QNo1:- A rectangular beam that must carry a service load of 2.47 kips/ft and a calculated dead load of 105 kip/ft (without selfweight) on an 18-ft simple span is limited to inches width and 20 inches total depth for architectural reasons. If $f_y = 60000$ psi and $f_c = 4000$ psi what steel area must be provided. Draw sketch of your final design.

Sol:- Given

$F_y = 60000$ psi $\quad w = 10''$

$f_c' = 4000$ psi $\quad h = 20''$

$D.L = 1.05\,K/ft \quad L.L = 2.47\,K/ft$

$F_y = 60$ ksi

$f_c' = 4$ ksi

$d = h - 3'' = 20'' - 3$

$= 17''$

$d' = 2.5''$

Step#01:-

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

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

$$\rho_{max} = 0.0181$$

2

Step#02:- Area of Steel

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

$$A_{st} = \delta_{max} \times b \times d$$
$$= 0.0181 \times 10 \times 17$$
$$= 3.077 \, in^2$$

Step#03:- Design factored moment

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

$$\cancel{a = 0.85}$$

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

$$= \frac{3.077 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

$$M_{u2} = 0.90 \times 3.08 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

$$M_{u2} = 2378.38 \, k''$$

Now,
Moment of the given load

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

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



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Now.

Total factored load = 1.2DL + 1.6LL

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

$= 5461.996\ lb/ft$

$= 5.46\ k/ft \approx 5461.996$

Ultimate factored moment $= \dfrac{wL^2}{8}$

$= \dfrac{5.46(18)^2}{8} \times 12$

$= 2653.56\ k''$

Thus $2378.38 < 2653.56$

it should be doubly design beam.

Step #04:-

$M_{U1} = M_U - M_{U2}$

$= 2653.56 - 2378.38$

$= 275.18\ k''$

Step # 05:- $M_{U1} = \phi \times A_s' \times f_y \times (d - d')$

$A_s' = \dfrac{M_{U1}}{\phi \times f_y \times (d - d')}$

$= \dfrac{275.18}{0.90 \times 60(17 - 2.5)} = 0.35\ in^2$

(41)

Step#06:-

$$AS = Ast + AS'$$
$$= 3.08 + 0.35$$
$$= 3.43 in^2$$

This lies in the Tension Zone of Steel-

Step#07:- Selection of Bars

For Tensile Steel; lets Take #6 having an area of

$$A = \frac{\pi D^2}{4} = \frac{3.14}{4}\left(\frac{6}{8}\right)^2 = 0.44 in^2$$

$$\text{No of bars} = \frac{3.43 in^2}{0.44 in^2} = 7.795$$

$$\approx 8$$

For Compression Steel; lets Take #6 having an area of $0.442 in^2$

$$\text{No of bars} = \frac{AS'}{A_6} = \frac{0.35}{0.442} = 0.79$$

$$\approx 1 \text{ bar}$$

Step#08:- Beam Minimum width

$$b_{min} = (2 \times 1.5) + 2\left(\frac{3}{8}\right) + \left(8 \times \frac{6}{8}\right) + \left(7 \times \frac{8}{8}\right)$$

$$= 16.75'' > 10''$$



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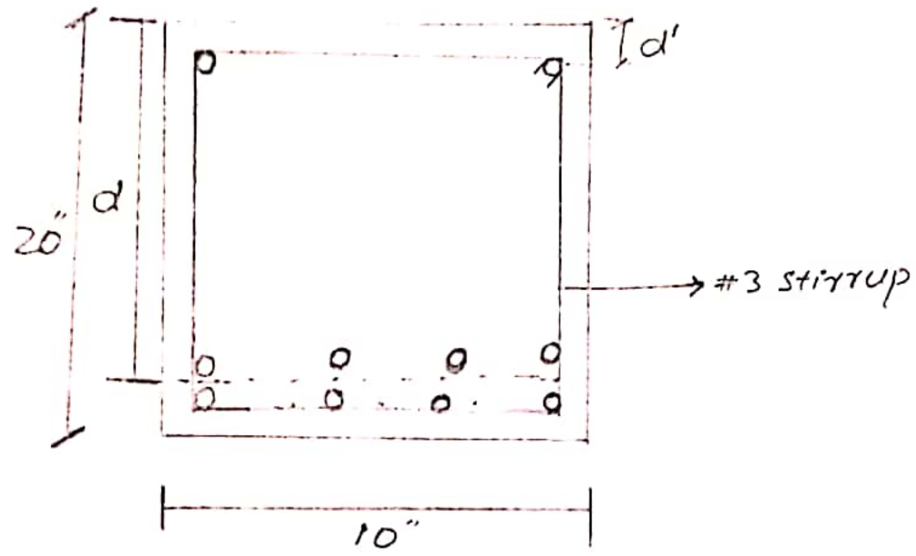
It Should be in multiple layers.




