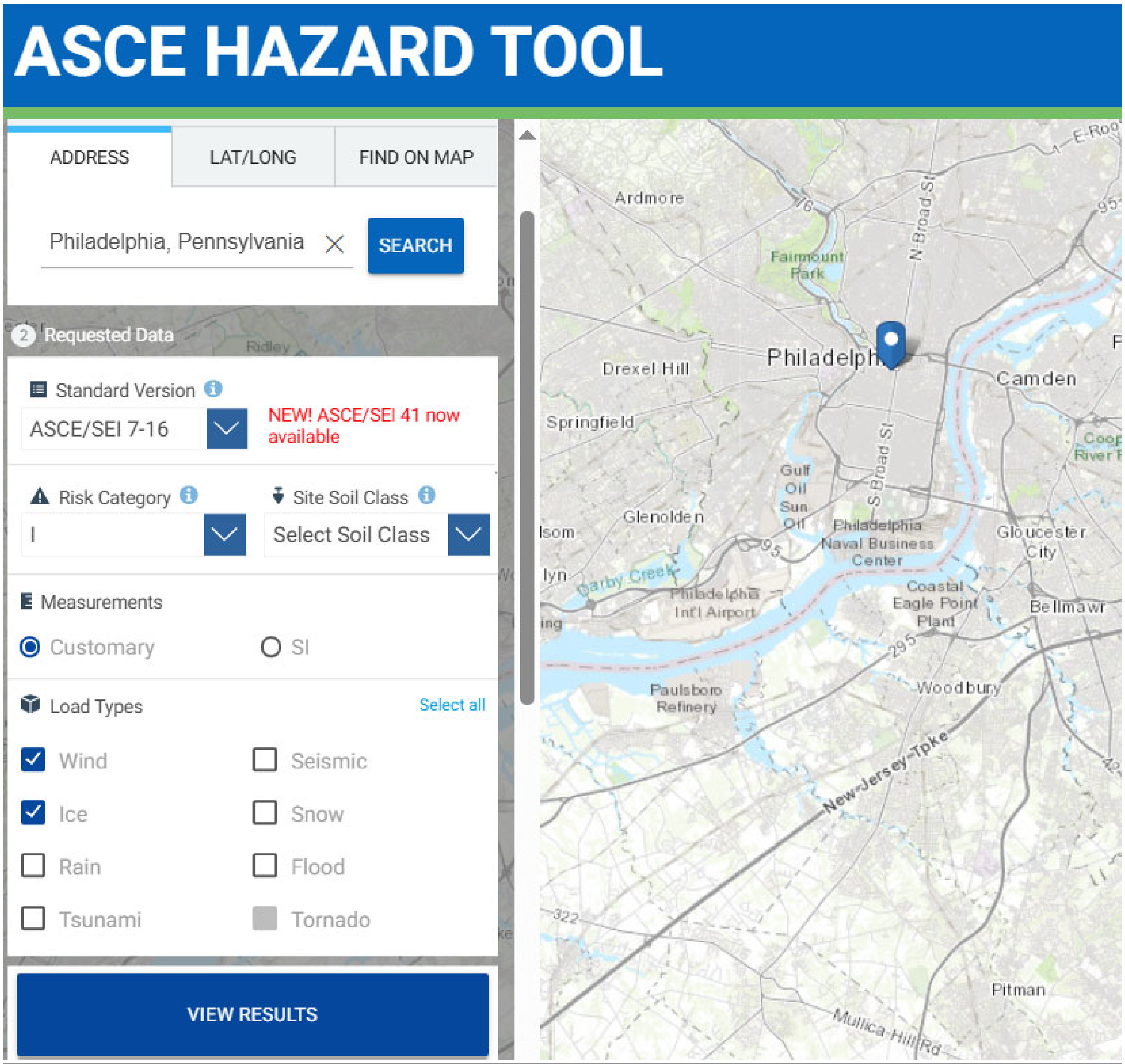
Example 3 – hand calculations – open fencing for wind loading – solid / mostly solid fencing for wind on ice loading

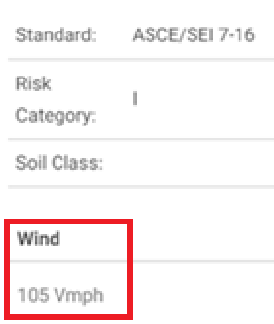
10’ high chain link fence 9Ga 1-3/4” mesh 96’ long 8’ post spacing

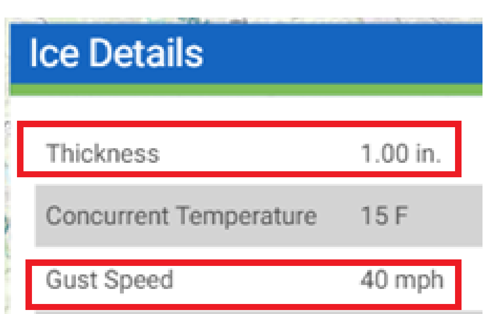
Site Location - Philadelphia, PA Exposure C Risk Category I Flat ground

