Section properties & consistent units

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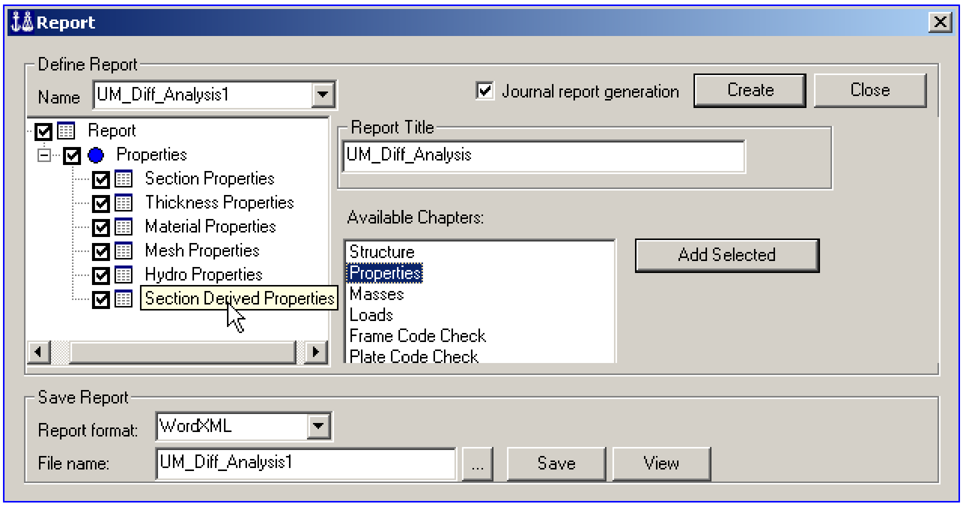
1. SECTION DERIVED PROPERTIES

This section describes how the section properties are computed by GeniE based on the respective input data. The section properties may be documented from the ***File|Save Report*** when including the relevant chapters to the report.

Add the chapter "Properties" and make sure that "Section Derived Properties" are ticked off.



Name	Description	Area [m^2]	Ix [m^4]	Iy [m^4]	Iz [m^4]	Iyz [m^4]	Wxmin [m^3]	Wymin [m^3]
		Wzmin [m^3]	Shary [m^2]	Sharz [m^2]	Shceny [m]	Shcenz [m]	Sy [m^3]	Sz [m^3]
BOX1	Box Section, h=1.6, w=1, wt=0.025, ft=0.04	0.156	0.0533205	0.0633152	0.0247325	0	0.0888674	0.079144
		0.049465	0.0693637	0.0693637	0	-5.96046e-008	0.04564	0.028525
BOX2	Box Section, h=1.6, w=0.8, wt=0.025, ft=0.04	0.14	0.0357489	0.0535787	0.0148292	0	0.0690435	0.0669733
		0.0370729	0.0561578	0.0679932	0	0	0.0394	0.021125
BOX3	Box Section, h=1, w=1, wt=0.05, ft=0.05	0.19	0.0428687	0.0286583	0.0286583	0	0.09025	0.0573167
		0.0573167	0.0846002	0.0846002	0	2.98023e-008	0.033875	0.033875
BOX4	Box Section, h=1, w=0.8, wt=0.035, ft=0.035	0.1211	0.0220511	0.017735	0.0125178	0	0.0516757	0.0354699
		0.0312946	0.0485447	0.0588981	0	2.98023e-008	0.0210779	0.0180504
BOX5	Box Section, h=1, w=1, wt=0.035, ft=0.035	0.1351	0.0314521	0.0209957	0.0209957	0	0.0651857	0.0419913

1.1 Formulae for section derived properties

The formulae employed in GeniE for computing the section parameters for the various beam cross sections are given in the following. The formulae are taken from Ref. /1/, Ref. /2/ and Ref. /3/.

The following notation is used:

AREA	Cross sectional area
IX	Torsional moment of inertia about shear centre
IY	Moment of inertia about y-axis
IZ	Moment of inertia about Z-axis
IYZ	Product of inertia about y- and z-axes
WXMIN	Minimum torsional sectional modulus about shear centre
WYMIN	Minimum sectional modulus about y-axis
WZMIN	Minimum sectional modulus about z-axis
SHARY	Shear area in the direction of y-axis
SHARZ	Shear area in the direction of z-axis
SHCENY	Shear centre location y-component
SHCENZ	Shear centre location z-component
SY	Static area moment about y-axis
SZ	Static area moment about z-axis
CY	Centroid location from bottom right corner y-component
CZ	Centroid location from bottom right corner z-component

Variables other than the ones above are only temporary.

