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Sec :- B

Semister :- 8th

Subject :- PRCD

Assignments.

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# Question

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

**Ans.**

## Stirrup:-

Stirrups are closed loop bars tied at regular intervals in beam reinforcement to hold the bars in Poistion

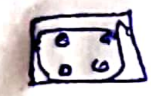
### Types of Stirrups

1) **Single legged stirrups**

The single-leg stirrups have rarely been used because they are mostly used when binding only two rods.

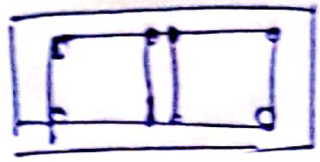
2) **Two legged stirrup:**

It is most commonly and widely used stirrups. Minimum 4 bar are required for Providing this stirrup.

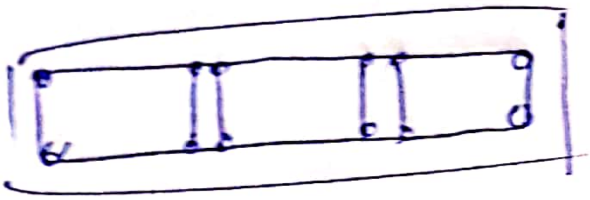


3) Four legged stirrup

These stirrups are used in case of web reinforcement.



4) Six legged Stirrup:-



## ACI codes for shear Design of A Beam:-

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

1- **Critical section:-**

critical section occur at 45° and it 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 required Provision of at least a minimum area of web reinforcement equal to.

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

4) No web - reinforcement is required.

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

∴ Between critical section "$V_u$" and "$\phi V_c$" Spacing b/w web reinforcement can be find as.

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

5) if $V_s \le 4 \times \sqrt{f'_c} \times b_w \times d$ then max spacing for stirrup will be the Smallest of the following

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

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 solved.

=> If $V_s > 8 \sqrt{f'_c} \times b_w \times d$
Then either increase cross-sectional dimension or increas $f'_c$

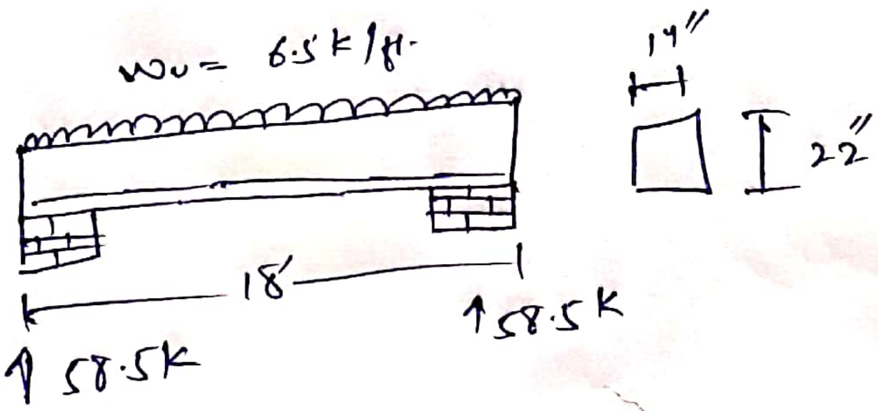
# Question No 02.

Given data.

Breadth of web beam (bw) = 14"
Effective depth (d) = 22"
Given load = 6.5 k/ft

Steel area = 7 in²
$f_c'$ = 4 ksi
$f_y$ = 60 ksi

Soil :-



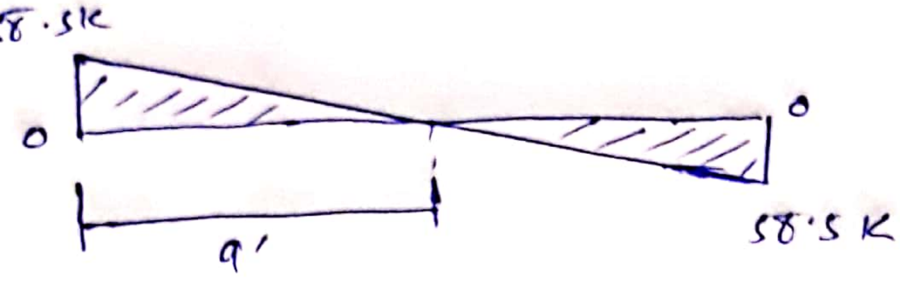

Step # 01
(Reaction on supports)

