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Modified steel tables for I sections

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Abstract

Steel structures have extremely good load carrying as well as moment resisting capacity. Yet, they are not common in India, because they demand greater precision and have more cost than those built with masonry or concrete. Steel tables contains ready to use properties of the standard sections which are required during the design of steel structures and to examine whether the sections withstand in the given condition or not. The currently available steel table has most of the properties but there is a scope to add more and make it simpler for the users. Since, some additional parameters are constant for a given section which can be obtained and added in the current table. Also, the variation of the bending moment and shear force are plotted as graphs, so that the designer can observe all the sections at a glance.

Keywords: Steel structures, Steel tables, Bending moment, Shear force.

Introduction

Concrete structures are less efficient than steel structures in terms of life cycle cost, strength, sustainability, time required erecting and steel can be used for comparatively longer spans and higher loads. Also, steel is manufactured under standard laboratory conditions and concrete under environment conditions (except precast concrete members).

Tapered flange sections are the most conventional sections in India, but in foreign countries parallel flange sections are commonly used in design and construction of steel structures. They both are hot rolled sections. But, nowadays productions of parallel flange sections have also been started in India since they have proved to be more efficient than tapered flange sections.

Additional Properties Added

Some additional properties that are being added in the current steel table are listed below:

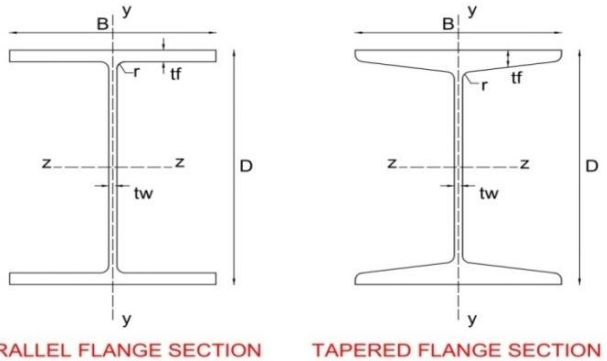

Figure-1: Cross-section of Parallel flange section and Tapered flange section.

Plastic Section Modulus and Elastic Section Modulus: The plastic section modulus has been taken from IS 800:2007 [1], IS 12778:2004 [2] and steel tables about major and minor axis.

Shape Factor: Shape factor about major and minor axis can be obtained as:
About major axis, Shape Factor $=Z_{pz}/ Z_{ez}$
About minor axis, Shape Factor $= Z_{py}/ Z_{ey}$

b/t_f ratio: It can be obtained as:
$b/t_f = \frac{B/2}{tf}$

d/t_w ratio: It can be obtained as:
$d/t_w = \frac{D-2tf-2r}{tw}$

Section Classification: According to Table-2 Limiting Width to Thickness Ratio and clause (3.7.2) of IS 800:2007 [1]; The b/t_f ratio and d/t_w ratio for section classification is given in Table-1.

Table-1: Table of section classification.

b/t_f Ratio	d/t_w Ratio	Class of Section
9.4ε	84ε	Plastic section
10.5ε	105ε	Compact section
15.7ε	126ε	Semi–compact section

Design Bending Moment: According to clause 8.2.1 Laterally Supported Beam of IS 800:2007 [1]. The design bending moment for laterally supported beams can be calculated as:
$M_d = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$

where, β_b = 1.0 for plastic and compact section, $\beta_b = Z_e / Z_p$ for semi compact section, Z_e = plastic and elastic section modulii of the cross-section, respectively; f_y = yield stress of the material; and γ_{m0} = partial safety factor

Design Shear Force: According to clause 8.4 Shear of IS 800:2007 [1]; The design shear force can be calculated as:

$$V_d = \frac{A_V f_y}{\sqrt{3}\gamma_{m0}}$$

where; A_v =shear area of section, f_y = yield stress of the material, γ_{m0} = partial safety factor.

Web Buckling: According to clause 8.7.3.1 of IS 800:2007 [1], SK Duggal[3], N. Subramanian[4];

For point load, $F_{cdw} = (b_1+n_1)t_w f_{cd}$
b_1 = stiff length of bearing, n_1 = dispersion of load through the web at 45 degrees, to half depth, f_{cd}= buckling strength of web about axis parallel to the web.

For support, $F_{cdw} = (b_1+n_1)t_w f_{cd}$
b_1 = stiff length of bearing (assumed as 150), n_1 = dispersion of load through the web at 45 degrees, to half depth, f_{cd}= buckling strength of web about axis parallel to the web.

Web bearing: According to clause 8.7.4 of IS 800:2007 [1], SK Duggal[3], N. Subramanian[4];

For point load, $F_w = \frac{(b_1+n_2)t_w f_y}{\gamma_{m0}}$
b_1 = stiff length of bearing, n_2 = length obtained by dispersion to the flange to the web junction at a slope of 1:2.5 to the plane of the flange, f_y = yield stress of the material, γ_{m0} = partial safety factor,

For support, $F_w = \frac{(b_1+n_2)t_w f_y}{\gamma_{m0}}$
b_1 = stiff length of bearing (assumed as 150), n_2 = length obtained by dispersion to the flange to the web junction at a slope of 1:2.5 to the plane of the flange, f_y = yield stress of the material, γ_{m0} = partial safety factor

Warping Constant: For tapered flange sections: As per research paper by M.K. Gupta[5] on Additional Sectional properties of tapered flange sections;

$$I_w = \frac{1}{4} I_{yy} (h - t_f)^2$$

For parallel flange sections: As per research paper by M.K. Gupta[6] on Additional Sectional properties of parallel flange sections;

$$I_w = \frac{1}{24} t_f {b_f}^3 (D - t_f)^2$$

Torsional Constant: For tapered flange sections: As per research paper by M.K. Gupta[5] on Additional Sectional properties of tapered flange sections;

$$I_t = \left(\frac{1}{6}\right)(b_t - t_w)(t_1 + t_2)(t_1^2 + t_2^2) + \left(\frac{2}{3}\right) t_w t_2^3 + \left(\frac{1}{3}\right)(h - 2t_2).t_w^3 + 2\alpha\varphi^4 - 4v_s t_1^4$$

Where for I shapes with flanges slopes of 1 in 6 (9.46 degrees slope)

$$\alpha_2 = -0.836 + 0.2540\frac{t_w}{t_2} + 0.1270\frac{R}{t_2} - 0.0806\frac{t_w.R}{t_2^2} - 0.0858\frac{t_w^2}{t_2^2}$$

And for I shape with parallel flanges (0 degrees slope)

$$\alpha_1 = -0.0420 + 0.2200\frac{t_w}{t_f} + 0.1360\frac{R}{t_f} - 0.0865\frac{t_w.R}{t_f^2} - 0.0725\frac{t_w^2}{t_f^2}$$

Darwish and Johnston[7] suggest that the expression for α for intermediate flange slopes may be found out by linear interpolation between α_2 and α_1 as given above.

Further,

$$V_s = 0.1050 + 0.1000S + 0.0848S^2 + 0.0675S^3 + 0.515S^4$$

$$\Phi = \frac{(F+m)^2 + t_w(R + \frac{t_w}{4})}{F+R+m}$$

$$F = RS\left(\sqrt{\frac{1}{S^2} + 1} - 1 - \frac{t_w}{R}\right)$$

$$S = \frac{2(m - t_1)}{b_f}$$

For parallel flange sections: As per research paper by M.K. Gupta on Additional Sectional properties of parallel flange sections[6];

$$I_t = \left(\frac{2}{3}\right) b_f t_f^3 + \left(\frac{1}{3}\right)(D - 2t_f).t_w^3 + 2\alpha\varphi^4 - 0.42t_f^4$$

Where,

$$\alpha_1 = -0.0420 + 0.2200\frac{t_w}{t_f} + 0.1360\frac{R}{t_f} - 0.0865\frac{t_w.R}{t_f^2} - 0.0725\frac{t_w^2}{t_f^2}$$

$$\Phi = \frac{(t_f+R)^2 + t_w(R + \frac{t_w}{4})}{2R + t_f}$$

Results and Discussion

Notations are mention in Table-2. The Table-3 and 4 for modified properties for ISMB and ISHB sections contains all those additional properties that were listed to be added. Results for Tapered Flange Section are mention in Figure-2,3,4,5. Results for Parallel Flange Section are mention in Figure-6,7. The Table-5,6,7,8 for modified properties for NPB sections contains all those additional properties that were listed to be added.

Table-2: Table for notations used.

