Name Khalil Ur Rehman

ID # 7831

Section B

Semester 6th

Subject Plain and Reinforced Concrete Design - I

Assignment "

Submitted To,

Engr. Fawlad Khan

(QUESTION - 01) (P-1)

Explain in detail types of Stirrups with figures and also explain ACI Codes for Shear design:

Ans **STIRRUP**:- Stirrups are closed loop bars tied at reguler intervals in beam reinforcement to hold the barrs in position

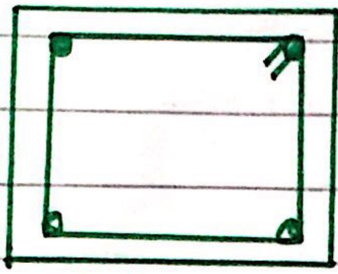
Types of STIRRUPS:-

1- Single Legged stirrup:-

the single lg stirrups have rarely been used because they are mostly used when binding only binding only two rods

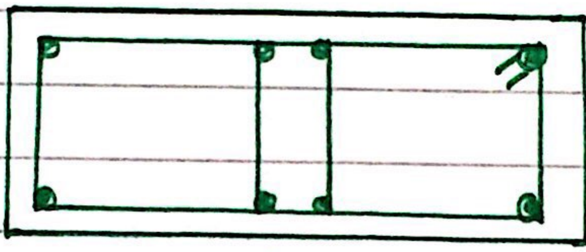
2 Two Legged stirrup:-

these stirrup are used in case of web reinforcement It is most comonly and widely used stirrop minimum bars are repuired for providing this stirrop



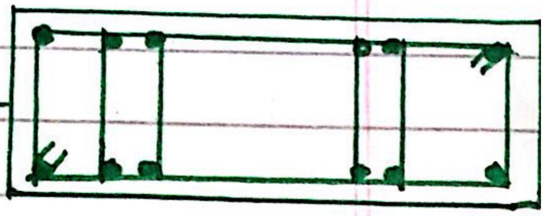
2 Legged stirrup

3 Four Legged Stirrop:-
these stirrop are used in Case of web reinforcement



4 Legged Stirrop

4 Six Legged Stirrup:-



ACI Codes for Shear Design Of A Bem

According to ACI-318, following are the formulas used for the Shear design of a Beam

1- Critcal Seation:- Critcal section occurs at 45° and is at distance (d) from the face the face of support which is equal to effective depth

2- **Shear Strength capacity of Conerete 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 theoriticlly no web reinforcment is required However ACI Code require provision of atleast a minimum are of web reinforcement equal to

$\phi = 0.75 \rightarrow$ for Shear design

(: V_u = Tote factored Shear applid at agiven section)

=> For minimum Reinfocement Area

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

or $\dfrac{50 \times b_w \times S}{f_y}$ → [Higher value Selected]

By interchanging the above formules we can obtain the

$S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$ or $\dfrac{A_v \times f_y}{50 \times b_w}$ → [Lesse value is selectey]

4- No web reinforcement required if

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

=> Between critical section "V_u" and "ϕV_c" spacing & b/w web reinforcement can be find by

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

5- $V_s \leq 4 \times \sqrt{f_c'} \times b_w \times d$

then max spacing for stirrups will be the smallest of the following

1- 24"

2- d/2

3- $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w}$

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

=> If $V_s \rightarrow 4 \times \sqrt{f_c'} \times b_w \times d$

max. spacing will be halved

=> If $V_s - 8 \times \sqrt{f_c'} \times b_w \times d$

↓

then either increase cross-sectional dimension or increse f_c'

(P-5) **-: QUESTION - 02 :-** (4)

A Simply Supported rectangular beam 14" wide having an effective depth of 22" to carry a lateral load of 6.5 K/Ft on a 18 Simple span It is reinforced with 7in² Then design the beam for Shear

