Section "A" PRCD I Page #01

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Q No! 01

Given data :

live load = 2.47 kips/ft

Dead load = 1.05 kips/ft

width = 10"

height = 20"

Span = 18'

f'_c = 4000 psi = 4 ksi

f_y = 60,000 psi = 60 ksi .

Solution :

Step #01

Effective depth (d) = h - 3

= 20 - 3 = 17"

Effective cover (d') = 2.5"

Reinforcement Ratio

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

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

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

Step # 02

Area of Steel :

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

$$= 0.0180 \times (10 \times 17)$$

$$A_{st} = 3.06 \text{ in}^2 .$$

Step # 03

Design moment by formula :

$$M_{U_2} = \phi \times A_{st} \times f_y \left(d - a/2\right)$$

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

$$M_{u_2} = \phi \times A_{st} \times f_y \times (d - a/2)$$

$$= 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$\boxed{M_{u_2} = 2362.931 \text{ kip inch}}$$

moment due to given loads

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

$= 208.33 \ lb/ft$

Total factored load $= 1.2(1050 + 208.33) + 1.6(2470)$

$= 5461.996 \ lb/ft$ or $5.46 \ kips/ft$

ultimate factor moment $= \frac{wL^2}{8}$

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

$$\boxed{M_u = 2653.561}$$

Now

$Mu_2 < Mu$

Step # 04

$M_{u1} = 2653.56 - 2362.92$

$M_{u1} = 290.64$ kip-inch

Step #05

Steel area in Compression zone

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

$= \frac{290}{0.90 \times 60 \times (17 - 2.5)}$

$= 0.37 \ in^2$

Step #06

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

$= 3.06 + 0.37$

$= 3.43 \ in^2$

Step #07

We used #8 bars, (dia $8/8 = 1''$)

Total Area = $0.785\ in^2$

$$\text{No. of bars} = \frac{A_{st}}{A.\text{of bar}}$$

$$= \frac{3.43}{0.785} = 4.36 \cong 5 \text{ bars}$$

So 5 #8 bars. Tensile zone.

Compression Steel. use #6 bars.

dia $(6/8) = 0.75''$, Area $= 0.44 in^2$

$$\text{No. of bars} = \frac{A_{st}}{A.\text{of 1 bar}} \quad \frac{0.37}{0.44} = 0.84 \cong 1 \text{ bar}$$

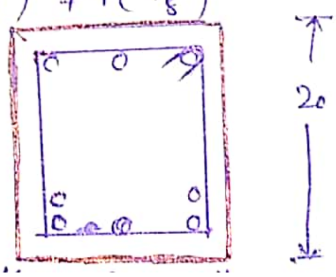
So 1 #6 bars in Compression zone.

Step #08: Beam minimum width

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

$b_{min} = 12.75 > 10''$

So in multiple layers.



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

$d_1 = 2.25''$

So Step # 07

Design moment is given :

$$M_d = \phi \times [A's_t \times f_y \times (d - d_1) + (A_{st} - A'_{st}) \times f_y \times (d - a/2)]$$

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

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

$$M_d = 0.90 \times [(1 \times 0.44) \times 60 \times (16.62 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60 (16.62 - 6.15/2)]$$

M_d = 2890.461 > 2653.56

So Design is ok.

Q No! 02:

Part (a) **Bond Stress :**

It is the result of bonding between concrate surface and the reinforcement surface. the stress acting at the interface of rebar and concrete that acts parallel to the bar. which is the result of

1- Adhesion between concrete and Reinforcement
2- friction between concrete and stell.

Development Length :-

The development length (LD) is the shortest length of bar, in which the bar stress can increase from 0 to the yield strenght.

If the distance from a point where the bar stress equall to the end of the bar is less than the development length. the bar will pull out from the concrete.

The develpment length in different in tension and compration.

(B) Conditions of doubly Reinforced beam :-

RCC beam which consist of reinforcement both in tension as well as compression zones.

Condition are, (1) when the size of the beam is Confined. ② When the Section of beam is Subjected to inversion stress

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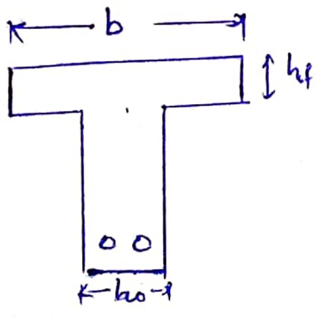
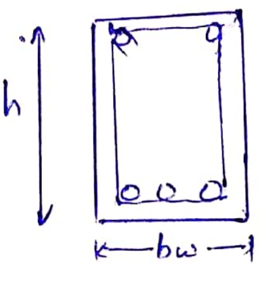
ⓒ <u>Differentiate b/w T-beam analysis and Rectangular beam analysis:</u>

Both beams have T shape but there analysis and design is quite different from one another.

In Case of T-beam, Slab and beam are Conected with one another and acts as one member



In Case of rectangular beam Slab has been placed on the Beam So that There is no connection slab and Beam



(D) Effect of Strength reduction factor in flexural strength :-

For the design of beam for flexural strength, Codes gives Strength reduction factor 0.9 for steel and 0.85 for concrete.

Now according to LRFD we dercease the Strength of Concrete to cope with meterial imperfection and reduction in dimension from actuall design dimension in field.

(E) Design Methods :-

Load and resistance factor design.

This method is base on the Principle the Strength resistance of various materials is scaled down by some factors while the applied loads are Scaled up by Same factors and there by The Structure elements are designed using reduced Strength and increase load The Strength of the material Consided for design is ultimate Strength which result in utilization of elastic, plastic and strain harding of material to give safe and econmocal.

