CODES AND standards

ASCE 7-16 Wind Load Provisions

How They Affect the Practicing Engineer

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The new ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (Standard) is adopted into the 2018 *International Building Code* (IBC) and is now hitting your desks. The 2018 IBC and the referenced Standard are being adopted by a few jurisdictions and will become more widely used in 2019. Thus starts the time when practicing engineers learn the new provisions of the Standard and how they apply to their practices. To help in this process, changes to the wind load provisions of ASCE 7-16 that will affect much of the profession focusing on building design are highlighted.

Basic Wind Speed Maps

An updated study of the wind data from over 1,000 weather recording stations across the country was completed during this last cycle. This study focused on the non-hurricane areas of the country and used a new procedure that separated the available data by windstorm type and accounted for changes in the site exposure characteristics at the recording anemometers. This separation was between thunderstorm and non-thunderstorm events. Also, a small revision was made to the hurricane wind speeds in the Northeast region of the country based upon updated hurricane models. Consequently, wind speeds generally decrease across the country, except along the hurricane coastline from Texas to North Carolina. The wind speeds in the northern Great Plains region remain approximately the same as in ASCE 7-10. The most significant reduction in wind speeds occurs in the Western states, which decreased approximately 15% from ASCE 7-10 (*Figures 1* and *2*). To meet the requirements of Chapter 1 of the Standard, a new map is added for Risk Category IV buildings and other structures (*Figure 3*). These new maps better represent the regional variations in the extreme wind climate across the United States.

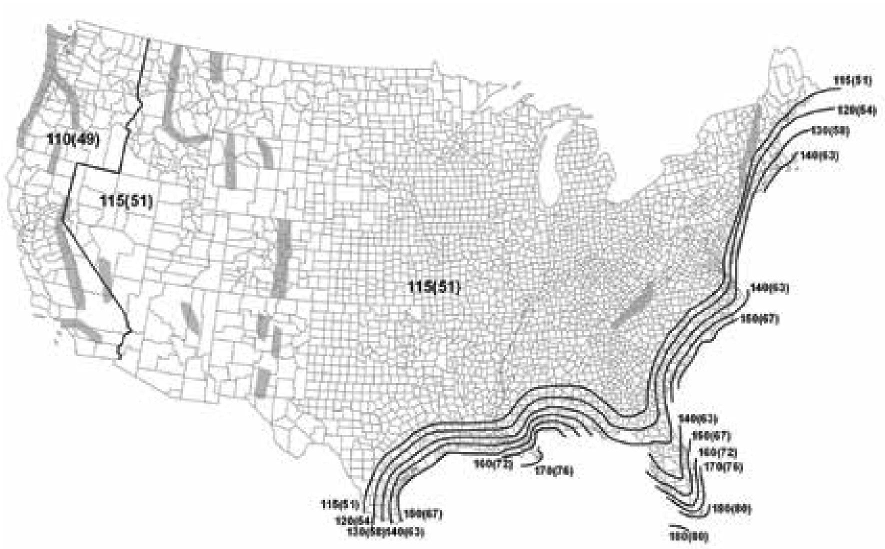

Figure 1. Example of ASCE 7-10 Risk Category II Basic Wind Speed Map. Printed with permission from ASCE. See ACSE 7-10 for important details not included here.

Additionally, "effective" wind speed maps are provided for the State of Hawaii. These maps differ from the other maps because the wind speed contours include the topographic effects of the varying terrain features (*Figure 4*). Thus, a Topographic Factor value, K_{zt} equal to 1.0 is to be used.

Not many users of the Standard utilize the Serviceability Wind Speed Maps contained in the *Commentary* of Appendix C, but these four maps (10, 25, 50 & 100-year MRI) are updated to be consistent with the new wind speed maps in the body of the Standard.

Table 26.9-1 – ASCE 7-16 ground elevation factor.

Ground elevation above sea level		Ground elevation adjustment factor
ft	**(m)**	K_e
0	(0)	1.00
1000	(305)	0.96
2000	(610)	0.93
3000	(914)	0.90
4000	(1219)	0.86
5000	(1524)	0.83
6000	(1829)	0.80

Ground Elevation Factor, K_e

The new K_e factor adjusts the velocity pressure to account for the reduced mass density of air as height above sea level increases (see *Table*). This reduction was provided in the *Commentary* of previous editions of the Standard; however, it is being brought into the body of the Standard to facilitate its use. This factor provides a simple and convenient way to adjust the velocity pressure in the wind pressure calculations for the reduced mass density of air at the building site. The adjustment can be substantial for locations that are located at higher elevations. For example, in Denver, CO, the "Mile High City," the ground elevation factor, K_e, is 0.82 which translates to an 18% reduction in design wind pressures.

