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Submitted To :- Engr - Fawad Khan

Assignment :- -02

Subject :- PRCD-1

Section :- B,

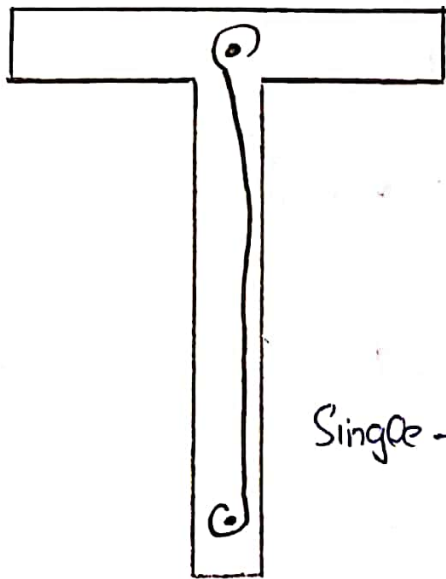
Q₁ Explain in detail types of stirrups with figures & also explain ACI codes for shear design?

Ans Following are the types of stirrups.

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

1- SINGLE LEGGED STIRRUPS:-

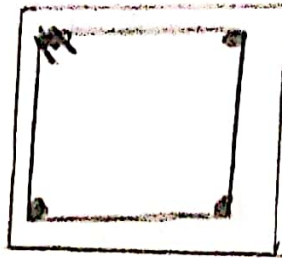
These type of stirrups are used to hold the longitudinal bars in position & prevent buckling.



Single-legged stirrups.

2- DOUBLE LEGGED STIRRUP:-

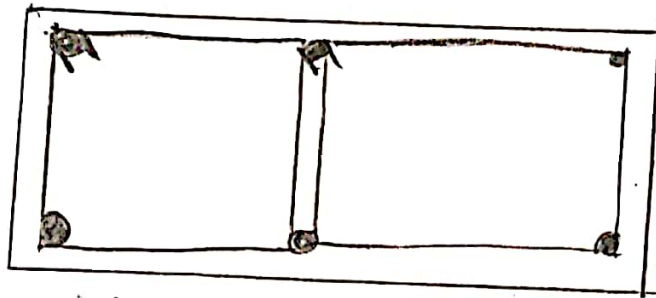
We use a single stirrup to tie a beam or a column at a time, we say it is two legged stirrups - Double legged stirrups are adequate for typical beams with relatively short widths.



Two-legged stirrups.

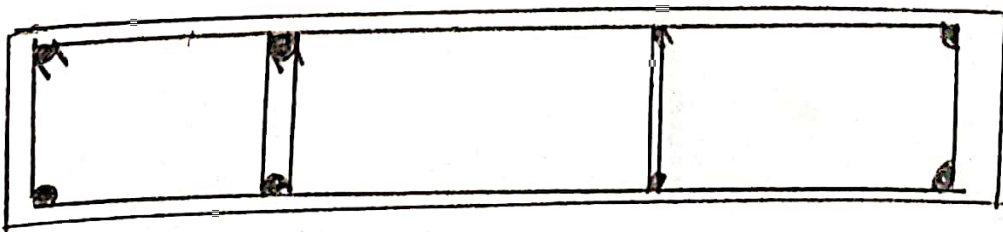
3- FOUR LEGGED STIRRUP:

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



4- SIX LEGGED STIRRUP:

These six legged stirrups are generally used for a continuous beam structure, it consists of regular upholding of structure at each junction while joints at the joining of beam & column.



ACI CODES FOR SHEAR DESIGN:

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

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

$$1) A_v = 0.75 \sqrt{f_c'} \times \frac{b_w \times s}{f_y} \quad \text{OR} \quad A_{\text{min}} = \frac{50}{f_y} \times b_w \times s$$

→ Max spacings can be found by these formula's.

$$s_{\text{max}} = \frac{A_v \times f_y}{0.7 \times \sqrt{f_c'} \times b_w} \quad \text{OR} \quad s_{\text{max}} = \frac{A_v \times f_y}{50 \times b_w}$$

4- If $V_u \leq \frac{\phi V_c}{2}$, 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.

