Assignment

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Subject : PRCD-I

Question # 01

Explain in detail types of Stirrup with fig and also explain aci codes for Shear design

Ans:

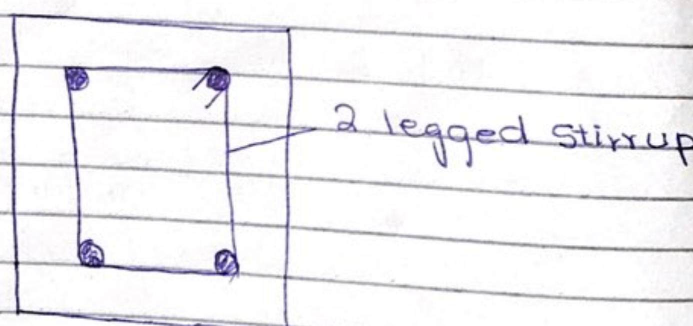
Stirrup:

Stirrup are closed-loop bars tied at regular intervals in beam reinforcement to hold bars in position.

Types of Stirrup:

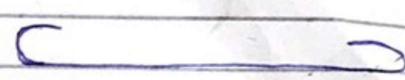
1: ~~Single~~ Two Legged Stirrup:

It is used commonly and widely used stirrup. minimum 4 bars are required for providing this stirrup.



a) Single legged stirrup:

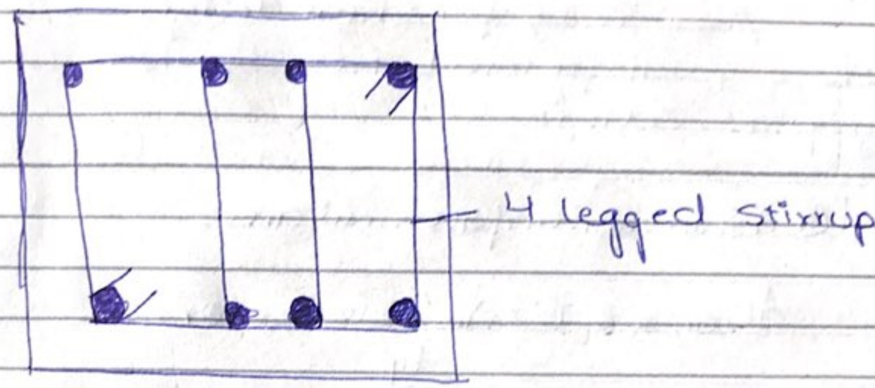
The simply leg stirrup have rarely been used because they are mostly used when binding only two rods



3) **Four legged Stirrup:**

~~It is used~~

These Stirrup 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 formulas used for Shear design of a beam.

1) Critical Section: Critical Section occurs at 45° and is at distances (d) from face of Support which is equal to effective depth.

2) Shear Strength Capacity of Concrete

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

3: Minimum web reinforcement

If $V_u \leq \phi V_c$, then theoratically 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

(∵ V_U = Total factored shear applied at a given Section.

=> For minimum Reinforcement area:-

$$A_{v_{min}} = 0.75 \times \frac{\sqrt{f_c'} \times b_w \times S}{f_y} \text{ or }$$

$$\frac{50 \times b_w \times S}{f_y} \rightarrow \left[\text{Higher value is Selected}\right]$$

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

$$S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f_c'} \times b_w} \text{ or } \frac{A_v \times f_y}{50 \times b_w} \left[\text{lesser value is Selected}\right]$$

4. 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 reinforcement can be find by

$$S = \frac{\phi \times A_v \times f_y \times d}{V_U - \phi V_C}$$

[redacted]

5. if $V_s \leq 4 \times \sqrt{F_c'} \times b_w \times d$ then: max. Spacing for Stirrup will be Smallest of 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 $V_s > 4 \times \sqrt{F_c'}\, b_w \times d$

max. spacing will be valued

• if $V_s > 8 \times \sqrt{f_c} \times b_w \times d$

Then either increase Cross Sectional dimensions or increase f_c'.