$$d = 20 - 1.5 - \frac{3}{8} - \frac{6}{8} - \frac{1}{2}\left(\frac{6}{8}\right)$$

$$d = 17$$

$$d' = 1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right) = 2.25''$$

Step # 09:-

Design Moment.

$$Md = \phi \times \left[As' \times Fy \times (d - d') + (As - As') \times Fy \times \left(d - \frac{a}{2}\right)\right]$$

$$a = \frac{(As - As') \times Fy}{0.85\, fc \times b} \Rightarrow \frac{(8 \times 0.442 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10}$$

$$a = 6.15''$$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(6)

$$Md = 0.90 \times \left[1 \times 0.44^2 \times 60 \times (17 - 2.25) + (8 \times 0.442 - 1 \times 0.442) \times 60 \times \left(17 - \frac{6.15}{2}\right)\right]$$

$$Md = 2666.466K'' > 2653.56K''$$

So the Design is Ok



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QNO2: Define the following Term.

(a) ⇒ Bond Stress:-

It is the longitudinal shear stress acting over a unit contact area between the reinforcing bar and concrete. this is known is bond stress. the direction of bond stress is parallel to the longitudinal direction of bars. it acts over contact surface in the midst of bars and surrounding concrete.

⇒ Development length:-

A development length can be define as the amount of reinforcement (bar) length needed to be embedded ~~the~~ or projected into the column to establish the desired bond strength between the concrete and steel

⇒ Reason for providing Development lengths:

* To develop a safe bond between the bar surface and the concrete so that no failure due to slippage of bar occurs during the ultimate



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Load Conditions.

* Also the extra length of the bar provided as development length is responsible for transferring the stress developed in any section to the adjoining sections (such as at column beam junction the extra length of bars provided from beam to column)

(b) In which conditions doubly reinforced beam can be used?

→ when the architecture restriction is given

→ when the cross section of the beam is fixed.

→ In the case of the continous beam

→ when dimensions of the beam are restricted for architectural or structure purposes.



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Q: Differentiate between T-beam analysis and rectangular beam analysis.

⇒ T-beam:-

→ T beam is more economical then rectangular beam.

→ In case of T-beam slab and beam are connected with another and all is a one member.

→ It consist of T shaped structure.

→ Analysis is required when

$a > hf$

$a$ = depth,

$hf$ = Slab thickness

⇒ Rectangular beam:-

→ Rectangular beam is less economically then T-beam.

→ In case of rectangular beam slab has been placed on the beam and there no connection b/w slab and beam.

→ It is generally used as compression in top fiber used and tension in bottom fibre.



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→ It is most commonly used in office and commercial building.

→ Analysis is required when

$a \leq h_f$

$a$ = depth

$h_f$ = heign of flenge.

(d) Write short note on the effect of strength reduction factor on flexural strength.

→ The flexural strength of reinforced concrete (RC) beam strengthened with a carbon fiber reinforced polymer plate which fails by intermediate crack debonding is evaluated.

→ A series of beam tests were performed to evaluate the ductility of reinforced concrete (RC) beam strengthened with carbon-fiber-reinforced polymer (CFRP) element. A total of Nine RC beams were produced and loaded up to failure in three-point bending under deflection control.

QNO2

(e) Briefly describe design methods which one of them can be best used for design of different structural members and why?

