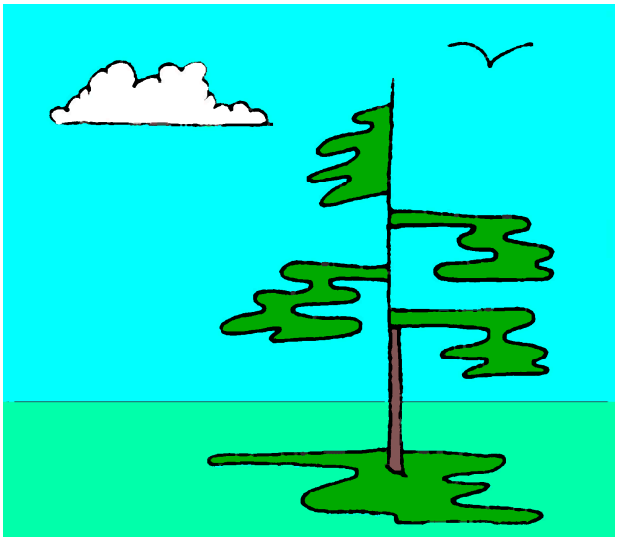
# NorthWoods Software



**Program Name:** Comp-W_C_1W

**Project Number:** -

**Project Description:** -

**Project Designer:** Dik

**Last Revised (yy-mm-dd):** 23.09.06

**Reference:** NBCC, CSA S16

**Disclaimer:**
The User is responsible to verify data and calculations using an alternative method

**Menu:**

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

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## Input Data

### Material Property Factors:

$\varphi_s := 0.90$

$\varphi_w := 0.67$

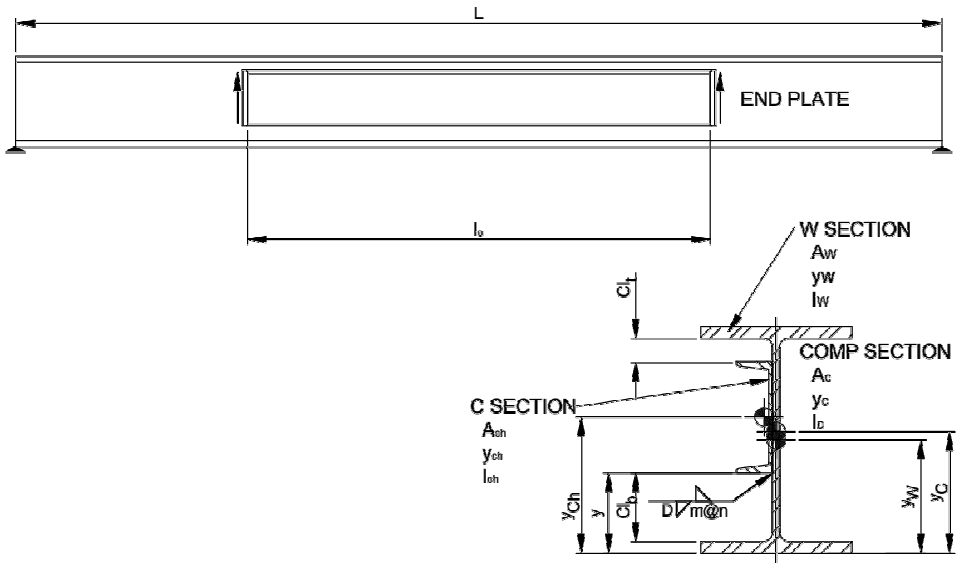
### Load Factors:

$\alpha_L := 1.50$

$\alpha_D := 1.25$

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

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




### Steel Properties:

**W Section:** $st_{NDX} := 1$

| | NDX | des | fy | Fu |
|---|---|---|---|---|
| $st :=$ | 1 | "G40.21-350W" | 50 Ksi | 65 Ksi |
| | 2 | "G40.21-300W" | 44 Ksi | 65 Ksi |
| | 3 | "A36" | 36 Ksi | 58 Ksi |

$desM_{st1} := st_{st_{NDX},2}$ $f_{y1} := st_{st_{NDX},3}$ $F_{u1} := st_{st_{NDX},4}$

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

**C Section:** $st_{NDX} := 1$ $desM_{st2} := st_{st_{NDX},2}$ $f_{y2} := st_{st_{NDX},3}$ $F_{u2} := st_{st_{NDX},4}$

### Beam Span:

$L := 12.25\ ft$ $L = 12.25\ ft$ $L = 3.73\ m$ Span Length

### Factored Design Moment:

$M_f := 250\ K\_ft$ $M_f = 250.00\ K\_ft$ $M_f = 338.95\ kN\_m$ Factored Design Moment

**Welding:**

**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:** $ws_{NDX} := 12$

$ws :=$

| 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 |

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

$desI_w = "E70xx"$

$desM_w = "E49xx"$

$X_u = 70\ ksi$ $X_u = 483\ MPa$

| | | | |
|---|---|---|---|
| $m := 12\ in$ | $m = 12.00\ in$ | $m = 304.8\ mm$ | Weld Length |
| $n := 12\ in$ | $n = 12.00\ in$ | $n = 304.8\ mm$ | Weld Spacing |
| $y := 1.4\ in$ | $y = 1.40\ in$ | $y = 35.6\ mm$ | Channel Location from Bottom |
| $Cl_{min} := 3\ in$ | $Cl_{min} = 3.00\ in$ | $Cl_{min} = 76.2\ mm$ | Minimum Clearance for Weld |

