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PRCD - 1

Section A

Final Exam

Ans 1:

Given data:

$F'c = 4000$ psi

$fy = 40$ ksi

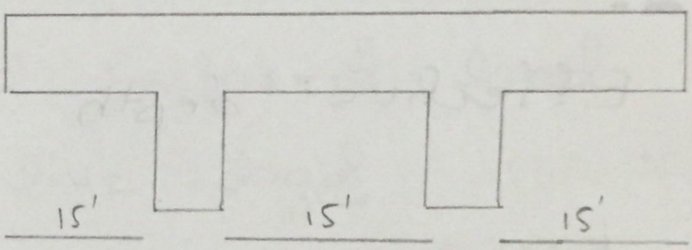
3 equal spans concrete slap

Clear span between supports = 15 ft

Factored live load = 160 lb/ft²

Service load finish load = 20 lb/ft²

Solution:



step 1:

Minimum thickness

By using formula

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

As $fy \longrightarrow 40$ ksi

so we will multiply a factor with this thickness.

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

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

$$= 0.8$$

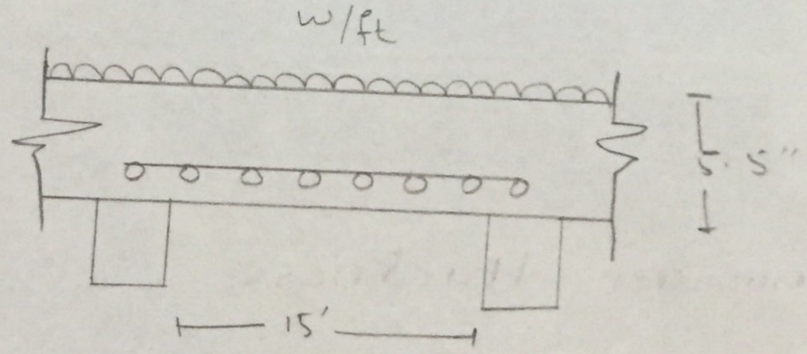
hence the minimum thickness will be

6.5×0.8

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

step 2:

Effective depth



using formula

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

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

$\boxed{d \cong 4.5''}$

Step 3:

Self weight of slab using formula

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

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

$$= 68.75 \text{ Lb/ft}$$

Step 4:

Total factored load

Factored live load = 160 lb/ft²

Hence the minimum thickness will be 6.5 × 0.8

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

So the factored dead load will be $D.L = 1.2(20 + 68.75)$

Total factored load = D.L + L.L

$$= 106.5 + 160$$

$$= 266.5 \text{ Lb/ft}^2$$

$$= 0.2665 \text{ k/ft}^2$$

Step 5:

Ultimate moment

using formula

$$Mu = \frac{wu \times L^2}{8} = \frac{0.2665 \times 15^2}{8} \times 12$$

$$\boxed{Mu = 89.94 \text{ kip-inch}}$$

Step 6:

Area of steel for main bars

Trial 01:

Let depth of compression block

$a = 0.2 \times t$

$= 0.2 \times 5.5$

$= 1.1''$

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

Trial 02:

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

$= 0.62 \text{ in}^2$

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

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

Trial 03:

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

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

$= 0.59 \text{ in}^2$

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

Step 7:

Area of steel for distribution reinforcement.

using formula

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

$= 0.002 \times 12 \times 5.5$

$= 0.132 \text{ in}^2$

Step 8:

spacing for main bar

using formula

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

we use # 6 bar dia = $\left(\frac{6}{8}\right)''$

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

Step 9:

Spacing for distribution bars

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

We use # 5 bars

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

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

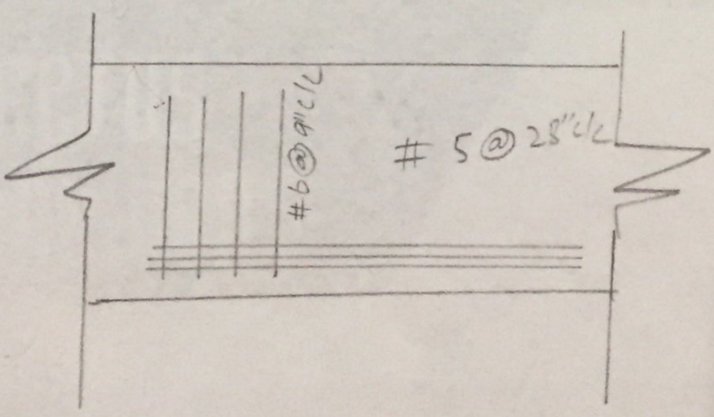
Step 10:

