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| SECTION | A |
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| PROGRAM | CIVIL ENGG |

# Q.No 1

A rectangular beam that must carry a service live load of 2.47 kips/ft & a calculated dead load of 1.05 kips/ft. (without self-weight) on an 18-ft. simple span is limited to 10 inches width & 20 inches total depth for architectural reasons. If fy = 60,000 psi & fc = 4,000 psi. what is steel area must be provided? Draw sketch of your final design.

Solution:-

$b = 10''$ , $h = 20''$

$L.L = 2.47$ kips/ft , $D.L = 1.05$ kips/ft

Span = 18ft , $f_c = 4,000$ psi , $f_y = 60,000$ psi

Let $d = h - 3$

$= 20 - 3 = 17''$

Assume $d' = 2.5''$

d is the effective depth

& d' is the effective cover.

pm

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**Step #01:-**

First we check the capacity of section as singly reinf. beam

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

$$= 0.85 \times 0.85 \times \frac{4000}{60{,}000} \times \left(\frac{0.003}{0.003 + 0.005}\right)$$

$$= 0.7225 \times 0.0667 \times 0.375$$

$$\rho_{max} = 0.0181$$

↓

we call it reinforcement ratio & formula of that is $\frac{A_{st}}{b \times d}$

So, As we know that

**Step #02:-**

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

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

$$= 0.0181 \times 10 \times 17$$

$$= 3.07 \text{ sq in}$$

## Step 03:-

$$M_{u_2} = \phi \times A_{st} \times f_y \times \left(d - \frac{a}{2}\right)$$

But first, $a = \dfrac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \dfrac{3.07 \times 60,000}{0.85 \times 4000 \times 10}$

$= 5.41''$

$$M_{u_2} = 0.90 \times 3.07 \times 60,000 \times \left(17 - \frac{5.41}{2}\right)$$

$= 2,369,825.1$ lb/in

So we convert it in to kip-inch

$= 2369.825$ kip-inch

In the given question the moment due to given loads are:-

Beam self weight $= 150 \times \dfrac{10}{12} \times \dfrac{20}{12}$

$= 150 \times 0.834 \times 1.67$

$= 208.917$ lb/ft

Total factored load $= 1.2(1.05 \times 1000 + 208.917) + 1.6(2.47 \times 1000)$

$= 5462.7004$ lb/ft

So convert it $= 5.462$ kips-ft

K 25

Ultimate factored moment

$$\frac{wl^2}{8} = \frac{5.462 \times (18)^2 \times 12}{8}$$

$$Mu = 2654.53$$

So,

$$Mu_2 < Mu$$

$$2369.82 < 2654.53$$

So Required doubly reinf.

## Step # 04:-

$$Mu_1 = Mu - Mu_2$$

$$= 2654.53 - 2369.82$$

$$= 284.71 \text{ Kip-inch}$$

## Step # 05:-

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

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

$$= \frac{284.71}{0.90 \times 60 \times (17 - 2.5)}$$

$$= 0.3636 \text{ Sq. inch}$$

## Step #06:-

Total steel Area

$A_s = A_{st} + A'_s = 3.07 + 0.3636$

$= 3.4336$ Sq. inch

## Step #07:- Selection of Bars

A- For tensile steel

let try #8 bar, having Area = $0.785 in^2$

No. of bars = $\frac{A_s}{\text{Area of 1 bar}} = \frac{3.4336}{0.785}$

$= 4.374 \approx 5$ bars

B- Compression steel

let try #6 Bar, having Area = $0.44 in^2$

No. of bars = $\frac{A'_s}{\text{Area of 1 bar}}$

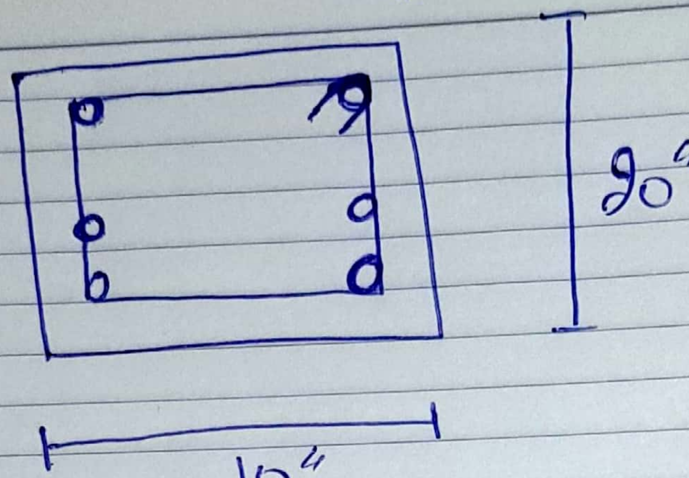
$= \frac{0.3636}{0.44} = 0.826 \approx 1$ bar

## Step #08:- Check on Minimum width on Beam

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

$= 12.75 > 10''$ => not good in one layer

So, provided in two layer.