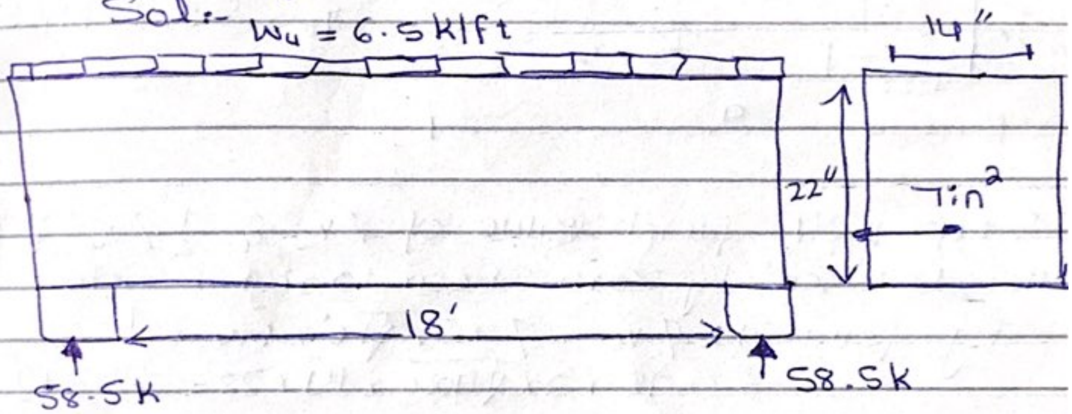
Q

Q2. A Simply supported rectangular beam 14" wide having an affective depth of 22" to carry a lateral load of 6.5 k/ft on a 18' simple span. & is reinforced with 7in^2 of tensile steel area if $F_c' = 4$ksi & $F_y = 60$ ksi then design the beam for shear.

Given data:-

Breadth of web of beam $(b_w) = 14"$
Effective depth $(d) = 22"$
Given load $= 6.5$ k/ft
Steel area $= 7$in^2
$F_c' = 4$ksi , $F_y = 60$ ksi

Sol:-



Step # 01 Reaction on support

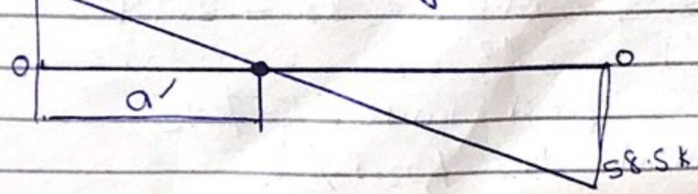
Find reaction due applied load

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

Step # 02

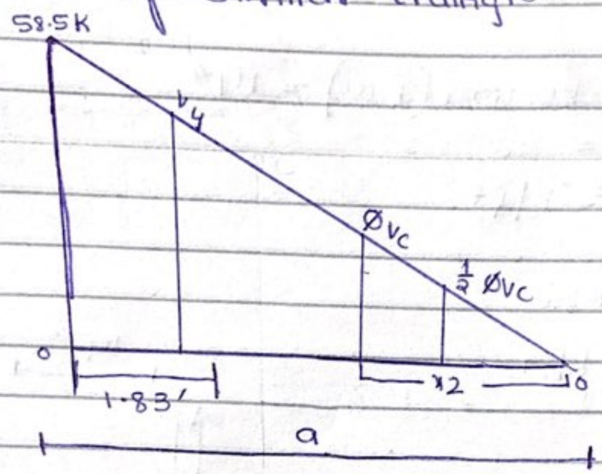
Shear force diagram

The require shear diagram will be



Step # 03 Find value of Critical Shear "V_c" & its location As we know that critical shear is located at distance "d" from force of Support $(d) = 22'' = 1.83'$

find value of critical shear at distance by using Similar traingle



from Similar traingle

$$\frac{58.5}{9} = \frac{V_4}{8.17}$$

$$V_u = \frac{5.85 \times 8.17}{9}$$

$$V_u = 53.10 \text{ kips}$$

Step # 04 find value of ϕV_c & $\frac{1}{2}\phi V_c$ & also its distance by Zero Shear to right side.

