Student No :

Assignment No.: 02

Assignment Name: Design of Beam

Design plan:

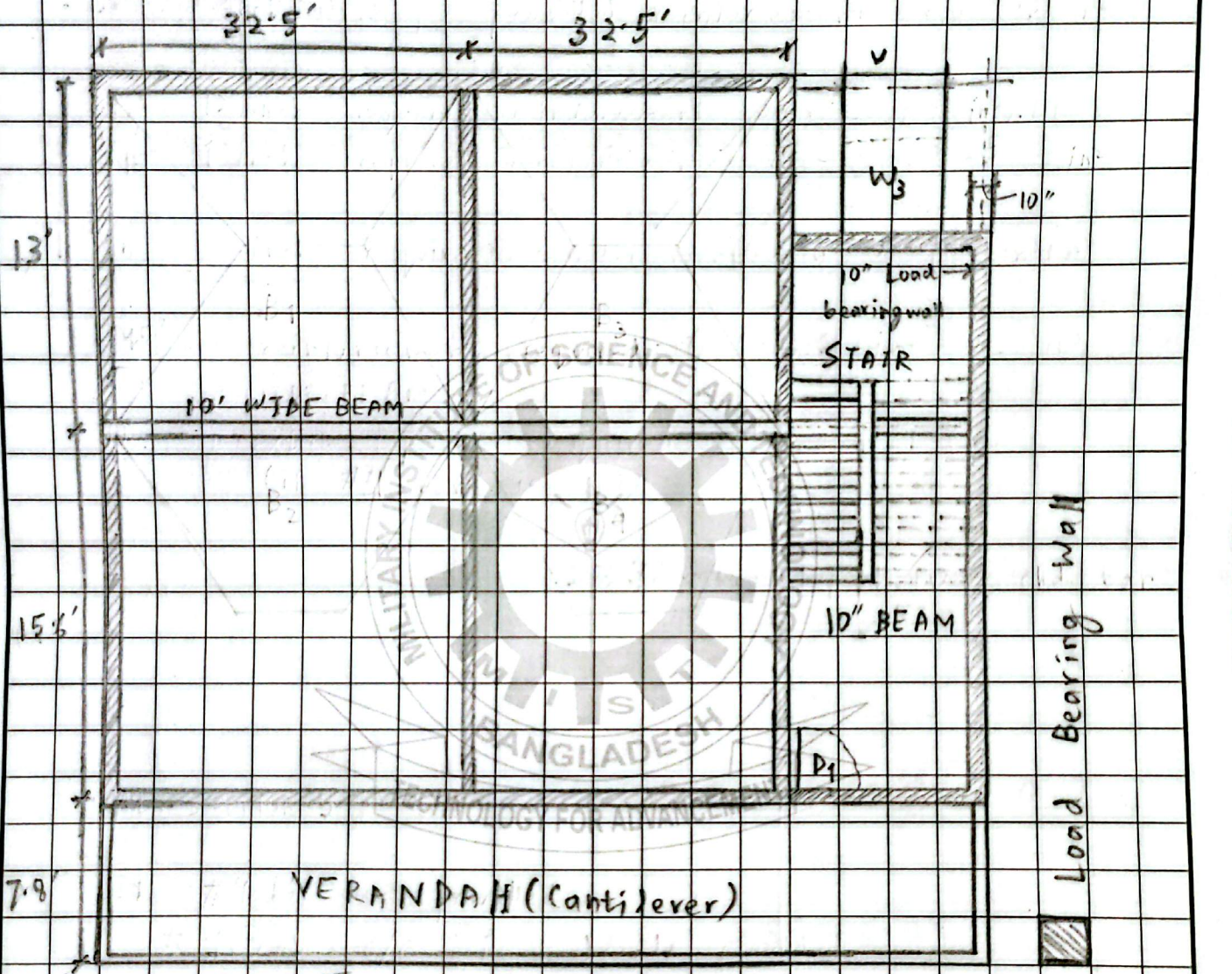


Fig: Typical Layout of Load Bearing Wall

Design Data:

Dimension, X = 13'

Ultimate strength of concrete, f_c' = 3.5 ksi.

Yield strength of steel, f_y = 50 ksi = 350 MPa.

Live Load on Floor (LL) = 50 psf

Floor Finish (FF) = 25 psf

Allowable soil bearing capacity, q_u = 2 ksf.

Student No :