Given :-

Breadth of web of beam $(b_w) = 14"$

Effective ~~of web~~ depth $d) = 22"$

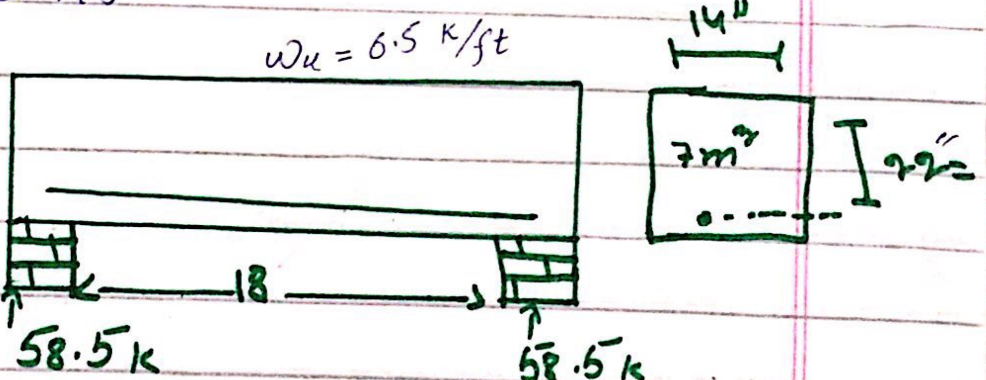
Given Load $= 6.5\ K/ft$

Steel Area $= 7 in^2$

$f'_c = 4$ ksi

$f_y = 60$ kis

Sol :-



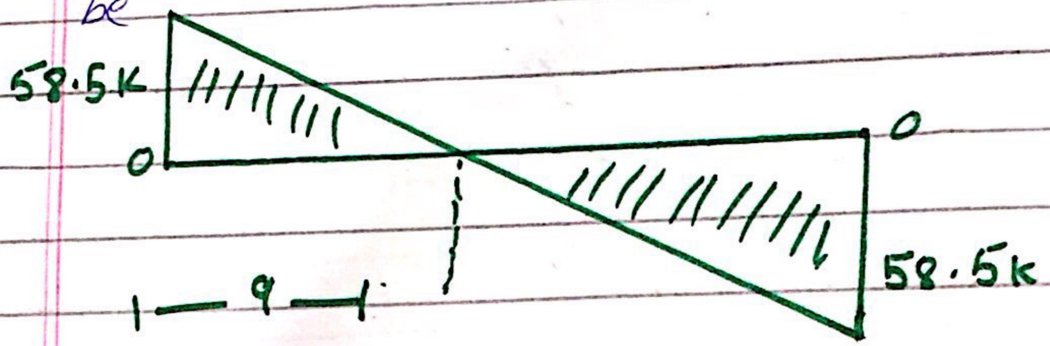
STEP#1:- (Reactions on Supports)

Finding the reactions due to applied load

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

STEP #2 :- (Shear force Diagram)

the required Sher diagram will be

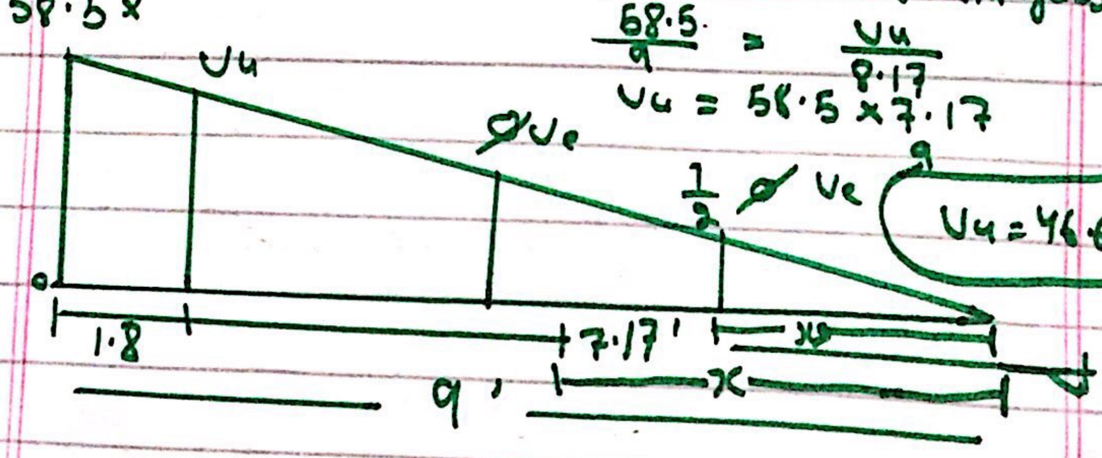


STEP # 3 :-

finding the value of critical Sher Vu" and its location

As we know that critical Sher is located at distance "d" form face of support (d) = 22" = 1.83

=> we will find the values of critical Shear at distance "d" by use of similar triangles



from - similar Triangles

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

$$Vu = \frac{58.5 \times 7.17}{9}$$

Vu = 46.61 kip

STEP #4 :-

Finding the value of ϕV_c and and also its distances from zero Shear to right Side

