International Roofing Expo
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New Orleans, LA

ASCE 7-16 and its impact on wind-uplift design

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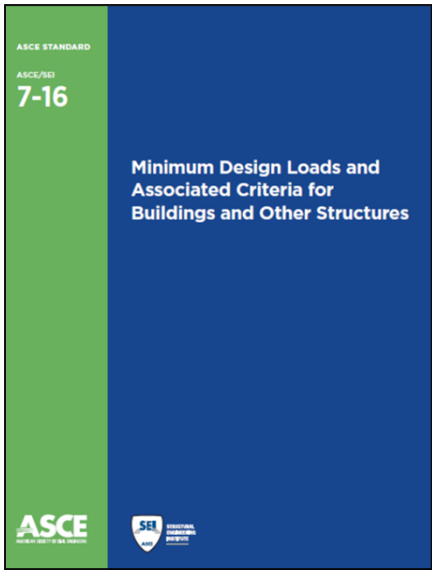
Learning objectives

- Learn about ASCE 7-16 and its applicability
- Review the roofing-related changes contained in ASCE 7-16
- Learn the ASCE 7-16's impact on perimeter and corner fastening
- Discover the differences in ASCE 7-16's results and those from ASCE 7-10 and ASCE 7-05

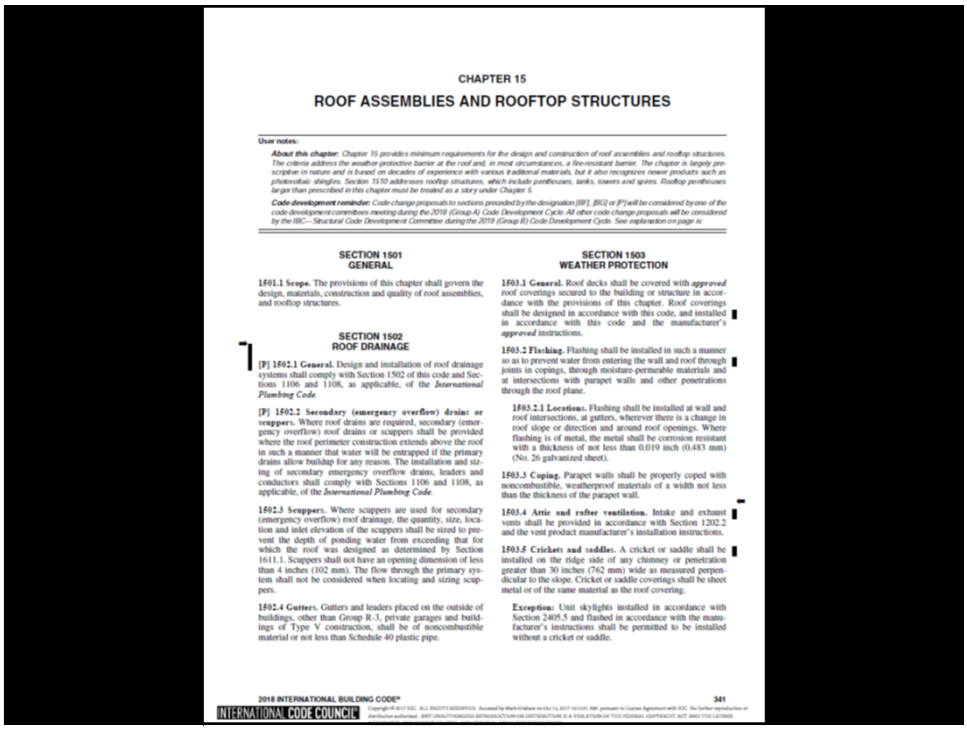
Last year's program

Link to access this presentation



American Society of Civil Engineers Standard 7, "Minimum design loads and associated criteria for buildings and other structures" (ASCE 7-16)

International Building Code, 2018 Edition



CHAPTER 15

ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

User notes:

About this chapter: *Chapter 15 provides minimum requirements for the design and construction of roof assemblies and rooftop structures. The criteria address the weather-protective barrier at the roof and, in most circumstances, a fire-resistant barrier. The chapter is largely prescriptive in nature and is based on decades of experience with various traditional materials, but it also recognizes newer products such as photovoltaic shingles. Section 1510 addresses rooftop structures, which include penthouses, tanks, towers and spires. Rooftop penthouses larger than prescribed in this chapter must be treated as a story under Chapter 5.*

Code development reminder: *Code change proposals to sections preceded by the designation [BF], [BG] or [P] will be considered by one of the code development committees meeting during the 2018 (Group A) Code Development Cycle. All other code change proposals will be considered by the IBC—Structural Code Development Committee during the 2019 (Group B) Code Development Cycle. See explanation on page ix.*

SECTION 1501
GENERAL

1501.1 Scope. The provisions of this chapter shall govern the design, materials, construction and quality of roof assemblies, and rooftop structures.

SECTION 1502
ROOF DRAINAGE

[P] 1502.1 General. Design and installation of roof drainage systems shall comply with Section 1502 of this code and Sections 1106 and 1108, as applicable, of the *International Plumbing Code*.

[P] 1502.2 Secondary (emergency overflow) drains or scuppers. Where roof drains are required, secondary (emergency overflow) roof drains or scuppers shall be provided where the roof perimeter construction extends above the roof in such a manner that water will be entrapped if the primary drains allow buildup for any reason. The installation and sizing of secondary emergency overflow drains, leaders and conductors shall comply with Sections 1106 and 1108, as applicable, of the *International Plumbing Code*.

1502.3 Scuppers. Where scuppers are used for secondary (emergency overflow) roof drainage, the quantity, size, location and inlet elevation of the scuppers shall be sized to prevent the depth of ponding water from exceeding that for which the roof was designed as determined by Section 1611.1. Scuppers shall not have an opening dimension of less than 4 inches (102 mm). The flow through the primary system shall not be considered when locating and sizing scuppers.

1502.4 Gutters. Gutters and leaders placed on the outside of buildings, other than Group R-3, private garages and buildings of Type V construction, shall be of noncombustible material or not less than Schedule 40 plastic pipe.

SECTION 1503
WEATHER PROTECTION

1503.1 General. Roof decks shall be covered with *approved* roof coverings secured to the building or structure in accordance with the provisions of this chapter. Roof coverings shall be designed in accordance with this code, and installed in accordance with this code and the manufacturer's *approved* instructions.

1503.2 Flashing. Flashing shall be installed in such a manner so as to prevent water from entering the wall and roof through joints in copings, through moisture-permeable materials and at intersections with parapet walls and other penetrations through the roof plane.

