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Section # B

Semester # 6th

Subject # P.r.c.d.1

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Assignment # 02.

(9)

Question # 01

Explain in details types of stirrups with figures and also explain ACI codes for shear design:->

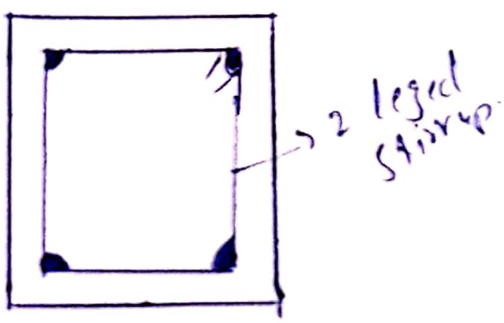
=> Ans

Stirrup :- Stirrups are closed-loop bars tied at regular intervals in beam reinforcement to holds the bars in position.

TYPES OF STIRRUPS :->

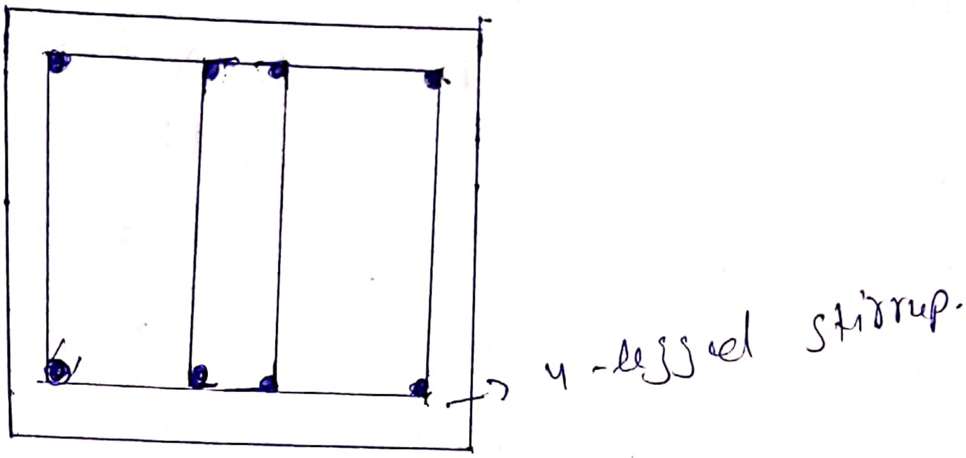
1) Single legged stirrup :-> The single-leg stirrups have rarely been used b/c they are mostly used when binding only two rods.

2) Two legged stirrup :-> It is most commonly and widly used stirrup. minimum 4 bars are required for providing this stirrup.

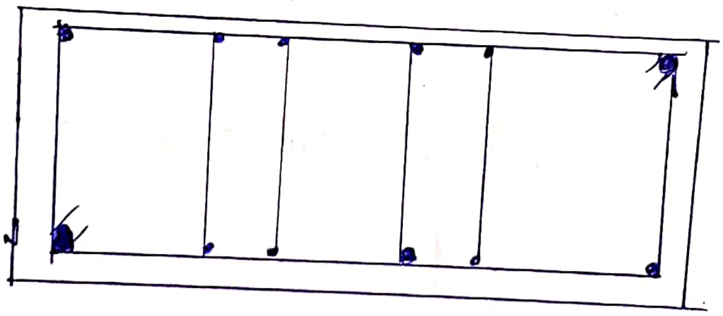


3) Four Legged stirrup :->

These stirrups are used in case of web reinforcement.



(4)-> Six leged stirrup :->



=> ACI CODES FOR SHEAR DESIGN OF A BEAM :->

According to ACI-318, following are the formulas used for the shear design of a beam.

1) Critical Section :-> critical section occurs at 45° and is at distance (d) from the force 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 $V_u \le \phi V_c$, Then Theoritically no web reinforcement is required, However ACI code require provision of atleast a minimum area of web reinforcement equal to,

$\phi = 0.75 \rightarrow$ For shear design

($\because V_u$ = total factored shear applied at a given section)

⇒ For minimum Reinforcement Area :→

$$A_{v\,min} = \frac{0.75 \sqrt{f'_c} \times b_w \times S}{f_y} \quad \text{or} \quad \frac{50 \times b_w \times S}{f_y}$$

→ [Higher value is selected]

By interchanging the above formulas, we can obtain the formula for maximum spacing.

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

→ [Lesser value is selected]

→ No web reinforcement is required if.

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

⇒ Between critical section "V_u" and "ϕV_c" spacing b/w web required reinforcement can be find by.

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

5) if $V_s \leq 4 \times \sqrt{f'_c} \times b_w \times d$, Then max spacing for stirrups will be The smallest of the following,

1 - 24"

2 - $d/2$

3 - $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

∵ V_s = shear force carried by web reinforcement)

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

⇒ If $V_s > 4 \times \sqrt{f'_c} \times b_w \times d$

max spacing will be halved.

