ASCE 7-16: CHAPTER 29 WIND LOAD ON BUILDING APPURTENANCES AND OTHER SRUCTURES: MWFRS (DIRECTIONAL PROCEDURE)

Pipe and Support

Risk Category (Table 1.5-1): RC

$RC :=$ III

Assumptions: See Table for additional Info.
RC I - Bldg. and Structures represent low risk to life in the event of failure
RC II - All Bldg. and Structures except listed in RC I, III, and IV
RC III - Bldg. and Structures failure could pose a substantial risk to human life
RC IV - Bldg. and Structures designated as essential facilities

LRFD Wind Importance Factor by Risk Category: I_w

$I_w := RC_1 = 1.00$

Wind Exposure/Surface Roughness (Sec 26.7.3)

$EXP :=$ B

Assumptions: See section for additional info.
Exp. B - Bldg. and Structures with mean roof height less than or equal to 30 ft
Exp. C - Apply for all case where Exp B or D does not apply
Exp. D - Apply where ground surface roughness for distance greater than 5,000 ft or 20 times the building height. Flat, unobstructed areas and water surface, includes smooth mud flats, salt flats, and unbroken ice.

Basic Wind Speed 3-sec Gust (Section 26.5): V

$V := 160\ mph$

(Assumptions: ASCE Figure 26.5-1A thru 26.5-2D, MOA Wind Map, Zone IV)

Estimated height above ground surface of the structure: z

$z := 4.53\ ft$

Height above ground surface of the component: h

$h := z = 4.53\ ft$

Structure Type (Table 26.6-1): $Type \equiv$ d1) Chimneys, Tanks, and Sim. Struc: Round

Terrain Exposure Constants (Table 26.11-1): α and z_g

$\alpha := EXP_1 = 7.0$

(Assumptions: $EXP_0 =$ "B")

$z_g := EXP_2 = 1200\ ft$

Velocity Pressure Exposure Coefficient (Table 26.10-1): K_z

$$K_z := \begin{cases} \text{if } 15\ ft \le z \le z_g \\ \quad 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} \\ \text{else} \\ \quad 2.01 \cdot \left(\frac{15\ ft}{z_g}\right)^{\frac{2}{\alpha}} \end{cases}$$

$K_z = 0.57$

(Assumptions: Notes 1.

For: $15\ ft \le z \le z_g$)

For: $z < 15\ ft$

Topographic Factor (Section 26.8.2): K_{zt}

$K_{zt} := 1.0$

(Assumptions: All conditions specified in Section 26.8.1 are not met, Lake Walkway not on hill or escapement)

Wind Directionality Factor (Table 26.6-1): K_d

$K_d := Type_0 = 1.00$

Assumptions:
[Used only in conjunction with ASCE Load Combinations, i.e. not deflection]

Ground Elevation Factor (Table 26.9-1): K_e $K_e := 1.00$

(Assumptions: Note 1 and 3 permitted in all cases)

Gust Effect Factor (Section 26.11.1): G $G := 0.85$

Velocity Pressure @ Height "z" (EQ 26.10-1): q_z $q_z := 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 \left(\frac{psf}{mph^2}\right)$

$q_z = 37.7\ psf$

$q_h := q_z = 37.7\ psf$

DESIGN WIND FORCE AND COEFFICIENTS CALCULATIONS:
Non-Insulated Round Member

Force Coefficients, C_f

Cross Section	Type of Surface	h/D = 1	h/D = 7	h/D = 25
Square (wind normal to face)	All	1.3	1.4	2.0
Square (wind along diagonal)	All	1.0	1.1	1.5
Hexagonal or octagonal	All	1.0	1.2	1.4
Round, $D\sqrt{q_z} > 2.5$	Moderately smooth	0.5	0.6	0.7
$D\sqrt{q_z} > 5.3$ (in S.I.)	Rough ($D'/D = 0.02$)	0.7	0.8	0.9
	Very rough ($D'/D = 0.08$)	0.8	1.0	1.2
Round, $D\sqrt{q_z} \le 2.5$	All	0.7	0.8	1.2
$D\sqrt{q_z} \le 5.3$ (in S.I.)				

Notation

D = Diameter of circular cross section and least horizontal dimension of square, hexagonal, or octagonal cross sections at elevation under consideration, in ft (m)

D' = Depth of protruding elements such as ribs and spoilers, in ft (m)

h = Height of structure, in ft (m)

q_z = Velocity pressure evaluated at height z above ground, in lb/ft^2 (N/m^2).

Notes

1. The design wind force shall be calculated based on the area of the structure projected on a vertical plane normal to the wind direction.
   The force shall be assumed to act parallel to the wind direction.
2. Linear interpolation is permitted for h/D values other than shown.

FIGURE 29.4-1 Other Structures (All Heights): Force Coefficients, C_f, for Chimneys, Tanks, and Similar Structures

Functions:

Force Coefficients (C_f):

(Assumptions *Applied to all round members, with or without insulation*)

$Cross\_Section_{RND1} \equiv$ Round D*sqrt(qz)> 2.5: Moderately Smooth

$Cross\_Section_{RND2} \equiv$ Round D*sqrt(qz) <= 2.5: All

$$h/D = \begin{bmatrix} 1 \\ 7 \\ 25 \end{bmatrix} \quad C_{f\_rnd1} = \begin{bmatrix} 0.5 \\ 0.6 \\ 0.7 \end{bmatrix} \quad C_{f\_rnd2} = \begin{bmatrix} 0.7 \\ 0.8 \\ 1.2 \end{bmatrix}$$