→ it is a procedure aids arts, Techniques for designing they offer a number of different kinds of activities that a designer might use with in an overall design process

→ Three methods of Structure design
(i) working Stress (ii) limit State
(iii) ~~working~~ ~~Stress~~ Ultimate load method -

Why:-
limit State method is used due to provid Strength and Serviceability

QNO3:- Given data:-

C/c distance = 10' Span = 32'

$h_f = 6''$ $b_w = 14''$ $h = 28''$

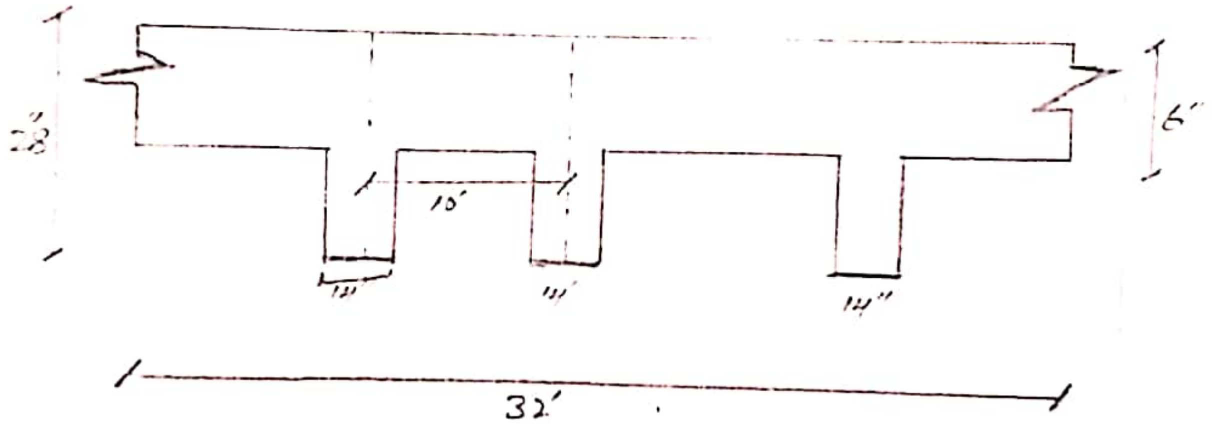
$d$ = Effective depth = $h - 3$

$= 28 - 3 = 25''$

D.L = 50 lb/ft² L.L = 225 lb/ft²

$F_y = 60{,}000\,psi = 60\,ksi$

$F'_c = 4000\,psi = 4\,ksi$




Step#01:-

Ultimate factored moment

$$M_u = \frac{wL^2}{8}$$

(i) Self weight of the beam

$w_t = b \times t \times \gamma_c$

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

$= 408.33$ lb/ft

$\because$ pcc = 140 lb/ft

Rcc = 150 lb/ft



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(iii) Total Factored Load

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

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

$= 909.99\ lb/ft = 0.909\ K/ft$

$Mu = 0.909 \times (32^2) = 116.352 \times 12$

$= 1396.224\ K/ft.$

⇒ Step#02:-

Determine the effective width "be"

1- $16 \times hf + bw = 16 \times 16 + 14 = 110''$

2- C/c distance $= 10 \times 12 = 120''$

3- Span /4 $= \frac{32}{4} \times 12 = 96''$

Select at least value of be i.e 96

Step#03:- Check weather Rectangular or T-beam analysis is required-

Trial#1:-

Let a $h_f = 6''$

$$Ast = \frac{MU}{\phi \times Fy \times d(d - \frac{a}{2})}$$

$$= \frac{1396.244}{0.90 \times 60 \times (25 - \frac{6}{2})} = 1.175 in^2$$



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Trial#02:-

$$a = \frac{Ast \times Fy}{0.85 Fc' \times be} = \frac{1.75 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.22'' < 6''$$

Thus Rectangular beam analysis is required.

$$Ast = \frac{MU}{\phi \times Fy \times (d - \frac{a}{2})} = \frac{1396.244}{0.90 \times 60 \times (25 - \frac{0.2}{2})}$$

$$= 1.04\ in^2$$

Trial#03:-

$$a = \frac{1.04 \times 60}{0.85 \times 4 \times 96} = 0.19''$$

$$Ast = \frac{1396.244}{0.90 \times 60 \times (25 - \frac{0.19}{2})} = 1.04\ in^2$$

Same area.

