Name

M. Zeshan Shahid

ID

7876

Section

"A"

Semester

6^{th}

Program.

B.E (Civil)

Assignment

Plain and Reinforcent Conclt - I

Subited To

Engr Fawad Sir.

Q No: 01

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

Ans:

Stirrup:

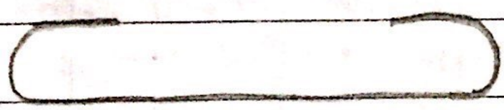
stirrup is closed loop bars tied at regular intervals in beam reinforcement to hold the bars in position.

Types Of Stirrups:

1 Single legged stirrup:-

The single legs stirrup have rarely been used because they are mostly used when building only two rods.

Fig.



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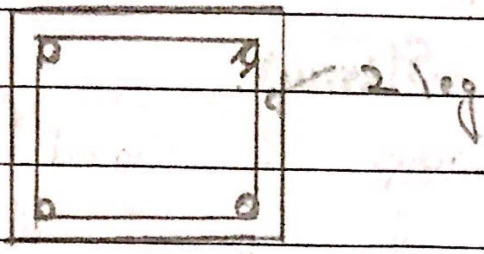
2: Two leg stirrup :-

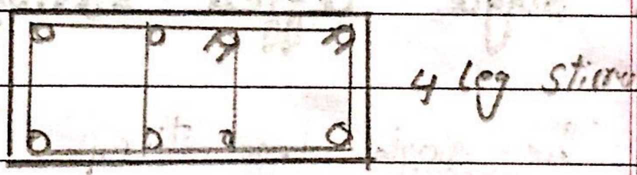
It is mostly commonly used stirrup minimum 4 bar are required for poviding this stirrup.

Fig

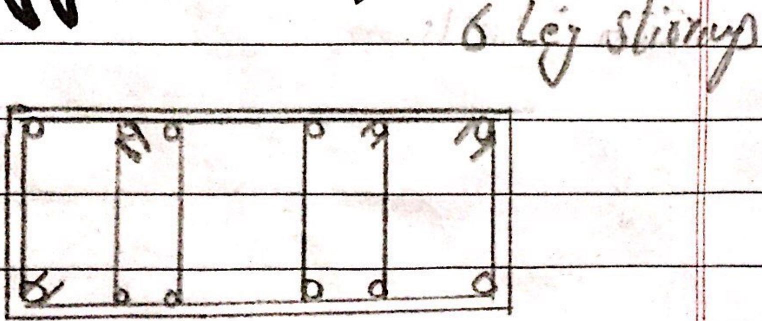


3: Four Leg Stirrup

These stirrup are used in case of Web reinforcement.



4: Six Legged Stirrup



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ACI Codes For sear design of a beam:

According to ACI-318 are useig the formula for the shear design of a beam.

1:- Critical section

Critical section occurs at 45° and is at distance (d) from the face of support which is equal to effective depth.

2:- Shear strenth Capacity of Concrete

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

3:- Minimum Web Reinforcment

If $V_u \leq \phi V_c$ then theoratically no web reinforcement is required. However ACI code require provision of at least a minmum area of web reinforcemt is equal to

$\phi = 0.75$ → For shear design

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∴ V_u = Total factored shear applied at given section

⇒ For minimum Reinforced Area.

$$A_{v(min)} = \frac{0.75 \times \sqrt{f'_c} \times b_w \times S}{f_y}$$

OR

[for higher value of selected] $\frac{S_o \times b_w \times S}{f_y}$

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

$$S_{(max)} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$$

OR

Lesser value is selected $\frac{A \times f_y}{S_o \times b_w}$

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4. No Web-reinforcement is required if

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

⇒ Between critical section "V_u" an "ϕV_c" spacing b/w web reinforcment 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 stirrup will be the smallest of the folling

1. # 24"
2. # d/2
3. # $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

⇒ If $V_s > 4 \times \sqrt{f'_c} \times b_w \times d$
max spacing will be halved

⇒ If $V_s > 8 \times \sqrt{f'_c} \times b_w \times d$
then either increase cross-sectional design dimention or increase f'_c

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A simply supported rectangular beam 14" wide bearing an effective depth of 22" to carry a lateral load of 6.5 k/ft on a 18' simply span.
It is required with 7 in^2 of tensile steel area, if f_c = 4 ksi and f_y = 60 ksi then design the beam for shear