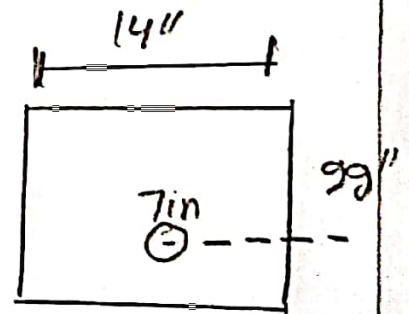
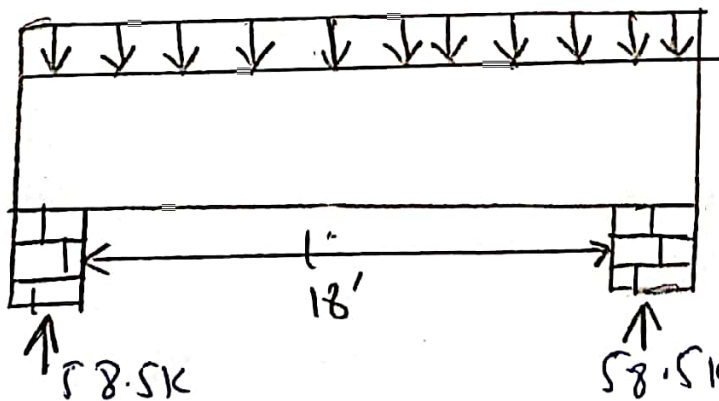
1- $24''$ 2- $d/8$ 3- $S_{max} = \frac{A_u \times f_y}{0.75 \times \sqrt{f_c} \times b_w}$ 4- s_{max}

$$\frac{A_u \times f_y}{S_o \times b_w}$$

8 If $V_s > 4 \times \sqrt{f_c} \times b_w \times d \rightarrow$ 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 "

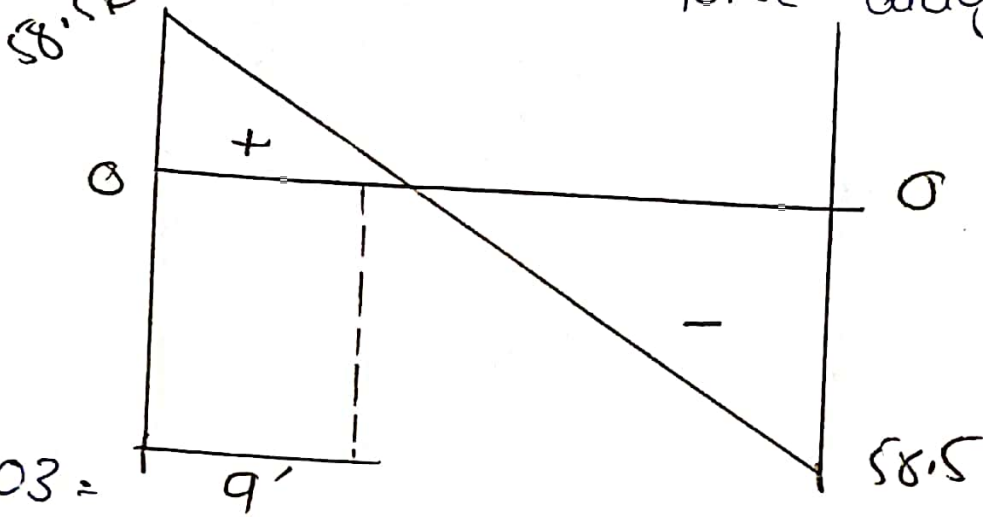
Q₂ A simply supported rectangular beam 14" wide having an effective depth 99" to carry a lateral load of 6.5 k/ft on a 18' simple span. It is reinforced with 7 in of tensile steel area, if f_c' is 4k & f_y is 60ksi then design the beam for shear. $w_u = 6.5 \text{ k/ft}$



Step 01: Find the reaction on support.

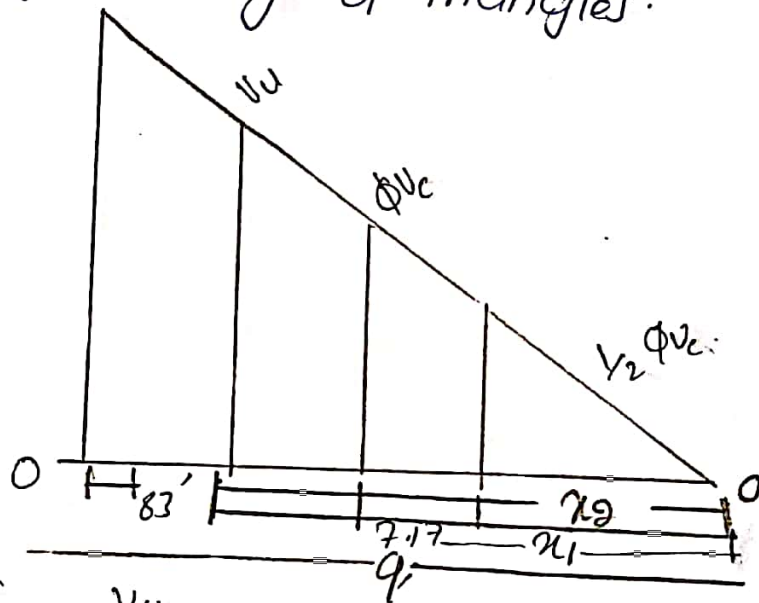
$$\text{total load} = \frac{6.5 \times 18}{2} = 58.5 \text{ k}$$