Symbol	Description	Unit
a	Sectional area	mm^2
D	Depth of section	mm
B	Width of flange	mm
t_f	Thickness of flange	mm
t_w	Thickness of web	mm
I_{xx}	Moment of inertia about major axis	mm^4
I_{yy}	Moment of inertia about minor axis	mm^4
R_{xx}	Radius of gyration about major axis	mm
R_{yy}	Radius of gyration about minor axis	mm
Z_{xx}	Modulus of section about major axis	mm^3
Z_{yy}	Modulus of section about minor axis	mm^3
r_1	Radius at root (Tapered flange section)	mm
r_2	Radius at toe (Tapered flange section)	mm
r	Root radius (Parallel flange section)	mm
Z_{pz}	Plastic section modulus about major axis	mm^3
Z_{ez}	Elastic section modulus about major axis	mm^3
Z_{py}	Plastic section modulus about minor axis	mm^3
Z_{ey}	Elastic section modulus about minor axis	mm^3
I_w	Warping constant	mm^6
I_t	Torsional constant	mm^4

Table-3: Modified Properties of ISMB and ISHB sections.

Designation	Weight Per Metre		Sectional Area (a) mm^2	Depth of Section (D) mm	Width of Flange (B) mm	Thickness of Flange (t) mm	Thickness of Web (t_w) mm	Moment of Inertia		Radii of Gyration		Moduli of Section		Radius at Root (r_1) mm	Radius at Toe (r_2) mm	Slope of Flange Degrees	Correction Details				
	kg/m	N/m						I_{XX} $mm^4 X 10^4$	I_{YY} $mm^4 X 10^4$	r_{xx} mm	r_{YY} mm	Z_{XX} $mm^3 X 10^3$	Z_{YY} $mm^3 X 10^3$				h_1 mm	h_2 mm	b_1 mm	C mm	g mm	g_1 mm
ISMB 100	11.5	112.8	1460	100	75	7.2	4.0	257.5	40.8	42.0	16.7	51.5	10.9	9.0	4.5	98.0	65.0	17.50	35.50	3.50	35	55
ISMB 125	13.0	127.5	1660	125	75	7.6	4.4	448.0	43.7	52.0	16.2	71.8	11.7	9.0	4.5	98.0	89.2	17.90	35.30	3.70	35	55
ISMB 150	14.9	146.2	1900	150	80	7.6	4.8	726.4	52.6	61.8	16.6	96.9	13.1	9.0	4.5	98.0	113.9	18.05	37.60	3.90	40	55
ISMB 175	19.3	189.3	2462	175	90	8.6	5.5	1272.0	85.0	71.9	18.6	145.4	18.9	10.0	5.0	98.0	134.5	20.25	42.25	4.25	50	55
ISMB 200	25.4	249.2	3233	200	100	10.8	5.7	2235.4	150.0	83.2	21.5	223.5	30.0	11.0	5.5	98.0	152.7	23.65	47.15	4.35	55	60
ISMB 225	31.2	306.1	3972	225	110	11.8	6.5	3441.8	218.3	93.1	23.4	305.9	39.7	12.0	6.0	98.0	173.3	25.85	51.75	4.75	60	60
ISMB 250	37.3	365.9	4755	250	125	12.5	6.9	5131.6	334.5	103.9	26.5	410.5	53.5	13.0	6.5	98.0	194.1	27.95	59.05	4.95	65	65
ISMB 300	44.2	433.6	5626	300	140	12.4	7.5	8603.6	453.9	123.7	28.4	573.6	64.8	14.0	7.0	98.0	241.5	29.25	66.25	5.25	80	65
ISMB 350	52.4	514.0	6671	350	140	14.2	8.1	13630.3	537.7	142.9	28.4	778.9	76.8	14.0	7.0	98.0	288.0	31.00	65.95	5.55	80	65
ISMB 400	61.6	604.3	7846	400	140	16.0	8.9	20458.4	622.1	161.5	28.2	1022.9	88.9	14.0	7.0	98.0	334.4	32.80	65.55	5.95	80	70
ISMB 450	72.4	710.2	9227	450	150	17.4	9.4	30390.8	834.0	181.5	30.1	1350.7	111.2	15.0	7.5	98.0	379.2	35.40	70.30	6.20	90	70
ISMB 500	86.9	852.5	11074	500	180	17.2	10.2	45218.3	1369.8	202.1	35.2	1808.7	152.2	17.0	8.5	98.0	424.1	37.95	84.90	6.60	100	75
ISMB 550	103.7	1017.3	13211	550	190	19.3	11.2	64893.6	1833.8	221.6	37.3	2339.8	193.0	18.0	9.0	98.0	467.5	41.25	89.40	7.10	100	75
ISMB 600	122.6	1202.7	15621	600	210	20.8	12	91813	2651	242.4	41.2	3060.4	252.5	20	10	98	509.7	45.15	99	7.5	140, 100	80
ISHB 150	27.1	265.9	3448	150	150	9.0	5.4	1455.6	481.7	65.0	35.4	194.1	57.6	8.0	4.0	94.0	112.0	19.00	72.20	4.20	90	55
ISHB 150	30.6	300.2	3898	150	150	9.0	8.4	1540.0	460.3	62.9	34.4	205.3	60.2	8.0	4.0	94.0	112.0	19.00	70.80	5.70	90	55
ISHB 150	34.6	339.4	4408	150	150	9.0	11.8	1635.6	494.9	60.9	33.5	218.1	63.2	8.0	4.0	94.0	112.0	19.00	69.10	7.40	90	55
ISHB 200	37.3	365.9	4754	200	200	9.0	6.1	3608.4	967.1	87.1	45.1	360.8	96.7	9.0	4.5	94.0	158.4	20.80	98.95	4.55	140, 100	55
ISHB 200	40.0	392.4	5094	200	200	9.0	7.8	3721.8	994.6	85.5	44.2	372.2	98.6	9.0	4.5	94.0	158.4	20.80	96.10	5.40	140, 100	55
ISHB 225	43.1	422.8	5494	225	225	9.1	6.5	5279.5	1353.8	98.0	49.6	469.3	120.3	10.0	5.0	94.0	180.5	22.20	109.25	4.75	140	55
ISHB 225	46.8	459.1	5966	225	225	9.1	8.6	5470.8	1396.6	95.8	48.4	487	123.0	10.0	5.0	94.0	180.5	22.20	108.20	5.80	140	55
ISHB 250	51.0	500.3	6496	250	250	9.7	6.9	7736.5	1961.3	109.1	54.9	618.9	156.9	10.0	5.0	94.0	203.5	23.20	121.55	4.95	140	60
ISHB 250	54.7	536.6	6971	250	250	9.7	8.8	7983.9	2011.7	107.0	53.7	638.7	139.7	10.0	5.0	94.0	203.5	23.20	120.60	5.90	140	60
ISHB 300	58.8	576.8	7485	300	250	10.6	7.6	12545.2	2193.6	129.5	54.1	836.3	175.5	11.0	5.5	94.0	249.8	25.10	121.20	5.30	140	60
ISHB 300	63.0	618.0	8025	300	250	10.6	9.4	12950.2	2246.7	127.0	52.9	863.3	178.4	11.0	5.5	94.0	249.8	25.10	120.30	6.20	140	60
ISHB 350	67.4	661.2	8591	350	250	11.6	8.3	19159.7	2451.4	149.3	53.4	1094.8	196.1	12.0	6.0	94.0	296.0	27.00	120.85	5.65	140	60
ISHB 350	72.4	710.2	9221	350	250	11.6	10.1	19802.8	2510.5	146.5	52.2	1131.6	199.4	12.0	6.0	94.0	296.0	27.00	119.95	6.55	140	60
ISHB 400	77.4	759.3	9866	400	250	12.7	9.1	28083.5	2728.3	168.7	52.6	1404.2	218.3	14.0	7.0	94.0	340.1	29.90	120.45	6.05	140	65
ISHB 400	82.2	806.4	10466	400	250	12.7	10.6	28823.5	2783.0	166.1	51.6	1444.2	221.3	14.0	7.0	94.0	340.1	29.90	119.70	6.80	140	65
ISHB 450	87.2	855.4	11114	450	250	13.7	9.8	38210.8	2985.2	187.8	51.8	1742.7	238.8	15.0	7.5	94.0	386.2	31.90	120.10	6.40	140	65
ISHB 450	92.5	907.4	11789	450	250	13.7	11.3	40349.9	3045.0	185.0	50.8	1793.3	242.1	15.0	7.5	94.0	386.2	31.90	119.35	7.15	140	65

Table-4: Modified Properties of ISMB and ISHB sections (continued...).