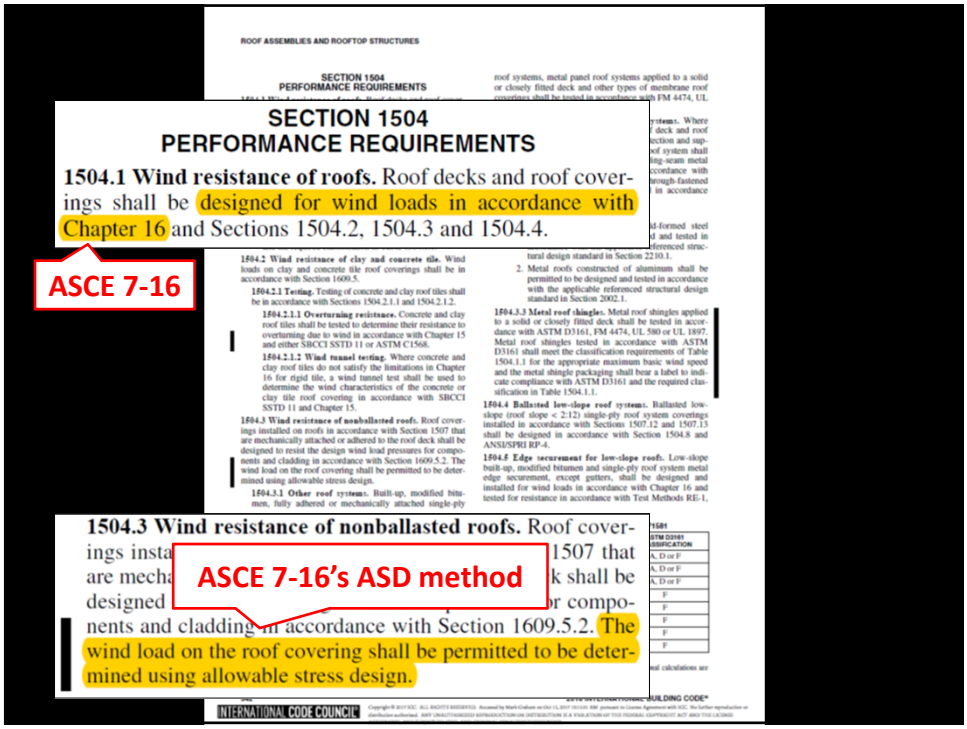
1503.2.1 Locations. Flashing shall be installed at wall and roof intersections, at gutters, wherever there is a change in roof slope or direction and around roof openings. Where flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than 0.019 inch (0.483 mm) (No. 26 galvanized sheet).

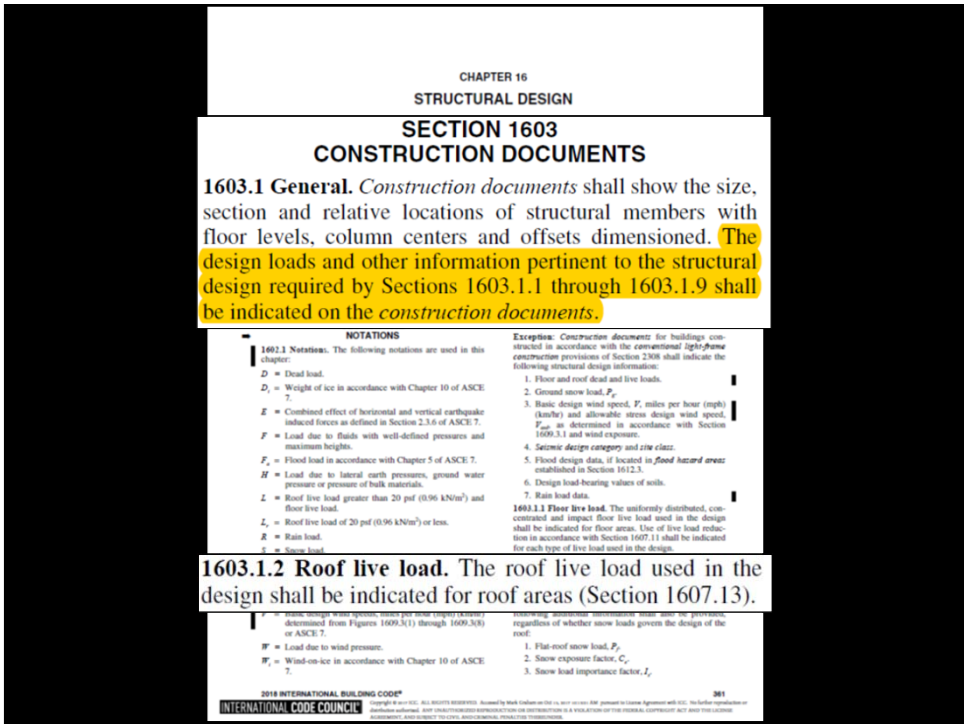
1503.3 Coping. Parapet walls shall be properly coped with noncombustible, weatherproof materials of a width not less than the thickness of the parapet wall.

1503.4 Attic and rafter ventilation. Intake and exhaust vents shall be provided in accordance with Section 1202.2 and the vent product manufacturer's installation instructions.

1503.5 Crickets and saddles. A cricket or saddle shall be installed on the ridge side of any chimney or penetration greater than 30 inches (762 mm) wide as measured perpendicular to the slope. Cricket or saddle coverings shall be sheet metal or of the same material as the roof covering.

Exception: Unit skylights installed in accordance with Section 2405.5 and flashed in accordance with the manufacturer's instructions shall be permitted to be installed without a cricket or saddle.