General Interpolation EQ for: h/D: C_f $C_f(h, D, CS_{RND}) \equiv \text{linterp}\left(h/D, C_f, \frac{h}{D}\right)$

Projected Unit Area Normal to Wind: A_{f2} $A_{f2} := 1.0 \cdot ft^2$

(Assumptions: h/D; Round Moderately Smooth surface)

Design Wind Loads Other Structures (WLOS) (EQ 29.4-1): F $F = q_z \cdot G \cdot C_f \cdot A_{f2} \cdot (psf)$

ROUND SHAPES (NON-INSULATED PIPES)

Member Diameter: Pipe 8" Dia

$D_8 = 8.625\ in$

Diameter or least horizontal dimension of square, hexagonal or octagonal section: $D_{8\phi}$

$D_{8\phi} := D_8 = 0.7\ ft$

Check: Minimum Cross Section w/o insulation: $CS_{8\phi}$

(Assumptions: Round, $D \cdot \sqrt{q_z}$ surface, w/ or w/o insulation)

$$CS_{8\phi} := \frac{D_{8\phi}}{ft} \cdot \sqrt{\frac{q_z}{psf}} = 4.4 \quad > 2.5$$

Structure Height-to-Diameter ratio (Fig 29.4-1): h/D

$$\frac{h}{D_{8\phi}} = 6.3$$

Force Coefficients (Figure 29.4-1): $C_{f8\phi}$

$C_{f8\phi} := C_{f\_RND}\left(h, D_{8\phi}, CS_{8\phi}\right)$

$C_{f8\phi} = 0.59$

Design Wind Force per Unit Area: F_8

$F_8 := q_z \cdot G \cdot C_{f8\phi} \cdot A_{f2} \cdot \left(ft^2\right)^{-1}$

$F_8 = 18.8\ psf$

Design Wind Force per Length for Pipe 8" Dia: $F_{8\phi}$

$F_{8\phi} := F_8 \cdot \left(D_{8\phi}\right) = 13.5\ plf$

Member Diameter: Pipe 12" Dia

$D_{12} = 12.75\ in$

Diameter or least horizontal dimension of square, hexagonal or octagonal section: $D_{12\phi}$

$D_{12\phi} := D_{12} = 1.1\ ft$

Check: Minimum Cross Section w/o insulation: $CS_{12\phi}$

(Assumptions: Round, $D \cdot \sqrt{q_z}$ surface, w/ or w/o insulation)

$$CS_{12\phi} := \frac{D_{12\phi}}{ft} \cdot \sqrt{\frac{q_z}{psf}} = 6.5 \quad > 2.5$$

Structure Height-to-Diameter ratio (Fig 29.4-1): h/D

$$\frac{h}{D_{12\phi}} = 4.3$$

Force Coefficients (Figure 29.4-1): $C_{f12\phi}$

$C_{f12\phi} := C_{f\_RND}\left(h, D_{12\phi}, CS_{12\phi}\right)$

$C_{f12\phi} = 0.55$

Design Wind Force per Unit Area: F_{12}

$F_{12} := q_z \cdot G \cdot C_{f12\phi} \cdot A_{f2} \cdot \left(ft^2\right)^{-1}$

$F_{12} = 17.7\ psf$

Design Wind Force per Length for Pipe 12" Dia: $F_{12\phi}$

$F_{12\phi} := F_{12} \cdot \left(D_{12\phi}\right) = 18.9\ plf$

Member Diameter: Pipe 7" Dia Pile

$D_7 = 7\ in$

Diameter or least horizontal dimension of square, hexagonal or octagonal section, $D_{7\phi\_Pile}$

$D_{7\phi\_Pile} := D_7 = 0.58\ ft$

Check: Minimum Cross Section w/o insulation, $CS_{7\phi\_Pile}$

(Assumptions: Round, $D \cdot \sqrt{q_z}$ surface, w/ or w/o insulation)

$$CS_{7\phi\_Pile} := \frac{D_{7\phi\_Pile}}{ft} \cdot \sqrt{\frac{q_z}{psf}} = 3.6 \quad > 2.5$$

Structure Height-to-Diameter ratio (Fig 29.4-1): h/D

$$\frac{h}{D_{7\phi\_Pile}} = 7.8$$

Force Coefficients (Figure 29.4-1): $C_{f7\phi\_Pile}$

$$C_{f7\phi\_Pile} := C_{f\_RND}\left(h, D_{7\phi\_Pile}, CS_{7\phi\_Pile}\right)$$
$$C_{f7\phi\_Pile} = 0.6$$

Design Wind Force per Unit Area: F_{7_Pile}

$$F_{7\_Pile} := q_z \cdot G \cdot C_{f7\phi\_Pile} \cdot A_{f2} \cdot \left(ft^2\right)^{-1}$$
$$F_{7\_Pile} = 19.3\ psf$$

Design Wind Force per Length for Pipe 7" Dia: $F_{7\phi\_Pile}$

$$F_{7\phi\_Pile} := F_{7\_Pile} \cdot \left(D_{7\phi\_Pile}\right) = 11.3\ plf$$

Summary:

ROUND SHAPES (NON-INSULATED PIPES)

Design Wind Force per Length for Pipe 8" Dia, $F_{8\phi}$

$$F_{8\phi} = 0.014\ klf$$

Design Wind Force per Length for Pipe 12" Dia, $F_{12\phi}$

$$F_{12\phi} = 0.019\ klf$$

Design Wind Force per Length for Pile 7" Dia, $F_{7\phi\_Pile}$

$$F_{7\phi\_Pile} = 0.011\ klf$$