By formula $\phi V_c = \phi \times 2 \times \sqrt{F_c'} \times b_w \times d$

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

$$= 29.21 \text{ kips}$$

Location by Similar traingle

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

$$x_1 = 4.49'$$

Similarly $\frac{1}{2}\phi V_c = \phi V_c/2 \Rightarrow \frac{29.21}{2} = 1.4.60 \text{ kips}$

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

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

Step # 05 find value of ϕV_s

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

$\emptyset vs = v_u - \emptyset v_c = 53.10 - 29.21$
$\emptyset vs = 23.89$ kips

Step # 06 Check on Section adequacy
$\emptyset \times 8 \times \sqrt{Fc'} \times bw \times d \Rightarrow 0.75 \times 8 \times \sqrt{4000} \times 14 \times 22$
$= 116877$ lbs $\Rightarrow 116.87$ kips
As $\emptyset \times 8 \times \sqrt{Fc'} \times bw \times d > \emptyset vs$
section is adequate

Step # 07 Check max Spacing for Stirrup
By formula $\emptyset \times 4 \times \sqrt{Fc'} \times bw \times d$
$= 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22 = 58438$ lbs
$= 58.43$ kips
AS $\emptyset \times 4 \times \sqrt{Fc'} \times bw \times d > \emptyset vs$
So max will Selected by following 4 condition (1) $S_{max} = 24''$ (2) $d/2 = \frac{22''}{2} = 11''$
(3) $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{Fc'} \times bw}$

$S_{max} = 19.87'' \Rightarrow$
(4) $S_{max} = \frac{Av \times fy}{50 \times bw}$

$= \frac{0.22 \times 60000}{50 \times 14}$

$S_{max} = 18.85''$

from above 4 condition, least value of Spacing for # 3 2 legged Stirrup will be Selected a $S_{max} = 11''$

Step # 08

Spacing of Stirrup from at Critical Section will be by formula

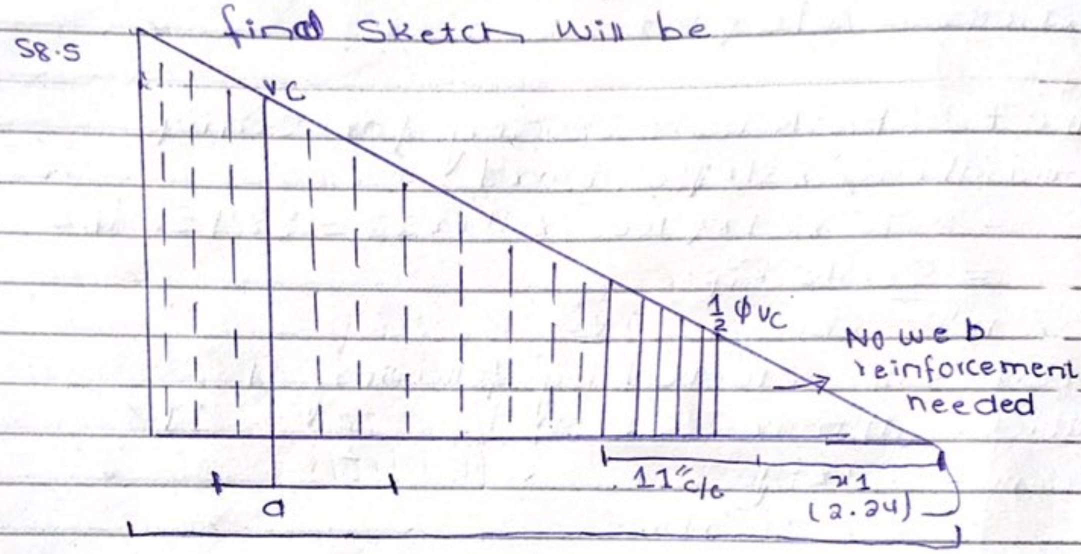
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{53.10 - 29.21}$$

