WIND LOADING ANALYSIS - Open Structures without Roofs

Per ASCE 7-05 Code

Using Method 2: Analytical Procedure (Section 6.5) for Other Structures of Any Height

Job Name:		Subject:			
Job Number:		Originator:		Checker:	

Input Data:

Wind Speed, V =	90	mph
Class., Occ. Category =	II	(Table 1-1)
Exposure Category =	C	(Sect. 6.5.6)
Topo. Factor, Kzt =	1.00	(Sect. 6.5.7)
Height of Structure, h =	125.00	ft.
Structure Width, B =	150.00	ft. (normal to wind)
Structure Length, L =	100.00	ft. (parallel to wind)
Damping Ratio, β =	0.010	(0.010 to 0.070)
Period Coefficient, Ct =	0.0200	(0.020 to 0.035)
Direct. Factor, Kd =	0.85	(Table 6-4)
Hurricane Region?	N	

Note: Per Code Section 6.1.4.1, design wind force for open buildings and other structures shall not be less than 10 psf multiplied by the area, 'Af', the area normal to wind direction.

Resulting Parameters and Coefficients:

If z < 15 then: Kz = 2.01*(15/zg)^(2/α)

If z >= 15 then: Kz = 2.01*(z/zg)^(2/α)

α =	9.50	(Table 6-2)
zg =	900	(Table 6-2)
I =	1.00	(Table 6-1)
freq., f =	1.337	Hz. (f >=1) Rigid
G =	0.850	(Gust Factor, Sect. 6.5.8)

Velocity Pressure (Sect. 6.5.10, Eq. 6-15):

qz = 0.00256*Kz*Kzt*Kd*V^2*I

Net Design Wind Pressures (Sect. 6.5.15):

p = qz*G*Cf (psf), where 'qz' is evaluated at height 'z' of the centroid of projected area.

Open Structure - Net Design Wind Pressures, p

	z (ft.)	Kz	qz (psf)	qz*G (psf)	Force Coefficient, Cf: 1.20 p (psf)	1.60 p (psf)	1.80 p (psf)	2.00 p (psf)
	0	0.85	14.96	12.72	15.26	20.35	22.89	25.44
	15	0.85	14.96	12.72	15.26	20.35	22.89	25.44
	20	0.90	15.90	13.51	16.21	21.62	24.32	27.02
	25	0.95	16.66	14.16	16.99	22.66	25.49	28.32
	30	0.98	17.31	14.72	17.66	23.55	26.49	29.43
	35	1.01	17.88	15.20	18.24	24.32	27.36	30.40
	40	1.04	18.39	15.63	18.76	25.02	28.14	31.27
	45	1.07	18.86	16.03	19.23	25.64	28.85	32.05
	50	1.09	19.28	16.39	19.66	26.22	29.50	32.77
	55	1.12	19.67	16.72	20.06	26.75	30.09	33.44
	60	1.14	20.03	17.03	20.43	27.24	30.65	34.06
	70	1.17	20.69	17.59	21.11	28.14	31.66	35.18
	80	1.21	21.28	18.09	21.71	28.95	32.56	36.18
	90	1.24	21.82	18.55	22.25	29.67	33.38	37.09
	100	1.27	22.31	18.96	22.75	30.34	34.13	37.92
	120	1.32	23.18	19.70	23.64	31.53	35.47	39.41
For z = h:	125	1.33	23.38	19.87	23.85	31.80	35.77	39.75

Determination of Gust Effect Factor, G:

Flexible? No f >=1 Hz.

1: Simplified Method for Rigid Structure

G = 0.85

Parameters Used in Both Item #2 and Item #3 Calculations (from Table 6-2):

α^ =	0.105	
b^ =	1.00	
α(bar) =	0.154	
b(bar) =	0.65	
c =	0.20	
l =	500	ft.
ε(bar) =	0.200	
z(min) =	15	ft.

Calculated Parameters Used in Both Rigid and/or Flexible Structure Calculations:

z(bar) =	75.00	= 0.6*h , but not < z(min) , ft.
Iz(bar) =	0.174	= c*(33/z(bar))^(1/6) , Eq. 6-5
Lz(bar) =	589.22	= l*(z(bar)/33)^(ε(bar)) , Eq. 6-7
gq =	3.4	(3.4, per Sect. 6.5.8.1)
gv =	3.4	(3.4, per Sect. 6.5.8.1)
gr =	4.258	= (2*(LN(3600*f)))^(1/2)+0.577/(2*LN(3600*f))^(1/2) , Eq. 6-9
Q =	0.848	= (1/(1+0.63*((B+h)/Lz(bar))^0.63))^(1/2) , Eq. 6-6

