WIND CODE EVALUATION

CUBA

Evaluation conducted by Carlos Llanes Burón

NAME OF DOCUMENT: NC 285: 2003. Carga de Viento. Método de Cálculo (Wind Pressure Loads. Calculating Method)

YEAR: 2003

GENERAL REMARKS: Official approval by "Oficina Nacional de Normalización" (NC).

SPECIFIC ITEMS:

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

1. SCOPE. [1]

1.1 Explicit Concepts and Limitations

It will be applied to all the terrestrial and marine constructions, except for constructions and facilities in a non usual way and not considered in the present standard.

1.2 Performance Objectives

All construction, building or part of it, not buried, it will be projected to resist the action of the wind.

2. WIND HAZARD

2.1 Basic Wind Speed [2.1 and Figure 1]

It is the pressure corresponding to a wind speed of reference measure to 10 meters high in a flat terrain without obstacles, considering an average time of 10 minutes and for a return period of 50 year.

Cuba is divided in three zones according to the wind pressure probable.

Regionalization according to the basic pressures of the wind.

2.2 Topography [2.2 and Table 2]

It takes into account the influence of defined topographical characters. As examples of possible exposed places the keys can be analyzed, the narrow peninsulas, strait valley where the wind is encased, the summits of promontories, the isolated or high mountains and others. (As structure example the lighthouses are in exposed place).

For elements and typical projects of multiple and national use the coefficient corresponding to normal place will be used; except in civil structures whose normal location is always in exposed place.

2.3 Height above Ground (Case Specific) [2.4 and Tables 3 and 4, 2.4.1and Figure 3 and Table 5]

The coefficient of height (C_h), according to the category of terrain type it will come given by the following expression:

$$C_h = k_{q_0} \left(\frac{z}{Z_0} \right)^{2\alpha}$$

There are three expressions one for each terrain type.

Terrain Type	C_h	Z_g (m)
A	$(Z/10)^{0,32}$	300
B	$0,65\ (Z/10)^{0,44}$	400
C	$0,30\ (Z/10)^{0,66}$	500

Where **Z_g** , is the gradient height and Z, is the analyzed height.

For structures located in hills, wavy lands, escarpment, the increment of the normative speed of the wind on hills and escarpments it is an important aspect to consider.

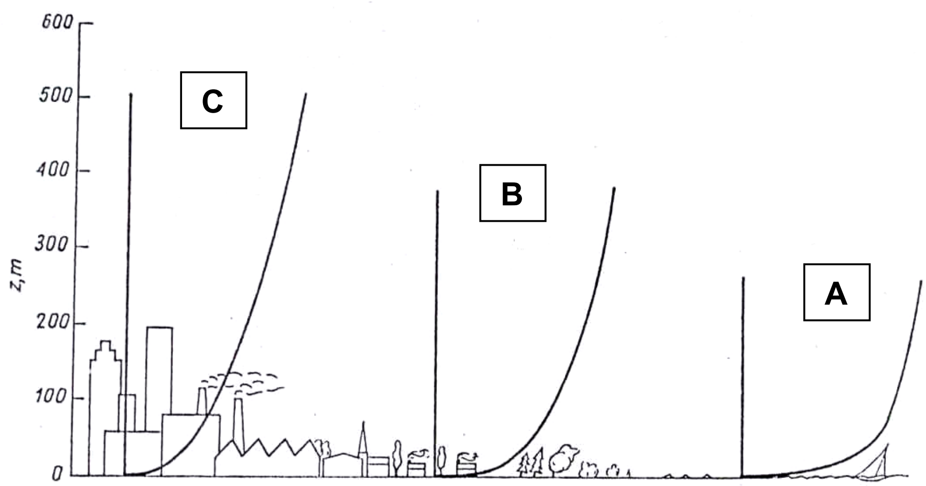
The height coefficient **C_h** in this case is similar to its defined value for the flat terrain from the category **A** multiplied by the following factor:

$$C_{h,\mathrm{mod}} = C_h \left[1 + \Delta S_{z,\max} \left(1 - \frac{|x|}{k_{red} L_H} \right) e^{-\left(\frac{a \cdot z}{L_H} \right)} \right]^2$$

2.4 Ground Roughness (Number of Exposure Categories) [2.3 and Figure 2]

Three Exposure Categories are defined (**A**, **B** and **C**).

The influence that reflect the great variations of the ruggedness of terrain that it varies according to the natural topography, the vegetation and existent constructions determines the three terrain categories in which the building or structure will be located.



Gradients of wind speed according to the terrain category.

3. WIND DESIGN ACTIONS

3.1 Importance Factors [1.5 and Table 1]

The recurrent coefficient in this case is combined with that of importance. The same one is adopted that in most of the countries C_T = 1 for 50 years.
This period of return is calculated for a probability, p(n) of 98 % that the value of the speed is not exceeded in anyone year, and with a probability p_1(n) of 64 % that the speed is exceeded at least once in (n) years.

Where *n* is the useful life of the construction in years.