Given Data:

Breadth of web of beam = 14"
Effective depth d = 22"
Load = 6.5 k/ft
Steel area = 7 in^2
f'_c = 4 ksi
f_y = 60 ksi

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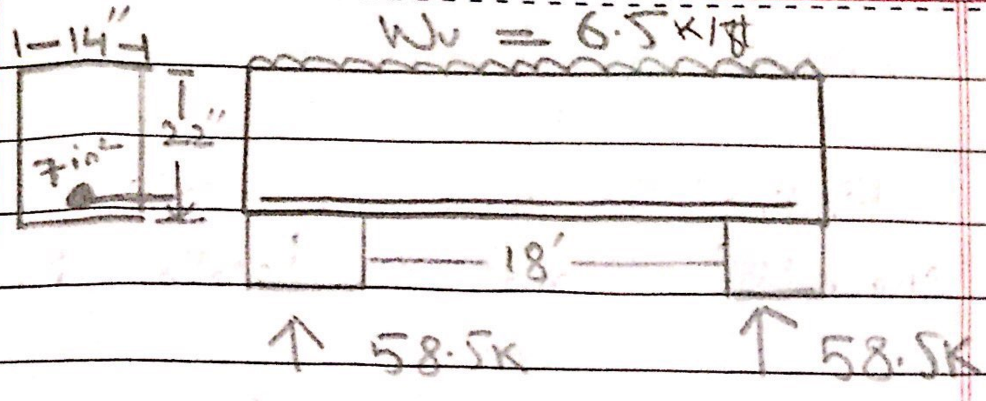


Step # 1
Reaction on Supports

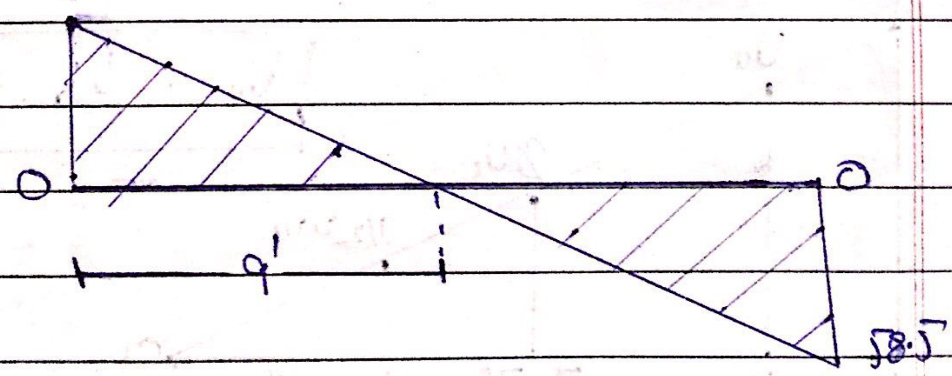
Finding the reaction due to applied Load

$$\text{Total Load} = \frac{65 \times 18}{2}$$

$$\text{Total Load} = 58.5$$

Step # 2 Shear force Digram

The required shear digram will be 58.5 K



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Step # 3

Finding the value of critical shear "Uu" and its location As

We know that critical shear is located at distance "d" from face of support "d" = 22"
d = 1.83'

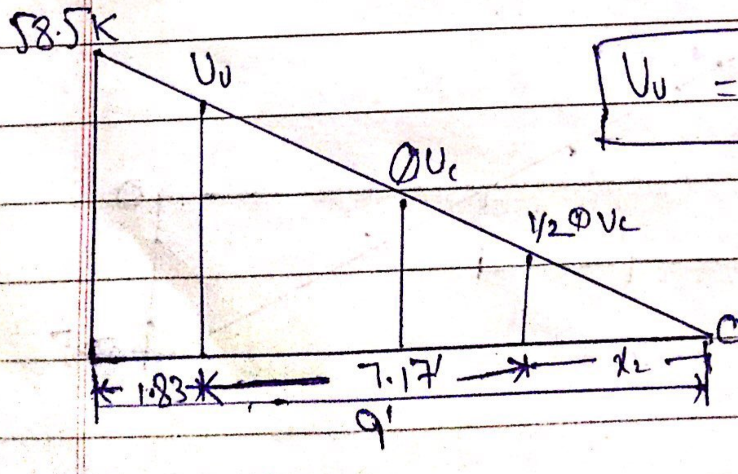
⇒ We will find value of critical shear at distance "d" by useing of similar trigle

