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Semester ⇒ Senior.

Subject Name ⇒ PRCD 1.

Date ⇒ 22-April-2020.

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QNo# 01:-

A rectangular beam that must Carry a service live load of 2.47 Kip/ft & a Calculated dead load of 1.05 Kip/ft (without self load) on an 18 ft Simple Span is limited to 10 inches width & 20 inches total depth of architectural reasons if fy = 60000 psi & fc = 4000 psi What steel area must be provided? Draw sketch.

Given Data:-

- width (b) = 10" inch.
- Height (H) = 20" inch.
- Live load (L.L) = 2.47 Kips/ft.
- Dead load (D.L) = 1.05 Kips/ft.
- Span = 18 ft.
- $f'c$ = 4000 psi = 4 Ksi.
- fy = 60000 psi = 60 Ksi.
- Assume Effective Cover = d' = 2.5 inch.

Let = d = h − 3.

d = 20 − 3.

d = 17 inch.

Sol:-

Step = 01 :. First Check the Capacity of section As simply reinforcement Beam.

Reinforcement Ratio:-

As we know that.

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

$$\rho_{max} = 0.85 \times 0.85 \times \frac{4}{60}\left[\frac{0.003}{0.003 + 0.005}\right].$$

$$\rho_{max} = 0.0181$$ → Reinforcement Ratio

Step # 02 :- Find area of the steel.

By formula!

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

$$Ast = \rho_{max} \times b \times d.$$

$$Ast = 0.0181 \times 10 \times 17.$$

$$Ast = 3.077 \text{ inch}^2$$

Step # 03:- Design Moment:-

By formula.

$$Mu_2 = \phi \times Ast \times fy \times (d - \frac{a}{2})$$

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{3.077 \times 60}{0.85 \times 4 \times 10} = 5.43''$$

there

$$Mu_2 = 0.90 \times 3.077 \times 60 (17 - \frac{5.43''}{2})$$

$$Mu_2 = 2373.567 \text{ Kips - inch.}$$

Moment due to given load:-

$$\text{Beam self weight} = \frac{10}{12} \times \frac{20}{12} \times 150 = 208.33 \text{ lb/ft}.$$

$$\text{Total factor load} = 1.2(1050 + 208.33) + 1.6(2470)$$

$$= 5461.99 \text{ lb/ft}.$$

$$= 5.46 \text{ Kips/ft}$$

$$\text{Ultimate factored Moment} = \frac{WL^2}{8}$$

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

$$Mu = 2653.56$$

As, $Mu_2 < Mu$.

237.35 < 2653.56

Now Doubly Reinforcement Required.

Step # 04 :-

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

$M_{u1} = 2653.56 - 2373.57$.

$M_{u1} = 279.99$.

$M_{u1} = 280$ Kips/inch.

Step # 05 :- Steel area in Compression zone will be,

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

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

$$= \frac{280}{0.90 \times 60 (17 - 2.5)}$$

$A_{st}' = 0.357 \ in^2$.

$A'_{st} = 0.36 \ in^2$

Step # 06 :- $A_{st} = A_{st} + A'_{st}$.

$A_s = 3.077 + 0.36$.

$A_s = 3.44 \ in^2$.

Step # 07 :- For Tensile zone.

using # 8 bar (dia = 8/8 = 1")

Area = $0.785 \ in^2$

$$\text{No of Bars} = \frac{A_{st}}{\text{Area of 1 bar}}$$

$= \frac{3.44}{0.785} = 04.38$

No of Bars $= 4.38 \cong 5$ bars.

So 5 # 8 bars.

For Compression zone :-

use # 6 bars :- dia $= \frac{6}{8} = 0.75''$

Area $= 0.44 \, in^2$.

No of bars $= \frac{A_{st}'}{\text{Area of 1 bar}}$

$= \frac{0.36}{0.44} = 0.84 \cong 1$

So 1 # 6 bar in Compression zone.

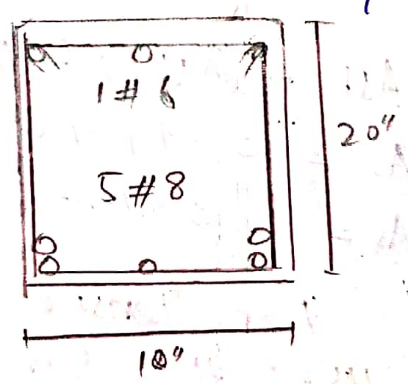
Step # 08 :-

Beam Minimum width.

$b_{min} = 2(1.5) + 2\left(\frac{3}{8}\right) + 5\left(\frac{8}{8}\right) + 4\left(\frac{8}{8}\right)$

$= 12.75 > 10''$

in multiple layer.




⇒ effective depth $d = 20 - 1.5 - 3/8 - 8/8 - 1/2(8/8)$

⇒ Effective Cover ($d'$) $= 1.5 + 3/8 + 1/2(8/8)$

$\{ d' = 2.25'' \}$

Step # 09

Design Moment is given.

$$Md = \phi \times \{A's_t \times fy \times (d-d') + (Ast - Ast') \times fy (d - \frac{a}{2})$$

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

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

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

$$Md = 2890.46 > 2663.66$$

Design is ok.