Load Calculation for Beam Design

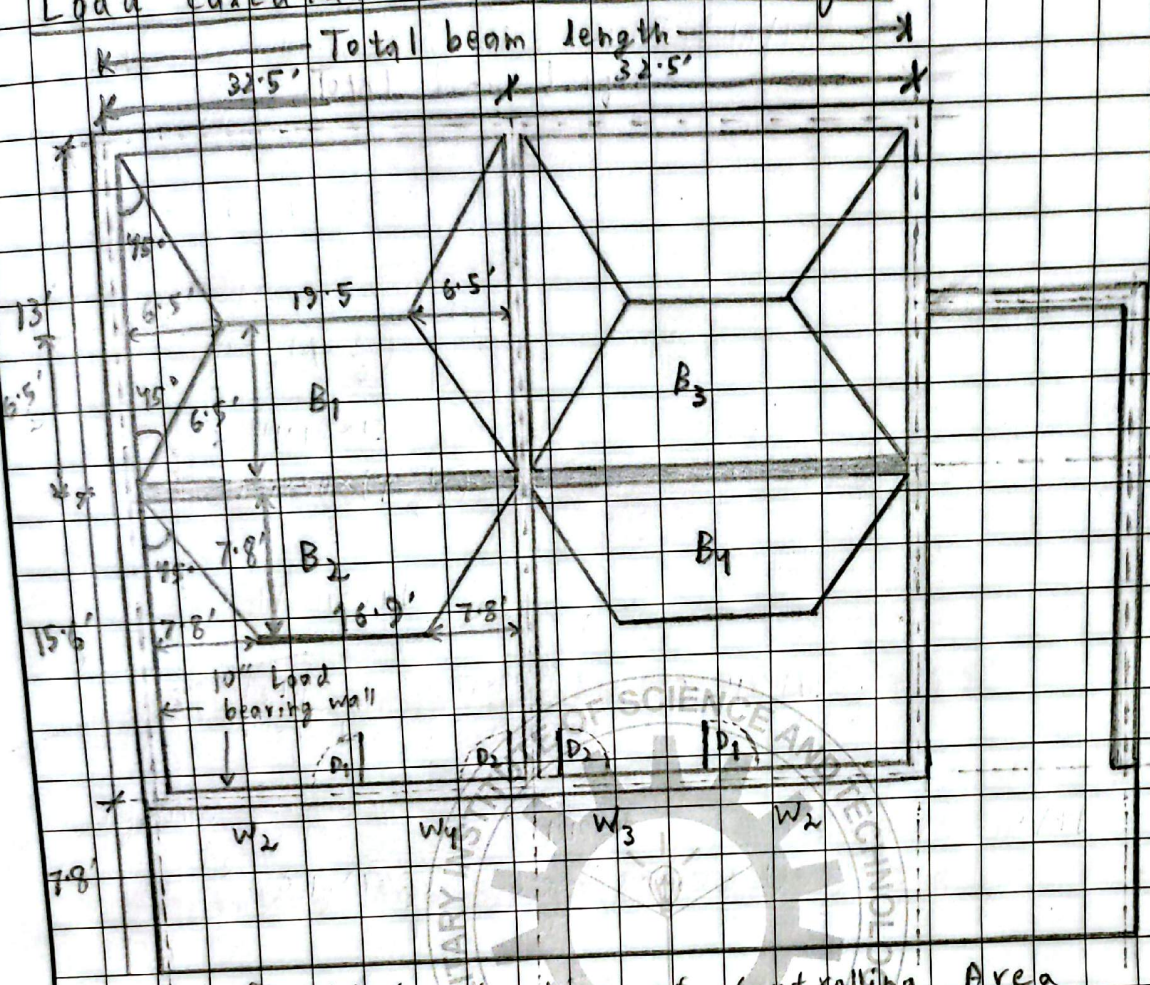


Fig.: Determination of Controlling Area for Load Calculation

In thickness determination,

Multiplying factor $= \left(0.4 + \frac{fy}{700}\right) = 0.4 + \frac{350}{700} = 0.9$

For one end continuous,

$$t = \frac{L}{24} \times 0.9 = \frac{13 \times 12}{24} \times 0.9 = 5.85 \approx 6.0''$$

For both end continuous,

$$t = \frac{L}{28} \times 0.9 = \frac{15.6 \times 12}{24} \times 0.9 = 6.02 \approx 6.5''$$

For cantilever,

$$t = \frac{L}{10} \times 0.9 = \frac{7.8 \times 12}{10} \times 0.9 = 8.42 \approx 8.5''$$

Student No :

From calculation, maximum thickness = 8.5"

So, t_{final} = 8.5"

Effective depth, d = (8.5 - 1)" = 7.5"

In load calculation,

LL = 50 psf

FF = 25 psf

$DL = \left\{\left(150 \times \frac{8.5}{12}\right) + 25\right\} = 131.25$ psf.

From figure,

Tributary Area, $B_1 = \frac{1}{2} \times (19.5 + 32.5)' \times 6.5'$

$= 169\ ft^2$.

Tributary Area, $B_2 = \frac{1}{2} \times (16.9 + 32.5)' \times 7.8'$

$= 192.66\ ft^2$.

Tributary Area, $B_3 = B_1$

$= 169\ ft^2$.

Tributary Area, $B_4 = B_2$

$= 192.66\ ft^2$.

Total beam length = (32.5 + 32.5)' = 65 ft.

Student No :

Load on beam from slab per unit length of the beam = $\frac{\text{Tributary area} \times \text{Total load from slab (psf)}}{\text{Total beam length}}$ lb/ft

For Dead Load (on slab),

$$W_{DL(slab)} = \frac{[B_1 + B_2 + B_3 + B_4] \times 131.25 \text{ psf}}{65'} \text{ lb/ft}$$

$$= \frac{(169 + 192.66 + 169 + 192.66) \times 131.25}{65}$$

$$= 1460.55 \text{ lb/ft}.$$

For Live Load (on slab),

$$W_{LL(slab)} = \frac{[B_1 + B_2 + B_3 + B_4] \times 50 \text{ psf}}{65'} \text{ lb/ft}$$

$$= \frac{(169 + 192.66 + 169 + 192.66) \times 50}{65} \text{ lb/ft}$$

$$= 556.4 \text{ lb/ft}.$$

For Dead Load (on beam),

Self wt of Beam, $W_{DL(beam)} = b \times h \times 150$

$$= \left(\frac{10}{12}\right)' \times \left(\frac{22}{12}\right) \times 150 \text{ pcf}$$

$$= 229.17 \text{ lb/ft}.$$

Depth of beam,

$h = \frac{L}{16} \times M.F$

$= \frac{32.5 \times 12}{16} \times 0.9$

$\therefore h = 21.94 \simeq 22''$.