From simelar Trinangle

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

$$V_u = \frac{585 \times 7.17}{9}$$

$$\boxed{V_u = 46.61 \text{ kips}}$$



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Step # 4

[redacted]

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

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

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

$$= 29219 \text{ lbs}$$

$$\phi V_c = 29.21 \text{ kips}$$

⇒ Location of ϕV_c by similar trigle.

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

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

Similarly

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

$$= 14.60 \text{ kips}$$

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

$$\frac{58.5}{9} = \frac{14.60}{x^2} \Rightarrow \boxed{x_2 = 2.24'}$$

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Step # 5

Finding the value of ϕV_s

By formula

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

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

$$\phi V_s = 46.61 - 29.21$$

$$\boxed{\phi V_s = 17.4 \text{ kips}}$$

Step # 6

Check on section adequacy

By formula

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

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

$$= 116877 \text{ lbs}$$

$$= 116.87 \text{ kips}$$

As

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

So section is Adequate

Step # 7

Check on maximum spacing for stirrup

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

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

$$= 58438 \text{ lb}$$

$$= 58.43 \text{ kips}$$

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As

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

So maximum will be slected the folling 4 condition

1 - $S_{max} = 24$

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

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

3 - $S_{max} = \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14}$

$S_{max} = 19.87$

4 - $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w} \Rightarrow \dfrac{0.22 \times 60000}{50 \times 14}$

$S_{max} = 18.85$

From above 4 condtion least value of spacing for #3, 2 legged strup will slected as

$S_{max} = 11''$

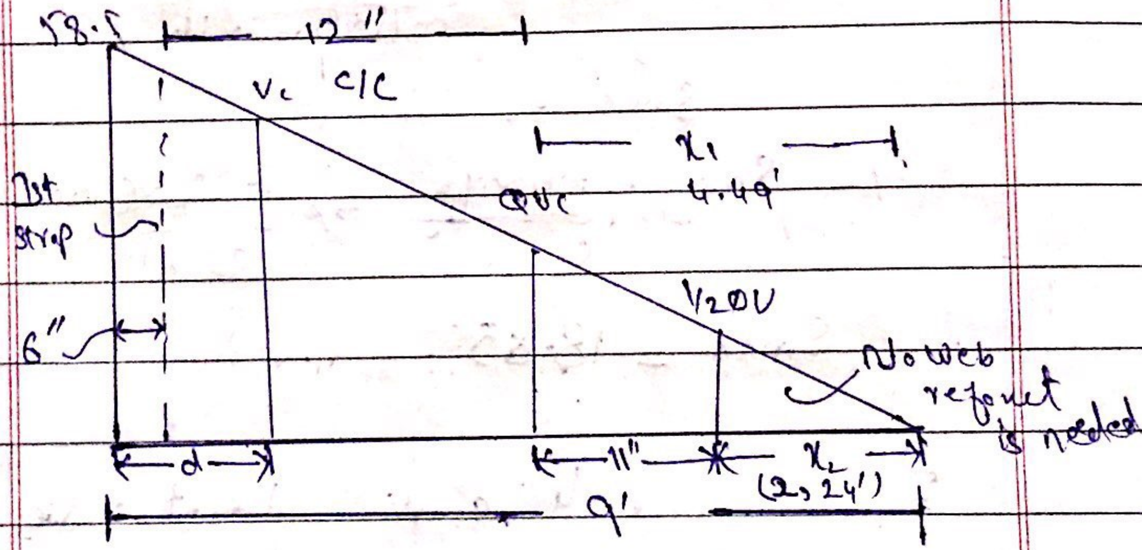
Stirrup spacing from at critical section will be

