ASSIGNMENT

SUBJECT : PRCD 1

SECTION : B

MODULE : 6th

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QUESTION 01

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

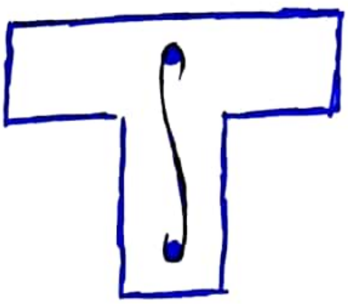
STIRRUPS:

Stirrups are used to resist lateral shear stress and diagonal tension stress in RCC structure. Thus stirrups help to prevent buckling failure in columns.

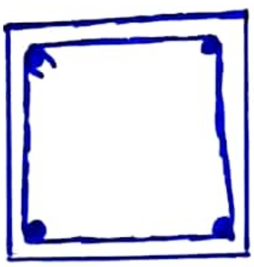
TYPES OF STIRRUPS :

Depending upon the nature of construction, the different types of stirrups used in beam and columns are as below.

1. Single Legged:



2. Two legged :



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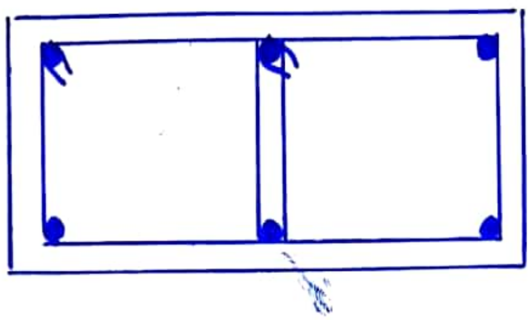
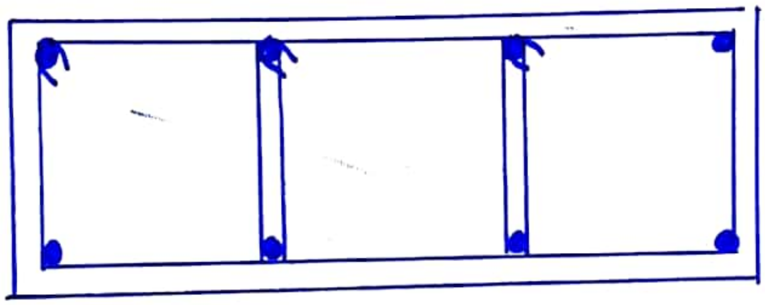
3. Four Legged:



4. Six Legged:



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ACI code Provisions For Shear Design :

→ Critical Section is at a distance "d" from the face of support.

a - Shear Strength Capacity of Concrete = V_c =

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

* V_u = Total factored shear force applied at a given Section

b - Minimum Web Reinforcement :

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

→ $Av_{min} = 0.75 \times \sqrt{f'c} \times \dfrac{b_w \times S}{f_y}$ OR $Av_{min} = \dfrac{50 \times b_w \times S}{f_y}$.

Also from these two formulas, you can find Max-Spacing.

→ $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'c} \times b_w}$ OR $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w}$.

→ If $V_u < \frac{1}{2} \times \phi \times V_c$ → then no web reinforcement is needed

→ First stirrup is provided at a distance $S/2$

→ shear at critical section is represented by "V_u"

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$\frac{1}{8}$ V_u & $\frac{1}{2}$

→ B/w critical section "Vu" and 'ϕV_c", spacing b/w web reinforcement can be ~~found~~ find by the following formula

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

→ Preferably S<4" because of proper compaction, vibration and pouring of concrete etc.

→ V_s = Shear force carried by web reinf/stirrups.
According to ACI code.

If $V_s \leq 4 \times \sqrt{f'c} \times b_w \times d$, Then max spacing of stirrup will be smallest of the following four conditions.

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 $V_s > 4 \times \sqrt{f'c} \times b_w \times d$ → Then 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 increases.

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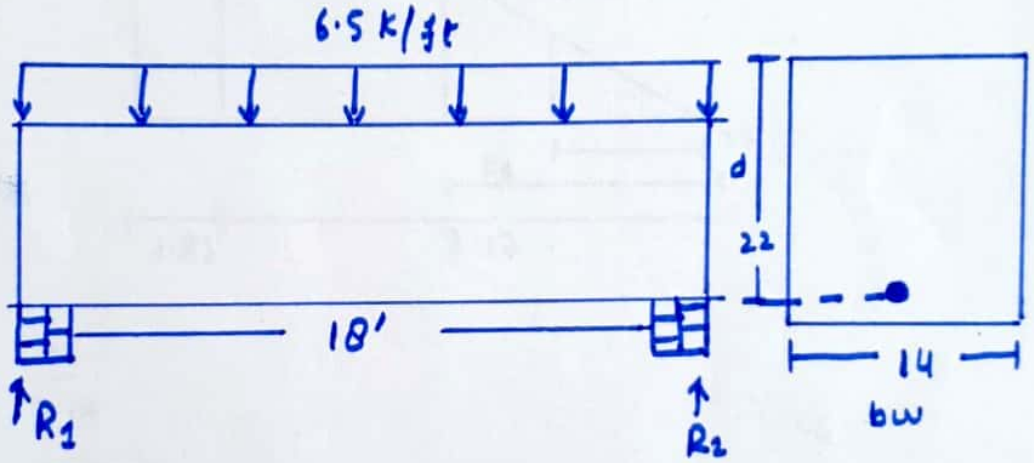
QUESTION 02

