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Assignement	prcd 1.
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Page 1

Q No 1 Explain in detail types of Stirrups with figures and Also explain ACI codes for shear design.

Ans:- Stirrup:-

Stirrup are closed-loop bars tied at reguler intervals in beam reinforment to hold The bars in position.

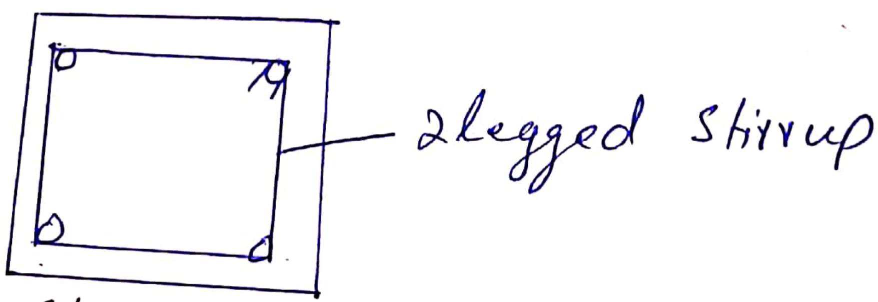
Types of stirrups:-

1- Single Legged Stirrup:-

The Single-leg Stirrups have rarely been used because they are mostly used when binding only two rods.

2- Two legged Stirrup:-

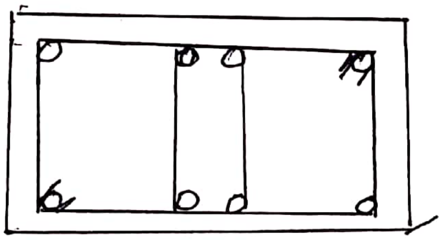
It is most commonly and widely used Stirrup minimum is bars are required for providing This Stirrup.



3) Four legged stirrup

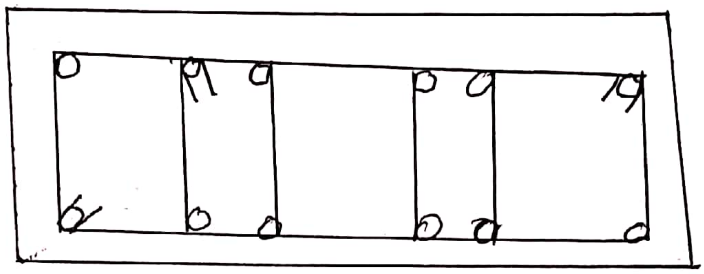
These stirrups are used in case of web rinforcement.

page 2



4-legged Stirrup.

4 Six legged Stirrup



ACI codes for shear Design of A Beam
According to Aci-318 following are the formula used for the Shear desig of a Beam.

1- Critical Section:- Critical Section occurs at 45° and it distance "d" from the face of support which is equal to effective depth.

2- Show Strength capacity of concret is

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

3- Mimum web Reinforcement.
If $V_u \leq \phi V_c$ then theoritcally no web reiforment is required However ACI codes require provision of atleast a minmium area of web reinforment equal to

$\phi = 0.75 \longrightarrow$ for shear. ~~applied~~ design.

V_u = Total factored Shear applied at a given Section.

For minimum Reinforement Area:

$Av_{min} = 0.75 \times \sqrt{f'c} \times bw \times S$ or $50 \times bw \times S$ → {Higher value is Selected}

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

$$S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw} \text{ or } \frac{Av \times fy}{50 \times bw} \rightarrow \{\text{Lesser value is selected}\}$$

4- No web-reinforcement is required if.

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

Between Critical Section "V_u" and "ϕV_c" Spacing b/w web reinforment can be find by

$$S = \frac{\phi \times Av \times fy \times d}{V_u - \phi V_c}$$

5- If $V_s \leq 4 \times \sqrt{f'c} \times bw \times d$ then max Spacing for stirrups will be the Smallest of the following.

1- 24"

2- d/2

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

∴ V_s = Shear force carried by web reinforment.

