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Section

A

Semester

6th

Paper

Mid-term

Subject

PRC Design-I

Teacher

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QNo (a1)

A rectangular beam that must carry a service live load of 2.47 kips/ft and a calculated dead load of 1.05 kip/ft without self-weight) on an 18 ft simple span is limited to 10 inches width and 20 inches total depth for architectural reason. If f_y = 60000 psi and f_c = 4000 psi what steel area must be provided? Draw sketch of your final design.

Given data:

Live Load = 2.47 kips/ft

dead load = 1.05 kip/ft

Simple span = 18 ft

Width = 10 inches =

Total Depth = 20 inches =

f_y = 60000 psi = 60 ksi

f_c = 4000 psi = 4 ksi

Required:

What steel area must be provided?

Solution:-

Step 01

↳ Effective depth (d) = h − 3

$h = 20$

$20 - 3 = 17''$

↳ Effective cover (d') = 2.5''

↳ Reinforcement Ratio

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

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

$$\rho_{max} = 0.0180$$

Step 02:-

Now we find area of steel

Formula

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

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

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

$A_{st} = 3.06 in^2$

Step = 03

Now we find moment by formula

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

First we find "a"

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

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

$$a = 5.4''$$

Now we find moment

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

$$M_u = 2362.43 \text{ Kip-inch}$$

Moment due to loads:

(a) Beam of self weight

$$= \frac{10}{12} \times \frac{20}{12} \times 150$$

208.33 lb/ft

(b) Due to factored Load

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

= 5461.99 lb/ft

$\boxed{= 5.46 \text{ kip/ft}}$

(c) Ultimate factored moment:-

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

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

$\boxed{M_u = 2653.56}$

$M_u > M_{u_1}$

2653.56 > 2362.92

So we provid doubly Reinforcement

Step 04:-

$M_{u_2} = 2653.56 - 2362.92$

$M_{u_2} = 290.64$ kip-inch

Step 05 :-

Steel Area in compression zone will be given

$Mu = \phi \times Ast \times fy \times (d-d')$

$Ast = \frac{Mu}{\phi \times fy \times (d-d')}$

$Ast = \frac{390.64}{0.90 \times 60 (17-2.5)}$

$Ast = 0.37 in^2$

Step 06

$Ast = Ast + Ast$

$Ast = 3.06 + 0.37$

$Ast = 3.43 in^2$

Step 07

So we use the # 8 bars

$dia \left(\frac{8}{8}\right) = 1''$

$Area = \frac{\pi D^2}{4} = \frac{(3.14)(1)}{4} = \boxed{0.785 in^2}$

The No of bars which required

$= \frac{As}{\text{Area of the bar}}$

$= \frac{3.43}{0.785}$

$= 4.36 \approx 5$ bars

So 5 #8 bars we use in the Tensile zone

Compression zone

We use #8 bars

$\frac{8}{8} = 1$

$\frac{\pi D^2}{4} = \frac{(3.14)(1)^2}{4} = 0.785 in^2$

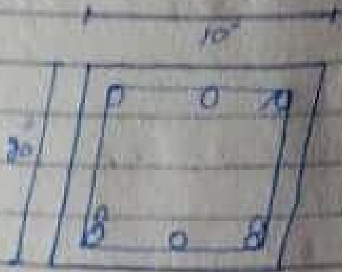
No of bars required

$= \frac{Asc}{\text{Area of one bar}}$

$= \frac{0.37}{0.785} = 0.471 \approx 1$

So 1 #8 bars in compression zone are using

Step # 8



Beam width

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

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

So we provide in the multiple layer because beam is 10"

Effective depth (d) $= 20 - 1.5 - \frac{3}{8} - \frac{8}{8} - \frac{1}{2}(\frac{8}{8})$

$d = 16.25''$

Effective cover (d') $= 1.5 + \frac{3}{8} + \frac{1}{2}(\frac{8}{8})$

$= 2.375$

Step 09 : Design moment

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

$$a = \frac{(Ast - Asc') \times fy}{0.85 \times fc' \times b}$$

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

$$\boxed{a = 6.15}$$

$Md = 0.90 \times [(1 \times 0.44) \times 60 \times (16.62 - 2.375) + (5 \times 0.785 -$

$1 \times 0.44) \times 60 \times (16.62 - \frac{6.15}{2})]$

$Md = 8931.39 > 2653.56$

$Md = 8931.39 > 2653.56$

The design is good and perfect

Q.No(2)
part (a)

Briefly describe Bond stress and Developement length.

Bond stress:-

The bond stress may be define as that the 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.

