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Calculation and Verification of Z_{PZ} Values in IS 800:2007

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Abstract:** Plastic Section Modulus of a section is the first moment of the cross sectional area about an axis which divides the sectional area into two equal halves. In this paper an attempt has been made to calculate and verify the Z_{pz} values of tapered flange I and C Sections. I-Section has been divided into a total of 13 component areas and C-Section into 7 component areas. The area of each component is calculated and the position of centroid of each component area is identified and used in the calculation of the Plastic Section Modulus of the cross section about Z-Z axis. Eleven I-sections and One C-section Z_{pz} values are found to differ from the values given in the IS 800 : 2007[2] by more than 100 mm^3, i.e., 0.1 cm^3 and are reported here. These verifications gain significance due to the fact that, in case of four I-sections, the difference is found to be more than 10000 mm^3, i.e., 10cm^3.
***Keywords:** I-Sections, C-Sections, Z_{pz}, IS 800 : 2007[2] , Axis of symmetry.*

I. INTRODUCTION

IS 800:2007[2] gives the values of Plastic Sectional Modulii, Z_{pz}, of I and C-Sections about z-z axis, in Annexure H, pages 138 to 140. The values given are in cm^3. The values of Z_{pz} are used in the determination of Moment of Resistance of Plastic and Compact sections as per IS 800: 2007[2] and hence play an important role in the design of beams by Limit State Method. For Semi-Compact sections Elastic Section Modulus Z_e is to be used as per the Code, which is the ratio of Moment of Inertia of the section, I, and the distance of extreme fibre from the neutral axis.

Plastic Section Modulus of a section is the first moment of the cross sectional area about an axis which divides the sectional area into two equal halves. It is usually called 'Equal Area Axis'. For symmetrical sections the identification of such axis is very simple – the axes of symmetry represent the Equal Area Axis. But in case of unsymmetrical sections it is necessary to first identify the Equal Area Axis, before proceeding to the calculations of Plastic Section Modulus. In unsymmetrical sections Neutral Axis (Centroidal Axis) and Equal Area Axis do not coincide.

In the present case the I-section has two axes
of symmetry and the Z-Z axis is located at half the depth of the section, while the Y-Y axis is located through the centerline of the web. In case of C-section, the Z-Z axis is the only axis of symmetry and is located at half the depth of the section, while the Equal Area Axis in 'Y' direction is to be worked out considering the geometry of the web, flange, fillet and rounded end of flange. For the calculation of Z_{pz}, the Z-Z axis is only necessary to be identified.

The Plastic Sectional Modulii, Z_{pz}, values for I and C sections have been calculated with higher accuracy, in mm^3, and presented here. A few values are found to differ from the values given in the IS 800:2007[2] and have been reported here.

II. METHOD OF CALCULATION

Typical calculations of Z_{pz} for one I-Section – ISLB 400 @ 558.2 N/m and one C-Section ISMC 300 @ 351.2 N/m have been given hereunder. I-Section has been divided into a total of 13 component areas and C-Section into 7 component areas. The area of each component is calculated and the position of centroid of each component area is identified and used in the calculation of the Plastic Section Modulus of the cross section about Z-Z axis.

A. *Plastic Section Modulus, Z_{pz}, of ISLB 400 @ 558.2 N/m:*

For ISLB 400@ 558.2 N/m the various geometrical parameters, as per SP: 6(1)-1964,[1] are as follows:

h = 400 mm ; b = 165 mm ; t_f = 12.5 mm ; t_w = 8 mm ; (D)$\theta = 98^o$; r_1 = 16 mm ; r_2 = 8 mm ;

In the Figure 1 :

Z-Z represents the horizontal neutral axis

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Z'-Z' represents the horizontal Equal Area Axis – Z-Z and Z'-Z' axes coincide.
Y-Y represents the vertical neutral axis
Y'-Y' represents the vertical Equal Area Axis – Y-Y and Y'-Y' axes coincide.