ROOF ASSEMBLIES AND ROOFTOP STRUCTURES
SECTION 1504
PERFORMANCE REQUIREMENTS
SECTION 1504
PERFORMANCE REQUIREMENTS
1504.1 Wind resistance of roofs. Roof decks and roof coverings shall be designed for wind loads in accordance with Chapter 16 and Sections 1504.2, 1504.3 and 1504.4.
ASCE 7-16
1504.3 Wind resistance of nonballasted roofs. Roof coverings insta 1507 that are mecha k shall be designed r components and cladding in accordance with Section 1609.5.2. The wind load on the roof covering shall be permitted to be determined using allowable stress design.
ASCE 7-16's ASD method
INTERNATIONAL CODE COUNCIL


CHAPTER 16
STRUCTURAL DESIGN
SECTION 1603
CONSTRUCTION DOCUMENTS
1603.1 General. Construction documents shall show the size, section and relative locations of structural members with floor levels, column centers and offsets dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.9 shall be indicated on the construction documents.
NOTATIONS
1603.1.2 Roof live load. The roof live load used in the design shall be indicated for roof areas (Section 1607.13).
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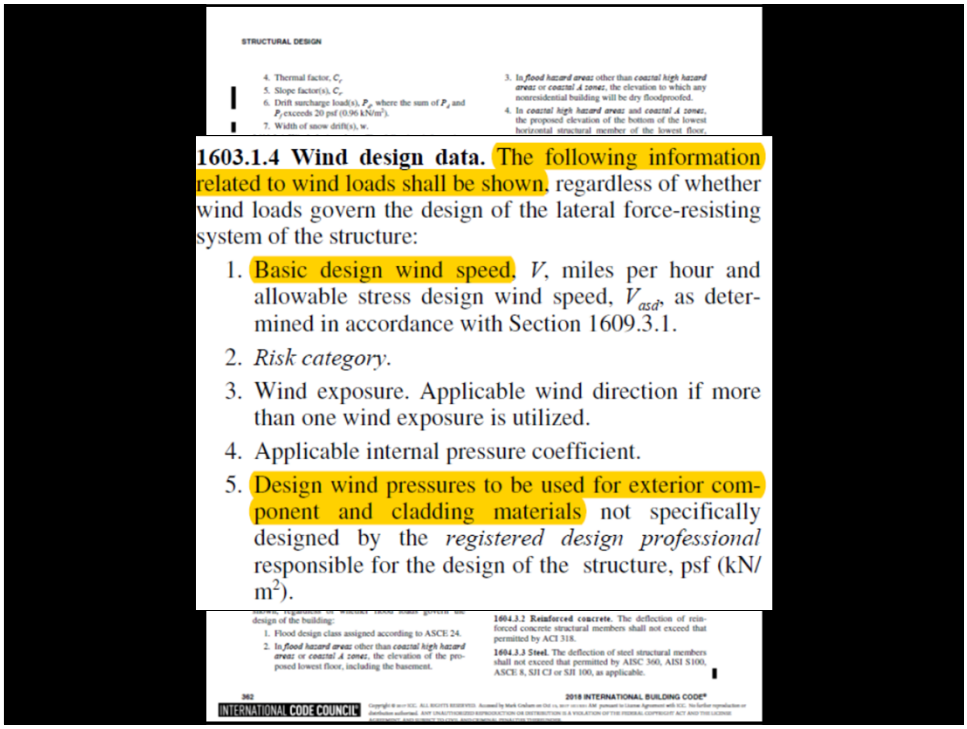

STRUCTURAL DESIGN

4. Thermal factor, C_t
5. Slope factor(s), C_s
6. Drift surcharge load(s), P_d, where the sum of P_d and P_f exceeds 20 psf (0.96 kN/m^2).
7. Width of snow drift(s), w.

3. In *flood hazard areas* other than *coastal high hazard areas* or *coastal A zones*, the elevation to which any nonresidential building will be dry floodproofed.
4. In *coastal high hazard areas* and *coastal A zones*, the proposed elevation of the bottom of the lowest horizontal structural member of the lowest floor,

1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force-resisting system of the structure:

1. Basic design wind speed, V, miles per hour and allowable stress design wind speed, V_{asd}, as determined in accordance with Section 1609.3.1.
2. *Risk category*.
3. Wind exposure. Applicable wind direction if more than one wind exposure is utilized.
4. Applicable internal pressure coefficient.
5. Design wind pressures to be used for exterior component and cladding materials not specifically designed by the *registered design professional* responsible for the design of the structure, psf (kN/m^2).

design of the building:

1. Flood design class assigned according to ASCE 24.
2. In *flood hazard areas* other than *coastal high hazard areas* or *coastal A zones*, the elevation of the proposed lowest floor, including the basement.

1604.3.2 Reinforced concrete. The deflection of reinforced concrete structural members shall not exceed that permitted by ACI 318.

1604.3.3 Steel. The deflection of steel structural members shall not exceed that permitted by AISC 360, AISI S100, ASCE 8, SJI CJ or SJI 100, as applicable.

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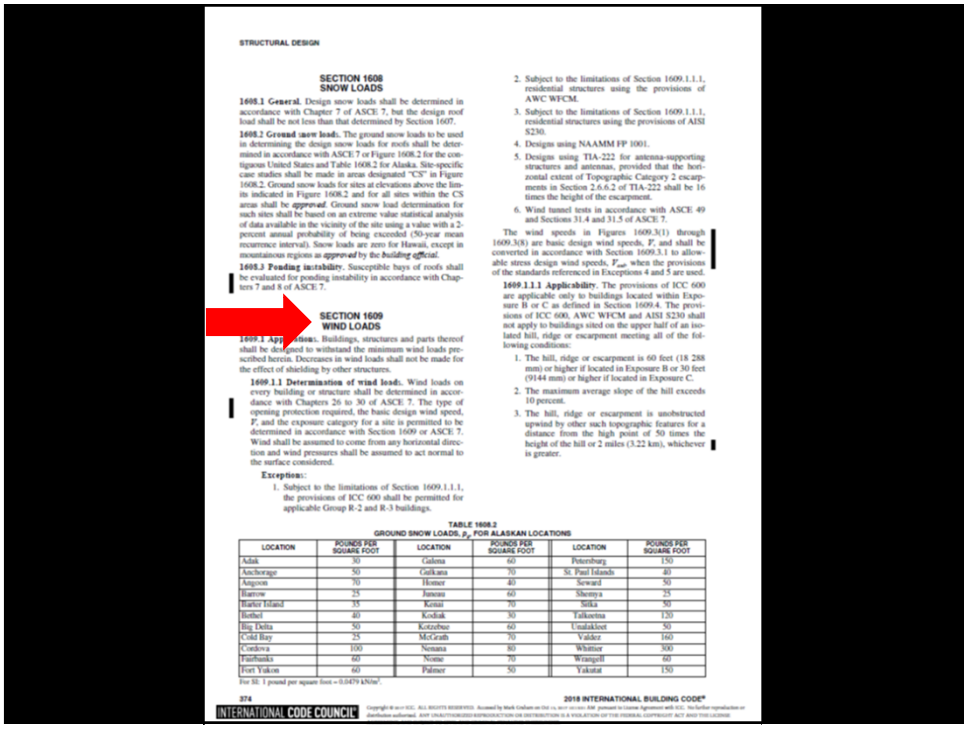

STRUCTURAL DESIGN

SECTION 1608
SNOW LOADS

1608.1 General. Design snow loads shall be determined in accordance with Chapter 7 of ASCE 7, but the design roof load shall be not less than that determined by Section 1607.

