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SEC: (B)

Assignment: PRCD1.

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Q1

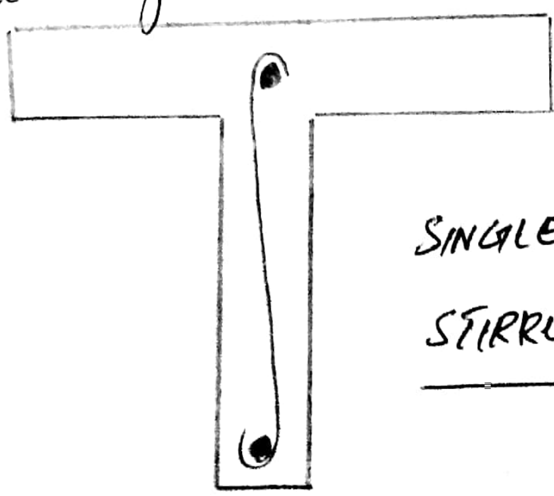
ANSWERS :

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:

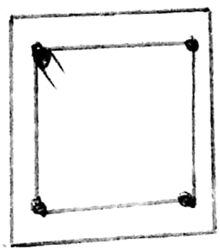
These type of stirrups are used to hold the longitudinal bars in position and prevent bucking.



SINGLE LEGGED STIRRUP.

(2) DOUBLE LEGGED STIRRUP:

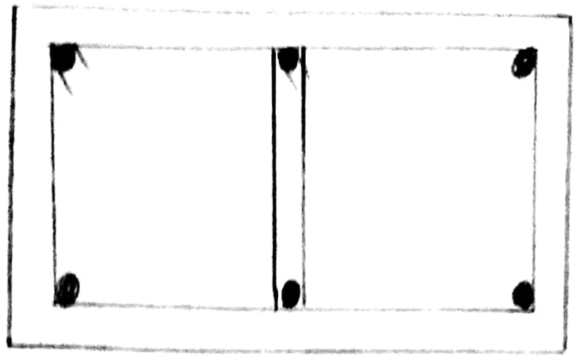
We use a single stirrup to tide a beam or a column at a time, we say it is two legged stirrup. Double legged stirrup are adequate for typical beams with relatively short width.



Two - legged stirrups.

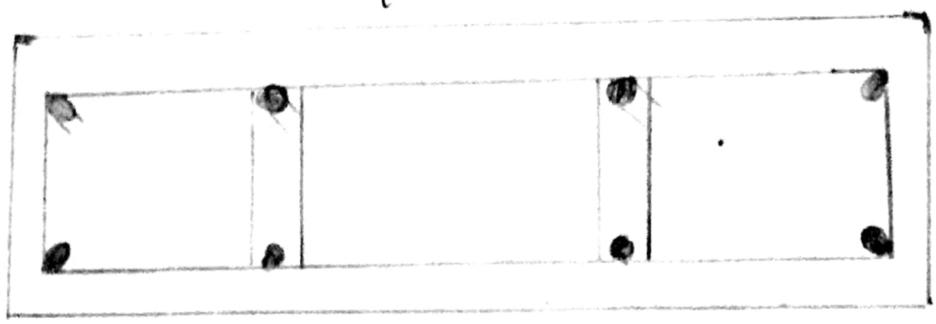
(3) FOUR LEGGED STIRRUPS:

We use double stirrups to tie a beam or column at a time we say it is four legged stirrups. For beam having longer width multiple 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 and 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.

If $V_u \leq \phi \times V_c$ so no web reinforcement needed. If it is not applicable then mini area of web reinforcement equal to:

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

→ Max spacings can be found by these formulas.

$$S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w} \quad \text{OR} \quad S_{max} = \frac{A_v \times f_y}{50 \times b_w}$$

(4) if $V_u \leq \frac{\phi V_c}{2}$, 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- $\frac{d}{2}$ 3- $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

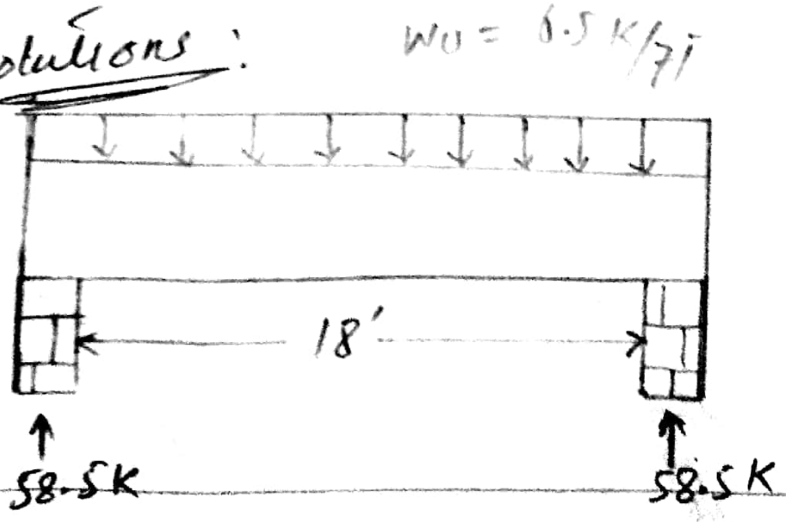
4- $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

