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Name: M.Mansoor

ID # 7810

Section "A"

Semester 6^{th}

Subject PRCD-I

Submitted To Engr Fawad Khan

M. Mamsoor 7810

Q NO 01 A Rectangular Beam That Must carry a service Live Load of 2.47 kips/ft and a calculated dead Load of 1.05 kip/ft (with out self weight) on an 18-ft simple span is limited to 10 inches width and 20 inches total depth for architectural reason if $f_y = 6000$ psi and $f'_c = 4000$ psi what steel area must be provided? Draw sketch of your final design.

Given Data :-

Beam Live Load (L.L) = 2.47 kips/ft
Beam Dead Load (D.L) = 1.05 kips/ft
span of Beam = 18-ft
width of the Beam = 10"
depth of the Beam = 20"
f_y = 60000psi = 60 ksi
f'_c = 4000 psi = 4 ksi

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Solution :-

Step # 01

Calculate effective depth (d)

$h - 3 = 20 - 3 = 17''$

Step # 02

Calculate effective cover (d')

Assume $d' = 2.5''$

Step # 03

Reinforcement Ratio

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

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

$$\rho_{max} = 0.0180625$$

Step # 04

Calculate Area of steel :-

As we know that

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

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

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

$A_{st} = 0.0180625 \times 10 \times 17$

$A_{st} = 3.070625 \text{ in}^2$

Step #05

By Formula of Design Moment

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

First we find the value of a

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

$$a = \frac{3.07 \times 60}{0.85 \times 4 \times 10} = 5.42''$$

$M_{u2} = 0.90 \times 3.07 \times 60 \times (17 - \frac{5.42}{2})$

$M_{u2} = 2368.99$ kips-inch

Moment Due to given Load :-

Beam self weight $= b \times t \times \gamma_c$

$= \frac{10}{12} \times \frac{20}{12} \times 150$

$= 208.33 \text{ lb/ft}^3$

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Total Factored Load:-

$W_T = 1.2\, D.L + 1.6\, L.L$

$= 1.2(1050 + 208.33) + 1.6(2470)$

$= 5461.99$ lb/ft

$= 5.46$ kips/ft

Step # 06

Ultimate Factored Moment:-

$$M_u = \frac{W \times L^2}{8} \times 12$$

$$= \frac{5.46 \times 18^2}{8} \times 12$$

$M_u = 2653.56$

As we have

$M_u > M_{u2}$

$2653.56 > 2368.99$

⇒ Design of a section is Doubly Reinforcement

Step # 07

To Find M_{u1}:-

$M_{u1} = M_u - M_{u2}$

$M_{u1} = 2653.56 - 2368.99$

$M_{u1} = 284.57$ kip-inch

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Step # 08

As we know That

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

$A_s' = \frac{M_{u1}}{\phi \times f_y \times (d-d')}$

$A_s' = \frac{284.57}{0.90 \times 60 \times (17-2.5)}$

$A_s' = 0.36 \, in^2$

This is The steel Area in Compression Zone

Total Steel Area :-

$A_{st} = A_{st} + A_s' = 3.07 + 0.36$

$A_s = 3.43 \, in^2$

Step # 09

Selection of Bars :-

(A) For Tensile steel :-

let try #8 bars having Area = $0.785 \, in^2$

=> Number of Bars = $\frac{A_s}{A_b} = \frac{3.43}{0.785}$

$= 4.369 \approx 5$ bars

So 5 ~~bars~~ #8 bars

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(B) For compression steel :-

Let try #6 bars having

Area = 0.44 in^2

$$\text{Number of Bar} = \frac{A'_s}{A_b} = \frac{0.36}{0.44}$$

$$= 0.81 \approx 1 \text{ bars}$$

So 1 #6 Bar in compresion Zone.

