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Wind action justification

Ejemplo práctico de cálculo

Date: 02/23/22

WIND LOAD

Design code used: ASCE/SEI 7-05

Minimum Design Loads for Buildings and Other Structures

Design method: Analytical procedure (ASCE/SEI 7-05, 6.5)

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 7-05, 6.5.4)

V : 67.0 m/s

Occupancy category (ASCE/SEI 7-05, 6.5.5): Category IV

Terrain category (ASCE/SEI 7-05, 6.5.6)

Category D

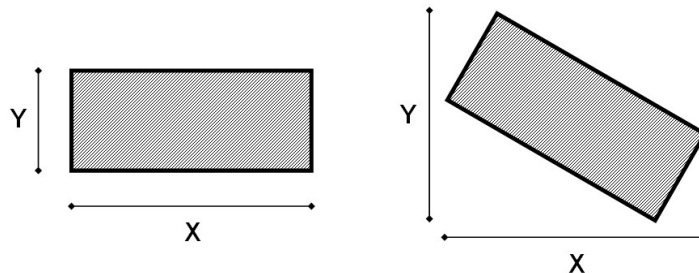
Land orography (ASCE/SEI 7-05, 6.5.7)

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	2.00	2.00
Floor 3	5.00	5.00
Floor 2	10.00	10.00
Floor 1	10.00	10.00
Ground floor	5.00	5.00

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:

$$q_z = 0.613 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2 \cdot I \quad (\text{ASCE/SEI 7-05, 6.5.10})$$

Parameters required to define the dynamic pressure

V: Basic Wind Speed (ASCE/SEI 7-05, 6.5.4)

V : 67.0 m/s

I: Importance factor (ASCE/SEI 7-05, Table 6-1)

I : 1.15

Occupancy category (ASCE/SEI 7-05, 6.5.5): Category IV

K_d : Directionality factor (ASCE/SEI 7-05, Table 6-4)

K_d : 0.85



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K_z : Exposure coefficient (ASCE/SEI 7-05, 6.5.6.6)

K_{zt} : Topographic factor (ASCE/SEI 7-05, 6.5.7.2)

1.2.1. Exposure coefficient

K_z : Exposure coefficient (ASCE/SEI 7-05, 6.5.6.6)

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

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

Terrain exposure constants (ASCE/SEI 7-05, Table 6-2)

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 7-05, Table 6-3)

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 7-05, 6.5.7.2)

K_{zt} : 1

1.2.3. Velocity pressure per floor

Velocity pressure q_z per floor (ASCE/SEI 7-05, 6.5.10)

q_z (kN/m ²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Roof	3.36	3.36	3.36	3.36
Floor 3	3.22	3.22	3.22	3.22
Floor 2	3.05	3.05	3.05	3.05
Floor 1	2.82	2.82	2.82	2.82
Ground floor	2.77	2.77	2.77	2.77

q_h (kN/m ²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
h	3.36	3.36	3.36	3.36

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:



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$$p = q_z G C_{p,w} - q_h G C_{p,l} \quad (\text{ASCE/SEI 7-05, 6.5.12.2 and fig. 6-6})$$

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 7-05, Figure 6-6)

$$C_{p,w} : \underline{0.80}$$

$C_{p,l}$: Leeward pressure coefficient (ASCE/SEI 7-05, Figure 6-6)

$$C_{p,l} : \underline{-0.50}$$

L/B: Ratio

$$L/B : \underline{1.00}$$

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

$$L : \underline{6.83} \text{ m}$$

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

$$B : \underline{6.83} \text{ m}$$

Y Direction [90° - 270°]

$C_{p,w}$: Windward pressure coefficient (ASCE/SEI 7-05, Figure 6-6)

$$C_{p,w} : \underline{0.80}$$

$C_{p,l}$: Leeward pressure coefficient (ASCE/SEI 7-05, Figure 6-6)

$$C_{p,l} : \underline{-0.50}$$

L/B: Ratio

$$L/B : \underline{1.00}$$

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

$$L : \underline{6.83} \text{ m}$$

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

$$B : \underline{6.83} \text{ m}$$

1.3.2. Gust-effect factor

Flexible structure: structure whose fundamental period is smaller than 1Hz.