$S = 9.1'' \simeq 9.5''$ So $9.5''$ c/c

Step # 9

final sketch will be

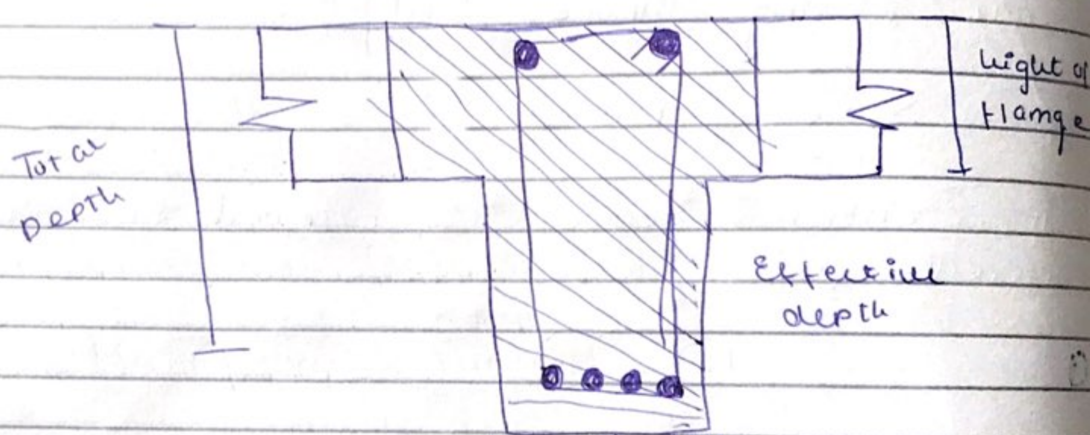


Question # 3

Define both T-beam and L-beam With help of example. also explain flexural analysis of T beam.

T-Beam:

In most of reinforcement Concrete Structures concrete slabs are cast monotithically With slam, So in case beam that act as an intermediate beam are called T_beam.

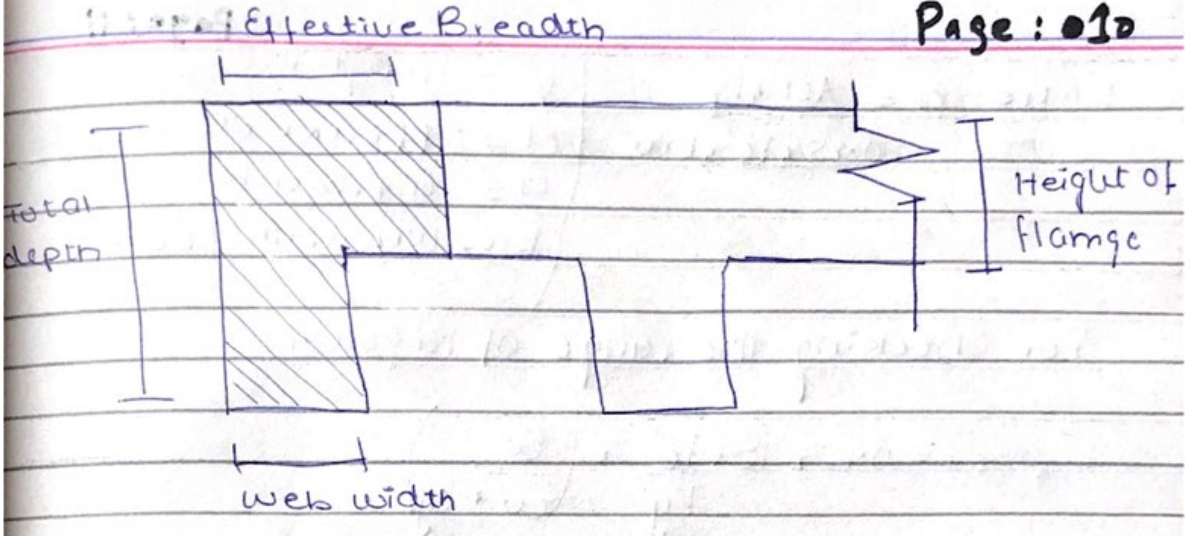


⇒ Because of their T_Shape, these beams are called T_Beams

⇒ The buttom rectangular portion of beam is called Webbeam

L-Beam

L-Shaped Structure that is in contact with slab and present at corner of floor is called L.beam.



=> L-Beam are typical floor beams because of the slab reduced over all structural depth are in prestressed a reinforced concrete.

