{max} = 11'$ c/c

Step # 8 :- spacing of stirrup from at critical section.

$S = \frac{\phi \times A_u \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40}$

$4.84''$ ~~4~~ $\approx 5''$ c/c

Step 9:- Find sketch

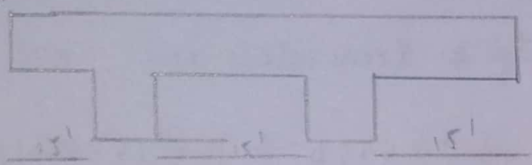


As we know that first stirrup from face of support

$\Rightarrow 5/2 = 2.5 \approx 2''$

Q no 1)

Ans 1) 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

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

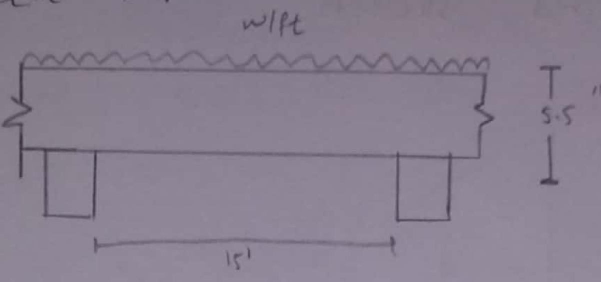
$= 0.4 + \frac{40}{100} = 0.8$

Hence the minimum thickness will be

6.5×0.8

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

Step 2:- Effective Depth.



By formula

d = t - clear cover - ½ (dia of main bars)

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

$d \simeq 4.5"$

Step 3 :- (self wt of slab)

By formula

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

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

Step 4:- Total factored load:-

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

Hence the minimum thickness will be

6.5×0.8

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

So the factored Dead load will be

$D.L = 1.2\ (20 + 68.75) = 106\ lb/ft^3$

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

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

$$= 89.94 \text{ kip-inches}$$

Step 6 :- Area of steel for main Bars By trial & repeat method.

Trial # 01 :-

Let depth of compression block

$$a = 0.2 \times t$$

$$= 0.2 \times 5.5 = 1.1''$$

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

Trial # 02

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

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

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

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

Trial 3 :-

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

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.507}{2})} = 0.59 \text{ in}^2$$

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

step # 07:-
Area of steel for distribution reinforcement

By formula

$A_{min} = 0.002 \times b \times t$ → (for Grade 40 steel)

$= 0.002 \times 12 \times 5.5 \Rightarrow 0.132\ in^2$

step 8:- spacing for main bars.

By formula

~~$A_{min} = 0.002 \times b \times t$ → for Grade 40 steel~~

~~$0.002 \times 12 \times 5.5 \Rightarrow 0.132\ in^2$~~

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

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.

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

we use #5 bars so

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

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

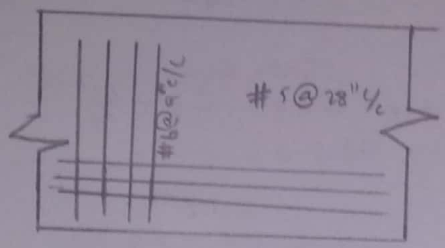
step #10:- Find sketch

$f'_c = 4ksi$, $f_y = 40ksi$

Main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c

(a)



Qno3)

Ans3) step 1:-

Find gross area of concrete

Ag = bxb (since it is square tied column)

Ag = 12X12 = 144in² (Actual)

step 2:-

Find area of steel

since As = 5% of Ag

= 0.05 X144

As = 7.2in²

step 3:-

Ultimate load carrying capacity

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

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

$$P_u = 466.50k$$

step 4:- sketch & design of Ties (c/c distance)

From below values we choose the least value of all these.

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

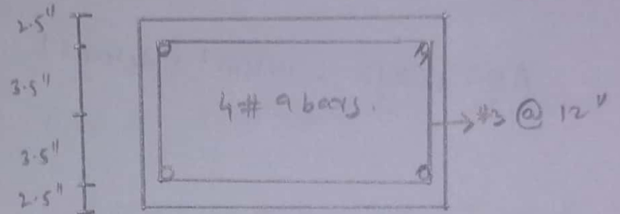
= 18"

2) 48 x dia of tie bar = 48 x 3/8

= 18"

3) least column dimension = 12"

so c/c 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 tie stirrups instead.

