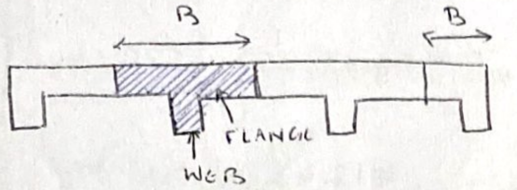
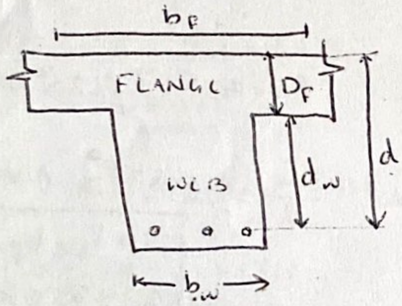
MODULE-2 Jahana

FLANGED BEAMS SECTIONS



- Common system
- In this system a portion of the slab of width B acts monolithically with the rectangular section of the beam giving rise to T-Beam
- Slab forms the compression flange while Narrow rectangular section forms the web of T-beam.



Terms

1) Breadth of the flange (b_f)
(cl 23.1.1 of IS 456 2000 page 36) and cl 23.1.2

2) Thickness of the flange (D_f)
Thickness of flange is taken equal to the total thickness of slab including cover.

3) Breadth of Web (b_w)
It is equal to width of the portion of the beam in tensile zone.

4) Depth of web (d_w)
Vertical distance b/w the bottom of flange and centre of tensile reinforcement

$$d = d_w + D_f$$

ANALYSIS OF FLANGED SECTIONS

1) When $x_u < D_f$ [

Find value of

→ $\frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f d}$ [cl. G.1.1 a]

→ If $\frac{x_u}{d} < \frac{x_{umax}}{d}$ [cl G.1.1.b]

$$M_u = 0.87 f_y A_{st} d \left(1 - \frac{A_{st} f_y}{b_f b f_{ck}}\right)$$

→ If $\frac{x_u}{d} = \frac{x_{umax}}{d}$ [cl G.1.1.c]

$$M_{ulim} = 0.36 \frac{x_{umax}}{d}\left(1 - 0.42 \frac{x_{umax}}{d}\right) b_f d^2$$

2) When $x_u > D_f$

i) $\frac{D_f}{d} < 0.2$ [cl G.2.2]

$$M_u = 0.36 \frac{x_{umax}}{d}\left(1 - 0.42 \frac{x_{umax}}{d}\right) f_{ck} b_w d^2 + 0.45 f_{ck}(b_f - b_w) D_f \left(d - \frac{D_f}{2}\right)$$

ii) $\frac{D_f}{d} > 0.2$ [cl G.2.2.1] , $y_f < D_f$

$$M_u = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] f_{ck} b_w d^2 + 0.45 f_{ck}(b_f - b_w) y_f \left(d - \frac{y_f}{2}\right)$$

where,

$$y_f = (0.15 x_u + 0.65 D_f)$$

3) $x_{umax} > x_u > D_f$, $\frac{D_f}{x_u} < 0.43$
(cl G.2.2)

Put x_u for x_{umax}

$x_{umax} > x_u > D_f$, $\frac{D_f}{x_u} > 0.43$
(cl G.2.2.1)

Substitute x_u for x_{umax}

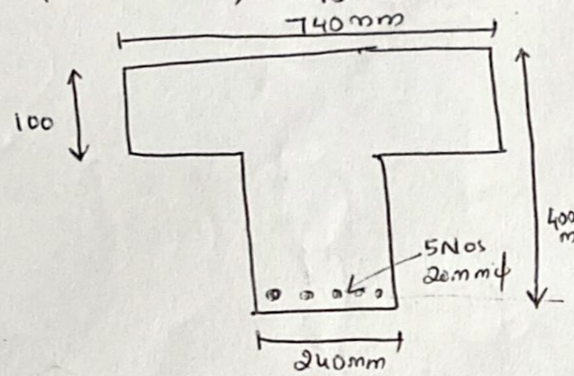
QUESTIONS

1) Determine the moment of resistance of an T-beam with following data.

