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Section:→ 'A'.
Subject:→ PRC Design-1.
Instructor:→ Fawad khan.
Semester:→ 6th.
Department:→ civil engineering.
Date:→ 20th April 2020.
exam:→ mid exam.

Q1:→ 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 limited to 10 inches ~~with~~ 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.

Given Data

width = 10"

Height = 20"

L.L = 2.47 kips/ft

D.L = 1.05 kips/ft

span = 18 ft

$f_y = 60000$ psi, $f_c = 4000$ psi

Sol:→

Step # 01

→ Effective depth (d) = h-3 => 20-3 = 17"

→ Effective cover (d') = 2.5"

→ Rainforcement Ratio:→

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

$$\rho_{max} = 0.85 \times 0.85 \times \frac{4000\,psi}{60000\,psi} \times \left(\frac{0.003}{0.003+0.005}\right)$$

$$\rho_{max} = 0.0180$$

*):→ Step # 02 :→

To find Area of steel.

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

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

$$A_{st} = 0.0180 \times (10 \times 17)$$

$$A_{st} = 3.06\, in^2$$

*):→ **Step # 03** :→

Design moment, by formula

$$Mu_2 = \lambda \times A_{st} \times f_y \times (d - a/2)$$

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10}$$

$$a = 5.4''$$

$$Mu_2 = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$Mu_2 = 2362.93 \text{ kip-inch.}$$

