GOVERNMENT POLYTECHNIC VAISHALI

Unit-6 Analysis and Design of T-Beam (LSM)

Sub Code: 1615604

Sub: Design of structures (As per Syllabus)

Civil Engg.

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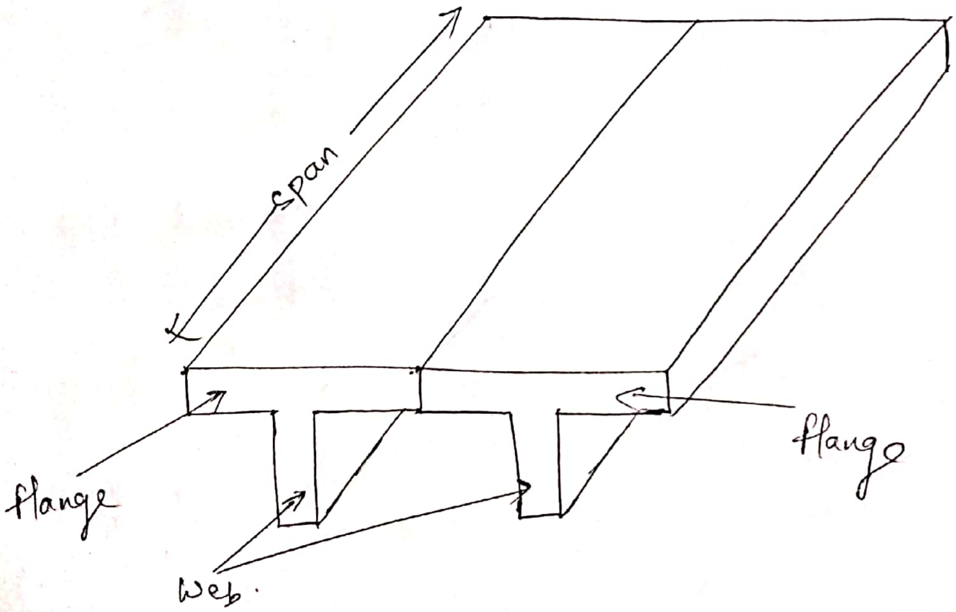
General features of T-Beam:



A T-Beam used in construction, is a load bearing structure of reinforced Concrete, with a T-shaped cross-section. The top of the T-shaped cross-section serves as a flange or compression member in resisting compressive stresses. The web (vertical section) of the beam below the compression flanges serves to resist shear stress.

Advantages of T-Beams:

1) Since the beam is cast monolithically with the slab, the flange also takes up the compressive stresses which mean, it will be more effective in resisting the sagging moment acting on the beam.

2) Better head room, this is direct outcome of the first point since the depth of beam can be considerably reduced.

3) For larger spans, T-beams are usually preferred rather than rectangular beam as the deflection is reduced to a good extent.

→ Effective width of flange as per IS code:

Refer IS 456: 2000

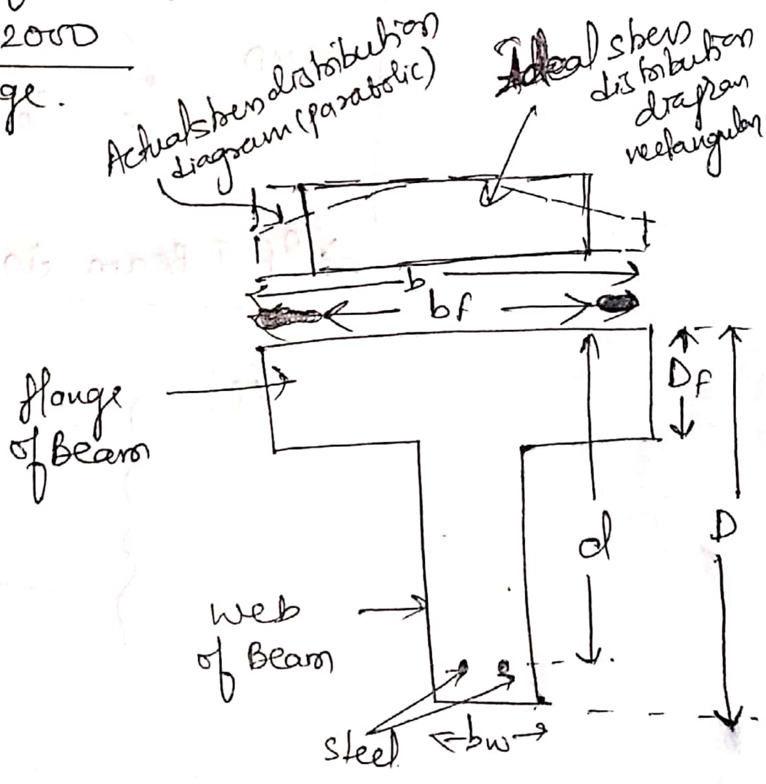
b = actual width of flange.

bf = effective width of flange.