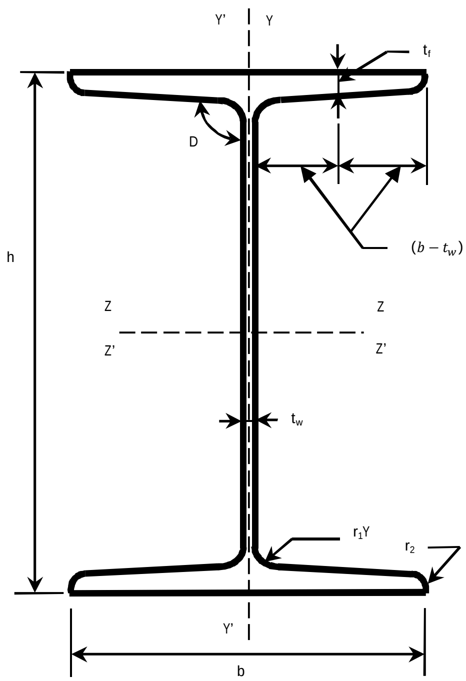

Figure 1 I- SECTION

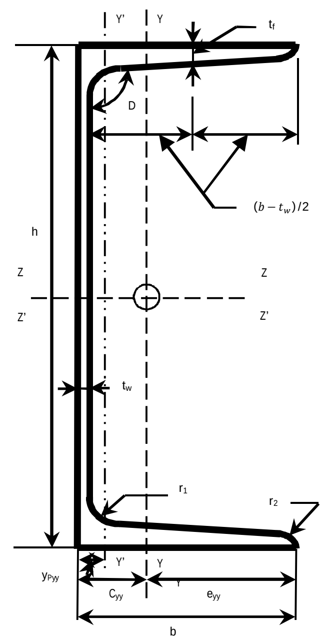

Figure 2 CHANNEL

1) *Calculations Of Areas, Centroids And Plastic Section Modulus*
   Refering to Figure 3 –

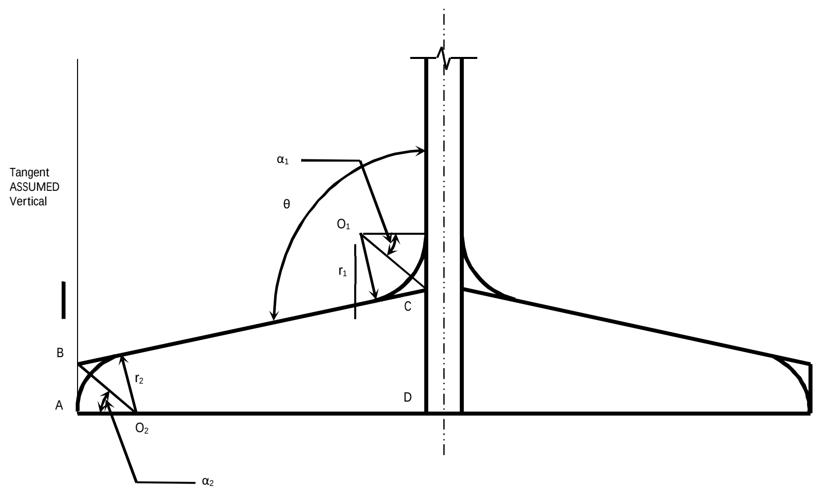

Fig. 3 Flange Geometry for I, C & T

Entire Web is taken as a Rectangle of -- (h X t_w) = 400 X 8.0 = **3200.0000 mm^2**
Each Tapered Flange Outstand is taken as --

i) Trapezium, ABCD
ii) Positive Spandrel area with radius r_1, i.e. the fillet between flange and web
iii) Negative Spandrel area at the toe of flange of radius r_2

Area of Trapezium: $A_t = AD \times ((AB + CD) / 2)$, where,

$AD = b_1 = \{ (b - t_w) / 2 \} = (165 - 8) / 2 = \mathbf{78.5000\ mm}$

$AB = t_f - \{ (b_1/2) X \tan(\theta-90) \} = 12.5 - \{ (78.5 / 2) X \tan(98-90) \} = \mathbf{6.9838\ mm}$

$CD = t_f + \{ (b_1/2) X \tan(\theta-90) \} = 12.5 + \{ (78.5 / 2) X \tan(98-90) \} = \mathbf{18.0162\ mm}$

Therefore, $A_t = AD \times ((AB + CD) / 2) = 78.5 \times \{ (6.9838 + 18.0162) / 2 \} = \mathbf{981.25\ mm^2}$

