ASCE 7-16: Changes to Wind Calculations for Rooftop Solar

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ASCE 7-16: Changes to Wind Calculations

Agenda

• Current Practice
• General changes to ASCE 7-16
• Solar-specific changes to ASCE
• Mitigations in SEAOC PV2 update
Determine design wind speed and calculate design wind pressures using ASCE 7-10


AC 428 is required to obtain an ICC-ES Evaluation Report; it is also useful as voluntary guidance

AC 428 allows internal pressure set equal to zero (within constraints) in Components & Cladding method

In future ASCE 7-16, there will be a calculation method specific to “flush mounted” PV systems on sloping “pitched” roofs
3.1.3.1 Wind Loads:

3.1.3.1.1 Flush-mounted System: All elements shall be designed for Component and Cladding (C&C) pressures defined within the applicable code (Chapters 26 and 30 of ASCE 7-10 for the 2012 IBC and Chapter 6 of ASCE 7-05 for the 2009 and 2006 IBC) using the Envelope Method prescribed in Chapter 30, Part I for the 2012 IBC and Method 2 (Analytical Procedure for Low-Rise Buildings and Building for Heights Less Than 60 feet) for the 2009 and 2006 IBC, except that the internal pressure coefficient, $G_{C_p}$, shall be equal to zero, and therefore the design wind pressure, $p$, shall be determined as follows:

Design Wind Pressure, $p = q_h(G_{C_p})$\geq10$ psf (479 Pa) for the 2009 and 2006 IBC; $p = q_h(G_{C_p})$\geq16$ psf (770 Pa) per Section 30.2.2 of ASCE 7-10 for the 2012 IBC

where:

$q_h$ = velocity pressure determined at mean height of the row of PV panels in the array, $h$, and appropriate exposure category from ASCE 7.

- Components & Cladding method
- Internal pressure shall be set equal to zero
- Physical constraints are needed for method to be valid
- Pressure equalization is dependent on gaps between modules
The following conditions shall be observed:

1. PV panels shall not be installed within 10 inches (254 mm) of a roof edge or ridge.
2. The distance between the roof or wall surface and the PV panel must be between 2 and 10 inches (51 and 254 mm).
3. A minimum gap of 0.25 inch (6.4 mm) must exist between PV panels and adjacent rows of panels.

Don’t forget to consider:
• Roof edge zones, which are changing in ASCE 7-16
• Fire setbacks, which are changing (for the better) in 2018 IFC & IRC

Physical constraints of AC 428 wind method:
• Required 10 inch minimum distance from roof edge or ridge
• Height above roof between 2 inches and 10 inches
• Minimum gap of 0.25 inch between adjacent rows of panels
• In earlier version of AC 428, minimum gap was 0.75 inch
ASCE 7-16 Wind Speed Maps Revised (again)

- Risk Category II
- Mean Recurrence Interval (MRI) 700 years
- ASCE 7-16 wind speed maps show contour lines in Western states

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Compare ASCE 7-10 and ASCE 7-16 Maps

ASCE 7-10 Risk Category II

ASCE 7-16 Risk Category II
Compare ASCE 7-10 and ASCE 7-16 Maps

ASCE 7-10 Risk Category II

ASCE 7-16 Risk Category II
Development of Corner & Edge Roof Zones

Mean pressure coefficients

(23° roof tilt angle)

$\beta=5:12, \theta=50^\circ$

Development of Corner & Edge Roof Zones
Development of Corner & Edge Roof Zones

ASCE 7-10 Roof Zones

ASCE 7-16 Roof Zones
C&C Roof Zones: ASCE 7-10 to 7-16

ASCE 7-10 Figure 30.4-2C

ASCE 7-16 Figure 30.43-2D
Roof $GC_p$ Coefficients: ASCE 7-10 to 7-16

ASCE 7-10 Figure 30.4-2C

ASCE 7-16
Figure
30.43-2D
Overhang Coefficients: ASCE 7-10 to 7-16

ASCE 7-16 Figure 30.43-2D

ASCE 7-10 Figure 30.4-2C
Experiments were conducted in UWO boundary layer wind tunnel

Two primary areas of investigation
- Height of PV system above roof
- Pressure equalization from various gaps between PV panels
Fig. 5. The worst case values of the peak (suction) external on the (a) upper surface, (b) lower surface, and (c) net pressure coefficients measured, area-averaged over a single PV module and (d) the pressure equalization coefficient ($C_{eq}$) with respect to $H$. 

$C_{p_{AD}}$, $C_{p_{AL}}$, $C_{p_{AL,N}}$, $C_{eq}$
Physical constraints of ASCE 7-16 method:

- Required minimum distance from roof edge or ridge \(2h_2\)
- Height above roof between 2 inches and 10 inches
- Minimum gap of 0.25 inch between all panels
Basic form of Equation 29.4-7 is very familiar

- Velocity pressure $q_h$ times pressure coefficient $GC_p$
- Velocity pressure includes the square of wind speed
- New coefficients $\gamma_E$ and $\gamma_a$ are solar-specific for “flush mounts” installed parallel to roof
Zone 1: ASCE 7-16 $G_{C_p}$ Pressure Coefficients

- **ASCE 7-10, Gable/hip 7°-27°**
- **ASCE 7-16 Gabled 7°-20° $z_1 + z_2e$**
- **ASCE 7-16 Gabled 20°-27° $z_1 + z_2e$**
- **ASCE 7-16 ($h > 0.8D$) hipped 7°-20°**
- **ASCE 7-16 ($h < 0.5D$) hipped 7°-20°**
- **ASCE 7-16 hipped 20°-27°**

**Zone 1 Diagram**

- **$G_{C_p}$** vs. **Effective Wind Area, ft²**

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Zone 1: Add ASCE 7-16 CA Wind Speeds

Graph showing wind speeds for different zones and orientations.
Zone 1: Closer to Roof, with PV2-2016 Equalization

Graph showing the effective wind area and corresponding Gc values for different roof inclinations and designs, as specified by ASCE 7-10 and ASCE 7-16.
Gable 27°-45°: ASCE 7-16 $G_{C_p}$ Pressure Coefficients

![Graph showing pressure coefficients for different zones and wind areas.](image-url)
Gable 27° - 45°: With Pressure Equalization Factor

![Chart showing Gable 27°-45° with different pressure equalization factors for various effective wind areas.]