A simply supported beam 14 inch wide having an effective depth 22 inch to carry a lateral load of 65 K/ft on a 18 feet simple span. It is reinforced with 7 inch^2 of tensile steel area. If f'c is 4 ksi and fy is 60 ksi then design the beam for shear.

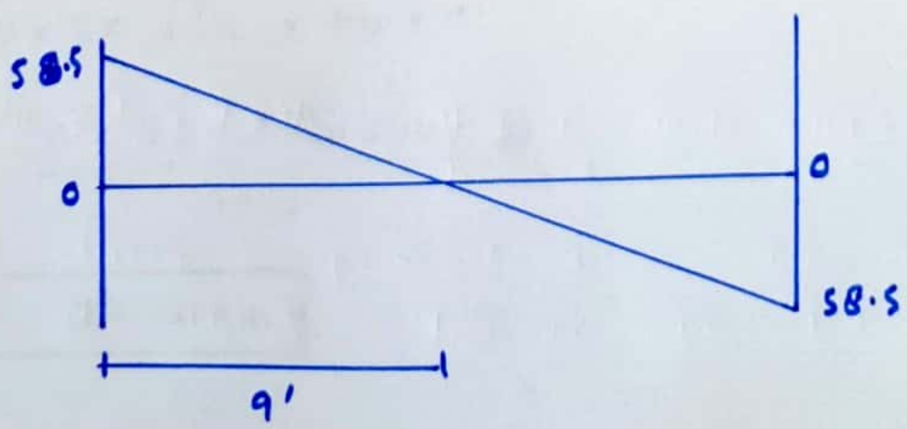
SOLUTION:



STEP 01: Find values of R_1 and R_2

Total load $= 6.5\ K/ft = \frac{6.5 \times 18}{2} = 58.5$

STEP 02: Draw shear force diagram.



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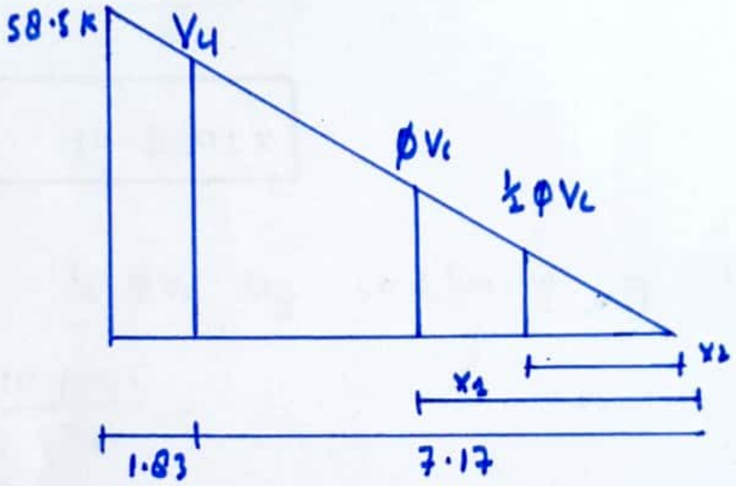
STEP 03 : Find the value of critical shear V_u and it location.

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

Value of critical shear at distance 'd' by similarity of triangles.



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

$$\boxed{V_u = 46.605}$$

STEP 04 Find the value of ϕV_c and $\frac{1}{2}\phi V_c$ and also its distance from zero shear to right side

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

$$= \frac{0.75 \times 2 \times \sqrt{4000} \times 14 \times 22}{1000}$$

$$\boxed{\phi V_c = 29.219 \text{ k}}$$

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⇒ Location of ϕV_c by similarity of triangles

$$\frac{58.5}{9} = \frac{29.219}{x_1}$$

$$\boxed{x_1 = 4.495'}$$

Now

$$\frac{1}{2}\phi V_c = \frac{29.219}{2}$$

$$\boxed{\frac{1}{2}\phi V_c = 14.6095K}$$

Location of $\frac{1}{2}\phi V_c$ by similarity of triangles

$$\frac{58.5}{9} = \frac{14.6095}{x_2}$$

$$\boxed{x_2 = 2.247'}$$

STEP 05 **Value of ϕV_s**

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

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

$$= 46.605 - 29.219$$

$$\boxed{\phi V_s = 17.386}$$

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STEP 06 Check on Section adequency

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

$$= \frac{0.75 \times 8 \times \sqrt{4000} \times 14 \times 22}{1000}$$

$$= 116.87$$

$\phi V_s < \phi\, 8 \sqrt{f'c}\, bw\, d.$

It means section is adequate.

