1548

Q1

Given data

=> 3 equal span concrete slab

=> clear span b/w supports = 15 ft

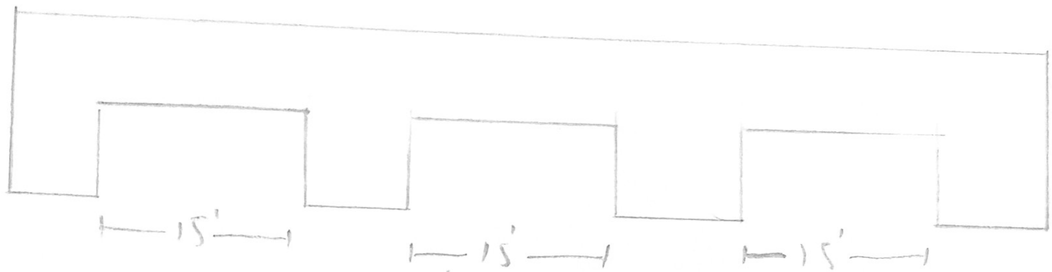
=> Factored live load = 160 lb/ft²

=> service floor finish load = 20 lb/ft²

=> $f'_c = 4000$ psi

=> $f_y = 40$ ksi

Sol



Step 1 (Minimum Thickness)

By using formula

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

As $f_y \rightarrow 40$ ksi

so we will multiply a factor with this thickness

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

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

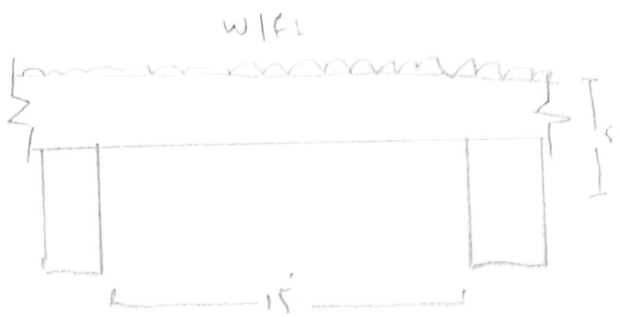
Hence the ~~max~~ minimum thickness will be

6.5×0.8

$t_{min} = 5.2 \approx 5.5$

7048

Step #2: effective depth.



By formula.

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

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

$d = 4.5''$

Step 3 Self weight slab.

By formula

$\frac{t}{12} \times \text{rconcret.}$

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

Step 4. Total factored load.

factored live load = 160 lb/ft^2

so the factored dead load will be

$D.L = 1.2(20 + 68.75) = 106.5 \text{ lb/ft}^2$

Total factored load = D.L + L.L

$= 106.5 + 160$

$= 266.5 \text{ lb/ft}^2 \Rightarrow 0.2665 \text{ k/ft}^2$

Step=5 : Ultimate moment

By using formula

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

$Mu = 89.94$ kips-inches

Step 6

Area of steel for main bars by Trial and report method.

Trial # 01

let depth of compression block

$a = 0.2 \times L$

$= 0.2 \times 5.5 = 1.1''$

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

$Ast = 0.63\ in^2$

Trial# 2

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

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

$Ast = 0.59\ in^2$

Trial # 03

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

$$Ast = \frac{89.94}{0.90 \times 40 \times (4.5 - 0.57)} = 0.59\ in^2$$

So we will be $Ast = 0.59\ in^2$

11,48

Step : 07

Area of steel for distribution reinforcement.

By formula.

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

$= 0.002 \times 12 \times 5.5$

$= 0.132 \, in^2$

Step : 08 Spacing for main bars

By formula

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

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

Area $= \frac{\pi}{4} (6/8)^2 = 0.441 \, in^2$

Step : 09 Spacing for distribution bar

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

we use #5 bars -

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

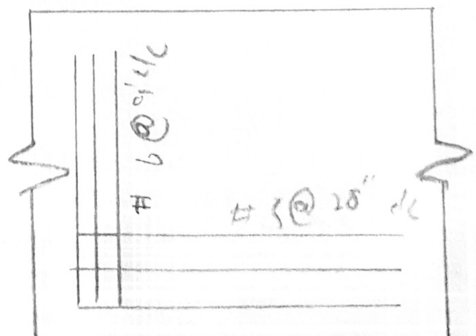
Spacing $= \frac{0.31}{0.132} \times 12 = 28.1'' \approx 28$

Step 10 : Find sketch

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

Main steel #6 at 9" c/c

Distribution steel #5 at 28" c/c



Q2 — A simply supported rectangular beam 16" wide .... Draw a sketch of your final diagram

