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An Evaluation of Present-Day Hurricane Resistant Building Codes*

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ABSTRACT

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A review of existing "model" building codes and regional building codes in hurricane-prone areas in the U.S.A. is presented. Some of the shortcomings and misconceptions involved in establishing hurricane-resistant design and construction criteria are pointed out. Generally, weak points are found (a) in the specified details of construction or lack thereof, (b) in curtainwall, cladding and window design criteria and construction requirements, and (c) in those foundation designs for structures within 1,500 feet of the high-water line.

SOUTH FLORIDA BUILDING CODE

Design criteria and building codes for preventing and mitigating structural damage from hurricanes have been pioneered in South Florida. (South Florida metropolitan areas consist of Greater Miami, Fort Lauderdale, and surrounding municipalities, with a population of over four million permanent residents).

The *South Florida Building Code* has been a regional code since 1957 when it was adopted by the new metropolitan government in the Greater Miami area. The code is based on what was formerly the Pacific Coast Building Code Officials Conference (now the International Conference of Building Officials (ICBO)). The *South Florida Building Code* has diverged from the ICBO Code and has stressed masonry and concrete construction. The code is a specification-type code with considerable detail on various phases of design and construction, with concentration on required details for resisting severe winds.

Basic design storm for the building code in use in South Florida is a 120 mph hurricane, at 30 feet elevation above grade. This corresponds to a Category 3 Hurricane on the Saffir-Simpson Hurricane Scale (111–130 mph wind velocity). A 1/7th power increase in velocity with increase in height is used. No gust factors are added. In addition, a reduction in velocity is permitted for elevations below 30 feet. Tables of pressure coefficients are given for various common shapes of buildings and for components of buildings in wall and roof. Pressure coefficients for all components contain a "built-in" figure of 0.3 to cover internal pressures in buildings.

Because of the recently adopted Florida legislation requiring that structures in the coastal building zone be designed for a 100-year storm event, the section on wind loads has recently been amended to include certain more rigorous requirements for the coastal building zone. The basic design storm remains 120 mph but additional shape factors for components of roof and wall areas near the corners and leading edges of buildings have been given. In addition, a table of "Use Factors" has been adopted increasing the wind loads for essential facilities. These changes are only for coastal buildings. The context of Section 161.053 of the Florida Statutes covers essentially the land area 1,500 feet back of the high water line and includes essentially all of the coastal barrier islands.

The shape factors added for these building components are based on factors that are used in

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the *Standard Building Code* which, in turn, are based on the wind load specifications of the Metal Building Manufacturers Association. In some cases they do not conform to the A-58 ASCE-7 Standard.

The additional data and shape factors for the coastal zone are not applied to the land zone away from the coast; it is unfortunate that these more detailed factors do not apply to the entire South Florida area, since, obviously, they act in any location; the adoption of the more detailed factors only for the coastal zone was based on the requirements of the new state laws mandating higher velocities for the coast-line areas.

The value of the *South Florida Building Code* is in the prescriptive details for construction in concrete and steel, especially valuable for those "non-engineered" buildings where structural engineers are not involved. Other advantages to this code, as a hurricane-resistant code, involve the product approval requirements which mandate that all building components in walls and roofs demonstrate by stress analysis or load test that they can withstand the loads exerted by hurricane winds.

STANDARD BUILDING CODE

This code, formerly the *Southern Standard Building Code,* is generally used in most of the southern states. The section on wind loads is adapted from the Metal Building Manufacturers Association wind load standards, which were based on wind tunnel work and recommendations of the University of Western Ontario. Section 1205, "Wind Loads," is better than the section in previous editions of the code.

Problems with using the *Standard Building Code* as a hurricane-resistant code relate primarily to its lack of specifications covering details of construction. It is primarily a performance-type code. Some of the details permitted in the code are weaker than comparative requirements in the *South Florida Building Code.* For instance, the Standard Code permits the use of U-block or open column block for concrete bond beams and concrete columns. The *South Florida Building Code* does not accept this type of construction and mandates formed reinforced concrete bond beams and tie beams in "non-engineered" construction.

