NAME = QASIM ZEB

ID NO = 7823

SECTION = A

SUBMITTED TO = ENGR FAWAD KHAN

SEMESTER = 6TH

QUESTION # 1

Explain in detail types of stirrups with figures and also explain ACI codes for shear design.

STIRRUPS:-

Stirrups are closed loop bars tied at Regular intervals in beam Reinforcement to hold the bars in position.

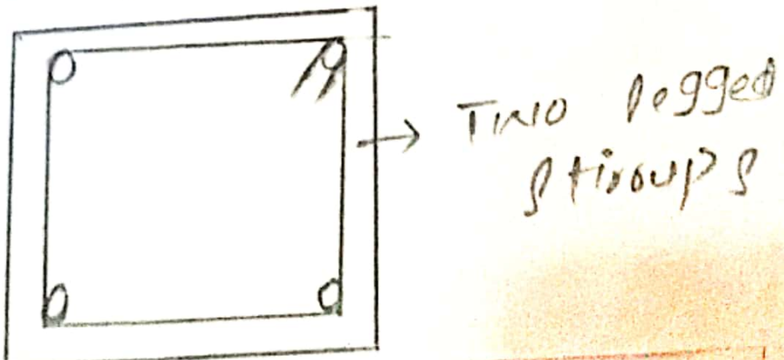
TYPES OF STIRRUPS:-

1)- Single legged Stirrups:-

The single legged stirrups have Rarely been used because they are mostly used when binding only two Rods.

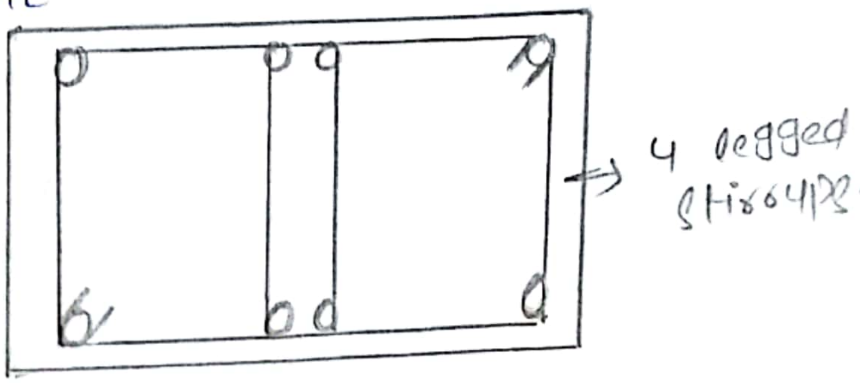
Two legged Stirrups:-

It is the mostly commonly and widely used stirrups. Minimum 4 bars are Required to providing this stirrups.

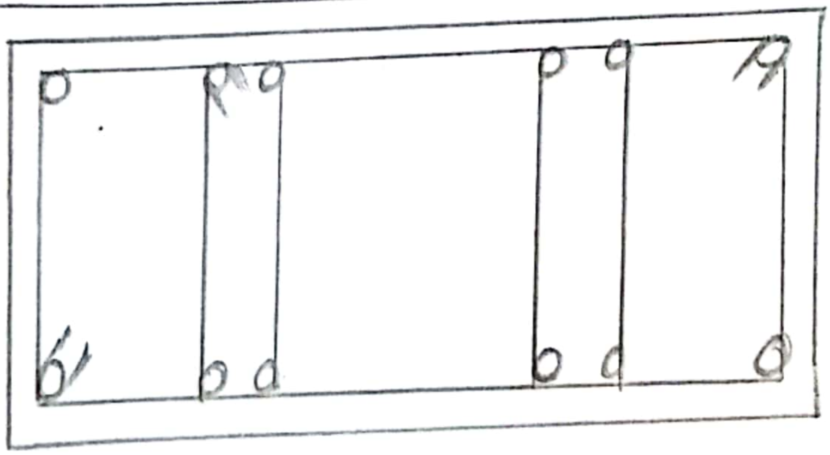


Four legged Stirrups:-

These stirroups are used in case of Web Reinforcement.



Six legged Stirrups:-



ACI CODES FOR SHEAR DESIGN OF A BEAM:-

According ACI-318 following are formula used for the shear design of a beam.

Critical Section:-

Critical Section occure at 45° and is at distance from the face of support which is equal to effective depth.

Shear strenght capacity of concrete is:-

$$Vc = 2 \times \sqrt{f'c} \times bw \times d$$

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,

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

(∵ V_U = total factored shear applied at a given section)

→ For Minimum Reinforced Area:

$$A_{V\,Min} = 0.75 \times \frac{\sqrt{f'_c} \times b_w \times S}{f_y} \quad \text{OR}$$

$$\frac{50 \times b_w \times S}{f_y} \rightarrow \text{(Higher value is selected)}$$

By interchainging the above formulas, we can obtain the formula for Maximum spacing.

$$S_{max} = \frac{A_V \times f_y}{0.75 \times \sqrt{f'_c} \times b_w} \quad \text{OR}$$

$$\frac{A_V \times f_y}{50 \times b_w} \quad \text{(lesser value is selected.)}$$

⇒ No Web Reinforcement is Required if $Vu < \frac{1}{2}\phi Vc$

Between critical section "Vu" and "ϕVc".
Spacing b/w web Reinforcement can be find by,

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

⇒ If $Vs \leq 4 \times \sqrt{f'c} \times bw \times d$:-
than Max spacing for stirrups is will be the smallest of the following.