Centroid of Trapezium from AB: $x_t = (b1/3) X \{ (AB + 2CD) / (AB + CD) \}$

$= (78.5/3) X \{(6.9838+2X18.0162) / (6.9838+18.0162)\}$

$= \mathbf{45.02365\ mm}$

Centroid of Trapezium from AD: $y_t = \{AB^2+(ABXCD)+CD^2\} / \{3X(AB+CD)\}$

$= \{6.9838^2+(6.9838 X18.0162)+18.0162^2\}/\{3X(6.9838 +18.0162)\}$

$= \mathbf{6.6557\ mm}$

Area of Positive Spandrel at Fillet: $= r_1^2 \{ (\tan \alpha) - \alpha \}$, where,

$\alpha_1 = \{(180-\theta)/2\} X (\pi/180)$ radians

$= \{(180-98)/2\} X (\pi/180) = \mathbf{0.71558\ radians}$

Therefore, required area $= 16^2 X \{(\tan 0.71558) - 0.71558\}$

$= \mathbf{39.34765\ mm^2}$

Centroid of Spandrel from apex C in figure above, along bisector:

$x_1 = \{ r_1 (\sin\alpha \cos\alpha + 2\tan\alpha - 3 \alpha)\} / \{ 3(\sin\alpha - \alpha \cos\alpha) \}$

$= \{16 X (\sin0.71558 X \cos0.71558 + 2 X \tan0.71558 - 3 X 0.71558)\} / \{ 3 X (\sin0.71558 - 0.71558 X \cos0.71558)\}$

$= \mathbf{3.9978\ mm}$

Area of Negative Spandrel at Flange end: $= r_2^2 \{ (\tan \alpha) - \alpha \}$, where,

$\alpha_2 = \{(180-\theta)/2\} X (\pi/180)$ radians

$= \{(180-98)/2\} X (\pi/180) = \mathbf{0.71558\ radians}$

Therefore, required area $= 8^2 X \{(\tan 0.71558) - 0.71558\}$

$= \mathbf{9.8369\ mm^2}$

Centroid of Spandrel from apex B in figure above, along bisector:

$x_2 = \{ r_2 (\sin\alpha \cos\alpha + 2\tan\alpha - 3 \alpha)\} / \{ 3(\sin\alpha - \alpha \cos\alpha) \}$

$= \{8 X (\sin0.71558 X \cos0.71558 + 2 X \tan0.71558 - 3X 0.71558)\} / \{ 3 X (\sin0.71558 - 0.71558 X \cos0.71558)\}$

$= \mathbf{1.9989\ mm}$

2) Plastic Section Modulus of ISLB 400@558.2 N/m about z-z axis (horizontal)

Web : $(t_w X h^2) / 4 = (8 X 400^2) / 4$

$= \mathbf{320000.0000\ mm^3}$

Top and Bottom Trapeziums on one side of web :

$\{AD \times ((AB + CD) / 2)\} X (h - 2y_t) = 981.25 X (400-2X 6.6557)$

$= \mathbf{379438.18875\ mm^3}$

Top and Bottom Positive Spandrels :

$\{r_1^2 [(\tan \alpha) - \alpha]\} X \{h -2[CD + x_1 \cos(\theta/2])\} = 39.34765X\{400-2X[18.0162 + 3.9978X \cos(98/2)]\}$

$= \mathbf{14114.8683\ mm^3}$

Top and Bottom Negative Spandrels :

$\{r_2^2 [(\tan \alpha) - \alpha]\} X \{h -2[AB - x_2 \cos(\theta/2)]\} = 9.8369X\{400-2X[6.9838-1.9989X\cos(98/2)]\}$

$= \mathbf{3823.1623\ mm^3}$

Therefore, Plastic Section Modulus of ISLB 400@ 558.2 N/m about z-z axis is:

$= 320000.0000+ \mathbf{2} X(379438.18875+14114.8683 - 3823.1623)$

$=1099459.70\mathbf{mm^3}$ (without rounding off any value)

$= (\mathit{1099459.7895}\ \mathbf{mm^3}$ small error due to rounding off)

The corresponding value in IS:800-2007[2] is $= \mathbf{1099.45\ cm^3} = \mathbf{1099450\ mm^3}$

The above calculated value and IS 800:2007[2] Code values differ by **0.01** cm^3 (i.e. **9.7** mm^3), which is a very negligible difference.