Recognizing the defects in the lack of prescriptive details in the Standard Code, the Southern Building Code Congress provided "Deemed-to-Comply" Standards, which give prescriptive details and methods for residential and multi-family construction in high wind regions, for both wood-frame and masonry construction. The Standards are highly detailed and relatively complex, since each detail and prescriptive design is given for a 90 mph design storm, for a 100 mph design storm and for a 110 mph design storm. Unfortunately, none of the Standards are legally a part of the building code and without being part of the building code, they will not be followed (unless the local governing body adopts them legally as a requirement for construction).

The Standard Building Code does not specify design wind storm velocities for individual areas, but incorporates the isotachs taken from the A58 ASCE A-7 Standard showing fastest-mile speeds throughout the U.S. at 33 feet above ground. These are based on a 50 year probability of occurrence.

STATE OF FLORIDA

The Department of Community Affairs in Tallahassee has the authority to determine whether local governments throughout the state follow minimum code requirements mandated by legislation. In general, this Florida state agency does not have the resources to conduct surveys and studies of local building departments and defers to the Southern Building Code Congress International for its reviews of code compliance and building department efficiency throughout the State of Florida.

BOCA NATIONAL CODE

The Boca National Code (Building Officials & Code Administrators International, Inc.) is generally a performance-type code with not a great deal of detail for design and construction. This is in keeping with the philosophy regarding building codes followed by this organization. Present wind load provisions in the BOCA Code are, in general, based on ANSI ASCE 7-88. The details of ASCE 7-88 are modified to fit the format and standard of the BOCA Code. The isotach map given in ASCE 7-88 showing the 50 year fastest-mile speeds is made a part of the BOCA Code. Omitted from the present wind load provisions are detailed design requirements for components and cladding and references to internal pressures. Only two exposure terrains are used: B and C.

UNIFORM BUILDING CODE (ICBO)

The Uniform Building Code of the International Conference of Building Officials is a highly

Table 1. *Wind shears on main wind force resisting system at base of building.*

Coastal Code	Velocity (mph)	x Shear (kips)	y Shear (kips)	x + y Shear (kips)	Comments	% Diff. ANSI 50 year D (X + Y)
ANSI ASCE 7-88*	110	1,178	6,327	7,505	Exposure D, 50 year Hurricane Ocean Line	0% (standard)
SFBC (88) So. Florida	120	1,423	5,692	7,115	Coastal 100 year	−5%
SSBC (88) Southern Standard	110	1,281	5,124	6,405	Coastal 50 year	−15%
UBC (88) ICBO	110	1,388	5,552	6,940	Exposure C, 50 year	−8%
BOCA 87	110	1,231	6,547	7,778	Coastal, Exposure C I = 1.11	+4%

*Wind load standard only (not a building code).
These shears apply to the main Wind Force Resisting Systems. The methods and procedures for handling design loads and design of curtainwall, windows, exterior glass and exterior building components are detailed in the prescriptive details of the code used. In this respect, the *South Florida Building Code* is the most detailed code.

detailed specification-type building code. It is not necessarily a hurricane-resistant code; it contains a considerable amount of data covering earthquake design requirements. As indicated above, the predecessor document of ICBO forms the basis for the first *South Florida Building Code.*

The code includes the isotach map of fastest-mile speeds at 33 feet above grade taken from ANSI ASCE A-7, as in codes indicated above.

Prescriptive details for masonry construction and high wind areas are covered in an Appendix (Chapter 24). This is a detailed specification code giving specific prescriptive details for construction in masonry buildings for the following wind speeds: 80 mph, 90 mph, 100 mph and 110 mph. An additional appendix (in Chapter 25) gives similar prescriptive details for light wood frame construction for 80 mph, 90 mph, 100 mph and 110 mph.

The code is well detailed and contains valuable tables of data.