1608.2 Ground snow loads. The ground snow loads to be used in determining the design snow loads for roofs shall be determined in accordance with ASCE 7 or Figure 1608.2 for the contiguous United States and Table 1608.2 for Alaska. Site-specific case studies shall be made in areas designated "CS" in Figure 1608.2. Ground snow loads for sites at elevations above the limits indicated in Figure 1608.2 and for all sites within the CS areas shall be *approved*. Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2-percent annual probability of being exceeded (50-year mean recurrence interval). Snow loads are zero for Hawaii, except in mountainous regions as *approved* by the *building official*.

1608.3 Pooling instability. Susceptible bays of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7.

SECTION 1609
WIND LOADS

1609.1 Applications. Buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.

1609.1.1 Determination of wind loads. Wind loads on every building or structure shall be determined in accordance with Chapters 26 to 30 of ASCE 7. The type of opening protection required, the basic design wind speed, V, and the exposure category for a site is permitted to be determined in accordance with Section 1609 or ASCE 7. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

Exceptions:

1. Subject to the limitations of Section 1609.1.1.1, the provisions of ICC 600 shall be permitted for applicable Group R-2 and R-3 buildings.
2. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of AWC WFCM.
3. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of AISI S230.
4. Designs using NAAMM FP 1001.
5. Designs using TIA-222 for antenna-supporting structures and antennas, provided that the horizontal extent of Topographic Category 2 escarpments in Section 2.6.6.2 of TIA-222 shall be 16 times the height of the escarpment.
6. Wind tunnel tests in accordance with ASCE 49 and Sections 31.4 and 31.5 of ASCE 7.

The wind speeds in Figures 1609.3(1) through 1609.3(8) are basic design wind speeds, V, and shall be converted in accordance with Section 1609.3.1 to allowable stress design wind speeds, V_{asd}, when the provisions of the standards referenced in Exceptions 4 and 5 are used.

1609.1.1.1 Applicability. The provisions of ICC 600 are applicable only to buildings located within Exposure B or C as defined in Section 1609.4. The provisions of ICC 600, AWC WFCM and AISI S230 shall not apply to buildings sited on the upper half of an isolated hill, ridge or escarpment meeting all of the following conditions:

1. The hill, ridge or escarpment is 60 feet (18 288 mm) or higher if located in Exposure B or 30 feet (9144 mm) or higher if located in Exposure C.
2. The maximum average slope of the hill exceeds 10 percent.
3. The hill, ridge or escarpment is unobstructed upwind by other such topographic features for a distance from the high point of 50 times the height of the hill or 2 miles (3.22 km), whichever is greater.

TABLE 1608.2
GROUND SNOW LOADS, p_g, FOR ALASKAN LOCATIONS

LOCATION	POUNDS PER SQUARE FOOT	LOCATION	POUNDS PER SQUARE FOOT	LOCATION	POUNDS PER SQUARE FOOT
Adak	30	Galena	60	Petersburg	150
Anchorage	50	Gulkana	70	St. Paul Islands	40
Angoon	70	Homer	40	Seward	50
Barrow	25	Juneau	60	Shemya	25
Barter Island	35	Kenai	70	Sitka	30
Bethel	40	Kodiak	30	Talkeetna	120
Big Delta	50	Kotzebue	60	Unalakleet	50
Cold Bay	25	McGrath	70	Valdez	160
Cordova	100	Nenana	80	Whittier	300
Fairbanks	60	Nome	70	Wrangell	60
Fort Yukon	60	Palmer	50	Yakutat	150

For SI: 1 pound per square foot = 0.0479 kN/m^2.

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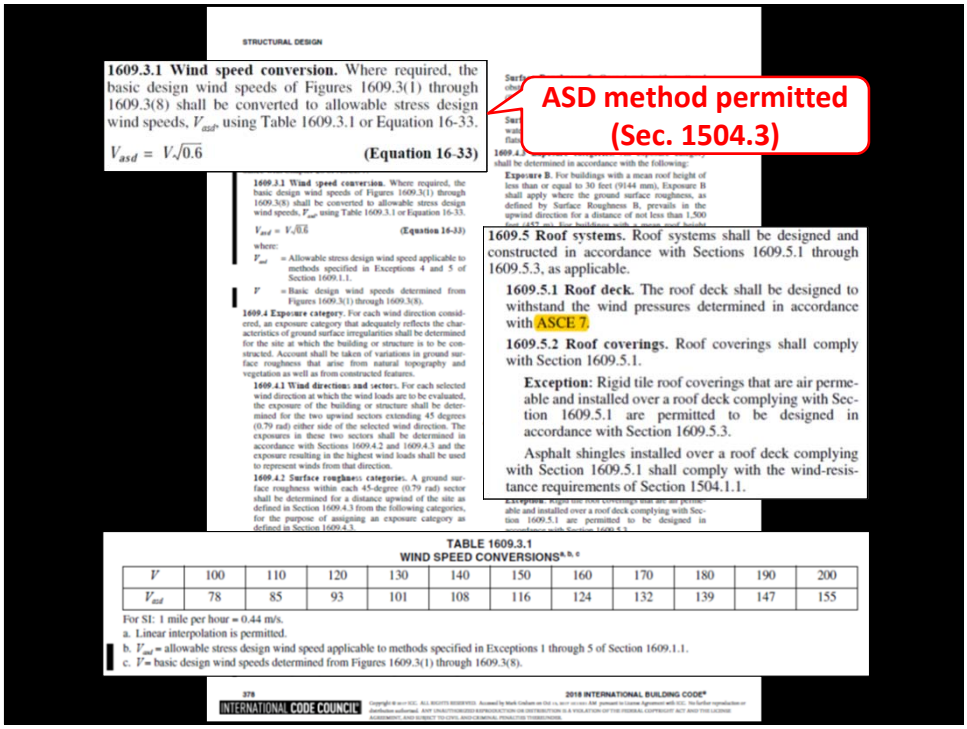
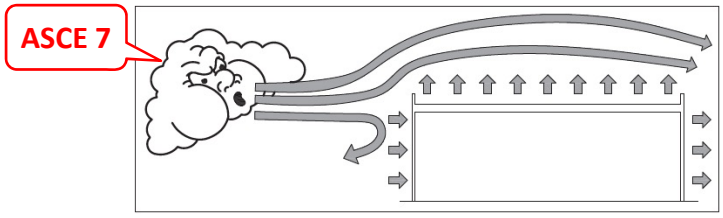