**PENNSYLVANIA**
2018 International Building Code (at the time of this writing) For IBC 2018 & 2021 use ASCE 7-16

https://asce7hazardtool.online/



| $q_w$ Values | |
|---|---|
| $V_w$ (mph) | $q_w$ (psf) |
| 85 | 8.02 |
| 90 | 8.99 |
| 95 | 10.02 |
| 100 | 11.10 |
| 105 | 12.24 |
| 110 | 13.43 |
| 115 | 14.68 |
| 120 | 15.98 |
| 130 | 18.75 |
| 140 | 21.75 |

| $q_i$ Values | |
|---|---|
| $V_i$ (mph) | $q_i$ (psf) |
| 30 | 1.17 |
| 40 | 2.07 |
| 50 | 3.24 |
| 60 | 4.66 |
| 70 | 6.34 |
| 80 | 8.29 |

| $K_z$ Values for ASCE 7-10 & 7-16 | | | |
|---|---|---|---|
| Fence | Exposure Class | | |
| Height, h (ft) | B | C | D |
| 0-15 | 0.57 | 0.85 | 1.03 |
| 16 | 0.59 | 0.86 | 1.04 |
| 17 | 0.60 | 0.87 | 1.05 |
| 18 | 0.61 | 0.88 | 1.06 |
| 19 | 0.61 | 0.89 | 1.07 |
| 20 | 0.62 | 0.90 | 1.08 |

| $K_e$ Values | | |
|---|---|---|
| Site | ASCE | |
| Elevation | 7-16 & 7-22 | 7-10 |
| $z_e$ (ft) | $K_e$ | $K_e$ = 1.0 |
| 0 | 1.00 | 1.00 |
| 500 | 0.98 | 1.00 |
| 1,000 | 0.96 | 1.00 |
| 1,500 | 0.95 | 1.00 |
| 2,000 | 0.93 | 1.00 |
| 2,500 | 0.91 | 1.00 |
| 3,000 | 0.90 | 1.00 |
| 3,500 | 0.88 | 1.00 |
| 4,000 | 0.87 | 1.00 |
| 4,500 | 0.85 | 1.00 |
| 5,000 | 0.84 | 1.00 |

| $K_{zt}$ = 1.0 for flat ground |
|---|
| See ASEC 7 Fig. 26.8-1 to calculate $K_{zt}$ values for site locations on hills or escarpments |

## 1-3/4" Chain Link Mesh Variables 11-1/2 ga to 5 ga

| 1-3/4" Mesh Wind & Weight Values | | | | |
|---|---|---|---|---|
| Gauge | Dia (in) | ε | $C_{fw}$ | $D_m$ (psf) |
| 5 | 0.207 | 0.22 | 1.3 | 1.9 |
| 6 | 0.192 | 0.21 | 1.3 | 1.6 |
| 8 | 0.162 | 0.18 | 1.3 | 1.2 |
| 9 | 0.148 | 0.16 | 1.3 | 1.0 |
| 10 | 0.135 | 0.15 | 1.3 | 0.8 |
| 11 | 0.120 | 0.13 | 1.3 | 0.6 |
| 11-½ | 0.113 | 0.12 | 1.3 | 0.6 |

ε = solidity ratio for chain link
ε' = solidity ratio for iced chain link
$C_{fw}$ = wind force coefficient
$C_{fi}$ = wind on ice force coefficient
$D_m$ = estimated weight of chain link mesh
Check with supplier for actual weight
$D_i$ = estimated weight of ice (includes 0.7 ASD factor)
The values below are only valid for Risk Category I and $K_{zt}$ = 1.0
For ice thickness not shown below, round up to next nearest value

| 1-3/4" Mesh (all gauges) Estimated Ice Loading Risk Category I $K_{zt}$ = 1.0 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASCE 7-10 Nominal Ice Thickness, t (in) | Fence Height, h | | | | | | | | | | | |
| | 5' | | | 10' | | | 15' | | | 20' | | |
| | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) |
| 0.25 | 0.69 | 1.5 | 1.5 | 0.72 | See solid wall $C_{fi}$ table below | 1.7 | 0.73 | See solid wall $C_{fi}$ table below | 1.8 | 0.74 | See solid wall $C_{fi}$ table below | 1.8 |
| 0.50 | 0.95 | See solid wall $C_{fi}$ table below | 4.0 | 0.97 | | 4.4 | 0.98 | | 4.6 | 0.99 | | 4.8 |
| 0.75 | 1.00 | | 6.8 | 1.00 | | 7.4 | 1.00 | | 7.9 | 1.00 | | 8.2 |
| 1.00 | 1.00 | | 9.8 | 1.00 | | 10.6 | 1.00 | | 11.1 | 1.00 | | 11.5 |
| 1.25 | 1.00 | | 12.6 | 1.00 | | 13.6 | 1.00 | | 14.2 | 1.00 | | 14.7 |
| 1.50 | 1.00 | | 15.4 | 1.00 | | 16.6 | 1.00 | | 17.4 | 1.00 | | 17.9 |
| ASCE 7-16 Nominal Ice Thickness, t (in) | Fence Height, h | | | | | | | | | | | |
| | 5' | | | 10' | | | 15' | | | 20' | | |
| | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) | ε' | $C_{fi}$ | $D_i$ (psf) |
| 0.25 | 0.47 | 1.5 | 0.6 | 0.49 | 1.5 | 0.6 | 0.50 | 1.5 | 0.7 | 0.51 | 1.5 | 0.7 |
| 0.50 | 0.69 | 1.5 | 1.5 | 0.72 | See solid wall $C_{fi}$ ... | 1.7 | 0.73 | See solid wall $C_{fi}$ ... | 1.8 | 0.74 | See solid wall $C_{fi}$ ... | 1.8 |
| 0.75 | 0.85 | See solid wall $C_{fi}$ ... | 2.7 | 0.88 | | 3.0 | 0.89 | | 3.1 | 0.90 | | 3.3 |
| 1.00 | 0.95 | | 4.0 | 0.97 | | 4.4 | 0.98 | | 4.6 | 1.00 | | 4.8 |
| 1.25 | 1.00 | | 5.3 | 1.00 | | 5.8 | 1.00 | | 6.1 | 1.00 | | 6.4 |
| 1.50 | 1.00 | | 6.8 | 1.00 | | 7.4 | 1.00 | | 7.9 | 1.00 | | 8.2 |