By formula

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

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

$= 29219 \text{ Lbs}$

$= 29.21 \text{ kips}$

$\Rightarrow$ Location of ϕV_c by similar triangles

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

$= x_1 \quad 4.49'$

$\Rightarrow$ Similarly

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

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

$\frac{58.5}{9} \; \frac{14.60}{x_2} \Rightarrow x_2 = 2.24'$

STEP #5 :- finding the value of ϕV_s

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

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

$= 46.61 - 29.21$

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

STeP #6:-
chech on section adequacy
By formula
$\Rightarrow \phi \times 8 \times \sqrt{f'_c} \times bw \times d$
$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 22$
$= 16877$ lbs
$= 16.87$ Kips

as $\phi \times 8 \times \sqrt{f'_c} \times bw \times d \rightarrow \phi Vs$
So ~~se~~ section is adequete

STeP #7:- check on maximum speceing ~~of~~ for stirrups
By formula
$= \phi \times 4 \times \sqrt{f'_c} \times bw \times d$
$= ~~\phi~~ = 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22$
$\Rightarrow 58438$ lbs
$= 58.43$ kips

As $\phi \times \sqrt{f'_c} \times bw \times d \rightarrow \phi Vs$
so, maximum will be selected from the following 4 conditions

1- $S_{max} = 24''$
2- $d/2 = 22/2 = 11''$
3 $S_{max} = \dfrac{Av \times fy}{0.75\sqrt{f'_c} \times bw}$

Here we are using #3 stirrup
dia $= (3/8)'' = 0.3575$
So are $= \pi (0.3757)^2 = 0.11$ in²
For 2 legged strrip
$\Rightarrow$ area $\times 2$
$= 0.11 \times 2 = 0.22$ ins²

(3) Smax $= \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14} = 19.87''$

(4) Smax $\dfrac{Av \times Fy}{50 \times bw} = \dfrac{0.22 \times 60000}{50 \times 14} = 18.85''$

From above 4 conditions least vale of spacing for #3 2 legged stirrp will be selected as Smax = 11''

STep # 8:-

Stirrups spacing from 1st critical will be By formale

$S = \dfrac{\phi \times Av \times Fy \times d}{Vu - \phi Vc}$

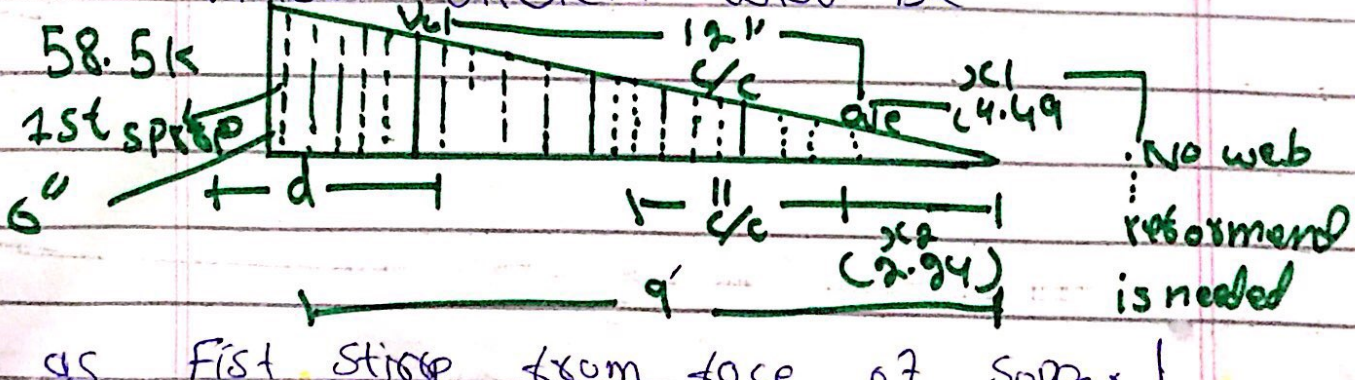
$= \dfrac{0.75 \times .22 \times 60 \times 22}{46.61 - 29.21}$