The fundamental concept



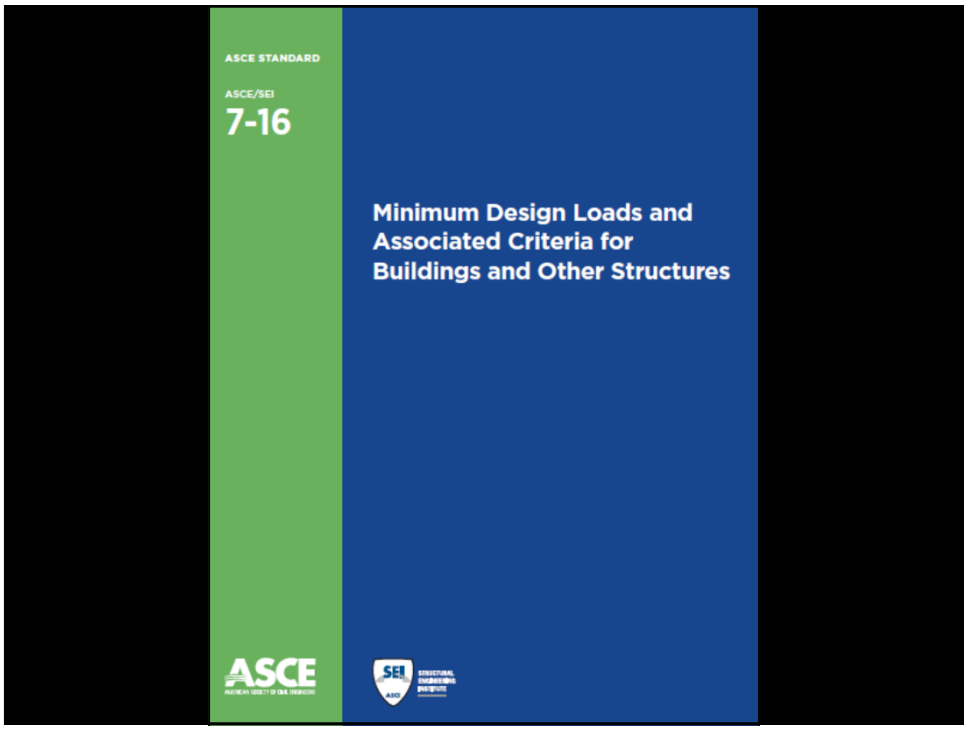
Wind creates pressures/forces
on building elements

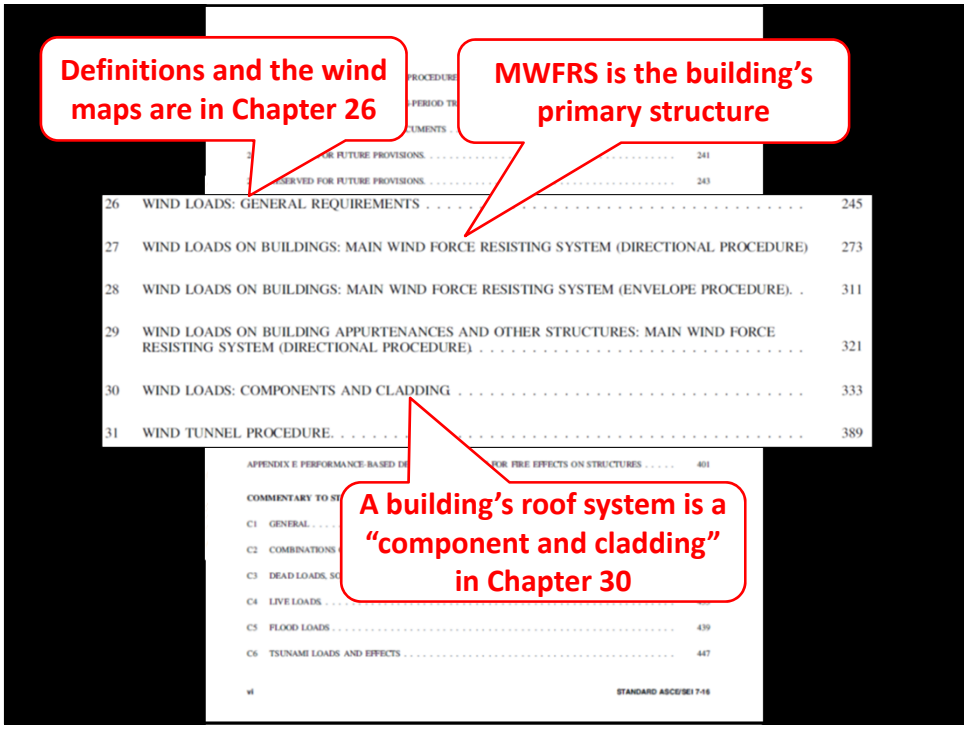
Fundamental concept -- continued

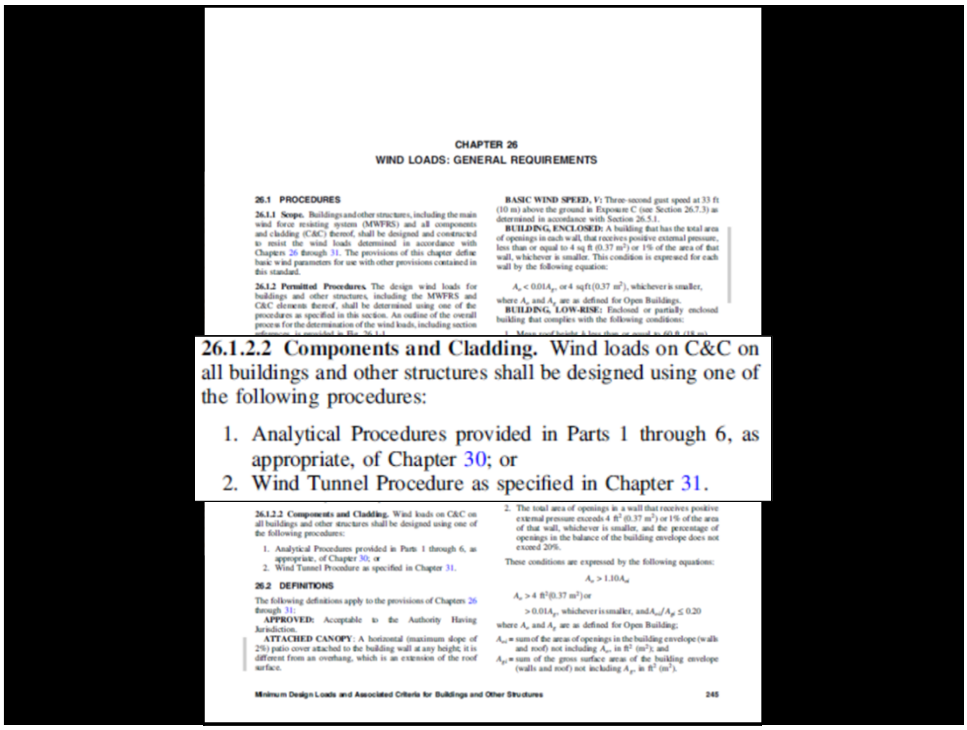
Adhesion or attachment ≥ Uplift pressure

