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WIND LOAD

Design code used: ASCE/SEI 7-10
Minimum Design Loads for Buildings and Other Structures
Design method: Wind loads on the MWFRS. Directional procedure for buildings of all heights (ASCE/SEI 7-10, Chapter 27)

1.1. General data

Wind action in the X direction is considered

Wind action in the Y direction is considered

Location data

V: Basic Wind Speed (ASCE/SEI 7-10, 26.5) V : *67.0* m/s

Occupancy category (ASCE/SEI 7-10, 26.5.1): Category IV

Terrain category (ASCE/SEI 7-10, 26.7.3)

Category D

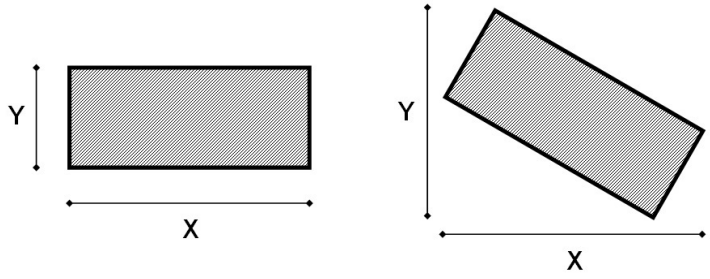
Land orography (ASCE/SEI 7-10, 26.8)

X Direction [0°- 180°]: Flat

Y Direction [90°- 270°]: Flat

Tributary widths

Tributary widths are the lengths of the façade exposed in the direction perpendicular to the wind action.



Floor	X Width (m)	Y Width (m)
Roof	2.50	2.50
Floor 3	8.00	8.00
Floor 2	10.00	10.00
Floor 1	10.00	10.00
Ground floor	10.00	10.00

Coefficients applied to the wind action

+X: 1.00 -X: 1.00

+Y: 1.00 -Y: 1.00

1.2. Velocity pressure

The velocity pressure, q_z, evaluated at height z, shall be calculated by the following equation:

$$q_z = 0.613 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$$ (ASCE/SEI 7-10, 27.3.2)

Parameters required to define the dynamic pressure

V: Basic Wind Speed (ASCE/SEI 7-10, 26.5) V : *67.0* m/s

K_d: Directionality factor (ASCE/SEI 7-10, 26.6) K_d : *0.85*

K_z: Exposure coefficient (ASCE/SEI 7-10, 27.3.1)

K_{zt}: Topographic factor (ASCE/SEI 7-10, 26.8)

1.2.1. Exposure coefficient

K_z: Exposure coefficient (ASCE/SEI 7-10, 27.3.1)

$$K_z = 2.01\left(z / z_g\right)^{2/\alpha} \qquad 4.6m \le z \le z_g$$

$$K_z = 2.01\left(4.6 / z_g\right)^{2/\alpha} \qquad z < 4.6m$$

Terrain exposure constants (ASCE/SEI 7-10, Table 26.9-1)

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Exposure	Category D	Category D	Category D	Category D
a	11.5	11.5	11.5	11.5
z_g (m)	213.36	213.36	213.36	213.36

Exposure coefficient K_z per floor (ASCE/SEI 7-10, 27.3.1)

K_z				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Roof	1.248	1.248	1.248	1.248
Floor 3	1.195	1.195	1.195	1.195
Floor 2	1.133	1.133	1.133	1.133
Floor 1	1.048	1.048	1.048	1.048
Ground floor	1.030	1.030	1.030	1.030

K_z				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
MAX(5, h)	1.248	1.248	1.248	1.248

1.2.2. Topographic factor

K_{zt}: Topographic factor (ASCE/SEI 7-10, 26.8.2) K_{zt} : *1*

1.2.3. Velocity pressure per floor

Velocity pressure q_z per floor (ASCE/SEI 7-10, 27.3.2)

q_z (kN/m²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Roof	2.92	2.92	2.92	2.92
Floor 3	2.80	2.80	2.80	2.80
Floor 2	2.65	2.65	2.65	2.65
Floor 1	2.45	2.45	2.45	2.45
Ground floor	2.41	2.41	2.41	2.41

q_h (kN/m²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
h	2.92	2.92	2.92	2.92

h: Mean roof height of a building h : *13.75* m

1.3. Design pressure

The design wind pressure for the main wind force-resisting system shall be determined by the following equation:

$$p = q_z G C_{p,w} - q_h G C_{p,l}$$ (ASCE/SEI 7-10, Figure 27.4-1)