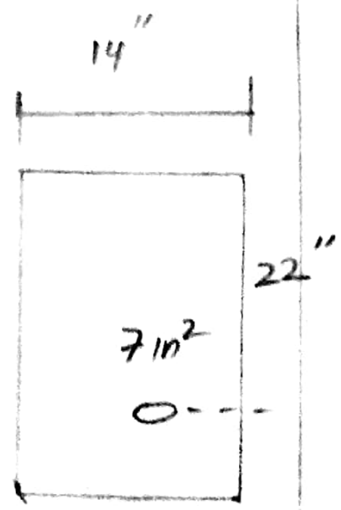
(8) If $V_s > 4 \times \sqrt{f'_c} \times b_w \times d$ → Then max spacing will be halved.

(9) If $V_s > 8 \times \sqrt{f'_c} \times b_w \times d$

Then either increase cross-sectional Dimensions or increase f'_c.

Q(2) Solutions:

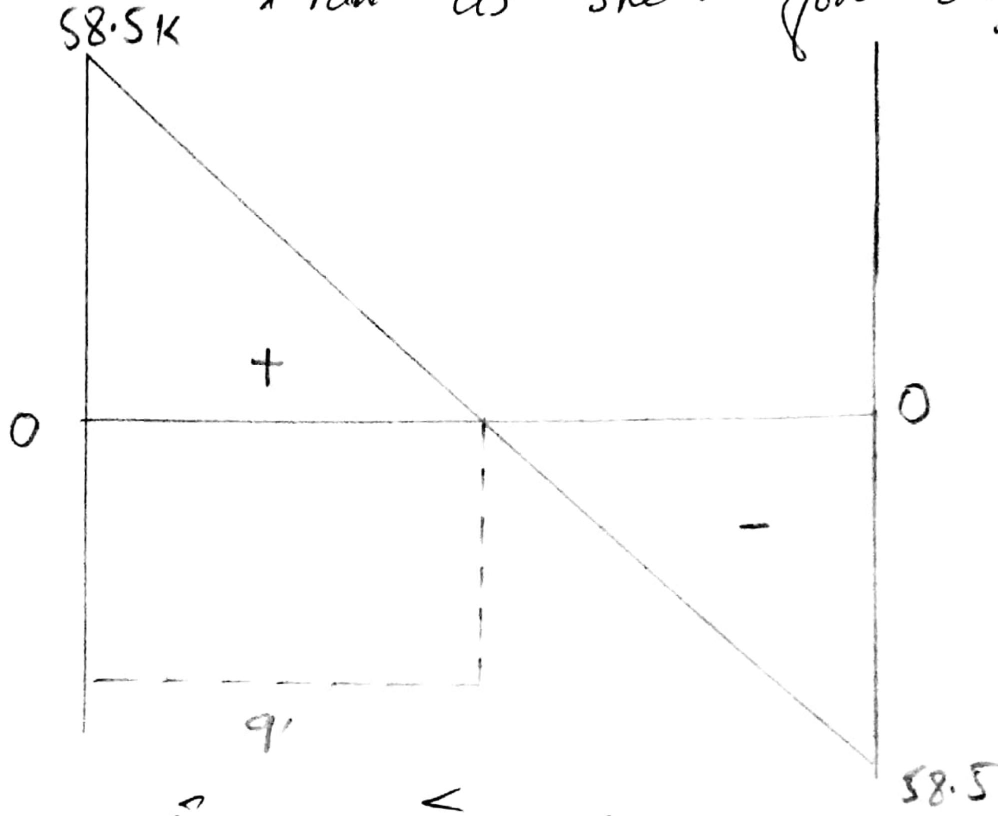




Step-01: Find The Reaction on Support

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

Steps-02: Draw its shear force Diagram



Step: 3 Finding the value of critical stress "V_u" and its locations.

As we know that critical shear is located at a distance (d) from the face of supports $d = 22'' = 1.83'$

Using Similarity of Triangles.

