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Subject Name :	PRC Design-I (CE-325)

Question No # 01

A Reatangular Beam that Must carry a service live load of 2.47 kips/ft and a calculated dead load of 1.05 kip/ft (without selfweight) on an 18-ft Simple span is limited to 10 inches width and 20 inches total depth for architectural reason if fy = 60000Psi and f'c = 4000 Psi. what steel area must be provide. Draw sketch of your final design.

Given Data:

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

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

Span of Beam = 18. ft

width of the Beam = 10"

depth of the Beam = 20"

f_y = 60000 Psi = 60ksi

f'_c = 4000 Psi = 4ksi

Solution :-

Step # 01

calculate the effective depth (d)

$h - 3 = 20 - 3 = 17''$

Step # 02

calculate the effective cover (d')

Assume $d' = 2.5''$

Step # 03

Reinforcment Ratio

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

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

$$\rho_{max} = 0.0180625$$

Step # 04

Calculate Area of steel:-

As we know that

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

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

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

$Ast = 0.0180625 \times 10 \times 17$

$Ast = 3.070625 \ in^2$

Step #05

By formula of Design Moment

$$Mu_2 = \phi \times Ast \times fy \times \left(d - \frac{a}{2}\right)$$

first find value of "a"

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

$$a = \frac{3.07 \times 60}{0.85 \times 4 \times 10} = 5.42''$$

$$Mu_2 = 0.90 \times 3.07 \times 60 \times \left(17 - \frac{5.42}{2}\right)$$

$Mu_2 = 2368.99$ kips - inch

Moment Due to given load:

Beam self weight = $b \times t \times \gamma_c$

$$= \frac{10}{12} \times \frac{20}{12} \times 50$$

$= 208.33 \ lb/ft^3$

Total Factored load :-

$W_T = 1.2\ D.L + 1.6\ L.L$

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

$= 5461.99\ lb/ft$

$= 5.46\ kips/ft$

Step = 06

Ultimate factored Moment :-

$$Mu = \frac{W \times L^2}{8} \times 12$$

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

$Mu = 2653.56$

As we have

$Mu > Mu_2$

$2653.56 > 2368.99$

=> Design of a section is Doubly Reinforcement.

Step = 07

To Find Mu_1 :-

$Mu_1 = Mu - Mu_2$

$Mu_1 = 2653.56 \cdot 2368.99$

$Mu_1 = 284.57$ Kip - inch.

Step # 08

As we know that

$$Mu_1 = \phi \times A_s' \times f_y \times (d-d')$$

$$A_s' = \frac{Mu_1}{\phi \times f_y \times (d-d')}$$

$$A_s' = \frac{284.57}{0.90 \times 60 \times (17-2.5)}$$

This is the steel Area in compression zone

Total steel Area :-

$$A_s = A_{st} + A_s' = 3.07 + 0.36$$

$$A_s = 3.43 \ in^2$$

Step # 09

selection of Bars.

(A) for Tensile steel :-

Let try # 8 bars having

$$Area = 0.785 \ in^2$$

$$\Rightarrow \text{Number of Bars} = \frac{A_s}{A_b} = \frac{3.43}{0.785}$$

$$= 4.369 \approx 5 \text{ bars}$$

So 5 # 8 bars.

(B) for compression steel :-

Let #6 bars having

$Area = 0.44 in^2$

$$\text{Number of Bar} = \frac{A_s'}{A_b} = \frac{0.36}{0.44}$$

$$= 0.81 \approx 1 \text{ bars}$$

So 1 #6 bars in compresion zone.

