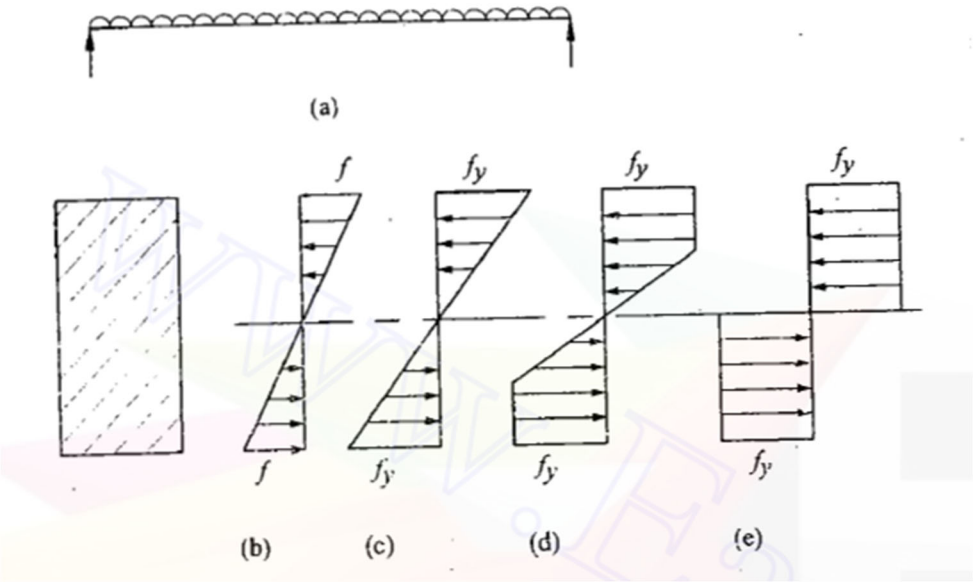
Plastic Modulus of Standard I-Section (As per IS808)

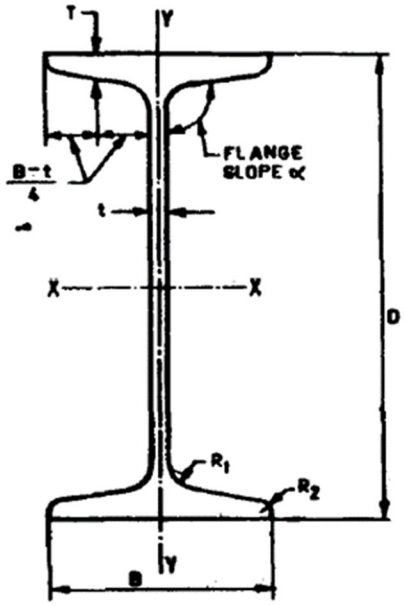
According to IS 800:2007 section 8.2.1.2, When the factored design shear force does not exceed 0.6Vd, where Vd is the design shear strength of the cross section, the design bending strength, Md shall be taken as

$$M_d = \beta_b Z_p f_y / \gamma_{mo}$$

Where, $Z_p = Plastic\ modulus\ of\ beam$



In case of plastic analysis, all the fibers of the beam yield the maximum stress and therefore this moment of maximum yielding is called plastic moment capacity, M_p.