$S = 12.5'' = 12''$

so = 12'' c/c

STep # 9:-

Final sketch will be



as Fist stirrp from face of support

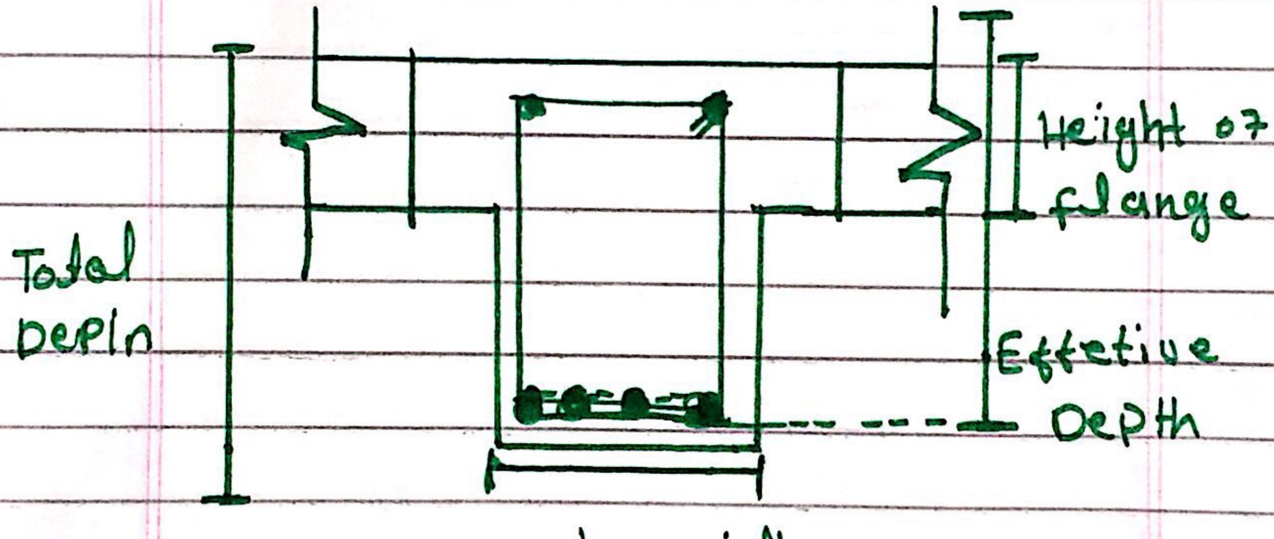
$S/2 = 12/2 = 6''$

(QUESTION - 03) (P-10)

Defione both the T-Bemam anel L- Beam with the halp of diagrom Alco explen flaralis of T-Bem

T-Beam:-

In most of the reinfcred concete Strotoes comcets Slabe are bem momlithically with the slob so in the called T-Beam



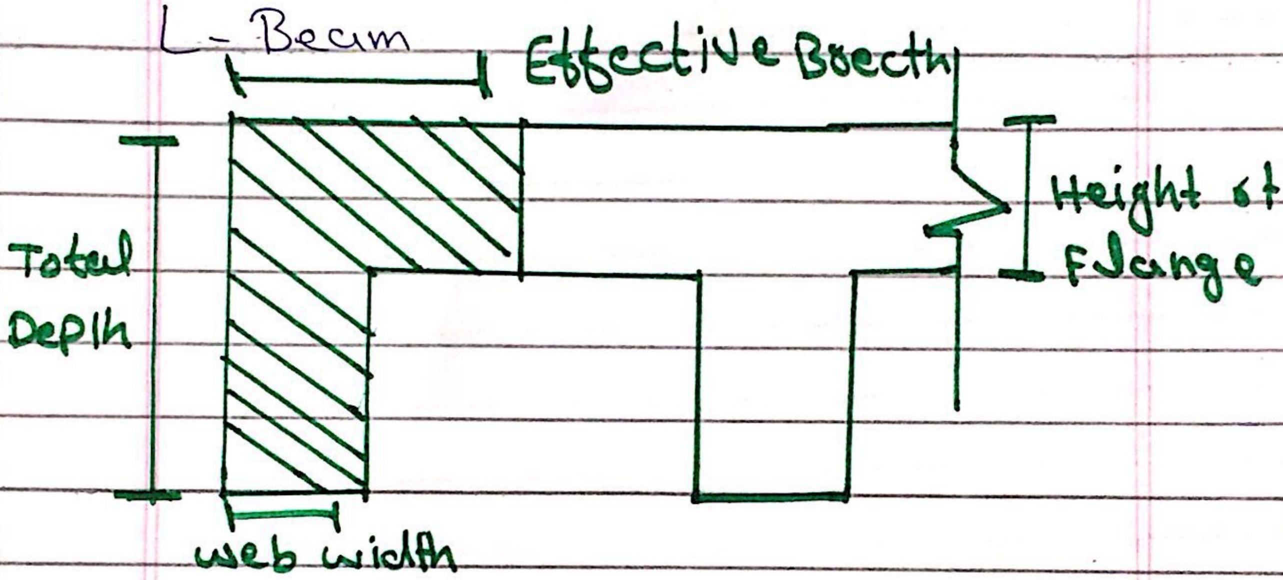
=> pocals of their T-Shape, these beams are called T-Beams

=> It is provide at the conte of the shop to ressite the lasts

=> the bottam rectangules portion of the beam is called well of the beam

L - Beam :-

= L - Shped Structues that is canted with the slob and Posend at the cron of the for is called L-Beam



=> L - Beams are also Called Edge Bemes

=> It is always proUded at the corr of the slob

=> L - Bems are typcel beams becom of thirs reduced overall strutal depth beams are in Prestssed or reunfical concets

