WIND CODE EVALUATION

VENEZUELA

Evaluation conducted by Jorge Gutiérrez

NAME OF DOCUMENT: "Acciones del Viento sobre las Construcciones" (Wind Effects on Constructions") Norm COVENIN-MINDUR-2003-86. Comisión Venezolana de Normas Industriales (COVENIN) (Venezuelan Committee on Industrial Norms)

YEAR: Provisionally approved on July 1986. Definitive approval on October 1989

GENERAL REMARKS: Based on "Minimum Design Loads for Buildings and other Structures", ANSI A58.1-1982, American National Standards Institute (ANSI).

SPECIFIC ITEMS:

NOTE: Bracketed numbers refer to Code specific chapters or articles: [6.2].
Parenthesis numbers refer to Items of this document: (see 3.3).

1. SCOPE

1.1 Explicit Concepts and Limitations. [1; 3.1]

Norms are minimum requirements for wind effects on new buildings and related structures as well as their components.

Wind effects defined in the norm are considered service loads.

1.2 Performance Objectives.

Not explicitly considered.

2. WIND HAZARD

2.1 Basic Wind Speed. [5.1]

The Basic Wind Speed V is defined as the maximum speed at 10m above the ground in Exposure Category C (see 2.4), corresponding to a Return Period of 50 years. The Basic Wind Speed can be either V_h, the average over a one hour period or V_t, the average over a period of t seconds. The Code uses the concept of “wind trajectory time pattern” (“tiempo patrón de recorrido del viento”); the Code Commentary defines the average time pattern as 74s [C-5.1].

Basic Wind Speed for the country is tabulated for the most important cities [Table 5.1] and mapped as equal speed curves (see figure). Minimum Basic Wind Speed is 70 km/h:

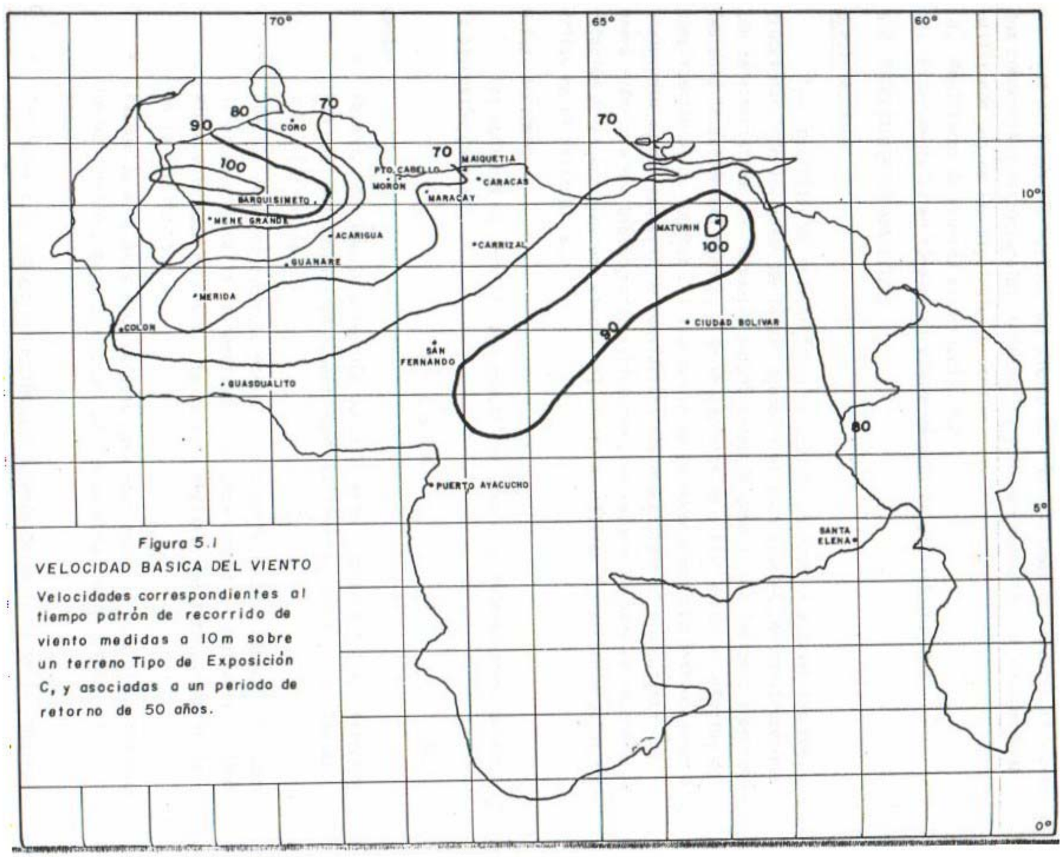

Figura 5.1
VELOCIDAD BASICA DEL VIENTO
Velocidades correspondientes al tiempo patrón de recorrido de viento medidas a 10m sobre un terreno Tipo de Exposición C, y asociadas a un periodo de retorno de 50 años.

2.2 Topography. [5.1.1]

No special equations account for topography factors. The Code states that specific considerations must be given to topography and wind speeds may be increased due to particular topographic conditions.

2.3 Height above Ground (Case Specific). [6.2.3]

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 as follows:

$K_z = 2.58\ (4.5 / z_g)^{2/\beta}$ for $z \leq 4.5$ m
$K_z = 2.58\ (z / z_g)^{2/\beta}$ for $z > 4.5$ m

With z_g and β defined in the following Table:

Exposure Type	β	z_g (m)
A	3.0	460
B	4.5	370
C	7.0	270
D	10.0	200

The values of K_z (or K_h, corresponding to z=h, see 3.3) are given in the following Table [Table 6.2.3.1]:

Velocity Pressure Coefficients K_z and K_h

Height z (m)	**Exposure Type** (see 2.4)			
	A	**B**	**C**	**D**
0 to 4.5	0.118	0.363	0.800	1.207
5	0.126	0.380	0.825	1.233
6	0.142	0.413	0.869	1.279
7	0.158	0.442	0.908	1.319
8	0.173	0.469	0.943	1.355
9	0.187	0.494	0.976	1.387
10	0.200	0.518	1.006	1.417
11	0.214	0.540	1.033	1.444
12	0.226	0.562	1.059	1.469
13	0.239	0.582	1.084	1.493
14	0.251	0.601	1.107	1.515
15	0.263	0.620	1.129	1.536

2.4 Ground Roughness (Number of Exposure Categories). [5.2]

Four Exposure Categories (A, B, C and D) are defined:

Exposure A. Large city centers with at least 50% of buildings with heights over 20m.
Exposure B. Urban and suburban areas, wooded areas, other terrain with numerous closely spaced obstructions having the size of single family dwellings or larger having average heights less than 10m.
Exposure B. Open terrain, plains and savannas with scattered obstructions having average heights less than 10m.
Exposure D. Flat unobstructed coastal areas exposed to wind flowing from open ocean. It extends 500m inland.

3. WIND DESIGN ACTIONS

3.1 Importance Factors. [4.1]

According to their importance and use, buildings are classified in three Exposure Types (A, B and C) as follows:

Type A: Essential facilities. Hazardous facilities or high occupancy public or private buildings.
Type B: Normal occupancy public or private buildings; industrial facilities not classified as Type A.
Type C: Buildings and related structures, not classified as Types A or B, whose failure represents low risk for human life and no damage for buildings Types A or B.

An importance Factor α is assigned to each category as follows [Table 4.1.2]:

Use Category	**Importance Factor α**
A	1.15
B	1.00
C	0.90

For components and cladding, their Exposure Types (and corresponding Importance Factors I) are modified according to the building Exposure Type and Structural Type (see 3.3) as follows:

Exposure Types for Components and Cladding [Table 5.3.2]

Structural Type			**Building Exposure Type**			
			A	**B**	**C**	**D**
I	Enclosed	h ≤ 20m	C	C	C	C
		h > 20m	B	B	C	D
II	Open	All h	B	B	C	D
III	Open	All h	B	B	C	D
	Enclosed	h ≤ 20m	C	C	C	C
		h > 20m	B	B	C	D

3.2 Scale Effects. [6.2.5.2]

For the definition of most of the specific GC_{pe} values (see 3.3), the area of the exposed surface or the tributary area are important factors [Tables 6.2.5.2]

3.3 Pressure (Internal and External). [4.2; 6.2]

Minimum wind pressure is 30 kg/m^2 acting on a projected area normal to the wind direction.

