* Question no: 1:—

A rectangular beam that must carry a service live load 2.47 kip/ft. and a Calculated dead load of 1.05 kip/ft (without self weight) on an 18ft. simple span is limited to 10 inches width and 20 inches total depth for architectural reasons, If fy = 60000 psi and fc = 4000 psi. what steel Area must be provided. Draw sketch of your final design.

* Given Data:-

Span = 18ft

Dead load = 1.05 K/ft.

live load = 2.47 K/ft.

width of beam = (b) = 10".

thickness: (h) = 20".

f_y = 60000 psi = 60 ksi.

f'_c = 4000 psi = 4 ksi.

* Solution:

⇒ Step#1:- Effective depth (d)

d = h − 2.5.

d' = 3" ⇒ Effective Cover.

d = 20 − 2.5

d = 17.5"

⇒ Step#2: First check the Capacity of Section as a Singly reinf beam.

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

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

$\varepsilon_u = 0.003$

$\varepsilon_y = 0.005$

Constant

$\rho_{max} = 0.0180625$

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

⇒ Step #3: (Find Area of Steel)

As we know

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

$\boxed{Ast = \rho_{max} \times b \times d}$ putting values.

$Ast = 0.018 \times (10 \times 17.5)$

⇒ $\boxed{Ast = 3.15\ in^2}$

⇒ Step#4 (Moment for this Area of steel)

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

⇒ First find a,

$a = \frac{Ast \times fy}{0.85 \times fc \times b} = \frac{3.15 \times 60}{0.85 \times 4 \times 10} = 5.5''$

$\boxed{a = 5.5''}$

$M_{u2} = 0.90 \times 3.06 \times 60 \times (17.5 - \frac{5.5}{2})$

$\Rightarrow$ $M_{u2} = 2437.29$ Kip-inch

Now we have to find Moment due to given load.

$\Rightarrow$ Self weight of beam :-

$b \times t \times \gamma_c$

$10 \times 20 \times 150$

$\div 12$ from inches to ft.

$\frac{10}{12} \times \frac{20}{12} \times 150 = 208.33 \, lb/ft$

RCC = $\gamma_c = 150 \, lb/ft^3$

PCC = $\gamma_c = 140 \, lb/ft^3$

$\Rightarrow$ Total factored load :- (External)

$w = 1.2 \times D.L + 1.6 \times L.L$

$1.2 \times (1050 + 208.33) + 1.6 \times (2470)$

$w = 5461.99 \, lb/ft$ or $w = 5.46 \, k/ft$

$\Rightarrow$ Ultimate factored Moment $= \frac{wl^2}{8} = \frac{5.46 \times (18)^2}{8} \times 12$

$M_u = 2653.56 k''$ (External)

$M_u = 2653.56 k''$ & $M_{u2} = 2437.29 \, k''$

$M_u > M_{u2}$

So design a Section as doubly reinforced

Step #5:

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

$M_{u_1} = 2653.56 - 2437.29$

$M_{u_1} = 216.27 K''$

Step #6:

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

A'_{st} = Area of steel in Compression Zone.

for Area of steel in compression Zone

$A'_s = \frac{M_{u_1}}{\phi \times f_y \times (d - d')} = \frac{216.27}{0.90 \times 60 \times (17.5 - 3)}$

$A'_s = 0.27 \, in^2$

Step #07:- Total Steel Area.

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

$A_s = 3.15 + 0.27$

$A_s = 3.42 \, in^2$

This total steel Area should must be provided in tensile zone as tension reinf.

⇒ Step#08: Selection of Bars for tensile & compression zone

⇒ For Tensile zone:

let try #8 bar.

Area = $0.785\,in^2$ | $\frac{\pi}{4}d^2 = 0.785\,in^2$

dia = $8/8 = 1''$

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

$$= \frac{3.42}{0.785} = \boxed{4.35 \approx 5 \text{ bars. \#8.}}$$

⇒ For tensile zone

⇒ For Compression Zone:

let try #6 bar.

