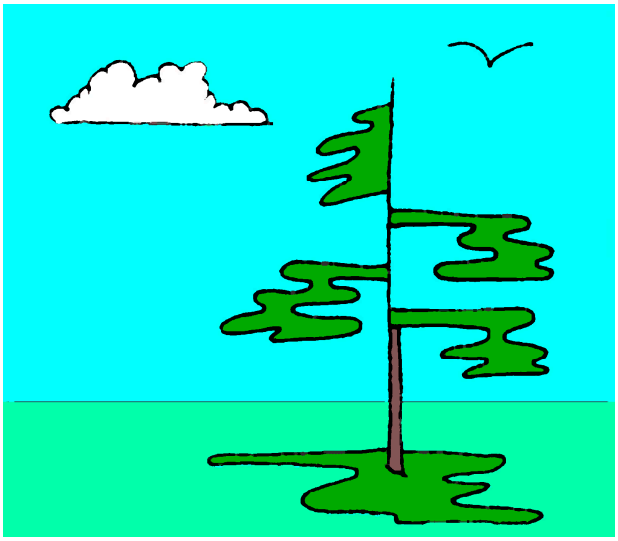
# NorthWoods Software



**Program Name:** Weld-Group_HSSr

**Project Number:** -

**Project Description:** -

**Project Designer:** Dik

**Last Revised (yy-mm-dd):** 22.02.02

**Reference:** NBCC, CSA S16

**Disclaimer:**
Created using SMath Studio, a MathCAD workalike from https://en.smath.info/view/SMathStudio. The User is responsible to verify data and calculations using an alternative method

**Menu:**

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| ..... Input Data | ..... Important Output | ..... Logical Constructs | Blue Units |
| ..... Sum / For | Red Important Note | Gray Temporary Variables | |

## Input Data

### Material Property Factors:

$\varphi_s := 0.90$

$\varphi_w := 0.67$

**Weld interface is taken at the face of the attached member rather than the centreline of the weld.**

### Load Factors:

$\alpha_L := 1.50$

$\alpha_D := 1.25$

$Check\left(\alpha_D \geq 1.25\right) = "...OK"$

$Check\left(\alpha_L \geq 1.5\right) = "...OK"$

### HSSr Shape Input Data:

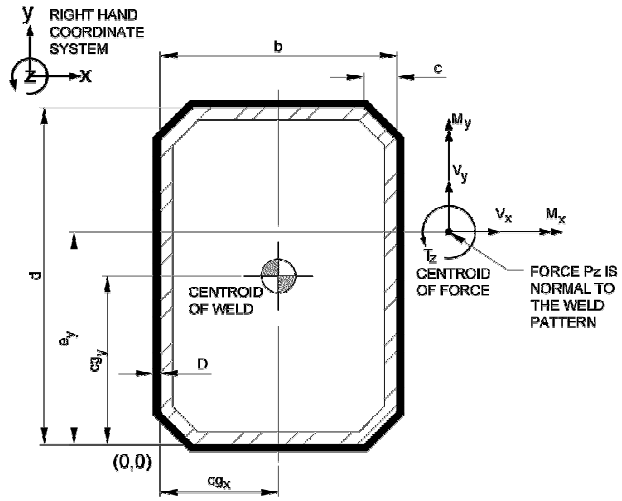
$d := 6\ in$

$b := 6\ in$

$c := .5\ in$

$d' := d - 2 \cdot c$

$b' := b - 2 \cdot c$




$d = 152.4\ mm$ Depth

$b = 152.4\ mm$ Width

$c = 12.70\ mm$ Chamfer Corner

### Applied Factored Loads:

$P_{fz} := 0\ K$

$V_{fx} := 0\ K$

$V_{fy} := 25\ K$

$M_{fx} := 30\ K\_ft$

$M_{fy} := 0\ K\_ft$

$T_{fz} := 0\ K\_ft$

$P_{fz} = 0.00\ kN$ Axial Load

$V_{fx} = 0.00\ kN$ Shear (X-Axis)

$V_{fy} = 111.21\ kN$ Shear (Y-Axis)

$M_{fx} = 40.67\ kN\_m$ Moment (X-Axis)

$M_{fy} = 0.00\ kN\_m$ Moment (Y-Axis)

$T_{fz} = 0.00\ kN\_m$ Torsion (Z-Axis)

**Load Eccentricity:**

$e_x := 3\ in$

$e_y := 3\ in$

$e_z := 0\ in$

$c$

$e_x = 76.2\ mm$ X-Axis Direction

$e_y = 76.2\ mm$ Y-Axis Direction

$e_z = 0.0\ mm$ Z-Axis Direction

**Steel Properties:**

**Part:** $st_{NDX} := 1$

$$st := \begin{bmatrix} \text{NDX} & \text{des} & \text{fy} & \text{Fu} \\ 1 & \text{"G40.21-350W"} & 50\ Ksi & 65\ Ksi \\ 2 & \text{"G40.21-300W"} & 44\ Ksi & 65\ Ksi \\ 3 & \text{"A36"} & 36\ Ksi & 58\ Ksi \end{bmatrix}$$