$$\frac{M_p}{I_p} = \frac{f_y}{y}$$

$$M_p = f_y * Z_P$$

Here, Z_p is called plastic sectional modulus

And in case of I-Section

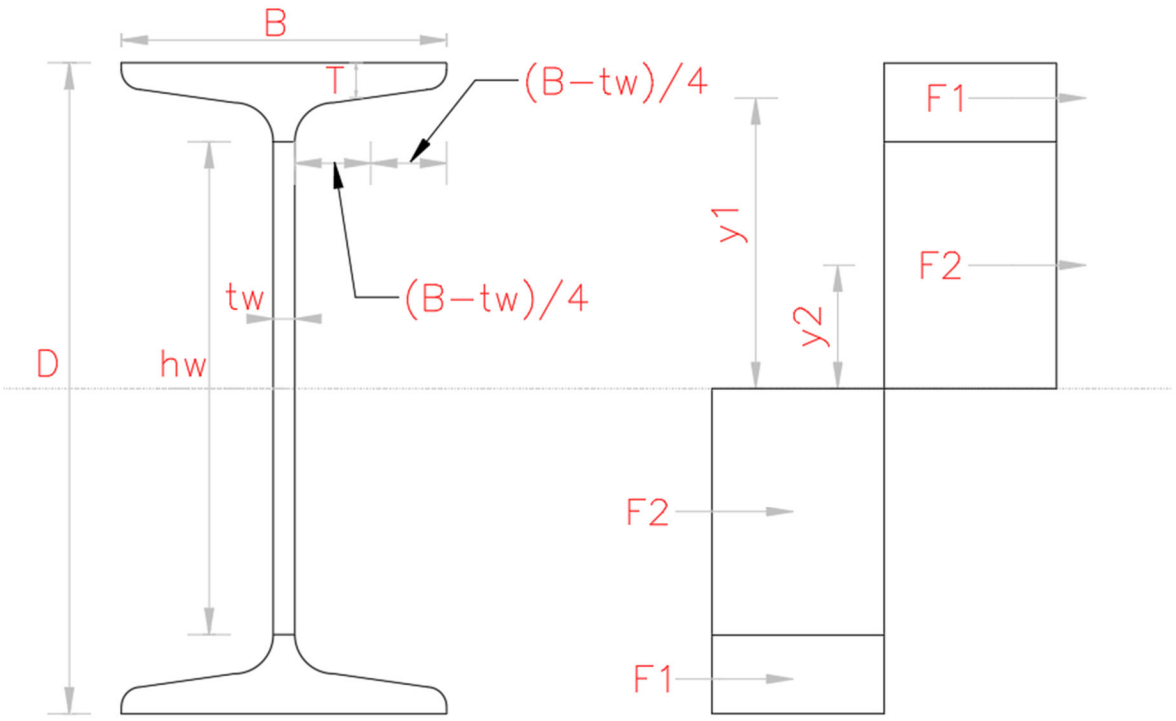
$$M_p = 2(F_1 * y_1 + F_2 * y_2)$$

And

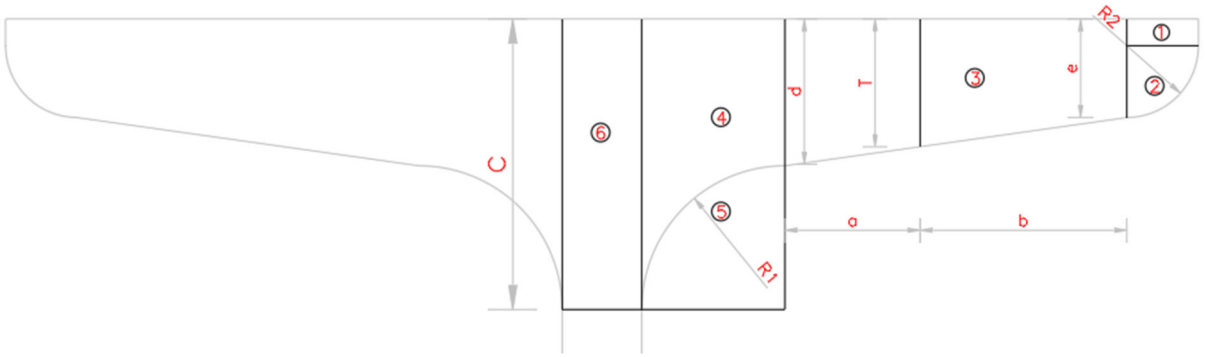
$$F_1 = A_f * f_y$$

$$F_2 = A_w * f_y$$

$$Z_p = \frac{M_p}{f_y} = 2(A_f * y_1 + A_w * y_2)$$



Therefore, we need to calculate the area of flange and web. Any methods to calculate area can be employed, however, in this case, I divided the section into parts;



