



Nilachal Polytechnic

Bhubaneswar

Sem. : 6th Subject : Structural Design I

Branch: Civil Engineering

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Text Book to be followed by Student / Faculty

Book- : A.K. Jain

Chapter-5: Analysis and Design of T-Beam (LSM)

1. Learning Objectives

Student will learn –

- identify the two types of numerical problems – analysis and design types,
- apply the formulations to analyse the capacity of a flanged beam,
- determine the limiting moment of resistance quickly with the help of tables of SP-16.

2. Essential Questions (Fundamental Question)

- What is flanged beam and where it is used?
- Write the provision for effective width of flange for an isolated T-beam.
- Define flange section.
- Define uses of T –Section.
- Draw a section derive each symbol.

3. Hours Required

Theory	2hr
Problems	3hr
Question & Answer Theory	3hr
Total	8hr

4. Question for Teaching / Assignment / Self Practice

Question sets	02 Marks	05 Marks	10Marks
Teaching	03	nill	03
Assignment	02	nill	02
Self Practice	nill	nill	01
Total	05	nill	06

Lesson Description

This lesson mentions about the two types of numerical problems (i) analysis and (ii) design types. In addition to explaining the steps involved in solving the analysis type of numerical problems, several examples of analysis type of problems are illustrated explaining all steps of the solutions both by direct computation method and employing SP-16. Solutions of practice and test problems will give readers the confidence in applying the theory explained in Lesson 10 in solving the numerical problems.

Enclosed :

1) Course Material.

Chapter-5

Analysis and Design of T-Beam (LSM)

5.11.1 Introduction

Lesson 10 illustrates the governing equations of flanged beams. It is now necessary to apply them for the solution of numerical problems. Two types of numerical problems are possible: (i) Analysis and (ii) Design types. This lesson explains the application of the theory of flanged beams for the analysis type of problems. Moreover, use of tables of SP-16 has been illustrated to determine the limiting moment of resistance of sections quickly for the three grades of steel. Besides mentioning the different steps of the solution, numerical examples are also taken up to explain their step-by-step solutions.

5.11.2 Analysis Type of Problems

The dimensions of the beam b_f , b_w , D_f , d , D , grades of concrete and steel and the amount of steel A_{st} are given. It is required to determine the moment of resistance of the beam.

Step 1: To determine the depth of the neutral axis x_u

The depth of the neutral axis is determined from the equation of equilibrium $C = T$. However, the expression of C depends on the location of neutral axis, D_f/d and D_f/x_u parameters. Therefore, it is required to assume first that the x_u is in the flange. If this is not the case, the next step is to assume x_u in the web and the computed value of x_u will indicate if the beam is underreinforced, balanced or over-reinforced.

Other steps:

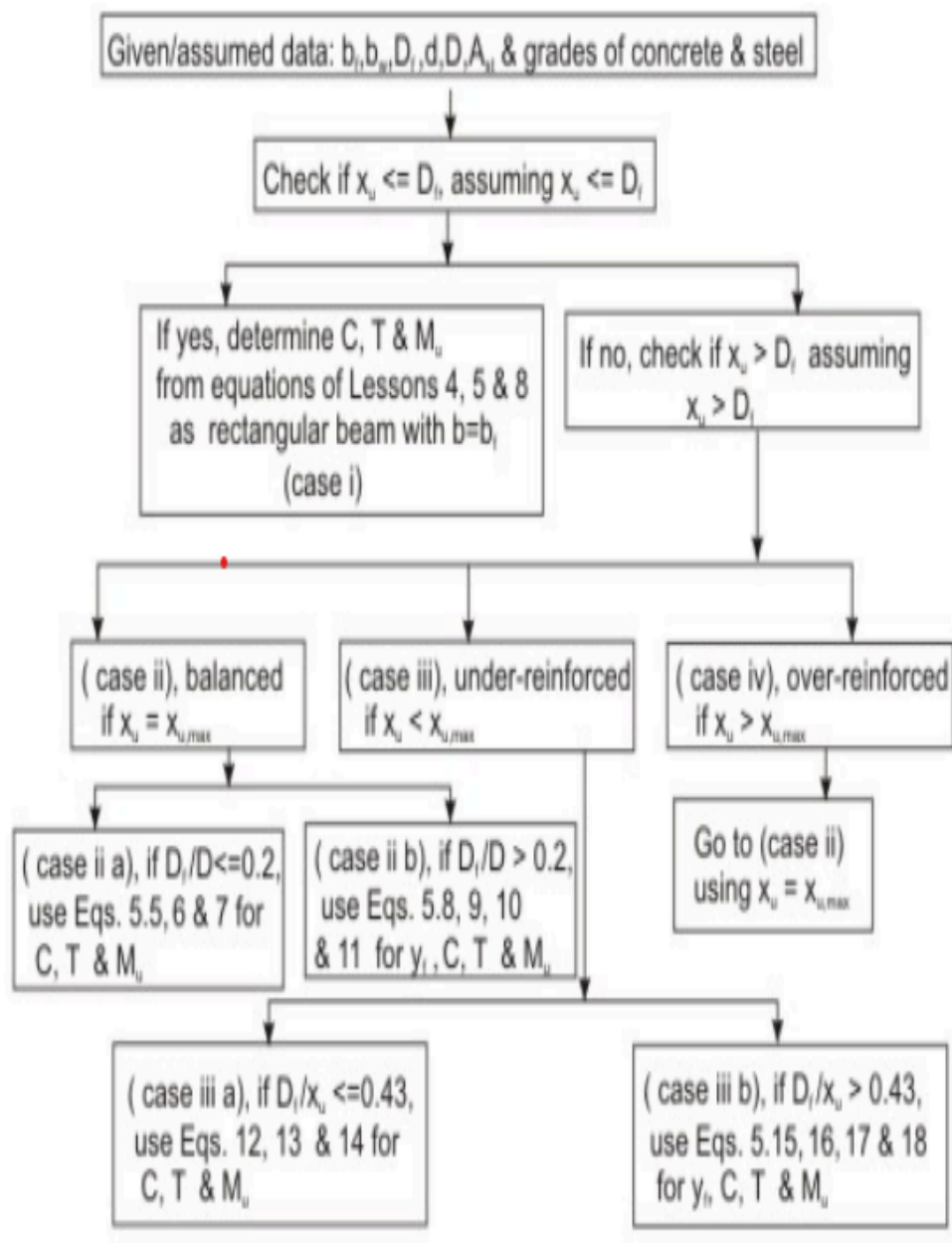


Fig. 5.11.1: Steps of solution of analysis type problems

After knowing if the section is under-reinforced, balanced or overreinforced, the respective parameter D_f/d or D_f/x_u is computed for the underreinforced, balanced or over-reinforced beam. The respective expressions of C , T and M_u , as established in Lesson 10, are then employed to determine their values. Figure 5.11.1 illustrates the steps to be followed.

5.11.3 Numerical Problems (Analysis Type)

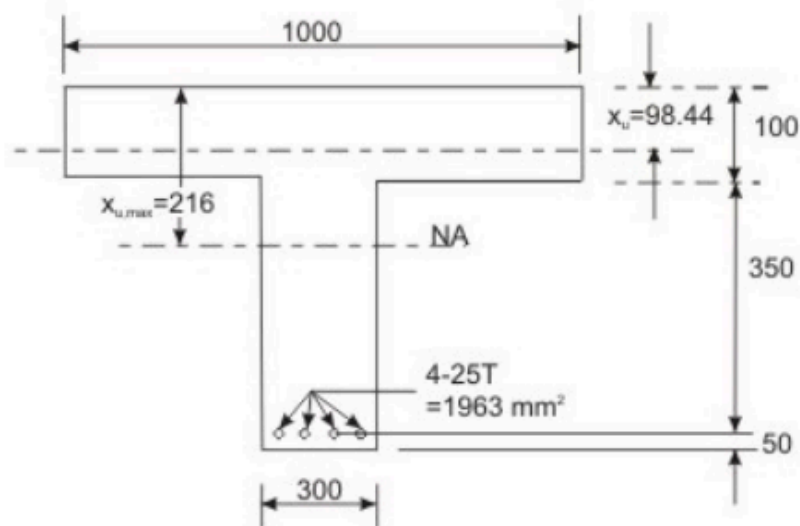


Fig. 5.11.2: Example 1, case (i)

Ex.1: Determine the moment of resistance of the T -beam of Fig. 5.11.2. Given data: $b_f = 1000$ mm, $D_f = 100$ mm, $b_w = 300$ mm, cover = 50 mm, $d = 450$ mm and $A_{st} = 1963$ mm² (4- 25 T). Use M 20 and Fe 415.

Step 1: To determine the depth of the neutral axis x_u

Assuming x_u in the flange and equating total compressive and tensile forces from the expressions of C and T (Eq. 3.16 of Lesson 5) as the T -beam can be treated as rectangular beam of width b_f and effective depth d , we get:

$$x_u = \frac{0.87 f_y A_{st}}{0.36 b_f f_{ck}} = \frac{0.87 (415) (1963)}{0.36 (1000) (20)} = 98.44 \text{ mm} < 100 \text{ mm}$$

So, the assumption of x_u in the flange is correct.

$x_{u, max}$ for the balanced rectangular beam = $0.48 d = 0.48 (450) = 216$ mm.