3.2 Scale Effects [4, 4.1 and 4.2 and Figure 4]

Reduction coefficient for exposed area, C_{ra}. It is function from (Maximum dimension $\geq$ 15 m, and H (maximum height of the building)).

3.3 Pressure (Internal and External) [Chapter 6, 7, 8, 10 and 11 with many Tables and Figures]

There are defined the aerodynamic coefficients of the most typical structures as: buildings with and without opening facades, industrial buildings, canopies, chimneys, tanks, towers, bridges, isolated panels, cables, pipes, plan and spatial trussing among others.

3.4 Dynamic and Aeroelastic Effects (Gust Effects)[3 and 12.5, 12.5.1 to 12.5.8 and Table 21 and Figure 17]

A **Gust Coefficient**, C_r is defined.

It has an unique value for **z = H**,

C_r = f (H, Terrain category)

For isolated panels of facades,

$C_r(z)$ = f(z, Terrain category)

For the calculation and design of the foundations, the gust coefficient to use will have the value of one (1).

Verification of the resonance: The resonance oscillation appears during the critical wind speed, V_{CRI} , corresponding to the "I th" mode of oscillation of structure, this speed is determined by the following formula:

$$V_{CRI}(i) = \frac{d}{T_I S_N}$$

where

T_I period of oscillations of the structure according to the" i th" oscillation mode, s.

S_N Strouhal number of the transversal section (for circular section S_N = 0,2).

d is the diameter or side of the structure, (m).

3.5 Directionality Effects [1.2 and Table 7. Case 2, 3, 12, 13 a and b, 8.1.1, 8.1.3, 8.3, 8.4.2 and Figure 10 and Table 11. Case 1 and Case 4]

It will be supposed, except for exceptional conditions that the wind acts horizontally and in any direction. Of these directions it will be considered the effect of the wind fundamentally, according to the main directions of the structure. In the specially exposed structures to the wind, such as lighthouses, towers and other, it will also be investigated their action in the direction of the diagonals of this structures.

4. METHODS OF ANALYSIS

4.1 Simplified Procedure[12.3, 13 and Figure 16]

It is only considered in the case of the dynamic component in industrial buildings, and for non extreme wind loads.

4.2 Analytical Procedure [5 and 12, with many Tables and Figures]

Static Analysis of wind load. In this case the pressure of wind load has been defined as

$$\mathbf{q = \{ q_{10}\, C_T\, C_h\, C_S \}\, C_r\, C_f\, C_{ra} \qquad [\, kN/m^2 \,]}$$

where

$\mathbf{q_{10}}$ is the basic pressure on a flat terrain, open to a height of 10 m on the land,[kN/m^2];
$\mathbf{C_T}$ is the recurrent coefficient;
$\mathbf{C_h}$ is the height and terrain category coefficient;
$\mathbf{C_S}$ is the topography or place coefficient;
$\mathbf{C_r}$ is the gust coefficient;
$\mathbf{C_f}$ is the pressure or aerodynamic coefficient, and
$\mathbf{C_{ra}}$ is the reduction coefficient for exposed area.

Dynamic Analysis of wind load. The dynamic component of wind load is the one that corresponds to the value of the fluctuating component of wind speed. Their magnitude depends in great measure in the dynamic response of the structure due to the pulsations caused by the wind.

The dynamic component of wind load should be considered in structures with own oscillations periods greater than one second (T> 1,0 s), like it happens in: towers, chimneys, transmission posts, masts; in high buildings.

The normative values of the dynamic component of wind load should be determined for each mode of oscillation of structure starting from an scheme of inertial forces applied on the concentrated masses in which the structure has been subdivided according to the adopted method.

The inertia force applied on the "j th" mass in the "i th" mode of oscillations of structure, is determined by the formula:

$$Q^N = M_J C_I^D C_{CE} N_{JI}$$ in kN

where

M_J "j th" concentrated mass in kg.
C_I^D dynamic coefficient in the mode "i th".
N_{JI} reduced acceleration of the "j th" mass, m/s^2.
C_{CE} Coefficient that takes into account the spatial correlation of the pulsations according to the height and facade of the building.

4.3 Experimental Procedure[2.3]

In the case of Terrain Category **C** is recommended to make test in tunnel of wind.

Any experimental procedure in particular is recommended.

5. INDUCED EFFECTS

5.1 Impact of Flying Objects [6.2]

In epigraph 6.2 a Remark about Impact of Flying Objects and Claddings Elements is presented.

5.2 Wind Driven Rain

Not considered.

6. SAFETY VERIFICATIONS

6.1 Structure [12.4.2 and (See 3.4)]

It is not presented inside this standard any other safety verification.

6.2 Claddings and Non-Structural Elements [6.2 and Figures 5, 6, 6a, 6b and 6c]

For Cladding Elements Idem to (5.1).

It is not defined a special safety verification for Non- Structural Elements.

7. SMALL RESIDENTIAL BUILDINGS

It is not defined a special methodology for this kind of buildings.

RECOMMENDATIONS FOR CODE IMPROVEMENT

The Wind Load Standard of Cuba can be considered a state of the art Standard, even though some Items are not considered. May be some small modifications can be added in order to improve the Standard.