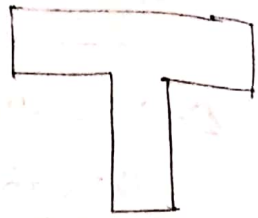
d = effective depth

bw = width of web or rib or beam

Df = depth of flange or slab.



Case a) Isolated T-Beam



$$B_f = \frac{l_o}{\left(\frac{l_o}{B} + 4\right)} + b_w$$

where B_f = effective width of flange

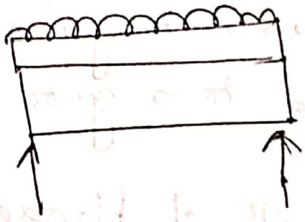
b_w = breadth of rib or web.

B = actual width of flange.

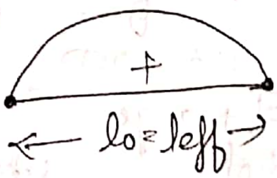
l_o = distance b/w points of zero moment

→ If T Beam is simply supported at ends.

Eg:



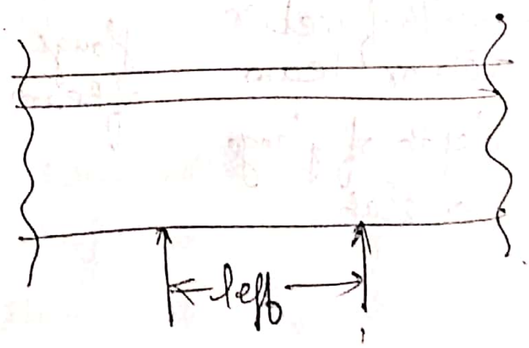
BMD



$l_o = l_{eff}$.

→ If T Beam is continous / fixed

Eg:



$l_o = 0.7\, l_{eff}$

Case b) **Monolithically Casted T-Beam**

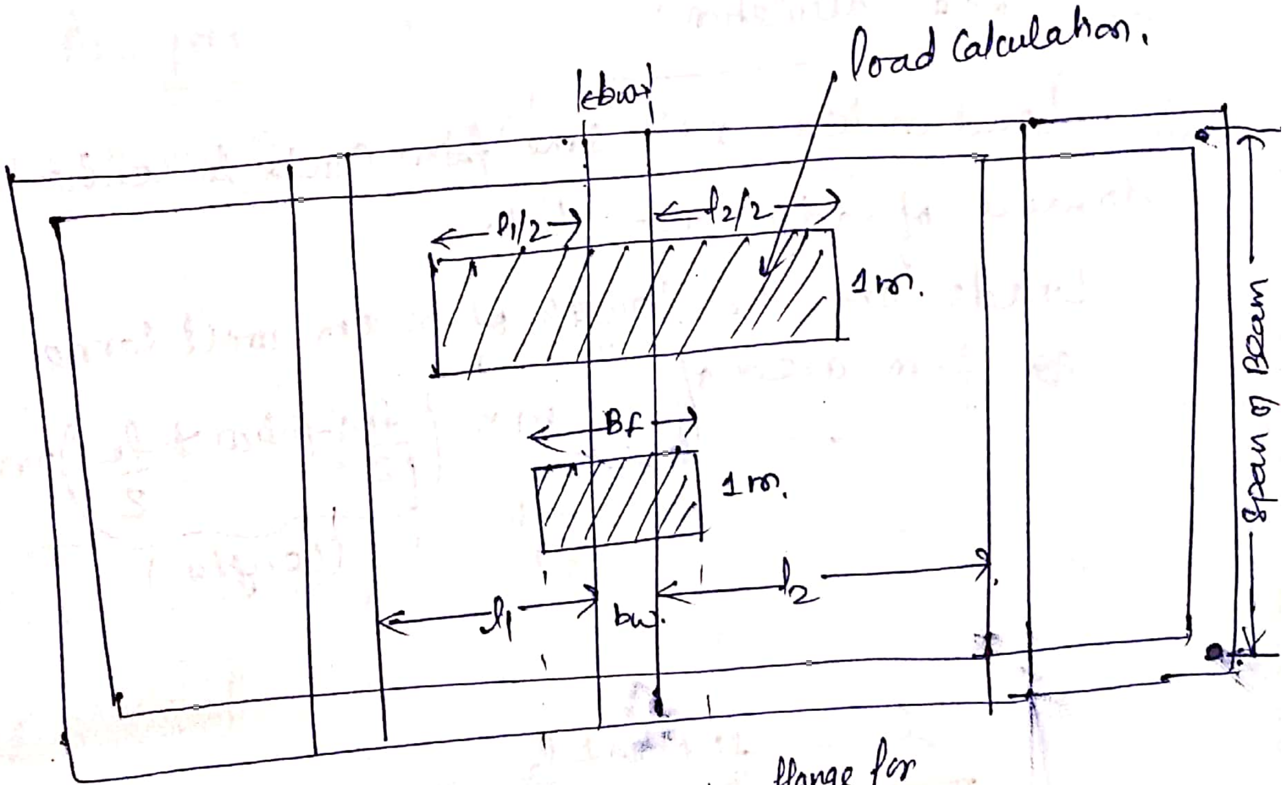
i.e. **Slab + Beam type T-Beam**

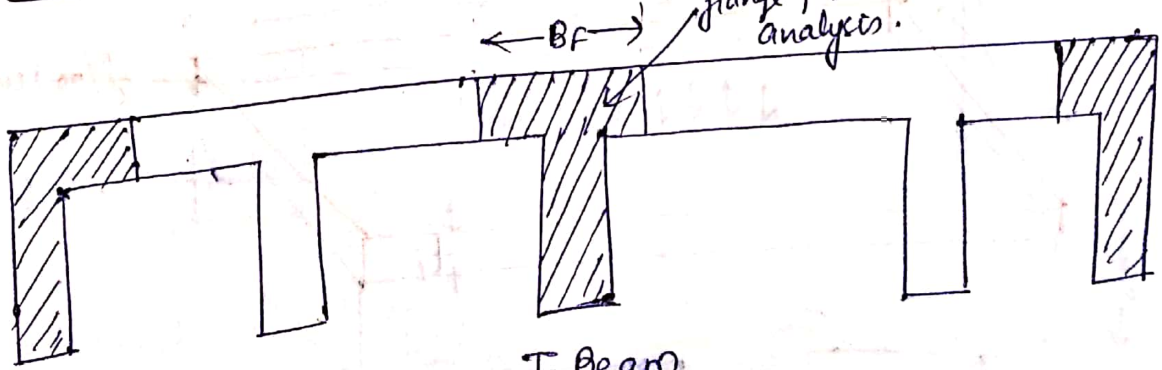
$$B_f = \left.\begin{array}{l} \frac{l_0}{6} + b_w + 6D_f \\ \text{or} \\ \frac{l_1}{2} + b_w + \frac{l_2}{2} \end{array}\right\} \text{Min}^m$$

($\frac{l_1}{2}$, $\frac{l_2}{2}$: Centre to Centre distance b/w slab.)

D_f = Depth of flange.

Rest all symbols in formula given above is same in meaning as of previous Case a.





T-Beam

Analysis of singly-reinforced T-Beam

As per syllabus we have to study only for the case of neutral axis lying within the flange

(1) $x_{u,lim}$ (limiting depth of neutral axis).

