SIMPSON Strong-Tie

Changes in Wind Design

With ASCE 7-16

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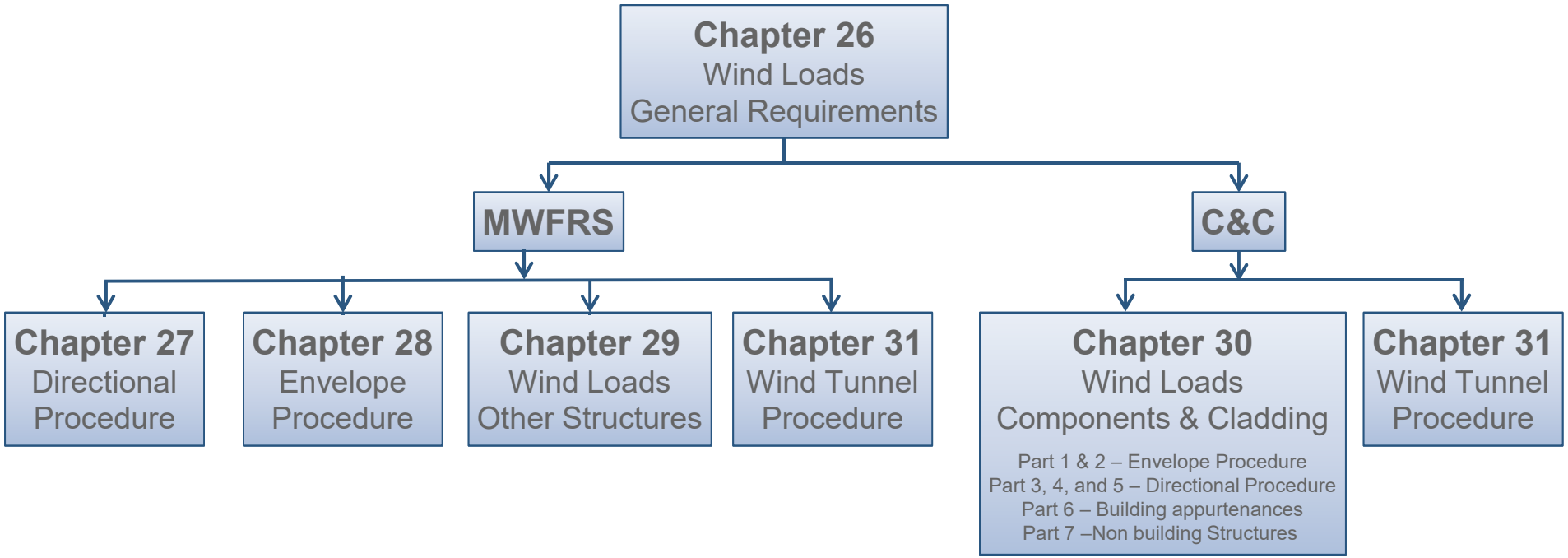
Fundamental Changes in the ASCE 7-16

- Let's summarize the fundamental changes between ASCE 7-10 and ASCE 7-16

Evolution of the Wind Codes

Year	Overview	UBC	IBC
ANSI A58.1-1955	Initial wind design standard		-
ANSI A58.1-1972	Quantum Leap in Sophistication, but plagued with ambiguities	1979	-
ANSI A58.1-1982	Fixed Issues with 1972 document	1982, 1985, 1988	-
ASCE7-88	ASCE took over maintenance of standard with few changes from ‘82	1991, 1994, 1997	-
ASCE7-93	No Changes Made	-	-
ASCE7-95	Significant update: 3-Second Gusts, topographic effects, wind-induced torsions, simplified procedure for buildings under 60 ft	-	-
ASCE7-98	Wind Speed Map updated, Wind Directionality Factor Added, Exp. C&D definitions changed, procedures defined, glazing protection added	-	2000
ASCE7-02	Minor Updates	-	2003
ASCE7-05	Surface Roughness Added to help better define Exposure Categories, Other Minor Updates	-	2006 2009
ASCE7-10	Wind Map Changes, Reorganization	-	2012 2015
ASCE7-16	Wind Map changes, new factors, zone changes, tornado guidelines		2018

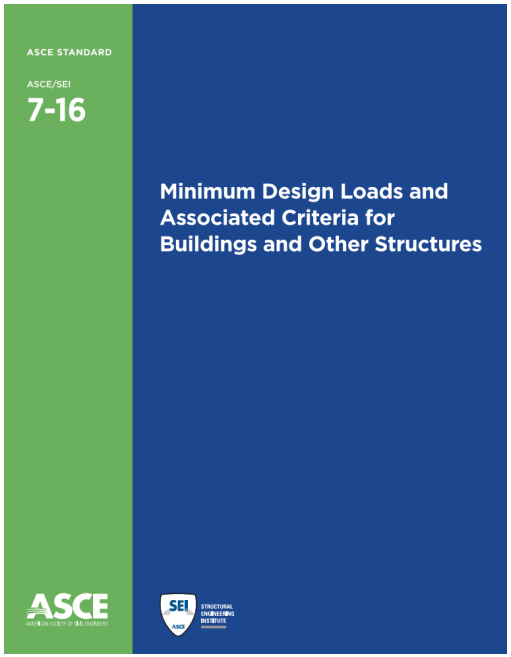
ASCE 7-16 Wind



Changes Pertaining to Wind Loads to ASCE 7-16

The 2016 version of this standard has several significant changes from 2010:

- Enclosure Classification
- Basic Wind Speed
- Ground elevation above Sea Level
- Edge Zones
- Rooftop Equipment
- Design Wind loads: Circular bins, Silos, Tanks
- Wind loads on Rooftop Solar Panels
- Design Wind Pressures Component Cladding Loads on roofs with h <= 60 ft
- Attached canopies on buildings with h <= 60 ft
- Tornado Limitations



Enclosure Classification

Building, Partially Openings – New enclosure classification in ASCE 7-16

Table 26.13-1 Main Wind Force Resisting System and Components and Cladding (All Heights): Internal Pressure Coefficient, (GC_{pi}), for Enclosed, Partially Enclosed, Partially Open, and Open Buildings (Walls and Roof)

Enclosure Classification	Criteria for Enclosure Classification	Internal Pressure	Internal Pressure Coefficient, (GC_{pi})
Enclosed buildings	A_o is less than the smaller of $0.01A_g$ or 4 sq ft (0.37 m) and $A_{oi}/A_{gi} \leq 0.2$	Moderate	+0.18 −0.18
Partially enclosed buildings	$A_o > 1.1A_{oi}$ and $A_o >$ the lesser of $0.01A_g$ or 4 sq ft (0.37 m) and $A_{oi}/A_{gi} \leq 0.2$	High	+0.55 −0.55
Partially open buildings	A building that does not comply with Enclosed, Partially Enclosed, or Open classifications	Moderate	+0.18 −0.18
Open buildings	Each wall is at least 80% open	Negligible	0.00

Notes

1. Plus and minus signs signify pressures acting toward and away from the internal surfaces, respectively.
2. Values of (GC_{pi}) shall be used with q_z or q_h as specified.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition:
   a. A positive value of (GC_{pi}) applied to all internal surfaces, or
   b. A negative value of (GC_{pi}) applied to all internal surfaces.

New

Enclosure Classification

ASCE 7-16 Contains Four Enclosure Classifications

View Table 26.13-1

- Enclosed Buildings
- Partially Enclosed Buildings
- NEW! Partially Open Buildings
- Open Buildings

Criteria

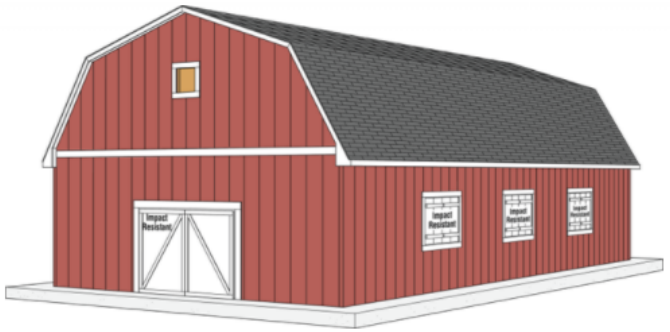
A_o is less than the smaller of $0.01A_g$ or 4 sq ft (0.37m) and $A_{oi}/A_{gi} \leq 0.2$

Internal Pressure

Moderate

GC_{pi}

+ 0.18
- 0.18



Ao = total area of opening in a wall that receives positive external pressure
Aoi = sum of the areas of openings in the building envelope (walls and roof) not including Ao
Agi = sum of the gross surface areas of the building envelope (walls and roof) not including Ag
Ag = gross area of that wall in which Ao is identified

Enclosure Classification

ASCE 7-16 Contains Four Enclosure Classifications

View Table 26.13-1

- Enclosed Buildings
- Partially Enclosed Buildings
- NEW! Partially Open Buildings
- Open Buildings

Criteria

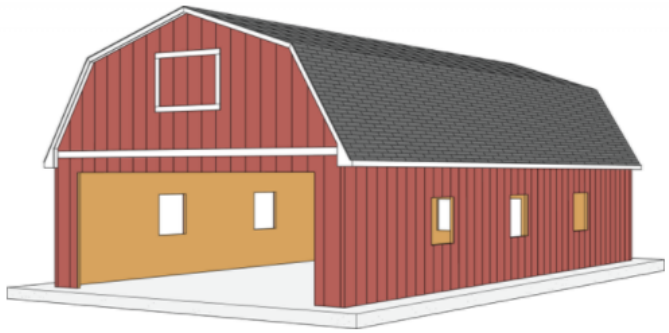
$A_o > 1.1A_{oi}$ and $A_o >$ the lesser of $0.01A_g$ or 4 sq ft (0.37m) and $A_{oi}/A_{gi} \leq 0.2$

Internal Pressure

High

GC_{pi}

+ 0.55
− 0.55



Ao = total area of opening in a wall that receives positive external pressure
Aoi = sum of the areas of openings in the building envelope (walls and roof) not including Ao
Agi = sum of the gross surface areas of the building envelope (walls and roof) not including Ag
Ag = gross area of that wall in which Ao is identified

Enclosure Classification

ASCE 7-16 Contains Four Enclosure Classifications

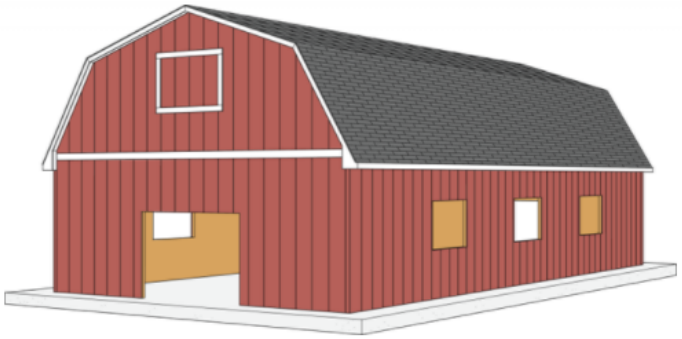
View Table 26.13-1

- Enclosed Buildings
- Partially Enclosed Buildings
- NEW! Partially Open Buildings
- Open Buildings