It is under-reinforced since $x_u < x_{u, max}$.

Step 2: To determine C , T and M_u

From Eqs. 3.9 (using $b = b_f$) and 3.14 of Lesson 4 for C and T and Eq. 3.23 of Lesson 5 for M_u , we have:

$$C = 0.36 b_f x_u f_{ck} \quad (3.9)$$

$$= 0.36 (1000) (98.44) (20) = 708.77 \text{ kN}$$

$$T = 0.87 f_y A_{st} \quad (3.14)$$

$$= 0.87 (415) (1963) = 708.74 \text{ kN}$$

$$M_u = 0.87 f_y A_{st} d \left(1 - \frac{A_{st} f_y}{f_{ck} b_f d} \right) \quad (3.23)$$

$$= 0.87 (415) (1963) (450) \left\{ 1 - \frac{(1963) (415)}{(20) (1000) (450)} \right\} = 290.06 \text{ kNm}$$

This problem belongs to the case (i) and is explained in sec. 5.10.4.1 of Lesson 10.

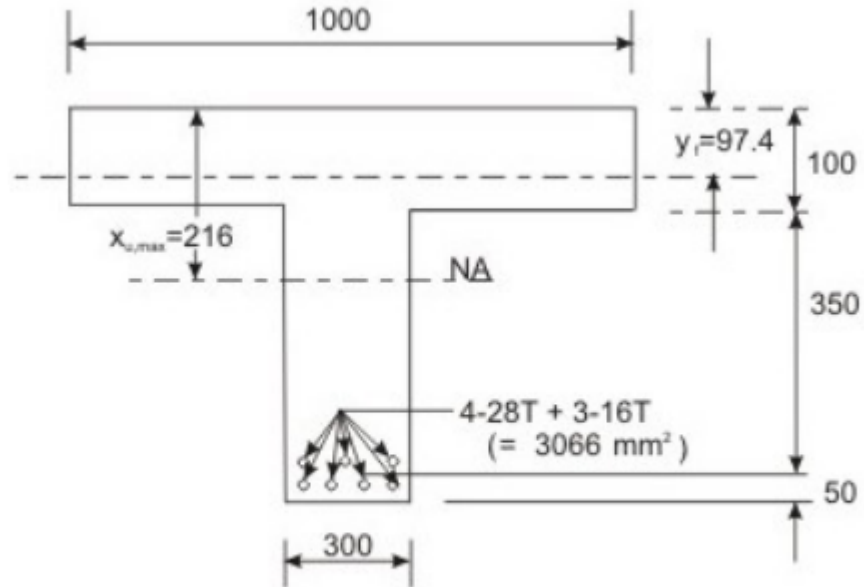


Fig. 5.11.3: Example 2, case (ii b)

Ex.2: Determine $A_{st,lim}$ and $M_{u,lim}$ of the flanged beam of Fig. 5.11.3. Given data are: $b_f = 1000$ mm, $D_f = 100$ mm, $b_w = 300$ mm, cover = 50 mm and $d = 450$ mm. Use M 20 and Fe 415.

Step 1: To determine D_f/d ratio For the limiting case $x_u = x_{u,max} = 0.48 (450) = 216$ mm $> D_f$. The ratio D_f/d is computed.

$$D_f/d = 100/450 = 0.222 > 0.2$$

Hence, it is a problem of case (ii b) and discussed in sec. 5.10.4.2 b of Lesson 10.

Step 2: Computations of y_f , C and T

First, we have to compute y_f from Eq.5.8 of Lesson 10 and then employ Eqs. 5.9, 10 and 11 of Lesson 10 to determine C , T and M_u , respectively.

$$y_f = 0.15 x_{u,max} + 0.65 D_f = 0.15 (216) + 0.65 (100) = 97.4 \text{ mm. (from Eq. 5.8)}$$

$$C = 0.36 f_{ck} b_w x_{u,max} + 0.45 f_{ck} (b_f - b_w) y_f \quad (5.9)$$

$$= 0.36 (20) (300) (216) + 0.45 (20) (1000 - 300) (97.4) = 1,080.18 \text{ kN.}$$

$$T = 0.87 f_y A_{st} = 0.87 (415) A_{st} \quad (5.10)$$

Equating C and T , we have

$$A_{st} = \frac{(1080.18) (1000) \text{ N}}{0.87 (415) \text{ N/mm}^2} = 2,991.77 \text{ mm}^2$$

$$\text{Provide } 4-28 \text{ T } (2463 \text{ mm}^2) + 3-16 \text{ T } (603 \text{ mm}^2) = 3,066 \text{ mm}^2$$

