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WIND LOAD

Design code used: IS:875 (Part 3) - 2015
Code of Practice for Design Loads (other than earthquake) for Buildings and Structures. Part 3 – Wind Loads
Design method: Analytical procedure (IS:875 (Part 3) - 2015, 7)

1.1. General data

Wind action in the X direction is considered

Wind action in the Y direction is considered

Location data

V_b: Basic wind speed (IS:875 (Part 3) - 2015, fig. 1) V_b : 55.0 m/s

Service period: 50 years

Importance category for the cyclonic region (IS:875 (Part 3) - 2015, 6.3.4): III

Terrain category (IS:875 (Part 3) - 2015, 6.3.2)

Wind at 0° Category I

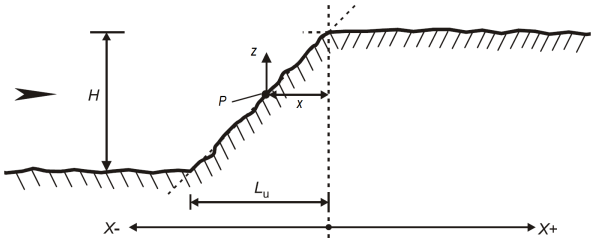
Wind at 90° Category II

Wind at 180° Category III

Wind at 270° Category IV

Land orography (IS:875 (Part 3) - 2015, 6.3.3)

X Direction [0°- 180°]: Ascending

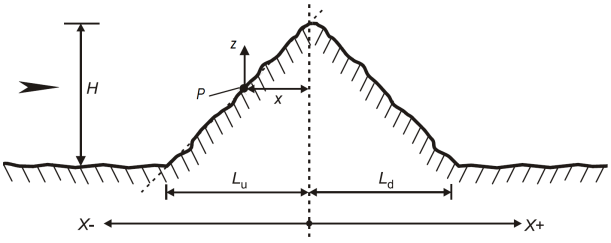


X_p : 0.00 m

H : 10.00 m

L_u : 20.00 m

Y Direction [90°- 270°]: Hill



Y_p : 5.00 m

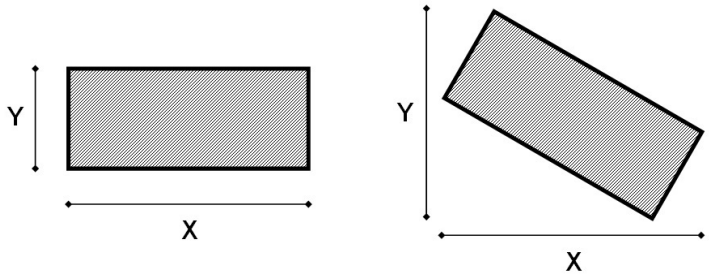
H : 10.00 m

L_u : 20.00 m

L_d : 20.00 m

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)
Casetón	2.00	2.00
Cubierta	2.00	2.00
Tercera planta	2.00	2.00
Segunda planta	2.00	2.00
Planta baja	2.00	2.00

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, p_d, evaluated at height z, shall be calculated by the following equation:

$$p_d = K_d \cdot K_a \cdot K_c \cdot p_z$$

Parameters requires to obtain the dynamic pressure

p_d: Design wind pressure (IS:875 (Part 3) - 2015, 7.2)

k_d: Wind directionality factor (IS:875 (Part 3) - 2015, 7.2.1) k_d : *1.00*

k_a: Area averaging factor (IS:875 (Part 3) - 2015, 7.2.2) k_a : *1.00*

k_c: Combination factor (IS:875 (Part 3) - 2015, 7.3.3.13) k_c : *1.00*

p_z: Wind pressure at height z (IS:875 (Part 3) - 2015, 7.2)

$$p_z = 0.6V_z^2$$

V_z: Design wind speed (IS:875 (Part 3) - 2015, 6.3)

