 <p><b>AUSTRALIAN STEEL INSTITUTE</b> (ABN)/ACN (94) 000973 839 www.steel.org.au</p> <p>ASI TECHNICAL NOTE TN004 V2</p>	REF: ASI TN004 <span style="float: right;">Version 2</span>	
	ASI Head Office Level 13, 99 Mount Street North Sydney NSW 2060 Tel: 02 9931 6666 Email: enquiries@steel.org.au	
	Author: T J HOGAN	
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## DESIGN PROPERTIES FOR CRANE RUNWAY BEAMS

### INTRODUCTION

Part 13 of the Australian Steel Institute publication “*Design Capacity Tables for Structural Steel, Volume 1: Open Sections*” (DCTV1—fourth edition 2009) provides information on Crane Runway Beam sections comprising a universal beam (UB) or welded beam (WB) section with a parallel flange channel (PFC) attached to the top flange via welding between the PFC web and the UB/WB top flange.

Table 13-1 of the DCTV1 lists the workable combinations of universal beams or welded beam sections and either 380 or 300 parallel flange channel sections and for each combination gives the dimensions and relevant design properties for the combined section.

There is limited guidance given in AS 4100 “*Steel Structures*” and AS 1418.18 “*Cranes, Part 18: Crane runways and monorails*” for the design of combined section of this type. Since the combined sections are used as laterally unsupported beams, the main source of design guidance in AS 4100 is Clause 5.6.1.2 “*I-sections with Unequal Flanges*” and Appendix H “*Elastic Resistance to Lateral Buckling*”.

Reference [1] provides an excellent coverage for such combined sections covering the design criteria, giving a design example, giving design capacity tables and other background information. Reference [2] discusses in detail a number of design aspects for this type of crane runway beam and contains a design example.

Table 13-1 of the DCTV1 gives some design properties to assist in design to AS 4100. The properties listed in the fourth edition have been unchanged since the first edition in 1991 and comprise section properties about the principal axes as well as values for the torsion constant and the warping constant. However, Reference [4] provides improved formulae for the calculation of both the torsion constant and warping constant and provides a formula for the calculation of the monosymmetry constant.

For this Technical Note, the section properties about the principal x- and y- axes have been calculated from first principles using conventional formulae and will not be further explained. The second moment of area of the top flange about the y-axis has been assessed assuming that it comprises the second moment of area of the PFC about its x-axis and half of the second moment of area of the of the UB/WB about the y-axis on the basis that the when calculating the second moment of area of the UB/WB about the y-axis the contribution of the web of the UB/WB is very small. The section modulus of the top flange about the y-axis has been obtained by dividing the second moment of area of the top flange about the y-axis by half of the depth of the PFC.

For the torsion constant, warping constant and monosymmetry parameter, Appendix H of AS 4100 provides some guidance. Recent checking has shown that the current values for the torsion constant and warping constant given in Table 13-1 of DCTV1 do not match results achieved using Appendix H of AS 4100. Table 13-1 of DCTV1 does not presently provide values for the monosymmetry parameter.

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Appendix H of AS 4100 is “Informative” rather “Normative” and accordingly a design engineer is not obliged to use the information therein. The formulae given in Appendix H are general formulae for monosymmetric I-sections and as such are more suited to I-sections with unequal flanges rather than the crane runway beam arrangement of I-section plus PFC combined into a single section.

Reference [4] contains specific formulae for the calculation of the torsion constant, the warping constant and the monosymmetry parameter for the combined crane beam section and these formulae have been used to calculate the revised version of Table 13-1 of DCTV1 presented in this Technical Note as Table [1]. These formulae are as set out below:

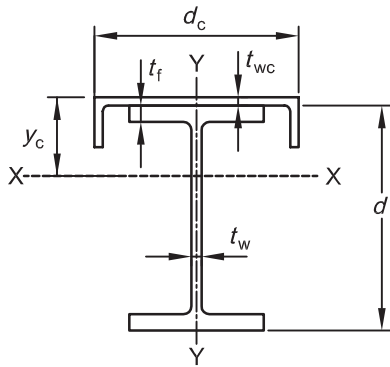


Fig. 1

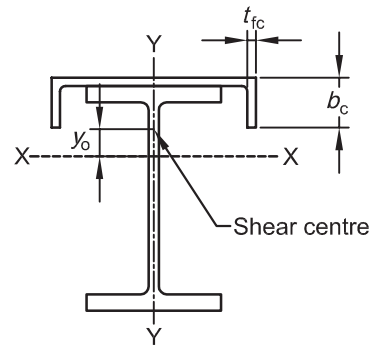


Fig. 2

A conservative estimate of the St. Venant torsional constant is given by:

$$J \approx J_I + J_c \quad \text{where} \quad J_I = \text{torsion constant of I-section}$$

$$J_c = \text{torsion constant of PFC-section}$$

Shear centre location (Fig. 2):

$$y_o = y_c - \frac{t_f + t_{wc}}{2} - a + e \quad (\text{Kitipornchai and Trahair 1980—Ref. [3]})$$

$$a = (1 - \rho)h, \quad b = \rho h$$

$$\rho = \frac{I_{y \text{ TOP}}}{I_{y \text{ TOP}} + I_{y \text{ BOT}}} = \frac{I_{y \text{ TOP}}}{I_y}$$

where  $I_{y \text{ TOP}}$ ,  $I_{y \text{ BOT}}$ , and  $I_y$  are the moments of inertia of the built-up top flange (channel + top flange of the I-shape), the bottom flange of the I-shape, and the entire built-up section about the vertical axis ( $y$ - $y$ ) respectively. With the channel on the top flange, as shown on Fig. 2, the value of  $y_o$  obtained will be positive, indicating that the shear centre is located above the centroid.

The distance between the shear centres of the top and bottom flanges is given by

$$h = d - t_f + \frac{t_{wc}}{2} + e$$

The distance between the shear centre of the built-up top flange and the centre line of the channel web and I-section top flange, taken together as a single plate, is given by:

$$e = \frac{b_c^2 d_c^2 t_{fc}}{4 \rho I_y}$$

Warping constant of the built-up section:

$$I_w = a^2 I_{y \text{ TOP}} + b^2 I_{y \text{ BOT}} \quad (\text{Kitipornchai and Trahair 1980—Ref. [3]})$$

Monosymmetry constant:

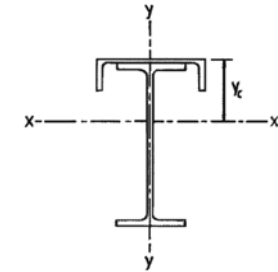
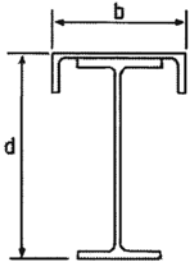
$$\beta_x \approx \delta 0.9(2\rho - 1)h \left[ 1 - \left( \frac{I_y}{I_x} \right)^2 \right] \left( 1 + \frac{b_c}{2d_b} \right), \quad \frac{I_y}{I_x} \leq 0.5 \text{ (Kitipornchai and Trahair 1980—Ref. [3])}$$

where  $d_b$  is the built-up section depth =  $d + t_{wc}$ ,  $\delta = + 1$  if the top flange is in compression.

NOTE: The section properties for the crane runway beams in Table 1 have been calculated using the actual calculated values of the section properties for the I-section and the PFC section and not the rounded values of section properties in 'Design Capacity Tables for Structural Steel, Volume 1: Open Sections' (DCT V1—Fourth Edition 2009).

## REFERENCES

- [1] Woolcock, S.T., Kitipornchai, S. and Bradford, M.A., 'Design of Portal Frame Buildings', third edition, Australian Institute of Steel Construction, 1999.
- [2] Gorenc, B.E., 'Crane Runway Girders—Limit States Design', Australian Steel Institute, Second Edition, 2003.
- [3] Kitipornchai, S., and Trahair, N.S., 'Buckling Properties of Monosymmetric I-Beams', ASCE, Journal of the Structural Division, Vol. 106 No ST5 May 1980, pp941–957.
- [4] Canadian Institute of Steel Construction, 'Torsional Section Properties of Steel Shapes', August 2002.



