# WIND CODE EVALUATION

# MEXICO

***Evaluation conducted by Jorge Gutiérrez***

"Normas Técnicas Complementarias para Diseño por Viento" ("Complementary Technical Norms for Wind Resistant Design")**.**

This document includes only specific wind design regulations and it is complemented by the **"**Reglamento de Construcciones para el Distrito Federal" ("Mexico City Building Code")

**YEAR:** 2003 (see General Remarks).

**GENERAL REMARKS:** The most recent wind regulations in México are those of Mexico City.

The Mexico City Building Code is constituted by general provisions included in the main body of the Code, and by Complementary Technical Norms for specific materials such as concrete, steel, masonry or timber and for some specific actions such as wind or earthquake.

This evaluation refers to a final draft of the Mexico City "Complementary Technical Norms for Wind Resistant Design" expected to be approved during 2003.

**NOTE:** Bracketed numbers refer to Code specific chapters or articles: [3.1].
Some references will be made to the general provisions contained in the main body of the Mexico City Building Code: [174 Building Code].
Parenthesis numbers refer to Items of this document: (see 2.1).

## 1. SCOPE

### 1.1 Explicit Concepts and Limitations. [1.1]

Wind actions, like earthquake effects and explosions, are considered accidental loads.

### 1.2 Performance Objectives.

Not specifically considered.

## 2. WIND HAZARD

### 2.1 Basic Wind Speed. [3.1.1]

The Regional Wind Speed $V_R$ is defined as the maximum 3 second gust speed at 10m above the ground in Exposure Category R2 (see 2.4). These speeds depend upon the two geographic zones and the Building Use (see 3.1) divided in three categories: Importance Factor A (200 years Return Period) and B (50 years Return Period) and temporary buildings (10 years Return Period), as presented in the following Table:

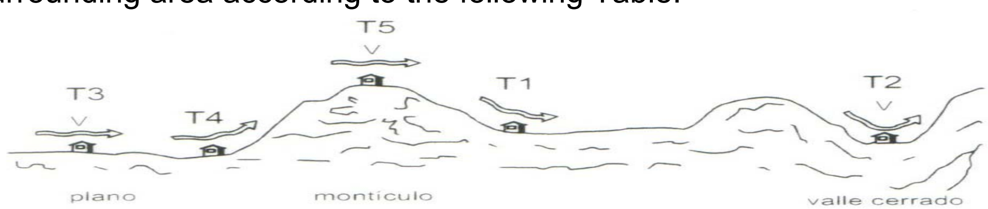
**Regional Wind Speed $V_R$** (m/s and km/h)

| **Mexico City Zones** | | **Building Use** | | |
|---|---|---|---|---|
| **Zone** | **Delegations** | **A** (RP=200) | **B** (RP=50) | **Temporary** (RP=10) |
| **I** | Alvaro Obregón, Azcapotzalco, Benito Juarez, Coyoacan, Cuauhtemoc, Madero, Iztacalco, Iztapalapa, Miguel Hidalgo, Venustiano Carranza | 39 m/s 140 km/h | 36 m/s 130 km/h | 31 m/s 112 km/h |
| **II** | Magdalena Contreras, Cuajimalpa, Milpa Alta, Tlalpan, Xochimilco | 35 m/s 126 km/h | 32 m/s 115 km/h | 28 m/s 101 km/h |

For design purposes, a Design Wind Speed $V_D$ that considers topography (see 2.2) and variations along height (see 2.3) is defined (see 3.3).