⇒ If $V_s > 8 \times \sqrt{f'_c} \times b_w \times d$

Then either increase cross sectional dimensions or increase f'_c

QUESTION - 02

5

A simply supported rectangular beam 14" wide have an effective depth of 22" to carry a

⇒ GIVEN :

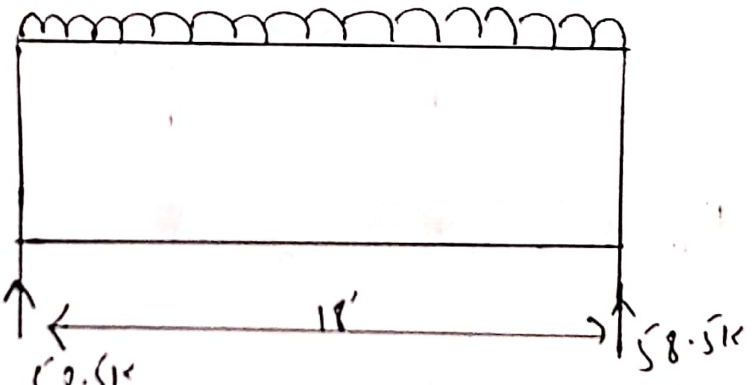
Breath of web of beam (b_w) = 14"

Effective depth di = 22"

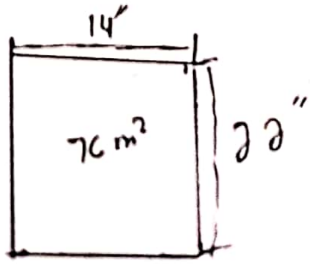
Load = 6.5 k/ft

f'_c = 4KSI

f_y = 60 KSi



Step : 02



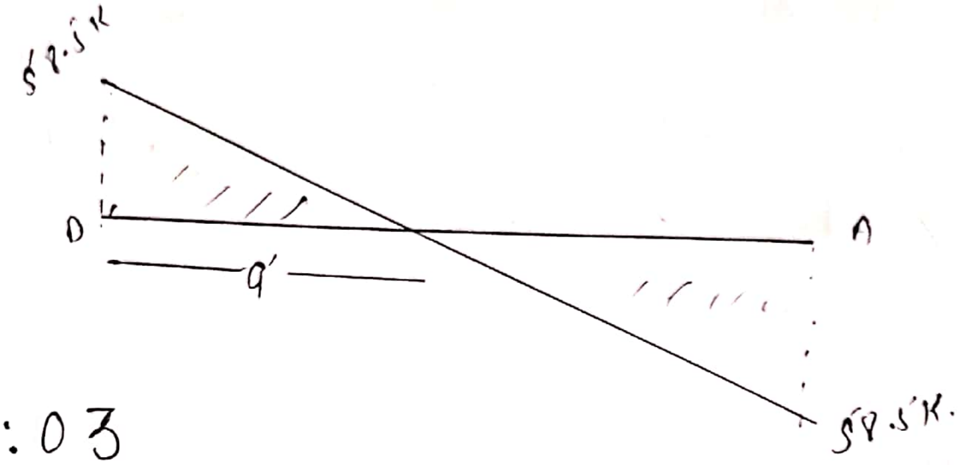
Rxn on suports.

$$\frac{6.5 \times 18}{2} = 58.5 \text{ kips.}$$

Step : 02

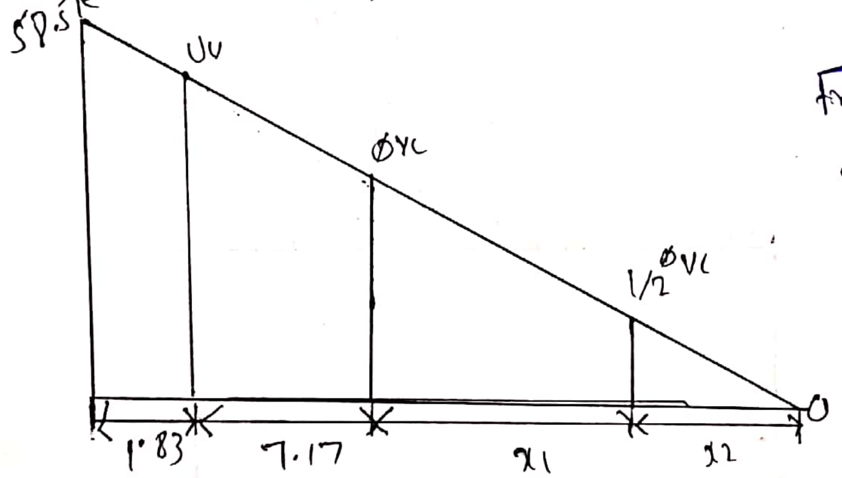
SFD

The require shear force Diagram is



Step : 03

Finding the value of V_u and its location
critical shear is located at distance d
from support (d) $= 22'' = 1.83'$



From similar as

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

Step = 4 $\quad V_u : 46.61$ kips.

