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Subject = R.C.C Design 1

Q NO 2

①

Given :-

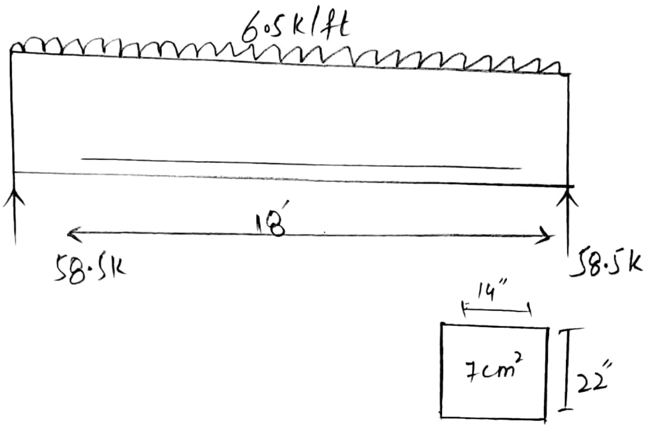
Breath of web of beam $(b_w) = 14''$

Effective depth $d = 22''$

Load $= 6.5k/ft$

$f'c = 4ksi$

$fy = 60ksi$



Step : 2

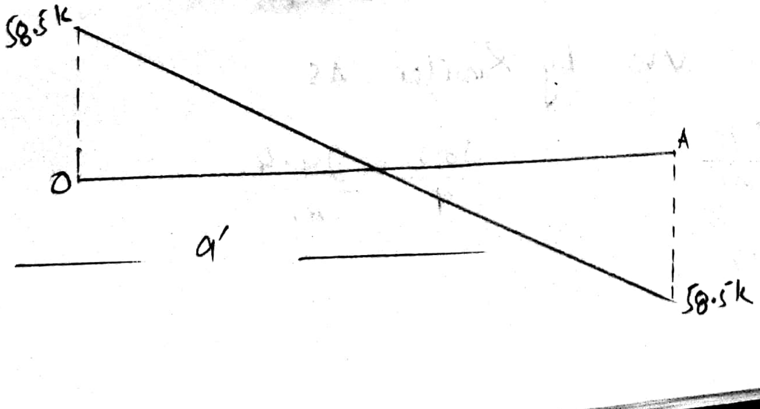
Rxn on Supports

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

Step . 2

SFD

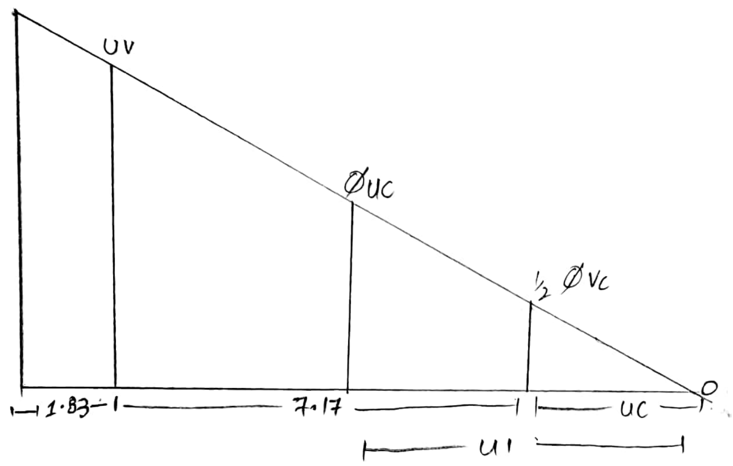
The realwise Shear force Diagram is



②

Step: 3

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



From similar Δs $\frac{58.5}{9} = \frac{V_u}{8.17}$

$V_u = 46.61$ kips

Step: 04

find value of ϕV_c and $\frac{1}{2}\phi V_c$

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

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

$= 29.21$ kips

location of ϕV_c by similar Δs

$\frac{58.5}{9} = \frac{\phi V_c}{x_1}$ $\frac{58.5}{9} = \frac{29.4}{x_1}$

$x_1 = 4.49'$

(3)

Similarly

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

=> 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

By formula

$\phi V_s = V_u - \phi V_c$

$= 46.61 - 29.21$

$\phi V_s = 17.4$ kips

Step:06

Check on section adequacy

By formula

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

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

$= 116877$ lbs

$= 116.87$ kips.