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 $d = 99' = 1.83'$ using similarity of triangles.



$$\frac{58.5}{9} = \frac{V_u}{1.83}$$

$$V_u = \frac{58.5 \times 1.83}{9} = 11.83 \text{ k}$$

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

By Formula,

$$\Rightarrow \phi V_c = \phi \times 2 \times \sqrt{F_c} \times b_w \times d$$

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

$$= 29.21 \text{ k}$$

* Location of " ϕV_c " by Similar triangles.

$$\frac{58.5}{9} = \frac{\phi V_c}{x_1} \Rightarrow \frac{58.5}{9} = \frac{99.21}{x_1}$$

$$x_1 = 4.49'$$

Now,

$$\frac{1}{2} \phi V_c = \frac{99.21}{9} = 14.60k$$

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

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

$$x_2 = 2.24'$$

Step 05: Finding the value of " ϕV_s "

$$\begin{aligned} \phi V_s &= V_u - \phi V_c \\ &= 46.605 - 99.21 \end{aligned}$$

$$\phi V_s = 17.395$$

Step 06: Check on section adequacy

By Formula

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

$$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 99$$

$$= 116.87k$$

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:

$$\begin{aligned} &= \phi \times 4 \times \sqrt{f'_c} \times b_w \times d = 0.75 \times 4 \times \sqrt{4000} \times 14 \times 99 \\ &= 58.43k \end{aligned}$$

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 condition.

1 - $s_{max} = 24"$

2 - $\frac{d}{2} = \frac{22}{2} = 11"$

3 - $s_{max} = \frac{A_u \times f_y}{0.75 \times \sqrt{f_c} \times b_w}$

Let's suppose we use #3 stirrups, dia = $\frac{3}{8} = 0.375"$

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

For - 2 legged stirrup Area $\times 2$
 $= 0.11 \times 2 = 0.22 \text{ in}^2$

3 - $s_{max} = \frac{0.22 \times 60000}{50 \times 14} = 18.25"$

4 - $s_{max} = \frac{A_u \times f_y}{50 \times b_w} = \frac{0.22 \times 60000}{50 \times 14} = 19.87"$

So we choose the last value from the above values
 $s_{max} = 11"$

Step 08: Stirrups spacing from critical section.