For the definition of wind pressures, buildings are classified according to the geometry of their exposed areas in four Structural Types [4.2]:

Type I: Enclosed buildings with a slenderness ratio less than 5 or natural period less than 1s that are insensitive to gusts and other dynamic wind effects. Also includes buildings enclosed with laminated sheets, with one or more open facades (industrial warehouses, theaters, auditoriums, etc.).
Type II: Open buildings with a slenderness ratio less than 5 or natural period less than 1s such as towers, guyed or free standing antennas, elevated tanks, commercial signs and parapets.
Type III: Buildings particularly sensitive to short duration gusts. Includes all buildings considered as Type I or Type II but with a slenderness ratio greater than 5 or natural period larger than 1s as well as those whose geometry can induce strong vibrations.
Type IV: This group includes all structures with specific aerodynamic problems such as suspended roofs, unstable aerodynamic forms, flexible structures having natural periods closed to each other, etc.

Dynamic wind pressure q is defined differently for upwind or downwind surface areas:

For upwind surfaces, the pressure q_z is a function of height z above ground as given by the following equation:

$$q_z = 0.00485\, K_z\, \alpha\, V^2$$

With:
q_z = Dynamic wind pressure at a height z above ground level, in kg/m^2.
K_z = Velocity Pressure Exposure Coefficient (see 2.3).
α = Importance Factor (see 3.1).
V = Basic Wind Speed, in km/h (see 2.1).

For downwind surfaces, the pressure q_h (as well as K_h) is taken as constant along the entire height and corresponds to the value calculated for a height, h, equal to the medium roof height for buildings Type I or total building height for the other building types.

Wind pressures p and forces F are related to the Dynamic Wind Pressure q, the Gust Effect Factors G_h and G_z (see 3.4) and the Shape Coefficients C_{pe} and C_{pi} for external and internal pressures, as well as C_f for roofs of open buildings and non building structures. Equations for p and F are presented in the following Tables:

Wind Actions on Resistant Systems [Table 6.2.2 (a)]

Building Type		Pressures p or Forces F
I	Enclosed	Upwind: $p_z = q_z\ G_h\ C_p$ Downwind $p_h = q_h\ G_h\ C_p$ For one story buildings the internal pressure is included as follows: Upwind: $p_z = q_z\ G_h\ C_p - q_h\ GC_{pi}$ Downwind: $p_h = q_h\ G_h\ C_p - q_h\ GC_{pi}$
II	Open	$F = q_z\ G_h\ C_f\ A_f$
III	Enclosed	Upwind: $p_z = q_z\ G_h\ C_p$ Downwind $p_h = q_h\ G_h\ C_p$
	Open	$F = q_z\ G_h\ C_f\ A_f$
IV	Open or Enclosed	Special studies are required, but the values of p or F cannot be smaller than those corresponding to Type III

Wind Actions on Components and Cladding [Table 6.2.2 (b)]

Building Type		Pressures p or Forces F
I	Enclosed	For h ≤ 20m: $p = q_h\ G\ C_{pe} - q_h\ (GC_{pi})$ For h > 20m: Upwind: $p = q_z\ (+GC_{pe}) - q_z\ (GC_{pi})$ Downwind: $p = q_h\ (-GC_{pe}) - q_z\ (GC_{pi})$
II	Open	$F = q_z\ G_z\ C_f\ A_f$
III	Enclosed	Upwind: $p = q_z\ (+GC_{pe}) - q_z\ (GC_{pi})$ Downwind: $p = q_h\ (-GC_{pe}) - q_z\ (GC_{pi})$
	Open	$F = q_z\ G_z\ C_f\ A_f$
IV	Open or Enclosed	Special studies are required, but the values of p or F cannot be smaller than those corresponding to Type III

A_f is the projection of the solid area normal to the wind direction. Values for C_p, GC_{pe}, C_f and GC_{pi} for different types of structures are presented in Tables [Tables 6.2.5.1, 6.2.5.2(a)-(d), 6.2.5.4, 6.2.5.5 (a),(b), 6.2.5.6, 6.2.5.7, 6.2.5.8, 6.2.5.9, 6.2.5.10]

3.4 Dynamic and Aeroelastic Effects (Gust Effects). [6.2.4]

Two Gust Effect Factors are defined, G_h for wind resistant systems and G_z for components and cladding. These factors cannot be less than 1.0.