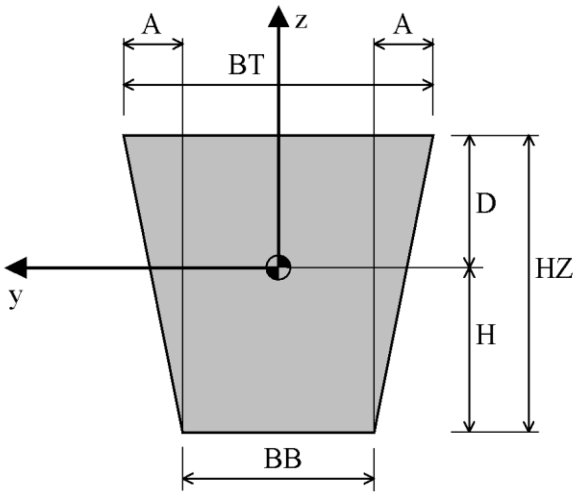
Note: The local x-axis of the beam or truss element goes through the centroid of the cross section. I.e. the nodal displacements and consequently the cross sectional constants above refer to this axis. The torsional moment of inertia, however, refers to the shear centre. In most beam element theories the torsional degree of freedom (DOF) is not coupled to the transverse DOF Therefore, when torsion is of importance the shear centre should not be located far away.

Note: The following function names are used: *abs( )* is absolute value, *atan()* is arcus tangent, *sqrt( )* is square root.

1.1.1 Bar section

1.1.1.1 Sectional Dimensions

HZ	Height
BB	Width at bottom
BT	Width at top
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.1.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY and SHARZ are taken from Ref. /1/. The expressions for SHCENY and SHCENZ are taken from Ref. /3/.

$A = (BT–BB)/2$

$H = HZ \bullet (BB+ 4 \bullet A ⁄ 3) ⁄ (BB + BT)$

$D = HZ–H$

$B = (BT ⁄ 2) – (A \bullet D ⁄ HZ)$

$BM = 2B \bullet HZ^2 ⁄ (HZ^2 + A^2)$

$AREA = (BB + BT) \bullet HZ ⁄ 2$

$IY = BB \bullet HZ^3/12 + HZ \bullet BB \bullet (HZ/2–H)^2 + 2 \bullet A \bullet HZ^3/36 + A \bullet HZ \bullet (2 \bullet HZ/3 – H)^2$

$WYMIN = IY ⁄ MAX(H,D)$

$IZ = HZ \bullet BB^3 ⁄ 12 + HZ \bullet A^3 ⁄ 18 + A \bullet HZ \bullet (BB ⁄ 2 + A ⁄ 3)^2$

$WZMIN = 2 \bullet IZ ⁄ MAX(BT, BB)$

$SY = BB \bullet H^2 ⁄ 2 + (B–BB ⁄ 2) \bullet H^2 ⁄ 3$

$SZ = HZ \bullet (BB^2 ⁄ 8 + A \bullet (BB ⁄ 4 + A ⁄ 6))$

$SHARY = IZ \bullet HZ \bullet SFY ⁄ SZ$

$SHARZ = 2 \bullet IY \bullet B \bullet SFZ ⁄ SY$

$SHCENY = 0$

$IYZ = 0$

If (HZ = BM) then	$CA = 0.141$
	$CB = 0.208$
	$IX = CA \bullet HZ^4$
	$WXMIN = CB \bullet HZ^3$
If (HZ < BM) then	$CN = BM/HZ$
	$CA = (1 - 0.63/CN + 0.052/CN^5)3$
	$CB = CA/(1 – 0.63/(1+CN^3))$
	$IX = CA \bullet BM \bullet HZ^3$
	$WXMIN = CB \bullet BM \bullet HZ^2$
Else	$CN = HZ/BM$
	$CA = (1 - 0.63/CN + 0.052/CN^5)3$
	$CB = CA/(1 – 0.63/(1+CN^3))$
	$IX = CA \bullet HZ \bullet BM^3$
	$WXMIN = CB \bullet HZ \bullet BM^2$

$SHCENZ = 0.354 \bullet HZ \bullet (BT-BB)/(BT+BB) + HZ/2 – H$

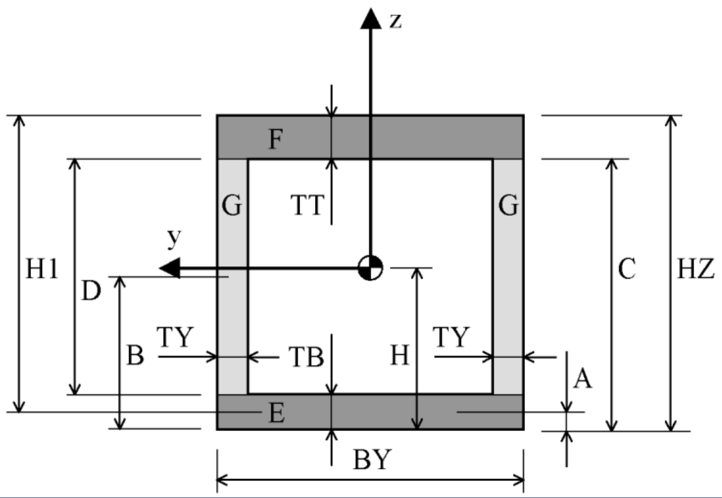
$CY = BB/2$

$CZ = H$

1.1.2 Box section

1.1.2.1 Sectional Dimensions

HZ	Height
BY	Width
TT	Thickness of top flange
TY	Thickness of webs (vertical walls)
TB	Thickness of bottom flange
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.2.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY, SHARZ and SHCENY are taken from Ref. /1/. The expression for SHCENZ is taken from Ref. /2/.