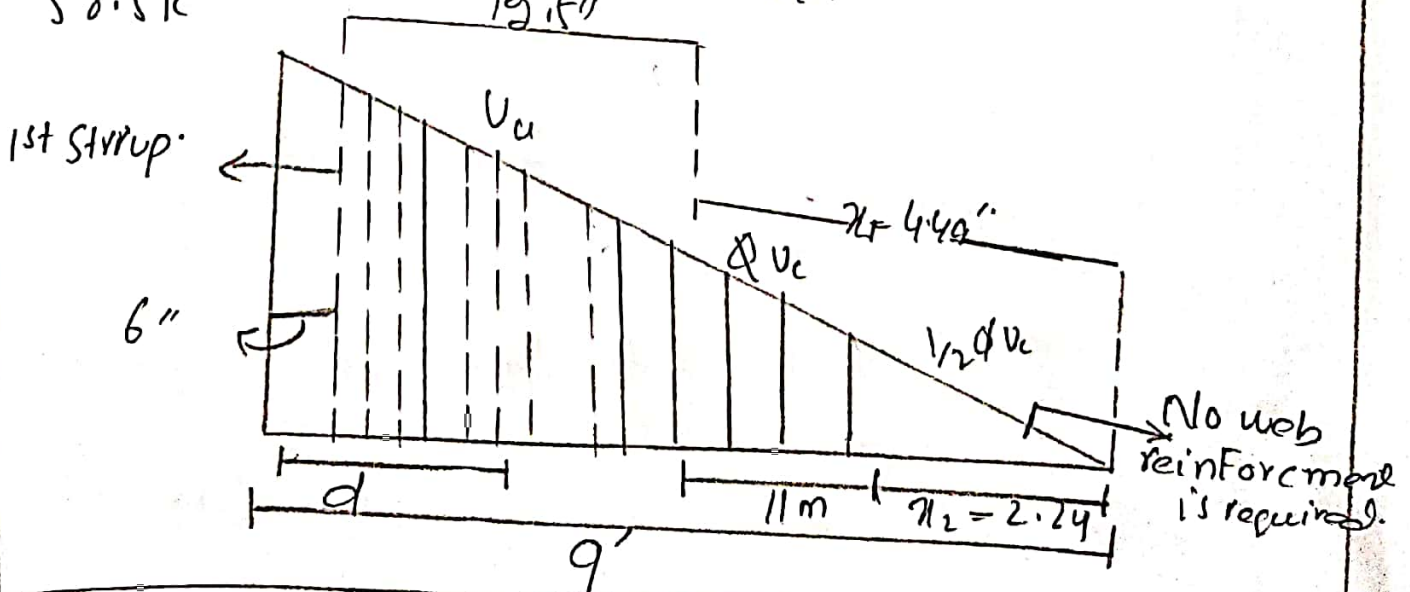
By Formula

$s = \frac{\phi \times A_u \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 80 \times 22}{48.605 - 29.21}$
 $s = 12.52 \approx 12.5"$

So 19.5" c/c.

Step 09: Final sketch will be.

58.5k



First Startup: From Face of Support.

$$s/2 = \frac{12 \cdot 5}{2} = 6 \cdot 25 \approx 6''$$

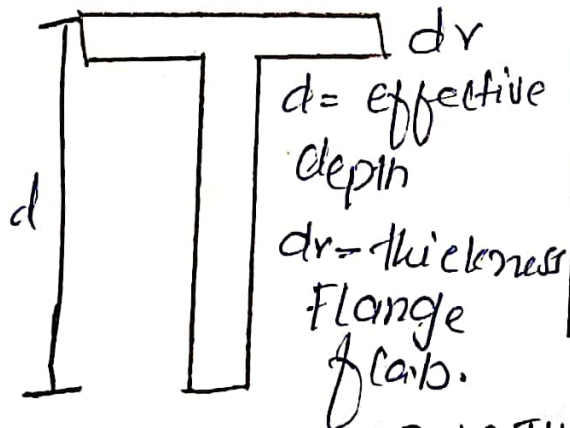
Q.3 Define both the T-beam and L-beam with the help of diagram - Also explain flexural strength analysis for T-beam

T BEAM

It is local bearing structure of reinforcement concrete, wood or metal, with a

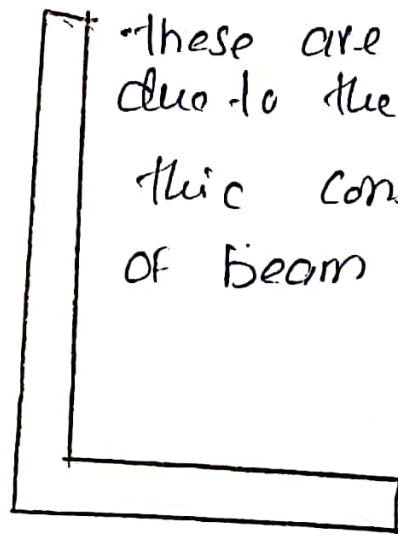
T-shaped cross section

The top of the T-shaped serves as flange or compression member in resisting compressive stress



L-BEAM

A beam whose 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 produced due to the monolithic construction of beam & slab.

FLEXURE STRENGTH ANALYSIS FOR T-BEAM.

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) $\frac{\text{Span}}{4}$ iv) $\frac{h}{2}$
 select last value from the above values.

3 Check whether Rectangular or T-beam Analysis is required.
 i) 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.
 $A_{st} = m_u$
 $\frac{\phi \times f_y \times (d - a/2)}{0.85 \times f'_c \times b_w}$, $a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b_w}$

5 Check the range of reinforcement ratio
 $f_{max} = 0.85 \times \beta \times f'_c$
 $f_{min} = \frac{200}{f_y} \left(\frac{e_u}{\epsilon_{ult}} \right)$
 $f = \frac{A_{st}}{b \times d}$

6 Find the bars - No of bars = $\frac{A_{st}}{A_b}$.
 7 Check min width For bar accommodation ($b_{min} = 2d + \text{No of bars (dia of bar) + Spacing b/w bars (dia of bar)}$)

8 Design moment is given as $m_d = \phi \times f_y \times A_{st} \times (d - a/2)$
 $= 1F a c h F$
 $m_d = \phi \times (A_{st} \times f_y \times (d - h_f/2)) (A_s - A_{st})$
 $+ F \times F_y (d - a/2)$
 IF $a > h_f$.