STEP 07 Check on maximum Spacing for Stirrups.

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

$$= \frac{0.75 \times 4 \times \sqrt{4000} \times 14 \times 22}{1000}$$

$$= 58.438k$$

As $\phi 4 \sqrt{f'c}\, bw\, d > \phi V_s$

So Max Spacing will be selected from following four conditions. using # 3, 2 legged stirrup.

1. $S_{max} = 24''$
2. $d/2 = 22/2 = 11''$
3. $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

$$= \frac{0.22 \times 60000}{0.75 \sqrt{4000} \times 14} = 19.877''$$

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4. $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

$= \frac{0.22 \times 60000}{50 \times 14}$

$= 18.857''$

From above 4 conditions, least value of spacing for # 3, 2 legged stirrup will be selected.

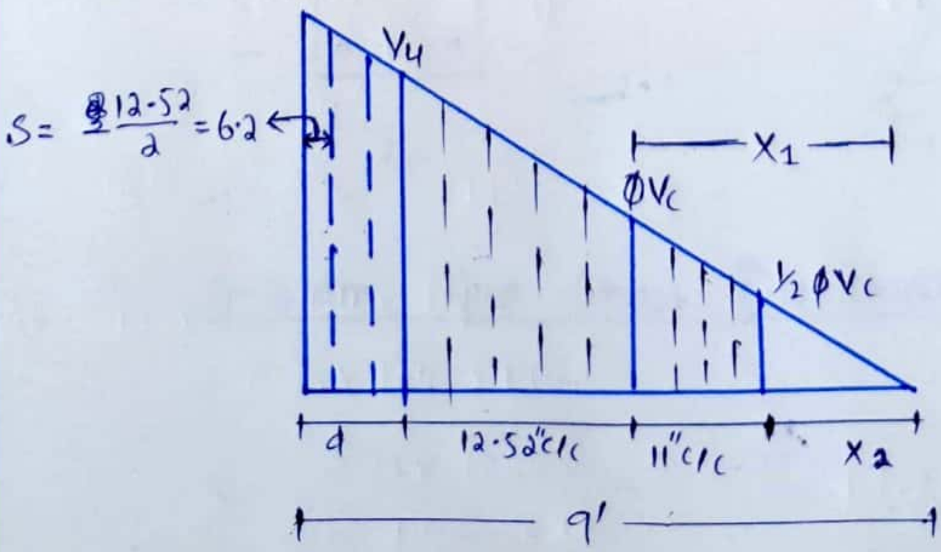
Step 08 Spacing of stirrup from central Section

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

$= \frac{0.75 \times 0.22 \times 60000 \times 22}{46.605 - 29.219}$

$S = 12.52$ c/c

Step 09 Final Sketch.



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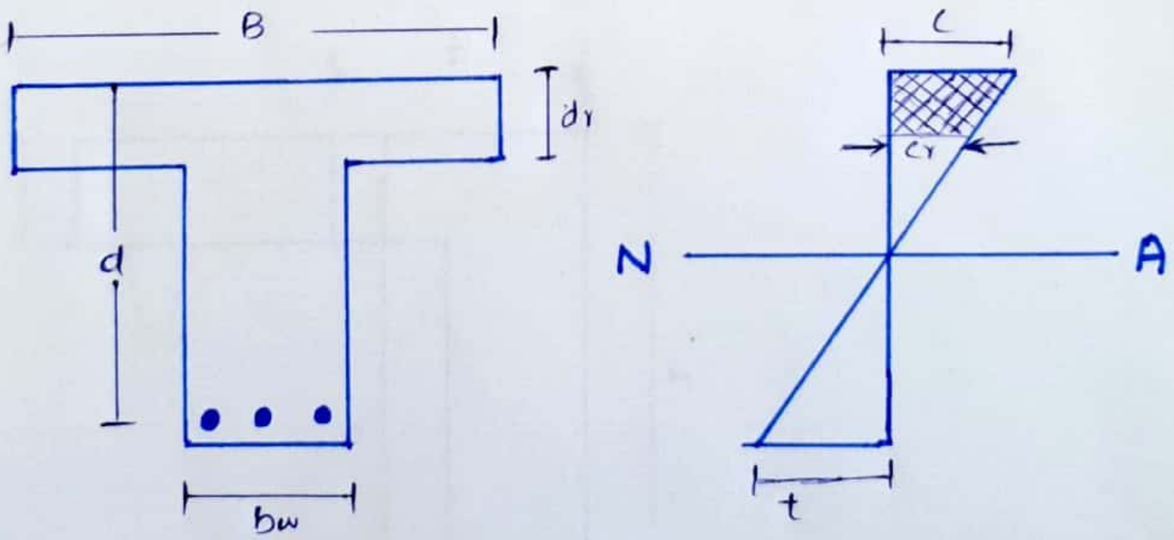
QUESTION 03

Define both T-Beam and L-Beam with the help of diagram. Also explain Flexural Strength analysis for T-Beam.

