Flexural Design of T-Sections

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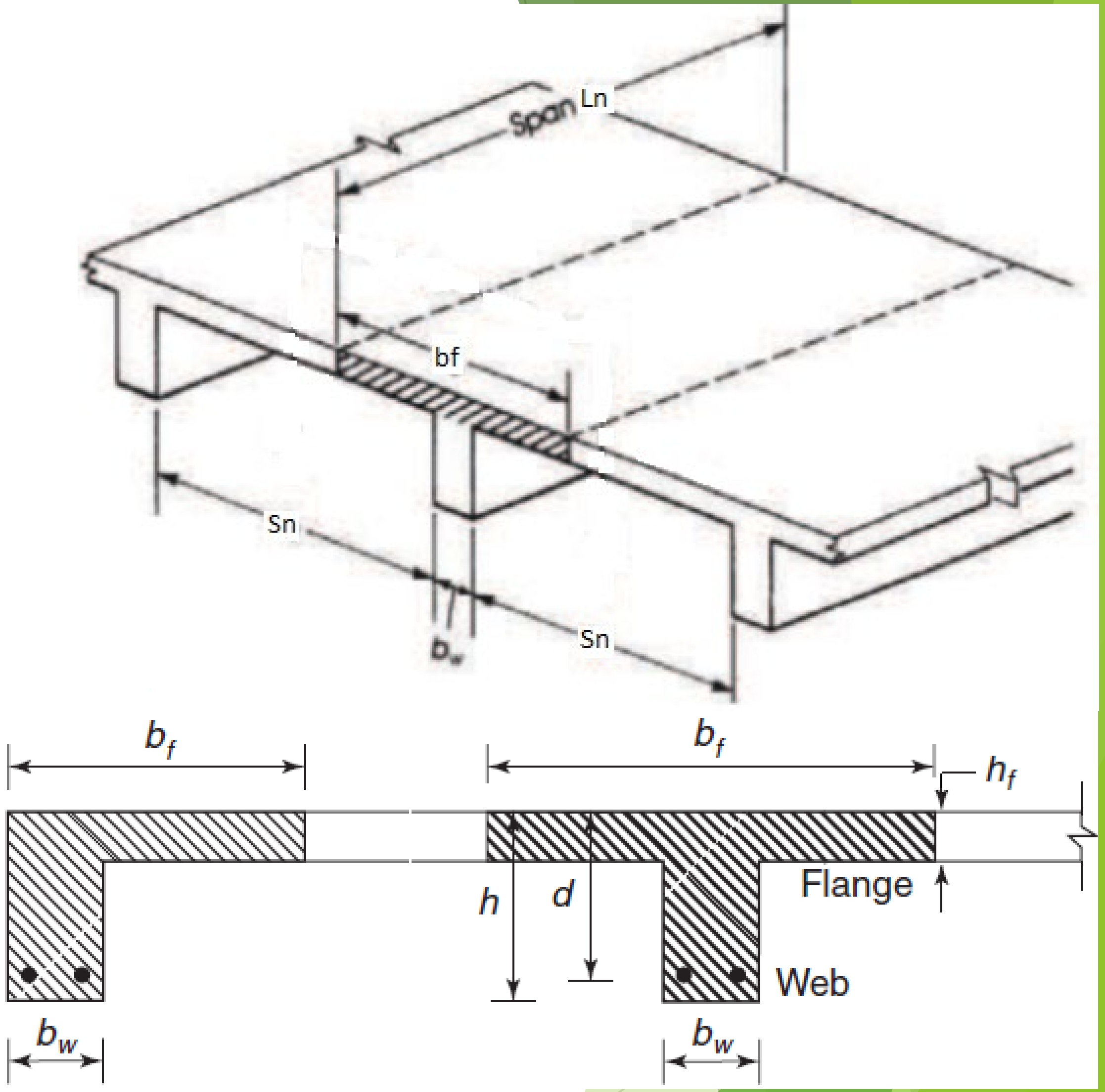
$$(T - Section):\ bf \le \begin{cases} bw + 2(8hf) \\ bw + 2\left(\dfrac{Ln}{8}\right) \\ bw + 2\left(\dfrac{Sn}{2}\right) \end{cases}$$

$$(L - Section):\ bf \le \begin{cases} bw + (6hf) \\ bw + \left(\dfrac{Ln}{12}\right) \\ bw + \left(\dfrac{Sn}{2}\right) \end{cases}$$

