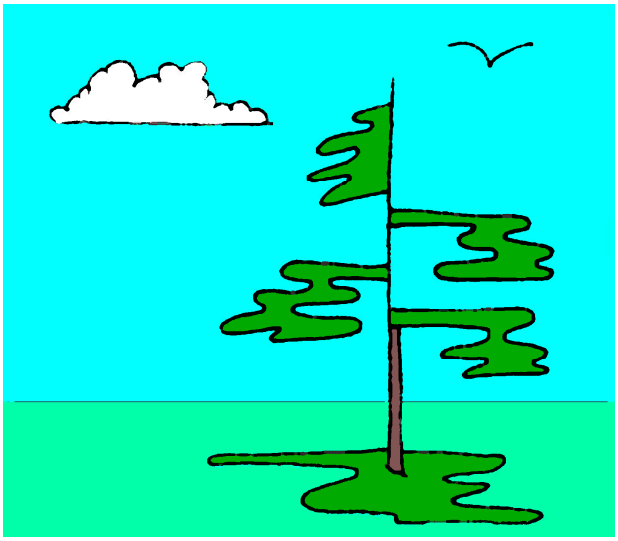
NorthWoods Software



Program Name: Chainlink_Fence

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 22.11.01

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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c b a

Input Data:

Material Property Factors:

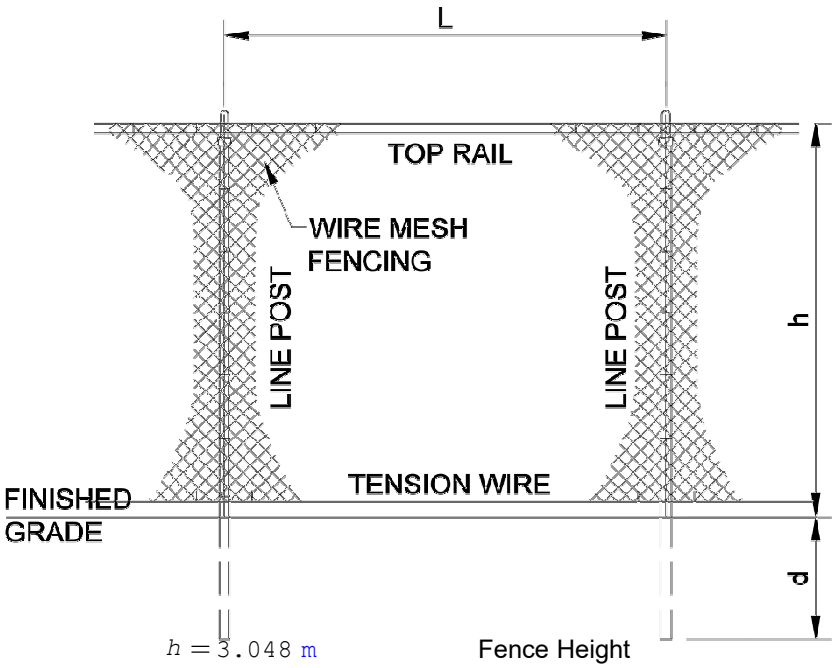
$\varphi_s := 0.90$	Steel
$\varphi_w := 0.67$	Weld
$\varphi_{sv} := 0.75$	Steel Shear

Load Factors:

$\alpha_D := 1.25$	Dead Load
$\alpha_L := 1.5$	Live Load
$SF := 1.67$	Safety Factor for ASD

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

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



Fence Dimensions:

$h := 10\ ft$	$h = 3.048\ m$	Fence Height
$B := 14\ ft$	$B = 4.267\ m$	Minimum Straight Run
$x := \frac{B}{h}$	$x = 1.40$	Ratio Min Spacing:h
$L := 9\ ft$	$L = 2.74\ m$	Line Post Spacing

Topography:

$V := 135\ mph$ $\quad V = 217\ kph$ Wind Speed

$K_{zt} := 1.00$ 26.8.2

$K_d := 0.85$ Table 26.6-1

$G := 0.85$ 26.9.1

Foundation Properties:

$\phi_{pile} := 12\ in$ $\quad \phi_{pile} = 304.8\ mm$ Diameter of Pile

$d_o := 54\ in$ $\quad d_o = 1371.6\ mm$ Original Length of Pile

$q_p := 200\ psf$ $\quad q_p = 9.58\ kPa$ Lateral Bearing Pressure

$F_{sa} := 1.0$ Soil Adjustment Factor

$q_{padj} := q_p \cdot F_{sa}$ $\quad q_{padj} = 200\ psf$ $\quad q_{padj} = 9.58\ kPa$ Adjusted Bearing Pressure