Maximum size of Flange Rivet mm	Major Axis			Minor Axis							Design Bending Moment (laterally supported) KNm	Design Shear Force (KN)	Web Buckling		Web Bearing		Warping Constant (I_w) $mm^6 X10^9$	Torsional Constant (J) $mm^4 X10^4$	Designation
	Z_{pz} mm^3 X 10^3	Z_{ez} mm^3 X 10^3	Shape Factor	Z_{ey} mm^3 X 10^3	Z_{ey} mm^3 X 10^3	Shape Factor	b/t Ratio	d/t_w Ratio	Section Classification				Point load	Support	Point load	Support			
12	41.68	36.60	1.1389	10.59	10.90	1.8892	5.21	16.90	Plastic		9.47	52.49	84.59	131.20	99.95	210.00	0.878	2.951	**ISMB 100**
12	81.85	71.80	1.1399	21.91	11.70	1.8723	4.93	20.86	Plastic		18.60	72.17	102.64	140.59	113.15	233.00	1.506	3.517	**ISMB 125**
12	110.48	96.90	1.1401	25.10	13.10	1.9158	5.26	24.33	Plastic		25.11	94.48	120.45	150.11	123.87	254.18	2.667	4.000	**ISMB 150**
12	166.08	145.40	1.1422	36.02	18.90	1.9060	5.23	25.05	Plastic		37.75	126.30	157.48	178.59	159.28	303.75	5.884	6.562	**ISMB 175**
16	253.86	223.50	1.1358	55.45	30.00	1.8483	4.63	27.44	Plastic		57.70	149.59	170.34	177.30	193.27	335.52	13.424	12.488	**ISMB 200**
20	348.27	305.90	1.1385	73.52	39.70	1.8518	4.66	27.29	Plastic		79.15	191.91	220.78	215.31	241.04	397.39	24.807	18.321	**ISMB 225**
22	465.71	410.50	1.1345	100.33	53.50	1.8754	5.00	28.84	Plastic		105.84	226.35	246.40	228.04	273.86	455.17	47.170	25.021	**ISMB 250**
22	651.74	573.60	1.1362	125.39	64.80	1.9350	5.65	32.96	Plastic		148.12	295.24	279.84	240.75	308.03	480.88	93.859	29.987	**ISMB 300**
22	889.57	779.00	1.1421	144.44	76.80	1.8807	4.93	36.25	Plastic		202.18	372.01	316.73	255.48	356.97	535.70	151.380	42.376	**ISMB 350**
22	1176.18	1020.00	1.1498	164.09	88.90	1.8458	4.38	38.20	Plastic		267.31	467.14	374.53	286.64	419.33	606.82	229.331	58.754	**ISMB 400**
22	1533.36	1350.70	1.1500	204.92	111.20	1.8428	4.31	40.98	Plastic		348.49	555.06	404.29	296.24	478.08	666.55	390.193	79.832	**ISMB 450**
28	2074.67	1808.70	1.1471	290.75	152.20	1.9103	5.23	42.31	Plastic		471.52	669.22	468.14	331.70	545.99	744.14	798.237	101.565	**ISMB 500**
32	2711.98	2359.80	1.1492	364.40	193.00	1.8881	4.92	42.45	Plastic		616.36	808.31	563.90	386.99	655.19	856.55	1291.190	147.389	**ISMB 550**
25,32	3510.63	3068.4	1.1471	478.74	252.5	1.896	5.05	43.2	Plastic		797.87	906.99	634.52	421.74	735.81	926.84	2223.34	204.810	**ISMB 600**
22	215.64	194.10	1.1110	102.21	57.60	1.7740	8.33	21.48	Plastic		49.01	106.29	150.90	165.76	144.54	288.41	23.942	9.765	**ISHB 150**
22	232.52	205.30	1.1326	103.58	60.20	1.7206	8.33	13.81	Plastic		52.85	165.34	298.12	361.07	230.57	448.64	22.878	12.432	**ISHB 150**
22	251.64	218.10	1.1538	105.84	63.20	1.6748	8.33	9.83	Plastic		57.19	232.26	465.83	554.05	333.02	630.23	24.598	18.045	**ISHB 150**
22,32	397.23	360.80	1.1010	181.69	96.70	1.8789	11.11	26.89	Semi-compact		82.00	160.09	190.43	202.89	172.81	332.73	88.202	14.399	**ISHB 200**
22,32	414.23	372.20	1.1129	182.77	98.60	1.8536	11.11	21.03	Semi-compact		84.59	204.70	297.62	314.81	223.98	425.45	90.710	16.433	**ISHB 200**
28	515.82	469.30	1.0991	232.53	120.30	1.9329	12.36	28.74	Semi-compact		106.66	191.91	214.43	215.31	194.88	362.67	157.761	17.753	**ISHB 225**
28	542.22	487.00	1.1134	234.17	123.00	1.9038	12.36	21.72	Semi-compact		110.68	253.91	361.11	339.71	261.95	479.84	162.749	21.039	**ISHB 225**
32	678.73	618.90	1.0967	305.87	156.90	1.9495	12.89	30.52	Semi-compact		140.66	226.35	238.84	228.04	214.09	389.69	283.134	23.778	**ISHB 250**
32	708.43	638.70	1.1092	307.59	159.70	1.9260	12.89	23.93	Semi-compact		145.16	288.68	383.61	363.87	276.84	497.00	290.409	27.327	**ISHB 250**
32	921.68	836.30	1.1021	335.28	175.50	1.9104	11.79	33.79	Semi-compact		190.07	299.18	282.64	248.16	258.56	445.64	469.288	31.368	**ISHB 300**
32	962.18	863.30	1.1145	337.41	178.40	1.8913	11.79	27.32	Semi-compact		196.20	370.04	440.19	384.45	323.64	551.18	470.416	35.996	**ISHB 300**
32	1213.53	1094.80	1.1084	368.13	196.10	1.8772	10.78	36.48	Semi-compact		248.82	381.19	329.20	270.48	308.54	505.55	701.802	41.438	**ISHB 350**
32	1268.69	1131.60	1.1211	370.83	199.40	1.8598	10.78	29.98	Semi-compact		257.18	463.86	505.89	413.76	379.59	615.18	718.722	47.667	**ISHB 350**
32	1556.33	1404.20	1.1083	404.63	218.30	1.8536	9.84	38.09	Compact		353.71	477.64	388.70	301.72	381.39	596.33	1023.121	55.846	**ISHB 400**
32	1626.36	1444.20	1.1261	407.40	221.30	1.8409	9.84	32.70	Compact		369.63	556.37	551.10	426.35	447.87	682.98	1043.634	62.671	**ISHB 400**
32	1955.03	1742.70	1.1218	438.27	238.80	1.8353	9.12	40.06	Plastic		444.33	578.68	442.05	328.40	441.62	653.70	1420.639	71.106	**ISHB 450**
32	2030.95	1793.30	1.1325	441.62	242.10	1.8241	9.12	34.74	Plastic		461.58	667.25	615.63	456.00	513.07	753.76	1449.098	79.816	**ISHB 450**

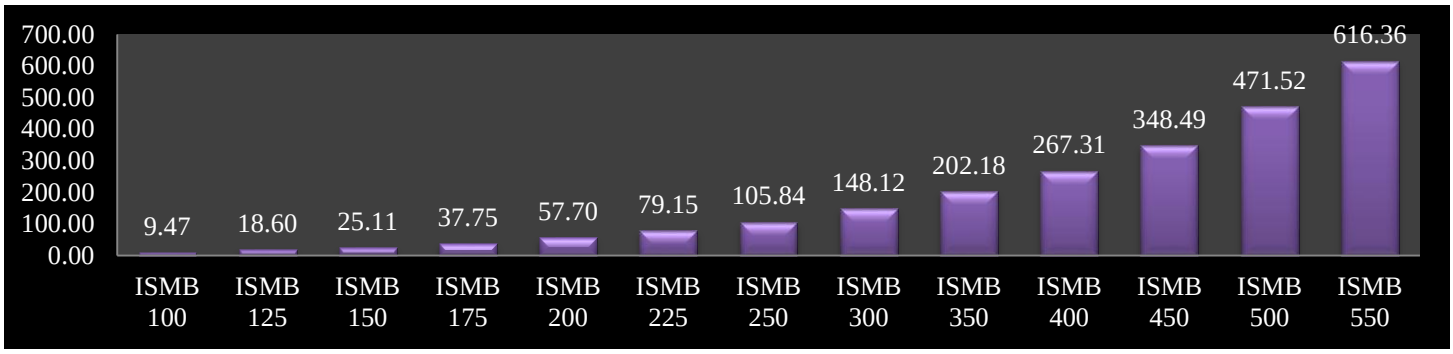

Figure-2: Design bending moment of ISMB sections.

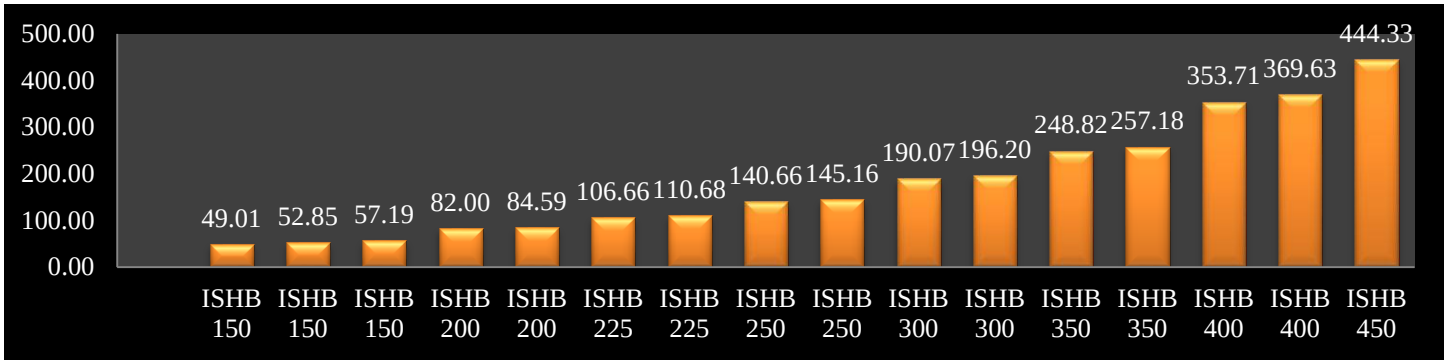

Figure-3: Design Bending moment of ISHB sections.