$$x_{u,lim} = Kd = \left(\frac{700}{1100 + 0.87 f_y}\right) d$$

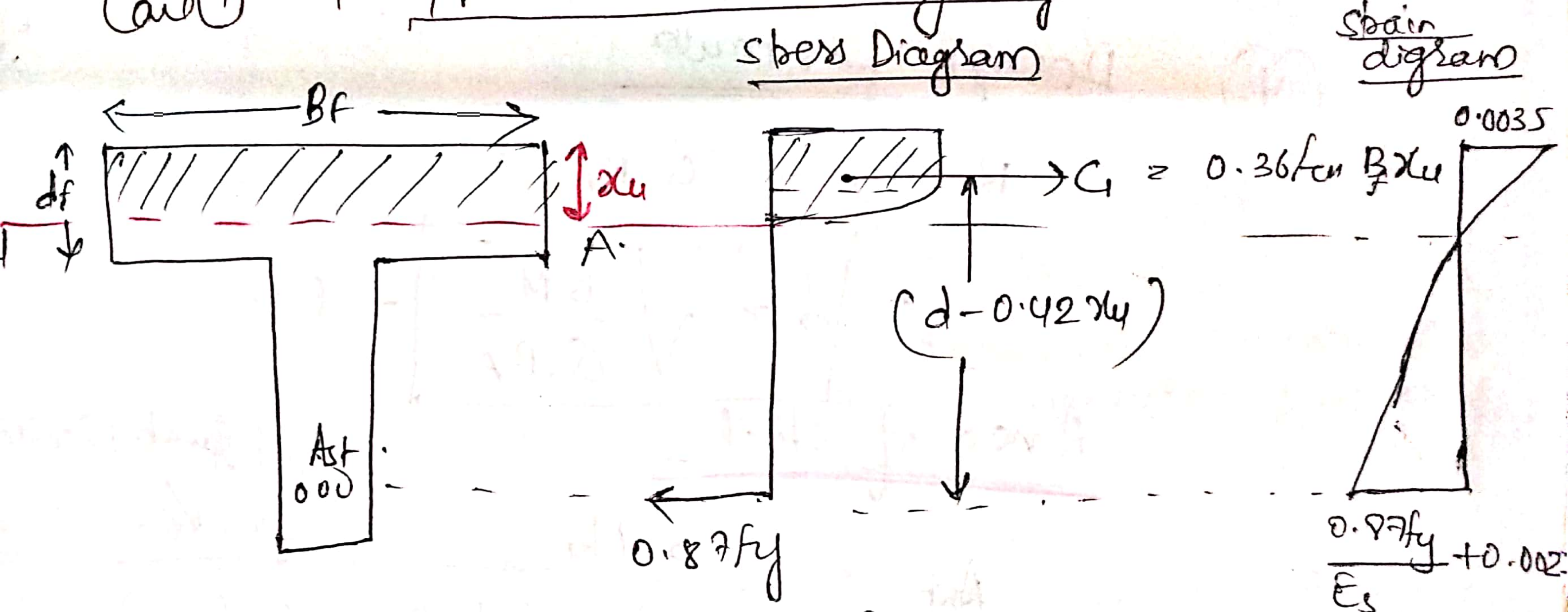
$= 0.53d \rightarrow$ Fe 250

$= 0.48d \rightarrow$ Fe 415

$= 0.46d \rightarrow$ Fe 500

② Actual depth of NA and Moment of resistance:

Case ① → If NA lie in flange.



$\therefore T = 0.87 f_y A_{st}$.

① So Actual depth of N.A :

$C = T$

$0.36 f_{cu} B_f \cdot x_u = 0.87 f_y \cdot A_{st}$.

$$\therefore x_u = \frac{0.87 f_y A_{st}}{0.36 f_{cu} B_f} \quad \text{— (A)}$$

② Moment of Resistance :

$M_u = 0.36 f_{cu} B_f X_u (d - 0.42 x_u)$.

If $x_u < x_{u,lim}$ then M_u (U.R.S)

" $x_u \geq x_{u,lim}$ then $M_u \simeq M_{u,lim}$.

OR

$M_u = 0.87 f_y A_{st} (d - 0.42 x_u)$

③ If $x_u < x_{u,lim} \rightarrow$ U.R.S $\rightarrow$ Use x_u

If $x_u \geq x_{u,lim} \rightarrow$ Limiting / ORS $\rightarrow$ Use $x_{u,lim}$

④ Design formula :