Sol → First of all find the unit load of beam

So

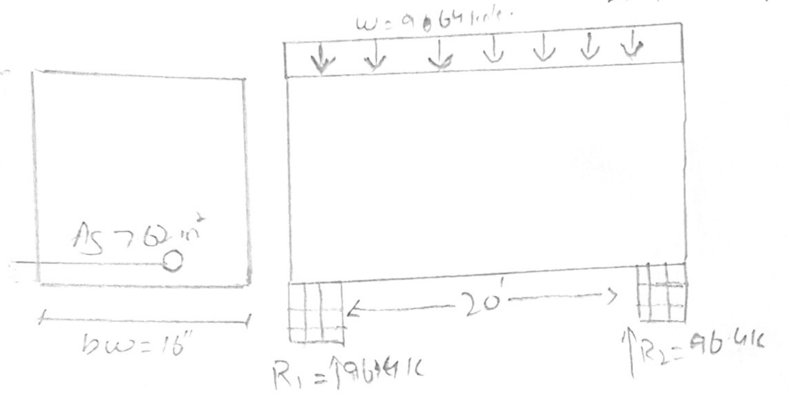
b × γc

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

$1.2 \times 0.2 = 0.24$

So total factor load $= 9.4 + 0.24$

$= 9.64\ k/ft$

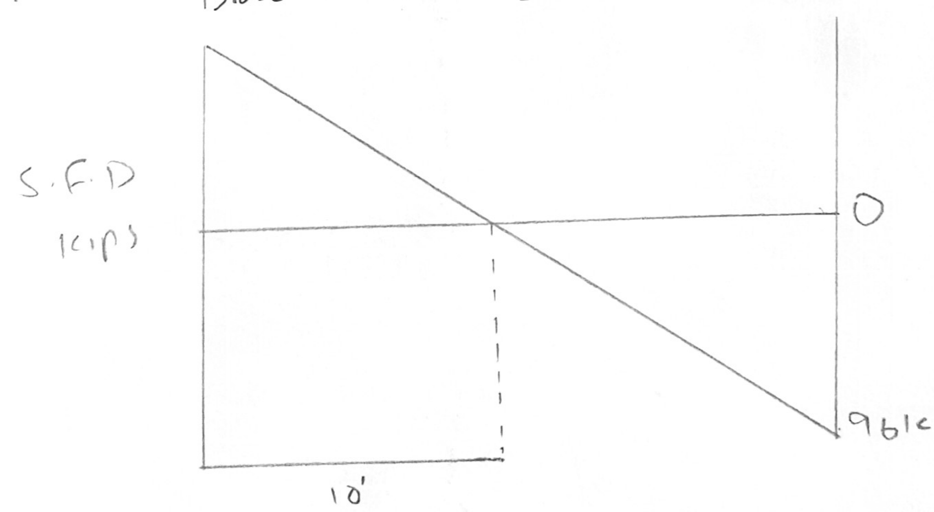


Step #01

Find the value of R_1 & R_2

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

Step # 2 Draw it shear force diagram

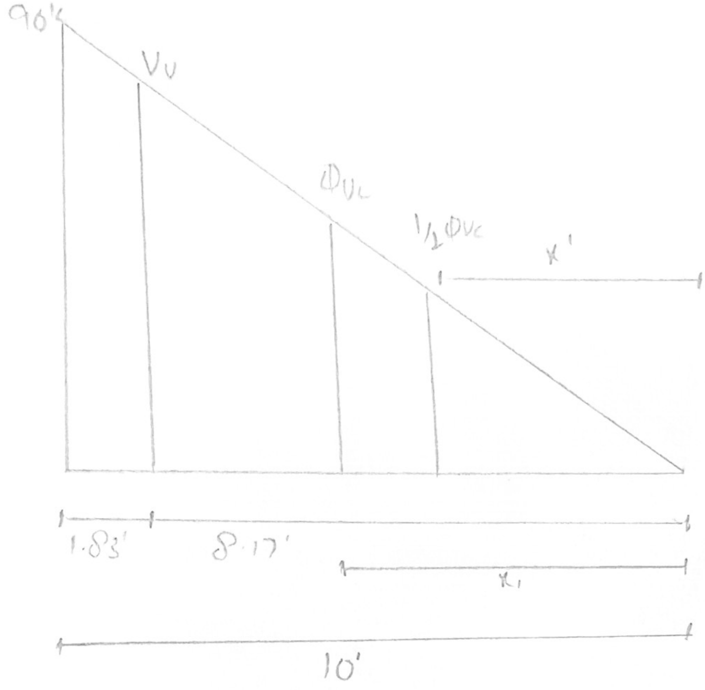


Step 3

Find the value of critical stress "V_u" 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

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

$V_u = 78.43^k$

Step 4 Find the value of "ϕV_c" & "$\frac{1}{2}\phi V_c$" & also its distance from zero shear to right

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

$\phi V_c = 33.40^k$

Location of ϕV_c by similarity of Δs'

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

$x_1 = 3.48'$

Now

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

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{96}{10} = \frac{16.70}{x_L}$

$x_L = 7.74'$

Step5: Value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

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

$= 78.43 - 33.40$

$\phi V_s = 45.03k$

Step6: check on section adequacy.