- ASCE 7-10 Zone 1
- ASCE 7-10 Zone 2&3
- ASCE 7-16 Gabled 27°-45° z1+z2r+z2e
- ASCE 7-16 Gabled 27°-45° z2n+z3r
- ASCE 7-16 Gabled 27°-45° z3e
Gable 27° - 45°: Add ASCE 7-16 CA Wind Speeds

Gable 27°-45°

- ASCE 7-10 Zone 1
- ASCE 7-10 zone 2&3
- ASCE 7-16 Gabled 27°-45° z1+z2r+z2e
- ASCE 7-16 Gabled 27°-45° z2n+z3r
- ASCE 7-16 Gabled 27°-45° z3e

Effective Wind Area, ft²

G Cp

-2.2
-2
-1.8
-1.6
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
1 10 100 1000
Gable 27°-45°: Qualify for SEAOC PV2 Equalization

Gable 27°-45°

-2.2
-2
-1.8
-1.6
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0

Effective Wind Area, ft²

1 10 100 1000

ASCE 7-10 Zone 1
ASCE 7-10 Zone 2&3
ASCE 7-16 Gabled 27°-45° z1+z2r+z2e
ASCE 7-16 Gabled 27°-45° z2n+z3r
ASCE 7-16 Gabled 27°-45° z3e
DRAFT Update to SEAOC PV2 Wind Paper

- Original SEAOC PV 2 wind paper was published in October 2012
- Dr. David Banks of CPP Wind is primary author of PV2 update
- PV2 paper is updated to all requirements of ASCE 7-16
- Updated PV2 is expected to be published by the end of 2016
- ASCE 7-16 intended to be referenced in the 2018 IBC, and in effect by January 1, 2020 in most states
Edge Factor $\gamma_E$ ("gamma E") is a direct, linear multiplier to the wind pressure.

- The value of $\gamma_E$ is either 1.5 or 1.0.
- In ASCE 7-16, panels within 1.5 $L_p$ from end of row are exposed.
- Result is three rows or fewer are 100% edge.

$\gamma_E = 1.5$ for panels that are exposed and those within a distance $1.5(L_p)$ from the end of a row at an exposed edge of the array; $\gamma_E = 1.0$ elsewhere, as illustrated in Figure 29.4-8. A panel is defined as exposed if $d_1$ to the roof edge > 0.5$h$ and one of the following applies:

- $d_1$ to the adjacent array > 4 ft (1.22m)
- $d_2$ to the next adjacent panel > 4 ft (1.22m)
4.2. Optional and Alternate Procedures

The following method will provide more accurate results, and will generally decrease loads when compared to the above procedures.

In these calculations, \( h_1 \) and \( h_2 \) are defined as the distance from the roof surface to the upper surface of the panel.

4.2.1. Size of edge factor zone is a multiple of array height.

\[ \gamma_E = 1.5 \] need only be applied to that portion of the panels within \( 3^*h_2 \) from the array edge.

4.2.2. Edge factor applies to one array edge at a time

\[ \gamma_E = 1.5 \] need only be applied to one array edge at a time (e.g. for calculation of the total load on the array).

4.2.3. Edge factors apply only to uplift values.

\[ \gamma_E = 1.0 \] for downforce calculations.

Flush mount only
ASCE 7-16: PV Pressure Equalization Factor, $\gamma_a$

Equalization Factor $\gamma_a$ is a direct multiplier to wind pressure.

Wind pressure is reduced for gaps between panels.

John Wolfe public comment was disapproved by the ASCE Wind Subcommittee.

Figure 29.4-8. Solar Collector Pressure Equalization Factor, $\gamma_a$, for enclosed and partially enclosed buildings of all heights.
4.2.5. Increased porosity
The blue line in Figure 4.2.1 can be used if the gaps between panels are wide enough and the height above the roof is small enough. Interpolation is allowed:

i. for gaps from 0.25 inches (6.4 mm) to 0.75 inches (19 mm) if $h_1 \leq 5$ inches (127 mm) from the roof surface, or

ii. for $h_1$ between 5 inches (127 mm) and 10 inches (254 mm) if gaps $\geq 0.75$ inches (19 mm).

- SEAOC PV2 update will include more options for pressure equalization
- Options are height of PV system above roof and gaps between modules
- This alternative method rewards designs that consider optimization for wind
- Wind pressures can be reduced by 25 percent from worst-case basis of ASCE 7-16
Recommendations

- Communicate with AHJ’s about SEAOC PV2 Wind paper
- Consider early adoption of $2h$ as minimum roof edge setback
- Ensure fire setbacks are observed if they apply to your project, based on local code adoption and local policy
- Consider panel height above the roof in the optimal range of 4 inches – 5 inches
- Consider using gap of 3/4 inch between panels
Questions?

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