$A = TB/2$

$B = (HZ+TB–TT)/2$

$C = HZ–TT/2$

$D = HZ–TB–TT$

$E = BY•TB$

$F = BY•TT$

$G = TY•D$

$AREA = E+F+2•G$

$H = (E•A+F•C+2•B•G)/AREA$

$HA = HZ–(TB+TT)/2$

$HB = BY – TY$

$IX = 4• (HA•HB)^2/(HB/TB+HB/TT+2•HA/TY)$

$IY = (BY• (TB^3 + TT^3)+ 2•TY•D^3)/12+E• (H–A)^2+F• (C–H)^2 + 2•G• (B–H)^2$

$IZ = ((TB+TT)•BY^3+2•D•TY^3)/12 + G•HB^2/2$

$IYZ = 0$

$WXMIN = IX• (HB+HA)/(HA•HB)$

$WYMIN = IY/MAX(HZ – H, H)$

$WZMIN = 2•IZ/BY$

$SY = E• (H – A)+(H–TB)^2•TY$

$SZ = (TB + TT) •BY^2/8 +G•HB/2$

$SHARY = (IZ/SZ)•(TB + TT)•SFY$

$SHARZ = (IY/SY)•2•TY•SFZ$

$SHCENY = 0$

$SHCENZ = C – H – TB•HA/(TB + TT)$

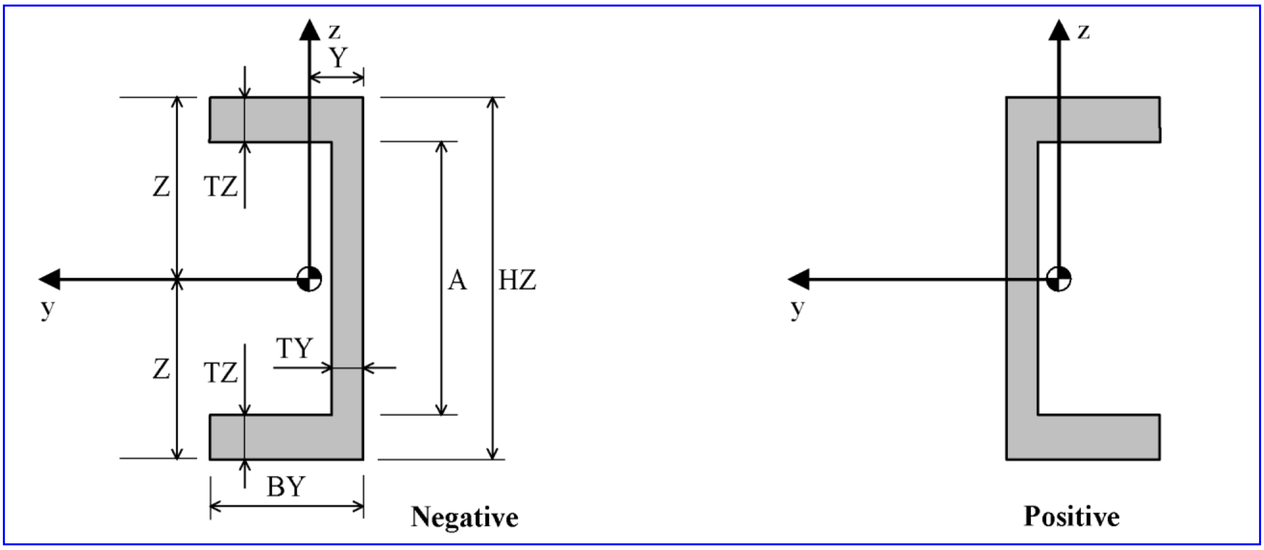
$CY = BY/2$

$CZ = H$

1.1.3 Channel section

1.1.3.1 Sectional Dimensions

HZ	Height
BY	Width of top and bottom flanges
TZ	Thickness of top and bottom flanges
TY	Thickness of web
SFY	Shear factor y-direction
SFZ	Shear factor z-direction
POSWEB	=1 for web location in positive y-direction, otherwise =-1



1.1.3.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY and SHARZ are taken from Ref. /1/. The expressions for SHCENY and SHCENZ are taken from Ref. /2/.

$A = HZ - 2 \cdot TZ$

$AREA = 2 \cdot BY \cdot TZ + A \cdot TY$

$Y = (2 \cdot TZ \cdot BY^2 + A \cdot TY^2) / (2 \cdot AREA)$

$Z = HZ / 2$

If (TZ = TY) then $IX = TY^3 \cdot (2 \cdot BY + A - 2.6 \cdot TY)/3$

$WXMIN = IX/IY$

Else $IX = 1.12 \cdot (2 \cdot BY \cdot TZ^3 + A \cdot TY^3)/3$

$WXMIN = IX/MAX(TZ,TY)$

$IY = TY \cdot A^3 / 12 + 2 \cdot (BY \cdot TZ^3 / 12 + BY \cdot TZ \cdot ((A + TZ) / 2)^2)$

$IZ = 2 \cdot (TZ \cdot BY^3/12 + TZ \cdot BY(BY/2 - Y)^2) + A \cdot TY^3/12 + A \cdot TY(Y-TY/2)^2$

