Simplifying the code

Overview of changes in the wind load provisions in the 2006 IBC/ASCE 7-05

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Early editions of the three model codes contained complete structural design provisions for load determination as well as material-specific structural design requirements for concrete, masonry, steel, and wood structures. During the past 20 years, the model building codes increasingly began to rely on national consensus standards for load determination and material-specific structural design requirements. This trend became more prominent in the first edition of the International Code Council's International Building Code (IBC) in 2000, and has continued in the subsequent 2003 and 2006 editions of the IBC.

The principal national standards used in structural design of buildings and structures include the national load standard as well as the design standards for the four major structural materials used in building construction — concrete, masonry, steel, and wood. These standards are as follows: The American Society of Civil Engineer's Minimum Design Loads for Buildings and Other Structures of the American Society of Civil Engineers (SEI/ASCE 7); The American Concrete Institute's Building Code Requirements for Structural Concrete and Commentary (ACI 318); ACI, ASCE, and The Masonry Society's Building Code Requirements for Masonry Structures (ACI 530/ASCE 5/TMS 402); The American Institute of Steel Construction's Manual of Steel Construction - Allowable Stress Design (AISC-ASD); AISC's Manual of Steel Construction Load and Resistance Factor Design (AISC-LRFD); and the AF&PA National Design Specification for Wood Construction (ANSI/AF&PA NDS).

Referenced standards

The 2003 IBC references the 2002 edition of the ASCE 7 standard, which contains complete provisions for the various types of loads encountered in structural design of buildings and other structures. The standard includes dead, roof and floor live, soil, hydrostatic pressure, flood, wind, snow, rain, and earthquake loads. The standard also includes provisions for combining the various loads using load combinations for both the allowable stress design and strength design procedures.

The 2003 IBC contains simplified wind load provisions that were transcribed from the ASCE 7-02 standard, but the code also allows the designer to determine wind loads directly from the standard. Since both the code and the standard contained wind load provisions, it was sometimes confusing for designers and building officials to determine what provisions applied. Recognizing this, the Structural Engineering Institute (SEI) of ASCE, in conjunction with the National Council of Structural Engineers Association (NCSEA), developed a proposal to the 2006 IBC that was intended to ensure that the wind load provisions in the code were as clear, succinct, and unambiguous as possible. The proposal, which was approved, references the latest 2005 edition of the ASCE 7 standard for all technical provisions related to determination of wind loads on buildings and other structures. The ASCE 7 standard is developed, published, and maintained by the Structural Engineering Institute of the American Society of Civil Engineers (SEI/ASCE) and is a nationally recognized standard accredited by the American National Standards Institute (ANSI). The current 2005 edition of the ASCE 7 standard is known as ASCE/SEI 7-05.

Changes to the wind load provisions in the 2006 IBC

In the opinion of the SEI/NCSEA coalition, the proposal simplifies wind design in general and will lead to more consistent enforcement and better wind-resistant construction. The proposal results in a significant reduction in the amount of wind design provisions that will remain in the 2006 IBC.

The wind load provisions that will remain within the 2006 IBC are as follows:

- provisions related to climactic, terrain, or other environmental conditions, such as basic wind speed, terrain effects, and exposure conditions, that often are specified by the building official;
- provisions related to specific types of structures and construction methods, such as residential structures constructed in accordance with the AF&PA Wood Frame Construction Manual for One- and Two-Family Dwellings, SBCCI SSTD 10 Standard for Hurricane

In addition to the new conversions for the 3-second gust wind speed to fastest mile, the 2006 IBC will include specific provisions for protecting buildings susceptible to wind borne debris.

Resistant Residential Construction for Group R2 and R3 Buildings, and special types of structures such as metal flag-poles and antenna structures; and

- provisions not currently covered by a nationally recognized standard, such as specific wind-resistant roof covering requirements and specific opening-protection requirements in hurricane prone regions.

New conversions for the 3-second gust — The 2000 and 2003 editions of the IBC included a table that permitted a designer to convert the new 3-second gust basic wind speed to a fastest-mile basic wind speed when using older design standards that are based on the older fastest-mile basic wind speed criteria. One of the changes in the 2006 IBC includes a revision to the conversion of the new 3-second gust basic wind speed to fastest-mile basic wind speed in IBC Table 1609.3.1. The table originally was based on the Durst curve shown in Figure C6.1 of the ASCE 7-98 commentary. The curve was revised to reflect more closely the original work of C.S. Durst in 1960, resulting in the new curve shown in Figure C6-2 of ASCE 7-02. The replotted curve resulted in changes in the conversion of wind speeds in comparison to the 2000 IBC, causing some of the fastest-mile wind speeds to be lower than they should have been. Since the wind pressure is proportional to the square of the wind speed, a 5-mile-per-hour (mph) increase in wind speed from 80 mph to 85 mph produces a 13-percent increase in pressure. Conversely, a 5-mph decrease in wind speed from 85 mph to 80 mph produces an 11-percent decrease in pressure. This fact resulted in two changes to the wind speed conversion provisions in IBC Section 1609.3.1 and Table 1609.3.1. In addition to the revised values in the table, a new formula is given in the code (Equation 16-31) that permits the designer to convert from 3-second gust basic wind speed to fastest-mile basic wind speeds directly. Equation 16-31 is as follows:

$$V_{fm} = \frac{V_{3S} - 10.5}{1.05}$$

where V_{3S} = 3-second gust basic wind speed from IBC Figure 1609 (ASCE Figure 6-1).