ε = 0.16 $C_{fw}$ = 1.3 $D_w$ = 1.0 psf ε' = 0.97 $C_{fi}$ value determined on following pages $D_i$ = 4.4 psf

For wind, $R_{1w} = 1.0$ For an open fence (e.g. chain link) with a Solidity Ratio, ε or ε′ ≤ 0.7, $R_1 = 1.0$.

For wind on ice, $R_{1i} = 1.01$ ( see below)

Case C Reduction Factor $R_{2i} = 0.8$ Return Corner Reduction Factor, $F_{3i} = 1.0$ as there is no return corner

Case C does not apply to the un-iced condition as the solidity ratio, $\varepsilon \leq 0.7$, so $R_{2w}$ & $R_{3w}$ are N/A

Inverted Fence Opening Reduction Factor, $R_1$

| ε or ε' | $R_1$ | ε or ε' | $R_1$ |
|---|---|---|---|
| 0.71 | 1.19 | 0.86 | 1.06 |
| 0.72 | 1.17 | 0.87 | 1.05 |
| 0.73 | 1.16 | 0.88 | 1.04 |
| 0.74 | 1.15 | 0.89 | 1.04 |
| 0.75 | 1.14 | 0.90 | 1.03 |
| 0.76 | 1.13 | 0.91 | 1.03 |
| 0.77 | 1.12 | 0.92 | 1.02 |
| 0.78 | 1.12 | 0.93 | 1.02 |
| 0.79 | 1.11 | 0.94 | 1.01 |
| 0.80 | 1.10 | 0.95 | 1.01 |
| 0.81 | 1.09 | 0.96 | 1.01 |
| 0.82 | 1.08 | 0.97 | 1.01 |
| 0.83 | 1.08 | 0.98 | 1.00 |
| 0.84 | 1.07 | 0.99 | 1.00 |
| 0.85 | 1.06 | 1.00 | 1.00 |

$R_{1w} = 1 / (1 - (1 - \varepsilon)^{1.5})$

$R_{1i} = 1 / (1 - (1 - \varepsilon')^{1.5})$

| Case C Reduction Factor, $R_2$ | |
|---|---|
| s/h | $R_2$ |
| 1.000 | 0.80 |
| 0.975 | 0.83 |
| 0.950 | 0.85 |
| 0.925 | 0.88 |
| 0.900 | 0.90 |
| 0.875 | 0.93 |
| 0.850 | 0.95 |
| 0.825 | 0.98 |
| ≥ 0.800 | 1.00 |
| $R_2 = (1.8 - s/h) \leq 1.0$ | |

For wind loading, $F_{hw} = 1.0$ For an open fence (e.g. chain link) with a Solidity Ratio, ε or ε' ≤ 0.7, $F_h = 1.0$

| Force Height Adjustment Factor, $F_h$ | | |
|---|---|---|
| s/h | $F_h$ | Notes |
| 1.000 | 1.100 | Per Solid Wall Table, Note 3 |
| 0.975 | 1.025 | $F_h = 2 - s/h$ |
| 0.950 | 1.050 | |
| 0.925 | 1.075 | |
| 0.900 | 1.100 | |
| 0.875 | 1.125 | |
| 0.850 | 1.150 | |
| 0.825 | 1.175 | |
| 0.800 | 1.200 | |

