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Section (A)

Q1) A rectangular that must carry a service line load,

Width (b) = 10"

Height (h) = 20"

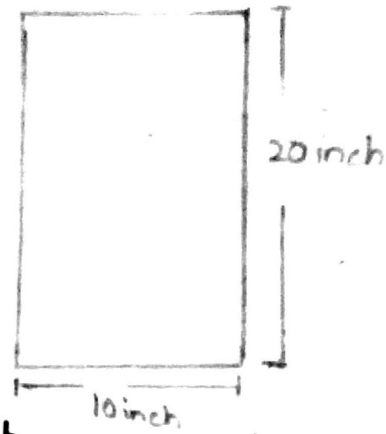
f_c = 4000 Psi

f_y = 60,000 Psi

Span = 18'

Live Load = 2.47 kips/ft

Dead Load = 1.05 kips/ft



Step 1:-

Effective Cover (d') = 2.5"

Effective depth (d) = 20-4

= 16

ρ_{max} = ? (Reinforcement Ratio)

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

$$\rho_{max} = 0.85 + 0.85 \times \frac{4}{60} \times \frac{0.003}{0.003 + 0.005}$$

$\therefore$ 4000 Psi = 4 ksi

$\therefore$ 60000 Psi = 60 ksi

ρ_{max} = **0.0181**

Step 2:- Area of Steel:-

$$\rho_{max} = \frac{A_{steel}}{B \times d}$$

Arranging eq for Area we get

$$A_{steel} = \rho_{max} \times B \times d$$

$$A_{steel} = 0.0181 \times 10 \times 16$$

$$A_{steel} = 2.896 \text{ in}^2$$

A_{steel} = 2.896 in² or 2.90 in²

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(2)

(MOMENTS)

Step No 3:- $M_{u_2} = \phi \times A_{steel} \times f_y \times (d - \frac{a}{2}) \rightarrow eq(i)$

$a = ?$ $\Rightarrow a = \frac{A_{steel} \times f_y}{0.85 \times f'_c \times b} = \frac{2.90 \times 60}{0.85 \times 4 \times 10}$

$a = 5.11 inch$ or $a = 5.11''$

Now put values of a in eq(i)

$M_{u_2} = 2.90 \times 60 \times (16 - \frac{5.11}{2})$

$M_{u_2} = 2340 in\text{-}kp$

Due to given Loads:-

Beam own weight or Self weight

As we know that $M_u = \frac{WL^2}{8}$ and $W = ?$

w is total factored load and is given as

factored load $= (1.2 \times 1.05) + (1.6 \times 2.47)$ ∴ (1.2 & 1.6 are for live and dead loads)

$= 5.21 \ kips/ft$

Now, $M_u = \frac{Wl^2}{8} \Rightarrow \frac{5.21 \times 18^2}{8}$

$M_u = 211 ft\text{-}kips$ or $2530 in\text{-}kips$

Double Reinforcement will be required as

$M_u > M_{u_2}$

Step 4:-

$M_{u_1} = \frac{M_u}{\phi} - M_{u_2} \Rightarrow \frac{2530}{0.90} - 2340 = 471.1 in\text{-}kip$

Steel Area in Compression zone:-

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

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

$A_{st'} = \frac{471}{0.90 \times 60 \times (16 - 2.5)} = 0.64 in^2$

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The total area of reinforcement is

$$A_s = 2.90 + A_{st}' \Rightarrow 2.90 + 0.64 = 3.54 in^2$$

$$A_s = 3.54 in^2$$

Step#5:- (No of bars for Compression & Tensile zone)

we use #8 bars ∴ (dia = 1", Area = 0.785 in² for No 8 bar)

$$\text{No of Bars} = \frac{A_{st}}{\text{Area of 1 bar}} \Rightarrow \frac{3.54}{0.785} = 4.50$$

No of Bars for tensile zone will be 5 of #8.