$B.M_u = Q B_f \cdot d^2$

$$\therefore d = \sqrt{\frac{BM}{Q \cdot B_f}} \quad \text{— (1)}$$

Area of steel

limiting section ✓

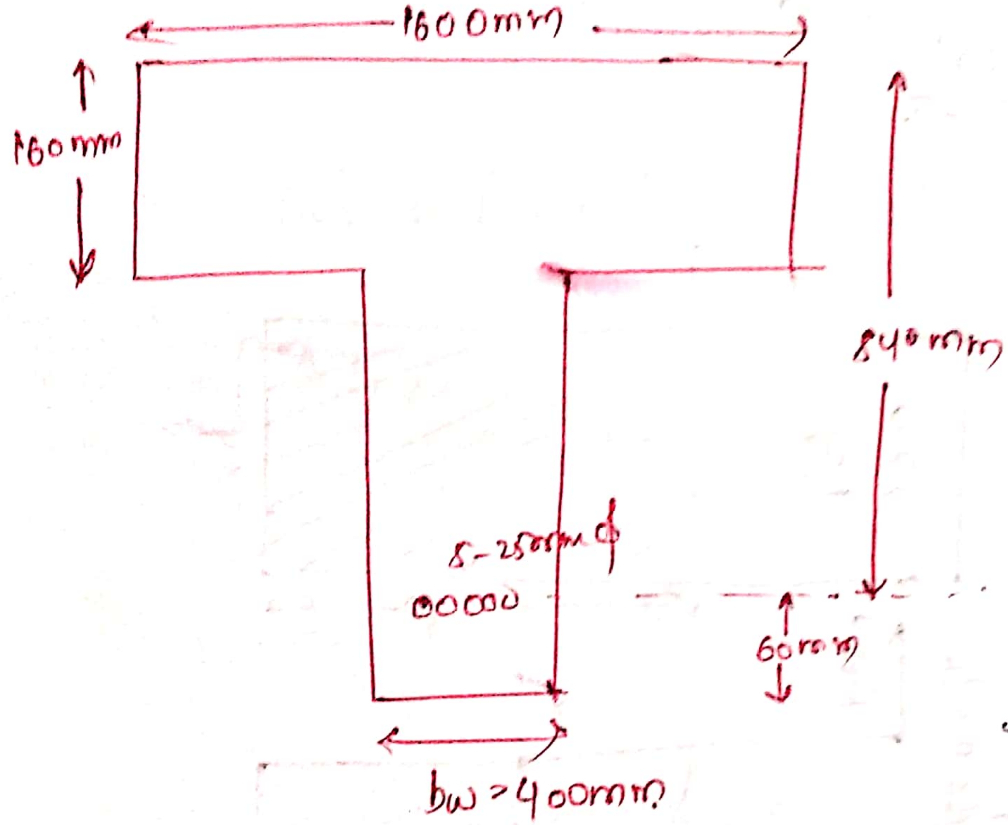
$$A_{st} = \frac{B \cdot M_u}{0.87 f_y (d - 0.42 x_{u,lim})}$$

$$\therefore \boxed{A_{st} = \frac{B \cdot M_u}{0.87 f_y j d}} \quad \text{--- (2)}$$

Case - 2) If N.A is in web area.

ie ($x_u > D_f$). (Not in syllabus)

Q. ① Calculate M.O.R of an isolated continuous T-Beam of effective span = 12m. Use M30, Fe415, LSM.



$l_{eff} = 0.7 l_0$
$= 0.7 \times 12$
$= 8.4$ m

Sol.

① $b_f = \dfrac{0.7 l_0}{\dfrac{0.7 l_0}{B} + 4} + b_w = \dfrac{8400}{\dfrac{8400}{1600} + 4} + 400$

$= \dfrac{8400}{9.5} + 400 =$ ~~1443.47 mm~~

= ~~1284.21 mm~~

= 1302.108 mm

② $x_{u,lim} = 0.48 \times 840 = 403.2$ mm

③ Calculate x_u.

Assuming $x_u < D_f$.

$C = T$.

$0.36 f_{ck} b_f x_u = 0.87 f_y A_{st}$

$\therefore x_u = \dfrac{0.87 \times 415 \times 5 \times \frac{\pi}{4} (25)^2}{0.36 \times 30 \times 1308.108}$

$= 62.72$ mm. $< D_f = 160$ mm

$< x_{u,lim}$ (so URS) (OK)

Hence it is U.R.S and assumptions is also correct.

$\therefore M_u = 0.36 f_{ck} b_f x_u (d - 0.42 x_u)$

$= 0.36 \times 30 \times 1308.108 \times 62.72 (840 - 0.42 \times 62.72)$

$= 720.97$ kN-m

. If depth of slab is 10 cm, width of web 30 cm, depth of web 50 cm, centre to centre distance of beams 3 m, effective span of beams 6 m, the effective flange width of the beam, is

[A]. 200 cm

[B]. 300 cm

[C]. 150 cm

[D]. 100 cm

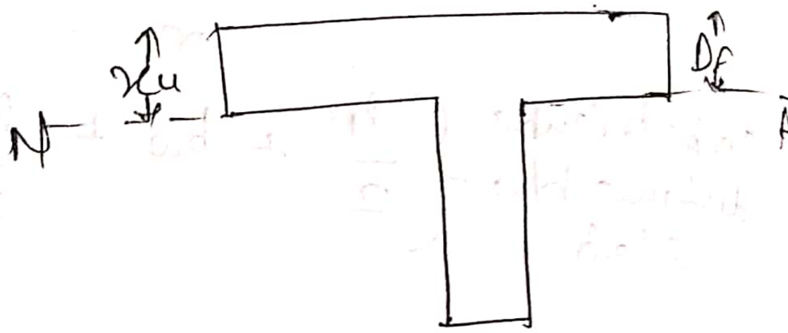
Solve the above Question

Design of T-Beam

As per syllabus → Neutral axis within or upto flange bottom.

i.e.