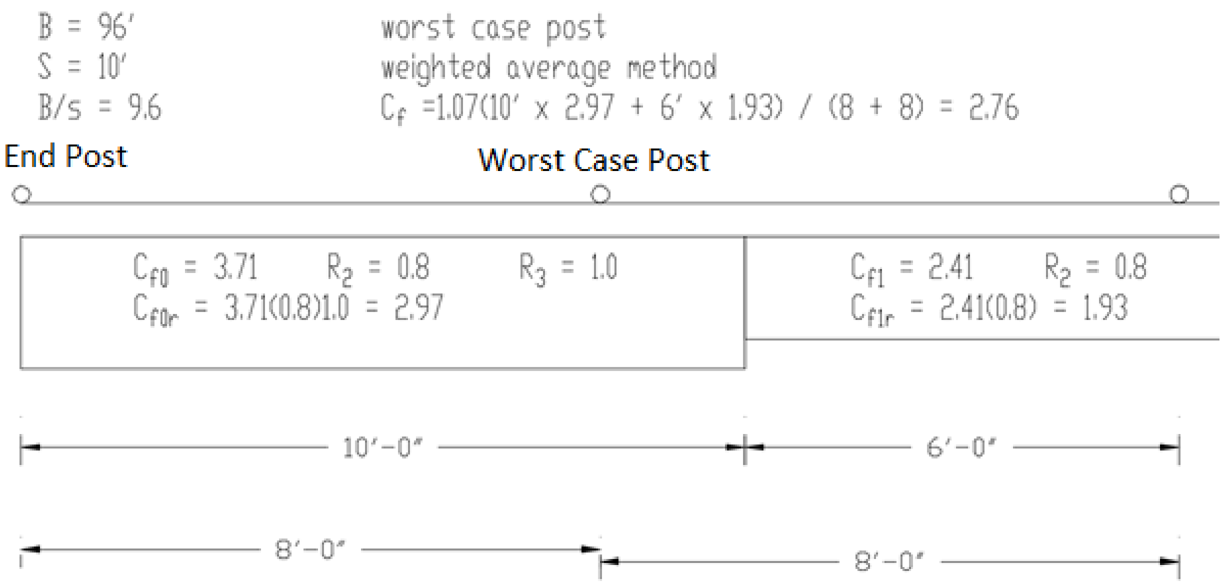
For wind on Ice Loading, $F_{hi} = 1.1$

Fence Length, B = 96 ft Fencing Height, s = 10’ Aspect Ratio B/s = 9.6

| $C_f$ values - Solid / Mostly Solid Fencing - Case C - Posts near ends and corners | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind | Aspect Ratio, B/s | | | | | | | | | | |
| Region | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 0 to s | 2.25 | 2.60 | 2.90 | 3.10* | 3.30* | 3.40* | 3.55* | 3.65* | 3.75* | 3.83* | 3.92* |
| s to 2s | 1.50 | 1.70 | 1.90 | 2.00 | 2.15 | 2.25 | 2.30 | 2.35 | 2.45 | 2.49 | 2.53 |
| 2s to 3s | - | 1.15 | 1.30 | 1.45 | 1.55 | 1.65 | 1.70 | 1.75 | 1.85 | 1.89 | 1.93 |
| > 3s | - | - | 1.10 | 1.05 | 1.05 | 1.05 | 1.05 | 1.00 | 0.95 | 1.13 | 1.32 |

You can conservatively use the highest $C_f$ value of intermediate B/s values, for example, for the 0 to s Region, $C_f = 3.75$ is acceptable. Values on the following page are more economical interpolated $C_f$ values.

For solid / mostly solid fencing, the post with the highest wind loading is typically the 1st post in from the end of the longest fence run. Return corners reduce the forces so for complicated fencing, multiple checks may need to be done to find the worst case post. In this case, a straight fence with no corners, the posts next to the end posts have the highest loading. End post get higer wind pressures, but only half the wind area.




$C_{fi}$ for the worst case post = 2.76 $f_i$ & $p_i$ values below are from the worksheet on the following pages

Ice loading controls $f_i$ = 419 lbs $p_i$ = 432 lbs 5 x $p_i$ = 2,160 lbs desired post diameter, 2-7/8"