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

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

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

$$S_o = 12'' \text{ c/c}$$



As

First stirrup from face of support

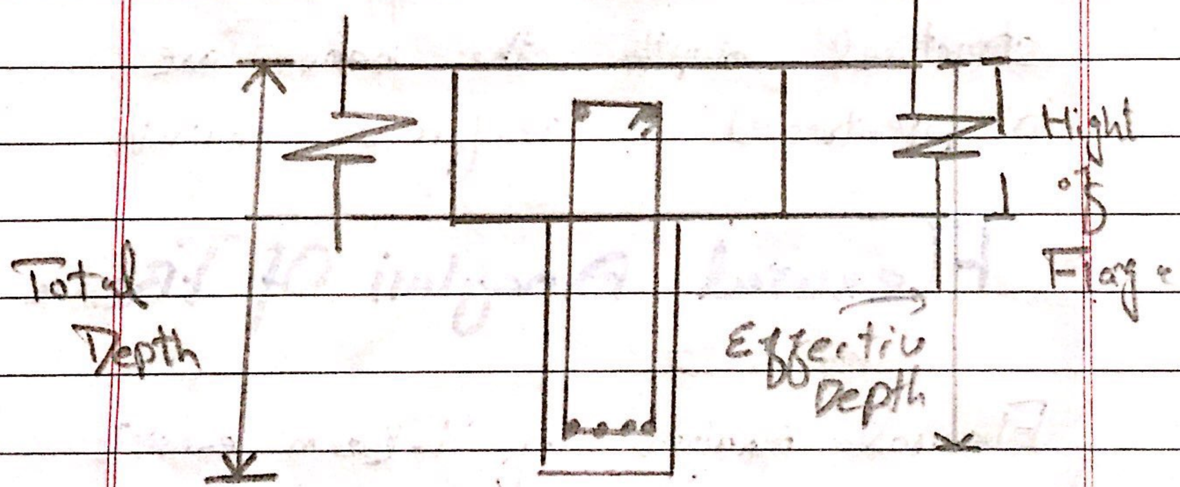
$$S/2 = 12/2 = 6''$$

Question - 03

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

T-Beam:-

⇒ In most the reinforced concrete structure, concrete slabs are cast monolithically with the slab so in this case the beam that act as an intermediate beam are called T-beam.

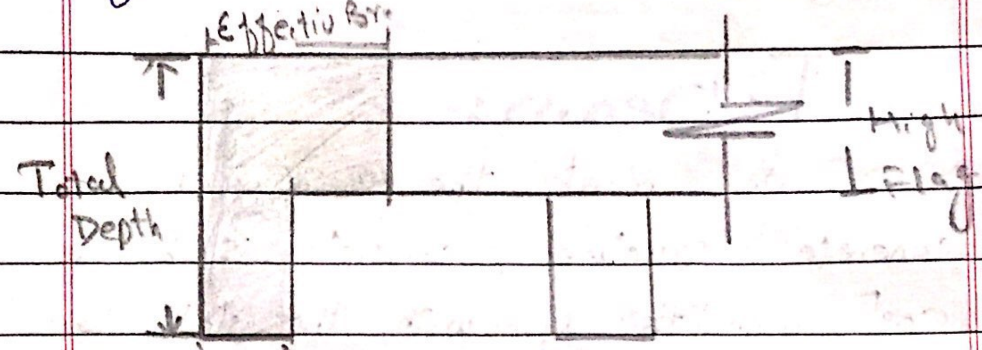


⇒ Because of their T-shape these beam called T-beams,

⇒ It is provided at the center of the slab to resiste the load.

L-Beam:-

L - Shap 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
⇒ L-Beam are typical floor beam Beacuse othere reduced overall structurel depth the beam are in prentressed or reinforced concrete

Flexural Anaylsis Of T-Beam

Flexural Analysis of T-Beam consists of the following steps

1- For Finding the Ultimate Factored moment we use the following Formula

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

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. $\frac{CTS}{2} + b_w$

h_f - height of flange

CTS = Clear transverse span.

3: Checking whether Rectangular or T beam Analysis is required.

