# NorthWoods Software

**Program Name:** Comp-W_2_BAR_Cut

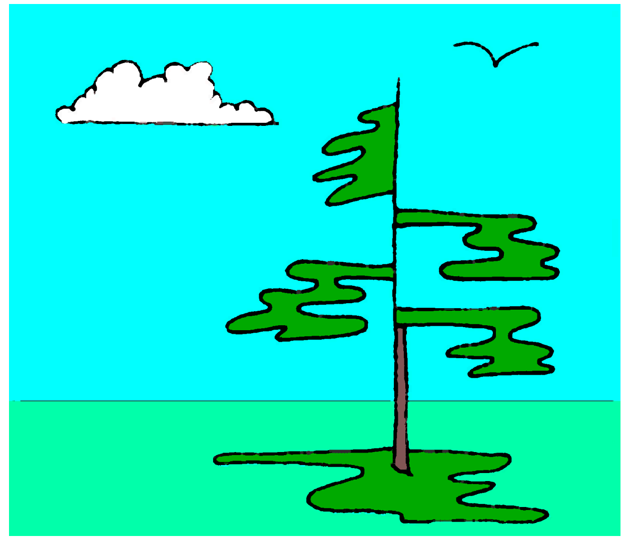
**Project Number:** -

**Project Description:** -

**Project Designer:** Dik

**Last Revised (yy-mm-dd):** 23.09.03

**Reference:** NBCC, CSA S16



**Disclaimer:**
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 | | |

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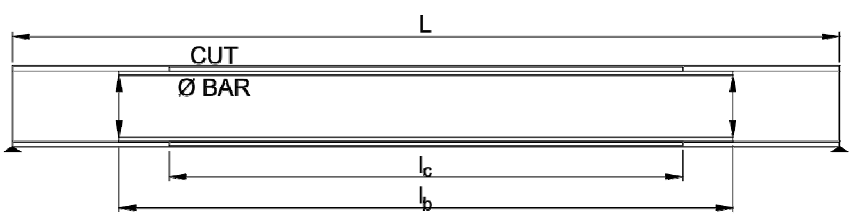
**Input Data**

**Material Property Factors:**

$\varphi_s := 0.90$

$\varphi_w := 0.67$



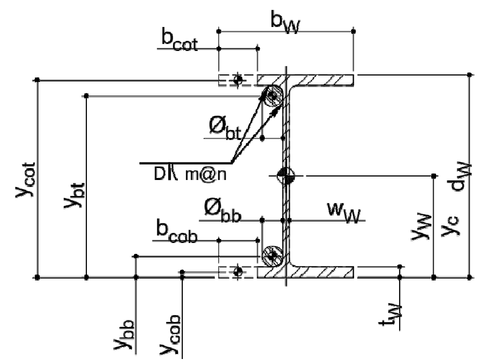

**Load Factors:**

$\alpha_L := 1.50$

$\alpha_D := 1.25$

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

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




**Steel Properties:**

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

$st :=$

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

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

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

**BAR Material:** $st_{NDX} := 1$ $\quad desM_{st2} := st_{st_{NDX},2}$ $\quad f_{y2} := st_{st_{NDX},3}$ $\quad F_{u2} := st_{st_{NDX},4}$

**Beam Span:**

$L := 20\ ft$ $L = 20.00\ ft$ $L = 6.10\ m$ Span Length

**Factored Design Moment:**

$M_f := 300\ K\_ft$ $M_f = 300.00\ K\_ft$ $M_f = 406.75\ kN\_m$ Factored Design Moment

**Beam Cut Out:**

$b_{cot} := 0.875\ in$ $b_{cot} = 0.8750\ in$ $b_{cot} = 22.2\ mm$ Flange Removed at Top

$b_{cob} := 0.875\ in$ $b_{cob} = 0.8750\ in$ $b_{cob} = 22.2\ mm$ Flange Removed at Bottom

**Reinforcing BAR ϕ:**

$\phi_{bt} := 0.75\ in$ $\phi_{bt} = 0.7500\ in$ $\phi_{bt} = 19\ mm$ BAR Reinforcing at Top

$\phi_{bb} := 0.75\ in$ $\phi_{bb} = 0.7500\ in$ $\phi_{bb} = 19\ mm$ BAR Reinforcing at Bottom

**Welding:**

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

$$we := \begin{array}{cccc} \text{NDX} & \text{DesI} & \text{DesM} & \text{UTS} \\ \end{array}$$

$$we := \begin{bmatrix} 1 & \text{"E60xx"} & \text{"E43xx"} & 60\ ksi \\ 2 & \text{"E70xx"} & \text{"E49xx"} & 70\ ksi \\ 3 & \text{"E80xx"} & \text{"E55xx-x"} & 80\ ksi \\ 4 & \text{"E90xx"} & \text{"E62xx-x"} & 90\ ksi \end{bmatrix}$$