### 2.2 Topography. [3.1.3]

The Topography Factor $F_{TR}$ considers five topographic local effects (T1 to T5, see figure). It depends on the Ground Roughness (see 2.4) of the surrounding area according to the following Table:




**Topography Factor $F_{TR}$**

| **Topography Group** | | **Surrounding Ground Roughness** | | | |
|---|---|---|---|---|---|
| | | **R1** | **R2** | **R3** | **R4** |
| **T1** | Protected downwind piedmonts | 1.00 | 0.80 | 0.70 | 0.66 |
| **T2** | Enclosed valleys | 1.00 | 0.90 | 0.79 | 0.74 |
| **T3** | Plain open land, slopes < 5% | 1.00 | 1.00 | 0.88 | 0.82 |
| **T4** | Inclined open land, slopes between 5% - 10% | 1.00 | 1.10 | 0.97 | 0.90 |
| **T5** | Top of hills and mountains, inclined land with slopes > 10% | 1.00 | 1.20 | 1.06 | 0.98 |

### 2.3 Height above Ground (Case Specific). [3.1.2]

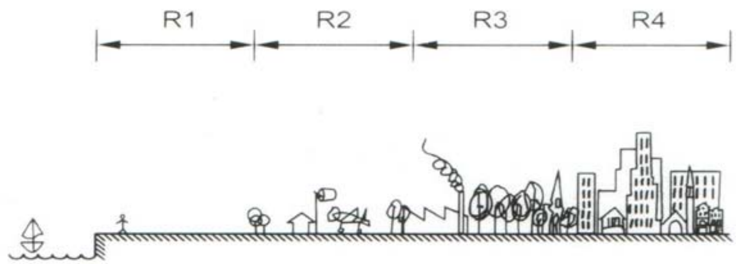
The Height Variation Factor $F_\alpha$ defines the variation of Regional Wind Speed $V_R$ along height z, as follows :

| | | |
|---|---|---|
| $F_\alpha = 1.0$ | for | $z \le 10$ m |
| $F_\alpha = (z/10)^\alpha$ | for | $10 \text{ m} < z < \delta$ |
| $F_\alpha = (\delta/10)^\alpha$ | for | $z \ge \delta$ |

Where:
$\delta$ = Gradient height limit (height at which wind speed is constant).
$\alpha$ = Variation Coefficient.
$\delta$ and $\alpha$ values depend on Ground Roughness (see 2.4).

### 2.4 Ground Roughness (Number of Exposure Categories). [3.1.3]

Four Exposure Categories (R1 to R4) are defined:




Their description and corresponding values of $\alpha$ and $\delta$ (see 2.3) are given in the following Table:

**Exposure Categories and corresponding values of $\delta$ and $\alpha$**

| Exposure Categories | | $\alpha$ | $\delta$ (m) |
|---|---|---|---|
| **R1** | Flat unobstructed areas. | 0.099 | 245 |
| **R2** | Flat or undulated terrain with scattered obstructions | 0.128 | 315 |
| **R3** | Urban and suburban areas. The site is surrounded by numerous closely spaced low height buildings or wooded areas. | 0.156 | 390 |
| **R4** | Large city centers. At least 50% of the buildings within a radius of 500m have heights over 20 m | 0.170 | 455 |

## 3. WIND DESIGN ACTIONS

### 3.1 Importance Factors. [2.2.1; 174 Building Code]

There are two Groups, with corresponding Importance Factors:

**Group A:** Are those buildings and related structures whose failure may cause a high number of deaths, high economic or cultural losses, hazard due to their toxic or explosive contents. Also includes those buildings which must remain serviceable after an urban emergency. Importance Factor I = 1.5

**Group B:** All buildings and related structures not included in Group A. Importance Factor I = 1.0

## 3.2 Scale Effects.

Not considered.

## 3.3 Pressure (Internal and External). [2.2.2; 3.2; 3.3; 3.4]

For the definition of wind pressures, buildings are classified in terms of its response to wind actions in four structural Types [2.2.2]:

**Type 1:** Structures less sensitive to gusts and other dynamic effects of wind. Includes enclosed buildings with rigid roof covers able to resist the wind forces without significant geometric changes. This type excludes structures with a slenderness ratio greater than 5 or natural period larger than 1s. Also excludes flexible roof covers, like hanging roofs, unless their dynamic response effects are limited by effective procedures (i.e. prestress).

