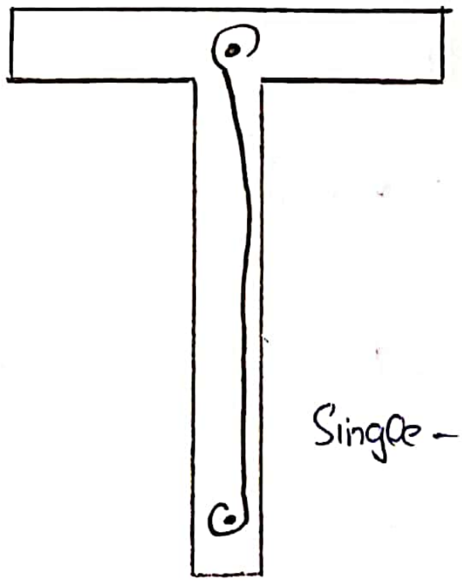
Q1 Explain in detial types of Stirrups with figures & also Explain ACI codes for Shear design?

Ans Following are the types of stirrups.

- Single legged stirrups.
- Two legged or double lagged stirrups.
- Four lagged stirrups.
- Six lagged stirrups.

1- SINGLE LEGGED STIRRUPS:-

These type of stirrups are used to hold the longitudinal bars in position & prevent buckling.



Single-legged Stirrups.

2- DOUBLE LEGGED STIRRUP:-

We use a single stirrup to tide a beam or a colum at a time, we say it is two legged stirrups - Double legged stirrups are adequate for typical beams with relatively short widths.

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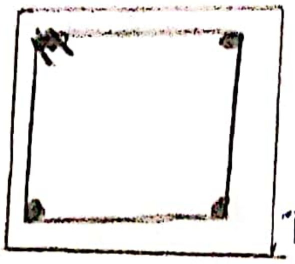
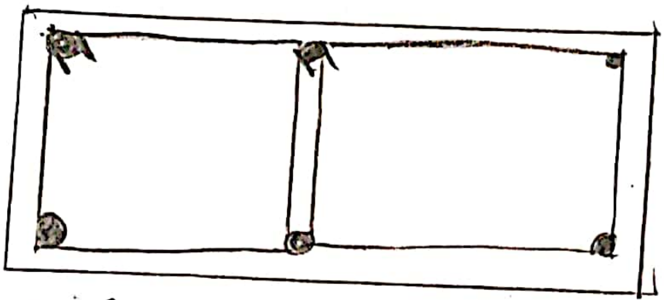


Two-legged stirrups.

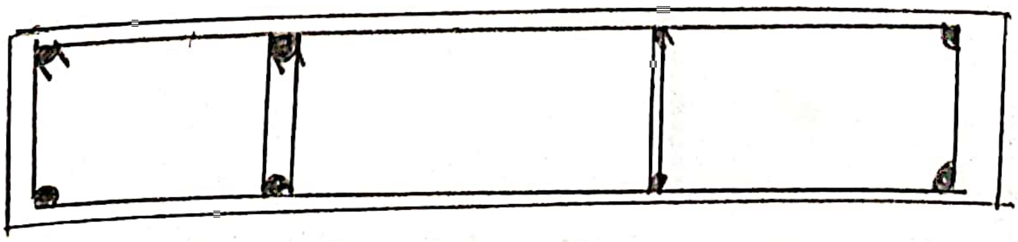
3- FOUR LEGGED STIRRUP:

We use double to the tie a beam or coloumn at a time, we say it is Four legged stirrup - For legged stirrup - For beam having longer widthes multiple legged or Four legged or four legged stirrups are required.



4- Six LEGGED STIRRUP:

These six legged stirrups are generally used for a continous beam structure, It consists of regular upheling of structure at each junction while joints at the joining of beam & Colomn.



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ACI CODES FOR SHEAR DESING:

1- Compute the design shear force, V_u, at appropriate location.

2- Compute shear strength capacity of concrete, $V_c = 2 \times \sqrt{f_c} \times b_w \times d$

3- Compute minimum web reinforcement.

If $V_u \leq \phi \times V_c$ so no web reinforcement needed.

If it is not applicable then min area of web reinforcement equal to.

i) $A_v = 0.75 \sqrt{f'_c} \times \frac{b_w \times s}{f_y}$ OR $A_{v min} = \frac{50 \times b_w \times s}{f_y}$

-> Max spacings can be found by these formula's.

$$S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c} \times b_w} \quad \text{OR} \quad S_{max} = \frac{A_v \times f_y}{50 \times b_w}.$$

4- If $V_u < \frac{\phi V_c}{2}$, if its true no stirrups are required

5- First stirrup is provided at a distance $S/2$

6- Between "V_u" and "ϕV_c" spacing b/w web reinforcement is found by formula.

