WIND CODE EVALUATION

COLOMBIA

Evaluation conducted by Guillermo Santana

NAME OF DOCUMENT: "Normas Colombianas de Diseño y Construcción Sismo Resistente" (*Colombian Standards for Seismic Resistant Design and Construcion*)

YEAR: 1998

GENERAL REMARKS: Document elaborated by technical committee AIS-100 of the Colombian Association of Earthquake Engineering. Replaces the Colombian Code for Seismic Resistant Constructions published in 1984. It is a large document that covers every aspect of construction including wind loads for the entire Republic of Colombia.

SPECIFIC ITEMS:

1. SCOPE

1.1 Explicit Concepts and Limitations [Title 1]

The norm applies to all structures, buildings and non-building structures and parts thereof. The design involves the definition of a unique base shear to be distributed through the height of the structure. The base shear is the stated minimum seismic demand for the facility, which should also comply with a maximum allowed drift based on inelastic response. No explicit restrictions are stated for structural building materials. The norm includes Titles that provide guidelines for structural concrete, masonry, steel, wood, precast prefabricated structures and one and two-story residential buildings.

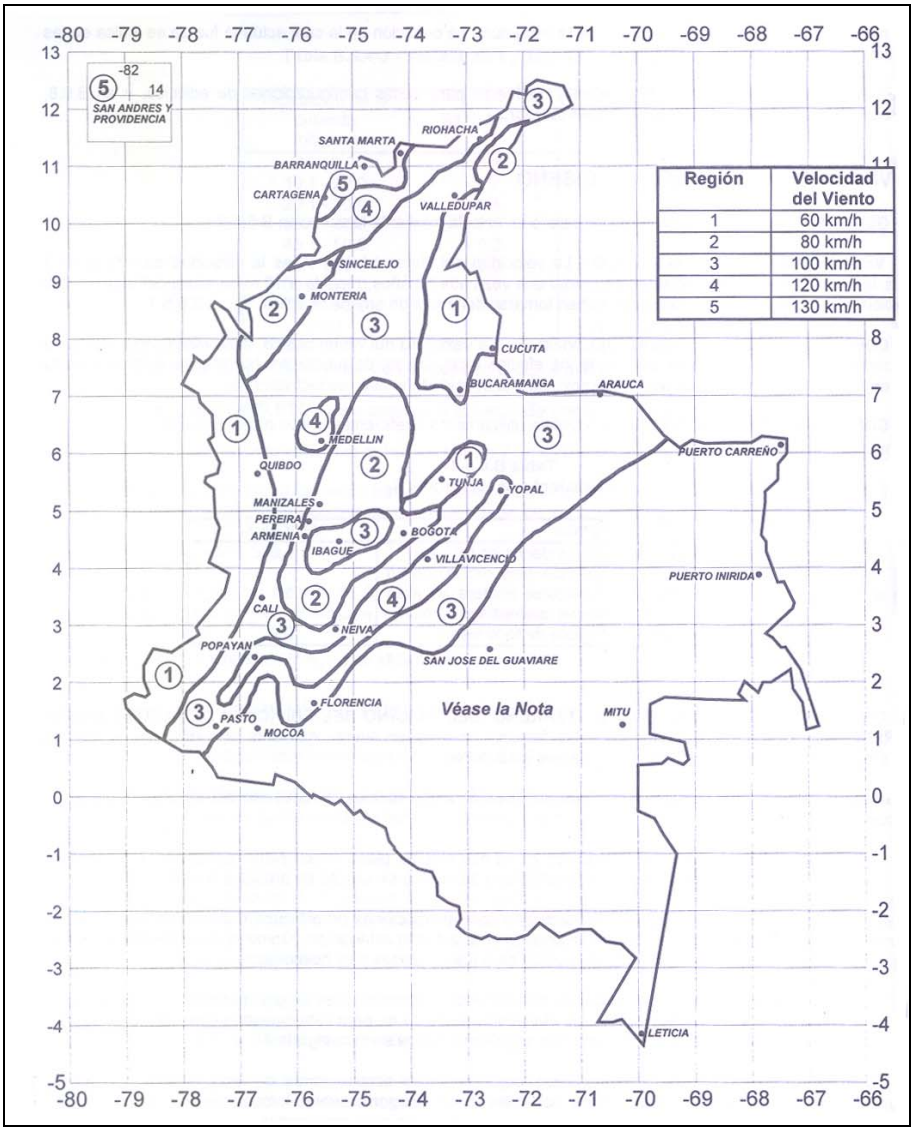
1.2 Performance Objectives [Title 1, Art. 1]