- FM rating
- UL classification ≥ ASCE 7
- Engineering

It is as "simple" as that…







CHAPTER 26
WIND LOADS: GENERAL REQUIREMENTS

26.1 PROCEDURES

26.1.1 Scope. Buildings and other structures, including the main wind force resisting system (MWFRS) and all components and cladding (C&C) thereof, shall be designed and constructed to resist the wind loads determined in accordance with Chapters 26 through 31. The provisions of this chapter define basic wind parameters for use with other provisions contained in this standard.

26.1.2 Permitted Procedures. The design wind loads for buildings and other structures, including the MWFRS and C&C elements thereof, shall be determined using one of the procedures as specified in this section. An outline of the overall process for the determination of the wind loads, including section

26.1.2.2 Components and Cladding. Wind loads on C&C on all buildings and other structures shall be designed using one of the following procedures:

1. Analytical Procedures provided in Parts 1 through 6, as appropriate, of Chapter 30; or
2. Wind Tunnel Procedure as specified in Chapter 31.

BASIC WIND SPEED, *V*: Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 26.7.3) as determined in accordance with Section 26.5.1.

BUILDING, ENCLOSED: A building that has the total area of openings in each wall, that receives positive external pressure, less than or equal to 4 sq ft (0.37 m^2) or 1% of the area of that wall, whichever is smaller. This condition is expressed for each wall by the following equation:

$A_o < 0.01A_g$, or 4 sq ft (0.37 m^2), whichever is smaller,

where A_o and A_g are as defined for Open Buildings.

BUILDING, LOW-RISE: Enclosed or partially enclosed building that complies with the following conditions:

2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft^2 (0.37 m^2) or 1% of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20%.

These conditions are expressed by the following equations:

$A_o > 1.10A_{oi}$

$A_o > 4$ ft^2 (0.37 m^2) or

$> 0.01A_g$, whichever is smaller, and $A_{oi}/A_{gi} \le 0.20$

where A_o and A_g are as defined for Open Building;

A_{oi} = sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft^2 (m^2); and

A_{gi} = sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft^2 (m^2).

26.2 DEFINITIONS

The following definitions apply to the provisions of Chapters 26 through 31.

APPROVED: Acceptable to the Authority Having Jurisdiction.

ATTACHED CANOPY: A horizontal (maximum slope of 2%) patio cover attached to the building wall at any height; it is different from an overhang, which is an extension of the roof surface.

Minimum Design Loads and Associated Criteria for Buildings and Other Structures 245

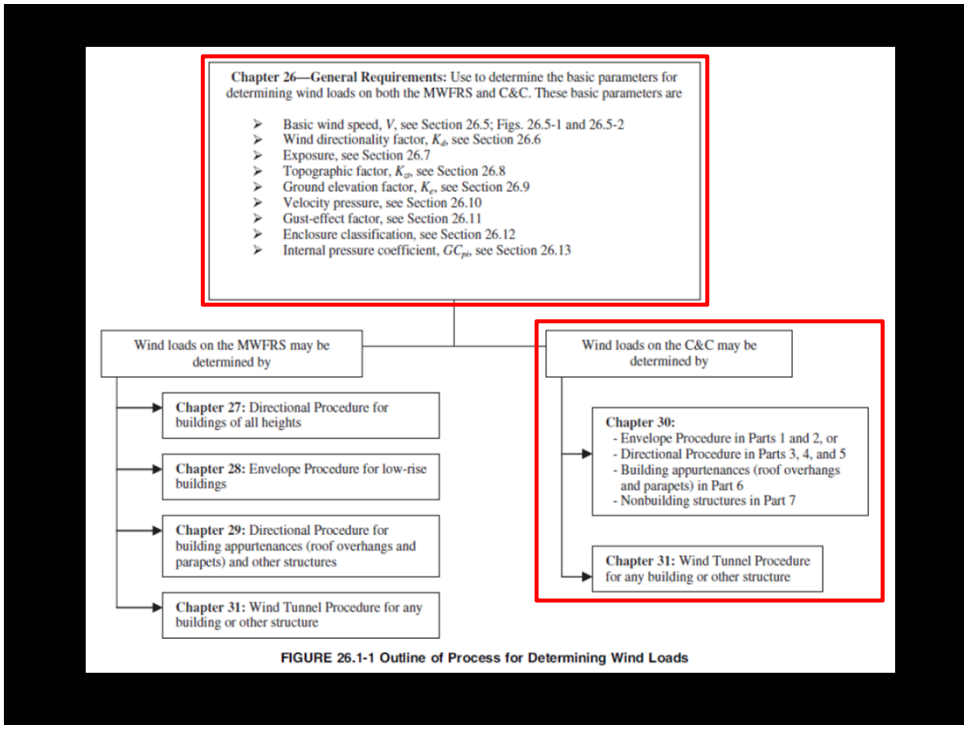
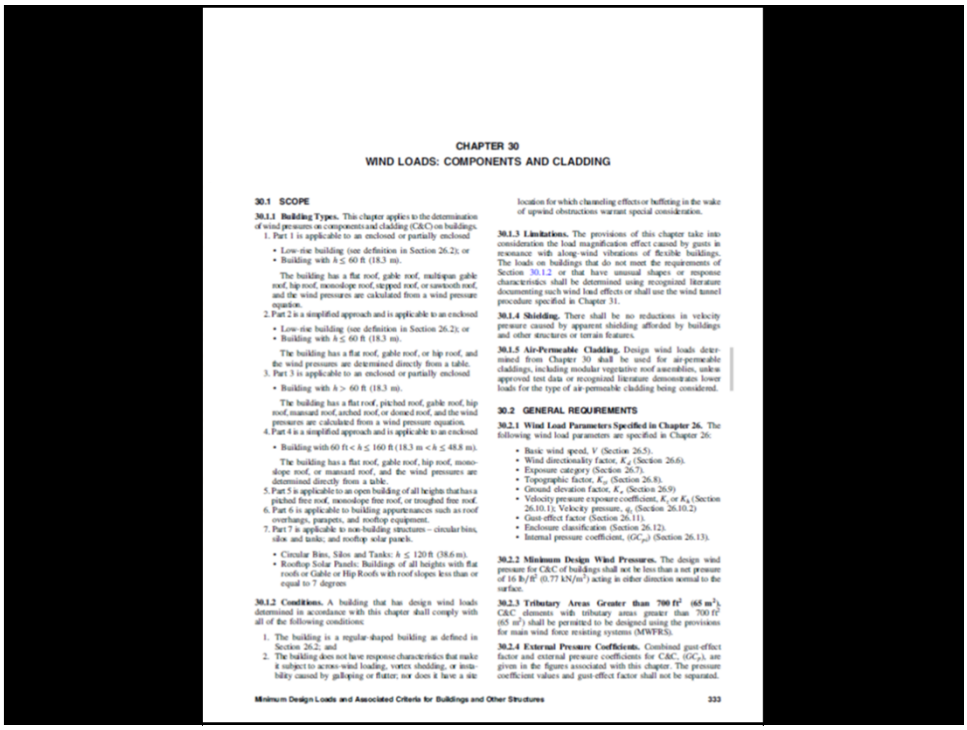