(OR)

The stress which acting on the outer interface of steel to the surrounding concrete is called bond stress.

Developement length:-

The developement length may be define as The Developement length is the length of bar required for transferring the stress into concrete.

(OR)

A development length can be defined as the amount of reinforcement (bar) or length needed to be embedded or projected into the column to establish the described bond strength between the concrete and steel (or any other two types of material)

QNo (3)
Part (b)

Q. In which condition doubly reinforced beam can be used?

Ans = Due to the following condition the doubly reinforced beam can be used.

The most important reason for providing the doubly reinforced beams is to ensure safety against reversel of stresses in the structure due to wind forces, seismic forces and temprature stresses.

(OR)

The Doubly reinforced concrete beams are used when functional requirements dicates that the beam needs to be small that that which can be accommodated using a singly reinforced concrete beam.

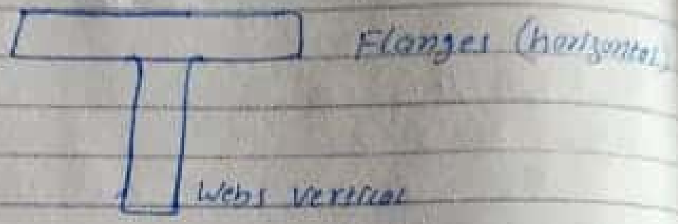
QNo (3)
Part (c)

Differentiate between T-beam analysis and rectangular beam analysis.

T-beam:- The T-beam used in construction is a load-bearing structure of reinforced concrete, wood or metal with a T-shaped cross-section.

The top of the T shaped cross section serves as a flange or compression member is resisting compressive stresses.

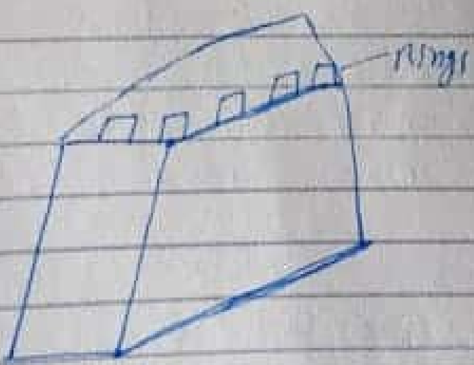
Shape:

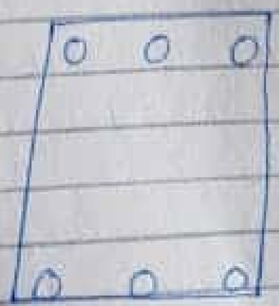


Rectangular beams:

The retangular beam may be define as that a beam which is generally used a compression in top fibre and tension in bottom fibre of that beam

Shape:





Rectangular beam

QNo (2)
part (d)

Write short note on the effect of strength reduction factor on flexural strength.
The following are the effect of strength reduction factor on flexural strength. The beams have a better reduction factor because they tend to have a more ductile failure. Assuming the beam is governed by the yielding of the steel there will be a fair amount of deformation before the beam loses all load supporting capacity. Columns and compression controlled beams tend to have much less ductile failure.

Example:
Crushing type failure in a column tends to happen relatively suddenly and with little warning.

OR

The reduction factors basically represent the uncertainty in determing the members behavior to the type of stresses to which it is subjected. As beam behavior is better understood than column hence the reduction factors are established accordingly.

Q no (3)
Part (e)

Briefly describe design methods which one of them can be best used for design of different structural member and why ?

Design methods:-
The Design methods are procedures or techniques, aid or tool for designing. They offer a number of different kinds and activities that a designer might use within an overall design process.

Best Structure member:-
There are three methods of structure design i.e. working stress, limit state and ultimate load method of structure design
The ultimate load method is best. This ultimate loads are obtained by increasing the working / service loads suitable by some factors. These factor which are multiplied by the working loads to obtain ultimate loads are called as load factors.

Q No(3)

A concrete floor system consist of parallel T beams spaced 10ft on centers and spanning 32ft between supports. The 6-inch thick slab is cast monolithically with T beam webs having width bw= 14-inch and total depth measured from the top of the slab 2 of h= 28 inches. The effective depth will be taken 3-inch less than the totel depth. In addition to its own weight, each beam must carry a superimposed DL of 50psf and service live load 225psf. Material strengths are fy = 60 000 psi and fc = 4000 psi. Determine the required tensile steel area and slect the reinforcement needed for a typical member. Draw sketch of your final design.