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

**Weld Sizes:** $ws_{NDX} := 7$

$$\begin{array}{cccc} \text{NDX} & \text{desI} & \text{desM} & \text{D} \end{array}$$

$$ws := \begin{bmatrix} 1 & \text{""} & \text{"3mm"} & 0.11811\ in \\ 2 & \text{"1/8"} & \text{""} & 0.125\ in \\ 3 & \text{""} & \text{"4mm"} & 0.15748\ in \\ 4 & \text{"3/16"} & \text{""} & 0.1875\ in \\ 5 & \text{""} & \text{"5mm"} & 0.19685\ in \\ 6 & \text{""} & \text{"6mm"} & 0.23622\ in \\ 7 & \text{"1/4"} & \text{""} & 0.25\ in \\ 8 & \text{""} & \text{"7mm"} & 0.275591\ in \\ 9 & \text{"5/16"} & \text{""} & 0.3125\ in \\ 10 & \text{""} & \text{"8mm"} & 0.314961\ in \\ 11 & \text{""} & \text{"9mm"} & 0.354331\ in \\ 12 & \text{"3/8"} & \text{""} & 0.375\ in \\ 13 & \text{""} & \text{"10mm"} & 0.3937\ in \\ 14 & \text{""} & \text{"11mm"} & 0.4331\ in \\ 15 & \text{"7/16"} & \text{""} & 0.4375\ in \\ 16 & \text{""} & \text{"12mm"} & 0.4724\ in \\ 17 & \text{"1/2"} & \text{""} & 0.50\ in \end{bmatrix}$$

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

$m := 8\ in$ $m = 8.0\ in$ $m = 203.2\ mm$ Weld Length

$n := 12\ in$ $n = 12.0\ in$ $n = 304.8\ mm$ Weld Spacing

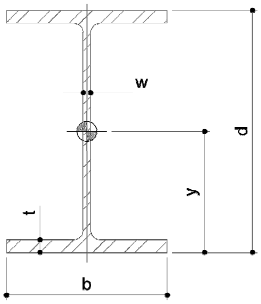
**Section Properties:**

**W Section:** $be_{NDX} := 1$ **Section Properties (from CISC Handbook):**

$$\begin{array}{ccccccc} \text{NDX} & \text{desI} & \text{desM} & \text{d} & \text{b} & \text{t} & \text{w} \end{array}$$

$$be := \begin{bmatrix} 1 & \text{"W14x22"} & \text{"W360x33"} & 13.70\ in & 5.00\ in & 0.335\ in & 0.23\ in \end{bmatrix}$$

$desI_W := be_{be_{NDX}\,2}$ $desM_W := be_{be_{NDX}\,3}$ $d_W := be_{be_{NDX}\,4}$ $b_W := be_{be_{NDX}\,5}$ $t_W := be_{be_{NDX}\,6}$ $w_W := be_{be_{NDX}\,7}$




| | | | |
|---|---|---|---|
| | $desI_W = \text{"W14x22"}$ | $desM_W = \text{"W360x33"}$ | Designation |
| | $d_W = 13.70\ \text{in}$ | $d_W = 348.0\ \text{mm}$ | Depth |
| | $b_W = 5\ \text{in}$ | $b_W = 127\ \text{mm}$ | Flange Width |
| | $t_W = 0.34\ \text{in}$ | $t_W = 8.5\ \text{mm}$ | Flange Thickness |
| | $w_W = 0.23\ \text{in}$ | $w_W = 5.8\ \text{mm}$ | Web Thickness |
| | $b_W = 5.000\ \text{in}$ | $b_W = 127\ \text{mm}$ | Flange Width |
| $y_W := \dfrac{d_W}{2}$ | $y_W = 6.85\ \text{in}$ | $y_W = 174.0\ \text{mm}$ | Depth to Outer Fibre |

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

$A_W = 6.35\ \text{in}^2$ | $A_W = 4095\ \text{mm}^2$ | Area

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

$Ix_W = 192.03\ \text{in}^4$ | $Ix_W = 7.99 \cdot 10^7\ \text{mm}^4$ | Moment of Inertia (X-Axis)

$Sx_W := \dfrac{Ix_W}{y_W}$ | $Sx_W = 28.03\ \text{in}^3$ | $Sx_W = 4.59 \cdot 10^5\ \text{mm}^3$ | Section Modulus (X-Axis)

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

$Zx_W = 32.15\ \text{in}^3$ | $Zx_W = 5.27 \cdot 10^5\ \text{mm}^3$ | Plastic Section (X-Axis)