FIGURE 26.1-1 Outline of Process for Determining Wind Loads



CHAPTER 30
WIND LOADS: COMPONENTS AND CLADDING

30.1 SCOPE

30.1.1 Building Types. This chapter applies to the determination of wind pressures on components and cladding (C&C) on buildings.

1. Part 1 is applicable to an enclosed or partially enclosed
   - Low-rise building (see definition in Section 26.2); or
   - Building with $h \leq 60$ ft (18.3 m).

   The building has a flat roof, gable roof, multispan gable roof, hip roof, monoslope roof, stepped roof, or sawtooth roof, and the wind pressures are calculated from a wind pressure equation.
2. Part 2 is a simplified approach and is applicable to an enclosed
   - Low-rise building (see definition in Section 26.2); or
   - Building with $h \leq 60$ ft (18.3 m).

   The building has a flat roof, gable roof, or hip roof, and the wind pressures are determined directly from a table.
3. Part 3 is applicable to an enclosed or partially enclosed
   - Building with $h > 60$ ft (18.3 m).

   The building has a flat roof, pitched roof, gable roof, hip roof, mansard roof, arched roof, or domed roof, and the wind pressures are calculated from a wind pressure equation.
4. Part 4 is a simplified approach and is applicable to an enclosed
   - Building with 60 ft $< h \leq 160$ ft (18.3 m $< h \leq$ 48.8 m).

   The building has a flat roof, gable roof, hip roof, monoslope roof, or mansard roof, and the wind pressures are determined directly from a table.
5. Part 5 is applicable to an open building of all heights that has a pitched free roof, monoslope free roof, or troughed free roof.
6. Part 6 is applicable to building appurtenances such as roof overhangs, parapets, and rooftop equipment.
7. Part 7 is applicable to non-building structures – circular bins, silos and tanks; and rooftop solar panels.
   - Circular Bins, Silos and Tanks: $h \leq 120$ ft (38.6 m).
   - Rooftop Solar Panels: Buildings of all heights with flat roofs or Gable or Hip Roofs with roof slopes less than or equal to 7 degrees

30.1.2 Conditions. A building that has design wind loads determined in accordance with this chapter shall comply with all of the following conditions:

1. The building is a regular-shaped building as defined in Section 26.2; and
2. The building does not have response characteristics that make it subject to across-wind loading, vortex shedding, or instability caused by galloping or flutter; nor does it have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.

30.1.3 Limitations. The provisions of this chapter take into consideration the load magnification effect caused by gusts in resonance with along-wind vibrations of flexible buildings. The loads on buildings that do not meet the requirements of Section 30.1.2 or that have unusual shapes or response characteristics shall be determined using recognized literature documenting such wind load effects or shall use the wind tunnel procedure specified in Chapter 31.

30.1.4 Shielding. There shall be no reductions in velocity pressure caused by apparent shielding afforded by buildings and other structures or terrain features.

30.1.5 Air-Permeable Cladding. Design wind loads determined from Chapter 30 shall be used for air-permeable claddings, including modular vegetative roof assemblies, unless approved test data or recognized literature demonstrates lower loads for the type of air-permeable cladding being considered.

30.2 GENERAL REQUIREMENTS

30.2.1 Wind Load Parameters Specified in Chapter 26. The following wind load parameters are specified in Chapter 26:

- Basic wind speed, V (Section 26.5).
- Wind directionality factor, K_d (Section 26.6).
- Exposure category (Section 26.7).
- Topographic factor, K_{zt} (Section 26.8).
- Ground elevation factor, K_e (Section 26.9)
- Velocity pressure exposure coefficient, K_z or K_h (Section 26.10.1); Velocity pressure, q_z (Section 26.10.2)
- Gust-effect factor (Section 26.11).
- Enclosure classification (Section 26.12).
- Internal pressure coefficient, (GC_{pi}) (Section 26.13).

30.2.2 Minimum Design Wind Pressures. The design wind pressure for C&C of buildings shall not be less than a net pressure of 16 lb/ft^2 (0.77 kN/m^2) acting in either direction normal to the surface.

30.2.3 Tributary Areas Greater than 700 ft^2 (65 m^2). C&C elements with tributary areas greater than 700 ft^2 (65 m^2) shall be permitted to be designed using the provisions for main wind force resisting systems (MWFRS).

30.2.4 External Pressure Coefficients. Combined gust-effect factor and external pressure coefficients for C&C, (GC_p), are given in the figures associated with this chapter. The pressure coefficient values and gust-effect factor shall not be separated.