$desM_1 := st_{st_{NDX},2}$ $f_{y1} := st_{st_{NDX},3}$ $F_{u1} := st_{st_{NDX},4}$

$G_s := \frac{E_s}{2\cdot(1+\nu)}$ $\gamma_s := 489\ pcf$ $\nu := 0.3$ $E_s := 29000\ Ksi$

**Base:** $st_{NDX} := 2$

$desM_2 := st_{st_{NDX},2}$ $f_{y2} := st_{st_{NDX},3}$ $F_{u2} := st_{st_{NDX},4}$

$$pts := \begin{bmatrix} \text{s} & \text{xi} & \text{yi} & \text{xj} & \text{yj} \\ 1 & c & 0\ in & 0\ in & c \\ 2 & 0\ in & c & 0\ in & c+d' \\ 3 & 0\ in & c+d' & c & d \\ 4 & c & d & c+b' & d \\ 5 & c+b' & d & b & c+d' \\ 6 & b & c+d' & b & c \\ 7 & b & c & c+b' & 0\ in \\ 8 & c+b' & 0\ in & c & 0\ in \end{bmatrix}$$

$pts' := \text{submatrix}(pts, 1, \text{rows}(pts), 2, 5)$

```
for c ∈ [1..rows(pts')]
    ptsn_{c,1} := pts'_{c,1} · 1/in
    ptsn_{c,2} := pts'_{c,2} · 1/in
    ptsn_{c,3} := pts'_{c,3} · 1/in
    ptsn_{c,4} := pts'_{c,4} · 1/in
```

$c := 0$

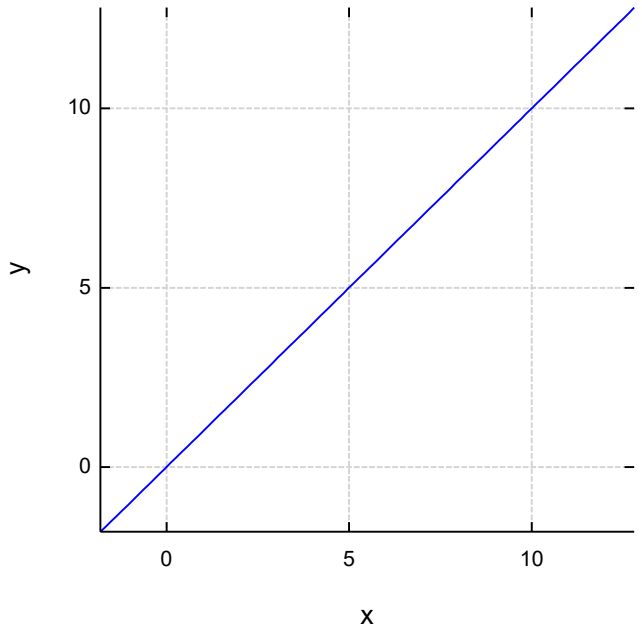
```
for c ∈ [1..rows(ptsn)]
    weld_{c,1} := ptsn_{c,1}
    weld_{c,2} := ptsn_{c,2}
```

$c := c + 1$

$weld_{c,1} := ptsn_{1,1}$

$weld_{c,2} := ptsn_{1,2}$

**Weld Pattern**




$weld$

**Weld Design:**

**Weld Electrodes:** $we_{NDX} := 2$

$we :=$

| | NDX | DesI | DesM | UTS |
|---|---|---|---|---|
| 1 | "E60xx" | "E43xx" | 60 ksi |
| 2 | "E70xx" | "E49xx" | 70 ksi |
| 3 | "E80xx" | "E55xx-x" | 80 ksi |
| 4 | "E90xx" | "E62xx-x" | 90 ksi |

$desI_w := we_{we_{NDX},2}$ $desM_w := we_{we_{NDX},3}$ $X_u := we_{we_{NDX},4}$

**Weld Sizes:** $ws_{NDX} := 13$

$ws :=$

| | NDX | desI | desM | D |
|---|---|---|---|---|
| 1 | "" | "3mm" | 0.11811 in |
| 2 | "1/8" | "" | 0.125 in |
| 3 | "" | "4mm" | 0.15748 in |
| 4 | "3/16" | "" | 0.1875 in |
| 5 | "" | "5mm" | 0.19685 in |
| 6 | "" | "6mm" | 0.23622 in |
| 7 | "1/4" | "" | 0.25 in |
| 8 | "" | "7mm" | 0.275591 in |
| 9 | "5/16" | "" | 0.3125 in |
| 10 | "" | "8mm" | 0.314961 in |
| 11 | "" | "9mm" | 0.354331 in |
| 12 | "3/8" | "" | 0.375 in |
| 13 | "" | "10mm" | 0.3937 in |
| 14 | "" | "11mm" | 0.4331 in |
| 15 | "7/16" | "" | 0.4375 in |
| 16 | "" | "12mm" | 0.4724 in |
| 17 | "1/2" | "" | 0.50 in |

