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Assignment: PPCD

Submitted to: Engr- Fawad Khan

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QNo: 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 regular intervals in beam reinforcement to hold the bar in position

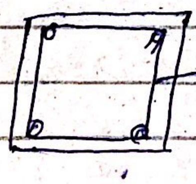
Types of STIRRUPS

① Single legged stirrups

the Sing leg Stirrup have rarely been used b/c they are mostly used when binding only two rods

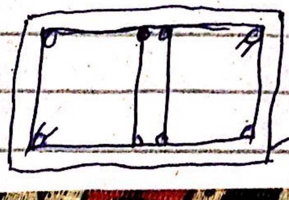
② Two legged Stirrups

It is most commonly and widely used b/c They are mostly used minimum 4 bars are required for providing this Stirrups.

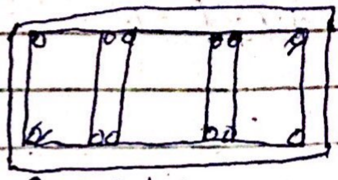


③ Four legged Stirrups

these stirrups are used in case of web reinforcement



(4) Six legged Stirrups



ACI codes for Shear Design of a beam

According to ACI Code-318 following are the formula used for Shear design of a beam

(1) Critical Section

Critical section occur at u/s end it distance from the force of support which is equal at 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 theortically 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 given section)

For minimum Reinforcement Area

$$A_{v\,min} = \frac{0.75 \times \sqrt{f'_c} \times b_w \times s}{f_y} \text{ or } \frac{50 \times b_w \times s}{f_y} \Rightarrow \left[\text{Higher value selected}\right]$$

by interchanging the above formula, we can obtain the formula for maximum opening

$$\frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w} \text{ or } \frac{A_v \times f_y}{50 \times b_w} \Rightarrow \left[\text{lesser value is selected}\right]$$

(4) No web reinforcement is required if:

$$Vu < 1/2 \phi Vc$$

between Critical section "Vu" and "ϕVc" spacing b/w web reinforcement can be find

$$S = \frac{\phi \times Av \times fy \times d}{Vu - \phi Vc}$$

(5)

If $Vs \le 4 \times \sqrt{f'c} \times bw \times d$ then max spacing for stirrup will be the smallest of the following

1 = 24"
2 = d/2
3 = $S_{max} = \frac{Av \times fy}{0.75 \times \sqrt{f'c} \times bw}$

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

If $Vs > 4 \times \sqrt{f'c} \times bw \times d$ → max spacing will be halved

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

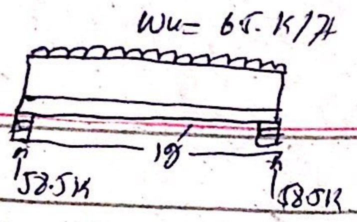
QUESTION NO: 2

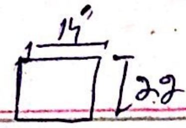
A simply supported rectangular beam 14" wide having an effective depth of 20" to carry a lateral load of 6.5 K/ft on a 18' simple span. It is reinforced with 7 in² of tensile steel area if $f'c$ = 4 ksi and fy = 60 ksi the design the beam for shear.

Given

bw = 14"
d = 20"
Given Load = 6.5 K/ft
Steel Area = 7 in²
$f'c$ = 4 ksi   Fy = 60 ksi

Sol.

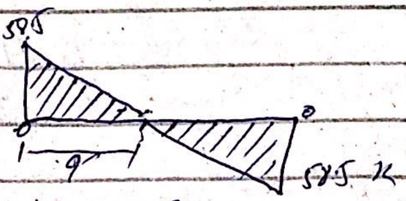




Step 1: Reaction on support

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

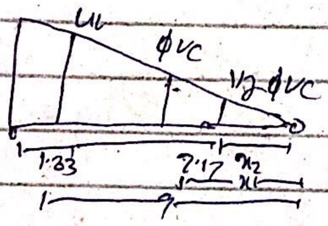
Step 2: Shear force diagram



Step 3: Finding the value of critical shear Vu and its location

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

We can find the value of critical shear at distance d by use of similar triangle



From similar triangles

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

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

Vu = 46.61 Kips

Step 4

Finding the value of ϕVc and 1/2 ϕVc and also distance from zero shear to right side by formula