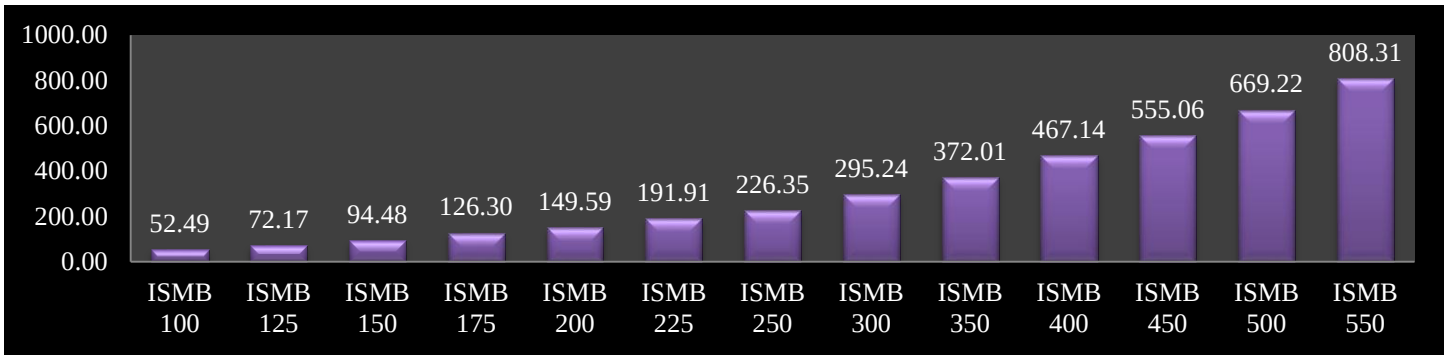

Figure-4: Design Shear force of ISMB sections.

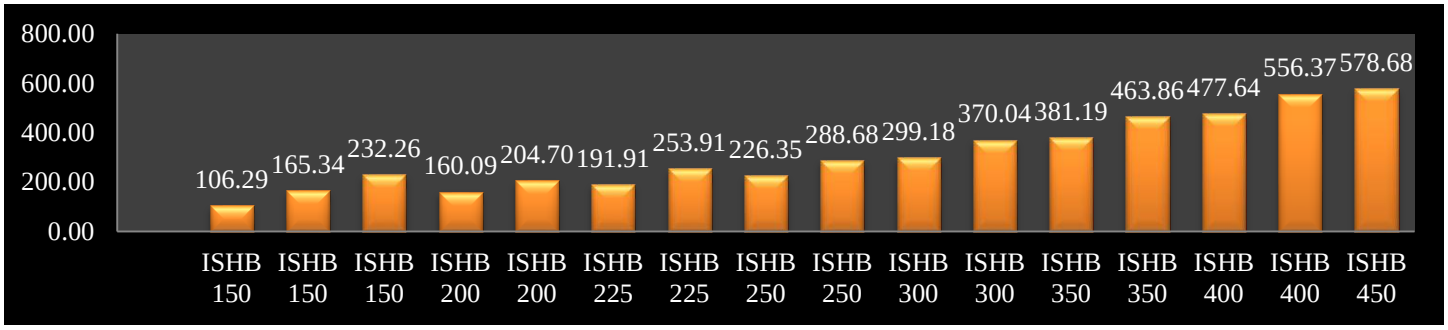

Figure-5: Design Shear force of ISHB sections.

The Figures-2,3,4,5 of Bending moment v/s sections and Shear force v/s sections, obtained from the tables of tapered flange sections above, are used to observe the trends of variation of Bending moment and shear force. If the loading is known, then by means of these graphs a section can be directly selected after calculating the actual bending moment and shear force acting.

Table-5: Modified Properties of NPB sections.

Designation				Weight Per Metre		Sectional Area (a) mm2	Depth of Section (D) mm	Width of Flange (B) mm	Thickness of Flange (t_f) mm	Thickness of Web (t_w) mm	Moment of Inertia		Radii of Gyration		Modulii of Section		Radius at Root (r) mm	Major Axis		
				kg/m	N/m						Ixx mm⁴ X 10⁴	I_yy mm⁴ X 10⁴	r_xx mm	r_yy mm	Z_xx mm³ X 10³	Z_yy mm³ X 10³		Z_pz mm³ X 10³	Z_az mm³ X 10³	Shape Factor
NPB	100	x	55	8.10	79.46	1030	100	55	5.7	4.1	171	15.9	40.7	12.4	34.2	5.8	7	39.41	34.20	1.1523
NPB	120	x	60	10.37	101.73	1320	120	64	6.3	4.4	318	27.7	49.0	14.5	53.0	8.6	7	60.73	53.00	1.1458
NPB	140	x	70	12.89	126.45	1640	140	73	6.9	4.7	541	44.9	57.4	16.5	77.3	12.3	7	88.35	77.30	1.1429
NPB	160	x	80	15.77	154.70	2010	160	82	7.4	5.0	869	68.3	65.8	18.4	108.7	16.7	9	123.87	108.70	1.1396
NPB	180	x	90	15.37	150.78	1960	177	91	6.5	4.3	1063	81.9	73.7	20.5	120.1	18.0	9	135.34	120.10	1.1269
NPB	180	x	90	18.80	184.43	2390	180	91	8.0	5.3	1317	100.9	74.2	20.5	146.3	22.2	9	166.42	146.30	1.1375
NPB	180	x	90	21.27	208.66	2710	182	92	9.0	6.0	1505	117.3	74.5	20.8	165.4	25.5	9	189.16	165.40	1.1437
NPB	200	x	100	18.42	180.70	2350	197	100	7.0	4.5	1591	117.2	82.3	22.3	161.6	23.4	12	181.67	161.60	1.1242
NPB	200	x	100	22.36	219.35	2850	200	100	8.5	5.6	1943	142.4	82.6	22.4	194.3	28.5	12	220.66	194.30	1.1357
NPB	200	x	100	25.09	246.13	3200	202	102	9.5	6.2	2211	168.9	83.2	23.0	218.9	33.1	12	249.44	218.90	1.1395
NPB	200	x	130	27.37	268.50	3490	207	133	8.5	5.8	2666	334.0	87.4	31.0	257.5	50.2	12	288.18	257.50	1.1191
NPB	200	x	130	31.55	309.51	4020	210	134	10.0	6.4	3153	401.9	88.6	31.6	300.3	60.0	12	337.19	300.30	1.1228
NPB	200	x	150	30.45	298.71	3880	194	150	9.0	6.0	2675	507.0	83.0	36.2	275.7	67.6	12	306.78	275.70	1.1127
NPB	200	x	165	35.68	350.02	4550	201	165	10.0	6.2	3414	749.5	86.7	40.6	339.7	90.9	12	376.80	339.70	1.1092
NPB	200	x	165	42.47	416.63	5410	205	166	12.0	7.2	4166	916.0	87.7	41.1	406.4	110.4	12	454.30	406.40	1.1179
NPB	200	x	165	48.00	470.88	6110	210	166	14.5	6.5	5025	1106.4	90.7	42.5	478.6	133.3	12	534.68	478.60	1.1172
NPB	220	x	110	22.18	217.59	2830	217	110	7.7	5.0	2317	171.4	90.5	24.6	213.5	31.2	12	240.23	213.50	1.1252
NPB	220	x	110	26.20	257.02	3340	220	110	9.2	5.9	2772	204.9	91.1	24.8	252.0	37.3	12	285.43	252.00	1.1327
NPB	220	x	110	29.35	287.92	3740	222	112	10.2	6.6	3134	239.8	91.6	25.3	282.3	42.8	12	321.17	282.30	1.1377
NPB	240	x	120	26.15	256.53	3330	237	120	8.3	5.2	3290	240.1	99.4	26.8	277.7	40.0	15	311.61	277.70	1.1221
NPB	240	x	120	30.71	301.27	3910	240	120	9.8	6.2	3892	283.6	99.7	26.9	324.3	47.3	15	366.68	324.30	1.1307
NPB	240	x	120	34.31	336.58	4370	242	122	10.8	7.0	4369	328.5	100.0	27.4	361.1	53.9	15	410.31	361.10	1.1363
NPB	250	x	125	30.11	295.38	3840	250	125	9.0	6.0	4138	294.3	103.9	27.7	331.1	47.1	15	373.65	331.10	1.1285
NPB	250	x	150	34.08	334.32	4340	238	146	9.2	6.1	5120	478.6	108.6	33.2	396.9	65.6	15	444.26	396.90	1.1193
NPB	250	x	150	39.78	390.24	5070	262	147	11.2	6.6	6200	594.5	110.6	34.3	473.3	80.9	15	530.17	473.30	1.1202
NPB	250	x	150	46.48	455.97	5920	266	148	13.2	7.6	7381	715.2	111.7	34.8	555.0	96.7	15	625.47	555.00	1.1270
NPB	250	x	175	43.94	431.05	5600	244	175	11.0	7.0	6091	984.2	104.3	41.9	499.3	112.5	15	555.60	499.30	1.1128
NPB	270	x	135	30.73	301.46	3910	267	135	8.7	5.5	4917	358.0	112.1	30.2	368.3	53.0	15	412.53	368.30	1.1201
NPB	270	x	135	36.07	353.85	4590	270	135	10.2	6.6	5790	419.9	112.3	30.2	428.9	62.2	15	484.04	428.90	1.1286
NPB	270	x	135	42.26	414.57	5380	274	136	12.2	7.5	6947	513.5	113.6	30.9	507.1	75.5	15	574.69	507.10	1.1333
NPB	300	x	150	36.52	358.26	4650	297	150	9.2	6.1	7173	519.0	124.2	33.4	483.1	69.2	15	541.83	483.10	1.1216
NPB	300	x	150	42.24	414.37	5380	300	150	10.7	7.1	8356	603.8	124.6	33.5	557.1	80.5	15	628.40	557.10	1.1280
NPB	300	x	150	49.32	483.83	6280	304	152	12.7	8.0	9994	745.7	126.1	34.5	657.5	98.1	15	743.86	657.50	1.1313