Total factored load, $W_u = 1.2(DL) + 1.6(LL)$

$= 1.2(W_{DL(slab)} + W_{DL(beam)}) + 1.6(W_{LL(slab)})$

$= 1.2(1460.55 + 229.17) + 1.6(556.4)$

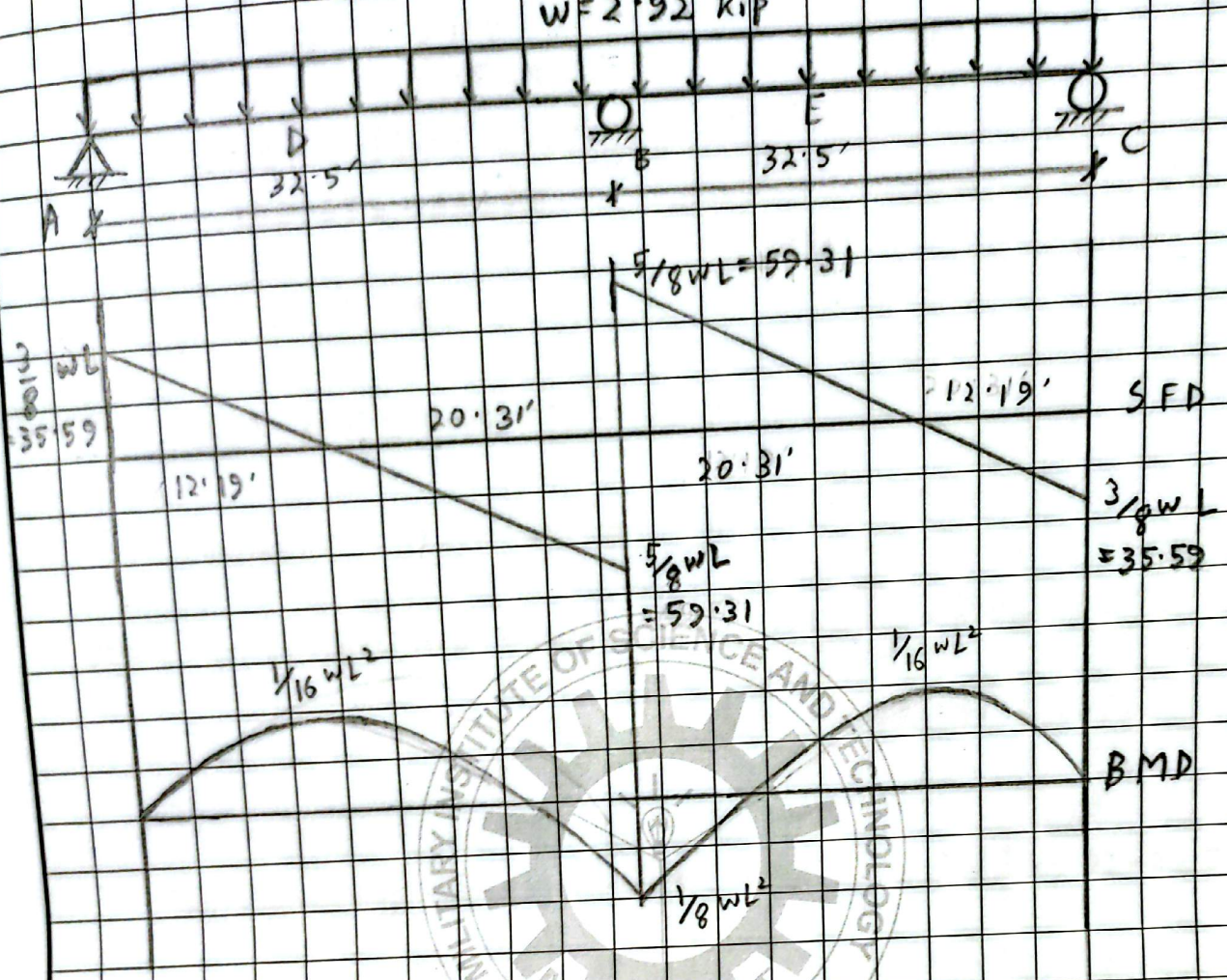
$= 1.2(1689.72) + 1.6(556.4)$

$\therefore W_u = 2917.9 \text{ lb/ft}.$

$= 2.92 \text{ kip/ft}.$

Student No :

Moment and Shear

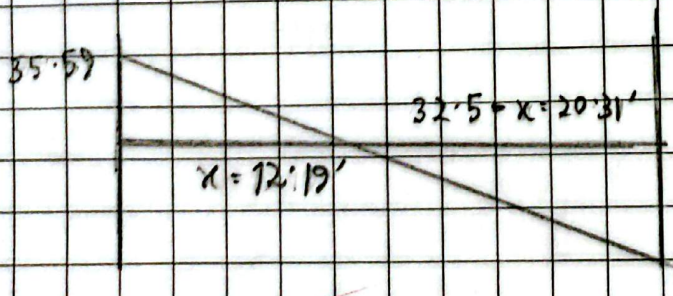


For shear force calculation,

Shear force at A = $\frac{3}{8}wL = \frac{3}{8} \times 2.92 \times 32.5 = 35.59$ kip.