T-BEAM:

The beam consists of a flange and a rib in the form of a T, generally made of RC concrete or metal is known as T-Beam.

- The top part of the slab which acts along the beam to resist the compressive stress is called flange. The part which lies below the slab and resists the shear stress is called rib



T-Beam And Stress Distribution Diagram.

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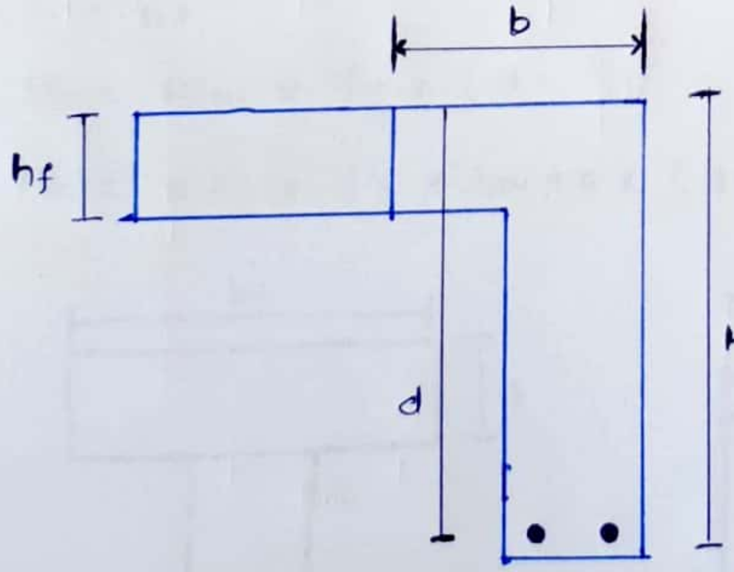
L - Beam :

The end beams which have slabs on one side only, acts as L-Beam. In most of the reinforced concrete structures, concrete slabs are cast monolithic. In a floor consisting of several beams where are the beam cast monolithically with the slab, the intermediate beam act as T-Beam whereas the beams at top of the cornors of the walls or beams around staircase or lift openings are called L-Beams. Thus T-Beams and L-Beams from a part of the floor system together with slab. L-Beams are typical floor beams because of the reduced overall structural depth, the beams are in prestressed or reinforced concrete.



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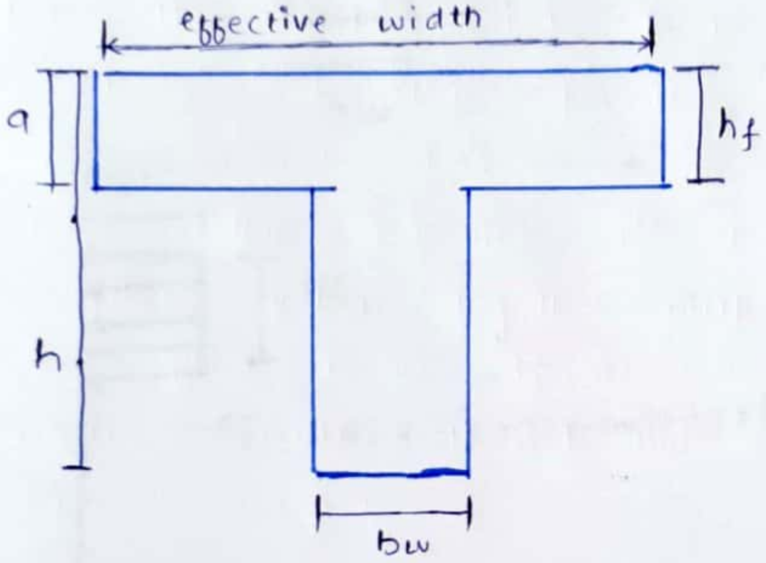
Flexural Strength Analysis For T-Beam:

There are two cases in T-Beam analysis which are as follow:

CASE 01

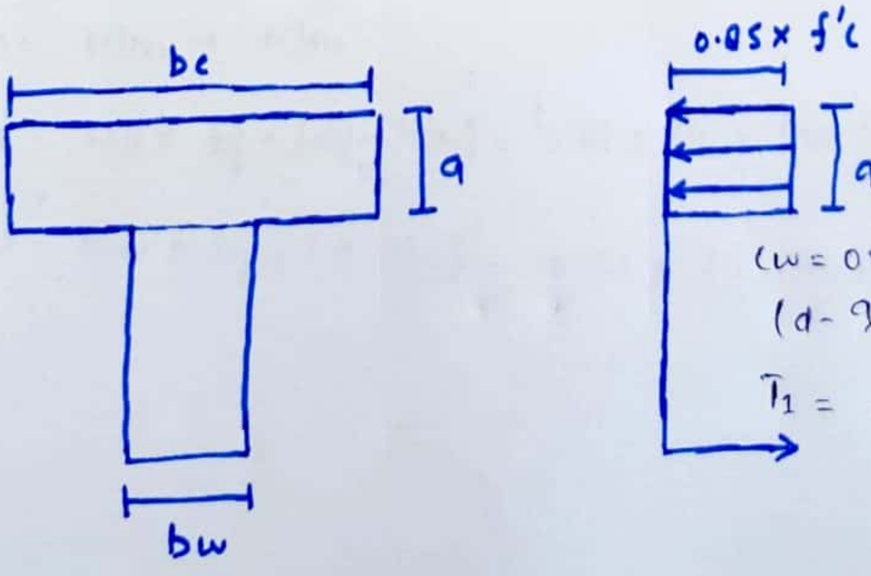
$a \leq h_f$



$b = b_e$

$M_n = A_{sw} \times f_y \times (d - \frac{a}{2})$

$M_n = 0.85 \times f'_c \times b_w \times a \times (d - a/2)$



$C_w = 0.85 \times f'_c \times b_w \times a$

$(d - a/2)$

$T_1 = A_{sw} \times f_y = (A_s - A_{sf}) \times f_y$

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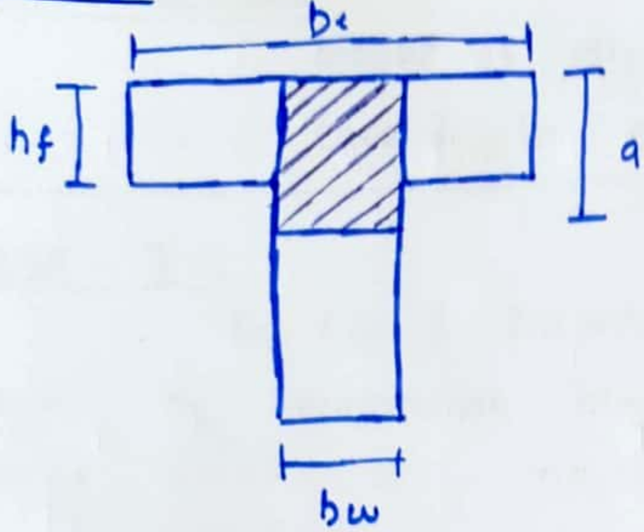
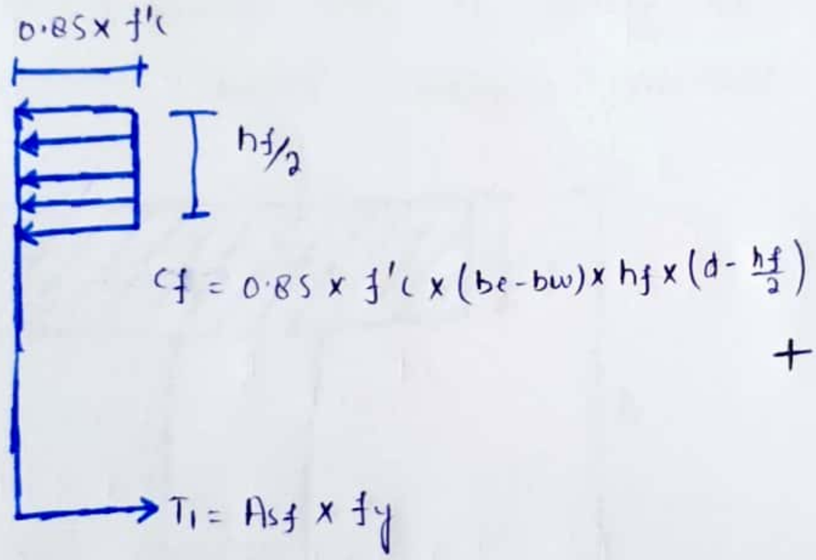
CASE 02: $a > h_f$





