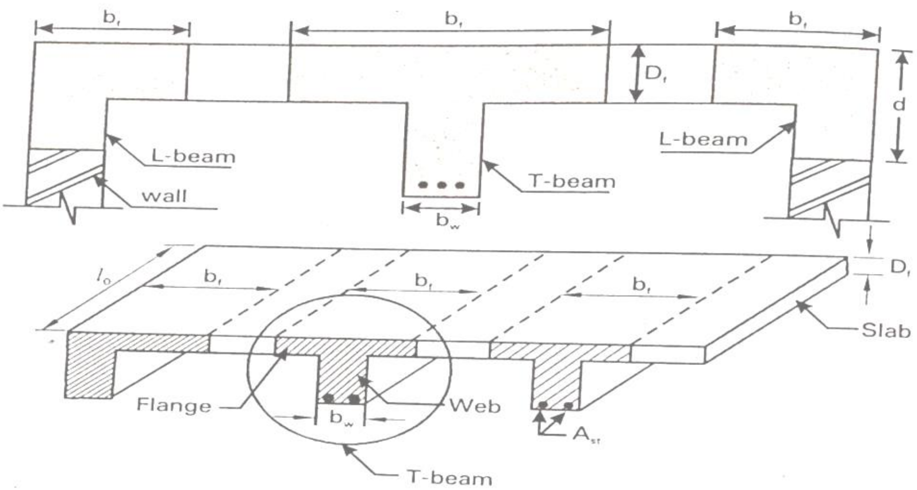
UNIT -II

DESIGN OF BEAMS

2.1 Analysis and design of Flanged beams

In actual practice, T-sections and L-sections are more common than the rectangular section since part of the RC slab, monolithic with the beam and participate with the structural behavior of the beam. For the same load and span T-beam and L- beam carries more moment of resistance than rectangular beams.



When a concrete slab is cast monolithically with and, connected to rectangular beams, a portion of the slab above the beam behaves structurally as a part of the beam in compression. The slab portions are called the flange and beam the web. If the flange projections are on either side of the rectangular web or rib, the resulting cross section resembles the T shape and hence is called a T-beam section. On the other hand, if the flange projects on one side, the resulting cross- section resembles an inverted L and hence is termed as L-beam.

Advantages of T-beam are

1.Beam and slab are casted monolithically hence; casting can be done at a time.

2.Slab and beam combined together to carry more bending moment.

For same section, T-beams have more M.R (flexural strength) than that ofrectangular beam.

EFFECTIVE WIDTH OF FLANGE:

It is that portion of slab which acts integrally with the beam and extends on either side of the beam forming the compression zone. The effective width of flange depends upon the span of the beam, thickness of slab and breadth of the web. It also depends upon the type of loads and support conditions.

As per code (clause 32.1.2 of IS: 456-2000)

Effective flange width for T and L beams are calculated as follows:

a) For T-beams: $b_f = l_0/6 + b_w + 6D_f$

b) For L-beams: $b_f = l_0/12 + b_w + 3D_f$

c) For isolated beams:

  i) For T-beams: $b_f = l_0/[(l_0/b)+4] + b_w$

  ii) For L-beams: $b_f = 0.5l_0/[(l_0/b)+4] + b_w$

Where,

b_f = effective width of the flange.

b_w = breadth of the web

D_f = thickness of the flange,

I = distance between point of zero moment (forcontinuous beam,

I = 0.7x (effective span of beam).

- First segment will be like a rectangular section and steel area A_{st1}.
- Second segment will be like a beam section having concrete section of area $[(b_f - b_w)D_f]$ and steel area of A_{st2}.
- Our consideration in design and analysis for depth of neutral axis $x_u > D_f$ will be ascertain the compressive force taken up by concrete in second segment and its line of action.
- If $x_u \le D_f$, the beam can be thought of as a rectangular section of width b_f. The stress distribution for various values of x_u

STEPS FOR CALCULATING DEPTH OF NEUTRAL AXIS AND MOMENT OF RESISTANCE:

Given: b_f, d, A_{st}, D_f, grade of steel and grade of concrete, span for load calculation.

