Lecture # 03 ; 03/04/2020

T Beam Design: Case-II : $a > h_f$

⇒ Depth of Compression Stress block extended into web.

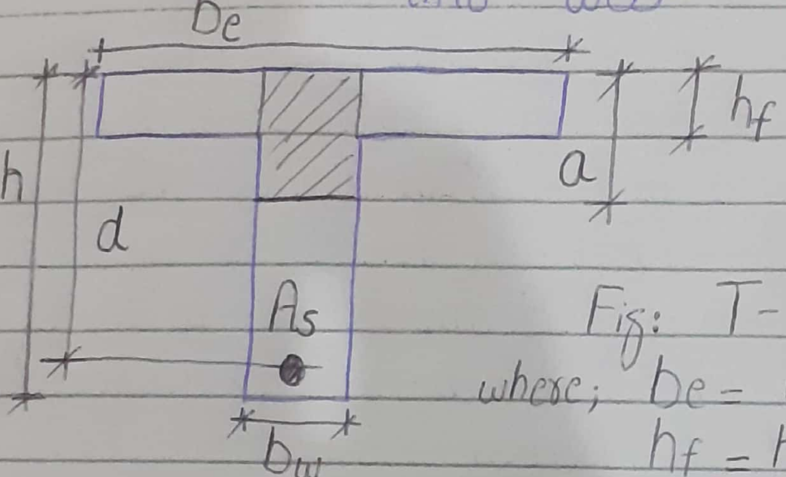


Fig: T-Beam Cross Section

where; b_e = Effective width of Beam
h_f = height of flange/slab thickness
a = depth of Compression block
h = Total depth of beam
d = Effective depth
b_w = breadth of web
A_s = Area of steel in tension zone.

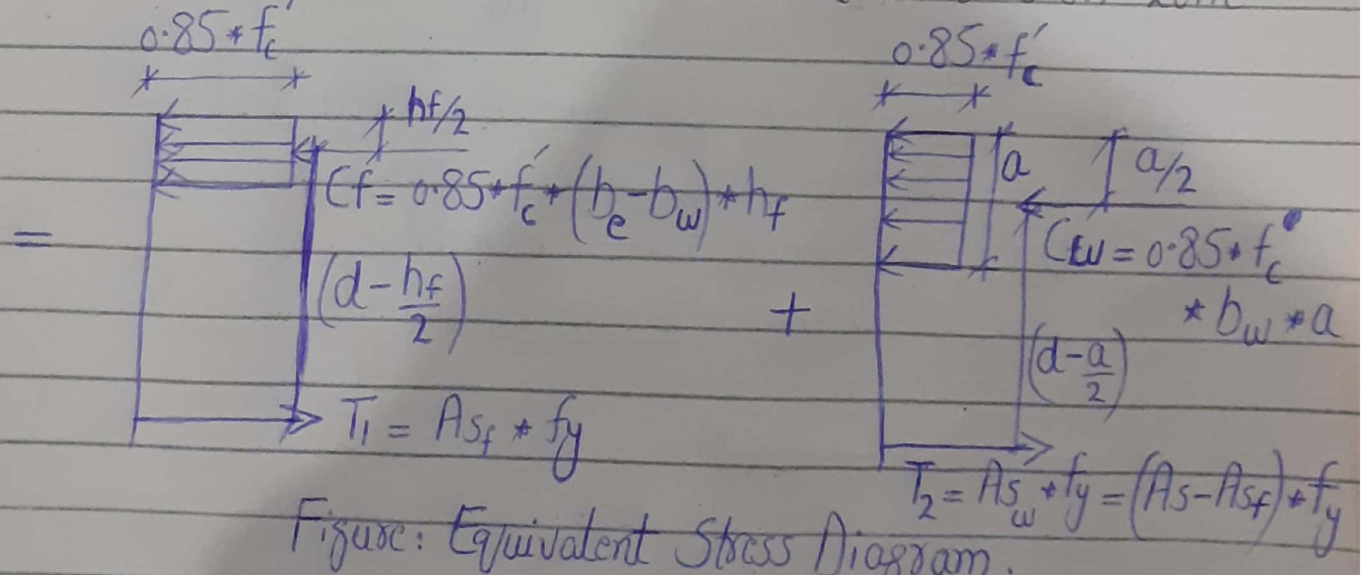


Figure: Equivalent Stress Diagram.