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

7- If $V_s \leq 4 \times \sqrt{f_c} \times b_w \times d$ then max spacing of stirrups will be smallest of the following.

Four Conditions.

1- 24" 2- $d/2$ 3- $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$ 4- S_{max}

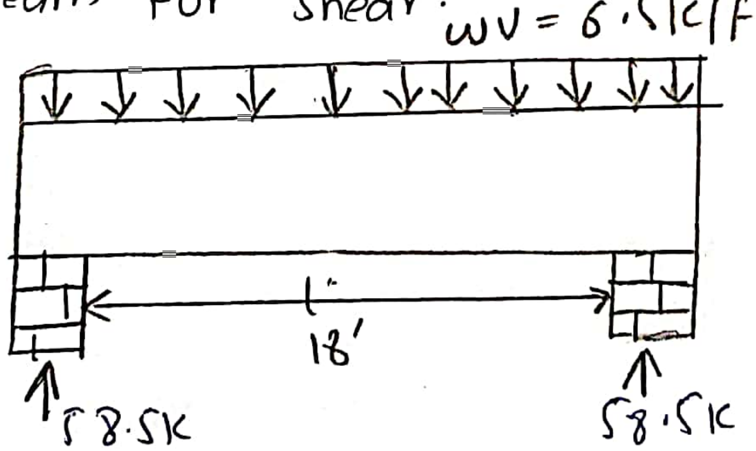
$$\frac{A_v \times f_y}{50 \times b_w}$$

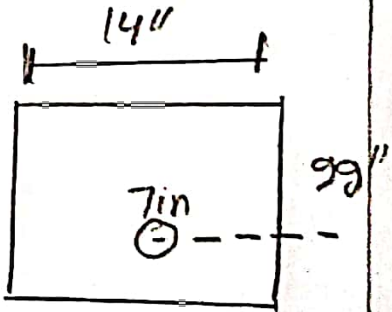
8 If $V_s > 4 \times \sqrt{f_c} \times b_w \times d$ → then max Spacing will be halved

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

then increase cross-sectional dimensions or increase "f_c"

Q-2 A Simply supported rectangular beam 14" wide having an effective depth 22 to carry a letral load of 6.5 K/ft on a 18 Simple span. It is reinforced with 7in of tensile steel area, if f'_c is 4K & fy is 60ksi then design the beam For shear.





Step 01: Find the reaction on support.

$$\text{total load} = \frac{6.5 \times 18}{2} = 58.5K$$

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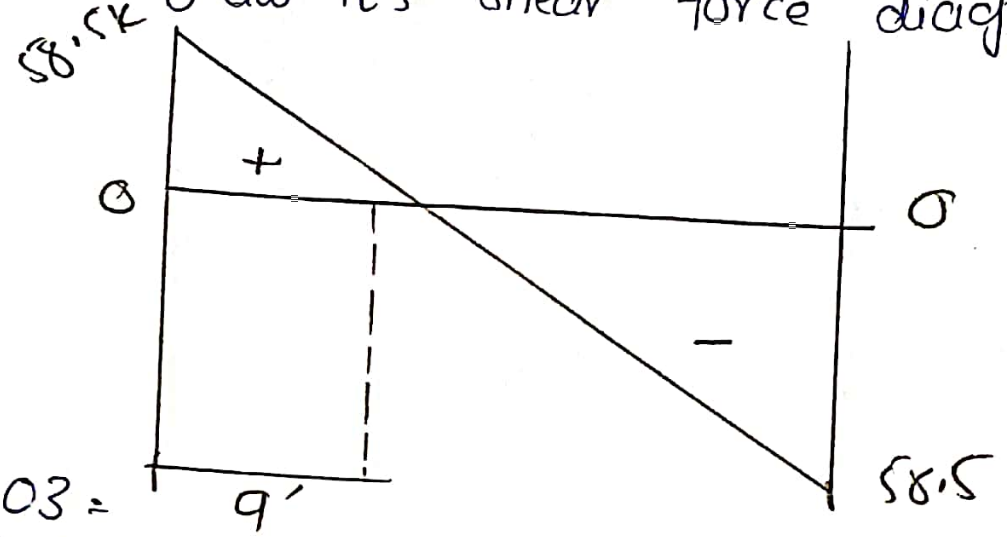
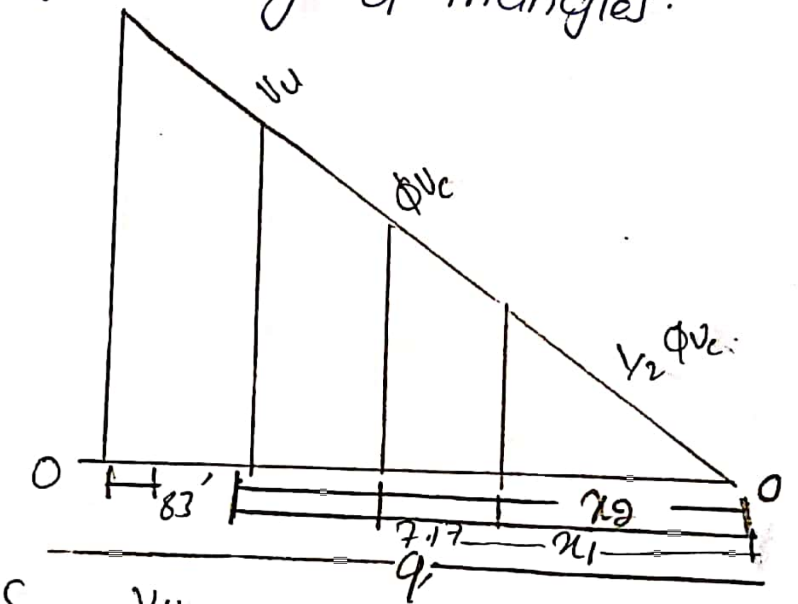
Step 02 = Draw it's Shear force diagram.