Rooftop Equipment

The provisions contained within ASCE 7-10 for determining the wind loads on rooftop equipment on buildings is limited to buildings with a mean roof height $h \le 60$ feet. This limitation

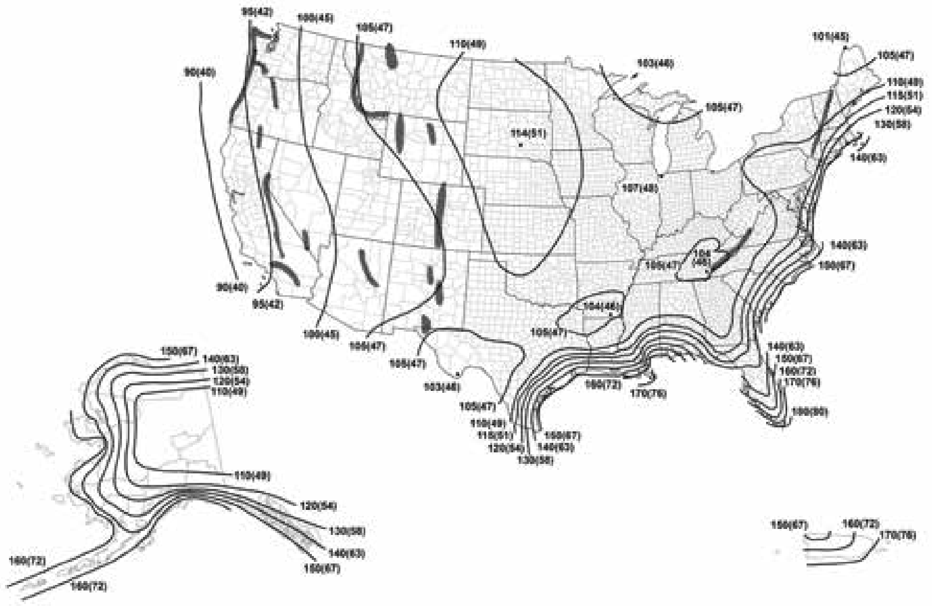

Figure 2. Example of ASCE 7-16 Risk Category II Basic Wind Speed Map. Printed with permission from ASCE. See ASCE 7-16 for important details not included here.

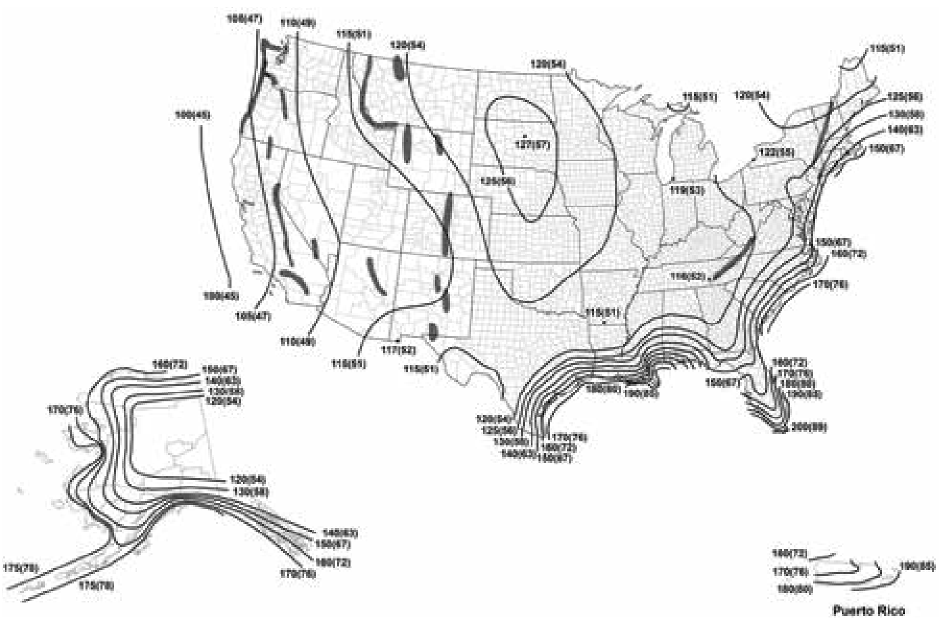

Figure 3. Example of ASCE 7-16 Risk Category IV Basic Wind Speed Map. Printed with permission from ASCE. See ASCE 7-16 for important details not included here.