$b_f = 740mm$, $d = 400mm$,

$b_w = 240mm$, $A_{st} = 5, 20mm\ \phi$ Fe 250

$D_f = 100mm$, M15 Concrete.



ans: $A_{st} = 5 \times \frac{\pi}{4} \times 20^2 = 1570mm^2$

From cl G.1.1 a of IS 456:2000

$$\frac{x_u}{d} = \frac{0.87 \times 250 \times 1570}{0.36 \times 15 \times 740 \times 400}$$

$$= 0.2136$$

$$x_u = 0.2136 \times d$$
$$= 0.2136 \times 400$$
$$= 85.5mm$$

$85.5 < 100$

$x_u < D_f$

∴ N.A lies inside flange. It behaves as a rectangular section.

$$\frac{x_{u_{max}}}{d} = 0.53$$

$$\frac{x_u}{d} < \frac{x_{umax}}{d}$$

It is under reinforced s/n.

From G.1.1 b of IS:456:2000,

∴ Moment of resistance

$$M_u = 0.87 \times f_y A_{st}\, d\left[1 - \frac{A_{st} f_y}{b_f d f_{ck}}\right]$$

$$= 0.87 \times 250 \times 1570 \times 400\left[1 - \frac{1570 \times 250}{740 \times 400 \times 15}\right]$$

$$= 1245kNm$$

2) Determine the moment of resistance of a T-beam with following data

$b_f = 740mm$, $d = 400mm$, $b_w = 240mm$

$A_{st} = 5, 20mm\ \phi$ fe 250 steel,

$D_f = 80mm$, M_{15} Concrete.

ans: $A_{st} = 5 \times \frac{\pi}{4} \times 20^2 = 1570mm^2$

$$\frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f d}$$
$$= \frac{0.87 \times 250 \times 1570}{0.36 \times 15 \times 740 \times 400}$$
$$= 0.2136.$$

$$x_u = 0.2136 \times d$$
$$= 0.2136 \times 400$$
$$= 85.5mm.$$

$x_u > D_f$, $\frac{x_{umax}}{d} = 0.53$

∴ N.A lies outside flange.

$\frac{D_f}{d} = \frac{85}{400} = 0.2125$ $\frac{D_f}{x_u} = \frac{80}{85.5} = 0.93 > 0.43$

$\frac{D_f}{d} > 0.2$

$$\cancel{M_u = 0.36\frac{x_{umax}}{d}\left[1-0.42\frac{x_{umax}}{d}\right] f_{ck} b d^2}$$
$$\cancel{+0.45 f_{ck}(b_f-b_w)y_f\left(d-\frac{y_f}{2}\right)}$$
$$\cancel{=0.36\times0.53\left[1-0.42\times0.53\right]\times15\times240\times400^2}$$
$$\cancel{+0.45\times15\left[740-240\right]\times64.825\times\left(400-\frac{64.825}{2}\right)}$$
$$\cancel{=85436881.92+80422401.44}$$
$$\cancel{=165.859\,kNm}$$

Find New value of x_u by equating $C_u = T_u$

$T_u = 0.87 f_y A_{st}$

$= 0.87\times250\times1570$

$= \underline{341475}$

$C_u = 0.36 f_{ck} b_w x_u + 0.45 f_{ck}(b_f-b_w)y_f$

$y_f = 0.15x_u + 0.65D_f$

$y_f = 0.15x_u + 0.65\times80$

$C_u = 0.36 f_{ck} b_w x_u + 0.45 f_{ck}(b_f-b_w)\left[0.15x_u+0.65\times D_f\right]$

$= 0.36\times15\times240\,x_u +$
$0.45\times15(740-240)\left[0.15x_u+0.65\times80\right]$