Lightest post that looks possible is 40 wt, / ASTM F1043 / Group 1C / 50 ksi

**Allowable Wind Force at Mid-height, $F_a$ (lbs) & Allowable Axial Force, $P_a$ (lbs) - Group IA and IC Posts**

| Post Size | Weight, $D_p$ lbs / ft | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fence Height, H (ft) | | | | | | | | | | | | | | | |
| Schedule 40 / ASTM F1043 / Group 1A / 30 ksi | | | | | | | | | | | | | | | | | | |
| 1-5/8" | 2.3 | $F_a$ | 182 | 152 | 130 | 114 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | $P_a$ | 1,745* | 1,212* | 890* | 681* | - | - | - | - | - | - | - | - | - | - | - | - |
| 1-7/8" | 2.7 | $F_a$ | 252 | 210 | 180 | 157 | 140 | - | - | - | - | - | - | - | - | - | - | - |
| | | $P_a$ | 2,773* | 1,926* | 1,415* | 1,083* | 856* | - | - | - | - | - | - | - | - | - | - | - |
| 2-3/8" | 3.7 | $F_a$ | 427 | 356 | 305 | 267 | 237 | 213 | 194 | 178 | - | - | - | - | - | - | - | - |
| | | $P_a$ | 5,943 | 4,127 | 3,032* | 2,321* | 1,834* | 1,485* | 1,227* | 1,031* | - | - | - | - | - | - | - | - |
| 2-7/8" | 5.8 | $F_a$ | 817 | 680 | 583 | 510 | 453 | 408 | 371 | 340 | 314 | 291 | 272 | - | - | - | - | - |
| | | $P_a$ | 13,272 | 9,494 | 6,975 | 5,340* | 4,219* | 3,418* | 2,824* | 2,373* | 2,022* | 1,743* | 1,519* | - | - | - | - | - |
| 3-1/2" | 7.6 | $F_a$ | 1,310 | 1,092 | 936 | 819 | 728 | 655 | 595 | 546 | 504 | 468 | 436 | 409 | 385 | 364 | - | - |
| | | $P_a$ | 22,458 | 17,944 | 13,733 | 10,514 | 8,307 | 6,729* | 5,561* | 4,673* | 3,981* | 3,433* | 2,990* | 2,628* | 2,328* | 2,076* | - | - |
| 4" | 9.1 | $F_a$ | 1,809 | 1,507 | 1,292 | 1,130 | 1,005 | 904 | 822 | 753 | 695 | 646 | 603 | 565 | 532 | 502 | 476 | 452 |
| | | $P_a$ | 30,535 | 25,757 | 21,064 | 16,666 | 13,168 | 10,666 | 8,815* | 7,407* | 6,311* | 5,442* | 4,740* | 4,166* | 3,690* | 3,292* | 2,954* | 2,666* |
| 4-1/2" | 10.8 | $F_a$ | 2,419 | 2,016 | 1,728 | 1,512 | 1,344 | 1,209 | 1,099 | 1,008 | 930 | 864 | 806 | 756 | 711 | 672 | 636 | 604 |
| | | $P_a$ | 39,301 | 34,390 | 29,370 | 24,481 | 19,876 | 16,100 | 13,305 | 11,180 | 9,526* | 8,214* | 7,155* | 6,289* | 5,570* | 4,969* | 4,459* | 4,025* |
| 5-9/16" | 14.6 | $F_a$ | 4,069 | 3,391 | 2,906 | 2,543 | 2,260 | 2,034 | 1,849 | 1,695 | 1,565 | 1,453 | 1,356 | 1,271 | 1,196 | 1,130 | 1,070 | 1,017 |
| | | $P_a$ | 59,190 | 54,288 | 49,016 | 43,565 | 38,117 | 32,830 | 27,809 | 23,367 | 19,910 | 17,167 | 14,955* | 13,144* | 11,643* | 10,385* | 9,321* | 8,412* |
| 6-5/8" | 19.0 | $F_a$ | 6,319 | 5,266 | 4,514 | 3,949 | 3,511 | 3,159 | 2,872 | 2,633 | 2,430 | 2,257 | 2,106 | 1,974 | 1,858 | 1,755 | 1,663 | 1,579 |
| | | $P_a$ | 81,532 | 76,751 | 71,462 | 65,810 | 59,943 | 54,002 | 48,119 | 42,408 | 36,967 | 31,890 | 27,780 | 24,416 | 21,628 | 19,291* | 17,314* | 15,626* |
| 8-5/8" | 28.6 | $F_a$ | 12,434 | 10,362 | 8,881 | 7,771 | 6,908 | 6,217 | 5,652 | 5,181 | 4,782 | 4,440 | 4,144 | 3,885 | 3,657 | 3,454 | 3,272 | 3,108 |
| | | $P_a$ | 129,849 | 125,342 | 120,217 | 114,564 | 108,477 | 102,056 | 95,401 | 88,609 | 81,773 | 74,982 | 68,314 | 61,841 | 55,623 | 49,640 | 44,552 | 40,208 |
| 40 Weight / ASTM F1043 / Group 1C / 50 ksi | | | | | | | | | | | | | | | | | | |
| 1-5/8" | 1.8 | $F_a$ | 244 | 203 | 174 | 152 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | $P_a$ | 1,455* | 1,010* | 742* | 568* | - | - | - | - | - | - | - | - | - | - | - | - |
| 1-7/8" | 2.3 | $F_a$ | 350 | 292 | 250 | 219 | 194 | 175 | - | - | - | - | - | - | - | - | - | - |
| | | $P_a$ | 2,385 | 1,656* | 1,217* | 931* | 736* | 596* | - | - | - | - | - | - | - | - | - | - |
| 2-3/8" | 3.1 | $F_a$ | 608 | 507 | 434 | 380 | 338 | 304 | 276 | 253 | - | - | - | - | - | - | - | - |
| | | $P_a$ | 5,178 | 3,596 | 2,642* | 2,022* | 1,598* | 1,294* | 1,069* | 899* | - | - | - | - | - | - | - | - |
| 2-7/8" | 4.6 | $F_a$ | 1,095 | 912 | 782 | 684 | 608 | 547 | 497 | 456 | 421 | 391 | 365 | - | - | - | - | - |
| | | $P_a$ | 11,274 | 7,829 | 5,752 | 4,404* | 3,479* | 2,818* | 2,329* | 1,957* | 1,667* | 1,438* | 1,252* | - | - | - | - | - |
| 4" | 6.6 | $F_a$ | 2,222 | 1,852 | 1,587 | 1,389 | 1,234 | 1,111 | 1,010 | 926 | 854 | 793 | 740 | 694 | 653 | 617 | 584 | 555 |
| | | $P_a$ | 28,899 | 22,018 | 16,247 | 12,439 | 9,828 | 7,961 | 6,579* | 5,528* | 4,710* | 4,061* | 3,538* | 3,109* | 2,754* | 2,457* | 2,205* | 1,990* |