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

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

max - Spacing will be halved

=> if $V_s > 8 \times \sqrt{f'_c} \times b_w \times d$

↓

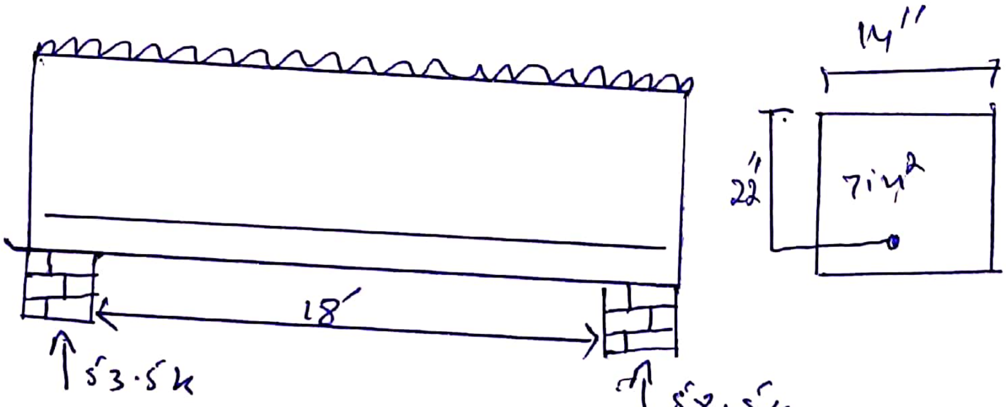
Then either increase cross-sectional dimensions or increase f'_c

Q No 2: A Simply Supported rectangular beam 14" wide having an effective depth of 22" to carry a load of 6.5 k/ft on a 18' simple Span It is reinforced with 7in² of tensil Steel area if fc' = 4ksi and fy = 60 then design the beam for Shear.

Given Data:

Breadth of web of beem (bw) = 14"
Effective depth (d) = 22"
Given load = 6.5 k/ft
Steel Area = 7in²
fc' = 4 ksi
fy = 60 ksi

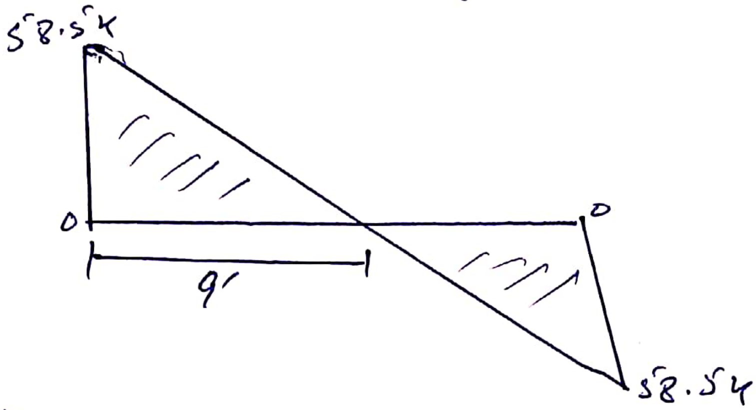
Sol:-



Step # 1 Reaction on Supports.
Finding the reaction due to applied load
Total load = $\frac{6.5 \times 18}{2}$ = 58.5 kips.

Step # 2 Shear force Diagram

The required Shear diagram will be

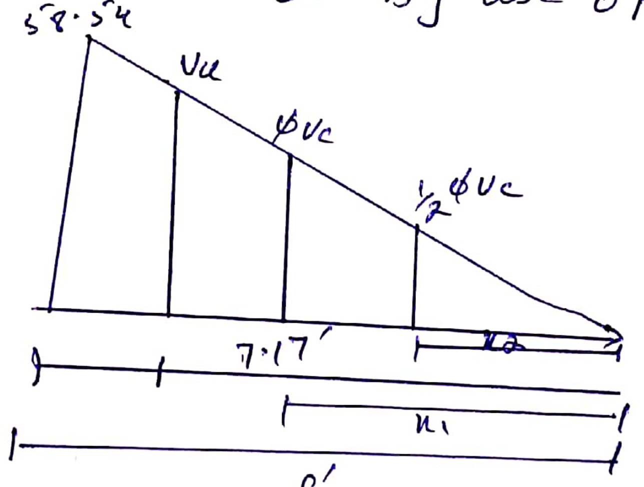


Step # 3

Finding the value of critical Shear "Vu" and its location As.