Find value of ϕV_c and $1/2\ \phi V_c$

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

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

$$= 29.21 \text{ kips}$$

Location of ϕV_c by similar As

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

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

Similarly

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

Location of $1/2\ \phi v_c$ will be

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

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

Step : 05

Finding the value of ϕv_s

By formula.

$$\phi v_s = V_v - \phi v_c$$

$$= 46.61 - 29.21$$

$$\phi v_s = 17.4 \text{ kips.}$$

Step : 06 :

Check on section adequacy

By formula

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

$$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 12$$

$$= 116877 \text{ lbs}$$

$$= 116.87 \text{ kips}$$

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As $\phi \times 8 \times \sqrt{f'c} \times bw \times d > \phi Vs$

So Section is Adequate

Step: 07

Check on maximum Spacing for stirrups

By formula

$= \phi \times 4 \times \sqrt{fc} \times bw \times d$

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

$= 58438$ lbs.

$\Rightarrow 58.43$ kips.

As: $\phi \times 4 \times \sqrt{fc} \times bw \times d > \phi Vs.$

1 — $S_{max} = 24''$

2 — $d/2 = 22/2 = 11''$

3 — $\dfrac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

Here we are using # 3 ~~Sett~~ Stirrups

dia $= (3/8)'' = 0.375''$

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

Scanned with CamScanner

For 2- Legged stirrup.

Area x 2

$\therefore 0.11 \times 2 = 0.22 \text{ in}^2$

$$S_{max} = \frac{0.22 \times 6000}{0.75 \times \sqrt{4000} \times 14} = 19.87''$$

4- $$S_{max} = \frac{A_v \times f_y}{50 \times b_w} = \frac{0.22 \times 60{,}000}{50 \times 14}$$

$$= 18.85''$$

⇒ Step: 08 :→

Stirrup spacing from/at critical section will be by formula.

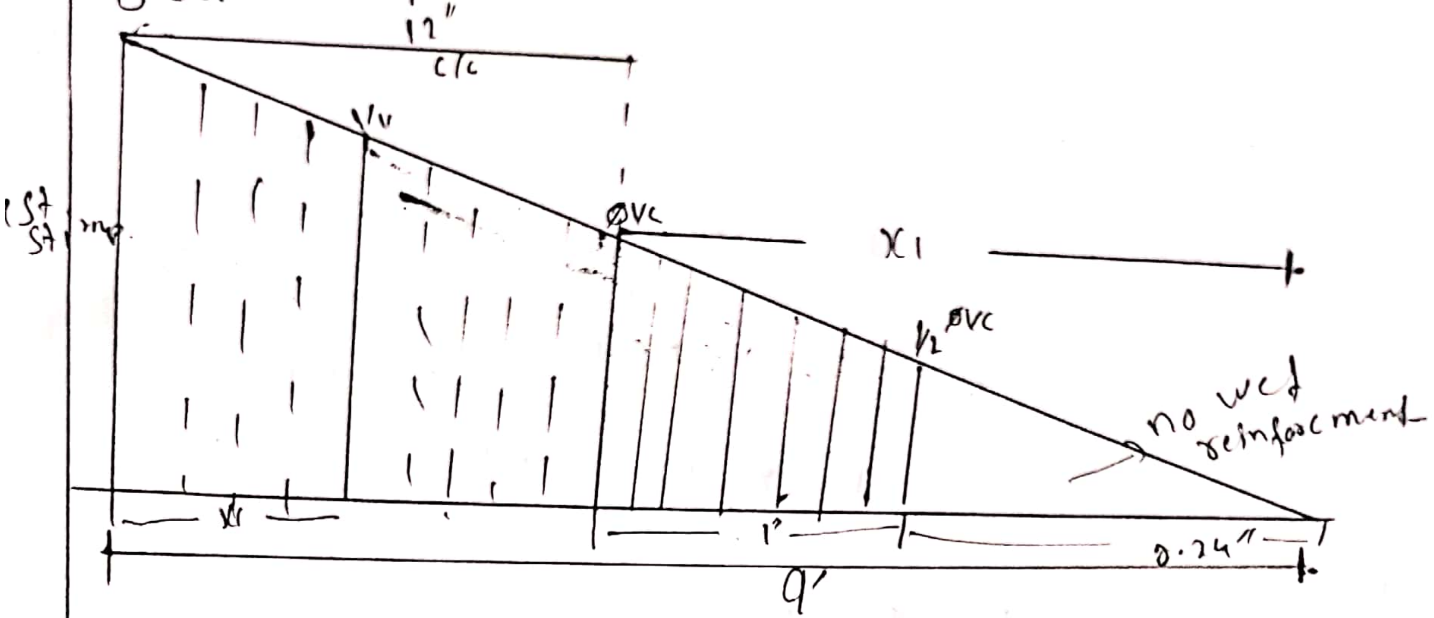
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{46.61 - 29.21}$$