Hand calculations on the following pages using the worksheets provided on the "Instructions" page of FenceDesign.com

# Worksheet – Open / Mostly Solid / Solid Fencing – Wind and Wind & Ice Loading

**Site Location:** Phladelphia, PA

**FenceDesign.com**

**Customer:**

## Site and Geometrical Variables

IBC 2018 ASCE 7- 16 Risk Category I Frost Depth 2.5 ft

Basic Wind Speed, $V_w$ = 105 mph Nominal Ice Thickness, t = 1.0 in

Gust / Concurrent Wind Speed for Ice Loading, $V_i$ = 40 mph

Wind Pressure, $q_w$ = 12.24 psf Wind on Ice Pressure, $q_i$ = 2.07 psf

Exposure Category C Topographical Factor, $K_{zt}$ = 1.0

Site Elevation, $Z_e$ = 44' ft Elevation Factor, $K_e$ = 1.0

Height of fence, h = 10 ft Gap at bottom of fence, g = 0 ft (zero if no gap)

Height of fencing material, s = h - g = 10 ft

Velocity Pressure Exposure Coefficient, $K_z$ = 0.85

## Wind & Axial Loading

Fence Run # 1 Length of Fence, $B =$ 96 ft Post spacing, $L =$ 8 ft

Post Type: Line Posts (X) Post near end or corner ( )

Solidity Ratio, $\varepsilon =$ 0.16 Inverted Fence Opening Reduction Factor, $R_{1w} =$ 1.0

Case C Reduction Factor, $R_{2w} =$ N/A Return Corner Reduction Factor, $R_{3w} =$ N/A

Force Height Adjustment Factor, $F_{hw} =$ 1.0 Wind Force Coefficient, $C_{fw} =$ 0.13

Expected Post Diameter or Width, $\varnothing_p =$ 2.875 in (Set to Zero for solid / mostly solid fencing)

Top Rail Diameter or Width, $\varnothing_r =$ 1.625 in Mid Rail Diameter or Width, $\varnothing_p =$ 1.625 in

($\varnothing_r$ & $\varnothing_m$ – set to Zero if not applicable for rails or for solid / mostly solid fencing)

Wind Area of Post, $A_p = \varnothing_p / 12 \times h = \underset{\varnothing_p}{2.875"} \div 12 \times \underset{h}{10'} = \underset{A_p}{2.40}\ ft^2$

($A_p = 0$ for solid / mostly solid fencing)

Wind Area of Rails, $A_r = (\varnothing_r / 12) \times 2 \times L + (\varnothing_m / 12) \times L$ ($A_r = 0$ for solid / mostly solid fencing)

$$A_r = (\underset{\varnothing_r}{1.625"} \div 12 \times 2 \times \underset{L}{8'}) + (\underset{\varnothing_m}{1.625"} \div 12 \times \underset{L}{8'}) = \underset{A_r}{3.25}\ ft^2$$

Wind area tributary to the post, $A_w = \varepsilon\, s\, L + A_p + A_r = \underset{\varepsilon}{0.16} \times \underset{s}{10'} \times \underset{L}{8'} + \underset{A_p}{2.4} + \underset{A_r}{3.25} = \underset{A_w}{18.45}\ ft^2$

Dead Load of fencing materials, $D_m$ 1.0 psf

**Lateral and Axial Forces for Wind Loading**

Minimum wind force to the post, $f_{min} = (0.6)\ 16.0\ A_w = 9.6 \times \underset{A_w}{18.45} = \underset{f_{min}}{177}$ lbs

Calculated Wind Force to the post, $f_w = q_w K_z K_{zt} K_e R_{1w} F_{hw} C_{fw} A_w$

$$f_w = \underset{q_w}{12.24} \times \underset{K_z}{0.85} \times \underset{K_{zt}}{1.0} \times \underset{K_e}{1.0} \times \underset{R_{1w}}{1.0} \times \underset{F_{hw}}{1.0} \times \underset{C_{fw}}{1.3} \times \underset{A_w}{18.45} = \underset{f_w}{250}\ \text{lbs}$$

Maximum wind force to the post, $f_w'$ = maximum value of either $f_{min}$ or $f_w = \underset{f_w'}{250}$ lbs