for Compression zone:-

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

we use bar #6 (dia = 0.75", Area = 0.44in²)

$$\text{No of bars} = \frac{0.64}{0.44} = 1.49 \approx 2$$

So two No of #6 bars will be used for Compression

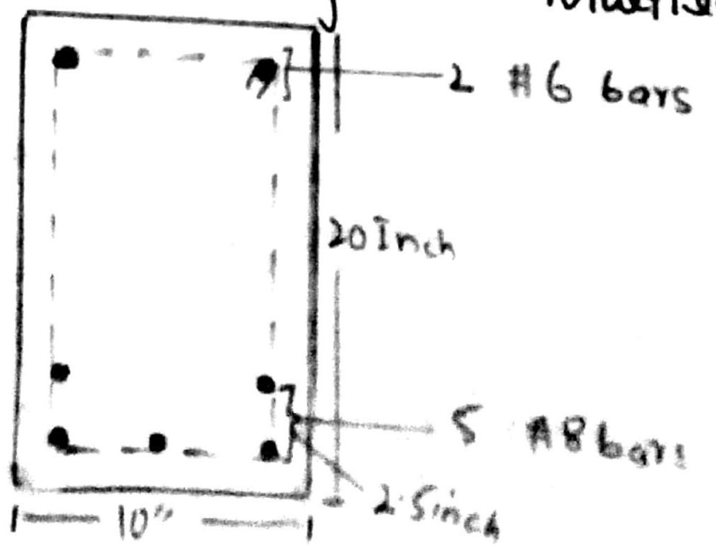
Beam Minimum Width:-

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

$$W_{min} = 12.8 \quad \therefore 12.8 > 10$$

So it will be lay in Multilayer

Main bar will be lay in Multilayer.



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Step 8:- Design Moment :-

$$Md = \phi \times (A_{st}' \times f_y \times (d - d') + (A_{st} - A_{st}') \times f_y \times d - \frac{a}{2})$$

$$a = \frac{(A_{st} - A_{st}') \times f_y}{0.85 \times f'_c \times b} \Rightarrow \frac{(0.785 \times 5) - (2 \times 0.44) \times 60}{0.85 \times 4 \times 10}$$

$$a = \frac{3.925 - 0.88(60)}{34}, \quad a = \frac{182.7}{34}, \quad a = 5.373''$$

$$Md = 0.90 \times [2 \times 0.44 \times 60 \times 16 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60 \times (16 - \frac{5.73}{2})]$$

$$Md = 0.90(52.8 \times 13.75) + (3.925 - 0.44) \times 60 \times (13.13)$$

$$Md = 653.4 + 3.485 \times 787.8$$

$$Md = 653.4 + 2145.483$$

$$Md = 2798.4 \text{ in-kips}$$

Md > Mu hence it is okay

Q2 Describe bond stress and Development length?

(i) **BOND STRESS:-**

It is defined as the resistive stress against the pulling out of steel bar from concrette mass, developed per unit surface area of a reinforcing bar.

The bond strees balances the force present in the bar. Incase of no bond, the steel bar will pulled out of concrette

Development length:-

It can be define as the amount of bar length needed to embaroded or projected into the column to established the desire bond strength the concrette and steel and is given by

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}}$$

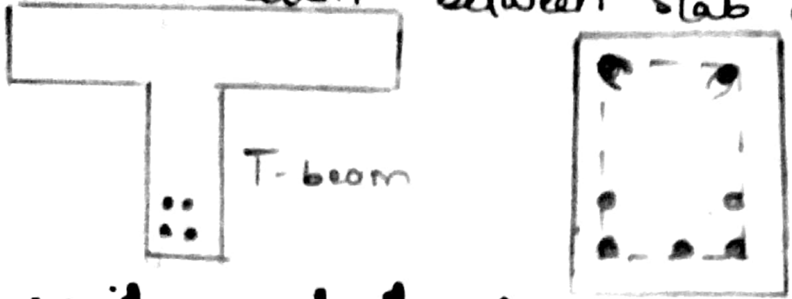
Q2 (ii) In which condition double reinforced beam used?

We used double reinforced beam due to the following reasons:-

=> When the cross section of beam is fixed
=> When moment to be carried by the beam is more than the balanced beam
=> In case of continous beam
=> When there is torsion on the beam

Q2:- (iii) Differentiate between T-beam & Rectangular beam?

Both beam have T-shape but their analysis is quite different from one another. Incase of T beam slab and beam are connected withone another and act as one member. In case of rectangular beam slab has been placed on beam and there is no connection between slab and beam.



Q2 (v) Write a short note on the effect of strength..?

When we design fluxeral strength, the strength reduction factor decrease from tension-controlled section to compression controlled section to decrease ductility and increase safety. so to determined the reduction factor for fluxeral strength of reinforced concrette beam according ACI code. In the ~~read~~ releability-based design the reliable prediction of the fluxeral strength of reinforced concrette members is assured by the use of reduction factors corresponding to different target reliability index.

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(Q2) Briefly describe design Method?

