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Section A

PRCD - I

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ANS 1

Given data:

Live load (L.L) = 2.47 K/ft

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

width = 10"

Height = 20"

$f'c$ = 4000psi

= 4ksi

fy = 60,000 psi

= 60 ksi

span = 18'

Solution:

step 1:

Effective cover d_c = 2.5"

Effective depth d = h-3

= 20-3

= 17"

Reinforcement ratio:

$$\rho_{max} = 0.85 \times \beta \times \frac{F'c}{Fy}\left(\frac{\varepsilon u}{\varepsilon u + \varepsilon y}\right)$$

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

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

step 2:

For Area of steel

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

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

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

$$\boxed{Ast = 3.06 \ in^2}$$

step 3:-

Design moment formula

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

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

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

$a = 5.4''$

$$M_{U2} = 0.90 \times 3.06 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

$M_{U2} = 2362.93$ kin

Moment due to given load:

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

$= 208.33$ lb/ft

Total factored load =

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

$= 5461.99$ lb/ft

$= 5.46$ k/ft

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

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

$M_U = 2653.56$

As $M_{U2} < M_U$

$2362.92 < 2653.56$

So here doubly reinforcement is required.

Step 04:

$M_{U1} = 2653.56 - 2362.92$

$= 290.64$ kip-inch

Step 5:

In compression zone steel area will be

$M_{U1} = \phi \times A_{st} \times f_y \times (d - d')$

$$A_{st} = \frac{M_{U1}}{\phi \times f_y \times (d - d')}$$

$$= \frac{290.64}{0.9 \times 60 \times (17 - 2.5)}$$

$= 0.37 \text{ in}^2$

Step 6:

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

$$= 3.06 + 0.37$$

$$= 3.43 \text{ in}^2$$

Step 7:

Using #8 bar

(dia of #8 = 1")

Area = 0.785 in^2

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

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

$$\approx 5 \text{ bars}$$

So using 5 #8 bars for tensile zone.

compression steel:

using # 6 bar.

dia of # 6 bar = 0.75"

Area = 0.44 in^2

$$\text{No of bars} = \frac{A_{st}'}{\text{Area of bar}}$$

$$= \frac{0.37}{0.44} = 0.84$$

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

so 1 # 6 bar in compression zone

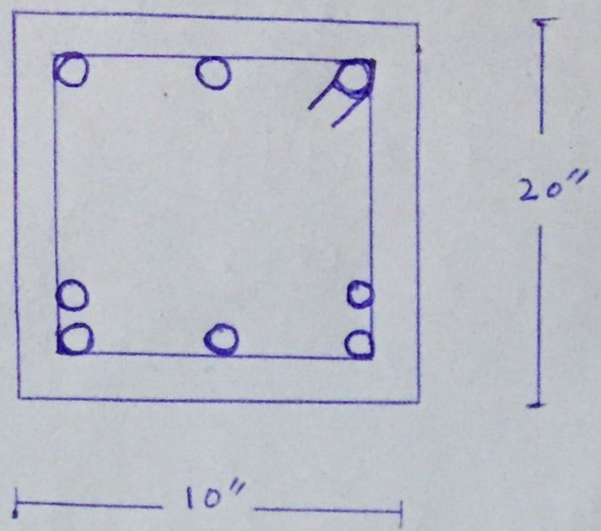
step 8:

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.



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

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

for $a = \frac{(Ast - Ast') \times fy}{0.85 \times f'c \times b}$

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

$= 6.15''$

$Md = 0.90 \times \left[(1 \times 0.44) \times 60 \times (16.82 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60 \times 16.62 - \frac{6.15}{2}\right]$

$Md = 2890.46$

$Md = 2890.46 > 2653.56$

Hence it is done.

<==>

Ans 2:

a) 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 & the type of reinforcement used.

*If plan rounded steel is used as reinforcement then the bond stress will be less,

*If same concrete is used with HYSD steel as reinforcement then the bond stress is higher.

Development Lenght:

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

b) The conditions in which doubly reinforced beam can be used are given below:

Conditions:

1) when the dimension of the beam are restricted due to any constraint like avalibility of head room, archetectural or space considerations and the moment of resistence of singly reinforced section is less than the external moment
2) when the load are eccentric
3) when the bam is subjected to accidental or sudden lateral loads.

4) In the case of continous beams or slab.

c) The main difference between a rectangular beam and a T-beam is reinforced concret is

* Design procedure
* Geometry
* Fluxural capacity

*In terms of geometry its very clear one is rectangular and the other is T. But here you should know that the T beam offers more moment of inertia.

* The fluxural capacity of T beam varies based on the sign of moment. The resistance of T-beam is higher for positive moment because the flange section would be in compression. But, for negative moment it yeilds the same strenght as an equivalent beam without the flange.

* The design procedure of T beams depend on the location of momen as the case of its fluxural strengh

$a > hf$ (T-beam analysis)

d) Effect of strenght reduction Factor on Fluxural strenght:

For Fluxural bending moment $\phi = 0 - 90°$, which means that the 90% strenght is being considered for the moment and the remaining 10% strenght will be used for future accidental moments.

ϕ = strenght reduction factor

It is the ratio of elastic strenght & yeild strenght.

E) Designing Methods:

There are two designing methods used for designing different concrete members.

1) Ultimate strenght Design (USD)

* When the structure is subjected to large external loads then the ultimate strenght is determined
* It is also known as ultimate load method.

