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Felt Tips

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ASCE 7 Revised

New Emphasis on the Effect of the Building Form on Envelope Design for Wind Resistance

Introduction

Continuity and quality assurance in the load path from each exterior component to the ground is the key to creating buildings and building elements that withstand wind loads. With the release this year of ASCE 7-95 *Minimum Design Loads for Buildings and Other Structures*, the American Society of Civil Engineers (ASCE) has placed new emphasis on the effect of the building form on pressures placed on the exterior envelope in wind-load analysis and design. This revision to ASCE 7-93 responds to the studies of the 1993 ASCE symposium, "The Hurricanes of 1992" which had been organized to learn from that year's turbulent Hurricanes Andrew, Iniki, and Omar [Heineman, p.32].

The Envelope: Cladding and Components

Those hurricanes reiterated the importance of envelope resistance to wind loads. Wind exerts positive pressure on windward walls and highly sloped roofs, and negative pressure (also called suction) on flat roofs and leeward walls. In addition, different portions of these surfaces respond differently to the wind, with the greatest pressures occurring near corners, sharp edges, and protrusions. These high-pressure zones can be as large as 1/10 to 1/8 of the surface's width [CTBUH, p. 66]. Therefore, in addressing cladding and components, the revised ASCE-7 has expanded its categories of building types to include more varied building profiles.

Where ASCE 7-93 gave component and cladding pressure coefficients for:

1. Buildings with mean roof height less than or equal to 60 feet. Loads at:
   a. Walls.
   b. Roofs.
2. Buildings with mean roof height greater than 60 feet. Loads at:
   a. Walls.
   b. Roofs.

The ASCE 7-95 categories include:

1. Buildings with mean roof heights less than or equal to 60 feet. Loads at:
   a. Walls
   b. Gabled and Hipped Roofs (with or without roof overhangs)
   c. Stepped Roofs
   d. Multispan gabled roofs
   e. Monoslope and Sawtooth roofs
   f. Sawtooth roofs - two or more spans
2. Buildings with mean roof height greater than 60 feet. Loads at:
   a. Walls.
   b. Roofs.

The Envelope: Openings

Building forms that which cup the wind can be greatly affected by the total wind force on the building (Figure 1). Openings in the windward building faces can allow positive pressures to reach the leeward surfaces which are also experiencing aerodynamic suction. Cladding failures that cause unplanned openings in the building skin can be especially catastrophic during hurricanes, as an unexpected hole amounting to less than 5 percent of the windward surface area can cause a building to collapse [Heineman, p. 36]. In response to these failure modes, a three-pronged approach to envelope design is appropriate: Protect openings, prevent unplanned openings, and design for internal pressure coefficients (Figure 2). ASCE 7-93 and ASCE 7-95 provide adjustment of design factors by a hurricane importance factor for buildings and structures in affected regions. While glazed areas are not considered openings from the wind engineer's point of view, an unprotected glazed area in a hurricane region could be a failure waiting to happen. As a result, ASCE 7-95 addresses unprotected glazed openings in hurricane regions as if they were unglazed.

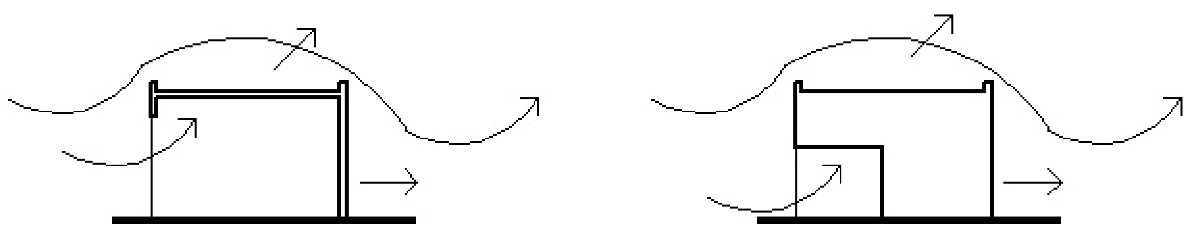

Figure 1. Partially enclosed buildings can cup the wind and increase pressures on the leeward side.

