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Sec :- A

Subject :- PRC-Design I

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MID TERM EXAM

Q1) A rectangular beam that must carry a service live load of 2.47 Kips/ft and calculated dead load of 1.05 Kips/ft (without self load) on an 18-ft simple span is limitted to 10 inches ~~total depth for architectural reasons. If fy = 60000 psi and fc.~~ width and 20 inches total depth for architectural reason. If fy = 60000 psi and fc = 4000 psi. What steel area must be provided? Draw sketch of your final design.

Sol:- Given Data:-

$f_y = 60{,}000 psi$, $w = 10''$
$h = 20''$
$f'_c = 4000 psi$, $D.L = 1.05 k/ft$
$d = h - 3$, $L.L = 2.47 k/ft$
$= 20 - 3 = 17''$, $d' = 2.5''$

Step 01:-

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

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

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

Step 02:-

Area of Steel

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

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

$$= 0.0181 \times 10 \times 17$$

$$A_{ST} = 3.07\ in^2$$

Step 03:-

Design Factor Moment

$$M_{u_2} = \phi \times A_{ST} \times f_y \times \left(d - \frac{a}{2}\right)$$

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

$$= \frac{3.08 \times 60}{0.85 \times 4 \times 10}$$

$$a = 5.4''$$

$$M_{u_2} = 0.90 \times 3.08 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

$$\boxed{M_{u_2} = 2378.3\ k''}$$

Now

Moment of a given load:

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

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

$= 208.3$ lb/ft

Total factored load = $1.2 D.L + 1.6 L.L$

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

$= 5.5$ k/ft

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

$M_u = \frac{5.5(18)^2 \times 12}{8}$

$= 2653.6$ k"

Thus $2378.3 < 2653.6$

It should be doubly designed beam.

Step 04:-

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

$$= 2653.6 - 2378.3$$

$$M_{u1} = 275.2\ K''$$

Step 05:-

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

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

$$= \frac{275.2}{0.90 \times 60 (17 - 2.5)}$$

$$A_s' = 0.35\ in^2$$

Step 06:-

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

$$= 3.08 + 0.35$$

$$= 3.43\ in^2$$

This lies in tension zone of steel.

Step 07:-

Bars Selections

→ For tensile steel; let's the take **#8** having an area of 0.785 in².

$$\text{No. of bars} = \frac{A_s}{A_b} = \frac{3.43}{0.785} = 4.36 \approx 5 \text{ bars}$$

→ For Compression steel; lets take **#6** having an area of 0.442 in²

$$\text{No. of bars} = \frac{A_s'}{A_b} = \frac{0.35}{0.442} = 0.79 \text{ bars} \approx 1 \text{ bar}$$

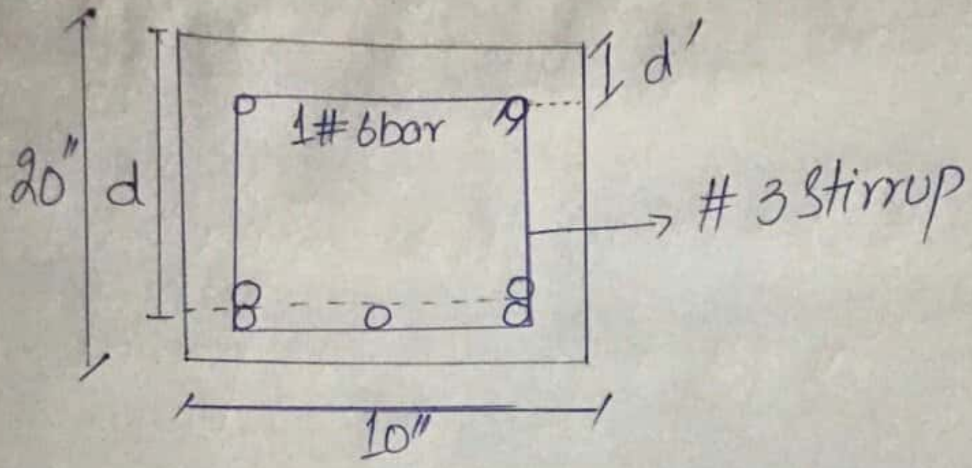
Step 08:-

Beam Minimum Width.

$$b_{min} = (2\times1.5) + 2\left(\frac{3}{8}\right) + \left(5\times\frac{8}{8}\right) + \left(4\times\frac{8}{8}\right)$$

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

It should be in multipals layers.



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

$$d = 16.62''$$

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

Step 09:-

Design Moment

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

$$a = \frac{(A_s - A_s') \times f_y}{0.85 f_c \times b} = \frac{(5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10}$$

$$a = 6.15''$$

$$= 0.90 \times \left[1 \times 0.44 \times 60 \times (16.62 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60 \times \left(16.25 - \frac{6.15}{2}\right)\right]$$

$$M_d = 2891.52$$

$$M_d = 2891.52 > 2653.56\,k''$$ Design is OK.