Criteria
Does not comply with Enclosed, Partially Enclosed, or Open classifications

Internal Pressure
Moderate

GC_{pi}
+ 0.18
− 0.18



Ao = total area of opening in a wall that receives positive external pressure
Aoi = sum of the areas of openings in the building envelope (walls and roof) not including Ao
Agi = sum of the gross surface areas of the building envelope (walls and roof) not including Ag
Ag = gross area of that wall in which Ao is identified

Enclosure Classification

ASCE 7-16 Contains Four Enclosure Classifications

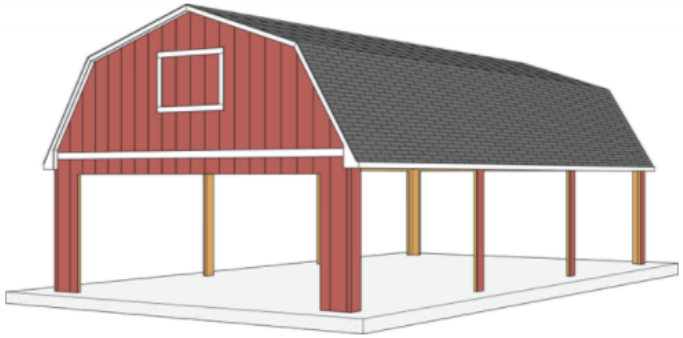
View Table 26.13-1

- Enclosed Buildings
- Partially Enclosed Buildings
- NEW! Partially Open Buildings
- Open Buildings

Criteria
Each wall is at least 80% open

Internal Pressure
Negligible

GC_{pi}
0.00



Ao = total area of opening in a wall that receives positive external pressure
Aoi = sum of the areas of openings in the building envelope (walls and roof) not including Ao
Agi = sum of the gross surface areas of the building envelope (walls and roof) not including Ag
Ag = gross area of that wall in which Ao is identified

Basic Wind Speed

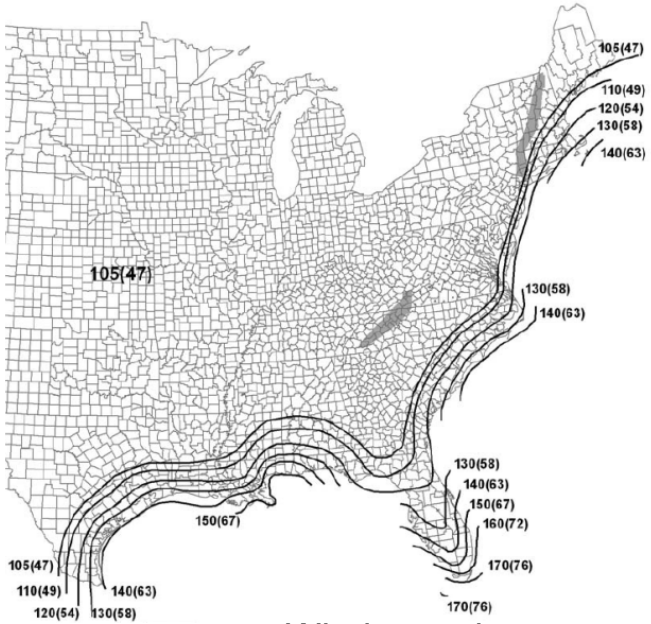
- Basic Wind Speed Maps
  - Maps have been revised outside hurricane prone regions
  - Decreased wind speeds outside hurricane prone areas
- Wind Speed Contours have been updated in the Northeast
  - Two updates to the hurricane simulation model used to create the wind maps for ASCE 7-10
  - Decrease of hurricane wind speeds from Virginia to Maine
- New Wind Speed Map for Risk Category IV Buildings

Building Risk Category	Description	Mean Recurrence Interval
I	Low hazard to human life in case of failure	300 years
II	Most Residential and Commercial Dwellings	700 years
III	Substantial risk to human life in case of failure	1,700 years
IV	Essential Facilities	3,000 years

Updated Wind Speed Maps

ASCE 7-10

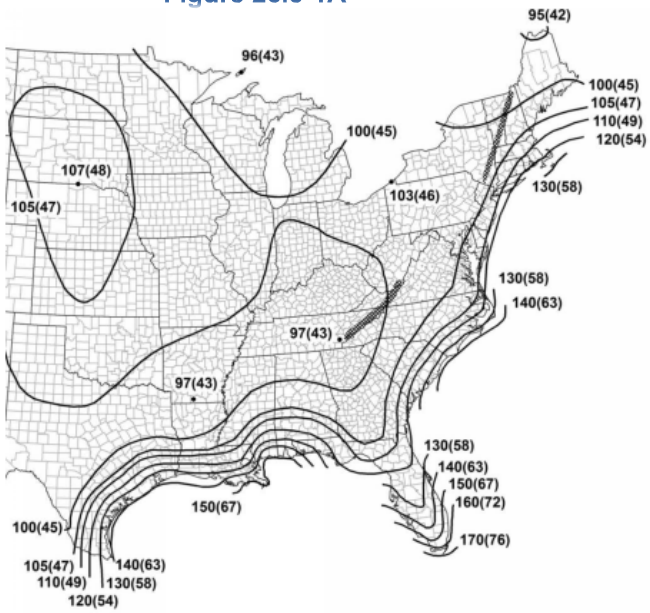
Figure 26.5-1C



Risk Category I Building

ASCE 7-16

Figure 26.5-1A

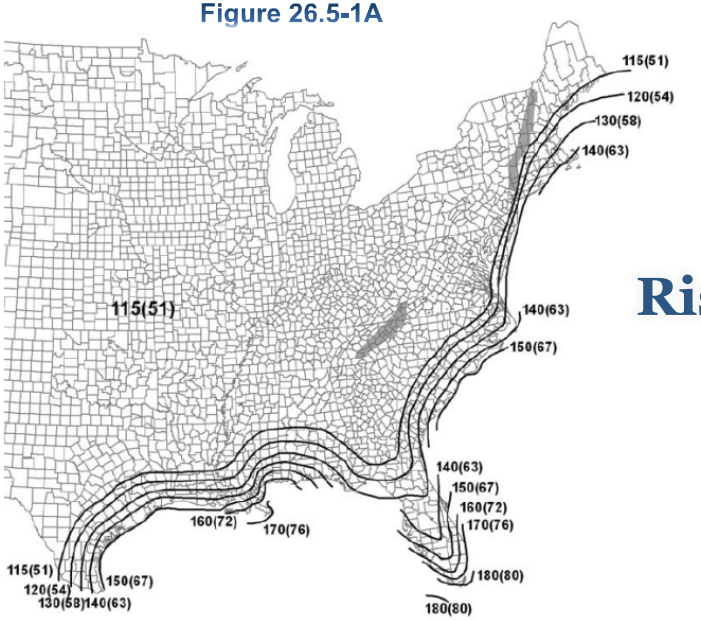


Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = **300 years**).

Updated Wind Speed Maps

ASCE 7-10

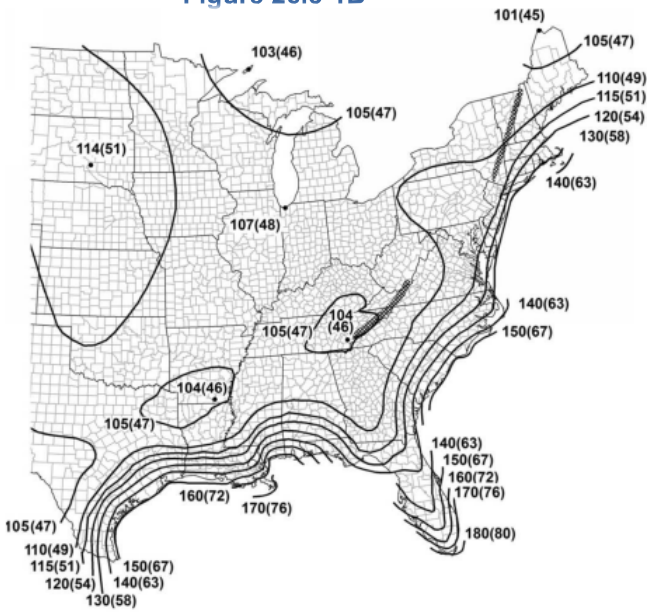
Figure 26.5-1A



Risk Category II Building

ASCE 7-16

Figure 26.5-1B

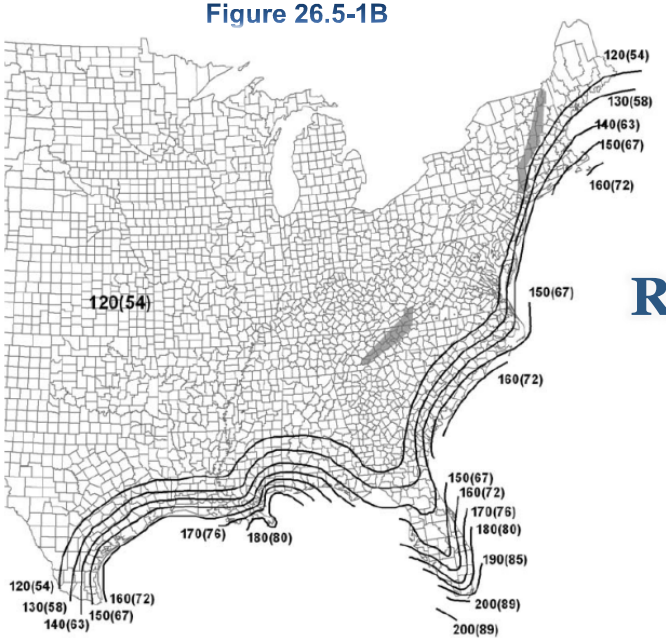


Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = **700 years**).