1- 24"
2- $d/2$
3- $Smax = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$
4- $Smax = \frac{Av \times fy}{50 \times bw}$

⇒ If $Vs > 4 \times \sqrt{f'c} \times bw \times d$

↓

Max spacing will be halved

⇒ If $Vs > 8 \times \sqrt{f'c} \times bw \times d$

Then either increase cross sectional dimension or increase $f'c$.

QUESTION = 2

A Simply supported Rectangular beam 14" wide having an effective depth of 22' to carry a lateral load of 6.5 K/ft on a 18' simple span. It is Reinforced at 7 in². of tensile steel area. if $f'c = 4$ Ksi and $fy = 60$ ksi then design beam for shear.

Given Data:-

Breath of web beam $(b_w) = 14''$

Effective depth = 22'

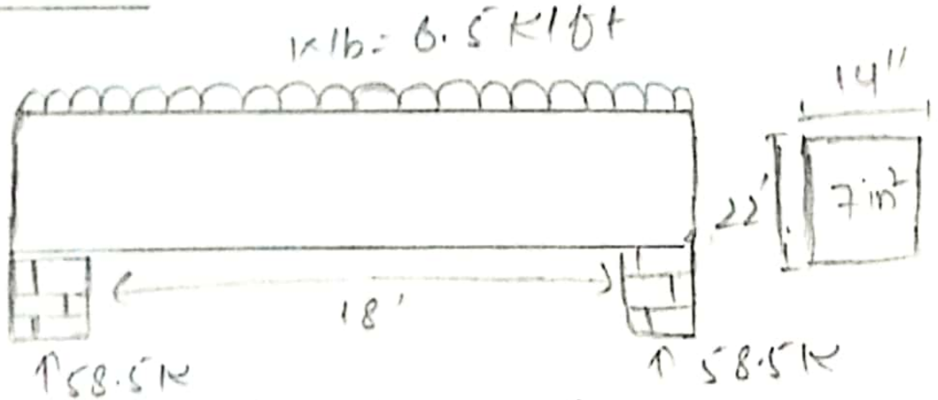
Given load = 6.5 K/ft

Steel area = $7 in^2$

$f'c = 4$ Ksi

$fy = 60$ Ksi

Solution:-



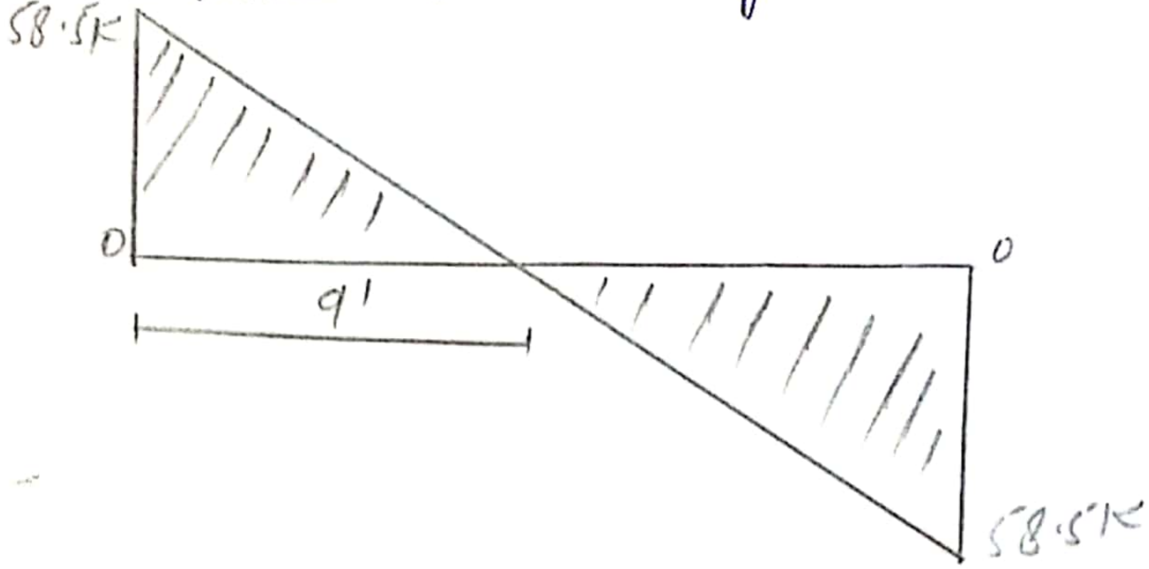
Step 1 **Reaction on Support**

Finding the Reaction due to the applied load.

$$\text{Total load} = \frac{6.5 \times 18}{2} = 58.5 \text{ Kips}$$

Step# 2 Shear force Diagramer-

The Required shear diagram will will.