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

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



From Similar triangles

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

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

Vu = 46.61 kips

Step # 4:-

finding the value of ϕVc and ½ ϕVc also the distance from zero shear to right Side.

By formula.

=> $\phi Vc = \phi \times 2 \times \sqrt{f'c} \times bw \times d$.

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

= **29.21 kips**

⇒ location of ϕV_c by similar triangles.

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

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

⇒ Similarly,

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

⇒ location of $\tfrac{1}{2}\phi V_c$ will be

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

Step #5

Find the value of ϕV_s

By formula $V_u = \phi V_s + V_c$

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

$$= 46.61 - 29.21$$

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

Step #6

Check on Section adequacy

By formula

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

$$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 22 = 116877 \text{ lbs}$$

$$= 116.877 \text{ kips}$$

As $\phi \times 8 \times \sqrt{f'_c} \times b_w \times d > \phi V_s$

So Section Adequate.

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Step # 7:-

Check on maximum spacing for stirrup

By formula.

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

$0.75 \times 4 \times \sqrt{4000} \times 14 \times 22 = 58438$ lbs

$= 58.43$ kips.

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

So maximum will be selected from the following 4 condition.

Here we are using #3 stirrup dia = 3/8 = 0.375

So

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

for 2-legged stirrup

=> Area x 2

=> 0.11 x 2 = 0.22 in².

1- Smax = 24"

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

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

3- $S_{max} = \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 14} = 19.87"$

4- $S_{max} = \dfrac{Av \times fy}{50 \times bw} = \dfrac{0.22 \times 60000}{50 \times 14} = 18.85$

from above 4 condition least value of spacing for # 3 2legged stirrup will be selected as,

Smax = 11"

Step #8

Stirrups Spacing from/at Critical Section will be By formula:

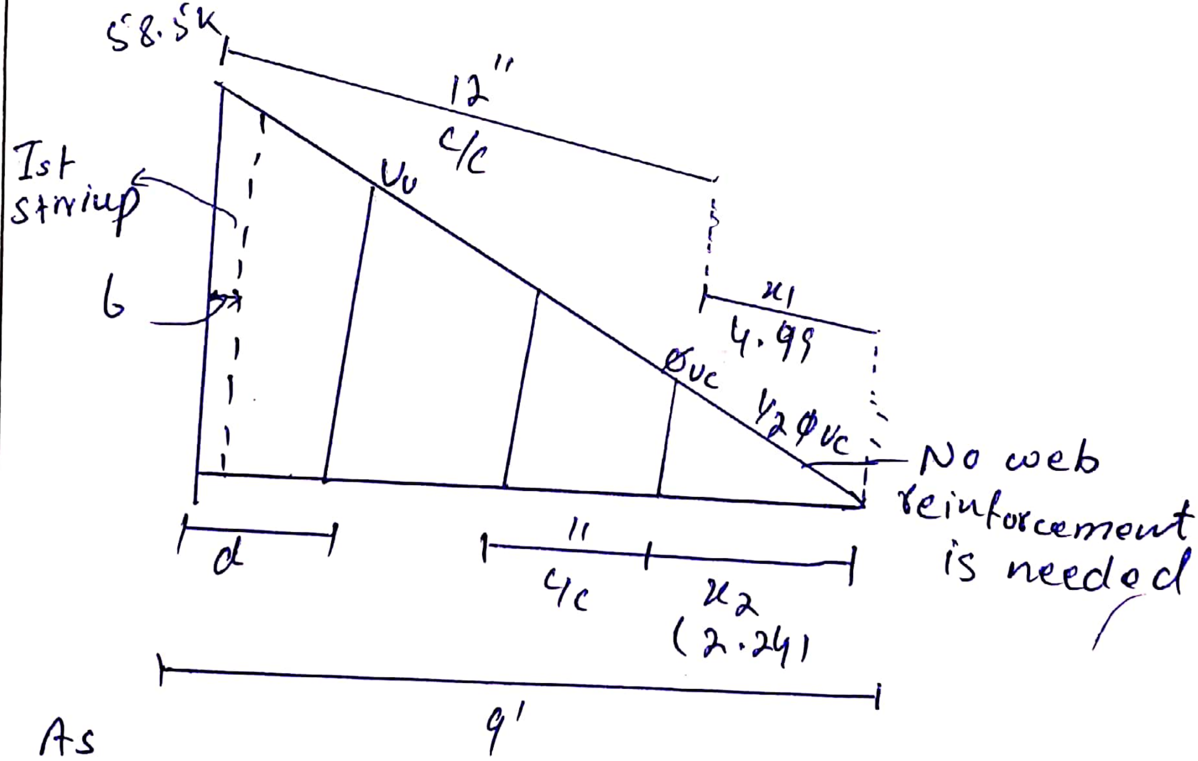
$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{46.61 - 29.81}$$