Step 03 =
Finding the Value of Critical Stress "V_u" and it's from the Face of Supports $d = 22'' = 1.83'$ using Similarity of triangles.



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

$$V_u = \frac{58.5 \times 7.17}{9} = 46.605k$$

Step 04 : Finding the value of "ϕV_c" and "$\frac{1}{2}\phi V_c$" and also it's distance from zero shear to right side By Formula.

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

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

$$= 29.21k$$

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* location of "ϕV_c" by Similar triangles.

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

$$x_1 = 4.49'$$

Now,

→ $\frac{1}{2}\phi V_c = \frac{29.21}{2} = 14.60k$

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

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

$$\boxed{x_2 = 2.24'}$$

Step·05: Finding the value of "ϕV_s"

$$\phi V_s = V_u - \phi V_c$$
$$= 46.605 - 29.21$$
$$\boxed{\phi V_s = 17.395}$$

Step 06: Check on ~~Sect~~ion adequacy

By Formula

$$= \phi \times 8 \times \sqrt{f'_c} \times b_w \times d$$
$$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 22$$
$$= \boxed{116.87K}$$

As $\phi \times 8 \times \sqrt{f'_c} \times b_w \times d > \phi V_s$ thus section is adequate.

Step 07 :- Check on Max spacing for Stirrups

By Formula:

$$= \phi \times \sqrt{f'_c} \times b_w \times d = 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22$$
$$= 58.43K$$

As $\phi \times 4 \times \sqrt{f'_c} \times b_w \times d > \phi V_s$

So max spacing will be selected from the following 4 condit~~~~ion.

1 - 24" 2 - $\frac{d}{2} = \frac{22}{2} = 11''$ 3 - $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

Lets Suppose we use # 3 stirrups, dia = 3/8 = 0.375"

$Area = \frac{\pi}{4}(0.375)^2 = 0.11 in^2$

For - 2 legged stirrup' Area x 2
$= 0.11 \times 2 = 0.22 in^2$

3 - $S_{max} = \frac{0.22 \times 60000}{50 \times 14} = 18.25''$

4 - $S_{max} = \frac{A_v \times f_y}{50 \times b_w} = \frac{0.22 \times 60000}{50 \times 14} = 19.87''$