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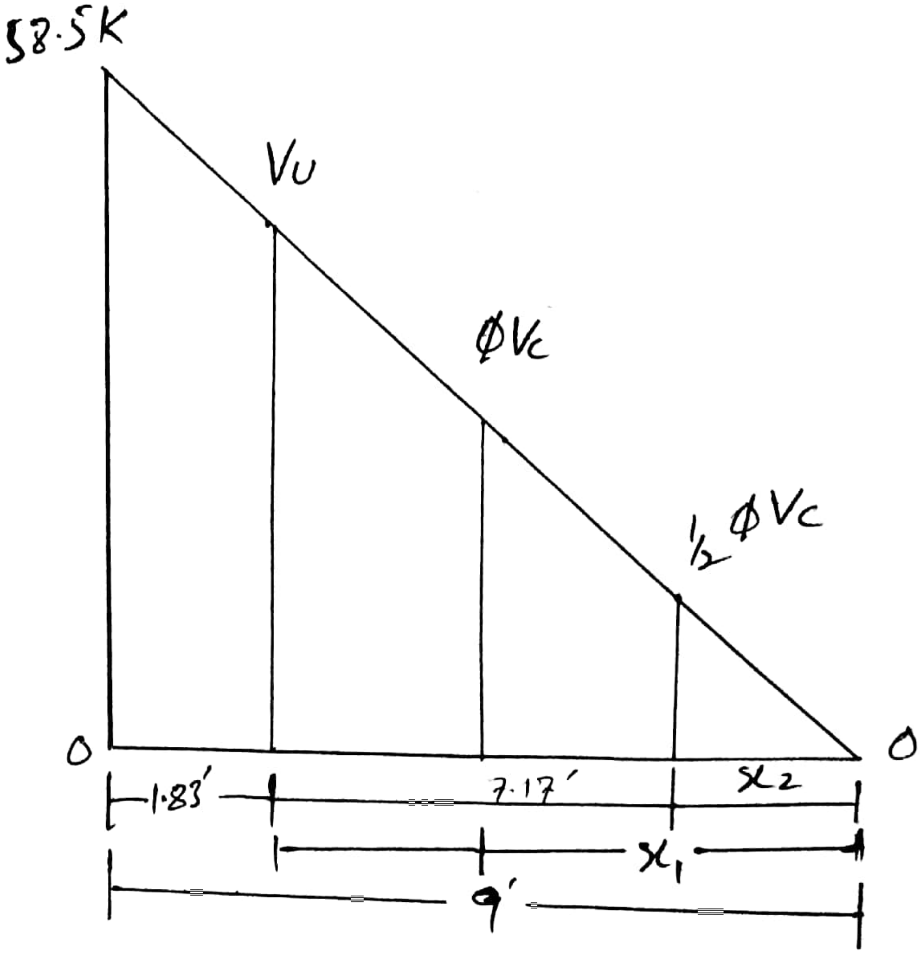


$$\frac{58.5}{9} = \frac{V_u}{7.17}$$

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

Step # 4 Finding the Value of "ϕV_c" and "$\frac{1}{2}\phi V_c$" and also its distance from zero shear to right side.

By formula,

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

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

$$= \boxed{29.21K}$$

* Location of "ϕV_c" by similar Triangles:

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

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

Now

$\rightarrow \frac{1}{2}\phi V_c = \frac{29.21}{2} = 14.60K$

$\rightarrow$ 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 section adequacy By formula.

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

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

$= 116.87K$

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

Step 07 : Check on Max spacing for stirrups

By formulas:

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

$= 58.43K$

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

So Max spacing will be selected from The following condition.

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

Let suppose ~~we~~ we use #3 stirrup,

dia $= \frac{3}{8}'' = 0.375''$

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

For 2-legged stirrup Area × 2

$= 0.11 \times 2 = 0.22\ in^2$

3- $S_{max} = \dfrac{0.22 \times 60000}{50 \times b_w} = 18.85''$

4- $S_{max} = \dfrac{0.22 \times 60000}{50 \times b_w} = 18.85''$

(5) $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w} = \dfrac{0.22 \times 60000}{50 \times 14}$

$= 19.87''$

So we choose the least value from the above values $S_{max} = 11''$

Step # 08) Stirrups spacing from/at critical section.

By formula.