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

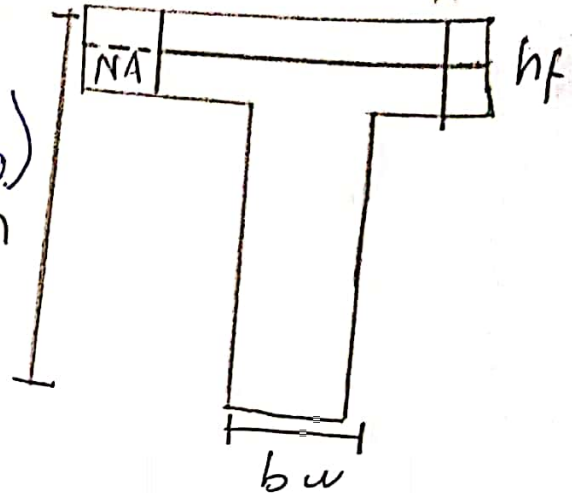
CASE - I:

From the figure

$$a < h_f$$

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

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



CASE II

From the figure

$$a > h_f$$

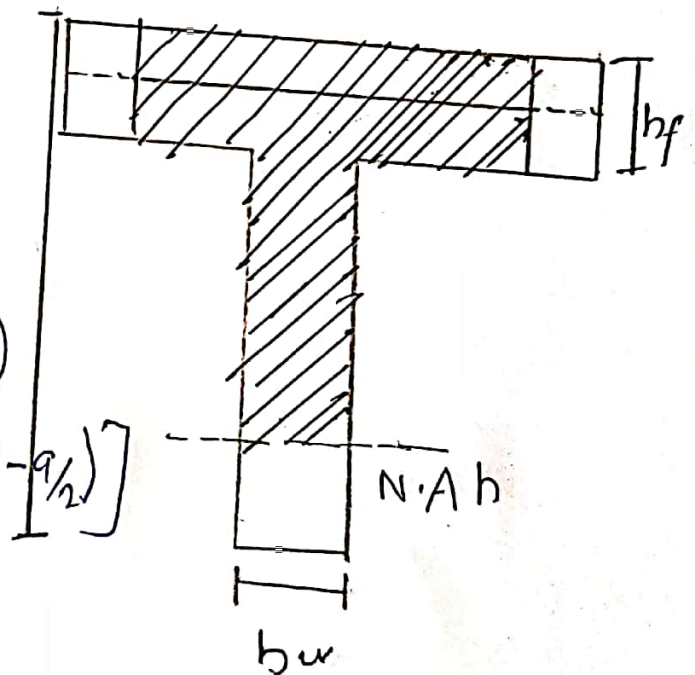
So in this, special beam analysis is required

So design moment

will be.

