WIND CODE EVALUATION

PANAMA

Evaluation conducted by Jorge Gutiérrez

NAME OF DOCUMENT: "Reglamento de Diseño Estructural para la República de Panamá" REP-2003 ("Structural Design Code for the Republic of Panama"). Chapter 3- Wind Loads.

YEAR: 2003 (expected year of approval)

GENERAL REMARKS: The first Panamanian Structural Provisions (REP-84) were approved in 1984 and the current version dates from 1994 (REP-94). A new version (REP-2003) has been drafted and it is in the process of final approval by the "Junta Técnica de Ingeniería y Arquitectura" (JTIA) (Technical Board of Engineering and Architecture). Implementation is expected sometime this year (source: Ernesto Ng, Panamanian structural engineer, personal e-mail communication). Under the Title of "Wind Loads", Chapter 3 of this new version contains specific regulations for Wind load definition, analysis and design. This is the document that has been evaluated.

SPECIFIC ITEMS:

NOTE: Bracketed numbers refer to Code specific chapters or articles: [3.2].
There are also bracketed references to the corresponding Chapters of ASCE-7-98, Minimum Design Loads for Buildings and Other Structures, which is the main reference for wind in REP-2003.
Parenthesis numbers refer to Items of this document: (see 1.1).

1. SCOPE

1.1 Explicit Concepts and Limitations. [3.1.1; 3.1.5]

The Code applies to buildings, including their primary structural system as well as components and claddings. It also applies to commercial signs.

A minimum wind pressure of 0.48 kN/m^2 must always be considered.

No reduction on wind pressure is allowed due to protection of the building by near by structures or by terrain conditions.

1.2 Performance Objectives.

Not explicitly defined.

2. WIND HAZARD

2.1 Basic Wind Speed. [3.2; 3.4.2]

The Basic Wind Speed is defined as the 3 second gust speed at 10m above the ground in Exposure Category C (see 2.4), corresponding to a Return Period of 50 years. Design values for Basic Wind Speed are 115 km/h for the Pacific and 140 km/h for the Caribbean [Table 3-2].

2.2 Topography. [3.3.7]

Wind effects due to sudden topography changes produced by escarpments, hills or ridges should be considered in the design. This effect is quantified by the Topography Factor K_{zt} 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 a figure [Fig.3-1, identical to Fig. 6.2 of ASCE 7-98]

2.3 Height above Ground (Case Specific). [3.3.6.2]

This effect is defined by the Velocity Pressure Exposure Coefficient K_z (or K_h) which is a function of the Exposure Category (see 2.4) as defined by the following Table [identical to Table 6.5 of ASCE 7-98]:

Velocity Pressure Coefficients K_z ans K_h [Table 3.5]

Height above ground level, z		**Exposure Categories** (see 2.4)					
		A		**B**		**C**	**D**
m	(ft)	Case 1	Case 2	Case 1	Case 2	Cases 1 y 2	Cases 1 y 2
0 – 4.6	(0 – 15)	0.68	0.32	0.70	0.57	0.85	1.03
6.1	(20)	0.68	0.36	0.70	0.62	0.90	1.08
7.6	(25)	0.68	0.39	0.70	0.66	0.94	1.12
9.1	(30)	0.68	0.42	0.70	0.70	0.98	1.16
12.2	(40)	0.68	0.47	0.76	0.76	1.04	1.22
15.2	(50)	0.68	0.52	0.81	0.81	1.09	1.27
18.0	(60)	0.68	0.55	0.85	0.85	1.13	1.31

Height above ground level, z		Exposure Categories (see 2.4)					
		A		B		C	D
m	(ft)	Case 1	Case 2	Case 1	Case 2	Cases 1 y 2	Cases 1 y 2
21.3	(70)	0.68	0.59	0.89	0.89	1.17	1.34
24.4	(80)	0.68	0.62	0.93	0.93	1.21	1.38
27.4	(90)	0.68	0.65	0.96	0.96	1.24	1.40
30.5	(100)	0.68	0.68	0.99	0.99	1.26	1.43
36.6	(120)	0.73	0.73	1.04	1.04	1.31	1.48
42.7	(140)	0.78	0.78	1.09	1.09	1.36	1.52
48.8	(160)	0.82	0.82	1.13	1.13	1.39	1.55
54.9	(180)	0.86	0.86	1.17	1.17	1.43	1.58
61.0	(200)	0.90	0.90	1.20	1.20	1.46	1.61
76.2	(250)	0.98	0.98	1.28	1.28	1.53	1.68
91.4	(300)	1.05	1.05	1.35	1.35	1.59	1.73
106.7	(350)	1.12	1.12	1.41	1.41	1.64	1.78
121.9	(400)	1.18	1.18	1.47	1.47	1.69	1.82
137.2	(450)	1.24	1.24	1.52	1.52	1.73	1.86
152.4	(500)	1.29	1.29	1.56	1.56	1.77	1.89

Notes:

1. **Case 1:** All components and cladding.
   Case 2: All primary systems for buildings and other structures.
2. Linear interpolation for intermediate z values is allowed .