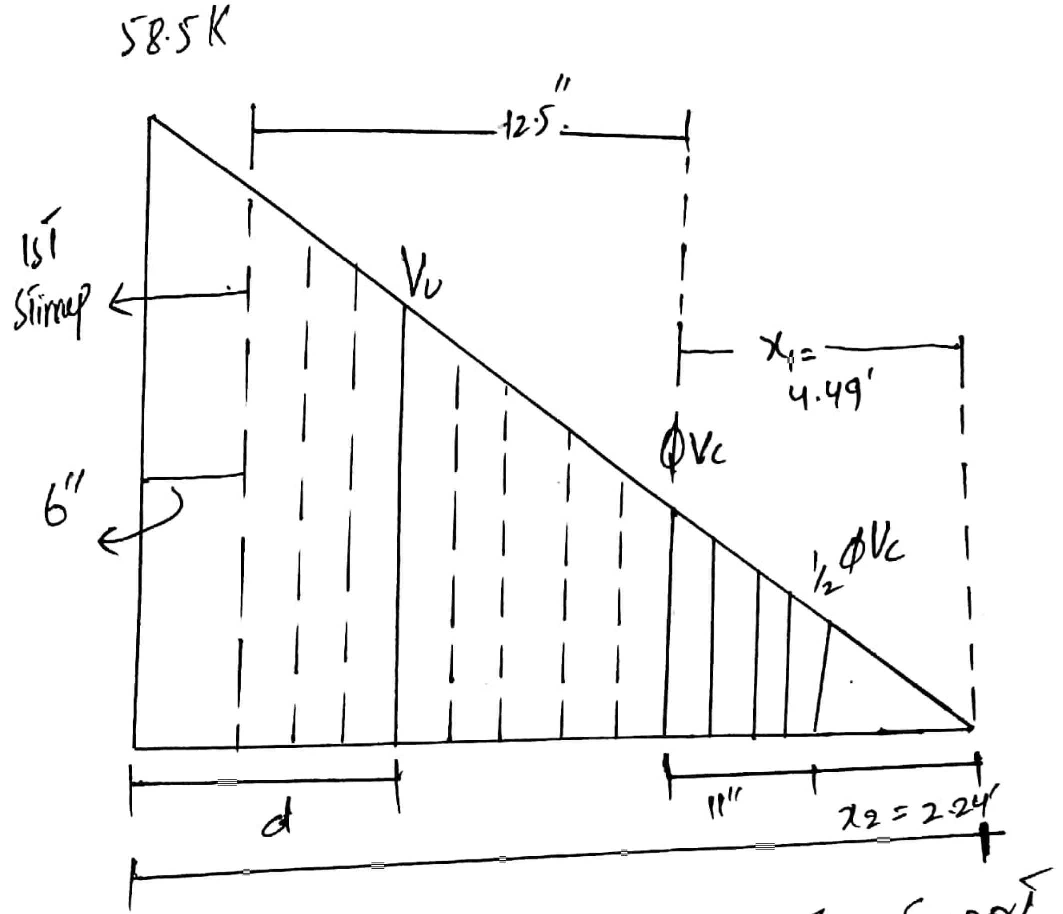
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{46.605 - 29.21}$$

$S = 12.52 \approx 12.5''$

So $12.5''$ c/c

Step# 09 Final Sketch will be.



First stirrup from face of support

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

Q(3) Definition:

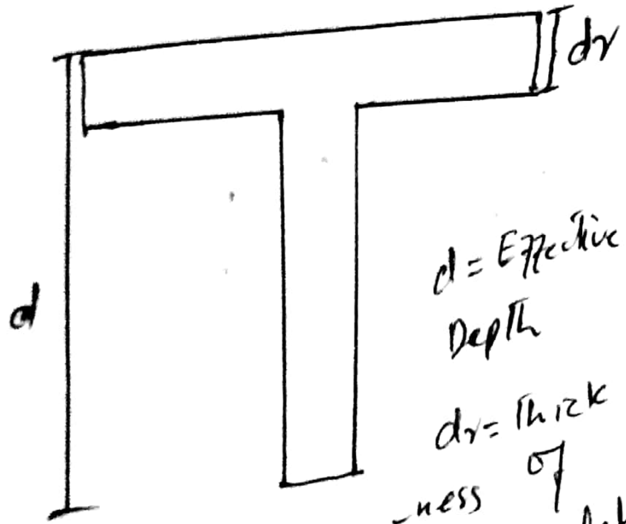
T- Beam:

It is load bearing structure of reinforced concrete, wood or metal, with

L - Beam:

A beam whose section has the form of an inverted L; usually placed so that its top flange forms parts a T-shaped cross-section

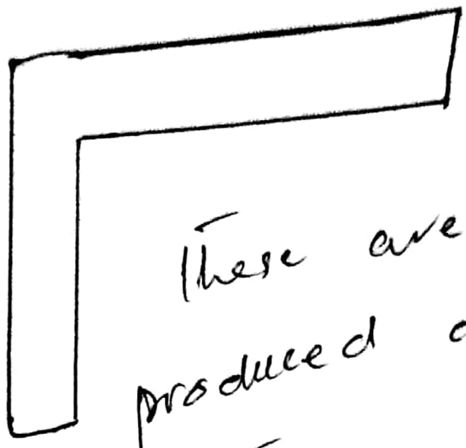
⊙ The Top of the T-shaped serves as flange or compression member in resisting compressive stresses.



d = Effective Depth

dr = Thickness of flange slab

of the edge of a floor



These are produced due to the monolithic construction of beam and slab.

