VERIFICATION OF AREAS OF INDIAN STANDARD I- SECTIONS WITH MULTIPLE UNIT WEIGHTS

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Abstract

Indian Standard I-Sections consist of some sections of the same designation but of different unit weights. The only major change in geometry indicated in SP:6(1)-1964 in these sections is the web thickness. The areas of such sections have been calculated by applying the corrections to the flange widths, considering the details of manufacturing process of such rolled steel sections given in IS 808 -1989 (Reaffirmed 1989). It is found that the area of only one such I-Section, namely, ISWB600 @ 145.1 kg/m, of this category, is differing from the area given in SP:6(1)-1964. It has also been found that the area of this section perfectly matches with the area given in SP: 6(1)-1964, if the correction to flange width due to the manufacturing process is neglected.

Index Terms: *SP: 6(1)-1964, IS 808-1989, I – Sections with multiple unit weights, Correction to flange width. Cross Sectional Areas*

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1. INTRODUCTION

In the Design of Steel Structures, I-Sections are very commonly used as Columns and Beams. These form very important structural components. Columns carry heavy axial loads or eccentric loads which may be transferred from the floor beams, trusses, bracket connections, etc. Beams take up the floor loadings, either in distributed or concentrated form. Many a times, the Columns and Beams are to be designed with restrictions on dimensions to suit the requirements of the Structural Design, Architecture or other site conditions. Hence, to cater to such conditions the Indian Standards provides a variety of I-Sections, namely, Junior, Light, Medium, Wide Flanged and Heavy Beams. Further, to help the designer to conform to the restricted dimensions in a design situation, the Heavy I-sections, designated as ISHB, are provided in multiple weights/unit length, for every designation, with the same overall nominal dimensions. One Wide Flanged Beam, ISWB 600, is also provided in two different weights/unit length, viz., 133.7 kg/m and 145.1 kg/m.

The only major change in geometry indicated in SP: 6(1)-1964 [1] in these sections is the web thickness. A brief mention of the manufacturing process of such I-Sections with the same designation, but multiple unit weights has been given in IS 808 -1989 (Reaffirmed 1999, Edition 4.1, 1992-07) [2]. As per IS 808-1989 (Reaffirmed 1999, Edition 4.1, 1992-07) [2], in the manufacturing process of these rolled sections, the flange widths get increased by the same amount as the increase in the web thickness. The flange width given in SP: 6(1)-1964 [1], holds good for only the section with the least weight for a particular designation; for higher weights/unit length, the actual flange width is to be calculated by increasing the nominal flange width by an amount equal to the increase in web thickness compared to the section with least unit weight.

In the present paper, the areas of these sections, with same designation but multiple weights are calculated using corrected flange widths, along with the other geometric parameters given in SP: 6(1)-1964 [1].

2. METHOD OF CALCULATION

Fig. 1 represents typical geometry of the flange with non-parallel sides of I-sections. The tangent at A is assumed to be vertical, which is true for heavier sections with thicker flanges, as in the present case, for which the centre of curvature lies within the flange thickness. Also, even if the centre of curvature lies outside the flange, the error involved is very negligible [3].

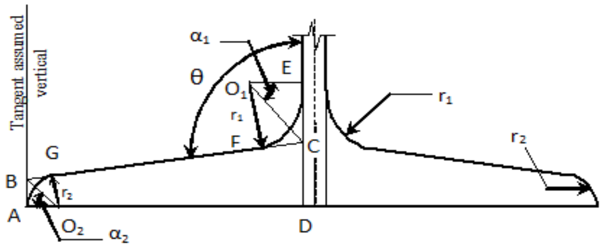

Fig.1 Flange Geometry of I, C & T Sections

The method of calculation is as given below [3]:
The web is treated as a rectangular area, with one side as the thickness of the web and the other side as the full depth of the section. The flange outstand is treated as made up of three components, namely – (i) Trapezoidal area ABCD (ii) Circular Spandrel (Fillet) area, ECF, at the junction with web (iii) Negative Circular Spandrel area ABG, at the free end, as shown in fig.1.