$$V_z = V_b \cdot k_1 \cdot k_2 \cdot k_3 \cdot k_4$$

V_b: Basic wind speed (IS:875 (Part 3) - 2015, fig. 1) V_b : *55.0* m/s

k_1: Probability factor (IS:875 (Part 3) - 2015, 6.3.1) k_1 : *1.00*

k_2: Roughness factor per floor (IS:875 (Part 3) - 2015, Table 2)

k_3: Topography factor (IS:875 (Part 3) - 2015, Annex C)

k_4: Importance factor for the cyclonic region (IS:875 (Part 3) - 2015, 6.3.4) k_4 : *1.00*

Importance category for the cyclonic region (IS:875 (Part 3) - 2015, 6.3.4): III

1.2.1. Roughness factor

k_2: Terrain roughness and height factor (IS:875 (Part 3) - 2015, Table 2)

Terrain parameters (IS:875 (Part 3) - 2015, 6.3.2)

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Exposure	Category I	Category II	Category III	Category IV
z_0 (m)	0.002	0.020	0.200	2.000

Roughness factor per floor (IS:875 (Part 3) - 2015, Table 2)

k_2 (z)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	0.81	0.71	0.54	0.29
Cubierta	0.79	0.68	0.51	0.25
Tercera planta	0.76	0.65	0.47	0.21
Segunda planta	0.72	0.60	0.41	0.14
Planta baja	0.64	0.51	0.30	0.01

1.2.2. Topographic factor

k_3: Topography factor (IS:875 (Part 3) - 2015, Annex C)

$k_3 = 1 + 1.2(Z/L) \cdot s_0 \quad 3^o < \theta_s \leq 17^o$

$k_3 = 1 + 0.36 \cdot s_0 \quad \theta_s > 17^o$

s_0: Factor derived in accordance with C-2-1 (IS:875 (Part 3) - 2015, Annex C)

q_s: Upwind slope (IS:875 (Part 3) - 2015, Annex C)

L: Actual length of the upwind slope (IS:875 (Part 3) - 2015, Annex C)

Z: Effective height of the topography feature (IS:875 (Part 3) - 2015, Annex C)

Orographic location factor (IS:875 (Part 3) - 2015, fig. 14 and 15)

s_0				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	0.41	0.40	---	0.38
Cubierta	0.52	0.49	---	0.46
Tercera planta	0.65	0.58	---	0.55
Segunda planta	0.80	0.65	---	0.64
Planta baja	0.96	0.73	---	0.72

Orography factor (IS:875 (Part 3) - 2015, Annex C)

k_3				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	1.15	1.14	1.00	1.14
Cubierta	1.19	1.18	1.00	1.16
Tercera planta	1.23	1.21	1.00	1.20
Segunda planta	1.29	1.24	1.00	1.23
Planta baja	1.35	1.26	1.00	1.26

1.2.3. Velocity pressure per floor

p_d: Design wind pressure (IS:875 (Part 3) - 2015, 7.2)

$p_d(z)$ (t/m²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	0.160	0.120	0.053	0.020
Cubierta	0.162	0.118	0.047	0.016
Tercera planta	0.162	0.112	0.040	0.011
Segunda planta	0.158	0.101	0.031	0.005
Planta baja	0.138	0.076	0.017	0.000

1.3. Design pressure

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

$$p = p_d(z) \cdot C_f \cdot G$$ (IS:875 (Part 3) - 2015, 7.3 and 10)

Where:

p_d: Design pressure evaluated at height z

C_f: Force coefficient

G: Gust factor

1.3.1. Pressure coefficients

X Direction [0°- 180°]

C_f: Force coefficient (IS:875 (Part 3) - 2015, Table 5) C_f : 1.53

h / b: Ratio h / b : 6.88

a / b: Ratio a / b : 1.00

h: Height of the structure h : 13.75 m

a: Depth of the structure (length parallel to the wind direction) a : 2.00 m

b: Width of the structure (length perpendicular to the wind direction) b : 2.00 m

