Q No 3 Design a 18"×18" tied column for a factored axial compressive load of 300kips the material strength are

$f_c' = 3ksi$ and $f_y = 40ksi$

Solution

Nominal strength (ϕPn) of axially loaded column is

- $\phi Pn = 0.80\phi(0.85f_c'(Ag - Ast) + Ast\,Fy)$
- $Ag = 18 \times 18 = 324 in^2$
- let $Ast = 1\%$ of $Ag = 0.01 \times 324 = 3.24$
- $\phi Pn = 0.80 \times 0.65\{0.85 \times 3(324 - 3.24) 3.24 + 40)$

$= 492 Kips > (Pu = 300kips$ ok.

Therefore $Ast = 0.01 \times 324 = 3.24 in^2$

Main Bar

- using #6 bar with bare area $Ab = 0.44 in^2$

Scanned with CamScanner

- No of bars $= \frac{As}{Ab} = \frac{3.24}{0.44} = 7.36 = 8$ bars

· Tie Bar

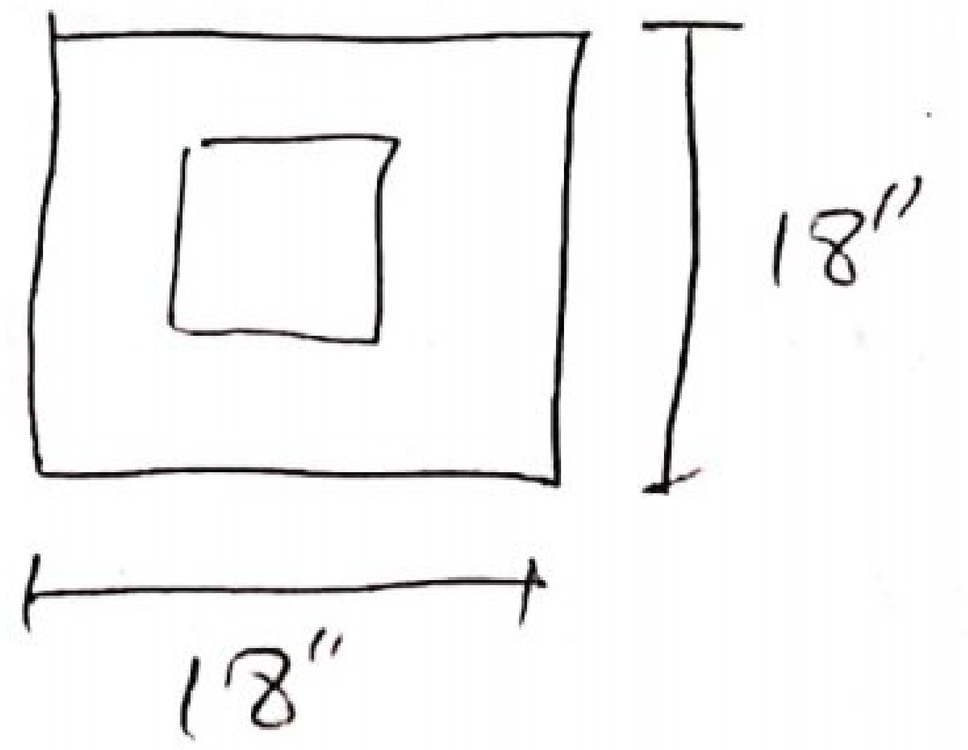
- using # bar with bar area $Ab = 0.11 in^2$
  center-to-center spacing shall exceed
  the least of