**Section Properties:**

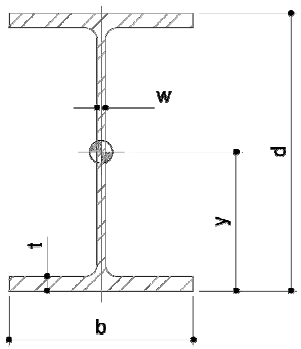
**W Section:** $be_{NDX} := 2$ **Section Properties (from CISC Handbook):**

$be :=$

| NDX | desI | desM | d | b | t | w | k | k1 |
|---|---|---|---|---|---|---|---|---|
| 1 | "W18x46" | "" | 18.1 in | 6.06 in | 0.605 in | 0.36 in | 1.01 in | 0.8125 in |
| 2 | "W16x26" | "" | 15.7 in | 5.50 in | 0.345 in | 0.25 in | 0.747 in | 0.75 in |
| 3 | "W14x26" | "" | 13.9 in | 5.03 in | 0.42 in | 0.255 in | 0.82 in | 0.75 in |
| 4 | "W12x14" | "" | 11.9 in | 3.97 in | 0.225 in | 0.200 in | 0.525 in | 0.5625 in |

$desI_W := be_{be_{NDX},2}$ $desM_W := be_{be_{NDX},3}$ $d_W := be_{be_{NDX},4}$

$b_W := be_{be_{NDX},5}$ $t_W := be_{be_{NDX},6}$ $w_W := be_{be_{NDX},7}$ $k_W := be_{be_{NDX},8}$ $k_{1W} := be_{be_{NDX},9}$




| | | |
|---|---|---|
| $desI_W = "W16x26"$ | $desM_W = ""$ | Designation |
| $d_W = 15.700\ in$ | $d_W = 398.8\ mm$ | Depth |
| $b_W = 5.5\ in$ | $b_W = 139.7\ mm$ | Flange Width |
| $t_W = 0.345\ in$ | $t_W = 8.8\ mm$ | Flange Thickness |
| $w_W = 0.25\ in$ | $w_W = 6.4\ mm$ | Web Thickness |
| $k_W = 0.75\ in$ | $k_W = 19\ mm$ | k Distance |
| $k_{1W} = 0.75\ in$ | $k_{1W} = 19\ mm$ | k1 Distance |

$y_W := \frac{d_W}{2}$ $y_W = 7.85\ in$ $y_W = 199.4\ mm$ Depth to Outer Fibre

$A_W := 2 \cdot b_W \cdot t_W + \left(d_W - 2 \cdot t_W\right) \cdot w_W$

$A_W = 7.55\ in^2$ $A_W = 4869\ mm^2$ Area

$Ix_W := \frac{1}{12} \cdot \left(b_W \cdot {d_W}^3 - \left(b_W - w_W\right) \cdot \left(d_W - 2 \cdot t_W\right)^3\right)$

$Ix_W = 294.18\ in^4$ $Ix_W = 1.22 \cdot 10^8\ mm^4$ Moment of Inertia (X-Axis)

$Sx_W := \frac{Ix_W}{y_W}$ $Sx_W = 37.48\ in^3$ $Sx_W = 6.14 \cdot 10^5\ mm^3$ Section Modulus (X-Axis)

$Zx_W := \frac{1}{4} \cdot \left(b_W \cdot {d_W}^2 - \left(b_W - w_W\right) \cdot \left(d_W - 2 \cdot t_W\right)^2\right)$

$Zx_W = 43.22\ in^3$ $Zx_W = 7.08 \cdot 10^5\ mm^3$ Plastic Section (X-Axis)

**Property Override:**

$A'_W := 7.68\ in^2$

if $A'_W = 0\ in$
  $A_W := A_W$
else
  $A_W := A'_W$

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$A_W = 7.68\ in^2$ $A_W = 4955\ mm^2$ Design Area

$Sx'_W := 38.4\ in^3$

if $Sx'_W = 0\ in^3$
  $Sx_W := Sx_W$
else
  $Sx_W := Sx'_W$

$Sx_W = 38.40\ in^3$ $Sx_W = 6 \cdot 10^5\ mm^3$ Design Section Modulus

$Ix'_W := 301\ in^4$

if $Ix'_W = 0\ in^4$
  $Ix_W := Ix_W$
else
  $Ix_W := Ix'_W$

$Ix_W = 301.00\ in^4$ $Ix_W = 1 \cdot 10^8\ mm^4$ Design Moment of Inertia

**Class of Section**

$bt_1 := \frac{145}{\sqrt{\frac{f_{y1}}{MPa}}}$ $bt_1 = 7.8095$ b/t Ratio Class 1

$bt_2 := \frac{170}{\sqrt{\frac{f_{y1}}{MPa}}}$ $bt_2 = 9.156$ b/t Ratio Class 2

$bt_3 := \frac{200}{\sqrt{\frac{f_{y1}}{MPa}}}$ $bt_3 = 10.7717$ b/t Ratio Class 3

$dw_1 := \frac{1600}{\sqrt{\frac{f_{y1}}{MPa}}}$ $dw_1 = 86.1738$ d/w Ratio Class 1

