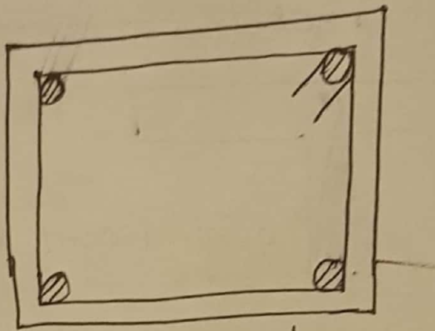
Question No:- 1

①

Name:- Mulhaar
ID :- 7789
Section:- A
Assignment: PRCDI.

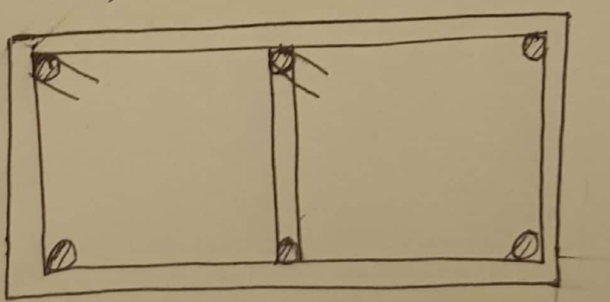
Types of Stirrups:-

1. Two legged Stirrups:- Two legged stirrups are used when width of web is less than the respective depth.



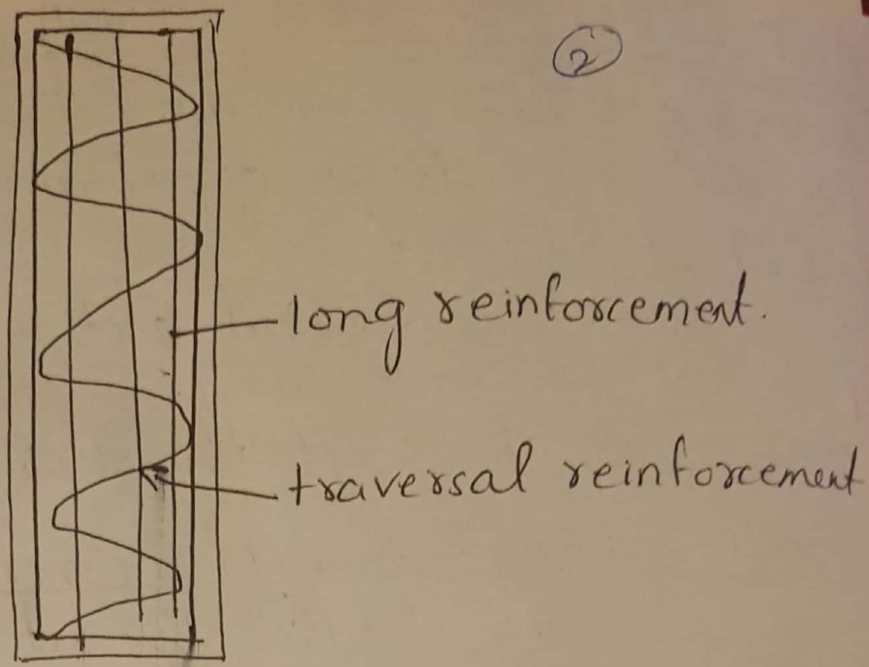
Two Legged.

2. Four Legged Stirrup:- When width of web is greater than the depth of web, we provide 4 legged stirrup.



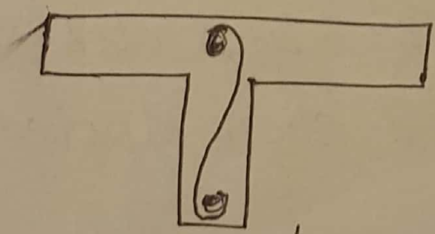
4 legged stirrups.

3. Helical Stirrups:- it is used in pile columns and also for the pile foundation the stirrups can Used can be either helical or circular.



4. Single legged Stirrup:-

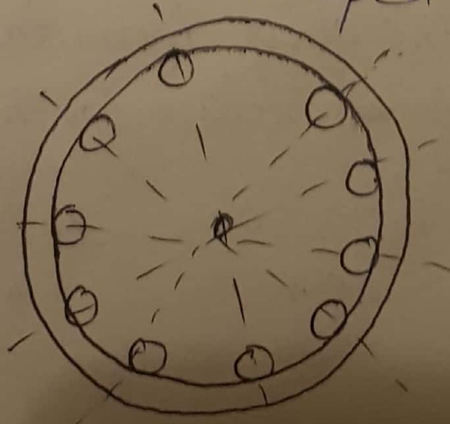
The single legged stirrup have rarely been used because they are mostly used when binding only two rods.



single legged stirrup.

5. Circular Stirrups:-

These are used when the column is round shaped.



circular stirrup.

ACI Codes For Shear Design Of A Beam. (3)

According to ACI-318; following are the formulas used for the shear design of a beam.

1. Critical Section:-

Critical section occurs at 45° & is at distance (d)" from the face of support which is equal to effective depth.

2. Shear Strength Capacity of Concrete is.

$$V_c = 2 \times \sqrt{f_c'} \times b_w \times d$$

3. Minimum Web Reinforcement:-

If $V_u \leq \phi V_c$, then theoritically no web reinforcement is required. However, ACI code require provision of atleast a minimum area of web reinforcement equal to;

$\phi = 0.75 \longrightarrow$ For shear design.

(∵ V_u = Total factored shear applied at again section).

=> For Minimum Reinforcement Area:-.

$$A_{vmin} = \frac{0.75 \times \sqrt{f_c'} \times b_w \times S}{f_y} \quad \text{or} \quad \frac{50 \times b_w \times S}{f_y}$$

[Higher value is selected]

By interchanging the above formulas, we can obtain the formula for maximum spacing.

$$S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w} \quad \text{or} \quad \frac{A_v \times f_y}{50 \times b_w} \rightarrow$$

[Lesser value is selected].