Updated Wind Speed Maps

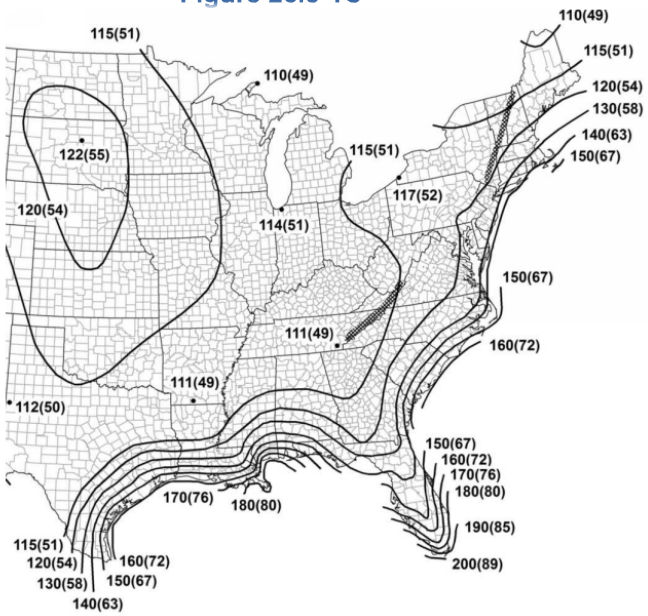
ASCE 7-10

Figure 26.5-1B



ASCE 7-16

Figure 26.5-1C

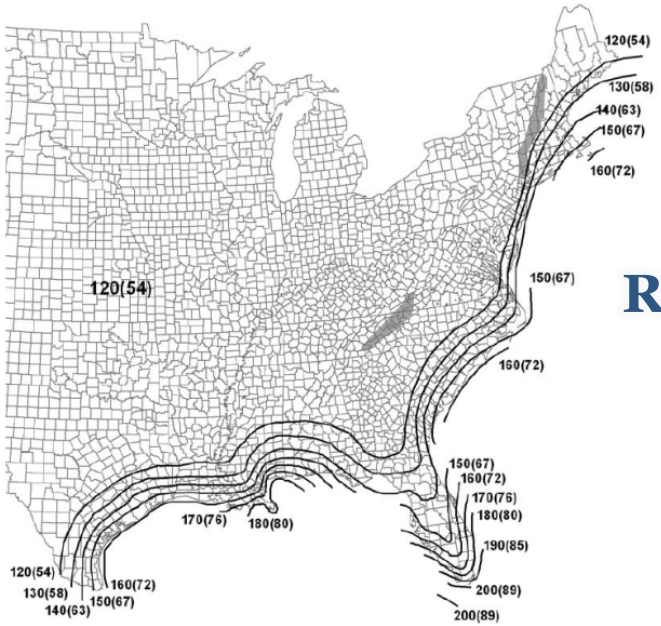


Risk Category III Building

Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = **1700 years**).

New Wind Speed Maps

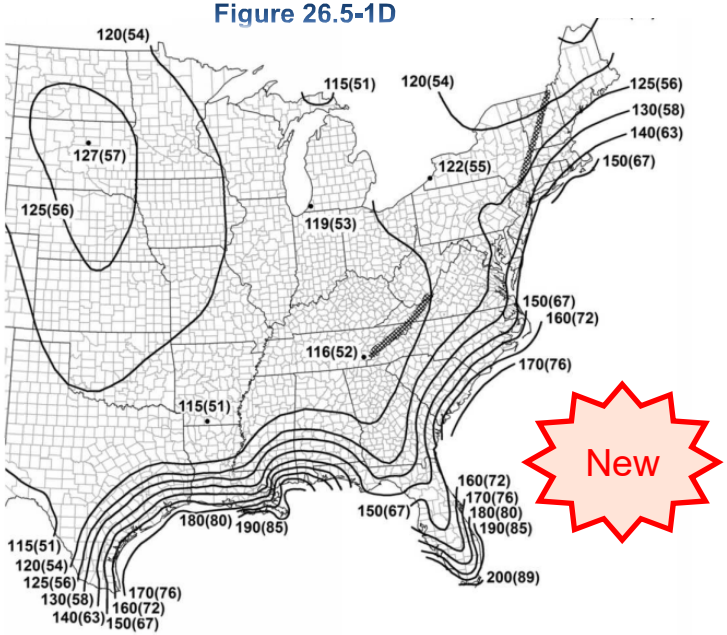
ASCE 7-10



Risk Category IV Building

ASCE 7-16

Figure 26.5-1D



Wind speeds correspond to approximately a 1.6% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000333, MRI = **3000 years**).

Ground Elevation Above Sea Level

$$q_z = 0.00256\, K_z\, K_{zt}\, K_d K_e V^2 \ (lb/ft^2) \quad (26.10\text{-}1)$$

K_z = velocity pressure exposure coefficient

K_{zt} = topographic factor

K_d = wind directionality factor

K_e = Ground Elevation Factor

New

q_z = velocity pressure at height z (lb/ft2)

V = velocity in mi/hour

Source: Significant Changes to the Minimum Design Load Provisions of ASCE 7-16 (ICC publication)

Ground Elevation Above Sea Level

$$q_z = 0.00256\, K_z\, K_{zt}\, K_d\, K_e\, V^2 \ (lb/ft^2) \quad (26.10\text{-}1)$$

$$P = \tfrac{1}{2}\, \rho\, V^2$$

Mass density at air standard atmosphere = 0.002378 lb-s^2/ft^4 (slug/ft^3)

$$P = \tfrac{1}{2}\,(0.002378\ lb\text{-}s^2/ft^4)\left(V \frac{mi}{hour} X \frac{5280\ ft}{1\ mi} X \frac{1 hour}{3600 s}\right)^2$$

$$P = 0.00256\, V^2$$

Source: Significant Changes to the Minimum Design Load Provisions of ASCE 7-16 (ICC publication)

Ground Elevation Above Sea Level

Table 26.9-1 Ground Elevation Factor, K_e

Ground Elevation above Sea Level		Ground Elevation Factor
ft	m	K_e
<0	<0	See note 2
0	0	1.00
1,000	305	0.96
2,000	610	0.93
3,000	914	0.90
4,000	1,219	0.86
5,000	1,524	0.83
6,000	1,829	0.80
>6,000	>1,829	See note 2

Notes

1. The conservative approximation K_e 1.00 is permitted in all cases.
2. The factor K_e shall be determined from the above table using interpo lation or from the following formula for all elevations:
   K_e $e^{-0.0000362z_g}$ (z_g ground elevation above sea level in ft).
   K_e $e^{-0.000119z_g}$ (z_g ground elevation above sea level in m).
3. K_e is permitted to be take as 1.00 in all cases.

Denver, Colorado
"Mile High City"
Elevation 5,280 ft
K_e is 0.82

18% reduction in design wind pressure

Source: ASCE 7-16 Minimum Design Loads for Buildings and Other Structures

Edge Zone Width (a)

Chapter 28

Wind Loads of Buildings: Main Wind Force Resisting System (Envelope Procedure)

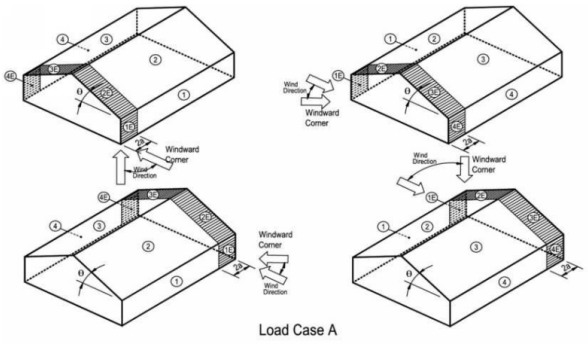
Part 1: Enclosed and Partially Enclosed Low-Rise Buildings
Part 2: Enclosed Simple Diaphragm Low-Rise Buildings

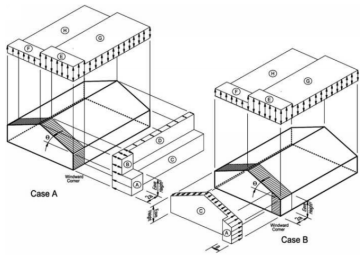
Figures for External Pressure Coefficient (GC_p)

Dimension a = 10% of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft

Exception: For buildings with Θ - 0 to 7° slope and a least horizontal dimension greater than 300ft, dimension a shall be limited to a maximum of 0.8h

New





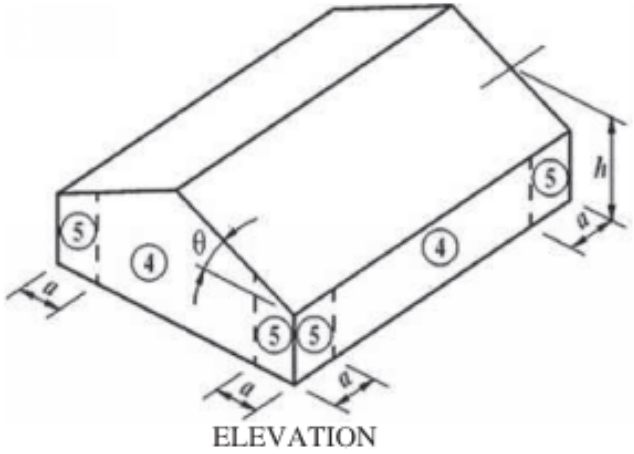
Edge Zone Width (a)

Chapter 30

Wind Loads: Components and Cladding

Part 1: Low-Rise Buildings (Envelope Procedure)
Part 2: Low-Rise Buildings (Simplified Envelope Procedure)

Figure 30.3-1 External Pressure Coefficient – (GC_p) (walls)



Dimension a = 10% of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft

Exception: For buildings with Θ - 0 to 7° slope and a least horizontal dimension greater than 300ft, dimension a shall be limited to a maximum of 0.8h

New

Rooftop Equipment

Section 29.4.1 has provisions for wind loads for rooftop equipment in buildings of all heights.

Section 26.10.2 gives direction specific on what basic wind speed to use in determining wind loads in roof structures including rooftop equipment

26.10.2 Velocity Pressure. Velocity pressure, q_z, evaluated at height z above ground shall be calculated by the following equation:

$$q_z = 0.00256 K_z K_{zt} K_d K_e V^2 \text{ (lb/ft}^2\text{)}; \; V \text{ in mi/h} \qquad (26.10\ 1)$$

$$q_z = 0.613 K_z K_{zt} K_d K_e V^2 \text{ (N/m}^2\text{)}; \; V \text{ in m/s} \qquad (26.10\ 1.\text{si})$$

where

K_z = velocity pressure exposure coefficient, see Section 26.10.1.
K_{zt} = topographic factor, see Section 26.8.2.
K_d = wind directionality factor, see Section 26.6.
K_e = ground elevation factor, see Section 26.9.
V = basic wind speed, see Section 26.5.
q_z = velocity pressure at height z.

The velocity pressure at mean roof height is computed as $q_h = q_z$ evaluated from Eq. (26.10 1) using K_z at mean roof height h.

The basic wind speed, V, used in determination of design wind loads on rooftop structures, rooftop equipment, and other building appurtenances shall consider the Risk Category equal to the greater of the following:

1. Risk Category for the building on which the equipment or appurtenance is located or
2. Risk Category for any facility to which the equipment or appurtenance provides a necessary service.

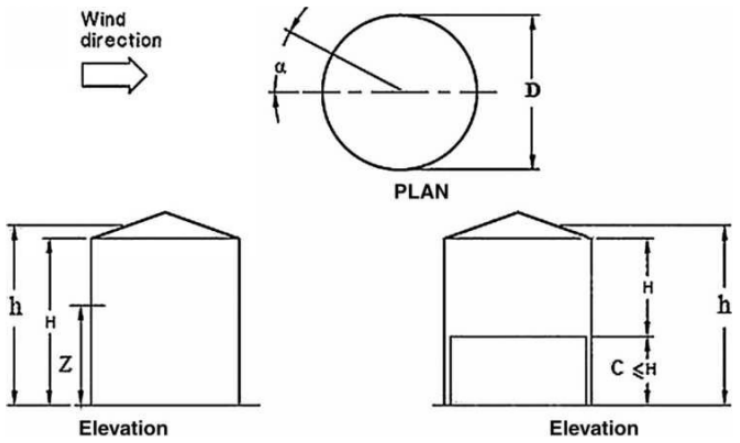
New

Circular Bins, Silos, and Tanks

Section 29.4.2 has provisions for wind loads for circular bins, silos and tanks.