No specific performance objectives for wind are given. The only mention of performance objectives is included in Title 1, Article 1 where it is stated that the "structures designed in conformance with these Norms should, in general, be able to: a) Resist minor level of earthquake ground motion without damage; b) resist a moderate level of earthquake ground motion without structural damage, but possibly experience some nonstructural damage; and c) resist a major level of earthquake ground motion without collapse, but possibly with some structural as well as nonstructural damage.

2. WIND HAZARD

2.1 Basic Wind Speed [B.6.5.2]

The basic wind speed in this norm is defined according to ASCE 7-95. It is defined as the 50-year mean recurrence interval of the 3-second gust wind speed at an elevation of 10 m above ground in flat open country (Exposure C). The map below presents the wind speeds defined by this norm for the entire country.



[Figure B.6.5.1 Wind Hazard Map: Basic Wind Speed]

A very important note is given for this map. It is indicated that this map presents wind speeds that have not been studied and a recommendations is made to be conservative when evaluating wind forces that may be indicated in it. Furthermore, it is stated that "in lieu of more reliable data, wind forces shall be calculated using a minimum wind speed of 100 km/h." It is this

reviewer's opinion that the norm contradicts itself by using this map and then immediately disqualifying it as an accurate source of information consistent with the precision expressed in the rest of the chapter**.**

2.2 Topography [B.6.5.4]

Three different values for the topography coefficient are given. Mountain slopes and summits are given a 1.1 coefficient value and enclosed valleys are given a 0.9 coefficient value.

2.3 Height above Ground (Case Specific)

Included as part of the Ground Roughness.

2.4 Ground Roughness (Number of Exposure Categories) [B.6.5.5]

Four different values for ground roughness coefficient S_2 are given for three different classes and different ground levels. These values are presented in [Table B.6.5-2].

3. WIND DESIGN ACTIONS

3.1 Importance Factors

Prescribed as the S3 factor. See section (4.2) below.

3.2 Scale Effects

Not considered

3.3 Pressure (Internal and External) [B.6.7]

Wind pressure is calculated according to the following expression:

$$F = \left(C_{pe} - C_{pi} \right) qA$$

where C_{pe} is the external pressure, C_{pi} is the internal pressure, A is the surface area of the structural element or cladding element and q is the dynamic wind pressure.

3.4 Dynamic and Aero-elastic Effects (Gust Effects)

Not considered.

3.5 Directionality Effects

No directionality effects were found in the document.

4. METHODS OF ANALYSIS

4.1 Simplified Procedure [B.6.4]

A simplified procedure is provided. The procedure requires the computation of a wind pressure based on tabulated coefficients. The wind pressure is computed as

$$p = C_p q S_4$$

the values for C_p, q and S_4 are given in the following tables.

Table 1. Dynamic wind pressure, q (kN/m^2)

Height (m)	Basic Wind Speed (km/h)						
	60	70	80	90	100	110	120
0-10	0.20	0.27	0.35	0.45	0.55	0.67	0.79
10-20	0.22	0.30	0.40	0.50	0.62	0.75	0.89
20-40	0.27	0.37	0.48	0.61	0.75	0.91	1.08
40-80	0.33	0.45	0.59	0.74	0.92	1.11	1.32
80-150	0.40	0.54	0.71	0.90	1.11	1.34	1.59
>150	0.50	0.68	0.88	1.12	1.38	1.67	1.99

Table 2. Pressure coefficient for vertical surfaces, C_p

Prismatic structures with h < 2b	1.2
Elongated prismatic structures	1.6
Cylindrical surfaces	0.7
Short flat surfaces such as fences	1.4