FLEXURAL Analysis of T- Beam

Flexural Analysis of t- Beam consist of following Steps :-

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

$$Mu = \frac{Wu \times l^2}{8}$$

- Wu = Total Factored load
- L = Total length or Span of beam

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

(1) 16 (hf) + bw

2- c/c distance

3- Span / 4

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

* we have select the lest value from above forms &
* If c/c distan is given then is on need of $\frac{CTs}{2}$ + bw

3- Checking whethes Rectangutes or T- Beam Analysis is requirul

i - If a > hf -> special analysis is requirel

ii - If a < hf - Retules beam amlysis is requicel wher

(a = Depth of compression block)

hf Height of flange

(4)- For Finding area of Steel we have use

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

where

$$a = \frac{Ast \times fy}{0.85 \times fc \times bw}$$

ϕ = strength Reduction factor
- d = Effective depth
= a = compression block deplte bw = web with of beam

5- For checking the range of Reinforcement Ration

$$f_{max} = 0.85 \alpha B \times \frac{fc}{fy} \alpha \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon y} \right)$$

$$f_{min} = \frac{200}{fy}$$

$$f = \frac{Ast}{bd}$$

6- formul for finding No of bors requir is

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

7- for checking mimum with of bare occomation

bmin = 2(cler cover) + 2 dia(of) (dia of bar) + spaing b/w (dia of bar)

8- Design momond is given by

md = $\phi \times fy \times Ast \times (d - a/2)$ -> if $a < hf$

md = $\phi \times [As \times fy \times (d - hf/2) As - Ast) + fy \times d - a/2$ -> if $a > hf$

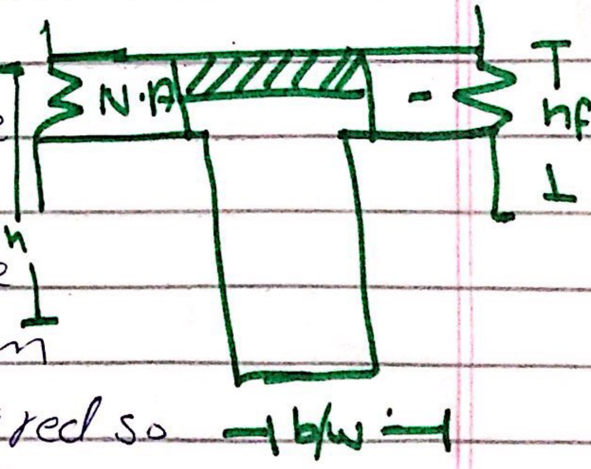
(QUESTION-04)

Wat is the differene b/w CASE-1 and CASE-2 in the desgn of T-Beam

(CASE-I)

from the figure $a < hf$

So in this case Rectomatles Beam Anlysis is Required so the Dessian momect formal with be

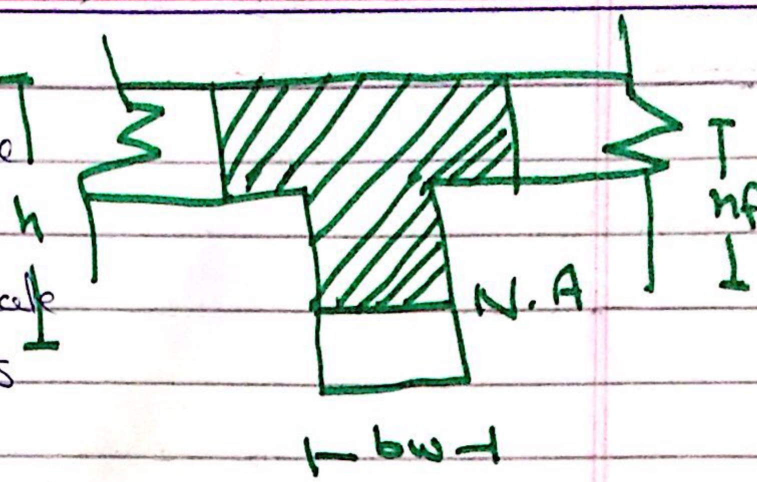


md = $\phi \times fy \times Ast \times (d - a/2)$

CASE - II :-

from the figue
a > hf
So in this space
beam analysis
i-e,
T - Bem anlysis
is reyused so
the required Bessinyn moment
will be $md = \phi \times [As \times fy \times (d - \frac{hf}{2}) +$