Flexural Analysis Of T- beam:.

Flexual analysis of T-beam consists of following

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

$$m_v = \frac{W_U \times L_2}{2} \rightarrow$$ (W_U = Total factored of laud , L = Total span of beam)

2) Checking wheather rectangular or T-Beam Analysis is required.

i) if $a > h_f$ Special analysis

ii) if $a < h_f$ Rectangular beam analysis

4:- For finding Area of Steel, we have to use

$$A_{st} = \frac{m_U}{\varnothing \times f_y \times b_w}$$

where $a = \frac{Ast \times fy}{0.85 \times Fc' \times bw}$:

ϕ = Strength product
d = Effective depth
a = Compression block dep
bw = Web width of beam

5. For Checking the range of reinforcement

$$\rho max = 0.85 \times \beta \times \frac{Fc'}{Fy} \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}\right)$$

$$\rho min = \frac{200}{Fy}$$

$$\rho = \frac{Ast}{b \times d}$$

6. Formula for finding no. of bars

$$No. of bar = \frac{Area of Steel}{Area of Single bar}$$

7) Design moment is given by

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

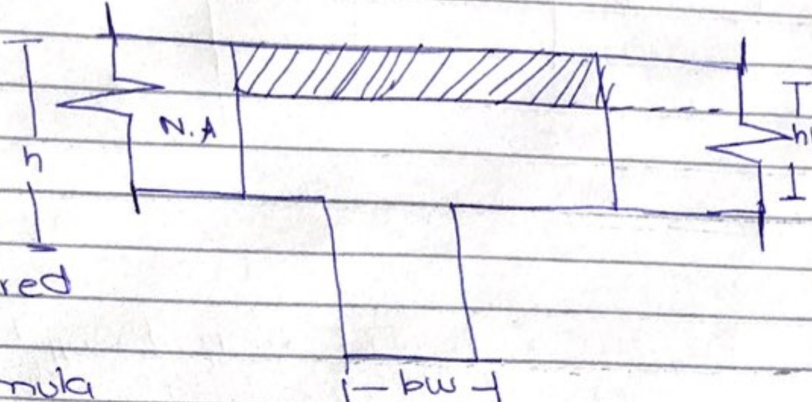
$$md = \phi \{ As \times fy \times (d - hf/2) + (As - Ast) + fy \times (d - a/2) \rightarrow if\ a > hf$$

Qusestion # 4

What is difference b/w case I and case II in design of T-beam?

Case I.

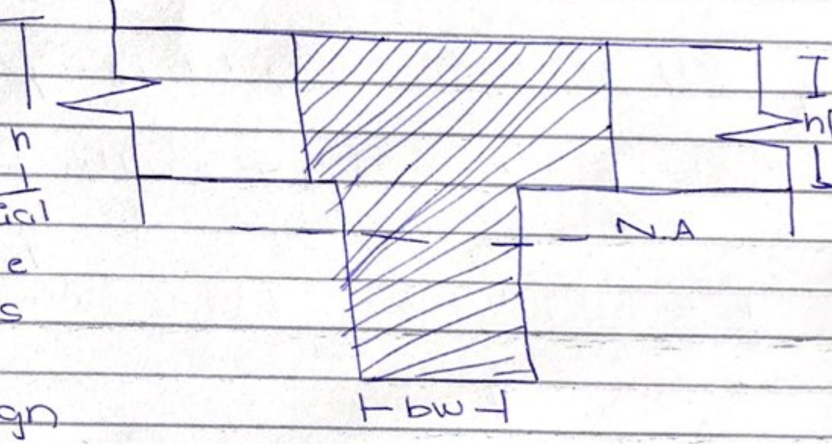
from figure
$a < h_f$
So in case rectangular Beam analysis is required so
The design formula will be



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

Case II

from figure
$a > h_f$
So in this, special beam analysis i-e T-Beam Analysis is required so required design moment will be



$md = \phi \times [As \times f_y \times d - \frac{h_f}{2} + (As - Ast) + f_y \times (d - \frac{a}{2})]$

