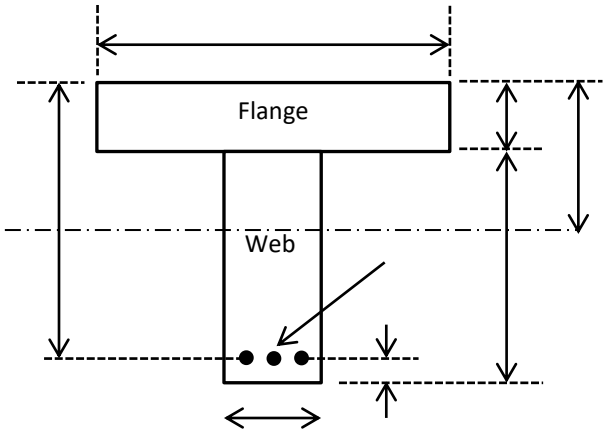
T-Beam: Analysis (IS: 456-2000 and SP: 16)

Given:

- Width of flange = b_f (mm)
- Depth of flange = D_f (mm)
- Width of web = b_w (mm)
- Effective depth = d (mm)
- Tension steel = A_{st} (mm^2)
- Concrete grade
- Steel grade



Find: Moment of resistance of T-beam (M_u) kN.m

Step:1 Find (F_c) and (F_t):

F_c = Compression force = $(0.36*f_{ck}*b_f*D_f)$ N

F_t = Tension force = $(0.87*f_y*A_{st})$ N

Step:2 Compare F_c and F_t:

CASE: 1

$F_c > F_t$ ⟷ $X_u < D_f$ Neutral axis is in flange.

Find: $X_u = (0.87*f_y*A_{st})/(0.36*f_{ck}*b_f)$ … (IS:456:page:96: G.1.1)… $b = b_f$

Find: $X_{u\text{-}max}$ … (SP:16:page:9-Table-B)

$X_u < X_{u\text{-}max}$ >>> $M_u = 0.87*f_y*A_{st}*d*(1-f_y*A_{st}/f_{ck}*b_f*d)$… (IS:456:page:96: G.1.1.b)… $b=b_f$

$X_u >= X_{u\text{-}max}$ >>> $M_u = 0.36* X_{u\text{-}max}/d*(1-0.42* X_{u\text{-}max}/d)*f_{ck}*b_f*d^2$…(IS:456:page:96: G.1.1.c)

CASE: 2

$F_c < F_t$ ⟷ $X_u > D_f$ Neutral axis is in web.

Find: X_u using following equation:

$C_1 + C_2 = T$

Where, $C_1 = (0.36*f_{ck}*b_w*X_u)$

$C_2 = (0.446*f_{ck}*(b_f - b_w)*D_f)$

$T = (0.87*f_y*A_{st})$

$X_u > D_f$ ... (OK)

find: $X_{u\text{-}max}$ ... (SP:16:page:9-Table-B)

$X_u < X_{u\text{-}max}$ and $D_f/X_u <= 0.43$ (Put: $X_{u\text{-}max} = X_u$)

$M_u = 0.36*X_u/d*(1-0.42*X_u/d)*f_{ck}*b_w*d^2 + 0.45*f_{ck}*(b_f - b_w)* D_f * (d - D_f / 2)$

(IS:456:page:96: G.2.2)

$X_u < X_{u\text{-}max}$ and $D_f/X_u > 0.43$ (Put: $X_{u\text{-}max} = X_u$) and $Y_f = (0.15*X_u + 0.65*D_f)$

$M_u = 0.36*X_u/d*(1-0.42*X_u/d)*f_{ck}*b_w*d^2 + 0.45*f_{ck}*(b_f - b_w)* Y_f * (d - Y_f / 2)$

(IS:456:page:97: G.2.2.1)

$X_u >= X_{u\text{-}max}$ and $D_f/d <= 0.2$ (Put: $X_{u\text{-}max} = X_{u\text{-}max}$)

$M_u = 0.36*X_{u\text{-}max}/d*(1-0.42*X_{u\text{-}max}/d)*f_{ck}*b_w*d^2 + 0.45*f_{ck}*(b_f - b_w)* D_f * (d - D_f / 2)$

(IS:456:page:96: G.2.2)

$X_u >= X_{u\text{-}max}$ and $D_f/d > 0.2$ (Put: $X_{u\text{-}max} = X_{u\text{-}max}$) and $Y_f = (0.15*X_u + 0.65*D_f)$

$M_u = 0.36*X_{u\text{-}max}/d*(1-0.42*X_{u\text{-}max}/d)*f_{ck}*b_w*d^2 + 0.45*f_{ck}*(b_f - b_w)* Y_f * (d - Y_f / 2)$

(IS:456:page:97: G.2.2.1)

$X_u < D_f$ ... (NOT OK)

$C_1 + C_2 = T$

Where, $C_1 = (0.36 * f_{ck} * b_w * X_u)$

$C_2 = (0.446 * f_{ck} * (b_f - b_w) * D_f)$

$T = (0.87 * f_y * A_{st})$

Put "D_f" = Y_f = $(0.15 * X_u + 0.65 * D_f)$, and find: X_u again.

Find: $X_{u\text{-}max}$ ... (SP:16:page:9-Table-B)

Check: $X_u > D_f$ and $Y_f < D_f$ (OK) Find: M_u as per above conditions.

- **To find width of flange (b_f) of T-Beam:**

$b_f = (L_o/6) + b_w + (6 * D_f)$ ... (IS:456-Page-37)

Where, L_o = Distance between point of zero moments

b_w = width of web (or) width of rib

D_f = Depth of flange (or) Thickness of flange