TALAT Lecture 2301

Design of Members

Torsion

Example 8.2 : Torsion constants for hollow cross section

3 pages

Advanced Level

prepared by Torsten Höglund, Royal Institute of Technology, Stockholm

Date of Issue: 1999

Example 8.2. Torsion constants for hollow cross section

a) Polygon

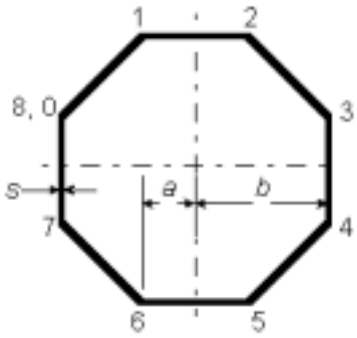
Half width $b := 50 \cdot mm$

Thickness $s := 6 \cdot mm$

Half width of flat parts $a := \frac{b}{1 + \sqrt{2}}$ $a = 20.711 \cdot mm$

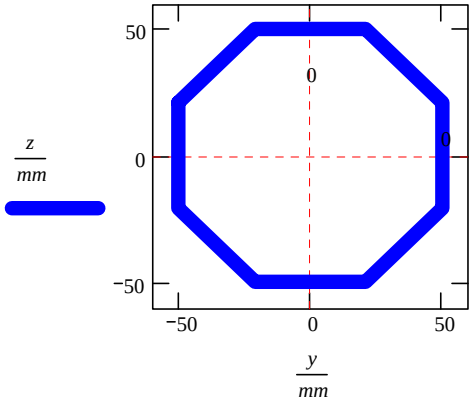
Nodes no., co-ordinates, thickness

$$i := \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \end{bmatrix} \quad y := \begin{bmatrix} -b \\ -a \\ a \\ b \\ b \\ a \\ -a \\ -b \\ -b \end{bmatrix} \quad z := \begin{bmatrix} a \\ b \\ b \\ a \\ -a \\ -b \\ -b \\ -a \\ a \end{bmatrix} \quad t := \begin{bmatrix} s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \end{bmatrix}$$



Nodes $i := 1 .. rows(y) - 1$

Area of cross section elements $dA_i := \left[t_i \cdot \sqrt{\left(y_i - y_{i-1}\right)^2 + \left(z_i - z_{i-1}\right)^2} \right]$



Cross section area $A := \sum_{i=1}^{rows(y)-1} dA_i$

First moment of area. Gravity centre $S_y := \sum_{i=1}^{rows(y)-1} \left(z_i + z_{i-1}\right) \cdot \frac{dA_i}{2}$

$z_{gc} := \frac{S_y}{A}$

$z_{gc} = -1.704 \cdot 10^{-15} \cdot mm$

Second moment of area $I_y := \sum_{i=1}^{rows(y)-1} \left[\left(z_i\right)^2 + \left(z_{i-1}\right)^2 + z_i \cdot z_{i-1} \right] \cdot \frac{dA_i}{3}$

$I_y := I_y - A \cdot z_{gc}^2$

$I_y = 2.627 \cdot 10^6 \cdot mm^4$

Area within mid-line $A_v := \sum_{i=1}^{rows(y)-1} 0.5 \cdot \left(y_i - y_{i-1}\right) \cdot \left(z_i + z_{i-1}\right)$

$A_v = 8.284 \cdot 10^3 \cdot mm^2$

Check:

$(2 \cdot b)^2 - 2 \cdot (b - a)^2 = 8.284 \cdot 10^3 \cdot mm^2$

Sum of l/t $Dn := \sum_{i=1}^{rows(y)-1} \frac{\sqrt{\left(y_i - y_{i-1}\right)^2 + \left(z_i - z_{i-1}\right)^2}}{t_i}$ $Dn = 55.228$

Torsion constant $I_v := \frac{4 \cdot A_v^2}{Dn}$

$I_v = 4.971 \cdot 10^6 \cdot mm^4$

Torsion resistance $W_v := 2 \cdot A_v \cdot min(t)$ $min(t) = 6 \cdot mm$

$W_v = 9.941 \cdot 10^4 \cdot mm^3$

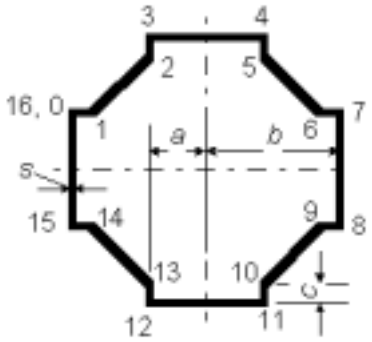
b) Symmetric hollow extrusion

Half width $b := 50 \cdot mm$

Indent $c := 10 \cdot mm$

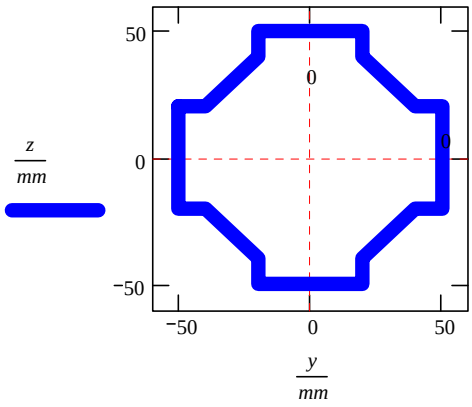
Half width of flat parts $a := 20 \cdot mm$

Thickness $s := 6 \cdot mm$



Nodes no., co-ordinates, thickness

$$i := \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \end{bmatrix} \quad y := \begin{bmatrix} -b \\ -b + c \\ -a \\ -a \\ a \\ a \\ b - c \\ b \\ b \\ b - c \\ a \\ a \\ -a \\ -a \\ -b + c \\ -b \\ -b \end{bmatrix} \quad z := \begin{bmatrix} a \\ a \\ b - c \\ b \\ b \\ b - c \\ a \\ a \\ -a \\ -a \\ -b + c \\ -b \\ -b \\ -b + c \\ -a \\ -a \\ a \end{bmatrix} \quad t := \begin{bmatrix} s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \\ s \end{bmatrix}$$



Nodes $i := 1 .. rows(y) - 1$

Area within mid-line $A_v := \sum_{i=1}^{rows(y)-1} 0.5 \cdot \left(y_i - y_{i-1}\right) \cdot \left(z_i + z_{i-1}\right)$ $A_v = 7.2 \cdot 10^3 \cdot mm^2$

Sum of l/t $Dn := \sum_{i=1}^{rows(y)-1} \frac{\sqrt{\left(y_i - y_{i-1}\right)^2 + \left(z_i - z_{i-1}\right)^2}}{t_i}$ $Dn = 58.856$

Torsion constant $I_v := \frac{4 \cdot A_v^{\,2}}{Dn}$ $I_v = 3.523 \cdot 10^6 \cdot mm^4$

Torsion resistance $W_v := 2 \cdot A_v \cdot min(t)$ $min(t) = 6 \cdot mm$ $W_v = 8.64 \cdot 10^4 \cdot mm^3$