Find sketch

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

Main steel # 6 at 9" c/c

Distribution steel # 5 at 28" c/c



Ans 2:

Given:

Let find the unit load of beam

$b \times \gamma_c$

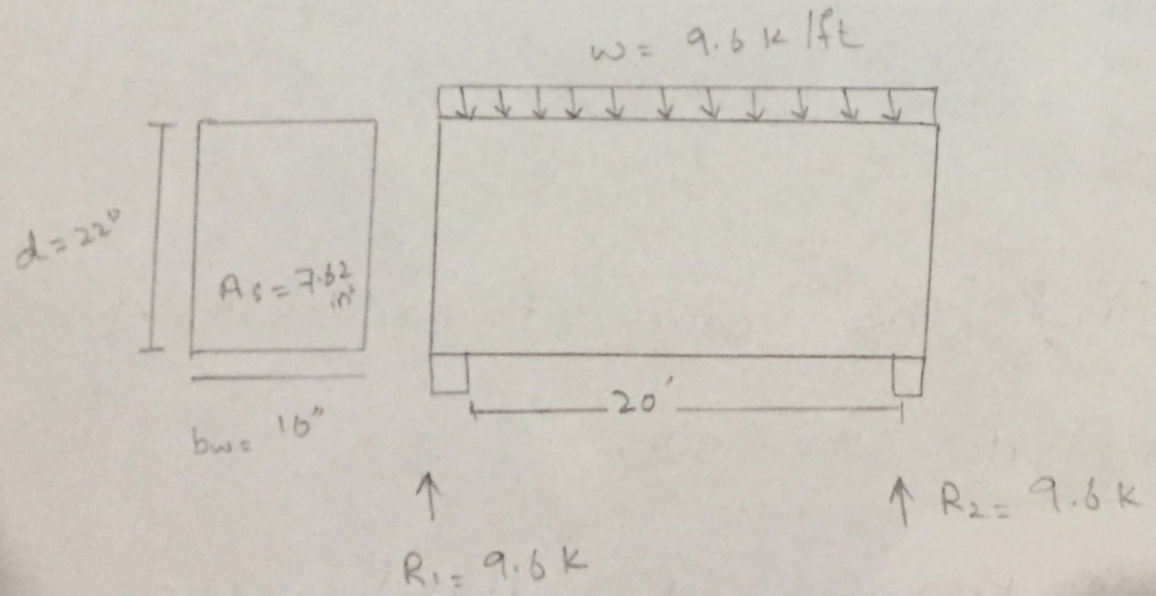
$= \frac{16}{12} \times 150$

$= 200$ lb/ft $= 0.2$ K/ft

So total factored load

$= 9.4 + 0.2$

$= 9.6$ K/ft



Step 1:

Find the values of R_1 & R_2

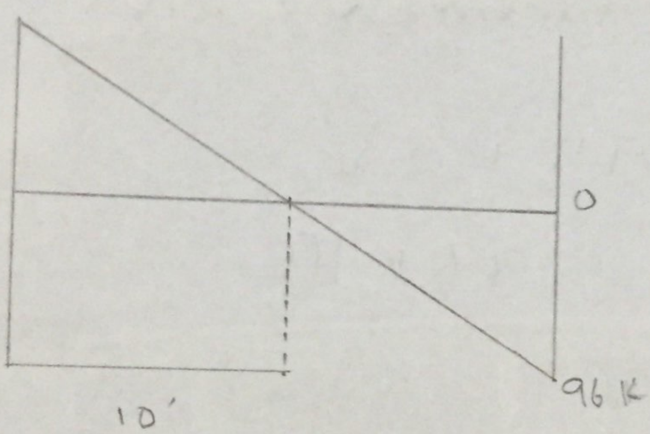
Total load $= 9.6 \times \frac{20}{2}$

$= 9.6\ K$

Step 2:

Draw its shear force diagram

SFD

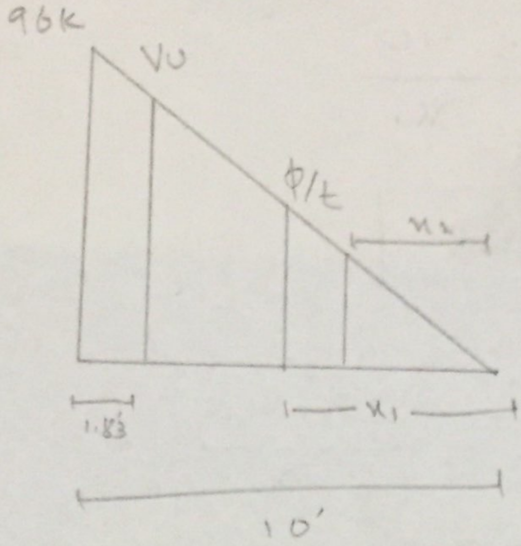


Step 3:

Find the value of critical stress "V_u" 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 triangles



From similar Δ's

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

$$\boxed{V_u = 78.43k}$$

step 4:

Find the value of "ϕV_c" & $\frac{1}{2}\phi V_c$ & also its distance from zero shear to right side.