Total Tensile Steel Area = $A_s = A_{sf} + A_{sw}$

$$M_{n_1} = A_{sf} * f_y * \left(d - \frac{h_f}{2}\right) = 0.85 * f_c' * (b_e - b_w) * h_f * \left(d - \frac{h_f}{2}\right)$$

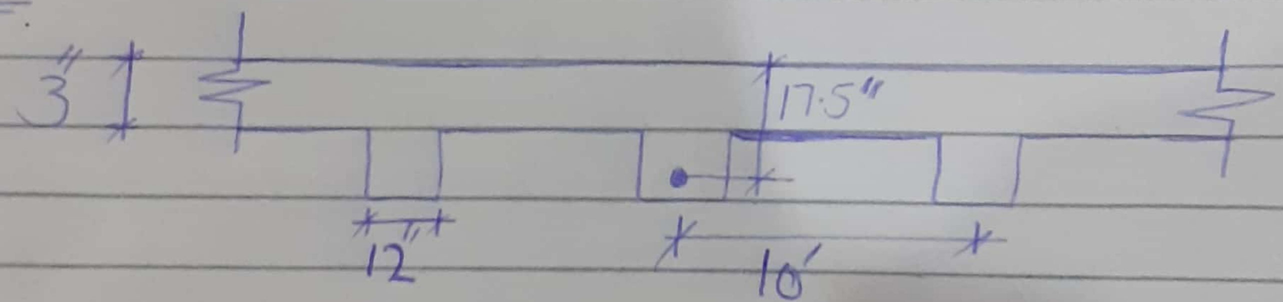
$$M_{n_2} = A_{sw} * f_y * \left(d - \frac{a}{2}\right) = 0.85 * f_c' * b_w * a * \left(d - \frac{a}{2}\right)$$

Note: To find value of 'a' for M_{n2}.

$$\Rightarrow a = \frac{A_{sw} * f_y}{0.85 * f'_c * b_w} = \frac{(A_s - A_{sf}) * f_y}{0.85 * f'_c * b_w}$$

Design Problem: A floor system consists of 3" slab supported by 18 ft. simple span beam having spaced at 10 ft. on centres. The beam have a web width 'b_w' of 12" and an effective depth 'd' = 17.5". Calculate the necessary reinf. for a typical interior T-Beam. If the factored applied moment is 6200 kip-inch. Use f'_c = 3000 Psi and f_y = 60 ksi

Sol:



Step-01: To find Effective breadth 'b_e':

a)- $16 * h_f + b_w = 16*3+12 = 60''$

b)- C/c distance = $10 * 12 = 120''$

c)- $\frac{\text{Span of beam}}{4} = \frac{18*12}{4} = 54''$

$\Rightarrow b_e = 54''$

Step-02: Check for rectangular or, T-Beam Analysis

Let $a = h_f = 3''$

$$A_s = \frac{M_u}{\phi * f_y * \left(d - \frac{a}{2}\right)} = \frac{6200}{0.90 * 60 * \left(17.5 - \frac{3}{2}\right)} = 7.18\ in^2$$

$$a = \frac{A_s * f_y}{0.85 * f'_c * b_e} = \frac{7.18 * 60}{0.85 * 3 * 54} = 3.13'' > h_f = 3''$$

$\Rightarrow$ T-Beam Analysis.

Step-03: Area of steel for flange section:

$$A_{sf} = \frac{0.85 * f'_c * (b_e - b_w) * h_f}{f_y} = \frac{0.85 * 3 * (54 - 12) * 3}{60}$$

$A_{sf} = 5.36\ in^2$

Step-04: Calculate Moment which can be resisted by 'A_{sf}' in Step-03.

$$M_{u_1} = \phi * A_{sf} * f_y * \left(d - \frac{h_f}{2}\right) = 0.90 * 5.36 * 60 * \left(17.5 - \frac{3}{2}\right)$$

$M_{u_1} = 4631\ k''$

Step-05: Difference b/w Externally applied moment & moment resisted by 'A_{sf}'.

$M_{u_2} = M_u - M_{u_1} = 6200 - 4631 = 1569$ Kip-inch

Step-06: Find 'A_{sw}' for this extra moment 'M_{u2}'.

As, You already know that from Page-01 that $A_{sw} = A_s - A_{sf}$

So, $A_{sw} = \dfrac{M_{u2}}{\phi * f_y * (d - \frac{a}{2})} = \dfrac{1569}{0.90 * 60 * (17.5 - \frac{3.5}{2})}$

Let $a = 0.2 * h \approx 3.5''$

$A_{sw} = 1.84 \text{ in}^2$

Step-07: Total Tensile Steel Area:

$A_s = A_{sf} + A_{sw}$

$= 5.36 + 1.84 = 7.20 \text{ in}^2$

Step-08:

Selection of Bars:

Let try # 10 bar having

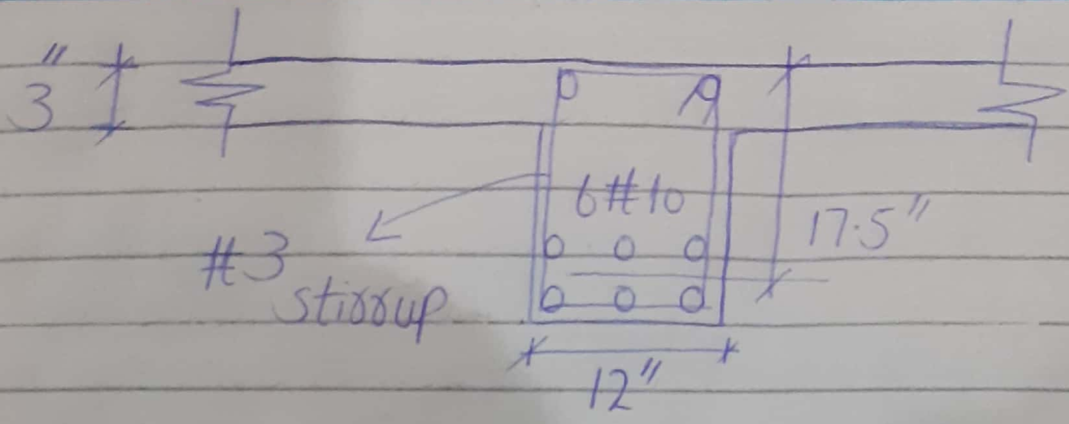
dia of bar $= \left(\frac{10}{8}\right)''$

and Area $= \frac{\pi}{4} * d_b^2 = \frac{3.14}{4} * \left(\frac{10}{8}\right)^2$

$A_b = 1.27 \text{ in}^2$

No. of Bars $= \dfrac{A_s}{A_b} = \dfrac{7.20}{1.27} = 5.68 \approx 6$ # 10 bars

Actual $A_s = 6 * 1.27 = 7.62 \text{ in}^2$



Step-09: Check Moment Capacity/Design Moment.

$$M_d = \phi * \left[A_s * f_y * \left(d - \frac{h_f}{2}\right) + (A_s - A_{sf}) * f_y * \left(d - \frac{a}{2}\right) \right]$$

But first find 'a'.

$$a = \frac{(A_s - A_{sf}) * f_y}{0.85 * f'_c * b_w}$$

$$a = \frac{(7.62 - 5.36) * 60}{0.85 * 3 * 12} = 4.43''$$

$$M_d = 0.90 * \left[5.36 * 60 * \left(17.5 - \frac{3}{2}\right) + (7.62 - 5.36) * 60 * \left(17.5 - \frac{4.43}{2}\right) \right]$$

$$M_d = 6496.42\ K'' > M_u = 6200\ K''$$

$\Rightarrow$ Design is OK.

Assignment Problem on T-Beam (Case # 02):

Compute the Positive Moment Strength (Md) for the beam shown in given figure. Assume that the concrete strength and steel strength are 3000 Psi and 60 ksi respectively. Also assume that the beam contains #3 stirrups as shear reinforcement which are not shown in Figure;

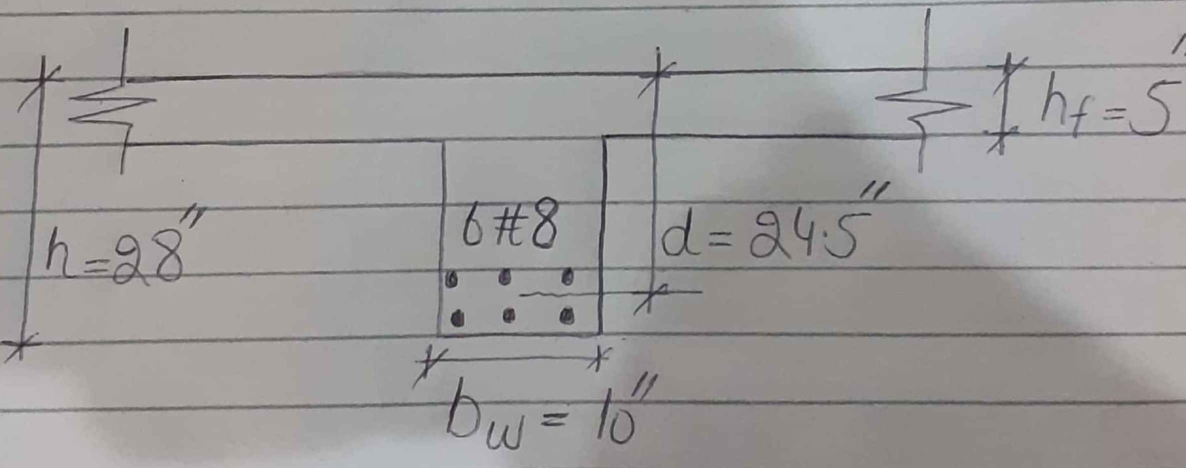


Figure: T-Beam Cross-Section.