Area = $0.44\,in^2$

dia = $6/8 = 0.75$

$$\text{No of bars} = \frac{A'_{st}}{A_b}$$

$$= \frac{0.27}{0.44} = \boxed{0.61 \approx 1 \text{ bar \#6.}}$$

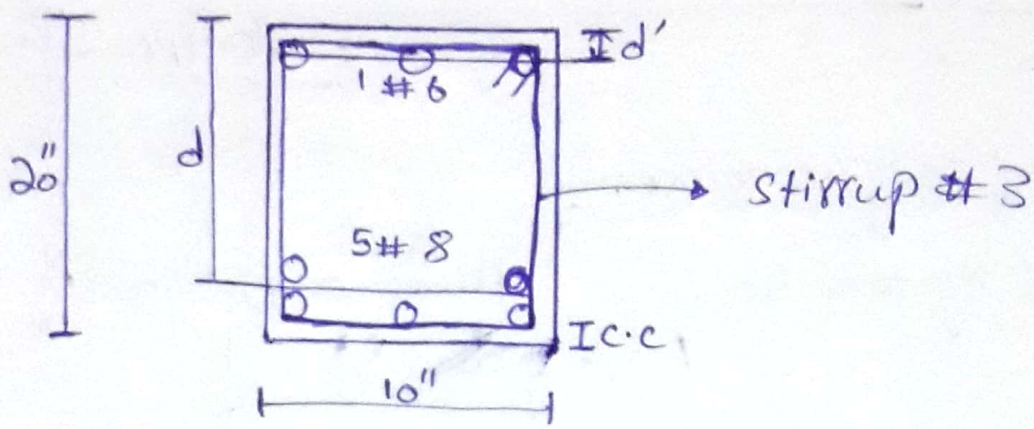
⇒ For Compression Zone.

⇒ Step#09: Check minimum width of beam.

b_{min} = (2 × Clear.c) + (2 × dia of stirrup) + (No of main bar × dia of main bar) + (No of spaces × dia of main bar).

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

$b_{min} = 12.75 > 10''$ (not good in one layer, so main bar should be provided in 2 layer.)



⇒ Effective depth = (d).

d = t - c.c - stirrup dia - ½ × longitudinal bar dia.

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

d = 16.62".

⇒ Effective Cover = (d').

d' = cc + dia of stirrup + ½ (compression bar dia)

$d' = 1.5 + 3/8 + 1/2 \times (6/8)$.

d' = 2.25"

⇒ Step #07 Design Moment:

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

Find "a" first, $a = \frac{(A_{st} - A'_{st}) \times f_y}{0.85 \times f'_c \times b}$.

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

$a = 6.15''$

$$M_d = 0.90\left[(1\times0.44)\times60\times(16.62-2.25)+(5\times0.785-1\times0.44)\times60\times\left(16.62-\frac{6.15}{2}\right)\right].$$

$M_d = 2890.46$

$M_d = 2890.46 > 2653.56.$

Design is O.K!

ID#7879

Question no: 2

* **Part (a):-**

BOND STRESSES:

The pulling out of steel bar from concrete is resisted by gripping action of concrete is known as Bond and the resulting stresses is called bond stresses.

DEVELOPMENT LENGTH:

The necessary length b/w the point of maximum stress in a bar and the end of bar.

* **Part (b):-**

In which condition doubly reinforced beam can be used.

we can use doubly reinforced beam in that condition when we the cross section of the beam are restricted.

* **Part (c):-**

T-BEAM ANALYSIS	RECTANGULAR BEAM ANALYSIS
If $a > h_f$ that beam will be design with T-Beam Analysis	If $a \leq h_f$ that beam will be design as Rectangular beam Analysis

Part (d):

STRENGTH REDUCTION FACTOR:

It is the ratio of elastic strength and yield strength denoted by "ϕ"

Part (e):

Design Methods:

Following are the methods.

i) Allowable Stress Design (ASD) Service load
ii) ultimate Strain Design (USD) factored load.

