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Section B

Subject PRC Design-I

Semester 6th

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QNo1:

Given Data:-

Width $b = 10''$
Height $h = 20''$
Live Load $= 2.47$ Kips/ft
Dead Load $= 1.05$ kips/ft
Span $= 18'$
$F_y = 60{,}000$ Psi ~~= 60 ksi~~

$f'_c = 4000$ Psi ~~= 4 ksi~~

Solution:-

Step # 1

Effective depth $(d) = h - 3$

$= 20-3 = 17''$

Effective Cover (d') $= 2.5''$

Reinforcement Ratio :-

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

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

$$\rho_{max} = 0.0180$$

Step # 2

Finding Area of steel

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

$$A_{st} = 0.0180 \times (10 \times 17) = 3.06\ in^2$$

Step # 3 :

By formula of design moment,

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

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

$$= \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

$$Mu_2 = 0.90 \times 3.06 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

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

Moment due to given Loads

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

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

Total Factored Load $= 1.2(1050 + 208.33) + 1.6(2470)$

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

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

Ultimate Factored Moment = $\frac{wl^2}{8}$

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

$M_u = 2653.56$

Now As,

$M_{u2} < M_u$

$2362.93 < 2653.56$

↓

Doubly reinforcement Required

Step #4

$M_{u1} = 2653.56 - 2362.93$

$= 290.64$ kip-inch

Step # 5

Steel Area in Compression Zone

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

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

$$= \frac{290.64}{0.90 \times 60 \times (17 - 2.5)}$$

$$= 0.37 \text{ in}^2$$

Step # 6

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

$$= 3.06 + 0.37 = 3.43 \text{ in}^2$$

Step # 7

We use # 8 bars , dia = $\frac{8}{8}$ = 1"

Area = 0.785 in²

No of bars = $\frac{Ast}{\text{Area of 1 bar}}$

= $\frac{3.43}{0.785}$ = 4.36

=> 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 in²

No of bars = $\frac{A_s't}{\text{Area of 1 bar}}$ = $\frac{0.37}{0.44}$

= 0.84

= 0.84 ≈ 1 bars

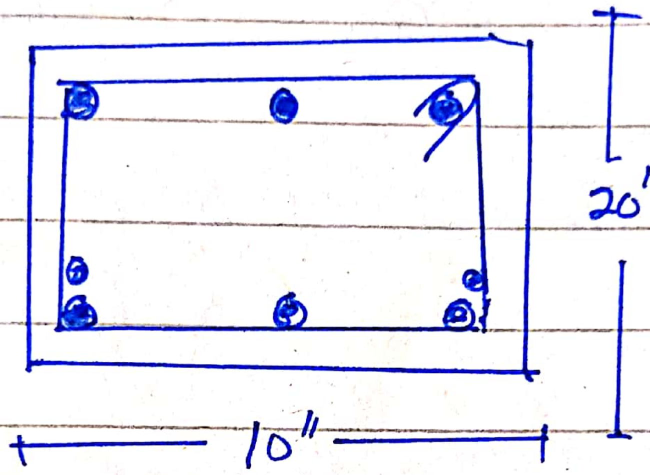
So 1 # 6 bars in → compression zone

Step #8

Beam minimum width

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

$= 12.75 > 10''$ in multiple Layers



Effective depth (d) $= 20 - 1.5 - \frac{3}{8} - \frac{8}{8}$

$- \frac{1}{2}\ \frac{8}{8}$

$d = 16.62''$

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,

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

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

$$= \frac{(5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 16}$$

$$= 6.15''$$

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

Ste

mi

$M_d = 2890.46$

$A's \; M_d = 2890.46 > 2653.56$

Design is ok

QNo2

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.

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 reinforced beam can be used?

Ans. Doubly reinforced sections are generally resorted to in situation where the cross sectional dimensions of the beam are restricted (By architectural or other considerations). Where singly reinforced section is not adequate the codes for designing a R.C beam are based on limit State method.

limit state consists of 2 types

1) Limit State of Serviceabilty :- This deals with deflections, cracking, bending etc under a given service loads.

2) Limit State Collapse :- The resistance to bending, shear, torsion and axial loads at any section shall not be less than the maximum

respective values produces by most unfavorable combination of loads (dead, live , wind, snow) on the structure using appropriate partial factor of safety.