FLEXURE STRENGTH ANALYSIS FOR T-BEAM.

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

$$M_u = \frac{W_u \times L^2}{8}$$

(2) Effective depth "be" for T-Beam is computed as follows.

(i) $16(hf) + bw$ (ii) c/c distance, iii Span/4

(iv) $\dfrac{CTS + bw}{2}$

Select the least values from the above values.

(3) Check wether Rectangular or T- Beams Analysis is Required.

(i) If $a > hf$ Then T- Beam analysis is required

(ii) If $a < hf$ Then Rectangular Analysis is Required.

(4) Find the Aree of steel

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

(5) Check the Range of Reinforcement ratio

P.T.O

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

$$\rho_{min} = \frac{2.00}{f_y}$$

$$\rho = \frac{A_{sT}}{b \times d}$$

Find the No of Bars. No of Bars = A_{sT} / A_b

Check min width for bars accommodation

b_{min} = 2 c.c + 2 dia of stirrup + No of bars (dia of bars) + spacing b/w bars (dia of bars)

Design Moment is Given A_s = $M_d = \phi \times f_y \times A_{sT} \times (d - a/2)$

$\Rightarrow$ If $a < h_f$

$M_d = \phi \times \left(A_s \times f_y \times \left(d - \frac{h_f}{2}\right) + (A_s - A_f) + f_y \times (d - a/2) \right)$ If $a > h_f$

(4). **Difference b/w Case-I and Case II.**

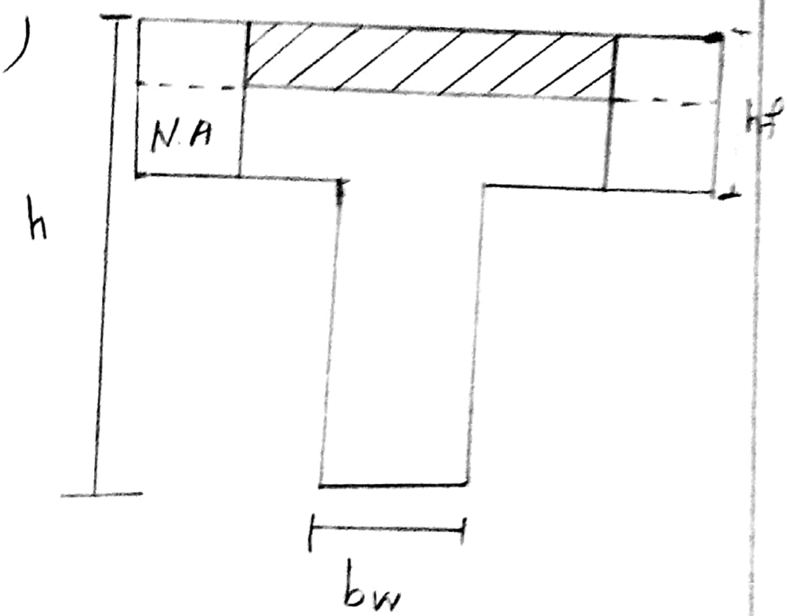
Case-(I):

From the fig $a < h_f$

So in This case, Rectangular — Beam

Analysis is Required so that the Design Moment Formula will be.

$Md = \phi \times fy \times AsT \times (d - \frac{a}{2})$



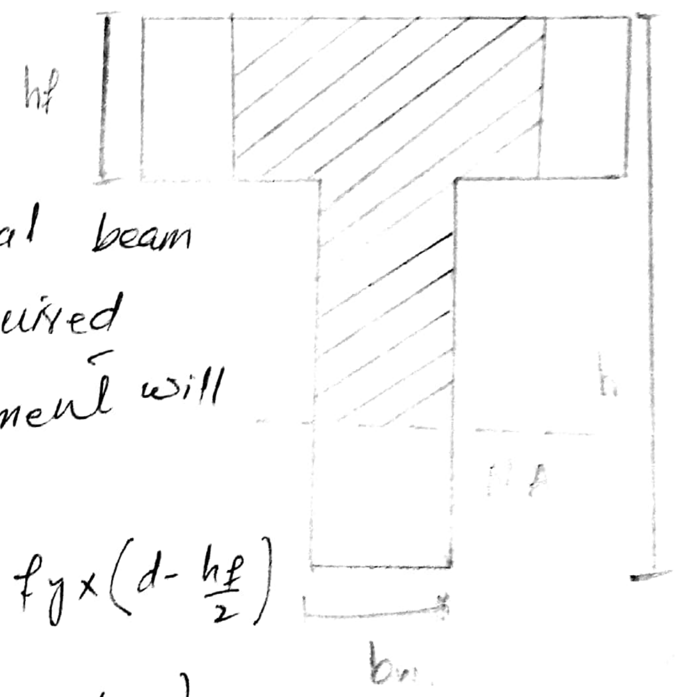
Case - II :

From the figure.