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 $\Rightarrow 5.46$ kips/ft

Ultimate factored moment $= wL^2/8$

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

$$= 2653.6$$

$Mu_2 < Mu$

$2362.92 < 2653.6$

Scanned with CamScanner

Step # 04 :→

$$M_{u1} = 2653.6 - 2362.92$$

$$M_{u1} = 290.68 \text{ kip-inch}$$

Step # 05 :→

Steel Area in compression zone will be,

$$M_{u1} = \phi \times A_{st}' \times f_y \times (d - d')$$

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

$$A_{st}' = \frac{290.68}{0.90 \times 60 \times (17 - 2.5)}$$

$$A_{st}' = 0.371 \text{ in}^2$$

Step # 06 :→

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

$$A_{st} = 3.06 + 0.37$$

$$A_{st} = 3.43 \text{ in}^2$$

Step # 07 :→

We use #8 bars

$$\text{Area} = 0.785 \text{ in}^2$$

No. of bars $= Ast / \text{Area of 1 bar}$

No of bars $= 3.43 / 0.785$

No of bars $= 4.36 \approx 5$ bars

5 #8 in Tensile zone

Compression steel:→

use No. 6 bars

dia of #6 $= 6/8 = 0.75''$

Area $= 0.44 \text{ in}^2$

No. of bars $= Ast' / \text{Area of 1 bars}$

No. of bars $= \dfrac{0.37}{0.44} = 0.84 \approx 1$

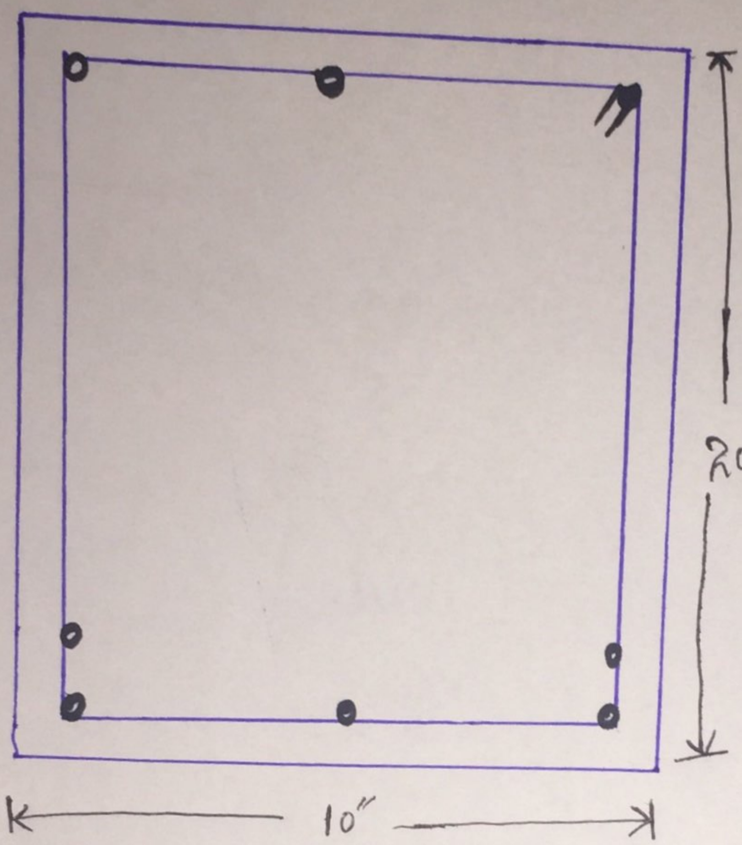
1 #6 bar in compression zone

Step # 08

Beam minimum width

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

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



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

$d = 16.62''$

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

$= 2.25''$

Step # 09

Design moment is given by,

$$M_d = \phi \times \left(Ast' \times f_y \times (d - d') + (Ast - Ast') \times f_y \times (d - a/2) \right)$$

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

$$a = \frac{(5\times0.785 - 1\times0.44)\times60}{0.85\times4\times10}$$

$$a = 6.15''$$

$$Md = 0.90\times\left[(1\times0.44)\times60\times(16.62-2.25) + (5\times0.785 - 1\times0.44)\times60 \times (16.62 - 6.15/2)\right)$$

$$Md = 2890.46$$

$$Md = 2890.46 > 2653.6$$

Q2:→

a):→ Briefly describe Bond stress and Development length?

(a)

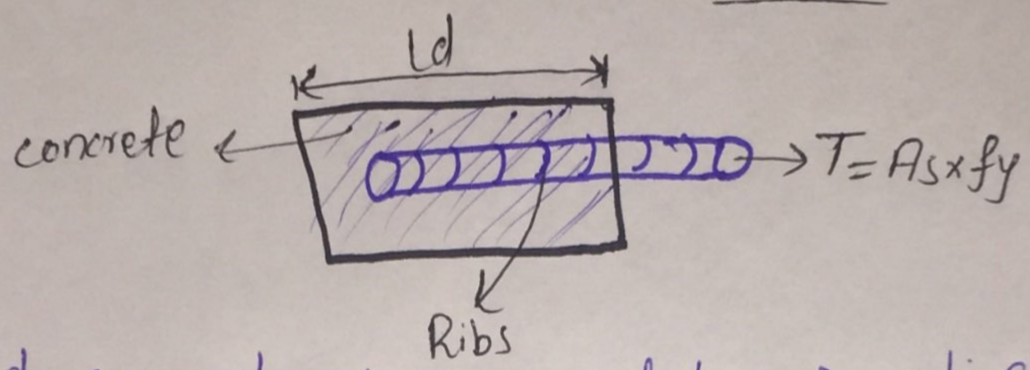
Ans:→ Bond stress:→ The pulling out of steel bar from concrete is resisted by gripping action of concrete is known as Bond and the resulting stress is called Bond stress.

⇒ Resistance offered to slipping of bars is due to three reasons;

1):→ Chemical adhesion b/w two materials

2):→ Friction due to natural roughness of bars

3):→ Due to closely spaced rib-shaped determinations made on the bar surface.



→ Bond can also be increased by providing;

1):→ Sufficient cover

2):→ Rich mix concrete.

3):→ Deformed Bars.

*):→ Development length:→ "The necessary length b/w the point of maximum stress in a bar and the end of bar."

=> For #11 or smaller bars the development length must not be less than the value obtained from the following three equation.

→ For tension bars:→

$$① \quad Ld - \frac{0.04 \times Ab \times fy}{\sqrt{fc'}}$$

2)→ $Ld = 0.0004 + db + fy$

3) – $Ld = 12''$

selected the minimum value.

for #14 Bar; $Ld = 0.085 \times fy / \sqrt{fc'}$

For # 18 Bar;

$$Ld = 0.11 \times fy / \sqrt{fc'}$$

→ For compression Bars:→

$$Ldc = \frac{0.02 \times db \times fy}{fc'} \geq 0.0003 \times db \times fy$$

Q2:→

b):→ In which conditions doubly reinforced beam can be used?