Step# 3

Finding the value of critical shear "Vu" and it's location; As we know that critical shear is located at distance (d) from the face of support

(d) = 22' = 1.83'

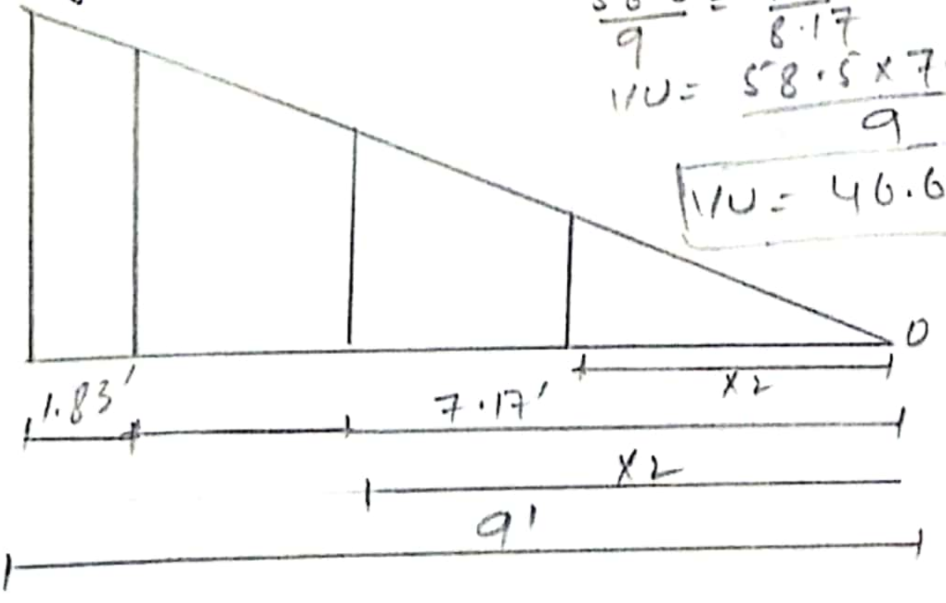
=) We will find the value of critical shear at distance (d) by use of similar triangles.

From similar triangles

$$\frac{58.5}{9} = \frac{Vu}{8.17}$$

$$Vu = \frac{58.5 \times 7.17}{9}$$

$$\boxed{Vu = 46.61 \text{Kips}}$$



Step#4

Finding the value of (ϕV_c) and $(1/2\,\phi V_c)$ and also it's distance from zero shear to R.S.

By formula;

$$\Rightarrow \phi V_c = \phi \times 2\sqrt{f'c} \times b_w \times d = 29219\text{ Lbs}$$

$$= 0.75 \times 2\sqrt{4000} \times 14 \times 22 = 29.21\text{ kips}$$

$\Rightarrow$ Location of ϕV_c by similar triangles

$$\frac{58.5}{9} = \frac{\phi V_c}{x_1} \Rightarrow \frac{58.5}{9} = \frac{29.21}{x_1}$$

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

Similarly,

$$1/2\,\phi V_c = \phi V_c/2 \Rightarrow 29.21/2 = 14.60\text{ kips}$$

location of $1/2\,\phi V_c$ will be

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

Step#5

Finding the value of ϕV_s

By formula; $V_u = \phi V_s + \phi V_c$

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

$$= 46.61 - 29.21$$

$$\boxed{\phi V_s = 17.4\text{ kips}}$$

Step# 6

check on section adequacy

By formula;

$= \phi \times 8 \times \sqrt{f'c} \times bw \times d$

$= 0.75 \times 8\sqrt{4000} \times 14 \times 22 =$ 116877 lbs

116.87 kips

As $\phi \times 8 \times \sqrt{f'c} \times bw \times d > \phi Vs$

(section is adequate)

Step# 7

check on maximum spacing for stirrups

By formula;

$= \phi \times 4 \times \sqrt{f'c} \times bw \times d$

$= 0.75 \times 4\sqrt{4000} \times 14 \times 22 =$ 58438 lbs

58.43 kips

As $\phi \times 4 \times \sqrt{f'c} \times bw \times d > \phi Vs$

so maximum will be selected from the following 4 condition.

1) $Smax = 24''$

2) $d/2 = 22/2 = 11''$

3) $Smax = \dfrac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

Here we are using #3 stirrups

dia $(3/8)'' = 0.375''$

so,

Area $= \pi/4\,(0.375)^2 = 0.11\text{ in}^2$

For 2-legged stirrups

→ Area × 2

→ $0.11 \times 2 = 0.22\text{ in}^2$

3) $$S_{max} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14} = 17.87''$$

4) $$S_{max} = \frac{A_v \times f_y}{50 \times b_w} = \frac{0.22 \times 60000}{50 \times 14} = 18.85''$$

From above least condition value of spacing for #3, 2 legged stirrups will will be selected as;

$$S_{max} = 11''$$

Step# 8

Stirrups spacing from/at critical section will be;