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

So $12''$ c/c.

Step # 9:-

Final Sketch will be

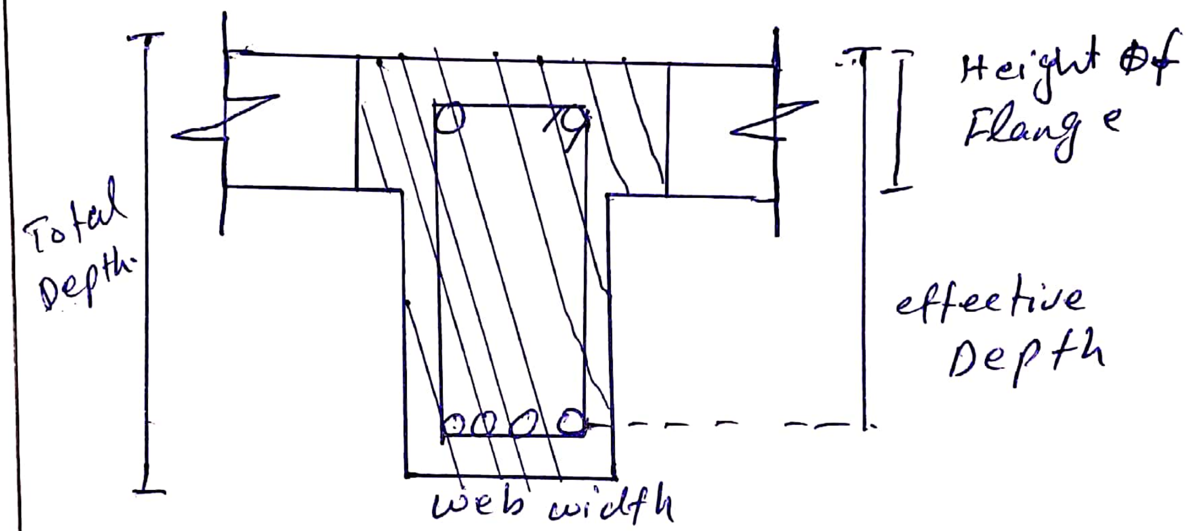


As first Stirrup from face Support
$S/2 = 12/2 = 6''$

Q No 3: Define both the T-Beam and L-Beam will the help of diagram Also explain flexural analysis of T-Beam.

T-Beam:-

=> In most of the reinforced concrete Structures Concrete Slabs are cast monolithically will the Slab So in this case the beam that act as an intermediat beam are called T-Beams.



=> Because of their T-Shap these beams are Called T-Beam.