$desI_D := ws_{ws_{NDX},2}$ $desM_D := ws_{ws_{NDX},3}$ $D := ws_{ws_{NDX},4}$

**Weld Material Strength**

$v_{rw} := \varphi_w \cdot 0.67 \cdot X_u \cdot \frac{1}{\sqrt{2}}$ $v_{rw} = 22.2$ ksi $v_{rw} = 153.2$ MPa Weld Strength

**HSSr Metal Strength**

$v_{rb1} := \varphi_w \cdot 0.67 \cdot F_{u1}$ $v_{rb1} = 29.2$ Ksi $v_{rb1} = 201.2$ MPa HSSr Strength

**Base Metal Strength**

$v_{rb2} := \varphi_w \cdot 0.67 \cdot F_{u1}$ $v_{rb2} = 29.2$ Ksi $v_{rb2} = 201.2$ MPa Base Metal Strength

**Minimum Weld Capacity**

$V_{rw} := \min\left(\left[\begin{array}{ccc} v_{rw} & v_{rb1} & v_{rb2} \end{array}\right]\right)$ $V_{rw} = 22.2$ Ksi $V_{rw} = 153.2$ MPa Weld Resistance

**Weld Properties:**

for $r \in [1..\text{rows}(pts)]$

$pts_{r,6} := \frac{pts_{r,2} + pts_{r,4}}{2}$ $c_x$

$pts_{r,7} := \frac{pts_{r,3} + pts_{r,5}}{2}$ $c_y$

$pts_{r,8} := pts_{r,4} - pts_{r,2}$ $m$

$pts_{r,9} := pts_{r,5} - pts_{r,3}$ $n$

$pts_{r,10} := \sqrt{(pts_{r,8})^2 + (pts_{r,9})^2}$ $L$

$pts_{r,11} := \frac{pts_{r,10} \cdot (pts_{r,9})^2}{12}$ $I_{xx}$

$pts_{r,12} := \frac{pts_{r,10} \cdot (pts_{r,8})^2}{12}$ $I_{yy}$

$pts_{r,13} := pts_{r,10} \cdot pts_{r,6}$ L cx

$pts_{r,14} := pts_{r,10} \cdot pts_{r,7}$ L cy

for $r \in [1..\text{rows}(pts)]$

$pts_{r,15} := pts_{r,6} - cg_x$ $d_x$

$pts_{r,16} := pts_{r,7} - cg_y$ $d_y$

$pts_{r,17} := pts_{r,11} + pts_{r,10} \cdot pts_{r,16}^2$ $I'_{xx}$

$pts_{r,18} := pts_{r,12} + pts_{r,10} \cdot (pts_{r,15})^2$ $I'_{yy}$

$pts_{r,19} := pts_{r,10} \cdot pts_{r,15} \cdot pts_{r,16}$ $I'_{xy}$

$pts_{r,20} := pts_{r,2} - cg_x$ $d_{xi}$

$pts_{r,21} := pts_{r,3} - cg_y$ $d_{yi}$

$pts_{r,22} := pts_{r,4} - cg_x$ $d_{xj}$

$pts_{r,23} := pts_{r,5} - cg_y$ $d_{yj}$

| | | | |
|---|---|---|---|
| $A := \sum \text{col}(pts, 10)$ | $A = 22.83\ \text{in}$ | $A = 579.8\ \text{mm}$ | Total Length of Weld |
| $cg_x := \sum \left( \frac{\text{col}(pts, 13)}{A} \right)$ | $cg_x = 3.00\ \text{in}$ | $cg_x = 76.2\ \text{mm}$ | Centroid of Weld X-Axis |
| $cg_y := \sum \left( \frac{\text{col}(pts, 14)}{A} \right)$ | $cg_y = 3.00\ \text{in}$ | $cg_y = 76.2\ \text{mm}$ | Centroid of Weld Y-Axis |
| $I'_{xx} := \sum \text{col}(pts, 17)$ | $I'_{xx} = 132.3\ \text{in}^3$ | $I'_{xx} = 2.17 \cdot 10^6\ \text{mm}^3$ | Moment of Inertia (X-Axis) |
| $I'_{yy} := \sum \text{col}(pts, 18)$ | $I'_{yy} = 132.3\ \text{in}^3$ | $I'_{yy} = 2.17 \cdot 10^6\ \text{mm}^3$ | Moment of Inertia (Y-Axis) |
| $I'_{xy} := \sum \text{col}(pts, 19)$ | $I'_{xy} = 3.9 \cdot 10^{-14}\ \text{in}^3$ | $I'_{xy} = 6.43 \cdot 10^{-10}\ \text{mm}^3$ | Product of Inertia |
| $I'_p := I'_{xx} + I'_{yy}$ | $I'_p = 264.6\ \text{in}^3$ | $I'_p = 4.34 \cdot 10^6\ \text{mm}^3$ | Polar Moment of Inertia |
| $I'_{prod} := I'_{xx} \cdot I'_{yy} - I'^2_{xy}$ | $I'_{prod} = 17498.6\ \text{in}^6$ | $I'_{prod} = 4.70 \cdot 10^{12}\ \text{mm}^6$ | Product of Inertia |