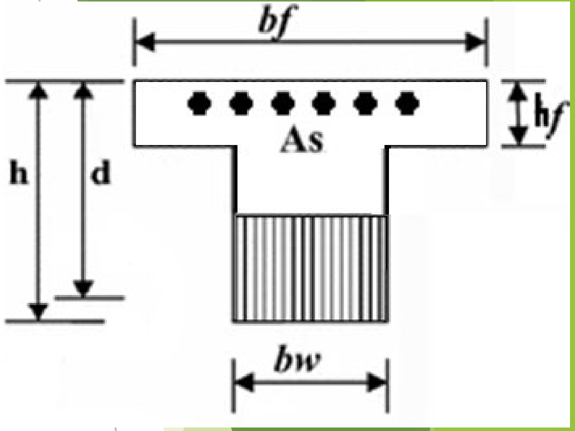
$$Isolated\ T\ beam \begin{cases} bf \le 4\ b_w \\ hf \ge 0.5\ b_w \end{cases}$$



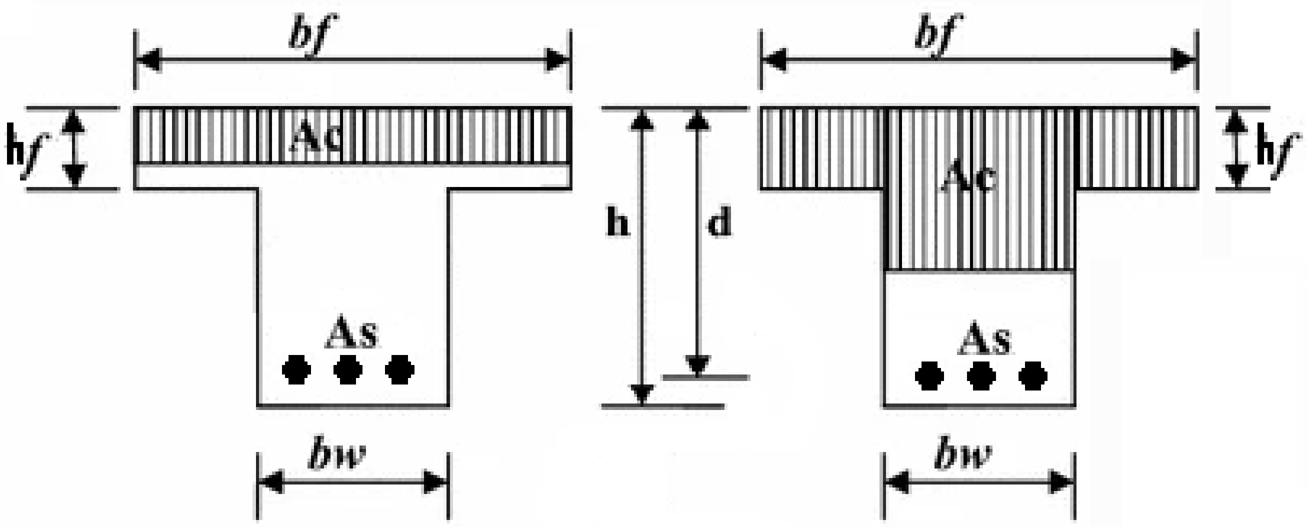
Generally, the depth of the beam is not determined depending on the T-section at the Mid-span, instead, the depth is calculated depending on the rectangular section at the support or depending on the max. Shear.

There are two cases for design of T-Section:

1. The T-Section is subjected to Negative B.M, “near the supports”.
   For this case the flange is subjected to tension, and will be not effective in resisting B.M, so the section will be a rectangular section with b=bw.



2. The T-Section is subjected to Positive B.M, “near midspan”. For this case there are two possibilities:
   a. The dimensions of the sections are known, “h, bw, bf, & hf” and the unknown is only As.
   b. The depth of the section “h” or “d” are unknowns as well as the As.