$\alpha_1 = \alpha_2 = (180-\theta)/2$

Area of the trapezium ABCD is given by:

$$AD \times ((AB + CD) / 2) \quad \ldots (1)$$

Area of Circular Spandrel (Fillet) ECF is given by:

$$r_1^2 \sin\alpha_1 (\cos\alpha_1 + \sin\alpha_1 \tan\alpha_1) - \alpha_1 r_1^2 \quad \ldots. (2)$$

Area of Negative Spandrel ABG is given by:

$$r_2^2 \sin\alpha_2 (\cos\alpha_2 + \sin\alpha_2 \tan\alpha_2) - \alpha_2 r_2^2 \quad \ldots. (3)$$

Area of Cantilevering Flange outstand,

AGFECDA = (1) + (2) – (3)

Typical calculation for ISWB 600 @ 133.7 kg/m:

As per SP: 6(1) – 1964 [1],
Area = 170.38 cm^2; Depth = 600 mm;
Width of flange = 250 mm; Thickness of flange = 21.3 mm;
Thickness of web = 11.2 mm; r_1 =17mm, r_2= 8.5mm
$\Theta = 96^o$; $\alpha_1 = (180 - 96) / 2 = 42^o = 0.73308$ Rad,
$\alpha_2 = (180 - 96) / 2 = 42^o = 0.73308$ Rad,
Area of web = 600 x 11.2 = 6720.0000 mm^2

For Trapezium, AB = 15.02528 mm; CD = 25.57472 mm;
AD = 119.4 mm

Therefore, Area of Trapezium = 2543.2200 mm^2

Area of Circular Spandrel (Fillet) ECF = 48.3687 mm^2
Area of Negative Spandrel ABG = 12.09218 mm^2
Area of flange outstand = 2543.2200 + 48.3687 – 12.09218
= 2579.49652 mm^2

Therefore Area of I – section = 6720.00 + (4x 2579.49652)
= 17037.98608 mm^2

Therefore Area in cm^2 = 170.38 cm^2 (correct to two decimal places);

The value exactly matches with the value given in SP: 6(1) – 1964 [1].

Typical calculation for ISWB 600 @ 145.1 kg/m:

As per SP: 6(1) -1964 [1];
Area = 184.86 cm^2 ; Depth = 600 mm
Width of flange (corrected) = 250.6 mm ;
Thickness of flange = 23.6 mm

Thickness of web = 11.8 mm; r_1 = 18 mm, r_2 = 9.0 mm
$\theta = 96^o$; $\alpha_1 = (180 – 96) / 2 = 42^o = 0.73308$ Rad,
$\alpha_2 = (180 – 96) / 2 = 42^o = 0.73308$ Rad,
Area of web = 600 x 11.8 = 7080.0000 mm^2

For trapezium, AB = 17.32528 mm; CD = 29.87472 mm;
AD = 119.4 mm
Therefore, Area of the trapezium = 2817.8400 mm^2
Area of Circular Spandrel (Fillet) ECF = 54.22651 mm^2
Area of Negative Spandrel ABG = 13.55663 mm^2
Area of flange outstand = (2817.8400 + 54.22651 – 13.55663)
= 2858.50988mm^2

Therefore, area of I section = 7080.00 + (4 x 2858.50988)
= 18514.04 mm^2

Therefore, area in cm^2 = 185.14 cm^2 (correct to two decimal places), the value differs by 28.04 mm^2 as compared to the value of 184.86 cm^2 given in SP: 6(1) -1964 [1].

However, if the flange width is taken with the nominal value 250.00 mm only, then the calculations are as follows;
Area of web = 600 x 11.8 = 7080.0000 mm^2

For Trapezium, AB = 17.34104 mm; CD = 29.85896 mm;
AD = 119.1 mm

Therefore, Area of Trapezium = 2810.7600 mm^2

Area of Circular Spandrel (Fillet) ECF = 54.22651 mm^2
Area of Negative Spandrel ABG = 13.55663 mm^2
Area of flange outstand = 2810.7600 + 54.22651 – 13.55663
= 2851.42988 mm^2

Therefore, area of I – section = 7080.00 + (4 x 2851.42988)
= 18485.71952 mm^2

Therefore area in cm^2 = 184.86 cm^2 (correct to two decimal places). This value exactly matches with the value given in SP: 6(1) -1964[1]. Also, it may be noted that the area given in IS 808-1989 [2] for ISWB 600 @ 145.1 kg/m is 185 cm^2.