So we choose the last value From the above values

$S_{max} = 11''$

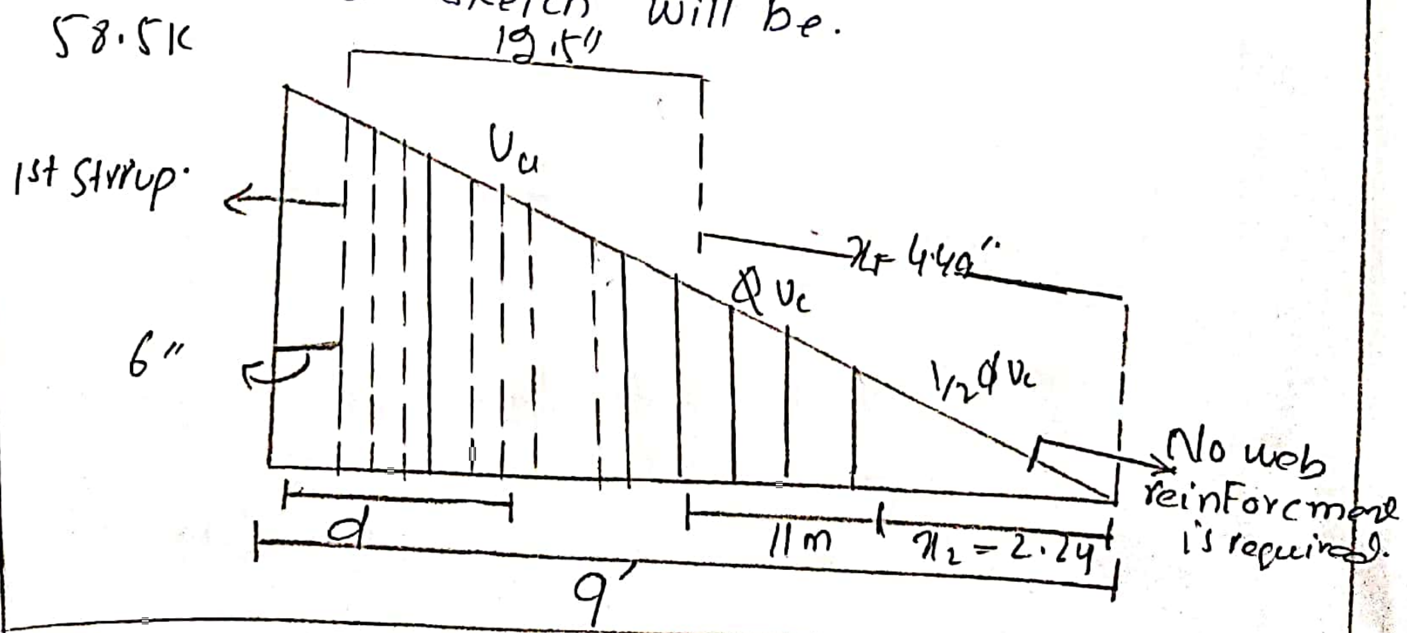
Step 08 : Stirrups spacing From at critical Section.

By Formula $S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{48.605 - 29.21}$

$S = 12.52 \simeq 12.5''$

So 12.5" OK.

Step 09 :: Final sketch will be.



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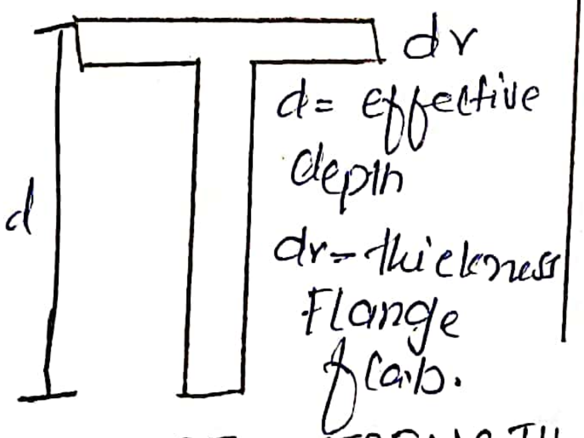
First Strrup: From Face of Support.

$$S/2 = \frac{12.5}{2} = 6.25 \approx 6''$$

Q3 Define both the T-beam and L-beam with the help of diagram - Also Explain Flexural Strength analysis For T-Beam

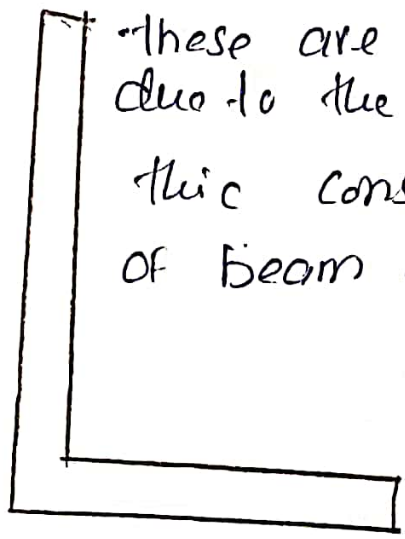
T BEAM

- It is local bearing structure of reinforcement Concert, wood or metal, with a T-Shaped crosection
- The top of the T-Shaped serves as Flange or compression member in resisting compressive stress



L-BEAM

- A beam whos section has the form of an inverted L, usually placed so that it's top flange forms part of the edge of a floor.



- These are produce due to the monolithic construction of beam & slab.

FLEXURE STRENGTH ANALYSIS FOR T-BAEM.

1. Find the ultimate factored load (moment) by the formula -

$$m_u = \frac{w_u \times L^2}{8}$$

3. Effective depth "be" For T-beam is computed as formula.

i. $16(h_F) + b_w$ ii, c/c distance iii) Span/4 iv) $\frac{C/S + t}{2}$

Select least value from the above values.