**Load Distance from Centroid:**

$e'_x := e_x - cg_x$ $e'_x = -1.43 \cdot 10^{-14}$ in $e'_x = -3.6276 \cdot 10^{-13}$ mm X-Axis Direction

$e'_y := e_y - cg_y$ $e'_y = -1.06 \cdot 10^{-14}$ in $e'_y = -2.6923 \cdot 10^{-13}$ mm Y-Axis Direction

$e'_z := e_z$ $e'_z = 0.00$ in $e'_z = 0$ mm Z-Axis Direction

**Stress from Applied Factored Loads:**

$\sigma_{fx} := \frac{V_{fx}}{A}$ $\sigma_{fx} = 0.00$ Kpi $\sigma_{fx} = 0$ kNpmm X-Axis Direction

$\sigma_{fy} := \frac{V_{fy}}{A}$ $\sigma_{fy} = 1.0951$ Kpi $\sigma_{fy} = 0.1918$ kNpmm Y-Axis Direction

$\sigma_{fz} := \frac{P_{fz}}{A}$ $\sigma_{fz} = 0$ Kpi $\sigma_{fz} = 0$ kNpmm Z-Axis Direction

**Load at Weld Group Centroid:**

$d_x := e_x - cg_x$ $d_x = -1.43 \cdot 10^{-14}$ in $d_x = -3.63 \cdot 10^{-13}$ mm

$d_y := e_y - cg_y$ $d_y = -1.06 \cdot 10^{-14}$ in $d_y = -2.69 \cdot 10^{-13}$ mm

$d_z := e_z$ $d_z = 0$ in $d_z = 0$ mm

$M'_{fx} := M_{fx} - V_{fy} \cdot d_z + P_{fz} \cdot d_y$ $M'_{fx} = 30.00$ K_ft $M'_{fx} = 40.67$ kN_m

$M'_{fy} := M_{fy} + V_{fx} \cdot d_z - P_{fz} \cdot d_x$ $M'_{fy} = 0$ K_ft $M'_{fy} = 0$ kN_m