Shear force at B = $\frac{5}{8}wL = \frac{5}{8} \times 2.92 \times 32.5 = 59.31$ kip.

Shear force at C = $\frac{3}{8}wL = \frac{3}{8} \times 2.92 \times 32.5 = 35.59$ kip.



Using Similar triangles,

$$\frac{38.88}{x} = \frac{64.8}{32.5 - x}$$

$$64.8x = 1263.6 - 38.88x$$

$$103.68x = 1263.6$$

$$x = 12.19'.$$

$$\therefore 32.5 - x = (32.5 - 12.19)' = 20.31'.$$

For moment calculation,

Maximum positive moment, $M_u^+ = \frac{1}{16} wL^2 = \frac{1}{16} \times 2.92 \times 32.5^2$

$= 192.77$ kip-ft.

Maximum negative moment, $M_u^- = \frac{1}{8} wL^2 = \frac{1}{8} \times 2.92 \times 32.5^2$

$= 385.53$ kip-ft.

Check d_{min}

$$\rho_{0.05} = 0.85 \beta_1 \frac{f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + 0.005}$$

$$= 0.85 \times 0.85 \times \frac{3.5}{50} \times \frac{0.003}{0.003 + 0.005}$$

$$= 0.0190.$$

$$d_{req}^2 = \frac{M_{u(max)}}{\phi \rho b f_y \left(1 - 0.59 \rho \frac{f_y}{f_c'}\right)}$$

$$d_{req} = \sqrt{\frac{385.53 \times 12}{0.90 \times 0.0190 \times 50 \times 12 \left(1 - 0.59 \times 0.0190 \times \frac{50}{3.5}\right)}}$$

CamScanner

Student No :

$\therefore d_{req} = 25.38''$.

$d_{provided} = 22 - 2.5 = 19.5''$

$d_{provided} < d_{required}$ so $d_{required}$ must be provided.

$\therefore d = 25.38 \approx 26''$

$h = 26 + 2.5 = 28.5'' \approx 30''$

$d_{provided} = 30 - 2.5 = 27.5''$.

Now, $d_{provided} > d_{required}$ so section is ok.

Determine effective depth

① $16\, t_s + b_w = 16 \times 8.5'' + 10'' = 146''$.

② $\frac{L}{4} = \frac{65 \times 12}{4} = 195''$.

③ C/C spacing $= 13 \times 12$
$= 156''$.

Max $b_{eff} = 195''$

Now,

$$A_{s\,min} = \text{Max of} \begin{cases} \frac{3\sqrt{f_c'}\, bd}{f_y} = \frac{3\sqrt{3500} \times 10 \times 27.5}{50000} \\ = 0.98 \text{ in}^2. \\ \frac{200\, bd}{f_y} = \frac{200 \times 10 \times 27.5}{50000} \\ = 1.10 \text{ in}^2. \end{cases}$$

$A_{s(min)} = 1.10 \text{ in}^2$.

Student No :

For Positive moment,

$a = t_s$

$a = 8.5''$

$$A_s = \frac{M_u^+}{\phi f_y (d - a/2)}$$

$$= \frac{192.77 \times 12}{0.90 \times 50 \times (27.5 - \frac{8.5}{2})}$$

$\therefore A_s = 2.21 \text{ in}^2.$

$$a = \frac{A_s f_y}{0.85 f_c' b_{eff}} = \frac{2.21 \times 50}{0.85 \times 3.5 \times 195} = 0.19 \text{ in.}$$

As $a < t_s$, so it is a rectangular beam.

$\therefore b = b_w = 10''.$

Assume, $a = 1''$.

$$A_s = \frac{192.77 \times 12}{0.9 \times 50 \times (27.5 - 1/2)} = 1.90 \text{ in}^2.$$

$$a = \frac{1.90 \times 50}{0.85 \times 3.5 \times 10}$$

$\therefore a = 3.20 \text{ in.}$

2nd trial,

$$A_s = \frac{192.77 \times 12}{0.9 \times 50 \times (27.5 - \frac{3.20}{2})} = 1.98 \text{ in}^2.$$

$$a = \frac{1.98 \times 50}{0.85 \times 3.5 \times 10} = 3.34 \text{ in.}$$

$A_s = 1.98 \text{ in}^2$ > A_s (min) ... it is okay.

Student No :

3rd trial,

$$A_s = \frac{192.77 \times 12}{0.90 \times 50 \times (27.5 - \frac{3.34}{2})}$$

$$= 1.99 \text{ in}^2$$

$$a = \frac{1.99 \times 50}{0.85 \times 3.5 \times 10} = 3.34 \text{ in.}$$

4th trial,

$$A_s = \frac{192.77 \times 12}{0.9 \times 50 \times (27.5 - \frac{3.34}{2})} = 1.99 \text{ in}^2.$$

$A_{s(+ve)} = 1.99 \text{ in}^2 > A_{s(min)}$ so it is okay.