$dw_2 := \frac{1700}{\sqrt{\frac{f_{y1}}{MPa}}}$ $dw_2 = 91.5597$ d/w Ratio Class 2

$dw_3 := \frac{1900}{\sqrt{\frac{f_{y1}}{MPa}}}$ $dw_3 = 102.3314$ d/w Ratio Class 3

```
if (bw/(2·tw) ≤ bt1) ∧ (dw/ww ≤ dw1)
  Classw := 1
else
  if (((bw/(2·tw) ≤ bt2) ∧ (dw/ww ≤ dw2)))
    Classw := 2
  else
    if (bw/(2·tw) ≤ bt3) ∧ (dw/ww ≤ dw3)
      Classw := 3
    else
      Classw := 4
```

$Class_W = 2$

**Moment Resistance:**

```
if (Classw = 1) ∨ (Classw = 2)
  Mrw := φs · fy1 · Zxw
else
  Mrw := φs · fy1 · Sxw
```

$M_{rW} = 162.1\ K\_ft$ $M_{rW} = 219.7\ kN\_m$ Moment Resistance

**C Section:** $ch_{NDX} := 1$ **Section Properties (from CISC Handbook):**

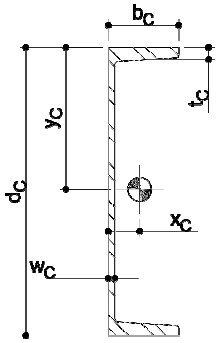
$ch :=$

| NDX | desI | desM | d | b | t | w |
|---|---|---|---|---|---|---|
| 1 | "C12x25" | "" | 12 in | 3.05 in | 0.501 in | 0.387 in |
| 2 | "C8x13.7" | "" | 8 in | 2.34 in | 0.39 in | 0.303 in |
| 3 | "C6x10.5" | "" | 6 in | 2.03 in | 0.343 in | 0.314 in |

$desI_{Ch} := ch_{ch_{NDX}, 2}$ $desM_{Ch} := ch_{ch_{NDX}, 3}$

$d_{Ch} := ch_{ch_{NDX}, 4}$ $b_{Ch} := ch_{ch_{NDX}, 5}$

$t_{Ch} := ch_{ch_{NDX}, 6}$ $w_{Ch} := ch_{ch_{NDX}, 7}$




$desI_{Ch} = "C12x25"$ Imperial Designation

$desM_{Ch} = ""$ Metric Designation

| | | |
|---|---|---|
| $b_{Ch} = 3.05\ in$ | $b_{Ch} = 77.5\ mm$ | Width |
| $d_{Ch} = 12.00\ in$ | $d_{Ch} = 304.8\ mm$ | Depth |
| $t_{Ch} = 0.50\ in$ | $t_{Ch} = 12.7\ mm$ | Flange Thickness |
| $w_{Ch} = 0.39\ in$ | $w_{Ch} = 9.8\ mm$ | Web Thickness |
| $y_{Ch} := \frac{d_{Ch}}{2} + y$ $y_{Ch} = 7.40\ in$ | $y_{Ch} = 188\ mm$ | Centroid of Channel from Bot |

**Weld Clearance:**

| | | | |
|---|---|---|---|
| $Cl_t := d_W - y - d_{Ch} - t_W$ | $Cl_t = 1.96\ in$ | $Cl_t = 49.7\ mm$ | Weld Clearance Top |
| $Cl_b := y - t_W$ | $Cl_b = 1.06\ in$ | $Cl_b = 26.8\ mm$ | Weld Clearance Bottom |

### Channel Properties

$A_{Ch} := d_{Ch} \cdot w_{Ch} + 2 \cdot \left( b_{Ch} - w_{Ch} \right) \cdot t_{Ch}$

$A_{Ch} = 7.31\ in^2$ $A_{Ch} = 4718\ mm^2$ Area

$Ix_{Ch} := \frac{1}{12} \cdot \left( b_{Ch} \cdot {d_{Ch}}^3 - \left( b_{Ch} - w_{Ch} \right) \cdot \left( d_{Ch} - 2 \cdot t_{Ch} \right)^3 \right)$

$Ix_{Ch} = 143.99\ in^4$ $Ix_{Ch} = 5.99 \cdot 10^7\ mm^4$ Moment of Inertia (X-Axis)

**Property Override:**

$A'_{Ch} := 7.32\ in^2$

```
if A'_Ch = 0 in
  A_Ch := A_Ch
else
  A_Ch := A'_Ch
```

$A_{Ch} = 7.32\ in^2$ $A_{Ch} = 4723\ mm^2$ Design Area

$Ix'_{Ch} := 143.9\ in^4$

c b a

```
if Ix'_Ch = 0 in^4
  Ix_Ch := Ix_Ch
else
  Ix_Ch := Ix'_Ch
```

$Ix_{Ch} = 143.90\ in^4$ $Ix_{Ch} = 6 \cdot 10^7\ mm^4$ Design Moment of Inertia

### Composite Section Centroid

$A_C := A_W + A_{Ch}$

$A_C = 15.000\ in^2$ $A_C = 9677\ mm^2$ Composite Area

$y_{Cb} := \frac{A_W \cdot y_W + A_{Ch} \cdot y_{Ch}}{A_C}$

$y_{Cb} = 7.630\ in$ $y_{Cb} = 193.8\ mm$ Composite Centroid Bottom

$y_{Ct} := d_W - y_{Cb}$

$y_{Ct} = 8.070\ in$ $y_{Ct} = 205.0\ mm$ Composite Centroid Top

$Ix_C := Ix_W + A_W \cdot \left( y_W - y_{Cb} \right)^2 + Ix_{Ch} + A_{Ch} \cdot \left( y_{Ch} - y_{Cb} \right)^2$