Find the reaction due to the applied load

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

Step : 02 (Shear Force Diagram)

The required shear diagram will be

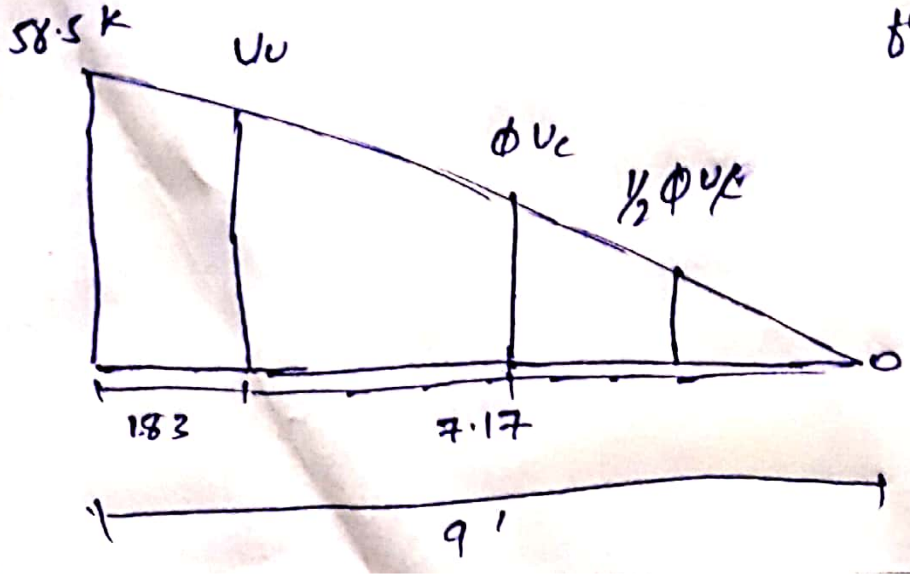



Step : 03

find the values of critical shear "Vu" and its location As.

we know that critical shear is located at distance d from face of support 'd' = 22" = 1.83'

we will find the value of critical shear at distance "d" by use of similar triangles




for similar triangle

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

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

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

## Step 04

find the value of $\phi V_c$ and $\frac{1}{2}\phi V_c$ and also it distance from zero shear to right side.

**By formula**

$$\phi V_c = \phi \times 2 \times \sqrt{f'c} \times b_w \times d$$

$$= 0.75 \times 2 \times \sqrt{4000} \times 14 \times 22 = 29219 \text{ lbs}$$

$$= 29.21 \text{ kips}$$

→ location of $\phi V_c$ by similar triangles.