14

As

$\phi \times 8 \times \sqrt{f'c} \times 6w \times d > \phi vs$

So section is Adequate

Step :07

Check on Maximum spacing for stirrips By formula

$= \phi \times 4 \times \sqrt{fc} \times 6w \times d$

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

$= 58\ 438\ lbs$

$= 58.43\ kips$

As

$\phi \times 4 \times \sqrt{fc} \times 6w \times d > \phi vs$

So maximum will be selected from the following 4 conditions

1- $S_{max} = 24''$

2- $d/2 = 22/2 = 11''$

3- $\dfrac{Av \times fy}{0.75 \times \sqrt{fc} \times 6w}$

Here we are using # 3 stirrip:

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

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

For 2-legged stirrup

Area x 2

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

$$S_{max} = \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14} = 19.87''$$

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

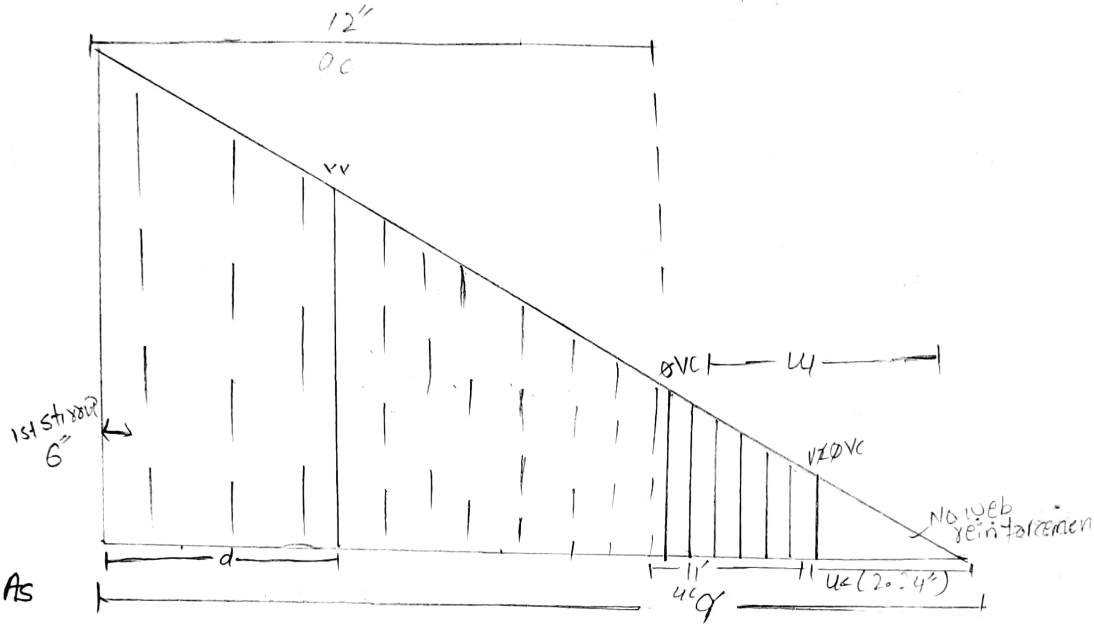
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

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

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

so $12\ c/c$

Step #09



First stirrup from face of support =

$S/2 = 12/2 = 6"$

Question No 5

GIVEN

Height of flange (hf) = 3.5

9C distance = 9'

Span of beam = 16

web width (bw) = 18"

Height, (h) = 23'

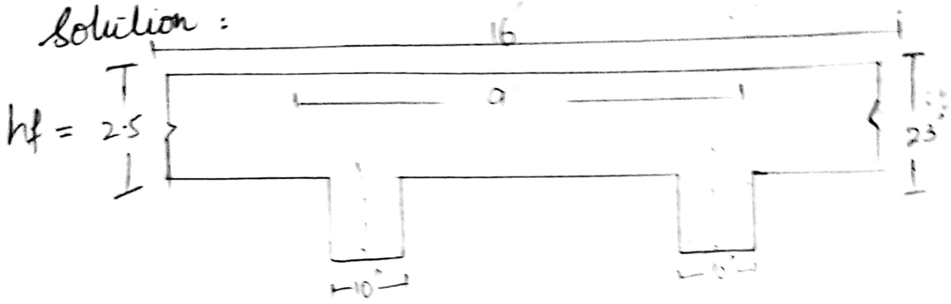
MU = 5800 Kip-inch

(7)

$f'c = 3ksi$

$f_y = 60ksi$

Solution :



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.