**Type 2:** Structures particularly sensitive to short duration gusts or flexible structures prone to respond with large displacements to the wind action. It includes structures with a slenderness ratio greater than 5 or natural period larger than 1s. It also includes towers, guyed or free standing antennas, elevated tanks, commercial signs and parapets and other type of structures having very short dimensions along the wind direction. It excludes structures explicitly classified as Type 3 or 4.

**Type 3:** Structures similar to Type 2 whose transverse section makes them particularly prone to vortex effects parallel to the larger dimension of the structure. It also includes cylindrical structures or components such as pipes, chimneys and circular plant buildings.

**Type 4:** This group includes all structures with specific aerodynamic problems such as suspended roofs not included as Type 1, unstable aerodynamic forms, flexible structures having natural periods closed to each other, etc.

The Design Wind Speed $V_D$ is obtained from the Regional Wind Speed $V_R$ (se 2.1) with the equation:

$$V_D = F_{TR} \, F_{\alpha} \, V_R$$

Where:
$F_{TR}$ = Topography Factor (see 2.2)
$F_{\alpha}$ = Height Variation Factor (see 2.3)

The design pressure $p_z$ produced by the wind flow on the structure is a function of the Design Wind Speed $V_D$ and a Pressure Coefficient $C_D$ as follows:

$p_z = 0.47\ C_p\ V_D^2$ ($p_z$ in Pascals, Pa) or
$p_z = 0.048\ C_p\ V_D^2$ ($p_z$ in kg/m$^2$)

The Pressure Coefficient $C_D$ is defined by the Code either for the primary structure or its components using a Simplified Method (see 4.1) or a more refined Static Method.

For the Static Method (see 4.2) the external pressure $p_z$ normal to the walls will be calculated with the Design Wind Speed $V_D$ and Pressure Coefficients $C_P$ defined for five specific cases defined in terms of their structural types and shapes:

**Case I.** Enclosed Buildings.
**Case II.** Isolated Walls and Commercial Signs.
**Case III.** Reticular Trusses and Frames.
**Case IV.** Chimneys, Silos and similar structures.
**Case V.** Antennas and Towers.

For example, for Case I Enclosed Buildings, the Pressure Coefficients $C_P$ are:

**Pressure Coefficient $C_P$ for Enclosed Buildings**

| | |
|---|---|
| Upwind walls | 0.8 |
| Downwind walls[1] | -0.4 |
| Lateral Walls | -0.8 |
| Flat Roofs | -0.8 |
| Inclined Upwind Roofs | -0.7 |
| Inclined Downwind Roofs[2] | $-0.8 < .004\ \theta - 1.6 < 1.8$ |

Notes: 1.- Negative pressures (suction) are considered as constant along height and correspond to z equal to the mid height of the building.
2.- θ is the angle of roof inclination (in degrees).

Additionally, for Partially Enclosed Buildings with openings greater than 30% of their total surface, Internal Pressures must be considered and they will be calculated with the following Pressure Coefficients $C_P$:

**Internal Pressure Coefficient $C_P$ for Partially Enclosed Buildings**

| | |
|---|---|
| Openings mainly in the Upwind walls | 0.75 |
| Openings mainly in the Downwind walls | -0.6 |
| Openings mainly in the Lateral Walls | -0.5 |
| Openings similarly distributed in all four sides | -0.3 |

### 3.4 Dynamic and Aeroelastic Effects (Gust Effects). [5; 6]

For Type 2 Buildings (see 3.3) the static and dynamic turbulence effects are considered by a factor G that increments the design pressure $p_z$.

For Type 3 Buildings (see 3.3) it is necessary to consider horizontal forces normal to the wind direction due to dynamic vortex effects.

### 3.5 Directionality Effects. [3.3.2]

Directionality Effects are not generally considered in the Code. As an exception, for Commercial Signs, an incoming wind direction of $45^o$ must be considered in addition to the orthogonal directions.