B. *Plastic Section Modulus of ISMC 300 @ 351.2 N/m:*

For ISMC 300@ 351.2 N/m the various geometrical parameters, as per SP: 6(1)-1964,[1] are as follows:
$h = 300$ mm ; $b = 90$ mm ; $t_f = 13.6$ mm ; $t_w = 7.6$ mm ; (D)$\theta = 96^o$; $r_1 = 13$ mm ; $r_2 = 6.5$ mm;
In the Figure 2 :
Z-Z represents the horizontal neutral axis
Z'-Z' represents the horizontal Equal Area Axis – Z-Z and Z'-Z' axes coincide.
Y-Y represents the vertical neutral axis
Y'-Y' represents the vertical Equal Area Axis – Y-Y and Y'-Y' axes do not coincide.

1) *Calculations Of Areas, Centroids and Plastic Section Modulus*

Refering to Figure 3 and using the formulae adopted in I-Section, we get--

Area of web -- (h X t_w) = 300 X 7.6 = **2280.0000 mm^3**

AD = b_1 = **82.4000 mm ;** AB = **9.2697 mm ;** CD = **17.9303 mm ;** A_t = **1120.64 mm^2** ; x_t = **45.5727 mm ;** y_t = **7.0298 mm ;** α_1 = **0.73304 radians ;** Area of Positive Spandrel at Fillet = **28.2848 mm^2 ;** x_1 = **3.4476 mm ;** α_2 = **0.73304 radians ;**

Area of Negative Spandrel at Flange end = **7.0712 mm^2 ;** x_2 = **1.7238 mm ;**

2) *Plastic Section Modulus of ISMC 300 @ 351.2 N/m ABOUT Z-Z AXIS (HORIZONTAL):*

For Web = **171000 mm^3 ;**
For Top and Bottom Trapeziums = **320436.2499 mm^3 ;**
For Top and Bottom Positive Spandrels = **7340.6303 mm^3 ;**
For Top and Bottom Negative Spandrels = **2006.5766 mm^3 ;**

Therefore, Plastic Section Modulus of ISMC 300 @ 351.2 N/m about z-z axis is:
= 171000.0000+320436.2499+7340.6303-2006.5766
= **496767.4893 mm^3** (without rounding off any value)
= (*496770.3036* mm^3 small error due to rounding off)

The corresponding value in IS:800-2007[2] is = **496.77 cm^3** = **496770 mm^3**

The above calculated value and IS 800:2007[2] Code values differ by **0.00** cm^3 (i.e. **2.5107** mm^3), which is a very negligible difference.

III. RESULTS AND DISCUSSIONS

1) Comparison of Zpz calculated values and the values given in IS:800-2007[2] for I-Sections:

Table 1 Descending order of Z_{pz} Values of I-sections as in IS 800:2007[2]

I Sections			Comparison			
Section	**Area**	**Cal. Z_{pz}**	**Z_{pz} (Code)**	**Z_{pz} (Code)**	**Diff mm^3**	**Diff cm^3**
ISWB600 @145.1kg/m	18514.04	4349755.83	4341.63	4341630	**8125.83**	**8.1258**
ISWB600 @133.7kg/m	17037.99	3986655.76	3986.66	3986660	-4.24	-0.0042
ISMB600 @122.6kg/m	15621.24	3510633.76	3510.63	3510630	3.76	0.0038
ISWB550 @112.5kg/m	14333.94	3066263.13	3066.29	3066290	-26.87	-0.0269
ISLB600 @99.5kg/m	12668.94	2798564.80	2798.56	2798560	4.80	0.0048
ISMB550 @103.7kg/m	13211.08	2711984.25	2711.98	2711980	4.25	0.0042
ISWB500 @95.2kg/m	12121.91	2353359.65	2351.35	2351350	**2009.65**	**2.0097**
ISLB550 @86.3kg/m	10997.40	2228192.82	2228.16	2228160	32.82	0.0328
ISMB500 @86.9kg/m	11074.38	2074672.55	2074.67	2074670	2.55	0.0025
ISHB450 @92.5kg/m	11789.35	2030971.94	2030.95	2030950	21.94	0.0219
ISHB450 @87.2kg/m	11114.35	1955034.44	1955.03	1955030	4.44	0.0044
ISLB500 @75.0kg/m	9549.82	1772678.93	1773.67	1773670	**-991.07**	**-0.9911**
ISWB450 @79.4kg/m	10115.05	1760583.22	1760.59	1760590	-6.78	-0.0068
ISHB400 @82.2kg/m	10465.89	1626357.36	1626.36	1626360	-2.64	-0.0026
ISHB400 @77.4kg/m	9865.89	1566357.36	1556.33	1556330	**10027.36**	**10.0274**
ISMB450 @72.4kg/m	9226.63	1553362.59	1533.36	1533360	**20002.59**	**20.0026**