$T'_{fz} := T_{fz} - V_{fx} \cdot d_y + V_{fy} \cdot d_x$ $T'_{fz} = -2.98 \cdot 10^{-14}$ K_ft $T'_{fz} = -4.03 \cdot 10^{-14}$ kN_m

```
for r ∈ [1..rows(pts)]
  if pts_{r 10} = 0 in
    pts_{r 24} := 0 pli                                              σz y from Mx      Stress at Start of Segment
    pts_{r 25} := 0 pli                                              σz y from My
    pts_{r 26} := 0 pli                                              σz x from Mx
    pts_{r 27} := 0 pli                                              σz x from My
    pts_{r 28} := pts_{r 24} + pts_{r 25} + pts_{r 26} + pts_{r 27}  Σσz from M
    pts_{r 29} := pts_{r 28} + σ_{fz}                                Σσz
    pts_{r 30} := 0 pli                                              σx from T
    pts_{r 31} := pts_{r 30} + σ_{fx}                                Σσx
    pts_{r 32} := 0 pli                                              σy from T
    pts_{r 33} := pts_{r 32} + σ_{fy}                                Σσy
    pts_{r 34} := √(pts_{r 29}^2 + pts_{r 31}^2 + pts_{r 33}^2)      σy combined
    pts_{r 35} := 0 pli                                              σz y from Mx
  else
    pts_{r 24} := (pts_{r 21} · M'_{fx} · I'_{yy}) / I'_{prod}                                  σz y from My
    pts_{r 25} := (pts_{r 21} · M'_{fy} · I'_{xy}) / I'_{prod}                                  σz x from Mx
    pts_{r 26} := ((−1 · pts_{r 20}) · M'_{fx} · I'_{xy}) / I'_{prod}                           σz x from My
    pts_{r 27} := ((−1 · pts_{r 20}) · M'_{fy} · I'_{xx}) / I'_{prod}                           Σσz from M
    pts_{r 28} := pts_{r 24} + pts_{r 25} + pts_{r 26} + pts_{r 27}                             Σσz
    pts_{r 29} := pts_{r 28} + σ_{fz}                                                           σx from T
    pts_{r 30} := ((−1 · pts_{r 21}) · T'_{fz}) / I'_{p}                                        Σσx
    pts_{r 31} := pts_{r 30} + σ_{fx}                                                           σy from T
    pts_{r 32} := (pts_{r 20} · T'_{fz}) / I'_{p}                                               Σσy
    pts_{r 33} := pts_{r 32} + σ_{fy}                                                           σy combined
    pts_{r 34} := √((pts_{r 29})^2 + (pts_{r 31})^2 + (pts_{r 33})^2)                           Σσy       Stress at Start of Segment
    pts_{r 35} := (pts_{r 23} · M'_{fx} · I'_{yy}) / I'_{prod}                                  σz y from Mx      Stress at End of Segment
```

```
for r ∈ [1..rows(pts)]
  if pts_{r 10} = 0 in
    pts_{r 36} := 0 pli                                   σz y from My
    pts_{r 37} := 0 pli                                   σz x from Mx
    pts_{r 38} := 0 pli                                   σz x from My
    pts_{r 39} := pts_{r 35} + pts_{r 36} + pts_{r 37} + pts_{r 38}   Σσz from M
    pts_{r 40} := (pts_{r 39} + σ_fz)                     Σσz
    pts_{r 41} := 0 pli                                   σx from T
    pts_{r 42} := pts_{r 41} + σ_fx                       Σσx
    pts_{r 43} := 0 pli                                   σy from T
    pts_{r 44} := pts_{r 43} + σ_fy                       Σσy
    pts_{r 45} := √((pts_{r 40})^2 + (pts_{r 42})^2 + (pts_{r 44})^2)   σy combined
    pts_{r 46} := 0 pli                                   σz y from Mx
    pts_{r 47} := 0 pli                                   σz y from My
    pts_{r 48} := 0 pli                                   σz x from Mx
  else
    pts_{r 36} := pts_{r 23} · M'_fy · I'_xy / I'_prod                  σz y from My
    pts_{r 37} := (−1 · pts_{r 22}) · M'_fx · I'_xy / I'_prod           σz x from Mx
    pts_{r 38} := (−1 · pts_{r 22}) · M'_fy · I'_xx / I'_prod           σz x from My
    pts_{r 39} := pts_{r 35} + pts_{r 36} + pts_{r 37} + pts_{r 38}     Σσz from M
    pts_{r 40} := (pts_{r 39} + σ_fz)                                   Σσz
    pts_{r 41} := (−1 · pts_{r 23} · T'_fz / I'_p)                      σx from T
    pts_{r 42} := pts_{r 41} + σ_fx                                     Σσx
    pts_{r 43} := pts_{r 22} · T'_fz / I'_p                             σy from T
    pts_{r 44} := pts_{r 43} + σ_fy                                     Σσy
    pts_{r 45} := √((pts_{r 40})^2 + (pts_{r 42})^2 + (pts_{r 44})^2)   σy combined   Stress at End of Segment
    pts_{r 46} := pts_{r 16} · M'_fx · I'_yy / I'_prod                  σz y from Mx   Stress at Midpoint of Segment
    pts_{r 47} := pts_{r 16} · M'_fy · I'_xy / I'_prod                  σz y from My
    pts_{r 48} := (−1 · pts_{r 15} · M'_fx · I'_xy) / I'_prod           σz x from Mx
```

```
for r ∈ [1..rows(pts)]
  if pts_{r 10} = 0 in
    pts_{r 49} := 0 pli                                              σz x from My
    pts_{r 50} := pts_{r 46} + pts_{r 47} + pts_{r 48} + pts_{r 49}  σz frin M
    pts_{r 51} := pts_{r 50} + σ_fz                                  σz Total
    pts_{r 52} := 0 pli                                              σx from T
    pts_{r 53} := pts_{r 52} · σ_fx                                  σx Combined
    pts_{r 54} := 0 pli                                              σy from T
    pts_{r 55} := pts_{r 54} + σ_fy                                  σy Combined
    pts_{r 56} := √((pts_{r 51})^2 + (pts_{r 53})^2 + (pts_{r 55})^2)  Total σ
  else
    pts_{r 49} := ((−1 · pts_{r 15}) · M'_fy · I'_xx) / I'_prod      σz x from My
    pts_{r 50} := pts_{r 46} + pts_{r 47} + pts_{r 48} + pts_{r 49}  σz frin M
    pts_{r 51} := pts_{r 50} + σ_fz                                  σz Total
    pts_{r 52} := ((−1 · pts_{r 16}) · T'_fz) / I'_p                 σx from T
    pts_{r 53} := (pts_{r 52} + σ_fx)                                σx Combined
    pts_{r 54} := (pts_{r 15} · T'_fz) / I'_p                        σy from T
    pts_{r 55} := pts_{r 54} + σ_fy                                  σy Combined
    pts_{r 56} := √((pts_{r 51})^2 + (pts_{r 53})^2 + (pts_{r 55})^2)  Total σ   Stress at Midpoint of Segment
```