Section 30.12 has provisions for wind loads for components and cladding of circular bins, silos and tanks

$h \le 120$ ft, $D \le 120$ ft, and $0.25 \le H/D \le 4$

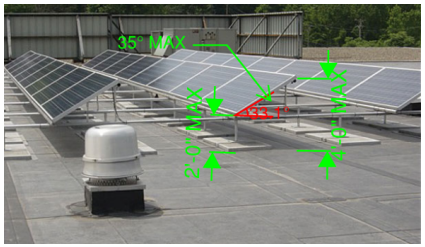


New

Rooftop Solar Panels Provisions

Section 29.4.3 has provisions for wind loads for rooftop solar panels for buildings of all heights with a flat roof or gable or hip roofs with slopes less than 7°.

Limited to
35° tilt with respect to the roof
Low height ≤ 2 ft
High height ≤ 4 ft
Min gap of ¼″
Maximum panel chord length of 6.7 ft



Section 29.4.4 has provisions for wind loads for parallel rooftop solar panels for buildings of all heights and roof slopes

Limited to
2° tilt with respect to the roof
Max height above roof ≤ 10 in.
Min gap of ¼″
Maximum panel spacing of 6.7 ft

Section 30.13 has provisions for wind loads for rooftop solar panels for non-building structures of all heights with a flat roof or gable or hip roofs with slopes less than 7°. – references back to **Section 29.4.3**

Limited to
35° tilt with respect to the roof
Low height ≤ 2 ft
High height ≤ 4 ft
Min gap of ¼″
Maximum panel chord length of 6.7 ft

Design Wind Pressures for Components and Cladding

Chapter 30 – Wind Loads – Components and Cladding (C&C)

ASCE 7-10

Part 1 – Enclosed and partially enclosed low-rise buildings with h ≤ 60 ft (18.3m)

Part 2 – Simplified approach for enclosed low-rise buildings with h ≤ 60 ft (18.3m)

Part 3 – Enclosed and partially enclosed for buildings with h > 60 ft(18.3m)

Part 4 – Simplified approach for enclosed buildings with h ≤ 160 ft

Part 5 – Open buildings for all heights

Part 6 – Building appurtenances such as roof overhangs, parapets, and rooftop equipment

ASCE 7-16

Part 1 – Enclosed and partially enclosed low-rise buildings with h ≤ 60 ft (18.3m)

Part 2 – Simplified approach for enclosed low-rise buildings with h ≤ 60 ft (18.3m)

Part 3 – Enclosed and partially enclosed for buildings with h > 60 ft(18.3m)

Part 4 – Simplified approach for enclosed buildings with h ≤ 160 ft

Part 5 – Open buildings for all heights

Part 6 – Building appurtenances such as roof overhangs, parapets, and rooftop equipment

Part 7 – Non Building structures circular bins, silos and tanks ≤ 120ft and rooftop solar panels for all building heights with flat roofs or gable or hip roofs with roof slopes less than or equal to 7 degrees.

Design Wind Pressures for Components and Cladding

Part 1 and 2 of Chapter 30 - Roof Component and Cladding Pressure Coefficient (GCp) for Enclosed and Partially Enclosed building with h ≤ 60 ft

ASCE 7-10

Figures 30.4 2A – C

A – Gable roofs and overhangs Θ ≤ 7°

B – Gable / Hip roofs 7° < Θ ≤ 27°

C – Gable Roofs 27° < Θ ≤ 45°

ASCE 7-16

Figures 30.3 2A – I

A – Gable roofs and overhangs Θ ≤ 7°

B – Gable roofs 7° < Θ ≤ 20°

C – Gable Roofs 20° < Θ ≤ 27°

D – Gable Roofs 27° < Θ ≤ 45°

E – Hip Roofs 7° < Θ ≤ 20°

F – Hip Roofs overhang 7° < Θ ≤ 20°

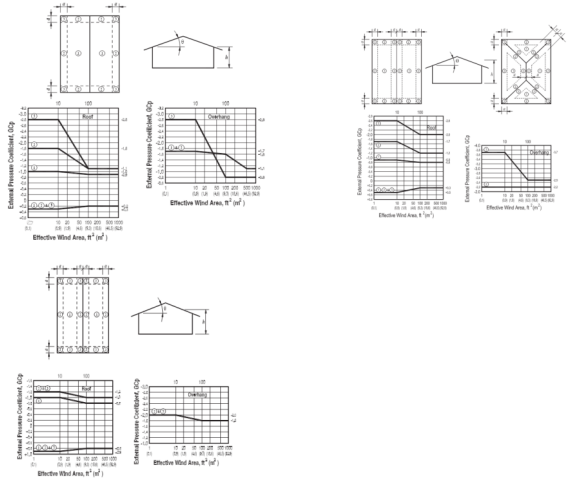
G – Hip Roofs and overhang 20° < Θ ≤ 27°

H – Hip Roofs 27° < Θ ≤ 45°

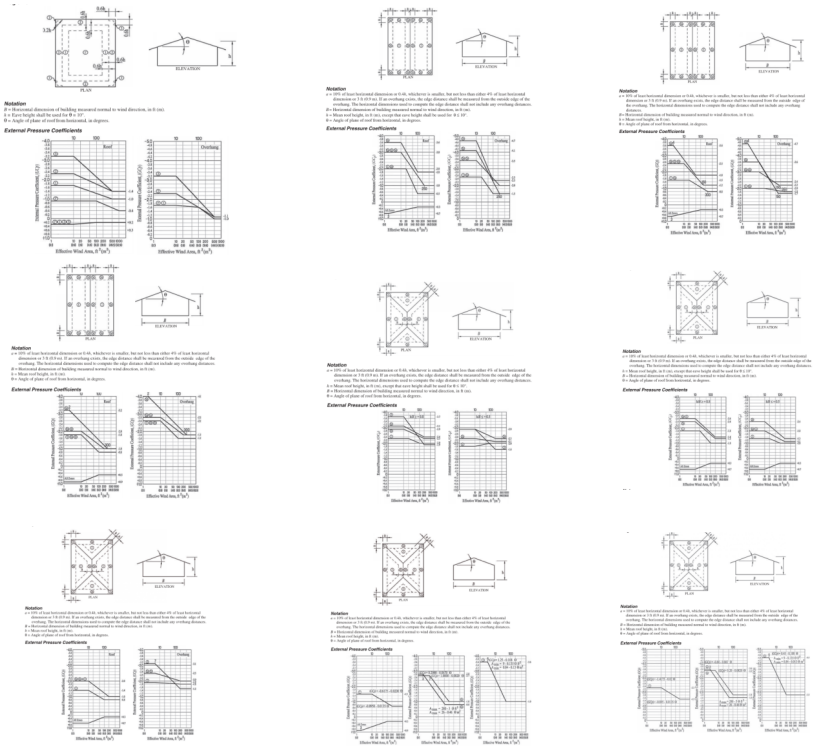
I – Hip Roofs overhang 27° < Θ ≤ 45°

Design Wind Pressures for Components and Cladding

ASCE 7-10



ASCE 7-16



Design Wind Pressures for Components and Cladding

Location	ASCE 7-10 Design Wind Speed (mph)[1]	ASCE 7-16 Design Wind Speed (mph)[2]	Elevation (feet above sea level)[3]	Roof Shape (Gable/Hip)	ASCE 7-10 pressures (psf)	ASCE 7-16 pressures (psf)
Boston, MA	129	120	23	Gable	-47.7	-47.8
				Hip	-47.7	-38.9
Miami, FL	171	169	7	Gable	-83.7	-94.9
				Hip	-83.7	-77.2
Houston, TX	138	136	47	Gable	-54.5	-61.4
				Hip	-54.5	-49.9
Pittsburgh, PA	115	110	765	Gable	-37.9	-39.1
				Hip	-37.9	-31.8
Denver, CO	115[4]	107	5232	Gable	-37.9	-31.5
				Hip	-37.9	-25.6
Oklahoma City, OK	115	109	1200	Gable	-37.9	-37.8
				Hip	-37.9	-30.8
Spokane, WA	110	102	1909	Gable	-34.6	-32.3
				Hip	-34.6	-26.3
San Francisco, CA	110	92	53	Gable	-34.6	-28.1
				Hip	-34.6	-22.8
Des Moines, IA	115	110	800	Gable	-37.9	-39.1
				Hip	-37.9	-31.8
Salt Lake City, UT	115	103	4261	Gable	-37.9	-30.2
				Hip	-37.9	-24.6

Wind Pressure Summary Table

Parameters:

- Zone 2 or 2r
- Exposure B
- 15 feet above grade
- Using location elevation factor K_e
- Using smallest applicable EWA (Effective Wind Area)
- Reduced wind speeds from new maps as appropriate

Source: From Structure Magazine article " Technical Aspects of ASCE 7-16" July 2018

Attached Flat Canopies on Buildings with h ≤ 60 ft

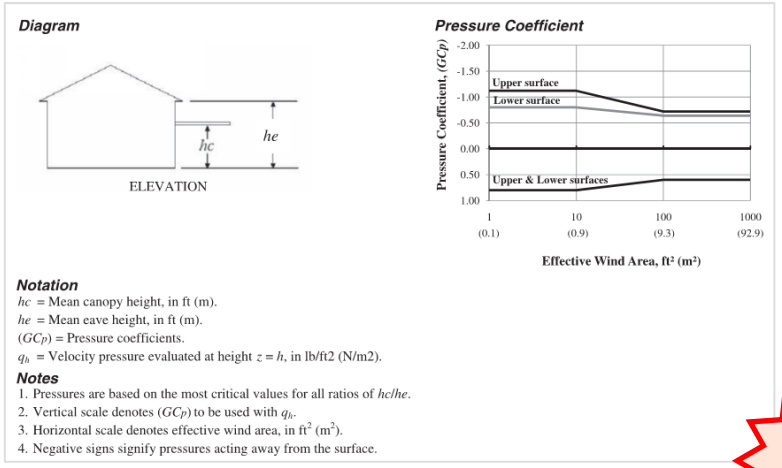
Section 30.11 has provisions for wind loads for attached canopies on buildings with h ≤ 60 ft and a maximum 2% horizontal slope

Figures 30.11-1A and 1B has pressure coefficients for both separate surfaces of attached canopies and considering simultaneous contributions from upper and lower surfaces respectively

New

Attached Canopies on Buildings with h ≤ 60 ft

Figure 30.11-1A



Diagram

Pressure Coefficient

Notation

hc = Mean canopy height, in ft (m).
he = Mean eave height, in ft (m).
(GCp) = Pressure coefficients.
q_h = Velocity pressure evaluated at height $z = h$, in lb/ft2 (N/m2).