ISLB450 @65.3kg/m	8313.56	1401303.72	1401.35	1401350	-46.28	-0.0463
ISWB400 @66.7kg/m	8501.25	1320182.59	1290.19	1290190	**29992.59**	**29.9926**
ISHB350 @72.4kg/m	9221.07	1268676.49	1268.69	1268690	-13.51	-0.0135
ISHB350 @67.4kg/m	8591.07	1213551.49	1213.53	1213530	21.49	0.0215
ISMB400 @61.6kg/m	7845.58	1176175.56	1176.18	1176180	-4.44	-0.0044
ISLB400 @56.9kg/m	7243.04	1099459.70	1099.45	1099450	9.70	0.0097
ISWB350 @56.9kg/m	7249.90	995488.47	995.49	995490	-1.53	-0.0015
ISHB300 @63.0kg/m	8024.95	962180.00	962.18	962180	0.00	0.0000
ISHB300 @58.8kg/m	7484.95	921680.00	921.68	921680	0.00	0.0000
ISMB350 @52.4kg/m	6671.34	889588.30	889.57	889570	18.30	0.0183
ISLB350 @49.5kg/m	6301.32	851114.56	851.11	851110	4.56	0.0046
ISWB300 @48.1kg/m	6132.75	731210.96	731.21	731210	0.96	0.0010
ISHB250 @54.7kg/m	6970.75	708432.97	708.43	708430	2.97	0.0030
ISLB325 @43.1kg/m	5489.84	687744.96	687.76	687760	-15.04	-0.0150
ISHB250 @51.0kg/m	6495.75	678745.47	678.73	678730	15.47	0.0155
ISMB300 @44.2kg/m	5626.38	651743.06	651.74	651740	3.06	0.0031
ISLB300 @37.7kg/m	4807.79	554316.93	554.32	554320	-3.07	-0.0031
ISHB225 @46.8kg/m	5966.31	542207.43	542.22	542220	-12.57	-0.0126
ISWB250 @40.9kg/m	5204.61	527558.60	527.57	527570	-11.40	-0.0114
ISHB225 @43.1kg/m	5493.81	515629.31	515.82	515820	**-190.69**	**-0.1907**
ISMB250 @37.3kg/m	4755.43	465722.80	465.71	465710	12.80	0.0128
ISLB275 @33.0kg/m	4201.74	443598.06	443.09	443090	**508.06**	**0.5081**
ISHB200 @40.0kg/m	5094.43	414232.11	414.23	414230	2.11	0.0021
ISHB200 @ 37.3kg/m	4754.43	397232.11	397.23	397230	2.11	0.0021
ISWB225 @33.9kg/m	4323.95	389932.81	389.93	389930	2.81	0.0028
ISMB225 @31.2kg/m	3971.50	348278.59	348.27	348270	8.59	0.0086
ISLB250 @27.9kg/m	3552.89	338681.15	338.69	338690	-8.85	-0.0088
ISWB200 @28.8kg/m	3670.87	293986.63	293.99	293990	-3.37	-0.0034
ISLB225 @23.5kg/m	2991.64	254708.93	254.72	254720	-11.07	-0.0111
ISMB200 @25.4kg/m	3232.67	253861.58	253.86	253860	1.58	0.0016
ISHB150 @34.6kg/m	4407.75	251643.31	251.64	251640	3.31	0.0033
ISHB150 @30.7kg/m	3897.75	232518.31	232.52	232520	-1.69	-0.0017
ISHB150 @27.1kg/m	3447.75	215643.31	215.64	215640	3.31	0.0033
ISWB175 @22.1kg/m	2811.29	194190.85	194.2	194200	-9.15	-0.0092
ISLB200 @19.8kg/m	2526.76	192943.51	184.34	184340	**8603.51**	**8.6035**
ISMB175 @19.3kg/m	2462.01	166080.56	166.08	166080	0.56	0.0006
ISLB175 @16.7kg/m	2129.72	142604.95	143.3	143300	**-695.05**	**-0.6950**
ISJB225 @12.8kg/m	1627.80	134158.25	134.15	134150	8.25	0.0082
ISWB150 @17.0kg/m	2166.53	126858.33	126.86	126860	-1.67	-0.0017
ISMB150 @14.9kg/m	1900.39	110479.69	110.48	110480	-0.31	-0.0003
ISLB150 @ 14.2kg/m	1808.32	104504.47	104.5	104500	4.47	0.0045
ISJB200 @9.9kg/m	1264.37	90897.36	90.89	90890	7.36	0.0074
ISMB125 @13.0kg/m	1660.47	81848.26	81.85	81850	-1.74	-0.0017
ISLB125 @11.9kg/m	1512.21	73929.79	73.93	73930	-0.21	-0.0002
ISJB175 @ 8.1kg/m	1027.65	64222.70	64.22	64220	2.70	0.0027
ISJB 150 @7.1 kg/m	900.77	49573.47	49.57	49570	3.47	0.0035
ISMB100 @11.5kg/m	1459.75	58652.70	41.68	41680	**16972.70**	**16.9727**
ISLB100 @8.0kg/m	1021.10	38885.38	38.89	38890	-4.62	-0.0046
ISLB75 @6.1kg/m	771.38	22350.91	22.35	22350	0.91	0.0009