**Max and Min Stress in Segment:**

| | | | |
|---|---|---|---|
| $\sigma'_z := \max(\mathrm{col}(pts, 34))$ | $\sigma'_z = 8.24$ Kpi | $\sigma'_z = 1.44$ kNpmm | Max Stress at Start Segment |
| $op'_1 := \min(\mathrm{col}(pts, 34))$ | $op'_1 = 6.89$ Kpi | $op'_1 = 1.21$ kNpmm | Min Stress at Start Segment |
| $\sigma'_x := \max(\mathrm{col}(pts, 45))$ | $\sigma'_x = 8.24$ Kpi | $\sigma'_x = 1.44$ kNpmm | Max Stress at End Segment |
| $op'_2 := \min(\mathrm{col}(pts, 45))$ | $op'_2 = 6.89$ Kpi | $op'_2 = 1.21$ kNpmm | Min Stress at End Segment |
| $\sigma'_y := \max(\mathrm{col}(pts, 56))$ | $\sigma'_y = 8.24$ Kpi | $\sigma'_y = 1.44$ kNpmm | Max Stress at Mid Segment |
| $op'_3 := \min(\mathrm{col}(pts, 56))$ | $op'_3 = 1.1$ Kpi | $op'_3 = 0.19$ kNpmm | Min Stress at Mid Segment |

**Max and Min Stress in Welds:**

| | | | |
|---|---|---|---|
| $op_{max} := \max([\sigma'_x \ \sigma'_y \ \sigma'_z])$ | $op_{max} = 8.24$ Kpi | $op_{max} = 1.44$ kNpmm | Max Stress in Segment |
| $op'_{min} := \min([op'_1 \ op'_2 \ op'_3])$ | $op'_{min} = 1.10$ Kpi | $op'_{min} = 0.19$ kNpmm | Min Stress in Segment |
| $v_r := v_{rw} \cdot D$ | $v_r = 8.75$ Kpi | $v_r = 1.532$ kNpmm | Weld Resistance per Unit Length |

**Summary:**

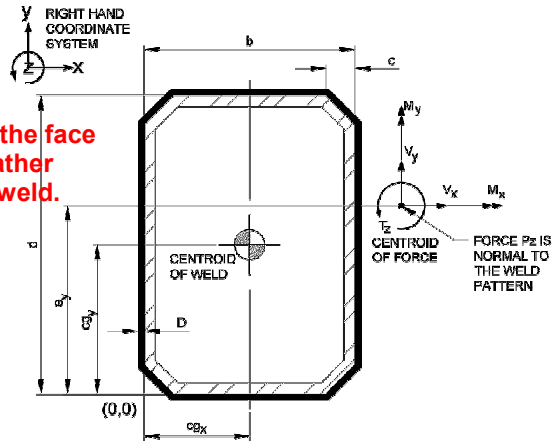
**Material Property Factors**

| | |
|---|---|
| Rolled Sections | $\varphi_s = 0.9$ |
| Weld | $\varphi_w = 0.67$ |
| Dead Load Factor | $\alpha_D = 1.25$ |
| Live Load Factor | $\alpha_L = 1.5$ |