$IYZ = 0$

$WYMIN = 2 \cdot IY / HZ$

$WZMIN = IZ / MAX(BY - Y, Y)$

$SY = BY \cdot TZ \cdot (TZ + A) / 2 + TY \cdot A^2 / 8$

$SZ = TZ \cdot (BY - Y)^2$

$SHARY = (IZ / SZ) \cdot (2 \cdot TZ) \cdot SFY$

$SHARZ = (IY / SY) \cdot TY \cdot SFZ$

If (TZ = TY) then $Q = (B-TY/2)^2 \cdot (HZ-TZ)^2 TZ/4IY$

Else $Q = (BY-TY/2)^2 TZ/(2 \cdot (BY-TY/2) \cdot TZ+(HZ-TZ) \cdot TY/3)$

If web located in positive y then $SHCENY = Y-TY/2+Q$

$CY = BY - Y$

Else $SHCENY = -(Y-TY/2+Q)$

$CY = BY - Y$

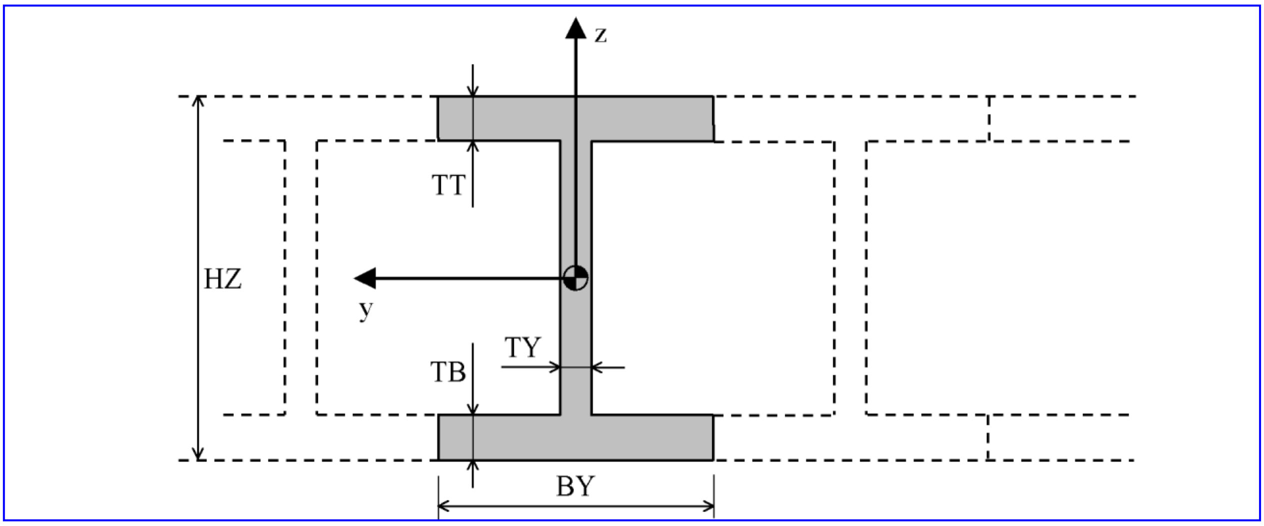
$CZ = Z$

1.1.4 Double-bottom section

Please notice that this section type is not implemented in GeniE.

1.1.4.1 Sectional Dimensions

HZ	Height
TY	Thickness of web
TB	Thickness of bottom plate
TT	Thickness of top plate
BY	Effective width of plates
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.4.2 Section derived properties

The calculation procedure for the double bottom section is the same as for the I section for computation of all parameters except IX and WXMIN. In the formulae below IXI is the IX for the I section.

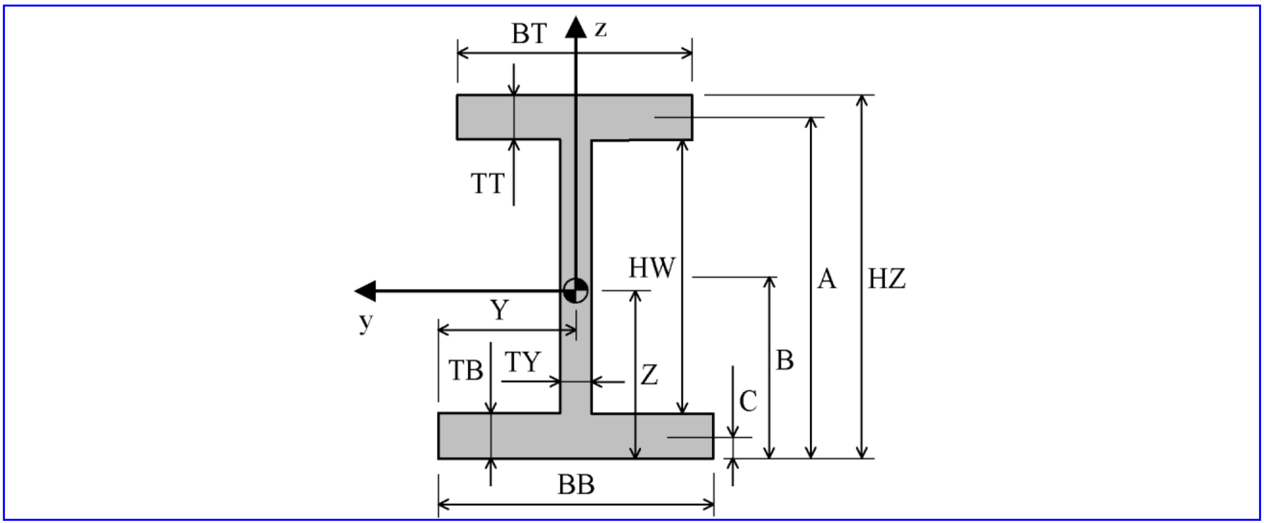
$IX = IXI + HZ^2 \cdot BY / (1/TB + 1/TT)$