4- No web-reinforcement is required if. (4)

$$V_u < \frac{1}{2}\phi V_c$$

=> Between critical section "V_u" and "ϕV_c" spacing b/w web reinforcement can be find by;

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

5- If $V_s \leq 4 \times \sqrt{f_c'} \times b_w \times d$, then maximum spacing for stirrups will be the smallest of the following:

1- 24"
2- $d/2$
3- $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w}$
4- $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

=> If $V_s > 4 \times \sqrt{f_c'} \times b_w \times d$

↓

max. spacing will be halved.

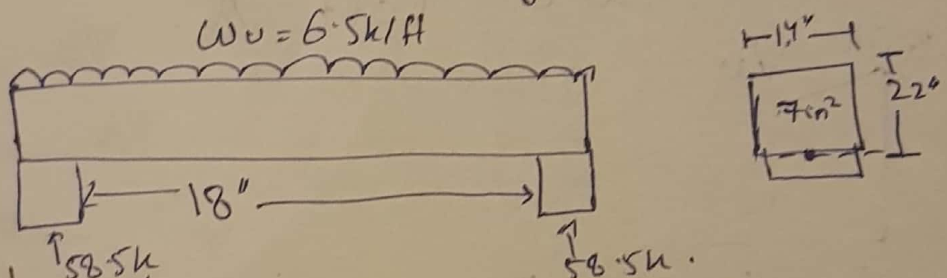
=> If $V_s > 8 \times \sqrt{f_c'} \times b_w \times d$.

Then either increase cross-sectional dimensions or increase f_c'.

Question :- 2

Solution :-

Breadth of web (b_w) = 14"
effective depth d = 22"
Lateral load, W_u = 6.5 k/ft.
Span = 18'
Steel Area A_s = 7 in^2
f_c' = 4 ksi
f_y = 60 ksi

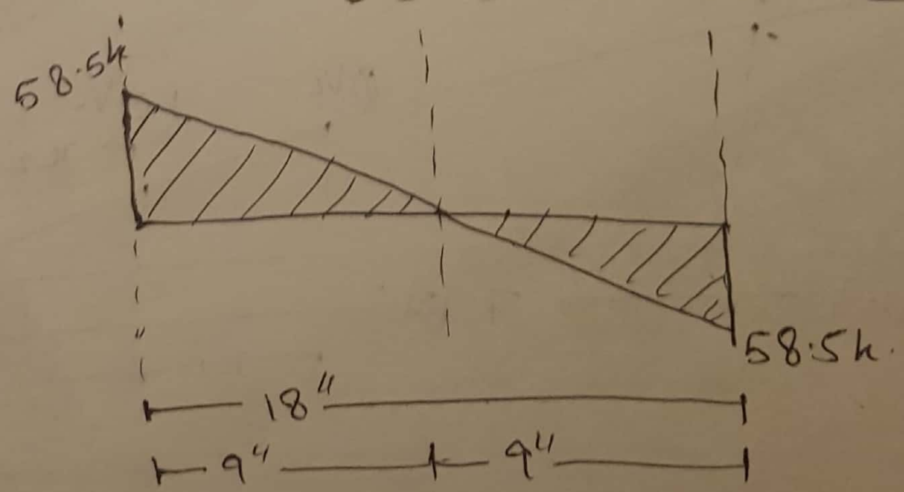


Step No :- 1 :- Reactions on Supports.

Finding values of R_1 & R_2

Total load = 6.5×18 = $\frac{117}{2}$ = 58.5 kips.

Step No :- 2 Draw Shear Force. Diagram.



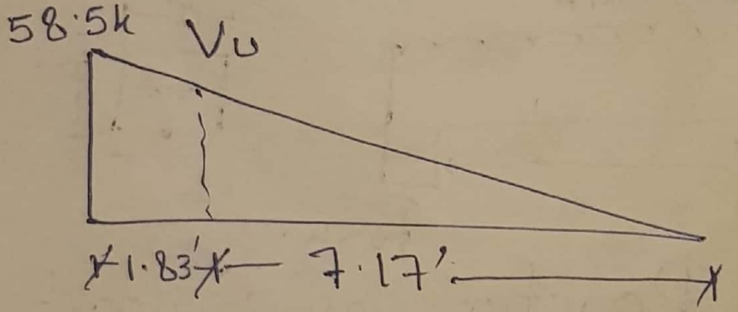
Step No:- 3 Now we will select one triangle and we will find no. of stirrups for it & then according to that we will place it in 2nd triangle as well.

Finding value of Critical Shear 'V_u':-

Critical shear is located at a distance 'd' from face of support.

Sind (d) effective depth = 22" = 1.83'

=> We have taken left Δ.