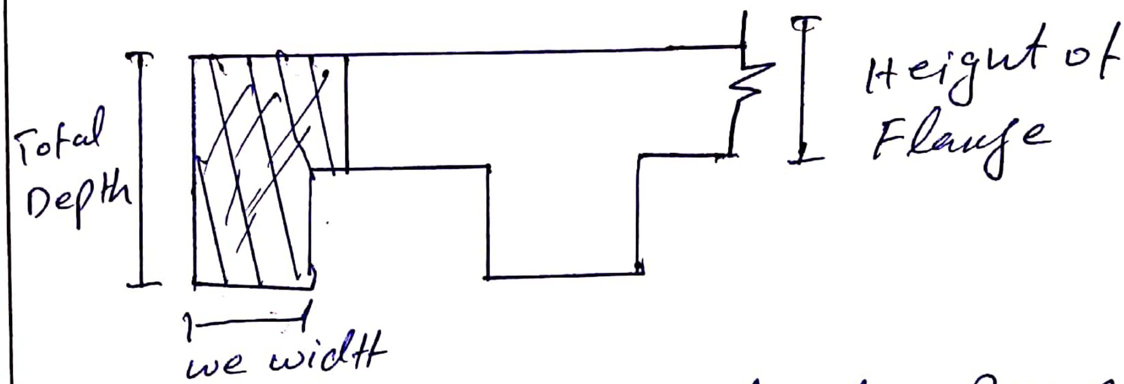
=> It is provided at the center of the Slab to resists the loads.

=> The upper most are of the beam attached to the Slab is called Flang.

=> 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 the corner of the floor is called L-Beam.



=> L-Beams are also called edge Beams
=> It is always provided at the corners of the slab.
=> L-Beams are typical floor beams because 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 the following steps:-

1- for finding the ultimate factored moment we use the following formula.

$$Mu = \frac{wu - L^2}{8}$$

→ wu = Total facted load
L = Total span of the beam.

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

1- 16(hf)+bw   hf = height of flange
2- c/c distance   CTs = Clear transverse Span)
3- Span/4
4- $\frac{CTS}{2} + bw$

- we have to Select the least value, above formulas.
- If c/c distance is given then there is no need of $\frac{CTs}{2} + bw$.

3- Checking whether Rectangular or T-Beam Analysis is required.

i If a > hf -> Special Analysis is required
ii If a < hf -> Rectangular beam Analysis is required

where
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

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

Ø = Strength Reduction fact
d = Effective depth
a = compression block depth
bw = web with width of beam

5- for checking the range of Reinforcement Ratio.

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

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

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

6 - formula for finding No. of bars required is

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

7- for checking minimum width for bars accomodation.

$b_{min} = 2(\text{clear cover}) + 2(\text{dia of stirrup}) + \text{No. of bars}(\text{dia of bars}) + \text{Spacing b/w bar}(\text{dia of bars})$

8- Design moment is given by

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

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

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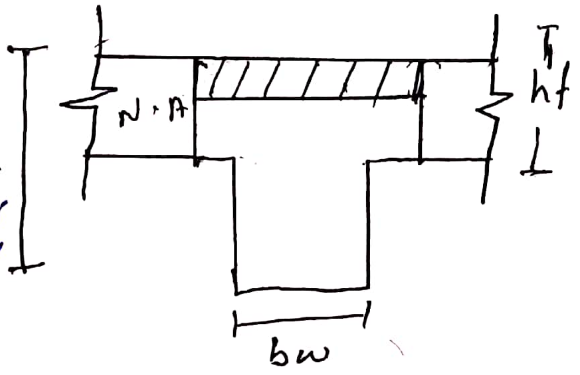
QNo4 What is the difference b/w case-1 and case-2 in the design of T-Beam?

Ans:- CASE I:-

from the figure
$a < hf$.
So in this cas Rectangler Beam Analysis is Required
So the Design moment formula will be

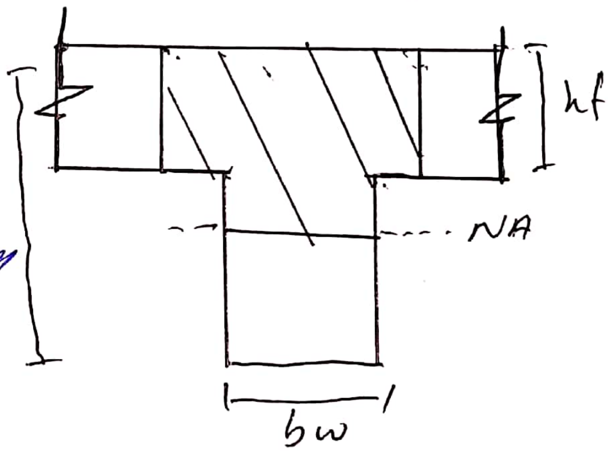
$md = \phi \times fy \times Ast \times (d - a/2)$