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

Location of ϕVc by similar triangles

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

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

Step5 :- Finding the value of ϕV_C by formula:-

$V_u = \phi V_s + \phi V_c$

$\phi V_s = V_u - \phi V_c$

$46.61 - 29.21$

$\boxed{\phi V_s = 17.4 \text{ Kips}}$

Step 6 :-

Check on Section Adequate

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

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

$= \boxed{116.87 \text{ Kips}}$

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

Step7 :- Check max spacing for stirrips

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

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

$= \boxed{58.43 \text{ Kips}}$

As $\phi \times 4 \times \sqrt{f'c} \times b_w \times d > \phi V_s$ so max will be selected

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

2 = $d/2 = 22/2 = 11$

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

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

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

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

$S_{max} = 11''$

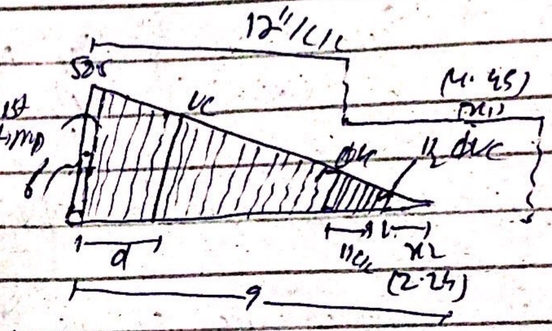
Step 8 .. Stirrup spacing from critical section will be the

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \frac{0.75 \times 0.22 \times 60 \times 22}{46.61 - 29.21}$$

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

So $12''$ C/C

Step 9 Final sketch



As 1st stirrup from face of support

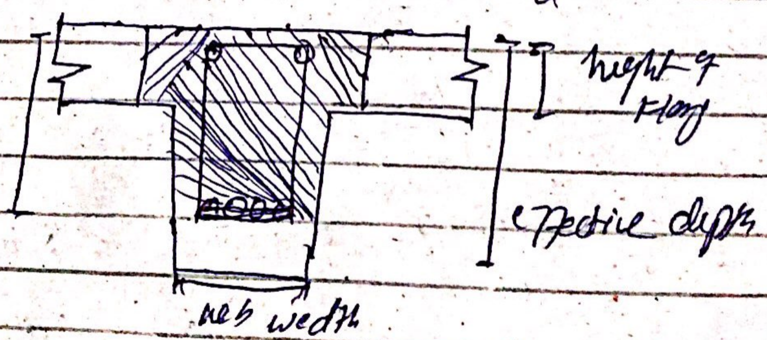
$S/2 = 12/2 = 6''$

Question No: 3

Define both T-beam and L-beam with the help of diagram. Also explain flexural analysis of T-beam.

T-Beam

In most of reinforced concrete structure, concrete slab are cast monolithically with the slab. So in this case the beam that act as an intermediate beam are c/d T-beam



→ b/c of their T-shap this become T-beam
→ It is provided at the centre of slab to resist the load
→ The upper most area of the beam attract to the slab is c/d Flange

the bottom rectangular portion of the beam is called web of the beam

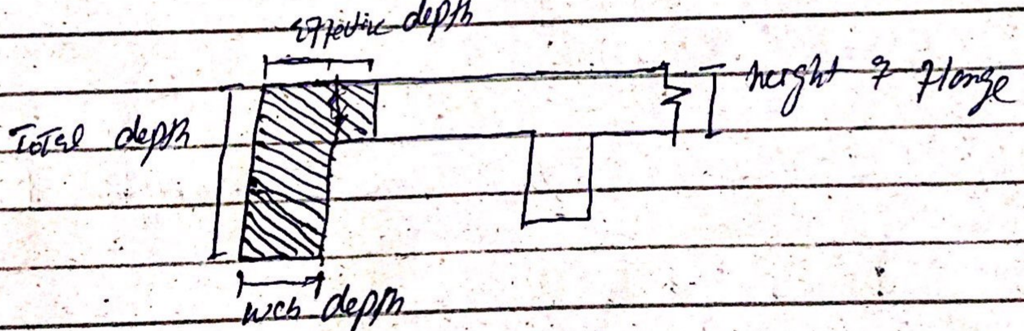
L- Beam

⇒ L-shaped structure that is contacted with slab and present at the centre of the floor c/d L-beam