$Ix_C = 446\ in^4$ $Ix_C = 1.85 \cdot 10^8\ mm^4$ Composite Moment of Inertia

$Sx_{Ct} := \frac{Ix_C}{y_{Ct}}$

$Sx_{Ct} = 55.2\ in^3$ $Sx_{Ct} = 9.05 \cdot 10^5\ mm^3$ Composite Sx (Top Fibre)

$Sx_{Cb} := \frac{Ix_C}{y_{Cb}}$

$Sx_{Cb} = 58.4\ in^3$ $Sx_{Cb} = 9.57 \cdot 10^5\ mm^3$ Composite Sx (Bottom Fibre)

**Moment Resistance as a Class 3 Section:**

$M_{rC3} := \left( \varphi_s \cdot \min\left( \left[ f_{y1} \cdot Sx_{Ct} \quad f_{y1} \cdot Sx_{Cb} \right] \right) \right)$

$M_{rC3} = 207.10\ K\_ft$ $M_{rC3} = 280.79\ kN\_m$ Moment Resistance (Class 3)

**Check Channel Leg and W Section as a Class 2 Section:**

$Check \left( \left( Class_W \leq 2 \right) \wedge \left( \frac{b_{Ch}}{t_{Ch}} \leq \frac{170}{\sqrt{\frac{f_{y2}}{MPa}}} \right) \right) = \text{"...OK"}$

**Determine Resisting Class 2 Moment:**

$F_{Wtf} := \varphi_s \cdot f_{y1} \cdot b_W \cdot t_W$ $F_{Wtf} = 85.39\ K$ $F_{Wtf} = 379.82\ kN$

$M_{Wtf} := F_{Wtf} \cdot \left( y_{Ct} - \frac{t_W}{2} \right)$ $M_{Wtf} = 56.19\ K\_ft$ $M_{Wtf} = 76.19\ kN\_m$

$F_{Wtw} := \varphi_s \cdot f_{y1} \cdot \left( y_{Ct} - t_W \right) \cdot w_W$

$F_{Wtw} = 86.90\ K$ $F_{Wtw} = 386.56\ kN$

$M_{Wtw} := F_{Wtw} \cdot \left( \frac{y_{Ct} - t_W}{2} \right)$ $M_{Wtw} = 27.97\ K\_ft$ $M_{Wtw} = 37.92\ kN\_m$

$F_{Chtf} := \varphi_s \cdot f_{y2} \cdot b_{Ch} \cdot t_{Ch}$ $F_{Chtf} = 68.76\ K$ $F_{Chtf} = 305.87\ kN$

$M_{Chtf} := F_{Chtf} \cdot \left( y_{Ct} - t_W - Cl_t - \frac{t_{Ch}}{2} \right)$

$M_{Chtf} = 31.63\ K\_ft$ $M_{Chtf} = 42.88\ kN\_m$

$F_{Chtw} := \varphi_s \cdot f_{y2} \cdot \left( y_{Ct} - t_W - Cl_t - t_{Ch} \right) \cdot w_{Ch}$

$F_{Chtw} = 91.75\ K$ $F_{Chtw} = 408.14\ kN$

$M_{Chtw} := F_{Chtw} \cdot \left( \frac{y_{Ct} - t_W - Cl_t - t_{Ch}}{2} \right)$

$M_{Chtw} = 20.14\ K\_ft$ $M_{Chtw} = 27.31\ kN\_m$

$A_{sum1} := b_W \cdot t_W + \left( y_{Ct} - t_W \right) \cdot w_W + b_{Ch} \cdot t_{Ch} + \left( y_{Ct} - t_W - Cl_t - t_{Ch} \right) \cdot w_{Ch}$

$A_{sum1} = 7.40\ in^2$ $A_{sum1} = 4771.38\ mm^2$

$F_{sum1} := F_{Wtf} + F_{Wtw} + F_{Chtf} + F_{Chtw}$

$F_{sum1} = 332.80\ K$ $F_{sum1} = 1480.39\ kN$

$F_{Chbw} := \varphi_s \cdot f_{y2} \cdot \left( y_{Cb} - t_W - Cl_b - t_{Ch} \right) \cdot w_{Ch}$

$F_{Chbw} = 99.78\ K$ $F_{Chbw} = 443.83\ kN$

$M_{Chbw} := F_{Chbw} \cdot \left( \frac{y_{Cb} - t_W - Cl_b - t_{Ch}}{2} \right)$

$M_{Chbw} = 23.82\ K\_ft$ $M_{Chbw} = 32.29\ kN\_m$

$F_{Chbf} := \varphi_s \cdot f_{y2} \cdot \left( b_{Ch} \cdot t_{Ch} \right)$ $F_{Chbf} = 68.76\ K$ $F_{Chbf} = 305.87\ kN$

