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Subject PRC I

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Q1 A rectangular beam that must carry . . . . your final design.

Given:-

Width (b) = 10"

Height (h) = 20"

Live Load (L.L) = 2.47 kips/ft

Dead load (D.L) = 1.05 kips/ft

Span = 18'

fc' = 4000psi = 4Ksi

fy = 60,000 psi = 60Ksi

Solution:-

Step # 1:-

=> Effective depth (d) = h - 3
= 20 - 3 = 17"

=> Effective Cover (d') = 2.5"

=> Reinforcement Ratio:-

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

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

$$\boxed{\rho_{max} = 0.0180}$$

Step # 2

Finding Area of Steel

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

$$Ast = 0.0180 \times (10 \times 17) = 3.06 \, in^2$$

Step # 3

By formula of Design Moment

$$M_{u_2} = \phi \times Ast \times f_y \times (d - \frac{a}{2})$$

$$a = \frac{Ast \times f_y}{0.85 \times f'_c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

Put in formula

$$M_{u_2} = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$\boxed{= 2362.93 \text{ Kip-inch}}$$

Moment due to given loads

$$\text{Beam self weight} = \frac{10}{12} \times \frac{20}{12} \times 150$$

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

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

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

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

Ultimate factored load = ~~[illegible]~~

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

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

$M_u = 2653.56$

Now As
$M_{u_2} < M_u$
$2362.92 < 2653.56$
↓
Doubly reinforcement required

Step # 4

$M_{u_1} = 2653.56 - 2362.92$
$= 290.64$ kip-inch

Step # 5

steel Area in compression zone will be

$$M_{u_1} = \phi \times A_{st}' \times f_y \times (d - d')$$

$$A_{st}' = \frac{M_{u_1}}{\phi \times f_y \times (d-d')}$$

$$= \frac{290.64}{0.90 \times 60 \times (17.25)} = 0.37 in^2$$

Step # 6

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

$$3.06 + 0.37 = 3.43 in^2$$

Step # 7

We use #8 bars, (dia = 8/8 = 1")

Area = $0.785 in^2$

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

$= \dfrac{3.43}{0.785} = 4.36 \approx 5$ bars

So 5 # 8 bars
⇓
For Tensile zone

⇒ Compression steel:-

use #6 bars,

dia $\left(\frac{6}{8}\right) = 0.75''$, Area $= 0.44 in^2$

No of bars $= \dfrac{A_{st}}{\text{Area of 1 bar}} = \dfrac{0.37}{0.44} = 0.84$

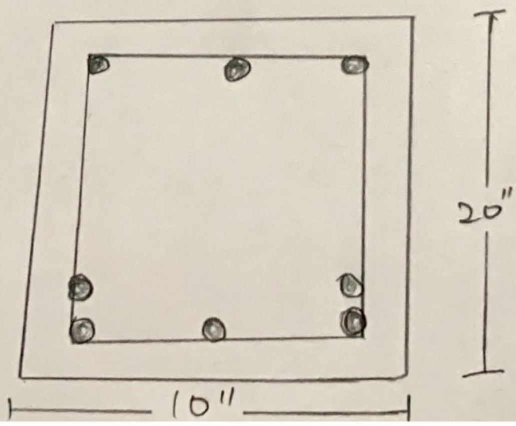
$= 0.84 \approx 1$ bars

So 1 # 6 bars in → compression zone

Step # 8 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 layers



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

$= 2.25''$

Step # 9

Design Moment is given by,

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

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

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

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

$M_d = 2890.46$

As $M_d = 2890.46 > 2653.56$

Design is OK

QNo 2

a) Briefly Describe Bond Stress and Development length.

Ans Bond Stress:-

Bond Stress is the result of the bonding between the concrete surface and the reinforcement steel. It varies depending upon the type of concrete and type of reinforcement used.
In simple terms it is like grip, more grip if surface is rough and less grip if surface is smooth.

Development length:-

It is the minimum length of the bar which must be embedded in concrete beyond any section to develop its full strength. This is also called as an anchorage length in case of axial tension or axial compression and development length in case of flexural tension or flexural compression

B) In which conditions doubly reinforcement beam can be used?

Ans Necessity of doubly reinforced sections due to the following conditions

1) when the dimensions (bxd) of the beam are restricted due to any constraints like availability of head room, architectural or space considerations and the moment of resistance of singly reinforced section is less than the external moment.