$be = 48'$

Step. 2

Check whether Rectangular or T-beam Analysis is required

Trial 01:

let $a = hf = 3.5'$

$$A_{st} = \frac{M_U}{\phi \times f_y \times (d - a/2)} = \frac{(8)\ 5800}{0.90 \times 60 \left(18 - \frac{3.5}{2}\right)}$$

$$= 6.61\ cm^2$$

Trial # 2

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

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

$$= 3.2''$$

$$3.2'' < 3.5''$$

and

$$A_{st} = 6.55\ cm^2$$

So Rectangular Beam Design in Required!

Trial # 3

$$a = 3.21''$$

and

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

$$= 6.55\ cm^2$$

So Area of Steel is $6.55\ cm^2$

Step:03

Check ρ_{max} and ρ_{min}

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

$= 0.85 \times 0.85 \times 3/60 \left(\frac{0.003}{0.003 + 0.005} \right) = 0.013$

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

$\Rightarrow \rho = \frac{Ast}{bxd} = \frac{6.55}{10 \times 18} = 0.036$

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

$0.003 < 0.036 < 0.013$

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

first we have to find the Area of steel against ρ_{max}

$\rho_{max} = \frac{Ast}{bxd}$

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

Scanned with CamScanner

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

$Ast = 2.34 \; in^2$

Step. 4

Finding the value of Mu^2

By formula

$Mu^2 = \phi \times Ast \times fy \times (d - a/2)$

first finding value of a

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

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

$a = 5.72''$

$Mu^2 = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$Mu^2 = 1986.67$ inch

$Mu^2 < Mu$

$1986.67 < 5800$

so we have to design the beam in such away that it can resist more bending moments than the applied external moment

Step: 05

finding differece in moments and Area of steel

$M_{U1} = M_U - M_{U2}$

$= 5800 - 1986.67$

$= 3813.33$ Kip-inch

By formula

$$A_{st} = \frac{M_U}{\phi \times f_y \times (d - d')}$$

$A_{st} = 4.56 in^2$

Step: 06

finding total steel Area

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

$= 2.43 + 4.56$

$= 6.99 in^2$

Step: 07

Selection of Bar:-

In tention zone :-

let we have use #8 bar

dia (8/8) = 1"

Area = $\pi/4\ (1)^2 = 0.78\ in^2$

By formula

No of bars = $\frac{\text{Area of steel}}{\text{Area of single bar}} = \frac{6.99}{0.785}$ ≅ 8.9≈9

~~So 9 # 8 bars~~

By formula

In Compression zone

$= \frac{\text{Area of steel}}{\text{Area of single bar}} = \frac{6.99}{0.785} =$

In Compression zone

Let use no 7 bar

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

= $0.60 \, in^2$

By formula

= $\frac{\text{Area of steel}}{\text{Area of single bar}}$ ≠ $\frac{8.99}{0.788}$ ≠

4.56 = 7.5 ≈ 8

So 8# 7 bars

Step: 08

Maximum width for Accomodation of bars

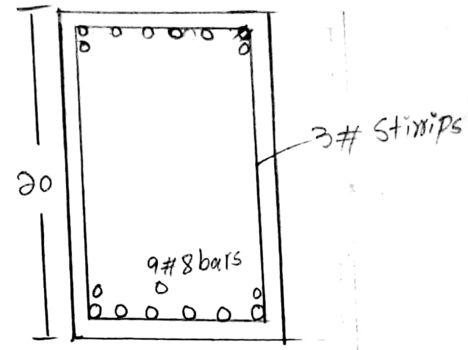
bmin = $(2 \times 1.5) + (2 + 3/8) + 9(8/8) + 8(8/8$

= 20.75"

As

20.75" > 10

bars will be place in multiple layers



Effective depth (d) = 23 - 1.5 + 3/8 + 3/8 + 1/2 (8/8) = 19.6"

Effective Cover (d') = 1.5 + 3/8 + 7/8 + 1/2 (7/8) = 3.18"

Step: 09

Finding Design Moment

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

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

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

Md = 6328.88

As 6328.38 > 5800

⟹ so Design is ok!