$M_{Chbf} := F_{Chbf} \cdot \left( y_{Cb} - t_W - Cl_b - \frac{t_{Ch}}{2} \right)$

$M_{Chbf} = 34.27\ K\_ft$ $M_{Chbf} = 46.46\ kN\_m$

$F_{Wbw} := \varphi_s \cdot f_{y1} \cdot \left( y_{Cb} - t_W \right) \cdot w_W$

$F_{Wbw} = 81.96\ K$ $F_{Wbw} = 364.58\ kN$

$M_{Wbw} := F_{Wbw} \cdot \left( \frac{y_{Cb} - t_W}{2} \right)$ $M_{Wbw} = 24.88\ K\_ft$ $M_{Wbw} = 33.73\ kN\_m$

$F_{Wbf} := \varphi_s \cdot f_{y1} \cdot \left( b_W \cdot t_W \right)$ $F_{Wbf} = 85.39\ K$ $F_{Wbf} = 379.82\ kN$

$M_{Wbf} := F_{Wbf} \cdot \left( y_{Cb} - \frac{t_W}{2} \right)$ $M_{Wbf} = 53.07\ K\_ft$ $M_{Wbf} = 71.95\ kN\_m$

$A_{sum2} := \left(y_{Cb} - t_W - Cl_b - t_{Ch}\right) \cdot w_{Ch} + \left(b_{Ch} \cdot t_{Ch}\right) + \left(y_{Cb} - t_W\right) \cdot w_W + \left(b_W \cdot t_W\right)$

$A_{sum2} = 7.46\ in^2$ $A_{sum2} = 4815.59\ mm^2$

$F_{sum2} := -F_{Chbw} - F_{Chbf} - F_{Wbw} - F_{Wbf}$

$F_{sum2} = -335.89\ K$ $F_{sum2} = -1494.10\ kN$

$M_{rC2} := M_{Wtf} + M_{Wtw} + M_{Chtf} + M_{Chtw} + M_{Chbw} + M_{Chbf} + M_{Wbw} + M_{Wbf}$

$M_{rC2} = 271.96\ K\_ft$ $M_{rC2} = 368.73\ kN\_m$ Moment Resistance (Class 2)

**Bauer's Method:**

$Zx_{C2B} := 71.95\ in^3$ $Zx_{C2B} = 71.95\ in^3$ $Zx_{C2B} = 1179049\ mm^3$ Plastic Section Modulus (Bauer)

$M_{rC2B} := \varphi_s \cdot Zx_{C2B} \cdot f_{y1}$ $M_{rC2B} = 269.8\ K\_ft$ $M_{rC2} = 368.7\ kN\_m$ Mom. Resist. (Bauer Class 2)

**Weld Capacity:**

$v_{rw} := \varphi_w \cdot 0.67 \cdot X_u \cdot \frac{1}{\sqrt{2}}$ $v_{rw} = 22.22\ ksi$ $v_{rw} = 153.20\ MPa$ Weld Material Strength:

$v_{rb1} := \varphi_w \cdot 0.67 \cdot F_{u1}$ $v_{rb1} = 29.18\ Ksi$ $v_{rb1} = 201.18\ MPa$ W Section Base Metal Strength

$v_{rb2} := \varphi_w \cdot 0.67 \cdot F_{u2}$ $v_{rb2} = 29.18\ Ksi$ $v_{rb2} = 201.18\ MPa$ T Section Base Metal Strength

$V_{rw} := \min\left(\left[\begin{array}{ccc} v_{rw} & v_{rb1} & v_{rb2} \end{array}\right]\right)$ $V_{rw} = 22.22\ Ksi$ $V_{rw} = 153.2\ MPa$ Minimum Weld Capacity

**Maximum UDL:**

$q_f := \frac{8 \cdot M_{rC2}}{L^2}$ $q_f = 14.5\ Klf$ $q_f = 211.6\ kNpm$ Maximum UDL

$Q_f := q_f \cdot L$ $Q_f = 177.6\ K$ $Q_f = 790.0\ kN$ Max Load based on UDL

$part := 50\ \%$

**Part Override:**

$part' := 0\ \%$

```
if part' = 0 %
  part := part
else
  part := part'
```

$part = 0.5000$

**Maximum Reaction (Shear):**

$V_f := Q_f \cdot part$ $V_f = 88.8\ K$ $V_f = 395.0\ kN$

**Length of Reinforcing:**

$\Delta M := M_{rC2} - M_{rW}$ $\Delta M = 109.90\ K\_ft$ $\Delta M = 149.00\ kN\_m$ Moment Prov by Composite

$l_C := \sqrt{\frac{8 \cdot \Delta M}{q_f}}$ $l_C = 7.7871\ ft$ $l_C = 7.7871\ ft$ Length of Reinforcing

**Shear Stress at W and Ch Junction**

$A' := A_{Ch}$ $A' = 7.32\ in^2$ $A' = 4723\ mm^2$ Area

$y_{bar} := \frac{d_{Ch}}{2} + y$ $y_{bar} = 7.40\ in$ $y_{bar} = 188.0\ mm$ Centroid of Area

$\tau := \frac{V_f}{Ix_C \cdot d_{Ch}} \cdot A' \cdot \left(y_{bar}\right)$ $\tau = 0.90\ Ksi$ $\tau = 6.2\ MPa$ Shear Stress at Ch-W Interface