There are some reasons due to which ultimate strengue design method is used.

* ASD better determines design for higher safty factor needs where a building is more prone to environmental pressure or must bear heavier loads that stress a

specific portion of a building.

* As the ultimate strenght of the material is considered we will get much slender sections for colums 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.

2) Allowable Stress Design: (ASD)

* In this method all loads are taken as service loads and no factor is applied to increase these service loads.
* It is also known as working stress design method.
* It is based on the principal that stresses developed in the structural

structure member should not exceed a certain limit of elastic limit.

Ans 3:

Given data:

Slab thickness = 6"

web width = 14"

Total depth = 28"

c/c distance = 10'

span 32'

Effective depth = 28-3

= 25"

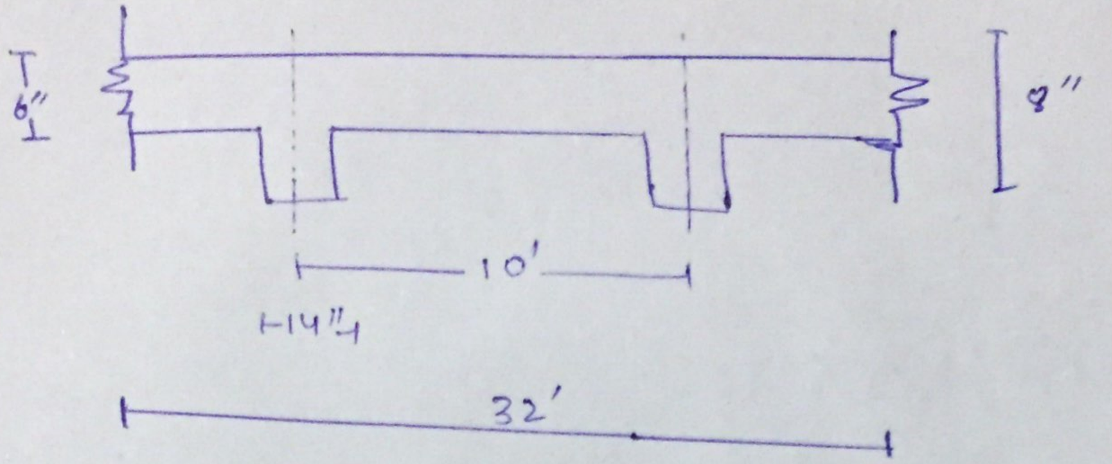
S. S = 225 lb/ft^2

Dead load = 50 lb/ft^2

f_y = 60,000 psi

$f'c$ = 4000psi

Solution:



Step 1:

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

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:

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

$$= 909.99 \ lb/ft$$

$$= 0.909 \ k/ft$$

Moment:

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

$$= 1396.23 \text{ kips-inch}$$

Effective breath:

1) $16(hf) + bw = 16(6) + 14$

$= 110''$

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

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

$b_e = 96''$

Step 3:

Rectangular or T-beam

Trial # 1

Let $a = hf = 6''$

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

$A_{st} = 1.017 \text{ in}^2$

Trial # 02

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

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

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

Rectangular beam design

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

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

Trial # 03:

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

$$= 0.18''$$

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

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

Step 4:

Check ρ_{max} & ρ_{min}

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

$$\rho_{max} = 0.018$$

$$\Rightarrow \rho_{min} = \frac{200}{f_y} = \frac{200}{60000} = 0.003$$

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

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

$$0.003 < 0.002 < 0.018$$

As

ρ is less than ρ_{min}

So,

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

$$A_{st} = 1.05 \text{ in}^2$$

Step 5:

Now number and selection of bars

Let we use # bar

dia = 1" , Area = 0.785 in^2

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

so we will use 2 # 8 bars

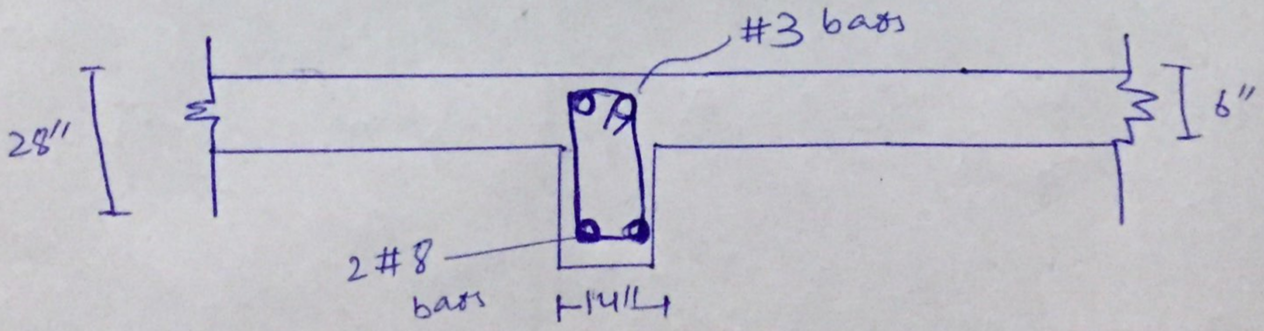
Step 6:

Minimum width

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

= 6.75" < 14"

so they are in one layer



Step 7:

Design moment

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

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

$= 0.785 \times 2$

$= 1.57 \text{ in}^2$

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

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

$= 2111.02 \text{ k-in}$

$2111.02 > 1396.23$

Hence design is ok.