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

$= 133.57k$

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

Step7: check on min spacing for stirrups

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

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

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

$A_v = 0.11 \times 2$

$A_v = 0.22$

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

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

$= 16.50$

From the above four condition, least value of spacing from the U stirrup will be selected so $S_{max} = 11"$ c/c

Step 8

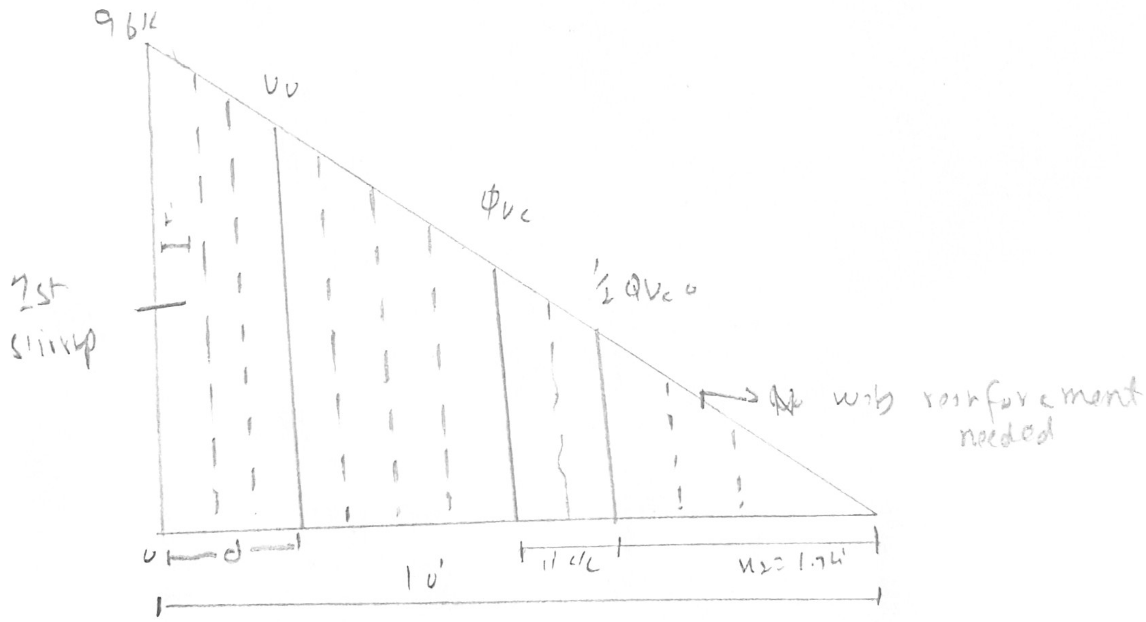
Spacing of stirrup from / at critical section

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

$48.4" \approx 5"$ c/c

Step 9

final sketch.



Q3 : 7648

calculate the axial ultimate .... design necessary spirals

Step 1

Find gross area of concrete.

Ag = b×b (since it's square tied column)

Ag = 12×12 = 144 in² (Actual)

Step 2

Find the area of steel.

Since

As = 5% of Ag

= 0.05×144

As = 7.2 in²

Step 3

Ultimate load carrying capacity

Pu = φ × 0.80 × [0.85 × fc' (Ag − As) + As × fy]

= 0.65 × 0.80 [0.85×4 [144 − 7.2] + 7.2 × 60]

Pu = 466.50 K.