**Connection Shear per Unit Length**

$\tau' := \tau \cdot n \cdot d_{Ch}$ $\tau' = 129.5\ K$ $\tau' = 576.2\ kN$

**Weld Provided**

$\tau_r := 2 \cdot V_{rw} \cdot D \cdot m$ $\quad \tau_r = 200.0\ K$ $\quad \tau_r = 889.5\ kN$

**End Connection Force:** | c | b | a

$\sigma_1 := \frac{-M_{rC2}}{Ix_C} \cdot \left(y + d_{Ch} - y_{Cb}\right)$ $\quad \sigma_1 = -42.3\ Ksi$ $\quad \sigma_1 = -291.3\ MPa$ At the Bottom Fibre of Channel

$\sigma_2 := \frac{-M_{rC2}}{Ix_C} \cdot \left(y + d_{Ch} - t_{Ch} - y_{Cb}\right)$ $\quad \sigma_2 = -38.6\ Ksi$ $\quad \sigma_2 = -266.0\ MPa$ At the Bottom Web of Channel

$\sigma_3 := \frac{-M_{rC2}}{Ix_C} \cdot \left(d_W - y_{Ct} - y_{Cb}\right)$ $\quad \sigma_3 = 2.0 \cdot 10^{-13}\ Ksi$ $\quad \sigma_3 = 1.4 \cdot 10^{-12}\ MPa$ At the Centroid of Channel

$\sigma_4 := \frac{-M_{rC2}}{Ix_C} \cdot \left(y + t_{Ch} - y_{Cb}\right)$ $\quad \sigma_4 = 42.0\ Ksi$ $\quad \sigma_4 = 289.3\ MPa$ At the Top Web of Channel

$\sigma_5 := \frac{-M_{rC2}}{Ix_C} \cdot \left(y - y_{Cb}\right)$ $\quad \sigma_5 = 45.6\ Ksi$ $\quad \sigma_5 = 314.6\ MPa$ At the Top Fibre of Channel

$F_1 := \frac{\sigma_1 + \sigma_2}{2} \cdot b_{Ch} \cdot t_{Ch}$ $\quad F_1 = -61.7582\ K$ $\quad F_1 = -274.7\ kN$

$M_1 := F_1 \cdot \left(d_{Ch} - \frac{t_{Ch}}{2}\right)$ $\quad M_1 = -60.4690\ K\_ft$ $\quad M_1 = -81.98\ kN\_m$

$F_2 := \frac{\sigma_2 + \sigma_3}{2} \cdot \left(y_{Ct} - t_W - Cl_t - t_{Ch}\right) \cdot w_{Ch}$

$F_2 = -39.3333\ K$ $\quad F_2 = -175.0\ kN$

$M_2 := F_2 \cdot \left(\left(y_{Cb} - t_W - Cl_b\right) + 2 \cdot \frac{\left(y_{Ct} - t_W - Cl_t - t_{Ch}\right)}{3}\right)$

$M_2 = -31.9347\ K\_ft$ $\quad M_2 = -43.30\ kN\_m$

$F_3 := \frac{\sigma_3 + \sigma_4}{2} \cdot \left(y_{Cb} - t_W - Cl_b - t_{Ch}\right) \cdot w_{Ch}$

$F_3 = 46.5145\ K$ $\quad F_3 = 206.9\ kN$

$M_3 := F_3 \cdot \left(t_{Ch} + \frac{\left(y_{Cb} - t_W - Cl_b - t_{Ch}\right)}{3}\right)$

$M_3 = 9.3448\ K\_ft$ $\quad M_3 = 12.67\ kN\_m$

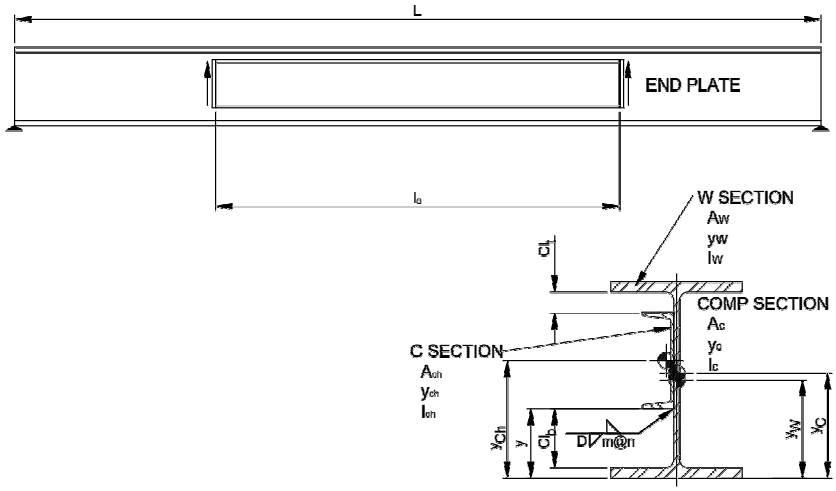
$F_4 := \frac{\sigma_4 + \sigma_5}{2} \cdot b_{Ch} \cdot t_{Ch}$ $\quad F_4 = 66.9145\ K$ $\quad F_4 = 297.7\ kN$