The K_z values of the Table above can be calculated with the following equations:

$K_z = 2.01\ (4.6 / z_g)^{2/\alpha}$ for $z < 4.6$ m
$K_z = 2.01\ (z / z_g)^{2/\alpha}$ for $4.6 \text{ m} < z < z_g$

With α and z_g defined by the following Table [Table 3.6]
:

Exposure	α	z_g (m)
A	5.0	457
B	7.0	366
C	9.5	274
D	11.5	213

2.4 Ground Roughness (Number of Exposure Categories). [3.3.6.1; 3.4.2]

Four Exposure Categories (A, B, C and D) are defined [the same of ASCE-7-98, article 6.5.6.1].

Exposure A. Large city centers with at least 50% of buildings with heights over 21m (Code states that this category does not apply in Panama).

Exposure B. Urban and suburban areas, wooded areas, other terrain with numerous closely spaced obstructions having the size of single family dwellings or larger.

Exposure C. Open terrain with scattered obstructions having heights less than 9m.

Exposure D. Flat unobstructed areas exposed to wind flowing from open ocean from 1.6 km. It extends 460m inland.

3. WIND DESIGN ACTIONS

3.1 Importance Factors. [3.1.2]

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

Category I: Buildings and related structures whose failure implies low risk for human life including but not limited to rural, storage or temporary facilities.

Category II: Normal occupancy public or private buildings (not included in categories I, III or IV.

Category III: Hazardous facilities or high occupancy public or private buildings.

Category IV: Essential facilities.

An importance Factor I is assigned to each category as follows [Table 3.4]:

Use Category	Importance Factor I
I	0.87
II	1.00
III	1.15
IV	1.15

3.2 Scale Effects.

Not considered.

3.3 Pressure (Internal and External). [3.1.5; 3.3.9; 3.3.10, 3.3.11]

Minimum net wind pressure will be 0.48 kN/m^2. Net pressure is the algebraic sum of pressures acting on opposite sides of the building.

In order to estimate the internal pressure coefficients, buildings are classified as Enclosed, Partially Enclosed or Open [3.3.9; identical to 6.2 of ASCE-7-98].

Wind velocity pressure q_z (in kN/m^2) at height z (in m) is given by the following equation:

$$q_z = 0.0473\, K_z\, K_{zt}\, K_d\, V^2\, I$$

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)

For roofs, the corresponding wind velocity pressure q_h is q_z for z = h, the medium roof height.

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	±0.55
Enclosed	±0.18

The External Pressure Coefficient C_p for primary systems (i.e. the structural elements and components of the lateral force resisting structural system) is presented in a Figure [Fig. 3-2, identical to Fig. 6.3 of ASCE-7-98]. Components and cladding External Pressure Coefficients GC_p are commented elsewhere (see 6.2).

For non building structures the corresponding Force Coefficients C_f are given in Tables [Tables 3.8 to 3.11, identical to Tables 6.9 to 6.12 of ASCE-7-98]

3.4 Dynamic and Aeroelastic Effects (Gust Effects). [3.3.8]

For regular buildings the design forces include gust magnification effects on flexible structures (see 1.1).

For rigid structures (natural period $T \leq 1$s) the Gust Effect Factor G will be 0.85 unless it is calculated following a specific procedure [equations 3-2 to 3-5, equivalent to equations 6-2 to 6-5 of ASCE-7-98 with dimensions in meters instead of feet]. For flexible structures (natural period $T > 1$ s), or for wind sensitive structures, the Gust Effect Factor G_f is also calculated following a specific procedure [equations 3-6 to 3-12, equivalent to equations 6-6 to 6-12 of ASCE-7-98 modified to use dimensions in meters instead of feet].

In lieu of the previous procedures, determination of Gust Effect Factors by any rational analysis defined in the recognized literature is permitted.

3.5 Directionality Effects. [3.3.4]

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 3-3, identical to Table 6-6 of ASCE-7-98]. This factor should only be applied when used in conjunction with load combinations given by ASCE-7-98 [Sections 2.3 and 2.4 of ASCE-7-98]; otherwise $K_d = 1$.

4. METHODS OF ANALYSIS

4.1 Simplified Procedure. [3.4]

The Simplified Procedure in REP-2003 is like a code within the Code. It contains its own definitions, structural type classification, wind pressures, drift limitations, etc. It departs from the Simplified Procedure of ASCE-7-98 [6.4 of ASCE-7-98] and it does not define when can be applied as a simpler alternative to the Analytical Procedure (see 4.2).

