WIND CODE EVALUATION

DOMINICAN REPUBLIC

Evaluation conducted by Jorge Gutiérrez

NAME OF DOCUMENT: “Manual de Diseño contra Viento” (Manual for Wind Design)

YEAR: 2000

GENERAL REMARKS: Drafted by the “Grupo Estabilidad Estructural” (Structural Stability Group) of “Instituto Tecnológico de Santo Domingo" and approved by the “Dirección General de Reglamentos y Sistemas” (DGRS) (“General Directory of Norms and Systems”) of the “Secretaría de Estado de Obras Públicas y Comunicaciones” (SEOPC) (“Secretary of Public Works and Communications”).

The Code states in its Methodology that three Codes had been mainly used for consultation and adaptation: “Minimum Design Loads for Buildings and Other Structures” (ASCE-7-98), “Barbados Standard” (BNS CP28) and “Australian Standard” (AS 1170.2.1989).

SPECIFIC ITEMS:

NOTE: Bracketed numbers refer to Code specific chapters or articles: [3.1].
Parenthesis numbers refer to Items of this document: (see 2.2).

1. SCOPE

1.1 Explicit Concepts and Limitations. [1.1; 1.2]

The Code defines minimum requirements for the analysis of wind gust effects upon structures by static pressure simulation.

The Code is mandatory for the entire country and applies to buildings and related structures such as industrial warehouses, commercial signs, chimneys, elevated water tanks, silos, etc.
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1.2 Performance Objectives.

Not explicitly defined.

2. WIND HAZARD

2.1 Basic Wind Speed. [1.3; 4.5]

The Basic Wind Speed is defined as the maximum 3 second gust speed at 10m above the ground in Exposure Category C (see 2.4), corresponding to a Probability of Exceedence of 0.02 (Return Period of 50 years).

According to Basic Wind Speed the country is divided in three zones:

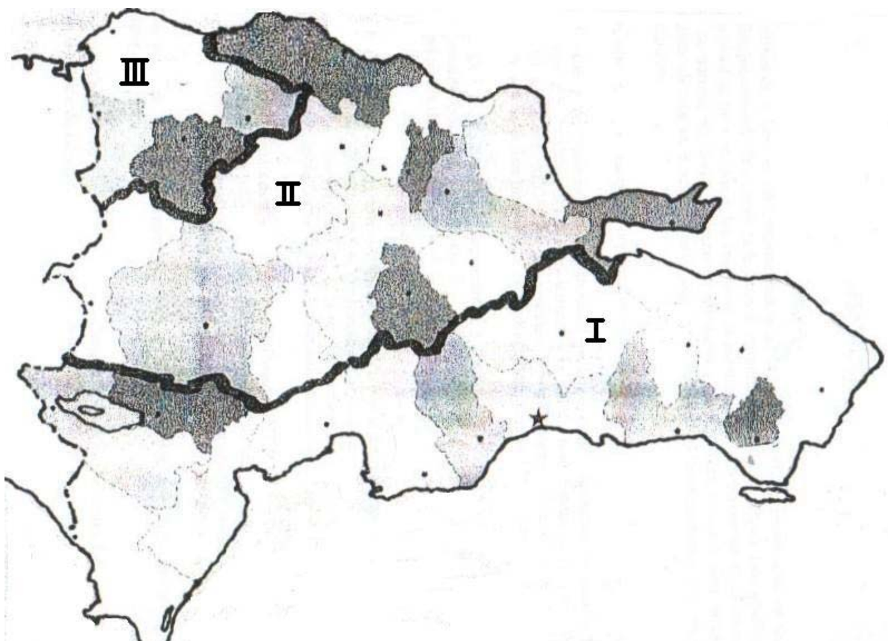


Figura C4. Zonificación Eólica para la República Dominicana

With their corresponding Basic Wind Speed:

Wind Zone	Wind Conditions	Basic Wind Speed (km/h)
I	Maximum intensity	240
II	Medium intensity	210
III	Low intensity	180

2.2 Topography. [4.4]

A Wind Topography Factor K_{zt} will be considered when the structure is located on a hill or elevation capable of increasing the windward wind velocity at 10m above ground. K_{zt} will be taken as 1.0 if:

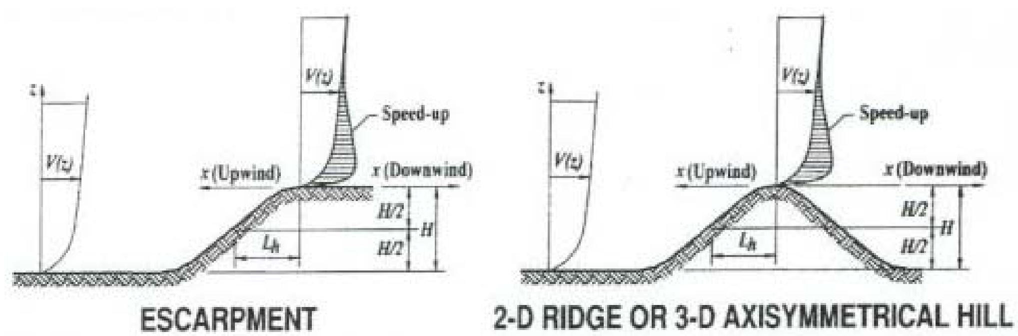
- $H/L_h < 0.2$
- H < 9.0 m for Exposure Category B (see 2.4)
- H < 18.0 m for Exposure Category c (see 2.4)

Where H = Height of the hill.
L_h = Upwind width of the hill at mid height.

For a general case the Topography Factor K_{zt} will be given by the following equation:

$$K_{zt} = (1 + K_1 K_2 K_3)^2$$

Values for K_1, K_2, K_3 are given in the following Table [Table D, based upon but not identical to Fig. 6.2 of ASCE 7-98]:



Exposure C				Exposure B and C							Exposure B			
H/L_h	K_1			x/L_h	K_2		z/L_h	K_3			H/L_h	K_1		
	2D Ridg	2D Esc.	3D Hill		2D Esc.	other		2D Ridg	2D Esc.	3D Hill		2D Ridg	2D Esc.	3D Hill
0.20	**0.29**	**0.17**	**0.21**	**0.00**	**1.00**	**1.00**	**0.00**	**1.00**	**1.00**	**1.00**	**0.20**	**0.26**	**0.15**	**0.19**
0.25	**0.36**	**0.21**	**0.26**	**0.50**	**0.88**	**0.67**	**0.10**	**0.74**	**0.78**	**0.67**	**0.25**	**0.33**	**0.19**	**0.24**
0.30	**0.44**	**0.26**	**0.32**	**1.00**	**0.75**	**0.33**	**0.20**	**0.55**	**0.61**	**0.45**	**0.30**	**0.39**	**0.23**	**0.29**
0.35	**0.51**	**0.30**	**0.37**	**1.50**	**0.63**	**0.00**	**0.30**	**0.41**	**0.47**	**0.30**	**0.35**	**0.46**	**0.26**	**0.33**
0.40	**0.58**	**0.34**	**0.42**	**2.00**	**0.50**	**0.00**	**0.40**	**0.30**	**0.37**	**0.20**	**0.40**	**0.52**	**0.30**	**0.38**
0.45	**0.65**	**0.38**	**0.47**	**2.50**	**0.38**	**0.00**	**0.50**	**0.22**	**0.29**	**0.14**	**0.45**	**0.59**	**0.34**	**0.43**
0.50	**0.73**	**0.43**	**0.53**	**3.00**	**0.25**	**0.00**	**0.60**	**0.17**	**0.22**	**0.09**	**0.50**	**0.65**	**0.38**	**0.48**
				3.50	**0.13**	**0.00**	**0.70**	**0.12**	**0.17**	**0.06**				
				4.00	**0.00**	**0.00**	**0.80**	**0.09**	**0.14**	**0.04**				
							0.90	**0.07**	**0.11**	**0.03**				
							1.00	**0.05**	**0.08**	**0.02**				
							1.50	**0.01**	**0.02**	**0.00**				

2.3 Height above Ground (Case Specific). [4.2.3]

This effect is defined by the Velocity Pressure Exposure Coefficient K_z which is a function of the Exposure Category (see 2.4) and the height above ground z.

The values of K_z (or K_h, corresponding to z=h, the roof mid height) are given in the following Table [Table B]:

Velocity Pressure Coefficients K_z and K_h

Height z (m)	Exposure			Height z (m)	Exposure		
	B		C		B		C
	Case 1	Case 2	Cases 1 & 2		Case 1	Case 2	Cases 1 & 2
≤5	0.70	0.57	0.85	35	1.03	1.03	1.30
6	0.70	0.62	0.90	40	1.07	1.07	1.34
8	0.70	0.67	0.96	45	1.10	1.10	1.37
10	0.72	0.72	1.00	50	1.14	1.14	1.40
12	0.76	0.76	1.04	55	1.17	1.17	1.43
14	0.79	0.79	1.07	60	1.20	1.20	1.46
16	0.82	0.82	1.11	65	1.23	1.23	1.48
18	0.85	0.85	1.13	70	1.25	1.25	1.51
20	0.88	0.88	1.16	75	1.28	1.28	1.53
22	0.90	0.90	1.18	80	1.30	1.30	1.55
24	0.92	0.92	1.20	85	1.32	1.32	1.57
25	0.93	0.93	1.21	90	1.35	1.35	1.59
28	0.96	0.96	1.24	95	1.37	1.37	1.61
30	0.98	0.98	1.26	100	1.39	1.39	1.63

Notes:

1. **Case 1:** All primary systems in buildings with height h < 18m and secondary systems of any type.
   Case 2: All primary systems for any structure except Case 1 structures.
2. Linear interpolation for intermediate z values is allowed.