Table 2 I-sections with more than 100 mm^3, i.e. 0.1 cm^3 difference in Z_{pz} values						
Section	Area (mm^2)	Cal. Z_{pz}	Z_{pz} (Code) cm^3	Z_{pz} (Code)	Diff mm^3	Diff cm^3
ISWB600 @145.1kg/m	18514.04	4349740.84	4341.63	4341630	8125.83	8.1258
ISWB500 @95.2kg/m	12121.91	2353350.98	2351.35	2351350	2009.65	2.0097
ISLB500 @75.0kg/m	9549.82	1772656.90	1773.67	1773670	-991.07	-0.9911
ISHB400 @77.4kg/m	9865.89	1566357.36	1556.33	1556330	10027.36	10.0274
ISMB450 @72.4kg/m	9226.63	1553347.46	1533.36	1533360	20002.59	20.0026
ISWB400 @66.7kg/m	8501.25	1320176.95	1290.19	1290190	29992.59	29.9926
ISHB225 @43.1kg/m	5493.81	515629.31	515.82	515820	-190.69	-0.1907
ISLB275 @33.0kg/m	4201.74	443585.76	443.09	443090	508.06	0.5081
ISLB200 @19.8kg/m	2526.76	192946.92	184.34	184340	8603.51	8.6035
ISLB175 @16.7kg/m	2129.72	142608.36	143.3	143300	-695.05	-0.6950
ISMB100 @11.5kg/m	1459.75	58649.43	41.68	41680	16972.70	16.9727

2) Comparison of Zpz calculated values and the values given in IS:800-2007[2] for C-Sections:

Table3 Decending order of Z_{pz} Values of C-sections as in IS 800:2007[2]						
Channel Sections			Comparison			
Section	Area (mm^2)	Cal. Z_{Pz} (mm^3)	Z_{pz} (Code)	Z_{pz} (Code)	Diff (mm^3)	Diff
ISMC400 @ 49.4 kg/m	6293.33	891024.4949	891.03	891030	-5.5051	-0.0055
ISLC400 @ 45.7 kg/m	5825.21	825023.5254	825.02	825020	3.5254	0.0035
ISMC350 @ 42.1 kg/m	5365.51	672193.9808	672.19	672190	3.9808	0.0040
ISLC350 @ 38.8 kg/m	4949.52	623307.4201	622.95	622950	357.4201	0.3574
ISMC300 @ 35.8 kg/m	4563.71	496770.3126	496.77	496770	0.3126	0.0003
ISLC300 @ 33.1 kg/m	4210.71	466724.2983	466.73	466730	-5.7017	-0.0057
ISMC250 @ 30.4 kg/m	3866.93	356722.9486	356.72	356720	2.9486	0.0029
ISLC250 @ 28.0 kg/m	3564.84	338115.5151	338.11	338110	5.5151	0.0055
ISMC225 @ 25.9 kg/m	3301.43	277930.4415	277.93	277930	0.4415	0.0004
ISLC225 @ 24.0 kg/m	3053.06	260130.1355	260.13	260130	0.1355	0.0001
ISMC200 @ 22.1 kg/m	2821.30	211255.7845	211.25	211250	5.7845	0.0058
ISLC200 @ 20.6 kg/m	2622.19	198772.7675	198.77	198770	2.7675	0.0028
ISMC175 @ 19.1 kg/m	2438.00	161644.8333	161.65	161650	-5.1667	-0.0052
ISLC175 @ 17.6 kg/m	2239.98	150360.4346	150.36	150360	0.4346	0.0004
ISJC200 @ 13.9 kg/m	1776.67	133106.5881	133.12	133120	-13.4119	-0.0134
ISMC150 @ 16.4 kg/m	2087.90	119824.0814	119.82	119820	4.0814	0.0041
ISLC150 @ 14.4 kg/m	1836.01	106171.5841	106.17	106170	1.5841	0.0016
ISJC175 @ 11.2 kg/m	1424.47	94222.74383	94.22	94220	2.7438	0.0027
ISMC125 @ 12.7 kg/m	1618.84	77153.97581	77.15	77150	3.9758	0.0040
ISJC150 @ 9.9 kg/m	1265.47	72046.4699	72.04	72040	6.4699	0.0065
ISLC125 @ 10.7 kg/m	1367.18	65446.51482	65.45	65450	-3.4852	-0.0035
ISJC125 @ 7.9 kg/m	1007.41	49081.6217	49.08	49080	1.6217	0.0016
ISMC100 @ 9.2 kg/m	1169.83	43826.13621	43.83	43830	-3.8638	-0.0039
ISLC100 @ 7.9 kg/m	1001.72	38084.7023	38.09	38090	-5.2977	-0.0053
ISJC100 @ 5.8 kg/m	741.32	28375.41024	28.38	28380	-4.5898	-0.0046
ISMC75 @ 6.8 kg/m	867.17	24165.68593	24.17	24170	-4.3141	-0.0043
ISLC75 @ 5.7 kg/m	726.02	20608.75524	20.61	20610	-1.2448	-0.0012

Table 4 C-sections with more than 100 mm^3, i.e. 0.1 cm^3 difference in Z_{pz} values						
Section	Area	Cal. Z_{Pz} (mm^3)	Z_{pz} (Code)	Z_{pz}	Diff	Diff
ISLC350 @ 38.8 kg/m	4949.52	623307.4201	622.95	622950	357.4201	0.3574

IV. DISCUSSION

A difference of more than 100 mm^3, i.e., 0.1 cm^3 in the value of Z_{pz} has been considered for reporting. These values affect the first decimal place of Z_{pz} value given by the IS:800-2007.[2] Even though differences from 10 to 99 affect the second decimal place, they have been neglected for reporting. It has been found that Eleven I- Sections and One C-Section come under the category selected for reporting. Particularly four I-Sections, viz., ISHB400@77.4kg/m, ISMB450@72.4kg/m, ISWB400@66.7kg/m and ISMB100@11.5kg/m have difference of more than 10000 mm^3 (10 cm^3) in the Z_{pz} values. The highest difference observed being 29992.59 mm^3 (29.9926 cm^3) for ISWB400@66.7kg/m. Some of the differences found, appear to be printing errors.