$M_4 := F_4 \cdot \frac{t_{Ch}}{2}$ $\quad M_4 = 1.3968\ K\_ft$ $\quad M_4 = 1.89\ kN\_m$

$M_{fCh} := M_1 + M_2 + M_3 + M_4$ $\quad M_{fCh} = -81.6621\ K\_ft$ $\quad M_{fCh} = -110.72\ kN\_m$ Unbalanced Moment in Channel

$F_{fE} := \frac{M_{fCh} \cdot 2}{l_C}$ $\quad F_{fE} = -20.9737\ K$ $\quad F_{fE} = -93.3\ kN$ End Plate Connection Force

**Summary:**




Material Property Factor

(Welds) $\varphi_w = 0.67$

(Steel) $\varphi_s = 0.9$

Dead Load Factor $\alpha_D = 1.25$

Live Load Factor $\alpha_L = 1.5$

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

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

**Steel Properties**

**W Section**

Designation $desM_{st1} = "G40.21\text{-}350W"$

Yield Strength $f_{y1} = 50\ Ksi$ $f_{y1} = 345\ MPa$

Ultimate Strength $F_{u1} = 65\ Ksi$ $F_{u1} = 448\ MPa$

**C Section**

Designation $desM_{st2} = "G40.21\text{-}350W"$

Yield Strength $f_{y2} = 50\ Ksi$ $f_{y2} = 345\ MPa$

Ultimate Strength $F_{u2} = 65\ Ksi$ $F_{u2} = 448\ MPa$

Young's Modulus $E_s = 29000\ Ksi$ $E_s = 1.9995 \cdot 10^{5}\ MPa$

Shear Modulus $G_s = 11153.8462\ Ksi$ $G_s = 76903\ MPa$

Density $\gamma_s = 489\ pcf$ $\gamma_s = 76.8\ kNpcm$

**Beam Span Length** $L = 12.25\ ft$ $L = 3.73\ m$

**Factored Design Moment (Arbitrary)** $M_f = 250.00\ K\_ft$ $M_f = 338.95\ kN\_m$

**Welds**

Designation (Welding Electrode) $desI_w = "E70xx"$ $desM_w = "E49xx"$

Ultimate Strength (Welding Electrode) $X_u = 70\ Ksi$ $X_u = 483\ MPa$

Designation (Fillet Weld Size) $desI_D = "3/8"$ $desM_D = ""$

Fillet Weld Size $D = 0.375\ in$ $D = 9.525\ mm$

Weld Length $m = 12\ in$ $m = 304.8\ mm$

Weld Spacing $n = 12\ in$ $n = 304.8\ mm$

$Check\left(\left(m \geq 1.5\ in\right) \wedge \left(m \geq 4 \cdot D\right)\right) = "...OK"$

$Check\left(\left(n - m\right) \leq 12\ in\right) = "...OK"$ **≤ 12" for Compression Attachment**

$Check\left(\left(n - m\right) \leq 18\ in\right) = "...OK"$ **≤ 18" for Tension Attachment**

**W Section**

Designation $desI_W = "W16x26"$ $desM_W = ""$

Depth $d_W = 15.70\ in$ $d_W = 398.8\ mm$

Flange Width $b_W = 5.5\ in$ $b_W = 139.7\ mm$

Flange Thickness $t_W = 0.345\ in$ $t_W = 8.8\ mm$

Web Thickness $w_W = 0.25\ in$ $w_W = 6.4\ mm$

| | | |
|---|---|---|
| k Distance | $k_W = 0.75\ in$ | $k_W = 19\ mm$ |
| k1 Distance | $k_{1W} = 0.75\ in$ | $k_{1W} = 19\ mm$ |
| Area | $A_W = 7.68\ in^2$ | $A_W = 4954.8\ mm^2$ |
| Moment of Inertia (x-axis) | $Ix_W = 301.00\ in^4$ | $Ix_W = 1.25 \cdot 10^8\ mm^4$ |
| Centroid Distance | $y_W = 7.85\ in$ | $y_W = 199.4\ mm$ |
| Class of Section | $Class_W = 2$ | |
| Moment Resistance | $M_{rW} = 162.1\ K\_ft$ | $M_{rW} = 219.7\ kN\_m$ |

**C Section**

| | | |
|---|---|---|
| Designation | $desI_{Ch} = "C12x25"$ | $desM_{Ch} = ""$ |
| Depth | $d_{Ch} = 12.00\ in$ | $d_{Ch} = 304.8\ mm$ |
| Web Width | $w_{Ch} = 0.39\ in$ | $w_{Ch} = 9.8\ mm$ |
| Area | $A_{Ch} = 7.32\ in^2$ | $A_{Ch} = 4722.6\ mm^2$ |
| Moment of Inertia (x-axis) | $Ix_{Ch} = 143.90\ in^4$ | $Ix_{Ch} = 5.99 \cdot 10^7\ mm^4$ |
| Centroid Distance | $y_{Ch} = 7.40\ in$ | $y_{Ch} = 188\ mm$ |
| Channel Location from Bottom | $y = 1.40\ in$ | $y = 35.6\ mm$ |
| Minimum Clearance for Weld | $Cl_{min} = 3.00\ in$ | $Cl_{min} = 76.2\ mm$ |
| Weld Clearance Top | $Cl_t = 1.96\ in$ | $Cl_t = 49.7\ mm$ |