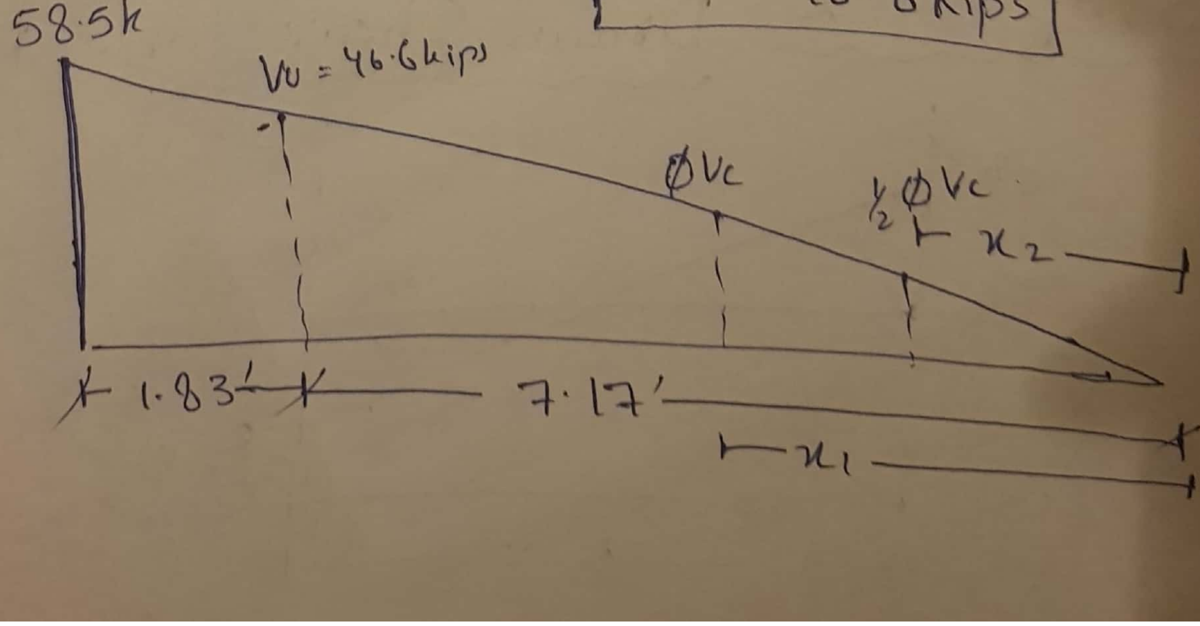
From similar Δ's

$$\frac{58.5}{9} = \frac{V_u}{7.17}$$

$$9V_u = 58.5 \times 7.17$$

$$V_u = \frac{419.44}{9}$$

$$\boxed{V_u = 46.6 \text{ Kips}}$$



Step 4:- Finding values of ϕV_c & $\frac{1}{2} V_c$ & also its distances from zero shear to right side.

As $\boxed{V_c = 2 \times \sqrt{f_c'} \times b_w \times d}$

~~Vc = 2~~

So; $\phi V_c = \phi\, 2 \times \sqrt{f_c'} \times b_w \times d$.

$= 0.75 \times 2 \times \sqrt{4000} \times 14'' \times 22$

$= 29219$ pounds

$= 29.21$ Kips.

→ Finding location of ϕV_c by similarity of Δs

$$\frac{58.5}{9} = \frac{\phi V_c}{x_1}$$

$$58.5 x_1 = 9 \times \phi V_c$$

$$x_1 = \frac{9 \times 29.21}{58.5}$$

$$\boxed{x_1 = 4.49'}$$

↳ Finding Location of $\frac{1}{2}\phi V_c$ by Δ's similarity;

$$\frac{1}{2}\phi V_c = \frac{1}{2}(29.21)$$

$$\frac{1}{2}\phi V_c = 14.60 \text{ kips.}$$

$$\frac{58.5}{9} = \frac{14.60}{x_2}$$

$$x_2 = \frac{9 \times 14.60}{58.5} \rightarrow \boxed{x_2 = 2.24'}$$

Step No:-5 Finding 'ϕV_s'. (8)

To find the capacity of stirrups as to how much shear force they will be able to resist.

$$V_u = \phi V_s + \phi V_c$$

$$46.6\,kips = \phi V_s + 29.21$$

$$\phi V_s = 46.6 - 29.21$$

$$\boxed{\phi V_s = 17.39\,Kips}$$

Step No:-6:- Checking the cross-section of beam to know if it can resist the shear force.

$$\phi \times 8 \times \sqrt{f_c'} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 14'' \times 22''}{1000}$$

$$= 116.8\,kips.$$

Since

$$\phi 8 \sqrt{f_c'} \times b_w \times d > \phi V_s$$

so, section is adequate and it can resist shear.

Step No:-7 Check Maximum stirrup spacing b/w ϕV_c & $\frac{1}{2}\phi V_c$.

$$\phi 4 \sqrt{f_c'} \times b_w \times d = 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22$$

$$= 58438\,lb$$

$$= 58.43\,kips.$$

Since values is more than ϕV_c we use following 4 conditions for spacing.

1. $S_{max} = \boxed{24''}$ 2. $d/2 = 22/2 \boxed{= 11''}$

3. $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w}$

Since we are using bar #3 stirrups

$dia = 3/8 = 0.375''$

$A = \dfrac{\pi d^2}{4} = 0.11 in^2$

$A_v = 2 \times 0.11$

$\boxed{A_v = 0.22}$

$= \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14} = \cancel{1.98'} = \boxed{19.8''}$

4. $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w} = \dfrac{0.22 \times 60,000}{50 \times 14}$

$\boxed{S_{max} = 18.85''}$

Selecting least value for spacing $= 11''$ C/C.

