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|---|---|
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| ID | 7802 |
| SECTION | " A " |
| SEMESTER | 6th |
| SUBJECT: | PRC DESIGN-1 |
| INSTRUCTOR: | Engr. FAWAD KHAN |
| EXAM: | MID TERM (ONLINE) |

# QUESTION: 01

## SOLUTION:

### Given Data:

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

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

Height (h) = 20"

Width (b) = 10"

Simple Span = 18 f

$f_y$ = 60000 psi

$f'_c$ = 4000 psi

### Required:

Steel area = ?

## Solution:

Step # 01

As we know, Effective depth = (d) = h - 3

Now according to given data h = 20

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So Effective depth $= h - 3$ $(h = 20)$

$= 20 - 3$

$d = 17''$

Effective cover $= 2.5''$

⇒ Reinforcement Ratio:-

As we know by formula

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

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

$$\rho_{max} = 0.0180$$

Step # 02

Now Finding Area of steel

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

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

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

$$\Rightarrow Ast = 3.06 \text{ sq. inches.}$$

Step # 03

According to the formula of design Moment

$$M_{U_2} = \phi \times Ast \times fy \times (d - a/2)$$

~~putting values~~

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

Now putting values

$$M_{U_2} = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$M_{U_2} = 2362.93 \text{ Kip. inch.}$$

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Moment due to given loads.

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

$= 5.46$ Kips/ft.

Now Ultimate Factored Moment = $\frac{wl^2}{8}$

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

$M_u = 2653.56$

Now we also know

$M_{u_2} < M_u$

$2362.92 < 2653.56$

↳ Doubly reinforcement is required.

## Step # 04

$M_{u_1} = 2653.56 - 2362.92$

$= 290.64$ Kip-inch

## Step # 05

Now steel area in compression zone can be calculated as

$M_{u_1} = \phi \times A'st \times f_y (d - d')$

Now ⇒ $Ast' = \frac{M_u'}{\phi \times f_y \times (d - d')}$

$Ast' = \frac{290.64}{0.90 \times 60 \times (17 - 2.5)} = 0.37$ sq. inch

Step # 06

As we know

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

$= 3.06 + 0.37$

So $A_s = 3.43$ sq.inch

Step # 07

We use # 8 bars (Dia = 8/8 = 1")

We have area = 0.785 sq.inch

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

$= \frac{3.43}{0.785} = 4.36 \approx 5$ Bars.

So 05 # 8 bars are required

↳ for tensile zone

→ Compression Steel:-

Use # 6 bars (Dia = 6/8 = 0.75")

We have area = 0.44 sq. inch

No. of Bars = $\frac{A_{st}'}{\text{Area of 1 bar}} = \frac{0.37}{0.44} = 0.84$

⇒ $0.84 \approx 1$ bar

So 01 # 6 bar in compression zone will be required.

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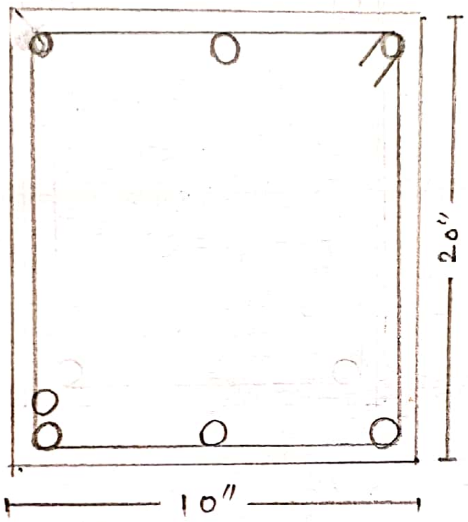
Step # 08

Now we know from formula

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

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

↓ in Multiple layers




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

$d = 16.62''$

→ Effective Cover $= d' = 1.5 + 3/8 + \frac{1}{2}(6/8)$

$= 2.25''$

Step # 09

Now we know that design movement is given by.

$Md = \phi \times [Ast' \times fy \times (d - d') + (Ast - Ast') \times fy \times (d - a/2)]$

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

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

$a = 6.15''$

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

$$M_d = 2890.46$$

As $M_d = 2890.46 > 2653.56$

So the design is OK.