$a > hf$

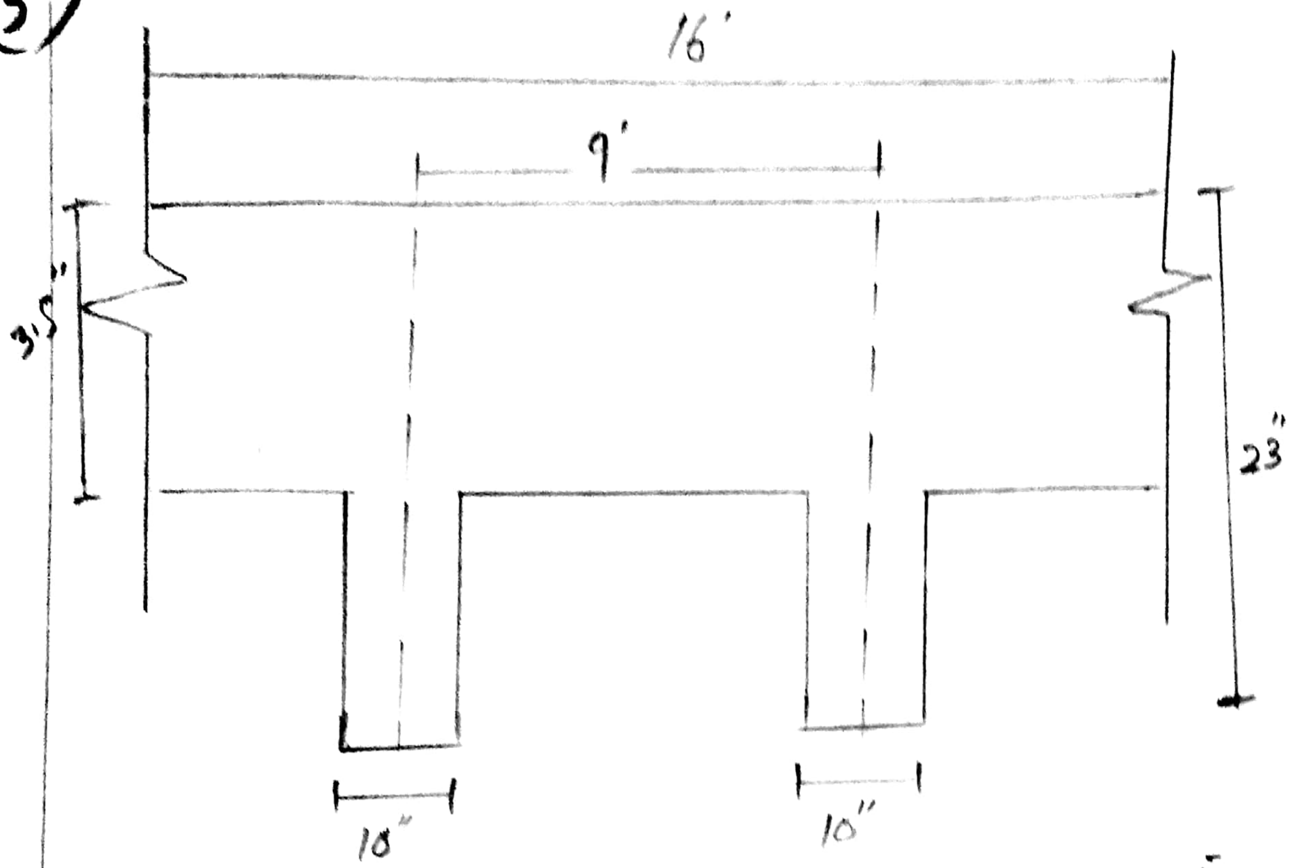
So in this special beam Analysis is required so Design moment will be

$$Md = \phi \times \left[As \times fy \times \left(d - \frac{hf}{2}\right) + As - AsT \right] + fy \times (d - a/2)$$



P.T.O

(5)



Step (01): Calculate the effective width (b_e) for T-Beam.

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

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

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

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

Step - 2: Check whether rectangular or T-Beam analysis is Required.

