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Q No1 A Rectangular beam that must carry a service live load of 2.47 Kips/ft. and a calculated dead load of 1.05 Kips/ft (without self-weight) on an 18-ft simple span is limit to 10 inches width and 20 inches total depth for architectural reasons. If $f_y = 60000$ psi and $f'_c = 4000$ psi. What steel area must be provided? Draw sketch of your final design.

Sol Given Data

Dead load = 1.05 Kip/ft

Live load = 2.47 Kip/ft

$f_y = 60000$ psi

$f'_c = 4000$ psi

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

$d' = 2.5''$

$h = 20''$, $w = 10''$

Solution

Step 1

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

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

$$\boxed{\rho_{max} = 0.0181}$$

Step 02

Area of steel [Ast]

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

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

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

$$\boxed{Ast = 3.077 \text{ in}^2}$$

Step 03

Design factored moment [Mu]

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

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

$$a = \frac{3.08 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

$$Mu_2 = 0.90 \times 3.08 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

$$\boxed{Mu_2 = 2378.38 k''}$$

Now

Moments of the given load

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

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

$= 208.33$ lb/ft

Now

Total Factored load = 1.2 D.Load + 1.6 L.Load

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

$= 5461.996$ lb/ft

$= 5.46$ K/ft

Ultimate factored moment $= \frac{WL^2}{8}$

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

$= 2653.56 K''$

Thus $2378.38 < 2653.56$

It should be double designed beam

Step 04

$M_{u_1} = M_u - M_{u_2}$

$M_{u_1} = 2653.56 - 2378.38$

$M_{u_1} = 275.18 K''$

step 05

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

$A_s' = \frac{M_{u_1}}{\phi \times f_y \times (d - d')}$

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$$A_s' = \frac{275.18}{0.90 \times 60(17-2.5)}$$

$A_s' = 0.35 in^2$

step 06

$A_s = A_{sT} + A_s'$

$= 3.08 + 0.35$

$= 3.43 in^2$

This lies in the tension zone of steel.

Step 07 Selections of Bars

For tensile steel

let's take #8 having an area of $0.785 in^2$

$$\text{No of bars} = \frac{A_s}{A_b} = \frac{3.43}{0.785} = 4.36 \approx 5 \text{ bars}$$

For compression steel

⇒ let's take #6 having an area of $0.442 in^2$

$$\Rightarrow \text{No of bars} = \frac{A_s'}{A_b}$$

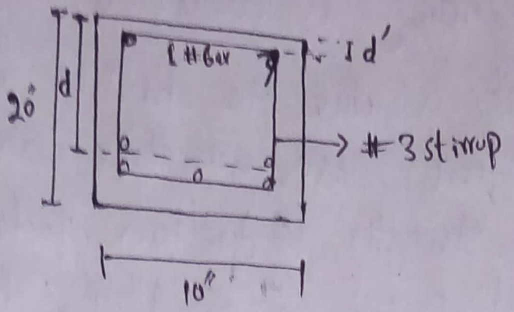
$$= \frac{0.35}{0.442} = 0.79 \text{ bar} \approx 1 \text{ bar}$$

Step 08 Beam minimum width

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

$= 12.75'' > 10''$

It should be in multiple layers.



Now

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

$d = 16.625''$

$d' = 1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right) = 2.25''$

Step 09 Design Moment

So

$M_d = \phi \times \left[A_s' \times f_y \times (d - d') + (A_s - A_s') \times f_y \times \left(d - \frac{a}{2}\right)\right]$

$a = \frac{(A_s - A_s') \times f_y}{0.85 f_c \times b} = \frac{5 \times 0.785 - 1 \times 0.44}{0.85 \times 4 \times 10} \times 60$

$a = 6.15''$

$M_d = 0.90 \times \left\{1 \times 0.44 \times 60 \times (16.625 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60 \times \left(16.625 - \frac{6.15}{2}\right)\right\}$

$M_d = 2891.5245$

which is

$M_d = 2891.5245 > 2653.56 k''$

Designed is ok

Bond stress :- The stress which is acting on the outer interface of steel to the surrounding concrete is called bond stress
⇒ This stress helps in keeping bond b/w reinforcement and concrete togather

Development length

A development length can be defined as that "The amount of reinforcement (bar) length needed to be embedded or project into the column to establish the desired bond strength b/w the concrete and steel.

(B) **Condition in which doubly reinforced beam used**

(i) ⇒ when the cross section of the beam is fixed.

(ii) when moment to be carried by the beam is more than the balanced moment.

(iii) In case of a continous beam

(iv) when dimension of the beam are restricted for architectural or structural purpose.

(v) The portion of the beam over middle support in continous T-beams has to be designed as double reinforced section

(c) T-Beam Analysis

① T-Beam is more economical then rectangular beam

② In consist of T-shaped structure.

③ In case of T-Beam slab and beam are connected with one another and Act as one member

④ Analysis is required when

$a > h_f$

a = depth

h_f = slab thickness

Rectangular Beam Analysis

① Rectangular beam is less economically then T-Beam

② In case of rectangular beam slab has been placed on the ~~basic~~ beam and there is no connection b/w slab and beam.