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# QUESTION : 02

## PART: (a)

**BOND STRESS:-** " The force of adhesion per unit area of the contact b/w two surfaces, that are bounded, such as concrete and steel reinforcing bar, is called bond stress."

(OR)

" It is result of Bonding b/w concrete surface and reinforcement steel."

- → It's value depend upon type of concrete and type of reinforcement.
- → Bond stress prevent the movement b/w bar and surrounding concrete.
- → It's value can be calculated as normal force divided by surface area of rebar embedded in concrete.

**DEVELOPMENT LENGTH:-** Development length can be defined as" amount of reinforcement (bar) length needed to be embedded or projected into column to establish the desired bond strength and adhesion between concrete and steel (or any other two types of material).

- → Development length creates a safe bond b/w bar surface and concrete
- → The beam will come out of concrete if development length is not provided

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## PART: (b)

**DOUBLY REINFORCED BEAM:** "Beam that has tensile as well as compressive reinforcement is called doubly reinforced beam.

**USES:**

The three important conditions where doubly reinforced beams are used include

(1) Sections subjected to reversal of bending Moment (piles, braces in water towers)

(2) When dimensions of beam are restricted for architectural and structural purpose.

(3) The portion of beam over middle support in continuous T-beam has to be designed as doubly reinforced beam.

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**PART: C** The main difference between a rectangular beam and T- beam is in
(1) Geometry
(2) Flexural capacity
(3) Design procedure

| T- Beam Analysis | Rectangular Beam Analysis |
|---|---|
| 1. GEOMETRY<br>it has 'T' shaped geometry and it offers more moment of inertia | 1. GEOMETRY<br>It has a rectangular geometry. |
| 2. Flexural Capacity<br>It varries based on sign of moment (+ve or -ve). Resistance of T-beam is higher for +ve moment because flange section would be in compression. But for -ve moment it yields same strength as an equivalent beam without flange. | 2. Flexural Capacity:<br>It only depends upon location of reinforcement to yield flexural capacity. |
| 3. DESIGN PROCEDURE<br>It depends upon location of moment as the case of its Flexural strength. For +ve moment we have 3 cases to be checked to proceed with design one of the neutral axis within the flange two neutral axis out of flange or in web. and three doubly reinforced T- beam | 3. DESIGN PROCEDURE<br>It is done by selecting depth and width of beam and then compute reinforcement area. Secondly, assume reinforcement area then calculate cross-sectional sizes. |

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## PART: D

The effect of strength reduction factors are

(1) Due to role of strength reduction factors it is possible to deal and cope with variations in dimension i.e structure remain safe

(2) It helps to absorb effects due to change in material strength.

(3) It ensures good level of safety of reinforced concrete structures

(4) possible inaccuracies in strength Equation

## PART: E

**DESIGN METHOD:** Design Method include the techniques, procedures, processes and aid for designing.

Design Method offer a number of techniques and activities that a designer might use with design process.

Some of design methods are

**SIMPLE DESIGN:-** This method is most commonly used method

This method is used in conditions where end connections of member in a structure do not develop restraint

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restraint moment that would possibly affect the structure.

**SEMI-REGID DESIGN METHOD:** This method allows reduction in maximum bending moment in beam which is suitably connected to their support as compared to simple design.

When this method of design is employed it is to be made sure 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.

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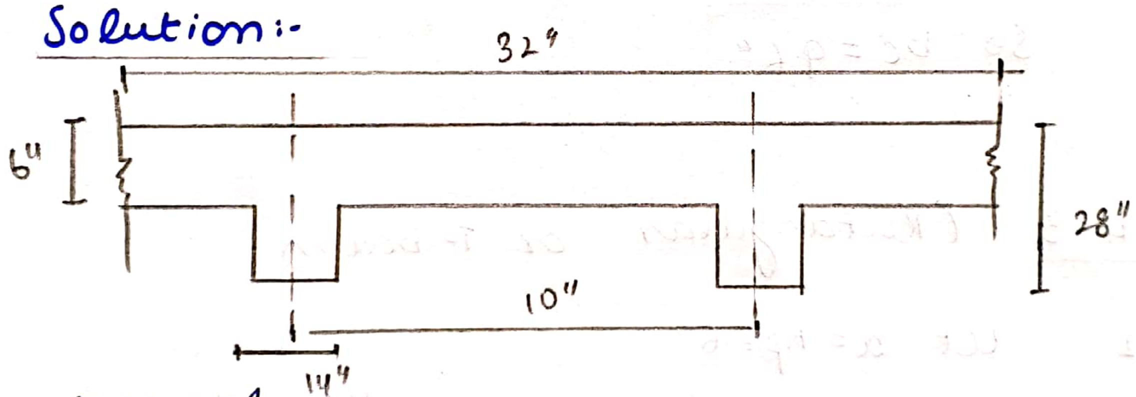
# QUESTION : 03