⇒ Eq of ASD:
$W_T = DL + L.L.$

⇒ Eq of USD.
$W_T = 1.2 \times DL + 1.6 \times L.L$ (we multiply a factor so factor load)

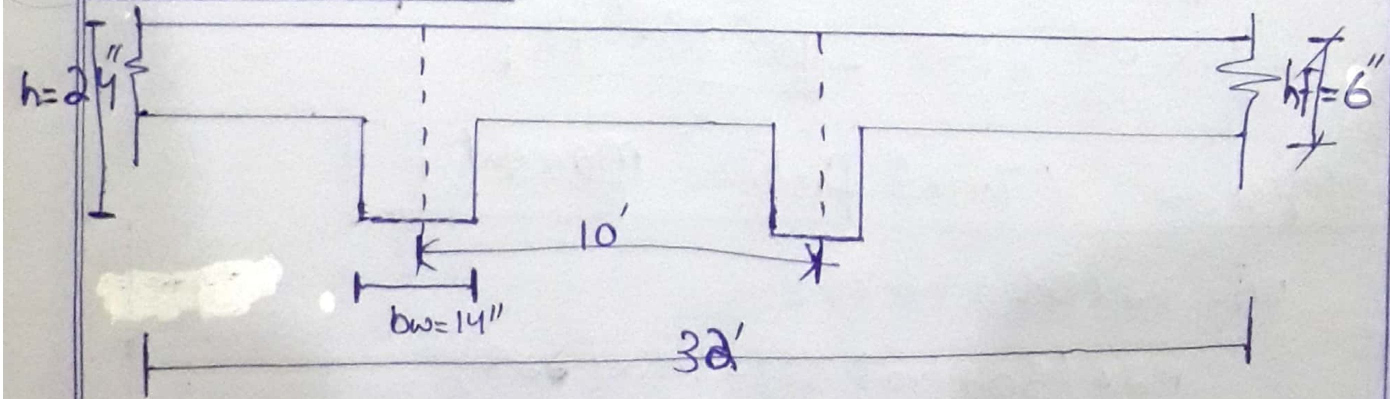
ID# 7879

Question no:3

A concrete floor system consist of parallel T-Beam spaced 10ft. On centers and spanning 32ft between supports. The 6inch thick slab is cast monolithically with T-Beam web having width $b_w = 14''$, and total depth measured from the Top of the slab, of $h = 28''$. The effective depth will be taken 3 inch less then the Total depth. in addition to its own weight, each beam must carry a super imposed D.L of 50 psf and service load of 225 psf. Material strength are $f_y = 60{,}000$ psi and $f'_c = 4000$ psi.

Determine the required tensile steel Area and select the reinforcement needed for a typical member. Draw sketch of your final diagram.

Given data:



ID #7879

$h_f = 6''$ (slab thickness).

c/c distance = 10'

Span (l) = 32'

web width (b_w) = 14''

Total depth (h) = 28''

Effective depth(d) = 28'' − 3 = 25''

Dead load = 50 lb/ft²

S. load = 225 lb/ft².

f'_c = 4000 psi = 4 ksi

f_y = 60,000 psi = 60 ksi

Solution:

⇒ Step #01: (Beam self weight.)

Unit wt of concrete γ_c for Rcc γ_c = 150 lb/ft³

$B \times h \times \gamma_c$

$14 \times 28 \times 150$.

÷ 12 from inches to feet

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

⇒ Step #02 (Total factored Load)

$w_T = 1.2 \times D.L + 1.6 \times L.L$.

$1.2 \times (50 + 408.33) + 1.6 \times (225)$

909.996 lb/ft

$w_T = 0.909$ kip/ft

⇒ Step#03 (ultimate factored Moment)

$$M_u = \frac{w \times l^2}{8} = \frac{0.909 \times 32^2}{8} \times 12$$

$$\boxed{M_u = 1396.224\ K''}$$

⇒ Step#04 Calculate effective width (be) For T-Beam.