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY
INSTITUTE
BANGLADESH
TECHNOLOGY FOR ADVANCEMENT

Student No :

For Negative moment,

Assuming, a = 1".

$$A_s = \frac{-M_u}{\phi f_y (d - a/2)}$$

$$= \frac{385.53 \times 12}{0.90 \times 50 \times (27.5 - 1/2)}$$

$A_s = 3.81 \text{ in}^2$.

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{3.81 \times 50}{0.85 \times 3.5 \times 10} = 6.40 \text{ in.}$$

2nd trial,

$$A_s = \frac{385.53 \times 12}{0.9 \times 50 \times (27.5 - \frac{6.40}{2})} = 4.23 \text{ in}^2.$$

$$a = \frac{4.23 \times 50}{0.85 \times 3.5 \times 10} = 7.11 \text{ in.}$$

3rd trial,

$$A_s = \frac{385.53 \times 12}{0.9 \times 50 \times (27.5 - \frac{7.11}{2})} = 4.29 \text{ in}^2$$

$$a = \frac{4.29 \times 50}{0.85 \times 3.5 \times 10} = 7.22 \text{ in.}$$

4th trial,

$$A_s = \frac{385.53 \times 12}{0.9 \times 50 \times (27.5 - \frac{7.22}{2})} = 4.30 \text{ in}^2.$$

$$a = \frac{4.30 \times 50}{0.85 \times 3.5 \times 10} = 7.23 \text{ in.}$$

5th trial,

$$A_s = \frac{385.53 \times 12}{0.9 \times 50 \times (27.5 - \frac{7.23}{2})} = 4.30 \text{ in}^2.$$

Student No :

$A_{s(-ve)} = 4.30\ in^2 > A_{s(min)}$ so it is okay.

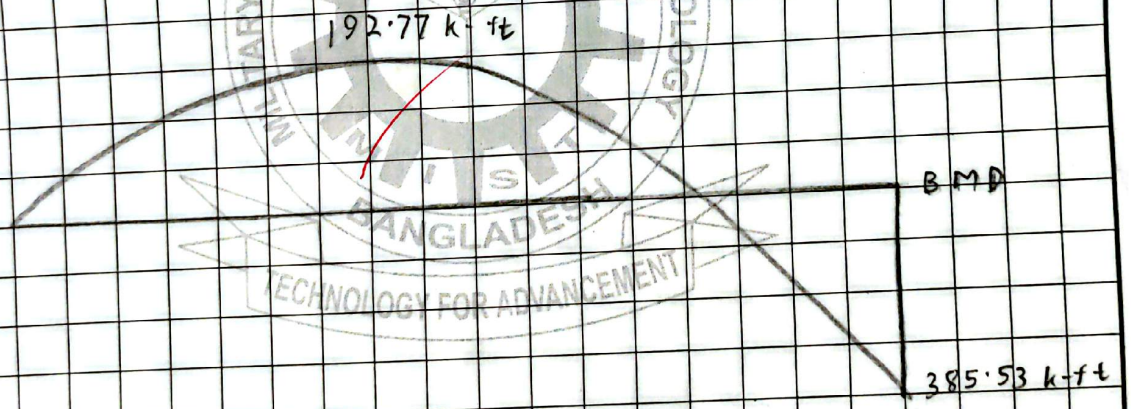
Now, $A_{s(+ve)} = 1.99\ in^2$ (3 #8 bar)
(Bottom bar)

$A_{s(-ve)} = 4.30\ in^2$ (2 #9 , 3 #8 bar)
(Top bar)

For span-1, left support (Bottom) $= \frac{4.30}{3} = 1.43\ in^2$ (3 #8 bar)

right support (Bottom) $= \frac{4.30}{3} = 1.43\ in^2$ (3 #8 bar)

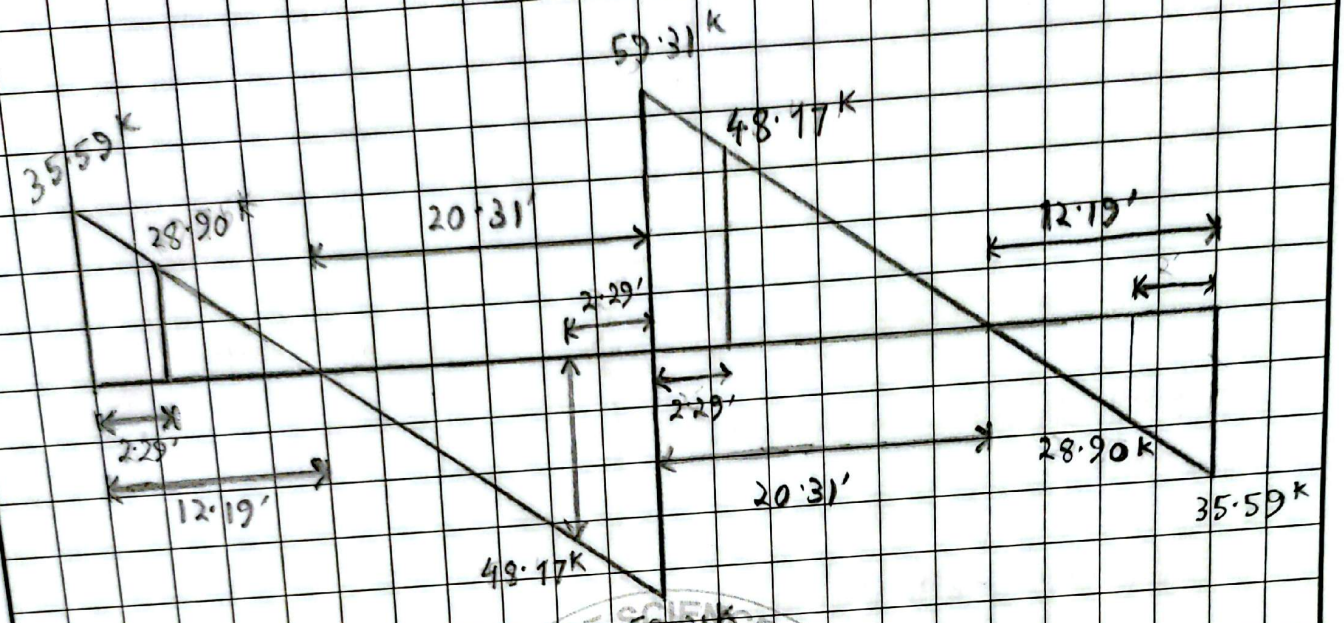
At Mid span (Top) $= \frac{4.30}{5} = 0.86\ in^2$ (2 #8 bar)