$S = 12.5'' \approx 12''$

So 12% c

Step # 09



As
first stirrup from face of support =
$S/2 = 12/2 = 6"$

Question # 05

Given:

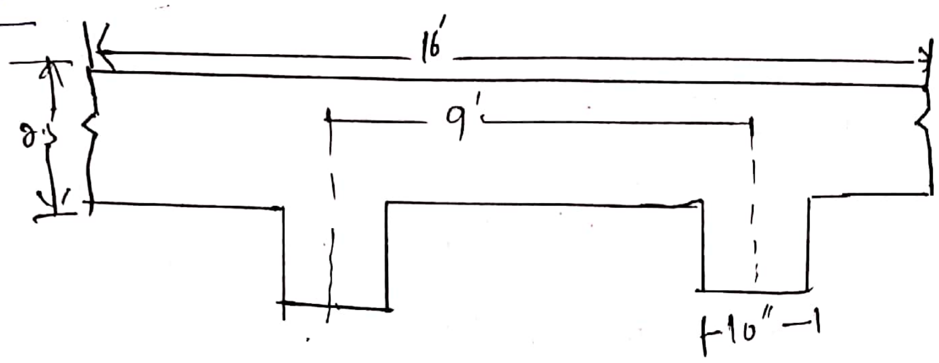
Height of flange (hf) = 3.5"
C/C distance = 9'
Span of beam = 16'
Web width (bw) = 18"
Height (h) = 23'
Mu = 5800 Kip-inch.

$f'c = 3 ksi$

$fy = 60 ksi$

Solution

hf.



Step # 01

Calculate the effective width (be) for T-beams

1 — $16(hf) + bw = 16(3.5) + 10 = 66''$

2 — C/c distance $= 9 \times 12 = 108''$

3 — span/4 $= \frac{16}{4} \times 12 = 48''$

Selecting the least value of be as

$bc = 48''$

Step : 02

Check wheather Rectangular or T-beam analysis is required.

Trail 01 : let $a = hf = 3.5'$

$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{5800}{0.90 \times 60 (18 - 3.5/2)}$

$\Rightarrow \boxed{= 6.61 \, in^2}$

Trial #02

$$a = \frac{Ast \times fy}{0.85 \times f'c \times be}$$

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

$\Rightarrow 3.2'' < 3.5''$

& $Ast = 6.55\ in^2$

So Rectangular Beam Design is required.

Trial #03

$a = 3.21''$

&

$$Ast = \frac{5800}{0.90 \times 60 \left(18 - \frac{3.21}{2}\right)}$$

$= 6.55\ in^2$

So Area of steel in $6.55\ in^2$

⇒ step : 03

Check δmax and δmin

$$\delta max = 0.85 \times \beta \times \frac{f'c}{fy} \left(\frac{\varepsilon u}{w + \varepsilon t}\right)$$

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

$= 0.013$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60,000} = 0.003$$

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

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

$$0.003 < 0.036 < 0.013$$

As the value of ρ_{max} is less than ρ, so we have to design it as Doubly Reinforcement Beam.

1st we have to find the area of steel against ρ_{max}.

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

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

$$A_{st} = 0.013 \times (10 \times 18)$$

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

Step : 04:

Finding the values of M_{U2} By formula.

$$M_{U2} = \phi \times A_{st} \times f_y \times (d - a/2)$$

1st finding value of a

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

$$\Rightarrow \frac{2.43 \times 60}{0.85 \times 3 \times 10}$$

$$a \Rightarrow 5.72''$$

$$M_{U2} = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$$

$$M_{U2} = 1986.67 \text{ inch}$$

$$1986.67 < 5800$$

So we have to design The beam in such away that it can resist more bending moment than the applied external moment.

Step : 05

Finding difference in moments and Area of steel.

$MU1 = MU - MU2$

$= 5800 - 1986.67$

$= 3813.33$ kip-inch.

By formula:

$$Ast = \frac{Mu}{\phi c \times fy \times (d - d_1)}$$

$Ast = 4.56\ in^2$

Step=6 :

Finding total steel Area.

$As = Ast + A'st$

$= 2.43 + 4.56$

$= 6.99\ in^2$

Step =07

Selection of Bar:-

In tension zone:

Let we have use # 8 bar.

dia $(8/8) = 1''$

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

(10)

By formula:

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

$$= \frac{6.99}{0.785} = 8.9 \approx 9.$$

So 9 # 8. bars.