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

2) c/c distance $= 10' \times 12'' = 120''$

3) $\frac{\text{Span}}{4} = \frac{32'}{4} \times 12'' = 96''$

we have to select least value from these above cases so,

$$\boxed{b_e = 96''}$$

⇒ Step#05: check wether Rectangular or T-Beam Analysis is required

⇒ Trial#01 let $a = h_f = 6''$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{1396.224}{0.90 \times 60 (25 - \frac{6}{2})}$$

$$\boxed{A_{st} = 1.175\ in^2}$$

⇒ Trial no 2:

$$a = \frac{A_s \times f_y}{0.85 \times f'_c \times b_e} = \frac{1.175 \times 60}{0.85 \times 4 \times 96''}$$

$a = 0.21 < 6''$ (Rectangular Beam design)

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - \frac{a}{2})} = \frac{1396.224}{0.90 \times 60 \times (25 - \frac{0.21}{2})}$$

$A_{st} = 1.038 \, in^2$

⇒ Trial no 3:-

$$a = \frac{1.038 \times 60}{0.85 \times 4 \times 96} = 0.19$$

$$A_{st} = \frac{1396.224}{0.90 \times 60 \times (25 - \frac{0.19}{2})}$$

$A_{st} = 1.038 \, in^2$

⇒ Step # 6: check ρ_{max} ρ_{min}

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

$\varepsilon_u = 0.003$
$\varepsilon_y = 0.005$
constant.

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

$\rho_{max} = 0.018$

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

use in psi

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

So,

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

ρ is less ρ_{min}

So, As we know, we have to use ρ_{min} as ρ.

$\rho_{min} = \frac{A_{st}}{b \times d} = \frac{1.03}{14 \times 25} = \boxed{0.0029}$.

⇒ **Step#07: Selection and No of bars for longitudinal**

Let try #8 Area = $0.785 in^2$, dia = $8/8 = 1''$

No. of bar = $\frac{A_{st}}{A_b} = \frac{1.03}{0.785} = 1.312 \approx 2$

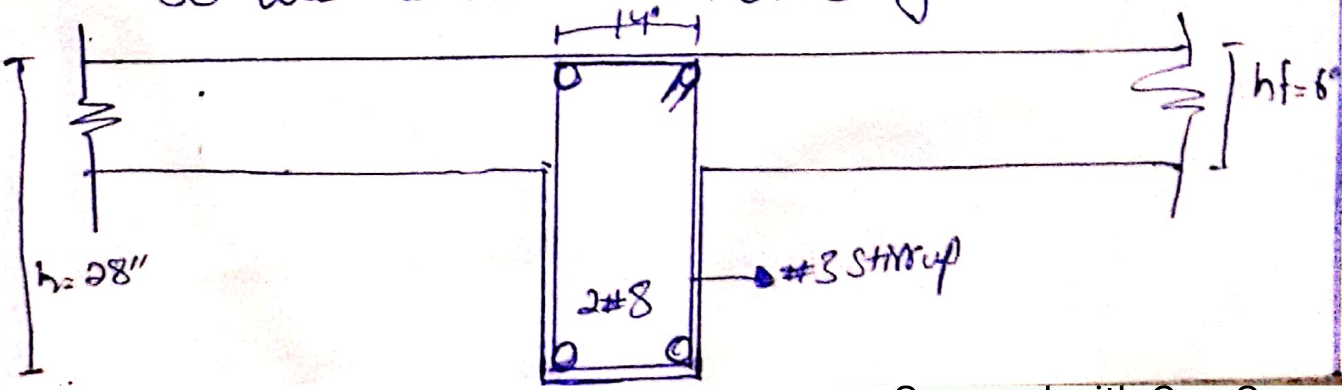
2 bars of #8. (Main bars)

⇒ **Step#08: Check bmin.**

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

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

So we can use it in one layer.



Scanned with CamScanner

⇒ Step#9: Design Moment.

$$Md = \phi \times fy \times Ast \times \left(d - \frac{a}{2}\right)$$

But first we have to find Ast and a

Ast = Area of one bar × No of bars.

$$Ast = 0.785 \times 2 = \boxed{1.57 in^2}.$$

Now

$$a = \frac{Ast \times fy}{0.85 \times fc \times be} = \frac{1.57 \times 60}{0.85 \times 4 \times 96} = \boxed{0.2''}.$$

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

$$\boxed{2111.022\ k''}$$

$$2111.022 > 1396.23$$

Design is O.K!