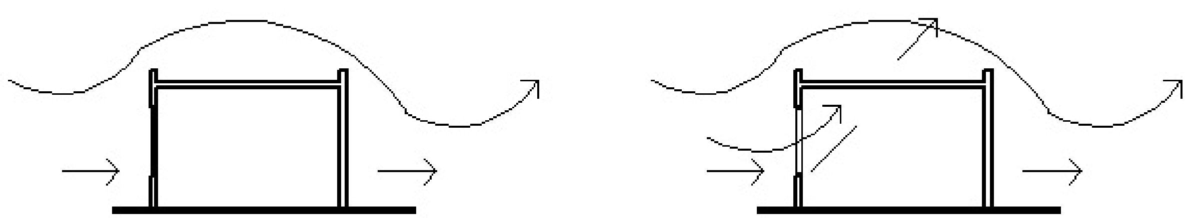

Figure 2. Glazed areas are not considered openings in wind analysis (left diagram). Under hurricane conditions, glazing might fail (right diagram). If the glazing is not designed to resist impact from airborne debris, ASCE 7-95 treats such structures as partially enclosed buildings.

In ASCE 7-93, internal pressure coefficients were provided for two types of envelopes:
1. Open buildings
2. All other buildings

ASCE 7-95 addresses internal pressure coefficients for:
1. Open buildings
2. Partially enclosed buildings
3. Buildings sited in hurricane regions and having glazed openings not protected from wind-borne debris.
4. All other buildings

The Primary Structural System

Sustained wind speeds are usually less of a problem than gusts. A gust is a brief increase, or surge, in the wind velocity. Due to its higher velocity and slamming effect, the gust actually represents the most critical wind effect in most cases. Gusts can be 20 to 30 percent faster than the prevailing wind speed, and cladding and components can fail within 1 to 3 seconds of a gust [Cook 1993, p. 30]. Wind-related failure of the main structural system is much more rare. Compared to cladding, the main structural system is usually much heavier and slower to move, and is less affected by gusts which usually last only a fraction of a second.

Wind-related failure of the primary structural system is more likely to occur if it depends on the cladding system for bracing and the cladding system fails. There were some examples of this in Dade County, Florida, during Hurricane Andrew. Precast concrete double-Tee decking failed in several cases [Mays, p. 112]. This type of construction is used for such partially open buildings as parking garages, and the concrete Tee is typically not designed to take lateral loads, or uplift loads greater than the counteracting dead load. In cases where the double-Tee decking was the only thing providing bracing to the columns, entire buildings failed. Similarly, the loss of roof sheathing in gabled stick-built construction caused truss failure during Andrew, in cases where the sheathing was the only thing providing bracing for the trusses [Mays, p. 112]. Due to their very different responses to wind loads, the type and amount of dependance between a building's cladding and it's primary structure can become an issue.

Other ASCE-7 95 Revisions

While the major revision in ASCE 7-95 is the greatly expanded section on wind loads as summarized above, new requirements have also been added in ASCE 7-95 for flood loads and ice loads. There is also a new appendix providing guidance for the design of building serviceability and the comfort of building occupants as affected by deflection, vibration, drift, and other environmental effects.

The ASCE-7 Standard in Baltimore

ASCE 7-93 has been adopted by all major building codes (BOCA National Building Code [NBC], SBCCI Standard Building Code [SBC], and ICBO Uniform Building Code [UBC]). ASCE 7-95 can be expected to be adopted across the nation as codes are updated. The Baltimore City Building Code uses NBC 1993. Other jurisdictions in Maryland already use, or will be adopting, NBC 1993 as a requirement of state building code legislation enacted in 1995. NBC is updated every three years, and the new NBC1996 has already been released. NBC 1996 however, still incorporates ASCE 7-93. Therefore, even when Baltimore City and other Maryland jurisdictions update to NBC 1996, ASCE 7-95 requirements will not be included, unless separate local amendments are made.

The Pedestrian Environment

It is important to remember that high winds affect not only buildings, but the spaces around them. Terraces, plazas, park areas, and other pedestrian environments next to tall buildings can have unacceptable wind effects [CTBUH, p 52]. ASCE 7 addresses the effect of environmental forces on structures, but not the sometimes significant effect of structures on the environmental forces.

Conclusion

Come let us mock at the great
That had such burdens on the mind
And toiled so hard and late
To leave some monument behind,
Nor thought of the leveling wind.
--W.B. Yeats

ASCE 7 is a *minimum* standard. It specifically advises the use of wind-tunnel testing, instead of its guidelines, for determining the wind-loading and structural response of structures with unusual geometries, response characteristics, or site location.

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