The details of calculations of areas of all sections under consideration are given in Table-2, along with the areas given in SP:6(1)-1964 [1] and IS 808-1989 [2]. Also the areas of all I-Sections, including the I-Sections with multiple unit weights taken for presentation in this paper, are available in reference [4].

3. RESULTS AND DISCUSSION

The areas calculated for all sections, except ISWB 600 @ 145.1 kg/m, match exactly with the areas given in SP: 6(1)-1964 [1], in cm^2, with two decimal places, considering the correction to flange widths as per the IS 808-1989 (Reaffirmed 1999, Edition 4.1, 1992-07) [2]. The IS 808-1989 [2], mentions of some additional classifications of RS sections, like ISSC, ISMCP, LB(P), which are not covered under SP:6(1)-1964 [1]. The sections ISMCP (parallel flanged channel sections) also have multiple weights for the same designation and a similar manufacturing process has been mentioned, which increases the overall dimension of either width or depth of the section, for the sections having higher unit weights. Also, LB (P) sections are the provisional sections, which are to be manufactured by a similar process, as per IS 808: 1989 [2]. Considering these facts, the flange width of ISWB 600 @ 145.1 kg/m, also is to be increased by an amount equal to the increase in its web thickness, 0.6mm, with respect to ISWB 600 @ 133.7 kg/m. Hence, an increase of 0.6 mm, over the nominal flange width of 250mm, has been taken in the calculation of the area of ISWB 600 @145.1 kg/m. If this increase in flange width is neglected, the area matches exactly with that given in SP: 6(1)-1964 [1].

Table 1: Geometric Details of I-Sections with Multiple Unit Weights [1, 2]

1	2	3	4	5	6	7	8	9	10	11	12
Sl. No.	Designation	Unit wt. (N/m)	Area (cm^2)	Depth (mm)	Web Thickness (mm)	Nominal Flange Width (mm)	Corrected Flange Width (mm)	Flange Thickness (mm)	Radius r_1 (mm)	Radius r_2 (mm)	Flange Slope D θ (deg)
1	ISWB600	133.7 kg/m	170.38	600	11.2	250	250	21.3	17	8.5	96
2	ISWB600	145.1 kg/m	184.86	600	11.8	250	250.6	23.6	18	9	96
3	ISHB150	27.1 kg/m	34.48	150	5.4	150	150	9	8	4	94
4	ISHB150	30.6 kg/m	38.98	150	8.4	150	153	9	8	4	94
5	ISHB150	34.6 kg/m	44.08	150	11.8	150	156.4	9	8	4	94
6	ISHB200	37.3 kg/m	47.54	200	6.1	200	200	9	9	4.5	94
7	ISHB200	40.0 kg/m	50.94	200	7.8	200	201.7	9	9	4.5	94
8	ISHB225	43.1 kg/m	54.94	225	6.5	225	225	9.1	10	5	94
9	ISHB225	46.8 kg/m	59.66	225	8.6	225	227.1	9.1	10	5	94
10	ISHB250	51.0 kg/m	64.96	250	6.9	250	250	9.7	10	5	94
11	ISHB250	54.7 kg/m	69.71	250	8.8	250	251.9	9.7	10	5	94
12	ISHB300	58.8 kg/m	74.85	300	7.6	250	250	10.6	11	5.5	94
13	ISHB300	63.0 kg/m	80.25	300	9.4	250	251.8	10.6	11	5.5	94
14	ISHB350	67.4 kg/m	85.91	350	8.3	250	250	11.6	12	6	94
15	ISHB350	72.4 kg/m	99.21	350	10.1	250	251.8	11.6	12	6	94
16	ISHB400	77.4 kg/m	98.66	400	9.1	250	250	12.7	14	7	94
17	ISHB400	82.2 kg/m	104.66	400	10.6	250	251.5	12.7	14	7	94