To calculate the area of flange, whole flange is divided in to 6 parts

$$A_f = (A_1 + A_2 + A_3 + A_4 - A_5) * 2 + A_6$$

And

$$A_w = \left(\frac{D}{2} - c\right) * t_w * 2$$

$$\beta = \alpha - 90$$

Where, α = angle of flange with the web (flange angle)

$$a = \frac{B - t_w}{4} - R_1$$

$$b = \frac{B - t_w}{4} - R_2$$

$$c = a\tan(\beta) + R_1 + T$$

$$d = \text{atan}(\beta) + T$$

$$e = T - b\tan(\beta)$$

Formulas used to calculate areas

$$A_1 = R_2(e - R_2)$$

$$y_1 = \left(\frac{D}{2} - \frac{e - R_2}{2}\right)$$

$$A_2 = \frac{1}{4}\pi R_2^2$$

$$y_2 = \frac{D}{2} - \left((e - R_2) + \left(\frac{4R_2}{3\pi}\right)\right)$$

$$A_3 = \frac{1}{2}(d + e)(a + b)$$

$$y_3 = \frac{D}{2} - R_1 + \frac{2de - e^2 + 2d^2}{3(e + d)}$$

$$A_4 = cR_1$$

$$y_4 = \frac{D}{2} - \frac{c}{2}$$

$$A_5 = \frac{1}{4}\pi R_1^2$$

$$y_5 = \frac{D}{2} - c + \frac{4R_1}{3\pi}$$

$$A_6 = ct_w$$

$$y_6 = \frac{D}{2} - \frac{c}{2}$$

Area of flange and web shall be calculated from the above formula

Centroid of flange may be calculated by the following formula

$$y_f = \frac{2(A_1y_1 + A_2y_2 + A_3y_3 + A_4y_4 - A_5y_5) + A_6y_6}{A_f}$$

$$y_w = \frac{D - 2c}{4}$$

So

$$Z_p = 2(A_f y_f + A_w y_w)$$

Table:

Designation	Weight per Meter (w)	Depth of Section (h)	Width of flange (b)	Thickness of Flange (t_f)	Thickness of Web (t_w)	Moment of Inertia		Raddi of Gyration		Modulli of Section		Radius		Flange slope	Plastic sectional modulus	Area
												R1	R2			
						I_{xx} cm^4	I_{yy} cm^4	r_{xx} cm	r_{yy} cm	Z_{xx} cm^3	z_{yy} cm^3			α		
	kg	mm	mm	mm	mm							mm	mm	degree	cm^3	cm^2
ISJB																
ISJB 150	7.1	150	50	4.6	3	322.1	9.2	5.98	1.01	42.9	3.7	5	1.5	91.5	49.50	9.01
ISJB 175	8.1	175	50	4.8	3.2	479.3	9.7	6.83	0.97	54.8	3.9	5	1.5	91.5	64.21	10.28
ISJB 200	9.9	200	60	5	3.4	780.7	17.3	7.86	1.17	78.1	5.8	5	1.5	91.5	91.00	12.64
ISJB 225	12.8	225	80	5	3.7	1308.5	40.5	8.97	1.58	116.3	10.1	6.5	1.5	91.5	133.46	16.28
ISLB																
ISLB 75	6.1	75	50	5	3.7	72.7	10	3.07	1.14	19.4	4	6.5	2	91.5	21.95	7.71
ISLB 100	8	100	50	6.4	4	168	12.7	4.06	1.12	33.6	5.1	7	3	91.5	38.72	10.21
ISLB 125	11.9	125	75	6.5	4.4	406.8	43.4	5.19	1.69	65.1	11.6	8	3	91.5	73.15	15.12
ISLB 150	14.2	150	80	6.8	4.8	688.2	55.2	6.17	1.75	91.8	13.8	8	3	91.5	102.47	17.87
ISLB 175	16.7	175	90	6.9	5.1	1096.2	79.6	7.17	1.93	125.3	17.7	9.5	3	91.5	140.72	21.30
ISLB 200	19.8	200	100	7.3	5.4	1696.6	115.4	8.19	2.13	169.7	23.1	9.5	3	91.5	191.10	25.27
ISLB 225	23.5	225	100	8.6	5.8	2501.9	112.7	9.15	1.94	222.4	22.5	12	6	98	252.63	29.88
ISLB 250	27.9	250	125	8.2	6.1	3717.8	193.4	10.23	2.33	297.4	30.9	13	6.5	98	335.14	35.48
ISLB 275	33	275	140	8.8	6.4	5375.3	287	11.31	2.61	392.4	41	14	7	98	439.18	41.96
ISLB 300	37.7	300	150	9.4	6.7	7332.9	376.2	12.35	2.8	488.9	50.2	15	7.5	98	548.83	48.01
ISLB 325	43.1	325	165	9.8	7	9874.6	510.8	13.41	3.05	607.7	61.9	16	8	98	680.84	54.83
ISLB 350	49.5	350	165	11.4	7.4	13158.3	631.9	14.45	3.17	751.9	76.6	16	8	98	846.90	62.94
ISLB 400	56.9	400	165	12.5	8	19306.3	716.4	16.33	3.15	965.3	86.8	16	8	98	1097.59	72.36
ISLB 450	65.3	450	170	13.4	8.6	27536.1	853	18.2	3.2	1223.8	100.4	16	8	98	1402.26	83.06
ISLB 500	75	500	180	14.1	9.2	38579	1063.9	20.1	3.34	1543.2	118.2	17	8.5	98	1773.17	95.42
ISLB 550	86.3	550	190	15	9.9	53161.6	1335.1	21.99	3.48	1933.2	140.5	18	9	98	2228.83	109.88
ISLB 600	99.5	600	210	15.5	10.5	72867.6	1821.9	23.98	3.79	2428.9	173.5	20	10	98	2794.28	126.58
ISMB																
ISMB 100	11.5	100	50	7	4.7	252	35.4	4.14	1.55	50.4	10.1	9	4.5	98	42.13	11.39
ISMB 125	13.4	125	70	8	5	445.1	38.5	5.16	1.51	71.2	11	9	4.5	98	81.97	17.00
ISMB 150	15	150	75	8	5	717.6	46.8	6.13	1.57	95.7	12.5	9	4.5	98	109.76	19.05
ISMB 175	19.5	175	85	9	5.8	1262.4	76.7	7.13	1.76	144.3	18	10	5	98	165.94	24.84
ISMB 200	25.4	200	100	10	5.7	2235.4	150	8.32	2.15	224	30	11	5.5	98	241.01	30.78
ISMB 225	31.2	225	110	11.8	6.5	3441.8	218.3	9.31	2.34	306	39.7	12	6	98	350.59	39.67
ISMB 250	37.3	250	125	12.5	6.9	5131.6	334.5	10.4	2.65	410	53.5	13	6.5	98	468.70	47.51
ISMB 300	46.1	300	140	13.1	7.7	8985.7	486.3	12.4	2.86	599	69.5	14	7	98	684.25	58.61
ISMB 350	52.4	350	140	14.2	8.1	13630.3	537.7	14.3	2.84	779	76.8	14	7	98	895.82	66.66