Step#04:-

Check $\delta max$ and $\delta min$

$$\rightarrow \delta max = 0.85 \times \beta \times \frac{Fc'}{Fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon t}\right)$$

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

$$\delta max = 0.018$$



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$$\delta_{min} = \frac{200}{FY} = \frac{200}{60000} = 0.003$$

$$\delta = \frac{AST}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$$

$$\delta_{min} < \delta < \delta_{max}$$

$$0.003 < 0.002 < 0.018$$

As $\delta$ is less than $\delta_{min}$ so

$$\delta = \frac{Ast}{b \times d}, \quad \therefore Ast = \delta_{min} \times b \times d$$

$$= 0.003 \times 14 \times 25$$

$$= 1.05 in^2$$

Step#05:-

Select NO 07 bars

using #10 bar having Area $1.27 in^2$

$$NO\ 07\ bars = \frac{Ast}{Ab} = \frac{1.05}{1.27} \approx 2 bars$$

Step#06:-

Check on minimum width

$$b_{min} = (2 \times 1.5) + (2 \times 3/8) + 2\left(\frac{10}{8}\right) + \left(1 \times \frac{10}{8}\right)$$

$$= 7.5'' \approx 14''$$



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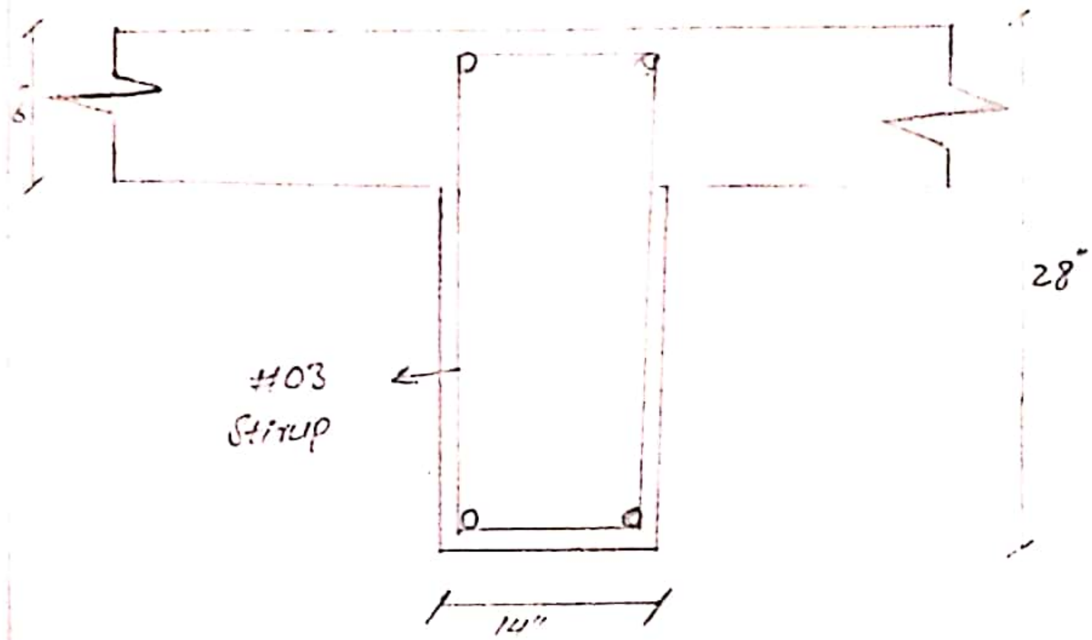


Step#07:- Dessign Moment

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

$\rightarrow$ $Ast = 1.27 \times 2 = 2.54 \, in^2$

$\rightarrow$ $a = \dfrac{Ast \times Fy}{0.85 \times Fc' \times be} = \dfrac{2.54 \times 60}{0.85 \times 4 \times 96}$

$= 0.467''$

$$Md = 0.90 \times 60 \times 2.54 \times \left(25 - \frac{0.467}{2}\right)$$

$\Rightarrow 3396.97$

$3396.97 > 1396244$

Design is Correct



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