Design for case "a" the unknow is "As" only

1. Calculate the effective depth 'd' by assuming one layer or two layers of tension reinforcement:

$$d = h - 65 \qquad (one\ layer\ rein.)$$

$$d = h - 90 \qquad (two\ layers\ rein.)$$

2. Assume a=hf and calculate the Mnf

$$M_{nf} = 0.85\ f_c'\ b_f\ h_f\ \left(d - \frac{h_f}{2}\right)$$

$$if\ M_{nf} \begin{cases} \geq \dfrac{M_u}{\emptyset} & Case\ I: rectangular\ section \\ < \dfrac{M_u}{\emptyset} & Case\ II: True\ T\ section \end{cases}$$

For Case I: Design as a rectangular section with b=bf

For Case II (T.T.S): Calculate Mnov

$$M_{nov} = 0.85\ f_c'\ h_f\ (b_f - b_w)\left(d - \frac{h_f}{2}\right)$$

$$A_{sov} = \frac{0.85\, f_c'\, h_f \left(b_f - b_w\right)}{f_y}$$

$$M_{n1} = \frac{M_u}{\emptyset} - M_{nov}$$

$$R_{n1} = \frac{M_{n1}}{b_w\, d^2}$$

$$\rho_1 = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2m\, R_{n1}}{f_y}}\right)$$

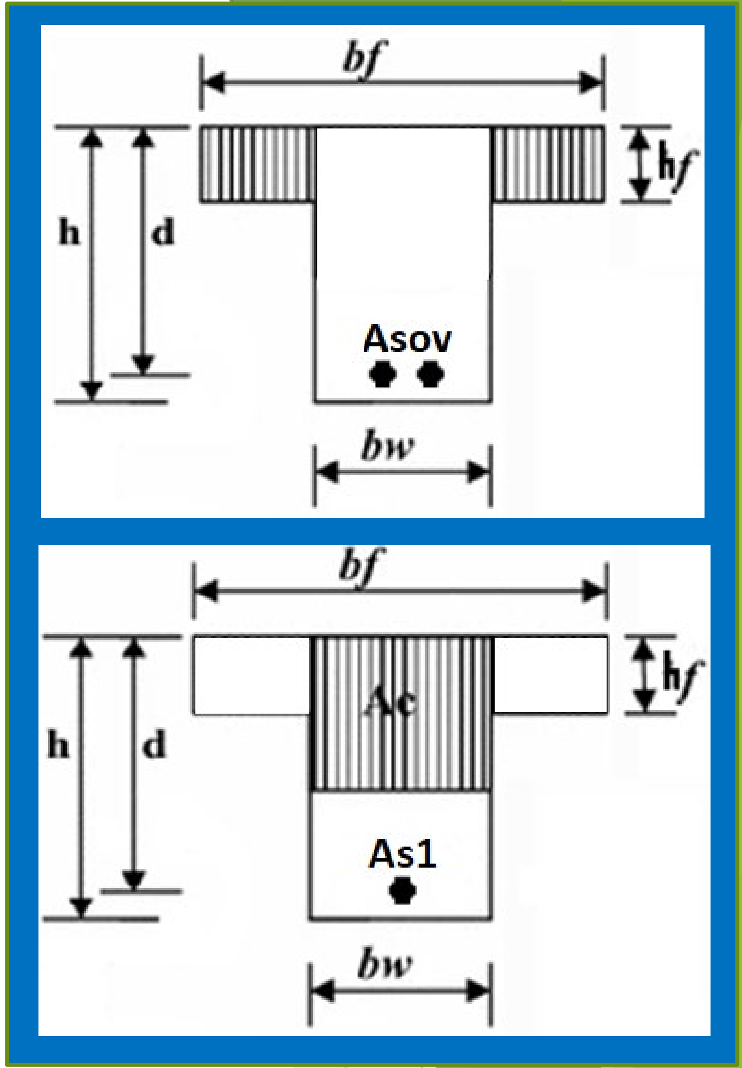
$$A_{s1} = \rho_1\, b_w\, d$$

$$A_s = A_{s1} + A_{sov}$$

$$\rho_1 \leq \rho_{max} = \frac{3}{8}\,\frac{\beta_1}{m}\left(\frac{d_t}{d}\right) \quad \left(for\ tension\ control\right)$$