## 4. METHODS OF ANALYSIS

### 4.1 Simplified Procedure. [3; 3.6]

A Simplified Method can be applied to Type 1 Structures (see 3.3) not higher than 15 m, having a plan that is regular or formed by a combination of rectangles and with a ratio of height to smaller plan dimension less than 4. In this case the Local Shape Pressure Coefficients $C_P$ are determined by the following Table [3.6]:

**Pressure Coefficients for the Simplified Method** [Table 3.14]

| Surface | $C_P$ | Border $C_P$ |
|---|---|---|
| Walls | ±1.45 | ±2.25 |
| Roofs | ±2.10 | ±3.40 |

The border Pressure Coefficients should be applied for the fastening of all structural elements and components located in the border areas defined in the following figure:

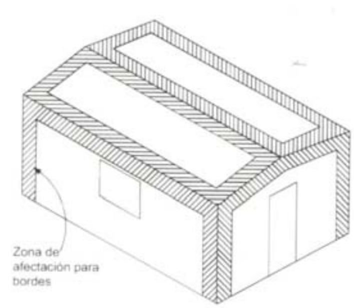



*Figura 3.6 Zonas de afectación para el diseño de los sujetadores*

The width of all the borders shall be taken as one tenth of its minimum dimension (either width, length or total height).

### 4.2 Analytical Procedure. [3]

A more refined Static Method should be applied to Type 1 Structures that do not satisfy the requirements of the Simplified Method (see 4.1). Wind external and internal pressures (see 3.3) are determined in terms of Design Wind Speed (see 2.1 and 3.3), Importance Factors (see 3.1), Exposure Categories (see 2.4), topography (see 2.2) and other related factors. A static analysis renders the internal forces due to wind in the structural elements and components.

### 4.3 Experimental Procedure. [2.4]

A brief paragraph states that wind tunnel tests can be used for structures of unusual geometry or aerodynamic characteristics. Results from similar structures can be used.

## 5. INDUCED EFFECTS

### 5.1 Impact of Flying Objects.

Not considered.

### 5.2 Wind Driven Rain.

Not considered.

## 6. SAFETY VERIFICATIONS

### 6.1 Structure. [2.1; 2.2.3; 2.5; 7]

All structures and their components must be designed to resist the internal forces generated upon their elements and components by the pressures or suctions produced by wind.

For the design of structures under wind effects the following effects should be considered according to the Structural Types (see 3.3):

- Static pressure or suction normal to the wall surface.
- Dynamic forces parallel and perpendicular to the main flow due to turbulence.
- Vibrations due to alternating vortex effects
- Aeroelastic instability.

For Type 1 Structures (see 3.3) only the static pressures normal to the wall surface should be considered.

The stability of the structure during construction must be considered. For this purpose the Basic Wind Speed will correspond to a 10 year Return Period (see 2.1).

Drift limits are defined in the following Table:

| Structural Conditions | Drift Limit ($\Delta/\Delta h$) |
|---|---|
| Structures without fragile infill elements likely to be damaged due to lateral displacements | 0.005 |
| Structures with fragile infill elements likely to be damaged during lateral displacements | 0.002 |

### 6.2 Claddings and Non-Structural Elements. [4]

The Code provides specific Pressure Coefficients $C_P$ for Claddings and Non-Structural Elements. Different Coefficients are defined for parapets, buildings less than 20m in height, taller than 20m or with an arched roof.

## 7. SMALL RESIDENTIAL BUILDINGS.

Not considered.

**RECOMMENDATIONS FOR CODE IMPROVEMENT**

**The main drawback on the proposed Wind Code Regulations for Mexico is the absence of a national Code. The evaluated Norms may be considered state of the art but they are specifically meant for Mexico City, which is not the most wind prone region in the country. National authorities should be encouraged to issue a National Code with due consideration to the country's specific wind conditions.**