Step 3: Computation of M_u

$$\begin{aligned} M_{u, \text{lim}} &= 0.36 \left(\frac{x_{u,max}}{d} \right) \left\{ 1 - 0.42 \left(\frac{x_{u,max}}{d} \right) \right\} f_{ck} b_w d^2 \\ &+ 0.45 f_{ck} (b_f - b_w) y_f (d - y_f / 2) \quad (5.11) \\ &= 0.36 (0.48) \{ 1 - 0.42 (0.48) \} (20) (300) (450)^2 \\ &+ 0.45 (20) (1000 - 300) (97.4) (450 - 97.4/2) = 413.87 \text{ kNm} \end{aligned}$$

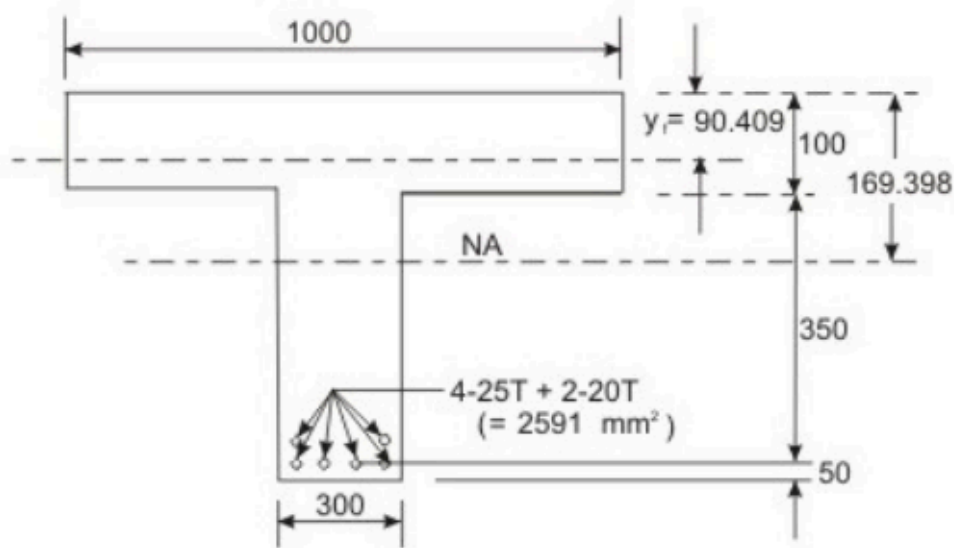


Fig. 5.11.4: Example 3, case (iii b)

Ex.3: Determine the moment of resistance of the beam of Fig. 5.11.4 when $A_{st} = 2,591 \text{ mm}^2$ (4- 25 T and 2- 20 T). Other parameters are the same as those of Ex.1: $b_f = 1,000 \text{ mm}$, $D_f = 100 \text{ mm}$, $b_w = 300 \text{ mm}$, cover = 50 mm and $d = 450 \text{ mm}$. Use M 20 and Fe 415.

Step 1: To determine x_u

Assuming x_u to be in the flange and the beam is under-reinforced, we have from Eq. 3.16 of Lesson 5:

$$x_u = \frac{0.87 f_y A_{st}}{0.36 b_f f_{ck}} = \frac{0.87 (415) (2591)}{0.36 (1000) (20)} = 129.93 \text{ mm} > 100 \text{ mm}$$

Since $x_u > D_f$, the neutral axis is in web. Here, $D_f/d = 100/450 = 0.222 > 0.2$. So, we have to substitute the term y_f from Eq. 5.15 of Lesson 10, assuming $D_f/x_u > 0.43$ in the equation of $C = T$ from Eqs. 5.16 and 17 of sec. 5.10.4.3 b of Lesson 10. Accordingly, we get:

$$\begin{aligned} 0.36 f_{ck} b_w x_u + 0.45 f_{ck} (b_f - b_w) y_f &= 0.87 f_y A_{st} \\ \text{or } 0.36 (20) (300) (x_u) + 0.45 (20) (1000 - 300) \{0.15 x_u + 0.65 (100)\} &= 0.87 (415) (2591) \end{aligned}$$

$$\text{Or } x_u = 169.398 \text{ mm} < 216 \text{ mm } (x_{u,\max} = 0.48 x_u = 216 \text{ mm})$$

So, the section is under-reinforced.