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

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

Trial# 2

$$a = \frac{A_{ST} \times f_y}{0.85 \times f_c' \times b_e} = \frac{6.61 \times 60}{0.85 \times 3 \times 48} = 3.24''$$

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5808}{0.90 \times 60 \times \left(18 - \frac{3.24}{2}\right)} = 6.56 \, in^2$$

Trial# 3

$$a = \frac{A_{ST} \times f_y}{0.85 \times f_c' \times b_e} = \frac{6.56 \times 60}{0.85 \times 3 \times 48} = 3.21 \, in$$

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{5800}{0.90 \times 60 \times \left(18 - \frac{3.21}{2}\right)}$$

$$= 6.56 \, in^2$$

Thus Rectangular Beam Analysis is Required

Step# 3: Check ρ_{max} and ρ_{min}.

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

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

$$= 0.014$$

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

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

Thus The value of $\rho_{max} <$ and ρ_{min} So we have to calculate Ast again.

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

$0.003 < 0.036 < 0.014$

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

$A_{st} = 0.014 \times 10 \times 18$

$A_{st} = 2.52 \text{ in}^2$

Step # 04: Selection and No of Bars

Let use # 8 Bar So dia $(8/8) = 1''$

$$Area = \frac{\pi}{4}(1)^2 = 0.785 \text{ in}^2$$

By formula

$$\text{No of Bars} = \frac{A_{st}}{A_b} = \frac{2.52}{0.785} = 3.21 \simeq 4 \text{ bars.}$$

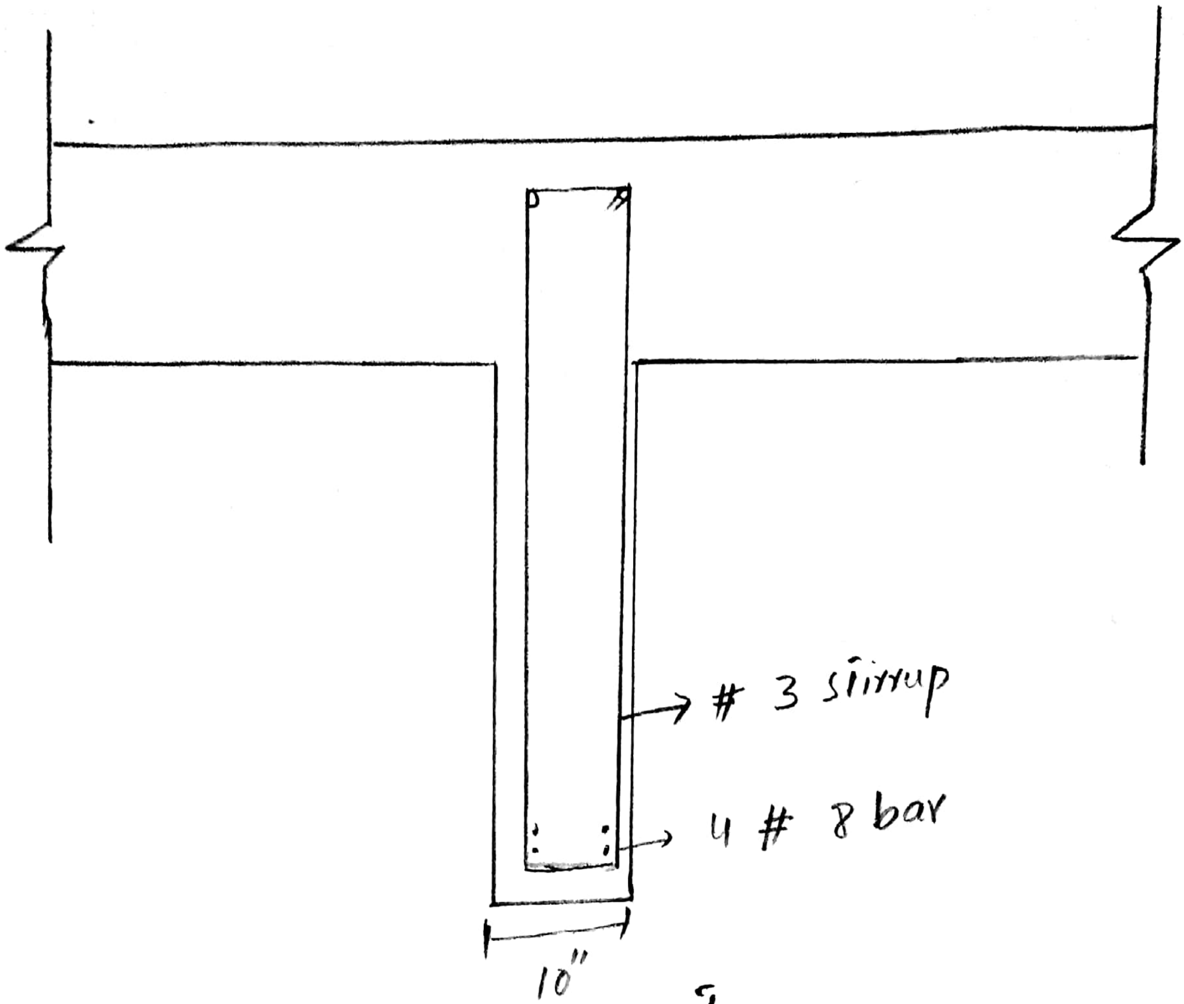
Step # 5: Check on Minimum Width.