⇒ L-beam are also c/d edge beam

⇒ It is always provided at the corner of the ~~beam~~ slab

⇒ L-beam are typical floor beam b/c of their reduced overall structure depth the beam are ~~pretressed~~ pretressed or reinforced concrete



Flexural analysis of T beam

① For finding the Ultimate factored Moment

$$M_u = \frac{W_u L^3}{8}$$

② Effective width for T-beam

1 = 16 (hf) + bw
2 = c/c distance
3 = span l4
4 = CTS/2 + bw

(3) Checking Westher rectangular or T-Beam

(i) = if $a > h_f$ → special Analyses is required

(ii) if $a < h_f$ → rectangular beam analysis required

where (a = depth of compression, h_f = Height of Flange)

(4) For finding Area of Steel,

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

Where

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

(5) For Checking the range of reinforcement Ratio

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

$$\rho_{min} = \frac{2000}{f_y}$$

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

(6) Finding number of bars

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

Scanned with CamScanner

(7) For Checking minimum width for bars accomodation

~~bmin = ϕ × fy × Ast × (d − a/2) → if a < hf~~

bmin = 2(Clear Cover) + 2(dia of Stirrup) +
No of bars (dia of bar) + Spacing b/w bar
(dia of bar)

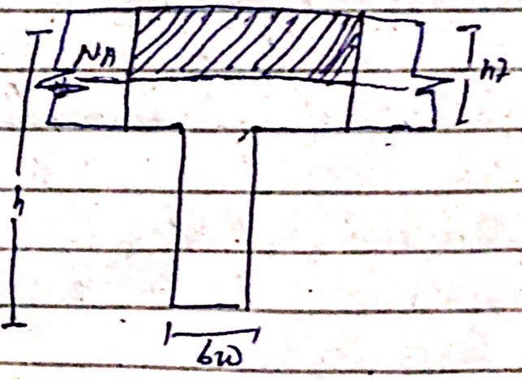
(8) Design moment

Md = ϕ × fy × Ast × (d − a/2) if a < hf

Md = ϕ × [As × fy × (d − a/2) + (As − Ast) × fy × (d − a/2)]
if a > hf

Qno: 4

What is the difference b/w CASE-1 and Case-2 in the T-beam



Case-1

From the figure a < hf
So in this case rectangular beam Analysis is required
So the design moment formula
Md = ϕ × fy × Ast × (d − a/2)

Step 1

Case-II

From Fig: a > hf

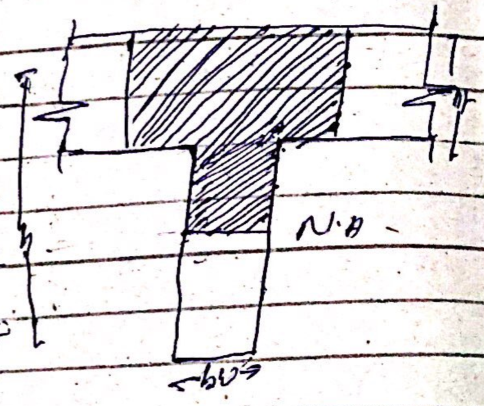
so in this special beam analysis T-beam Analysis is required

so

the required design moment will be

$Md = \phi \times [Asf \times fy \times (d - a/2) + (d - hf/2) +$

$(As - Asf) \times fy \times (d - a/2)]$



Step

Question No:5

A Floor system consist of 3.5" concrete slap supported by 16' simple span spaced at 9' c/c the beam having a web width of 10" and effective depth of 18" and total height 23". Calculate the nessecary flexural reinforcement if the factored applied moment is 5800 kip-inch. Use f'c = 3 ksi and fy = 60 ksi

Given data

Height of Flange hf = 3.5"

C/C distance = 9'

length span of the beam = 16'

web width (bw) = 10"

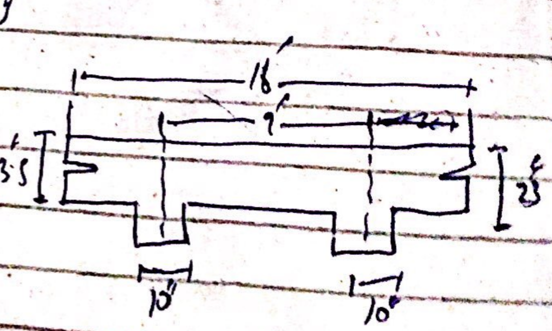
effective depth (d) = 18"