Table 3. Pressure coefficient for inclined surfaces, C_p

Roof inclination (degrees)	Windward	Leeward
0 - 10.0	- 0.8	- 0.5
10.1 – 20.0	- 0.7	- 0.5
20.1 – 30.0	- 0.4	- 0.5
30.1 – 40.0	- 0.1	- 0.5
40.1 – 50.0	+ 0.2	- 0.5
50.1 – 60.0	+ 0.5	- 0.5
60.1 – 70.0	+ 0.7	- 0.5
70.1 – 80.0	+ 0.8	- 0.5
> 80.0		See Table 2

Table 4. Coefficient S_4

Height	
(m)	S_4
0	1.00
500	0.94
1000	0.88
1500	0.83
2000	0.78
2500	0.73
3000	0.69

4.2 Analytical Procedure [B.6.4.3]

A more thorough procedure is provided and it is designated as “complete analysis.” According to this procedure, the basic wind speed is affected by three factors denominated S_1, topography factor [Table B.6.5-1], S_2, ground roughness factor [B.6.5.5.1], and S_3, importance factor [B.6.5.6]. The importance factor is given in the table below:

Table 5. Importance factor S_3 according to Occupancy Categories

Occupancy Categories		Occupancy Type or Function of Structure	S_3
IV	**Essential Facilities**	Hospitals and other medical facilities having surgery, and emergency treatment areas; structures and equipment in communication centers and other facilities required for emergency response; tanks or other structures containing, housing, or supporting water or other fire-suppression materials or equipment required for the protection of essential or hazardous facilities, or special occupancy structures; structures and equipment in emergency preparedness centers; stand-by power generating equipment for essential facilities.	1.05
III	**Special Occupancy Structures**	Emergency vehicle and equipment shelters and garages; fire and police stations; all facilities so designated by the municipali administration.	1.05
II		Covered structures whose primary occupancy is public assembly—capacity more than 3000 persons; buildings for schools (through secondary) or day-care centers—capacity more than 200 students; buildings for colleges or adult education schools— capacity more than 200 students; all structures with occupancy more than 2000 persons; stores and shopping centers of more than 500 m² per story; all governmental buildings.	1.05
I	**Standard Occupancy Structures**	All structures having occupancies or functions not listed above.	1.00

The design wind speed is then computed according to

$$V_s = VS_1S_2S_3$$

and the dynamic pressure q is then computed as

$$q = 0.000048V_s^2S_4$$

where q is in kN/m² and V_s is in kph. From there, the norm requires the computation of the wind force as

$$F = \left(C_{pe} - C_{pi}\right)qA$$

where C_{pe} is the external pressure coefficient and C_{pi} is the internal pressure coefficient and A is the surface area.

4.3 Experimental Procedure

No experimental procedure is stated.

5. INDUCED EFFECTS

5.1 Impact of Flying Objects

Not considered.

5.2 Wind Driven Rain

Not considered.

6. SAFETY VERIFICATIONS

6.1 Structure

Wind pressure is included in the load combinations as given in sections [B.2.3] and [B.2.4]. These load combinations are borrowed from the source document ASCE 7-95.

6.2 Claddings and Non-Structural Elements

Claddings and Non-Structural Elements are considered by using the ASCE 7-95 provisions as guideline.

7. SMALL RESIDENTIAL BUILDINGS[Title E]

Provisions are given for one and two-story residential buildings. The provisions are prescriptive and cover foundations, structural walls made from concrete masonry blocks, confining elements (columns), flooring systems, roofing, partitions and parapets. The provisions do not give any prescriptive rules for the wind hazard, only for the seismic hazard.

RECOMMENDATIONS FOR CODE IMPROVEMENT

The wind code provisions are included in this norm as merely a chapter within Title B for Loadings. These provisions do need refurbishing since they are based on little supporting data and studies performed some 20 years ago by the power industry in Colombia. Therefore it is recommended that the current chapter dealing with this type of loading be improved.