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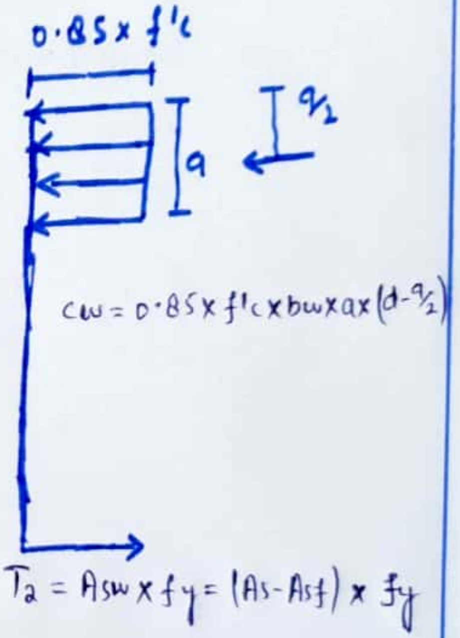

Total Tensile steel Area $= A_s = A_{sf} + A_{sw}$

$$M_n = M_{n1} + M_{n2}$$

$$M_{n1} = A_{sf} \times f_y \times (d - h_f/2) = 0.85 \times f'_c \times (b_e - b_w) \times h_f \times (d - h_f/2)$$

$$M_{n2} = A_{sw} \times f_y \times (d - a/2) = 0.85 \times f'_c \times b_w \times a \times (d - a/2)$$

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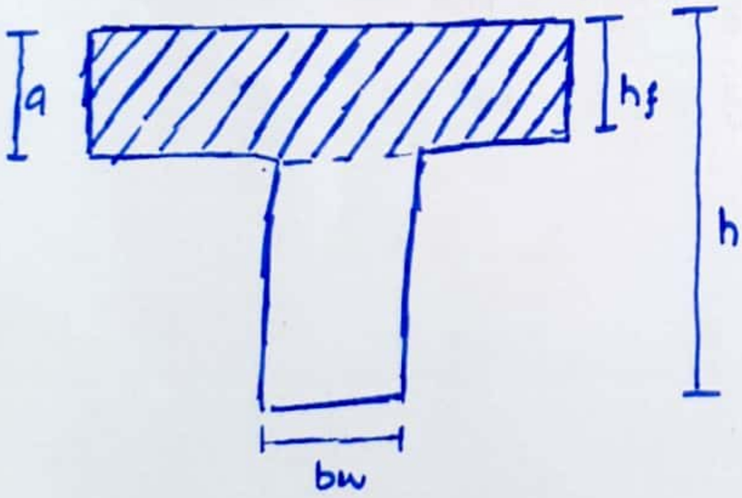
QUESTION 04

What is difference b/w Case 1 and Case 2 in design of T-Beam.

CASE - I :

In Case I ($a \leq hf$), which shows that the height of compression block is less then or upto flange level. Its indication is that the beam is rectangular and it will be analysed by rectangular beam analysis method.



CASE II :

In Case II ($a > hf$), which shows that the height of compression block is more then the flange level and it indicates that the beam will be analysed by T-Beam analysis method.

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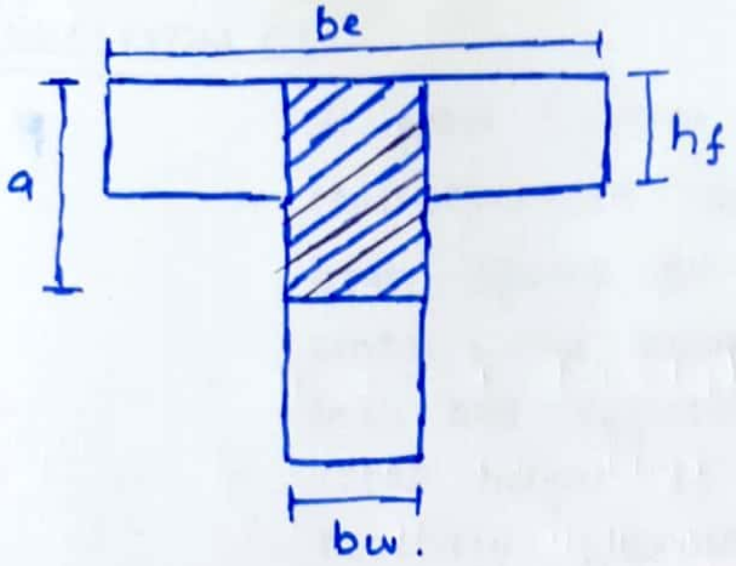

Moment $M_n = M_{n1} + M_{n2}$

$$M_{n1} = A_{sf} \times f_y \times \left(d_y - \frac{h_f}{2}\right)$$

$$M_{n2} = A_{sw} \times f_y \times (d - a/2)$$

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QUESTION 05

A floor System consist of 3.5 inch concrete slab support by 16 feet simple beam spaced at 9 feet centers to center, the beam have a web width of 10 inch and effective depth of 18 inch and total height is 23 inch Calculate the necessory flexural reinforcement if the factored applied moment is 5800 k-inch use f'c 3 ksi and fy 60 ksi

GIVEN DATA:

$f'c = 3ksi$, $fy = 60$ ksi

factored Moment = 5800 k-inch = 5.8 k/ft.