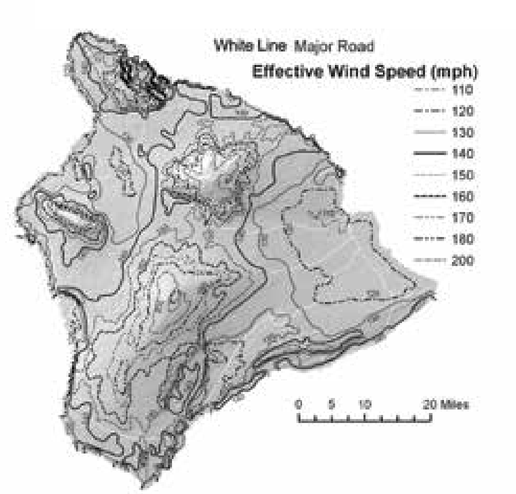

Figure 4. Example of ASCE 7-16 Risk Category II Hawaii effective wind speed map. Printed with permission from ASCE. See ASCE 7-16 for important details not included here.

was removed in ASCE 7-16, and thus the provisions apply to rooftop equipment on buildings of all heights. One new clarification is that the basic design wind speed for the determination of the wind loads on this equipment needs to correspond to the Risk Category of the building or facility to which the equipment provides a necessary service. This means that if a cooling tower is located on an administration building (Risk Category II) of a hospital but serves the surgery building (Risk Category IV) of the hospital, the wind loads determined for the cooling tower would be based on the Risk Category IV wind speed map.

Wind Loads on Rooftop Solar Panels

New additions to the Standard are provisions for determining wind loads on solar panels on buildings. These provisions give guidance to the users of ASCE 7 that has been missing in the past. Previously, designers commonly attempted to use a combination of the component and cladding provisions and other provisions in the Standard to determine these loads, often resulting in unconservative designs.

There are two methods provided in the new Standard. One method applies specifically to a low-sloped roof (less than 7 degrees) (*Figure 5, page 14*) and the second method applies to any roof slope where solar panels are installed parallel to the roof. Each of these provisions was developed from wind tunnel testing for enclosed structures. Thus, these provisions are not applicable to open structures because the flow of the wind over the roof of enclosed structures and open structures varies significantly. Further testing is currently underway for open structures, and these results will hopefully be included in future editions of the Standard.

The wind loads for solar panels do not have to be applied simultaneously with the component and cladding wind loads for the roof. However, the roof still needs to be designed appropriately assuming the solar panels are removed or not present.

Roof Pressure Coefficients (h < 60 feet)

The component and cladding pressure coefficients, (GC_p), for roofs on buildings with an h < 60 feet, have been revised significantly in ASCE 7-16. The new roof pressure coefficients are based on data from recent wind tunnel tests and then correlated with the results from full-scale tests performed at Texas Tech University. The full-scale tests indicated that the turbulence observed in the wind tunnel studies from the 1970s, that many of the current roof pressure coefficients were based on, was too low. Also, the technology available to measure the results of these wind tunnel tests has advanced significantly since the 1970s. Therefore, the new wind tunnel studies used flow simulations that better matched those found in the full-scale tests along with improved data collection devices; these tests yielded increased roof pressures occurring on the roofs. Thus, the roof pressure coefficients have been modified to more accurately depict roof wind pressures.

In conjunction with the new roof pressure coefficients, it was determined that the existing roof zoning used in ASCE 7-10 and previous editions of the Standard did not fit well with the roof pressure distributions that were found during these new tests for low-slope (≤ 7 degrees) roof structures. These tests established that the zoning for the roof on these low-slope roof structures was heavily dependent on the building height, *h*, and much less dependent on the plan dimensions of the building. The tests showed that the "corner zones" were too small for the high roof pressures that were being measured at these locations on the building. Considering all of these effects, a new zoning procedure for low-sloped roofs for buildings with $h \le 60$ feet was developed. The zones are shown best in the *Commentary* Figure C30-1 as shown in *Figure 6*.

The roof zoning for sloped roofs kept the same configurations as in previous editions of the Standard; however, many of the zone designations have been revised (*Figure 7*). This revision in zone designations was required because the values in zones around the roof in previous editions of the Standard were shown as having the same pressure coefficient, i.e., corners at the eave versus corners at the ridge have been found to have varying pressures.

Attached Canopies on Buildings

New provisions have been added to determine the wind pressures on canopies attached to the sides of buildings. This is the first edition of the Standard that has contained such provisions.

Previously, designers were required to use various provisions of overhangs, free roof structures, and more to determine the wind loads on canopies. Research became available for the wind pressures on low-slope canopies during this last code cycle of the Standard. This research was limited to low-slope canopies and only for those attached to buildings with a mean roof height of $h < 60$ feet. Research is continuing on sloped canopies, and the Committee hopes to be able to include that research in the next edition of the Standard.