③ It is most commonly used in office/ Commercial building

④ Analysis is required when

$a \leq h_f$

where
a = depth

h_f = height of flange

(D) Effective of strength reduction factor on flexural strength

The flexural strength of reinforced concrete (RC) beams strengthened with a carbon fiber reiforced polymers plate which fails by intermediate crack debonding is evaluated.

⇒ The effect is due to higher debonding resistance in the first case, ~~whether~~ where the comparision of the strength Reduction factor with experimental data and Factore propared for that.

(e) Design Methods

It is a procedure, techniques aids, or tool for designing.

⇒ They offer a number of different kinds of activites that a designer might use with in an overall design process.

⇒ Three methods of structural design

Q No 3

Ans **Given Data**

C/c distance = 10'

Span = 32'

slab thickness = 6"

web width = 14"

Total depth (h) = 28"

Effective depth = 28" − 3" = 25"

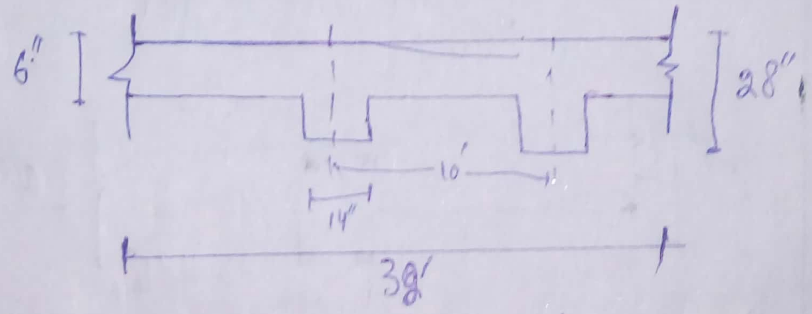
D.L = $50\ lb/ft^2$

L.L = $225\ lb/ft^2$

f_y = 60,000 psi

f'_c = 4000 psi

Sol



Step #1 Ultimate factored moment

we know that

$$M_u = \frac{W_u \times l^2}{8}$$

i Beam self wt per feet

Beam self wt per feet:

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

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

$$= 408.34 \ lb/ft$$

Total Factored Load

$$\Rightarrow 1.2(50 + 408.34) + 1.6(225)$$

$$\Rightarrow 909.99 \ lb/ft$$

$$\Rightarrow 0.909 \ kip/ft$$

Moment

$$\frac{wL^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12 = 1396.23 \ kip/in$$

step.02 Calculate effective width "be"

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

(2) c/c distance $= 10(12) = 120''$

(3) $\frac{span}{4} = \frac{32}{4} \times 12 = 96''$

So $\boxed{be = 96''}$

step-03 Check whether Rectangular or T Beam:

Trial #1, let $a = h_f = 6''$

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

$$A_{st} = 1.17 \ in^2$$

Trial #02

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{1.17 \times 60}{0.85 \times 4 \times 96} = 0.2'' < 6''$$

So Rectangular Beam design

$$A_{st} = \frac{1396.23}{0.90 \times 60 \times (25 - 0.2/2)} = \boxed{1.03 in^2}$$

Trial #03

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

$$A_{st} = \frac{1396.23}{0.90 \times 60 \left(25 - \frac{0.18}{2}\right)}$$

$$= 1.03 in^2$$

Step #04 check ρ_{max} and ρ_{min}

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

$$\rho_{max} = 0.018$$

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

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

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

$0.003 < 0.002 < 0.018$

As ρ is less than ρ_{min}

So

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

$$Ast = \rho_{min} \times b \times d = 0.003 \times 14 \times 25 = 1.05\ in^2$$

Step #05 , No and section of Bar

Let use #8 bar, then

dia = $8/8 = 1''$, Area = $0.785\ in^2$

Now

$$\#\ of\ bars = \frac{1.05}{0.785} = \boxed{1.3 \approx 2}$$

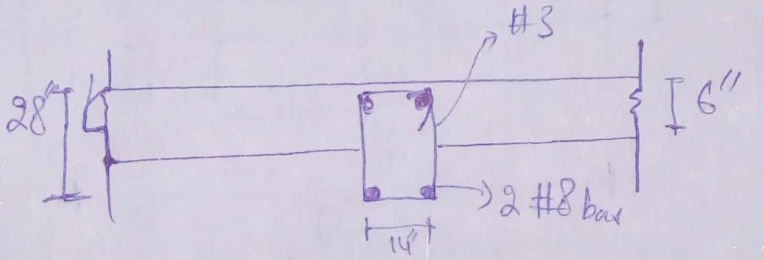
So we use 2 #8 bars

Step #06 Check on minimum width

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

$$= 6.75'' < 14''$$

So good in one layer



Step #07 Design moment

So

$$\Rightarrow M_d = \phi \times f_y \times Ast \times \left(d - \frac{a}{2}\right)$$

First we find Area of steel

$\Rightarrow$ Area of steel = Area of 1 bar × No of bars

Put the values

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

Area of steel $= 1.57\ in^2$

Now

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

$$a = 0.2$$

Then

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

$M_d = 2111.02$ kip-inch

As $2111.02 > 1396.23$

Design is ok?