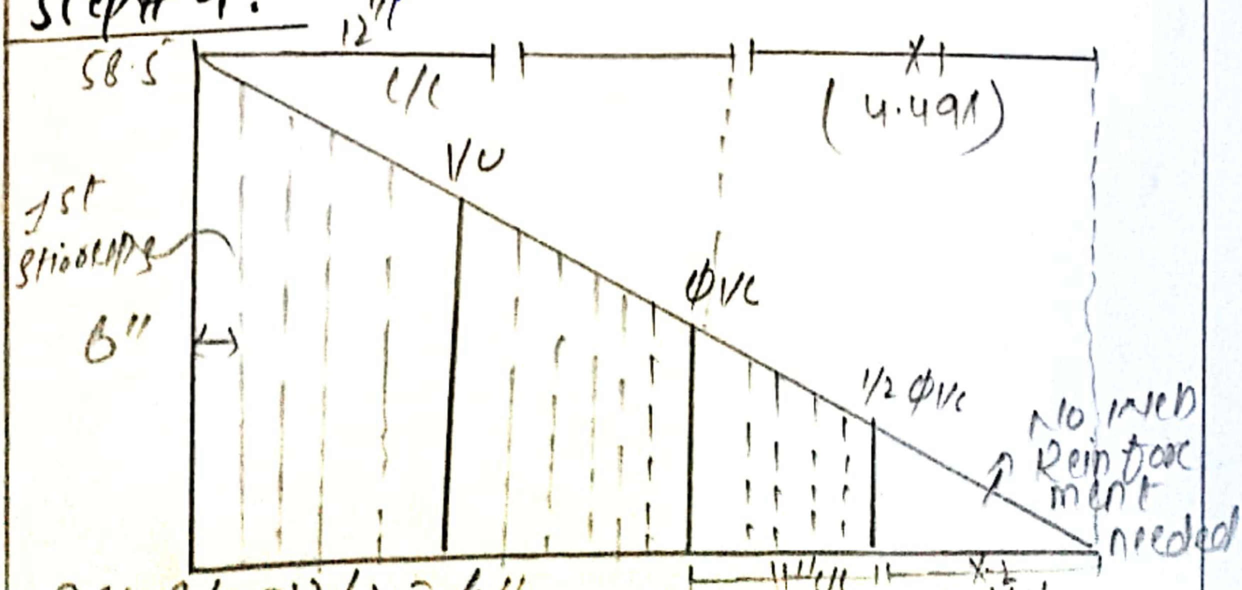
By formula;

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{46.61 - 29.21}$$

$$S = 12.5'' \approx 12''$$

$$S = 12'' \text{ c/c}$$

Step# 9:- Final sketch will be;



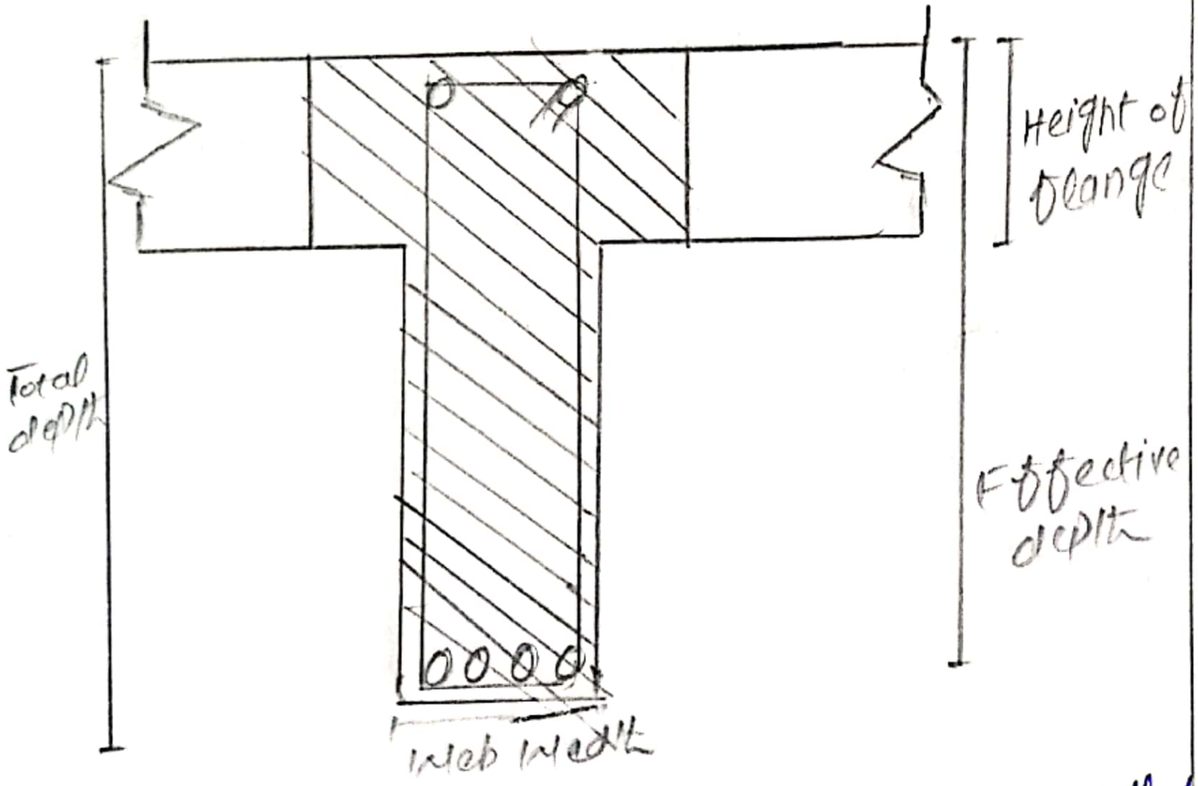
AS; $S/2 = 12/2 = 6''$

QUESTION = 3

Define both T-beam and L-beam with help of diagram. Also Expain flexural analysis and T-beam.