$\boxed{S_{max} = 11'' C/C}$

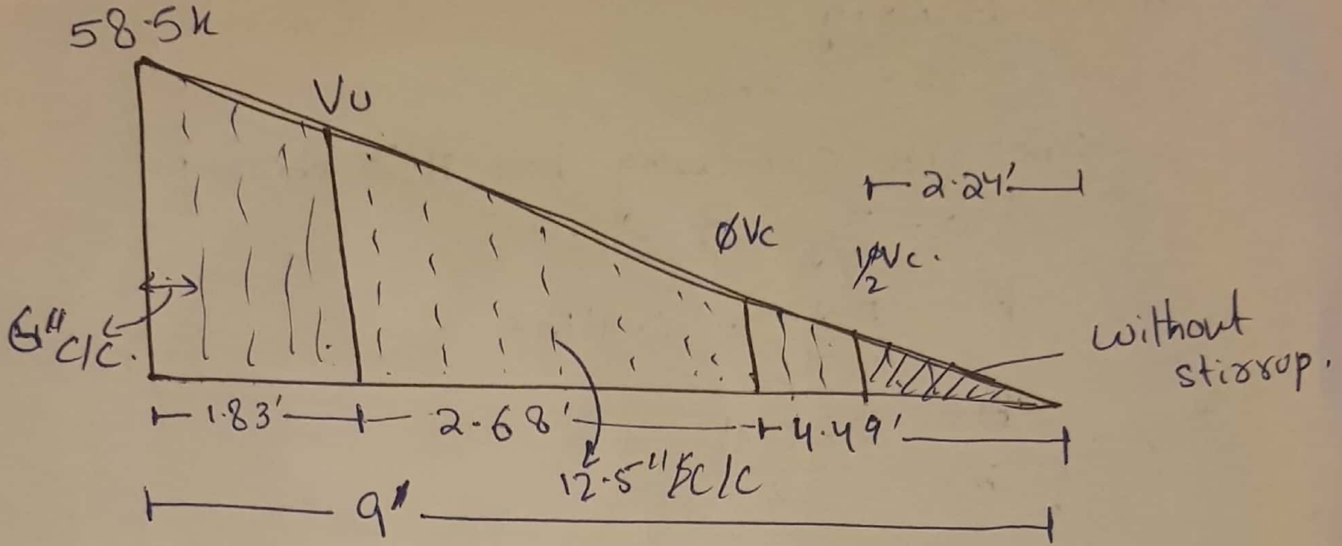
Step No:-8 Now finding stirrup spacing for critical section i.e b/w V_u & ϕV_c.

Formula;

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times (0.11 \times 2) \times 60 \times 22}{46.6 - 29.21}$$

$S = 12.52'' \approx 12.5''$ C/C.

Step 9:- Final Sketch:-



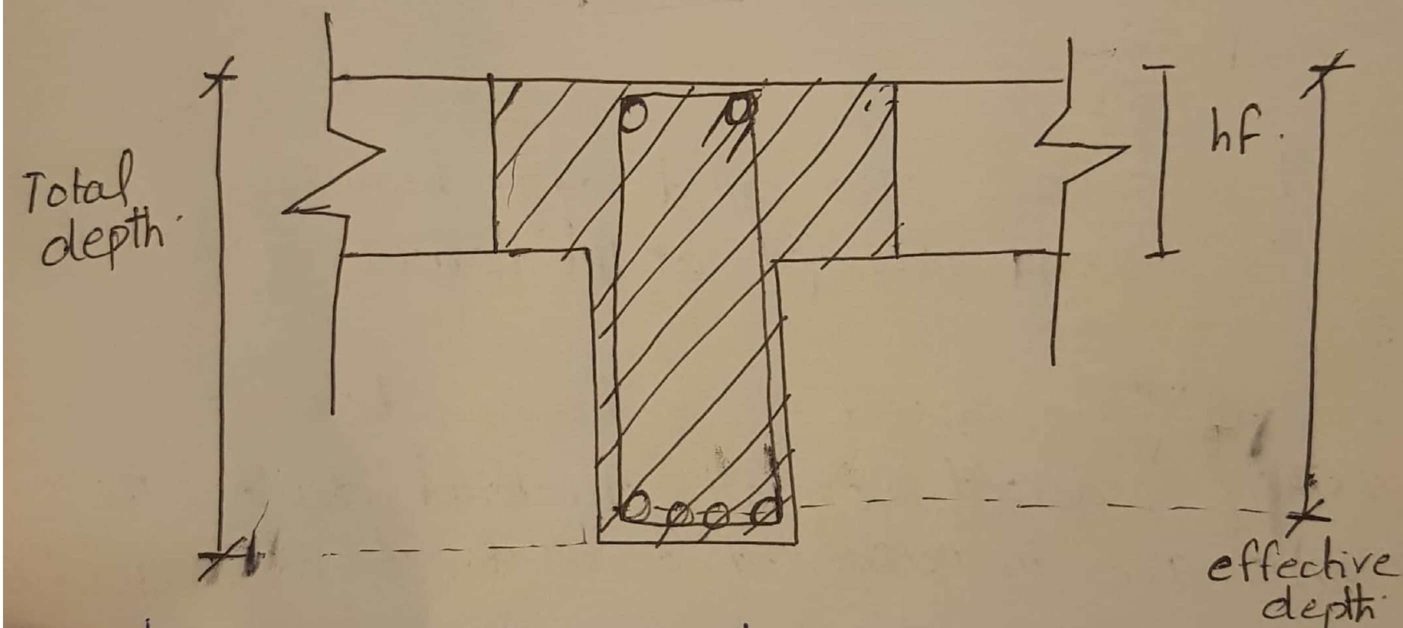
$$\boxed{\frac{12.5}{2} = 6.25 \approx 6"}$$

Question No:- 3

Define both the T-beam and L-beam with the help of diagram. Also, explain flexural analysis of T-beam.

T- beam:-

↳ In most of the required concrete structures, concrete slabs are caste monolithically with the slab. So, in this case the beam that act as an intelmediate beam are called T-beams.



=> because of their T-shape, these beams are called are called T-beams.