$WXMIN = IX / MAX(TT,TY,TB)$

1.1.5 I (or H) section

1.1.5.1 Sectional Dimensions

HZ	Height
BT	Width of top flange
TT	Thickness of top flange
TY	Thickness of web
BB	Width of bottom flange
TB	Thickness of bottom flange
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.5.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY, SHARZ and SHCENY are taken from Ref. /1/. The expression for SHCENZ is taken from Ref. /2/.

HW = HZ – TT – TB

A = TB+HW+TT/2

B = TB+HW/2

C = TB/2

AREA = TY•HW + BT•TT + BB•TB

Y = MAX(BB/2, BT/2)

Z = (BT•TT•A+HW•TY•B+BB•TB•C)/AREA

TRA = BT•TT^3/12 + BT• TT•(HZ – TT/2 – Z)^2

TRB = TY•HW^3/12 + TY•HW•(TB + HW/2 – Z)^2

TRC = BB•TB^3/12 + BB•TB•(TB/2 – Z)^2

If (TT = TY and TT = TB) then	IX = TT^3• (HW+BT+BB – 1.2•TT)/3
	WXMIN = IX/TT
Else	IX = 1.30• (BT•TT^3 + HW•TY^3 + BB•TB^3)/3
	WXMIN = IX/MAX(TT,TY,TB)

IY = TRA+TRB+TRC

IZ = (TB•BB^3 + HW•TY^3 + TT•BT^3)/12

IYZ = 0

WYMIN = IY/MAX(HZ – Z, Z)

WZMIN = 2•IZ/MAX(BB, BT)

SY = (BB • TB • (Z - TB / 2) + (Z - TB)^2 • TY / 2 + BT • TT • (A-Z) + (HW - Z + TB)^2 • TY / 2) / 2

SZ = (TT•BT^2+TB•BB^2+HW•TY^2)/8

SHARY = (IZ/SZ)•(TB + TT)•SFY

SHARZ = (IY/SY)•TY•SFZ

SHCENY = 0

SHCENZ =((HZ – TT/2)•TT•BT^3 + TB^2•BB^3/2)/(TT•BT^3 + TB•BB^3)– Z

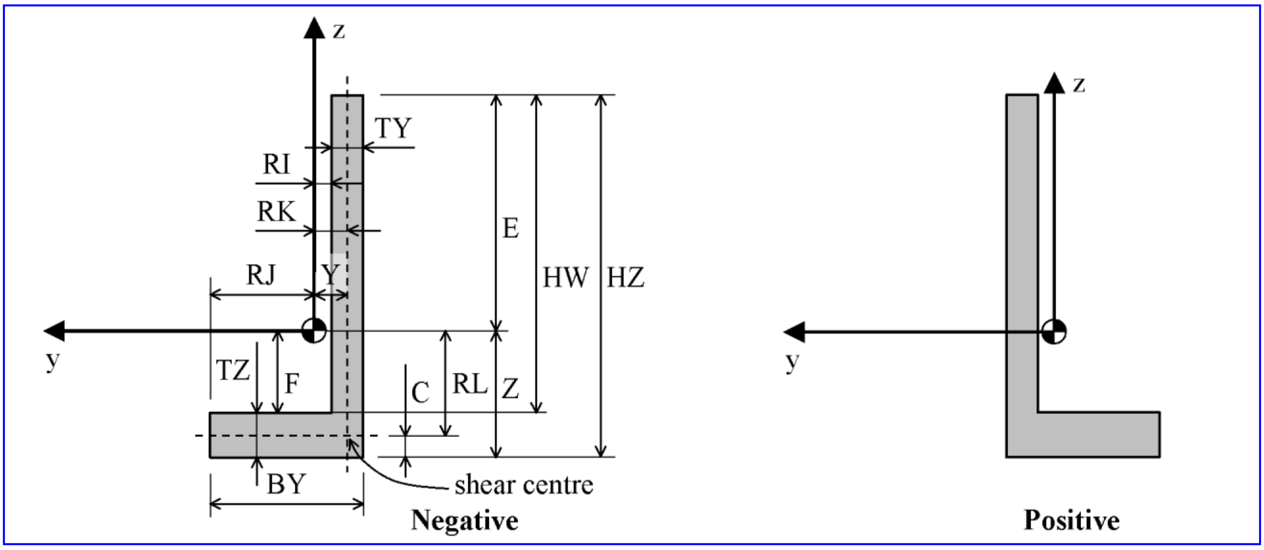
CY = BB/2

CZ = Z

1.1.6 L section

1.1.6.1 Sectional Dimensions

HZ	Height
TY	Thickness of web
BY	Width of flange
TZ	Thickness of flange
SFY	Shear factor y-direction
SFZ	Shear factor z-direction
POSWEB	=1 for web location in positive y-direction, otherwise =-1



1.1.6.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY, SHARZ and SHCENY are taken from Ref. /1/. The expression for SHCENZ is taken from Ref. /2/.