Allowable Stress design :

This method is base on the Principle that Streses developed in Structural members should not exceed a contain friction of elastic limit. all loads are taken as Serivice loads and no factor is applied to increase these Service loads.

Reliability of Methods :

① LRFD

The method is generaly used for the design of beams and Colums or, When high Strength Reinforcing Steel and Concrete are used. LRFD is used because of introducing appropite choice of load factor . This method assign different load factors under combined loading condition . overcoming the shortcoming of WSM .

2- **ASD**

This Method is used not only for reinforce concrete but ~~f~~ structural steel and timber design . as This assume structural material behaves as a linear elastic manner and adeqate safty can be obtained by restricting the stresses in the material induced by the working loads on the structural .

Q No: 03

Given data

Total depth = 28"

web width = 14"

Slab Thickness = 6"

c/c distance = 10'

Span = 32'

Effective depth = 28" - 3" = 25"

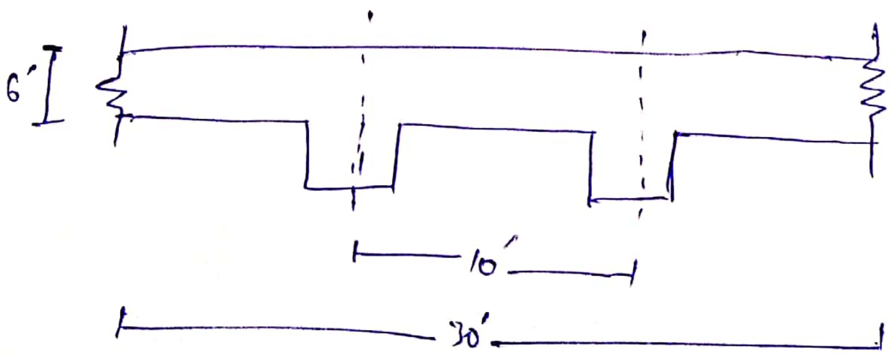
Dead load = 50 lb/ft²

Service live load = 225 lb/ft²

fy = 60000 psi

fc = 4000 psi

Solution:



Step #01

$$M_U = \frac{W_U \times L^2}{8}$$

The Beam 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

Total factor load :-

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

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

Step #02

moment

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

$\Rightarrow = 1396.23$ kip-inch

Effective Breath :

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 $b_e = 96''$

Step #03 (Rectangular or T-beam)

Trial #1 let $a = h_f = 6''$

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

$$= \frac{1396.23}{0.90 \times 60 \, (25 - 6/2)}$$

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

Trial #2

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

$$= \frac{1.17 \times 60}{0.85 \times 4 \times 96}$$

$0.2'' < 6''$

So Rectangular Beam is design

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

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

Trial # 3

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{1.03 \times 60}{0.85 \times 4 \times 96} = 0.18''$$

$$Ast = \frac{1396 \times 83}{0.80 \times 60\,(25 - 0.18/2)}$$

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

Step #04 Check ρ_{max} and ρ_{min}

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

$\rho_{max} = 0.018$

$\Rightarrow$ $\rho_{min} = \frac{200}{fy} = \frac{200}{60{,}000} = 0.003$

$\Rightarrow$ $\rho = \frac{Ast}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 < 0.018$

Needed As

ρ is less than ρ_{min}

So $\rho = \frac{Ast}{bxd} \Rightarrow Ast = \rho_{min} \times bxd$

$Ast = 0.003 \times 14 \times 25 = 1.05\ in^2$

Step #05

No. of bars Seclection

Let use #8 bar Then dia $= 8/8 = 1''$

Area is $0.785\ in^2$

No. of bars $= \frac{1.05}{0.785} = 1.3 \cong 2$

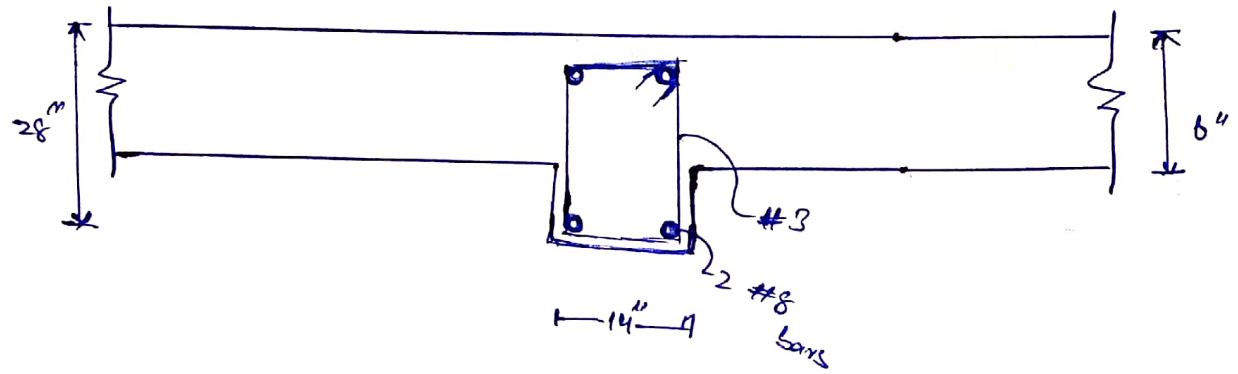
So we can use 2 #8 bars.

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 #07 Design moment

$md = \phi \times fy \times Ast \times (d - a/2)$

Area of Steel = Area of 1 bar × No of bars

0.785 × 2

area = $1.57\ in^2$

$Md = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2)$

$md = 2111.02$ kip - inch

As we have

2111.02 > 1396.23

So its design is ok.