PRC DESIGN-I (CE-325)

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QNo:1 A Rectangular Beam that carry a service live load of 2.47 Kips/ft and a calculated Dead load of 1.05 kips/ft (without Self wt) on an 18 ft simple span is limited to 10 inches width and 20 inches total depth for architectural reasons. If $f_y' = 60000$ psi & $f_c' = 4000$ psi. What steel area must be provided! Draw Sketch of your final Design.

Solution:.

Given Data:-

Service Live load = 2.47 Kips/ft
Service Dead load = 1.05 kips/ft

Span of Beam = 18 ft

Width of Beam = 10 inches

Depth or height of the Beam = 20 inches.

$f_c' = 4000$ psi or 4 ksi
$f_y' = 60000$ psi or 60 ksi

Step #01

$d = 20 - 3$

$d = 17''$

Assume $d' = 2.5''$

First we have to check the capacity of the Beam as Singly Reinforced Beam.

We know that,

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

Putting values,

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

$$\rho_{max} = 0.0181$$

Step #02.

Area of Steel.

We know that,

$$\rho_{max} = \frac{A_{st}}{b \times d} \quad \text{or} \quad A_{st} = \rho_{max} \times b \times d$$

Putting values.

$A_{st} = 0.0181 \times 10 \times 17$

$A_{st} = 3.077 \text{ inch}^2$

Step # 04

$$M_{u2} = \phi \times A_{st} \times f_y \times (d - a/2)$$

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b} = \frac{3.077 \times 60}{0.85 \times 4 \times 10}$$ $\boxed{a = 5.43\,inch}$

Now,

$$M_{u2} = \phi \times A_{st} \times f_y \times (d - a/2)$$

Putting values.

$$M_{u2} = 0.90 \times 3.077 \times 60 \times \left(17 - \frac{5.43}{2}\right)$$

$$\boxed{M_{u2} = 2373.56\ Kip/inch}$$

Step # 05

Self weight of Beam:- $\quad \gamma_c = 150\,lb/ft^3$

$$\text{Self wt} = b \times t \times \gamma_c$$

$$\text{Self wt} = \frac{10}{12} \times \frac{20}{12} \times 150$$

Self wt. of Beam = 208.33 lb/ft

or

" $\boxed{= 0.20\ Kip/ft}$

* Total factored load (wu):-

Factored load = 1.2 (D.L) + 1.6 (L.L)

Factored load = 1.2 (1.05 + 0.20) + 1.6 (2.47)

Factored load = 5.45 Kips/ft (wu)

Step # 06

Ultimate factored Moment

$$Mu = \frac{wu l^2}{8}$$

Putting values

$$Mu = \frac{5.45 \times (18)^2}{8} \times 12$$

$Mu = 2648.7$ kips / inch > 2373.56 kips/inch (Mu_2)

So, Design it as Doubly Reinforced Beam.

$Mu_2 < Mu$

Step #07.

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

Putting values.

$$M_{u1} = 2648.7 - 2373.56$$

$$M_{u1} = 275.14 \text{ kips/inch.}$$

Step # 08

we know that,

$$M_{u1} = \phi \times As' \times fy' \times (d - d')$$

$$M_{u1} = 0.90 \times As' \times fy' (d - d')$$

or.

$$Ast' = \frac{M_{u1}}{0.90 \times fy \times (d - d')}$$

Putting values.

$$A_s' = \frac{275.14}{0.90 \times 60 \times (17 - 2.5)}$$

$$\boxed{A_s' = 0.35 \text{ in}^2}$$

Step # 09

Total Steel Area.

we know that

$As = Ast + A's$

Putting values

$As = 3.08 + 0.35$

$\boxed{As = 3.43 \, in^2}$ (In Tensile Zone of Beam)

Step # 10. Selection of Bars.

i): For Tensile Steel:-

we Take #8 Bar

$Ab = 0.785 in^2$.

Now, $No. \text{ of Bars} = \frac{Ast}{Ab}$

Putting values.