$(As - Ast) + fy + (d - a/o)$



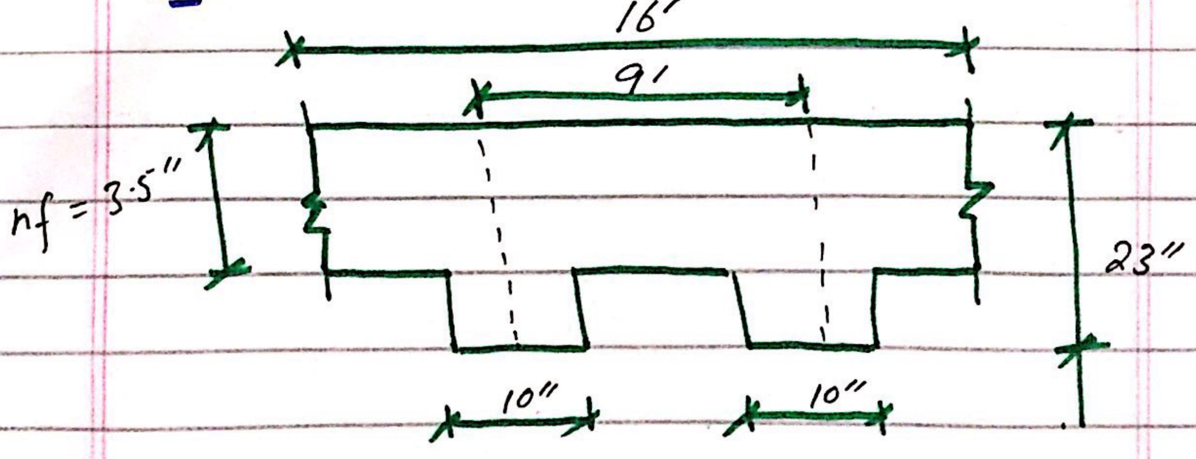
QUESTION-05:-

Given Data:-

Height OF flange $h_f = 3.5''$
c/c distance $= 9'$
length OF beam $= 16'$
web width $(b_w) = 10''$
Effective depth $(d) = 18''$
Height $(h) = 23''$

Total factored moment
$M_u = 5800$ kip-inch
$f'_c = 3$ ksi
$f_y = 60$ ksi

Sol:-



Step #1:-

Calculate the effective depth (be) For T- Beam

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

2- c/c distance $= 9 * 12 = 108''$

3- Span/4 $= \frac{16}{4} * 12 = 48$

Select least value From above values as;

$$b_e = 48''$$

Step #2

Checked whether Rectangular or T- beam Analysis is Required

Trial ① Let $a = h_f = 3.5$

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

$$= \frac{5800}{0.90 * 600 (18 - 3.5/2)} = 6.61 \, in^2$$

Trial ②

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

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

and Ast = 6.55 in2 => 3.2" < 3.5"

So Rectangular Beam Design is Required.

Trial (3)

$a = 3.21''$

$$A_{st} = \frac{5800}{0.90 \times 60 (18 - 3.21/2)} = \underline{6.55 \text{ in}^2}$$

So Area of Steel is 6.55 in2

Step (3):-

Checked ρ_{max} and ρ_{min}

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

$$= 0.085 \times \frac{3}{60} \times 0.85 \left(\frac{0.003}{0.003 + 0.005} \right)$$

$$\boxed{\rho_{max} = 0.013}$$

⊙ $$\rho_{min} = \frac{200}{fy} = \frac{200}{6000} = 0.003$$

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

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

$0.003 < 0.036 < 0.013$

As the value of ρ_{max} is less then ρ, So we have to design as "Doubly Reinfored beam"

First we find Area of Steel against ρ_{max}

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

$Ast = 0.013 (10 * 18)$

$Ast = 2.34 in^2$

Step (4):-

Finding $Mu_2 = ?$

By Formula

$Mu_2 = \phi * Ast * fy * (d - a/2)$ — (*)

For Mu_2 we find $a = ?$

$a = \frac{Ast * fy}{0.85 * f'c * b} = \frac{2.43 * 60}{0.85 * 3 * 10}$

$a = 5.72''$ put eq (*)

$Mu_2 = 0.90 * 2.43 * 60 (18 - 5.7/2)$

$Mu_2 = 1986.67$ Kip-inch

As $Mu_2 < Mu$

$1986.67 < 5800$

So we design the beam in such a away that it can resists more bending moment than the applied external moment.