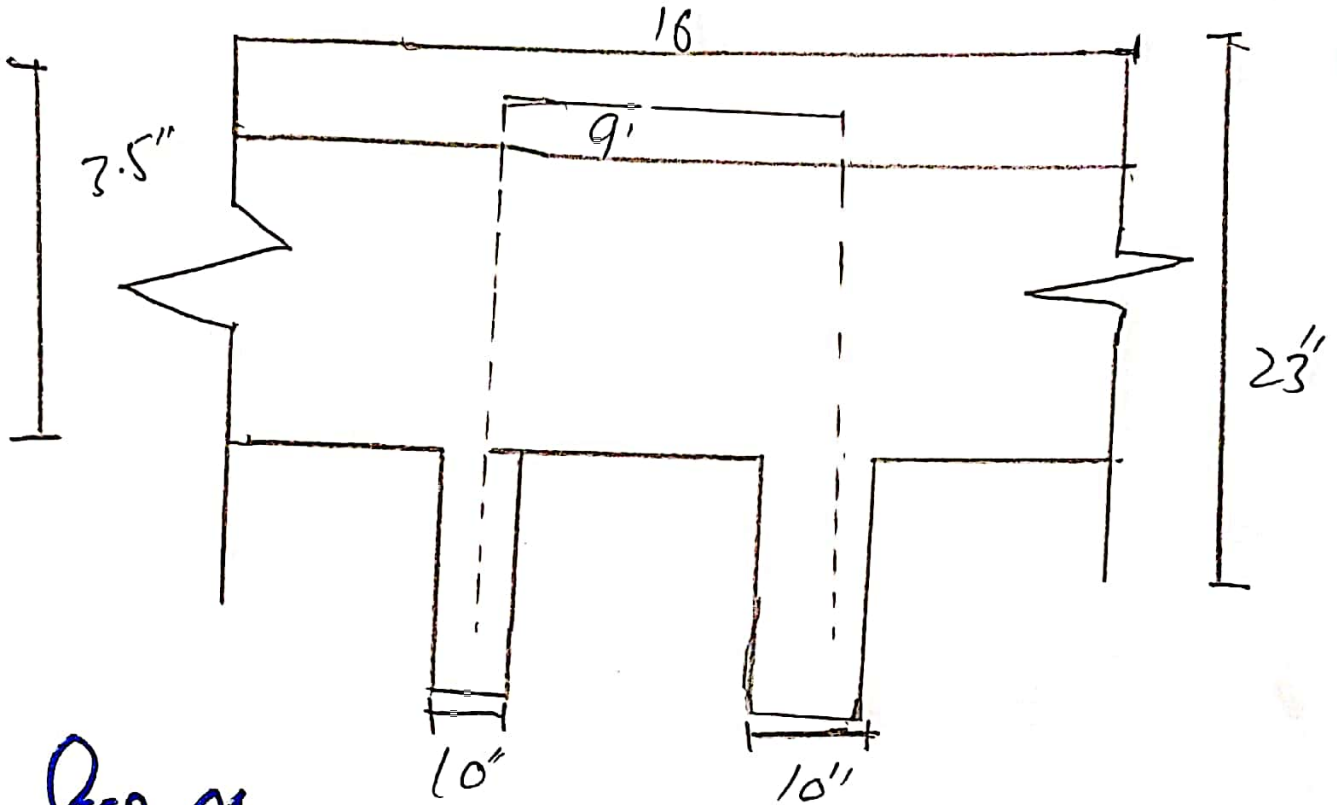
$$M_d = \phi \times [A_{sx} f_y \times (d - h_f/2)$$

$$+ (A_s - A_{st}) \times f_y \times (d - a/2)]$$



Q.5 A floor consists of 3.5" concrete slab supported by 16 simple spans spaced at 9' c/c, the beam having a web width of 10" and effective

depth of 18" and total height is 23"
 Calculate the necessary flexural reinforcement
 + applied moment is 5800 k-in use f_c'
 = 3ksi and f_y 60ksi



STEP 01:

Calculate the effective width (b_e)
 for T beam -

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

$$2 - \text{etc distance} = 9 \times 12 = 108''$$

$$3 - \text{span} / 4 = 16 / 4 \times 12 = 48''$$

Selecting the last value of $b_e = 48''$

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

TRIAL # 1

$$\text{let } a = hf = 3.5''$$

$$A_s = \frac{m_u}{\rho \times f_y \times (d - a/2)} = \frac{5800}{0.9 \times 60 \times (18 - 3.5/2)} = 6.6 \text{ in}^2$$

Trial # 2

$$A = \frac{AST \times fy}{0.85 \times fc \times be} = \frac{6.61 \times 60}{0.85 \times 3 \times 48} = 3.26$$

$$AST = \frac{MU}{\phi \times b \times (d - g/2)} = \frac{5800}{0.90 \times 60 \times (18 - \frac{3.24}{2})} = 6.56 \text{ in}^2$$

Trial # 3

$$A = \frac{AST \times fy}{0.85 \times fc \times be} = \frac{6.56 \times 60}{0.85 \times 3 \times 48} = 3.21 \text{ in}^2$$

$$AST = \frac{MU}{\phi \times fy \times (d - g/2)} = \frac{5800}{0.90 \times 60 \times (18 - \frac{3.21}{2})} = 6.58 \text{ in}^2$$

thus rectangular beam analysis is required

STEP 03: Check $f_{max} \leq f_{min}$

$$f_{max} = 0.85 \times \beta \times \frac{fc}{fy} \times \left(\frac{\epsilon_u}{\epsilon_u - \epsilon_t} \right)$$

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

$$= 0.014$$

$$f_{min} = \frac{200}{fy} = \frac{200}{8000} = 0.003$$

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

thus the value of $f_{max} \leq f_{min}$ so we have to

$$f_{min} < f < f_{max}$$

calculate AST again

$$0.003 < 0.036 < 0.014$$

$$AST = f_{max} \times b \times d$$

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

$$AST = 2.52 \text{ in}^2$$

STEP 04: Selection and No of Bars.