STEP 01 Calculate effective width "be"

1. $16 \times h_f + b_w = 16 \times 3.5 + 10 = 66''$
2. c/c distance $= 9 \times 12 = 108''$
3. Span/4 $= 16/4 \times 12 = 48''$

$be = 48''$

STEP 02 Check whether Rectangular or T-Beam Analysis is Required.

Trail 01: Let $a = h_f = 3.5''$

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

$$= \frac{5800}{0.90 \times 60 \times (18 - \frac{3.5}{2})}$$

$$= 6.609$$

TRAIL 02:

$$a = \frac{A_s \times f_y}{0.85 \times f'c \times be} = \frac{6.609 \times 60}{0.85 \times 3 \times 48} = 3.23$$

$$A_{st} = \frac{5800}{0.90 \times 60 \times (18 - \frac{3.23}{2})}$$

$$= ~~3.21~~ \ 6.55$$

TRAIL 03:

$$a = \frac{6.55 \times 60}{0.85 \times 3 \times 48} = 3.21$$

$$A_{st} = \frac{5800}{0.90 \times 60 (18 - \frac{3.21}{2})} = 6.55$$

STEP 03 **Check ρ_{max} And ρ_{min}**

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

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

$$= 0.0135$$

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$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60000} = 0.003$$

$$\rho = \frac{A_{st}}{b \times d} = \frac{6.55}{10 \times 18} = 0.03$$

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

$$0.003 < 0.03 > 0.0135$$

So

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

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

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

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

STEP 04 Design it as a Doubly Reinf. Beam.

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

For a,

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{2.34 \times 60}{0.85 \times 3 \times 10} = 5.72$$

$$M_{u2} = 0.90 \times 2.34 \times 60 \times (18 - \frac{5.72}{2})$$

$$M_{u2} = 1913.09 \text{ k''} < M_u = 5800 \text{ k''}$$

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STEP 06 Finding Value of Mu1

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

$= 5800 - 1913.09$

$= 3886.9096 \, k''$

$M_{u1} = \phi \times A'_s \times f_y \times (d - d')$

$$A'_s = \frac{3886.9096}{0.90 \times 60 \times (18 - 2.5)}$$

$A'_s = 4.643 \, in^2$

STEP 07 Total Steel Area

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

$= 2.34 + 4.643$

$A_s = 6.98 \, in^2$

STEP 08 Selection Of Bars.

A. FOR TENSION ZONE:

using bar # 10. Area $= 1.227 \, in^2$

$$\text{no of bars} = \frac{6.98}{1.227}$$

$= 5.688 \simeq 6$ # 10 bars.

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B. FOR COMPRESSION ZONE

using # 6 , Area = $0.44 in^2$

No of bars = $\frac{4.643}{0.44} = 10.55 \approx 11$ bars.

STEP 09 Check minimum width.

$b_{min} = 2 \times 1.5 + 2 \times 3/8 + 6 \times 10/8 + 5 \times 10/8$

$= 17.5'' > 10''$

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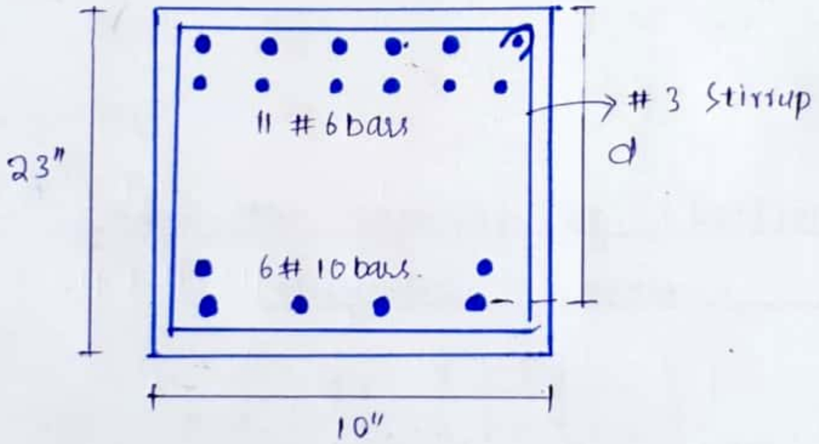

STEP 10 Design Moment.

$a = \frac{(A_s - A'_s) f_y}{0.85 \times f'_c \times b} = \frac{(6 \times 1.227 - 11 \times 0.44) \times 60}{0.85 \times 3 \times 10} = 5.934$

$M_d = 0.90 \left[(11 \times 0.44) \times 60 \times (19.625 - 3) + (6.98 - 4.643) \times 60 \times (16.658) \right]$

$M_d = 6447.316 k'' > M_u = 5800 k''$

Design is OK.