The Commentary to article 4.2 [C-4.2] states that the K_z values of the Table above can be calculated with the following equations:

$K_z = 2.01\,(5 / z_g)^{2/\alpha}$ for $z < 5$ m
$K_z = 2.01\,(z / z_g)^{2/\alpha}$ for $5 \text{ m} < z < z_g$

With z_g and α defined in the following Table:

Exposure	α	z_g (m)
B	7.0	366
C	9.5	274

2.4 Ground Roughness (Number of Exposure Categories). [4.2]

Two Exposure Categories (B and C) are defined [based on ASCE-7-98, article 6.5.6.1].

Exposure Category B. Urban and suburban areas, wooded areas, other terrain with numerous closely spaced obstructions having the size of single family dwellings with average height larger than 10 m.
Exposure Category C. Open terrain with scattered obstructions having heights less than 10 m.

The Velocity Pressure Exposure Coefficient K_z (or K_h) is a function of the height above ground and the Exposure Category (see 2.3)

3. WIND DESIGN ACTIONS

3.1 Importance Factors. [2.4]

According to their importance and use, buildings are classified in four types (I, II, III and IV) as follows:

Type I: Buildings and related structures whose failure implies low risk for human life including but not limited to rural, storage or temporary facilities.
Type II: Normal occupancy public or private buildings (housing, offices, commerce, etc). Additionally, it includes hazardous facilities not classified as Category IV if it is insured that that any damage or toxic spill can be immediately controlled.
Type III: Hazardous facilities or high occupancy public or private buildings.
Type IV: Essential facilities.

An importance Factor I is assigned to each category as follows [Table A]:

Use Category	Importance Factor I
I	0.77
II	1.00
III	1.15
IV	1.15

3.2 Scale Effects.

Not specifically considered in the text but the numerical values of GC_p factors (see 3.3) for roof secondary systems depend on the effective area of the exposed surface [Tables K_1, K_2, K_3].

3.3 Pressure (Internal and External). [4; 5.1; 5.2]

In order to estimate the internal pressure coefficients, buildings are classified as Enclosed, Partially Enclosed or Open [1.3.1; similar to 6.2 of ASCE-7-98].

For the Analytical Procedure (see 4.2) the Basic Wind Pressure q (in kN/m^2) is given by the following equation:

$$q = 0.04572\ K_z\ K_{zt}\ K_d\ V^2\ I$$

Where:
K_z = Velocity pressure exposure coefficient (see 2.3)
K_{zt} = Topography Factor (see 2.2)
K_d = Directionality Factor (see 3.5)
V = Basic Wind Speed in km/h (see 2.1)
I = Importance Factor (see 3.1)

The design pressure p for primary systems in Enclosed or Partially Enclosed structures is defined by the following equation that takes into consideration the internal pressures:

$$p = q\ GC_p - q_h\ GC_{pi}$$

The design pressure p for primary systems in Enclosed or Partially Enclosed buildings cannot be less than 50 kg/m^2 (491 N/m^2).

For secondary systems in Enclosed or Partially Enclosed buildings the design pressure p is defined as:

$$p = q_h\ [(GC_p) - (GC_{pi})] \qquad \text{for structures with } h \le 18m$$
$$p = q\ [(GC_p) - (GC_{pi})] \qquad \text{for structures with } h > 18m$$

For primary or secondary systems in Open buildings p is given by the expression:

$$p = q_z\ GC_f \qquad \text{with p no less than 50 } kg/m^2 \text{ (491 } N/m^2\text{)}$$

In all these equations:

p = Design pressure (in N/m^2).
q_h = Velocity pressure evaluated at mean roof height h.
$q = q_z$ for upwind walls calculated at height z above the ground.
$q = q_h$ for downwind walls, side walls and roofs, evaluated at height h.
G = Gust Factor (see 3.4).
C_p = External Pressure Coefficient.

(GC_{pi}) = Internal Pressure Coefficient.

G_f = External Pressure Coefficient for Open structures. It is also the corresponding Force Coefficient for non building structures (see 6.2).

Combined gust effect factor G and external pressure coefficients C_p and C_f are given in specific Tables [Tables E, F, G1, G2 and H same as Figs. 6-5 through 6-7 and 6-8 respectively of ASCE-7-98]. The Pressure Coefficient and Gust Effect Factor shall not be separated.