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

$d = 16.62''$

$d' = 1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right)$

$= 2.25''$

## Step #09 Design Moment

$Md = \phi \times [A's \times fy \times (d - d') + (As - A's) \times fy \times (d - \frac{a}{2})]$

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

$= \frac{(5 \times 0.785 - 1 \times 0.44) \times 60000}{0.85 \times 4000 \times 10} = 6.15''$

$Md = 0.90 \times [(1 \times 0.44) \times 60000 (16.62 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60000 \times (16.62 - \frac{6.15}{2})]$

$Md = 2890464.75$

$= 2890.464 > 2653.56$ So perfect design.

## Q.No 2 Part (a)

**Bond stress:-** The tension that influences the underlying concrete's exterior layer of steel is bond stress.

-> The resultant bond tension is referred to as bond tension.

-> This tension serves to maintain the connection between the concrete & the reinforcement to receive.

-> Bond stress results in any force which attempts to pull out the concrete rods.

-> If you seek to take the reinforcing bar out of the reinforced base, the bonding tension becomes resistant to the bar.

**Development Length:-** The appropriate duration b/w the highest stress point in a bar & the end of a bar is called the production period.

## Reason for Providing development length:-

→ Build a secure connection between certain bar surface & the concrete such that during the optimal loading state no loss happens due to breakage of the chain.

→ The extra bar size given as the length of the construction shall also be liable for moving the tension creation to every portion of the neighboring segment.

## Q.No2 Part (b)

→ Under the basis we will use the strengthened beam while the beam size constraint arises.

For e.g if someone suggested that the depth of the beam could not be greater than 12 inches & that the exterior load on the beam could not withstand. a single reinforced beam under the this situation that we used double reinforced beam.

## Q.No 2 Part (c)

**T-Beam:-** In the category of T-beam slabs & beams, they are intertwined & function as one unit.

→ T beams are used mainly for heavy duty & wide gaps such as bridges.

→ T projection is more energy efficient than R-beam.

**Rectangular Beam:-** In the context of rectangular frame slab, the frame was positioned such that there is no relation between slab & the frame.

→ Rectangular beams are often seen in industrial building.

→ Rectangular beam is less cost efficient than T-beam.

## Q.No 2 Part (d)

The meditation factors decreases from the tension management portion to the compression in the configuration of the flexure power-Regulated segment to softly raise with rising mechanability this indicates the restriction factor for flexure strength of reinforced concrete.

## Q.No 2 Part (e)

**Design Method**:- Two techniques are used wordly for the construction of concrete & specific component systems.

i. ASD Method
ii. USD Method

**ASD Method**:- Often recognized as the operating tension modeling process is the ASD method. it is focused on the theory that stresses produced in the structural component should not surpass any elastic limit friction.

→ All loads are regarded as duty loads in this system & no consideration is added to raise the duty load.

**USD Method:-** Ultimate form of power construction is sometimes called process of load factor.

→ The ultimate strength factor is calculated by the elastic study for the system exposed to broad external load.

→ USD approach is ideally adapted to develop various structural systems for the following purpose.

i) Since the material's overall strength is known, we will get a ton of regular column segment & beam relative to other approaches.

ii) The consequence of the USD method approach is more affordable construction for a house with less special needs & specifications for configuration.

## Q.No 3

c/c distance = 10'

Span = 30'

slab thickness = 6"

Beam web width = 14"

Total depth = 28"

effective depth = 28" − 3" = 25"