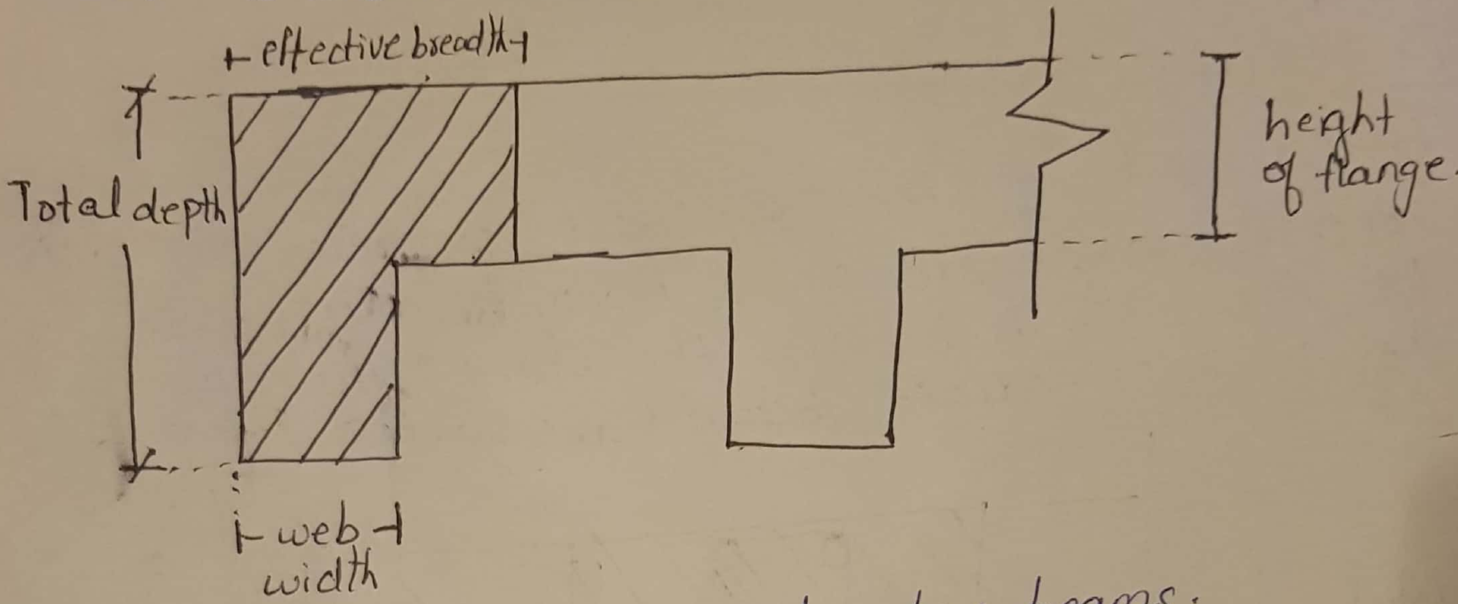
=> It is provided at the centre of the slab to resist the loads.

=> The upper most area of the beam attached to the slab is called flange.

=> The bottom rectangular portion of the beam is called web of the beam.

L-Beam:-

↳ L-shaped structure that is in contact with the slab and present at the cornor of the floor is called L-beam.



=> L-beams are also called edge beams.

=> It is always provided at the cornor of the slab.

=> L-Beam are typical floor beams because of their reduced overall structural depth, the beams are in prestressed or reinforced concrete.

Flexural Analysis of T-beam:-

Flexural analysis of T-beam consists of the following steps:-

1. For finding the ultimate Factored moment we use the following formula.

$$M_U = \frac{W_U \times L^2}{8}$$

∴ (W_U = Total factored load
L = Total span of the beam)

2. Effective width (b_e) for T-beam is calculated as;

1. $16(h_f) + b_w$
2. C/C distance
3. $\text{span}/4$
4. $\frac{CTS}{2} + b_w$

- We select the least value from above formulas
- If C/C distance is given, then there is no of "$\frac{CTS}{2} + b_w$".

3. Checking Whether Rectangular or T-beam Analysis is required;

i. If $a > h_f$ → special analysis is required.
ii. If $a < h_f$ → Rectangular beam analysis is required,

where
(a = Depth of compression block
h_f = Height of flange).

4. For finding Area of Steel, We have to use;

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

(ϕ = Strength Reduction factor.
d = effective depth.
a = compression block depth
b_w = web width of beam)

Where;

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_w}$$

5. For Checking the Range of Reinforcement Ratio

$$\rho_{max} = 0.85 \times \beta \times \frac{f_c'}{f_y}\left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}\right)$$

$$\rho_{min} = \frac{200}{f_y}$$

$$\rho = \frac{A_{st}}{b \times d}$$

6. Formula for finding No. of bars :

$$\text{No. of bars} = \frac{\text{Area of steel}}{\text{single bar area}}.$$

7. Formula for finding Minimum width of bars :

$b_{min} = 2(\text{clear cover}) + 2(\text{dia of stirrup}) + \text{No. of bars}(\text{dia of bars}) + \text{spacing b/w bars}.$

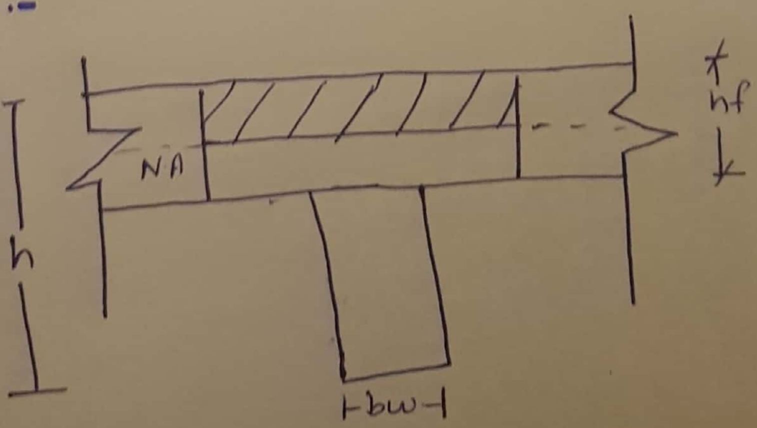
8. Design Moment is given by :

$$M_d = \phi \times f_y \times A_{st} \times (d - a/2) \rightarrow \text{if } a < h_f$$

$$M_d = \phi \times [A_s \times f_y \times (d - h_f/2) + (A_s - A_{st}) + f_y \times (d - a/2)] \rightarrow \text{if } a > h_f.$$