Step (5):-

Finding Difference is moment and Area of Steel

$Mu_1 = Mu - Mu_2$

$= 5800 - 1986.67$

$Mu_1 = 3813.33$ Kip-inch

By Formula

$$Ast' = \frac{Mu}{\phi * fy * (d - d_1)} = \frac{3813.33}{0.90*60(18-2.5)}$$

$Ast' = 4.56$ in^2

Step ⑥ :-

Finding Total Area

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

$A_s = 2.34 + 4.56$

$\boxed{A_s = 6.99 \, in^2}$

Step ⑦ :-

Selection of Bar

In Tension Zone:-

let we try #8 bar

∴ dia #8 = 1"

$\text{No. of bars} = \frac{\text{Area of Steel}}{\text{Area of 1 bare}}$

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

So 9 #8 bars

In Compression:-

let try #7 bar

∴ dia #7 = 0.601 in²

$\text{No. of bar} = \frac{4.56}{0.601} = 7.5 \approx 8$

So 8 #7 bars

Step # 8 :-

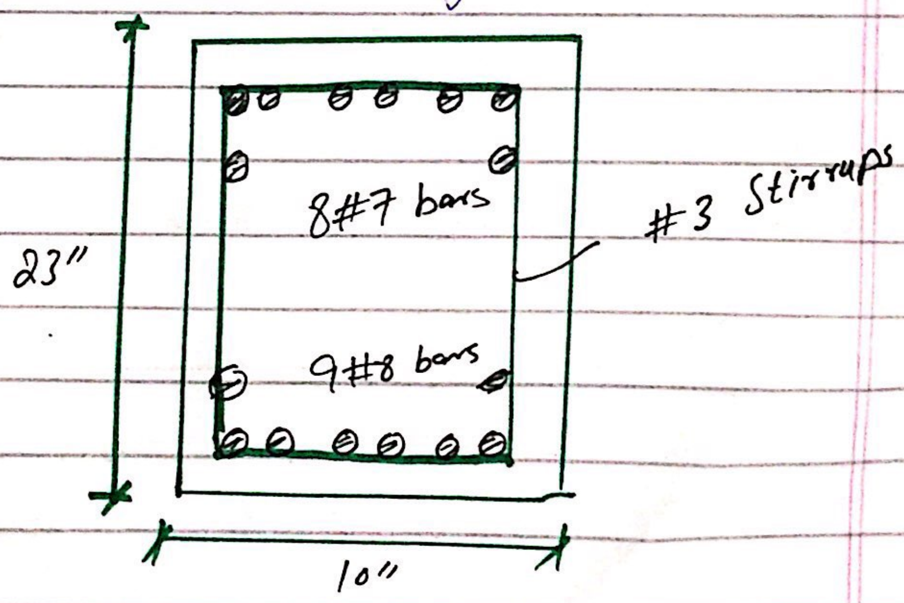
Minimum width For Accomodation of bar

$$b_{min} = (2 * 1.5) + \left(2 * \tfrac{3}{8}\right) + 9\left(\tfrac{8}{8}\right) + 8\left(\tfrac{8}{8}\right)$$

$$= 20.75''$$

As $20.75'' > 10''$

So the bar will be placed in multiple layers as;



Effective depth (d) $= 23 - 1.5 + \tfrac{3}{8} + \tfrac{8}{8} + \tfrac{1}{2}\left(\tfrac{8}{8}\right)$

$$d = 19.6''$$

Effective Cover (d') $= 1.5 + \tfrac{3}{8} + \tfrac{7}{8} + \tfrac{1}{2}\left(\tfrac{7}{8}\right)$

$$d' = 3.18''$$

Step (9) :-

Finding the Design moment

$$Md = \phi [A's * fy * (d-d') + (Ast - A's t) * fy * (d - a/2)] \quad -(K)$$

First $a = ?$

$$a = \frac{As - A's t * fy}{0.85 * f'c * b}$$

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

$\boxed{a = 5.31''}$ put in eq (K)

$$Md = 0.90 [(8 * 0.601) * 60 * (19.6 - 3.18) + (9 * 0.785 - 8 * 0.601) * (60 * 19.6 - 5.31/2)]$$

$$Md = 6328.38 \text{ kip-inch}$$

As $6328.38 > 5800$

So Design is Okey

Question - 6) (P-24)

A beam is reused to developed and ultimate moment of 6000 Kip-inches limited to 14 x 26 inch size, use $f''_c = 4$ Kis and $f_y = 60$ Kis determine feural reinforcement assume two rows of tesile reinforcement and effective depth of beam is 22 inches

So:-

Give:-

Breadth (b) = 14"

Height (b) = 26"

Comete compression Stength (f_c') = 4 Kis

Steel Tensle strength (f_y) = 60 Kis

Ultimate factored moment (M_u) = 6000 Kip

Effective depth of beam (d) = 22"

Assume Effective case (d) = 2.5"

STEP #2 (Area of Steel)

As we know that

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

$$\Rightarrow A_{st} = 0.0180 \times (14 \times 22) \, (5.54 \, in^2)$$

(P-25)