3. Check whether Rectangular or T-beam analysis is required.

1. If $a > h_F$ then T-beam analysis required.

ii. If $a < h_F$ then rectangular analysis is required

4. Find the Area of Steel.

$$A_{st} = \frac{M_u}{\phi \times f_y' \times (d - a/2)}, \quad a = \frac{A_{ST} \times f_y}{0.85 \times f'_c \times b_w}$$

5. Check 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. Find the bars - No of bars = A_{ST}/A_b.

7. Check min width for bar accommodation (b_{min} = 2(c.c) + 2 dia of stirrups + No of bars (dia of bar) + Spacing b/w bars (dia bar))

8. Design moment is given as $M_d = \phi \times f_y \times A_{ST} \times (d - a/2)$ = If $a < h_F$

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

If $a > h_f$.

What is the difference b/w CASE-I & Case-II in the desingh of T-beam.

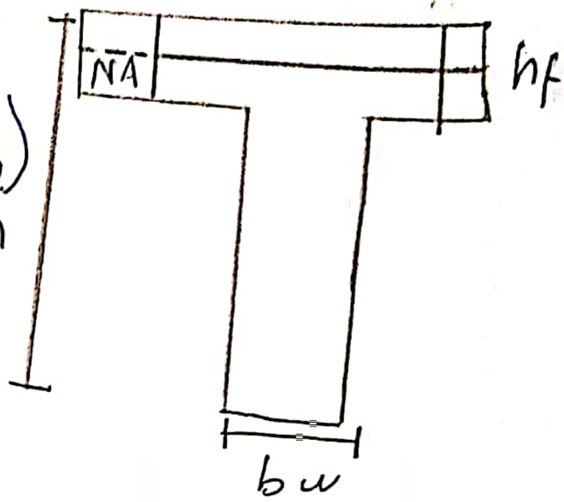
CASE-I:

From the figure

$a < h_f$

So in this case, rectangular beam analysis is required so the design moment formula will be.

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



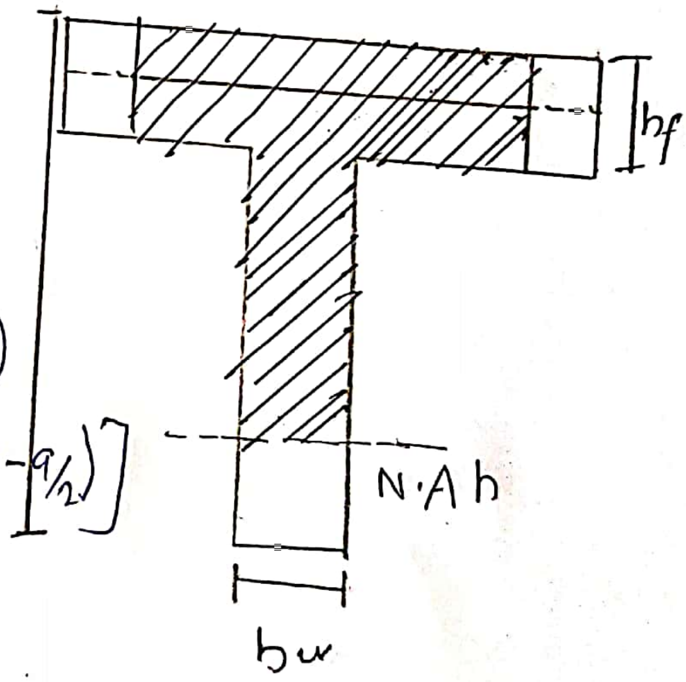
CASE II

From the figure

$a > h_f$

So in the, special beam analysis is required

So design moment will be.



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

Q5 A floor comosist of 3.5" concert slab support by 16' simple span spaced at 9 c/c, the beam having a web wedth of 10" and effective