Notes

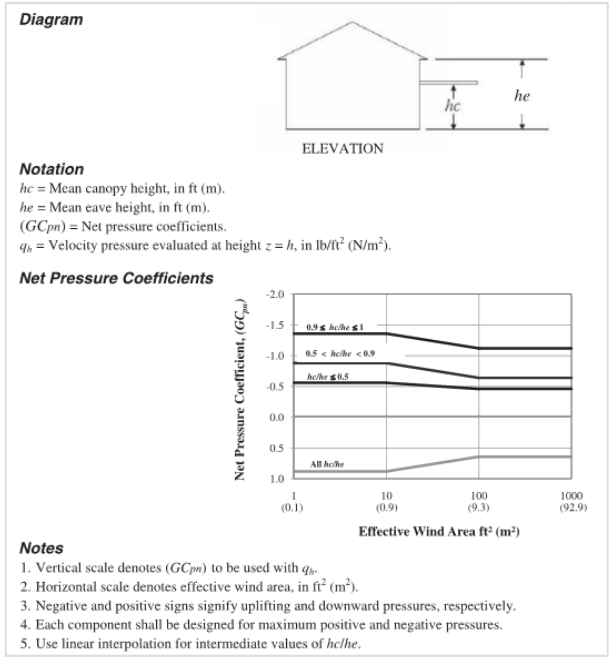
1. Pressures are based on the most critical values for all ratios of hc/he.
2. Vertical scale denotes (GCp) to be used with q_h.
3. Horizontal scale denotes effective wind area, in ft^2 (m^2).
4. Negative signs signify pressures acting away from the surface.

New

Design wind pressure

$p = q_h (GC_p)$ (30.11 – 1)

Figure 30.11-1B



Diagram

Notation

hc = Mean canopy height, in ft (m).
he = Mean eave height, in ft (m).
$(GCpn)$ = Net pressure coefficients.
q_h = Velocity pressure evaluated at height $z = h$, in lb/ft^2 (N/m^2).

Net Pressure Coefficients

Notes

1. Vertical scale denotes $(GCpn)$ to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft^2 (m^2).
3. Negative and positive signs signify uplifting and downward pressures, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Use linear interpolation for intermediate values of hc/he.

Tornado Limitations in Commentary

Section C26.14 has provisions providing guidance for designing buildings for tornadoes.

New

1. Tornado wind speeds and probability
2. Wind pressures induced by tornadoes vs. other windstorms
3. Designing for occupant protection
4. Designing to minimize building damage
5. Design to maintain continuity of building operations
6. Designing trussed communication towers for wind-borne debris

Photo courtesy of Twitter via@Jberm236 – also found in NSF StEER Event Briefing from Dallas, TX 10/20/2019 EF-3 Tornado

Tornado Limitations in Commentary

1 – Tornado Wind Speeds and Probability (Section C26.14.1)

New

Tornado-related winds have a significantly lower probability of occurrence at a specific location than the high winds associated with meteorological events (frontal systems, thunderstorms, and hurricane winds) responsible for the basic wind speeds given in ASCE 7.

Table C26.14-1 Enhanced Fujita (EF) Scale

EF Number	Wind Speed (mph)	(m/s)
EF0	65 85	29 38
EF1	86 110	39 49
EF2	111 135	50 60
EF3	136 165	61 73
EF4	166 200	74 89
EF5	>200	>89

Note: Speeds are for 3 s peak gust, Exposure C, 33 ft (10 m) above grade. Conversion of mph to m/s: mph × 0.44704 m/s.
Source: NOAA (http://www.spc.noaa.gov/efscale/ef scale.html).

EF Number	MRI (Mean Recurrence Interval)
EF0 – EF1	4,000 year MRI
EF4 – EF5	10,000,000 year MRI

Tornado Limitations in Commentary

Figure C26.14-12

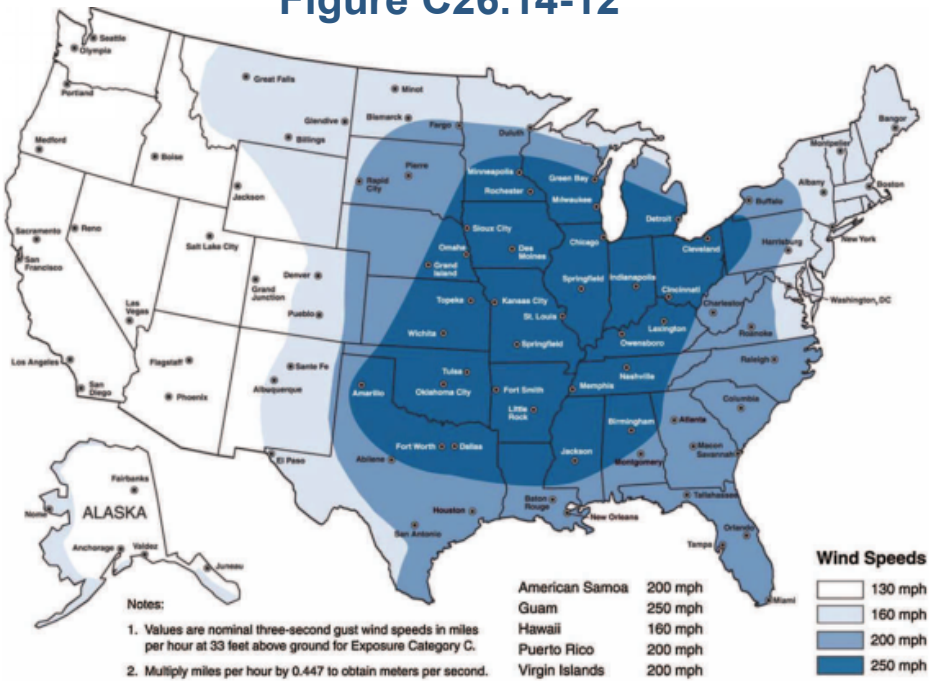


FIGURE C26.14-2 Tornado Safe Room Design Wind Speed Map

Source: FEMA (2008)

New

Tornado Limitations in Commentary

2 – Wind Pressures Induced by Tornadoes Vs. Other Windstorms (Section C26.14.2)

New

Tornado wind-borne debris shed from buildings indicates that tornado debris has a greater vertical trajectory than hurricane debris. Updrafts are greater in tornadoes than in other windstorms.

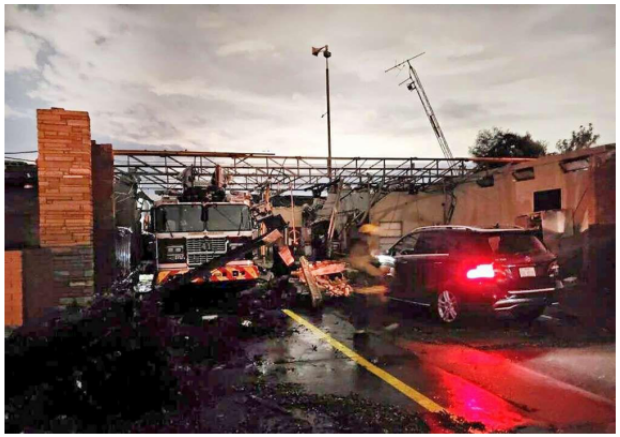


Photo of Dallas Fire Station #41 courtesy of MSN 2019, DALLAS FIRE-RESCURE/HANDOUT/EPA-EFE/Shutterstock – also found in NSF StEER Event Briefing from Dallas, TX 10/20/2019 EF-3 Tornado

Tornado Limitations in Commentary

New

3 – Designing for occupant protection (Section C26.14.3)	**ICC 500** residential and community storm shelters **FEMA P 320** – prescriptive solutions for residential and small business safe rooms up to 16 occupants **FEMA P 361** – residential and community safe rooms and design and construction QA.
5 – Design to maintain continuity of building operations (Section C26.14.5)	**FEMA P 908** – designing a building to ensure that it will remain operational if struck by an EF4or EF5 rated tornado
6 – Designing trussed communication towers for wind borne debris (Section C26.14.6)	**FEMA 2012** – minimum design for 40 ft^2 of projected surface area of clinging debris at mid height of the tower or 50 ft.

Tornado Limitations in Commentary

4 – Designing to minimize building damage (Section 26.14.4)

Two methods:

1. **Extended method:** modified wind pressure calculation parameters – then the design wind pressure can simply be calculated using the normal equations in ASCE 7
2. **Simplified method:** combines all parameters into a TF factor

Tornado Limitations in Commentary

Extended method:

- Wind Speed **V**: Design for the upper range wind speed within the target EF scale.
- $\mathbf{K_z}$: The velocity pressure exposure coefficient should be based on Exposure Category C
- Directionality $\mathbf{K_d}$: The directionality factor should be taken as 1.0
- Topography $\mathbf{K_{zt}}$: The topographic factor should be taken as 1.0
- Gust effect factor, **G**: The gust effect factor should be taken as 0.90 or higher if appropriate
- Internal pressure $\mathbf{GC_{pi}}$: The internal pressure coefficient should be taken as ± 0.55
- Velocity pressure **q**: The velocity pressure should be determined at mean roof height, q_h
- MWFRS $\mathbf{C_p}$: Pressures on the MWFRS should be based on the pressure coefficient, CP specified for the directional procedure in Chapter 27
- C&C, $\mathbf{GC_p}$ values: the pressure coefficients, GC_p, for components and cladding are permitted to be reduced by 10%

Tornado Limitations in Commentary

Simplified method:

New

Table C26.14-4 Increases in Design Loads to Address Tornado Risks Using Recommended Tornado Factors

Original Enclosure Classification	Loading	Original Exposure B	Original Exposure C or D
Partially enclosed buildings	MWFRS	1.8	1.2
	C&C	1.6	1.1
Enclosed buildings[a]	MWFRS	2.5	1.6
	C&C	2.1	1.5

[a]The tornado factors to be used to increase the design loads on elements of enclosed buildings are based on the effects of high internal pressures. High internal pressures have a much greater effect on elements that typically receive less wind, so the net effect of these increase factors is typically much higher than would result if the building were designed for the specific tornado loads or if the tornado factors for partially enclosed buildings were used with partially enclosed building designs.

$$p_{tornado} = p_{design} (V_{tornado}/V_{design})^2 \, TF$$

Recap

Changes in the 2016 edition of the ASCE 7 include:

- Wind maps modified to include more data. New Risk Category map, all maps include interior basic wind velocities.
- Component and cladding GC_p information include more data. Zones increased, more maps to include hip roofs. Overall increase in external pressure coefficient
- New elevation factor K_e to be included in the velocity pressure formula q to account the drop in pressure as site elevation increases with respect to sea level
- New wind loads specific to silos, tanks, solar panels, canopies attached to buildings
- Modifications to roof top equipment parameters
- Guidelines for tornado design available in the commentary

Design Example: C&C Low-Rise Buildings (Simplified) Procedures (2010 vs. 2016)

