FINAL TERM

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Section: "B"

Semester: "6th"

Subject: Plain & Reinforced concrete Design-I

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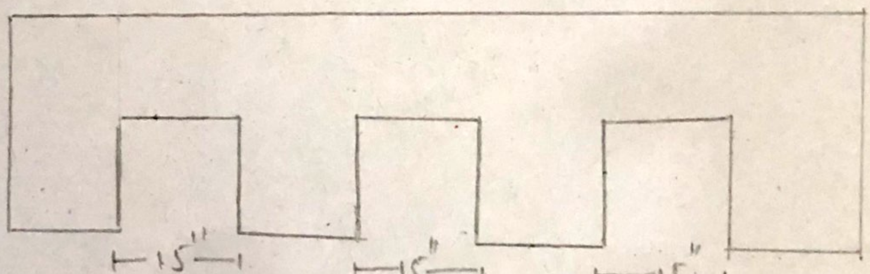
Question #01

Given data:

* Clear and span b/w support = 15'
* Factored live load = 160 lb/ft^2
* Some floor finish load = 20 lb/ft^2
* f'_c = 4000 psi

Solution:



Step #01

Minimum thickness

By using formula

$$t_{min} = L/28 = \frac{15}{28} = 0.4 \approx 0.5''$$

As $f_y \rightarrow 40ksi$

so we will multiply a factor with this thickness

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

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

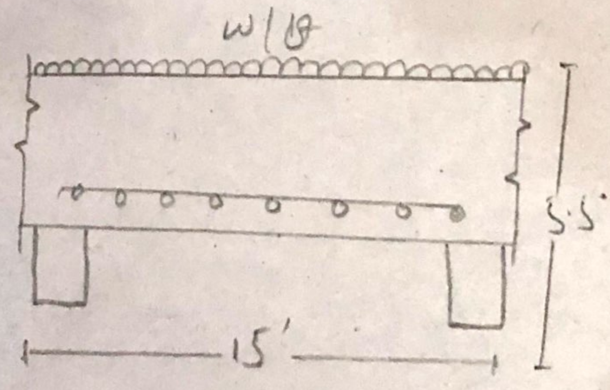
Hence the minimum thickness will be

6.5×0.8

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

Step #02

Effective depth



By formula

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

$= 5.5 - 0.75 - \frac{1}{2}(5/8) \Rightarrow \boxed{d = 4.5''}$

Step #03

Self weight slab

By formula

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

$= \frac{5.5}{12} \times 150 = 68.75$ lb/ft²

Step #04

Total Factored load

Factored live load = 160 lb/ft²

So the factored dead load will be

D.L = 1.2 (20+68.75) = 106.5 lb/ft²

Total factored load = D.L + L.L

= 106.5 + 160

= 266.3 lb/ft² => 0.2665 k/ft²

Step #05

Ultimate moment

By using formula

$M_U = \frac{W_U \times L^2}{8} = \frac{0.2665 \times (15)^2 \times 1.2}{8}$

MU = 89.94 kips-inches

Step #06 Area of steel bar main bars by trail and repeat method.

Trial #01

Let depth of compression block

$a = 0.2 \times t$

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

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

$A_{st} = 0.63 in^2$

Trial #02

$a = \frac{A_{s1} \times f_y}{0.85 \times f'_c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12} \Rightarrow 0.62 in^2$

$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - \frac{0.62}{2})}$

$A_{st} = 0.59 in^2$

Trial #03

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

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

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

Step #07

Area of steel for distribution Reinforcement.

By formula

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

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

Step #08

spacing for main bars

By formula

$\text{Spacing} \ \frac{A_b}{A_{S1}} \times 12$

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

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

Step #09

Spacing for distribution Bars.