T-beam :

In Most of the Reinforced concrete Structure concrete slab, are cast Monolithically with the slab, so in this case the beam that act as an intermediate beam are called T-beam.



=) Because of their T-shape, these beams are called T-beam.

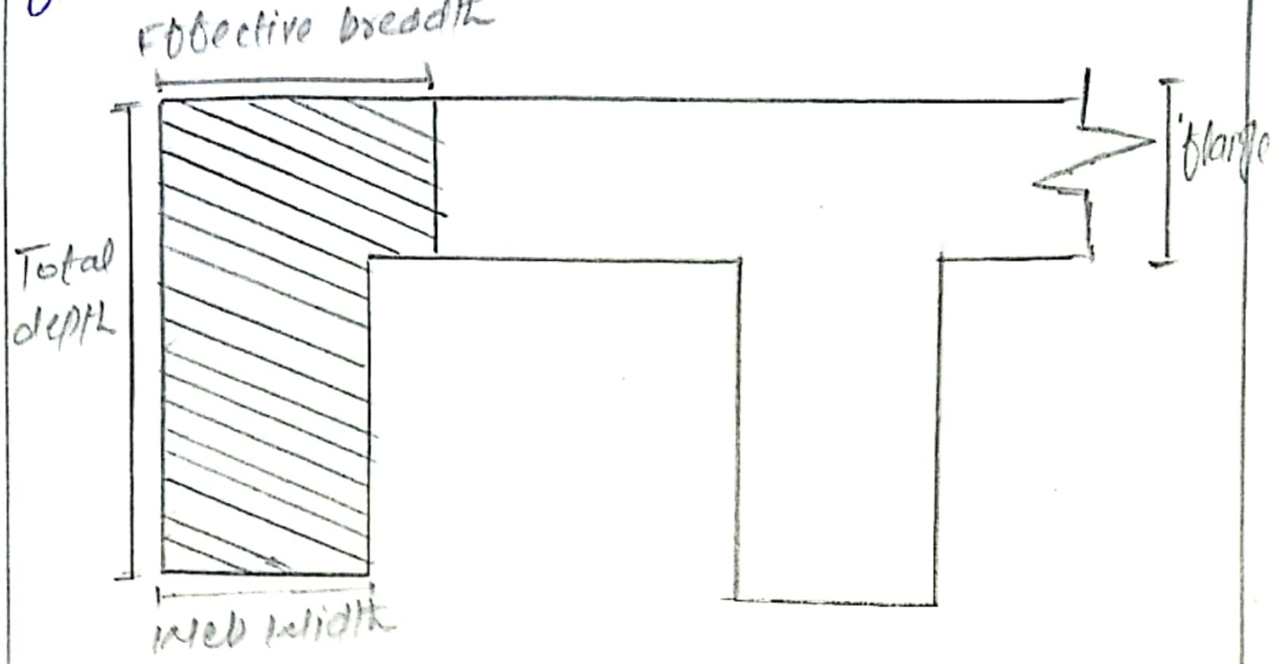
=) It is provided at the center of slab to resists the load.

=) 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 corner of the floor is called L-Beam.



=) L-Beam are also called edge beam.

=) It is always provided at corner of the slab

=) L-beams are typically floor beams because of their Reduce overall structure 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 of T-beam is calculated as

1) $16(h_f) + b_w$
2) c/c distance
3) span/4
4) $CTS/2 + b_w$

(h_f = height of flange
CTS = clear transverse span)

We have to select the least value from above formulas;

If c/c distance is given, then there is no need of $CTS/2 + b_w$.

3) Checking whether Rectangular or T-beam beam Analysis:

i) If $a > h_f$ → special Analysis is Required.
ii) If $a < h_f$ → Rectangular beam Analysis Required.

where;
(a = depth of depression block)
h_f = Height of flange

4) For Finding Area of steel, we have to use

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

where

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

ϕ = Strength Reduction factor.
d = Effective depth
a = Compression block depth
b_w = web width of beam.

5) For checking the Range of Reinforced Ratio;

$$\rho_{max} = 0.85 \times B \times \frac{f'c}{fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon y} \right)$$

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

$$\rho = \frac{Ast}{b \times d}$$

6) Formula for finding No. of bars required is;

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

7) For checking Minimum Width for bar accomodation.

bmin = 2 (clear cover) + 2 (dia of stirrups) + No. of bars (dia of bar) + spacing b/w bar