I. If $a > h_f$ → Spacial Analysis is required

II. If $a \not> h_f$ → Rectangular beam Analysis is required

Where

a = Depth of compression block

h_f = Height of flange

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4: For Finding Area of Steel we have to use

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

where

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_w}$$

ϕ = strength Reduction factor
d = Effective depth
a = compression block depth
b_w = Web width of beam

5 ⇒ For checking the rang of Reinforcement Ratio

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

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

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

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6 ⇒ Formula for Finding No. of bar required is

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

7) For checking minimum width for bar accomodation

$$b_{min} = 2(\text{clear cover}) + 2(\text{dia of strip}) + \text{No of barr}\,(\text{dia of bar}) + (\text{spacing b/t barr})(\text{dia of bar})$$

8) Design Moment is given by

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

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

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QNO: 04

What is the differene b/w case-1 and case-2 in the design of T-Beam?

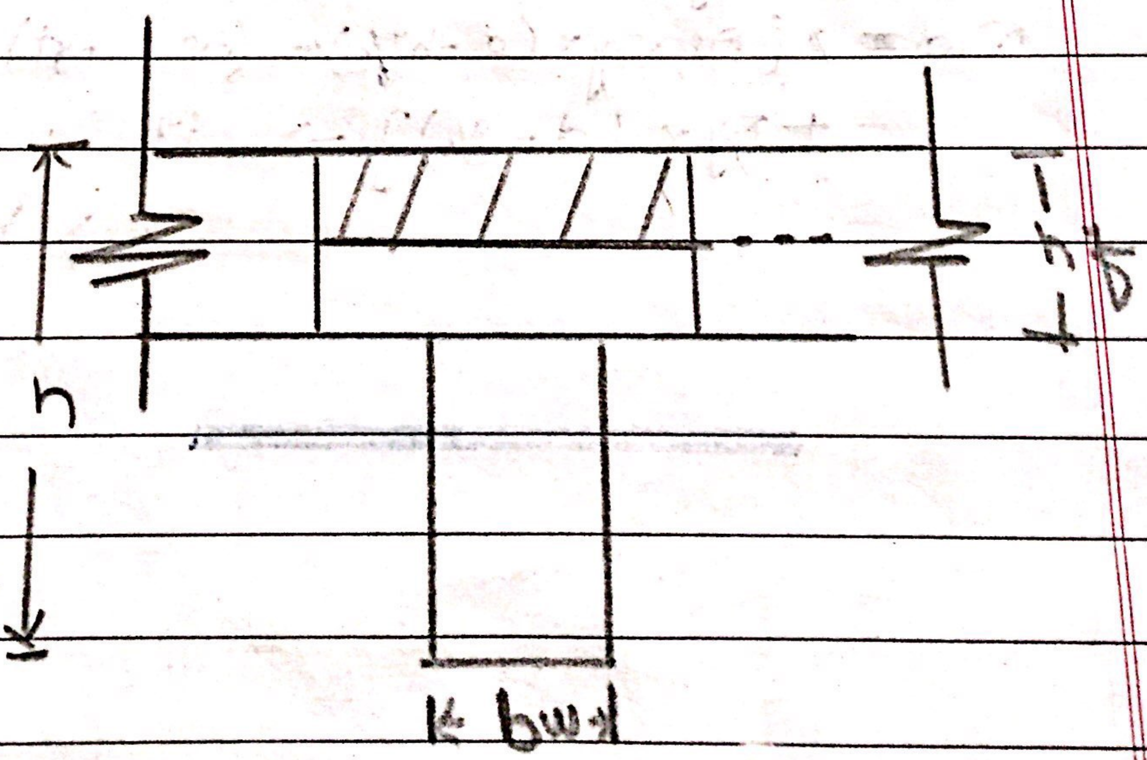
Case - I

From the figure $a < h_f$ so in this case. Rectangular Beam Analysis is required

so

The Design moment formula will be

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



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Case - II

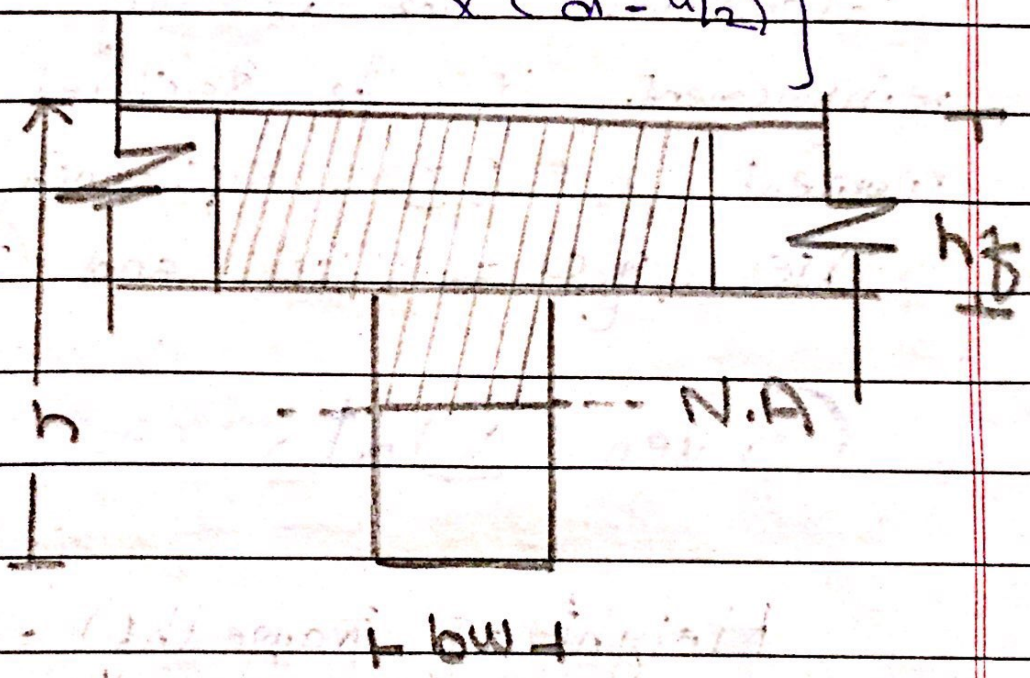
From the figure $a > h_f$

So in this specifical beam analyses i.e

T - Beam Analysis is required

So the required design moment will be

$$M_d = \phi \times [A_{sf} \times f_y \times (d - \frac{h_f}{2}) + (A_s - A_{sf}) \times f_y \times (d - a/2)]$$



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Q.No - 05

A floor consist of 3.5" concrete slab supported by 16' simple span spaced at 9' C/C the having a weidth of 10" and effected depth of 18" and total hight is 23". Calculated the necessary flexural reinforcement if the factored applied moment is 5800 kips-inch. Use $f'c = 3$ ksi and $fy = 60$ ksi.

Given Data

Height of flange (h_f) = 3.5"

C/C distance = 9'

Legth / span of Beam = 16'

web weidth = 10"

depth = d = 18"

Height h = 23"

Total factored moment (M_u) = 5800.

$f'_c = 3$ ksi

$f_y = 60$ ksi

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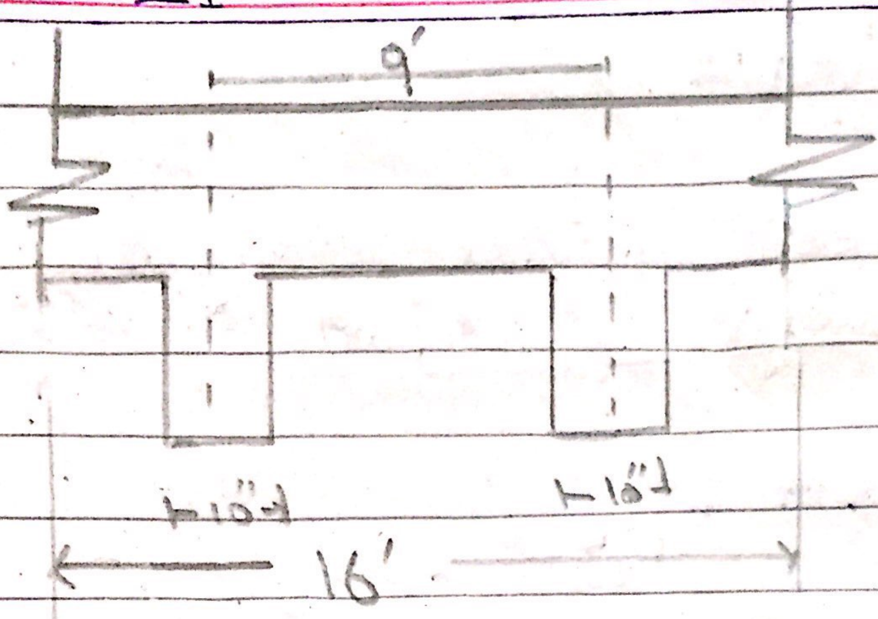