Y Direction [90°- 270°]

C_f: Force coefficient (IS:875 (Part 3) - 2015, Table 5) C_f : 1.53

h / b: Ratio h / b : 6.88

a / b: Ratio a / b : 1.00

h: Height of the structure h : 13.75 m

a: Depth of the structure (length parallel to the wind direction) a : 2.00 m

b: Width of the structure (length perpendicular to the wind direction) b : 2.00 m

1.3.2. Gust-effect factor

Fundamental frequency

f_a: Fundamental frequency $f_{a,x}$: 1.14 Hz

$f_{a,y}$: 1.14 Hz

$$f_a = \frac{\sqrt{d}}{0.09 \cdot h}$$

h: Height of the structure h : 13.75 m

d: Maximum base dimension of building in a direction parallel to the applied wind force d_x : 2.00 m

d_y : 2.00 m

Gust factor

Gust factor is given by:

$$G = 1 + r\sqrt{g_v^2 B_s (1+\phi)^2 + \frac{H_s g_R^2 SE}{\beta}}$$ (IS:875 (Part 3) - 2015, 10)

r: Roughness factor (IS:875 (Part 3) - 2015, 10)

$$r = 2 \cdot I_h$$

I_h: Longitudinal turbulence intensity at height h (IS:875 (Part 3) - 2015, 6.5)

$$I_{h,1} = 0.3507 - 0.0535 \log_{10}\left(\frac{h}{z_{0,1}}\right)$$ for terrain category 1

$$I_{h,2} = I_{h,1} + \frac{1}{7}\left(I_{h,4} - I_{h,1}\right)$$ for terrain category 2

$$I_{h,3} = I_{h,1} + \frac{3}{7}\left(I_{h,4} - I_{h,1}\right)$$ for terrain category 3

$$I_{h,4} = 0.466 - 0.1358\log_{10}\left(\frac{h}{z_{0,4}}\right)$$ for terrain category 4

h: Height of the structure h : 13.75 m

$z_{0,i}$: Equivalent aerodynamic roughness height for terrain category i

g_v: Peak factor for upwind velocity fluctuation (IS:875 (Part 3) - 2015, 10)

B_s: Background factor (IS:875 (Part 3) - 2015, 10)

$$B_s = \frac{1}{1 + \frac{\sqrt{0.26(h-s)^2 + 0.46b_{sh}^2}}{L_h}}$$

B_{sh}: Average breadth of the building between heights s and h

L_h: Measure of effective turbulence length scale at the height h

$$L_h = 85\left(\frac{h}{10}\right)^{0.25}$$ for terrain category 1 to 3

$$L_h = 70\left(\frac{h}{10}\right)^{0.25}$$ for terrain category 4

j : Factor to account for the second order turbulence intensity (IS:875 (Part 3) - 2015, 10)

$$\phi = \frac{g_v I_h \sqrt{B_s}}{2}$$

H_s: Height factor for resonance response (IS:875 (Part 3) - 2015, 10)

$$H_s = 1 + \left(\frac{s}{h}\right)^2$$

S: Size reduction factor (IS:875 (Part 3) - 2015, 10)

$$S = \frac{1}{\left[1 + \frac{3.5 f_a h}{\overline{V}_{h,d}}\right]\left[1 + \frac{4 f_a b_{0,h}}{\overline{V}_{h,d}}\right]}$$

B_{0h}: Average breadth of the building between heights 0 and h

f_a: First mode natural frequency of the building in along wind direction

$V_{h,d}$: Design hourly mean wind speed at height h (IS:875 (Part 3) - 2015, 6.4)

$$\overline{V}_{h,d} = V_b \cdot k_1 \cdot \overline{k}_2 \cdot k_3 \cdot k_4$$

k_2: Hourly mean wind speed factor

$$\overline{k}_2 = 0.1423\left[\ln\left(\frac{h}{z_{0,i}}\right)\right]\left(z_{0,i}\right)^{0.0706}$$