Where:

q_z: Velocity pressure evaluated at height z

q_h: Velocity pressure evaluated at height h

$C_{p,w}$: Windward pressure coefficient

$C_{p,l}$: Leeward pressure coefficient

G: Gust-effect factor

1.3.1. Pressure coefficients

X Direction [0°- 180°]

$C_{p,w}$: Windward pressure coefficient (ASCE/SEI 7-10, Figure 27.4-1) $C_{p,w}$: 0.80

$C_{p,l}$: Leeward pressure coefficient (ASCE/SEI 7-10, Figure 27.4-1) $C_{p,l}$: -0.50

L/B: Ratio L/B : 1.00

L: Horizontal dimension of the building measured parallel to the wind direction L : 8.69 m

B: Horizontal dimension of the building measured normal to the wind direction B : 8.69 m

Y Direction [90°- 270°]

$C_{p,w}$: Windward pressure coefficient (ASCE/SEI 7-10, Figure 27.4-1) $C_{p,w}$: 0.80

$C_{p,l}$: Leeward pressure coefficient (ASCE/SEI 7-10, Figure 27.4-1) $C_{p,l}$: -0.50

L/B: Ratio L/B : 1.00

L: Horizontal dimension of the building measured parallel to the wind direction L : 8.69 m

B: Horizontal dimension of the building measured normal to the wind direction B : 8.69 m

1.3.2. Gust-effect factor

Low-rise buildings are permitted to be considered rigid.

Low-Rise Building: Enclosed or partially enclosed buildings that comply with the following conditions:

1.Mean roof height h less than or equal to 60 ft (18 m).

2.Mean roof height h does not exceed least horizontal dimension.

Gust-effect factor for flexible buildings

For flexible buildings, the gust-effect factor shall be calculated by the formula:

$$G = 0.925\left(\frac{1+1.7I_{\bar{z}}\sqrt{g_Q^2Q^2+g_R^2R^2}}{1+1.7g_vI_{\bar{z}}}\right)$$ (ASCE/SEI 7-10, 26.9.5)

I_z: Intensity of turbulence at height z

$$I_{z_s} = c\left(\frac{10}{\bar{z}}\right)^{1/6}$$

z: Equivalent height of the structure

$$\bar{z} = MAX\left(0.6\cdot h, z_{\min}\right)$$

h: Mean roof height of a building h : 13.75 m

z_{min}: Exposure constant (ASCE/SEI 7-10, Table 26.9-1)

c: Turbulence intensity factor (ASCE/SEI 7-10, Table 26.9-1)

g_Q: Peak factor for background response (ASCE/SEI 7-10, 26.9.4) g_Q : 3.4

g_v: Peak factor for wind response (ASCE/SEI 7-10, 26.9.4) g_v : *3.4*

Q: Background response factor (ASCE/SEI 7-10, 26.9.4)

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}}$$

B: Horizontal dimension of the building measured normal to the wind direction

h: Mean roof height of a building

L_z: Integral length scale of turbulence

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{10}\right)^{\bar{\epsilon}}$$

l: Integral length scale factor (ASCE/SEI 7-10, Table 26.9-1)

e: Integral length scale power law exponent (ASCE/SEI 7-10, Table 26.9-1)

g_R: Peak factor for resonant response (ASCE/SEI 7-10, 26.9.5)

$$g_R = \sqrt{2\ln\left(3600\cdot n_1\right)} + \frac{0.577}{\sqrt{2\ln\left(3600\cdot n_1\right)}}$$

R: Resonant response factor (ASCE/SEI 7-10, Table 26.9-1)

$$R = \sqrt{\frac{1}{\beta}R_n R_h R_B\left(0.53+0.47R_L\right)}$$

b: Damping ratio b : *0.01*

$$R_n = \frac{7.47N_1}{\left(1+10.3N_1\right)^{5/3}}$$

N_1: Reduced frequency

$$N_1 = \frac{n_1 L_{\bar{z}}}{\overline{V}_{\bar{z}}}$$

$$R_h = \frac{1}{\eta} - \frac{1}{2\eta^2}\left(1-e^{-2\eta}\right);\ \eta = 4.6\frac{n_1 h}{\overline{V}_{\bar{z}}}$$

$$R_B = \frac{1}{\eta} - \frac{1}{2\eta^2}\left(1-e^{-2\eta}\right);\ \eta = 4.6\frac{n_1 B}{\overline{V}_{\bar{z}}}$$

$$R_L = \frac{1}{\eta} - \frac{1}{2\eta^2}\left(1-e^{-2\eta}\right);\ \eta = 15.4\frac{n_1 L}{\overline{V}_{\bar{z}}}$$

