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Section A

Semester 6th

Subject PRCI

QNo : 1

Given Data:-

Height = h = 20"
Width = b = 10"
Live Load = L.L = 2.47 kips/ft
Dead load = D.L = 1.05 kips/ft
f'_c = 4000 psi = 4 ksi
f_y = 60,000 psi = 60 ksi
Span = 18'

Sol:-

Step 1

Effective depth = d = h − 3
= 20 − 3
= 17"

Now
Effective cover = d' = 2.5"

Reinforcement Ratio:-

$$\rho_{max} = 0.85 \times B \times \frac{f'_c}{f_y} \times ($$

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

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

Step 2

Area of steel

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

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

$A_{st} = 3.06 in^2$

Step 3

Using formula of design moment

$M_{u2} = \emptyset \times A_{st} \times f_y \times (d - a/2) \rightarrow eq\ A$

Now

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

Putting values

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

$a = 5.4''$

Put values in eq A

$M_{u2} = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$

$= 2362.93$ kp-inch

Moment due to given Loads

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

$= 208.33$ Lb/ft

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

$= 5461.99$ Lb/ft

$= 5.46$ kips/ft.

Ultimate Factored Moment

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

$M_u = 2653.56$

As we know

$M_{u2} < M_u$

$2362.92 < 2653.56$.

As M_{u2} is less than M_u so doubly Reinforcement is required.

Step 4

$M_{u1} = 2653.56 - 2362.92$.

$\doteq 290.64$ kip-inch.

Step 5

Finding Steel area in compression zone.

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

$$A_{st} = \frac{M_{u1}}{\emptyset \times f_y \times (d - d_1)}$$

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

$= 0.37 in^2$

Step 6

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

$= 3.06 + 0.37$

$= 3.43 in^2$

Step 7

We will use #8 bar whose dia = 1" & Area = $0.785 in^2$

Now finding numbers of bars

$$\text{No of bars} = \frac{A_{st}}{\text{Area of 1 bar}}.$$

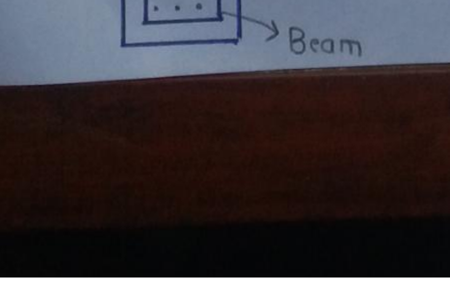
Q2(b) In which condition doubly reinforced beam can be used?

Doubly reinforced beam are used when the dimension of the beam are restricted for architectural or stuctural purpose.
Doubly reinforced beam are provided when we want to increase the moment carrying capacity of section We can also increase the moment carrying capacity of beam by increasing its depth but it is not always possible to increase the depth of beam because of architectural restrictions.

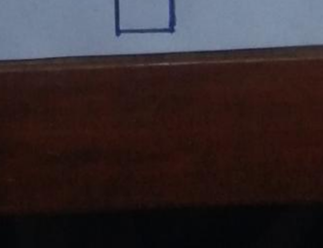
Q2(c) Differentiate b/w T-beam analysis and rectangular beam analysis?

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 act as a single member.
In case of rectangular beam, slab has been placed on beam so there is no connection between slab and beam. and T beam offer more moment of inertia.
T beam is also called mono lithic joint.

T Beam



Rectangular beam.



Q2 (d)

Write a short note on effect of strength reduction factor on flexural strength.

i) Strength reduction factor help to absorb the effect due to change in material strength.

ii) Possible inaccuracies in strength equation.

iii) Good level of safety of reinforced concrete structure is ensured.

iv) Because of strength reduction factor it is possible to cope with variation in dimension i-e structure remains same.

Trial 3

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

$= 0.18''$

$A_{st} = \frac{1396.23}{0.90 \times 60 (25 - 0.18/2)} = 1.03 \text{ in}^2.$

Step 4

Check ρ_{min} & ρ_{max}

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

$= 0.018$

$\rho_{min} = \frac{200}{f_y} = \frac{200}{60,000} = 0.03$

$\rho = \frac{A_{st}}{b \times d} = \frac{1.03}{14 \times 25} = 0.0089.$

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

$0.003 < 0.002 < 0.018.$

As ρ is less than ρ_{min}

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

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

Step 5

Selection and number of bar.

We use #8 bar

dia $= (8/8) = 1''$ area $= 0.785 \text{ in}^2$

No of bar $= \frac{1.05}{0.785} = 1.3 \simeq 2$

We use 2 #8 bars.

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

$= 0.84 \simeq 1$ bar.

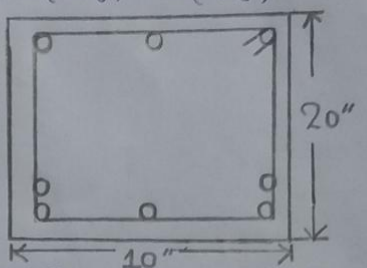
So 1 #6 bars in compression zone.