$$\text{Spacing} = \frac{A_b}{A_{S1}}$$

we use # 5 bars so

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

$$\text{spacing} = \frac{0.31}{0.132} \times 12 = 2.81'' \approx 28'' \; c/c$$

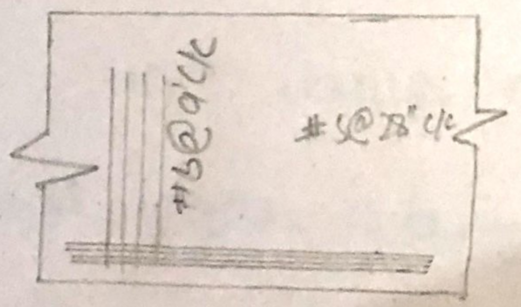
Step #10

Final sketch

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

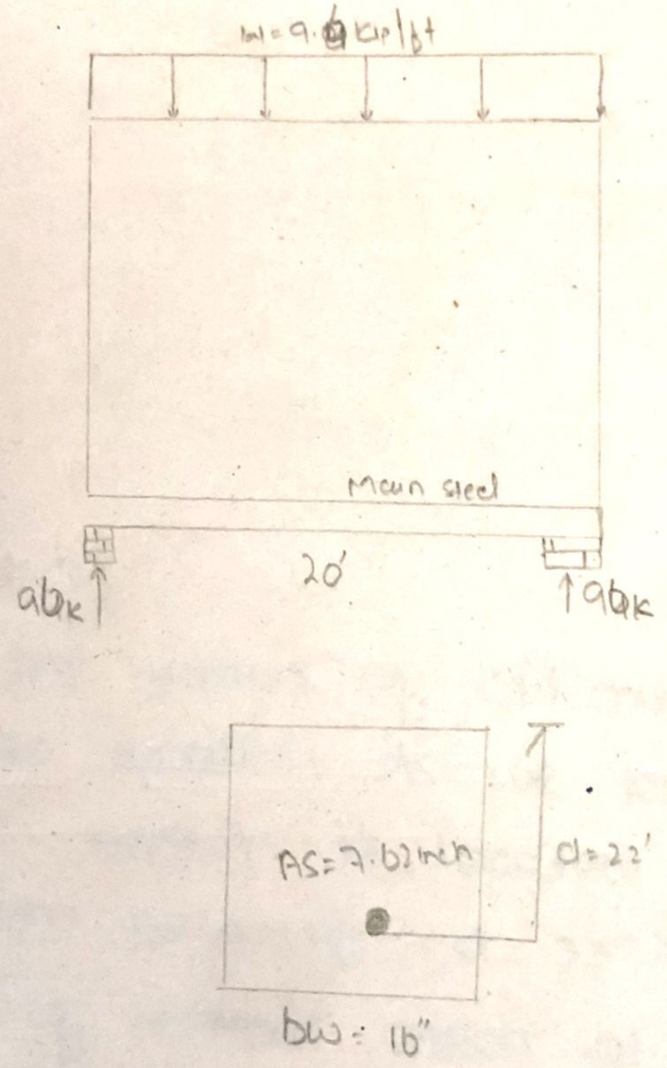
Main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c



Question #02

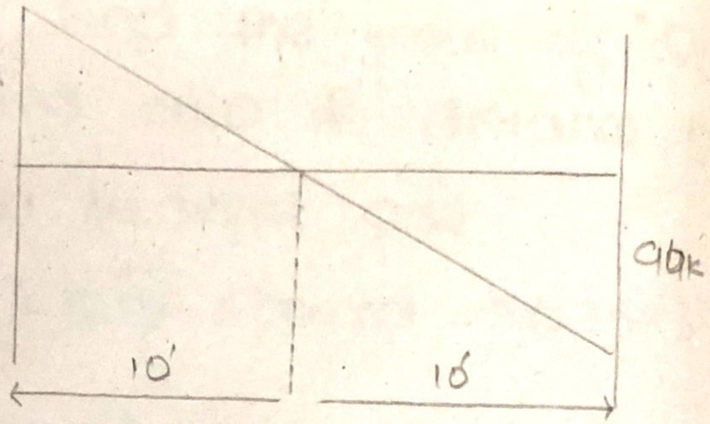
Solution:



Step #01 Find values of R_1 and R_2.

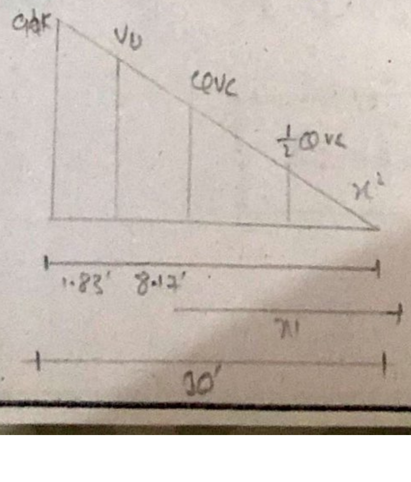
Total loads $= 9.6 \times \frac{20}{2} =$ [illegible] $= 96k$

Step # 02 Draw its shear force diagram



Step # 03

Find the values of critical shear 'Vu' and its location. As we know that critical section is located at distance "d" from face of = d = 22" = 1.83'
value of critical shear at distance 'd' by similarity of triangles.



