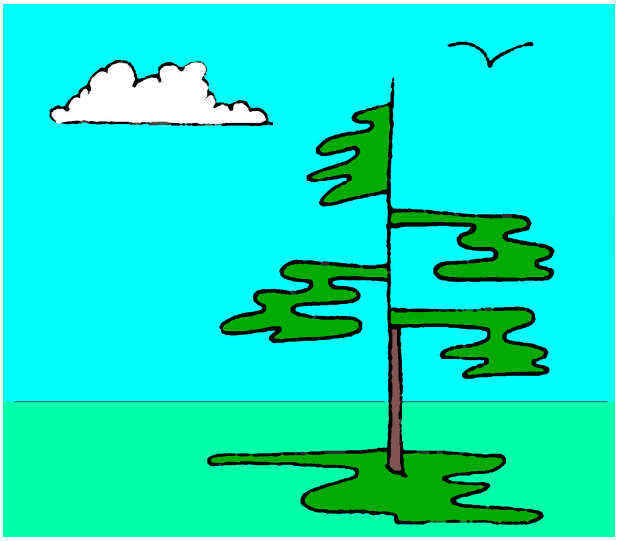
NorthWoods Software



Program Name: Composite-W_W

Project Name: -

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 21-03-10

Reference: NBCC, CSA S16

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

Menu:

..... Input Data ..... Important Output ..... Logical Constructs **Blue** **Units**

..... Sum / For **Red** **Important Note**

Defined Units:

$K := kip$

$K\_ft := K\ ft$ $kN\_m := kN\ m$ $K\_in := K\ in$ Moment

$pcf := \frac{lbf}{ft^3}$ $kNpcm := \frac{kN}{m^3}$ $kgpcm := \frac{kg}{m^3}$ Density

$Klf := \frac{K}{ft}$ $plf := \frac{lbf}{ft}$ $kNpm := \frac{kN}{m}$ $Kpi := \frac{K}{in}$ $KNpmm := \frac{kN}{mm}$ Force/Unit Length

$psf := \frac{lbf}{ft^2}$ $Ksf := \frac{K}{ft^2}$ $Ksi := \frac{K}{in^2}$ $kNpsm := \frac{kN}{m^2}$ $psi := \frac{lbf}{in^2}$ Pressure

$pci := \frac{lbf}{in^3}$ Subgrade Modulus

$psfpf := \frac{psf}{ft}$ $kPapm := \frac{kPa}{m}$ Pressure per Depth

$pmcf := \frac{lb}{ft^3}$ $lb := lbf$ Force

User Defined Functions:

```
Check(arg) := if arg = 1
                Check := "...OK"
              else
                Check := "...NG"
```

$Check(2 = 3) = "...NG"$

$Check(2 \neq 3) = "...OK"$

$Check(2 \leq 3) = "...OK"$

$Check(3 \geq 2) = "...OK"$

Input Data

Material Property Factors:

$\varphi_s := 0.90$

$\varphi_w := 0.67$

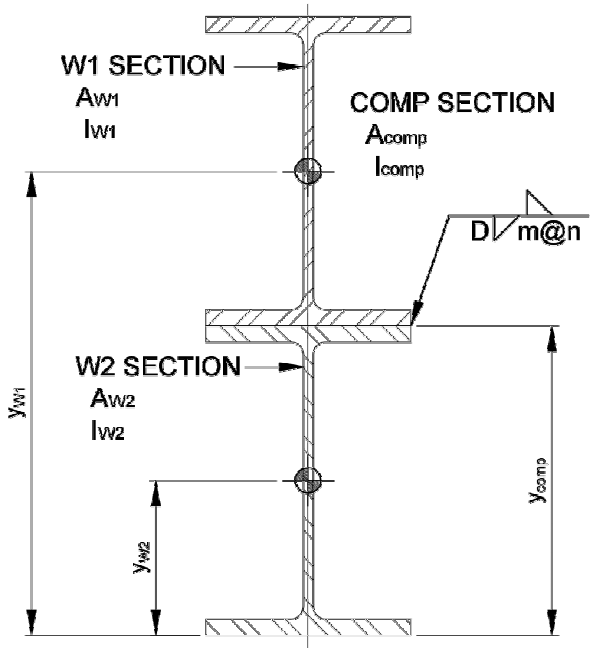
Load Factors:

$\alpha_L := 1.50$

$\alpha_D := 1.25$

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

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



Steel Properties:

W Section $stl_{NDX} := 1$

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

$desI := stl_{stl_{NDX},2}$ $\quad f_y := stl_{stl_{NDX},3}$ $\quad F_u := stl_{stl_{NDX},4}$ $\quad E_s := 29000\ \text{Ksi}$

$\nu := 0.3$ $\quad G_s := \dfrac{E_s}{2\cdot(1+\nu)}$ $\quad G_s := 11154\ \text{Ksi}$ $\quad \gamma_s := 489\ \text{pcf}$

Beam Span:

$L := 20.667\ \text{ft}$ $\quad L = 6.30\ \text{m}$ Span Length

Welding Electrodes:

$Weld_{NDX} := 2$

$$Weld := \begin{bmatrix} \text{NDX} & \text{DesI} & \text{DesM} & \text{Xu} \\ 1 & \text{"E60xx"} & \text{"E410xx"} & 60\ \text{ksi} \\ 2 & \text{"E70xx"} & \text{"E480xx"} & 70\ \text{ksi} \\ 3 & \text{"E80xx"} & \text{"E550xx"} & 80\ \text{ksi} \\ 4 & \text{"E90xx"} & \text{"E620xx"} & 90\ \text{ksi} \end{bmatrix}$$

$desI_{we} := Weld_{Weld_{NDX},2}$ $\quad desM_{we} := Weld_{Weld_{NDX},3}$ $\quad X_u := Weld_{Weld_{NDX},4}$

Weld Sizes:

$weld_{NDX} := 9$

$weld :=$

NDX	DI	DM	W
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

$desI_D := weld_{weld_{NDX},2}$

$desM_D := weld_{weld_{NDX},3}$

$D := weld_{weld_{NDX},4}$

$m := 7\ in$ $\quad m = 177.8\ mm$ Weld Length

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

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

$Check((n - m) \leq 12\ in) = "...OK"$

W Section

$desI_{W1} := "HP12x74"$

$desM_{W1} := "HP310x110"$

$d_{W1} := 12.13\ in$ $\quad d_{W1} = 308.1\ mm$ W Beam Depth

$A_{W1} := 21.8\ in^2$ $\quad A_{W1} = 14064.5\ mm^2$ W Beam Area

$Ix_{W1} := 569\ in^4$ $\quad Ix_{W1} = 2.4 \cdot 10^8\ mm^4$ W Beam Ix

$y_{W1} := 6.065\ in$ $\quad y_{W1} = 154.1\ mm$ W Centroid Dist

WT Section

$desI_{W2} := "HP12x74"$

$desM_{W2} := "HP310x110"$

$d_{W2} := 12.13\ in$ $\quad d_{W2} = 308.1\ mm$ W2 Beam Depth

$b_{W2} := 12.22\ in$ $\quad b_{W2} = 310.4\ mm$ W2 Conn Width

$A_{W2} := 21.8\ in^2$ $\quad A_{W2} = 14064.5\ mm^2$ W2 Beam Area

$Ix_{W2} := 569\ in^4$ $\quad Ix_{W2} = 2.4 \cdot 10^8\ mm^4$ W2 Beam Ix

$y_{W2} := 6.065\ in$ $\quad y_{W2} = 154.1\ mm$ W2 Centroid Dist

Composite Section Centroid

$$A_{comp} := A_{W1} + A_{W2}$$

$$y_{comp} := \frac{A_{W1} \cdot \left(y_{W1} + d_{W2}\right) + A_{W2} \cdot y_{W2}}{A_{comp}}$$

$y_{comp} = 12.13\ \text{in}$ $y_{comp} = 308.1\ \text{mm}$

Moment of Inertia (x-Axis)

$$Ix_{comp} := Ix_{W1} + \left(A_{W1} \cdot \left(y_{W1} + d_{W2} - y_{comp}\right)^2\right) + Ix_{W2} + \left(A_{W2} \cdot \left(y_{W2} - y_{comp}\right)^2\right)$$

$Ix_{comp} = 2742\ \text{in}^4$ $Ix_{comp} = 1.14 \cdot 10^9\ \text{mm}^4$

Design shear stress is determined based on the uniform distributed load that produces the maximum resisting moment for the fully braced span under consideration.