Given data =

↳ T beams spaced 10ft on centers

↳ Spanning 32 ft between support

↳ Slab thickness = 6 inch

↳ T beam webs having width bw= 14 inch

↳ Totel depth measured from the top of the slab h = 28 inch

↳ The effective depth will be taken 3-inch less than the total depth.

↳ superimposed DL = 50psf

↳ service live load = 225psf

↳ f_y = 60,000 psi = 60ksi

↳ f'_c = 4000 psi = 4ksi

<u>Required:-</u>

→ Tensile steel area ?

→ Select the reinforcement needed for a typical member.

<u>Solution:-</u>

The effective depth
= h - 3 = 28-3 = 25 inch

<u>Step=01</u>

First we find factored load

The self weight of the beam per foot.

Formula

$W_t = b \times h \times \gamma_c$

$W_t = \frac{14}{12} \times 150\,lb/ft^3 \times \frac{28}{12}$

$W_t = 408.33\ lb/ft$

We multiply 1.2 by DL and 1.6 by LL for total factored load

$W_u = 1.2 \times DL + 1.6\,LL$

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

$W_u = 909.996\ lb/ft$

Step (02)

Know the ultimate factored moment

Formula

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

for inch x 12

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

$M_u = 1397.76\ Kip\text{-}inch$

Step =03

The Effective Breadth

* 16(hf) + bw
  = 16(6) + 14 = 110"

* C/C distance = 10(12) = 138

* $\frac{Span}{4} = \frac{32 \times 12}{4} = 96"$

Step 04:-

Which type beam is

Trail # 01:-

Let a = hf = 6"

Formula

$$As = \frac{mu}{\phi \times fy \times (d - a/2)}$$

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

$$\boxed{As = 1.17 in^2}$$

Trail # 02

Know find "a"

Formula

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

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

$$= 0.2 < 6$$

The beam is rectangular

$$As = \frac{1397.76}{0.90 \times 60 \times (25 - \frac{0.216}{2})}$$

$$\boxed{Ast = 1.044 \text{ in}^2}$$

Trail #03:

$$a = \frac{1.044 \times 60}{0.85 \times 4 \times 96}$$

$$\boxed{a = 0.191 \text{ in}}$$

$$Ast = \frac{1397.76}{0.9 \times 60 (25 - \frac{0.191}{2})}$$

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

Step 05:

Now to find Smin and Smax

Formula

$$Smax = 0.85 \times \frac{\beta \times f'c}{fy} \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}\right)$$

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

$$\boxed{Smax = 0.0181}$$

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

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

We know that

$\boxed{\rho = \frac{Ast}{b \times d}}$

$\boxed{\rho = \frac{1.044}{14 \times 85}}$

$\boxed{\rho = 0.00997}$

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

Its not perfect

The $\rho > \rho_{min}$ is not satisfied

$\rho_{min} = \frac{Ast}{b \times d}$ cross multiply

$Ast = \rho_{min} \times b \times d$

$Ast = 0.0033 \times 25 \times 14 =$

$\boxed{Ast\ 1.155 in^2}$

Step 06

Now we select the No of bars and also the bar section

We use #8 bar

$8/8 = 1'' = \frac{\pi D^2}{4} = \boxed{0.785 in^2}$

Now No of bars $= \frac{Ase}{Ab} = \frac{1.155}{0.785}$

No of bars = 1.47 ≅ 2

So we select #8 and 2 bars

Step 07:-

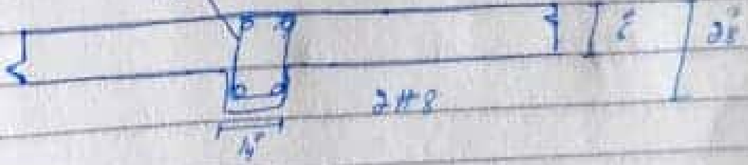
The minimum width (bmin)

bmin = 2 x c.c + 2 x stirrup + 2 x max bars + (1 x (8/8))

bmin = 2(1.5) + 2(3/8) + 2(8/8) + 1 (8/8)

bmin = 14'' > 6.75''

So we provide it in one layer



Step 08 :-

Design moment

Formula

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

$Md = 0.9 \times 60 \times 1.57 \times (25 - a/2)$ → ①

Now first we find "a"

$A_{st} = 0.785 \times 2$

$A_{st} = 1.57 in^2$

$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_e}$

"a" = 0.289 in   Now put in eq ①

$Md = 0.9 \times 60 \times 1.57 \times (25 - \frac{0.289}{2})$

$Md = 2160.94$

$Mu < Md$

The design is ok