Height (h) = 23"

Total factored moment (Mu) = 5800 kip

f'c = 3 ksi

Fy = 60 ksi



Step 1

Calculate the effective width (b_e) for T-beam

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

2 = c/c distance $= 9+D = 108''$

3- span/4 $= 16/4 \times 12 = 48''$

selecting the least value of b_e as

$$b_e = 48''$$

Step 2: Check whether Rectangular or T-beam Analysis

Trial 01:

let $a = h_f = 3.5''$

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

Trial 2:

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

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

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

So rectangular beam design is required

Trial 3

$a = 3.21''$

$$A_{st} = \frac{58000}{0.90 \times 60 (18 - \frac{3.21}{2})} = 6.55 in^2$$

So Area of steel is $6.55 in^2$

Step 3 ρ_{max} and ρ_{min}

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

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

$\Rightarrow \rho_{min} = \frac{200}{fy} = \frac{200}{60000} = 0.003$

$\rho = \frac{Ast}{b \times d} = \frac{0.35}{10 \times 18} = 0.036$

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

$0.003 < 0.036 < 0.013$

the value of ρ_{max} is less than ρ so we use doubly reinforced beam

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

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

$Ast = 2.34\ in^2$

Step 4

Finding the value of Mu_2

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

1st finding the value of a

$a = \frac{Ast \times fy}{0.85 \times f'cb} = \frac{2.43 \times 60}{0.85 \times 3 \times 10}$ $a = 5.72''$

$Mu_2 = 0.90 \times 2.43 \times 60 \times (18 - 5.72/2)$

$Mu_2 = 1986.07\ Kip.in$

As $Mu_2 < Mu$

$1986.07 < 5800$

Step 5 Finding ~~in~~ difference in moment and Area of Steel

$M_u = M_u - M_{u2}$

$5800 - 1986.67$

$M_{u1} = 3813.33$ kip.inch

~~By formula~~

$A_{st} = \frac{M_u}{\phi f_y (d - a/2)} = \frac{3813.33}{0.90 \times 60 \times (18 - 2.5)}$

$A_{st} = 4.56 \text{ in}^2$

Step 6: Finding Total Steel Area

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

$= 2.43 + 4.56 = 6.99 \text{ in}^2$

Step 7

Selection of bar

In Tension zone

let we use #8 bar

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

No of bars = $\frac{\text{Area of Steel}}{\text{Area of Single bar}} = \frac{6.99}{0.785} = 8.9 = 9$

So 9 #8 bars

In Compression zone

let use #7 bar

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

No of bars = $\frac{\text{Area of Steel}}{\text{Area of Single bar}} = \frac{4.56}{0.601} = 7.5 \approx 8$

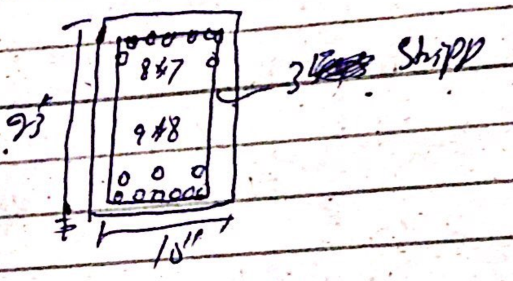
So 8 #7 bars

Step 8 minimum width for accomodation bar

$b_{min} = (2 \times 1.5) + (2 \times 3/8) + 9(8/8) + 8(8/8) = 20.75''$

As $= 20.75'' > 10''$

So the bars will be placed in multiple layers



effective depth

$(d) = 23 - 1.5 + 3/8 + 8/8 + 1/2(8/8)$

$19.6''$

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

Step 9

Finding the design moment

$Md = \phi[As' \times fy \times (d - d') = \frac{(9 \times 0.785 - 8 \times 0.601)}{0.85 \times 3 \times 10} + (As - As')fy \times (d - a/2)]$

1st $a = \frac{(As - As') \times fy}{0.85 \times fc \times b} = \left(\frac{9 \times 0.785 - 8 \times 0.601}{0.85 \times 3 \times 10}\right) \times 60 = 5.31''$