Question No : 06 (15)

Solution

Breadth (b) = 14"

Height (h) = 26"

Concrete Compression Strength $f'c$ = 4 Ksi

Steel Tensile strength (f_y) = 60 Ksi

Mu = 6000 Kip - inch

Effective depth of beam (d) = 22"

Assume effective cover (d') = 2.5"

Step : 01 (Reinforcement Ratio

By formula

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

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

ρ_{max} = 0.0180

Step : 2 (Area of steel)

As we know that

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

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

$= 5.54\ in^2$

Step:03 (Design Moment)

By using formula

$M_{U_2} = \phi \times A_{st} \times f_y \times (d - a/2)$

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

$= 6.98''$

So $M_{U_2} = 0.90 \times 5.54 \times 60 (22 - 6.98/2)$

$= 5537.4 < 6000$

So, we have to design a section as doubly reinforced

Step:04 ((Differece In Moment)

$M_{U_1} = M_U - M_{U_2}$

$= 6000 - 5537.4$

$= 462.6$ kip-inches

(17)

Step :05 : (Area of steel)

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

So Area of steel in compressive zone will be

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

$$\Rightarrow Ast = 4.44 \, in^2$$

Step #06

(Total steel Area)

$$As = Ast + Ast$$

$$= 5.54 + 0.44$$

$$= 5.98 \, in^2$$

Step :07

1- Steel in tention zone:-

we use #7 bars

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

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

$$= 0.601 \, in^2$$

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

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

So 10 # 7 bars

2- Steel in compressive zone:

We use # 5 bars

dia = 5/8 = 0.625"

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

$= 0.306 \text{ in}^2$

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

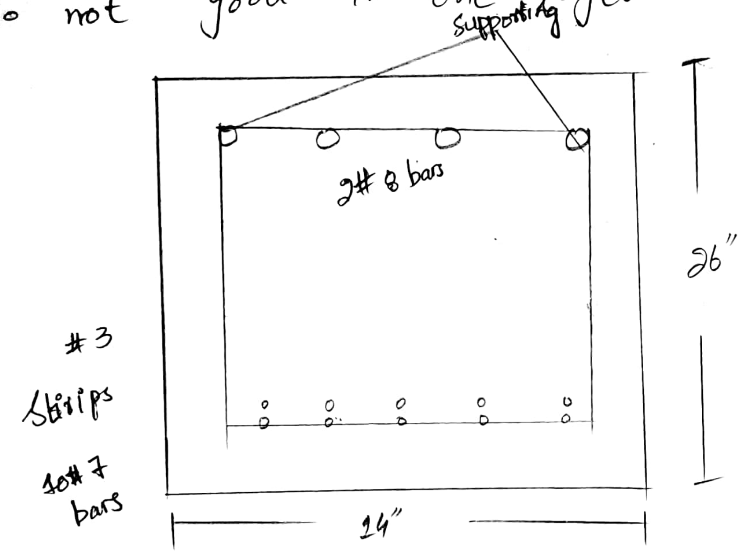
Step:08

(Minimum Width of Beam)

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

$b_{min} = 20.37 > 14"$

So not good in one layer



Now

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

$= 22.82"$

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

$= 2.18"$

Step: 9 (Design Moment)

$Md = \phi\,[Ast \times fy \times (d - d') + (Ast - A'st) \times fy \times (d - \frac{a}{2})]$

$a = \dfrac{(Ast - Ast') \times fy}{0.85 \times f'c \times b}$

$$= \frac{(10 \times 0.667 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14}$$

$= 6.80''$

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

$Md = 7047.6$ kip - inches

Md = 7047.6 kip - inches

As 7047.6 > 6000

Design is ok

QNo 1

Explain in detal types of Stirrips with figures and Also explain ACI Codes for Shear design,

ANSWER

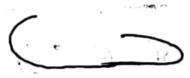
STIRRUP:-

Stirrups are closed-loop bars tied at regular intervals in beam reinforcement to hold the bars in Position

Types of Stirrups :-

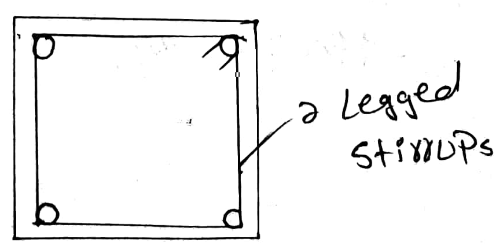
1- Single Legged Stirrup:

The single legged stirrups have rarely been used because they one montly used when binding only two rods.