Step 2: To determine M_u

$$D_f/x_u = 100/169.398 = 0.590 > 0.43$$

This is the problem of case (iii b) of sec. 5.10.4.3 b. The corresponding equations are Eq. 5.15 of Lesson 10 for y_f and Eqs. 5.16 to 18 of Lesson 10 for C , T and M_u , respectively. From Eq. 5.15 of Lesson 10, we have:

$$y_f = 0.15 x_u + 0.65 D_f = 0.15 (169.398) + 0.65 (100) = 90.409 \text{ mm}$$

From Eq. 5.18 of Lesson 10, we have

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

or
$$M_u = 0.36 (169.398/450) \{1 - 0.42 (169.398/450)\} (20) (300) (450) (450) \\ + 0.45 (20) (1000 - 300) (90.409) (450 - 90.409/2) \\ = 138.62 + 230.56 = 369.18 \text{ kNm.}$$

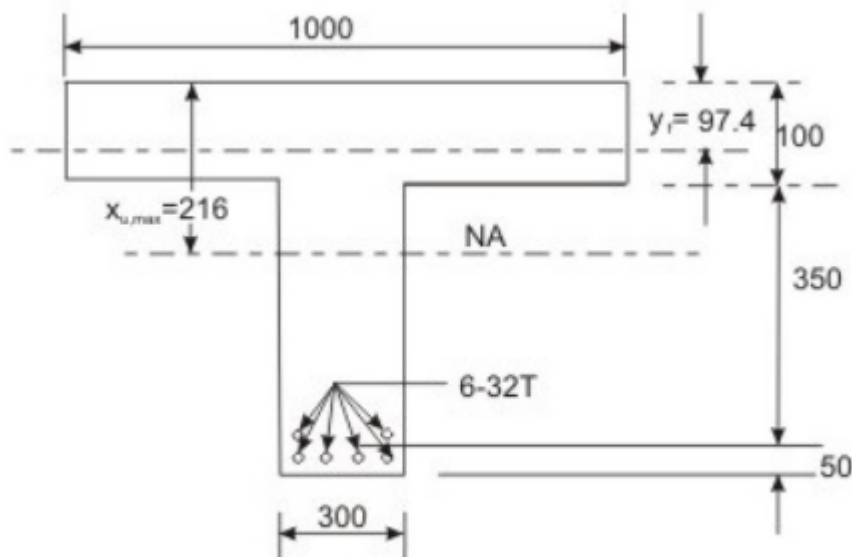


Fig. 5.11.5: Example 4, case (iv b)

Ex.4: Determine the moment of resistance of the flanged beam of Fig. 5.11.5 with $A_{st} = 4,825 \text{ mm}^2$ (6- 32 T). Other parameters and data are the same as those of Ex.1: $b_f = 1000 \text{ mm}$, $D_f = 100 \text{ mm}$, $b_w = 300 \text{ mm}$, cover = 50 mm and $d = 450 \text{ mm}$. Use M 20 and Fe 415.

Step 1: To determine x_u

Assuming x_u in the flange of under-reinforced rectangular beam we have from Eq. 3.16 of Lesson 5:

$$x_u = \frac{0.87 f_y A_{st}}{0.36 b_f f_{ck}} = \frac{0.87 (415) (4825)}{0.36 (1000) (20)} = 241.95 \text{ mm} > D_f$$

Here, $D_f/d = 100/450 = 0.222 > 0.2$. So, we have to determine y_f from Eq. 5.15 and equating C and T from Eqs. 5.16 and 17 of Lesson 10.

$$y_f = 0.15 x_u + 0.65 D_f \quad (5.15)$$

$$0.36 f_{ck} b_w x_u + 0.45 f_{ck} (b_f - b_w) y_f = 0.87 f_y A_{st} \quad (5.16 \text{ and } 5.17)$$

$$\begin{aligned} \text{or } 0.36 (20) (300) (x_u) + 0.45 (20) (1000 - 300) \{0.15 x_u + 0.65 (100)\} \\ = 0.87 (415) (4825) \end{aligned}$$

$$\text{or } 2160 x_u + 945 x_u = - 409500 + 1742066$$

$$\text{or } x_u = 1332566/3105 = 429.17 \text{ mm}$$

$$x_{u,max} = 0.48 (450) = 216 \text{ mm}$$

Since $x_u > x_{u,max}$, the beam is over-reinforced. Accordingly.

$$x_u = x_{u, max} = 216 \text{ mm.}$$

Since $x_u > x_{u,max}$, the beam is over-reinforced. Accordingly.

$$x_u = x_{u, max} = 216 \text{ mm.}$$

Step 2: To determine M_u

This problem belongs to case (iv b), explained in sec.5.10.4.4 b of Lesson 10. So, we can determine M_u from Eq. 5.11 of Lesson 10.

$$M_u = 0.36(x_{u, max}/d)\{1 - 0.42(x_{u, max}/d)\} f_{ck} b_w d^2 + 0.45 f_{ck}(b_f - b_w) y_f(d - y_f/2) \quad (5.11)$$

$$\text{where } y_f = 0.15 x_{u, max} + 0.65 D_f = 97.4 \text{ mm} \quad (5.8)$$

From Eq. 5.11, employing the value of $y_f = 97.4 \text{ mm}$, we get:

$$M_u = 0.36 (0.48) \{1 - 0.42 (0.48)\} (20) (300) (450) (450)$$

$$+ 0.45 (20) (1000 - 300) (97.4) (450 - 97.4/2)$$

$$= 167.63 + 246.24 = 413.87 \text{ knm}$$

It is seen that this over-reinforced beam has the same M_u as that of the balanced beam of Example 2.