$No. \text{ of Bar} = \frac{3.43}{0.785} = 4.36 \approx 5 \text{ Bars}$

Area of #8 Bar

$A = \frac{\pi}{4} d^2$.

$A = \frac{3.14}{4} (8/8)^2$

$A = 0.785 in^2$

ii): For Compression Steel:.

we Take #6 Bar

Now,

$No. \text{ of Bar} = \frac{As'}{Ab} = \frac{0.35}{0.44} = 0.79$ or $\approx$ 1 Bar

Area of #6 Bar:

$A = \pi/4 (d^2)$

$A = \frac{3.14}{4} \times (6/8)^2$

$\boxed{A = 0.44 in^2}$

Step # 11

Minimum Beam width (b_{min}):-

we know that,

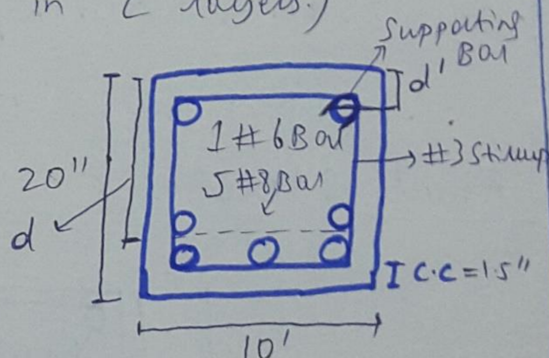
b_{min} = 2 x C.C + 2 x (dia of stirrup) + No. of Main bar) * (dia of main bar) + No of spaces between them) x (dia of main bar).

Putting values.

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

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

(Provide main bars in 2 layers.)



Step # 12 Actual Effective Depth

$d = 20 - 1.5 - 3/8 - 8/8 - 1/2(8/8)$

$d = 16.625''$ (Actual)

$d' = 1.5 + 3/8 + 1/2(6/8)$

$d' = 2.25$ (Actual)

C.C = 1.5

Step #13

Design Moment.

$M_d = \phi \times [A_s' \times f_y \times (d-d') + (A_s - A_s') \times f_y \times (d - a/2)]$

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

$\boxed{a = 6.15''}$

$M_d = \phi \times [A_s' \times f_y \times (d-d') + (A_s - A_s') \times f_y \times (d - a/2)$

Putting values.

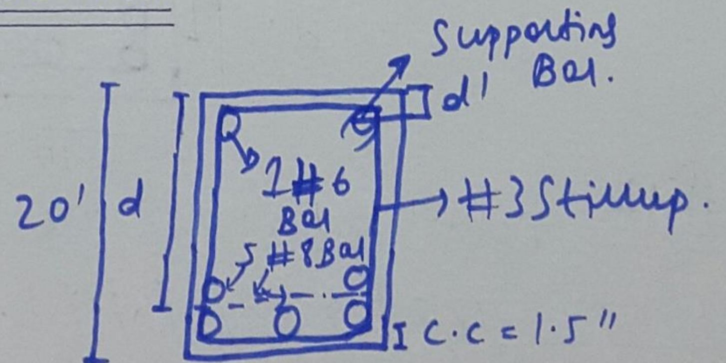
$M_d = 0.90 \times [(1 \times 0.441) \times 60 \times (16.625 - 2.25) +$

$(5 \times 0.785) - (1 \times 0.441) \times 60 \times (16.625 - \frac{6.15}{2})]$

$\boxed{M_d = 2891.52 \text{ kip/inch.}} > 2648.7 \text{ kip/inch}$ (M_u).

⟹ Design is OK!

Final Sketch:.



QNo:2): QNo:2): a): Briefly describe Bond stress and Development length?

Ans:

BOND STRESS:

It can be defined as the stresses which is acting on the outersurface of steel to the surrounding concrete which is called Bond stress.

OR.

It can be defined as the stresses which develop between concrete and steel bar which makes a bond.

→ It keeps the reinforcement bar and concrete together. It resists forces which tries to separate or pullout the steel bar from the concrete.

→ Different Concrete grades have different Bond Stress.

→ Nowadays different Chemical epoxy are used which create a strong bond between steel and concrete. that can resist big loads depending upon the situation.