Table 1 (page 13) shows the degree to which fastest-mile wind speed and wind pressure could be underestimated based on the new formula in comparison to what is currently in the equivalent basic wind speed tables in the 2000 and 2003 editions of the IBC and IRC. The updated fastest-mile wind speeds shown in the second column of Table 1 will be included in the 2006 IBC Table 1609.3.1.

Wind borne debris protection — Section 1609.1.4 of the 2003 IBC requires protection of openings for exterior glazing in the lower 60 feet of buildings located in the wind borne debris region. The section includes an exception for one- and two-family buildings where precut wood structural panels may be used to cover glazed openings. The fastening system must be designed to resist component and cladding loads. For buildings with a mean roof height less than or equal to 33 feet where wind speeds do not exceed 130 mph, Table 1609.1.4 gives prescriptive fastening requirements in lieu of fasteners designed to resist component and cladding loads. The 2006 IBC includes the following clarifications and improvements to Section 1609.1.4 and Table 1609.1.4:

- precut panels must be attached to the framing surrounding the opening and secured with the attachment hardware provided;
- fasteners must be located a minimum of 1 inch from the edge of the panel;
- fasteners must be of sufficient length to penetrate through the exterior wall covering a minimum of 1-3/4 inches into wood wall framing;
- fasteners must be located a minimum of 2-1/2 inches from the edge of concrete block or concrete; and
- fasteners must be of sufficient length to penetrate through the exterior wall covering and have a minimum embedment of 1-1/4 inch into concrete block or concrete.

The new version of Table 1609.1.4 is shown in Table 2 (page 14). Because of deleted sections, this table is numbered 1609.1.2 in the 2006 IBC.

Asphalt shingle wind uplift resistance — Asphalt shingles are required to be tested in accordance with the American Society of Testing and Materials' (ASTM) D6381-03 Standard Test Method for Measurement of Asphalt Shingle Mechanical Uplift Resistance to determine the resistance of the sealant to

Table 1: The fastest mile wind speed and wind pressure could be underestimated using the 2000 or the 2003 IBC.

$V_{3\text{-sec}}$	Calculated V_{fm}	2003 IBC & IRC V_{fm}	Underdesign with present table[a]
85	71	70	3%
90	76	75	3%
100	85	80	11%
105	90	85	11%
110	95	90	10%
120	104	100	8%
125	109	105	7%
130	114	110	7%
140	123	120	5%
145	128	125	5%
150	133	130	4%
160	142	140	3%
170	152	150	3%

[a] Equals (V_{fm} IBC/IRC ÷ V_{fm} calculated)^2, which represents how using a velocity that is too low affects the design wind pressure.

wind uplift forces. The referenced standard, ASTM D6381, is included in IBC Chapter 35. Asphalt shingles are permitted to be designed in accordance with Underwriter Laboratory's (UL) 2390 Test Method for Measuring the Wind Uplift Coefficients for Asphalt Shingles to determine the appropriate uplift and force coefficients to be applied to the shingle. This referenced standard is included in IBC Chapter 35.

Changes to the ASCE 7-05 Standard

In addition to changes in the wind load provisions in the 2006 IBC, there are many changes in the wind load provisions of the ASCE/SEI 7-05, the more significant ones are described below.

Clarified and expanded the application of Method 1 – Simplified Method — To use Method 1, it is critical that the building contain no expansion joints or structural separations because Method 1 is predicated on the assumption that the internal pressures cancel one another. In the 2002 edition of the standard, the restriction on expansion joints and structural separations was included in the list of nine restrictions under the scope of the simplified procedure. In the 2005 edition of the standard this requirement was moved and integrated directly into the definition of a simple diaphragm building. In addition, the restriction that the building not be subject to topographic effects was removed from the list of restrictions under the scope of the simplified procedure and the topographic effect factor was inserted directly into the pressure equation 6-1 ($p_s = \lambda K_{zt} I p_{S30}$). As in previous editions of the standard, if the building is not subject to topographic effects, then the topographic effect factor is equal to 1.0.

Excluded torsionally sensitive buildings from simplified Method 1 —

Table 2: A new version of TABLE 1609.1.4 prescribes wind-borne debris protection fastening schedule for wood structural panels.