**Property Override:**

$A'_W := 0\ \text{in}^2$

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```
if  A'_W = 0 in^2
    A_W := A_W
else
    A_W := A'_W
```

$A_W = 6.35\ \text{in}^2$ | $A_W = 4095\ \text{mm}^2$ | Design Area

$Sx'_W := 0\ \text{in}^3$

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

$Sx_W = 28.03\ \text{in}^3$ | $Sx_W = 5 \cdot 10^5\ \text{mm}^3$ | Design Section Modulus

$Ix'_W := 0\ \text{in}^4$

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

$Ix_W = 192.03\ \text{in}^4$ | $Ix_W = 8 \cdot 10^7\ \text{mm}^4$ | Design Moment of Inertia

**Class of Section**

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

$bt_2 := \dfrac{170}{\sqrt{\dfrac{f_{y1}}{\text{MPa}}}}$ | $bt_2 = 9.156$ | 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 ((b_W/(2·t_W)) ≤ bt_1) ∧ (d_W/w_W ≤ dw_1)
  Class_W := 1
else
  if (((b_W/(2·t_W)) ≤ bt_2) ∧ (d_W/w_W ≤ dw_2))
    Class_W := 2
  else
    if (b_W/(2·t_W) ≤ bt_3) ∧ (d_W/w_W ≤ dw_3)
      Class_W := 3
    else
      Class_W := 4
```

$Class_W = 1$ Section Class

**Moment Resistance:**

```
if (Class_W = 1) ∨ (Class_W = 2)
  M_rW := φ_s · f_y1 · Zx_W
else
  M_rW := φ_s · f_y1 · Sx_W
```

$M_{rW} = 120.6\ K\_ft$ $M_{rW} = 163.5\ kN\_m$ Moment Resistance

**Section Properties of Flange Cut Out:**

$A_{cot} := b_{cot} \cdot t_W$ $A_{cot} = 0.29\ in^2$ $A_{cot} = 189\ mm^2$ Area of Top Cutout

$y_{cot} := d_W - \frac{t_W}{2}$ $y_{cot} = 13.53\ in$ $y_{cot} = 344\ mm$ Centroid Dist. to Top Cutout

$Ix_{cot} := \frac{b_{cot} \cdot t_W^3}{12}$ $Ix_{cot} = 0.00\ in^4$ $Ix_{cot} = 1141\ mm^4$ Moment of Inertia of Top Cutout

$A_{cob} := b_{cob} \cdot t_W$ $A_{cob} = 0.29\ in^2$ $A_{cob} = 189\ mm^2$ Area of Bottom Cutout

$y_{cob} := \frac{t_W}{2}$ $y_{cob} = 0.17\ in$ $y_{cob} = 4\ mm$ Centroid Dist. to Bottom Cutout

$Ix_{cob} := \frac{b_{cob} \cdot t_W^3}{12}$ $Ix_{cob} = 0.00\ in^4$ $Ix_{cob} = 1141\ mm^4$ Moment of Inertia of Bottom Cutout

**Section Properties of Reinforcing BAR φ:**

| | | | |
|---|---|---|---|
| $A_{bt} := \frac{\pi \cdot \phi_{bt}^{2}}{4}$ | $A_{bt} = 0.44\ in^{2}$ | $A_{bt} = 285\ mm^{2}$ | Area of BAR |
| $y_{bt} := d_W - t_W - \frac{\phi_{bt}}{2}$ | $y_{bt} = 12.99\ in$ | $y_{bt} = 330\ mm$ | Centroid Dist. to Top BAR |
| $Ix_{bt} := \frac{\pi \cdot \phi_{bt}^{4}}{64}$ | $Ix_{bt} = 0.02\ in^{4}$ | $Ix_{bt} = 6465\ mm^{4}$ | Moment of Inertia of Top BAR |
| $A_{bb} := \frac{\pi \cdot \phi_{bb}^{2}}{4}$ | $A_{bb} = 0.44\ in^{2}$ | $A_{bb} = 285\ mm^{2}$ | Area of Bottom BAR |
| $y_{bb} := t_W + \frac{\phi_{bb}}{2}$ | $y_{bb} = 0.71\ in$ | $y_{bb} = 18\ mm$ | Centroid Dist. to Bottom BAR |
| $Ix_{bb} := \frac{\pi \cdot \phi_{bb}^{4}}{64}$ | $Ix_{bb} = 0.02\ in^{4}$ | $Ix_{bb} = 6465\ mm^{4}$ | Moment of Inertia of Top BAR |

**Composite Section Centroid:**

$$A_c := \left(A_W + A_{bt} + A_{bb} - A_{cot} - A_{cob}\right)$$

$A_c = 6.64\ in^{2}$ $A_c = 4287\ mm^{2}$ Composite Area

$$y_{cb} := \frac{A_W \cdot y_W - A_{cot} \cdot y_{cot} - A_{cob} \cdot y_{cob} + A_{bt} \cdot y_{bt} + A_{bb} \cdot y_{bb}}{A_c}$$

$y_{cb} = 6.85\ in$ $y_{cb} = 174\ mm$ Composite Centroid Bottom

$y_{ct} := d_W - y_{cb}$ $y_{ct} = 6.85\ in$ $y_{ct} = 174\ mm$ Composite Centroid Bottom