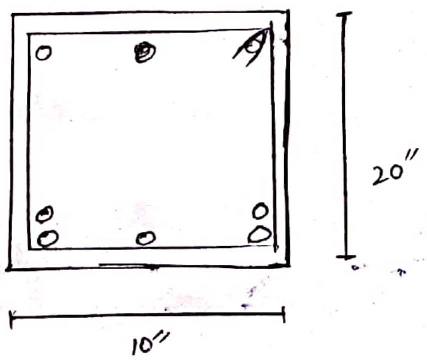
Step # 09 :

Check on Minimum Width of Beam :-

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

$$= 12.75'' > 10''$$

⇒ Not good in one layer



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

$$d = 16.62''$$

⇒ Effective cover (d') $= 1.5 + 3/8 + 1/2(8/8)$

$$d' = 2.25''$$

Step # 10

Design Moment :-

$$M_d = \phi \times [A_s' \times f_y \times (d-d') + (A_{st} - A_s't) \times f_y \times (d - a/2)]$$

As we know that

$$a = \frac{(A_{st} - A_s't) \times f_y}{0.85 \times f_c' \times b}$$

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

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

$$M_d = 2890.46$$

As $M_d = 2890.46 > 2653.56 \, k''$

So the design is OK.

(8)

Question No # 02
(a)

Briefly describe Bond stress and development length.

Bond Stress :-

The stress which is acting on the outer interface of steel to the sourrounding concrete is called bond stress. This stress helps in keeping bond between reinforc-ement and concrete together. Bond stress resists any force that tries to pull out the rods from the concrete.

when you try to pull out the reinforcement bar from hardened concrete, then this bond stress resists the bar to come out.

By the way different grade of concrete has different bond stress

well, these bonds are classified into two types.

1) Anchorage bond
2) flexular bond

Development Length :-

A development length can be defined as the amount of reinforcement (bar) length needed to embadded or projected into the column to establish the desired bond strength between the concrete and steel

Reason for Providing Development length.

- The develop a safe bond b/w the bar surface & the concrete so that no failure due to slippage of bar occurs during the ultimate load condition.
- Also. the extra length of the bar Provided a development length is responsible for transferring the stress developend in any section to theadjoining section (Such as a column beam Junction the extra length of bars Provided from to column)

b) In which conditions doubly reinforced beam can be used?

Ans:- Doubly reinforced beams are Provided because of the following reasons.

1) Doubly reinforced beam are provided in ordered to increase the moment carrying capacity of the section. we also know that we can increase the moment carrying capacity of beams by increasing its depth but it is not always Possible to increase the depth of beam because of Architectural and Aesthetic restriction.

2) Minimum compression reinforcement is Provided to hold the shear reinforcement in Position and for increasing the ductility of beam.

3) Most important reason for Providing the doubly reinforced beam is to ensure safety against reversal of stresses in the structure due to wind forces, Seismic force and temperature stresses.

c) Differentiate between T. beam analysis and rectangular beam analysis.

T- beam	Rectangular Beam.
It is more econimical	It is less economical
In case of T-beam slab and beam are connected with another and act is a one members	In case of rectangular beam slab has beam placed on the beam and there is no connection b/w slab and beam
It consist of T-shaped structured	It is used generally as compression in top fibre and tension in bottom fibre.
Analysis is required when a > hz	Analysis is required when a ≤ hz

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

Answer :-

In the design of flexural strength. the strength reduction factor φ decrease from tension - controlled sections to compression - control section to increase safety with decreasing ductility. In the reliability based design the reliable prediction of the flexural strength of reinforced concrete members is assured by the used of reduction factor corresponding to different target reliability index β.

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

Ans :-

There are three method of structural member design. which are the following.

1) working stress method.
2) Ultimate load Method.
3) Limit state method.

1) Working stress method :-

This method basically assumes that the structural material behaves as a linear elastic manner, and the adequate Safety can be ensured by suitably restricting the stress in the material induced by the expected working loads on structure.

2. Ultimate load Method :-

In this method, the stress condition at the site of impending collapse of the structure is analysis and the non-linear stress - strain curves of concrete and steel are made use of.

The Ultimate load method make it Possible for different types of loads to be assigned different load factors under combined loading conditions.

3. Limit State Method :-

The Philosphy of the limit state method of design represent a definite advancement over the traditional design Philosphies.