For wind resistant systems classified as Type I or II (see 3.3), G_h has a single value for upwind and downwind walls and facades given by the equation:

$$G_h = 0.65 + 3.65\,\delta_h \qquad \text{with} \qquad \delta_h = 2.35\,(K)^{1/2} / (h/9.0)^{1/\beta}$$

Where:

δ_h = Exposure factor representing the gust intensity evaluated at roof mid height for Type I buildings or at total height for Type II buildings.

K = Drag Coefficient, related to Exposure Categories (see 2.4) as follows [Table 6.2.4.1]:

Exposure Category	**Drag Coefficient** (K)
A	0.025
B	0.010
C	0.005
D	0.003

For wind resistant systems classified as Type III, the Gust Effect Factor G_h will be calculated by analytical methods that take into consideration the dynamics of the structural system. Optional procedures are presented in the Commentary [C-6.2.4].

For components and cladding of enclosed buildings classified as Type I or III, the Gust Effect Factor G_z is combined with the external and internal pressure coefficients C_{pe} and C_{pi} resulting in coefficients GC_{pe} and GC_{pi} (see 3.3).

For components and cladding of open buildings classified as Type II or III, the Gust Effect Factor G_z, corresponding to its height z above ground, is given by the equation:

$$G_z = 0.65 + 3.65\,\delta_z \qquad \text{with} \qquad \delta_z = 2.35\,(K)^{1/2} / (z/9.0)^{1/\beta}$$

With Drag Coefficients K defined as above.

3.5 Directionality Effects. [3.1]

Wind should be considered as coming from two orthogonal horizontal directions, without considering superposition effects. These directions must be selected as to produce the most unfavorable condition to the structure or its components.

4. METHODS OF ANALYSIS

4.1 Simplified Procedure.

Not considered.

4.2 Analytical Procedure. [6.2]

This procedure can be applied to all buildings and related structures. However, for buildings having unusual aerodynamic conditions, specialized bibliography or experimental procedures (see 4.3) must be used.

The wind design service loads W are defined as:

$$W = q\ G\ C\ A$$

Where:

W = Wind service force acting on the centroid of surface A.
q = Dynamic wind pressure (see 3.3) due to Basic Wind Speed V (see 2.1).
G = Gust Effect Factor (see 3.4).
C = Pressure Coefficient, external or internal (see 3.3).
A = Exposed surface area or projected area normal to the wind direction.

Design loads W for the elements and components of the structure will be determined by static linear analysis methods.

4.3 Experimental Procedure. [6.3]

Wind Tunnel Tests (or tests with other kinds of fluids) are presented as an alternative to the Analytical Procedure (see 4.2). To validate the results, the Code defines specific conditions:

- Natural wind is modeled as to reproduce its variations along height.
- Natural wind is modeled as to reproduce the longitudinal component gust effects.
- Geometric scale is smaller than three times the geometric scale of the longitudinal component gust effects.
- The instrumentation is adequate for the precision required for measured data.
- Due consideration is given to Reynolds Number as related to wind pressures (including suction).

Additionally, if the dynamic response of the structure is important, due consideration to dimensional effects on mass, stiffness and damping is necessary.

5. INDUCED EFFECTS

5.1 Impact of Flying Objects.

Not considered.

5.2 Wind Driven Rain.

Not considered.

6. SAFETY VERIFICATIONS

6.1 Structure. [3.2; 3.3]

Wind Loads W (see 4.2) are service loads and must be combined with Dead D and Live L loads according to the specific requirements defined for each structural material. Simultaneous effects of wind and earthquake should not be considered.

For stability (sliding or overturning) considerations on wind resistant structures, only external forces will be considered.

No lateral displacement or drift limitations are defined.

6.2 Claddings and Non-Structural Elements. []

No specific safety verifications are presented for claddings or non-structural elements.

7. SMALL RESIDENTIAL BUILDINGS.

Not specifically considered.

RECOMMENDATIONS FOR CODE IMPROVEMENT

Although 17 years old, this is a very comprehensive Code and it is not outdated. However, it should be reviewed to include a few specific considerations like a Topography Factor and Directionality Effects as well as drift limitations.