• Development length :.

It can be defined as the specific length of the bar required for transfering the load into the concrete.

OR

In other words development length is the quantity of bar length that is required to be enclosed into the concrete to make the desired bond strength between two materials and furthermore the produced required stress in the steel at that area.

• Why we providing Development length :.

→ We provide development length because of creating a safe bond between steel bar and concrete. So that no failure occur due to slippage of bar when their is ultimate loading condition.

→ It is also provided for safe transfer of stresses from one section to the adjoining section. That's why development length is provided between different adjoining structures.

Qno2) (Part -b) In which condition doubly reinforcement beam can be used?

Ans:. **Doubly Reinforced Beam:.**

Doubly Reinforced Beams are one of the Beam which reinforcement is provided in both compression zone and tension zone.

***CONDITION:.**

It can used in those places where there are restriction on the depth of the beam because of architectural consideration or any other

For Example:-

If we have to provide a beam on which there is too much load which cannot be resisted on Single Reinforced beam. And we have restrictions on the size of beam. So, at that time we provide Doubly Reinforced beam. in which there is reinforcement in both compression and tension zone. And it resists big loads.

QNo:2):(Part - c) Differentiate between T-Beam Analysis and Rectangular Beam Analysis?

	Rectangular Beam	T-Beam.
1).	Rectangular Beam is less economical than T-Beam	T-Beams are more economical than Rectangular Beam.
2).	In case of Rectangular Beam slab has been placed on the beam so their no connection between slab and Beam.	In case of T-Beam slab and beam act as a one member as they are connected with one another.
4).	In this beam compression is in the top fiber and Tension zone in the bottom fiber	In this Beam, slab and beam has composite section.
5).	It can used more oftenly in the offices or commercial buildings they can be cast in sites. using Standard Reinforcement.	They can be used for heavy loads eg; bridges etc. They have longer span They are cast using pre ~~cast~~ stress Reinforcement.

QNo: 2) Part-d):. Write short note on the effect of Strength reduction factor on flexural Strength:

Ans:. **Effect of Strength Reduction Factor:.**

In the design of flexural strength, the strength reduction factor decrease from tension control section to compression controlled section to increase safety decrease ductility. It is a factor which is used in the design of different structures. eg: Beams, columns, slab etc.

QNo:.2 (Part-e):. Briefly describe design methods, Which one of them can be best used for different structures member and why?

* **Designing Methods:.**

Two methods are used widely for designing of concrete and different structure member.

1). USD Method.

2). ASD Method.

1). USD Method:-

Ultimate Strength Method is also known as load factor method, This is for the structures subjected to heavy external loads the ultimate strength is determine by the unelastic analysis.

It is the best method because of the following ways.
As in this method the Ultimate strength of the material is considered so, we get § much standard section for different structures as compare to the other method.
So, that why it is the best method for designing.

2) ASD Method:.

Allowable Stress Design Method or working stress design method. It is based on the principle that stresses develop in the structural members should not exceed a certain limit friction of elastic limit
In this method all loads are taken as service loads and no factor loads are considered to increase these service loads. And safe the structure.

Q.No:3):- **Given Data:-**

C/C Distance = 10 ft

Span of Beam = 32 ft (L)

Slab Thickness (h_f) = 6 inches

Height of Beam (h) = 28 inches

width of web = 14 inches (b_w).

Effective depth (d) = 28 − 3 = 25 inches.

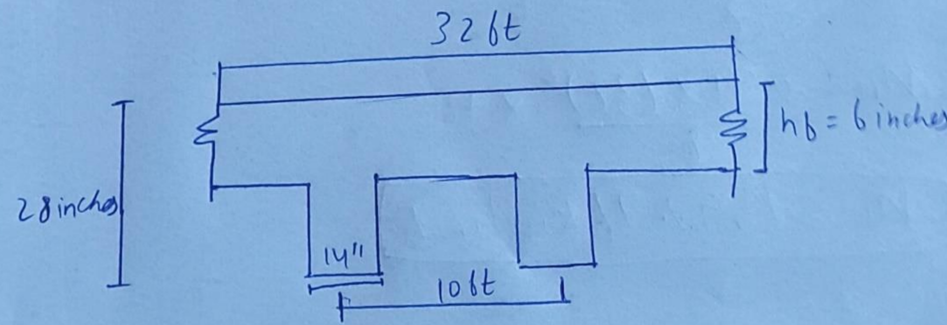
Dead load (D.L) = 50 psf
or
50 lb/ft^2.