ISMB 400	61.6	400	140	16	8.9	20458.4	622.1	16.2	2.82	1020	88.9	14	7	98	1188.03	78.40
ISMB 450	72.4	450	150	17.4	9.4	30390.8	834	18.2	3.01	1350	111	15	7.5	98	1568.99	92.20
ISMB 500	86.9	500	180	17.2	10.2	45218.3	1369.8	20.2	3.52	1810	152	17	8.5	98	2087.78	110.66
ISMB 550	104	550	190	19.3	11.2	64893.6	1833.8	22.2	3.73	2360	193	18	9	98	2733.31	132.02
ISMB 600	123	600	210	20.8	12	91813	2651	24.2	4.12	3060	252	20	10	98	3535.09	156.10
	ISWB															
ISWB 150	17	150	100	7	5.4	839.1	94.8	6.22	2.09	111.9	19	8	4	96	127.41	21.66
ISWB 175	22.1	175	125	7.4	5.8	1509.4	188.6	7.33	2.59	172.5	30.2	8	4	96	196.43	28.10
ISWB 200	28.8	200	140	9	6.1	2624.5	328.8	8.46	2.99	262.5	47	9	4.5	96	298.70	36.70
ISWB 225	33.9	225	150	9.9	6.4	3920.5	448.6	9.52	3.22	348.5	59.8	9	4.5	96	398.21	43.23
ISWB 250	40.9	250	200	9	6.7	5943.1	857.5	10.69	4.06	475.4	85.7	10	5	96	536.03	52.03
ISWB 300	48.1	300	200	10	7.4	9821.6	990.1	12.66	4.02	654.8	99	11	5.5	96	739.96	61.31
ISWB 350	56.9	350	200	11.4	8	15521.7	1175.9	14.63	4.03	887	117.6	12	6	96	1006.15	72.48
ISWB 400	66.7	400	200	13	8.6	23426.7	1388	16.6	4.04	1711.3	138.8	13	6.5	96	1333.84	84.99
ISWB 450	79.4	450	200	15.4	9.2	35057.6	1706.7	18.63	4.11	1558.1	170.7	15	7	96	1780.61	101.31
ISWB 500	95.2	500	250	14.7	9.9	52290.9	2987.8	20.77	4.96	2091.6	239	15	7.5	96	2377.30	121.18
ISWB 550	112.5	550	250	17.6	10.5	74906.1	3740.6	22.86	5.11	2723.9	299.2	16	8	96	3106.14	143.30
ISWB 600(1)	133.7	600	250	21.3	11.2	106198.5	4702.5	24.97	5.25	3540	376.2	17	8.5	96	4054.26	170.33
ISWB 600(2)	145.1	600	250	23.6	11.8	115626.6	5298.3	25.01	5.35	3854.2	423.9	18	9	96	4425.18	184.81
	ISHB															
ISHB 150(1)	27.1	150	150	9	5.4	1455.6	431.7	6.5	3.54	194.1	57.6	8	4	94	221.96	34.47
ISHB 150(2)	30.6	150	150	9	8.4	1540	460.3	6.29	3.44	205.3	60.2	8	4	94	234.78	38.43
ISHB 150(3)	34.6	150	150	9	11.8	1635.6	494.9	6.09	3.35	218.1	63.2	8	4	94	249.32	42.92
ISHB 200(1)	37.3	200	200	9	6.1	3608.4	967.1	8.71	4.51	360.8	96.7	9	4.5	94	405.33	47.54
ISHB 200(2)	40	200	200	9	7.8	3721.8	994.6	8.55	4.42	372.2	98.6	9	4.5	94	419.26	50.63
ISHB 225(1)	43.1	225	225	9.1	6.5	5279.5	1353.8	9.8	4.96	469.3	120.3	10	5	94	523.03	54.93
ISHB 225(2)	46.8	225	225	9.1	8.6	5478.8	1396.6	9.58	4.84	487	123	10	5	94	545.31	59.27
ISHB 250(1)	51	250	250	9.7	6.9	7736.5	1961.3	10.91	5.49	618.9	156.9	10	5	94	691.87	64.95
ISHB 250(2)	54.7	250	250	9.7	8.8	7983.9	2011.7	10.7	5.37	638.7	159.7	10	5	94	716.91	69.33
ISHB 300(1)	58.8	300	250	10.6	7.6	12345.2	2193.6	12.95	5.41	836.3	175.5	11	5.5	94	934.94	74.84
ISHB 300(2)	63	300	250	10.6	9.4	12950.2	2246.7	12.7	5.29	863.3	178.4	11	5.5	94	969.70	79.86
ISHB 350(1)	67.4	350	250	11.6	8.3	19159.7	2451.4	14.93	5.34	1094.8	196.1	12	6	94	1227.39	85.90
ISHB 350(2)	72.4	350	250	11.6	10.1	19802.8	2510.5	14.65	5.22	1131.6	199.4	12	6	94	1275.21	91.78
ISHB 400(1)	77.4	400	250	12.7	9.1	28083.5	2728.3	16.87	5.26	1404.2	218.3	14	7	94	1575.68	98.64
ISHB 400(2)	82.2	400	250	12.7	10.6	28823.5	2783	16.61	5.16	1444.2	221.3	14	7	94	1628.13	104.26
ISHB 450(1)	87.2	450	250	13.7	9.8	39210.8	2985.2	18.78	5.18	1742.7	238.8	15	7.5	94	1964.42	111.13
ISHB 450(2)	92.5	450	250	13.7	11.3	40349.9	3045	18.5	5.08	1793.3	242.1	15	7.5	94	2031.21	117.47