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

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

similary

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

Location of $\frac{1}{2}\phi V_c$ will be

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

## Step 05

finding the value of $\phi V_s$

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

$\rightarrow \phi V_c = V_u - \phi V_c$

$= 46.61 - 29.21$

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

## Step 06

check on the section adequacy

By formula

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

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

$= 116.8 \text{ kips}$

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

## Step 07

check on the maximum spacing

By formula

$= \phi \times 4 \times \sqrt{f_c'} \times b_w \times d$

$= 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22 = 58438 \text{ lb.}$

$58.43 \text{ Kip}$

## Step # 08

stirrup spacing from /at critical section will be formula

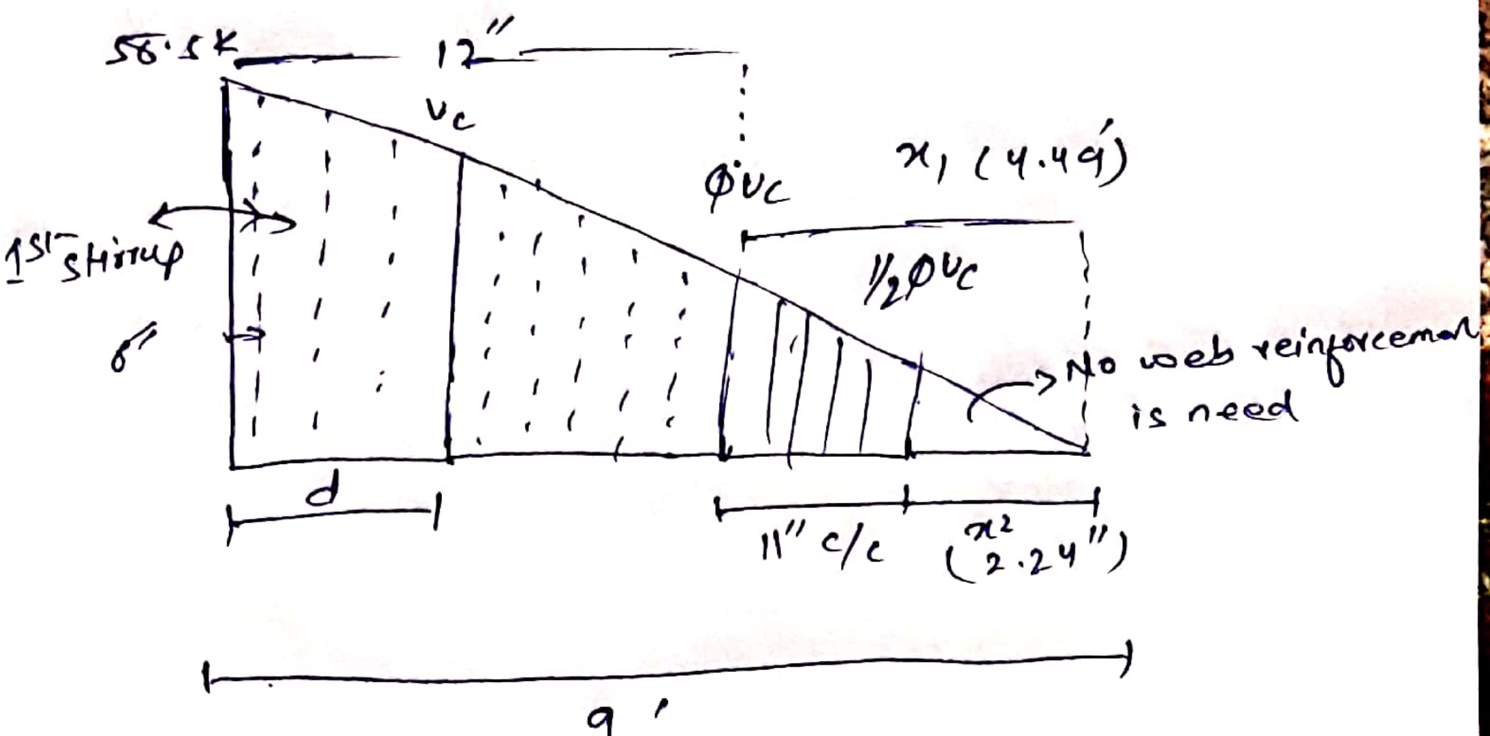
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{46.61 - 29.21}$$

$S = 12.5'' \approx 12$

so $12''$ c/c

## Step # 09

Final skatch will be

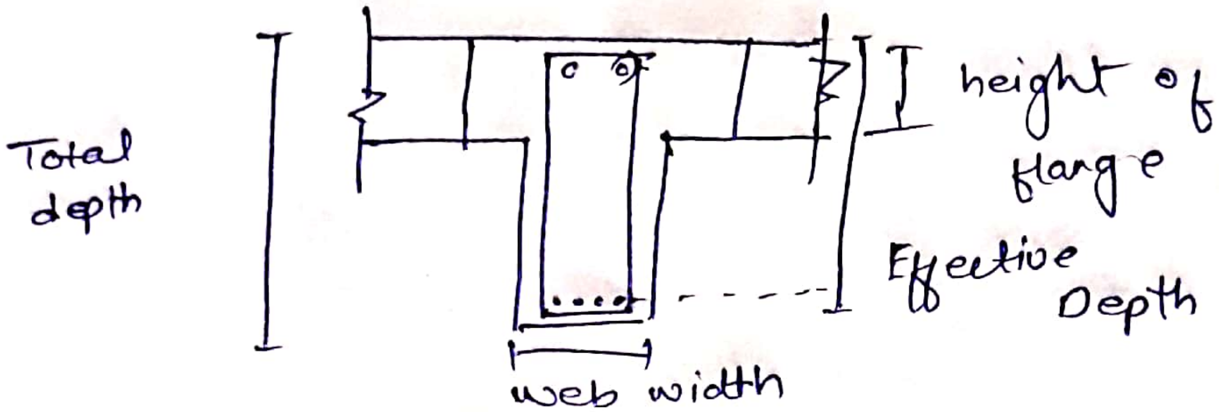


# Question No 03

## Answer No 03

### T- Beam

In most of reinforcement concrete structure concrete slabs are cast monolithically with the slab so. in this case the beam that act as in intermediate beam are called T- Beams.