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

By Formula:-

$$Area = \pi/4 (1)^2 = 0.785 in^2$$

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

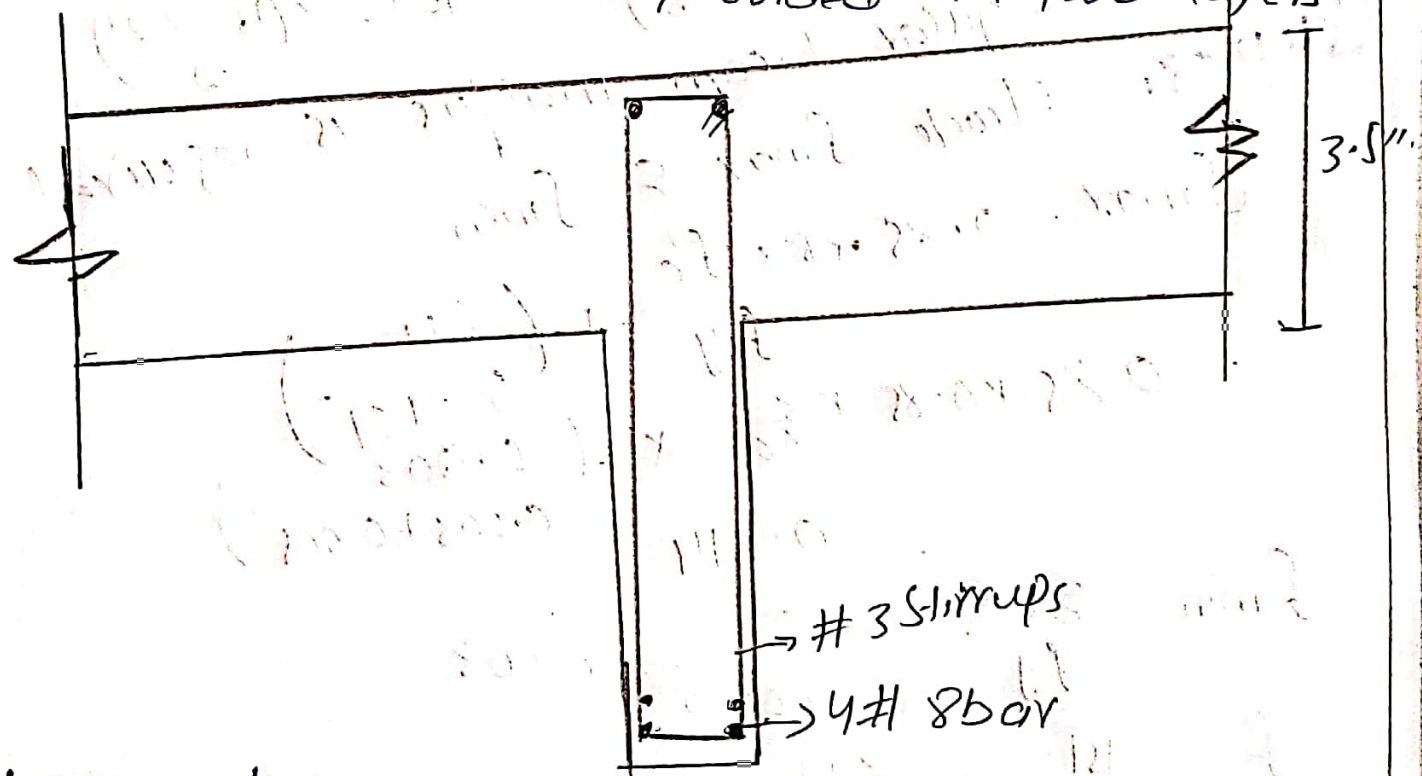
STEP 05:

Check on minimum width

$$b_{min} (2 \times 1.5) + (2 \times 3/8) + (4 \times 3/8) + 3 (8/8) = 10.75"$$

As 10.75" > 10"

So it should be provided in two layers.



STEP 06: design moment 100

By using Formula

$$M_d = \phi \times f_y \times AST (d - a/2)$$

$$\therefore AST \Rightarrow No\ of\ bars \times Area\ of\ single\ bar$$

$$= 4 \times 0.785$$

$$= 3.14 in^2$$

$$a = \frac{A_{st} \times f_y}{0.85 \times f_{ck} \times b} = \frac{3.14 \times 60}{0.85 \times 3 \times 14} = 1.54$$

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

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

$2921.52 < 5800$ thus design is ok!