Step # 1

Calculat the effective width (b_e) for T-beam

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

2) C/C distanc $= 9 \times 12 = 108''$

3) Span/4 $= 16/4 \times 12 = 48''$

Selecting the least value of b_e as

$$b_e = 48''$$

Step# 2

Check whether rectangular or T-beam Analysis is required

Trial # 1

let $a = h_f = 3.5''$

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

Trail # 2

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

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

Ad

$A_{st} = 6.55 in^2 \Rightarrow 3.2'' < 3.5''$

Trail = 3

$a = 3.21''$

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

$A_{st} = 6.55 in^2$

So Area of steel $6.55 in^2$

(23)

Step #3

Check ρ_{max} and ρ_{min}

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

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

$$= 0.013$$

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

$\rho_{min} = 0.003$

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

$$= 0.036$$

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

$$0.003 < 0.036 < 0.013$$

↓

As the value of ρ_{max} is less the ρ so to design it as (Doubly Renforc Beam)

$\Rightarrow$ First we find Area of steel ρ_{max}

$$\rho_{max} = \frac{A_{st}}{10 \times d}$$

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

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

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

Step # 4

Find the value of Mu
By formula

$Mu_2 = \phi \times A_{st} \times f_y \times (d - a/2)$

First find "a"

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} \Rightarrow \frac{2.43 \times 60}{0.85 \times 3 \times 10}$$

$a = 5.72''$

$\Rightarrow$ $Mu_2 = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$Mu_2 = 1986.67$ kip-inch

$Mu_2 < Mu$

$1986.67 < 5800$

So we have design the beam is such away that it can resist more bending

Step # 5

Finding difference in moments and area of steel

$Mu_1 = Mu_1 - Mu_2$

$= 5800 - 1986.67$

$Mu_1 = 3813.33$

By formula

$A'st = \frac{Mu}{\phi \times fy \times (d - d')}$

$Ast = \frac{3813.33}{0.90 \times 60 \times 18 - 2.5} = 4.56 \text{ in}^2$

Step-6

Finding Total steel Area

$As = Ast + Ast'$

$As = 2.43 + 4.56$

$As = 6.99 \text{ in}^2$

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Step-7

Selection of bar

In tension of zone

let use #8 bar

dia (8/8) = 1"

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

By formula

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

$$= \frac{6.99}{0.785} = 8.9$$

No of bar ≃ 9

So 9 #8 bars

In compression zone

let we use #7 bar

dia (7/8)" $\text{Area}\ \frac{\pi}{4}(7/8)^2$

Area = 0.601 in²

By formula

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

$= \frac{4.56}{0.601} = 7.5$

No of Bar = ≅ 8

So 8 #7 bar

Step 8

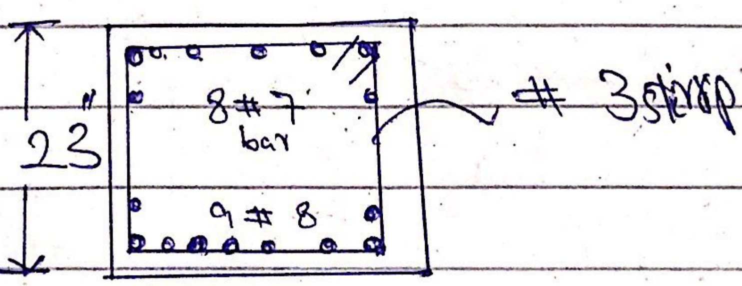
Minmum width for accomodation of bar.

bmin = (2 x1.5) + (2 x 3/8) + 9 (8/8) + 8 (8/8)

bmin = 20.75

20.75" > 10"

So the bar will be placed in multipl layers



Effective depth = $d = 23 - 1.5$
$3/8 + 8/8 + 1/2(8/8$

$= 19.6''$

Effective cover $= 1.5 + 3/8 + 7/8 + 1/2(7/8)$

$= 3.18''$

Step # 9

Finding the design moment

$M_d = \phi\,[A_s \times f_y \times (d - d') + (A_s - A_s') \times f_y \times (d - a/2)]$

First $a = \dfrac{(A_s - A_s')\,f_y}{0.85 \times f_c' \times b}$

$a = \dfrac{9 \times 0.785 - 0.60)\,60}{0.85 \times 3 \times 10}$

$a = 5.31''$

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$$M_d = 0.90\left[(8 \times 0.601) \times 60 \times (19.6 - 3.18) + (9 \times 0.785 - 8 \times 0.601 \times 60 \times 19.6 - \frac{5.31}{2}\right]$$

$$M_d = 6328.38$$

As $6328.36 > 5800$

So design is ok!