**Composite Moment of Inertia:**

| | | | |
|---|---|---|---|
| $a_b := y_{bt} - y_{ct}$ | $a_b = 6.14\ in$ | $a_b = 156\ mm$ | |
| $b_b := y_{bb} - y_{cb}$ | $b_b = -6.14\ in$ | $b_b = -156\ mm$ | |
| $I_1 := Ix_W$ | $I_1 = 192.03\ in^{4}$ | $I_1 = 8 \cdot 10^{7}\ mm^{4}$ | |
| $I_2 := A_W \cdot \left(y_W - y_{cb}\right)^{2}$ | $I_2 = 4.10 \cdot 10^{-27}\ in^{4}$ | $I_2 = 2 \cdot 10^{-21}\ mm^{4}$ | |
| $I_2 := I_2 \cdot \left(I_2 \geq 0.01\ in^{4}\right)$ | $I_2 = 0.00\ in^{4}$ | $I_2 = 0\ mm^{4}$ | |
| $I_3 := Ix_{bt}$ | $I_3 = 0.02\ in^{4}$ | $I_3 = 6465\ mm^{4}$ | $Ix_{c1} := I_1 + I_2 + I_3$ |
| $I_4 := \left(A_{bt} \cdot \left(y_{bt} - y_{ct}\right)^{2}\right)$ | $I_4 = 16.66\ in^{4}$ | $I_4 = 7 \cdot 10^{6}\ mm^{4}$ | |
| $I_5 := Ix_{bb}$ | $I_5 = 0.02\ in^{4}$ | $I_5 = 6465\ mm^{4}$ | $Ix_{c2} := I_4 + I_5$ |
| $I_6 := A_{bb} \cdot \left(y_{bb} - y_{cb}\right)^{2}$ | $I_6 = 16.66\ in^{4}$ | $I_6 = 7 \cdot 10^{6}\ mm^{4}$ | $Ix_{c3} := I_6$ |
| $I_7 := Ix_{cot}$ | $I_7 = 0.00\ in^{4}$ | $I_7 = 1141\ mm^{4}$ | |
| $I_8 := A_{cot} \cdot \left(y_{cot} - y_{ct}\right)^{2}$ | $I_8 = 13.09\ in^{4}$ | $I_8 = 5 \cdot 10^{6}\ mm^{4}$ | |
| $I_9 := Ix_{cob}$ | $I_9 = 0.00\ in^{4}$ | $I_9 = 1141\ mm^{4}$ | $Ix_{c4} := I_7 + I_8 + I_9$ |
| $I_{10} := A_{cob} \cdot \left(y_{cob} - y_{cb}\right)^{2}$ | $I_{10} = 13.09\ in^{4}$ | $I_{10} = 5 \cdot 10^{6}\ mm^{4}$ | $Ix_{c5} := I_{10}$ |

$a_b := y_{bt} - y_{ct}$ $\quad a_b = 6.14\ \mathrm{in}$ $\quad a_b = 156\ \mathrm{mm}$

$b_b := y_{bb} - y_{cb}$ $\quad b_b = -6.14\ \mathrm{in}$ $\quad b_b = -156\ \mathrm{mm}$

$I_1 := Ix_W$ $\quad I_1 = 192.03\ \mathrm{in}^4$ $\quad I_1 = 8 \cdot 10^7\ \mathrm{mm}^4$

$I_2 := A_W \cdot \left(y_W - y_{cb}\right)^2$ $\quad I_2 = 4.10 \cdot 10^{-27}\ \mathrm{in}^4$ $\quad I_2 = 2 \cdot 10^{-21}\ \mathrm{mm}^4$

$I_2 := I_2 \cdot \left(I_2 \geq 0.01\ \mathrm{in}^4\right)$ $\quad I_2 = 0.00\ \mathrm{in}^4$ $\quad I_2 = 0\ \mathrm{mm}^4$

$I_3 := Ix_{bt}$ $\quad I_3 = 0.02\ \mathrm{in}^4$ $\quad I_3 = 6465\ \mathrm{mm}^4$

$I_4 := \left(A_{bt} \cdot \left(y_{bt} - y_{ct}\right)^2\right)$ $\quad I_4 = 16.66\ \mathrm{in}^4$ $\quad I_4 = 7 \cdot 10^6\ \mathrm{mm}^4$

$I_5 := Ix_{bb}$ $\quad I_5 = 0.02\ \mathrm{in}^4$ $\quad I_5 = 6465\ \mathrm{mm}^4$

$I_6 := A_{bb} \cdot \left(y_{bb} - y_{cb}\right)^2$ $\quad I_6 = 16.66\ \mathrm{in}^4$ $\quad I_6 = 7 \cdot 10^6\ \mathrm{mm}^4$

$I_7 := Ix_{cot}$ $\quad I_7 = 0.00\ \mathrm{in}^4$ $\quad I_7 = 1141\ \mathrm{mm}^4$

$I_8 := A_{cot} \cdot \left(y_{cot} - y_{ct}\right)^2$ $\quad I_8 = 13.09\ \mathrm{in}^4$ $\quad I_8 = 5 \cdot 10^6\ \mathrm{mm}^4$

$I_9 := Ix_{cob}$ $\quad I_9 = 0.00\ \mathrm{in}^4$ $\quad I_9 = 1141\ \mathrm{mm}^4$