Table-6: Modified Properties of NPB sections (continued...).

Minor Axis			b/t_f Ratio	d/t_w Ratio	Section Classification	Design Bending Moment (laterally supported) KNm	Design Shear force (KN)	Web Buckling		Web Bearing		Warping Constant (I_w) mm^6x10^{12}	Torsional Constant (I_t) mm^4x10^4	Designation
Z_{py} mm^3 X 10^3	Z_{ey} mm^3 X 10^3	Shape Factor						Point load	support	Point load	support			
9.15	5.80	1.5776	4.82	18.20	Plastic	8.96	53.80	84.41	136.47	81.26	198.94	0.000351	1.158	NPB 100 x 55
13.58	8.60	1.5791	5.08	21.23	Plastic	13.80	69.28	98.97	143.14	91.70	216.50	0.000890	1.691	NPB 120 x 60
19.25	12.30	1.5650	5.29	23.87	Plastic	20.08	86.34	113.48	149.76	102.76	234.47	0.001981	2.400	NPB 140 x 70
26.10	16.70	1.5629	5.54	25.44	Plastic	28.15	104.98	129.44	156.40	127.67	263.64	0.003959	3.542	NPB 160 x 80
27.96	18.00	1.5533	7.00	33.95	Plastic	30.76	99.87	91.07	106.03	102.95	222.33	0.005933	2.675	NPB 180 x 90
34.60	22.20	1.5586	5.69	27.55	Plastic	37.82	125.18	144.43	163.62	140.75	283.07	0.007431	4.728	NPB 180 x 90
39.91	25.50	1.5651	5.11	24.33	Plastic	42.99	143.29	185.37	206.30	169.84	327.27	0.008740	6.649	NPB 180 x 90
36.54	23.40	1.5615	7.14	35.33	Plastic	41.29	116.33	98.44	106.56	130.46	250.57	0.010529	4.139	NPB 200 x 100
44.62	28.50	1.5656	5.88	28.39	Plastic	50.15	146.97	161.77	170.88	177.12	321.36	0.012988	6.921	NPB 200 x 100
51.90	33.10	1.5680	5.37	25.65	Plastic	56.69	164.34	200.17	208.25	206.80	362.84	0.015566	9.362	NPB 200 x 100
77.47	50.20	1.5432	7.82	28.62	Plastic	65.50	157.54	172.80	179.63	183.71	332.84	0.032831	8.484	NPB 200 x 130
92.46	60.00	1.5410	6.70	25.94	Plastic	76.63	176.36	213.11	216.97	218.86	378.18	0.040102	12.813	NPB 200 x 130
103.54	67.60	1.5317	8.33	25.33	Plastic	69.72	152.74	187.62	199.70	195.09	347.73	0.043316	10.497	NPB 200 x 150
138.58	90.90	1.5245	8.25	25.32	Plastic	85.64	163.53	201.07	208.77	211.74	366.36	0.068282	14.594	NPB 200 x 165
168.46	110.40	1.5259	6.92	21.81	Plastic	103.25	193.68	241.65	243.81	270.43	441.82	0.085194	24.170	NPB 200 x 165
202.43	133.30	1.5186	5.72	24.15	Plastic	121.52	179.12	227.50	223.50	268.96	417.33	0.105627	37.900	NPB 200 x 165
48.49	31.20	1.5542	7.14	35.52	Plastic	54.60	142.37	121.28	124.67	151.10	282.39	0.018707	5.683	NPB 220 x 110
58.11	37.30	1.5579	5.98	30.10	Plastic	64.87	170.32	177.57	178.70	193.58	343.27	0.022672	9.036	NPB 220 x 110
66.91	42.80	1.5633	5.49	26.91	Plastic	72.99	192.26	225.47	223.70	228.10	391.50	0.026785	12.172	NPB 220 x 110
62.41	40.00	1.5603	7.23	36.62	Plastic	70.82	161.72	129.78	126.08	184.22	314.95	0.031257	8.512	NPB 240 x 120
73.93	47.30	1.5630	6.12	30.71	Plastic	83.34	195.26	195.94	186.68	235.85	386.09	0.037391	12.964	NPB 240 x 120
84.40	53.90	1.5659	5.65	27.20	Plastic	93.25	222.29	254.88	239.69	278.70	443.86	0.043678	17.106	NPB 240 x 120
73.63	47.10	1.5633	6.94	33.67	Plastic	84.92	196.83	178.13	168.00	220.34	368.18	0.042540	11.113	NPB 250 x 125
101.53	65.60	1.5477	7.93	34.36	Plastic	100.97	206.51	182.83	169.99	226.09	375.70	0.073848	12.857	NPB 250 x 150
124.91	80.90	1.5440	6.56	31.76	Plastic	120.49	226.91	220.08	200.41	266.37	421.50	0.093242	20.326	NPB 250 x 150
149.41	96.70	1.5451	5.61	27.58	Plastic	142.15	265.27	301.10	268.31	332.64	502.64	0.113947	31.553	NPB 250 x 150
172.49	112.50	1.5332	7.95	27.43	Plastic	126.27	224.12	254.85	238.55	280.92	445.45	0.133354	22.469	NPB 250 x 175
82.35	53.00	1.5538	7.76	39.93	Plastic	93.76	192.70	139.38	128.51	198.73	335.63	0.059506	10.421	NPB 270 x 135
96.96	62.20	1.5588	6.62	33.27	Plastic	110.01	233.83	216.30	195.96	255.87	414.00	0.070578	15.914	NPB 270 x 135
117.71	75.50	1.5591	5.57	29.28	Plastic	130.61	269.66	289.02	256.43	316.16	487.50	0.087640	25.002	NPB 270 x 135
107.33	69.20	1.5510	8.15	40.75	Plastic	123.14	237.73	169.77	149.46	226.09	375.70	0.107160	13.359	NPB 300 x 150
125.23	80.50	1.5557	7.01	35.01	Plastic	142.82	279.50	245.74	213.02	281.71	449.40	0.125934	19.930	NPB 300 x 150
152.59	98.10	1.5555	5.98	31.08	Plastic	169.06	319.13	323.74	275.42	344.51	524.55	0.157690	30.991	NPB 300 x 150

Table-7: Modified Properties of NPB sections.