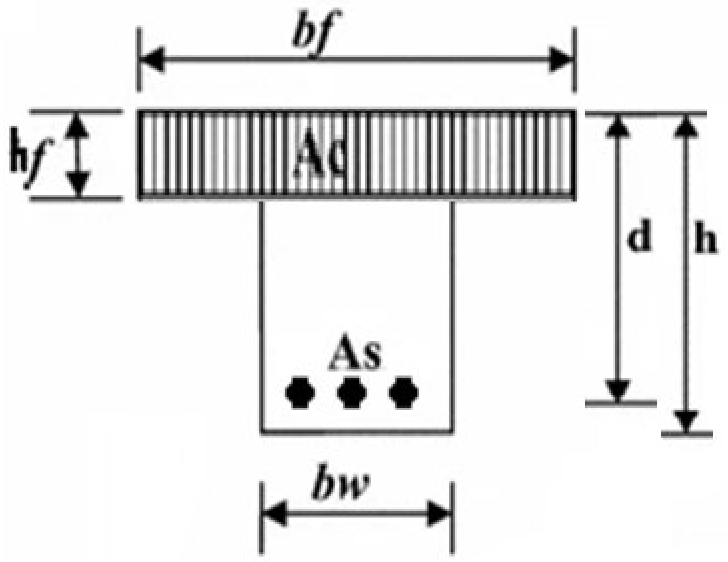
$$M_n = M_{n1} + M_{nov}$$

$$M_u = \emptyset\, M_n$$



3. For the case that (h , d & As) all are unknowns:

$$Assume\ a = h_f \quad (a\ rectangular\ section\ with\ b = bf)$$



$$A_s = \frac{0.85\, f_c'\, b_f\, h_f}{f_y}$$

$$M_n = \frac{M_u}{\emptyset} = A_s\, f_y \left(d - \frac{h_f}{2}\right)$$

$$d = \frac{M_n}{A_s\, f_y} + \frac{h_f}{2}$$

If value of d is acceptable then:

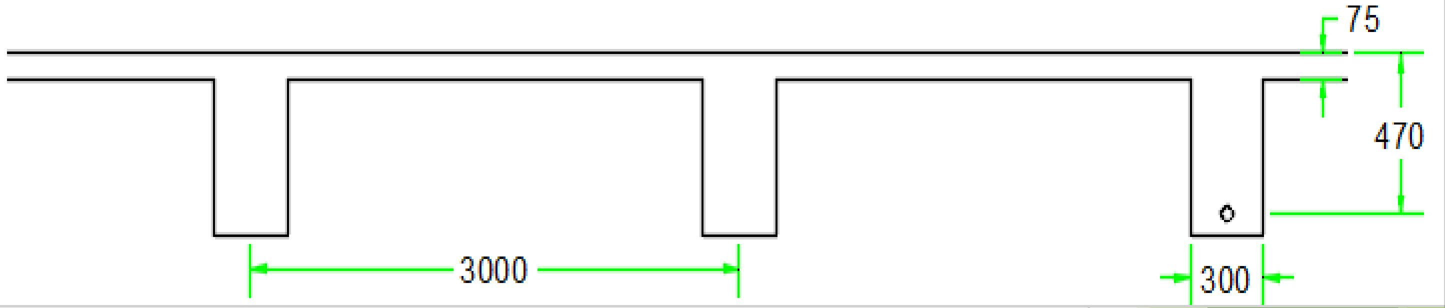
$$h = d + 65 \qquad (one\ layer\ rein.)$$

$$h = d + 90 \qquad (two\ layers\ rein.)$$

If we choose d(new) greater than the d calculated above, the section need to be redesign as a (rectangular section) with d=dnew

If we choose d(new) smaller than the d calculated above, the section need to be redesign as a (True T section) with d=dnew

Ex1: The floor system shown in figure, consist of 75mm slab supported by 4 m clear span beams, spaced at 3.0m on center. The beams have a web width bw=300mm, and an effective depth d=470mm. Calculate the necessary reinforcement for a typical interior beam if the factored applied moment=720 kN.m.
use fc'=21 MPa, fy=420MPa.



Solution:

$$(T - Section):\ bf \le \begin{cases} bw + 2(8hf) \\ bw + 2\left(\dfrac{Sn}{2}\right) \\ bw + 2\left(\dfrac{Ln}{8}\right) \end{cases}$$

$$(T - Section):\ bf \le \begin{cases} 300 + 2(8 \times 75) = 1500 \\ 300 + 2\left(\dfrac{2700}{2}\right) = 3000 \\ 300 + 2\left(\dfrac{4000}{8}\right) = 1300 \end{cases}$$