A_s^-		$A_s^- = 0.86$		$A_s^- = 4.30\ in^2$	
2 #9, 3 #8		2 #8		2 #9, 3 #8	
$A_s^+ = 1.43$	3 #8	3 #8		3 #8	$\frac{4.30}{3} = 1.43$
A_s^+		$A_s^+ = 1.99\ in^2$		A_s^+	

BANGLADESH TECHNOLOGY FOR ADVANCEMENT

Shear Reinforcement Determination



$V_c = 2\lambda\sqrt{f_c'}\, bd$

$= 2 \times 1 \times \sqrt{3500} \times 10 \times 27.5$

$= 32538.44$

$\therefore V_c = 32.54$ kip.

$\therefore \phi V_c = 0.75 \times 32.54 = 24.40$ kip.

$\therefore \frac{\phi V_c}{2} = \frac{24.40}{2} = 12.20$ kip.

Now,

$V_u = 28.90^K > \phi V_c = 24.40^K$.

$V_u = 48.17^K > \phi V_c = 24.40^K$.

$\therefore$ Shear Reinforced is required.

If we use #3 bar for stirrup

$$s = \frac{\phi A_v f_y d}{V_u - \phi V_c}$$

Student No :

$$S = \frac{0.75 \times (0.11 \times 2) \times 50 \times 27.5}{48.17' - 24.40}$$

$S = 9.54''$

$S = 9.5''$

S_{max} = min. value of

- $\frac{d}{4} = \frac{27.5}{4} = 6.875 \approx 6.5''$
- 8x smallest main bar dia = $8 \times 1.0.75$ = 8".
- 24x stirrup dia = 24×0.375 = 9".
- 300 mm = 11.81".

$S > S_{max}$.

$\therefore S = S_{max} = 6.5''$.