8) Design Moment is given by

$Md = \phi \times fy \times Ast \times (d - a/2) \rightarrow$ if $a < hf$

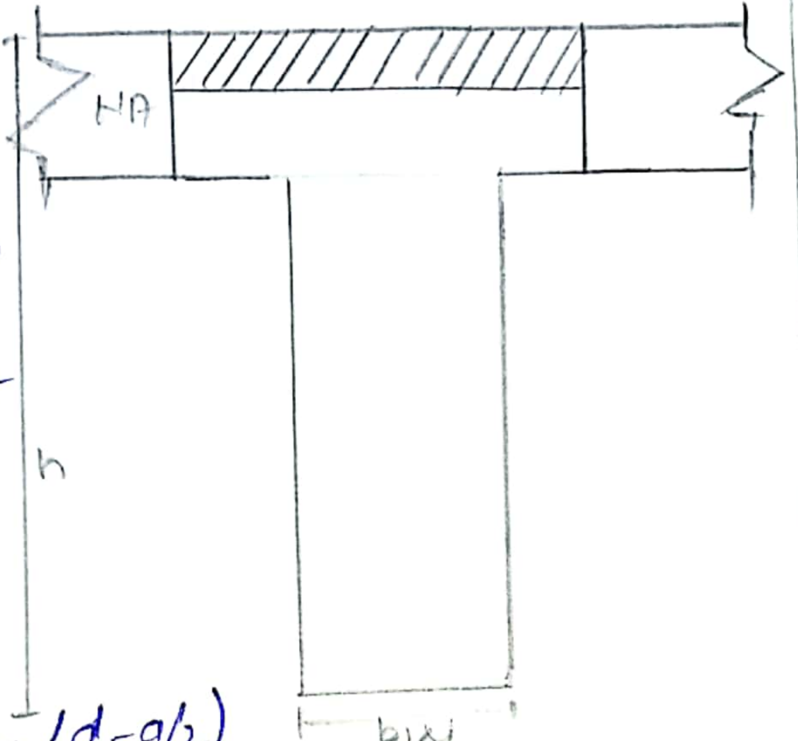
$Md = \phi \times [As \times fy \times (d - hf/2) + (As - Ast) + fy \times (d - a/2)] \rightarrow$ if $a > hf$.

QUESTION # 4

What is difference b/w case-I and case-II in the design of T-beam?

CASE-I

From the fig
$a < h_f$
So in this case
Rectangular beam
Analysis is Req
The design Moment formula will be



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

From the fig
$a > h_f$
So in the special beam analysis,
T-beam Analysis is Req
The Req design moment will be

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

QUESTION#5

GIVEN DATA:-

Height of flange (h_f) = 3.5"

c/c distance = 9'

lenght/span of the beam = 16'

Web width = (b_w) = 10"

Effective depth (d) = 18"

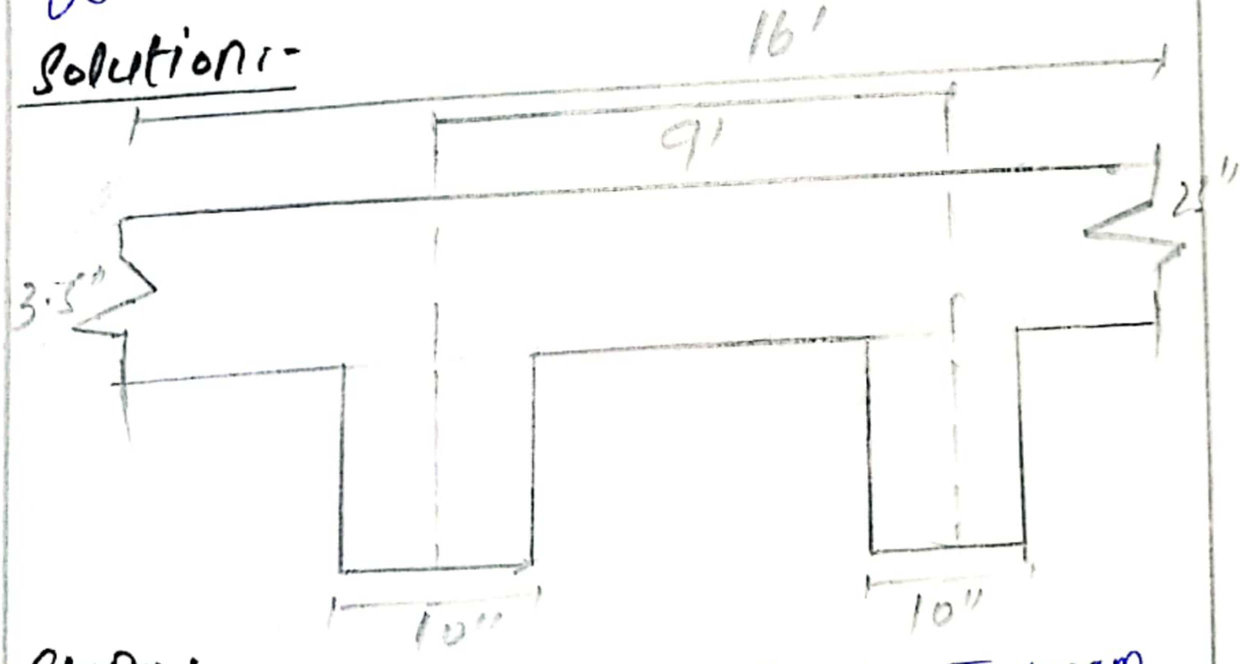
Height (h) = 23"

Total factored Moment (M_u) = 5800 Kip-inch

f'_c = 3 ksi

f_y = 60 ksi

Solution:-



Step#1

Calculate the effective width for T-beam

1) $16(h_f) + b_w = 16(3.5) + 10 = 66''$

2) c/c distance $= 9 \times 12 = 108''$

3) $Span/4 = \frac{16}{4} \times 12 = 48''$

Selecting least value;

$$\boxed{be = 48''}$$

Step# 2:-

Check wheather Rectangular OR T-beam Analysis is Required.

