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Section = A

Assignment = Plain and Reinforcement concrete Design I

Subject = PRCD I

Date = 24/6/2020

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Q No (1)

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

Ans

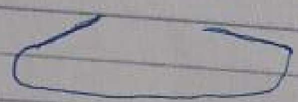
Stirrup:

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

Types of stirrups:

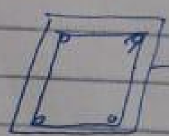
① Single legged stirrup:

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



② Two legged stirrup:

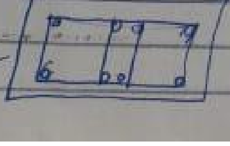
It is most commonly and widely used stirrup. Minimum 4 bars are required for providing this stirrup



2 legged stirrup

③ Four legged stirrup:

These stirrups are used in case of web reinforcement.



4 legged stirrups

As $M_{u2} < M_u$

$1986.67 < 5800$

So we have to design the beam in each Gway that it can resist more bending moment that the applied external moment.

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

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

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

$0.003 < 0.036 < 0.013$

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

⇒ First we have to find the Area of Steel against ρ_{max}.

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

$A_{st} = 0.013 \times 10 \times 18 = \boxed{2.34 in^2}$

Step #4

Finding the value of M_{u2}

By formula

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

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

$\boxed{a = 5.72''}$

$M_{u2} = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$\boxed{M_{u2} = 1986.67 \text{ kip-inch}}$

Step#2 Check whether Rectangular or T-beam design is required

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

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

Trail #02

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

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

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

So Rectangular Beam Design is Required

Trail #03

$$a = 3.21$$

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

So Area of the Steel $6.55\,in^2$

Step# 3

Check ρ_{max} and ρ_{min}

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

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

Q No 5

A floor system consists of 3.5" concrete slab supported by 16' simple spaced at 9' c/c, the beam having a web width of 10" and effective depth of 18" and total height is 23" calculate the necessary flexural reinforcement if the factored applied moment is 5800 kip-inch use $f_c' = 3ksi$ and $f_y = 60$ ksi

Given

Height of flange $(h_f) = 3.5"$

c/c distance $= a'$

Length / span of the beam $= 16'$

Web width $(b_w) = 10"$

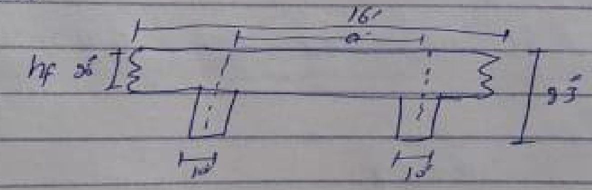
Effective depth $(d) = 18"$

Total factored moment $(M_u) = 5800$ kip inch

$f_c' = 3ksi$

$f_y = 60ksi$

Solution



Step #1

Calculate the effective width (b_e) for T-beam

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

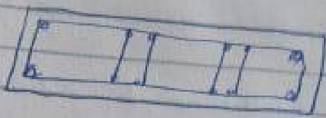
② c/c distance $= 9 \times 12 = 108"$

③ span/4 $= 16/4 \times 12 = 48"$

selecting the least value of be as

$$\boxed{b_e = 48"}$$

④ Six legged stirrup:-



ACI Codes for Shear Design of a beam:-

According to ACI-318 following are the formulas used for the shear design of a beam

① Critical Section:- Critical section occurs at 45° and it 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 $V_u < \phi V_c$ then theoretically no web reinforcement is required. However ACI code required provision of at least 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:

$$A_{v\,min} = \frac{0.75 \times \sqrt{f'_c} \times b_w \times s}{f_y} \text{ or } \frac{50 \times b_w \times s}{f_y} \rightarrow \text{(Higher value will selected)}$$

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

$S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$ or $\frac{Av \times fy}{50 \times bw}$ → lesser value be selected)

(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

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

(5) If $V_s \leq 4 \times \sqrt{f'c} \times bw \times d$ - then more spacing for stirrups will be the smallest of the following

(a) 24"
(b) d/2
(c) $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

(d) $S_{max} = \frac{Av \times fy}{50 \times bw}$

⇒ If $V_s > 4 \times \sqrt{f'c} \times bw \times d$
↓
max. spacing will be halved

⇒ If $V_s > 8 \times \sqrt{f'c} \times bw \times d$
↓
Then either increase cross-sectional dimension or increase $f'c$

Q No (2)

A simply supported rectangular beam 14" wide having an effective depth of 35" to carry a lateral load of 6.5 k/ft on a 18' simply span. It is reinforced with 7in² of tensile steel and if $f'_c = 4ksi$ and $f_y = 60ksi$ then design the beam for shear.