$I_{10} := A_{cob} \cdot \left(y_{cob} - y_{cb}\right)^2$ $\quad I_{10} = 13.09\ \mathrm{in}^4$ $\quad I_{10} = 5 \cdot 10^6\ \mathrm{mm}^4$

$Ix_c := I_1 + I_2 + I_3 + I_4 + I_5 + I_7 + I_9$

**Composite Section Modulus:**

$Sx_{ct} := \dfrac{Ix_c}{y_{ct}}$ $\quad Sx_{ct} = \blacksquare\ \mathrm{in}^3$ $\quad Sx_{ct} = \blacksquare\ \mathrm{mm}^3$ $\quad$ Section Modulus of Top Fibre

$Sx_{cb} := \frac{Ix_c}{y_{cb}}$ $\qquad Sx_{cb} = \blacksquare\ \mathrm{in}^{\smile}$ $\qquad Sx_{cb} = \blacksquare\ \mathrm{mm}^{\smile}$ Section Modulus of Bot Fibre

**Moment Resistance**

**Maximum Outer Fibre Stress (Top):**

$$\sigma_t := \min\left(\left[\, f_{y1} \quad f_{y2} \cdot \frac{y_{ct}}{y_{ct} - t_w} \,\right]\right)$$

$\sigma_t = 50\ \mathrm{Ksi}$ $\qquad \sigma_t = 344.7379\ \mathrm{MPa}$

**Maximum Outer Fibre Stress (Bottom):**

$$\sigma_b := \min\left(\left[\, f_{y1} \quad f_{y2} \cdot \frac{y_{cb}}{y_{cb} - t_w} \,\right]\right)$$

$\sigma_b = 50\ \mathrm{Ksi}$ $\qquad \sigma_b = 344.7379\ \mathrm{MPa}$

$$M_{rc} := \left(\varphi_s \cdot \min\left(\left[\, f_{y1} \cdot Sx_{ct} \quad f_{y2} \cdot Sx_{cb} \,\right]\right)\right)$$

$M_{rc} = \blacksquare\ \mathrm{K\_ft}$ $\qquad M_{rc} = \blacksquare\ \mathrm{kN\_m}$ Moment Resistance

**Weld Capacity:**

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

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

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

$V_{rw} := \min\left(\left[\, v_{rw} \quad v_{rb1} \quad v_{rb2} \,\right]\right)$ $\qquad V_{rw} = 22.22\ \mathrm{Ksi}$ $\qquad V_{rw} = 153.2\ \mathrm{MPa}$ Minimum Weld Capacity

**Maximum UDL:**

$q_f := \frac{8 \cdot M_{rc}}{L^2}$ $\qquad q_f = \blacksquare\ \mathrm{Klf}$ $\qquad q_f = \blacksquare\ \mathrm{kNpm}$ UDL for Composite Section

**Maximum Reaction (Shear):**

$V_f := q_f \cdot \frac{L}{2}$ $\qquad V_f = \blacksquare\ \mathrm{K}$ $\qquad V_f = \blacksquare\ \mathrm{kN}$

**Length of Reinforcing:**

$\Delta M := M_f - M_{rW}$ $\qquad \Delta M = 179.44\ \mathrm{K\_ft}$ $\qquad \Delta M = 243.29\ \mathrm{kN\_m}$ Moment Prov by Composite

$l_c := \sqrt{\frac{8 \cdot \Delta M}{q_f}}$ $\qquad l_c = \blacksquare\ \mathrm{ft}$ $\qquad l_c = \blacksquare\ \mathrm{ft}$ Length of Reinforcing

**Shear Stress at W and BAR P1 Junction:**

$A' := b_W \cdot t_W$ $\qquad A' = 1.675\ \mathrm{in}^2$ $\qquad A' = 1080.643\ \mathrm{mm}^2$

$y_{bar} := y_{cb} - \frac{t_W}{2}$ $\qquad y_{bar} = 6.6825\ \mathrm{in}$ $\qquad y_{bar} = 169.7355\ \mathrm{mm}$

$$\tau_1 := \frac{V_f}{Ix_c \cdot \left(2 \cdot b_{P1} + w_W\right)} \cdot A' \cdot y_{bar}$$

$\tau_1 = \blacksquare\ \mathrm{Ksi}$ $\qquad \tau_1 = \blacksquare\ \mathrm{MPa}$ Shear at BAR P1 and Bot Flange

**Connection Shear per Unit Length**

$\tau'_1 := \tau_1 \cdot n \cdot \left(2 \cdot b_{P1} + w_W\right)$ $\qquad \tau'_1 = \blacksquare\ \mathrm{K}$ $\qquad \tau'_1 = \blacksquare\ \mathrm{kN}$ Shear per Unit Length at BAR P1

**Weld Provided**

$\tau_{r1} := 2 \cdot V_{rw} \cdot D \cdot m$ $\qquad \tau_{r1} = 88.9\ \mathrm{K}$ $\qquad \tau_{r1} = 395.3\ \mathrm{kN}$ Weld Provided at BAR P1