- In compression zone.

Let use no 7 bars.

$$\text{Area} = \frac{\pi}{4} d^2 = 7/8 \times \pi/4$$

$$= 0.60 \text{ in}^2.$$

By formula :->

$$\Rightarrow \frac{\text{Area of steel}}{\text{Area of single bar}} \Rightarrow 6.$$

$$\Rightarrow \frac{4.56}{0.60} \Rightarrow 7.5 \approx 8.$$

So 8 # 7 bars.

Step :-> 08

maximum width for Accomodation of bars.

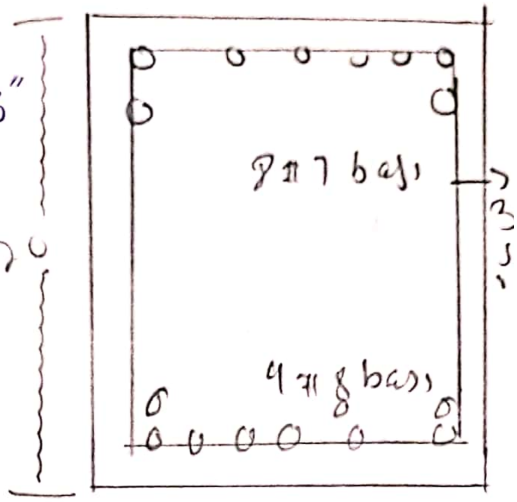
$$b_{min} = (2 \times 1.5) + (2 \times 3/8) + 9\,(8/8) \times 8\,(8/8)$$

$$= 20.75'' \Rightarrow 20.75'' > 10.$$

⇒ bars will be place in multiple layers

Effective depth d ⇒

$23 - 1.5 \times 3/8 + 3/8 + \frac{1}{2}(7/8) = 19.6''$



∴ Effective Cover (d') ⇒

⇒ $1.5 + 3/8 + 7/8 + 1/2\,(7/8) = 3.18''$

Step #09

Finding Design moment.

$$Md = \frac{\phi\ [As' \times fy \times (d-d')]}{0.85 \times fc \times b}$$

$$= \frac{(9 \times 0.785 - 8 \times 0.601) \times 60}{0.85 \times 3 \times 10} \Rightarrow 5.31''$$

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

$Md = 6328.88$

As $6328.38 > 5800$

⇒ So Design is OK!

⇒ Question No : 06 :→ (18)

Solution :→

Breadth (b) = 14"
Height (h) = 26"
Concrete compression strength $f'c = 4$ KSi
steel tensile strength (fy) = 60 KSi

Mu = 6000 Kip-inch
effective depth of beam (d) = 22"
Assume effective cover (d') = 2.5"

Step: 01

Reinforcement Ratio :→

By formula.

$$\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon y}\right)$$

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

$$\rho_{max} = 0.0180$$

step : 2 (Area of steel)

we know that.

$$\rho_{max} = \frac{Ast}{bxd} \Rightarrow Ast = \rho_{max} \times (bxd)$$

in comp...

$= 0.0180 \times (14 \times 22)$

Step :03 (Design moment:)

By using formula.

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

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{5.54 \times 60}{0.85 \times 40 \times 14}$$

$$= 6.98''$$

So

$$M_{u2} = 0.90 \times 5.54 \times 60 \left(22 - \frac{6.98}{2}\right)$$

$$= 5537.4 < 6000.$$

So we have to design a section as doubly Reinforcement.

Step #04 :→ (Difference in moment)

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

$$= 6000 - 5537.4$$

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

Step:05: (Area of steel)

$$M_{u1} = (\phi \times A_{st} \times f_y \times d - d')$$

so Area of steel in compressive zone will be.

$$Ast = \frac{Mu_1}{\phi \times fy \times (d - d')} = \frac{462.6}{0.92 \times 60 \times (22 - 2.5)}$$

20

$\Rightarrow Ast = 0.44 \text{ inch}^2$

Step #06 :→

(Total steel Area)

$AS = Ast + Ast'$

$= 5.54 + 0.44$

$= 5.98 \text{ inch}^2$

Step# 07 :→

1→ steel in tension Zone :→

we use #7 bars

dia $= (7/8) = 0.875''$

Area $= \frac{\pi}{4}(0.875)^2$

$= 0.601 \text{ inch}^2$

No of bars :⇒ $\frac{Ast}{\text{Area of single bar}}$

$\Rightarrow \frac{5.98}{0.601} = 9.9 \approx 10$ bars.

So 10 # 7 bars.

7. steel in compressive zone.

we use #5 bars.