The Axial Force supported by the post, $p_a = D_m\, s\, L$

$p_w = \underset{D_m}{1.0} \times \underset{s}{10'} \times \underset{L}{8'} = \underset{p_w}{80}$ lbs (rails neglected - can be added in later)

$5 \times p_w =$ 400 lbs (used for stability check)

## Wind on Ice Loading

Fence Run # 1     Length of Fence, $B = \underline{96}$ ft     Post spacing, $L = \underline{8}$ ft

Post Type: Line Posts( )     Post near end or corner(X)

### Wind on Ice Force Variables

Iced Solidity Ratio, $\varepsilon' = \underline{0.97}$     Inverted Fence Opening Reduction Factor, $R_{1i} = \underline{1.01}$

Case C Reduction Factor, $R_{2i} = \underline{0.8}$     Return Corner Reduction Factor, $R_{3i} = \underline{1.0}$

Force Height Adjustment Factor, $F_{hi} = \underline{1.1}$     Wind Force Coefficient, $C_{fi} = \underline{2.76}$

Dead Load of Ice, $D_i = \underline{4.4}$ psf

Wind area tributary to the post in the iced condition, $A_i = \varepsilon' \, s \, L$

$$A_i = \underset{\varepsilon'}{\underline{0.97}} \times \underset{s}{\underline{10'}} \times \underset{L}{\underline{8'}} = \underset{A_i}{\underline{77.6}} \text{ ft}^2$$

Wind on Ice Force to the post, $f_i = q_i \, K_z \, K_{zt} \, K_e \, R_{1i} \, F_{hi} \, C_{fi} \, A_i$

$$f_i = \underset{q_i}{\underline{2.07}} \times \underset{K_z}{\underline{0.85}} \times \underset{K_{zt}}{\underline{1.0}} \times \underset{K_e}{\underline{1.0}} \times \underset{R_{1i}}{\underline{1.01}} \times \underset{F_{hi}}{\underline{1.1}} \times \underset{C_{fi}}{\underline{2.76}} \times \underset{A_i}{\underline{77.6}} = \underset{f_i}{\underline{419}} \text{ lbs}$$

Axial Force supported by the post, $p_i = (D_w + D_i) \, s \, L$

$$p_i = \left( \underset{D_w}{\underline{1.0}} + \underset{D_i}{\underline{4.4}} \right) \times \underset{s}{\underline{10'}} \times \underset{L}{\underline{8'}} = \underset{p_i}{\underline{432}} \text{ lbs}$$

$5 \times p_i = \underline{2,160}$ lbs (used for stability check)

## Post Selection

Using the diameter of the desired post size, O.D., and the Fence Height, h, look through the post charts for post types that have $F_a$ values larger than the $f_w$' & $f_i$ values, and $P_a$ values larger than the $p_w$ & $p_i$ values. If the post has an * next to the $P_a$ value, only use it if the $P_a$ value is ≥ 5 × $p_i$ due to stability requirements.

Put in the O.D, post type, weight per foot, $D_p$ and fence height, h and calculate $p_w$' and $p_i$' to include the weight of the post. Add any additional weight if needed.

$f_w' / F_a$ is the bending strength ratio for Wind.
$p_w' / P_a$ is the axial strength ratio for Wind.
$f_i / F_a$ is the bending strength ratio for Wind & Ice.
$p_i' / P_a$ is the axial strength ratio for Wind & Ice.

If the sum of the bending strength and axial strength ratios for both Wind and Wind & Ice loading are ≤ 1.0, the post is acceptable.

| O.D. | Post Type | $D_p$ (lb/f) | h (ft) | $p_w' = p_w + (D_p \times h)$ | $p_i' = p_i + (D_p \times h)$ |
|---|---|---|---|---|---|
| 2.875 | 40 wt / 50 ksi | 4.6 | 10' | $p_w'$ = 126 lbs | $p_i'$ = 478 lbs |

**Wind**

$$\frac{f_w' = 250}{F_a = 547} = 0.46 \qquad \frac{p_w' = 126}{P_a = 2{,}818} = 0.05 \qquad \frac{f_w'}{F_a} + \frac{p_w'}{P_a} = 0.51 \text{ OK}$$

**Wind & Ice**

$$\frac{f_i = 419}{F_a = 547} = 0.77 \qquad \frac{p_i' = 478}{P_a = 2{,}818} = 0.17 \qquad \frac{f_i}{F_a} + \frac{p_i'}{P_a} = 0.94 \text{ OK}$$

The following pages show the iterative design steps for sizing the post footing. The minimum footing diameter is 2.875 + 4" or about 7". 9" is a more common auger size so that is what is used below. Soil class 4 is assumed for soil lateral and bearing strength. See Footing Design page of FenceDesign.com for IBC table 1806.2

First guess at footing depth is 5'.