FASTENER TYPE	FASTENER SPACING (inches)		
	Panel Span ≤ 4 feet	4 feet < Panel Span ≤ 6 feet	6 feet < Panel Span ≤ 8 feet
No. 6 Wood Screws	16	12	9
No. 8 Wood Screws	16	16	12

In the 2005 edition of the standard, Method 1 has an additional restriction that the building must either be exempted from torsional loading conditions as prescribed in Note 5 of Figure 6-10, or the torsional load cases do not control the design of any main wind force resisting system (MWFRS) of the building. Buildings with flexible roof and floor diaphragms that distribute lateral forces to the vertical resisting elements (shear walls, braced frames, moment frames, etc) of the MWFRS generally are not considered capable of transferring torsional moments and therefore can use Method 1. See Commentary Section C6.4 for a detailed discussion and guidance to determine whether or not torsion controls the design.

Modified the pressures for parapets and clarified their application for low-slope roofs — Prior to the 2002 edition of the standard there were no provisions for wind load determination on parapets because of a lack of specific research to support a design methodology. Many engineers used the combined effects of wall and roof pressures depending on the particular parapet involved. The 2002 edition of the standard included a rational approach to wind loading on parapets based on the intuition, experience and engineering judgment of the committee. The 2005 edition of the standard includes parapet design provisions based on the results of recent research.

Added a definition for eave height — The term “eave height” is used but was not defined in early editions of the standard. The 2005 edition includes a definition of eave height as the distance from the ground surface adjacent to the building to the roof eave line at a particular wall and allows the use of the average height where the eave height varies along a wall line.

Clarified footnote 8 of Figure 6-10 — The footnote delineates the boundary between the windward zone pressures (interior zone 2 and end zone 2E) from the leeward zone pressures (interior zone 3 and end zone 3E). The 2002 edition did not explicitly include the end zones 2E and 3E. The 2005 edition of the standard includes the end zones for clarification.

Added new provisions for freestanding walls and solid signs — The 2005 edition of the standard includes a new Section 6.5.14, and Figure 6-20 has force coefficients necessary for the design wind load determination on solid freestanding walls and signs.

Added new provisions for canopies and free roofs — Section 6.5.13 has been improved and expanded to include open buildings with monoslope, pitched, and troughed roofs. New design pressure equations for both main wind force resisting system and components and cladding have been added along with corresponding Figures 6-18 and 6-19 for determination of the net pressure coefficient (C_N) for the various roof configurations. This new material is based on recent research and the approach used in an Australian wind design standard.

Clarified exposure categories for main wind force resisting systems and components and cladding — The 2002 standard duplicated the single requirement that design pressures be based on the exposure resulting in the highest wind load for any direction at the site. The two sections were consolidated into the single Section 6.5.6.5 Exposure Category for Components and Cladding. In addition, the required fetch distance upwind for tall buildings is increased from 10 times the building height to 20 times the building height. This increase was determined to be more realistic based on calculations of the distance required to affect the boundary layer resulting from a change in surface roughness. See Commentary Section C6.5.6.4.

Provided objective and enforceable criteria for using climatic data to determine the basic wind speed in special wind regions and other non-hurricane-prone regions — For areas outside the hurricane-prone region, the 2005 edition of the standard explicitly requires that where the basic wind speed is determined from regional climactic data, the basic wind speed cannot be less than that associated with the 2 percent annual probability of exceedance (50 year mean recurrence interval) wind speed adjusted to 3-second gust at 33 feet above ground in exposure C.

Clarified that the basic wind speed obtained from regional climactic data may be less than that in Figure 6-1 — Section 6.5.4.2 Estimation of Basic Wind Speeds from Regional Climactic Data of the 2005 standard explicitly allows a reduction in the basic wind speed below the value obtained from Figure 6-1 where appropriately determined based on regional climactic data as prescribed in the section.

Modified provisions for rooftop equipment — The 2005 standard includes a new Section 6.5.15 and Figures 6-21 through 6-23 that have force coefficients for determining design wind loads on other structures including roof top structures for buildings with mean roof height less than or equal to 60 feet.

Expanded required protection of glazing in wind borne debris regions; clarified its requirement when loads are determined using Method 3; and updated referenced standards — The 2005 standard includes a new Section 6.6.5 under Method 3 - Wind Tunnel Procedure requiring glazing protection in wind-borne debris regions in accordance with the general requirements under the Analytical Procedure as prescribed in Section 6.5.9.3. The section includes references to the ASTM test standards ASTM E1886-02 and ASTM E1996-02.

Conclusion

Although most engineers would certainly welcome less change where building codes and structural engineering standards are concerned, this is an unrealistic wish because of the dynamic nature of engineering technology and the many new and innovative technical refinements that ultimately become incorporated into the codes and standards. In the case of the 2006 IBC and ASCE 7-02 standard, many of the changes are improvements resulting from clarification, consolidation, and reorganization of the provisions to make the code and standard more user friendly. ■

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