**End Connection Force per Side:**

$\sigma_1 := \frac{M_f \cdot (y_{cb} - t_W - t_{P1})}{Ix_c}$ $\sigma_1 = \blacksquare$ Ksi $\sigma_1 = \blacksquare$ MPa Stress at Top of BAR P1 Section

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$\sigma_2 := \frac{M_f \cdot (y_{cb} - t_W)}{Ix_c}$ $\sigma_2 = \blacksquare$ Ksi $\sigma_2 = \blacksquare$ MPa Stress at Bot of BAR P1 Section

$F_{P1} := (\sigma_1 \cdot b_{P1} \cdot t_{P1}) + \left(\left(\frac{\sigma_2 - \sigma_1}{2}\right) \cdot b_{P1} \cdot t_{P1}\right)$

$F_{P1} = \blacksquare$ K $F_{P1} = \blacksquare$ kN Force in BAR P1

$M_{P1} := (\sigma_1 \cdot b_{P1} \cdot t_{P1}) \cdot \frac{t_{P1}}{2} + \left(\left(\frac{\sigma_2 - \sigma_1}{2}\right) \cdot b_{P1} \cdot t_{P1}\right) \cdot \frac{t_{P1}}{3}$

$M_{P1} = \blacksquare$ K_in $M_{P1} = \blacksquare$ kN_mm Moment from Force in BAR P1

$F_{fe1} := \frac{2 \cdot (M_{P1})}{l_c}$ $F_{fe1} = \blacksquare$ K $F_{fe1} = \blacksquare$ kN End Connection Force

$l_{e1} := \frac{F_{fe1}}{D \cdot V_{rw}}$ $l_{e1} = \blacksquare$ in $l_{e1} = \blacksquare$ mm Length of Weld Required

**Shear Stress at W and BAR P2 Junction:**

$A' := b_W \cdot t_W$ $A' = 1.675\ in^2$ $A' = 1080.643\ mm^2$

$y_{bar} := y_{ct} - \frac{t_W}{2}$ $y_{bar} = 6.6825$ in $y_{bar} = 169.7355$ mm

$\tau_2 := \frac{V_f}{Ix_c \cdot (2 \cdot b_{P2} + w_W)} \cdot A' \cdot y_{bar}$

$\tau_2 = \blacksquare$ Ksi $\tau_2 = \blacksquare$ MPa Shear at BAR P2 and Top Flange

**Connection Shear per Unit Length**

$\tau'_2 := \tau_2 \cdot n \cdot (2 \cdot b_{P2} + w_W)$ $\tau'_2 = \blacksquare$ K $\tau'_2 = \blacksquare$ kN Shear per Unit Length at BAR P2

**Weld Provided**

$\tau_{r2} := 2 \cdot V_{rw} \cdot D \cdot m$ $\tau_{r2} = 88.9$ K $\tau_{r2} = 395.3$ kN Weld Provided at BAR P2

**End Connection Force per Side:**

$\sigma_3 := \frac{M_f \cdot (y_{ct} - t_W - t_{P2})}{Ix_c}$ $\sigma_3 = \blacksquare$ Ksi $\sigma_3 = \blacksquare$ MPa Stress at Bot of BAR P2

$\sigma_4 := \frac{M_f \cdot (y_{ct} - t_W)}{Ix_c}$ $\sigma_4 = \blacksquare$ Ksi $\sigma_4 = \blacksquare$ MPa Stress at Top of BAR P2

$F_{P2} := (\sigma_3 \cdot b_{P2} \cdot t_{P2}) + \left(\left(\frac{\sigma_4 - \sigma_3}{2}\right) \cdot b_{P2} \cdot t_{P2}\right)$

$F_{P2} = \blacksquare$ K $F_{P2} = \blacksquare$ kN Force in BAR P2

$M_{P2} := (\sigma_3 \cdot b_{P2} \cdot t_{P2}) \cdot \frac{t_{P2}}{2} + \left(\left(\frac{\sigma_4 - \sigma_3}{2}\right) \cdot b_{P2} \cdot t_{P2}\right) \cdot \frac{t_{P2}}{3}$

$M_{P2} = \blacksquare$ K_in $M_{P2} = \blacksquare$ kN_mm Moment from Force in BAR P2

$F_{fe2} := \frac{2 \cdot (M_{P2})}{l_c}$ $F_{fe2} = \blacksquare$ K $F_{fe2} = \blacksquare$ kN End Connection Force

$l_{e2} := \frac{F_{fe2}}{D \cdot V_{rw}}$ $l_{e2} = \blacksquare$ in $l_{e2} = \blacksquare$ mm Length of Weld Required