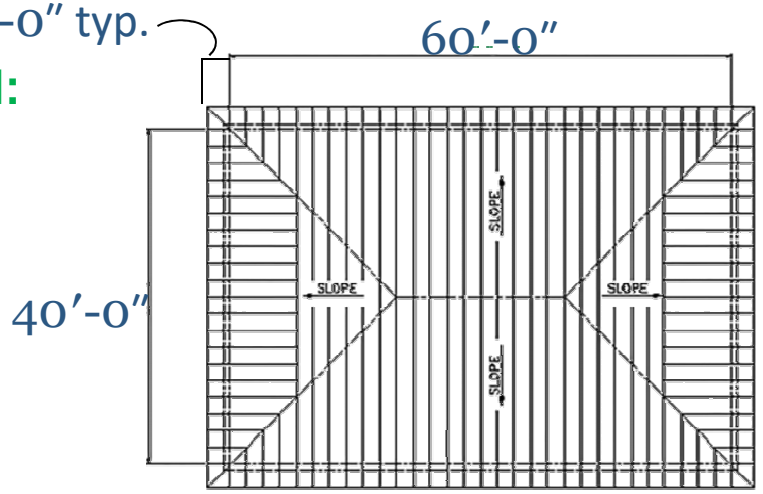
- Let's compare the differences in low-rise building simplified wind pressure calculation procedures between ASCE 7-2010 and ASCE 7-2016

The Problem Statement

Low-Rise Hip Roof Building

- Hurricane Shelter Building
- Building Risk Category IV
- Located in St. Augustine, FL
- Rigid, Simple Diaphragm
- Enclosed Building
- Exposure Category D
- Flat Terrain, Neglect Topographic Effects

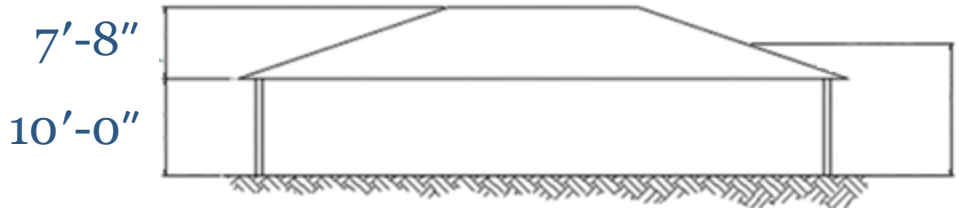
PLAN:



Slope:
4.4:12

Angle:
20.13°

ELEVATION:

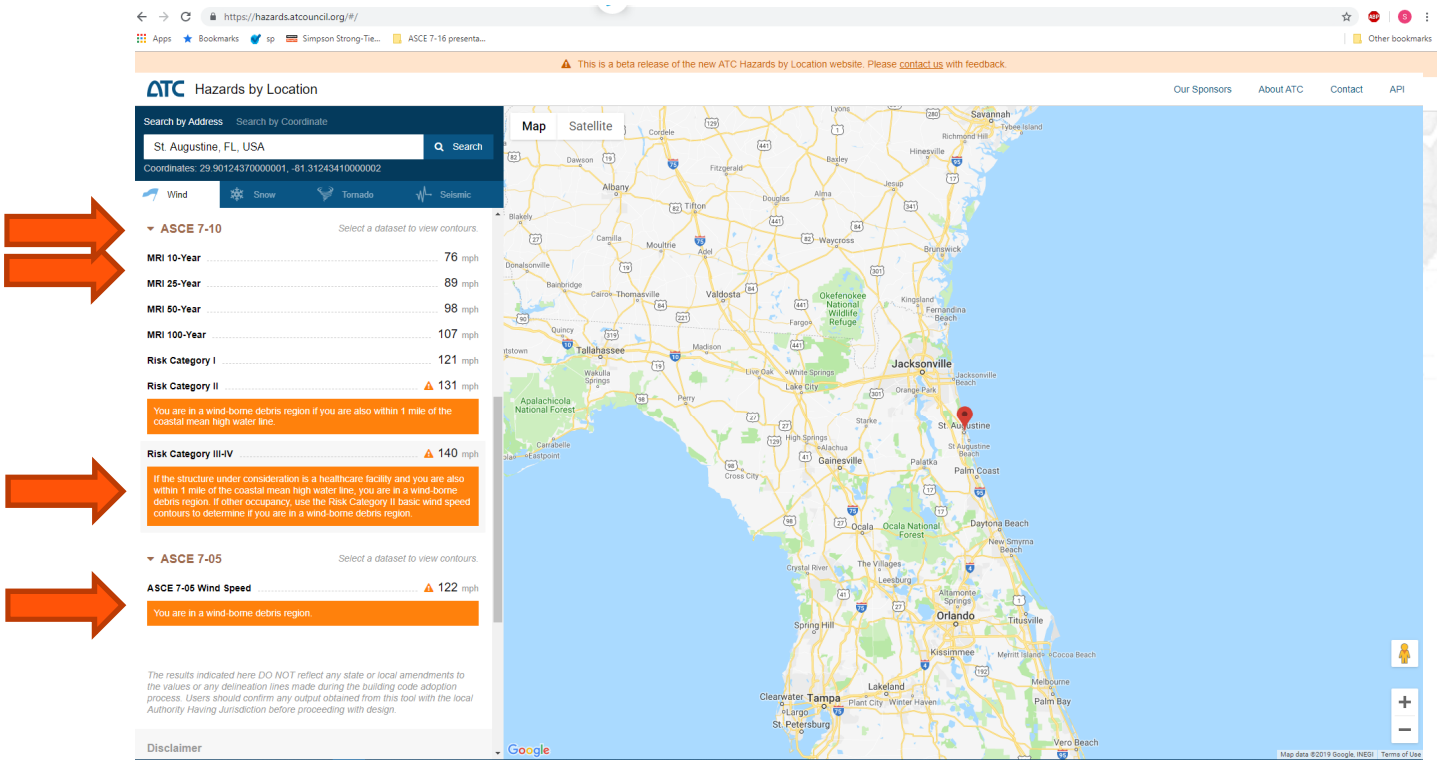


Mean Roof Height:
15′-0″

Simplified Procedure Overview

	Steps	ASCE 7-16 Ref.	ASCE 7-10 Ref.
1	Verify building general requirements and conditions to use this method	Sections 30.4 and 30.4.1	Sections 30.5 and 30.5.1
2	Establish building Risk Category	Table 1.5-1	Table 1.5-1
3	Determine Basic Wind Speed	Figure 26.5-1D	Figure 26.5-1B
4	Determine Wind load Parameters (Exposure Category and Topographic factor K_{zt})	Sections 26.7, 26.8 and Figure 26.8-1	Section 26.7, 26.8 and Figure 26.8-1
5	Select Simplified Design Wind Pressure (p_{S30})	Figure 30.4-1	Figure 30.5-1
6	Select Height and Exposure Coefficient (λ)	Figure 30.4-1	Figure 30.5-1
7	Calculate Adjusted Wind Pressure (p_{net})	Equation 30.4-1	Equation 30.5-1

Alternative Method for Basic Wind Speed

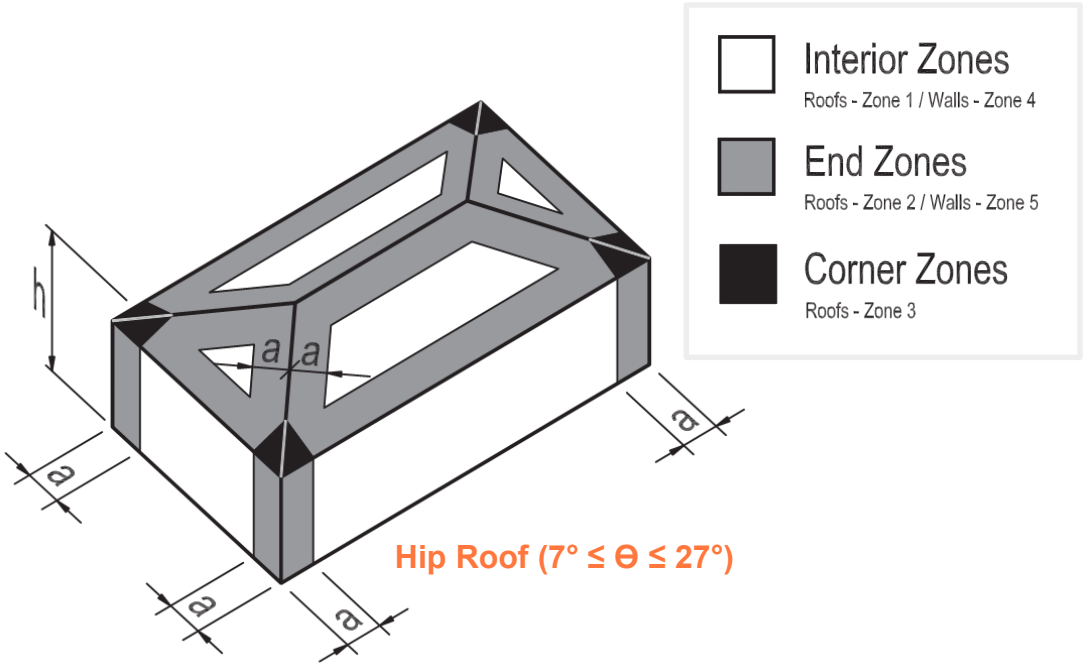


Available at hazards.atcouncil.org

2010 Simplified Procedure Wind Pressure

Note 3:
For hip roofs with Θ ≤ 25°, Zone 3 shall be treated as Zone 2

Note 5:
a: 10% of least horizontal dimension or .4h, whichever is smaller but not less than either 4% of least horizontal dimension or 3 ft



Hip Roof (7° ≤ Θ ≤ 27°)

a = 4'-0"

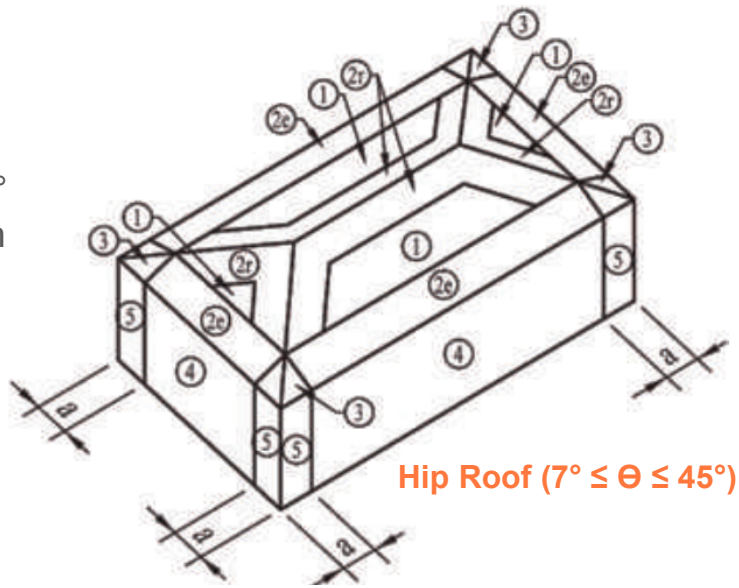
(Figure 30.5-1 ASCE 7-10)
Components and Cladding, Part 2 [h ≤ 60ft (h ≤ 18.3m)]: Design Wind Pressure for Enclosed Buildings – Walls and Roofs

2016 Simplified Procedure Wind Pressure

Notation: a = 10% of least horizontal dimension or .4h, whichever is smaller but not less than either 4% of least horizontal dimension or 3 ft

Exception: for buildings with Angle = 0° to 7° and a least horizontal dimension greater than 300 ft, dimension *a* shall be limited to a maximum of 0.8h

Note 3: For hip roofs with Θ ≤ 25°, Zone 3 shall be treated as Zone 2e and 2r.