$Check\left(\alpha_D \geq 1.25\right) = "...OK"$

$Check\left(\alpha_L \geq 1.5\right) = "...OK"$

**Weld interface is taken at the face of the attached member rather than the centreline of the weld.**



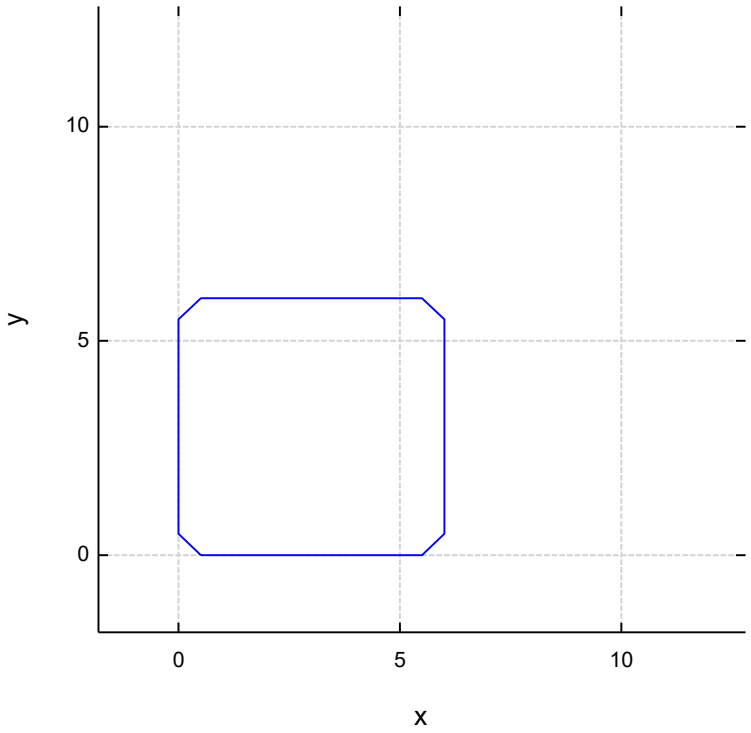

**Applied Factored Loads:**

| | | |
|---|---|---|
| Axial Load | $P_{fz} = 0$ K | $P_{fz} = 0$ kN |
| Shear (X-Axis) | $V_{fx} = 0$ K | $V_{fx} = 0$ kN |
| Shear (Y-Axis) | $V_{fy} = 25$ K | $V_{fy} = 111.2055$ kN |
| Moment (X-Axis) | $M_{fx} = 30$ K_ft | $M_{fx} = 40.6745$ kN_m |
| Moment (Y-Axis) | $M_{fy} = 0$ K_ft | $M_{fy} = 0$ kN_m |
| Torsion (Z-Axis) | $T_{fz} = 0$ K_ft | $T_{fz} = 0$ kN_m |

**Load Eccentricity from Origin:**

| | | |
|---|---|---|
| X-Axis Direction | $e_x = 3$ in | $e_x = 76.2$ mm |
| Y-Axis Direction | $e_y = 3$ in | $e_y = 76.2$ mm |
| Z-Axis Direction | $e_z = 0$ in | $e_z = 0$ mm |

**Weld Pattern**




*weld*

**Segment Input Data:**

Row Represents Segment
Number Columns represent
S(xi, yi, xj, yj) coordinates

$$pts' = \begin{bmatrix} 0.5 & 0.0 & 0.0 & 0.5 \\ 0.0 & 0.5 & 0.0 & 5.5 \\ 0.0 & 5.5 & 0.5 & 6.0 \\ 0.5 & 6.0 & 5.5 & 6.0 \\ 5.5 & 6.0 & 6.0 & 5.5 \\ 6.0 & 5.5 & 6.0 & 0.5 \\ 6.0 & 0.5 & 5.5 & 0.0 \\ 5.5 & 0.0 & 0.5 & 0.0 \end{bmatrix} \text{ in}$$

$$pts' = \begin{bmatrix} 12.7 & 0 & 0 & 12.7 \\ 0 & 12.7 & 0 & 139.7 \\ 0 & 139.7 & 12.7 & 152.4 \\ 12.7 & 152.4 & 139.7 & 152.4 \\ 139.7 & 152.4 & 152.4 & 139.7 \\ 152.4 & 139.7 & 152.4 & 12.7 \\ 152.4 & 12.7 & 139.7 & 0 \\ 139.7 & 0 & 12.7 & 0 \end{bmatrix} \text{ mm}$$

## Steel Properties

### Part

| | | |
|---|---|---|
| Designation | $desM_1 = \text{"G40.21-350W"}$ | |
| Yield Strength | $f_{y1} = 50\ \text{Ksi}$ | $f_{y1} = 345\ \text{MPa}$ |
| Ultimate Strength | $F_{u1} = 65\ \text{Ksi}$ | $F_{u1} = 448\ \text{MPa}$ |

### Base

| | | |
|---|---|---|
| Designation | $desM_2 = \text{"G40.21-300W"}$ | |
| Yield Strength | $f_{y2} = 44\ \text{Ksi}$ | $f_{y2} = 303\ \text{MPa}$ |
| Ultimate Strength | $F_{u2} = 65\ \text{Ksi}$ | $F_{u2} = 448\ \text{MPa}$ |
| Young's Modulus | $E_s = 29000\ \text{Ksi}$ | $E_s = 1.9995 \cdot 10^{5}\ \text{MPa}$ |
| Shear Modulus | $G_s = 11153.8462\ \text{Ksi}$ | $G_s = 76903\ \text{MPa}$ |
| Density | $\gamma_s = 489\ \text{pcf}$ | $\gamma_s = 76.8158\ \text{kNpcm}$ |

## Welding Electrodes

| | | |
|---|---|---|
| Imperial Designation | $desI_w = \text{"E70xx"}$ | |
| Metric Designation | $desM_w = \text{"E49xx"}$ | |
| Ultimate Strength | $X_u = 70\ \text{ksi}$ | $X_u = 483\ \text{MPa}$ |