$R = 0$

$HW = HZ - TZ$

$B = TZ - HW/2$

$C = TZ/2$

$PIQRT = \mathrm{atan}(1.0)$

$AREA = TY \cdot HW + BY \cdot TZ + (1 - PIQRT) \cdot R^2$

$Y = (HW \cdot TY^2 + TZ \cdot BY^2)/(2 \cdot AREA)$

$Z = (HW \cdot B \cdot TY + TZ \cdot BY \cdot C)/AREA$

$D = 6 \cdot R + 2 \cdot (TY + TZ - \mathrm{sqrt}(4 \cdot R(2 \cdot R + TY + TZ) + 2 \cdot TY \cdot TZ))$

$E = HW + TZ - Z$

$F = HW - E$

$RI = Y - TY$

$RJ = BY - Y$

$RK = RI + 0.5 \cdot TY$

$RL = Z - C$

If (TZ≥TY) then $TS = TZ$

$TL = TY$

$BA = BY$

$H = HW$

$ALPHA = TL \cdot (0.07 + 0.076 \cdot R/TS)/TS$

$IY = (TY \cdot HW^3 + BY \cdot TZ^3)/12 + HW \cdot TY(B - Z)^2 + BY \cdot TZ(Z - C)^2$

$IZ = (HW \cdot TY^3 + TZ \cdot BY^3)/12 + HW \cdot TY \cdot RK^2 + TZ \cdot BY(BY/2 - Y)^2$

$IYZ = RL \cdot TZ/2 \cdot (Y^2 - RJ^2) - RK \cdot TY/2 \cdot (E^2 - F^2)$

$WXMIN = IX/D$

$WYMIN = IY/MAX(Z, HZ - H)$

$WZMIN = IZ/MAX(Y, RJ)$

$SY = E^2 \cdot TY/2$

$SZ = RJ^2 \cdot TZ/2$

$SHARY = (IZ \cdot TZ/SZ) \cdot SFY$

$SHARZ = (IY \cdot TZ/SY) \cdot SFZ$

If web located in positive y then	IYZ = -IYZ
	SHCENY = RK
	CY = BY – Y
Else	SCHENY = -RK
	CY = Y

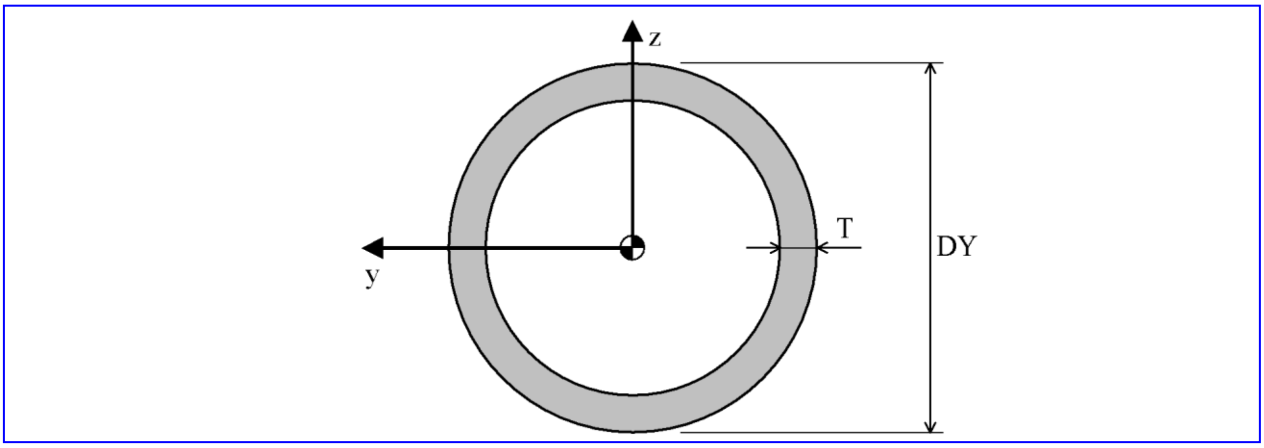
SCHENZ = -RL

CZ = Z

1.1.7 Pipe section

1.1.7.1 Sectional Dimensions

DY	Outer diameter
T	Thickness of wall
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.7.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY, SHARZ, SHCENY and SHCENZ are taken from Ref. /1/.