Question 4# :-

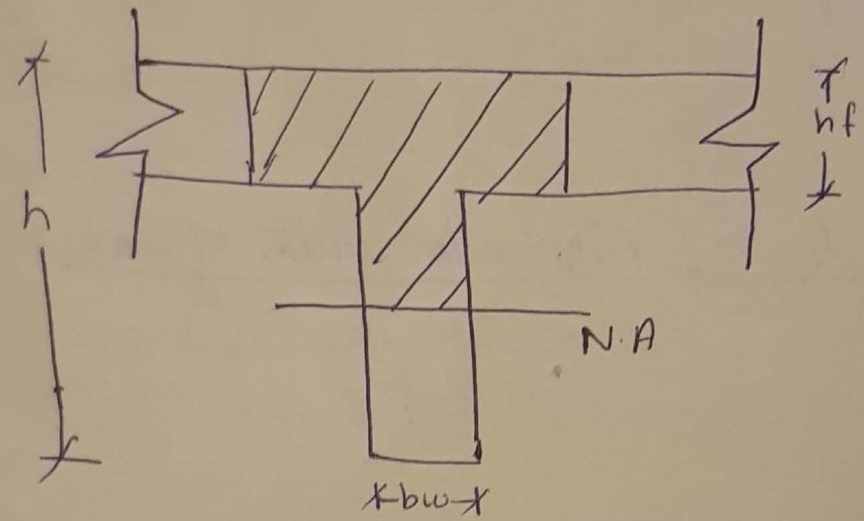
Case 1 :-



From the fig $a < h_f$ so this case, Rectangular beam analysis is required so, the design (15) moment formula will be;

$$M_d = \phi \times f_y \times A_{st} \times (d - a/2).$$

Case - II :-



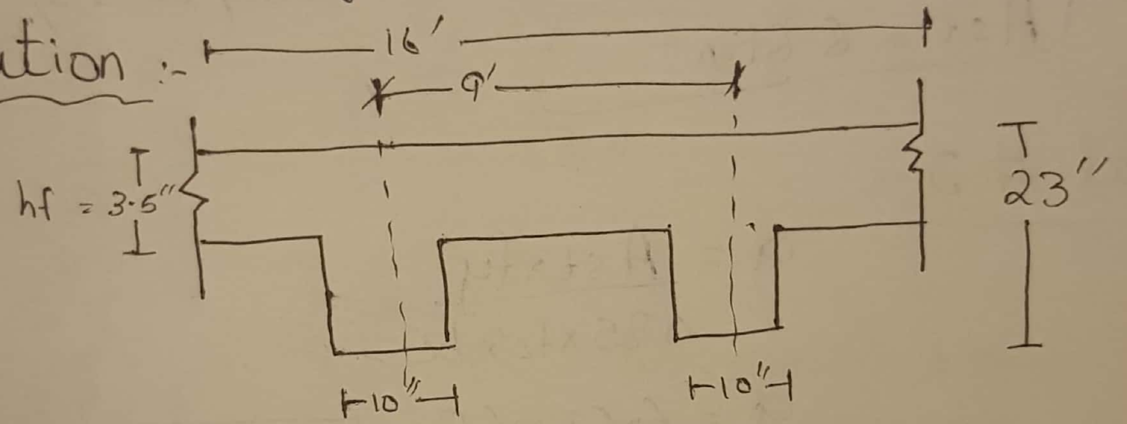
From the fig $a > h_f$ So, in this, special beam analysis i.e T-beam analysis is required.
So, the required design moment will be

$$M_d = \phi \times [A_s \times f_y \times (d - \frac{h_f}{2}) + (A_s - A_{st}) + f_y \times (d - a/2)]$$

Question No:- 5.

$h_f = 3.5''$
$C/C = 9'$
Span of beam = 16'
web width (b_w) = 10"
effective depth (d) = 18"
height (h) = 23".
M_u = 5800 kip-inch
f_c' = 3ksi
f_y = 60ksi

Solution :-



Step No:- 1.

Ultimate factored moment is already given M_u = 5800kip-inch.

Step 2:-

Calculate effective width 'be'. For T-beam.

1. $16 \times h_f + b_w = 16(3.5) + 10 = 66''$
2. C/C distance = $9'' \times 12 = 108''$
3. Span/4 $= \frac{16}{4} \times 12'' = 48''$

Since C/C distance is given so there is no need for applying condition 4.

Selecting least value $\boxed{b_e = 48''}$.

Step #3 :- To check whether beam is Rectangular or T-beam.

Trial #1 :-

Let compression block $a = h_f = 3.5''$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - 3.5/2)}$$

$$\boxed{A_{st} = 6.61 \, in^2}$$

Trial #2 :-

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_e}$$

$$a = \frac{6.61 \times 60}{0.85 \times 3 \times 48} \quad \boxed{a = 3.2''}$$

since $a < h_f$

so Rectangular beam design.