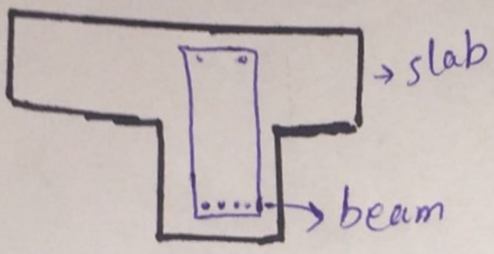
Ans:→ Doubly reinforced concrete beams are used when aesthetic or functional requirements dicate that the beam needs to be smaller than that which can be accommodated using a singly reinforced concrete beam.

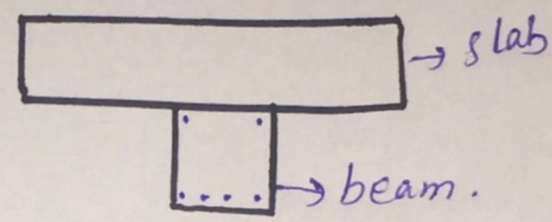
Q2:→

(c):→ Differentiate between T-beam analysis and rectangular beam analysis?

T-beam	Rectangular beam
→ T-shape beam. but their analysis and design is quite different from one another.	→ Aslo T-shape beam.

T-beam	Rectangular beam.
→ In case of T-beam slab and beam are connected with one another and acts as a one member	→ In case of rectangular beam, slab has been placed on the beam so there is no connection between slab and beam.





Q 2:→

d):→ write short note on the effect of strength reduction factor on flexural strength?

Ans:→ Strength reduction factor is defined as the of strength to yield strength the importance of estimating R_1 factor originates in the need for directly deriving inelastic spectra. However the flexural strength of a material is defined as the maximum bending stress that can be applied to that material it yields. In the design of flexural strength. The tension controlled section to compression controlled sections to increase safety with decreasing ductility.

Q3:→

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Given Data

distance = 10'

span = 32'

thickness = 6"

width = 14"

Total depth = 28"

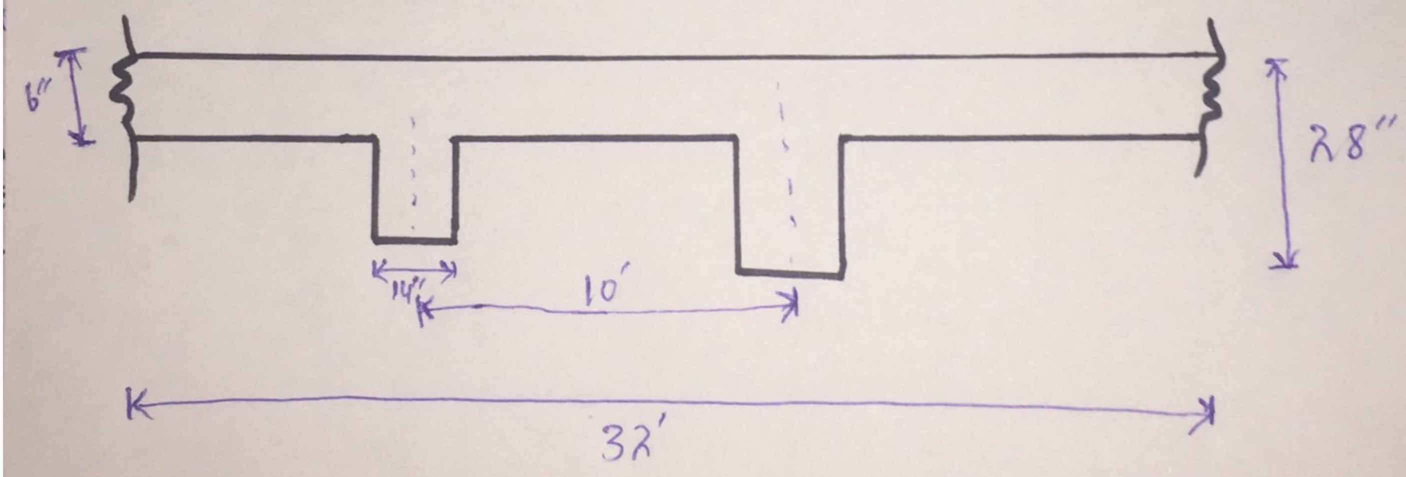
Effective depth = 28" − 3" = 25"

Dead load = 50 lb/ft²

Live load = 225 lb/ft²

fy = 60000 psi , fc' = 4000psi

Sol:→



Step#01:→

$M_u \times L^2/8$

→ self weight of beam per feet.