(i) 16 db of longitudinal bar $= 16 \times 0.75 = 12''$

(ii) 48db of tie bar $= 48 \times \frac{3}{8} = 18''$

(iii) smaller dimension of member $= 18''$

there fore use # 3 bars ties @12" c/c



Q No 1

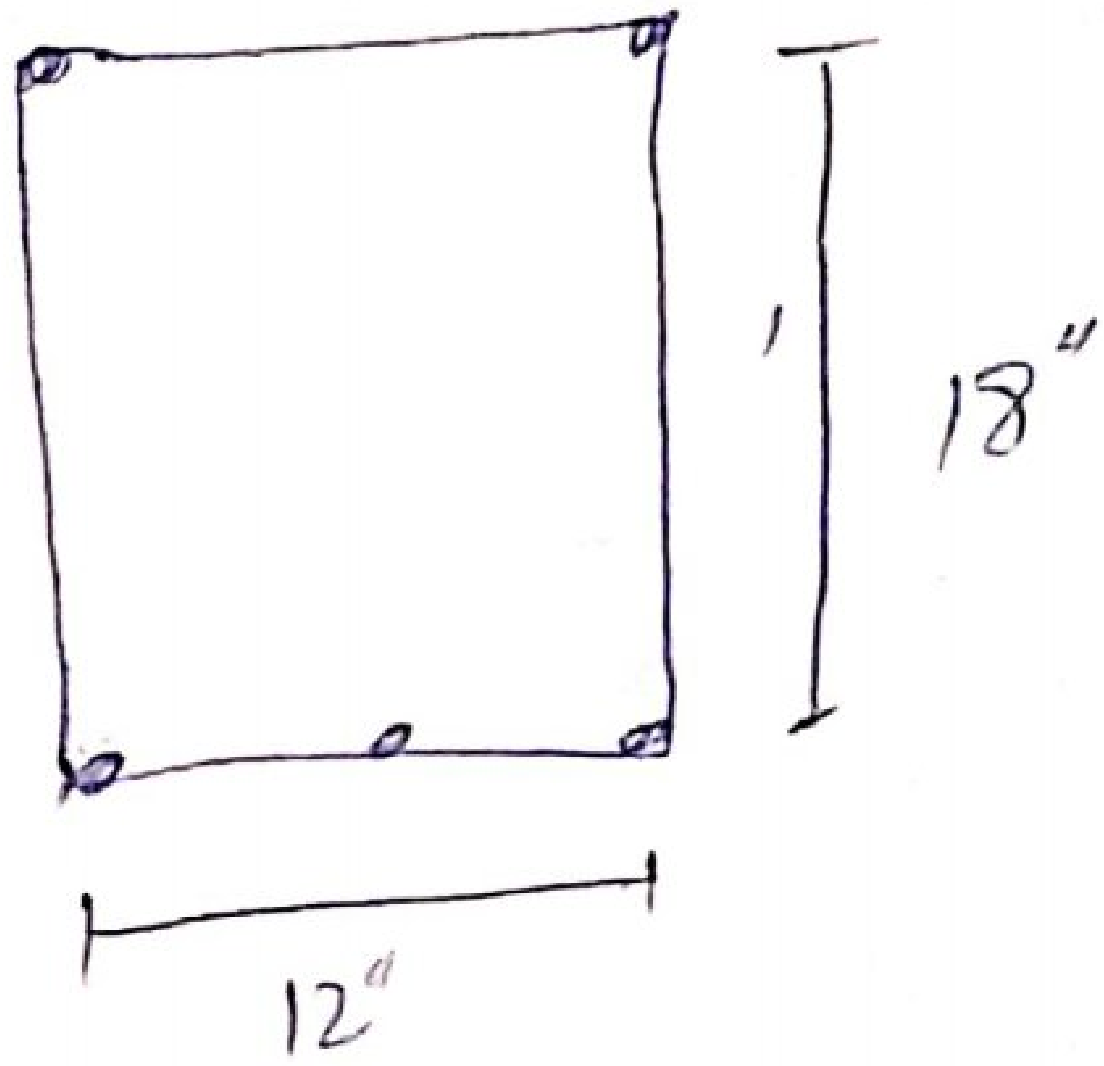
- Flexural and Shear Design of Beam as per ACI
- Solution:
- Step No 1 Sizes
- For 20' length $h_{min} = \frac{l}{16} = \frac{20 \times 12}{16} = 15$ inch
- For grade 40 we have $= h_{min} = 15'' \times \left(\frac{0.4 + 40000}{100000} \right)$

$= 12''$

- This is the minimum requirement of the code for depth of beam.
- However we select 18" deep beam
- Generally the minimum beam width is 12" therefore, width of the beam is taken as 12"
- The final selection of beam size depends on several factors specifically the availability of formworks

- Depth of beam $h = 18''$
  - $h = d + \bar{y}$: $\bar{y}$ is usually taken from 2.5 to 3.0 inches
  - For $\bar{y} = 2.5$ in: $d = 18 - 2.5 = \boxed{15.5''}$
- width of beam cross section $(b_w) = 12''$

in RCD width beam is usually denoted by bw instead of b



Step No 2 loads

- self weigh of beam $= \gamma_c b_w h = 0.15 \times \left(\frac{12 \times 18}{144}\right) = 0.225$ Kips/ft
- $W_u = 1.2 W_D + 1.6 W_L$

$$= 1.2 \times (0.225 + 0.75) + 1.6 \times 0.75 = 2.37 \text{ Kips/ft}$$

Step No 3 Analysis

- Flexural Analysis

$$M_u = \frac{W_u l^2}{8} = 2.37 \times (20)^2 \times \frac{12}{8}) = 1422 \text{ in-Kips}$$