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QNO# 02 :-

(a) Briefly describe Bond Stress & development length:-

Bond Stress:- The stress which is acting on the outer interface of steel & the surrounding Concrete is called bond stress.

⇒ This stress help in keeping bond b/w reinforcement & Concrete together bond stress resists any force that tries to pull out the rods from the Concrete there this bond stress resists the bar to come out.

⇒ It is different grades of Concrete has different bond stress.

Development length:⇒ Development length Can be define as "the length of the bar required for Transfering the stress into the Concrete.

⇒ In other words development length is the quantity of the reber length that is actually required

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To be enclosed into the Concrete to make the desired bond strength b/w two materials &
furthermore the produced required stress in the steel of that area.

**Why we providing Development length**

we providing development length b/c of
⇒ To develop a safe bond b/w the bar surface & concrete so that no facture 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 transfering the stress development in any section of the adjoining section.

QNO# 02:-
part (B) In which Condition doubly reinforcement beam Can be used:-

**Doubly Reinforced Beam:-**

Beams reinforced with steel in Compression zone & tension zone are called doubly reinforced beam.

**Condition When Doubly Reinforced Beam Used:-**

we Can used the doubly reinforced beam on that Condition when the restriction occurs in the size of beam.
For Example:- if some one said that the depth of the beam should not be greater "12" & the external load on beam is very much which Cannot resist a beam of singly reinforcement is that Condition we used Doubly reinforced beam.

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QNO# 02:
Part (c):- Differentiate b/w T-Beam Analysis & Rectangular Beam Analysis -

| T-Beam | Rectangular Beam. |
| --- | --- |
| ⇛ T-Beam having beam & slab composite section. | ⇛ A rectangular Beam is one which as generally used as compression in top fiber & tension in bottom fiber of that beam. |
| ⇛ A T-Beam is more economical then rectangular Beam. | ⇛ Rectangular Beam is less economical then T-Beam. |
| ⇛ T-Beam are more often used for more heavy duty or larger span such as Bridges these are almost always precast using pre-stress reinforcement. | ⇛ Rectangular beams are more often used an office or commercial buildings. Then can be cost in site using standard reinforcement. |
| ⇛ In case of T-Beam slab are connected with one another & act as a one member. | ⇛ In case of rectangular Beam slab has been placed on the beam so there is no connection b/w slab & beam. |

QNO# 02:-
part (d) Write short Note on the effect of strength reduction factor on flexural strength.

Effect of strength reduction factor on Flexural strength:- In the design of flexural strength the strength reduction factor decreases from tension control section to compression controlled section to increase safty with decreasing ductility this show to determine the reduction factor for

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flexural Strength of reinforcement Concrete.

QNO# 02:-

part (e):- Briefly describe design methods which one of them can be best used for design of different structure member by why?

Designing Method:- Two method are wordly used for the designing of concrete by different structure member

(1) ASD Method.
(2) USD Method.

1) ASD Method:- ASD method is also known as working stress design method. It is based on the principle that stresses developed in the structural members should not exceed a certain limit friction of elastic limit.

⇒ In this method all load are taken as service load by no factor is applied to increase these service load.

2) USD Method:- Ultimate strength design method is also known as load factor method. For the structural subjected to large external load the ultimate strength is determine by the inelastic analysis.

* USD method is best for designing different structure method b/c of the following reasons:

* As the ultimate strength of the material is considered we will get much standard section for column by beam compare by other methods.

QNo # 03:-



Given Data:-

C/c distance = 10 ft.

Total Span = L = 32 ft.

Slab thickness = hf = 6 inch.

web width = bw = 14 inch.

depth = h = 28 inch.

Dead load = D.L = 50 psf = 50 lb/ft$^2$.

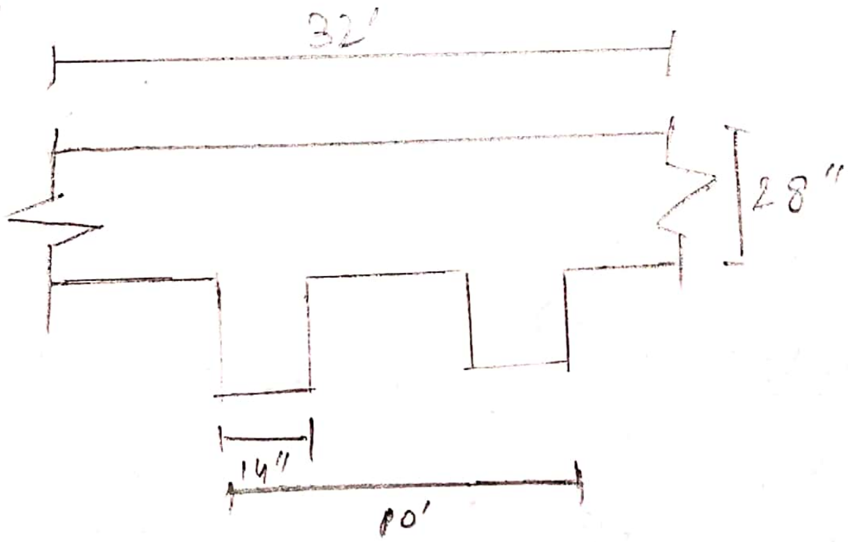
Live load = L.L = 225 psf = 225 lb/ft$^2$

f'c = 4000 psi = 4 ksi.

fy = 60000 psi = 60 ksi.