Designation						Weight Per Metre		Sectional Area (a) mm2	Depth of Section (D) mm	Width of Flange (B) mm	Thickness of Flange (t) mm	Thickness of Web (t_w) mm	Moment of Inertia		Radii of Gyration		Moduli of Section		Radius at Root (r) mm	Major Axis		Shape Factor
						kg/m	N/m						Ixx mm^4 X 10^4	I_{yy} mm^4 X 10^4	r_{xx} mm	r_{yy} mm	Z_{XX} mm^3 X 10^3	Z_{yy} mm^3 X 10^3		Z_{pz} mm^3 X 10^3	Z_{ez} mm^3 X 10^3	
NPB	300	x	165			38.88	391.22	5080	310	165	9.7	5.8	8795	727.6	131.6	37.8	567.4	88.2	15	630.54	567.40	1.1113
NPB	300	x	165			45.76	448.91	5830	313	166	11.2	6.6	10210	855.6	132.3	38.3	652.4	103.1	15	727.91	652.40	1.1157
NPB	300	x	165			53.46	524.44	6810	317	167	13.2	7.6	12123	1026.8	133.4	38.8	764.8	123.0	15	857.61	764.80	1.1214
NPB	300	x	200			59.56	584.28	7590	303	203	13.1	7.5	12860	1828.6	130.2	49.1	848.9	180.2	15	940.72	848.90	1.1082
NPB	300	x	200			66.75	654.82	8500	306	204	14.6	8.5	14511	2068.5	130.6	49.3	948.4	202.8	15	1056.85	948.40	1.1144
NPB	300	x	200			75.37	739.38	9600	310	205	16.6	9.4	16676	2386.8	131.8	49.9	10759	232.9	15	1204.62	1075.90	1.1196
NPB	330	x	160			42.97	421.54	5470	327	160	10.0	6.5	10231	685.2	136.7	35.4	625.7	85.6	18	702.00	625.70	1.1219
NPB	330	x	160			49.15	482.16	6260	330	160	11.5	7.5	11767	788.1	137.1	35.5	713.1	98.5	18	804.40	713.10	1.1280
NPB	330	x	160			57.00	559.17	7260	334	162	13.5	8.5	13910	960.4	138.4	36.4	833.0	118.6	18	942.86	833.00	1.1319
NPB	350	x	170			50.21	492.56	6400	357.6	170	11.5	6.6	14515	944.3	150.6	38.4	811.8	111.1	18	906.84	811.80	1.1171
NPB	350	x	170			57.09	560.05	7270	360	170	12.7	8.0	16266	1043.5	149.5	37.9	903.6	122.8	18	1019.22	903.60	1.1280
NPB	350	x	170			66.04	647.85	8410	364	172	14.7	9.2	19047	1251.2	150.5	38.6	1046.6	145.5	18	1186.16	1046.60	1.1333
NPB	350	x	250			79.18	776.76	10090	340	250	14.0	9.0	21530	3650.1	146.1	60.2	1266.5	292.0	18	1402.36	1266.30	1.1073
NPB	400	x	180			57.38	562.90	7310	397	180	12.0	7.0	20293	1170.6	166.6	40.0	1022.3	130.1	21	1144.02	1022.30	1.1191
NPB	400	x	180			66.30	650.40	8450	400	180	13.5	8.6	23128	1317.8	165.5	39.5	1156.4	146.4	21	1307.26	1156.40	1.1305
NPB	400	x	180			75.66	742.22	9640	404	182	15.5	9.7	26747	1564.2	166.6	40.3	1324.1	171.9	21	1502.29	1324.10	1.1346
NPB	400	x	200			67.28	660.02	8570	400	200	13.0	8.0	24224	1738.4	168.1	45.0	1211.2	173.8	21	1355.08	1211.20	1.1188
NPB	450	x	190			67.15	658.74	8530	447	190	13.1	7.6	29759	1502.4	186.5	41.9	1331.5	158.1	21	1494.42	1331.50	1.1224
NPB	450	x	190			77.57	760.96	9880	450	190	14.6	9.4	33743	1675.9	184.8	41.2	1499.7	176.4	21	1701.93	1499.70	1.1348
NPB	450	x	190			92.36	906.05	11770	456	192	17.6	11.0	40923	2085.4	186.5	42.1	1794.9	217.2	21	2046.40	1794.90	1.1401
NPB	500	x	200			79.36	778.52	10110	497	200	14.5	8.4	42933	1939.2	206.1	43.8	1727.7	193.9	21	1946.16	1727.70	1.1264
NPB	500	x	200			90.68	889.57	11550	500	200	16.0	10.2	48199	2141.7	204.3	43.1	1927.9	214.2	21	2194.27	1927.90	1.1382
NPB	500	x	200			107.31	1052.71	13670	506	202	19.0	12.0	57777	2621.7	205.6	43.8	2283.7	259.6	21	2613.13	2283.70	1.1443
NPB	550	x	210			92.07	903.21	11730	547	210	15.7	9.0	59979	2432.2	226.1	45.5	2193.0	231.6	24	2474.87	2193.00	1.1285
NPB	550	x	210			105.52	1035.15	13440	550	210	17.2	11.1	67116	2667.6	223.5	44.5	2440.6	254.1	24	2787.22	2440.60	1.1420
NPB	550	x	210			122.52	1201.92	15610	556	212	20.2	12.7	79157	3244.4	225.2	45.5	2847.4	304.2	24	3263.59	2847.40	1.1462
NPB	600	x	220			107.56	1055.16	13700	597	220	17.5	9.8	82919	3116.3	246.0	47.7	2777.8	283.3	24	3141.42	2777.80	1.1309
NPB	600	x	220			122.45	1201.23	15600	600	220	19.0	12.0	92083	3387.3	243.0	46.6	3069.4	307.9	24	3512.64	3069.40	1.1444
NPB	600	x	220			154.46	1515.25	19680	610	224	24.0	15.0	118302	4520.8	245.2	47.9	3878.8	403.6	24	4471.27	3878.80	1.1527
NPB	700	x	250			113.45	1112.94	14450	694	250	16.0	9.0	118957	4176.5	286.9	53.8	3428.1	334.1	24	3859.34	3428.10	1.1258
NPB	700	x	250			128.41	1259.70	16360	695	250	16.5	11.5	128015	4312.4	279.8	51.3	3683.9	345.0	24	4220.06	3683.90	1.1455
NPB	700	x	250			143.42	1406.95	18270	700	250	19.0	12.5	145636	4966.4	282.3	52.1	4161.0	397.3	24	4765.55	4161.00	1.1453
NPB	700	x	250			153.86	1509.37	19600	704	250	21.0	13.0	159165	5488.8	285.0	52.9	4521.7	439.1	24	5171.33	4521.70	1.1437
NPB	700	x	250			171.47	1682.12	21840	709	250	23.5	14.5	178390	6145.5	285.8	53.0	5032.2	491.6	24	5777.24	5032.20	1.1481
NPB	750	x	270			145.29	1425.29	18510	750	265	16.6	13.2	161958	5165.3	295.8	52.8	4318.9	389.8	17	5009.90	4318.90	1.1600
NPB	750	x	270			174.54	1712.24	22230	760	270	21.6	14.4	206351	7107.0	304.6	56.5	5430.3	526.4	17	6244.16	5430.30	1.1499
NPB	750	x	270			202.48	1986.33	25790	770	270	26.6	15.6	249537	8752.4	311.0	58.3	6481.5	648.3	17	7431.05	6481.50	1.1465

Table-8: Modified Properties of NPB sections (continued...).