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - \frac{3.2}{2})}$$

$$\boxed{A_{st} = 6.55 \, in^2}$$

Trial #3 :-

$a = 3.21''$

& $A_{st} = \dfrac{5800}{0.90 \times 60 \times (18 - \frac{3.21}{2})} = \boxed{6.55 \, in^2}$

So, area of steel is $6.55 \, in^2$

Step 4 #:-

Check ρ_{max} & ρ_{min}

ρ = Reinforcement Ratio i.e how much steel can be provided in the cross-section area of steel.

$$\rho_{max} = 0.85 \times \beta \times \frac{f_c'}{f_y}\left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t}\right)$$

$$\rho_{max} = 0.85 \times 0.85 \times \frac{3}{60}\left(\frac{0.003}{0.003+0.005}\right) = 0.013$$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60{,}000} = 0.003$$

$$\rho = \frac{A_{st}}{b \times d} = \frac{6.55}{10 \times 18} = 0.036$$

ρ = The steel which is originally being provided in the beam.

$$\rho_{min} < \rho < \rho_{max}$$

$$0.003 < 0.036 < 0.013$$

Since value of ρ_{max} is less than ρ, so finding A_{st} against ρ_{max}.

$$\rho_{max} = \frac{A_{st}}{b \times d} \Rightarrow A_{st} = \rho_{max}(b \times d)$$

$$\boxed{A_{st} = 2.34 \text{ in}^2}$$

(1a)

Step#5:- Finding Value of M_{U_2}:-

By formula;

$M_{U2} = \phi \times A_{st} \times f_y \times (d - a/2)$

First Finding the value of "a".

↳ $a = \dfrac{A_{st} \times f_y}{0.85 \times f_c' \times b} = \dfrac{2.43 \times 60}{0.85 \times 3 \times 10}$

$a = 5.72"$

↳ $M_{U2} = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$M_{U2} = 1986.67$ kip-inch.

As $M_{U2} < M_U$

$1986.67 < 5800.$

So, we ~~can~~ have to design the beam in such a way that it can resist more bending moment than the applied external moment

Step 6#:- Now we find Difference in moments & Area of steel.

$M_{U1} = M_U - M_{U2}$

$= 5800 - 1986.67$

$\boxed{M_{U1} = 3813.33 \text{ kip-inch.}}$

By formula;

$A_{st} = \dfrac{M_U}{\phi \times f_y \times (d-d')} = \dfrac{3813.33}{0.90 \times 60 \times (18 - 2.5)}$

$\boxed{A_{st} = 4.56 in^2.}$

20

Step 7 #:- Finding Total Area of Steel.

$A_s = A_{st} + A'_{st}$

$= 2.43 + 4.56$

$\boxed{A_s = 6.99 in^2}$

Step 8 #:- Selection of Bar:-

In tension Zone :-

Let us use # 8 bar

dia $= (8/8) = 1''$, Area $= \frac{\pi(1)^2}{4} = 0.785 in^2$

By formula

No. of bars $= \frac{\text{Area of steel}}{\text{Area of single bar}} = \frac{6.99}{0.785}$

$= 8.9 \cong 9$

So, 9 # 8 bars.

In Compression Zone :-

Let we use # 7 bars

dia $= (7/8)''$, Area $= \frac{\pi}{4}(7/8)^2$

Area $= 0.60 in^2$.

By formula ;

No. of bars $= \frac{\text{Area of steel}}{\text{Area of single bar}} = \frac{4.56}{0.601}$

$= 7.5 \cong 8$.

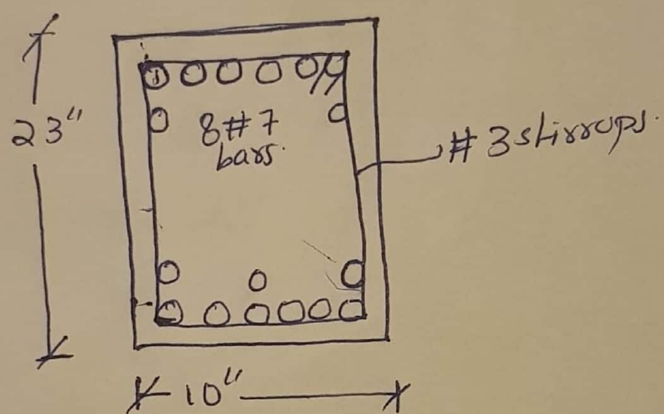
So 8 # 7 bars.

Step 9 :- Minimum width for accomodation of bars.

$$b_{min} = (2\times1.5) + (2\times 3/8) + 9(8/8) + 8(8/8)$$
$$= 20.75''$$

As $20.75'' > 10''$

So, the bars will be placed in multiple layers.



Effective depth $(d) = 23 - 1.5 + \frac{3}{8} + \frac{8}{8} + \frac{1}{2}\left(\frac{8}{8}\right) = 19.6''$

Effective cover $(d') = 1.5 + \frac{3}{8} + \frac{7}{8} + \frac{1}{2}\left(\frac{7}{8}\right) = 3.18''$

Step 10 # :- Finding Design Moment.

$$M_d = \phi\left[A_s' \times f_y \times (d-d') + (A_{st} - A_{st}') \times f_y \times (d - a/2)\right]$$

First $a = \dfrac{(A_s - A_{st}') \times f_y}{0.85 \times f_c' \times b} = \dfrac{(9\times0.785 - 8\times0.601)\times60}{0.85\times3\times10}$

$$\boxed{a = 5.31''}$$

$\Rightarrow M_d = 0.90\left[(8\times0.601)\times60\times(19.6 - 3.18) + (9\times0.785 - 8\times0.601)\times60\times\left(19.6 - \frac{5.31}{2}\right)\right]$

$M_d = 6328.38$

As $6328.38 > 5800 \rightarrow$ So, design is Ok!

Question No:- 6 # :

Solution:-

Breadth (b) = 14"
Height (h) = 26"
Concrete compression strength (f_c') = 4ksi.
Steel Tensile Strength (f_y) = 60ksi.
Ultimate Factored Moment (M_u) = 6000kip-inch.
Effective depth of beam (d) = 22".

Assume Effective cover (d') = 2.5"

Step # 1:- (Reinforcement Ratio)

By formula,

$$\rho_{max} = 0.85 \times \beta \times \frac{f_c'}{f_y} \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}\right)$$

$$= 0.85 \times 0.85 \times \frac{4}{60} \left(\frac{0.003}{0.003 + 0.005}\right)$$

$$\boxed{\rho_{max} = 0.0180}$$

Step # 2:- Area of Steel.