- Analysis For shear in beams

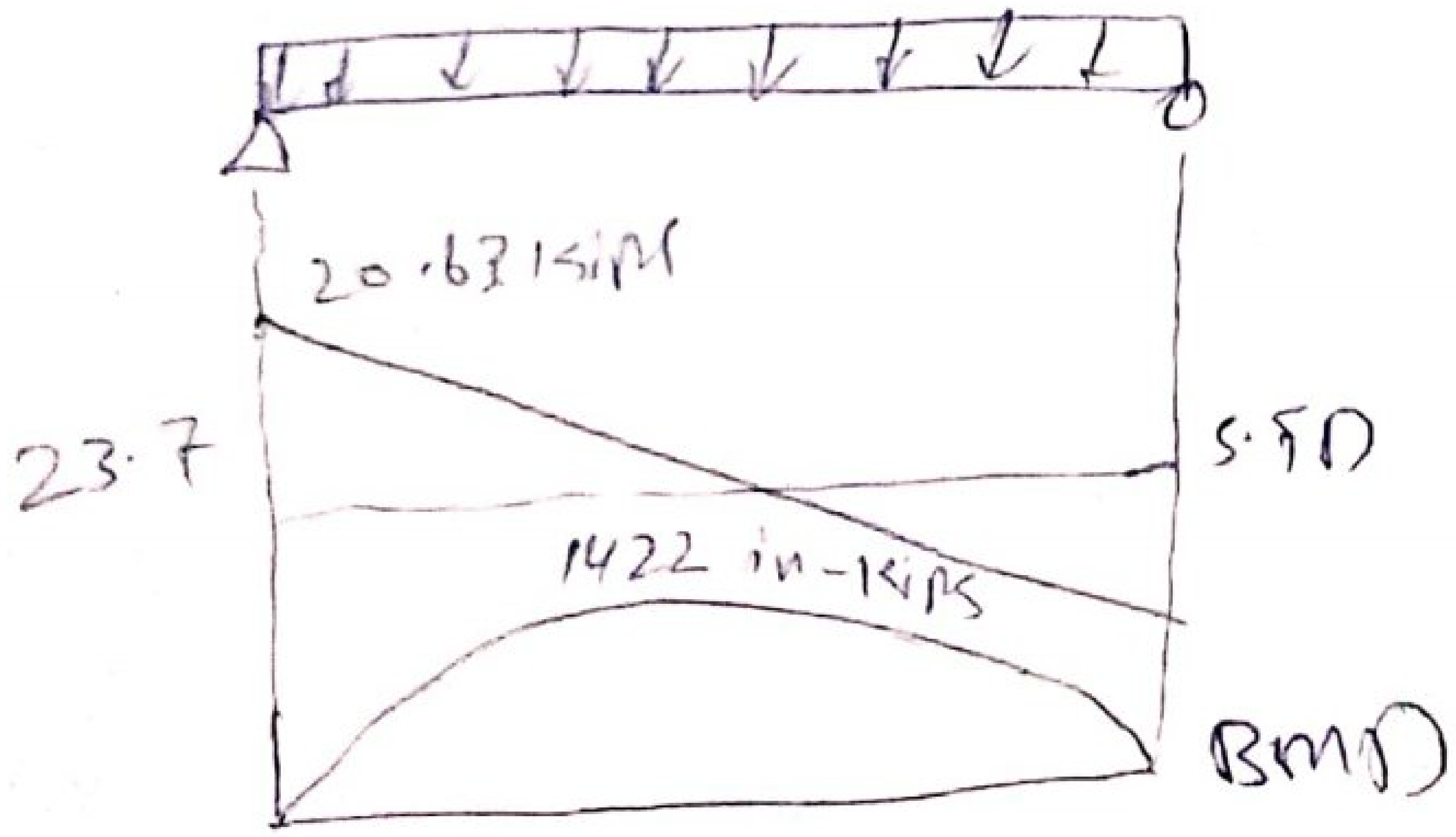
$V = 23.7$ KIPS

- To Find V_u at a distance 'd' from face of support $d = 15.5'' = 1.29'$

using similarity of triangles:

$$V_u / (10 - 1.29) = \frac{23.7}{10}$$

$$V_u = \frac{23.7 \times (10 - 1.29)}{10} = 20.63K$$



Step No 4

• Design For flexure:

• $\phi M_n \geq M_u$ (ϕM_n is M design or capacity)

• For $\phi M_n = M_u$

• $\phi A_s f_y (d - a/2) = M_u$

• $A_s = \dfrac{M_u}{\phi F_y (d - a/2)}$

• Calculate "A_s" by trial and success method

• First Trial

• Assume $a = 4"$

• $A_s = \dfrac{1422}{(0.9 \times 40 \times \{15.5 - 4/2\})} = 2.92 \, in^2$

• $a = \dfrac{A_s f_y}{0.85 f_c b_w}$

• $= \dfrac{2.92 \times 40}{0.85 \times 3 \times 12} = 3.81$ inches

Second Trial

- $A_s = \dfrac{1422}{\{0.9 \times 40 \times [15.5 - \frac{3.82}{2})\}} = 2.90 in^2$

- $a = \dfrac{2.90 \times 40}{0.85 \times 3 \times 12} = 3.79$ inches

Third Trial

- $A_s = \dfrac{1422}{0.9 \times 40 \times \{15.5 - (\frac{3.79}{2})\}} = 2.90 in^2$

- $a = \dfrac{4.49 \times 40}{0.85 \times 3 \times 12} = 3.79$ inche

- Close enough to the previous value of "a" so that $A_s = 2.90 in^2$ o.k.

- check for maximum and minimum reinforcement allowed by ACI

- $A_{s min} = \dfrac{3\sqrt{f'c}}{f_y} b_w d \geq \left(\dfrac{200}{f_y}\right) b_w d$

- $\dfrac{3\sqrt{f'c}}{f_y} b_w d = \dfrac{3 \times \sqrt{3000}}{40000} b_w d = 0.004 \times 12 \times 15.5 = 0.744 in^2$

- $\dfrac{200}{f_y} b_w d = \dfrac{200}{40000} \times 12 \times 15.5 = 0.93 in^2$

Scanned with CamScanner

- $As_{max} = 0.27\left(\frac{f_c'}{f_y}\right) b_w d = 0.27 \times \left(\frac{3}{40}\right) \times 12 \times 15.5 = 3.76 in^2$
- $As_{min} (0.93) < As (2.90) < As_{max} (3.76)$ o.k
- Bar placement 5#7 bars will provide 3.0 in^2 of steel area which is slightly greater than required
- other options can be explored for example
  - 7#6 bars (3.08 in^2)
  - 4#8 bars (3.16 in^2)
  - or combination of two different steel bars
- $V_u = 20.63$ Kips
- ΦV_c = capacity of concrete in shear)

$$= \Phi 2 \sqrt{f_c'} b_w d$$

$$= \frac{0.75 \times 2 \times \sqrt{3000} \times 12 \times 15.5}{1000} = 15.28 \text{ kips}$$

As $\Phi V_c < V_u$ shear reinforcement is required

- Assuming #3, 2 legged (0.22 in^2) vertical stirrups
- spacing required (S_d) = $\Phi A_v f_y d / (V_u - \Phi V_c)$

$$= \frac{0.75 \times 0.22 \times 46 \times 15.5}{(20.63 - 15.28)} = 19.12''$$

Scanned with CamScanner

Page No 9

maximum spacing and minimum reinforcement requirements as permitted by ACI is minimum of

- $S_{max} = \left(\frac{A_v f_y}{50 b_w}\right) = \frac{0.22 \times 40000}{50 \times 12} = 14.66''$
- $S_{max} = \frac{d}{2} = \frac{15.5}{2} = 7.75''$
- $S_{max} = 24''$
- $\frac{A_v f_y}{0.75 \sqrt{f_c'}\, b_w} = \frac{0.22 \times 40000}{0.75 \times \sqrt{3000} \times 12} = 17.85''$