Foundation Restraint: $FC_{NDX} := 1$

NDX	Restrained
1	"Foundation Restrained"
2	"Foundation Not Restrained"

$F_{rest} := FC_{FC_{NDX}\ 2}$

Exposure: $Ex_{NDX} := 1$ Table 26.9.1

NDX	Exposure	α	Zg
1	"Exposure B"	7	1200 ft
2	"Exposure C"	9.5	900 ft
3	"Exposure D"	11.5	700 ft

$des_{Ex} := Ex_{Ex_{NDX}\ 2}$ $\quad \alpha := Ex_{Ex_{NDX}\ 3}$ $\quad z_g := Ex_{Ex_{NDX}\ 4}$

Mesh Size: $ms_{NDX} := 6$

NDX	Opening
1	"3/8"
2	"1/2"
3	"5/8"
4	"1"
5	"1-1/4"
6	"1-3/4"
7	"2"
8	"2-1/4"

$size := ms_{ms_{NDX}\ 2}$

Wire Size: $GA_{NDX} := 4$

NDX	Gauge
1	"5 GA"
2	"6 GA"
3	"8 GA"
4	"9 GA"
5	"10 GA"
6	"11 GA"

$ga := GA_{GA_{NDX}\ 2}$

Privacy Slats: $PS_{NDX} := 1$

NDX	Privacy
1	"No Privacy Slats"
2	"Privacy Slats"

$slats := PS_{PS_{NDX}\ 2}$

Velocity Exposure Pressure Coefficient (Kz):

if $h < 15\ ft$

$$K_z := 2.01 \cdot \left(\frac{15}{\frac{z_g}{ft}} \right)^{\frac{2}{\alpha}}$$

else

$$K_z := 2.01 \cdot \left(\frac{h}{\frac{z_g}{ft}} \right)^{\frac{2}{\alpha}}$$

$K_z = 0.57$

Post Steel Properties: $S_{pNDX} := 2$

NDX	Material	Yield
1	"Pipe STN"	30 Ksi
2	"Pipe STN HS"	50 Ksi
3	"HSS"	50 Ksi

$S_p :=$ (above)

$des_{sp} := S_{p\ S_{pNDX}\ 2}$ $f_{yp} := S_{p\ S_{pNDX}\ 3}$

Rail Steel Properties: $S_{pNDX} := 1$

$des_{sr} := S_{p\ S_{pNDX}\ 2}$ $f_{yr} := S_{p\ S_{pNDX}\ 3}$

Post and Rail:

Post: $HSS_{cNDX} := 4$

NDX	Size	Diameter	t	Sx
1	"1-5/8 STN"	1.66 in	0.140 in	0.235 in^3
2	"1-7/8 STN"	1.90 in	0.145 in	0.326 in^3
3	"2-3/8 STN"	2.375 in	0.154 in	0.561 in^3
4	"2-7/8 STN"	2.875 in	0.203 in	1.064 in^3
5	"3-1/2 STN"	3.50 in	0.216 in	1.724 in^3
6	"4 STN"	4.00 in	0.226 in	2.394 in^3
7	"4-1/2 STN"	4.50 in	0.237 in	3.215 in^3
8	"6-5/8 STN"	6.625 in	0.280 in	8.496 in^3
9	"8-5/8 STN"	8.625 in	0.322 in	16.809 in^3
10	"1-5/8 HSS"	1.66 in	0.111 in	0.196 in^3
11	"1-7/8 HSS"	1.90 in	0.120 in	0.281 in^3
12	"2-3/8 HSS"	2.375 in	0.130 in	0.488 in^3
13	"2-7/8 HSS"	2.875 in	0.160 in	0.878 in^3
14	"3-1/2 HSS"	3.50 in	0.160 in	1.341 in^3
15	"4 HSS"	4.00 in	0.160 in	1.782 in^3
16	"4-1/2 HSS"	4.50 in	0.160 in	2.286 in^3

$HSS_c :=$ (above)