18	ISHB450	87.2 kg/m	111.14	450	9.8	250	250	13.7	15	7.5	94
19	ISHB450	92.5 kg/m	117.89	450	11.3	250	251.5	13.7	15	7.5	94

Table 2: Calculations for the Areas of I Sections with Multiple Unit Weights

Designation	AB (mm)	CD (mm)	AD (mm)	$\alpha_1 = \alpha_2$ (rad)	Area of Web (mm^2)	Area ABCD (mm^2)	Fillet Area ECF (mm^2)	Negative Spandrel Area ABG (mm^2)	Net Area (Calculated in mm^2)	Area in SP: 6(1) - 1964 (cm^2) [1]	Area in IS 808: 1989 (cm^2)[2]
ISWB600 @133.7 kg/m	15.02528	27.57472	119.40	0.733038	6720	2543.22	48.3687	12.09218	17037.99	170.38	170
ISWB600 @145.1 kg/m	17.32528	29.87472	119.40	0.733038	7080	2817.84	54.22651	13.55663	18514.04	184.86	185
ISHB150 @27.1 kg/m	6.472146	11.52785	72.30	0.750492	810	650.70	11.6495	2.912376	3447.75	34.48	34.5
ISHB150 @30.6 kg/m	6.472146	11.52785	72.30	0.750492	1260	650.70	11.6495	2.912376	3897.75	38.98	39.0
ISHB150 @34.6 kg/m	6.472146	11.52785	72.30	0.750492	1770	650.70	11.6495	2.912376	4407.75	44.08	44.1
ISHB200 @37.3 kg/m	5.610298	12.3897	96.95	0.750492	1220	872.55	14.7439	3.685976	4754.43	47.54	47.5
ISHB200 @40.0 kg/m	5.610298	12.3897	96.95	0.750492	1560	872.55	14.7439	3.685976	5094.43	50.94	50.9
ISHB225 @43.1 kg/m	5.280248	12.91975	109.25	0.750492	1462.5	994.175	18.20235	4.550588	5493.81	54.94	54.9
ISHB225 @46.8 kg/m	5.280248	12.91975	109.25	0.750492	1935	994.175	18.20235	4.550588	5966.31	59.66	59.7
ISHB250 @51.0 kg/m	5.450198	13.9498	121.55	0.750492	1725	1179.035	18.20235	4.550588	6495.75	64.96	65.0
ISHB250 @54.7 kg/m	5.450198	13.9498	121.55	0.750492	2200	1179.035	18.20235	4.550588	6970.75	69.71	69.7
ISHB300 @58.8 kg/m	6.362435	14.83756	121.20	0.750492	2280	1284.72	22.02484	5.506211	7484.96	74.85	74.8
ISHB300 @63.0 kg/m	6.362435	14.83756	121.2	0.750492	2820	1284.72	22.02484	5.506211	8024.96	80.25	80.2
ISHB350 @67.4	7.374672	15.82533	120.85	0.750492	2905	1401.86	26.21139	6.552846	8591.07	85.91	85.9

kg/m											
ISHB350 @72.4 kg/m	7.374672	15.82533	120.85	0.750492	3535	1401.86	26.21139	6.552846	9221.07	92.21	92.2
ISHB400 @77.4 kg/m	8.488658	16.91134	120.45	0.750492	3640	1529.715	35.67661	8.919152	9865.89	98.66	98.7
ISHB400 @82.2 kg/m	8.488658	16.91134	120.45	0.750492	4240	1529.715	35.67661	8.919152	10465.89	104.66	105
ISHB450 @87.2 kg/m	9.500895	17.89911	120.1	0.750492	4410	1645.37	40.95529	10.23882	11114.35	111.14	111
ISHB450 @92.5 kg/m	9.500895	17.89911	120.1	0.750492	5085	1645.37	40.95529	10.23882	11789.35	117.89	118

CONCLUSIONS

The areas of I sections having multiple unit weights, i.e., seventeen ISHB and two ISWB Sections, have been calculated by applying the corrections to the flange widths, considering the details of manufacturing process of such Rolled steel sections given in IS 808 -1989 (Reaffirmed 1989). It has been observed that the area of ISWB 600 @145.1 kg/m only differs with this correction. This may lead to change in values of other parameters like, Moment of Inertia, Radius of Gyration, Section Modulus, etc., which are dependent on the areas or component areas of these sections. These results may be of interest for the calculation of other dependent parameters.

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BIOGRAPHIES

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