Q. A beam is revised to developed and ultimate moment of 6000 k-m limited to 14 x 26 inch size use f_c is 4ksi and f_y is 60ksi. Determine flexural reinforcement and effective depth of beam is 22".

Breadth = 14"

Height = 26"

concrete compression strength (f_c) = 4ksi

$f_y = 60$ ksi

MU = 6000 k-in

$d = 22$ "

Assume $d' = 2.5$ "

Step 01: Reinforcement Ratio

$$f_{max} = 0.85 \times \beta \frac{f_c}{f_y} \times \left(\frac{\epsilon_u}{\epsilon_u + \epsilon_y} \right)$$

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

$$f_{max} = 0.0180$$

Step 02: Area of Steel

As we know that

$$f_{max} = \frac{A_{st}}{b \times d} \Rightarrow A_{st} = f_{max} \times b \times d$$

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

Area 5.54 in²

15
Step 03 : Design Moment
Using Formula

$$M_{u2} = \phi \times A_s \bar{t} \times f_y \times (d - a/2)$$

$$a = \frac{A_s \bar{t} \times f_y}{0.85 \times f'_c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = 6.48''$$

$$M_{u2} = 5537.4 \text{ k-in}$$

As $5537.4 < 6000$

So we have to design a section as double reinforcement beam

Step 04: Difference in moment.

$$M_{u1} = M_u - M_{u2}$$
$$= 6000 - 5537.4$$

$$M_{u1} = 462.6 \text{ k-in}$$

Step 05: Area of Steel

$$M_{u1} = \phi \times A_s \bar{t} \times f_y \times (d - d')$$

So Area of Steel in compression zone will be

$$A_s \bar{t} = \frac{M_{u1}}{\phi \times f_y \times (d - d')} = \frac{462.6}{0.9 \times 60 \times (22 - 2.5)} = 0.44 \text{ in}^2$$

Step 06: Selection and No of bars used.

Steel and tension zone

We use #7 bar.

$$\text{dia } (7/8) = 0.875'', \text{ Area } \pi/4 (0.875)^2 = 0.60 \text{ in}^2$$

So, No of bars in compression

$$= \frac{A_s}{A_b} = \frac{5.93}{0.601} = 9.9 \approx 10 \text{ bar}$$

So, 10 #7 bars.

2 - Steel in Compression Zone.

Let's use # 5 bar

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

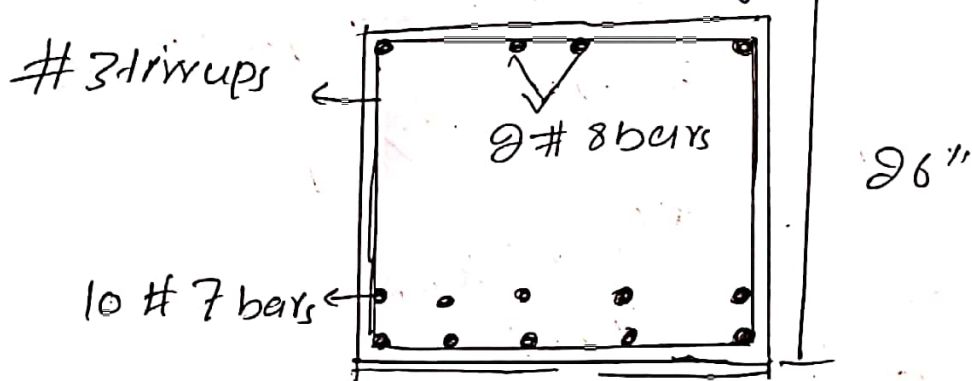
No of bars = $\frac{A_s}{A_b} = \frac{0.44}{0.306} = 1.43 \approx 2 \text{ Bars}$

So 2 # 5 bars.

STEP 08: Minimum width of beam

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

So not good in one layer



Now,

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

$$= 22.88''$$

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

$$= 2.18''$$

Step 09:

Design Moment.

$$M_d \phi \times [A_{s1} \times f_y \times (d-d') + (A_{s1} - A_{s1}) \times f_y \times (d - a/2)]$$

$$a = \frac{(A_{s1} - A_{s1}) \times f_y}{0.85 \times f_c' \times b} = \frac{(10 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14}$$

$$a = 6.80''$$

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

$$M_d = 7047.6 \text{ k-in.}$$

$$A_s = 7047.6 > 8000$$

Design is ok!