Given Data

Breadth of web of beam (b_w) = 14"
Effective depth (d) = 35"
Given Load = 6.5 k/ft
Steel area = 7in²
f'_c = 4ksi
f_y = 60ksi

Solution

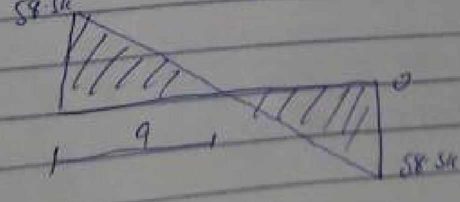
Step#1 Reaction on supports

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 diagram

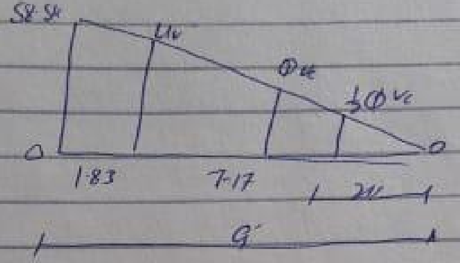


Step # 3

Finding the value of critical shear 'V_u' and its location As

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

⇒ We will find the values of critical shear at distance "d" by use of similar triangles.



Step 4 : Finding the value of ϕV_c and $1/2\ \phi V_c$ and also the distance from zero shear to right side by formula

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

$$\phi V_c = 0.75 \times 2 \times \sqrt{4000} \times 14 \times 22 = 29219\ lbs = 29.21\ kips$$

⇒ Location of ϕV_c by similar triangles

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

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

⇒ Similarly

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

→ location of $1/2\ \phi V_c$ will be

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

Step #5
Findin...
by...

Step #6

As ...

Step #7

As
So ...

① S...
② d...
③ Sm...

③ ...

④ Sm...

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

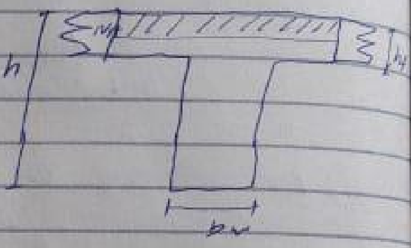
$Md = \phi \times [A_{sf} \times f_y \times (d - h_f/2) + (A_s - A_{sf}) \times f_y \times (d - a/2)] \rightarrow$ if $a > h_f$

Question No 4

What is difference b/w case I and case-2 in the design of T beam

Case-I :

From the figure
$a < h_f$



So in this case Rectangular beams Analysis is required

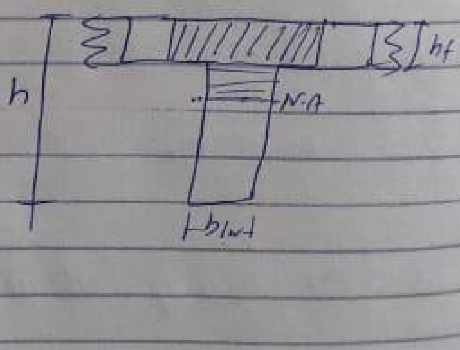
So,

The Design moment formula will be

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

Case II :

From the figure
$a > h_f$



So in this special beam analysis i.e T-beams Analysis

So

the required Design moment will be

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

A f...
supported
beam ...
effective
calculate
factored
f'c - 3ksi
Given
Height of
c/c d...
length
web
Effective
Total
f'c =
fy =

Solution

Step #

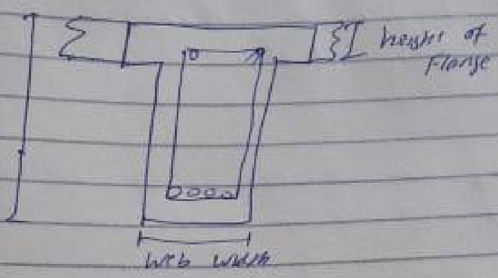
1 - 16

② c/c

③ spa...

so ...

