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Section	A
Assignment	~~697~~ PRCD 1
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Q no 1)

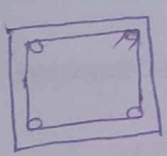
Ans 1) stirrup:-

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

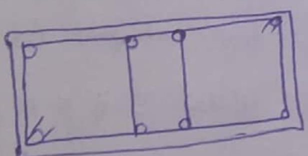
Type of stirrups:-

(i) single legged stirrup:- The single leg stirrups have rarely been used because they are mostly used when binding only two rods.

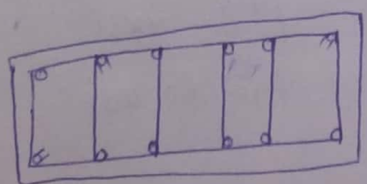
(ii) Two legged stirrup:- It is most commonly & widely used stirrup. Minimum 4 bars are required for providing the stirrup.



(iii) Four legged stirrup:- These stirrups are used in case of web reinforcement



six legged stirrup:-



ACI codes for shear Design of a Beam:-

(1) Critical section:-

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

2) Shear strength capacity of concrete is

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

3) Minimum web Reinforcement

if $Vu \leq \phi Vc$, then theoritically 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.

($\because$ Vu = Total factored shear applied at a given section.

Qno 2)

Ans 2) Given data:-

$bw = 14"$

effective depth (d) = 22"

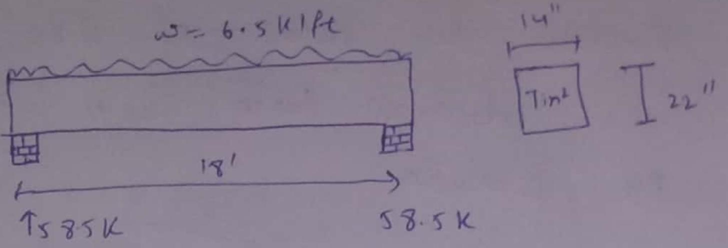
Given load = 6.5 k/ft

steel Area = $7 in^2$

$f'c = 4 ksi$

$fy = 60 ksi$

Sol:-

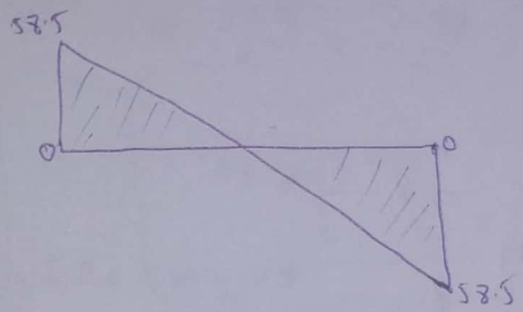


Step 1):- Reaction on support:-

Finding the reactions due to applied load

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

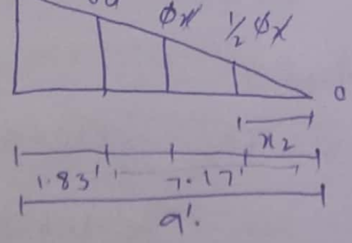
Step 2:- shear force diagram:-



Step No 3:-

Finding the value of critical shear "Vu" & its location As we know that critical shear is located at distance "d" from face to support (d) = 22" = 1.83'

we will find the value of critical shear at distance "d" by use of similar triangles



Step 4:-

Finding the value of 'ϕV_c' & $\frac{1}{2}\phi V_c$ & also its distance from zero shear to right side. By formula.

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

$$= 29.21 \text{ Kips}$$

⇒ Location of ϕV_c by similar triangle

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

$$\Rightarrow x_1 = 4.49'$$

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

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

Step 5:-

By formula

$$V_x = \phi V_c + \phi V_c$$

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

Step 6:-

check on section adequency

By formula

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

$$= 116.87 \text{ kips} > \phi V_s$$

So section is adequete

Step 7

check on maximum spacing for stirrups

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

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

$= 58.43$ kips

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

so maximum will be selected from the 4 condition

1) $S_{max} = 24''$

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

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

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

$0.11 \times 2 = 0.22 in^2$

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

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 from #3, 2 legged stirrup will be selected as,

$S_{max} = 11''$

Step #8

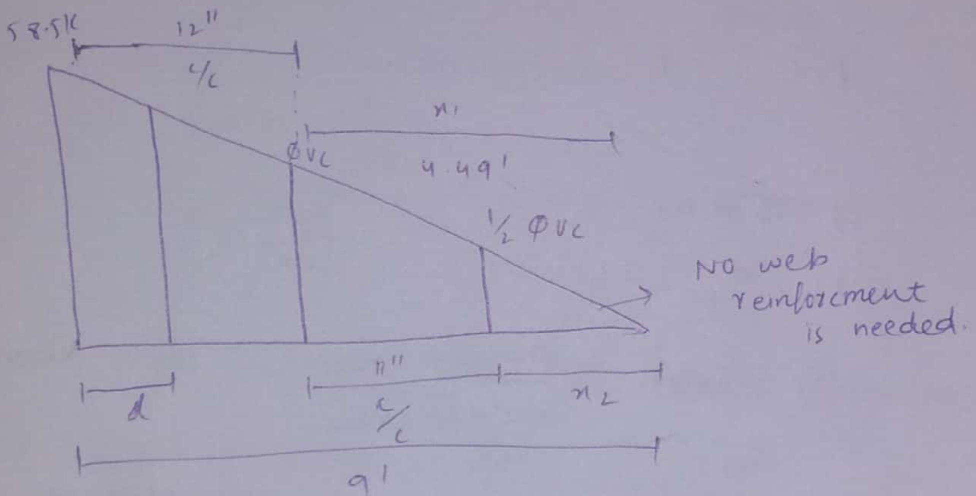
Stirrups spacing from/at critical section will be

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = 12.5'' \approx 12''$$

so 12" c/c

Step 9:-

Final sketch will be



As first stirrup from face of support

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

Qno 3)

Ans 3) T - Beam:-

An most of the reinforced concrete structures 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 are called T - Beams.