Q5. A floor System consist of 3.5" concrete slab supported by 16' simple Span Spaced at 9' c/c, the beam having a web width of 10" and Effective depth of 18" & total height is 23" calculate necessary flexural reinforcement if the factored applied moment is 5800 kip-inch use $F_c' = 3ksi$, $f_y = 60ksi$

Given:-

Height of flange $(h_f) = 3.5"$

c/c distance $= 9'$

Length / Span of beam $= 16'$

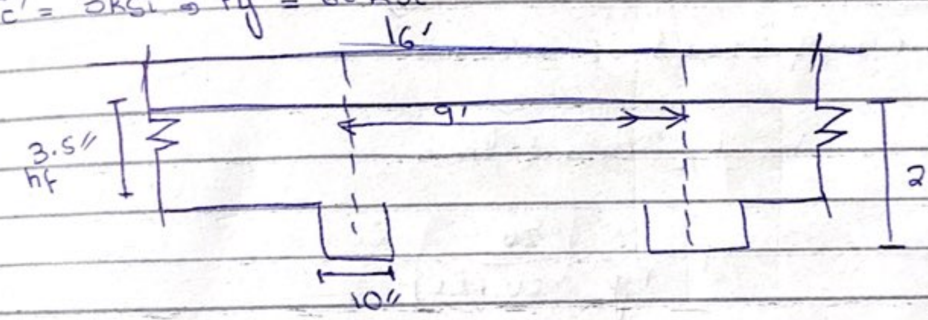
Web width $(b_w) = 10"$

Effective depth $= 18"$

Height $(h) = 23"$

total factored moment $(M_u) = 5800$ kip-inch

$F_c' = 3ksi$, $F_y = 60ksi$



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) Span/4 $= \frac{16}{4} \times 12 = 48"$

Selecting least value of be as

$b_e = 48"$

Step #02

Check weather rectangular or T-beam

Trial # 01 let $a = h_f = 3.5''$

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

Trial # 02 $a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_e} = \frac{6.61 \times 60}{0.85 \times 3 \times 48} = 3.2''$

& $A_{st} = 6.55 \, in^2 \Rightarrow 3.2'' \nless 3.5''$

So rectangular beam is required.

Trial # 03 $a = 3.21''$

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

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

Step # 03 Check ρ_{max} & ρ_{min}

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

$$= 0.85 \times 0.85 \times \frac{3}{600} \left(\frac{0.003}{0.003 + 0.005} \right)$$

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

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

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

$0.003 < 0.036 < 0.013$

As value of ρ_{max} is less than ρ, So we have to design it as doubly reinforced Beam"

⇒ first we have to find Area Steel (bxd)

Ksh/1± $\rho_{max} = \frac{Ast}{b \times d} \Rightarrow Ast = \rho_{max} \times (b \times d)$

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

$Ast = 2.34 \; in^2$

Step # 04 find M_{u2} By formula

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

find value of "a" $\quad a = \frac{Ast \times f_y}{0.85 \times f_c' \times b} = \frac{2.45 \times 60}{0.85 \times 3 \times 10}$

$a = 5.72''$ As

$M_{u2} = 0.90 \times 2.43 \times 60 \times \left(18 - \frac{5.72}{2}\right) = 1986.67$ kip/inch

As $M_{u2} < M_u \Rightarrow 1986.67 < 5800$

So we design a beam that resist more bending moment than applied external moment.

Step # 05 Finding dif moment & Area of steel

$M_{u1} = M_u - M_{u2} \Rightarrow 5800 - 1986.67$

$M_{u1} = 3813.23$ kip.inch

By formula.

$$A'st = \frac{M_u}{\phi \times f_y \times (d - d')} = \frac{3813.23}{0.90 \times 60 \times (18 - 2.5)}$$