Therefore $S_{max} = 7.75''$

Other checks

$\phi V_s \le \phi 8 \sqrt{f_c'}\, b_w d$

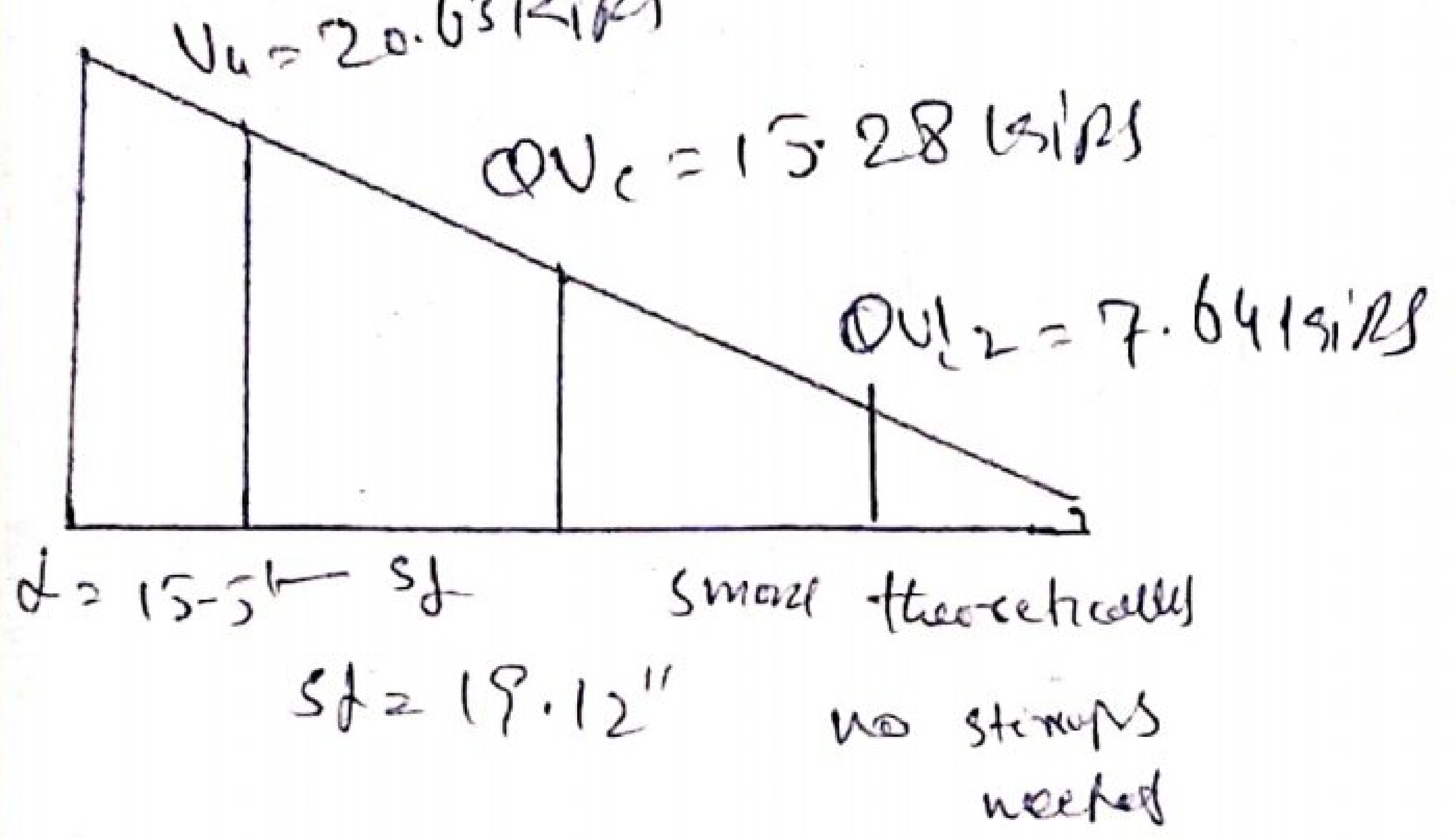
$\phi 8 \sqrt{f_c'}\, b_w d = 0.75 \times 18 \times \sqrt{3000} \times 12 \times 15.5 / 1000 = 61$ kips