Hip Roof (7° ≤ Θ ≤ 45°)

Roof Zones
1: Interior
2e: End
2r: Ridge
3: Corner

Wall Zones
4: Interior
5: End

a = 4'-0"

(Figure 30.4-1 ASCE 7-16)
Components and Cladding, Part 2 [h ≤ 60ft (h ≤ 18.3m)]: Design Wind Pressure for Enclosed Buildings – Walls and Roofs

Simplified Procedure Exposure Coefficient

Find the Exposure Coefficient

- Mean roof height = 15 ft
- Exposure Category D
- Exposure Coefficient = 1.47

Adjustment Factor for Building Height and Exposure, λ			
Mean roof height (ft)	Exposure		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

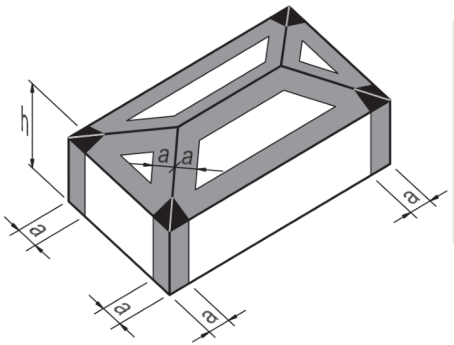
Figure 30.4-1 ASCE 7-16 or Figure 30.5-1 ASCE 7-10

2010 Simplified Procedure Wind Pressure, cont.

Components and Cladding – Method 1		h ≤ 60 ft.
Figure 30.5-1 (cont'd)	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Net Design Wind Pressure, p_{net30} (psf) *(Exposure B at h = 30 ft.)*

	Zone	Effective wind area (sf)	Basic Wind Speed V (mph)																	
			110		115		120		130		140		150		160		180		200	
Roof > 7 to 27 degrees	1	10	12.5	-19.9	13.7	-21.8	14.9	-23.7	17.5	-27.8	20.3	-32.3	23.3	-37.0	26.5	-42.1	33.6	-53.3	41.5	-65.9
	1	20	11.4	-19.4	12.5	-21.2	13.6	-23.0	16.0	-27.0	18.5	-31.4	21.3	-36.0	24.2	-41.0	30.6	-51.9	37.8	-64.0
	1	50	10.0	-18.6	10.9	-20.4	11.9	-22.2	13.9	-26.0	16.1	-30.2	18.5	-34.6	21.1	-39.4	26.7	-49.9	32.9	-61.6
	1	100	8.9	-18.1	9.7	-19.8	10.5	-21.5	12.4	-25.2	14.3	-29.3	16.5	-33.6	18.7	-38.2	23.7	-48.4	29.3	-59.8
	2	10	12.5	-34.7	13.7	-37.9	14.9	-41.3	17.5	-48.4	20.3	-56.2	23.3	-64.5	26.5	-73.4	33.6	-92.9	41.5	-114.6
	2	20	11.4	-31.9	12.5	-34.9	13.6	-38.0	16.0	-44.6	18.5	-51.7	21.3	-59.3	24.2	-67.5	30.6	-85.4	37.8	-105.5
	2	50	10.0	-28.2	10.9	-30.9	11.9	-33.6	13.9	-39.4	16.1	-45.7	18.5	-52.5	21.1	-59.7	26.7	-75.6	32.9	-93.3
	2	100	8.9	-25.5	9.7	-27.8	10.5	-30.3	12.4	-35.6	14.3	-41.2	16.5	-47.3	18.7	-53.9	23.7	-68.2	29.3	-84.2
	3	10	12.5	-51.3	13.7	-56.0	14.9	-61.0	17.5	-71.6	20.3	-83.1	23.3	-95.4	26.5	-108.5	33.6	-137.3	41.5	-169.5
	3	20	11.4	-47.9	12.5	-52.4	13.6	-57.1	16.0	-67.0	18.5	-77.7	21.3	-89.2	24.2	-101.4	30.6	-128.4	37.8	-158.5
	3	50	10.0	-43.5	10.9	-47.6	11.9	-51.8	13.9	-60.8	16.1	-70.5	18.5	-81.0	21.1	-92.1	26.7	-116.6	32.9	-143.9
	3	100	8.9	-40.2	9.7	-44.0	10.5	-47.9	12.4	-56.2	14.3	-65.1	16.5	-74.8	18.7	-85.1	23.7	-107.7	29.3	-132.9
Wall	4	10	21.8	-23.6	23.8	-25.8	25.9	-28.1	30.4	-33.0	35.3	-38.2	40.5	-43.9	46.1	-50.0	58.3	-63.2	72.0	-78.1
	4	20	20.8	-22.6	22.7	-24.7	24.7	-26.9	29.0	-31.6	33.7	-36.7	38.7	-42.1	44.0	-47.9	55.7	-60.6	68.7	-74.8
	4	50	19.5	-21.3	21.3	-23.3	23.2	-25.4	27.2	-29.8	31.6	-34.6	36.2	-39.7	41.2	-45.1	52.2	-57.1	64.4	-70.5
	4	100	18.5	-20.4	20.2	-22.2	22.0	-24.2	25.9	-28.4	30.0	-33.0	34.4	-37.8	39.2	-43.1	49.6	-54.5	61.2	-67.3
	4	500	16.2	-18.1	17.7	-19.8	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	34.3	-38.2	43.5	-48.4	53.7	-59.8
	5	10	21.8	-29.1	23.8	-31.9	25.9	-34.7	30.4	-40.7	35.3	-47.2	40.5	-54.2	46.1	-61.7	58.3	-78.0	72.0	-96.3
	5	20	20.8	-27.2	22.7	-29.7	24.7	-32.4	29.0	-38.0	33.7	-44.0	38.7	-50.5	44.0	-57.5	55.7	-72.8	68.7	-89.9
	5	50	19.5	-24.6	21.3	-26.9	23.2	-29.3	27.2	-34.3	31.6	-39.8	36.2	-45.7	41.2	-52.0	52.2	-65.8	64.4	-81.3
	5	100	18.5	-22.6	20.2	-24.7	22.0	-26.9	25.9	-31.6	30.0	-36.7	34.4	-42.1	39.2	-47.9	49.6	-60.6	61.2	-74.8
	5	500	16.2	-18.1	17.7	-19.8	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	34.3	-38.2	43.5	-48.4	53.7	-59.8



Basic 3-sec Gust Wind Speed, V_{ult}
140 mph

Note 3: For hip roofs with Θ ≤ 25°, Zone 3 shall be treated as Zone 2

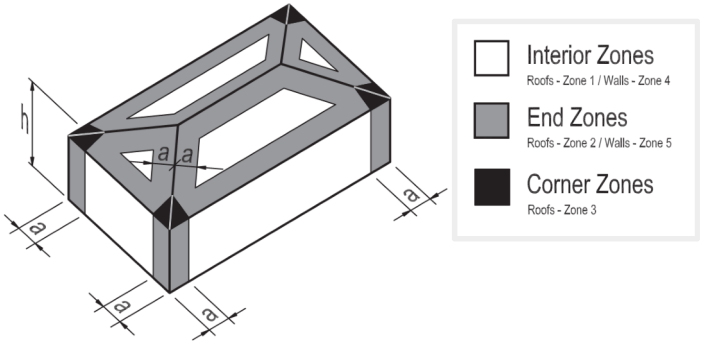
2010 Simplified Procedure Wind Pressure, cont.

Components and Cladding – Method 1		h ≤ 60 ft.
Figure 30.5-1 (cont'd)	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Roof Overhang Net Design Wind Pressure , p_{net30} (psf)

(Exposure B at h = 30 ft.)

	Zone	Effective Wind Area (sf)	Basic Wind Speed V (mph) 110	115	130	140	150	160	180	200
Roof 0 to 7 degrees	2	10	-31.4	-34.3	-43.8	-50.8	-58.3	-66.3	-84.0	-103.7
	2	20	-30.8	-33.7	-43.0	-49.9	-57.3	-65.2	-82.5	-101.8
	2	50	-30.1	-32.9	-42.0	-48.7	-55.9	-63.6	-80.5	-99.4
	2	100	-29.5	-32.3	-41.2	-47.8	-54.9	-62.4	-79.0	-97.6
	3	10	-51.6	-56.5	-72.1	-83.7	-96.0	-109.3	-138.3	-170.7
	3	20	-40.5	-44.3	-56.6	-65.7	-75.4	-85.8	-108.6	-134.0
	3	50	-25.9	-28.3	-36.1	-41.9	-48.1	-54.7	-69.3	-85.5
	3	100	-14.8	-16.1	-20.6	-23.9	-27.4	-31.2	-39.5	-48.8
Roof > 7 to 27 degrees	2	10	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	20	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	50	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	100	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	3	10	-68.3	-74.6	-95.3	-110.6	-126.9	-144.4	-182.8	-225.6
	3	20	-61.6	-67.3	-86.0	-99.8	-114.5	-130.3	-164.9	-203.6
	3	50	-52.8	-57.7	-73.7	-85.5	-98.1	-111.7	-141.3	-174.5
	3	100	-46.1	-50.4	-64.4	-74.7	-85.8	-97.6	-123.5	-152.4



Basic 3-sec Gust Wind Speed, V_{ult}
140 mph

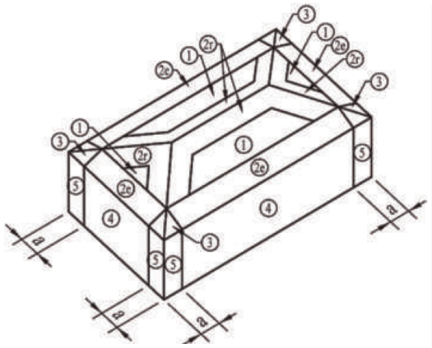
Note 3: For hip roofs with Θ ≤ 25°, Zone 3 shall be treated as Zone 2

2016 Simplified Procedure Wind Pressure, cont.

Net Design Wind Pressure, p_{net30}, in lb/ft^2, for Exposure B at h = 30 ft, V= 140–200 mph