$z_{0,i}$: Equivalent aerodynamic roughness height for terrain category i

g_r: Peak factor for resonant response (IS:875 (Part 3) - 2015, 10)

$$g_R = \sqrt{2 \cdot \ln(3600 \cdot f_a)}$$

E: Spectrum of turbulence in the approaching wind stream (IS:875 (Part 3) - 2015, 10)

$$E = \frac{\pi N}{\left(1 + 70.8N^2\right)^{5/6}}$$

N: Effective reduced frequency (IS:875 (Part 3) - 2015, 10)

$$N = \frac{f_a \cdot L_h}{V_{h,d}}$$

b: Damping coefficient of the building (IS:875 (Part 3) - 2015, Table 36) b : *0.02*

Terrain parameters (IS:875 (Part 3) - 2015, 6.3.2)

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Exposure	Category I	Category II	Category III	Category IV
z_0 (m)	0.002	0.020	0.200	2.000

Calculation of the gust factor G

Direction	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
I_h	0.15	0.17	0.23	0.35
r	0.29	0.35	0.47	0.70
L_h	92.04	92.04	92.04	75.80
g_v	3.00	3.00	4.00	4.00
S	0.41	0.37	0.27	0.16
N	2.06	2.37	3.56	4.81
E	0.06	0.05	0.04	0.03
g_r	4.08	4.08	4.08	4.08

Gust factor, G (IS:875 (Part 3) - 2015, 10)

G				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	3.08	3.36	4.37	6.23
Cubierta	2.92	3.19	4.22	6.07
Tercera planta	2.79	3.05	4.12	5.96
Segunda planta	2.70	2.95	4.04	5.86
Planta baja	2.64	2.89	3.98	5.79

1.3.3. Design pressure per floor

Design pressure, p (IS:875 (Part 3) - 2015, 7.3 and 10)

p (t/m²)				
Floor	Wind at 0°	Wind at 90°	Wind at 180°	Wind at 270°
Casetón	0.757	0.619	0.358	0.189
Cubierta	0.727	0.575	0.307	0.148
Tercera planta	0.695	0.526	0.255	0.102
Segunda planta	0.655	0.456	0.193	0.048
Planta baja	0.560	0.336	0.105	0.001

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 (t/m²)	b (m)	h (m)	F (t)
Casetón	0.757	2.00	1.50	2.272
Cubierta	0.727	2.00	2.93	4.254
Tercera planta	0.695	2.00	2.85	3.962
Segunda planta	0.655	2.00	2.85	3.734
Planta baja	0.560	2.00	2.98	3.332

Wind at 90° (-Y)				
Floor	p (t/m²)	b (m)	h (m)	F (t)
Casetón	0.619	2.00	1.50	-1.858
Cubierta	0.575	2.00	2.93	-3.366
Tercera planta	0.526	2.00	2.85	-3.000
Segunda planta	0.456	2.00	2.85	-2.600
Planta baja	0.336	2.00	2.98	-2.001

Wind at 180° (-X)				
Floor	p (t/m²)	b (m)	h (m)	F (t)
Casetón	0.358	2.00	1.50	-1.073
Cubierta	0.307	2.00	2.93	-1.795
Tercera planta	0.255	2.00	2.85	-1.452
Segunda planta	0.193	2.00	2.85	-1.098
Planta baja	0.105	2.00	2.98	-0.623

Wind at 270° (+Y)				
Floor	p (t/m²)	b (m)	h (m)	F (t)
Casetón	0.189	2.00	1.50	0.568
Cubierta	0.148	2.00	2.93	0.863
Tercera planta	0.102	2.00	2.85	0.583
Segunda planta	0.048	2.00	2.85	0.275
Planta baja	0.001	2.00	2.98	0.003