i.e $x_u \leq D_f$

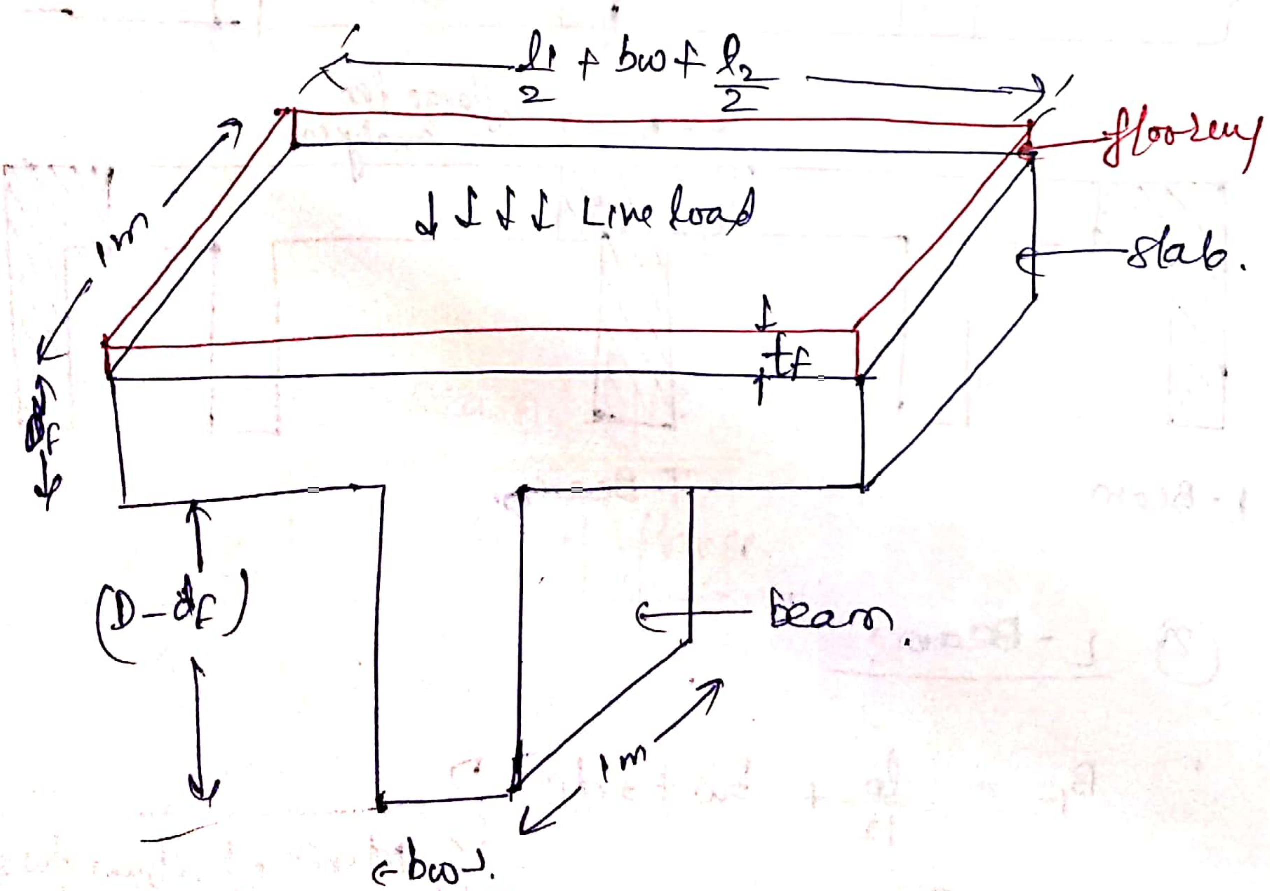


Design of T-Beam for moment and shear.

Load Calculation:

Load on beam will come from centre to centre distance of adjacent slabs.

Loads over 1m length of beam will come from area of $\underbrace{1\,m}_{\text{width (w)}} \times \underbrace{\left(\frac{l_1}{2} + b_w + \frac{l_2}{2}\right) m}_{\text{(Length)}}$.



(1) Line load $= W_L \times 1m \times \left(\frac{l_1}{2} + b_w + \frac{l_2}{2}\right) = W_1$

(2) weight of flooring $= t_f \times 1m \times \left(\frac{l_1}{2} + b_w + \frac{l_2}{2}\right) \times w_f$ (Unit wt of flooring) $= W_2$.