5.11.4 Summary of Results of Examples 1-4

The results of four problems (Exs. 1-4) are given in Table 5.1 below. All the examples are having the common data except A_{st} .

Table 5.1 Results of Examples 1-4 (Figs. 5.11.2 – 5.11.5)

Ex. No.	A_{st} (mm ²)	Case	Section No.	M_u (kNm)	Remarks
1	1,963	(i)	5.10.4.1	290.06	$x_u = 98.44 \text{ mm} < x_{u, max} (= 216 \text{ mm})$, $x_u < D_f (= 100 \text{ mm})$, Under-reinforced, (NA in the flange).
2	3,066	(ii b)	5.10.4.2 (b)	413.87	$x_u = x_{u, max} = 216 \text{ mm}$, $D_f/d = 0.222 > 0.2$, Balanced, (NA in web).
3	2,591	(iii b)	5.10.4.3 (b)	369.18	$x_u = 169.398 \text{ mm} < x_{u, max} (= 216 \text{ mm})$, $D_f/x_u = 0.59 > 0.43$, Under-reinforced, (NA in the web).
4	4,825	(iv b)	5.10.4.4 (b)	413.87	$x_u = 241.95 \text{ mm} > x_{u, max} (= 216 \text{ mm})$, $D_f/d = 0.222 > 0.2$, Over-reinforced, (NA in web).

It is clear from the above table (Table 5.1), that Ex.4 is an over-reinforced flanged beam. The moment of resistance of this beam is the same as that of balanced beam of Ex.2. Additional reinforcement of 1,759 mm² ($= 4,825 \text{ mm}^2 - 3,066 \text{ mm}^2$) does not improve the M_u of the over-reinforced beam. It rather prevents the beam from tension failure. That is why over-reinforced beams are to be avoided. However, if the M_u has to be increased beyond 413.87 knm, the flanged beam may be doubly reinforced.

5.11.5 Use of SP-16 for the Analysis Type of Problems

Using the two governing parameters (b_f/b_w) and (D_f/d), the $M_{u,lim}$ of balanced flanged beams can be determined from Tables 57-59 of SP-16 for the three grades of steel (250, 415 and 500). The value of the moment coefficient $M_{u,lim}/b_w d^2 f_{ck}$ of Ex.2, as obtained from SP-16, is presented in Table 5.2 making linear interpolation for both the parameters, wherever needed. $M_{u,lim}$ is then calculated from the moment coefficient.

Table 5.2 $M_{u,lim}$ of Example 2 using Table 58 of SP-16 Parameters:

- (i) $B_f/b_w = 1000/300 = 3.33$
- (ii) $D_f/d = 100/450 = 0.222$

$(M_{u,lim}/b_w d^2 f_{ck})$ in N/mm^2			
D_f/d	b_f/b_w		
	3	4	3.33
0.22	0.309	0.395	
0.23	0.314	0.402	
0.222	0.31*	0.3964*	0.339*

* by linear interpolation

So, from Table 5.2, $\frac{M_{u,lim}}{b_w d^2 f_{ck}} = 0.339$

$$M_{u,lim} = 0.339 b_w d^2 f_{ck} = 0.339 (300) (450) (450) (20) 10^{-6} = 411.88 \text{ kNm}$$

$M_{u,lim}$ as obtained from SP-16 is close to the earlier computed value of $M_{u,lim} = 413.87 \text{ kNm}$ (see Table 5.1).

5.11.6 Practice Questions and Problems with Answers

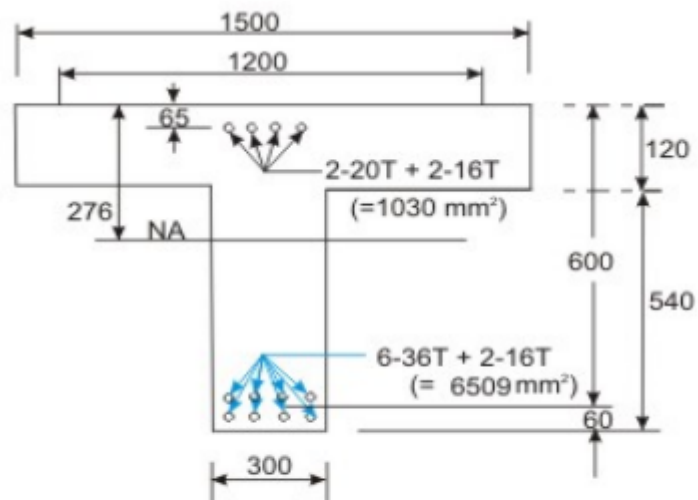


Fig. 5.11.6: Q. 1

Q.1: Determine the moment of resistance of the simply supported doubly reinforced flanged beam (isolated) of span 9 m as shown in Fig. 5.11.6. Assume M 30 concrete and Fe 500 steel.