Minor Axis			b/t_f Ratio	d/t_w Ratio	Section Classification	Design Bending Moment (laterally supported) KNm	Design Shear force (KN)	Web Buckling		Web Bearing		Warping Constant (I_w) $mm^6 x10^{12}$	Torsional Constant (I_t) $mm^4 x10^4$	Designation			
Z_{py} mm^3 X 10^3	Z_{ey} mm^3 X 10^3	Shape Factor						Point load	support	Point load	support						
135.70	88.20	1.5385	8.51	44.93	Plastic	143.30	235.93	146.01	126.24	219.19	360.52	0.163728	15.426	NPB	300	x	165
158.77	103.10	1.5400	7.41	39.48	Plastic	165.43	271.07	202.34	172.47	266.37	421.50	0.194433	22.594	NPB	300	x	165
189.65	123.00	1.5419	6.33	34.29	Plastic	194.91	316.13	284.85	238.42	332.64	502.64	0.236422	35.212	NPB	300	x	165
275.19	180.20	1.5271	7.75	32.91	Plastic	213.80	298.20	281.01	239.15	326.90	495.17	0.383747	39.581	NPB	300	x	200
310.27	202.80	1.5299	6.99	29.04	Plastic	240.19	341.30	371.58	311.64	392.70	575.68	0.438542	54.318	NPB	300	x	200
356.48	232.90	1.5306	6.17	26.26	Plastic	273.78	382.37	460.43	379.36	466.11	658.00	0.512954	77.645	NPB	300	x	200
133.28	85.60	1.5570	8.00	41.69	Plastic	159.55	278.91	190.58	159.49	277.13	428.41	0.171501	19.656	NPB	330	x	160
153.69	98.50	1.5603	6.96	36.13	Plastic	182.82	324.77	270.74	223.49	339.37	507.10	0.199097	28.085	NPB	330	x	160
185.00	118.60	1.5599	6.00	31.88	Plastic	214.29	372.53	363.41	294.94	413.59	594.03	0.245654	42.229	NPB	330	x	160
171.87	111.10	1.5470	7.39	45.24	Plastic	206.10	309.70	188.31	151.65	297.29	446.25	0.281992	27.389	NPB	350	x	170
191.11	122.80	1.5563	6.69	37.33	Plastic	231.64	377.91	304.64	242.54	378.17	551.82	0.313580	37.464	NPB	350	x	170
226.93	145.50	1.5597	5.85	32.46	Plastic	269.58	439.43	423.01	331.46	466.68	655.50	0.380267	55.770	NPB	350	x	170
446.20	292.00	1.5281	8.93	30.67	Plastic	318.72	401.53	411.24	330.57	446.11	634.09	0.968661	63.410	NPB	350	x	250
202.09	130.10	1.5533	7.50	47.29	Plastic	260.00	364.66	205.75	158.42	350.97	501.14	0.432224	36.199	NPB	400	x	180
229.02	146.40	1.5643	6.67	38.49	Plastic	297.10	451.40	347.30	264.13	454.85	630.34	0.490048	51.319	NPB	400	x	180
269.11	171.90	1.5655	5.87	34.12	Plastic	341.43	514.22	463.84	347.89	546.31	733.01	0.587647	73.390	NPB	400	x	180
269.29	173.80	1.5494	7.69	41.50	Plastic	307.97	419.90	289.84	221.20	415.66	581.82	0.648999	48.545	NPB	400	x	200
245.76	158.10	1.5545	7.25	49.84	Plastic	339.64	445.78	235.35	173.92	395.39	553.59	0.704856	47.174	NPB	450	x	190
276.40	176.40	1.5669	6.51	40.30	Plastic	386.80	555.06	405.43	296.24	515.32	700.73	0.791005	66.792	NPB	450	x	190
341.01	217.20	1.5700	5.45	34.44	Plastic	465.09	658.20	593.86	426.11	659.53	857.50	0.997576	109.011	NPB	450	x	190
301.64	193.90	1.5556	6.90	50.71	Plastic	442.31	547.82	284.79	203.02	457.25	625.23	1.125230	64.324	NPB	500	x	200
335.90	214.20	1.5682	6.25	41.76	Plastic	498.70	669.22	470.03	331.70	583.75	776.59	1.249365	89.145	NPB	500	x	200
408.55	259.60	1.5738	5.32	35.50	Plastic	593.89	796.77	698.69	484.95	748.94	954.55	1.547585	142.843	NPB	500	x	200
361.53	231.60	1.5610	6.69	51.96	Plastic	562.47	646.00	321.58	221.26	546.19	712.84	1.710117	89.368	NPB	550	x	210
400.56	254.10	1.5764	6.10	42.13	Plastic	633.46	801.10	554.20	377.68	705.43	898.09	1.884098	122.891	NPB	550	x	210
480.54	304.20	1.5797	5.25	36.82	Plastic	741.73	889.51	760.24	510.62	837.45	1028.01	2.302253	187.203	NPB	550	x	210
442.09	283.30	1.5605	6.29	52.45	Plastic	713.96	767.71	379.74	254.22	624.59	796.25	2.607364	122.203	NPB	600	x	220
485.68	307.90	1.5774	5.79	42.83	Plastic	798.33	944.78	642.87	426.60	799.44	995.45	2.845527	165.295	NPB	600	x	220
640.11	403.60	1.5860	4.67	34.27	Plastic	1016.20	1152.63	1083.66	703.25	1083.69	1276.36	3.859573	316.495	NPB	600	x	220
518.31	334.10	1.5514	7.81	68.22	Plastic	877.12	819.60	266.14	173.33	550.49	715.91	4.788375	107.328	NPB	700	x	250
543.03	345.00	1.5740	7.58	53.39	Plastic	959.10	1048.77	516.86	334.98	719.08	921.31	4.945298	136.390	NPB	700	x	250
628.38	397.30	1.5816	6.58	49.12	Plastic	1083.08	1148.17	644.51	413.88	834.17	1036.93	5.736627	190.903	NPB	700	x	250
690.11	439.10	1.5716	5.95	47.23	Plastic	1175.30	1152.89	708.51	451.86	873.96	1063.64	6.377779	240.082	NPB	700	x	250
775.44	491.60	1.5774	5.32	42.34	Plastic	1313.01	1295.05	933.70	589.83	1034.91	1225.91	7.189382	328.156	NPB	700	x	250
616.68	389.80	1.5820	7.98	51.73	Plastic	1138.61	1299.08	697.82	448.79	702.97	954.00	6.923350	150.693	NPB	750	x	270
827.22	526.40	1.5715	6.25	47.42	Plastic	1419.13	1378.63	867.86	549.20	849.94	1077.64	9.658667	272.194	NPB	750	x	270
1016.07	648.30	1.5673	5.08	43.77	Plastic	1688.88	1513.16	1065.93	664.09	1043.98	1252.54	12.056099	450.988	NPB	750	x	270

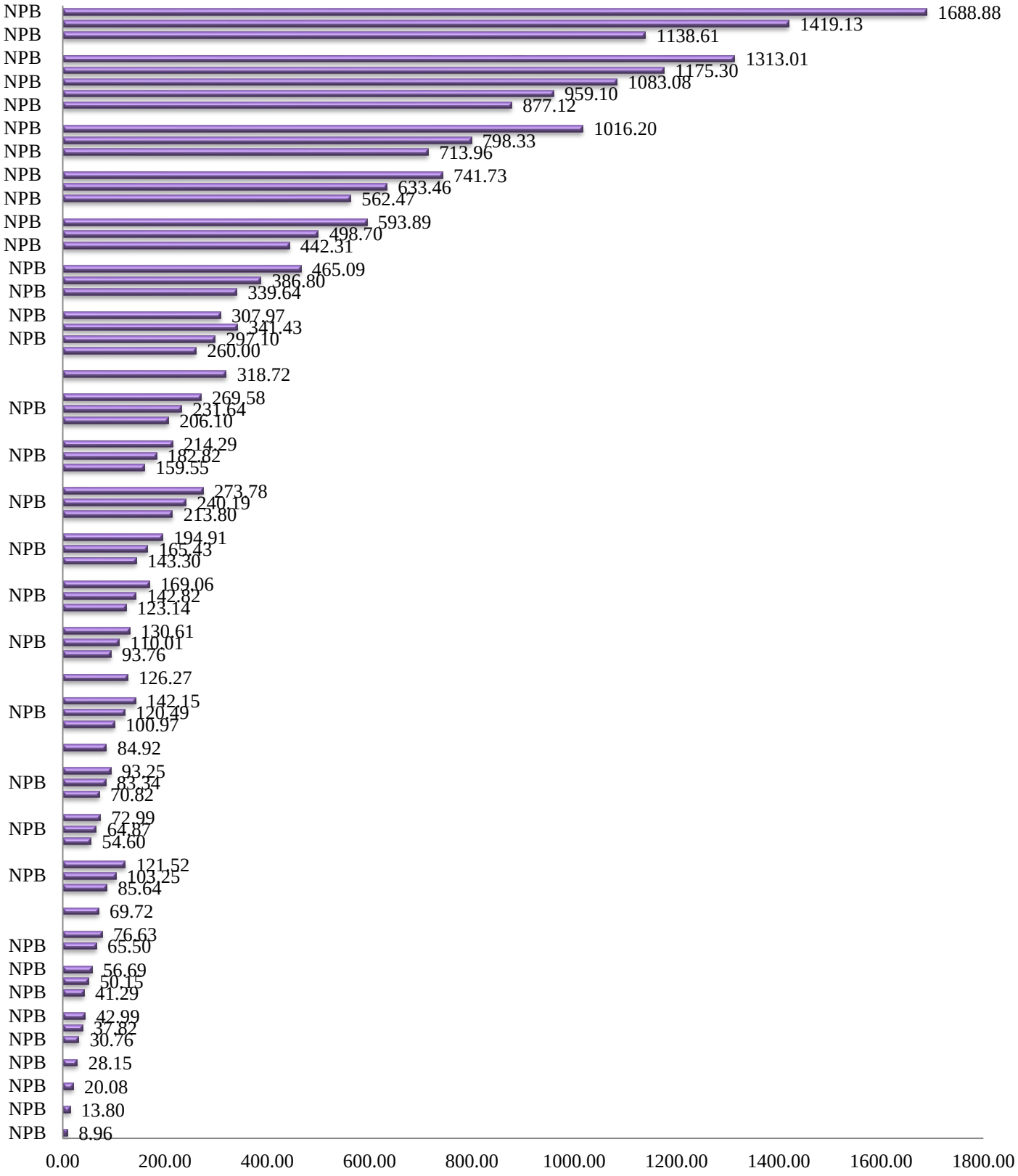

Figure-6: Design bending moment of NPB sections.