V. CONCLUSIONS

The Z_{pz} values are very important in the design of beams and other structural elements like beam-columns which are subjected to bending moments, especially when the sections chosen are plastic or compact sections, by classification according to IS:800-2007.[2] Correct selection of sections during the process of structural designing requires correct values of Z_{pz}. Hence the results obtained are of importance in structural designs. These values will also affect built up beams, gantry girders, etc. if the sections with large differences in Z_{pz} values mentioned above, are used in the designs. However, a further scrutiny of the methodology and calculations, presented here, is always helpful, if differences found herein are to be finally accepted.

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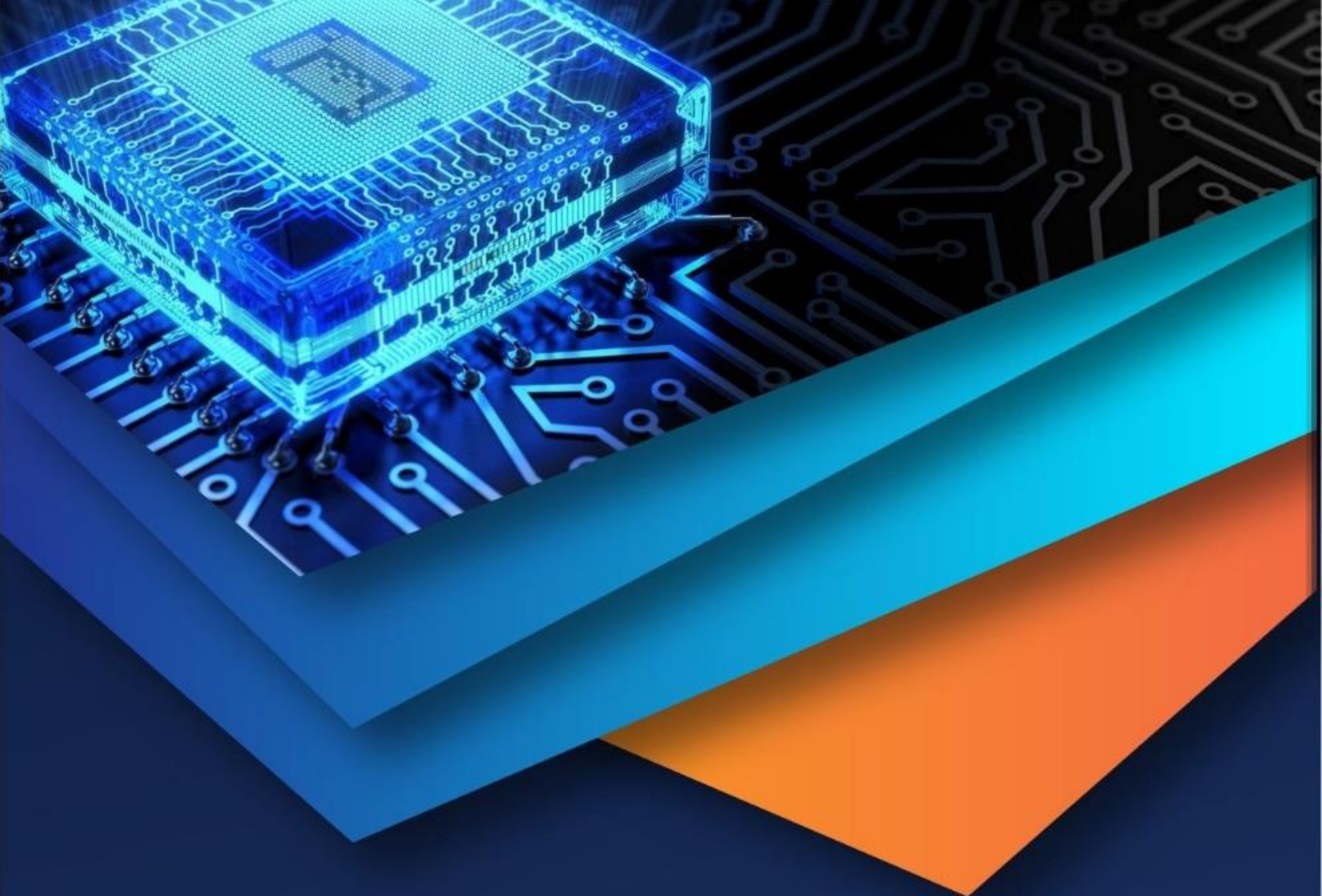

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