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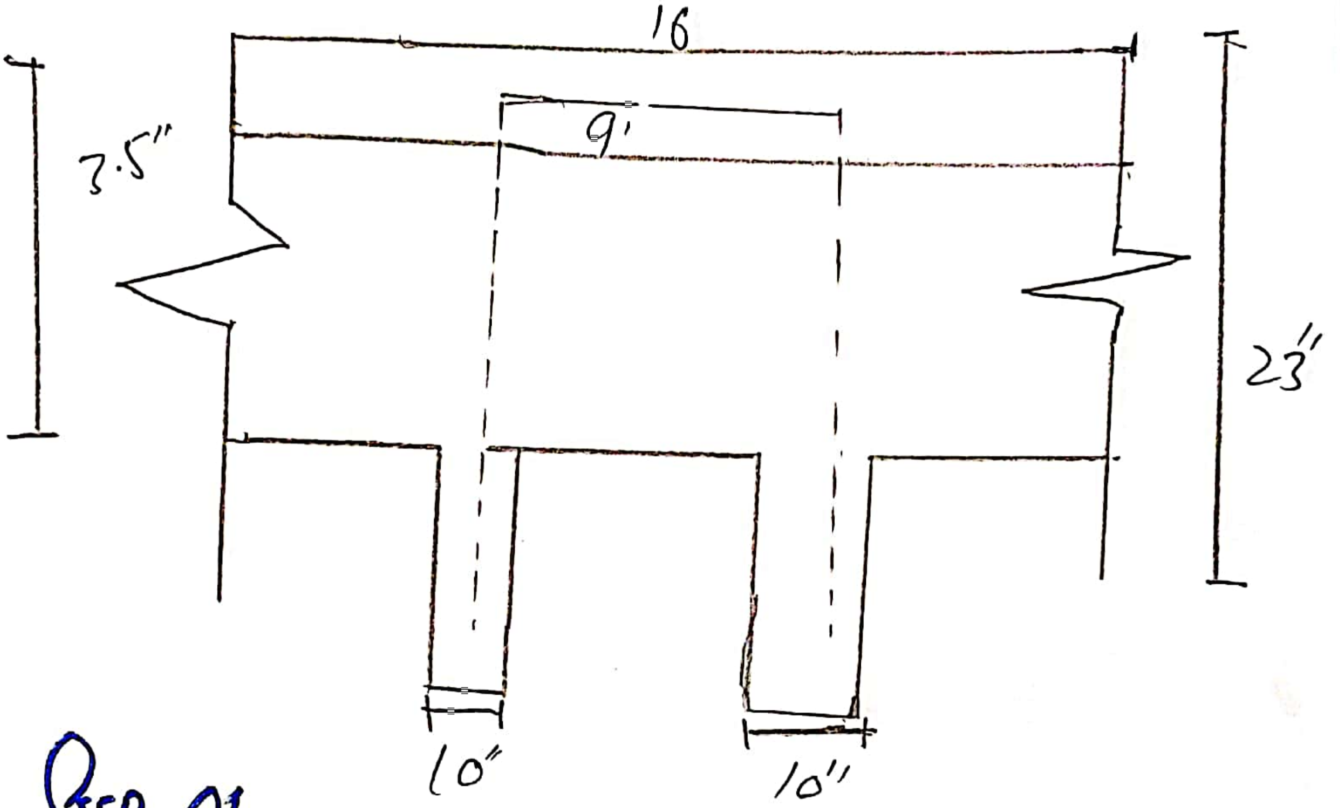
depth of 18" and total height is 23"
Calculat the necessory Flexural reinforcement.
applied momentom is 5800 k-in use fc' = 3ksi and fy 60 ksi



STEP 01: Calculat the effective width (be) 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 $= 16/4 \times 12 = 48''$

Selecting the last value of Be = 48"

STEP 02: Check the whether rectangular or T-beam angles is required.

Trial# 1

let $a = h_f = 3.5''$

$$A_s = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - 3.5/2)} = 6.61 in^2$$

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Trial # 2

$$a = \frac{AST \times fy}{0.85 \times f_c \times b_e} = \frac{6.61 \times 60}{0.85 \times 3 \times 148} = 3.25$$

$$AST = \frac{Mu}{\emptyset \times fy \times (d - a/2)} = \frac{5800}{0.90 \times 60 (18 - \frac{3.24}{2})} = 6.56 in^2$$

Trial # 3

$$a = \frac{Ast \times fy}{0.85 f'_c \times b_e} = \frac{6.56 \times 60}{0.85 \times 3 \times 48} = 3.21 in^2$$

$$AST = \frac{Mu}{\emptyset \times fy \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times (18 - \frac{3.21}{2})} = 6.55 in^2$$

thus rectangular beam analysis is required

STEP 03: Check ρmax & ρmin

$$\rho max = 0.85 \times B \times \frac{f'_c}{fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon t}\right)$$

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

$$= 0.014$$

$$\rho min = \frac{200}{fy} = \frac{200}{60000} = 0.003$$

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

thus the value of ρmax & ρmin so we have to calculate AST again

$\rho min < \rho max$

$0.003 < 0.036 < 0.014$

$$AST = \rho max \times b \times d$$

$$AST = 0.014 \times 10 \times 18$$

$$AST = 2.52 in^2$$

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STEP 04: Slection and No of Bars.

let's use #8 So dia (8/8) = 1"