$w_t = b \times t \times \gamma_c$

$$wt = \frac{14}{12} \times \frac{28}{12} \times 150 = 408.33 \text{ lb/ft}$$

Total factored load $= 1.2(50 + 408.33) + 1.6(225) = 909.99$ 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

→ Effective Breadth:→

- → $16(h_f) + b_w = 16(6) + 14 = 110''$
- → c/c distance $= 10(12) = 120''$
- → span/4 $= \frac{32}{4} \times 12$

$b_e = 96''$

Step # 02 (Rectangular or T-beam)

<u>Trial #1</u> $a = h_f = 6''$

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

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

Trial # 2:→

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

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

$= 0.2'' < 6''$ Rectangular beam design.

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

$Ast = 1.03\ in^2$ ✓

Trial #3:→

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

$a = 0.18''$

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

$Ast = 1.03\ in^2$ ✓

Step # 03:→ ρ_{max} and ρ_{min}

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

$\rho_{max} = 0.018.$

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

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

$$\rho_{min} = 0.003$$

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

$$\rho = \frac{1.03}{14 \times 25}$$

$$\rho = 0.0029$$

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

$$0.003 < 0.0029 < 0.018$$

ρ is less than ρ_{min}

$$\rho = \frac{A_{st}}{bd}$$

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

$$A_{st} = 0.003 \times 14 \times 25$$

$$A_{st} = 1.05 \text{ in}^2$$

Step # 04 :→ Number of bars

use # 8 bar

dia = 1" , Area = 0.785 in²

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

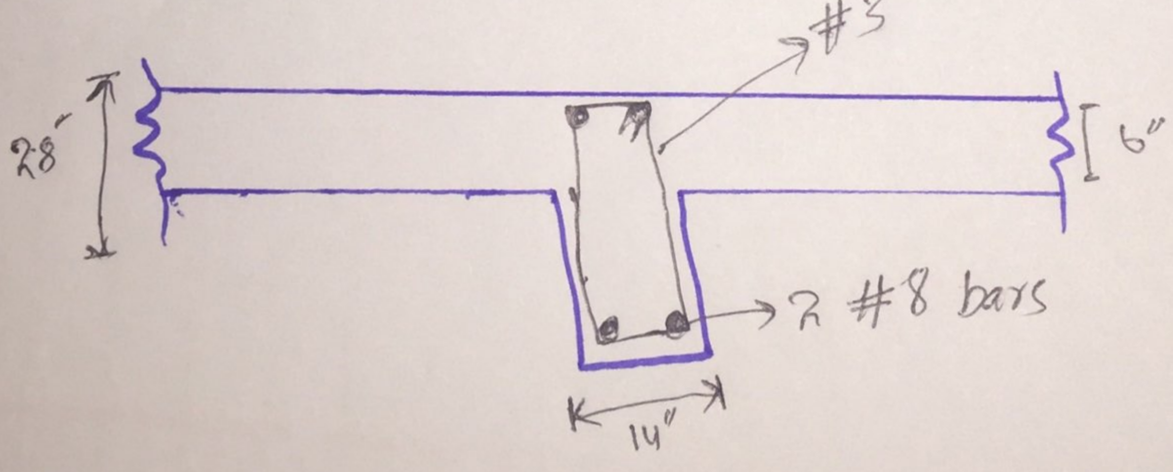
$$= 1.3 \approx 2$$

use 2 #8 bars

Step # 05 :→ bmin

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

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



Step # 06 :→

Design moment

$Md = \phi \times fy \times Ast\,(d - a/2)$

Ast = Area of 1 bar × No of bars

$Ast = 0.785 \times 2$

$Ast = 1.57\,in^2$

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

$a = 0.2''$

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

$Md = 2111.02$ kip-inch

$2111.02 > 1396.83$

Design is ok.