As we know that;

$$\rho_{max} = \frac{A_{st}}{b \times d} \Rightarrow A_{st} = \rho_{max} \times (b \times d).$$

$$A_{st} = 0.0180 \times (14 \times 22)$$

$$\boxed{A_{st} = 5.54 in^2}$$

Step 3 # Design Moment.

By using formula.

$Mu_2 = \phi \times Ast \times fy \times (d - a/2)$.

$\hookrightarrow a = \dfrac{Ast \times fy}{0.85 \times fc' \times b} = \dfrac{5.54 \times 60}{0.85 \times 4 \times 14} = 6.98''$

$\boxed{a = 6.98''}$

So,

$Mu_2 = 0.90 \times 5.54 \times 60 \left(22 - \dfrac{6.98}{2}\right)$

$= 5537.4$ Kip-inch.

As;

$5537.4 < 6000$.

So, we have to design a section as doubly reinforced.

Step # 4:- (Difference In Moments).

$Mu_1 = Mu - Mu_2$

$= 6000 - 5537.4$

$\boxed{Mu_1 = 462.6 \text{ kip-inches.}}$

Step # 5:- Area of Steel.

$Mu_1 = \phi \times A'st \times fy \times (d - d')$

Compression zone area;

$A'st = \dfrac{Mu_1}{\phi \times fy \times (d - d')} = \dfrac{462.6}{0.90 \times 60 \times (22 - 2.5)}$

$\boxed{A'st = 0.44 \text{ in}^2}$

Step # 6 :- Total Steel Area

$A_s = A_{st} + A_{st}'$
$= 5.54 + 0.44$

$\boxed{A_s = 5.98 in^2}$

Step # 7 :- Selection of Bars & No. of bars.

1. Steel in Tension Zone :-

We use #7 bars.

dia $= (7/8)'' = 0.875''$, Area $= \frac{\pi}{4}(0.875)^2$

$\boxed{A = 0.601 in^2}$

So;

No. of bars $= \frac{A_s}{\text{Area of single bar}}$

$= \frac{5.98}{0.601} = 9.9 \approx 10$ bars.

So, 10 #7 bars.

2. Steel in Compression Zone :-

We use #5 bars

dia $= (5/8)'' = 0.625''$, Area $= \frac{\pi}{4}(0.625)^2$

$\boxed{A = 0.306 in^2}$

No. of bars $= \frac{A_{st}'}{\text{Area of single bar}}$

$= \frac{0.44}{0.306} = 1.43 \approx 2$ bars.

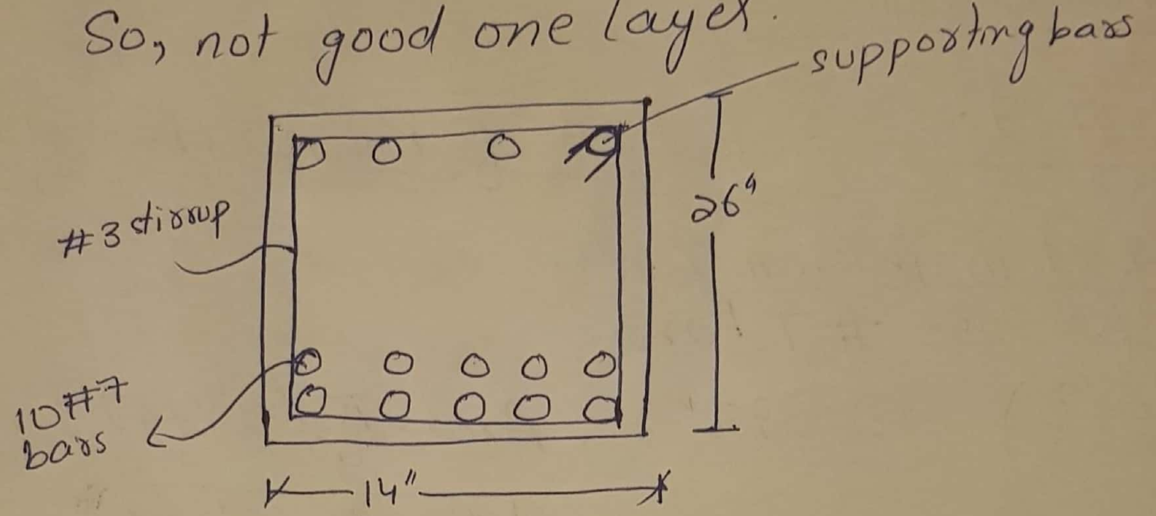
So, 2 #5 bars.

Step#8:- Minimum Width of Beam. 25

$b_{min} = 2(1.5) + 2(3/8) + 10(7/8) + 9(7/8)$

$\boxed{b_{min} = 20.37 > 14"}$

So, not good one layer.



Now;

=> effective depth $(d) = 26 - 1.5 - 3/8 - 7/8 - 1/2(7/8)$

$= 22.82"$

=> Effective cover $(d') = 1.5 + \frac{3}{8} + 1/2(5/8)$

$= 2.18"$

Step 9 #:- Design Moment

$Md = \phi \times [A'_{st} \times fy \times (d-d') + (A_{st} - A'_{st}) \times fy \times (d - a/2)]$

$a = \frac{(A_{st} - A'_{st}) \times fy}{0.85 \times f'_c \times b}$

$= \frac{(10 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14} = 6.80"$

$Md = 0.90[(2 \times 0.306) \times 60 \times (22.82 - 2.18) + (10 \times 0.601 - 2 \times 0.30$
$\times 60 \times (22.82 - 6.80/2)]$

$Md = 7047.6$ kip-inch

$= 7047.6 > 6000$

Design is Ok!

Scanned with CamScanner