By formula:- Area = $\pi/4 (1)^2 = 0.785\ in^2$

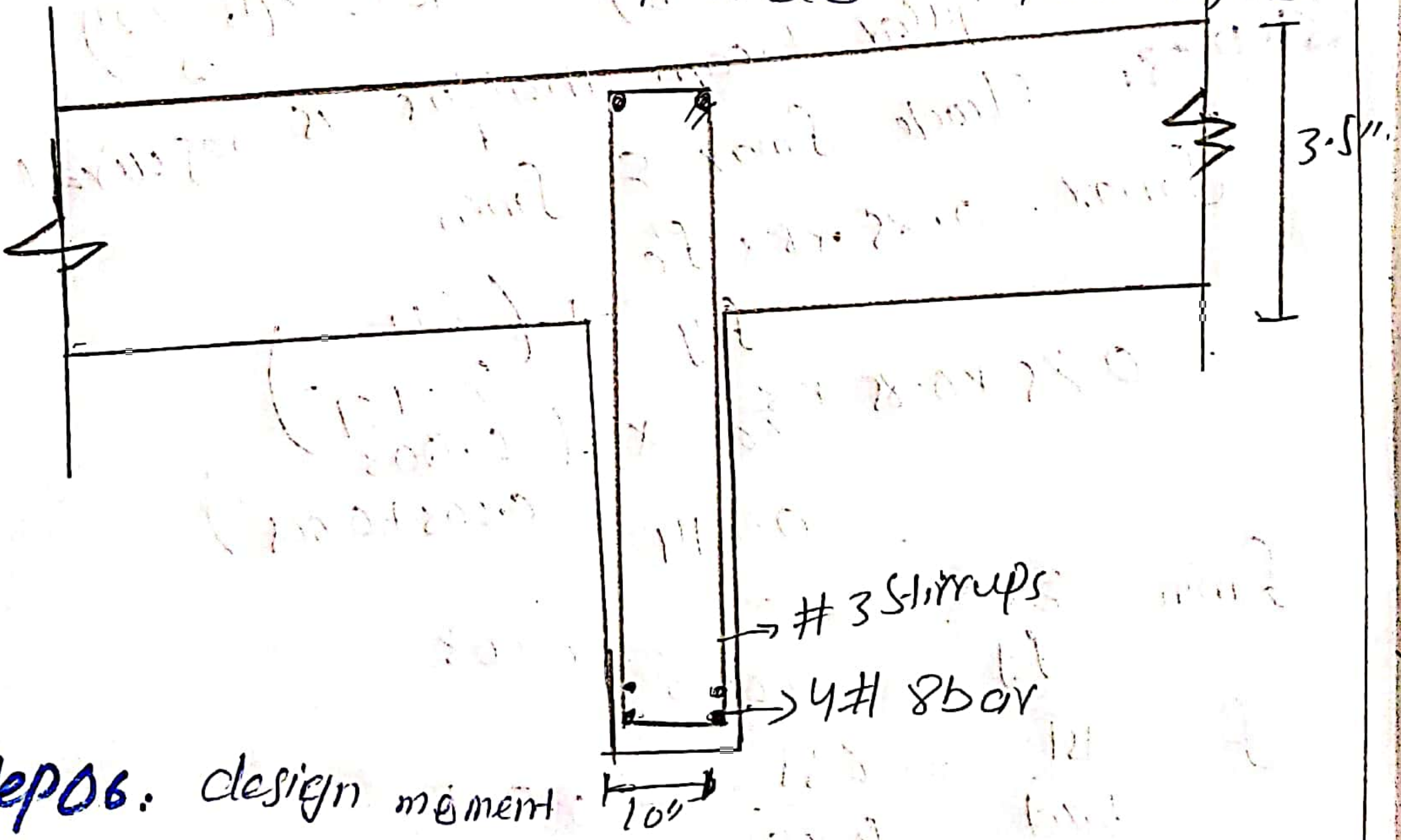
No of bars = $\frac{AST}{Ab} = \frac{2.59}{0.785} = 3.21 \simeq 4$ bars

STEP 05:- Check on minimum width

bmin $(2 \times 1.5) + (2 \times 3/8) + (4 \times 8/8) + 3\ (8/8)$
$= 10.75''$

As $10.75'' > 10''$

∴ So it should be provided in two layers.



Step 06. design moment

By using Formula

$Md = \phi \times fy \times AST\ (d - a/2)$

∴ AST ⇒ No of bars × Area of single bar
$= 4 \times 0.785$
$= 3.14\ in^2$

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$$a = \frac{A_{ST} \times f_y}{0.85 \times f'_c b} = \frac{3.14 \times 60}{0.85 \times 3 \times 48} = 1.54$$

$$M_d = 0.90 \times 60 \times 3.14 \times (18 - \frac{1.54}{2})$$

$$M_d = 2921.52 \text{ k-in}$$

2921.52 < 5800 thus design is ok!