DI = DY – 2T

PI = 4•atan(1.0)

AREA = PI•T(DY – T)

IX = PI• $(DY^4 – (DY – 2•T)^4) ⁄ 32$

IY = IX ⁄ 2

IZ = IY

IYZ = 0

WXMIN = 2•IX ⁄ DY

WYMIN = 2•IY ⁄ DY

WZMIN = 2•IZ ⁄ DY

SY = $(DY^3 – DI^3) ⁄ 12$

SZ = SY

SHARY = (2•IZ•T ⁄ SY)•SFY

SHARZ = (2•IY•T ⁄ SZ)•SFZ

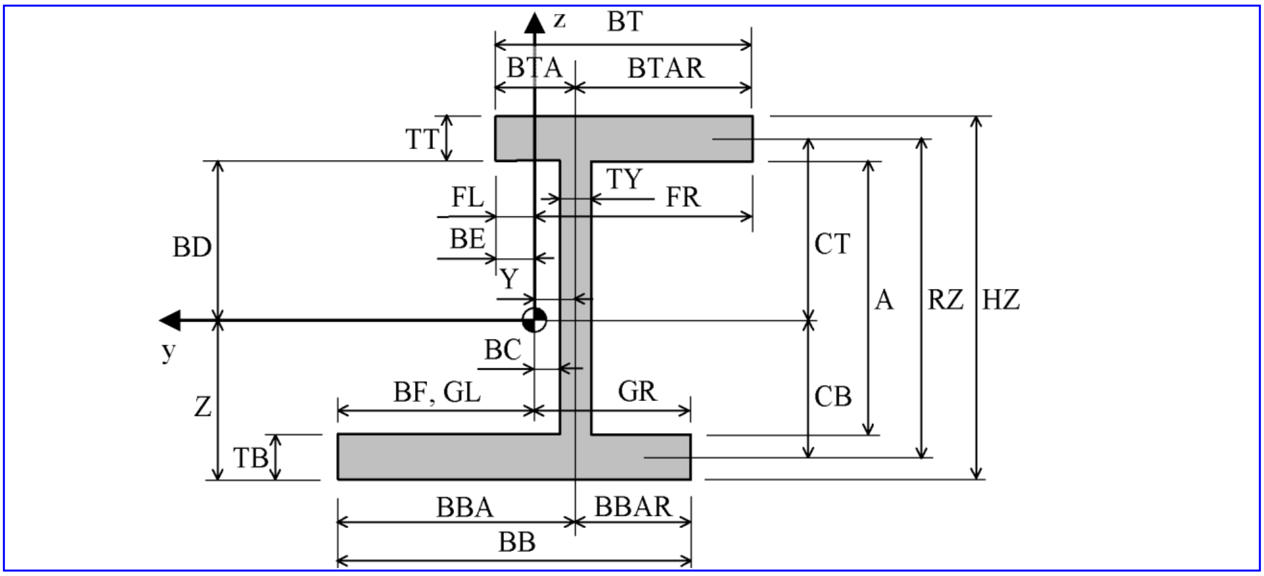
SHCENY = 0

SHCENZ = 0

1.1.8 Un-symmetrical I section

1.1.8.1 Sectional Dimensions

HZ	Height
BT	Width of top flange
BTA	Width of part of top flange along positive y-axis
TT	Thickness of top flange
TY	Thickness of web
BB	Width of bottom flange
BBA	Width of part of bottom flange along positive y-axis
TB	Thickness of bottom flange
SFY	Shear factor y-direction
SFZ	Shear factor z-direction



1.1.8.2 Section derived properties

The expressions below for IX, IY, IZ, WXMIN, WYMIN, WZMIN, SHARY and SHARZ are taken from Ref. /1/. The expressions for SHCENY and SHCENZ are taken from Ref. /3/.

A = HZ–TB– TT

AREA = BB•TB+BT•TT+A•TY

Y = (BB•TB• (BBA – BB ⁄ 2) + BT•TT• (BTA – BT ⁄ 2)) ⁄ AREA

$Z = (BB \cdot TB^2/2 + A \cdot TY(TB+A/2) + BT \cdot TT \cdot (HZ - TT/2))/AREA$

If (TT = TY) and (TT = TB) then $IX = TT^3 \cdot (BT + A + BB - 2.66 \cdot TT)/3$

WXMIN = IX/TT

Else $IX = 1.1 \cdot (BT \cdot TT^3 + A \cdot TY^3 + BB \cdot TB^3)/3$

WXMIN = IX/MAX(TT,TY,TB)

$IY = (BT \cdot TT^3+TY \cdot A^3+BB \cdot TB^3)/12 + BT \cdot TT \cdot (HZ - Z - TT/2)^2$

$+TB \cdot BB(Z - TB/2)^2 + TY \cdot A \cdot (TB + A/2 - Z)^2$

$IZ = (TT \cdot BT^3+A \cdot TY^3 +TB \cdot BB^3)/12 + TT \cdot BT \cdot (BT/2 - BTA - Y)^2$

$+BB \cdot TB \cdot (BB/2 - BBA + Y)^2 + TY \cdot A \cdot Y^2$

IYZ = –BT•TT(BD + TT ⁄ 2)•(BT ⁄ 2 – BTA + Y) – A•TY•Y• (TB+A ⁄ 2 – Z)

–BB•TB• (TB ⁄ 2 – Z)•(BB ⁄ 2 – BBA + Y)

WYMIN = IY ⁄ MAX(HZ – Z, Z)

WZMIN = IZ ⁄ MAX(MAX(BTA, BBA) –Y,MAX(BT – BTA, BB – BBA) + Y)