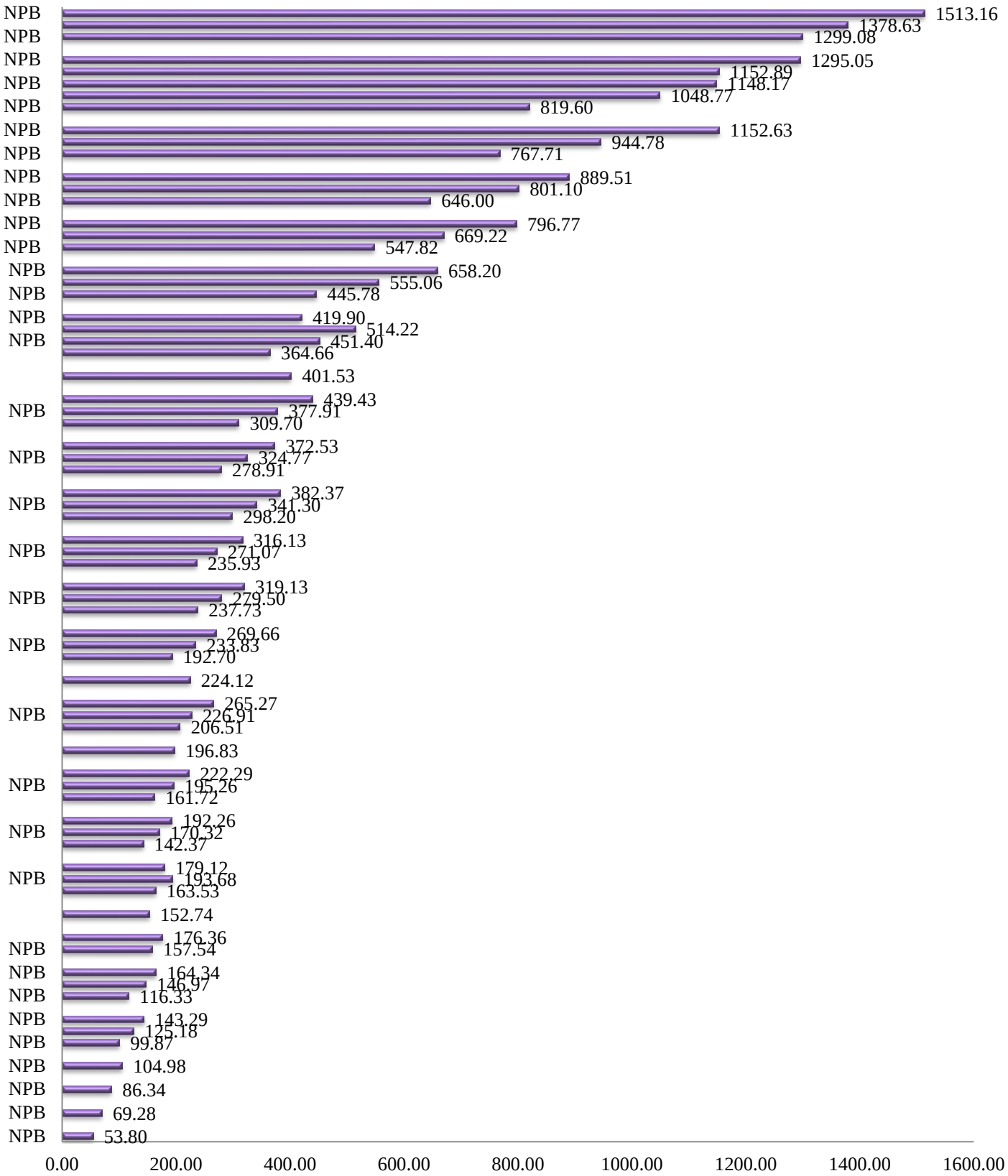

Figure-7: Design Shear force of NPB sections.

The same results (Figure-6 and 7) can be drawn as in the case of tapered flange sections. For parallel flange sections also, through graphs a section can be chosen that can bear the bending moment and shear force coming due to applied loading.

Discussion: Facts about Tapered Flange Section: Both shear force and bending moment carrying capacity increases with unit weight.

Table-9: Comparison between ISHB sections.

Designation	Unit Weight (kg/m)	Design Shear Force (KN)	Design Bending Moment (KNm)
ISHB 150	27.1	106.29	49.01
ISHB 150	30.6	165.34	52.85
ISHB 150	34.6	232.26	57.19

From the Table-9 for tapered flange sections; we can notice that with the increase in unit weight of sections having same depth, the design shear force and bending moment also increases.

Section with maximum shape factor along: Major Axis- ISJB 175 @ 8.1 kg/m with shape factor as 1.1799. Minor Axis- ISLB 325 @ 43.1 kg/m with shape factor as 2.2156.
ISWB 600 @ 145.1 kg/m is strongest against moments; it can carry moment upto986.73KNm.
ISLB 75 @ 6.1 kg/m is weakest against moments; it can carry moment upto 5.08 KNm.
ISMB 600 @ 122.6 kg/m is strongest against shear force; it can carry shear force upto906.99 KN.
ISLB 75 @ 6.1 kg/m is weakest against shear force; it can carry shear force upto 36.41 KN.
For all sections, shape factor about minor axis is greater than shape factor about major axis.

Facts about Parallel Flange Sections: Both shear force and bending moment carrying capacity increases with unit weight of both NPB and WPB sections.

Table-10: Comparison between NPB sections.

Designation	Unit Weight (kg/m)	Design Shear Force (KN)	Design Bending Moment (KNm)
NPB 180 x 90	15.37	99.87	30.76
NPB 180 x 90	18.8	125.18	37.82
NPB 180 x 90	21.27	143.29	42.99

From the above Table-10 we can notice that with the increase in unit weight of sections having same depth, the design shear force and bending moment also increases.

Section with maximum shape factor along: Major Axis- NPB 750 x 270 @ 145.29 kg/m with shape factor as 1.1600. WPB 100 x 100 @ 41.79 kg/m with shape factor as 1.2386. Minor Axis- NPB 600 x 220 @ 154.46 kg/m with shape factor as 1.5860.
WPB 900 x 300 @ 198 kg/m with shape factor as 1.5888.
NPB 750 x 270 @ 202.48 kg/m is strongest against moments; it can carry moment upto1688.88KNm.
NPB 100 x 55 @ 8.1 kg/m is weakest against moments; it can carry moment upto 8.96 KNm.
NPB 750 x 270 @ 202.48 kg/m is strongest against shear force; it can carry shear force upto1513.16KN.
NPB 100 x 55 @ 8.1kg/m is weakest against shear force; it can carry shear force upto53.8 KN.
WPB 900 x 300 @ 291.45 kg/m is strongest against moments; it can carry moment upto2860.15KNm.
WPB 100 x 100 @ 12.24 kg/m is weakest against moments; it can carry moment upto13.26 KNm.
WPB 900 x 300 @ 291.45 kg/m is strongest against shear force; it can carry shear force upto2097.4KN.
WPB 100 x 100 @ 12.24 kg/m is weakest against shear force; it can carry shear force upto50.15 KN.
For all sections, shape factor about minor axis is greater than shape factor about major axis.

Comparison between parallel and tapered flange sections: Comparison between parallel and tapered flange sections when used as flexure members are mention in Table-11 and when used as compression members are mention in Table-12.

Table-11: Comparison between tapered flange section and parallel flange section when used as flexure member.

Designation	Unit Weight (kg/m)	Depth (mm)	Section Modulus about major axis (mm^3 x 10^3)	Bending Moment (KNm)
ISMB 175	19.3	175	145.4	37.75
NPB 180 x 90	18.8	180	146.3	37.82
ISMB 200	25.4	200	223.5	57.7
NPB 240 x 120	26.15	237	277.7	70.82

From the Table-11 it can be observed that for approximately same unit weight, parallel flange sections have more section modulus about major axis and also are able to resist more moment, thus prove to be better than tapered flange sections when subjected to bending. i. ISMB 175 and NPB 180 x 90: NPB section has less unit weight but has slightly more section modulus about major axis and design bending moment. ii. ISMB 200 and NPB 240 x 120: NPB section has slightly more unit weight but has significantly more section modulus about major axis and design bending moment.

Table-12: Comparison between tapered flange section and parallel flange section when used as compression member.

Designation	Unit Weight (kg/m)	Depth (mm)	Radius of gyration about minor axis (mm)	Bending Moment (KNm)
ISHB 150	34.6	150	33.5	57.19
WPB 200 x 200	34.64	186	49.2	71.95
ISHB 200	40	200	44.2	84.59
WPB 220 x 220	40.4	205	54.2	92.48

From the Table-12 it can be observed that for approximately same unit weight, parallel flange sections have more radius of gyration about minor axis and also are able to resist more moment, thus prove to be better than tapered flange sections when subjected to compression. i. ISHB 150 and WPB 200 x 200: WPB section has approximately same unit weight but has more radius of gyration about minor axis and design bending moment. ii. ISHB 200 and WPB 220 x 220:- WPB section has approximately same unit weight but has more radius of gyration about minor axis and design bending moment.

Conclusion

From the results, it can be concluded that by use of additional properties that are being included in the currently available steel tables, one can visually conclude that a particular section will suit the given loading conditions or not, without doing lengthy calculations.

Use of Figures makes the study of steel structures more interesting and helps viewers understand the trends of variation of different parameters for the available Indian standard sections. Comparison of different tapered flange sections and parallel flange sections makes users understand which section is better and then sections should be preferred accordingly.

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