Design Wind Pressures and ASCE 7

This bulletin provides a general overview of the current codes and standards related to design wind pressures and their use.

The question of design pressure has been one of confusion for many cladding and component manufacturers and suppliers. Often, a specifier will stipulate a design wind speed for projects, which is a very valuable piece of information – except that testing standards and specifications identify design pressures. It would seem that this is not a big issue, simply convert the indicated wind speed into a workable design pressure; wind is basically air with a mass traveling at a velocity.

However, it is not nearly that straightforward, as anyone who has attempted to use current design and building codes is aware. Beyond just wind speed, many other factors such as terrain, location, use of the building, and component elevation come into play when determining design pressure. Wind speed is not a constant and as a result, surface pressures on a building are not uniform. They vary with height, time and wind direction, and can be positive or negative on any face of the building.

ASCE 7 and Building Codes

The ASCE 7 Minimum Design Loads for Buildings and Other Structures is the result of years of research and data analysis to reduce an extremely complex phenomenon into a set of equations, coefficients, and tables for use in building design. The document is the foundation for wind load design in provisions in the major model codes used in the US.

Like most codes and standards, the ASCE 7 has undergone a few changes throughout its lifetime. The most significant occurred in ASCE7-95, when the use of 3-second gust speed replaced fastest-mile speed for basic wind velocity. Also, the ASCE7-98 and 7-02 editions provide a simplified option if the building in question meets certain criteria. The project specification must state which method to use. If a specific method is not referenced for the project, it is strongly suggested that a formal Request for Information be submitted to the authority having jurisdiction.

Basic Wind Speed and Wind Directionality Factor

Selecting the basic wind speed is the easiest step in the process. ASCE 7 provides maps with contours indicating the wind speed for
a given area. If the address of the project is known, it is simply a matter of picking that location on the map. For locations in between contours, interpolation may be used to determine the actual wind speed at that location. The wind directionality factor, \( K_d \), is applied when wind load is combined with other loads, such as snow or seismic conditions. For most fenestration applications, \( K_d \) is 1.0.

**Importance Factors**

The use of the project building is of concern when determining the design pressure and is seen in the calculations as an importance factor. Importance factors, ranging from 0.77 to 1.15, are determined based on basic wind speed and building category. Buildings are categorized on a scale from I to IV, depending on use and hazard to human life. The category definitions can be found in Table 1-1 of the ASCE 7. For example, agricultural facilities are considered Category I, but hospitals and police stations are Category IV structures.

**Exposure Category and Enclosure Classification**

Like real estate, design pressures are highly dependent on three things: location, location, location! The very first step in establishing the design pressure of a project is to determine the location of that project in the US. It is also crucial to verify the topographic location of the project. For instance, is it in a city, in open terrain, or near the shore? Obstructions such as other existing buildings and trees, or a lack of obstructions such as a coastal setting can have a profound effect on the wind contacting the building. The surroundings or surface roughness category of a project are what is used to determine the exposure category. The last "location" to consider is the component location on the face of the building – it's proximity to the ground and to corner or eave conditions.

The enclosure classification refers to whether a building is completely enclosed, partially enclosed, or open. A building is considered "open" if more than 80% of each wall is open. When designing for wind borne debris regions, windows are evaluated as open wall area in a wind analysis unless they are impact resistant or protected.

**Other Coefficients and Factors**

1. The velocity pressure exposure coefficient, \( K_z \) or \( K_h \), is based on the building exposure category and height above ground level.

2. Isolated hills, ridges, and escarpments (steep slopes separating two relatively level surfaces) cause abrupt changes in the general topography of a job site. These types of changes also cause wind to speed up and thus have an effect on the design pressure of a building. The topographic factor, \( K_{zt} \), takes this rapid change in terrain into consideration.

3. The internal pressure coefficient, \( GCP_i \), is determined by the enclosure classification. As most buildings qualify as fully enclosed structures, this is generally \( \pm 0.18 \). External pressure coefficients, \( C_p \), take into account the geometry of a building, particularly the roof line. ASCE 7 provides tables for the values of \( C_p \) for wall and roof surfaces including various roof configurations.

**Velocity Pressure and Design Wind Pressure**

The velocity pressure, \( q_z \), is calculated applying the wind directionality, velocity pressure coefficient, importance and topographic factors to the square of the basic wind speed times a numerical constant. The velocity pressure is calculated at both the
elevation of interest (typically the topmost story) and at the mean roof height.

Finally, the design pressure is in sight. The internal and external pressure coefficients are applied to the velocity pressures to yield the design pressure of the component or cladding element. The equations for this calculation vary depending on building height and component, with different equations for parapets, flexible buildings, and low-rise buildings.

Need More Information?

The staff of professional licensed engineers at Architectural Testing, Inc. is very experienced working with all of the building codes and standards, and are always available to assist with questions or concerns.