**TABLE 1**  
**CRANE RUNWAY BEAMS**  
**COMPOSITION AND DIMENSIONS AND PROPERTIES**

Composed of		Approx size d x b	Mass per m kg/m	Area A <sub>g</sub> mm <sup>2</sup>	y <sub>c</sub> mm	About x-axis			About y-axis			Torsion Constant J (Note 3) 10 <sup>3</sup> mm <sup>4</sup>	Warping Constant I <sub>w</sub> (Note 4) 10 <sup>9</sup> mm <sup>5</sup>	Monosymmetry Constant β (Note 4) mm		
Beam	Top Flange Channel					I <sub>x</sub> 10 <sup>6</sup> mm <sup>4</sup>	Top Z <sub>x</sub> 10 <sup>3</sup> mm <sup>3</sup>	Bot Z <sub>x</sub> 10 <sup>3</sup> mm <sup>3</sup>	r <sub>x</sub> mm	I <sub>y</sub> 10 <sup>6</sup> mm <sup>4</sup>	r <sub>y</sub> mm				Top F I <sub>y</sub> (Note 1) 10 <sup>6</sup> mm <sup>4</sup>	Top F Z <sub>y</sub> (Note 2) 10 <sup>3</sup> mm <sup>3</sup>
<b>WELDED BEAMS with PARALLEL FLANGE CHANNELS</b>																
1200WB249	380PFC	1180 x 380	304	38700	492	8240	16800	12000	461	239	78.5	195	1030	4780	49560	705
800WB168	380PFC	820 x 380	223	28400	319	3290	10300	6560	340	238	91.7	195	1030	3460	23980	497
146		810 x 380	201	25600	305	2790	9150	5530	330	221	92.9	186	981	2140	19600	534
122		802 x 380	178	22600	288	2270	7880	4420	317	193	92.4	173	908	1390	12430	609
700WB173	380PFC	726 x 380	228	29000	286	2690	9410	6100	304	249	92.6	200	1050	4500	20500	421
150		720 x 380	205	26100	274	2300	8380	5160	297	217	91.1	184	970	3160	14510	483
130		710 x 380	186	23600	261	1950	7470	4340	287	204	92.9	178	935	1980	11790	511
115		702 x 380	170	21600	249	1670	6710	3690	278	193	94.6	173	908	1360	9570	536
<b>UNIVERSAL BEAMS with PARALLEL FLANGE CHANNELS</b>																
610UB125	380PFC	622 x 380	180	23000	228	1400	6150	3550	247	191	91.1	171	902	2030	7080	481
113		617 x 380	169	21500	220	1270	5770	3190	243	186	93.0	169	888	1610	6200	491
101		612 x 380	157	20000	211	1130	5370	2830	238	181	95.1	166	875	1260	5340	501
530UB 92.4	380PFC	543 x 380	148	18800	183	834	4540	2320	210	175	96.5	164	861	1250	3480	456
82.0		538 x 380	137	17500	175	739	4220	2040	205	172	99.0	162	851	998	2950	459
530UB 92.4	300PFC	541 x 300	133	16900	200	776	3890	2270	214	96.2	75.4	84.3	562	1070	3220	402
82.0		536 x 300	122	15600	192	687	3580	1990	210	92.5	77.0	82.4	550	816	2750	416
460UB 82.1	300PFC	468 x 300	122	15600	169	528	3120	1760	184	91.0	76.5	81.7	545	991	1950	368
74.6		465 x 300	115	14600	163	484	2960	1600	182	89.0	78.0	80.7	538	820	1750	375
67.1		462 x 300	107	13700	157	438	2780	1440	179	87.0	79.7	79.7	531	668	1540	381
410UB 59.7	300PFC	411 x 300	99.8	12700	137	323	2350	1170	159	84.4	81.4	78.4	523	627	1050	346
53.7		411 x 300	93.8	12000	132	290	2190	1040	155	82.7	83.0	77.5	517	524	904	348
360UB 56.7	300PFC	367 x 300	96.8	12300	121	242	2000	987	140	83.5	82.2	77.9	519	628	773	299
50.7		364 x 300	90.8	11600	116	218	1880	880	137	82.0	84.1	77.2	515	531	673	296
44.7		360 x 300	84.8	10800	110	192	1740	767	133	80.5	86.2	76.4	510	451	567	288

Notes: (1) Top F I<sub>y</sub> = I<sub>x</sub> of channel + (I<sub>y</sub> of Universal or Welded Beam top flange)  
 (2) Top F Z<sub>y</sub> = (I<sub>y</sub> Top F)/(b/2)

(3) J = J of Universal of Welded Beam + J of channel  
 (4) See earlier text for formulae