(3) weight of slab $= d_f \times 1m \times \left(\frac{l_1}{2} + b_w + \frac{l_2}{2}\right) \times W_c$ (Unit wt of Concrete) $= W_3$

(4) weight of web portion of beam $= b_w \times 1m \times (D - d_f) \times W_c = W_4$

∴ Total load w = $W_1 + W_2 + W_3 + W_4$

If size of beam is given:

Given Values:

① Size of the beam:

$B_F, d_F, b_w, d, D.$

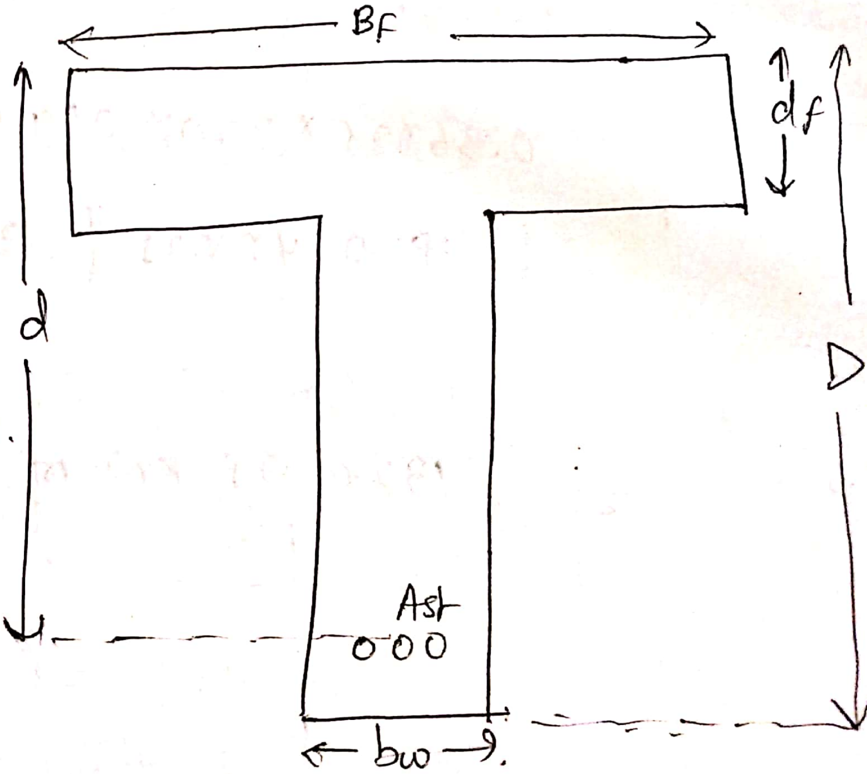
② Grade of Conc / steel

f_{cu} f_y

③ Bending Moment $= BM_u$.

Find out

① $A_{st} = ?$



से M.R ही fixed section का।

Case (1) Calculate M.R of the section, when $x_u = d_f$ & it is 1st case :

$$MR_{u_1} = 0.36 f_{ck} B_f x_u (d - 0.42 x_u)$$

$$= 0.36 f_{ck} B_f d_f (d - 0.42 d_f)$$

→ Designing for moment.

① If $BMU_1 < MRU_1$
$\downarrow \quad \downarrow$
$x_{u1} < d_f$. This is first case.