$A'st = 4.56 \; in^2$

Step # 6 find total Steel Area

$A_s = A_{st} + A'_{st} = 2.43 + 4.56$

$A_s = 6.99 in^2$

Step # 07 Select bar

In tension zone. Let we use #8 bar

dia (8/8) = 1", Area = $\frac{\pi}{4}(1)^2 = 0.785 in^2$

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

$= \frac{6.99}{0.78} = 8.9 \simeq 9$

So 9 #8 bars

In compression zone let use #7 bar

dia = $(\frac{7}{8})''$, Area $\frac{\pi}{4}(7/8)^2 = 0.601 in^2$

So 8 #7 bars

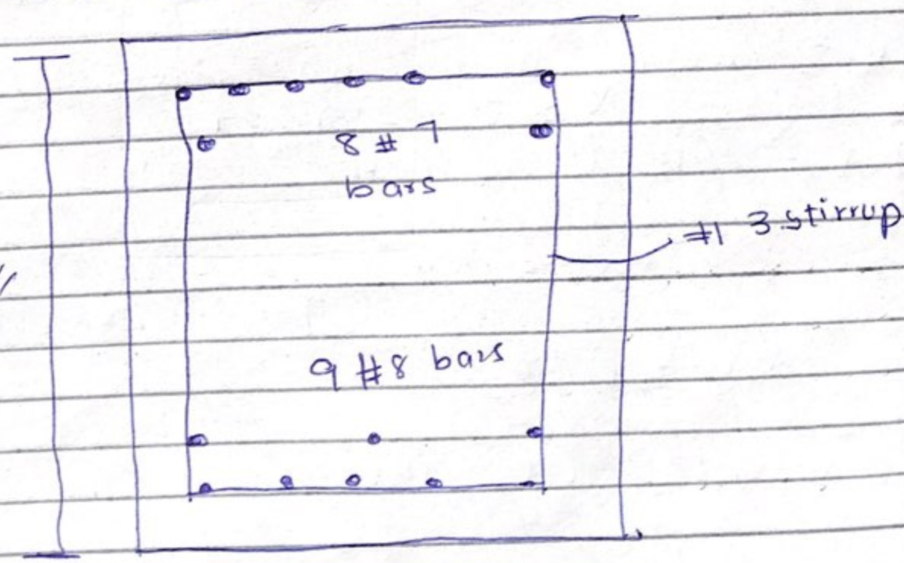
Step # 8 mini width for accomodation of bar

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

$= 20.75''$

As $20.75 > 10''$

bar will be multiple layers.



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

Effective Cover = 1.5 + $\frac{3}{8}$ + $\frac{7}{8}$ + $\frac{1}{2}\left(\frac{7}{8}\right)$ = 3.18

Step # 09 find design moment

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

= 5.31 //

$$Md = 0.90\left[(8 \times 0.601) \times 60 \times (19.6 - 3.18) + (9 \times 0.785) - 8 \times 0.60\right] \times 60 \times \left(19.6 - \frac{5.31}{2}\right)$$

Md = 6328.38

AS 6328.38 > 5800

design ok.

Q6. A beam is revised to develop & ultimate moment of 6000 kip-inch limited to 14x21 inch size use F_c' = 4ksi & fy = 60ksi. Determine flexusal reinforcement & affective depth of beam is 22 inches.

Given data:

Breadth = 14' (b) , Height (h) = 26"

Concrete Compression Strength (F_c') = 4ksi

Steel tensile Strength (F_y) = 60ksi

ultimate factored moment (M_u) = 6000 kip-inch

effective depth of beam (d) = 22"

Sol:

Assume Effective cover (d') = 2.5"

Step # 1 Reinforcement Ratio

$$\rho_{max} = 0.85 \times \beta \times \frac{F_c'}{F_y} \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_o}\right)$$

$$\rho = 0.85 \times 0.85 \times \frac{4}{60} \times \left(\frac{0.003}{0.003 + 0.05}\right)$$

Step # 02 Area of Steel

As we know

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

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

Step # 03 Design moment

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

$$\Rightarrow a = \frac{A_{st} \times F_y}{0.85 \times F_c' \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14}$$

$$= 6.98''$$

So $M_{u2} = 0.90 \times 5.54 \times 60 \times \left(22 - \frac{6.98}{2}\right)$
$= 5537.4$ kip-inch