Question No 3:-

A concrete floor system consists of Parallel T beams spaced 10 ft. on centers and spanning 32 ft. between Supports. The 6-inch-thick slab is cast monolithically with T beam webs having width b_w = 14inches and total depth measured from the top of the slab of h= 28 inch. The effective depth will be taken 3-inches less than the total depth. In addition to its own weight, each beam must carry a superimposed D.L of 50 psf and service live load of 225 psf. Material strength are f_y= 60,000 psi and f_c = 4000 Psi. Determine the required tensile steel area and select the reinforcement needed for a typical member. Draw sketch of your final design.

Answer No # 3:

Given data :-

C/c distance = 10'

Span = 32'

h_f = 6" bw = 14" h = 28"

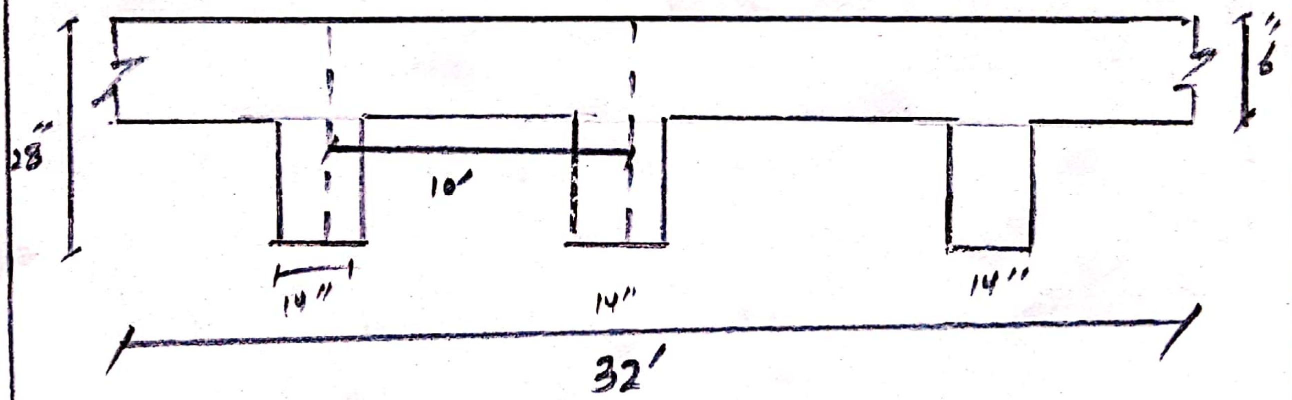
d = Effective depth = h − 3

= 28 − 3 = 25"

D.L = 50 lb/ft² L.L = 225 lb/ft²

Fy = 60000 psi = 60 ksi

F'c = 4000 psi = 4 ksi



Step # 01 :-

Ultimate factored moment

$$M_u = \frac{wL^2}{8}$$

(i) self weight of the beam.

wt = b × t × γc

$= \frac{14}{12} \times \frac{28}{12} \times 150$ ∵ PCC = 140 lb/ft
RCC = 150 lb/ft

$= 408.33$ lb/ft

ii) Total factored load.

$= 1.2\ D.L + 1.6\ L.L$

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

$= 909.99$ lb/ft $= 0.909$ k/ft

$Mu = 0.909 \times (32^2) = 116.352 \times 12$

$= 1396.224$ k/ft.

Step # 02 :-

Determine the effective width "be"

1- $16 \times hf + bw = 16 \times 16 + 14 = 110''$

2- C/c distance $= 10 \times 12 = 120''$

3- Span $14 = \frac{32}{4} \times 12 = 96''$

Select at least value of be i.e 96

Step # 03:

Check weather Rectangular or T-beam analysis is required

Trail # 1 ::

Let a $h_f = 6''$

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

$$= \frac{1396.244}{0.90 \times 60 \times \left(25 - \frac{6}{2}\right)}$$

$$= 1.175 \text{ in}^2$$

Trail # 2 ::

$$a = \frac{A_{st} \times F_y}{0.85 f'_c \times b_e}$$

$$= \frac{1.75 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.22'' < 6''$$

Thus Rectangular beam analysis is required

$$A_{st} = \frac{M_u}{\phi \times F_y \times \left(d - \frac{a}{2}\right)} = \frac{1396.244}{0.90 \times 60 \times \left(25 - \frac{0.2}{2}\right)}$$

$$= 1.04 \text{ in}^2$$

Traid # 03:.

$$a = \frac{1.04 \times 60}{0.85 \times 4 \times 96} = 0.19''$$

$$A_{st} = \frac{1396.244}{0.90 \times 60 \times \left(25 - \frac{0.19}{2}\right)}$$

$$= 1.04 in^2$$

Same area.