Q 8 A beam is revised to developed and ultimate moment of 6000 k-m limited to 14×26 inch size use f'c is 4ksi and fy is 60ksi Determine flexural reinforcement and effective depth of beam is 22"

Sol given data.

Breadth = 14"

Heagth = 26"

concrete compression strength (f'_c) = 4ksi

fy = 60ksi

MU = 6000 k-in

d = 22"

Assume d' = 2.5"

Step 01: Reinforcement Ratio

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

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

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

Step 02: Area of Steel

As we know that

$$\rho_{max} = \frac{A_{ST}}{bd} \Rightarrow A_{ST} = \rho_{max} \times b \times d$$

$$= 0.0180 \times 14 \times 22$$

Area 5.54 in^2

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STEP 03 : Design Moment

Using Formula

$Mu_2 = \phi \times A_{ST} \times f_y \times (d - a/2)$

$a = \frac{A_{ST} \times f_y}{0.85 \times f'_c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = 6.98''$

$Mu_2 = 5537.4 kin$

As $5537.4 < 6000$

So we have to design a section as double reinforcement beam

STEP 04: Differnce in moment.

$Mu_1 = Mu - Mu_2$

$= 6000 - 5537.4$

$\boxed{Mu = 462. k-in}$

STEP 05 : Area OF Steel

$Mu_1 = \phi \times A_{ST} \times f_y \times (d-d')$

So Area OF Steel in Compression Zone will be

$A'_{ST} = \frac{Mu_1}{\phi \times f_y \times (d-d')} = \frac{462}{0.9 \times 60 \times (22-2.5)} = 0.44in^2$

STEP 06: Selection and No of bars used.

Steel and tension Zone

We use #7 bar.

dia $(7/8) = 0.875''$, Area $\pi/4\,(0.875) = 0.601 in^2$

So, No OF bars in compression

$= \frac{A_S}{A_b} = \frac{5.98}{0.601} = 9.9 \approx 10 bar$

So, 10 #7 bars.

2 - Steel in Compression zone.

let's use # 5 bar

dia $5/8 = 0.625''$, $A = \frac{\pi}{4}(0.625)^2 = 0.306 in^2$

So, No of bars $= \frac{A_s}{A_b} = \frac{0.44}{0.306} = 1.43 \approx 2$ Bars

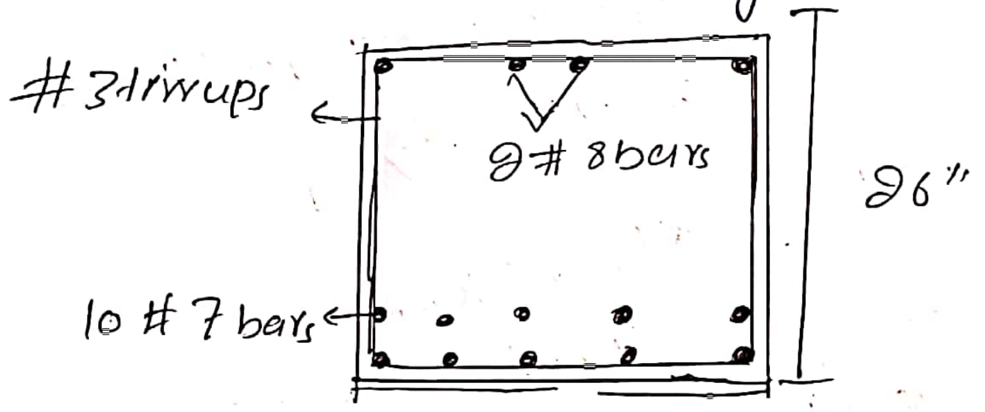
So 2 # 5 Bars.

STEP 08: Minimum width of Beam.

$Mini = (2 \times 1.5) + (2 \times 3/8) + 10(7/8) + 9(7/8)$

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

So not good in one layer



Now,

→ Effective depth $(d) = 26 - 1.5 - 3/8 - 7/8 - 1/2 (7/8)$

$= 22.88''$

= Effective cover $(d') = 1.5 + 3/8 + (5/8) \cdot 1/2$

$= 2.18''$

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Step 09: Design Moment.

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

$$a = \frac{(A_{st} - A_{st}') \times f_y}{0.85 \times f_c' \times b} = \frac{(10 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14}$$

$$a = 6.80''$$

$$M_d = 0.90 [(2 \times 0.306) \times 60 \times (22.82 - 2.18) + (10 \times 0.61 - 2 \times 0.306) \times 60 \times (22.82 - 6.80/2)]$$

$$M_d = 7047.6 \text{ Kin.}$$

$$AS = 7047.6 > 6000$$

Design is ok!