→ It is provided at the center of the beam ~~at~~ to resist the load

The upper most area of the beam attached to the slab is called Flang

⇒ The bottom ~~at~~ rectangular portion of the beam is called web of the beam.

L - Beam:-

L - shaped structure that is in contact with the slab & present at the corners of the floor is called L-Beam

L-Beam are also called Edge Beam provided at the corner of the slab

Fluxural analysis 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

$$MU = \frac{Wu \times L^2}{8}$$ { Wu = Total factored load) L = Total spam of the beam)

2) Effective width (be) for T beam is calculated as;

i - 16 (hf + bw)

(ii) C/C distance

(iii) span/4

(iv) $\frac{CTS}{2} + bw$

we have to select the least value from above formula.

(3) Checking whether rectangular or T-Beam Analysis:-

(i) if a > hf → special Analysis is required

if a < hf → rectangular Analysis is required.

∵ where a = depth of compression block

H_f = height of flange

For Area of steel:-

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

For checking the range of reinforcement ratio;

$$\rho_{max} = 0.85 \times B \times \frac{f'_c}{f_y} \times \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}$$

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

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

Formula for finding No of bars required is

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

Design moment given by;

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

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

Q no 4

Ans 4:- case 1:-

From figure $a < h_f$

so in this case, Rectangular beam analysis is required.

So the design moment formula will be

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

Case 02:-

From figure $a > h_f$

so in this case T-Beam analysis is required

so the required Design moment formula will be

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

Qno5:-

Ans 5:-

Height of the flange = 3.5"

c/c distance = 9'

length / span of the beam = 16'

web width (b_w) = 10"

Height h = 23"

effective depth (d) = 18"

Mu = 5800 kib-inch

fy = 60 ksi

fc' = 60ksi

Sol:-

step 1:-

calculate the effective (be) for T-beam

1) 16 (hf) + bw = 66"

2) span/4 = 48"

3) c/c distance = 108"

selecting the least value of be as,

be = 48"

step 2:-

check whether rectangular or T.beam analysis

Trial # 1:-

let $a = h_f = 3.5''$

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

Trial 2:-

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b_e} = 3.2''$$

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

so rectangular beam analysis.

Trial No 3:-

$a = 3.21''$

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

so Area of steel is $6.55 in^2$

step 3:-

check ρ_{max} & ρ_{min}

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

$= 0.0013$

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

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

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

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}

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

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

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

step 4:-

Finding the value of Mu_2

By formula

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

find a?

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

$$a = 5.72''$$

$$\Rightarrow Mu_2 = 0.90 \times 2.43 \times 60 \times (18 - \frac{5.72}{2})$$

$$\Rightarrow Mu_2 = 1986.67 \text{ kip-inch}$$

As $Mu_2 < Mu$

$$1986.67 < 5800$$

so we have to design a beam in such way that it can resist more bending moment than the applied external moment.

step 5:-

Finding difference in moment & Area of steel

$Mu_1 = Mu - Mu_2$

$= 5800 - 1986.67$

$Mu_1 = 3813.33$

By formula

$$A_{st}' = \frac{Mu}{\phi \times f_y \times (d-d')} = \frac{3813.33}{0.90 \times 60 \times (18-2.5)}$$

$A_{st}' = 4.56 in^2$

step 6:-

Finding total steel area.

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

$= 6.99 in^2$

step 7:-

selection of bar

In tension zone

let we use #8 bar

dia $\left(\frac{8}{8}\right) = 1''$ & Area $= \frac{\pi}{4}(1)^2 = 0.785 in^2$

By formula

$$\text{No of bars} = \frac{\text{Area of steel}}{\text{Area of single bar}} = \frac{6.99}{0.785} = 8.9 \approx 9$$

so 9 #8 bars

In compression zone

Let we use #7 bar

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

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

Step #8:-

Min width for Accomodation of bars

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

$$= 20.75''$$

As $20.75'' > 10''$

so the bars will be placed in multiple layer

Effective depth $(d_1) = 23 - 1.5 + 3/8 + 8/8 + 1/2\,(8/8) = 19.6''$

Effective cover $(d') = 1.5 + 3/8 + 7/8 + 1/2\,(7/8) = 3.18''$

Step #9:-

Finding the design moment

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

First $a = \dfrac{(A_s - A_{st}') \times f_y}{0.85 \times f'_c \times b} = 5.31''$

$$\Rightarrow M_d = 0.90\,[(8 \times 0.601) \times 60 \times (19.6 - 3.18) + (9 \times 0.785 - 8 \times 0.601) \times 60 \times (19.6 - 5.31/2)]$$

$M_d = 6328.38$

As $6328.38 > 5800$

Design is perfect.

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