Then: bf=1300mm, d=470, Mu=720 kN.m

$$M_n = \frac{M_u}{\emptyset} = \frac{720}{0.9} = 800\ kN.m$$

assume a=hf

$$M_{nf} = 0.85\ f_c'\ b_f\ h_f\ \left(d - \frac{h_f}{2}\right)$$

$$M_{nf} = 0.85 \times 21 \times 1300 \times 75\ \left(470 - \frac{75}{2}\right) = 752.71 < 800\ (T.T.S)$$

$$M_{nov} = 0.85\ f_c'\ h_f (b_f - b_w) \left(d - \frac{h_f}{2}\right)$$

$$M_{nov} = 0.85 \times 21 \times 75 \times (1300 - 300) \left(470 - \frac{75}{2}\right)$$

$$M_{nov} = 579\ kN.m$$

$$A_{sov} = \frac{0.85\ \times 21 \times 75(1300 - 300)}{420} = 3187.5\ mm^2$$

$$M_{n1} = \frac{M_u}{\emptyset} - M_{nov}$$

$$M_{n1} = 800 - 579 = 221\ kN.m$$

$$R_{n1} = \frac{M_{n1}}{b_w\ d^2}$$

$$R_{n1} = \frac{221 \times 10^6}{300 \times 470 \times 470} = 3.335$$

$$\rho_1 = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2m\ R_{n1}}{f_y}}\right)$$

$$m = \frac{f_y}{0.85\ f_c'} = \frac{420}{0.85 \times 21} = 23.53$$

$$\rho_1 = \frac{1}{23.53}\left(1 - \sqrt{1 - \frac{2 \times 23.53 \times 3.335}{420}}\right)$$

$$\rho_1 = 0.00886$$

$$\rho_{max} = \frac{3}{8}\ \frac{\beta_1}{m}\left(\frac{d_t}{d}\right) = \frac{3}{8} \times \frac{0.85}{23.53} \times (1) = 0.0135 > 0.00886\ (ok.T.C)$$

$$A_{s1} = \rho_1\ b_w\ d = 0.00886 \times 300 \times 470 = 1249.26\ mm^2$$

$$A_s = A_{s1} + A_{sov}$$

$$A_s = 1249.26 + 3187.5 = 4436.76\ mm^2$$

$$A_{smin} = \frac{1.4}{f_y}\ b_w\ d$$

$$A_{smin} = \frac{1.4}{420}\ \times 300 \times\ 470 = 470\ mm^2 \ll 4436.76\ (ok)$$

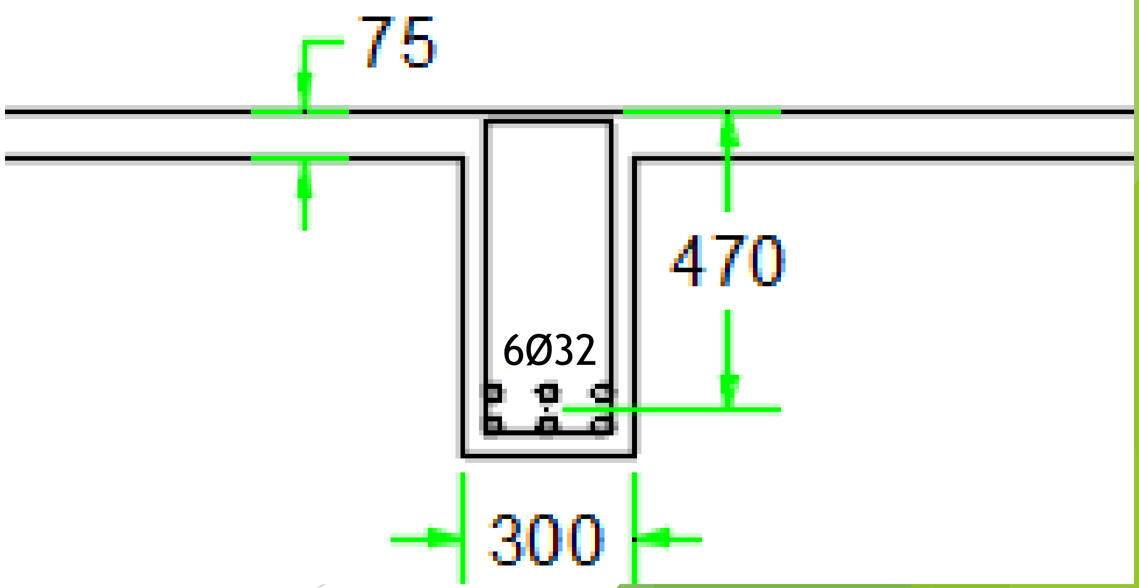
Use 6Ø32 in two layers:

$$As = 6 \times 804 = 4824\ mm^2 > 4436.76$$

$$As1(provided) = 4824 - 3187.5 = 1636.5\ mm^2$$

$$\rho_{1(provided)} = \frac{1636.5}{300 \times 470} = 0.0116 < 0.0135\ (ok.T.C)$$

$$s = \frac{200 - 3 \times 32}{2} = 52 > 32\ (ok)$$



Thank you…