Q2a) Briefly Describe Bond Stress and Development length.

"Bond Stress:" The Stress which is acting on the outer interface of steel to the surrounding concrete is called bond stress. This stress help in keeping bond b/w reinforced and concrete together. Bond stress resist any force that tries to pull out the rods from the concrete.

"Development length:-" The length of the bar required on either side of the section to develop the required stress in steel at the section through bond. In other words we can say that the development length of the bar required to develop the design stress in reinforcement at the critical section.

b) In which Condition doubly reinforced beam can be used?

Ans. This type of beam is provided when the depth of beam is restricted. If a beam with limited depth is reinforced on the tension side, it might not have sufficient resistance to oppose the bending moment.

- Major reason for providing doubly reinforced beam is to ensure there is increase in moment carrying capacity, ensure safety against reversal of stress in the structure due to wind forces, sesmic force and temperature stress.

c) Differentiate b/w T-beam analysis and rectangular beam analysis.

T-beam	Rectangular beam
• In T-beam, slab and beams are connected with eachother and acts as one member	• In R-beam, slab is placed on the beam so that there is no connection b/w slab and beam.
• Flexural capacity of T-beam varies based on the sign of moment	• Flexural capacity depends on location of reinforcement to the yield
• Design procedure depends on the location of moment	• Simple design with no complexion.

d) Write short Note on effect of strength reduction factor on flexural strength.

Ans: In the design of flexural strength, the strength reduction factor decrease from tension-controlled section to compression controlled section to increase the safety with decreasing ductility. The tension controlled sections are desirable for their ductile behaviour for giving sufficent warning to failure. Depending on the structure compression controlled section have less ductility thus they acts simultaneously to hold together the structure

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e) Briefly describe methods, which one of them can be used for design of different member and why?

Ans: Following are the Design method of PRC:

1) "Ultimate load design:-" It is ~~designated~~ defined as the method which limit the structural usefulness of material of the structure upto ultimate load.

2) "**Limit State Method**:-" It is defined as the method which limit the structural usefulness of material of structure upto certain load at which acceptable limit of service ability and safety are applied so that the failure of the structure doesnot happen.

3) "**Elastic Method of Design**:-" It is defined as the method which limits the structural usefulness of the material of the structure upto certain load at which the min stress is extreme fiber reaches the characteristic strength of material in bending.

Q3) A concrete floor system consist of parallel T-beam spaced 10ft. on center & spanning 32 ft. b/w supports. The 6inch-thick slab is cast monolithically with the T-beam web having width bw= 14 inch & total depth measured from the top of the slab, of h=28 inch. The effective depth will be taken 3-inch less then the total depth. In addition to its own weight, each beam must carry a superimposed D.L of 50psf and service live load of 225 psf. Material strength are fy = 60,000 psi & fc' = 4000 psi. Determine the required steel area and select the reinforcement needed for a typical member. Draw a sketch of final design.

"Given data:-"

c/c distance = 10'

$h_f = 6''$

$b_w = 14''$

$h = 28''$

Span = 32'

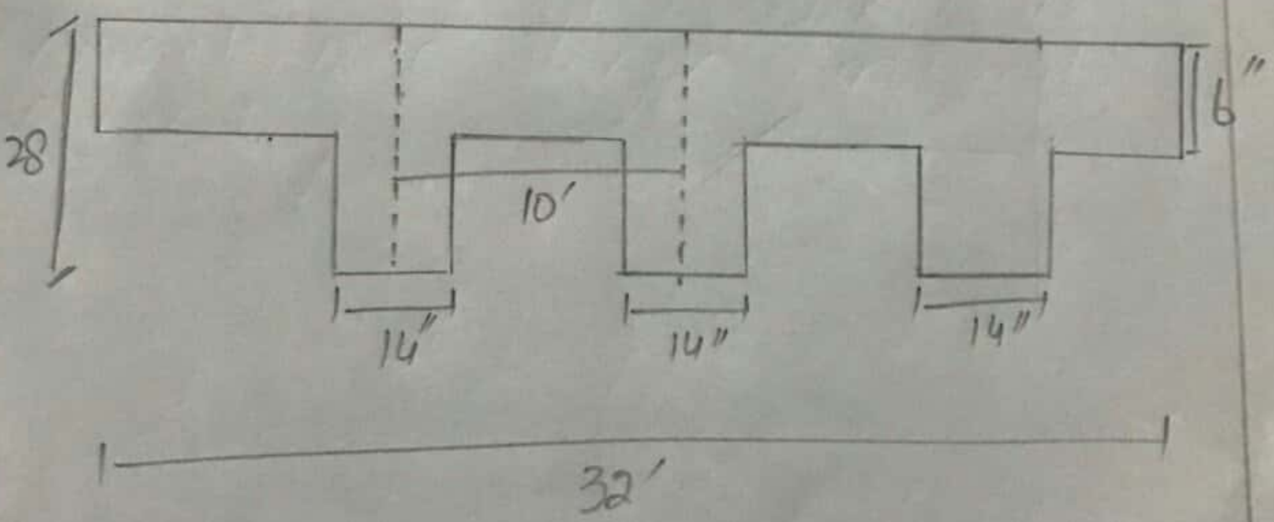
d = Effective depth = h - 3 = 28 - 3 = 25''