Required: Factored moment or moment of resistance and load.

Case I: Neutral axis lies within the flange

Steps:1 Calculate depth of neutral axis assuming neutral axis lies within the flange

$X_u/d = (0.87.f_y.A_{st})/(0.36.f_{ck}.b.d)$

Calculate x_u

If $x_u \le D_f$ (Assumption is correct)

Where, D_f = depth of flange or slab

2.Note down the value of $x_{u,max}$ /d from IS:456-2000Calculate

$x_{u,max}$

If $x_u < x_{u,max}$ section is under reinforced, calculate the moment of resistance bythe following expression

$$M_u=0.87.\ f_y.\ A_{st}.d.\ [1-((\ f_y.\ A_{st})/(\ f_{ck}.b.d))]$$

3.If $x_u > x_{u,max}$ section is over reinforced, calculate the moment of resistance bythe following expression

$$M_{u.lim}= 0.36.\ f_{ck}.b_f.x_{u,max}.(\ d-0.42.x_{u,max})$$

Case II: Neutral axis lies below the flangeSteps:

Calculate neutral axis assuming neutral axis (NA) lies within flange. If $x_u > D_f$,assumption is wrong. NA lies below the flange.

Recalculate the value of x_u by using following relation $C_1+C_2=T$Where, C_1 = $0.36.f_{ck}.x_u.b_w$

$C_2 = 0.45.f_{ck}.(b_f - b_w).D_f$ $T = 0.87.\ f_y.\ A_{st}$

$0.36.f_{ck}.x_u.b_w + 0.45.f_{ck}.(b_f - b_w).D_f = 0.87.\ f_y.\ A_{st}$ (assume $(D_f / x_u) < 0.43$) andfind x_u

If $x_u > D_f$, assumption is correct, follow step 3.

If $x_u < D_f$, assumption is that $(D_f / x_u) > 0.43$

Then recalculate x_u by using relation $C_1 + C_2$ =

TWhere, $C_1 = 0.36.f_{ck}.x_u.b_w$

$C_2 = 0.45.f_{ck}.(b_f - b_w).y_f$

$T = 0.87.\ f_y.\ A_{st}$

$y_f = (0.15\ x_u + 0.65D_f$

If $x_u \geq x_{u,max}$ section is over reinforced or balanced.

D_f / d ≤ 0.2 use equation G.2.2 page No.96, IS:456-2000 for M_u calculation

$$M_{u.lim}= 0.36.\ f_{ck}.b_w.d^2.(x_{u,max}/d).(\ 1-0.42.(x_{u,max}/d)) + 0.45.f_{ck}.(b_f - b_w).D_f.(d-(D_f/2))$$

D_f / d > 0.2 use equation G.2.2.1 page No.97, IS:456-2000 for M_u calculation

$$M_{u.lim}= 0.36.\ f_{ck}.b_w.\ d^2.(\ (x_{u,max}/d).(\ 1-0.42.(x_{u,max}/d)) + 0.45.f_{ck}.(b_f - b_w).y_f.(d-(y_f/2))$$

Where, $y_f = (0.15\ x_u + 0.65D_f)$, but should not be greater than D_f.

If $x_u < x_{u,max}$ section is under reinforced.

1.D_f / $x_u \leq 0.43$ use equation G.2.2 page No.96, IS:456-2000 for M_u calculation

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

2.D_f / $x_u > 0.43$ use equation G.2.2.1 page No.97, IS:456-2000 for M_u calculation

$$M_u = 0.36.\ f_{ck}.b_w.\ d^2.(\ (x_u/d).(\ 1-0.42.(x_u/d)) + 0.45.f_{ck}.(b_f - b_w).y_f.(d-(y_f/2))$$

Where, $y_f = (0.15\ x_u + 0.65D_f)$, but should not be greater than D_f.