$Check\left(\left(Cl_t\right) \geq Cl_{min}\right) = "...NG"$

| | | |
|---|---|---|
| Weld Clearance Bottom | $Cl_b = 1.06\ in$ | $Cl_b = 26.8\ mm$ |

$Check\left(Cl_b \geq Cl_{min}\right) = "...NG"$

**Check Channel Leg and W Section as a Class 2 Section:**

$$Check\left(\left(Class_W \leq 2\right) \wedge \left(\frac{b_{Ch}}{t_{Ch}} \leq \frac{170}{\sqrt{\frac{f_{y2}}{MPa}}}\right)\right) = "...OK"$$

**Composite Section**

| | | |
|---|---|---|
| Area | $A_C = 15\ in^2$ | $A_C = 9677\ mm^2$ |
| Moment of Inertia (x-axis) | $Ix_C = 446\ in^4$ | $Ix_C = 1.85 \cdot 10^8\ mm^4$ |
| Centroid Distance (top) | $y_{Ct} = 8.1\ in$ | $y_{Ct} = 205\ mm$ |
| Centroid Distance (bot) | $y_{Cb} = 7.6\ in$ | $y_{Cb} = 194\ mm$ |
| Section Modulus (design x-axis) | $Sx_{Ct} = 55.2\ in^3$ | $Sx_{Ct} = 9.05 \cdot 10^5\ mm^3$ |
| Section Modulus (design x-axis) | $Sx_{Cb} = 58.4\ in^3$ | $Sx_{Cb} = 9.57 \cdot 10^5\ mm^3$ |
| Moment Resistance (Class 3) | $M_{rC3} = 207.1\ K\_ft$ | $M_{rC3} = 280.8\ kN\_m$ |

$Check\left(M_{rC3} \geq M_f\right) = "...NG"$

$$Check\left(\frac{M_{rC3}}{\varphi_s} \geq M_f\right) = "...NG"$$

**Allow for Overload**

| | | |
|---|---|---|
| Moment Resistance (Class 2) | $M_{rC2} = 272.0\ K\_ft$ | $M_{rC2} = 368.7\ kN\_m$ |

$Check\left(M_{rC2} \geq M_f\right) = "...OK"$ $Check\left(\frac{M_{rC2}}{\varphi_s} \geq M_f\right) = "...OK"$ **Allow for Overload**

**Moment Resistance (Bauer Class 2)**

| | | |
|---|---|---|
| Plastic Section Modulus (Bauer) | $Zx_{C2B} = 71.95\ in^3$ | $Zx_{C2B} = 1179049\ mm^3$ |
| Mom. Resist. (Bauer Class 2) | $M_{rC2B} = 269.8\ K\_ft$ | $M_{rC2} = 368.7\ kN\_m$ |
| Maximum UDL | $q_f = 14.5\ Klf$ | $q_f = 211.6\ kNpm$ |
| Maximum Reaction (Shear) | $V_f = 88.8\ K$ | $V_f = 395.0\ kN$ |
| Length of Reinforcing | $l_C = 7.7871\ ft$ | $l_C = 2.3735\ m$ |

$Check\left(l_C \leq L\right) = "...OK"$

| | | |
|---|---|---|
| Shear Stress at W and C Junction based on Max Shear | $\tau = 0.90\ Ksi$ | $\tau = 6.2\ MPa$ |
| Minimum Weld Capacity | $V_{rw} = 22.22\ Ksi$ | $V_{rw} = 153.2\ MPa$ |
| Connection Shear per Unit Length | $\tau' = 129.5\ K$ | $\tau' = 576.2\ kN$ |
| Minimum Weld Capacity | $V_{rw} = 22.22\ Ksi$ | $V_{rw} = 153.20\ MPa$ |
| Weld Resistance per Unit Length | $\tau_r = 200\ K$ | $\tau_r = 889.5\ kN$ |

$Check\left(\tau_r \geq \tau'\right) = "...OK"$ $Check\left(\frac{\tau_r}{\varphi_s} \geq \tau'\right) = "...OK"$ **Allow for Overload**

**End Connection Force:**

| | | |
|---|---|---|
| At the Bottom Fibre of Channel | $\sigma_1 = -42.3\ Ksi$ | $\sigma_1 = -291.3\ MPa$ |
| At the Bottom Web of Channel | $\sigma_2 = -38.6\ Ksi$ | $\sigma_2 = -266.0\ MPa$ |
| At the Centroid of Channel | $\sigma_3 = 2.0 \cdot 10^{-13}\ Ksi$ | $\sigma_3 = 1.4 \cdot 10^{-12}\ MPa$ |
| At the Top Web of Channel | $\sigma_4 = 42.0\ Ksi$ | $\sigma_4 = 289.3\ MPa$ |
| At the Top Fibre of Channel | $\sigma_5 = 45.6\ Ksi$ | $\sigma_5 = 314.6\ MPa$ |
| Unbalanced Moment in Channel | $M_{fCh} = -81.7\ K\_ft$ | $M_{fCh} = -110.7\ kN\_m$ |

**Effect of Composite Weld not Included**

| | | |
|---|---|---|
| End Connection Force | $F_{fE} = -21.0\ K$ | $F_{fE} = -93.3\ kN$ |