Step 8 :-

Finding Minimum Width of Beam

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

$= 12.75 > 10''$



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

$d = 16.62''$

Effective cover $(d') = 1.5 + 3/8 + 1/2\,(6/8)$

$= 2.25''$

Step 9

Design Moment (Md):-

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

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

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

$= 6.15''$

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

$$M_d = 2890.46 > 2653.56$$

As $M_d > M_u$ so design is Ok.

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Q2

(a) Briefly describe bond stress and development length.

Bond stress:-

Bond stress is defined as "The force of adhesion per unit area of contact between two bounded surfaces, such as between concrete and steel reinforcing bar.

Bond stress is shear stress at the surface of reinforcing bar which prevent movement between bar and surrounding concrete.

Bond stress resist any force that tries to pull out rods from concrete.

Development Length:-

Development length is defined as " The minimum length of a steel rod that is inserted inside concrete column, to ensure sufficient adhesion force between concrete and steel.

The beam will come out of concrete column, if development length is not provided at time of construction.

Development length creates a safe bond between bar surface and concrete it also ensures during ultimate load conditions the reinforcement bar should not sleep through the complete it transfer stress from beam to column.

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

Design method:-

Design method are procedure, techniques and aid for designing. They offer a number of different kinds of activities that a designer might use with an overall design process.

Some of design method are given as.

Simple Design:-

This is most commonly used design method.

It is used where end connections of the member in a structure do not develop restraint moment that would affect the structure.

· Semi rigid Design Method

It permits a reduction in maximum bending moment in beam suitably connected to their support as compared to simple design.

In cases where this method of designed is employed, it is ensured that assumed partial fixity is available and calculation based on general or particular experimental evidence shall be made to show that stress in any part of structure are not in excess.

· Plastic Design Method:-

It is a recently developed method of design but even today there are many difficulties and problem using this method.

Q3

Given Data

Span = 32'

distance = 10'

Web width = 14"

Slab thickness = 6"

Total depth (h) = 28"

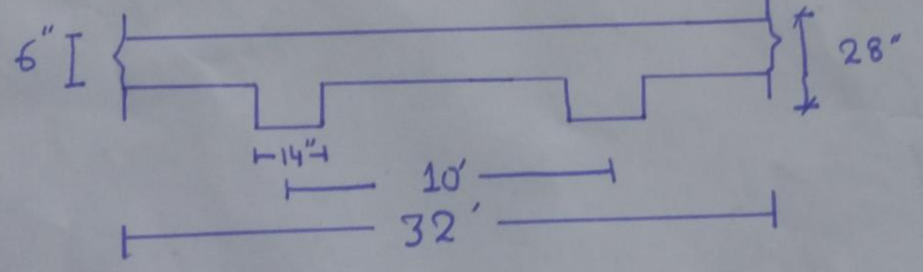
Effective depth = 28" - 3" = 25"

S.S = 225 lb/ft²

D.L = 50 lb/ft²

fc = 4000psi

fy = 60,000psi



Step 1

1. Beam self weight per feet

$Wt = t \times b \times \gamma_c$

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

$= 408.33 \text{ lb/ft}$

Total Factored Load :-

1.2 (50 + 408.33) + 1.6(225)

= 909.99 lb/ft = 0.909 kip/ft

Now Moment

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

= 1396.23 kips-inch.

Effective Breath.

16(6) + 14 = 110"

C/C distance = 10(12) = 120"

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

be = 96"

Step 3

Trial 1

Let a = hf = 6"

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

= 1.17 in²

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" < 6"

So rectangular Beam design.

Ast = 1396.23 / 0.90 × 60 × (25 − 0.2/2)

= 1.03 in²

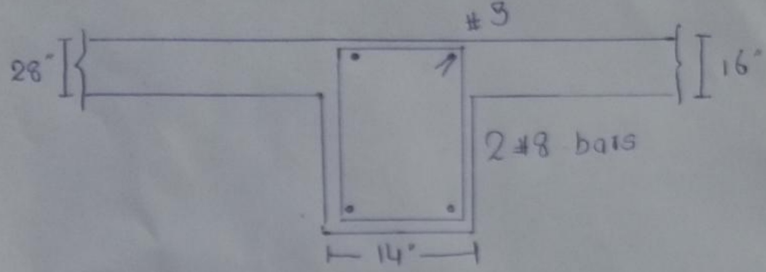
Step 6

Minimum width.

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

$= 6.75'' < 14''$

Good in one layer.



Step :- 7

Design moment

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

Area of steel $= 0.785 \times 2 = 1.57 in^2$

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

$= 0.2''$

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

$= 2111.02$ kip-inch

As

$2111.02 > 1396.23$

Design is OK.