CasE II

from the figure
$a > hf$.
So in this Special beam analysis i.e T-Beam Analysis is required
So the required Design will be

$md = \phi \times [As \times fy \times (d - \frac{hf}{2}) + (A_2 - Ast) + fy \times (d - a/2)]$



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No 5 A floor System consist of 3.5″ concrete Slab Supported by 16′ Simple spin Spaced at a c/c the beam having a web width of 10″ and effective depth of 18″ and total height is 23″ calculet the necessary flexural reinforment if the factored applied moment is 5800 kip inch use $f_c' = 3ksi$ and $f_y = 60ksi$

Given data

Height of flange (h_f) = 3.5″

c/c distance = 9′

length/span of the beam = 16′

web width (b_w) = 10″

effective depth (d) = 18″

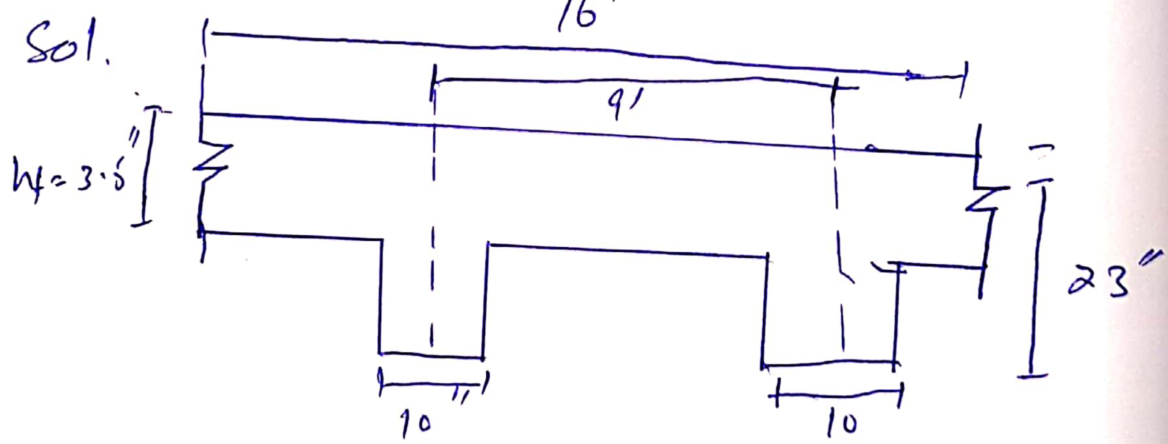
Height (h) = 23″

Total factored moment (M_u) = 5800 kip inch

f_c' = 3 ksi

f_y = 60 ksi

Sol.



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Step#1:.
Calculate the effective width be for T-beam.

1- 16 (hf) + bw = 16(3.5)+10 = 66"

2- C/c distance = 9×12 = 108"

3- Span/4 = $\frac{16}{4}$ ×12 = 48"

Selecting the least value of be as

be = 48"

Step # 2:.
Chec whether Rectangular or T-beam Analysis is required.

Trial #01 Let a = hf = 3.5"

$$Ast = \frac{Mu}{\phi \times fy \times d - a/2} = \frac{5800}{0.90 \times 60 (18 - 3.5/2)} = 6.61 in^2$$

Trial 2

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

$$a = 6.61 \times 60 = 3.2"$$

Ast = 6.55in² = 3.2" < 3.5"

So Rectangular Beam Design is Required

Trial 03

a = 3.21"

and $Ast = \frac{5800}{0.90 \times 60 (18 - \frac{3.21}{2})}$ 6.55in

So Area of steel is 6.55in²

Step # 3

check ρ_{max} and ρ_{min}

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

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

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

$$\rho_1 = \frac{A_{st}}{b \times d} = \frac{6.55}{10 \times 18} = 0.036$$

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

$$0.003 < 0.036 < 0.013$$

As the value of ρ_{max} is less the ρ So we have to design it as Doubly Reinforced Beam.