Section Modulus (x-Axis)

$$y_{compt} := d_{W1} + d_{W2} - y_{comp}$$ $y_{compt} = 12.1\ \text{in}$ $y_{compt} = 308.1\ \text{mm}$

$$Sx_{compt} := \frac{Ix_{comp}}{y_{compt}}$$ $Sx_{compt} = 226.0\ \text{in}^3$ $Sx_{compt} = 3.70 \cdot 10^6\ \text{mm}^3$

$$Sx_{compb} := \frac{Ix_{comp}}{y_{comp}}$$ $Sx_{compb} = 226.0\ \text{in}^3$ $Sx_{compb} = 3.7 \cdot 10^6\ \text{mm}^3$

$$Sx_{des} := \min\left(\left[\begin{array}{cc} Sx_{compt} & Sx_{compb} \end{array}\right]\right)$$

$Sx_{des} = 226\ \text{in}^3$ $Sx_{des} = 3.7 \cdot 10^6\ \text{mm}^3$

Moment Resistance

$$M_{Rc} := \varphi_s \cdot Sx_{des} \cdot f_y$$ $M_{Rc} = 847.6\ \text{K\_ft}$ $M_{Rc} = 1149.2\ \text{kN\_m}$

Maximum UDL

$$Q_{max} := \frac{8 \cdot M_{Rc}}{L^2}$$ $Q_{max} = 15.9\ \text{Klf}$ $Q_{max} = 231.7\ \text{kNpm}$

Maximum Reaction (Shear)

$$V_{max} := Q_{max} \cdot \frac{L}{2}$$ $V_{max} = 164.1\ \text{K}$ $V_{max} = 729.7\ \text{kN}$

Shear Stress at W and WT Junction

$$A' := A_{W2}$$

$$y_{bar} := d_{W2} - y_{W2}$$

$$\tau := \frac{V_{max}}{Ix_{comp} \cdot b_{W2}} \cdot A_{W2} \cdot \left(d_{W2} - y_{W2}\right)$$

$\tau = 0.65\ \text{Ksi}$ $\tau = 4.46\ \text{MPa}$

Weld Material Strength

$v_{Rw} := \varphi_w \cdot 0.67 \cdot X_u \cdot \frac{1}{\sqrt{2}}$ $v_{Rw} = 22.22\ ksi$ $v_{Rw} = 153.20\ MPa$

Weld Material Strength / Unit Length

$V_{Rw} := v_{Rw} \cdot D$ $V_{Rw} = 6.94\ Kpi$ $V_{Rw} = 1.22\ KNpmm$

Base Metal Strength / Unit Length

$V_{Rb} := \varphi_s \cdot D \cdot f_y$ $V_{Rb} = 14.06\ Kpi$ $V_{Rb} = 2.46\ KNpmm$

Minimum Weld Capacity

$V_{Rmin} := \min\left(\left[\begin{array}{cc} V_{Rw} & V_{Rb} \end{array}\right]\right)$ $V_{Rmin} = 6.94\ Kpi$ $V_{Rmin} = 1.22\ KNpmm$

Connection Shear per Unit Length

$\tau' := \left(\tau \cdot n \cdot b_{W2}\right)$ $\tau' = 94.9\ K$ $\tau' = 422.3\ kN$

Weld Provided

$\tau_R := 2 \cdot V_{Rmin} \cdot m$ $\tau_R = 97.2\ K$ $\tau_R = 432.4\ kN$

$Check\left(\tau_R \geq \tau'\right) = "...OK"$

Summary:

Material Property Factor (Welds)	$\varphi_w = 0.67$	
Material Property Factor (Steel)	$\varphi_s = 0.9$	
Dead Load Factor	$\alpha_D = 1.25$	
Live Load Factor	$\alpha_L = 1.5$	
Steel		
Designation	$desI = \text{"G40.21-350W"}$	
Yield Strength	$f_y = 50\ \text{Ksi}$	$f_y = 345\ \text{MPa}$
Ultimate Strength	$F_u = 65\ \text{Ksi}$	$F_u = 448\ \text{MPa}$
Young's Modulus	$E_s = 29000\ \text{Ksi}$	$E_s = 2.00 \cdot 10^5\ \text{MPa}$
Shear Modulus	$G_s = 11154\ \text{Ksi}$	$G_s = 76904\ \text{MPa}$
Density	$\gamma_s = 489\ \text{pcf}$	$\gamma_s = 76.8\ \text{kNpcm}$
Welds		
Designation (Welding Electrode)	$desI_{we} = \text{"E70xx"}$	$desM_{we} = \text{"E480xx"}$
Ultimate Strength (Welding Electrode)	$X_u = 70\ \text{Ksi}$	$X_u = 483\ \text{MPa}$
Designation (Fillet Weld Size)	$desI_D = \text{"5/16"}$	$desM_D = \text{""}$
Fillet Weld Size	$D = 0.3125\ \text{in}$	$D = 7.9375\ \text{mm}$
W1 Section		
Designation	$desI_{W1} = \text{"HP12x74"}$	$desM_{W1} = \text{"HP310x110"}$
Depth	$d_{W1} = 12.1\ \text{in}$	$d_{W1} = 308.1\ \text{mm}$
Area	$A_{W1} = 21.8\ \text{in}^2$	$A_{W1} = 14064.5\ \text{mm}^2$
Moment of Inertia (x-axis)	$Ix_{W1} = 569\ \text{in}^4$	$Ix_{W1} = 2.4 \cdot 10^8\ \text{mm}^4$
Centroid Distance	$y_{W1} = 6.1\ \text{in}$	$y_{W1} = 154.1\ \text{mm}$
W2 Section		
Designation	$desI_{W2} = \text{"HP12x74"}$	$desM_{W2} = \text{"HP310x110"}$
Depth	$d_{W2} = 12.1\ \text{in}$	$d_{W2} = 308.1\ \text{mm}$
Web Width	$b_{W2} = 12.220\ \text{in}$	$b_{W2} = 310.4\ \text{mm}$
Area	$A_{W2} = 21.8\ \text{in}^2$	$A_{W2} = 14064.5\ \text{mm}^2$
Moment of Inertia (x-axis)	$Ix_{W2} = 569\ \text{in}^4$	$Ix_{W2} = 2.4 \cdot 10^8\ \text{mm}^4$
Centroid Distance	$y_{W2} = 6.1\ \text{in}$	$y_{W2} = 154.1\ \text{mm}$
Composite Section		
Area	$A_{comp} = 43.6\ \text{in}^2$	$A_{comp} = 28129\ \text{mm}^2$
Moment of Inertia (x-axis)	$Ix_{comp} = 2742\ \text{in}^4$	$Ix_{comp} = 1.14 \cdot 10^9\ \text{mm}^4$
Centroid Distance (top)	$y_{compt} = 12.1\ \text{in}$	$y_{compt} = 308\ \text{mm}$
Centroid Distance (bot)	$y_{comp} = 12.1\ \text{in}$	$y_{comp} = 308\ \text{mm}$
Section Modulus (design x-axis)	$Sx_{des} = 226\ \text{in}^3$	$Sx_{des} = 3.70 \cdot 10^6\ \text{mm}^3$

Composite Connection Design

Beam Span	$L = 20.67$ ft	$L = 6.299$ m
Maximum Resisting Moment	$M_{Rc} = 847.6$ K_ft	$M_{Rc} = 1149.2$ kN_m
Maximum Uniformly Distributed Load	$Q_{max} = 15.9$ Klf	$Q_{max} = 231.7$ kNpm
Maximum Design Shear	$V_{max} = 164.1$ K	$V_{max} = 729.7$ kN
Shear Stress at Interface	$\tau = 0.6474$ Ksi	$\tau = 4.4636$ MPa
Weld Length	$m = 7$ in	$m = 177.8$ mm
Weld Spacing	$n = 12$ in	$n = 304.8$ mm
Total Shear per Unit Length	$\tau' = 94.9$ K	$\tau' = 422.3$ kN
Minimum Weld Capacity	$V_{Rmin} = 6.94$ Kpi	$V_{Rmin} = 1.22$ KNpmm
Shear Resistance per Unit Length	$\tau_R = 97.2$ K	$\tau_R = 432.4$ kN

$Check\left(\tau_R \geq \tau'\right) = "...OK"$