2: Calculation of G for Rigid Structure

G = 0.855 = 0.925*((1+1.7*gq*Iz(bar)*Q)/(1+1.7*gv*Iz(bar))) , Eq. 6-4

3: Calculation of Gf for Flexible Structure

β =	0.010	Damping Ratio
Ct =	0.020	Period Coefficient
T =	0.748	= Ct*h^(3/4) , sec. (Period)
f =	1.337	= 1/T , Hz. (Natural Frequency)
V(fps) =	N.A.	= V(mph)*(88/60) , ft./sec.
V(bar,zbar) =	N.A.	= b(bar)*(z(bar)/33)^(α(bar))*V*(88/60) , ft./sec. , Eq. 6-14
N1 =	N.A.	= f*Lz(bar)/(V(bar,zbar)) , Eq. 6-12
Rn =	N.A.	= 7.47*N1/(1+10.3*N1)^(5/3) , Eq. 6-11
ηh =	N.A.	= 4.6*f*h/(V(bar,zbar))
Rh =	N.A.	= (1/ηh)-1/(2*ηh^2)*(1-e^(-2*ηh)) for ηh > 0, or = 1 for ηh = 0 , Eq. 6-13a,b
ηb =	N.A.	= 4.6*f*B/(V(bar,zbar))

RB =	N.A.	= (1/ηb)-1/(2*ηb^2)*(1-e^(-2*ηb)) for ηb > 0, or = 1 for ηb = 0 , Eq. 6-13a,b
ηd =	N.A.	= 15.4*f*L/(V(bar,zbar))
RL =	N.A.	= (1/ηd)-1/(2*ηd^2)*(1-e^(-2*ηd)) for ηd > 0, or = 1 for ηd = 0 , Eq. 6-13a,b
R =	N.A.	= ((1/β)*Rn*Rh*RB*(0.53+0.47*RL))^(1/2) , Eq. 6-10
Gf =	N.A.	= 0.925*(1+1.7*Iz(bar)*(gq^2*Q^2+gr^2*R^2)^(1/2))/(1+1.7*gv*Iz(bar)) , Eq. 6-8
Use: G =	0.850	

Other Structures - Method 2		All Heights	
Figure 6-22	Force Coefficients Cf	Open Signs & Lattice Frameworks	
ε	Flat-Sided Members	Rounded Members	
		D*SQRT(qz) <= 2.5	D*SQRT(qz) > 2.5
< 0.1	2.0	1.2	0.8
0.1 to 0.29	1.8	1.3	0.9
0.3 to 0.7	1.6	1.5	1.1

Notes: 1. Signs with openings comprising 30% or more of the gross area are classified as open signs.
2. The calculation of the design wind forces shall be based on the area of all exposed members and elements projected on a plane normal to the wind direction. Forces shall be assumed to act parallel to the wind direction.
3. The area 'Af' consistent with these force coefficients is the solid area projected normal to the wind direction.
4. Notation:
ε = ratio of solid area to gross area
D = diameter of a typical round member, in feet.
qz = velocity pressure evaluated at height 'z' above ground in psf.

Other Structures - Method 2		All Heights
Figure 6-23	Force Coefficients Cf	Trussed Towers
Open Structures		
Tower Cross Section		Cf

Square	4.0*ε^2 - 5.9*ε + 4.0
Triangle	3.4*ε^2 - 4.7*ε + 3.4

Notes:
1. For all wind directions considered, area 'Af' consistent with force coefficients shall be solid area of tower face projected on plane of that face for tower segment under consideration.
2. Specified force coefficients are for towers with structural angles or similar flat-sided members.
3. For towers containing rounded member, it is acceptable to multiply specified force coefficients by following factor when determining wind forces on such members: 0.51*ε^2 + 0.57 <= 1.0.
4. Wind forces shall be applied in directions resulting in maximum member forces and reactions. For towers with square cross-sections, wind forces shall be multiplied by following factor when wind is directed along a tower diagonal: 1+ 0.75*ε <= 1.2.
5. Wind forces on tower appurtenances such as ladder, conduits, lights, elevators, etc., shall be calculated using appropriate force coefficients for these elements.
6. Notation: ε = ratio of solid area to gross area of one tower face for segment considered.

Version 1.4

Note: this worksheet DOES NOT address open structures with roofs!

Note: User is to input applicable values of Cf in table at left. Use force coefficients, Cf, from Figures 6-22 and 6-23.

User Input for Height, z (ft.):

N	Use Input Values?

For Flat Sided Members from Figure 6-22:

Solid Area =	6250.00	ft.^2	
Gross Area =	12500.00	ft.^2	
Solidity Ratio, e =	0.500		ε = Solid Area/Gross Area
Cf =	1.6		Cf from Figure 6-22

For Rounded Members from Figure 6-22:

D =	10.000	ft.	
qz =	25.00	psf	
Solid Area =	6250.00	ft.^2	
Gross Area =	12500.00	ft.^2	
Solidity Ratio, e =	0.500		ε = Solid Area/Gross Area
D*SQRT(qz) =	50.00		
Cf =	N.A.		Cf for D*SQRT(qz) <= 2.5
Cf =	1.1		Cf for D*SQRT(qz) > 2.5
Use: Cf =	1.1		Cf from Figure 6-22

For Trussed Towers from Figure 6-23:

Solid Area =	6250.00	ft.^2		
Gross Area =	12500.00	ft.^2		
Solidity Ratio, ε =	0.500			ε = Solid Area/Gross Area
Square Tower Cf =	2.05			Cf = 4.0*ε^2 - 5.9*ε + 4.0
Triangle Tower Cf =	1.90			Cf = 3.4*ε^2 - 4.7*ε + 3.4