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

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

1) Self weight of the beam

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

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

$= 408.3\ lb/ft$

2) Total factored load

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

$= 1.2(50 + 408.3) + 1.6(225)$

$= 909.99\ lb/ft$

$= 0.909\ K/ft$

$M_u = \frac{0.909 \times (32^2)}{8} = 116.35 \times 12$

$= 1396.22\ K/ft$

"**Step 02:-**"

Determine "be"

1) $16 \times h_f + b_w = 16 \times 6 + 14 = 110''$

(2) c/c distance $= 10 \times 12 = 120''$

(3) span /4 $= \frac{32}{4} \times 12 = 96''$

Select the least value of "be" ie 96

Step 03:- "Check whether Rectangular or T-beam analysis is required.

Trail #1 : let $a = h_f = 6"$

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.24}{0.90 \times 60 \times (25 - 6/2)}$$

$$A_{ST} = 1.175 \text{ in}^2$$

Trail #2:

$$a = \frac{A_{ST} \times f_y}{0.85 f_c \times b_e} = \frac{1.175 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.22" < 6"$$

Thus Rectangular beam analysis is required.

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.24}{0.90 \times 60 \times \left(25 - \frac{0.2}{2}\right)}$$

$$= 1.04 \text{ in}^2$$

Trail # 3:-

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

$$A_{ST} = \frac{1396.24}{0.90 \times 60 \times (25 - 0.19/2)} = 1.04 \text{ in}^2$$

→ Area is same

"Step 04 :-"

ρ_{max} and ρ_{min}

- $\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon t}\right)$

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

$\rho_{max} = 0.018$

- $\rho_{min} = \frac{200}{fy} = \frac{200}{6000} = 0.003$

- $\rho = \frac{A_{ST}}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 < 0.018$

As ρ is less then ρ_{min} Thus;

$\rho = \frac{A_{ST}}{b \times d}$; $A_{ST} = \rho_{min} \times b \times d$

$= 0.003 \times 14 \times 25$

$= 1.05 \; in^2$

"Step 05:-" Selection and No of bars

let use #10 bar having area of $1.27 in^2$

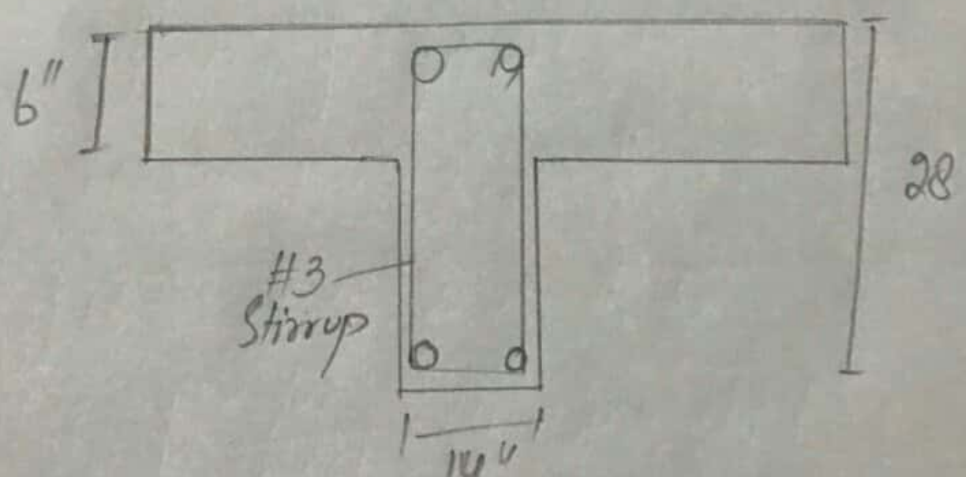
No of bars $= \frac{A_{ST}}{A_s} = \frac{1.05}{1.27} \approx 2$ bars

"Step 06:-" Check on minimum width

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

$= 7.5'' < 14''$

It is good in one layer



"Step 07:-" Design Moment

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

- $A_{ST} = 1.27 \times 2 = 2.54 in^2$

- $a = \frac{A_{sT} \times f_y}{0.85 f'_c \times b_e} = \frac{2.54 \times 60}{0.85 \times 4 \times 96} = 0.46''$

$\rightarrow M_d = 0.90 \times 60 \times 2.54 \times \left(25 - \frac{0.46}{2}\right) = 3396.97$

$\Rightarrow 3396.97 > 1396.24$

Design is OK.

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