a) Find out x_{u1} by equating BMU_1 = MR formula

i.e $B.M_{U1} = 0.36 f_{ck} B_f x_{u1} (d - 0.42 x_{u1})$

So get $x_{u1} = ?$

b) **Area of steel :**

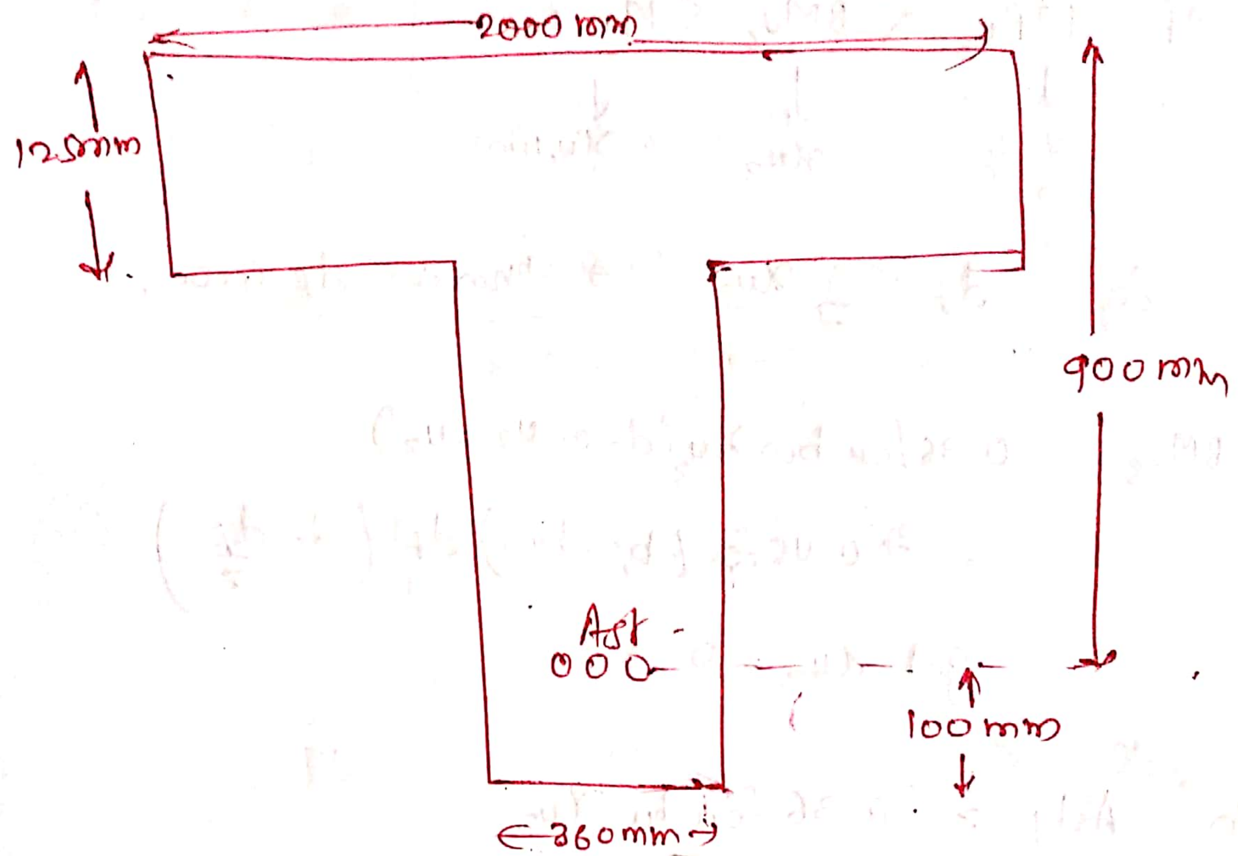
$$B.M_{u_1} = 0.87\, f_y A_{st} (d - 0.42 x_u)$$

$$\therefore A_{st} = \frac{BM_{u_1}}{0.87 f_y (d - 0.42 x_u)} \quad \text{—— (A)}$$

Q) A T beam as shown in fig is simply supported over an effective span of 10 m. Design the beam; if the beam is subjected to following B.M's. Use M25, Fe 500.

factored Moment

Design for (I) 450 kN-m } = 675 kN-m



Sol^n finding M.O.R at specified locations.

1) when $x_u = d_f$.

So $M_{RU_1} = 0.36 f_{ck} b_f d_f (d - 0.42 d_f)$

and $b_f = \frac{l_o}{\left(\frac{l_o}{B} + 4\right)} + b_w$

$= \frac{10{,}000}{\left(\frac{10{,}000}{2000} + 4\right)} + 360$

$= 1471.11$ mm

$\therefore M_{RU_1} = 0.36 \times 25 \times 1471.11 \times 125 (900 - 0.42 \times 125)$

$= 1402.61$ kN-m.

$x_{u,lim} = 0.46 \times 900 = 414$ mm

Case 1) when $BM_{u_1} = 1.5 \times 450 = 675$ kN-m.

Is $BM_{u_1} < MR_{u_1}$ → $\{x_u < d_f ?\}$ Ist Case.

Equating:

$$B.M_{u_1} = 0.36 f_{cu} . B_f . x_{u_1} (d - 0.42 x_{u_1})$$

$$675 \times 10^6 = 0.36 \times 25 \times 1471.11 x_{u_1} (900 - 0.42 x_{u_1})$$

$\therefore x_{u_1} = 58.23$ mm < 125 mm $\checkmark$ OK

So $A_{st} = \dfrac{0.36 f_{cu} B_f x_{u_1}}{0.87 f_y}$

$$= \frac{0.36 \times 25 \times 1471.11 \times 58.23}{0.87 \times 500}$$

$= 1772.33$ mm^2.

So provide 6-20mm ϕ bars.

Scanned with CamScanner

- Design of T-Beam for shear will be same as studied in Unit -5 of Syllabus.

→ <u>Types of Problems</u>:

1) Finding effective flange width.
2) Finding moment of resistance of T-Beam Section with N.A lies within or upto the bottom of flange.
ie ($x_u \leq d_f$).