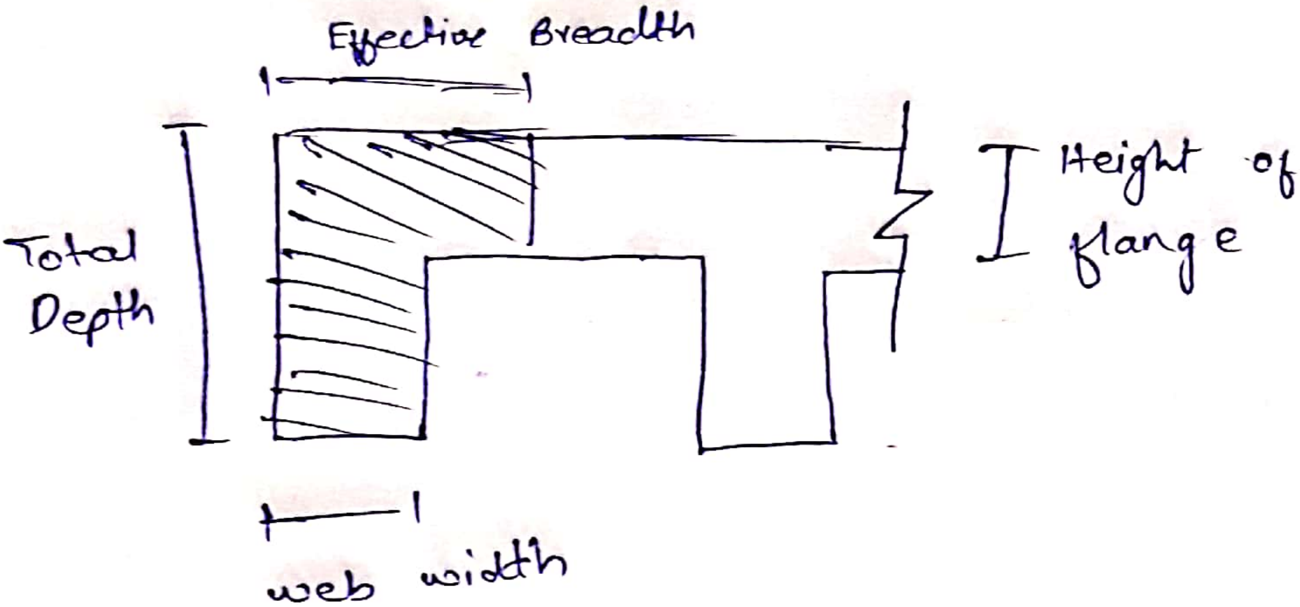



-> Because of their T-shape these Beam are called T- Beams.

-> It is Provided at the center of the slab to resist the load.

## 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.

## Flexural Analysis OF T-Beam :-

flexural analysis consist the following steps.

1- for finding the ultimate moment, we use the following formula

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

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

1- $16(h_f) + b_w$
2- c/c distance
3- span/4
4- $\frac{CTS}{2} + b_w$

3- For finding Area of steel, we have to use.

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

where

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

4) checking whether Rectangular or T. Beam analysis.

i- If $a > h_f$ → special Analysis is required
ii- If $a < h_f$ → Rectangular beam analysis

(5) for checking the Range Reinforcement

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

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

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

(6) formula for finding No of bars required is.

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

(7) for checking Minimum width for bar accommodation.

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

(8) Design Moment is given by

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

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

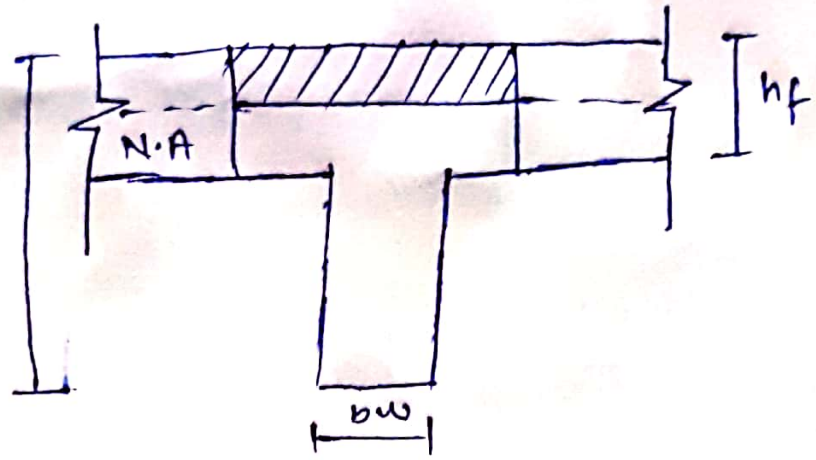
→ if $a > h_f$

Question No: 04 (14)

what is the difference b/w case-1 and case-2 in the design of T-Beam?