## Given Data:-

c/c distance = 10 feet.
Span = 32 feet
Slab Thickness = 6"
Web Width = 14"
Total depth (h) = 28"
Effective Depth = (28" − 3") = 25"
D.L = 50 $lb/ft^2$
S.S = 225 $lb/ft^2$
$f_y$ = 60,000 psi
$f'_c$ = 4000 psi.

## Solution:-




**Step # 01** Since we know;

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

Beam self weight per feet

$$W_t = b \times t \times \gamma_c$$

$$W_t = \frac{14}{12} \times \frac{28}{12} \times 150 = 408.33 \ lb/ft.$$

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→ Total factored load Step # 02.

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

$= 909.99$ lb/ft $= 0.909$ Kip/ft

→ Moment: Now as we have

$\frac{wl^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12 = 1396.23$ Kips.

→ Effective breadth: We have

(1) $16(h_f) + b_w = 16(6) + 14 = 110''$

(2) C/C Distance $= 10(12) = 120''$

(3) Span/4 $= \frac{32}{4} \times 12 = 96''$.

So $b_e = 96''$.

Step #03 (Rectangular or T-beam)

Trial # 01 Let $a = h_f = 6''$

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

$A_{st} = 1.17$ sq.inch.

Trial # 02 We know

$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{01.17 \times 60}{0.85 \times 4 \times 96}$

So rectangular beam design

$A_{st} = \frac{1396.23}{0.90 \times 60 \times (25 - 0.2/2)}$

$A_{st} = 1.03$ sq.inch.

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**Trial #03**

We have

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96} = 0.18''$$

We also know

$$A_{st} = \frac{1396.23}{0.90 \times 60(25 - 0.2/2)} = 1.03 \text{ sq.inch}$$

**Step # 04** we have to check $\rho_{max}$ and $\rho_{min}$

We have

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

$$\rho_{max} = 0.018$$

We also have

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60{,}000} = 0.003$$

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

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

$$0.003 < 0.002 < 0.018$$

As we know $\rho$ is less than $\rho_{min}$

So

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

$$A_{st} = 0.003 \times 14 \times 25 = 105 \text{ sq.inch.}$$

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**Step # 05** No and Selection of Bars

let's use # 8 bar, then

dia = 8/8 = 1" , Area = 0.785 sq.inch

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

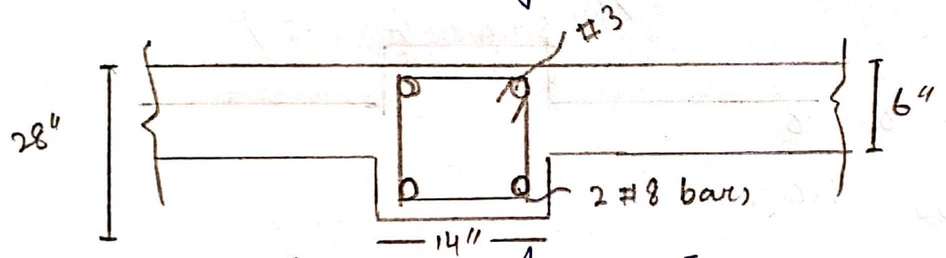
So we use 02 # 8 bars.

**Step # 06** Minimum Width

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

= 6.75" < 14"

So the good one in one layer




**Step # 07** Design Moment

Md = φ × fy × Ast × (d − a/2)

Area of steel = Area of 1 bar × No. of Bars

= 0.785 × 2 = 1.57 sq inch

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

⇒ Md = 0.90 × 60 × 1.57 × (25 − 0.2/2)

= 2111.02 > 1396.23

So this means design is accurate.