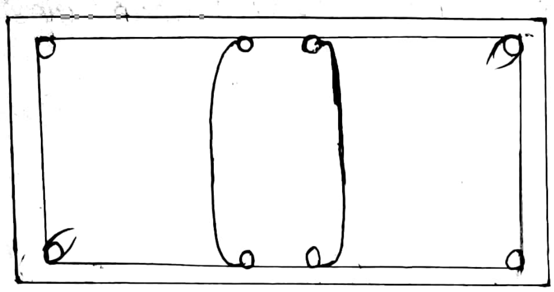
2- Two-Legged Stirrup:

It is most Commonly and widely used stirrup. Minimom 4 bars are required for Providing this stirrup.

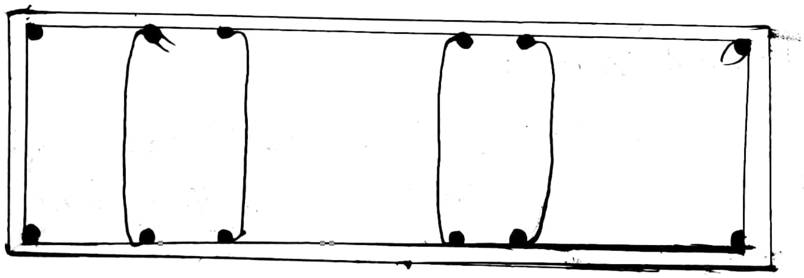


3- Four Legged stirrup:-

These stirrups are used in case of web reinforcement.



4. Six Legged stirrup:



ACI CODES FOR SHEAR DESIGN OF A BEAM:-

According to ACI-318, following are the shear design of a beam

← Critical section: Critical section occur at 45° and is at distance "(d)" from the face 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 $V_u \leq \phi V_c$, then theoretically no web reinforcement is required. However ACI code require provision of at least minimum area of web reinforcement equal to

4. For Minimum Reinforcement Area:-

If $V_u \leq \phi V_c$, then theoretically no web reinforcement is required. However ACI Code require provision of at least minimum area of web reinforcement

$\phi = 0.75 \rightarrow$ For shear design.

$$A_{v,min} = \frac{0.75 \times \sqrt{f'c} \times b_w \times S}{f_y}$$

By interchanging the formula, we can obtain the formula for maximum spacing

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

4: No web reinforcement is required if $Vu < \frac{1}{2} \phi Vc$

⇒ Between Critical section "Vu" and "ϕVc" Spacing b/w web reinforcement can be find by

$$S = \frac{\phi \times Av \times fy \times d}{Vu - \phi Vc}$$

5: If $Vs \leq 4 \times \sqrt{f'c} \times bw \times d$, then max spacing for Stirrups will be the Smallest of the following

1- 24"

2- d/2

3- $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

4- $S_{max} = \frac{Av \times fy}{50 \times bw}$

If $Vs > 4 \times \sqrt{f'c} \times bw \times d$

Max Spacing will be halved.

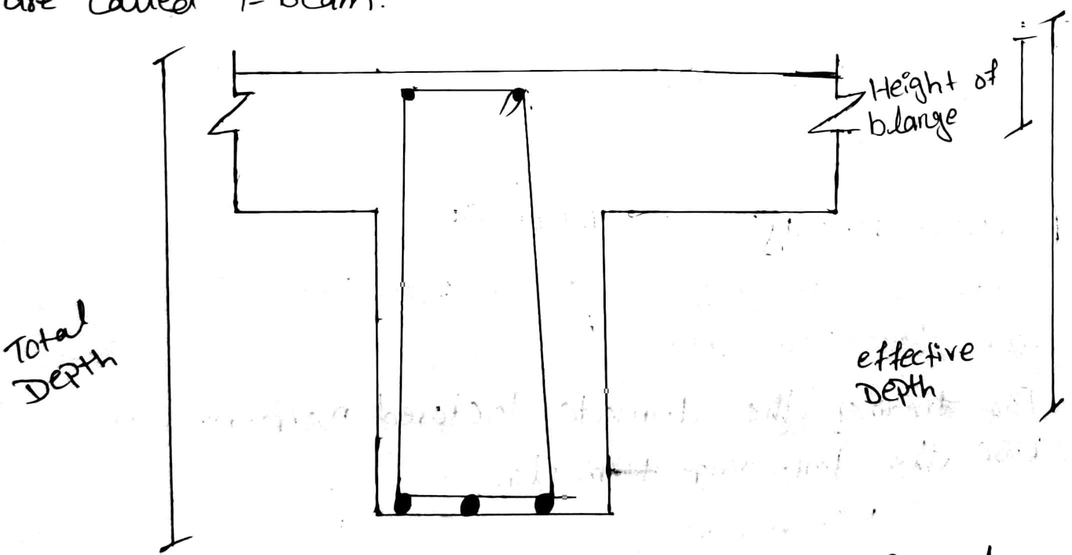
Question No: 3

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

ANSWER

T-BEAM

In most of reinforcement Concrete slabs are cast monolithically with the slab so, in this case the beam that act as an intermediate beam are called T-beam.