Ans # 04

Case-I :-

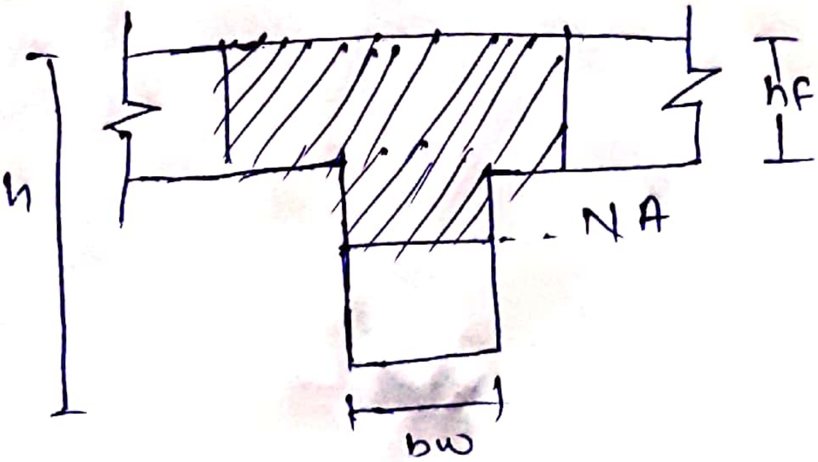



from the figure $a < h_f$ so in this case. Rectangular Beam analysis is Required so,

The design Moment formula will be

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

Case II :-




from the figure $a > h_f$ so in this, special beam analysis i.e, T. beam Analysis is required so the required Design Moment will be

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

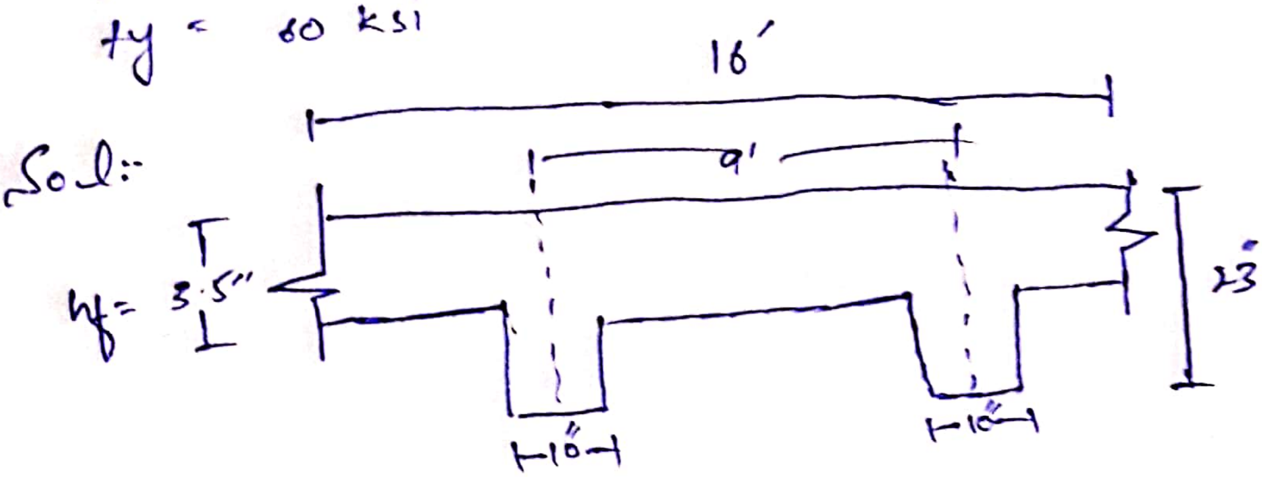
# Question No : 05

A floor System consists of 3.5" . . . . .
. . . . .