=> First we have to find the Area of Steel again ρ_{max}.

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

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

$$\boxed{A_{st} = 2.34\,in^2}$$

Step # 4

Finding the value of M_{u2}:-

By formula.

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

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first Finding the value of "a"

$$\Rightarrow a = \frac{Ast \times fy}{0.85 \times fc' \times b} = \frac{2.43 \times 60}{0.85 \times 3 \times 10}$$

$a = 5.72$

$\Rightarrow Mu_2 = 0.92 \times 2.43 \times 60 \times (18 - 5.72/2)$

$Mu_2 = 1986.67$ kip-inch

As $Mu_2 < Mu$

$1986.67 < 5800$

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

Step#5 :-

Finding Difference in moment and Area of Steel.

$Mu_1 = Mu - Mu_2$

$= 5800 - 1986.67$

$Mu_1 = 3813.33$ kip-inch

By formula

$$Ast = \frac{Mu}{\phi \times fy \times d - d_1} = \frac{3813.33}{0.90 \times 60 \times 18 - 2.5}$$

$Ast = 4.56 \text{ in}^2$

age 19

Step # 6:-
Finding total Steel Area
$As = Ast + As't$
$= 3.43 + 4.56 = 6.99 in^2$

Step # ~~4~~7
Seletion of Bar:-
In Tension Zone

~~Uset~~ let we use # 8 bas
dia $8/8 = 1$ Area $= \frac{\pi}{4}(1)^2 = 0.785 in^2$
By formula.
$$\text{No. of base} = \frac{\text{Area of Steel}}{\text{Area of Single bar}} = \frac{6.99}{0.785}$$
$= 8.9 \simeq 9.$
So 9 # 8 bars

In Compression Zone
Let we use # 7 bars
dia $= 7/8$ Area $= \frac{\pi}{4}(7/8)^2 = 0.601$
By formula
$$\text{No. of bars} = \frac{\text{Area of Steel}}{\text{Area of Single bar}}$$
$= \frac{4.56}{0.601} = 7.5 \approx 8$
So 8 # 7 bars.

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Step # 8

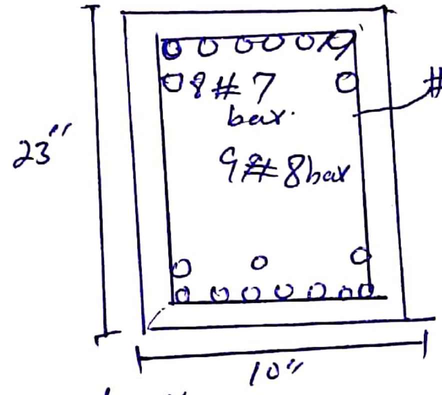
minimum width for Accommodation of bars

$b_{min} = (2\times1.5) + (2\times3/8) + 9(8/9) + 8(8/8)$

$= 20.75$

As $20.75 > 10"$

So the bars will be placed in multiple layers.



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

effective cover $(d_1) = 1.5 + 3/8 + 7/8 + 1/2\,7/8 = 3.18"$

Step # 9

Finding the Design moment

$M_d = \phi\,[A_s' \times f_y \times (d - d') + (A_s - A_{s1}) \times f_y \times d - a/2$

~~md = ϕ f~~

First $a = \dfrac{A_s - A_{s1} \times f_y}{0.85 \times f_c \times b} = \dfrac{9\times0.785 - 8\times0.60\times60}{0.85\times3\times10}$

$= 5.31"$

$\Rightarrow M_d = 0.90\,[(8\times0.601)\times60\times(19.6-3.18) + (9\times0.785 - 8\times0.601)\times60\times(19.6-\frac{5.31}{2})]$

$M_d = 6328.38$

As $6328.38 > 5800$ → So design is ok.

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Q No 61 - A beam is revised to developed and ultimate moment of 600 kip inches limited to 14x26 inch size use fc' = 4ksi row and fy = 60 ksi Determine flexural reinforment assume two rows of tensile reinforcement and effective depth of beam is 22 inches.