$dia = 5/8 = 0.625''$.

$$Area = \frac{\pi}{4}(0.625)^2$$

$$= 0.306\ in^2$$

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

$$= \frac{0.44}{0.306} = 1.43 \approx 2 \text{ bars.}$$

So 2 #5 bars.

<u>Step</u> = 08 (Minimum width of Beam)

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

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

$\Rightarrow 20.37 > 14''$.

so not good in one layer.

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Now,

effective depth (d)

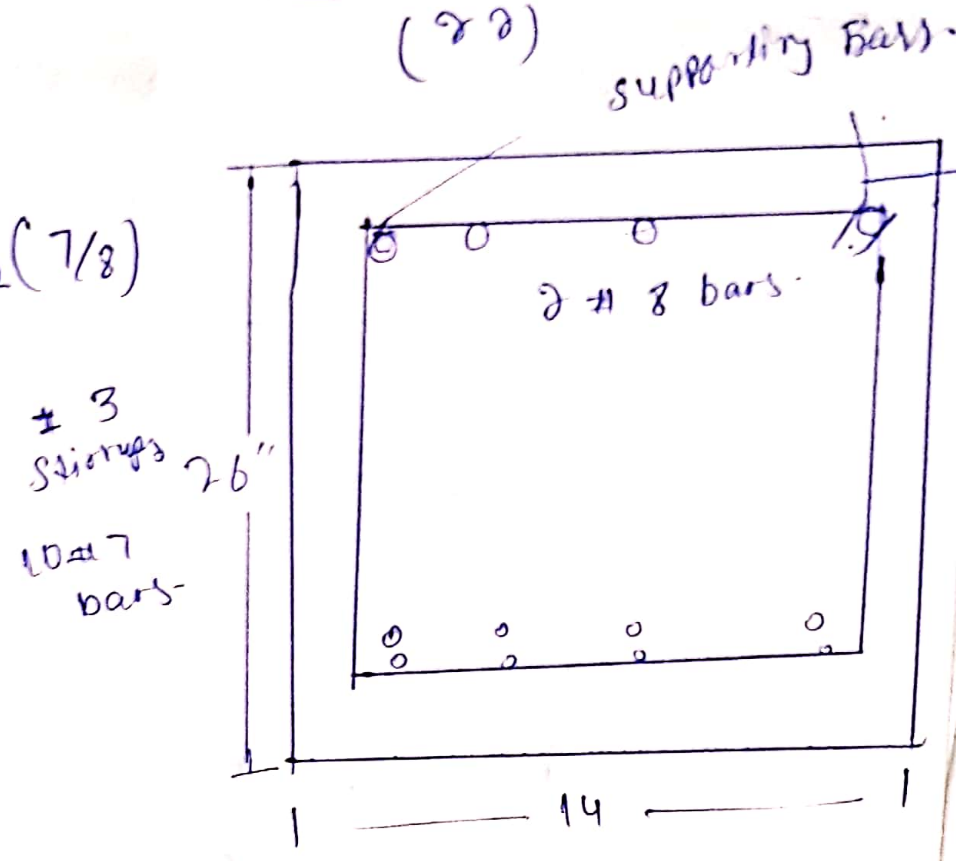
$\Rightarrow 26 - 1.5 - 3/8 - 7/8 - 1/2(7/8)$

$= 22.82''$

effective cover (d') =>

$1.5 + 3/8 + 1/2(5/8)$

$= 2.18''$



Step #09 :-> (Design Moment)

$$Md = \phi\left[A'st \times fy \times (d - d') + (Ast - A'st) \times fy \times (d - a/2)\right]$$

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

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

$$Md = 7047.6 > 6000$$

Design is OK.