Again, $S = \frac{d}{2}$

$= \frac{27.5}{2}$

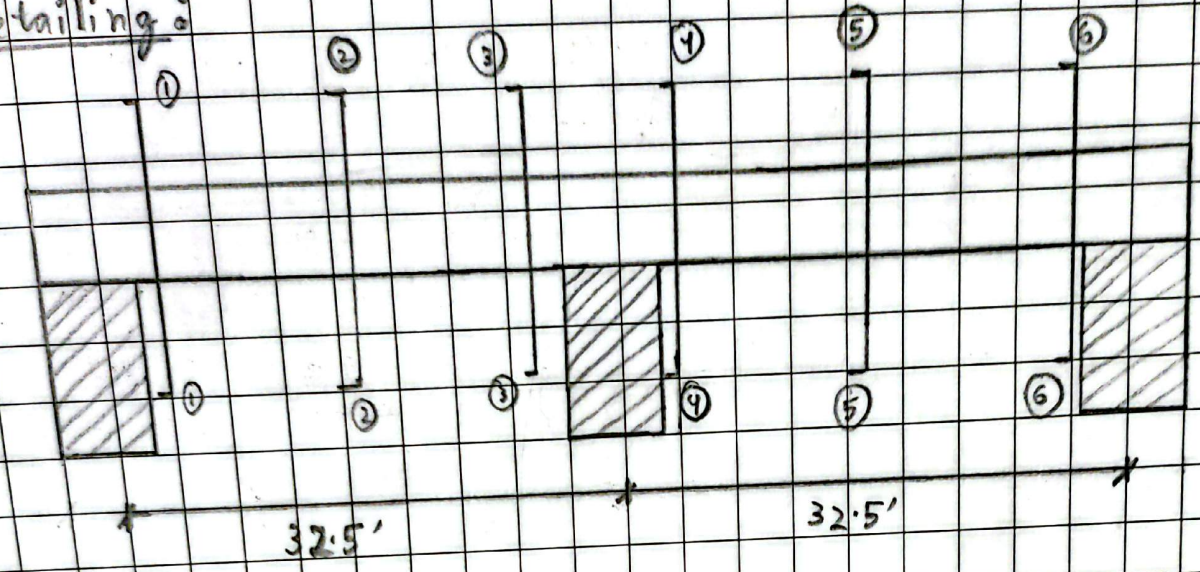
$= 13.75$

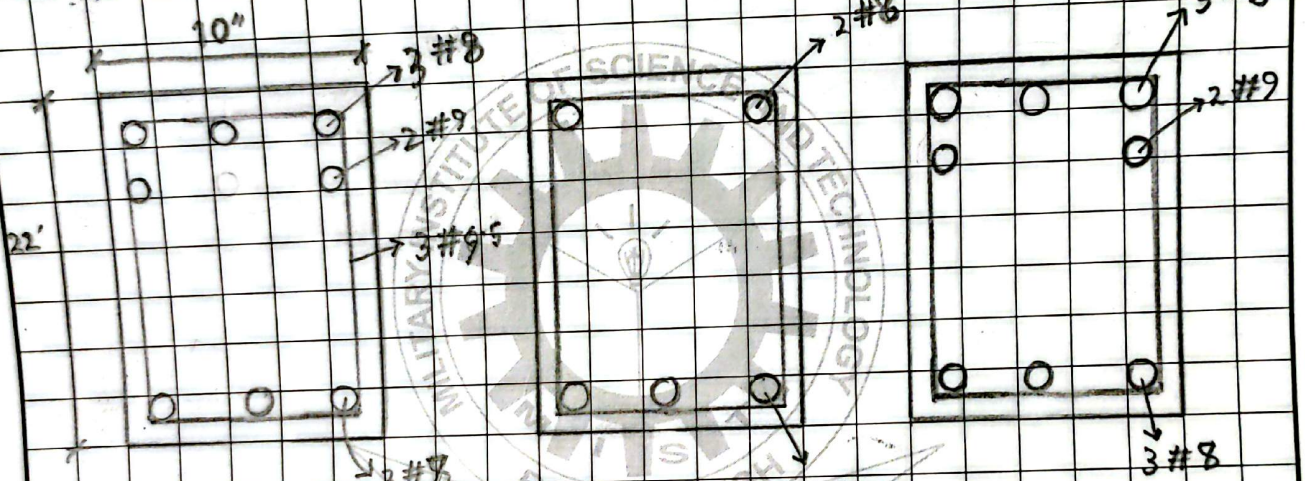
$\therefore S = 13.5''$.

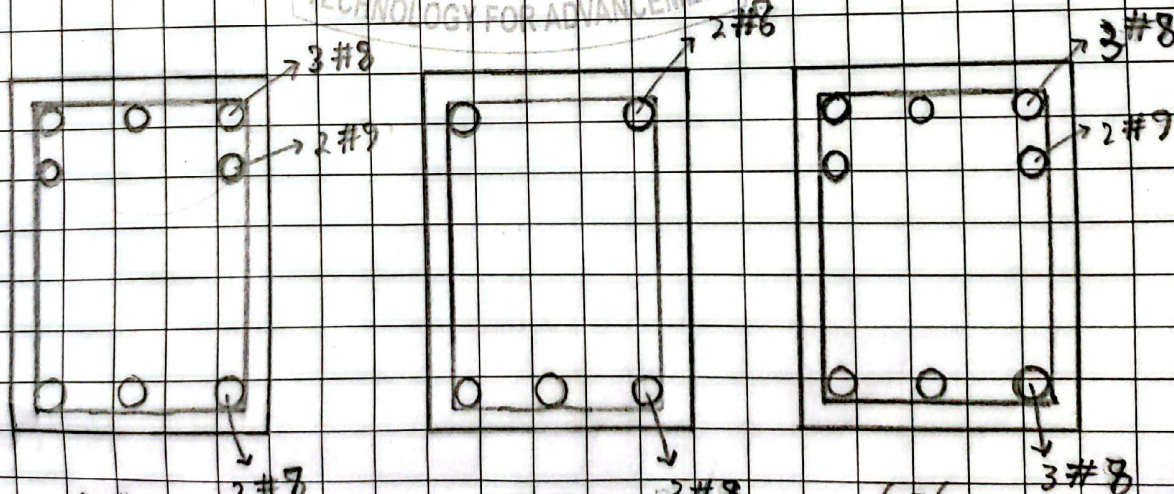
MIST INSTITUTE OF SCIENCE AND TECHNOLOGY
BANGLADESH
TECHNOLOGY FOR ADVANCEMENT

Student No :

Detailing :