Solution:-

Effective depth = h - 3 = 28 - 3 = 25 inch.




Step # 01:- To factored load:-

To find Beam self weight per feet.

⇒ Wt = b × h × $\gamma_c$

$Wt = \frac{14}{12} \times \frac{28}{12} \times 150 \ lb/ft^3$.

$Wt = 408.33 \ lb/ft$.

As we know that total factored load.

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

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

$W_u = 909.996 \ lb/ft$.

$W_u = 0.91 \ Kip/ft$.

Step # 02:- Ultimate factored ~~load~~ Moment:-

$M_u = \frac{w_u \times l^2}{8} = \frac{0.91 \times (32)^2}{8} \times 12$.

$M_u = 1397.76$ Kips-inch.

Step # 03:- Effective width ($b_e$)

* $16 \times h_f + b_w$.

$16 \times 6 + 14 \Rightarrow 110$ inch.

* c/c distance $\Rightarrow 10 \times 12 = 120$ inch.

* $\frac{Span}{4} = \frac{32}{4} = 8' = 8 \times 12 = 96''$.

than the $B_e = 96$ inch

Step # 04:- To check which type of analysis is Required.

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Trial = 01:- let Suppose $a = h_f = 6''$.

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

$$A_{st} = \frac{1397.76}{0.9 \times 60 \times (25 - \frac{6}{2})}$$

$$A_{st} = 1.177 \ in^2.$$

Trial = 02

$$a = \frac{A_{st} \times f_y}{0.85 \times f'c \times b_e} = \frac{1.177 \times 60}{0.85 \times 4 \times 96}$$

$a = 0.216'' < h_f = 6''$

So Design by Rectangular Beam

$$A_{st} = \frac{1397.76}{0.90 \times 60 \times (25 - \frac{0.216}{2})}$$

$$A_{st} = 1.04 \ in^2$$

Trial = 03

$$a = \frac{1.04 \times 60}{0.85 \times 4 \times 96} = 0.191 \ in$$

$$A_{st} = \frac{1397.76}{0.9 \times 60 \times (25 - \frac{0.191}{2})}$$

$A_{st} = 1.04\ in^2$

## Step # 05

To Find $\rho_{max}$ & $\rho_{min}$ :-

As we know that.

$$\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy} \times \left(\frac{\varepsilon_u}{\varepsilon_u \times \varepsilon_y}\right)$$

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

$$\rho_{max} = 0.0181$$

$$\rho_{min} = \frac{200}{fy} = \frac{200}{60,000} = 0.0033.$$

As we know that:-

$$\rho = \frac{A_{st}}{b_c \times d} = \frac{1.04}{14 \times 25}$$

$$\rho = 0.00297$$

So $\rho_{min} < \rho < \rho_{max}$ → Not ok

Not satisfied have we $\rho_{min} < \rho$

Now,

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

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$A_{st} = 0.0033 \times 14 \times 25.$

$A_{st} = 1.155 \, in^2.$

Step # 06:-

No's of Bar cy Bar section

let # 8 bar use.

Area of #8 is 0.785

$\text{No of bars} = \frac{A_{st}}{A_b} = \frac{1.155}{0.785}$

$\text{No of bars} = 1.47 \cong 2.$

we take 2 # 8 Bars As main bars.

Step # 07:-

Minimum width (bmin)

$b_{min} = 2 \times c.c + 2 \times \text{Stirup} + 2 \times \text{max bar} + 1 \times \text{Spacing}$

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

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

So the main bars are good in one layers.

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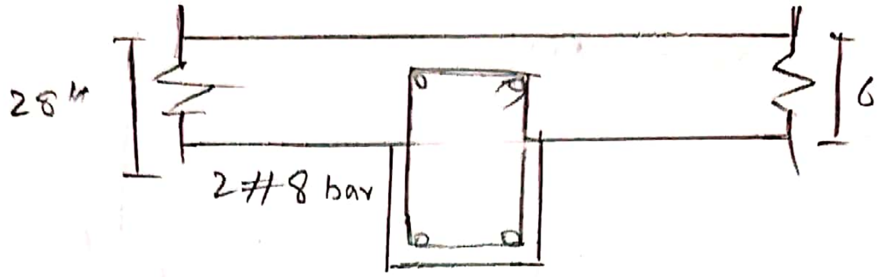


Step # 08:

Design Moment :-

As we know that.

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

$$M_d = 0.9 \times 60 \times 1.57 \times \left(25 - \frac{0.289}{2}\right)$$

$$M_d = 2180.24$$

$$M_d > M_u \quad \therefore$$

Design is ok!

$$A_{st} = 0.785 \times 2$$

$$A_{st} = 1.57 \text{ in}^2$$

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

$$a = 0.289 \text{ in}$$