Q No # 06

A beam require to developed and ultimate momet is 6000 kip-inc limted to 14x26 inc size
Use $f'c$ = 4ksi and fy = 60 ksi

Determine the flexural renforcmt assume two row of tensile reainforcmt and effective depth of beam is 22 inche

Given data

Breadth = b = 14"
hight = h = 26"
Concrete comp. $f'c$ = 4ksi
steel Tensi. fy = 60 ksi

Mu = 6000 ksi-in
d = 22"

Assum effective cover = 2.5"

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Step# 1 Reinforcement Ratio

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

$$= 0.85 \times 0.85 \times 4/80 \times \frac{0.003}{0.003 + 0.00}$$

$$\rho_{max} = 0.0180$$

Step #2 Area of Steel

As we know that

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

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

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

$$Ast = 5.54\ in^2$$

Step #3

Design Moment

By using formula

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

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} \Rightarrow \frac{5.54 \times 60}{0.85 \times 4 \times 14}$$

$$a = 6.98''$$

So

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

5537.4 kips-in

~~5537.4~~

As

$$5537 < 6000$$

So we have to design the section as doubly reinforced.

Step #4 Difference in Moment

$$Mu_1 = Mu - Mu_2$$

$$Mu_1 = 6000 - 5537.4$$

$$Mu_1 = 462.6 \text{ kip-in}$$

Step #5 Area of steel

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

So area of steel in comp zone

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

$$\boxed{A'st = 0.44 \text{ in}^2}$$

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Step #6 Total steel Area

$A_s = A_{st} + A'_{st}$
$= 5.54 + 0.44$
$= 5.98 \text{ in}^2$

Step #7

Section & No of Bar

Stee in tension zone
we use #7 bar
dia (7/8") = 0.875

$\text{Area} = \frac{\pi}{4}(0.875)^2$
$= 0.601 \text{ in}^2$

So

$\text{No of bars} = \frac{A_s}{\text{Area of single bar}}$
$= \frac{5.98}{0.601} \approx 9.9$

No of bar ≅ 10 bars

2) Steel in compression zone

we have #5 bar

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

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

$$= 0.306 in^2$$

So

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

$$\text{No of Bar} = \frac{0.44}{0.306} = 1.43$$

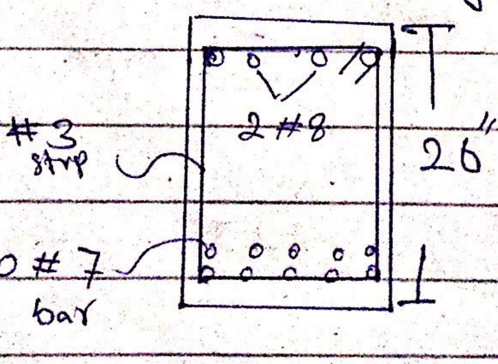
$$\cong 2 \text{ bar}$$

So 2 #5 bars

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

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

so not good in one layer



Now

Effective depth = d = 20 + 1.5 - 3/8 - 7/8 - 1/2(7/8)

= 22.82

Effeictive cover = 1.5 + 3/8 + 1/2(5/8)

= 2.18"

Step # 9 Design Moment

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

$$a = \frac{(A_{st} - A'_{st}) \times f_y}{0.85 \times f'_c \times b}$$

$$a = \frac{(10 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14}$$

$$a = 6.80''$$

$$M_d = 0.90 \{ 2 \times 0.306 \times 60 \times (22.82 - 2.18) + (10 \times 0.601 - 2(0.306)) \times 60 \times (22.82 - 6.80/2) \}$$

Md = 7044.6 kip-inch

As 7047.6 > 6000

Desigin is OK !