Sol:-

Given data

Breath b = 14"

Height h = 26"

concrete compression strength (fc') 4ksi

Steel tensile strength fy = 60 ksi

Ultimite factored moment Mu = 600 kip inches

effective depth of beam (d) = 22.

Aussum effective cover (d') = 2.5

Step #1 Reinforment Ratio

By formula

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

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

$$\rho_{max} = 0.0180$$

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Step # 2 Area of Steel

As we know that

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

$Ast = 0.0180 \times 14 \times 22$

$= 5.54 \, in^2$

Step # 3 Design moment.

By using formula.

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

$\Rightarrow a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 4} = 6.98''$

So

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

$= 5537.4$ kip inch

As $5537.4 < 6000$

So we have to design a Section as doubly reinforced.

Step # 4 Difference in moment

$Mu_1 = Mu - Mu_2$

$= 6000 - 5537.4$

$Mu_1 = 462.6$ kip inches.

Step

Step#5 Area of ~~A~~ Steel

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

So Area of steel in compression Zone will be.

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

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

Step #6:- Total Steel Area

$A_s \quad A_{st} + A'_{st}$

$5.54 + 0.44 = 5.98 in^2$

Step #7 Selection & No of bars used

i- 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

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

$$= \frac{5.98}{0.601} = 9.9 \simeq 10 \text{ bar}$$

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

So
No. of bar = $\frac{Ast}{\text{Aree of single bar.}}$

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

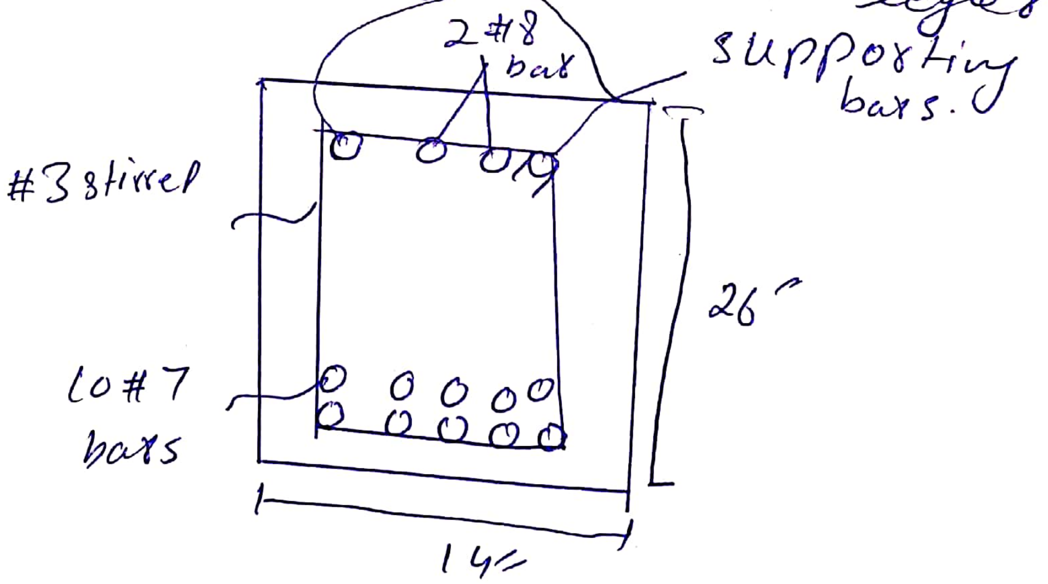
So 2 # 5 bars.

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 − 1/2(7/8)
= 22.82"

= effective cover d' = 1.5 + 3/8 + 1/2(5/8)
= 2.18

Step #9 Design moment.

md = ϕ × [A's × fy × (d − d') + (Ast − A'st) × fy × (d − a/2)

a = (Ast − Ast') × fy / (0.85 × f'c × b)

= ((10 × 0.601 − 2 × 0.306) × 60) / (0.85 × 4 × 4) = 6.80"

md = 0.90 [(2 × 0.306) (60) (22.82 − 2.18) + (10 × 0.601 − 2 × 0.306) × 60 × (22.82 − 6.80/2)]

md = 7047.6 kip inches

As 7047.6 > 6000

Design is ok.

end.