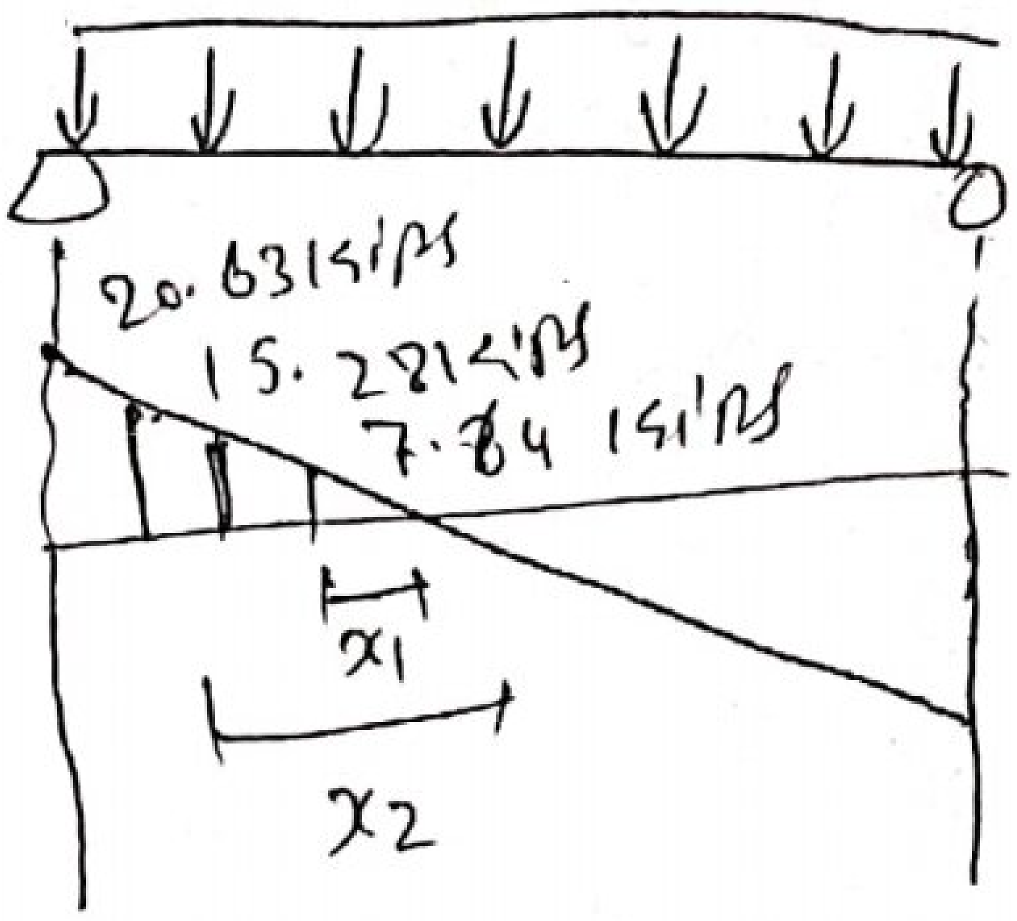
$\phi V_s = V_u - \phi V_c = 20.63 - 15.28 = 5.35\text{ k} < 61.12\text{ k}$, o.k

check if $\phi V_s \le \phi 4 \sqrt{f_c'}\, b_w d$

- $5.35\text{ kips} < 30.56\text{ kips}$ o.k
- $\phi V_s \le \phi 4 \sqrt{f_c'}\, b_w d$ the maximum spacing (S_{max}) is o.k otherwise reduce spacing by on half

Onus Drafting





Scanned with CamScanner

QNo2 Page No 11

- Step # 01 Estimate the thickness of Footing. h
- Assuming a trial thickness $h = 12in$
- Effective depth $d = 12 - 3$ in cover $- \frac{1}{2}$ (bar diameter)

$\cong 8.5 in$

Step # 02: calculate weight of fill and weight of concrete w

- $w = W_{conc} + W_{fill} = 1 \times 0.15 + 4 \times 0.12 = 0.63 ksf$

- Step No 3 calculate effective bearing capacity q_e

- $q_e = q_o - w$

$q_e = 5 - 0.63 = 4.37 ksf$

Step No 4

calculate bearing area Areq

- A_{req} = service load / q_e

service load = $10 + 12.5 = 22.5$ kips/ft

$A_{req} = \frac{22.5}{4.37} = 5.15 ft^2$ per foot of length

- Trying a footing 5ft 2 in wide

- **Step #05** calculate design pressure on base a footing due to factored loads q_u