$des_p := HSS_{c\ HSS_{cNDX}\ 2}$ $\phi_p := HSS_{c\ HSS_{cNDX}\ 3}$

$t_p := HSS_{c\ HSS_{cNDX}\ 4}$ $Sx_p := HSS_{c\ HSS_{cNDX}\ 5}$

Rail: $HSS_{cNDX} := 5$ $des_r := HSS_{c\ HSS_{cNDX}\ 2}$ $\phi_r := HSS_{c\ HSS_{cNDX}\ 3}$ $t_r := HSS_{c\ HSS_{cNDX}\ 4}$ $Sx_r := HSS_{c\ HSS_{cNDX}\ 5}$

Cf:

```
if x ≤ 0.05
  C_f := 1.8
else
  if x ≤ 0.1
    C_f := 1.8 + (1.7 − 1.8) · (x − .05) / (.1 − .05)
  else
    if x ≤ 0.2
      C_f := 1.7 + (1.65 − 1.7) · (x − .1) / (.2 − .1)
    else
      if x ≤ 0.5
        C_f := 1.65 + (1.55 − 1.65) · (x − .2) / (.5 − .2)
      else
        if x ≤ 1
          C_f := 1.55 + (1.45 − 1.55) · (x − .5) / (1 − .5)
        else
          if x ≤ 2
            C_f := 1.45 + (1.4 − 1.45) · (x − 1) / (2 − 1)
          else
            if x ≤ 4
              C_f := 1.4 + (1.35 − 1.4) · (x − 2) / (4 − 2)
            else
              if x ≤ 5
                C_f := 1.35
              else
                if x ≤ 10
                  C_f := 1.35 + (1.3 − 1.35) · (x − 5) / (10 − 5)
                else
                  if x ≤ 1000
                    C_f := 1.3
                  else
                    dummy := 0
```

$C_f = 1.43$

qz and qasd:

$q_z := 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot \left(\frac{V}{\text{mph}}\right)^2 \text{ psf}$

$q_z = 22.79 \text{ psf}$ $\quad q_z = 1.09 \text{ kPa}$

$q_{asd} := 0.6 \cdot q_z$ $\quad q_{asd} = 13.68 \text{ psf}$ $\quad q_{asd} = 0.65 \text{ kPa}$

Cf1:

$C''_{f1} :=$

		3/8	1/2	5/8	1	1-1/4	1-3/4	2	2-1/4
1	"5 GA"	.01	.01	.01	2.92	3.52	4.73	5.33	5.92
2	"6 GA"	.01	.01	.01	3.3	3.75	5.06	5.71	6.37
3	"8 GA"	.01	.01	.01	3.58	4.36	5.89	6.67	7.44
4	"9 GA"	1.77	2.2	2.6	3.87	4.73	6.4	7.26	8.09
5	"10 GA"	1.88	2.36	2.8	4.19	5.13	6.96	7.9	8.82
6	"11 GA"	2.06	2.6	3.1	4.65	5.71	7.77	8.83	9.86
7	"12 GA"	2.16	2.72	3.25	4.91	6.04	8.22	9.35	10.44

$C_{f1} := C''_{f1\, GA_{NDX}\, ms_{NDX}} + 2$

$C_{f1} = 6.40$

Design of Post (ASD):

$A_{tp} := L \cdot h$ $A_{tp} = 90.00\ ft^2$ $A_{tp} = 8.36\ m^2$ Tributary Area on Post

$P_s := A_{tp} \cdot q_{asd} \cdot G \cdot C_f$ $P_s = 1.50\ K$ $P_s = 6.65\ kN$ Force on Solid Fence

$F_{wl} := \frac{1}{C_{f1}}$ $F_{wl} = 0.16$ Wind Load Factor

$P_p := F_{wl} \cdot P_s$ $P_p = 0.23\ K$ $P_p = 1.04\ kN$ Force on Perforated Fence

$c := 0.55 \cdot h$ $c = 5.50\ ft$ $c = 1.68\ m$ Ht of Result Force Fig. 29.4-1

```
if PS_NDX = 1
  M_p := c · P_p
else
  M_p := c · P
```

$M_p = 1.29\ K\_ft$ $M_p = 1.74\ kN\_m$ Overturning Moment at Grade

$M_{rp} := \frac{f_{yp} \cdot Sx_p}{SF}$ $M_{rp} = 2.65\ K\_ft$ $M_{rp} = 3.60\ kN\_m$ Safe Resisting Moment

Design of Rail (ASD):