**Summary:**

Material Property Factor

(Welds) $\varphi_w = 0.67$

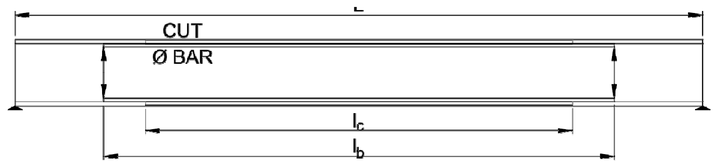
(Steel) $\varphi_s = 0.9$

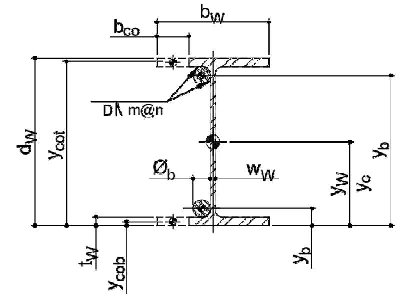
Dead Load Factor $\alpha_D = 1.25$

Live Load Factor $\alpha_L = 1.5$

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

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




**Steel Properties**

**W Section**

| | | |
|---|---|---|
| Designation | $desM_{st1} = \text{"G40.21-350W"}$ | |
| Yield Strength | $f_{y1} = 50\ \text{Ksi}$ | $f_{y1} = 345\ \text{MPa}$ |
| Ultimate Strength | $F_{u1} = 65\ \text{Ksi}$ | $F_{u1} = 448\ \text{MPa}$ |

**BAR Section**

| | | |
|---|---|---|
| Designation | $desM_{st2} = \text{"G40.21-350W"}$ | |
| Yield Strength | $f_{y2} = 50\ \text{Ksi}$ | $f_{y2} = 345\ \text{MPa}$ |
| 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 | $\gamma_s = 489\ \text{pcf}$ | $\gamma_s = 76.8\ \text{kNpcm}$ |

| | | |
|---|---|---|
| **Beam Span Length** | $L = 20.00\ \text{ft}$ | $L = 6.10\ \text{m}$ |
| **Factored Design Moment** | $M_f = 300.00\ \text{K\_ft}$ | $M_f = 406.75\ \text{kN\_m}$ |

**Welds**

| | | |
|---|---|---|
| Designation (Welding Electrode) | $desI_w = \text{"E70xx"}$ | $desM_w = \text{"E49xx"}$ |
| Ultimate Strength (Welding Electrode) | $X_u = 70\ \text{Ksi}$ | $X_u = 483\ \text{MPa}$ |
| Designation (Fillet Weld Size) | $desI_D = \text{"1/4"}$ | $desM_D = \text{""}$ |
| Fillet Weld Size | $D = 0.25\ \text{in}$ | $D = 6.35\ \text{mm}$ |
| Weld Length | $m = 8\ \text{in}$ | $m = 203.2\ \text{mm}$ |
| Weld Spacing | $n = 12\ \text{in}$ | $n = 304.8\ \text{mm}$ |

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

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

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

**W Section**

| | | |
|---|---|---|
| Designation | $desI_W = \text{"W14x22"}$ | $desM_W = \text{"W360x33"}$ |
| Depth | $d_W = 13.70\ \text{in}$ | $d_W = 348\ \text{mm}$ |
| Area | $A_W = 6.35\ \text{in}^2$ | $A_W = 4094.8\ \text{mm}^2$ |
| Moment of Inertia (x-axis) | $Ix_W = 192.03\ \text{in}^4$ | $Ix_W = 7.99 \cdot 10^7\ \text{mm}^4$ |
| Centroid Distance | $y_W = 6.85\ \text{in}$ | $y_W = 174\ \text{mm}$ |

| | | |
|---|---|---|
| Section Modulus (X-Axis) | $Sx_W = 28.03\ \mathrm{in}^3$ | $Sx_W = 4.59 \cdot 10^5\ \mathrm{mm}^3$ |
| Plastic Section (X-Axis) | $Zx_W = 32.15\ \mathrm{in}^3$ | $Zx_W = 5.27 \cdot 10^5\ \mathrm{mm}^3$ |
| Section Class | $Class_W = 1$ | |
| Moment Resistance | $M_{rW} = 120.6\ \mathrm{K\_ft}$ | $M_{rW} = 163.5\ \mathrm{kN\_m}$ |

$Check\left(M_{rW} \le M_f\right) = \text{"...OK"}$

**BAR P1 Section**

| | | |
|---|---|---|
| Designation | $desI_{P1} = ■$ | $desM_{P1} = ■$ |
| Width | $b_{P1} = ■\ \mathrm{in}$ | $b_{P1} = ■\ \mathrm{mm}$ |
| Thickness | $t_{P1} = ■\ \mathrm{in}$ | $t_{P1} = ■\ \mathrm{mm}$ |
| Area | $A_{P1} = ■\ \mathrm{in}^2$ | $A_{P1} = ■\ \mathrm{mm}^2$ |
| Moment of Inertia (x-axis) | $Ix_{P1} = ■\ \mathrm{in}^4$ | $Ix_{P1} = ■\ \mathrm{mm}^4$ |
| Centroid Distance | $y_{P1} = ■\ \mathrm{in}$ | $y_{P1} = ■\ \mathrm{mm}$ |