## Given data.

Height of flange ($h_f$) = 3.5
c/c distance = 9'
length / span of the beam = 16'
web weight (bw) = 10"
Effective depth (d) = 18"
Height (H) = 23"
Total factored movement (Mu) = 5800 kip.inch
$f_c'$ = 3 ksi
$f_y$ = 60 ksi

Sol:-




## Step 01 :-

calculate the effective width (be) for T-beam

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

2 - c/c distance = 9×12 = 108"

3 - Span/4 = 16/4 × 12 = 48"

select the least value of be as

| be = 48" |

## Step # 2

check whether Rectangular or T- beam Analysis is required.

Trial # 01 let $a = h_f = 3.5"$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - 8.5/2} = 6.61 \text{ in}^2$$

Trail # 02

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

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

and | $A_{st} = 6.55 \text{ in}^2$ | => 3.2" < 3.5"

So Rectangular beam design is required.

## Triad # 03

$a = 3.21''$

and $Ast = \dfrac{5800}{0.90 \times 60 \left(18 - \frac{3.21}{2}\right)} = \boxed{6.55 \text{ in}^2}$

so Area steel is $6.55 \text{ in}^2$

## Step # 3

check $\rho max$ and $\rho min$

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

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

$\Rightarrow \rho_{min} = \dfrac{200}{f_y} = \dfrac{200}{60000} = 0.003$

$\Rightarrow \rho = \dfrac{Ast}{b \times d} = \dfrac{6.55}{10 \times 18} = 0.036$

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

$0.003 < 0.036 < 0.013$

As the value of $\rho max$ is less than $\rho$. so we design a "Doubly Reinforced Beam"

$\rho_{max} = \dfrac{Ast}{b \times d} \Rightarrow Ast = 0.013 \times (10 \times 18) \Rightarrow \boxed{2.34 \text{ in}^2}$

Step # 04

find the value of $Mu_2$ ::
by formula

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

first finding the value of "a"

$$\Rightarrow a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{2.43 \times 60}{0.85 \times 3 \times 10}$$

$$a = 5.72''$$

$$\Rightarrow Mu_2 = 0.90 \times 2.43 \times 60 \times (18 \times 5.72/2)$$

$$Mu_2 = 1986.67 \text{ kip-inch}$$

As $Mu_2 < Mu$

$1986.67 < 5800$

so we have to design the beam in such away that it can resist more bonding moment than the applied external moment

## Step # 05

finding Difference in moment and Area of steel.

$Mu_1 = Mu - Mu_2$

$= 5800 - 1986.67$

$Mu_1 = 3813.33$ kip - inch

By formula

$A_{s}' = \frac{Mu}{\phi \times fy \times (d-d')} = \frac{3813.13}{0.90 \times 60 \times (18-2.5)}$

$Ast = 4.56\ in^2$

## Step # 06

Finding Total steel Area.

$As = Ast + A_{s}'$

$= 2.43 + 4.56 = 6.99\ in^2$

## Step # 07

selection of Bar :-

In Tension zone :-

Let we use # 8 bars

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

By formula

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

= 8.9 = 9

so 9 # 8 bars

In compression zone :-

Let we use # 7 bar

dia = (7/8)".  Area = $\frac{\pi}{4}(7/8)^2 = 0.601\ in^2$

By formula

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

= 7.8 ≈ 8

so 8 # 7 bars

## Step # 08

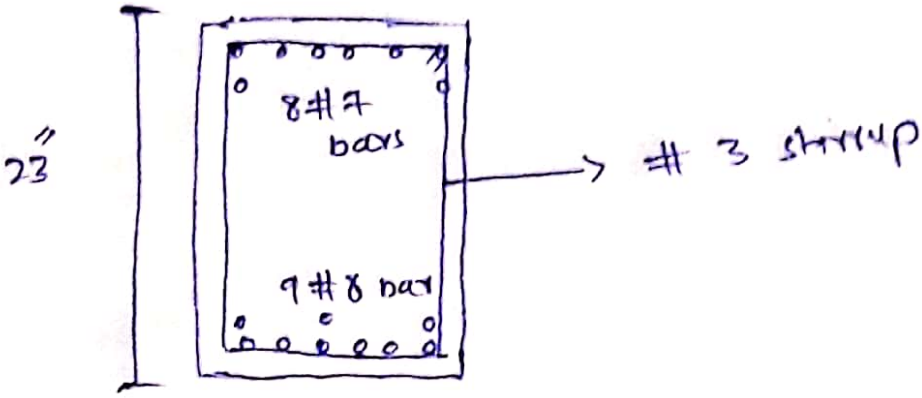
minimum width for Accomodation of bars

bmin = (2x 1.5) + (2 + 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 + 3/8 + 8/8 + 1/2 (8/8)