STEP #3 :- (Design moment)

By using formal

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

$\Rightarrow a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = 6.98''$

So

$M_{u2} \; 0.90 \times 5.54 \times 60 \times (28 - 6.98)$

$= 5537.4$ Kip - inch

as

$5537.4 < 6000$

So we have to desinyn a section as doubly renfored

STEP# 4 (Differece In momets

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

$= 6000 - 5537.4$

$M_{u1} = 462.6$ Kip inches

STEP #5 :- (Area of steel)

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

So area of steel in compression zone will be

$= A'_{st} \; \frac{M_{u1}}{\phi \times f_y \times (d - d')} = \frac{462.6}{0.90 \times 60 \times (22 - 2.5)}$

$A'_{st} = 0.44 \, in^2$

STEP #6:- Total Steel Area

$A_s = A_{st} + A'_{st} = 5.54 + 0.44$

$A_s = 5.98 \, in^2$

Step ⑦ :-

Selection and No.s of bars used :—

1 - Steel in Tension Zone :-

we used #7 bar

Dia of #7 = 0.601 in2

So

No. of bar = Ast / Area of 1 #7 bar

$= 5.98 / 0.601 = 9.9 \approxeq 10$

So 10 #7 bars

2- Steel in Compression Zone

try to #5 bars

∴ dia of #5 = 0.306 in2

No of bars = $0.44 / 0.306 = 1.43 \approxeq 2$

So 2 #5 bars

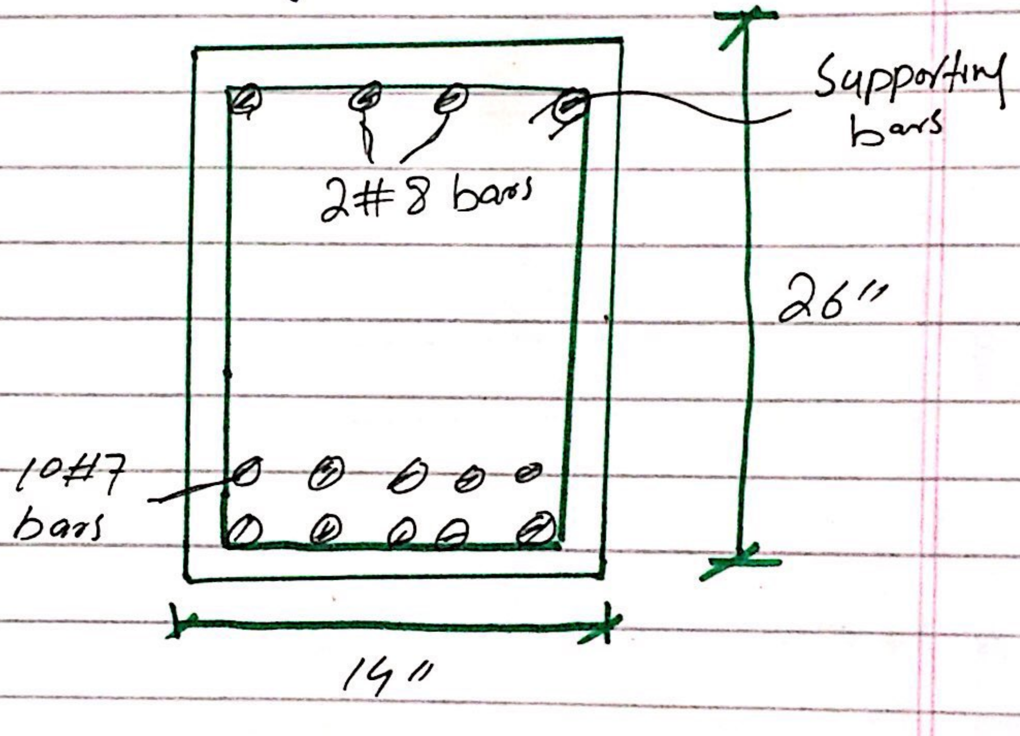
Step ⑧ :-

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

$$d = 22.82''$$

⊙ effective cover (d') $= 1.5 + 3/8 + \frac{1}{2}(5/8)$

$$d' = 2.18''$$

Step (9) Design moment:-

$$Md = \phi [Ast' * fy * (d-d'') + (Ast - Ast') * fy (d - a/2)$$

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

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

$$\boxed{a = 6.80''}$$

Now

$$Md = 0.90 [(2 * 0.306) 60 * (22.82 - 2.18) + 10 * 0.601 - 2 * 0.306)]$$

$$Md = 7047.6 \text{ kip-inch}$$

As $7047.6 > 6000$

Thus the Design is

Okey

& End