	Zone	Effective Wind Area (ft^2)	Basic Wind Speed (mph) 140		150		160		170		180		190		200	
Walls	4	10	35.3	–38.2	40.5	–38.2	46.1	–50.0	52.0	–56.4	58.3	–63.2	64.9	–70.4	72.0	–78.1
	4	20	33.7	–36.7	38.7	–36.7	44.0	–47.9	49.6	–54.1	55.7	–60.6	62.0	–67.5	68.7	–74.8
	4	50	31.6	–34.6	36.2	–34.6	41.2	–45.1	46.6	–51.0	52.2	–57.1	58.1	–63.7	64.4	–70.5
	4	100	30.0	–33.0	34.4	–33.0	39.2	–43.1	44.2	–48.6	49.6	–54.5	55.2	–60.7	61.2	–67.3
	5	10	35.3	–47.2	40.5	–47.2	46.1	–61.7	52.0	–69.6	58.3	–78.0	64.9	–87.0	72.0	–96.3
	5	20	33.7	–44.0	38.7	–44.0	44.0	–57.5	49.6	–64.9	55.7	–72.8	62.0	–81.1	68.7	–89.9
	5	50	31.6	–39.8	36.2	–39.8	41.2	–52.0	46.6	–58.7	52.2	–65.8	58.1	–73.4	64.4	–81.3
	5	100	30.0	–36.7	34.4	–36.7	39.2	–47.9	44.2	–54.1	49.6	–60.6	55.2	–67.5	61.2	–74.8

	Zone	Effective Wind Area (ft^2)	Basic Wind Speed (mph) 140		150		160		170		180		190		200	
Hip Roof > 20 to 27 Degrees	1	10	26.3	–47.2	30.2	–54.2	34.3	–61.7	38.8	–69.6	43.5	–78.0	48.4	–87.0	53.7	–96.3
	1	20	22.7	–41.8	26.1	–48.0	29.6	–54.6	33.5	–61.7	37.5	–69.1	41.8	–77.0	46.3	–85.3
	1	50	17.9	–34.7	20.6	–39.8	23.4	–45.3	26.5	–51.1	29.7	–57.3	33.0	–63.9	36.6	–70.8
	1	100	14.3	–29.3	16.5	–33.6	18.7	–38.2	21.1	–43.2	23.7	–48.4	26.4	–53.9	29.3	–59.8
	2e	10	26.3	–65.1	30.2	–74.8	34.3	–85.1	38.8	–96.0	43.5	–107.7	48.4	–120.0	53.7	–132.9
	2e	20	22.7	–58.2	26.1	–66.8	29.6	–76.0	33.5	–85.9	37.5	–96.2	41.8	–107.2	46.3	–118.8
	2e	50	17.9	–49.1	20.6	–56.3	23.4	–64.1	26.5	–72.4	29.7	–81.1	33.0	–90.4	36.6	–100.2
	2e	100	14.3	–42.2	16.5	–48.4	18.7	–55.1	21.1	–62.2	23.7	–69.7	26.4	–77.7	29.3	–86.1
	2r	10	26.3	–65.1	30.2	–74.8	34.3	–85.1	38.8	–96.0	43.5	–107.7	48.4	–120.0	53.7	–132.9
	2r	20	22.7	–58.2	26.1	–66.8	29.6	–76.0	33.5	–85.9	37.5	–96.2	41.8	–107.2	46.3	–118.8
	2r	50	17.9	–49.1	20.6	–56.3	23.4	–64.1	26.5	–72.4	29.7	–81.1	33.0	–90.4	36.6	–100.2
	2r	100	14.3	–42.2	16.5	–48.4	18.7	–55.1	21.1	–62.2	23.7	–69.7	26.4	–77.7	29.3	–86.1
	3e	10	26.3	–65.1	30.2	–74.8	34.3	–85.1	38.8	–96.0	43.5	–107.7	48.4	–120.0	53.7	–132.9
	3e	20	22.7	–58.2	26.1	–66.8	29.6	–76.0	33.5	–85.9	37.5	–96.2	41.8	–107.2	46.3	–118.8
	3e	50	17.9	–49.1	20.6	–56.3	23.4	–64.1	26.5	–72.4	29.7	–81.1	33.0	–90.4	36.6	–100.2
	3e	100	14.3	–42.2	16.5	–48.4	18.7	–55.1	21.1	–62.2	23.7	–69.7	26.4	–77.7	29.3	–86.1



Roof Zones
1: Interior
2e: End
2r: Ridge
3: Corner

Wall Zones
4: Interior
5: End

Basic 3-sec Gust Wind Speed, V_{ult}
150 mph

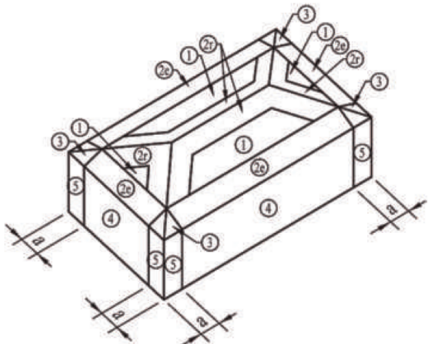
Note 3: For hip roofs with $\Theta \leq 25°$, Zone 3 shall be treated as Zone 2e and 2r.

Figure 30.4-1 Components and Cladding, Part 2 [h ≤ 60ft (h ≤ 18.3m)]: Design Wind Pressure for Enclosed Buildings – Walls and Roofs

2016 Simplified Procedure Wind Pressure, cont.

Net Design Wind Pressure for Roof Overhang p_{net30}, in lb/ft^2, for Exposure B at h = 30 ft, V= 95–200 mph

	Zone	Effective Wind Area (ft^2)	Wind Speed (mph)													
			95	100	105	110	115	120	130	140	150	160	170	180	190	200
Hip Roof > 20 to 27 Degrees	1	10	–26.0	–28.9	–31.8	–34.9	–38.2	–41.6	–48.8	–56.6	–64.9	–73.9	–83.4	–93.5	–104.2	–115.4
	1	20	–25.7	–28.5	–31.5	–34.5	–37.7	–41.1	–48.2	–55.9	–64.2	–73.0	–82.5	–92.4	–103.0	–114.1
	1	50	–25.4	–28.1	–31.0	–34.0	–37.2	–40.5	–47.5	–55.1	–63.2	–71.9	–81.2	–91.0	–101.4	–112.4
	1	100	–25.1	–27.8	–30.6	–33.6	–36.7	–40.0	–46.9	–54.4	–62.5	–71.1	–80.3	–90.0	–100.2	–111.1
	2e	10	–33.7	–37.3	–41.1	–45.1	–49.3	–53.7	–63.0	–73.1	–83.9	–95.5	–107.8	–120.9	–134.7	–149.2
	2e	20	–32.2	–35.7	–39.4	–43.2	–47.2	–51.4	–60.4	–70.0	–80.4	–91.5	–103.2	–115.7	–129.0	–142.9
	2e	50	–30.4	–33.6	–37.1	–40.7	–44.5	–48.4	–56.9	–65.9	–75.7	–86.1	–97.2	–109.0	–121.4	–134.6
	2e	100	–28.9	–32.1	–35.4	–38.8	–42.4	–46.2	–54.2	–62.8	–72.1	–82.1	–92.7	–103.9	–115.8	–128.3
	2r	10	–33.7	–37.3	–41.1	–45.1	–49.3	–53.7	–63.0	–73.1	–83.9	–95.5	–107.8	–120.9	–134.7	–149.2
	2r	20	–32.2	–35.7	–39.4	–43.2	–47.2	–51.4	–60.4	–70.0	–80.4	–91.5	–103.2	–115.7	–129.0	–142.9
	2r	50	–30.4	–33.6	–37.1	–40.7	–44.5	–48.4	–56.9	–65.9	–75.7	–86.1	–97.2	–109.0	–121.4	–134.6
	2r	100	–28.9	–32.1	–35.4	–38.8	–42.4	–46.2	–54.2	–62.8	–72.1	–82.1	–92.7	–103.9	–115.8	–128.3
	3	10	–40.3	–44.7	–49.2	–54.0	–59.1	–64.3	–75.5	–87.5	–100.5	–114.3	–129.1	–144.7	–161.2	–178.7
	3	20	–35.8	–39.6	–43.7	–47.9	–52.4	–57.1	–67.0	–77.7	–89.1	–101.4	–114.5	–128.4	–143.0	–158.5
	3	50	–29.7	–33.0	–36.3	–39.9	–43.6	–47.5	–55.7	–64.6	–74.1	–84.4	–95.2	–106.8	–119.0	–131.8
	3	100	–25.2	–27.9	–30.8	–33.8	–36.9	–40.2	–47.2	–54.7	–62.8	–71.5	–80.7	–90.4	–100.8	–111.6



Roof Zones
1: Interior
2e: End
2r: Ridge
3: Corner

Wall Zones
4: Interior
5: End

Basic 3-sec Gust Wind Speed, V_{ult}
150 mph

Note 3: For hip roofs with $\Theta \leq 25°$, Zone 3 shall be treated as Zone 2e and 2r.

Figure 30.4-1 Components and Cladding, Part 2 [h ≤ 60ft (h ≤ 18.3m)]: Design Wind Pressure for Enclosed Buildings – Walls and Roofs

Results Comparison

ASCE 7-10: St. Augustine FL V_{Ult} = 140mph								
	Roof Pressures (psf)			Wall Pressures (psf)		Roof Pressures w/ Overhangs (psf)		
Zone – ASCE 7-10	1	2	3	4	5	1	2	3
P_{net30}	20.3 -32.3	20.3 -56.2	20.3 -56.2	35.3 -38.2	35.3 -47.2	20.3 -32.3	20.3 -65.7	20.3 -65.7
P_{net}	29.8 -47.5	29.8 -82.6	29.8 -82.6	51.7 -56.2	51.7 -69.4	29.8 -47.5	29.8 -96.6	29.8 -96.6

Risk Category IV Building, Exposure Category D ($\lambda = 1.47$), roof angle of 20.14° (roof slope of 4.4:12), and flat terrain ($K_{zt} = 1.0$).

ASCE 7-16: St. Augustine FL V_{Ult} = 150mph										
	Roof Pressures (psf)				Wall Pressures (psf)		Roof Pressures w/ Overhangs (psf)			
Zone – ASCE 7-16	1	2e	2r	3	4	5	1	2e	2r	3
P_{net30}	30.2 -54.2	30.2 -74.8	30.2 -74.8	30.2 -74.8	40.5 -38.2	40.5 -47.2	30.2 -64.9	30.2 -83.9	30.2 -83.9	30.2 -83.9
P_{net}	44.4 -79.7	44.4 -110.0	44.4 -110.0	44.4 -110.0	59.5 -56.2	59.5 -69.4	44.4 -95.4	44.4 -123.3	44.4 -123.3	44.4 -123.3

Things To Go Do

- Bookmark the following websites:
  - Free I-Codes: https://codes.iccsafe.org/public/collections/I-Codes
  - ATC Wind Speed by Location: http://hazards.atcouncil.org/
- Go check out the *High-Performance Solutions for High-Wind Forces* microsite www.strongtie.com/hw

Simpson Strong-Tie

Changes in Wind Design with ASCE 7-16

THANK YOU!

For a library of **Simpson Strong-Tie** AIA CES courses,
visit http://www.strongtie.com/workshops