V_z: Mean hourly wind speed at height z

$$\overline{V}_{\bar{z}} = \bar{b}\left(\frac{\bar{z}}{10}\right)^{\bar{\alpha}} V$$

b: Mean hourly wind speed factor (ASCE/SEI 7-10, Table 26.9-1)

a: Mean hourly wind-speed power law exponent (ASCE/SEI 7-10, Table 26.9-1)

V: Basic Wind Speed (ASCE/SEI 7-10, 26.5) V : *67.0* m/s

Fundamental natural frequency of the structure

$n_{1,x}$: Fundamental natural frequency (X Direction) (ASCE/SEI 7-10, 26.9.3) $n_{1,x}$: *1.41* Hz

$$n_1 = \frac{14.9}{h^{0.9}}$$

h: Mean roof height of a building h : *13.75* m

$n_{1,y}$: Fundamental natural frequency (Y Direction) (ASCE/SEI 7-10, 26.9.3) $n_{1,y}$: *1.41* Hz

$$n_1 = \frac{14.9}{h^{0.9}}$$

h: Mean roof height of a building h : *13.75* m

Terrain exposure constants (ASCE/SEI 7-10, Table 26.9-1)

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Exposure	Category D	Category D	Category D	Category D
z_{min} (m)	2.13	2.13	2.13	2.13
c	0.15	0.15	0.15	0.15
l	198.1	198.1	198.1	198.1
e	0.13	0.13	0.13	0.13
b	0.80	0.80	0.80	0.80
a	0.11	0.11	0.11	0.11

Calculation of the gust-effect factor, G

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
z_{min} (m)	2.13	2.13	2.13	2.13
I_z	0.16	0.16	0.16	0.16
L_z	193.27	193.27	193.27	193.27
Q	0.93	0.93	0.93	0.93
g_Q	3.40	3.40	3.40	3.40
g_v	3.40	3.40	3.40	3.40
g_R	4.27	4.27	4.27	4.27
V_z	52.43	52.43	52.43	52.43
R	0.86	0.86	0.86	0.86
G	1.11	1.11	1.11	1.11

1.3.3. Design pressure per floor

Design pressure, p (ASCE/SEI 7-10, Figure 27.4-1)

p (kN/m²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Roof	4.21	4.21	4.21	4.21
Floor 3	4.10	4.10	4.10	4.10
Floor 2	3.97	3.97	3.97	3.97
Floor 1	3.79	3.79	3.79	3.79
Ground floor	3.76	3.76	3.76	3.76

1.4. Wind loads per floor

The design wind loads for the main wind force-resisting system shall be determined using the following equation:

$$F_i = (p_i \cdot A_i) \cdot c$$

Where:

F_i: Wind load that acts on floor 'i'

p_i: Design pressure on floor 'i'

A_i: Are of floor 'i' on which the design wind pressure acts

$$A_i = b_i \cdot h_i$$

b_i: Tributary width of floor 'i' perpendicular to the analysed direction

h_i: Height of floor 'i'

c: Coefficient applied to the wind action

Wind at 0° (+X)				
Floor	p (kN/m²)	b (m)	h (m)	F (kN)
Roof	4.21	2.50	1.50	15.779
Floor 3	4.10	8.00	2.93	95.922
Floor 2	3.97	10.00	2.85	113.140
Floor 1	3.79	10.00	2.85	108.122
Ground floor	3.76	10.00	2.53	94.851

Wind at 90° (-Y)				
Floor	p (kN/m²)	b (m)	h (m)	F (kN)
Roof	4.21	2.50	1.50	-15.779
Floor 3	4.10	8.00	2.93	-95.922
Floor 2	3.97	10.00	2.85	-113.140
Floor 1	3.79	10.00	2.85	-108.122
Ground floor	3.76	10.00	2.53	-94.851

Wind at 180° (-X)				
Floor	p (kN/m²)	b (m)	h (m)	F (kN)
Roof	4.21	2.50	1.50	-15.779
Floor 3	4.10	8.00	2.93	-95.922
Floor 2	3.97	10.00	2.85	-113.140
Floor 1	3.79	10.00	2.85	-108.122
Ground floor	3.76	10.00	2.53	-94.851

Wind at 270° (+Y)				
Floor	p (kN/m²)	b (m)	h (m)	F (kN)
Roof	4.21	2.50	1.50	15.779
Floor 3	4.10	8.00	2.93	95.922
Floor 2	3.97	10.00	2.85	113.140
Floor 1	3.79	10.00	2.85	108.122
Ground floor	3.76	10.00	2.53	94.851