## Footing Sizing (non-constrained footings)

First pass

Design Footing Depth, $D$ = 5 ft

Footing Diameter, $b$ = 0.75 ft

Lateral Bearing Pressure per foot of depth, $S$ = 150 psf / ft    per geotechnical analysis or table 1806.2

Maximum Wind Force, $P$ = maximum value of $f_w$' or $f_i$ = 419 lbs

Post Height, $h$ = ~~105~~ 10 ft

Modifier for Isolated Posts, $M$ = 2.0    per IBC §1086.3.4

Allowable Lateral Soil Bearing Pressure for non-constrained footings, $S_1 = \frac{1}{3} D\, S\, M$

$S_1 = \frac{1}{3} \times \underset{D}{\underline{5'}} \times \underset{S}{\underline{150}} \times \underset{M}{2.0} = \underset{S_1}{\underline{500}}$ psf    per IBC §1807.3.2.1

Soil Bearing Factor, $A = 2.34\, P / (S_1\, b)$    per IBC §1807.3.2.1

$A = 2.34 \times \underset{P}{\underline{419}} \div ( \underset{S_1}{\underline{500}} \times \underset{b}{\underline{0.75}} ) = \underset{A}{\underline{2.615}}$

Minimum Depth, $d = \frac{1}{2} A \left(1 + \sqrt{1 + \frac{4.36\ \frac{1}{2}h}{A}}\right)$    per Eq. 18-1, modified for fencing

$d = \frac{1}{2} \times \underset{A}{\underline{2.615}} \times \left(1 + \sqrt{1 + \left(4.36 \times \frac{1}{2} \times \underset{h}{\underline{10'}} \div \underset{A}{\underline{2.615}}\right)}\right) = \underset{d}{\underline{5.3}}$ ft

d = 5.3 ft > D= 5.0 ft - start over with a larger footing depth

Calculations continue on the next page

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## Footing Sizing (non-constrained footings) Second pass

Design Footing Depth, $D = \underline{5.5}$ ft    Footing Diameter, $b = \underline{0.75}$ ft

Lateral Bearing Pressure per foot of depth, $S = \underline{150}$ psf / ft    per geotechnical analysis or table 1806.2

Maximum Wind Force, $P$ = maximum value of $f_w$ or $f_i = \underline{419}$ lbs    Post Height, $h = \underline{10}$ ft

Modifier for Isolated Posts, $M = 2.0$    per IBC §1086.3.4

Allowable Lateral Soil Bearing Pressure for non-constrained footings, $S_1 = ⅓\, D\, S\, M$

$$S_1 = ⅓ \times \underset{D}{\underline{5.5'}} \times \underset{S}{\underline{150}} \times \underset{M}{2.0} = \underset{S_1}{\underline{549.5}} \text{ psf}$$

per IBC §1807.3.2.1

Soil Bearing Factor, $A = 2.34\, P / (S_1\, b)$    per IBC §1807.3.2.1

$$A = 2.34 \times \underset{P}{\underline{419}} \div (\underset{S_1}{\underline{549.5}} \times \underset{b}{\underline{0.75}}) = \underset{A}{\underline{2.379}}$$

Minimum Depth, $d = ½\, A \left(1 + \sqrt{1 + \frac{4.36\ ½h}{A}}\right)$    per Eq. 18-1, modified for fencing

$$d = ½ \times \underset{A}{\underline{2.379}} \times \left(1 + \sqrt{1 + (4.36 \times ½ \times \underset{h}{\underline{10'}} \div \underset{A}{\underline{2.379}})}\right) = \underset{d}{\underline{4.98}} \text{ ft}$$

d < D  OK

Area of the bottom of the footing, $A_f = \pi\,(½\, b)^2 = 3.14 \times (½ \times \underset{b}{\underline{0.75}})^2 = \underset{A_f}{\underline{0.44}}$ ft$^2$

Footing Volume, $V = A_f\, D = \underset{A_f}{\underline{0.44}} \times \underset{D}{\underline{5.5}} = \underset{V}{\underline{2.42}}$ ft$^3$

Weight of footing, $D_f = 150\, V = 150 \times \underset{V}{\underline{2.42}} = \underset{D_f}{\underline{363}}$ lbs    (Typical Concrete weight is 150 lbs / ft$^3$)

Axial Dead Load, $D_{max} = D_f + p_i'$ for fencing plus ice loading. $D_{max} = D_f + p_w'$ if there is no ice loading

$$D_{max} = \underset{D_f}{\underline{363}} + \underset{p_i' \text{ or } p_w'}{\underline{478}} = \underset{D_{max}}{\underline{841}} \text{ lbs}$$

Maximum Vertical Foundation Pressure, $S_y = \underline{2{,}000}$ psf    per geotechnical analysis or table 1806.2

Maximum Axial Pressure on the soil, $s_y = D_{max} / A_f = \underset{D_{max}}{\underline{841}} \div \underset{A_f}{\underline{0.44}} = \underset{s_y}{\underline{1{,}911}}$ psf

Actual to Allowable Soil Strength Ratio, $s_y / S_y = \underset{s_y}{\underline{1{,}911}} \div \underset{S_y}{\underline{2{,}000}} = \underline{0.96} \leq 1.0$ is OK

$s_y / S_y$ must be less than 1.0. If not, start over with a larger footing diameter, b

Footing depth of 5' 6" and footing diameter of 9" are OK for this example