$$q_u = \frac{\text{factored load}}{\text{Bearing area}}$$

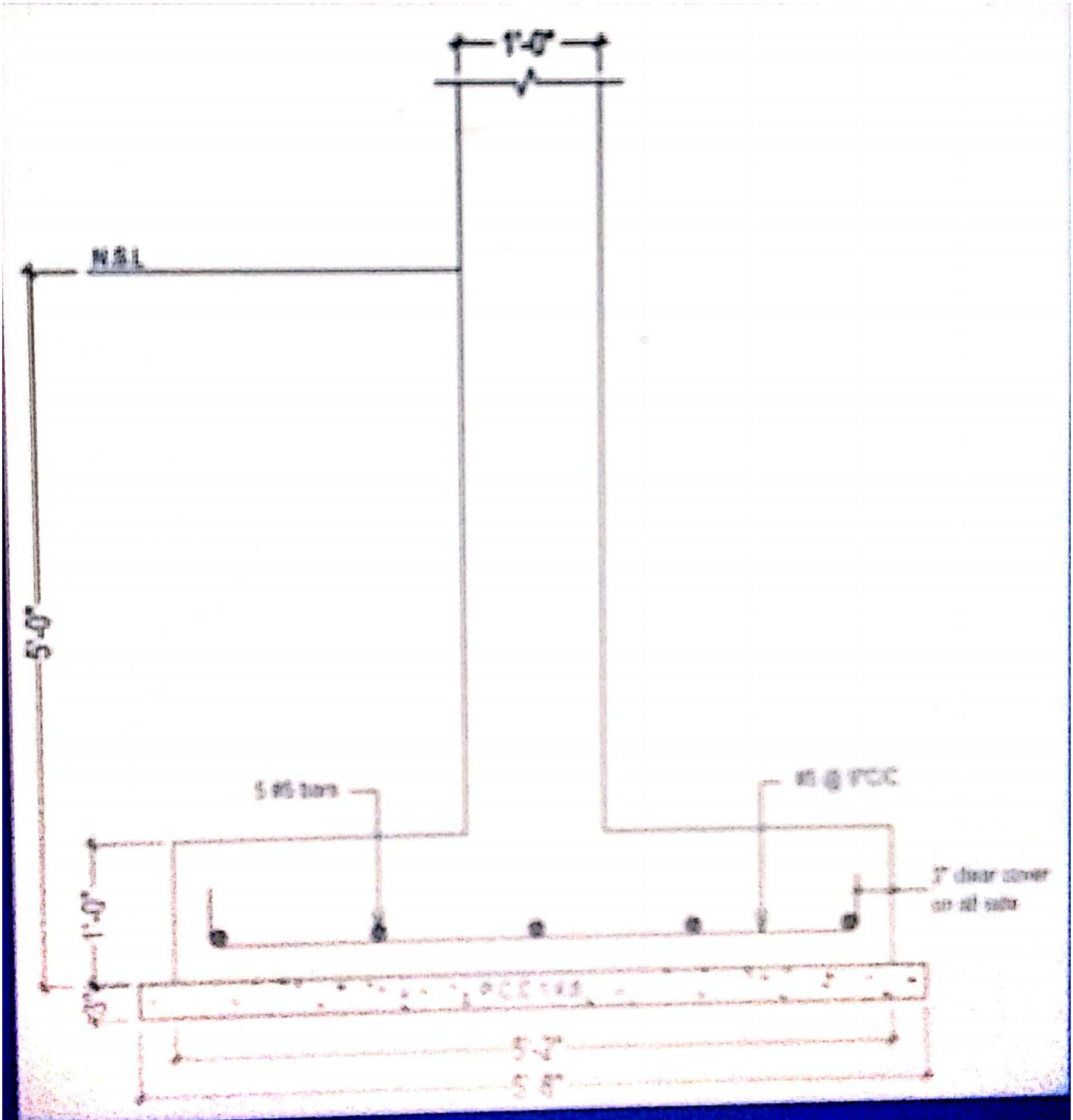
factored loads = 1.2(60) + 1.6(12.5) = 32 ks/ft

- $q = \frac{32}{5.17} = 6.19$ ksf

- **Step #06** calculate the critical shear V_u
- only one-way shear is significant in wall footing hence determining critical shear at distance d from the face of support
  - d = 12 - 3 in cover - ½ (bar diameter) = 8.5 in
  - $V_u = q_u b(15 - d)$
  - $V_u = 6.19 \times 1\{(25 - 8.5)/12\}$

    = 8.511 kips/ft

Scanned with CamScanner



CE 320 Reinforced Concrete Design-I