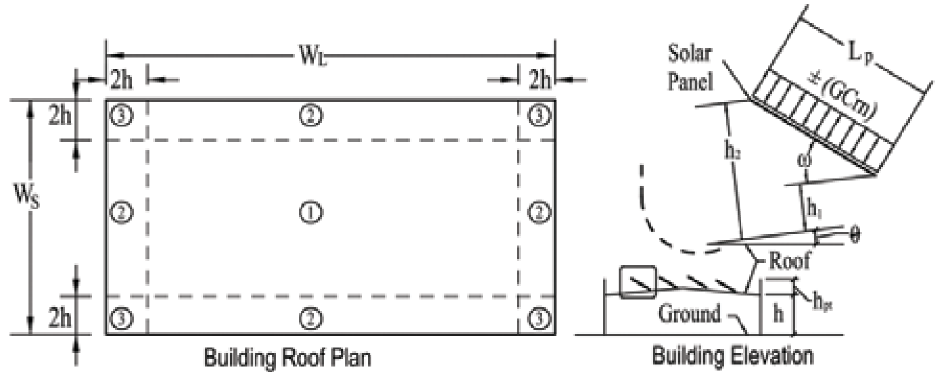

Figure 5. Example of ASCE 7-16 Figure 29.4-7 Excerpt for rooftop solar panel design wind loads. Printed with permission from ASCE. See ASCE 7-16 for important details not included here.

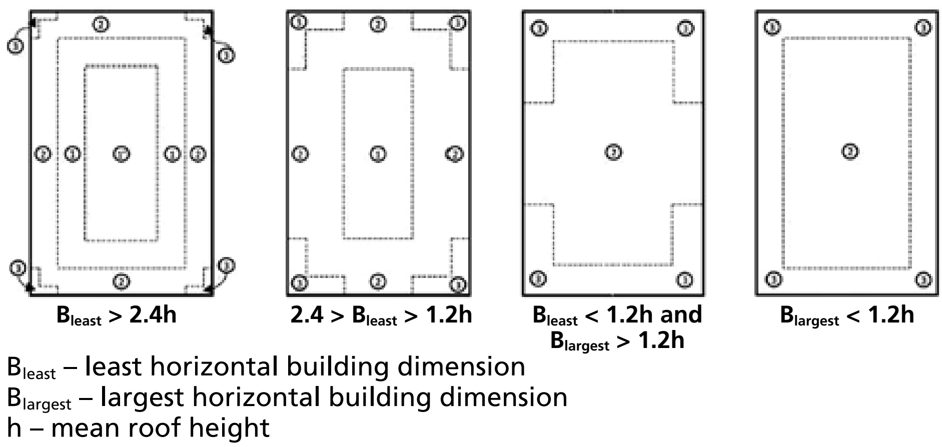

Figure 6. Example of ASCE 7-16 low slope roof component and cladding zoning.

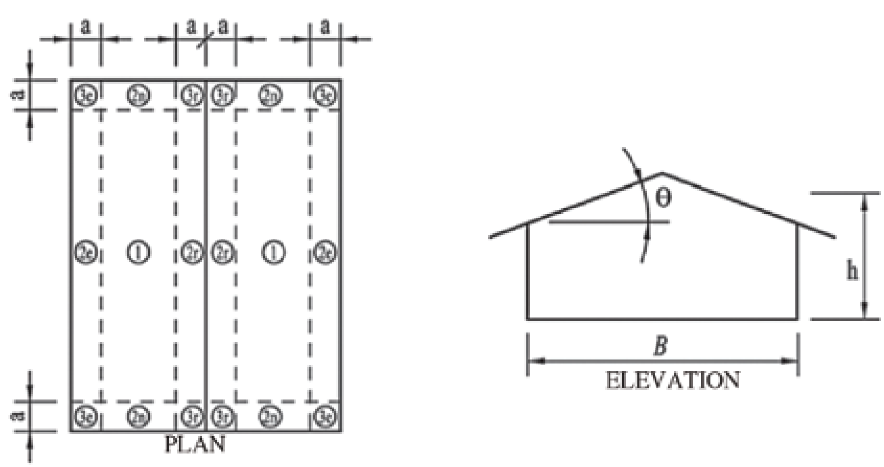

Figure 7. Example of ASCE 7-16 Sloped Roof Component & Cladding Zoning for 7 to 20 degree roof slopes. Printed with permission from ASCE. See ASCE 7-16 for important details not included here.

Summary

Major revisions to ASCE 7-16 that affect the wind design of buildings have been highlighted. There are also many minor revisions contained within the new provisions. Each of these revisions is intended to improve the safety and reliability of structures while attempting to reduce conservatism as much as possible. It is necessary to look at the impact of the provisions as a whole, instead of individually, to understand how design procedures are affected.▪