Limit state method of design is more preferred as | area of cross section required is comparatively less than working stress design.

2) It considers uncertainity in loads as well as design strength of materials and takes factor of safety for both. Besides saying

in terms of moment-resisting Capacity.

Most important reason for providing the doubly reinforced beams is to ensure safety against reversal of stresses in the structure due to wind forces, Siesmic forces and temperature stresses.

c) Difference between T-beam analysis and rectangular beam analysis.

Ans Both beams have T shape but their analysis and design is quite different from one another. In case of T beam, Slab and beam are connected with one another and acts as a one member. In case of rectangular beam, slab has been placed on the beam so there is no connection b/w slab and beam.

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

Ans In the design of flexural strength, the strength reduction factors decreases from tension-controlled sections to compression

Contolled sections to increase safety with decreasing ductility. In the reliability-based design, the reliable prediction of flexural strength of reinforced concrete members is assured by the use of reduction factors corresponding to different target reliability index.

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

Ans **Design Methods:**

Design Methods are procedures, techniques, aids or tools for designing. The offer a numbers of different kind of activities that a designer might use within on overall design process. Conventional procedures of design, such as drawing can be regarded as design methods. but since the 1950s new procedures have been developed that are more usually grouped together under the name of design methods Design methodology is the broder

Study of method in design, the study of the principles, practices and procedures of designing.

There are 3 Method to design a R.C beam.

1) Limit State method

2) Working state method

3) Ultimate load Method.

Most extensively used method is limit state Method. All that three are some advantages of working stress method over limit state method. noticeably the reinforcement required is lesser in WSM than limit state for design of same/equal load carrying structure, but that would require more volume of concrete.

QNo3 :

Given Data :-

C/C distance = 10'
Span = 32'

Slab thickness = 6"
Web width = 14"
Total depth = 28"

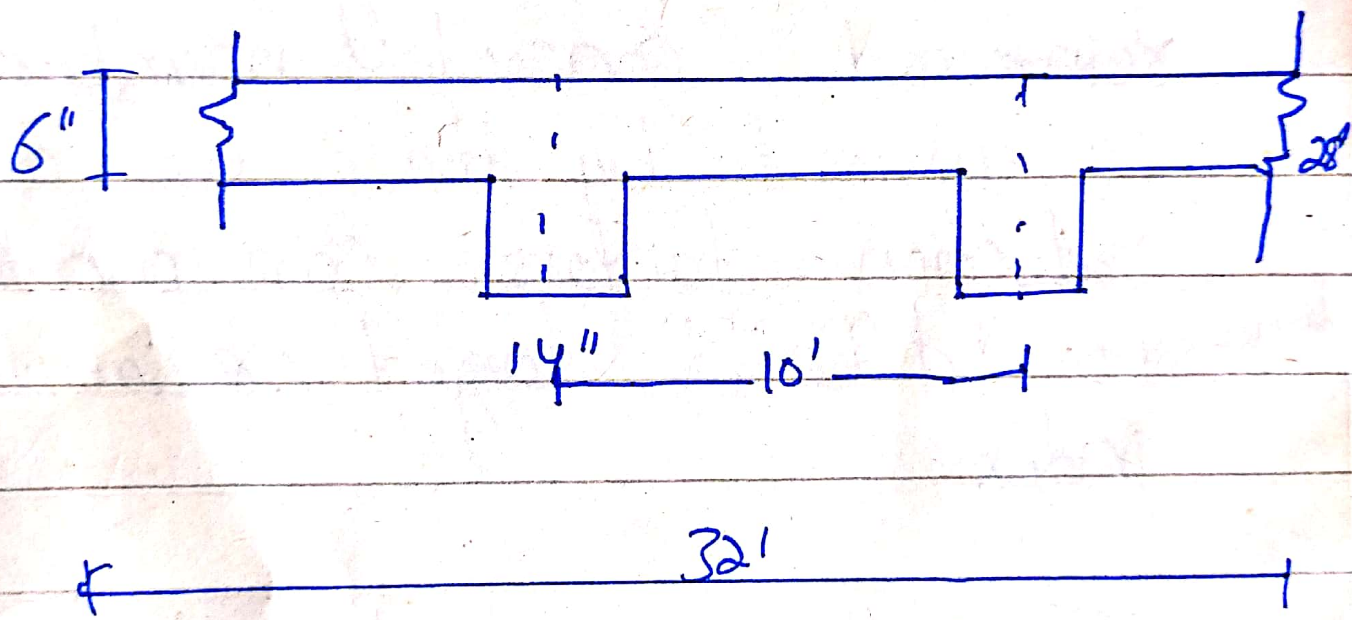
Effective depth = 28 - 3 = 25"