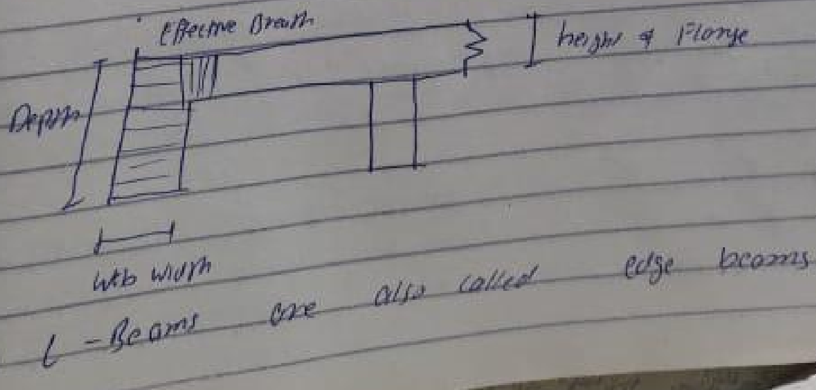
structure, concrete slabs are cast monolithically with the slab so, in this case the beam that act as an intermediate beam are called T-Beams



→ Because of their T-shape these beam are called T-beams
→ It is provided at the center of the slab to resists for Loads
→ The upper most area of the beam attached to the slab is called Flange
→ The bottom rectangular portion of the beam is called web of the beam

L-Beam

→ L shapeed structure that is in contact with slab and present at the cornor of the floor is called L-Beam



→ L-Beams are also called edge beams

Where

a = Depth of compressive block

hf = Height of flange.

(4) For finding Area of steel we have to use.

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

where

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

(5) For checking the range of Reinforcement ratio.

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

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

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

(6) Formula for finding no of bars required

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

(7) For checking minimum width for bars accomodation

$b_{min} = 2\,(\text{clear cover}) + (2\ \text{dia of stirrup}) + \text{No of}_{bar}\,(\text{dia of bars})$

$+\ \text{spacing b/w bars}\ (\text{dia of bars})$

(8) Design moment is given by

Step #5

Finding the value of ϕV_s
by formula $V_u = \phi V_s + \phi V_c$

$\phi V_s = V_u - \phi V_c$

$\phi V_s = 46.61 - 29.21 = \boxed{17.4 \text{ kips}}$

Step #6 Check on Section adequacy
by formula

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

$= 0.75 \times 8 \times \sqrt{4000} \times 14 \times 22 = 116873 \text{ lbs} = 116.87 \text{ kips}$

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

Step #7
Check on maximum spacing for stirrups
by formula

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

$= 0.75 \times 4 \times \sqrt{4000} \times 14 \times 22 = 58438 \text{ lbs} = 58.43 \text{ kips}$

As $\phi \times 4 \times \sqrt{f'_c} \times b_w \times d > \phi V_s$
So maximum will be selected from the following 4 condition

① $S_{max} = 24''$

② $d/2 = 22/2 = 11''$

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

Here we are using #3 stirrups dia $= (3/8'') = 0.375''$
So
for 2-legged stirrups
→ Area × 2
$0.11 \times 2 = 0.22 \text{ in}^2$

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

④ $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w} = \dfrac{0.22 \times 60000}{50 \times 14} = 18.85''$

⇒ It is always provided at the corner of the slab
⇒ L-Beam are typically floor beams, because of their required overall structure depth the beams are in prestressed or reinforced concrete

Flexural Analysis of T-Beam:

Flexural Analysis of T-Beams consider of the following steps

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

$$M_u = \frac{W_u l^2}{8}$$

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

① $16 h_f + b_w$
② c/c distance
③ Span/4
④ $\frac{CTS}{8} + b_w$

→ We have to select the least value from above formula
→ If c/c distance is given, then there is no need of $\frac{CTS}{8} + b_w$.

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

i) If $a > h_f$ → Special Analysis is required
ii) If $a < h_f$ → Rectangular beam analysis is required

Where
a = Depth
hf = Height

④ For Finding

Where

⑤ For

Smax

Smin =

⑥

⑦ For

bmin =

⑧

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

$S_{max} = 12.5$

Step #8

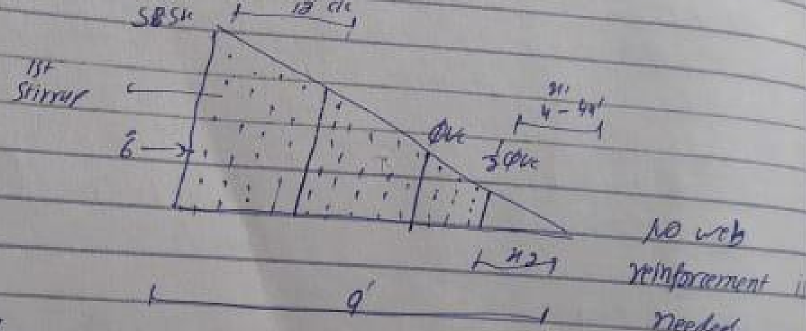
~~Final~~ Stirrups spacing from at critical section will be by formula

$S = 12.5 \approx 12$

$S_o = 12$ c/c

Step # 9

Final Sketch



As

First stirrup from face of support

$S/2 = 12/2 = 6$

QNo (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 of the reinforcement concrete