$Md = 0.90[(8 \times 0.601) \times 60 \times (19.6 - 3.18) + (9 \times 0.785 - 8 \times 0.601) \times 60 \times (19.6 - \frac{5.11}{2})]$

$\boxed{Md = 6328.38}$

As $6328.38 > 5800 \rightarrow$ so design is OK

QNO: 6

A beam is revised to developed and Ultimate moment of 6000 kip-inches limited to 14×26 inch size use $f'c = 4$ ksi and $fy = 60$ ksi. Determine Flexural reinforcement assume two rows of tensile reinforcement and effective depth of beam.

Solution

$b = 14''$

$h = 26$

$f'c = 4$ ksi

$fy = 60$ ksi

$Mu = 6000$

$d = 22$ assume effective cover $d = 2.5'')$

(14)

Step1 Reinforcement Ratio

$\rho max = 0.85 \times \beta \times f'c/fy \times \left(\frac{\epsilon u}{\epsilon u + \epsilon y}\right) \Rightarrow 0.85 \times 0.85 \times 4/60 + \frac{0.003}{(0.003+0.005)}$

$\boxed{\rho max = 0.0180}$

Step2 Area of Steel

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

$Ast = 0.0180 \times (14 \times 22) = \boxed{5.54\ in^2}$

Step3 Design Moment

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

$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{5.54 \times 60}{0.85 \times 4 \times 14} = \boxed{6.98''}$

$(d - a/2)$

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

$= 5537.4\ kip\text{-}inch$

As

$5537.4 < 6000$

So we have to design a section as doubly reinforced

Step4 ~~Area of Steel~~ Moment

$Mu_1 = Mu - Mu_2$

$= 6000 - 5537.4$

$\boxed{Mu_1 = 462.6\ kip\cdot inches}$

Step Area of Steel

$Mu_1 = \phi \times Ast \times fy \times (d - d')$

$Ast = \frac{Mu_1}{\phi \times fy \times (d - d')} = \frac{462.6}{0.90 \times 60 \times (22 - 2.5)} = \boxed{Ast = 0.44\ in^2}$

Step6 Total Steel Area

$As = Ast + Ast'$

$= 5.54 + 0.44 = \boxed{5.98\ in^2}$

Step 7 No 9 bars

① Steel in tension zone

use #7 bar

dia = (7/8)" = 0.875". Area = $\pi/4 (0.875)^2$
= 0.601 in²

No 9 bars = $\frac{Ast}{\text{Area of single bar}}$

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

So 10 #7 bars

② Steel in Compression zone

use #5 bars

dia = (5/8)" = 0.625", Area = $\pi/4 (0.625)^2$
= 0.306 in²

No 9 bars $\frac{Ast}{\text{Area of single bar}}$

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

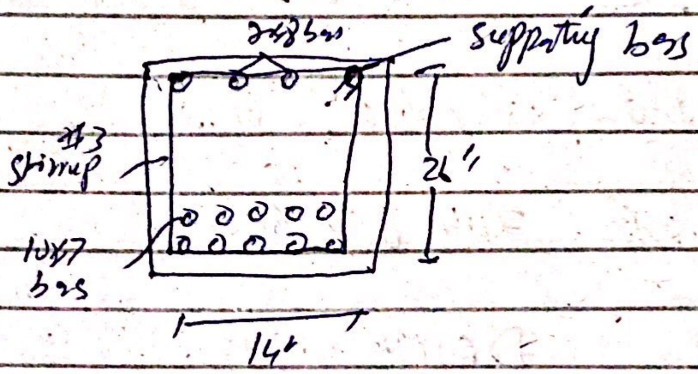
So 2 #5 bars

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



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

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

$$a = \frac{(As - As') \times fy}{0.85 \times fc \times b}$$

$$= \frac{(90 \times 0.601 - 2 \times 0.306) \times 60}{0.85 \times 4 \times 14} = 6.80''$$

$$M_d = 0.90 [(2 \times 0.306) \times 60 \times (22.82 - 2.18) + (10 \times 0.601 - 2 \times 0.306) \times 60 \times (22.22 - \frac{6.80}{2})]$$

$M_d = 7047.6$ kip-inches

$A_s = 7047.6 > 6000$

Design is ok