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

$$= 10.75''$$

As $10.75'' > 10''$

So it should be provided in Two layers.



Step # 06: Design Moment

By Using formula. $Md = \phi \times f_y \times A_{ST} \times (d - \frac{a}{2})$

∴ A_{ST} ⇒ No of Bars x Area of Single Bar.

$= 4 \times 0.785 = 3.14 \; in^2$

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

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

$Md = 2921.52$ K-in

$= 2921.52 < 5800$ Thus design is OK.

(6) Given DATA:

Breadth = 14" Height = h = 26"

Concrete Compression strength (f_c') = 4ksi

f_y = 60 ksi; M_u = 6000 K-in

d = 22" Assume d' = 2.5"

Step# 1: REINFORCEMENT RATIO:

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

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

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

Step# 02 Area of steel

~~Area~~ As we know that

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

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

Area = 5.54 in^2

Step # 3 Design Moment.

Using Formula.

$$M_{u_2} = \phi \times A_{st} \times f_y \times \left(d - \frac{a}{2}\right)$$

Scanned with CamScanner

$a = \frac{Ast \times fy}{0.85 \times f_c' \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = 6.98''$

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

$Mu_2 = 5537.4 K\text{-}in$

As $5537.4 K\text{-}in < 6000$

So we have To Design a section as Doubly Reinforced Beam

step # 4 Difference in moments.

$Mu_1 = Mu - Mu_2$

$= 6000 - 5537.4$

$\boxed{Mu_2 = 462.6 K\text{-}in}$

step # 05 Area of steel

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

So Area of steel in compression zone will be ~~so~~.

$Ast = \frac{Mu_1}{\phi_1 \times fy \times (d - d')} = \frac{462.6}{0.90 \times 60 \times (22 - 2.5)}$

$= 0.44\ in^2$

Step# 06: Total steel Area.

$A_s = A_{s1} + A_{s1}'$

$= 5.54 + 0.44$

$= 5.98 in^2$

Step 07: Selection and No of Bar used.

(1) We use # 7 bar.

Dia $(7/8)'' = 0.875''$; Area $= \frac{\pi}{4}(0.875) = 0.601 in^2$

So No of Bars $= \frac{A_s}{A_b} = \frac{5.98}{0.601} = 9.9 \approx 10$ bar

So 10 # 7 bars.

(2) Steel in compression zone:

Let 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

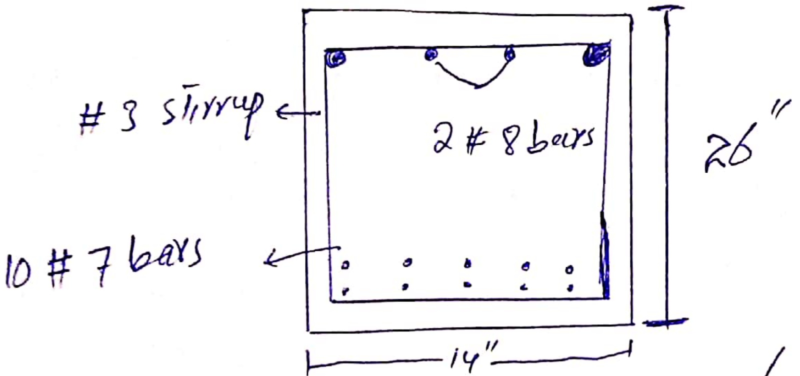
So 2 # 5 bars.

Step # 08 Minimum width of Beam:

$$b_{min} = (2\times1.5) + (2\times 3/8) + 10\,(7/8) + 9\,(7/8)$$

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

So NOT Good in one layer.



Now Effective Depth $(d) = 26 - 1.5 - 3/8 - 7/8 - \frac{1}{2}\,(7/8)$

$$= 22.82''$$

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

$$= 2.18''$$

Step # 09: Design Moment

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

$$a = \frac{(A_{st} - A'_{st}) \times f_y}{0.85 \times f'_c \times b} = \frac{(10\times0.601 - 2\times0.306)\times60}{0.85\times4\times14}$$

$a = 6.80''$

$$Md = 0.90\left[(2\times 0.306)\times 60\times(22.82-2.18)+(10\times 0.601 - 2\times 0.306)\times 60 \times \left(22.82-\frac{6.89}{2}\right)\right.$$

$Md = 7047.6$ K-in

As $7047.6 > 6000$

Design is OK!