**BAR P2 Section**

| | | |
|---|---|---|
| Designation | $desI_{P2} = ■$ | $desM_{P2} = ■$ |
| Width | $b_{P2} = ■\ \mathrm{in}$ | $b_{P2} = ■\ \mathrm{mm}$ |
| Thickness | $t_{P2} = ■\ \mathrm{in}$ | $t_{P2} = ■\ \mathrm{mm}$ |
| Area | $A_{P2} = ■\ \mathrm{in}^2$ | $A_{P2} = ■\ \mathrm{mm}^2$ |
| Moment of Inertia (x-axis) | $Ix_{P2} = ■\ \mathrm{in}^4$ | $Ix_{P2} = ■\ \mathrm{mm}^4$ |
| Centroid Distance | $y_{P2} = ■\ \mathrm{in}$ | $y_{P2} = ■\ \mathrm{mm}$ |

**Composite Section**

| | | |
|---|---|---|
| Area | $A_c = 6.6\ \mathrm{in}^2$ | $A_c = 4287\ \mathrm{mm}^2$ |
| Moment of Inertia (x-axis) | $Ix_c = ■\ \mathrm{in}^4$ | $Ix_c = ■\ \mathrm{mm}^4$ |
| Centroid Distance (top) | $y_{ct} = 6.9\ \mathrm{in}$ | $y_{ct} = 174\ \mathrm{mm}$ |
| Centroid Distance (bot) | $y_{cb} = 6.8\ \mathrm{in}$ | $y_{cb} = 174\ \mathrm{mm}$ |
| Section Modulus (design x-axis) | $Sx_{ct} = ■\ \mathrm{in}^3$ | $Sx_{ct} = ■\ \mathrm{mm}^3$ |
| Section Modulus (design x-axis) | $Sx_{cb} = ■\ \mathrm{in}^3$ | $Sx_{cb} = ■\ \mathrm{mm}^3$ |
| Moment Resistance | $M_{rc} = ■\ \mathrm{K\_ft}$ | $M_{rc} = ■\ \mathrm{kN\_m}$ |

$Check\left(M_{rc} \ge M_f\right) = ■$ $\quad$ $Check\left(\dfrac{M_{rc}}{\varphi_s} \ge M_f\right) = ■$

**Allow for Overload**

| | | |
|---|---|---|
| Maximum UDL | $q_f = ■\ \mathrm{Klf}$ | $q_f = ■\ \mathrm{kNpm}$ |
| Maximum Reaction (Shear) | $V_f = ■\ \mathrm{K}$ | $V_f = ■\ \mathrm{kN}$ |
| Length of Reinforcing | $l_c = ■\ \mathrm{ft}$ | $l_c = ■\ \mathrm{ft}$ |

$Check\left(l_c \le L\right) = ■$

**End Connection Force for BAR P1**

| | | |
|---|---|---|
| Shear at BAR P1 and Bot Flange | $\tau_1 = ■\ \mathrm{Ksi}$ | $\tau_1 = ■\ \mathrm{MPa}$ |
| Shear per Unit Length at BAR P1 | $\tau'_1 = ■\ \mathrm{K}$ | $\tau'_1 = ■\ \mathrm{kN}$ |
| Weld Provided at BAR P1 | $\tau_{r1} = 88.9\ \mathrm{K}$ | $\tau_{r1} = 395.3\ \mathrm{kN}$ |

$Check\left(\tau_{r1} \ge \tau'_1\right) = ■$

| | | |
|---|---|---|
| Stress at Top of BAR P1 Section | $\sigma_1 = ■$ Ksi | $\sigma_1 = ■$ MPa |
| Stress at Bot of BAR P1 Section | $\sigma_2 = ■$ Ksi | $\sigma_2 = ■$ MPa |
| Force in BAR P1 | $F_{P1} = ■$ K | $F_{P1} = ■$ kN |
| Moment from Force in BAR P1 | $M_{P1} = ■$ K_in | $M_{P1} = ■$ kN_mm |
| End Connection Force | $F_{fe1} = ■$ K | $F_{fe1} = ■$ kN |
| Length of Weld Required | $l_{e1} = ■$ in | $l_{e1} = ■$ mm |

**End Connection Force for BAR P2**

| | | |
|---|---|---|
| Shear at BAR P2 and Top Flange | $\tau_2 = ■$ Ksi | $\tau_2 = ■$ MPa |
| Shear per Unit Length at BAR P2 | $\tau'_2 = ■$ K | $\tau'_2 = ■$ kN |
| Weld Provided at BAR P2 | $\tau_{r2} = 88.9$ K | $\tau_{r2} = 395.3$ kN |
| Stress at Bot of BAR P2 | $\sigma_3 = ■$ Ksi | $\sigma_3 = ■$ MPa |
| Stress at Top of BAR P2 | $\sigma_4 = ■$ Ksi | $\sigma_4 = ■$ MPa |
| Force in BAR P2 | $F_{P2} = ■$ K | $F_{P2} = ■$ kN |
| Moment from Force in BAR P2 | $M_{P2} = ■$ K_in | $M_{P2} = ■$ kN_mm |
| End Connection Force | $F_{fe2} = ■$ K | $F_{fe2} = ■$ kN |
| Length of Weld Required | $l_{e2} = ■$ in | $l_{e2} = ■$ mm |