ANSI STANDARD ASCE 7-88 (formerly ANSI A58.1) (Approved November 27, 1990)

The only widely used rational standard that covers hurricane wind loadings is the American National Standard ASCE 7-88 "Minimum Design Loads for Buildings and Other Structures." This standard adopts design wind storms for those states fronting on the Gulf of Mexico and the Atlantic Ocean, in hurricane-prone areas. All design wind velocities are fastest-mile, at 33 feet above grade, based on a 50 year period of recurrence. Maximum design wind is 110 mph in the south Florida coastal areas.

For coastal areas of other states fronting along the Gulf of Mexico in hurricane-prone areas, the design wind storm drops to 100 mph for Texas, Louisiana, Mississippi, Alabama and northern Florida.

For highly exposed coastal areas in North Carolina, the design storm increases to 110 mph; further north along the Atlantic Ocean coast line, the design storm drops to 90 mph.

To briefly note the main points of ANSI ASCE 7-88, the Standard does the following:

(1) Gives varying gust response factors and gives pressure coefficients for varying common configurations of buildings and roof lines: (a) up to 60 feet above grade, and (b) above 60 feet above grade.

(2) Distinguishes between: (a) loads on main wind-force resisting systems and (b) loads on building components and cladding.

(3) Gives four exposure categories from Exposure A, large city centers, down to Exposure D, flat, unobstructed coastal areas.

(4) Adopts a concept of "Importance Factors" with adjustments of design wind speeds to annual probabilities of being exceeded other than the value 0.02 on which the design wind speeds are based. Four categories of importance are adopted; importance factors depend on building categories and occupancies and distance from hurricane oceanline.

(5) Gives internal pressures for design of components and cladding due to wind loads.

(6) Divides a building into several zones, such

as corners, edges, and portions of walls and roofs, and gives different wind loads for each zone for design of components and cladding.

COMPARATIVE VALUE OF CODES

In the opinion of the author, the *South Florida Building Code* because of its wealth of prescriptive requirements for masonry construction and because of its system of product control approvals, is probably best for hurricane-resistant construction. The ICBO Uniform Building Code is a valuable document because of its wealth of reference data, but those data are not essentially those relating to hurricane-resistant construction.

In all of the codes, regional and model, the author recommends that the ASCE 7-88 requirements be used without modifications, except for those local modifications covering the choice of design storm for a specific locality.

COMPARISON OF WIND FORCES

A comparison of the wind forces under different codes was made by John Pepper, P.E., in connection with a study by Pepper and the author for a private client. For the hypothetical high-rise building used, 300 feet high and 240 feet by 60 feet in plan, the wind shears at the base of the building are as shown in Table 1.

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□ RESUMEN □

Este trabajo presenta una revisión del modelo del código de edificios y códigos regionales de edificación en áreas de los Estados Unidos sujetas al ataque de los huracanes. Se ponen de manifiesto algunas neglicencias y errores conceptuales relativos a la resistencia a los huracanes de los proyectos y criterios de construcción. En general, los puntos críticos son los referidos a: a) detalles específicos de construcción o carencia de ellos: b) paredes, revestimientos y criterios para proyectos de ventanas y requerimientos de construcción; c) fundaciones para las estructuras proyectadas dentro de una distancia de 450 m (1500 pies) de la línea de la pleamar.—*Department of Water Sciences, University of Cantabria, Santander, Spain.*

□ ZUSAMMENFASSUNG □

Es wird eine Übersicht über die existierenden Vorschriften und regionalen Bauverordnungen für die von Hurricanes betroffenen Regionen der USA vorgelegt. Dabei wird auf einige Mängel und Fehler in den Konstruktionsvorschriften und Entwürfen für sturmfeste Bauten hingewiesen. Generell werden Schwachpunkte gefunden in: (a) speziellen Konstruktionsdetails oder ihr Fehlen, (b) Bauvorschriften für Fenster, Plattierungen und Verblendungen, and (c) allgemein für Fundamentierungsvorschriften von Gebäuden im Abstand von weniger als 500 m zur Hochwasserlinie.—*Dieter Kelletat, Essen, F.R.G.*