Live load (L.L) = 225 psf
or
225 lb/ft^2

f_c' = 4000 psi
or
4 ksi

f_y = 60,000 psi or 60 ksi

Figure:-



Step #01

To find Self weight of Beam.

Self wt of Beam $= b_w \times h \times \gamma_c$ $\quad \gamma_c = 150\ lb/ft^3$

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

Self wt = 408.33 lb/ft

Now find Total Factored load:

$w_u = 1.2(D.L) + 1.6(L.L)$

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

$w_u = 909.99\ lb/ft$

or

$w_u = 0.91\ Kip/ft$

Step #02.

Ultimate Factored Moment.

$$M_u = \frac{w_u l^2}{8}$$

$$M_u = \frac{0.91 \times (32)^2}{8} \times 12$$

$M_u = 1397.76\ kip/inch$

Step # 03.

Calculate Effective width (be).

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

ii). C/C Distance $= 10 \times 12 = 120''$

iii). $\frac{Span}{4} = \frac{32}{4} \times 12 = 96''$

Taking the minimum value of be.

Select $\boxed{be. = 96''}$

Step # 04

Check whether T-Beam or Rectangular Beam.

Trial # 01

Assume $a = h_f = 6''$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1397.76}{0.90 \times 60 \times (28 - 6/2)}$$

$\boxed{A_{st} = 1.177\ in^2}$

Now, Trial # 02

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times be} = \frac{1.177}{0.85 \times 4 \times 96}$$

$a = 0.216\ in < h_f = 6''$

(Design it as Rectangular Beam)

$$A_{st} = \frac{1397.76}{0.90 \times 60 \times (25 - \frac{0.216}{2})}$$ $A_{st} = 1.04\ in^2$

Trial #03.

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96}$$ $a = 0.191\ in$

$$A_{st} = \frac{1397.76}{0.90 \times 60 \times (25 - \frac{0.191}{2})}$$ $A_{st} = 1.04\ in^2$

Step #05

Check ρ_{max} and ρ_{min}.

we know that,

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

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

$\rho_{max} = 0.018$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60,000} = 0.0033 = \rho_{min}$$

$$\rho = \frac{A_{st}}{b \times d} = \frac{1.04}{14 \times 25} = \rho = 0.0029$$

So Condition Not satisfied, which is

$\rho_{min} < \rho < \rho_{max}$ → (Not satisfied). Ok!

because, $\rho < \rho_{min}$

$\rho_{min} = \frac{A_{st}}{b \times d}$ or $A_{st} = \rho_{min} \times b \times d$.

$A_{st} = 0.0033 \times 14 \times 25$

$A_{st} = 1.155 \, in^2$

Step #06

Selection and No. of Bars.

No. of Bars $= \frac{A_{st}}{A_b}$ Choose #8 Bar $A = 0.785$

No. of Bars $= \frac{1.55}{0.785} = 1.47 \approx 2$ Bars (Main Bars)

Step # 07.

Minimum width (b_{min}).

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

$b_{min} = 6.75'' < 14''$ ok!

Step #08. Design Moment. (M_d)

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

$A_{st} = 0.785 \times 2 = A_{st} = 1.57 in^2$

$a = \frac{A_{st} \times f_y}{0.85 \times f_c \times b_e} = a = \frac{1.57 \times 60}{0.85 \times 4 \times 96}$ $a = 0.289 \, in$

Now,

$M_d = 0.90 \times 60 \times 1.57 \times (25 - \frac{0.289}{2})$

$M_d = 2160.2$ Kip/inch Answer $M_d > M_u$

→ Design is ok.

Final Sketch:-