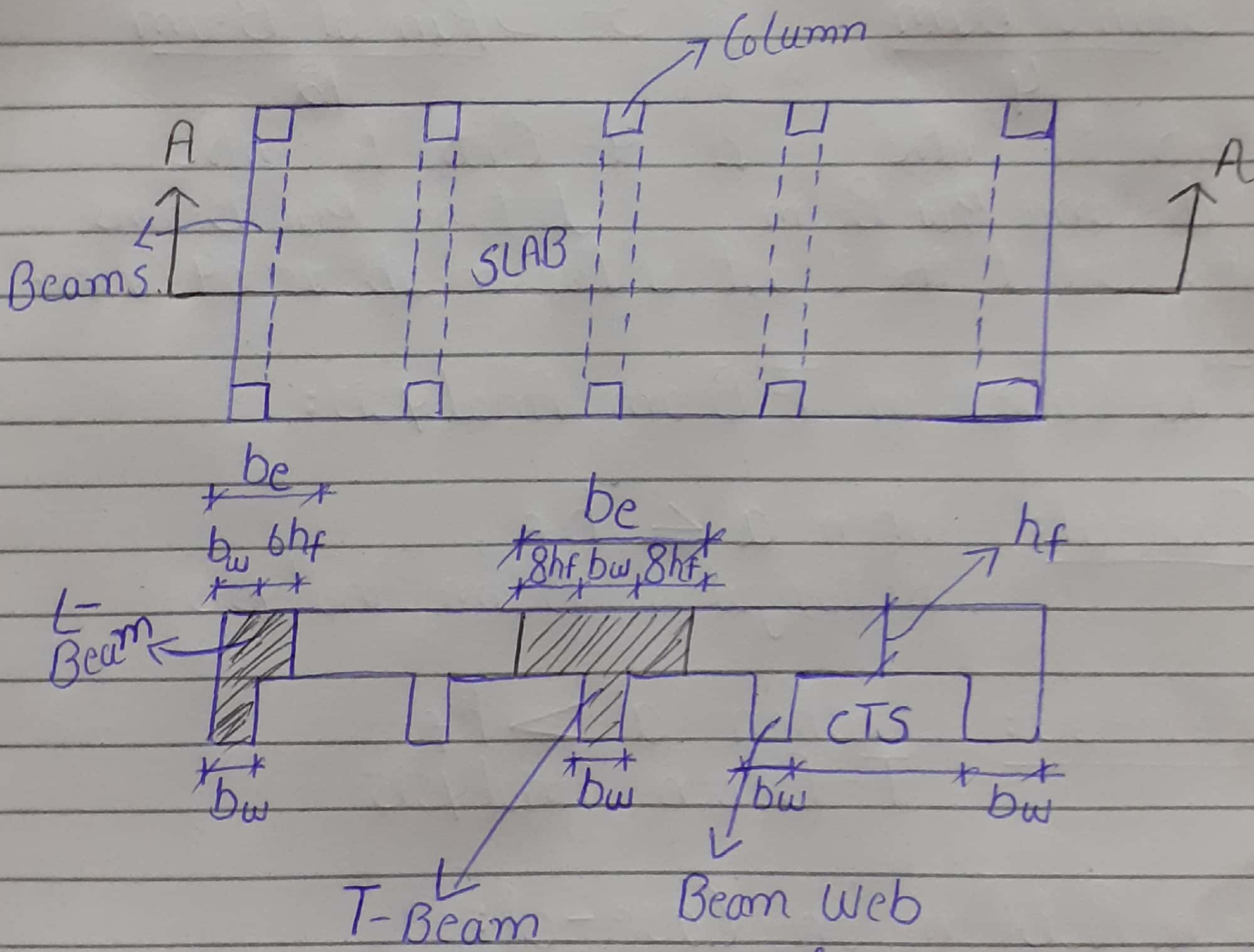
T-Beams and L-Beams: Beams with T-shape and L-shape cross-sections are built when concrete beams are poured monolithically with slabs to form the ~~th~~ floor of building and road way of bridges. The slab form the beam flange while the part of the beam projecting below the slab forms the web or, stem.



where; h_f = height of flange = Slab thickness
b_w = breadth of web or, stem of beam.
b_e = Effective breadth.
CTS = Clear Transverse Span.
L-Beam is also known as Edge Beam OR, Spandred Beam

Calculation of Effective Flange Width: (be):

T-Beam	L-Beam
1- $16 * h_f + b_w$	1- $6 * h_f + b_w$
2- $\frac{CTS}{2} + b_w$	2- $\frac{CTS}{2} + b_w$
3- $\frac{\text{Span of Bam}}{4}$	3- $\frac{\text{Span of Beam}}{12}$
4- Centre to Centre distance b/w Beam	4- Centre to Centre distance b/w Beams

Note: Select the least value in above 04 Cases.