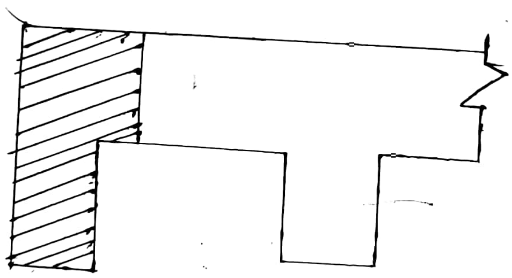


Because of then T-shape these beams are caused T-beams

⇒ It is Provided at the center of the slab let resists the load.

L-BEAM

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



⇒ L-beam are also called Edge Beam

⇒ It is always provided at the corner of He slab.

Flexural Analysis OF T-BEAM:

Flenural Analysis of T-Beam Consists of the following steps

1. For finding the ultimate factored moment, we use the following formula.

$$M_U = \frac{W_U \times L^2}{8}$$

2. Effective width (be) for T-Beam is calculated as:

1 - 16 (hf) + bw

2- c/c distance

3- Span/4

4 - $\frac{CTs}{2}$ + bw

3- Checking Whether Rectangular or T-Beam Analysis

i) If a > hf → Special Analysis Required

ii) If a < hf → Rectangular beam analysis is required

a = Depth of compression block
hf = Height of flange

4) For finding Area of Steel, we have to use

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)}$$

where

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

5- For checking the range of Reinforcement ratio.

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

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

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

Question NO 4

What is the difference b/w Case-I and Case-2 in the Design of T- Beam?

Answer:

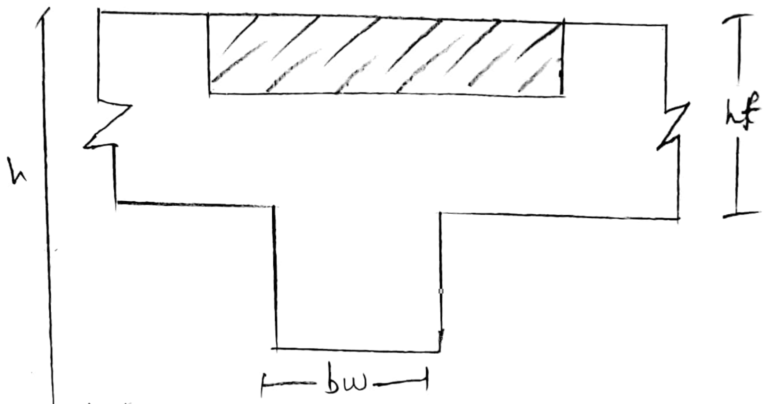
Case - I

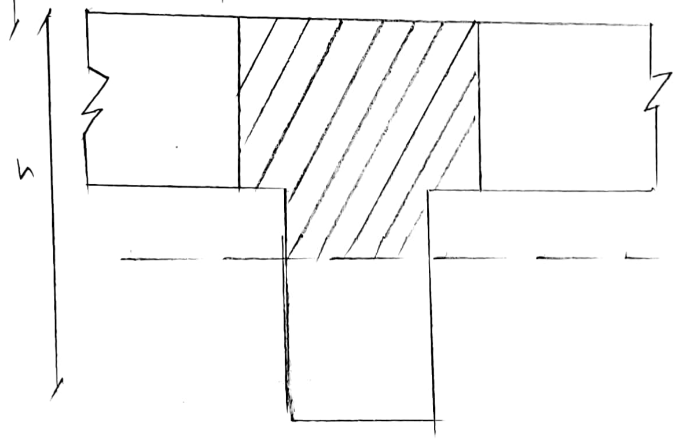
From the figure

$a < h_f$

So in this Case, Rectangular Beam Analysis is required so, The Design moment formula will be

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





Case - II

From figure

$a > hf$

So in this special beam analysis is required

So the required Design moment

$$Md = \phi \times \left[As \times f_y \times \left(d - \frac{hf}{2}\right) + (As - Ast) + f_y\left(d - \frac{a}{2}\right)\right)$$