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QUESTION 06:

A beam is revised to developed and ultimate moment of 6000 k-inch's limited to 14 x 26 inch size, use f'c 4ksi and fy 60 ksi. Determine flexural reinforcement assume rows of tensile reinforcement and effective depth of beam is 22 inch.

GIVEN DATA:

$b = 14''$ $h = 26''$ $M_u = 6000$ k-inch

$f'_c = 4$ ksi $f_y = 60$ ksi $d = 22''$

Assume $d' = 2.5''$

STEP 01 Check the capacity of section as singly reinforced beam.

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

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

$$= 0.018.$$

STEP 02

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

So, $A_{st} = \rho_{max}\, b \times d$

$$= 0.018 \times 14 \times 22$$

$$A_{st} = 5.544 \text{ in}^2$$

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STEP 03

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

But first $a = \dfrac{A_{st} \times f_y}{0.85 \times f'_c \times b}$

$= \dfrac{5.544 \times 60}{0.85 \times 4 \times 14}$

$a = 6.988''$

$M_{u2} = 0.90 \times 5.544 \times 60 \times \left(22 - \dfrac{6.988}{2}\right)$

$M_{u2} = 5540.26\ k'' < 6000\ k'' = M_u$.

Design a Section as Doubly Reinforced.

STEP 04 :

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

$= 6000 - 5540.25$

$M_u = 459.74\ k''$

STEP 05 :

$M_{u1} = \phi \times A'_s \times f_y \times (d - d'$

So $A'_s = \dfrac{M_{u1}}{\phi \times f_y (d - d')}$

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$$A's = \frac{459.74}{0.90 \times 60 \times (22 - 2.5)}$$

$$A's = 0.43 \ in^2$$

STEP 06: Total Area of Steel.

A. Tension

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

$$= 5.544 + 0.43$$

$$= 5.98 \ in^2$$

This steel area should be provided in tensile ~~steel~~ zone as tension reinforced.

STEP 07 Selection Of Bars.

A. FOR TENSION STEEL

let try # 8 bar, Area = $0.785 \ in^2$

$$\text{No of bars} = \frac{A_s}{A_b} = \frac{5.98}{0.785} = 7.61$$

$$= 7.61 \approx 8 \ \# \ 8 \text{ bars}$$

B. FOR COMPRESSION STEEL:

let try # 6 bar, Area = 0.44

$$\text{No of bars} = \frac{A's}{A_b} = \frac{0.43}{0.44}$$

$$= 0.97 \approx 1 \ \# \ 6 \text{ bars}$$

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STEP 08 — Check Minimum Width

$b_{min} = 2 \times 1.5 + 2 \times \frac{3}{8} + 8 \times \frac{8}{8} + 7 \times \frac{8}{8}$

$= 18.75'' > 14''$

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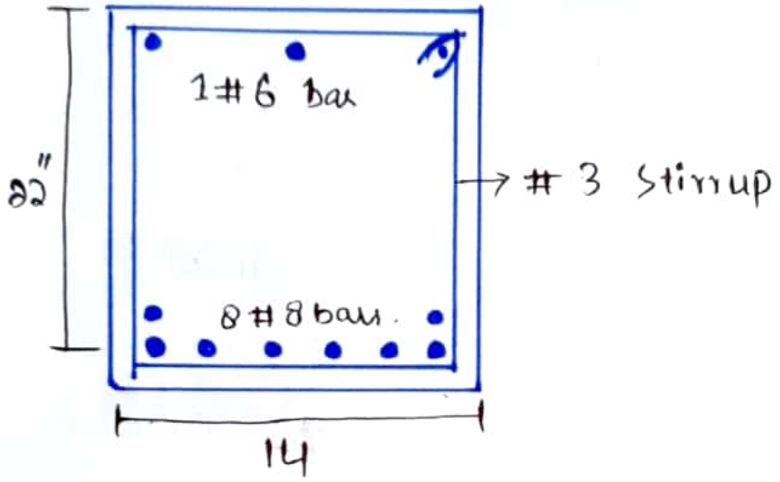

STEP 09 — DESIGN MOMENT

$M_d = \phi \left[A's \times f_y \times (d - d') + (A_s - A's) \times f_y (d - a/2) \right]$

$a = \frac{(A_s - A's) f_y}{0.85 \times f'c \times b} = \frac{(8 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 14}$

$a = 7.361''$

$M_d = 0.90 (1 \times 0.44) \times 60 \times (22 - 2.5) + (8 \times 0.785 - 1 \times 0.44) \times 60 \times \left(22 - \frac{7.361}{2}\right)$

$= 6882.47 > M_u = 6000$

Design is OK

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