Trial#1   let $a = hf = 3.5''$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - 3.5/2)} = 6.61in^2$$

Trial#02 $a = \frac{Ast \times fy}{0.85 \times f'c \times be}$

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

and $\boxed{Ast = 6.55 in^2}$ $\Rightarrow 3.2'' < 3.5''$

So Rectangular beam design is Required.

Trial#03 $a = 3.21''$

and $Ast = \frac{5800}{0.90 \times 60(18 - 3.21/2)} = 6.55in^2$

(Area of steel is 6.55 in²)

Step#03:-

check ρ_{max} and ρ_{min}

⇒ $\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy}\left(\frac{\epsilon u}{\epsilon u+\epsilon t}\right)$

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

⇒ $\rho_{min} = \frac{200}{fy} = \frac{200}{60000} = 0.003$

⇒ $\rho = \frac{Ast}{b \times d} = \frac{6.55}{10 \times 18} = 0.036$

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

$0.003 < 0.036 < 0.013$

As the value of ρ_{max} is less than ρ, so we have to design it's doubly Reinforced beam.

⇒ First we have to find Area of steel against ρ_{max}.

$\rho_{max} = \frac{Ast}{b \times d} \Rightarrow Ast = \rho_{max} \times b \times d$

$Ast = 0.013 \times (10 \times 18)$

$\boxed{Ast = 2.34 in^2}$

Step# 04

Find the value of Mu_2

By formula;

$M_{u2} = \phi \times A_{st} \times f_y \times (d - a/2)$

First finding the value of (a)

=) $a = \dfrac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \dfrac{2.43 \times 60}{0.85 \times 3 \times 10}$

$a = 5.72''$

=) $M_{u2} = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$\boxed{M_{u2} = 1986.67 \text{ Kip-inch}}$

As $M_{u2} < M_u$

$1986.67 < 5800$

So we have to design beam in such away that it can Resist more bending moment than the applied external Moment

Step# 05

Finding differance in Moment and area of steel.

$M_{u1} = M_u - M_{u2}$

$= 5800 - 1986.67$

$\boxed{M_{u1} = 3813.33 \text{ Kip-inch}}$

By formula;

$A_{st} = \dfrac{M_u}{\phi \times f_y \times (d - d_1)} = \dfrac{3813.33}{0.90 \times 60 \times (18 - 2.5)}$

$\boxed{A'_{st} = 4.56 \text{ in}^2}$

Step# 06

Finding total steel area

$A_s = A_{st} + A_{s't}$

$= 2.43 + 4.56 = 4.99 \text{ in}^2$

Step# 07

Section of bar

In tension Zone:-

let me use #8 bar

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

By formulas

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

$$= 8.9 \approx 9$$

so (9 #8 bars)

In compression Zone:-

let me use #7 bar

$dia = (7/8)'' = Area = \pi/4 (7/8)^2 = .601 \text{ in}^2$

By formulas

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

$$7.5 \approx 8$$

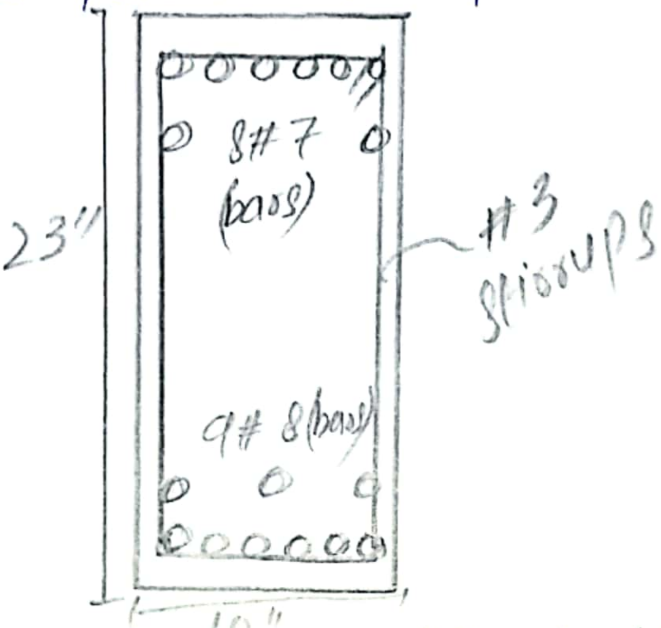
so (8 #7 bars)

Step# 08 Minimum Width for accomodation bar

$b_{Min} = (2 \times 1.5) + (2 \times 3/8) + 9(8/8) + 8(8/8) = 20.75''$

As $20.75'' > 10''$

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

Step# 09

Finding the design Moment

$Md = \phi\left[A's \times fy \times (d - d') + (As - As't) \times fy \times (d - a/2)\right]$

First $a = \frac{(As - As't) \times fy}{0.85 \times f'c \times b} = \frac{(9 \times 0.785 - 8 \times 0.601)}{0.85 \times 3 \times 10} = 5.31''$

$\Rightarrow Md = 0.90\left[(8 \times 0.601) \times 60(19.6 - 3.18) + (9 \times 0.785 - 8 \times 0.601)60 \times (19.6 - 5.31/2)\right.$

$\boxed{Md = 6328.38}$

$6328.38 > 5800 \rightarrow$ Design is OK!