2) When the external loads may occur on either face of the member i-e the loads are alternating or reversing and may cause tension on both faces of the member

3) when the loads are eccentric

4) When the bam is subjected to accidental or sudden lateral loads.

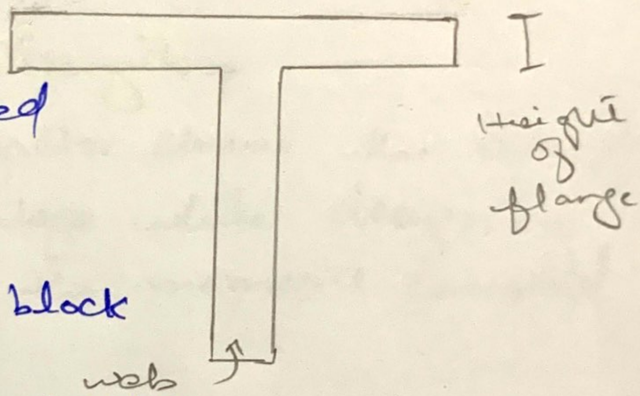
5) In the case of continous beams or slap, the sections at supports are generally designed as doubly reinforced sections.

c) Difference b/w T-beam analysis and rectangular beam analysis

Ans T- Beam Analysis:-

A T-Beam consists of T-Shaped structure. The top of T- shaped cross-section serves as a compression member in resisting compression stresses. The lower part serves to resist the shear stresses.

It is more economical the rectangular beam and is cast ~~[illegible]~~ monolithically with the slab



Its analysis is required when

$a > hf$

a = depth of compression block

hf = slab thickness / flange height

Rectangular Beam Analysis:-

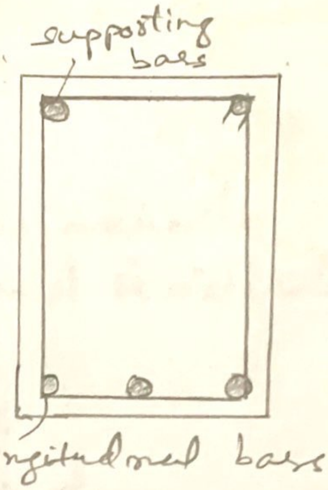
A rectangular beam is one which is generally used as compression in top fiber and tension in bottom fibre. They are used in mostly in office / commercial buildings. These can be used in-situ using standard reinforcement or pre-cast.

Its analysis is required when

$a \leq h_f$

a = depth of compression block

h_f = height of flange



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

Ans Effect on flexural Strength :-

Strength reduction factor shows the strength in terms of percentage while designing a section to resist the moment caused by loads.

It represents the uncertainity in determining the member behaviour to the type of stresses to which it is subjected.

E) Describe briefly Design Methods, which of them can be used for design of different structural members and why?

Ans Design Methods:-

There are two methods for the designing of concrete and structural members.

1) Allowable stress Design method
2) Ultimate Stress Design Method.

1) Allowable Stress Design Method:-

It is known as working stress design method. It is based on the principle that stress developed in the structural members should not exceed a certain limit/fraction of elastic limit.

In this method all loads are taken as service loads and no factor is applied to increase these service loads.

2) Ultimate ~~Stress~~ Strength Design method:-

Ultimate ~~Stress~~ Strength design method is also known as load factor method.

For the structure subjected to large external loads the ultimate strength is determined by the inelastic (non linear) analysis.

Ultimate Strength Design is best for designing different structural members because

=> As the ultimate strength of the material is considered we will get much slender sections for columns and beams compared to other methods

=> Ultimate Design method results in more economical design for a building with fewer special needs for customised areas of reinforcement.

Qno (3)

A concrete floor system consists - - - - - - Draw sketch of your final Design.

Data:-

c/c distance = 10'

Span = 32'

Slab thickness = 6"

Web width = 14"

Total depth = h = 28"

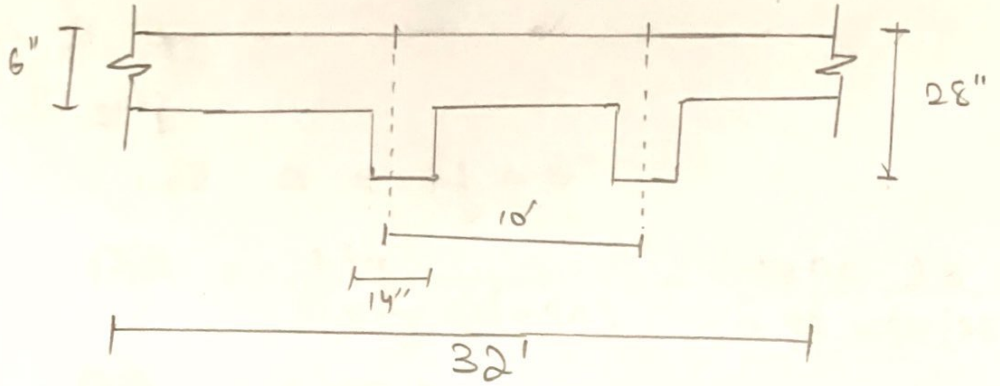
Effective depth = 28" - 3" = 25"