BC = abs(Y) – TY ⁄ 2

BD = HZ – TT – Z

BE = BTA – Y

BF = BBA – Y

If BC 0 < ( ) then $SZ = TT \cdot BE^2/2 + TB \cdot BF^2/2 + A \cdot BC^2/2$

If (Y < 0) then $SZ = (TT \cdot BE^2 + TB \cdot BF^2)/2 + A \cdot TY \cdot BC$

Else $SZ = (TT \cdot BE^2 + TB \cdot BF^2)/2$

$SY = BT \cdot TT \cdot (BD + TT/2) + TY \cdot BD^3/2$

SHARY = (IZ ⁄ SZ)•(TB + TT)•SFY

SHARZ = (IY ⁄ SY)•TY•SFZ

RZ = HZ – (TT + TB)/2

If (Y<0) then FL = BTA + abs(Y)

GL = BBA + abs(T)

Else FL = BTA – abs(Y)

GL = BBA – abs(Y)

FR = BT – FL

GR = BB – GL

CT = BD + TT ⁄ 2

$CB = Z - TB/2$

$BTAR = BT - BTA$

$BBAR = BB - BBA$

$BG = (BBA^3 + BBAR^3)/3 - (GL \cdot BBA^2 + GR \cdot BBAR^2)$

$SHCENY = -Y + 0.5 \cdot RZ \cdot TB \cdot (IYZ \cdot BG - IZ \cdot CB \cdot (BBA^2 - BBAR^2))/(IY \cdot IZ - IYZ^2)$

$BH = (BTA^3 + BTAR^3)/3 - (FL \cdot BTA^2 + FR \cdot BTAR^2)$

$CY = Y + BB - BBA$

$CZ = Z$

2. CONSISTENT UNITS

This Appendix shows some typical consistent units.

2.1 Consistent SI units

Length Unit *L*	Mass Unit *M*	Force Unit ML/T^2	Typical program input values Yield stress for steel $M/(LT^2)$	Density of steel (Mass/Volume) M/L^3	Young's modulus for steel (Force/Area) $M/(LT^2)$
M	kg	1 N	$4.2 \cdot 10^8$	$7.85 \cdot 10^3$	$2.10 \cdot 10^{11}$
M	10^3 kg = 1 t	10^3 N = 1 KN	$4.2 \cdot 10^5$	7.85	$2.10 \cdot 10^8$
Cm	kg	10^{-2} N	$4.2 \cdot 10^6$	$7.85 \cdot 10^{-3}$	$2.10 \cdot 10^9$
Cm	10^3 kg = 1 t	1 kgf ≈ 10 N	$4.2 \cdot 10^3$	$7.85 \cdot 10^{-6}$	$2.10 \cdot 10^6$
Mm	kg	10^{-3} N	$4.2 \cdot 10^5$	$7.85 \cdot 10^{-6}$	$2.10 \cdot 10^8$
Mm	10^3 kg = 1 t	1 N	$4.2 \cdot 10^2$	$7.85 \cdot 10^{-9}$	$2.10 \cdot 10^5$
Cm	10^2 kg	1 N	$4.2 \cdot 10^4$	$7.85 \cdot 10^{-5}$	$2.10 \cdot 10^7$
M	10^4 kg	1 tonnef ≈ 10000 N	$4.2 \cdot 10^4$	$7.85 \cdot 10^{-1}$	$2.10 \cdot 10^7$
Cm	10^6 kg	1 tonnef ≈ 10000 N	4.2	$7.85 \cdot 10^{-9}$	$2.10 \cdot 10^3$
Mm	10^7 kg	1 tonnef ≈ 10000 N	$4.2 \cdot 10^{-3}$	$7.85 \cdot 10^{-13}$	2.10
M	10 kg	1 kgf ≈ 10 N	$4.2 \cdot 10^7$	$7.85 \cdot 10^2$	$2.10 \cdot 10^{10}$
Cm	10^3 kg	1 kgf ≈ 10 N	$4.2 \cdot 10^3$	$7.85 \cdot 10^{-6}$	$2.10 \cdot 10^6$
Mm	10^4 kg	1 kgf ≈ 10 N	$4.2 \cdot 10^1$	$7.85 \cdot 10^{-10}$	$2.10 \cdot 10^4$

2.2 Consistent Empirical units

Length Unit *L*	Mass Unit *M*	Force Unit ML/T^2	Typical program input values Yield stress for steel $M/(LT^2)$	Density of steel (Mass/Volume) M/L^3	Young's modulus for steel (Force/Area) $M/(LT^2)$
Foot	1 lb	Poundal		491	$1.39 \cdot 10^{11}$
Inch	12 lbs	Poundal		$2.37 \cdot 10^{-2}$	$9.66 \cdot 10^8$
Foot	32.2 lbs (1 slug)	Pound(f)		15.2	$4.32 \cdot 10^9$
Inch	386 lbs	Pound(f)		$7.35 \cdot 10^{-4}$	$3.0 \cdot 10^7$
Foot	$3.22 \cdot 10^4$ lbs	Kip		$1.52 \cdot 10^{-2}$	$4.32 \cdot 10^6$
Inch	$3.86 \cdot 10^5$ lbs	Kip		$7.35 \cdot 10^{-7}$	$3.0 \cdot 10^4$
Foot	$7.21 \cdot 10^4$ lbs	Ton(f)		$6.81 \cdot 10^{-3}$	$1.93 \cdot 10^6$
Inch	$8.66 \cdot 10^5$ lbs	Ton(f)		$3.28 \cdot 10^{-7}$	$1.34 \cdot 10^4$

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