$= 1296x_u + 506.25x_u + 175500$

equating $C_u = T_u$

$1296x_u + 506.25x_u + 175500 = 341475$

$1802.25x_u = 165975$

$x_u = 92.09$

$\therefore y_f = 0.15\times92.09 + 0.65\times80 = 65.8135$

$\therefore y_f < D_f$

$\frac{D_f}{x_u} = \frac{80}{92.09}$

$= 0.86$

$\frac{D_f}{x_u} > 0.43$

$\therefore$ In cl. G.2.2.1 Sub x_{umax} by x_u

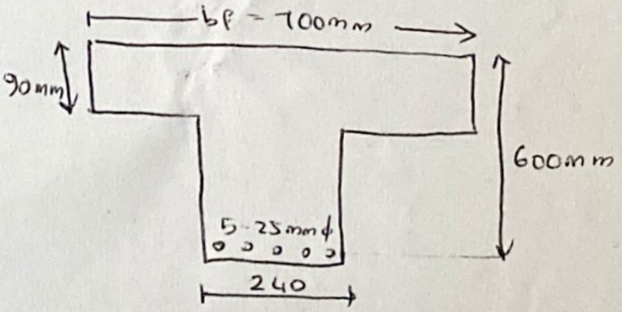
$$M_u = 0.36\frac{x_u}{d}\left[1-0.42\frac{x_u}{d}\right] f_{ck} b_w d^2 + 0.45 f_{ck}(b_f-b_w)y_f\left(d-\frac{y_f}{2}\right)$$

$$= 0.36\times\frac{92.09}{400}\left[1-0.42\times\frac{92.09}{400}\right]\times15\times240\times400^2$$
$$+0.45\times15\left[740-240\right]\times65.8135\times\left[400-\frac{65.8135}{2}\right]$$

$= 43123313.17 + 79061079.74$

$= \underline{122.184\,kNm}$

3) Determine the moment of resistance of T-beam shown in figure. Use M15 & Fe 415 steel



$A_{st} = 5\times\frac{\pi}{4}\times25^2 = 2454.4\,mm^2$

$\frac{x_u}{d} = \frac{0.87\times415\times2454.4}{0.36\times15\times700\times600} = 0.39$

$\frac{x_{umax}}{d} = 0.48$

$\frac{x_u}{d} < \frac{x_{umax}}{d}$

$\frac{x_u}{d} = 0.39$

$x_u = 0.39 \times 600$

$= 234mm$

$x_u > D_f$

N.A falls outside the flange.

To find new value of x_u

$T_u = C_u$

$\frac{D_f}{D} < 0.2$ [cl. G.2.2 of IS456:2000]

$T_u = 0.87 f_y A_{st}$

$= 0.87 \times 415 \times 2454.4$

$= 886161 N$

$C_u = 0.36 x_u f_{ck} b_w + 0.45 f_{ck} (b_f - b_w) D_f$

$= 0.36 \times x_u \times 15 \times 240 +$

$0.45 \times 15 [700 - 240] \times 90$

$= 1296 x_u + 279450$

$C_u = T_u$

$1296 x_u + 279450 = 886161$

$x_u = 468.14 mm$

$x_{umax} = 0.48 \times 600$

$= 288$

$x_u > x_{umax}$

Moment of resistance limited to M_{ulim}.

$M_u = M_{ulim} = 0.36 \frac{x_{umax}}{d} \left(1 - 0.42 \frac{x_{umax}}{d}\right) f_{ck} b_w d^2$

$+ 0.45 f_{ck} (b_f - b_w) D_f \left(d - \frac{D_f}{2}\right)$

$= 0.36 \times 0.48 (1 - 0.42 \times 0.48) \times 15 \times 240 \times 600^2$

$+ 0.45 \times 15 [700 - 240] \times 90 \left(600 - \frac{90}{2}\right)$

$= 178800721.9 + 155094750$

$= 333.895 kNm$