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

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

$\phi V_c = 33.40\,k$

Location of ϕV_c by similarity Δ's.

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

$x_1 = 3.48'$

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

$= 16.70\,k$

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 $\phi V_s = V_u - \phi V_c$

$\phi V_s = 78.43 - 33.40$

$\phi V_s = 45.03\,k$

step 6:

Check on section adequacy:

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

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

$$= 133.57\,K$$

As $\phi \times \sqrt{f'c} \times b_w \times d > \phi V_s$

it means section is adequate.

step 7:

Check on minimum spacing for stirrups.

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

$$= 66.79\,K$$

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

Thus max spacing will be selected from the following four condition

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

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

3) $$\frac{A_U \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$$

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

$A_U = 0.11 \times 2$

$A_U = 0.22$

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, U-shaped will be selected so $S_{max} = 11''$ c/c

Step 8:

Spacing of stirrup from at critical section

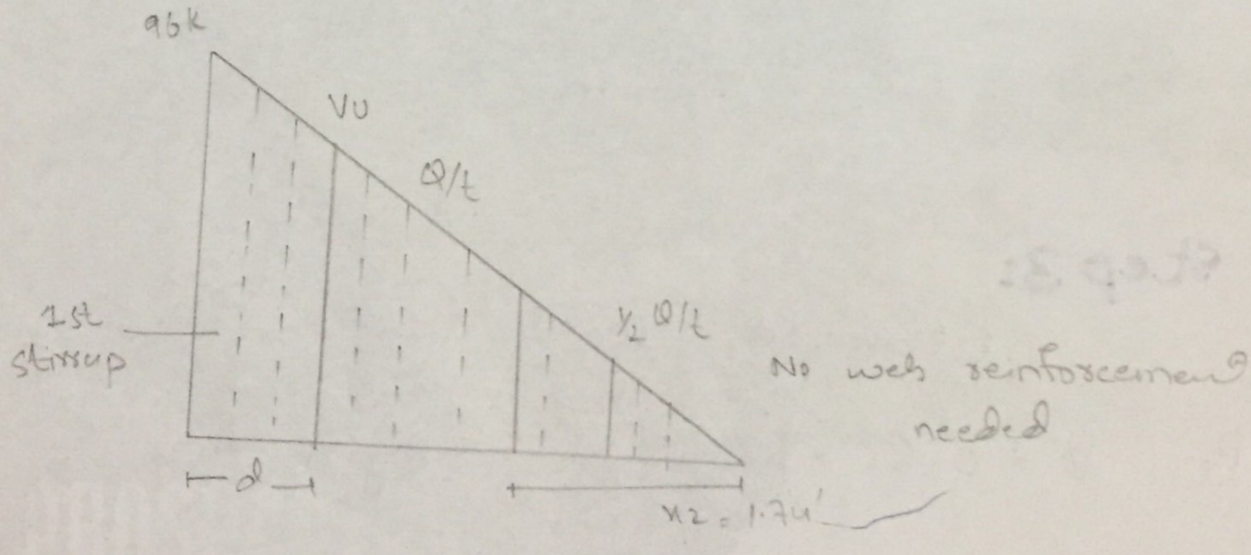
$$S = \frac{\phi \times Av \times fy \times d}{Vu - \phi Vc}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40}$$

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

Step 9:

Find sketches



As we know that first stirrup from face of support

$$\frac{5}{2} = 2.5 \approx 2''$$

Ans 3:

Step 1:

Find gross area of concrete

$A_g = b \times d$ (since its squirehed column)

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

~~Find the~~

Step 02:

Find the Area of steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$= 7.2\ in^2$

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:

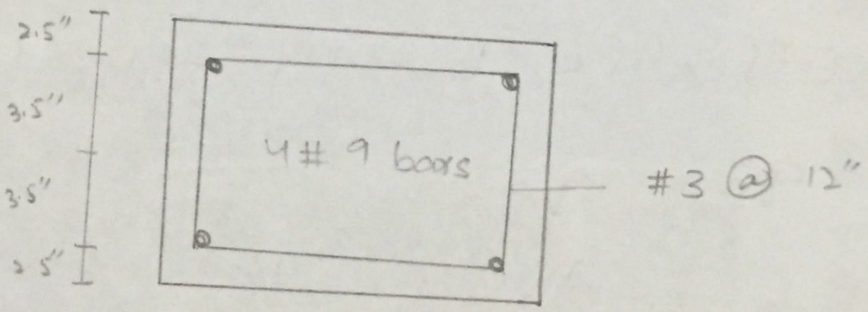
From the below value we choose the least value of all this:

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

2) 48x dia of tie bar = 48x 3/8
= 18"

3) least colum dimension = 12"

so C/C distance between 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 use tie stirrups instead.

Ans 4:

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

$q_e = q_a - w$

$= 2.50 - 0.660$

$= 1.84$ ksf

step 4:

Required Area for foundation

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

$= 119.57 \text{ ft}^2$

step 5:

Since foundation is square

$A_{req} = b \times b = 119.57$

$\Rightarrow B \cong 11'$

step 6:

upward bearing capacity of soil.

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

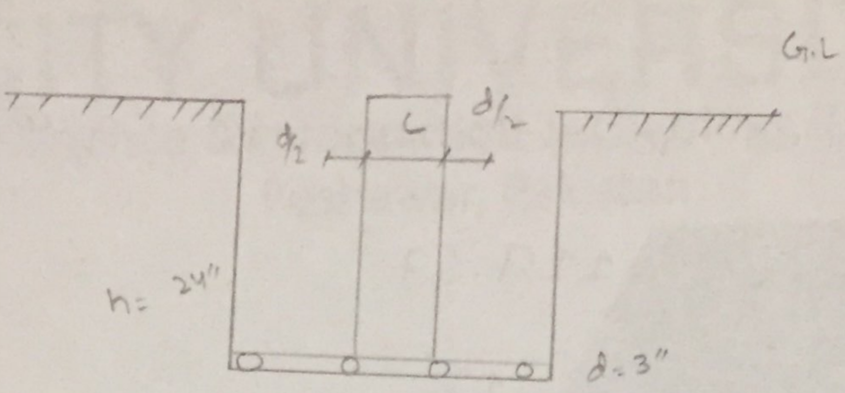
$$= \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$$

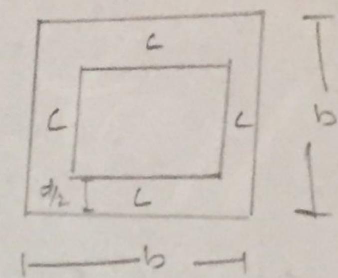
$$\boxed{q_{up} = 2.58 \ k/y^2}$$

step 7:

Punching shear

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





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

Take #8 bar
dia = 1"

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

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

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

step 8:

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

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

$V_{u2} = 289.60\ k$

Step 9:

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

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

$$\phi\ K/p = 525.38$$

Step 10:

One way shear check

$$V_{u1} = q_{up} \times B \times \left[B/_2 - c/_2 - d \right]$$

$$V_{u1} = 2.58 \times 11 \times \left[11/_2 - \frac{16/_{12}}{2} - 19.5 \right]$$

$$\boxed{V_{u1} = 90.95\,K}$$

Step 11:

Self shear capacity

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

$$= 0.75 \times 2 \times \sqrt{4000} \times \left[11 \times 12 - 16 \right]$$

$$= 110.04\,K > V_{u1}$$

$$\Rightarrow OK$$

Step 12:

Ultimate moment

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

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

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

Step 13:

Area of steel for main bars by Trial & repeat method

Trial 01

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

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

$= 8.56\ in^2$

Trial 02:

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

$$A_s = \frac{3977.93}{0.90 \times 60 \left(11 - \frac{1.28}{2}\right)}$$

$$= 7.1\ in^2$$

Area = $7.1 m^2$

step14:

Check the min reinforcement by the following 03 method:

a) $$As_{min} = 0.0018 \times B \times h$$
$$= 0.0018 \times (11 \times 12) \times 24$$
$$= 5.70\ in^2$$

b) $$As_{min} = \frac{200}{fy} \times b \times d$$
$$= \frac{200}{60000} \times (11 \times 12) \times 19.5$$
$$= 8.58\ in^2$$

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

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

$= 7.05 \ in^2$

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

Step 15:

$A_b = 0.785 \ in^2$

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

$= 10.92 \cong 11$ bars in each direction