QUESTION = 6

Given Data: -

Breadth $(b) = 14''$
Height $(H) = 26''$
Concrete compression strenght $(f'c) = 4\,\text{Ksi}$
Steel tensile strenght $(fy) = 60\,\text{Ksi}$
ultimate factored Moment $(Mu) = 60000\,\text{kip.in}$
Effective depth of beam $(d) = 22''$

Affectice cover assume $= 2.5''$

Step#1 Reinforcement Ratio:-

By formula;

$$\rho_{max} = 0.85 \times B \times \frac{f'c}{fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon y}\right)$$

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

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

Step # 2 Area of Steel:

As we know that

$$\rho_{max} = \frac{Ast}{b \times d} \Rightarrow Ast = \rho_{max}\,(b \times d)$$

$$\Rightarrow Ast = 0.018 \times (14 \times 22) \Rightarrow \boxed{5.54\,in^2}$$

Step#3 Design Moment:-

BY using formula

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

$$\Rightarrow a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = \boxed{6.98''}$$

So,

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

$$= 5537.4 \text{ Kip-inch}$$

As, $5537.4 < 60000$

We have to design a section as doubly Reinforced.

Step# 4 Difference in Moments

$$Mu_1 = Mu - Mu_2$$

$$= 60000 - 5537.4$$

$$\boxed{Mu_1 = 462.6 \text{ Kip-inch}}$$

Step#5 Area of Steel:-

$$Mu_1 = \phi \times As't \times fy \times (d - d_1)$$

Area of Steel in Compression Zone will be

$$\Rightarrow As't = \frac{Mu_1}{\phi \times fy \times (d - d')} = \frac{462.6}{0.90 \times 60 (22 - 2.5)}$$

$$\Rightarrow \boxed{As't = 0.44 in^2}$$

Step # 6 Total Steel Area :-

$As = Ast + As't$

$= 5.54 + 0.44 = 5.98 \, in^2$

Step # 7 Selection and No. of bars used :-

1) **Steel in tension Zone :-**

We use # 7 bar

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

$= 0.601 \, in^2$

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

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

So 10 # 7 bars

2) Steel in Compression Zone :-

We use # 5 bars

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

$= 0.306 \, in^2$

$$No. \ of \ bars = \frac{As't}{Area \ of \ single \ bar}$$

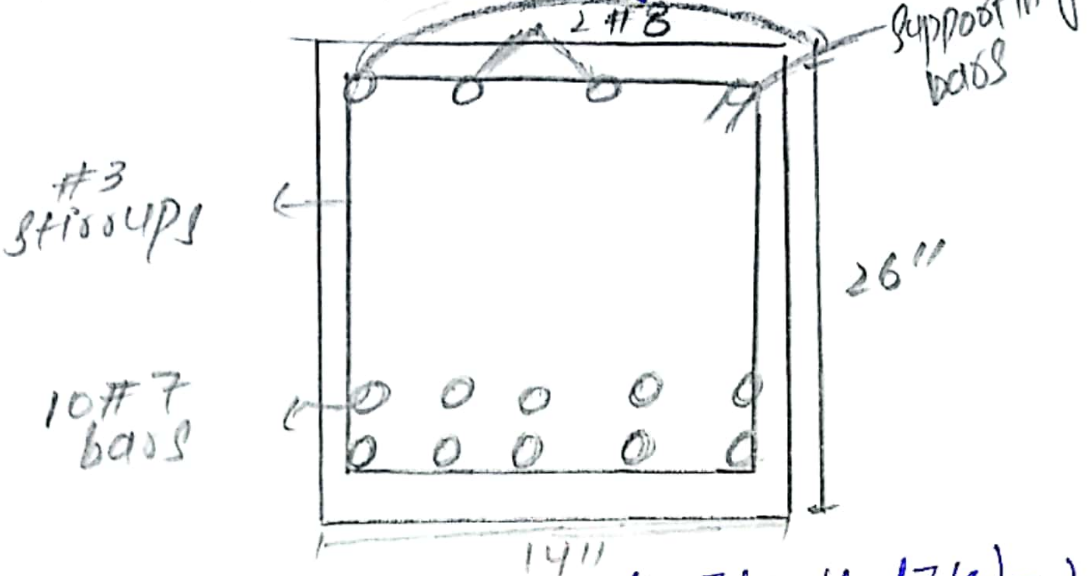
$$= \frac{0.44}{0.306} = 1.43 \approx 2 \ bars$$

So => 2 # 5 bars

Step#8 Minimum width of beam:-

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

$b_{min} = 20.37 > 14''$ (Not good in one layer).



Effective depth $= 26 - 1.5 - 3/8 - 7/8 - 1/2(7/8) = 22.82''$

Effective cover $= 1.5 + 3/8 + 1/2(5/8) = 2.18''$

Step#9 Design moment:-

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

$a = \dfrac{(A_{st} - A_{s}') \times f_y}{0.85 \times f'_c \times b} = \dfrac{(10 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 9 \times 14} = 6.80''$

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

$M_d = 7047.6$ Kip-inches

As $7047.6 > 6000$

Design is ok!