= 19.6"

Effective cover (d') = 1.5 + 3/8 + 7/8 + 1/2 (7/8)

= 3.18"

## Step # 09

Finding the Design Moment

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

First $a = \dfrac{(A_s - A_{st}') \times f_y}{0.85 \times f_c \times b} = \dfrac{(9 \times 0.785 - 8 \times 0.60) \times 60}{0.85 \times 3 \times 10}$

= 5.31"

→ $M_d = 0.90\ [(8 \times 0.61) \times 60 \times (19.6 - 3.18) + (9 \times 0.785 - 8 \times 0.60) \times 60 \times (19.6 - \frac{5.31}{2})]$

**Md = 6328.38**

As 6328.38 > 5800 → so design is ok.

# Question # 06

**Solution :-**

**Given**

Breadth (b) = 14"
Height (h) = 26"
concrete compression strength ($f_c'$) = 4 ksi
steel Tensile strength ($f_y$) = 60 ksi
Ultimate factored Moment ($M_u$) = 6000 kip/in
Effective depth of beam (d) = 22"
Assume of effective cover d' = 2.5"

**Step: 01** (Reinforcement Ratio)

By formula

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

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

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

**Step # 02** (Area of Steel)

As we know that

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

$$\Rightarrow A_{st} = 0.0180 \times (14 \times 22) = \boxed{5.54\ in^2}$$

## Step # 03 (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

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

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

As

$$5537.4 < 6000$$

So we have to design a section as doubly reinforced.

## Step # 04 (Difference In Moments)

$$Mu_1 = Mu - Mu_2$$

$$= 6000 - 5537.4$$

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

## Step # 05 (Area of steel)

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

So Area of steel in compression zone will be

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

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

## Step # 06 (Total steel Area)

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

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

## Step # 07

1- steel in Tension zone :-

we use # 7 bar,

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

$= 0.601\ in^2$

so

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

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

so 10 # 7 bars

2) steel in compression zone :-

we use # 5 bar,

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

$= 0.306\ in^2$

So

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

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

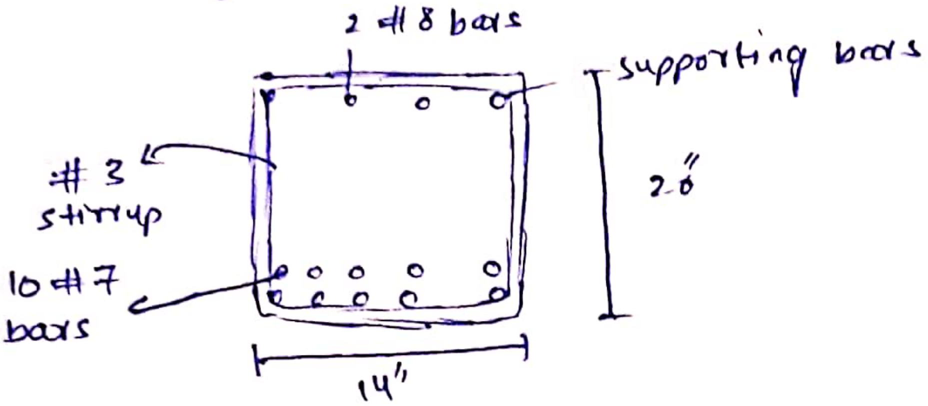
so 2 # 5 bars

## Step # 08 (Minimum width of Beam)

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

$b_{min} = 20.37 > 14''$

So not good in one layer




Now

⇒ Effective depth $(d) = 26 - 1.5 - 3/8 - 7/8 - \frac{1}{2}(7/8)$
$= 22.82''$

⇒ Effective cover $(d') = 1.5 + 3/8 + \frac{1}{2}(5/8)$
$= 2.18''$

## Step # 09

"Design Moment"

$Md = \phi \times [A's t \times fy \times (d - d') + (Ast - A'st) \times fy \times (d - a/2)$

$a = \dfrac{(Ast - A'st) \times fy}{0.85 \times f'c \times b}$

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

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

$Md = 7047.6$ kip-inches

As $7047.6 > 6000$

Design is ok