Qno 4)

Ans 4) step 1:- let h = 24"

Step #2:-

Total weight = wt of soil + wt of RC

= 3 X 120 + 2 X 150

= 660 psf = 0.660 ksi

Step 3:- Effective bearing capacity

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84$ ksi

Step 4:- Required area for 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

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

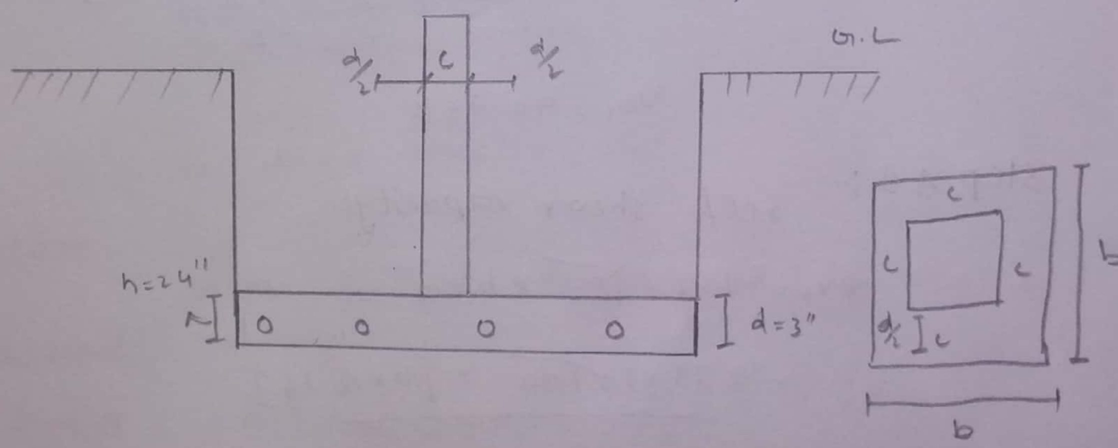
Step 6:- upward bearing capacity of soil

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

$q_{up} = 2.58$ k/ft²

Step 7:- Punching shear

$b_0 = 4 \times (c + d)$



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

$\because$ take #8 bar
dia $= 8/8'' = 1''$

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

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

Step #8:-

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

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

$V_{u2} = 289.60K$

Step #9:-

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

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

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

Step 10:- Beamshear / one way shear check

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

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

$V_{u1} = 90.95K$.

Step 11:- 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 12 ultimate moment

$$Mu = \frac{qupxB}{8} \times (B-c)^2 = \frac{2.58 \times 11}{8} \times \left(11 - \frac{1.6}{12}\right)^2$$

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

step 13:- Area of steel for main bars by Trial & repeat method.

Trial #1:-

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

$$As = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{3977.93}{0.90 \times 60 \times (11 - \frac{4.8}{2})} = 8.56 in^2$$

Trial #2:-

$$a = \frac{As \times fy}{0.85 \times fc' \times b} = \frac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.53''$$

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

Trial No 3:-

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

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

so that area $= 7.1 m^2$

step 14:- check the min reinforcement by the 03 method

a) $Asmin = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$

$= 5.70 m^2$

B) $A_{smin} = \frac{200}{f_y} \times B \times d = \frac{200}{60000} \times (11 \times 12) \times 19.5$

$= 8.58 in^2$

c) $A_{smin} = \frac{3 \times \sqrt{f'c}}{f_y} \times B \times d = \frac{3 \times \sqrt{3000}}{60000} \times (11 \times 12) \times 19.5$

$= 705 in^2$

From above value greater value will be selected thus Asmin 8.58 in^2

Step 15:- using #8 bar

$A_b = 0.785 in^2$

No of bars $= \frac{A_s}{A_b} = \frac{8.58}{0.783} = 10.92 \approx$ 11 bars in each direction