From similar △'s

$$\frac{96}{10} = \frac{Vu}{8.17} \Rightarrow \boxed{Vu = 78.43k}$$

Step #04 Find the value of "ΦVc" and "$\frac{1}{2}$ ΦVc" and also its distance from zero shear to right side.

$$\Phi Vc = \Phi \times 2 \times \sqrt{f'c} \times bw \times d \Rightarrow \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 28}{1000}$$

$$\boxed{\Phi Vc = 33.40k}$$

Location of ΦVc by similarity of △s'

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

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

Now $\frac{1}{2}\Phi Vc = \frac{33.40}{2} = 16.70k$

Location of ½ ΦVc $\Rightarrow \frac{96}{10} = \frac{16.70}{x_2}$

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

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

So

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

$$\phi V_s = 78.43 - 33.40$$

$$\boxed{\phi V_s = 45.03k}$$

Step #06 check on section adequacy

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

$$\boxed{= 133.57k}$$

As

$\phi \times 8\sqrt{f'_c} \times b_w \times d > \phi V_s$ → It means section is adequate.

Step#07 check on min spacing b/w stirrups.

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

$$= 66.79k$$

As

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

The max spacing will be selected from the following condition.

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

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

3: $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$\therefore A_v = \frac{\pi}{4}\left(\frac{3}{5}\right)^2 = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$

$A_v = 0.11 \times 2$

$A_v = 0.22$

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

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

$= 16.50$

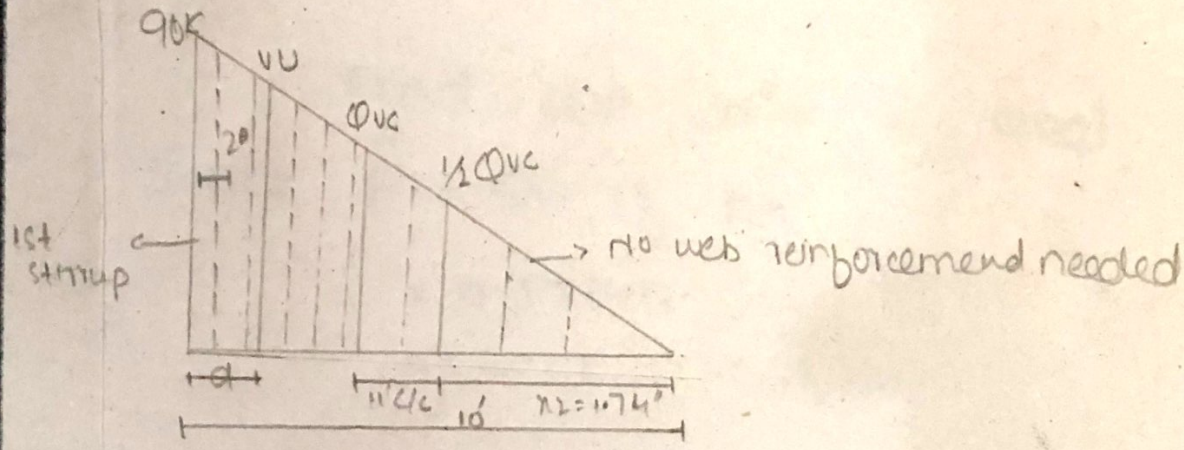
From the above four condition. Least value of spacing from #3, U shaped will be selected so $S_{max} = 11''$ C/c

Step #08 spacing of stirrup from / at critical section

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

$$48.84 \approx 5'' c/c$$

Step #09



As we know that first stirrup from face to support $\Rightarrow \frac{5}{2} = 2.5 \approx 2$

Question #01

Solution:

Step #01

Find gross area of concrete

$Ag = b \times b$ (so it square tied column)

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

Step #02

Find the area of steel

Since $AS = 5\%$ of Ag

$= 0.5 \times 144$

$AS = 7.2 in^2$

Step #03

Ultimate load carrying capacity

$PU = \phi \times 0.80 \times [0.85 \times f'c \times (Ag - AS) + AS \times fy)$

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

$PU = 460.50 K$

Step #04

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

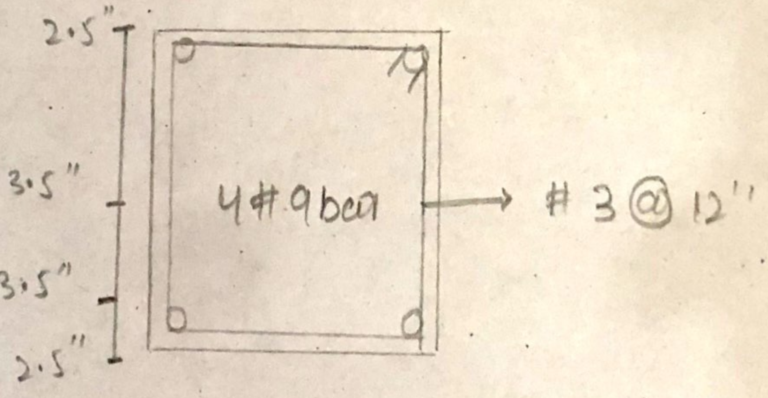
From the below value we chose the least value of all thus:

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

2: 48x dia of Tie bar = 48x 3/8 = 18"

3: least column dimension = 12"

So c/c distance btw ties = 12"



⇒ since it is a tied square column so their is not spiral stirrup used it of rectangular shape due to the specification of the the structure thus we will close tie stirrups instead.