Two Cases in T-Beam Analysis:

Case-01: when $a \leq h_f$,
Rectangular Beam Analysis

Case-02: when $a > h_f$
T-Beam Analysis

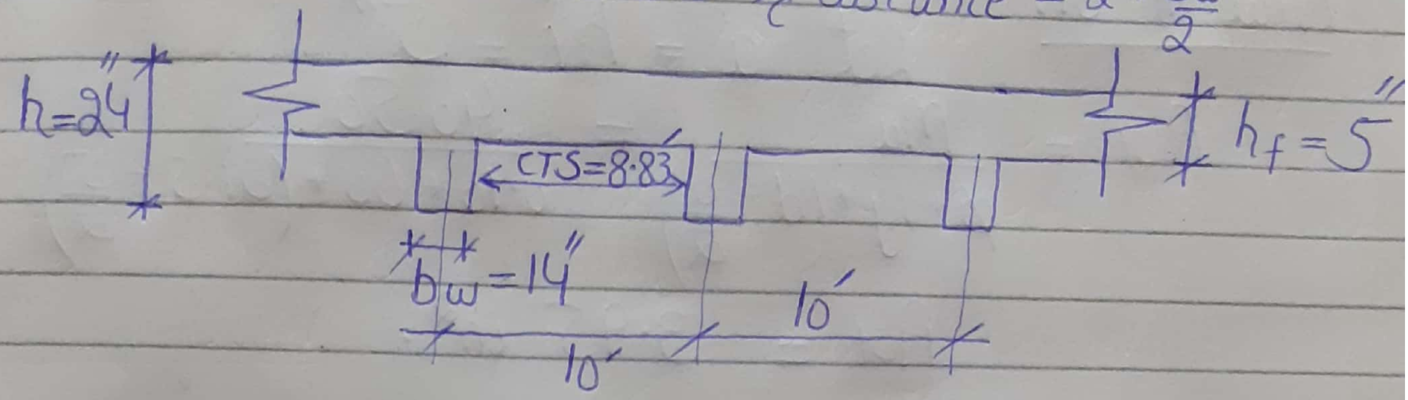
Design Problem on Case-01:

A roof of a hall has 5 inch thick slab supported on beams having 30 ft span. Beams are placed 10 ft centre to centre and has been cast monolithic with slab. Over all depth of the beam being 24 inch and width of the beam web being 14 inch. Calculate the steel reinforcement area for the beam for total factored load of 3000 lb/ft. over length of beam.

Use $f'_c = 3$ksi and $f_y = 60$ ksi

Sol:

CTS = c/c distance − 2 * $\frac{b_w}{2}$



$h_f = 5''$, c/c distance = 10', $l = 30'$
$h = 24''$, $d = 24 - 2.5 = 21.5''$, $b_w = 14''$,
$W_u = 3000$ lb/ft = 3 kip/ft.
$f'_c = 3$ksi, $f_y = 60$ ksi

Step-01: Ultimate factored moment;

$$M_u = \frac{W_u * l^2}{8} = \frac{3 * (30)^2}{8} * 12 = 4050 \text{ K-inch}$$

Step-02: Calculate effective width 'be':

For T-Beam:

1- $16 * h_f + b_w = 16 * 5 + 14 = 94''$.
2- c/c distance = $10 * 12 = 120''$.
3- Span/4 = $\frac{30}{4} * 12 = 90''$
4- $\frac{CTS}{2} + b_w$ = ~~10 * 12~~ If c/c distance is given, then there is no need for this check or, condition-4.

Select least value of 'be' from above;

So, $b_e = 90''$

Step-03: Check whether Rectangular or, T-Beam Analysis is required;

Trial # 01:

Let $a = h_f = 5''$

$$A_{st} = \frac{M_u}{\phi * f_y * \left(d - \frac{a}{2}\right)} = \frac{4050}{0.90 * 60 * \left(21.5 - \frac{5}{2}\right)}$$

$$A_{st} = 3.95 \ in^2.$$

Trial # 02:

$$a = \frac{A_s * f_y}{0.85 * f'_c * b_e}$$

$$a = \frac{3.95 * 60}{0.85 * 3 * 90} = 1.03'' < h_f = 5''$$

$\Longrightarrow$ Rectangular Beam Design.

~~Trial # 03:~~

$$A_s = \frac{4050}{\phi * 60 * \left(21.5 - \frac{1.03}{2}\right)}$$

$$A_s = 3.57 \ in^2$$

Trial # 03:

$$a = \frac{3.57 * 60}{0.85 * 3 * 90} = 0.93''$$

$$A_s = \frac{4050}{0.90 * 60 * \left(21.5 - \frac{0.93}{2}\right)} = 3.57 \ in^2$$

Step # 04: Check ρ_{max} and ρ_{min}.