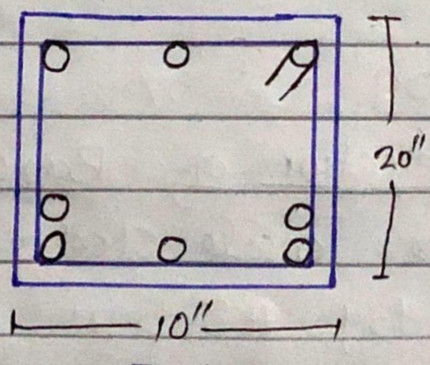
Step#09

Check on Minimum width of Beam :-

$$b_{min} = 2(1.5) + 2(3/8) + 5(8/8) + 4(8/8)$$

$$= 12.75'' > 10''$$

=> Not good in one layer



=> Effective Depth $(d) = 20 - 1.5 - \frac{3}{8} - \frac{8}{8} - \frac{1}{2}\left(\frac{8}{8}\right)$

$$d = 16.62''$$

=> Effective cover $(d') = 1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right)$

$$d' = 2.25''$$

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Step #10

Design Moment:-

$$Md = \phi \times [A's \times fy \times (d-d') + (Ast - A'st) \times fy \times (d - a/2)]$$

As we know that

$$a = \frac{(Ast - A'st) \times fy}{0.85 \times f'c \times b}$$

$$a = \frac{(5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10} = 6.15$$

$$Md = 0.90[(1 \times 0.44) \times 60 \times (16.62 - 2.25) + 5 \times 0.785 - 1 \times 0.44 \times 60 \times (16.62 - \frac{6.15}{2})]$$

$$Md = 2890.46.$$

As $Md = 2890.46 > 2653.56$ K"

So the Design is OK

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QNo02 (a) Briefly describe bond stress and development length.

Bond stress:-

The stress which is acting on the outer inter face of steel to the surrounding concrete is called called bond stress

=> The resulting stress of bond is called bond stress

=> This stress help in keeping bond between reinforcment and concrete togather

=> Bond stress result any force that tries to pull out the rods from the concrete.

=> when you try to pull out the reinforcment bar from hardened concrete then bond stress resist the bar to come out

Development length:-

The Necessary length b/w the point of max stress in a bar and the end of a bar is called.

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Development length OR

=> The length of bar required to transfer the force in the bar to surrounding concrete through bond is called development length.

Reason For providing Development length

-> To develop a safe bond between the bar surface and concrete so that no failure due to slippage of bar occure during the ultimate loading condition.

-> Also the extra length of the bar provided as development length is responsible for transferring the stresses development in any section of the adjoing section.

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Q NO 2 (b) In which condition doubly reinforced beam can be Used

We can used the doubly reinforced beam on that condition when the restriction occure in the size of beam.

⇒ For example if some one said that the depth of beam should not be greter then 12" and the external load on beam is very much which can not resist a beam of singly reinforcement in that condition we used Doubly Reinforced Beam.

Q No 2 (C) Differentiate between T-Beam analysis and Rectangulear Beam Analysis.

T-Beam	Rectangulear Beam
→ In case of T-Beam slab and beam are connected with one another	→ In case of Rectangulear Beam slab has been placed on the

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and act as a one member ~~=> In T Beam The o~~	beam so There is no connection b/w slab and beam
=> T Beam are mostly Used and heavy duty and large space such is bridge.	-> Rectangular Beam are mostly Use in commercial building
-> T Beam are more ecnomical Than R- Beam	-> Rectangular Beam are less ecnomical Than T - Beam

QNo 2 (d) Write short Note on the effect of Strength reduction factor on flexural strength.

In The design of fluxural strength The strength reduction factor decrease from tension control section to compression. Controlled section to increase safty with decreasing ductility This Show to determine The reduction factor for flextural Strength of reinforcement Concrete.

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Q No 2 (e) Briefly describe design Methods which one of Them can be best Used for design of diffrent structure member and why?

Designing Methods:

Two Methods are worldly Used for the designing of concrete and diffrent Structure member.