A.1: Solution of Q.1:

$$\text{Effective width } b_f = \frac{l_o}{(l_o/b) + 4} + b_w = \frac{9000}{(9000/1500) + 4} + 300 = 1200 \text{ mm}$$

Step 1: To determine the depth of the neutral axis

Assuming neutral axis to be in the flange and writing the equation $C = T$, we have:

$$0.87 f_y A_{st} = 0.36 f_{ck} b_f x_u + (f_{sc} A_{sc} - f_{cc} A_{sc})$$

Here, $d'/d = 65/600 = 0.108 = 0.1$ (say). We, therefore, have $f_{sc} = 353 \text{ N/mm}^2$.

From the above equation, we have:

$$x_u = \frac{0.87 (500) (6509) - \{(353) (1030) - 0.446 (30) (1030)\}}{0.36 (30) (1200)} = 191.48 \text{ mm} > 120 \text{ mm}$$

So, the neutral axis is in web.

$$D_f/d = 120/600 = 0.2$$

Assuming $D_f/x_u < 0.43$, and Equating $C = T$

$$0.87 f_y A_{st} = 0.36 f_{ck} b_w x_u + 0.446 f_{ck} (b_f - b_w) D_f + (f_{sc} - f_{cc}) A_{sc}$$

$$\begin{aligned} x_u &= \frac{0.87 (500) (6509) - 1030 \{353 - 0.446 (30)\} - 0.446 (30) (1200 - 300) (120)}{0.36 (30) (300)} \\ &= 319.92 > 276 \text{ mm } (x_{u,max} = 276 \text{ mm}) \end{aligned}$$

So, $x_u = x_{u,max} = 276 \text{ mm}$ (over-reinforced beam).

$$D_f/x_u = 120/276 = 0.4347 > 0.43$$

Let us assume $D_f/x_u > 0.43$. Now, equating $C = T$ with y_f as the depth of flange having constant stress of $0.446 f_{ck}$. So, we have:

$$y_f = 0.15 x_u + 0.65 D_f = 0.15 x_u + 78$$

$$0.36 f_{ck} b_w x_u + 0.446 f_{ck} (b_f - b_w) y_f + A_{sc} (f_{sc} - f_{cc}) = 0.87 f_y A_{st}$$

$$0.36 (30) (300) x_u + 0.446 (30) (900) (0.15 x_u + 78)$$

$$= 0.87 (500) (6509) - 1030 \{353 - 0.446 (30)\}$$

$$\text{or } x_u = 305.63 \text{ mm} > x_{u,max}. \quad (x_{u,max} = 276 \text{ mm})$$

The beam is over-reinforced. Hence, $x_u = x_{u,max} = 276 \text{ mm}$. This is a problem of case (iv), and we, therefore, consider the case (ii) to find out the moment of resistance in two parts: first for the balanced singly reinforced beam and then for the additional moment due to compression steel.

Step 2: Determination of $x_{u,lim}$ for singly reinforced flanged beam

Here, $D_f/d = 120/600 = 0.2$, so y_f is not needed. This is a problem of case (ii a) of sec. 5.10.4.2 of Lesson 10. Employing Eq. 5.7 of Lesson 10, we have:

$$\begin{aligned} M_{u,lim} &= 0.36 (x_{u,max}/d) \{1 - 0.42 (x_{u,max}/d)\} f_{ck} b_w d^2 \\ &\quad + 0.45 f_{ck} (b_f - b_w) D_f (d - D_f/2) \\ &= 0.36(0.46) \{1 - 0.42(0.46)\} (30) (300) (600) (600) \\ &\quad + 0.45(30) (900) (120) (540) \\ &= 1,220.20 \text{ kNm} \end{aligned}$$

$$\begin{aligned} A_{st,lim} &= \frac{M_{u,lim}}{0.87 f_y d \{1 - 0.42 (x_{u,max}/d)\}} \\ &= \frac{(1220.20) (10^6)}{(0.87) (500) (600) (0.8068)} = 5,794.6152 \text{ mm}^2 \end{aligned}$$