Rigid structure: structure whose fundamental period is greater than or equal to 1Hz.

Gust-effect factor for rigid buildings

For rigid buildings, the gust-effect factor shall be calculated using the formula:

$$G = 0.925 \left(\frac{1 + 1.7 g_o I_z Q}{1 + 1.7 g_v I_z} \right) \quad (\text{ASCE/SEI 7-05, 6.5.8.1})$$

I_z : Intensity of turbulence at height z

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

z : Equivalent height of the structure

$$\bar{z} = 0.6 \cdot h$$

h : Mean roof height of a building

$$h : \underline{13.75} \text{ m}$$

c : Turbulence intensity factor (ASCE/SEI 7-05, Table 6-2)

g_o : Peak factor for background response (ASCE/SEI 7-05, 6.5.8.1)

$$g_o : \underline{3.4}$$

g_v : Peak factor for wind response (ASCE/SEI 7-05, 6.5.8.1)

$$g_v : \underline{3.4}$$

Q : Background response factor (ASCE/SEI 7-05, 6.5.8.1)



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

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

$$L_z = \ell \left(\frac{z}{10} \right)^{\bar{e}}$$

ℓ : Integral length scale factor (ASCE/SEI 7-05, Table 6-2)

e : Integral length scale power law exponent (ASCE/SEI 7-05, Table 6-2)

Terrain exposure constants (ASCE/SEI 7-05, Table 6-2)

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Exposure	Category D	Category D	Category D	Category D
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	---	---	---	---
a	---	---	---	---

Calculation of the gust-effect factor, G

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
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_o	3.40	3.40	3.40	3.40
g_v	3.40	3.40	3.40	3.40
g_R	---	---	---	---
V_z	---	---	---	---
R	---	---	---	---
G	0.89	0.89	0.89	0.89

1.3.3. Design pressure per floor

Design pressure, p (ASCE/SEI 7-05, 6.5.12.2 and fig. 6-6)

Floor	p (kN/m ²)			
	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Roof	3.90	3.90	3.90	3.90
Floor 3	3.80	3.80	3.80	3.80
Floor 2	3.68	3.68	3.68	3.68
Floor 1	3.52	3.52	3.52	3.52
Ground floor	3.49	3.49	3.49	3.49

1.4. Wind loads per floor

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



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

Where:

F_i : Wind load that acts on floor 'i'

p_i : Design pressure on floor 'i'

A_i : Area 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/m ²)	b (m)	h (m)	F (kN)
Roof	3.90	2.00	1.50	11.712
Floor 3	3.80	5.00	2.93	55.625
Floor 2	3.68	10.00	2.85	104.975
Floor 1	3.52	10.00	2.85	100.319
Ground floor	3.49	5.00	2.53	44.003

Wind at 90° (-Y)				
Floor	p (kN/m ²)	b (m)	h (m)	F (kN)
Roof	3.90	2.00	1.50	-11.712
Floor 3	3.80	5.00	2.93	-55.625
Floor 2	3.68	10.00	2.85	-104.975
Floor 1	3.52	10.00	2.85	-100.319
Ground floor	3.49	5.00	2.53	-44.003

Wind at 180° (-X)				
Floor	p (kN/m ²)	b (m)	h (m)	F (kN)
Roof	3.90	2.00	1.50	-11.712
Floor 3	3.80	5.00	2.93	-55.625
Floor 2	3.68	10.00	2.85	-104.975
Floor 1	3.52	10.00	2.85	-100.319
Ground floor	3.49	5.00	2.53	-44.003

Wind at 270° (+Y)				
Floor	p (kN/m ²)	b (m)	h (m)	F (kN)
Roof	3.90	2.00	1.50	11.712
Floor 3	3.80	5.00	2.93	55.625
Floor 2	3.68	10.00	2.85	104.975
Floor 1	3.52	10.00	2.85	100.319
Ground floor	3.49	5.00	2.53	44.003