1) ASD Method
2) USD Method

1) => ASD Method:-

ASD method is also Know as working stress design method. it is based on The principle That stresses developed in The structural member should not exceed a certain limit friction of elastic limit.

=> In This method all load are taken as service load and no factor is

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is applied to increase these service load.

2) => USD Method:

-> Ultimate strength design method is also called as load factor method.

-> for the structure subjected to large external load the ultimate strength is determine by the inelastic analysis.

=> USD method is best for designing diffrent structural method becuse of the following reason.

1) As the ultimate strength of the material is considered we will get much slender section for coloum and beam compare to other method.

2) USD method result is more economical design for a building with fewer special need for customized area and requirment.

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Q NO 03 A concrete floor system consist of parallel T beam spaced 10 ft. on centers and spanning 32 ft between support the 6 inch thick slab is cast monolithically with beam web having width b_w = 14 inch and total depth measured from the top of the slab of h = 28 inch the effective depth will taken 3 inch less than the total depth. In addition to its own weight. each beam must carry a superimposed D.L of 50 psf and service live load of 225 psf Material strength are fy = 60000 psi and f'c = 4000 psi Determine the required tensile steel area and selected the reinforcement needed for a typical member, Draw sketch of final Design.

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Given Data:-

C/C distance = 10'

Length = 32'

Thickness of slab (h_f) = 6"

Beam web width (b_w) = 14"

Total Depth (h) = 28"

Effective depth = 28" − 3" = 25"

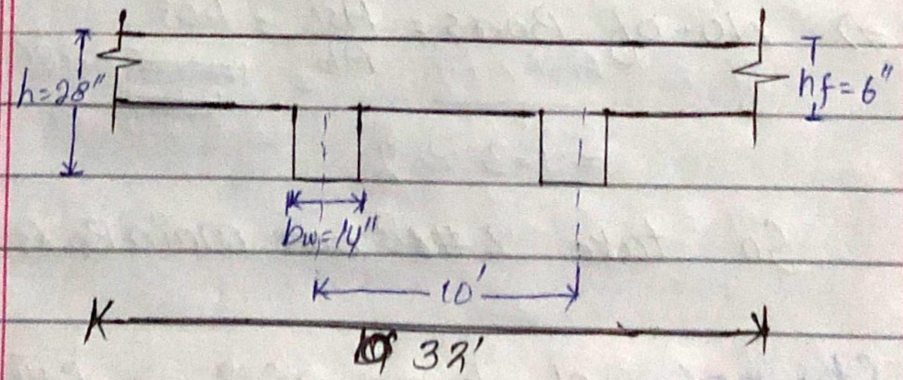
Dead Load = 50 lb/ft^2

Live Load (L.L) = 225 lb/ft^2

f_y = 60000 psi = 60 ksi

f'_c = 4000 psi = 4 ksi

Solution:-



Step #01 Ultimate Factored Moment

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

W_u = Total factored load.

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Find self weight per feet:-

$W_t = b \times t \times \gamma_c$

$= \frac{14}{12} \times \frac{28}{12} \times 150$

$= 408.33\ lb/ft$

Find Total Factord Load

$W_u = 1.2\ D.L + 1.6\ D.L$

$W_u = 1.2(50 + 408.33) + 1.6(225)$

$W_u = 909.96\ lb/ft$

$W_u = 0.909\ Kips/ft$

Now Moment:-

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

$= \frac{0.909 \times (32)^2 \times 12}{8}$

$M_u = 1396.22\ Kips\text{-}inch$

Step#02 Calculate effective width "be"

1) $16 \times h_f + b_w = 16 \times 6 + 14 = 110''$
2) c/c distance $= 10 \times 12 = 120''$
3) Span/4 $= 32/4 \times 12 = 96''$
4) So $b_e = 96''$

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Step # 03 Check whether Rectangular or T-beam:-

Trial # 01:

Let $a = h_f = 6$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.23}{0.90 \times 60 \times (25 - \frac{6}{2})}$$

$$A_{st} = 1.175 \ in^2$$

Trial # 02 :-

$$a = \frac{A_s \times f_y}{0.85 \times f_c' \times b_e}$$

$$a = \frac{1.175 \times 60}{0.85 \times 4 \times 96}$$

$$a = 0.21'' < 6''$$

=> So Rectangular Beam Design

$$A_s = \frac{1396.23}{0.90 \times 60 \times (25 - \frac{0.21}{2})}$$

=> $\boxed{A_{st} = 1.03 \ in^2}$

Trial # 03 :-

$$a = \frac{A_s \times f_y}{0.85 \times f_c' \times b_e}$$

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96} = 0.18''$$

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$$A_{st} = \frac{1396.23}{0.90 \times 60 (25 - \frac{0.18}{2})}$$

$$\Rightarrow \boxed{A_{st} = 1.03 \ in^2}$$

Step#04 Check ρ_{max} and ρ_{min}:

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

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

$$\Rightarrow \rho_{max} = 0.018$$

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

$$\Rightarrow \rho = \frac{A_{st}}{b \times d} = \frac{1.03}{14 \times 25} =$$

$$\Rightarrow \rho = 0.00294$$

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

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

$$0.003 \geq 0.00294 < 0.018$$

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As we know that
ρ is less than ρ_{min}
So

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

$$A_{st} = 0.003 \times 14 \times 25 = 1.05 \, in^2$$

Step#05 <u>Selection and No. of Bars</u>

let try #8 main bar
having area of one # 10 bar
$= 1.27 \, in^2$

$\Rightarrow$ No. of Bars $= \frac{A_{st}}{A_b} = \frac{1.05}{0.785}$

$= 1.3 \approx 2$

So take 2 #8 main Bars

Step#06 <u>Check on minimum width</u>

$$b_{min} = 2 \times 1.5 + 2 \times \left(\frac{3}{8}\right) + 2\left(\frac{8}{8}\right) + 1\left(\frac{8}{8}\right)$$

$$b_{min} = 6.75'' < 14''$$

$\Rightarrow$ so good in one layer.

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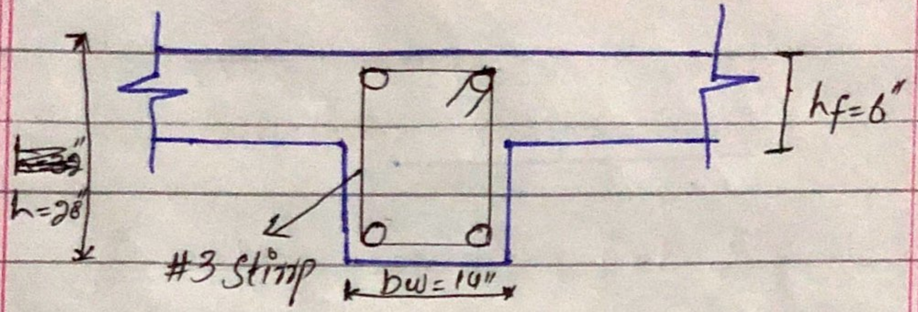

Step#07 Design Moment

$$Md = \phi \times fy \times Ast \times \left(d - \frac{a}{2}\right)$$

But first find "Ast" & "a"

Ast = Area of one bar x No of bars

$Ast = 0.785 \times 2 = 1.57\,in^2$

$$a = \frac{Ast \times fy}{0.85 \times fc \times be} = \frac{1.57 \times 60}{0.85 \times 4 \times 96}$$

$a = 0.2''$

$$Md = 0.90 \times 60 \times 1.57 \times \left(25 - \frac{0.2}{2}\right)$$

$Md = 2111.02$ Kips-inc

$Md = 2111.02\,k'' > Mu = 1396.23\,k''$

The design is OK ✓✓