Step. 4

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

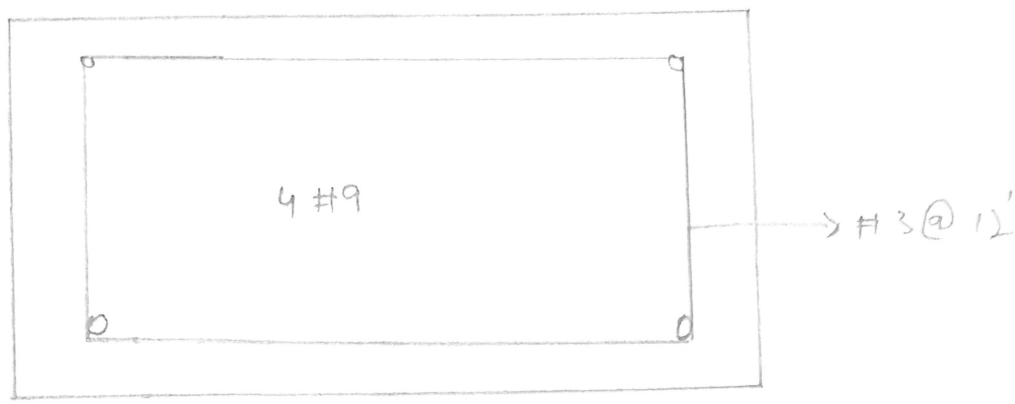
From the below values we choose the least value of all these -

1) ⇒ 16 × dia of long bar = 16 × 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 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.

Q4) Design a square footing ..... sketch of your final design.

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

$q_e = q_a - w$

$= 2.50 - 0.660$

$q_e = 1.84 ksf$

Step 4: Required Area for foundation

$Area = \frac{\text{Service load}}{q_e} = \frac{100 + 120}{1.80}$

$= 119.57 ft^2$

Step 5 Since foundation is square

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

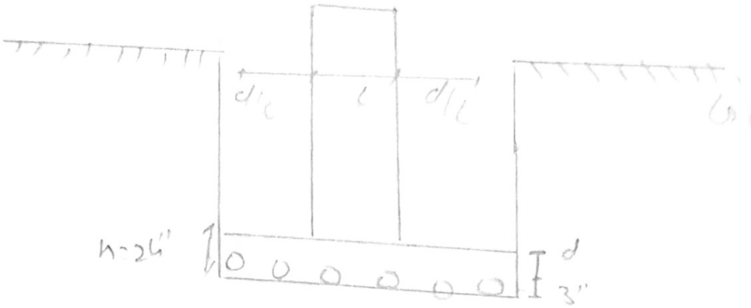
Step 6 Upward bearing capacity of soil.

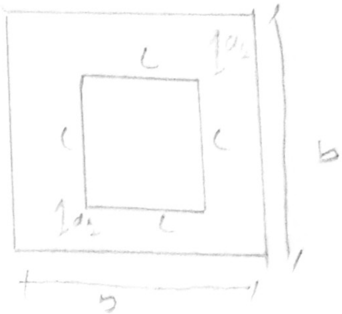
$q_{up} = \frac{\text{Factored load}}{(B)} = \frac{1.2 \times 100 + 1.6 \times 120}{11^2}$

$q_{up} = 2.5814 y^2$

Step 7: Punching shear

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





Take #8 bar

dia = 8/8 = 1"

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

$= 24 - 3 - 1 - 1/2(1) = 19.5"$

$b_0 = 4 \times (16 + 19.5) = 142"$

Step : 08

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

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

$V_{u2} = 289.60k$

Step 9 :

$\phi V_{cp} = \phi \times 4\sqrt{f'c} \times b_0 \times d$

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

$\phi V_{cp} = 525.38k.$

STEP10: Beam shear / one way shear check

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

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

$V_{u1} = 90.91k$

step 11: self shear capacity

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

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

$= 110.04K > V_u = 70.K$

step 12: Ultimate moment.

$M_u = \dfrac{q_u p \times B}{8} \times (B-c)^2 = \dfrac{2.58 \times 11}{8} \times \left(11 - \dfrac{16}{12}\right)^2$

$M_u = 331.49K' = 3977.93K''$

step 13: Area of steel for member by trial & Repeat method -

trial 1

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

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

$= 8.56 \, in^2$

trial 2:

$a = \dfrac{A_s \times f_y}{0.85 \times f_c \times b} = \dfrac{8.56 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.55$

$A_s = \dfrac{3977.93}{0.9 \times 60 \left(11 - \dfrac{1.55}{2}\right)} = 7.197 in^2$

trial 3 =

$a = \dfrac{7.197 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.27$

$A_s = \dfrac{3977.93}{0.90 \times 60 \left(11 - \dfrac{1.28}{2}\right)} = 7.13$

Area = 7.11 in²

step 14 = check the min reinforcement by the following as method.

A_s min = 0.0018 × B × h = 0.0018 × (11×12) × 24

A_s min = 5.70 in^2

A_s min = 8.58 in^2

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

= 7.05 in^2

step 15.

Using #8 bar

A_b = 0.785 in^2

No of bar = $\frac{A_s}{A_b}$ = $\frac{8.58}{0.785}$ = 10.92

≈ 11 bar in each direction