## Weld Size

| | | |
|---|---|---|
| Imperial Designation | $desI_D = \text{""}$ | |
| Metric Designation | $desM_D = \text{"10mm"}$ | |
| Size | $D = 0.3937\ \text{in}$ | $D = 10\ \text{mm}$ |
| Weld Strength | $v_{rw} = 22.2\ \text{ksi}$ | $v_{rw} = 153.2\ \text{MPa}$ |
| Part to be Welded Strength | $v_{rb1} = 29.2\ \text{Ksi}$ | $v_{rb1} = 201.2\ \text{MPa}$ |
| Base Metal Strength | $v_{rb2} = 29.2\ \text{Ksi}$ | $v_{rb2} = 201.2\ \text{MPa}$ |
| Weld Resistance | $V_{rw} = 22.2\ \text{Ksi}$ | $V_{rw} = 153.2\ \text{MPa}$ |
| Total Length of Weld | $A = 22.8284\ \text{in}$ | $A = 579.8\ \text{mm}$ |
| Centroid of Weld X-Axis | $cg_x = 3\ \text{in}$ | $cg_x = 76.2\ \text{mm}$ |
| Centroid of Weld Y-Axis | $cg_y = 3\ \text{in}$ | $cg_y = 76.2\ \text{mm}$ |
| Moment of Inertia (X-Axis) | $I'_{xx} = 132.3\ \text{in}^3$ | $I'_{xx} = 2.17 \cdot 10^{6}\ \text{mm}^3$ |
| Moment of Inertia (Y-Axis) | $I'_{yy} = 132.3\ \text{in}^3$ | $I'_{yy} = 2.17 \cdot 10^{6}\ \text{mm}^3$ |
| Product of Inertia | $I'_{xy} = 3.9 \cdot 10^{-14}\ \text{in}^3$ | $I'_{xy} = 6.43 \cdot 10^{-10}\ \text{mm}^3$ |
| Polar Moment of Inertia | $I'_p = 264.6\ \text{in}^3$ | $I'_p = 4.34 \cdot 10^{6}\ \text{mm}^3$ |
| Prod of Moment of Inertia | $I'_{prod} = 17498.6\ \text{in}^6$ | $I'_{prod} = 4.70 \cdot 10^{12}\ \text{mm}^6$ |

## Weld Force from Direct Loads

| | | |
|---|---|---|
| X-Axis Direction | $\sigma_{fx} = 0.00\ \text{Kpi}$ | $\sigma_{fx} = 0.00\ \text{kNpmm}$ |
| Y-Axis Direction | $\sigma_{fy} = 1.10\ \text{Kpi}$ | $\sigma_{fy} = 0.19\ \text{kNpmm}$ |
| Z-Axis Direction | $\sigma_{fz} = 0.00\ \text{Kpi}$ | $\sigma_{fz} = 0.00\ \text{kNpmm}$ |

**Load at Weld Group Centroid:**

| | | |
|---|---|---|
| Moment (X-Axis) | $M'_{fx} = 30\ K\_ft$ | $M'_{fx} = 40.6745\ kN\_m$ |
| Moment (Y-Axis) | $M'_{fy} = 0.00\ K\_ft$ | $M'_{fy} = 0.00\ kN\_m$ |
| Torsion (Z-Axis) | $T'_{fz} = -2.98 \cdot 10^{-14}\ K\_ft$ | $T'_{fz} = -4.03 \cdot 10^{-14}\ kN\_m$ |
| Max Weld Force at Start of Segment in Pattern | $\sigma'_x = 8.237\ Kpi$ | $\sigma'_x = 1.44\ kNpmm$ |
| Min Weld Force at Start of Segment in Pattern | $op'_1 = 6.891\ Kpi$ | $op'_1 = 1\ kNpmm$ |
| Max Weld Force at End of Segment in Pattern | $\sigma'_y = 8.237\ Kpi$ | $\sigma'_y = 1.44\ kNpmm$ |
| Min Weld Force at End of Segment in Pattern | $op'_2 = 6.891\ Kpi$ | $op'_2 = 1.21\ kNpmm$ |
| Max Weld Force at Mid Point of Segment in Pattern | $\sigma'_z = 8.237\ Kpi$ | $\sigma'_z = 1.44\ kNpmm$ |
| Min Weld Force at Mid Point of Segment in Pattern | $op'_3 = 1.095\ Kpi$ | $op'_3 = 0.19\ kNpmm$ |
| Maximum Weld Force in Pattern | $op_{max} = 8.237\ Kpi$ | $op_{max} = 1.44\ kNpmm$ |
| Minimum Weld Force in Pattern | $op'_{min} = 1.095\ Kpi$ | $op'_{min} = 0.19\ kNpmm$ |
| Weld Resistance: | $v_r = 8.748\ Kpi$ | $v_r = 1.53\ kNpmm$ |

$Check\left(v_r \geq 0.95 \cdot op_{max}\right) = "...OK"$

$Check\left(v_r \geq op_{max}\right) = "...OK"$

$Check\left(v_r \geq \left|op'_{min}\right|\right) = "...OK"$