AS

5537.4 < 6000

So we have to design a section as doubly reinforced

Step # 04 Difference in moment

$M_{u1} = M_U - M_{u2}$
$= 6000 - 5537.4$
$M_{u1} = 462.6$ kip-inch

Step # 05 Area of Steel

$M_{u1} = \phi \times Ast \times fy \times (d - d')$

So Area of steel in compression zone will be

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

$A'st = 0.44 in^2$

Step # 06 Total Steel Area

$AS = Ast + A'st$
$= 5.54 + 0.44 = 5.98 in^2$

Step # 07 Selection & No of used bars

(1) Steel in tension zone :-

We use # 7 bar, dia = $(7/8)'' = 0.875''$

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

So No of bars $= \frac{As}{\text{Area of Single bar}}$

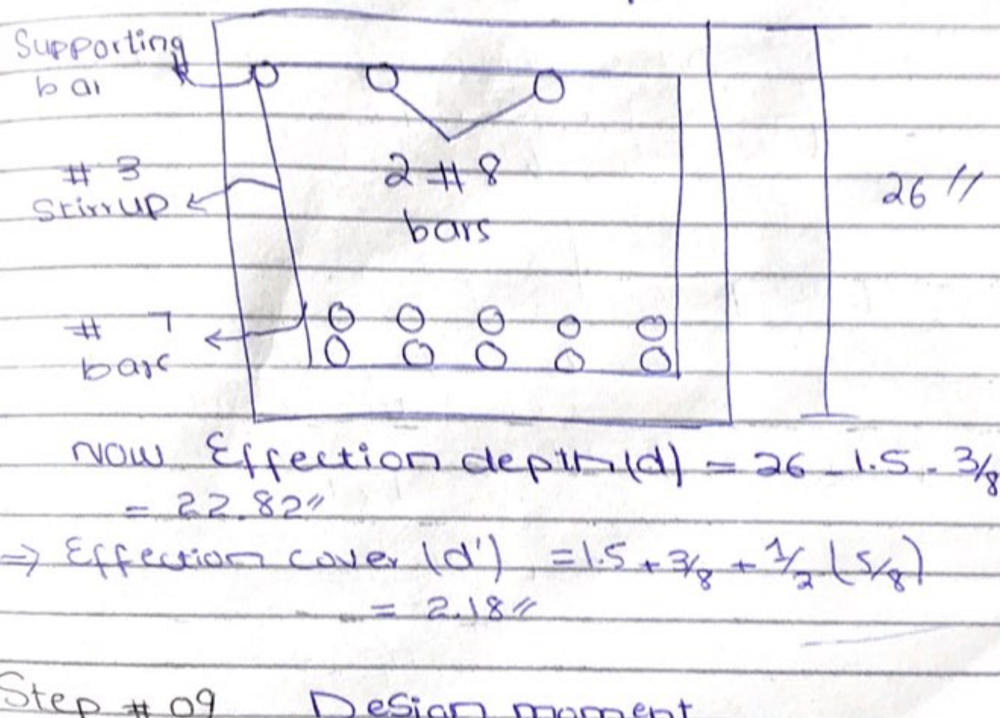
$= \frac{5.98}{0.601} = 9.9 \simeq 10$ bars

So 10 # 7 bars

(2) Steel in compression zone
We use # 5 bar
dia = $(5/8)''$ = 0.625'' , Area = $\frac{\pi}{4}(0.625)^2$
= 0.306 in^2

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

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 Effection depth (d) = $26 - 1.5 - 3/8 - 7/8 - 1/2(7/8)$
= 22.82''
→ Effection cover (d') = $1.5 + 3/8 + 1/2(5/8)$
= 2.18''

Step # 09 Design moment
$M_d = \phi \times [A'_{st} \times f_y \times (d - d') + (A_{st} - A'_{st}) \times f_y \times (d - a/2)]$

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

$$= \frac{\left((10 \times 0.601) - [2 \times 0.306]\right) \times 60}{0.85 \times 4 \times 14}$$

$= 6.80''$

$Md = 0.90 \ [(2 \times 0.306) \times 60 \times (22.82 - 2.18) + (10 \times 0.6$ ... $- 2 \times 0.306$

Md = 7047.6 kip-inch

AS 7047.67 > 6000

Design is Okay.