$w_{tr} := \frac{h}{2}$ $w_{tr} = 5\ ft$ $w_{tr} = 1.524\ m$ Tributary Width on Rail

$q_r := w_{tr} \cdot q_{asd}$ $q_r = 68.38\ plf$ $q_r = 1.00\ kNpm$

$M_r := \frac{q_r \cdot L^2}{8}$ $M_r = 0.69\ K\_ft$ $M_r = 0.94\ kN\_m$ Bending Moment of Rail

$M_{rr} := \frac{f_{yr} \cdot Sx_r}{SF}$ $M_{rr} = 2.58\ K\_ft$ $M_{rr} = 3.50\ kN\_m$ Safe Resisting Moment

Design of Foundation:

$$d_r := \left(\left(\frac{4.25 \cdot \frac{M_p}{lb\_in}}{\frac{q_p}{psf} \cdot \frac{\phi_{pile}}{in}} \right) \right)^{\frac{1}{3}} ft$$

$d_r = 3.01\ ft$ $d_r = 0.918\ m$ Restrained Foundation Depth

Variables are made unitless to speed up calculations in the 'for' looping series

$d' := \frac{d_r}{ft}$ $d' = 3.01$

$q'_p := \frac{q_p}{psf}$ $q'_p = 200.00$

$P' := \frac{P_p}{lbf}$ $P' = 233.75$

$\phi'_{pile} := \frac{\phi_{pile}}{in}$ $\phi'_{pile} = 12.00$

$c' := \frac{c}{ft}$ $c' = 5.50$

$S_i := \frac{q'_p \cdot d'}{3}$ $S_i = 200.79$

$A_i := \frac{(2.34 \cdot P' \cdot 12)}{\frac{q'_p \cdot d'}{3} \cdot \phi'_{pile}} = 2.72$ $A_i = 2.72$

$$d_i := 0.5 \cdot A_i \cdot \left(1 + \left(1 + \left(\frac{4.36 \cdot \frac{c}{ft}}{A_i} \right) \right)^{.5} \right)$$

$d_i = 5.63$

for $count \in [1..10]$

$$S := \frac{q'_p \cdot d_i}{3}$$

$$A := \frac{(2.34 \cdot P' \cdot 12)}{\frac{q'_p \cdot d_i}{3} \cdot \phi'_{pile}}$$

$$d := 0.5 \cdot A \cdot \left(1 + \left(1 + \left(\frac{4.36 \cdot c'}{A}\right)\right)^{.5}\right)$$

$$d_i := d$$

10 Iterations should be reasonably close and takes several seconds. Additional iterations take a much greater time to calculate.

$d_u := d$ ft $\quad d_u = 4.41$ ft $\quad d_u = 1.35$ m Un-restrained Footing Depth

Summary:

Material Property Factor

$\varphi_s = 0.9$ (Steel)

$\varphi_{sv} = 0.75$ (Steel Shear)

$\varphi_w = 0.67$ (Weld)

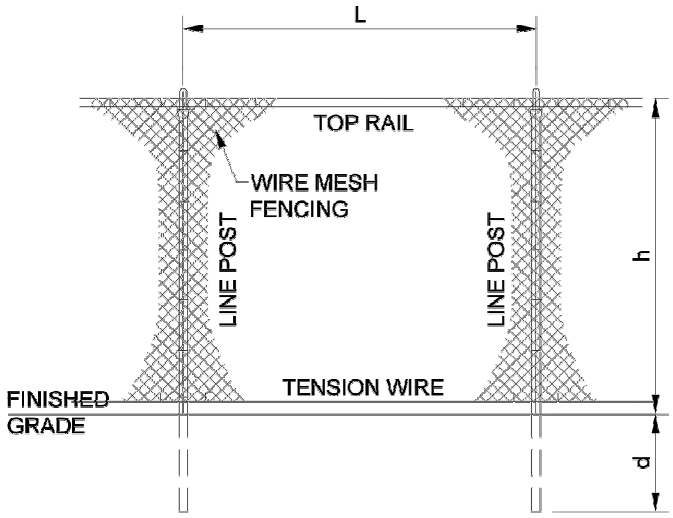
Load Factors

Dead Load $\alpha_D = 1.25$

Live Load $\alpha_L = 1.5$

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

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



Wind Load Topography:

Wind Speed	$V = 135$ mph	$V = 217$ kph
ASCE 7 26.8.2	$K_{zt} = 1.00$	
ASCE 7 Table 26.6-1	$K_d = 0.85$	
ASCE 7 26.9.1	$G = 0.85$	
ASCE 7 Table 26.9.1 Exposure	$des_{Ex} = "Exposure\ B"$	
α Coefficient ASCE 7 Table 26.9.1	$\alpha = 7$	
zg Coefficient ASCE 7 Table 26.9.1	$z_g = 1200$ ft	$z_g = 366$ m
Velocity Exposure Pressure Coefficient	$K_z = 0.57$	
Wind Pressure (Limit States)	$q_z = 22.8$ psf	$q_z = 1.09$ kPa
Wind Pressure (ASD)	$q_{asd} = 13.7$ psf	$q_{asd} = 0.65$ kPa

Fence Properties

Fence Height	$h = 10$ ft	$h = 3.048$ m
Minimum Straight Run	$B = 14$ ft	$B = 4.267$ m
Line Post Spacing	$L = 9$ ft	$L = 2.7432$ m
Mesh Opening Size	$size = "1\text{-}3/4"$	
Mesh Gauge	$ga = "9\ GA"$	
Privacy Slats	$slats = "No\ Privacy\ Slats"$	

Steel Post Properties

Steel Post Material	$des_{sp} = "Pipe\ STN\ HS"$	
Steel Post Yield Strength	$f_{yp} = 50$ Ksi	$f_{yp} = 345$ MPa
Post Designation	$des_p = "2\text{-}7/8\ STN"$	
Post Diameter	$\phi_p = 2.88$ in	$\phi_p = 73.0$ mm
Post Thickness	$t_p = 0.20$ in	$t_p = 5.2$ mm
Post Section Modulus	$Sx_p = 1.06\ in^3$	$Sx_p = 17436\ mm^3$

Steel Rail Properties

Steel Post Material	$des_{sr} = "Pipe\ STN"$	
Steel Post Yield Strength	$f_{yr} = 30$ Ksi	$f_{yr} = 207$ MPa
Rail Designation	$des_r = "3\text{-}1/2\ STN"$	

Rail Diameter	$\phi_r = 3.50\ in$	$\phi_r = 88.9\ mm$
Rail Thickness	$t_r = 0.22\ in$	$t_r = 5.5\ mm$
Rail Section Modulus	$Sx_r = 1.72\ in^3$	$Sx_r = 28251\ mm^3$

Foundation Properties

Diameter of Pile	$\phi_{pile} = 12\ in$	$\phi_{pile} = 304.8\ mm$
Original Length of Pile	$d_o = 54\ in$	$d_o = 1371.6\ mm$
Lateral Bearing Pressure	$q_p = 200\ psf$	$q_p = 9.5761\ kPa$
Soil Adjustment Factor	$F_{sa} = 1.00$	
Adjusted Bearing Pressure	$q_{padj} = 200\ psf$	$q_{padj} = 9.5761\ kPa$
Foundation Restraint	$F_{rest} =$ "Foundation Restrained"	

Fence Design

Effect of Openings in Mesh on Wind Load Coef	$C_{f1} = 6.4$	
Wind Load Factor	$F_{wl} = 0.1562$	
Wind Force on Solid Fence	$P_s = 1.50\ K$	$P_s = 6.65\ kN$
Wind Force on Perforated Fence	$P_p = 0.23\ K$	$P_p = 1.04\ kN$
Post Overturning Moment at Grade	$M_p = 1.29\ K\_ft$	$M_p = 1.74\ kN\_m$
Post Safe Resisting Moment	$M_{rp} = 2.65\ K\_ft$	$M_{rp} = 3.60\ kN\_m$

$Check\left(M_{rp} \geq M_p\right) =$ "...OK"

Bending Moment of Rail	$M_r = 0.69\ K\_ft$	$M_r = 0.94\ kN\_m$
Safe Resisting Moment	$M_{rr} = 2.58\ K\_ft$	$M_{rr} = 3.50\ kN\_m$

$Check\left(M_{rr} \geq M_r\right) =$ "...OK"

c b a

Foundation Design

Restrained Foundation Depth	$d_r = 3.01\ ft$	$d_r = 0.918\ m$

$Check\left(d_r \leq d_o\right) =$ "...OK"

Un-restrained Footing Depth	$d_u = 4.41\ ft$	$d_u = 1.345\ m$

$Check\left(d_u \leq d_o\right) =$ "...OK"