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

$$\rho_{max} = 0.85 * 0.85 * \frac{3}{60} * \left(\frac{0.003}{0.003 + 0.005}\right) = 0.013$$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60000} = 0.003$$

$$\rho = \frac{A_{st}}{b*d} = \frac{3.57}{14 * 21.5} = 0.0119$$

So; $\rho_{min} < \rho < \rho_{max} \Rightarrow$ O.K

Step # 05: Selection and No. of Bars:

Let try # 10 Main Bar having
Area of one # 10 bar = $1.27 \, in^2$

$\Rightarrow$ No. of Bars $= \frac{A_{st}}{A_b} = \frac{3.57}{1.27} = 2.81 \approx 3$

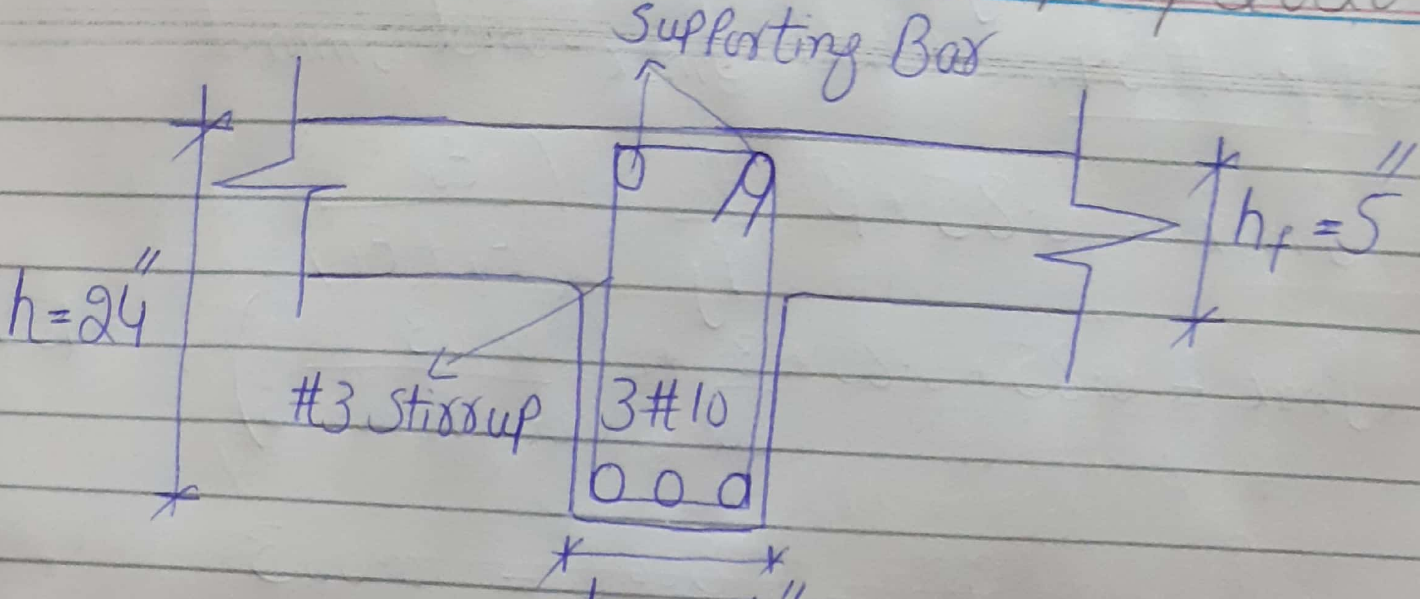
So, take 3 # 10 Main Bars.

Step # 06: Check on minimum width.

$$b_{min} = 2*1.5 + 2*\left(\frac{3}{8}\right) + 3*\left(\frac{10}{8}\right) + 2*\left(\frac{10}{8}\right)$$

$b_{min} = 10'' < 14''$

$\Rightarrow$ Main Bars is good in one Layer



Step # 07: Design Moment.

$$M_d = \phi * f_y * A_{st} * \left(d - \frac{a}{2}\right)$$

But first find 'A_{st}' and 'a'.

A_{st} = Area of one bar * No. of bars

$A_{st} = 1.27 * 3 = 3.81\ in^2$.

$$a = \frac{A_{st} * f_y}{0.85 * f'_c * b_e} = \frac{3.81 * 60}{0.85 * 3 * 90} = 1.00''$$

$$M_d = 0.90 * 60 * 3.81 * \left(21.5 - \frac{1}{2}\right)$$

$M_d = 4320.54$ k-inch

$> M_u = 4050$ k-inch

Okay.

Home Assignment: Example 3.14 and 3.15 on Page-108, 109, 110.

Book: Design of Concrete Structure (13 edition) by Nilson, Darwin and Dolan.