D.L = 50 lb/ft²

S.S = 225 lb/ft²

fy = 60,000 Psi
f'c = 4000 Psi

Solution:-



Step #1

$$MU = \frac{WU \times L^2}{8}$$

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 factored Load :-

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

$= 909.99$ lb/ft

$= 0.909$ kip/ft.

Moment

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

$= 1396.23$ kip inch

Effective Broadth :-

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

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 $a = h_f = 6''$

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

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

$Ast = 1.17\ in^2$

Trial # 2

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b}$$

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

$$= 0.2 < 8''$$

so rectangular Beam design

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

$$= 1.03\ in^2$$

Trial #3

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

$$A_{st} = \frac{1396.23}{0.90 \times 60 \left(25 - \frac{0.18}{2}\right)}$$

$$= 1.03 \ in^2$$

Step #4:-

Check ρ_{max} and ρ_{min}

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

$$\rho_{max} = 0.018$$

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

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

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

$$0.003 < 0.002 < 0.018$$

As

ρ is less than ρ_{min}

So,

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

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

Step#05

No and Selection of Bar

Let Use #8 bar, then

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

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

$$= 1.3 \approx 2$$

So use 2 #8 bars.

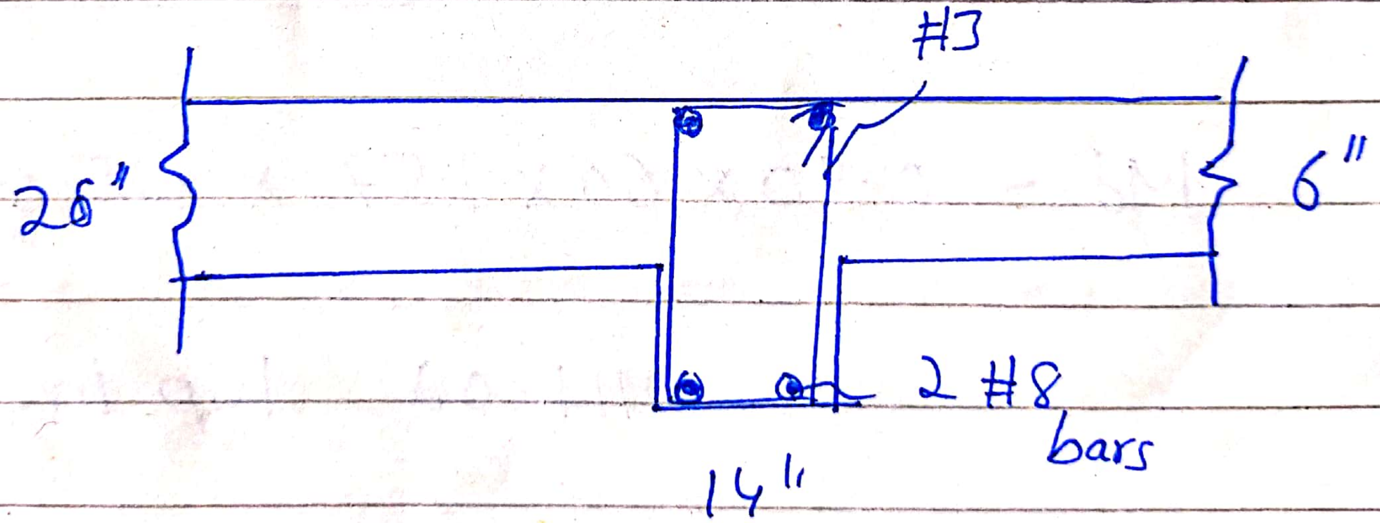
Step #6

Minimum Width

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

$$= 6.75'' < 14''$$

So good in one layer



Step #7:

Design moment

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

Area of steel = Area of 1 bar × No of bars.

$= 0.785 \times 2 = 1.57 \ in^2$

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

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

$= 2111.02$ Kip inch

As $2111.02 > 1396.23$

Design ok.