Step 3: Determination of M_{u2}

$$\text{Total } A_{st} = 6,509 \text{ mm}^2, \quad A_{st,lim} = 5,794.62 \text{ mm}^2$$

$$A_{st2} = 714.38 \text{ mm}^2 \text{ and } A_{sc} = 1,030 \text{ mm}^2$$

It is important to find out how much of the total A_{sc} and A_{st2} are required effectively. From the equilibrium of C and T forces due to additional steel (compressive and tensile), we have:

$$(A_{st2}) (0.87) (f_y) = (A_{sc}) (f_{sc})$$

$$\text{If we assume } A_{sc} = 1,030 \text{ mm}^2$$

$$A_{st2} = \frac{1030(353)}{0.87(500)} = 835.84 \text{ mm}^2 > 714.38 \text{ mm}^2, \text{ (714.38 mm}^2 \text{ is the total}$$

A_{st2} provided). So, this is not possible.

Now, using $A_{st2} = 714.38 \text{ mm}^2$, we get A_{sc} from the above equation.

$$A_{sc} = \frac{(714.38)(0.87)(500)}{353} = 880.326 < 1,030 \text{ mm}^2, \text{ (1,030 mm}^2 \text{ is the total } A_{sc} \text{ provided).}$$

$$M_{u2} = A_{sc} f_{sc} (d - d') = (880.326)(353)(600 - 60) = 167.807 \text{ kNm}$$

$$\text{Total moment of resistance} = M_{u,lim} + M_{u2} = 1,220.20 + 167.81 = 1,388.01 \text{ kNm}$$

$$\text{Total } A_{st} \text{ required} = A_{st,lim} + A_{st2} = 5,794.62 + 714.38 = 6,509.00 \text{ mm}^2, \text{ (provided } A_{st} = 6,509 \text{ mm}^2 \text{)}$$

$$A_{sc} \text{ required} = 880.326 \text{ mm}^2 \text{ (provided 1,030 mm}^2 \text{)}.$$

2) Question Set.

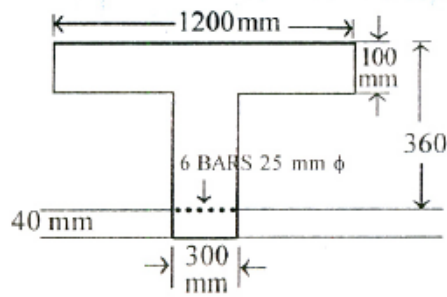
Teaching

Group-A

1. What is flanged beam and where it is used?
2. Write the provision for effective width of flange for an isolated T-beam.
2015
3. Define flange section.

Group-c

1. Determine the moment of resistance of a T-beam section reinforced as shown in (Fig-1)
Use M15 concrete and follow the limit state method. [2013(S)]



2. A T-beam of effective flange width 1500 mm thickness of slab 100 mm, width of rib 230 mm and effective depth 450 mm subjected to factored moment of 350 knm. Design the reinforcement for flexure. The materials are M 20 grade concrete and HYSD reinforcement of grade Fe415. [2019]
3. With the aid of SP-16, determine separately the limiting moments of resistance and the limiting areas of steel of the simply supported isolated, singly reinforced and balanced flanged beam of Q.1 as shown in Fig. 5.11.6 if the span = 9 m. Use M 30 concrete and three grades of steel, Fe 250, Fe 415 and Fe 500, respectively. Compare the results obtained above with that of Q.1 of sec. 5.11.6, when balanced.

Assignment Group-A

1. Define uses of T –Section.
2. Draw a section derive each symbol.

Group-c

1. A T-beam of effective flange width 1800 mm, thickness of slab 100 mm., width of rib 230 mm and effective depth of 500 mm is reinforced with 4 Nos. 25 mm diameter. The materials are M20 grade concrete and HYSD reinforced of grade Fe415. [2017,2016,2015,

- A) Find actual NA
- B) Find factored MOR
- C) Find factored UDL inclusive of its own weight assuming simply supported at both ends having effective span 4.5m.

[2016-S, 2015-W]

2. Determine $M_{u,lim}$ of the flanged beam of Ex. 2 (Fig. 5.11.3) with the help of SP-16 using (a) M 20 and Fe 250, (b) M 20 and Fe 500 and (c) compare the results with the $M_{u,lim}$ of Ex. 2 from Table 5.2 when grades of concrete and steel are M 20 and Fe 415, respectively. Other data are: $b_f = 1000$ mm, $D_f = 100$ mm, $b_w = 300$ mm, cover = 50 mm and $d = 450$ mm.

Self Practice

Group-c

1. A T-beam having an effective flange width of 2500 mm is required to resist an ultimate moment of 1200 kn-m. The width of rib is 300 mm and the effective depth is 900 mm. Using M15 concrete and Fe250 steel, determine the area of reinforcement required using LSM.

Faculty

HOD

Principal