D.L = 50 lb/ft²

S.S = 225 lb/ft²

f_y = 60,000 psi

f_c = 4000 psi



Step # 1

$$Mu = \frac{wu \times l2}{8}$$

Beam self weight per feet

$wt = b \times t \times \gamma c$

$= \frac{14}{12} \times \frac{28}{12} \times 150 = 408.33$ lb/ft

Total factored load:-

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

$= 909.99$ lb/ft $= 0.909$ kip/ft

Moment:-

$$\frac{wl^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12 = 1396.25 \text{ kip-inch}$$

Effective Breadth:-

1) $16(hf) + bw = 16(6) + 14 = 110"$
2) c/c distance $= 10(12) = 120"$
3) span/4 $= \frac{32}{4} \times 12 = 96"$

so **be = 96"**

Step # 3

Trial # 1

Let $a = h_f = 6''$

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

$$A_{st} = 1.17 in^2$$

Trial # 2

$$a = \frac{A_{st} \times f_y}{0.85 f_c b} = \frac{1.17 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.2'' < 6''$$

So rectangular Beam design

$$A_{st} = \frac{1396.23}{0.90 \times 60 \times (25 - \frac{0.2}{2})}$$

$$= \boxed{1.03 in^2}$$

Trial # 3

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

$$A_{st} = \frac{1396}{0.90 \times 60 (25 - \frac{0.18}{2})} = \boxed{1.03 in^2}$$

Step # 4

Check ρ_{max} and ρ_{min}

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

$$\rho_{max} = 0.018$$

$\Rightarrow \rho_{min} = \dfrac{200}{f_y} = \dfrac{200}{60,000} = 0.003$

$\Rightarrow \rho = \dfrac{A_{st}}{bd} = \dfrac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 < 0.018$

As
ρ is less than ρ_{min}
So,

$\rho = \dfrac{A_{st}}{bd} \Rightarrow A_{st} = \rho_{min} \times b \times d$

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

Step # 5

No of selection of bars

Let use #8 bar, then

dia $= \left(\frac{8}{8}\right) = 1''$, Area $= 0.785 in^2$

No of bars $= \dfrac{1.05}{0.785} = 1.3 \approx 2$

So we use 2 #8 bars

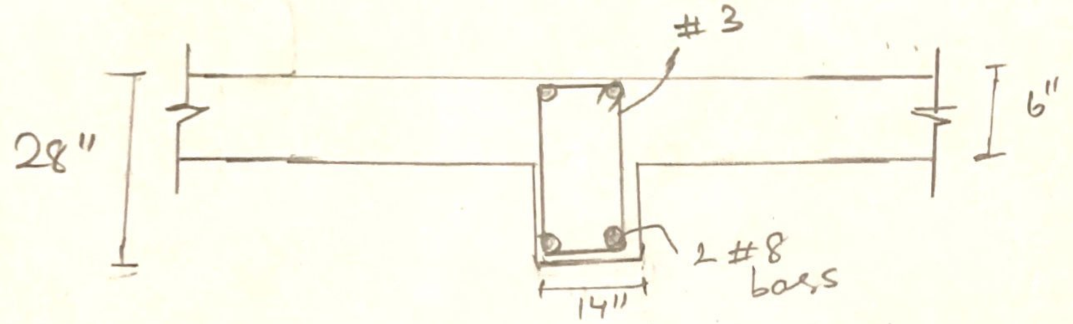
Step # 6

Minimum width

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

$= 6.75'' < 14''$

So good in one layer.



Step # 7

Design Method

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

Area of steel = Area of 1 bar x No of bars

= 0.785 x 2 = 1.57 in²

$a = \frac{1.57 \times 60}{0.85 \times 4 \times 96} = 0.2"$

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

= 2111.02 kip-inch

As, 2111.02 > 1396.23

Design is OK