Step # 04:.

Check ρ_{max} and ρ_{min}

$$\rightarrow \rho_{max} = 0.85 \times \beta \times \frac{FC'}{FY} \times \left(\frac{\varepsilon u}{\varepsilon u + \varepsilon T}\right)$$

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

$$\rho_{max} = 0.018$$

$$\rho_{min} = \frac{200}{fy} = \frac{200}{60000} = 0.003$$

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

$$= 0.0029$$

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

$$0.003 < 0.002 < 0.018$$

As ρ is Less than ρ_{min} So

$$\rho = \frac{Ast}{b \times d} \quad \therefore \quad Ast = \rho_{min} \times b \times d$$

$$= 0.003 \times 14 \times 25$$

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

Step # 05 :-

Select No of bars.

using # 10 bar having Area 1.27 in^2

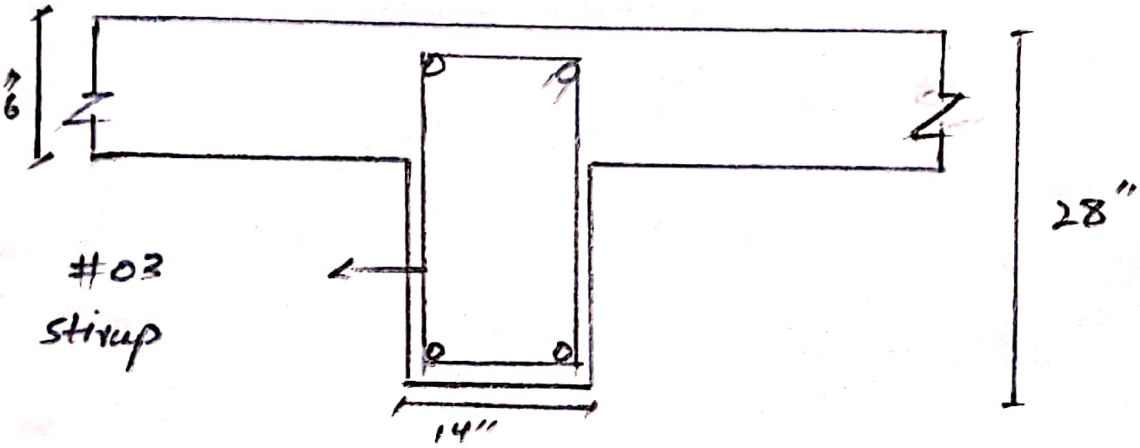
$$\text{No of bars} = \frac{Ast}{Ab} = \frac{1.05}{1.27} \approx 2 \text{ bars}$$

Step # 06 :-

Check on the minimum width.

$$b_{min} = (2 \times 1.5) + (2 \times 3/8) + 2\left(\frac{10}{8}\right) + \left(1 \times \frac{10}{8}\right)$$

$$= 7.5'' < 14''$$



Step # 07 Design Moment

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

→ $A_{st} = 1.27 \times 2 = 2.54 \text{ inch}^2$

→ $a = \dfrac{A_{st} \times F_y}{0.85 \times f'_c \times b_e} = \dfrac{2.54 \times 60}{0.85 \times 4 \times 96}$

$= 0.467''$

$$M_d = 0.90 \times 60 \times 2.54 \times \left(25 - \frac{0.467}{2}\right)$$

$\Rightarrow 3396.97$

$3396.97 > 1396.244$

Design is OK.