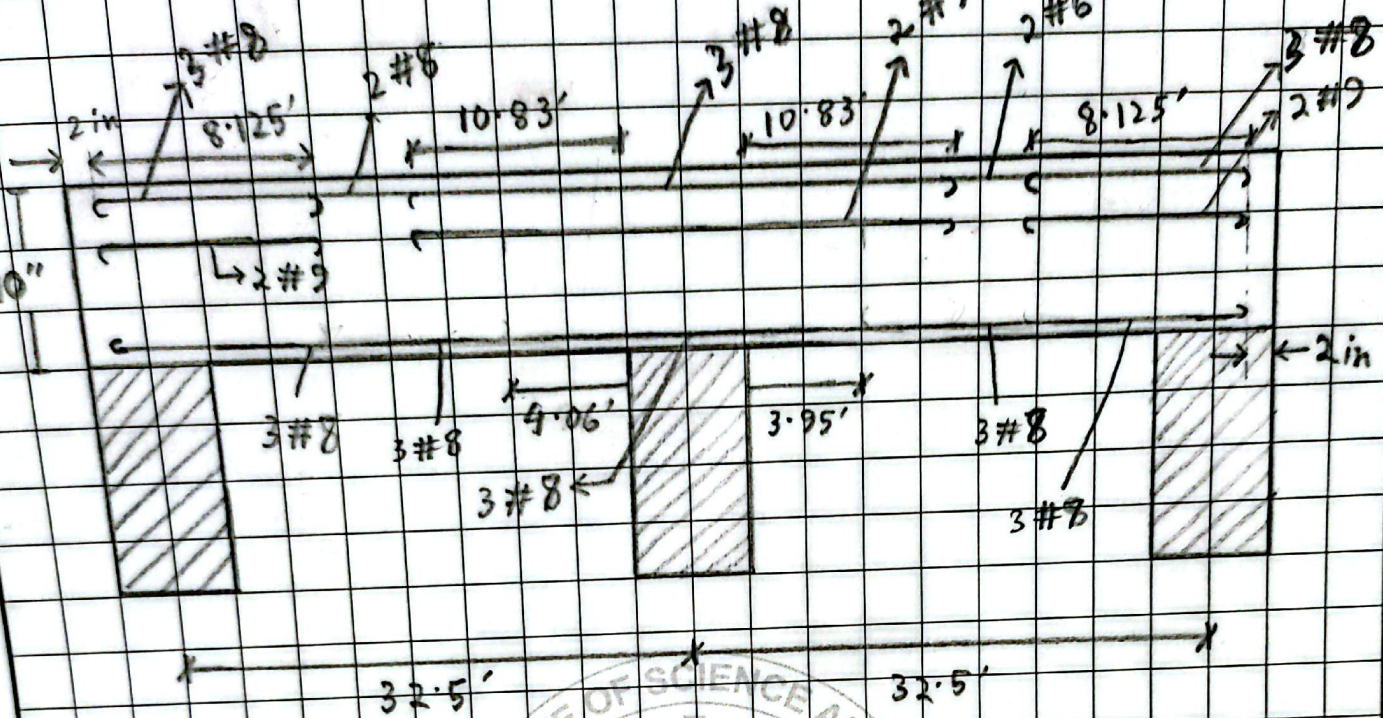






Cross sectional view

Student No : _____



Cross sectional view for flexural reinforcement

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY
BANGLADESH
TECHNOLOGY FOR ADVANCEMENT

Student No :_____

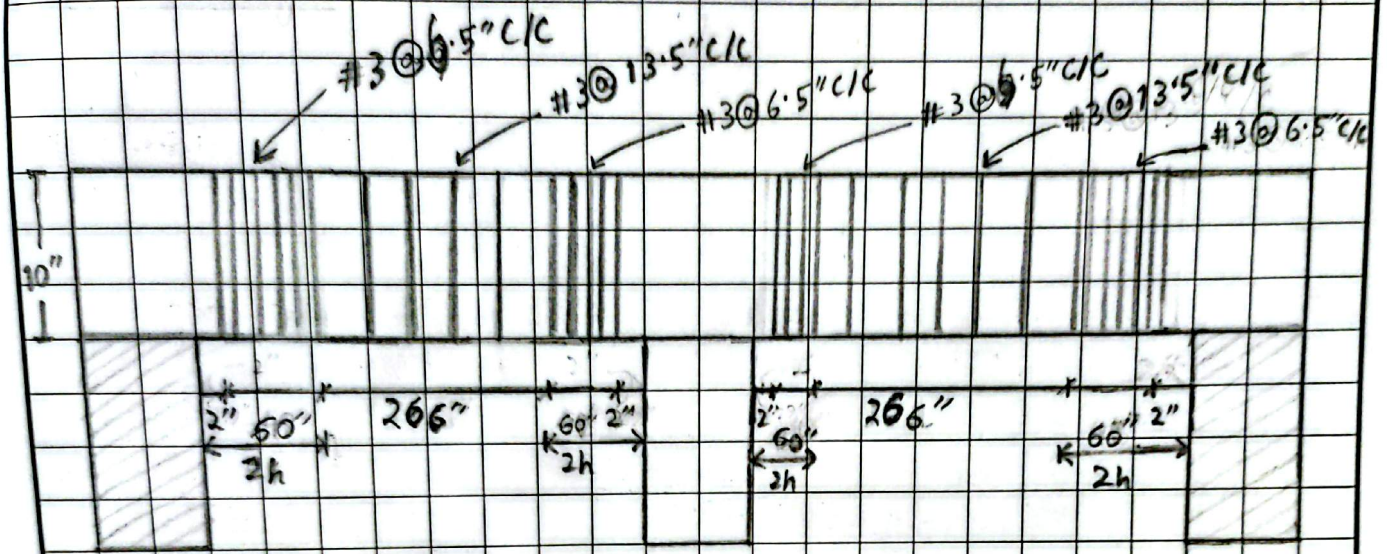


Fig.: Cross sectional view for shear Reinforcement

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY
MIST
BANGLADESH
TECHNOLOGY FOR ADVANCEMENT