The Internal Pressure Coefficient (GC_{pi}) is a function of the enclosure conditions according to the following Table:

Enclosure Type	**(GC_{pi})**
Open	0.00
Partially Enclosed	$\pm$0.55
Enclosed	$\pm$0.18

3.4 Dynamic and Aeroelastic Effects (Gust Effects). [5.1.1; Commentary C-1.3]

The external and internal pressures calculated to define the design forces include a Gust Effect Factor G (see 3.3).

Oddly enough, not in the text of the Code but in the Commentary to article 3.1, "Definitions and Notations" [C-1.3] it is stated that, for rigid structures (natural period $T \leq 1$s), the Gust Effect Factor G will be 0.85. For flexible structures (natural period $T > 1$ s), or for wind sensitive structures, the design pressure p is determined with the following equation:

$$p = q\, G_f\, C_p - q_f\, GC_{pi} \qquad \text{[equation C1in the Commentary]}$$

In this equation the Gust Effect Factor G_f is calculated following a specific procedure [equations C2-a, -b, -c, -d, -e, -f, -g, -h, -i, -k and -l, equivalent to equations 6-2 to 6-12 of ASCE-7-98 modified for dimensions in meters instead of feet]. The remaining terms have been defined elsewhere (see 3.3)

3.5 Directionality Effects. [4.3]

Wind should be considered as coming from any direction. The Wind Directionality Factor K_d (see 3.3) varies from 0.85 to 0.95 and shall be determined from a Table [Table C, identical to Table 6-6 of ASCE-7-98]. This factor should only be applied when used in conjunction with specific load combinations (see 6.1), otherwise K_d = 1.

4. METHODS OF ANALYSIS

4.1 Simplified Procedure.

Not included.

4.2 Analytical Procedure. [3.2.1]

This is the only procedure described in the Code. Wind external and internal pressures (see 3.3) are determined in terms of basic wind speed (see 2.1), wind directionality (see 3.5), use category (see 3.1), ground roughness (see 2.4), topography (see 2.2) and other related factors.

4.3 Experimental Procedure. [3.3.2]

A brief paragraph states that wind tunnel tests can be used for structures of unusual aerodynamic characteristics. This experimental method is a requirement for especial structures.

5. INDUCED EFFECTS

5.1 Impact of Flying Objects.

Not considered.

5.2 Wind Driven Rain.

Not considered.

6. SAFETY VERIFICATIONS

6.1 Structure. [2; 3.1]

For design of primary or secondary structural systems, the wind forces W determined from the design pressures p (see 3.3) using the Analytical Procedure (see 4.2) or more refined theories or experimental procedures (see 4.3), shall be combined with the Dead Loads D and Live Loads L, L_R (roof live load) to determine the Ultimate Load as follows:

$$1.4\ D$$
$$1.2\ D + 1.6\ L + 0.5\ L_R$$
$$1.2\ D + 1.6\ L_R + (0.5\ L \text{ or } 0.8\ W)$$
$$1.2\ D + 1.6\ W + 0.5\ L + 0.5\ L_R$$
$$0.9\ D + 1.6\ W$$

All structural elements must be dimensioned and detailed so that their strength equals or exceeds these factored loads.

Allowable stress design (ASD) is also possible with the following load combinations:

$$D$$
$$D + L + L_R$$
$$D + L + W + L_R$$
$$0.6D + W$$

Both for Strength and Allowable Stress Design, the above equations have been simplified by neglecting other types of loads. The complete load combinations are identical to ASCE-7-98 [Sections 2.3 and 2.4 of ASCE-7-98].

It should be noted that the wind forces W calculated with the Code are not extreme loads but service loads. The extreme loads are 1.6 W.

Drift limits are not defined in the Code.

6.2 Claddings and Non-Structural Elements. [6.1]

The Code contains no specific regulations for claddings and non-structural elements. However, Chapter 6, "Pressures in Special Structures", covers non building structures, including commercial signs, arches and domes, towers, silos, chimneys and tanks as well as irregular buildings. For commercial signs the total design force F is given by the following expression:

$$F = q_z \, G \, C_f \, A_f$$

Where A_f is the projection of the solid area normal to the wind direction. The remaining terms have been defined elsewhere (see 3.3).

7. SMALL RESIDENTIAL BUILDINGS.

Not specifically considered.

RECOMMENDATIONS FOR CODE IMPROVEMENT

The Dominican Republic "Manual for Wind Design" is a state of the art Wind Code that follows very closely the Wind Load requirements of ASCE-7-98.

The main objections that can be pointed out are the lack of drift limits for wind forces, the absence of specific requirements for claddings and non-structural elements and components and the fact that the Commentaries contain complementary norms not included in the main body, including some equations that are essential for some of the calculations (see 3.4).