Question # 04

Solution:

Step #01

let $h = 24''$

Step #02

Total weight = wt of soil + wt of RC

$= 3\times120 + 2\times150 = 660\ psf$

$= 0.660$

Step #03

Effective bearing capacity

$q_e = q_a - w = 2.50 - 0.660$

$q_e = 1.84\ ksf$

Step #04

Required area of foundation

$$Area = \frac{Service\ Load}{q_e} = \frac{100+120}{1.84}$$

$Area = 119.56\ ft^2$

Step # 05

Since foundation is square

$Area = b \times b = 119.57 \Rightarrow \cong 11'$

Step #06

Upward bearing capacity of soil

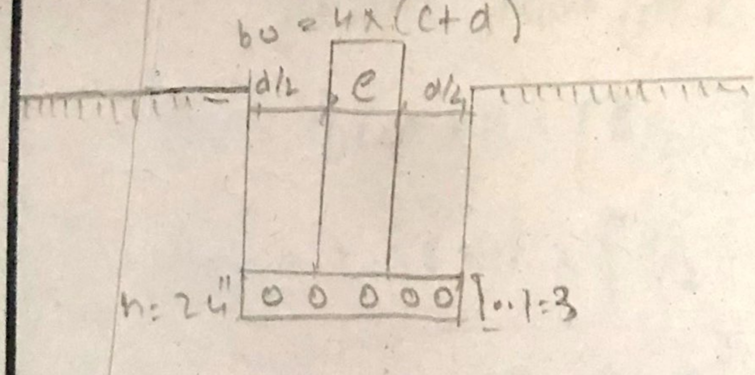
$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2 \times 160 \times 1.6 \times 120}{11^2}$$

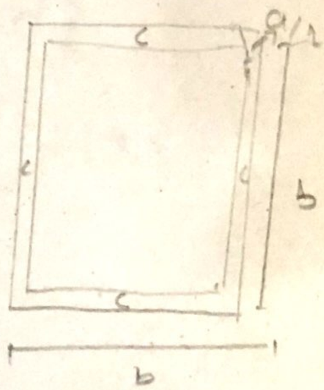
$$\boxed{q_{up} = 2.58\ KlA^2}$$

Step # 07

Punching shear

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





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

$= 24.3 - 1 - \frac{1}{2}(1) = 19.5'$

$\therefore$ Take #8 bar, dia $= 8/8 = 1$

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

Step # 08

$$Vu_2 = q_u P \times [B^2 - (c+d)^2]$$

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

$$Vu_2 = 289.60k$$

Step # 09

$$\phi v_{c/p} = \phi \times 4 \times \sqrt{f'c} \times b_o \times d$$

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

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

Step # 10

Beam shear / one way shear check

$$Vu_1 = q_{u/p} \times B \times [B/2 - c/2 - d]$$

$$Vu_1 = 2.58 \times 11 \times [11/2 - \frac{16/12}{2} - 19.5]$$

$$\boxed{Vu_1 = 90.95k}$$

Step # 11 self shear capacity

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

$$= 0.75 \times 2 \times \frac{\sqrt{400} \times (11 \times 12 - 10)}{100}$$

$= 110.04k > Vu1 \Rightarrow O.K$

Step #12

Ultimate moment

$$Mu = \frac{qup \times B}{8} \times (B-c)^2 = \frac{2.58 \times 11}{8} \times \frac{(11-16)^2}{12}$$

$Mu =$ ~~33.49~~ $331.49k' = 3977.93k''$

Step #13

Area of steel for main bars of trail and Repeat method

Trial #01

Let $a = 0.2 \times h = 0.2 \times 2.4 = 4.8''$

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

$= 8.56 in^2$

Trial #02

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

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

Trial #03

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

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

Thus Area = $17.1\ in^2$

Step # 04

Check the main reinforcement by the following 03 methods:

$$A_{smin} = 0.0018 \times B \times h = 0.0018 \times (11 \times 12) \times 24$$

$$A_{smin} = 5.70\ in^2$$

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

$$= 8.58\ in^2$$

$$A_{smin} = \frac{3 \times \sqrt{f'c}}{fy} \times B \times d = \frac{3 \times \sqrt{5000}}{60000} \times 11 \times 12 \times 19.5$$

$$= 7.05\ in^2$$

From the above values the greater value will be selected thus

$A_{s\,min} = 8.58\ in^2$

Step #15

Using #8 Bars

$A_b = 0.785\ in^2$

No of Bars $= \frac{A_s}{A_b} = \frac{8.58}{0.785}$

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

The End