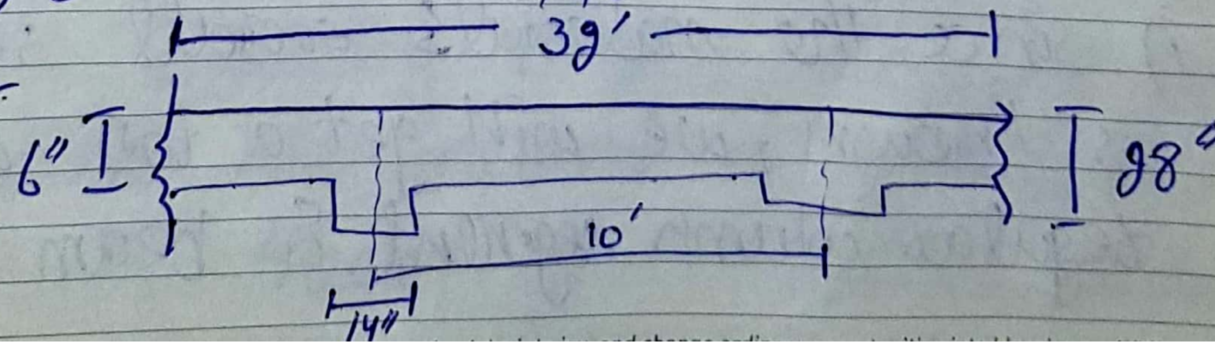
fy = 60,000 psi

f'c = 4000 psi

S.S = 225 lb/ft$^2$

D.L = 50 lb/ft$^2$

Sol:-



**Step #02 Ultimate Factored Moment**

$$Mu = \frac{Wu \times l^2}{8}$$

Wu = Total factored load

Evaluate self mass per feet :-

$$wt = b \times t \times \gamma c$$

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

$$= 408.34 \ lb/ft$$

Evaluate full load factored

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

$$Wu = 909.96 \ lb/ft$$

$$= 0.909 \ kip/ft$$

Then for the moment

$$Mu = \frac{Wu \times l^2}{8}$$

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

$$Mu = 1396.22 \ kips\text{-}inch$$

**Step #02 :- Compute the appropriate broadness**

1) $16 \times hf + bw = 16 \times 6 + 14$

$$= 110''$$

2) span/4 = $32/4 \times 12$

= 96"

3) c/c distance = $10 \times 12$

= 120"

So be = 96"

**Step #03:- Tests whether T-Beam or Rectangular**

Analysis #01

let a = hf = 6

$$As = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{1396.23}{0.90 \times 60 \times (25 - 6/2)}$$

As = 1.175 Sq inch

Analysis #02

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

$$a = \frac{1.175 \times 60}{0.85 \times 4 \times 96}$$

a = 0.21" < 6"

So rectangular frame shape.

$$As = \frac{1396.23}{0.90 \times 60 \times (25 - \frac{0.21}{2})}$$

$$= 1.03 \text{ Sq inch}$$

**Analysis #03**

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

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

$$= 0.18 \text{ inch}$$

$$As = \frac{1396.23}{0.90 \times 60 (25 - \frac{0.18}{2})}$$

$$As = 1.03 \text{ Sq inch}$$

**step #04**

Check $\rho_{max}$ & $\rho_{min}$:-

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

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

$$\rho_{max} = 0.018.$$

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

$= \frac{200}{60000} = 0.003$

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

$\rho = 0.00294$

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

$0.003 > 0.00294 < 0.018$

while we both learn

$\rho$ is less than $\rho_{min}$

$\rho = \frac{As}{b \times d} =$

$As = \rho \times b \times d$

$= 1.05$ sq inch

**step #05:-** Assortment of bar list

let try # 8 bar, having area = 1.27 in²

No. of bars = $\frac{As}{Ab} = \frac{1.05}{0.785}$

$= 1.3 \approx 2$

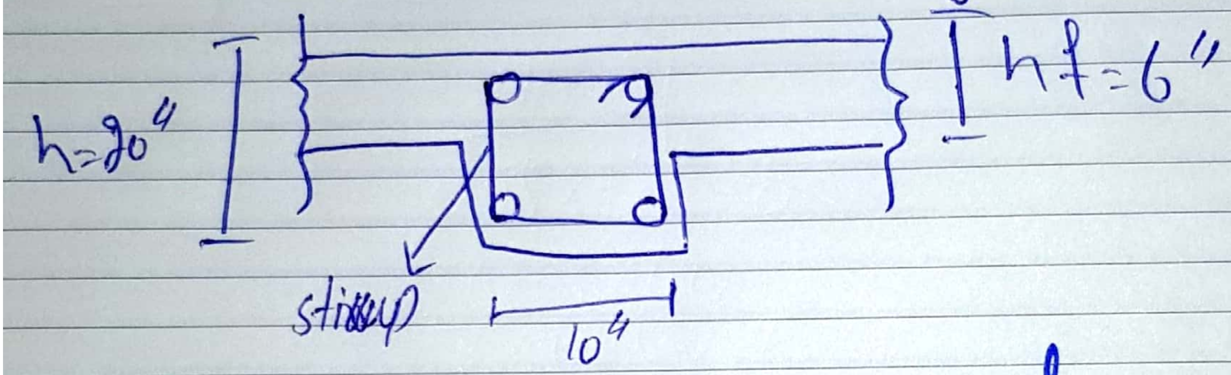
Taking 2 # 8 main bars.

# Step#06:- Check on Minimum width

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

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

Take it in one layer




# Step#07 :- Design moment

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

$A_s = 0.785 \times 2$

$= 1.57 in^2$

$a = \dfrac{A_s \times f_y}{0.85 \times f'_c \times b_e}$

$= \dfrac{1.57 \times 60}{0.85 \times 4 \times 96}$

$a = 0.2''$

$M_d = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2)$

$= 2111.02$ kips-inch

$M_d = 2111.02$ kip-inch $> M_u = 1396.23$ kip-inch

design is perfect.