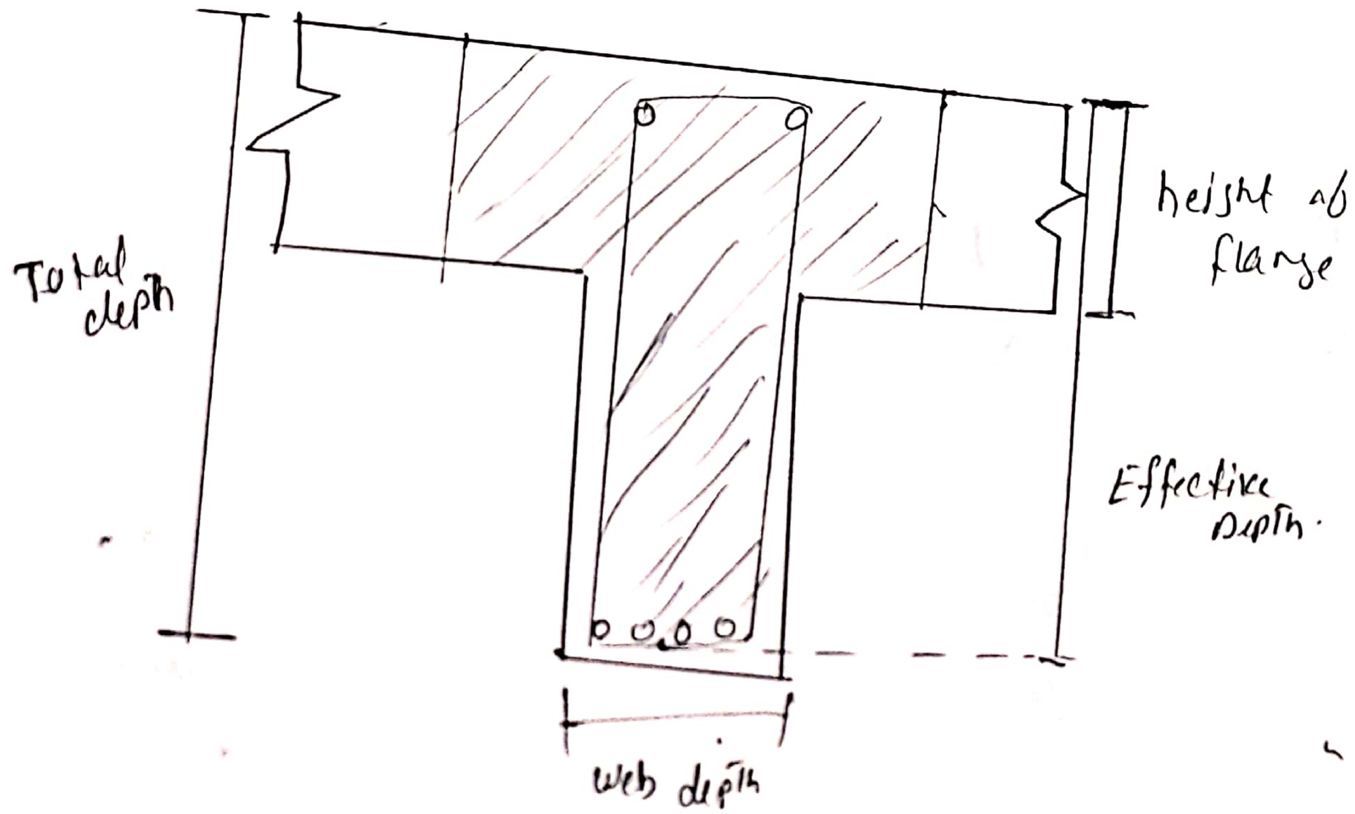
QUESTION#03

Define both the T-beam and L-Beam with The help of diagram. Also explain flexural analysis of T-Beam.

Ans

T-BEAM

In most of The reinforcement concrete structure Concrete slabs are cast monolithically with slab So in this case The beam that act as an intermediate beam are called T-beams.



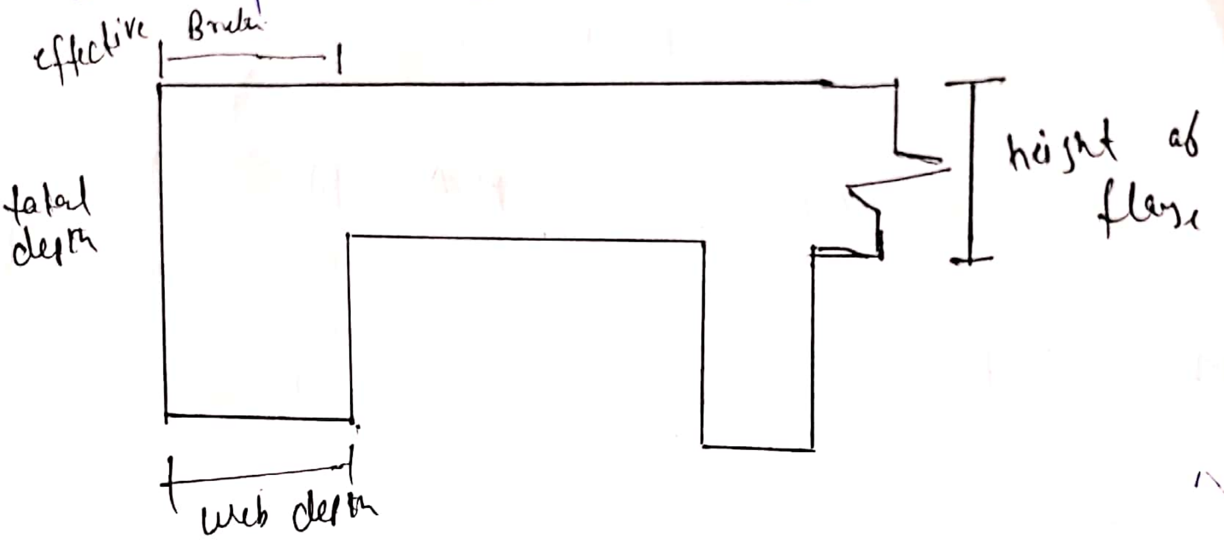
⇒ It is provided at The center of The slab to resist The loads.