(A) Design Method are particularly based on condal provisions of a country so they vary from places to places There are three methods of design that is Working Stress, Ultimate load Method, Limit state These design are used for reinforced concrette as well as for stell design.

Out of these three limit state method is much more preffered because of

i) Area of cross section required is less than working stress design.

ii) It considers uncertainity in load as well as design strength of materials and takes factors of safety for both

iii) State of servicibity is checked for design.

Q3:-

Data:-

Slab thickness = 6"

Span = 32'

C/C distance = 10'

Web Width = 14"

Effective depth = 28" - 3" = 25"

Total depth (h) = 28"

D.L = 50 lb/ft^2

S.S = 225 lb/ft^2

f_y = 60000 Psi = 60 kips

f'_c = 4000 Psi = 4 kips

Solution:-

Step 1 :-

$$Mu = \frac{Mu \times L^2}{8}$$

Beam Self weight per ft

$$Wt = b \times l \times \gamma_c = \frac{14}{12} \times \frac{18}{12} \times 150 \quad (\because 1'' = \frac{1}{12}')$$

$$Wt = 408.33 \ lb/ft$$

Factored Load :-

$$= 1.2(50 + 408.33) + 1.6(225) \quad \because (1.2 \ \& \ 1.6 \text{ are constant and factor of live \& dead loads})$$

$$= 0.909 \ kip/ft \quad (lb \rightarrow kip) \ (\div \text{ by } 1000)$$

Moment :-

$$\frac{WL^2}{8} = \frac{0.909 \times 32^2}{8} \times 12 = 1396.23 \ kip\text{-}inch$$

Effective breadth.

$$16(hf) + bw = 16(6) + 14 = 110''$$

$$C/C \text{ distance} = 10(12) = 120''$$

$$Span/4 = 32/4 = 8' \times 12 = 96'' \Rightarrow b_e = 96''$$

(Rectangular or T-beam) :-

Trial # 1 :-

$$a = hf = 6''$$

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

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

$$A_{steel} = 1.17 in^2$$

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Trial 2:-

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

$a = 0.2"$

and $0.2 < 6$ so it is rectangular beam.

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

Step 3:- ρ_{max} and ρ_{min}

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

$\rho_{max} = 0.018$

$$\rho_{min} = \frac{200}{f_y} = \frac{2000}{60,000} = 0.003$$

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

$\rho_{min} < \rho < \rho_{max}$ $\therefore$ $0.003 < 0.002 < 0.018$

So, $\rho = \frac{A_{st}}{bd}$, $A_{st} = \rho_{min} \times bd \Rightarrow A_{st} = 0.003 \times 14 \times 25$

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

Selection of Bars :-

let use # 6 bar then (~~Area = 0.75, dia = 0.44~~) (Area = 0.44 in², dia = 0.75)

$$\text{No of bars} = \frac{1.05}{0.44} = 2.386 \approx 3 \text{ bars } \#6$$

Minimum Width:-

$b_{min} = 2(1.5) + 2(3/8) + 2(0.75) + 1(0.75)$

$b_{min} = 3 + 0.75 + 1.5 + 0.75$

$b_{min} = 6"$

$6" < 14"$ so it be in one layer

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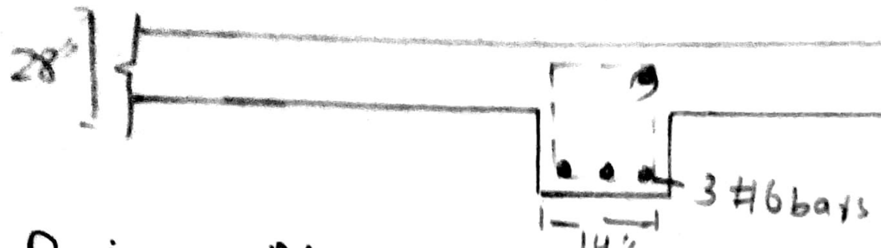

Design Momen:-

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

Area of steel = Area of 1 bar x No of bars

$A_{st} = 0.44 \times 3 \Rightarrow 1.32 in^2$

$a = \frac{1.32 \times 60}{0.85 \times 4 \times 96} \Rightarrow \frac{79.2}{326.4} = 0.242"$

$Md = 0.90 \times 60 \times 1.32 \times (25 - \frac{0.24}{2}) = 2092.3$ kip-inch

As $2092.3 > 1396.23$

so the Resign is ok.