Three Structural Types are defined for this procedure:

Type 1. One and two story single family dwellings; any enclosed structure with less than 18 m in height.
Type 2. All buildings whose structure is not dynamically sensitive to wind.
Type 3. All buildings whose structure is dynamically sensitive to wind.

Wind Pressures for each Structural Type are tabulated according to height and Category of Exposure [Table 3-12 for Structural Type 1, Tables 3-13 to 3-16 for Structural Types 2 and 3]. For Structural Type 3 these are minimum pressure values and a detailed analysis following ASCE-7-98 is required.

Drift limits are defined in the following Table:

Structural Material	Drift Limit (Δ/Δh)
Steel	0.00200 (1/500)
Reinforced concrete	0.00278 (1/360)

For parapets, commercial signs, cladding and non-structural components the methods defined in the Analytical Procedure (see 4.2) are used (see 6.2).

4.2 Analytical Procedure. [3.3]

This method applies to regular buildings (i.e. those without unusual geometry) as well as other type of regular structures.

The method does not apply to buildings whose characteristics may induce complex effects (vortex effects, instability) that do require special analyses.

For regular buildings the design forces include gust magnification effects on flexible structures. For unusual structures these effects must be considered by means of refined theories or wind tests (see 4.3).

The Design Procedure follows 10 steps [3.3.3 and 6.5.3 of ASCE-7-98]:

- The Basic Wind Speed V (see 2.1) and Wind Directionality Factor K_d shall be determined (see 3.5).
- The Importance Factor I shall be determined (see 3.1).
- An Exposure Category and Velocity Pressure Exposure Coefficient K_z or K_h shall be determined for each wind direction (see 2.3 and 2.4).
- A Topographic Factor K_{zt} shall be determined (see 2.2).
- A Gust Effect Factor G or G_f shall be determined (see 3.4).
- An Enclosure Classification shall be determined (see 3.3).
- Internal Pressure Coefficients GC_{pi} shall be determined (see 3.3).
- External Pressure Coefficients C_p or GC_{pf} shall be determined (see 3.3).
- Velocity Pressure q_z or q_h shall be determined (see 3.3).
- Design Wind Load P or F shall be determined (see 3.3).

For parapets, commercial signs, cladding and non-structural components the method defined is the same as for the Simplified Procedure (see 6.2).

4.3 Experimental Procedure. [3.3.2]

A brief paragraph states that for unusual and flexible structures gust magnification effects must be considered either via refined theories or wind tests (see 4.2).

5. INDUCED EFFECTS

5.1 Impact of Flying Objects.

Not considered.

5.2 Wind Driven Rain.

Not considered.

6. SAFETY VERIFICATIONS

6.1 Structure.

The Code contains no specific requirements for safety verifications. However, it is evident that Wind loads W are considered ultimate loads and must be combined with Dead D and Live L loads to determine the Ultimate Load. All structural elements must be dimensioned and detailed according to strength design theory. Drift limits are defined for the Simplified Procedure only (see 4.1) but they should be applied to all analytical procedures.

6.2 Claddings and Non-Structural Elements. [3.3.11.2.2; 3.3.12.4]

For both the Simplified and Analytical Procedures (see 4.1 and 4.2) wind pressure p for claddings and non-structural elements are calculated with the following equations:

Buildings with h ≤ 18m: $p = q_h [(GC_p) – (GC_{pi})]$
Buildings with h > 18m: $p = q (GC_p) – q_i (GC_{pi})$

Where:

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.
$q_i = q_h$ for upwind walls, lateral walls, downwind walls and roofs.
G = Gust Factor (see 3.4).
C_p = External Pressure Coefficient.
(GC_{pi}) = Internal Pressure Coefficient (see 3.3)

Combined gust effect factor G and external pressure coefficients C_p (see 3.3) for components and cladding (GC_p) are given in specific figures [Fig. 3-3 to 3-5 for h ≤ 18m or Fig. 3-6 for h > 18m; same as Figs. 6-5 through 6-7 and 6-8 respectively of ASCE-7-98]. Pressure coefficient values and gust effect factor shall not be separated.

7. SMALL RESIDENTIAL BUILDINGS. [3.4]

No specific requirements are given for Small Residential Buildings. However, the Simplified Procedure can be applied to one and two story single family units classified as Type 1 Structures (see 4.1).

RECOMMENDATIONS FOR CODE IMPROVEMENT

Chapter 3 of the REP-2003 Code, Wind Loads, is a state of the art Wind Code that follows very closely the Wind Load requirements of ASCE-7-98.

However, a Simplified Procedure is presented (see 4.1) that does not derive from ASCE-7-98 and in practice becomes a code within the Code, with independent definitions and concepts and sometimes misleading requirements, in addition to the fact that it is not clear when it can be applied as an alternative to the more advanced Analytical Procedure. It is therefore recommended that the scope and design requirements of the Simplified Procedure should be modified along the lines of ASCE-7-98 or its updated version ASCE-7-02.