⇒ The uppermost area of The beam attached to The slab is called Flange.

→ The bottom rectangular portion of The beam is called web of The beam

→ L - Beam:→

L - shaped structure that is in contact with the slab and present at corner of the floor is called L - Beam.



→ also called Edge Beams.

→ It is always provided at the slab

→ L - Beams are typical floor beams b/c of their reduced. overall structural depth the beams are in prestressed or reinforced concrete

⇒ FLEXURAL ANALYSIS OF T- Beam:→

Flexural analysis of T- beam consist of following steps:→

(25)

1 - For finding the Ultimate factored moment We use the following formula,

$$Mu = \frac{Mu \times L^2}{8}$$

2 → Effective width (b_e) 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) checking whether Rectangular or T-Beam Analysis :→

i- If $a > h_f$ → special Analysis is required,

ii) If $a < h_f$ → Rectangular beam is required

4) → For Finding Area of steel, we have to use:-

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

∵ ϕ = Strength Reduction f

$d = \varepsilon \cdot d$.

$a = c \cdot b \cdot d$.

5) For checking the range of Reinforcement Ratio :-

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

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

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

6) Formula for Finding no. of bars required is:

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

7) For checking minimum width for bars accomodation:

$b_{min} = 2(\text{clear cover}) + 2(\text{dia of stirup}) + \text{no of}(\text{bar}) + \text{spacing}_{b/w \text{ bars}}(\text{dia of bars})$

8) Design moment is given by :-

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

$M_d = \phi\left[A_s \times f_y \times \left(d - h_f/2\right) + (A_s - A_{st}) + f_y \times (d - a/2)\right] \rightarrow \text{if } a > h_f.$

(27)

QUESTION #04.

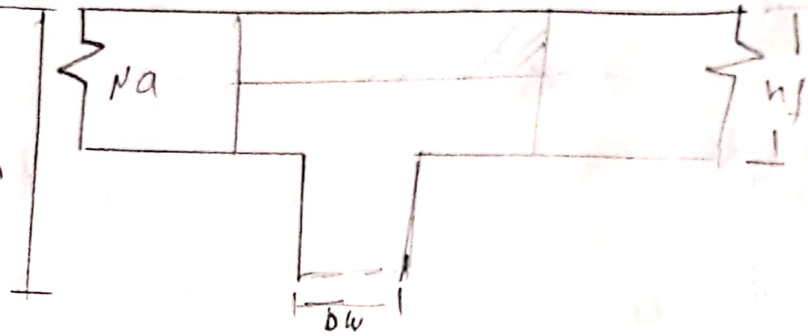
⇒ What is the difference b/w ~~CAES~~ CASE-1 & CASE 2 in design of T-beam

⇒ CASE I

From the figure $a < hf$

So in this case

Rectangular Beam Analysis is Required Beam. so the Design moment formula will be



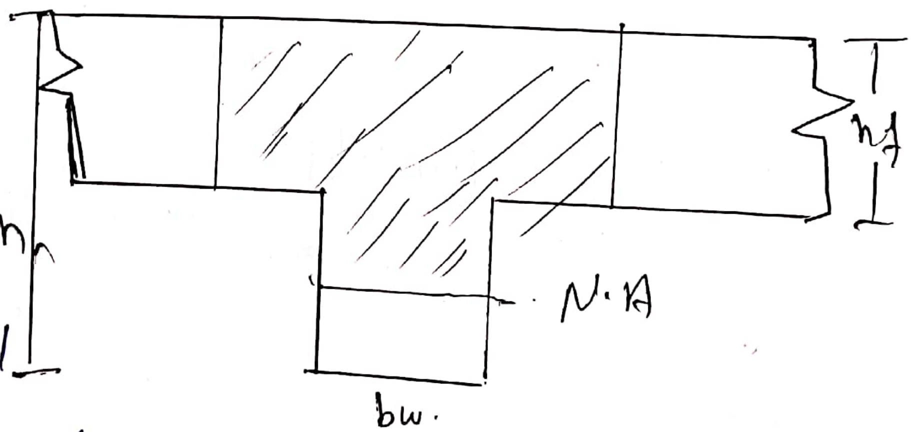
$$Md = \phi \times f_y \times A_{st} \times (d - a/2)$$

CASE - II

From figure

$a > hf$

So in this, special beam analysis is required



So the required Design moment will b

$$Md = \phi \times \left[A_s \times f_y \times \left(d - hf/2\right) + (A_s - A_{st}) \times f_y \times (d - a/2) \right]$$