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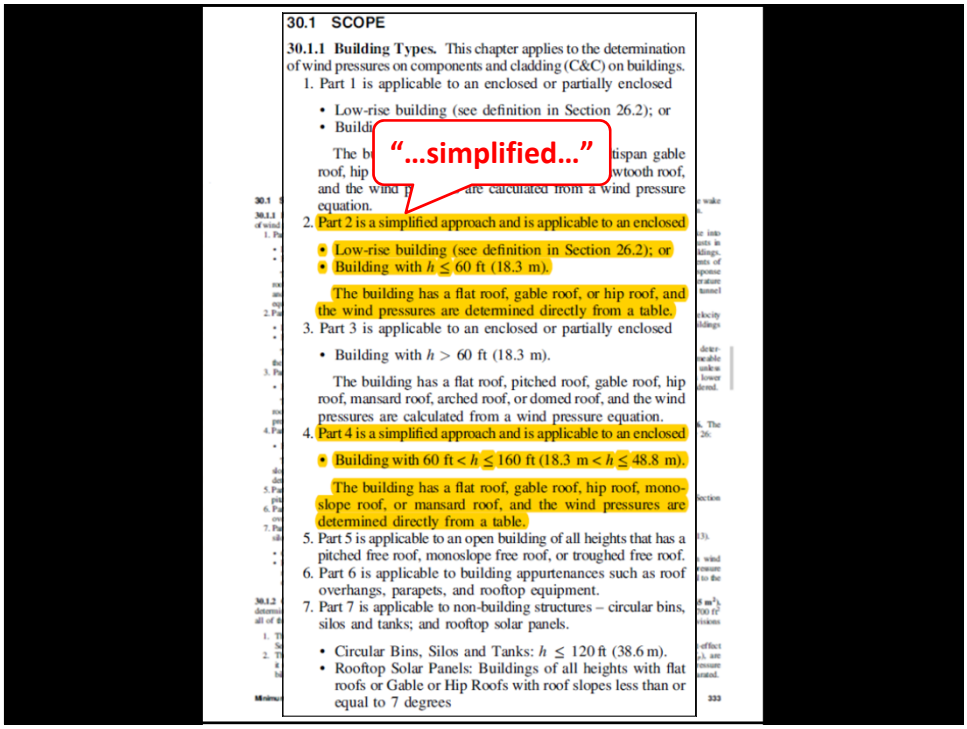
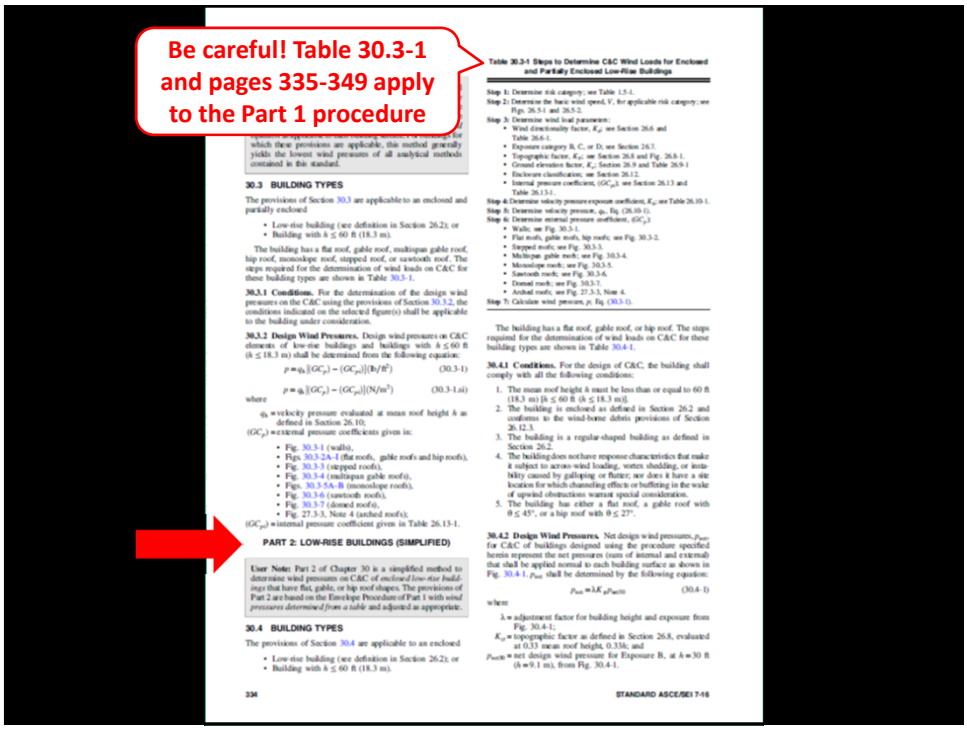

30.1 SCOPE
30.1.1 Building Types. This chapter applies to the determination of wind pressures on components and cladding (C&C) on buildings.
1. Part 1 is applicable to an enclosed or partially enclosed
• Low-rise building (see definition in Section 26.2); or
• Buildi
"...simplified..."
The b tispan gable roof, hip wtooth roof, and the wind p are calculated from a wind pressure equation.
2. Part 2 is a simplified approach and is applicable to an enclosed
• Low-rise building (see definition in Section 26.2); or
• Building with h ≤ 60 ft (18.3 m).
The building has a flat roof, gable roof, or hip roof, and the wind pressures are determined directly from a table.
3. Part 3 is applicable to an enclosed or partially enclosed
• Building with h > 60 ft (18.3 m).
The building has a flat roof, pitched roof, gable roof, hip roof, mansard roof, arched roof, or domed roof, and the wind pressures are calculated from a wind pressure equation.
4. Part 4 is a simplified approach and is applicable to an enclosed
• Building with 60 ft < h ≤ 160 ft (18.3 m < h ≤ 48.8 m).
The building has a flat roof, gable roof, hip roof, monoslope roof, or mansard roof, and the wind pressures are determined directly from a table.
5. Part 5 is applicable to an open building of all heights that has a pitched free roof, monoslope free roof, or troughed free roof.
6. Part 6 is applicable to building appurtenances such as roof overhangs, parapets, and rooftop equipment.
7. Part 7 is applicable to non-building structures – circular bins, silos and tanks; and rooftop solar panels.
• Circular Bins, Silos and Tanks: h ≤ 120 ft (38.6 m).
• Rooftop Solar Panels: Buildings of all heights with flat roofs or Gable or Hip Roofs with roof slopes less than or equal to 7 degrees


Be careful! Table 30.3-1 and pages 335-349 apply to the Part 1 procedure
Table 30.3-1 Steps to Determine C&C Wind Loads for Enclosed and Partially Enclosed Low-Rise Buildings
30.3 BUILDING TYPES
30.3.1 Conditions.
30.3.2 Design Wind Pressures.
PART 2: LOW-RISE BUILDINGS (SIMPLIFIED)
30.4 BUILDING TYPES
30.4.1 Conditions.
30.4.2 Design Wind Pressures.
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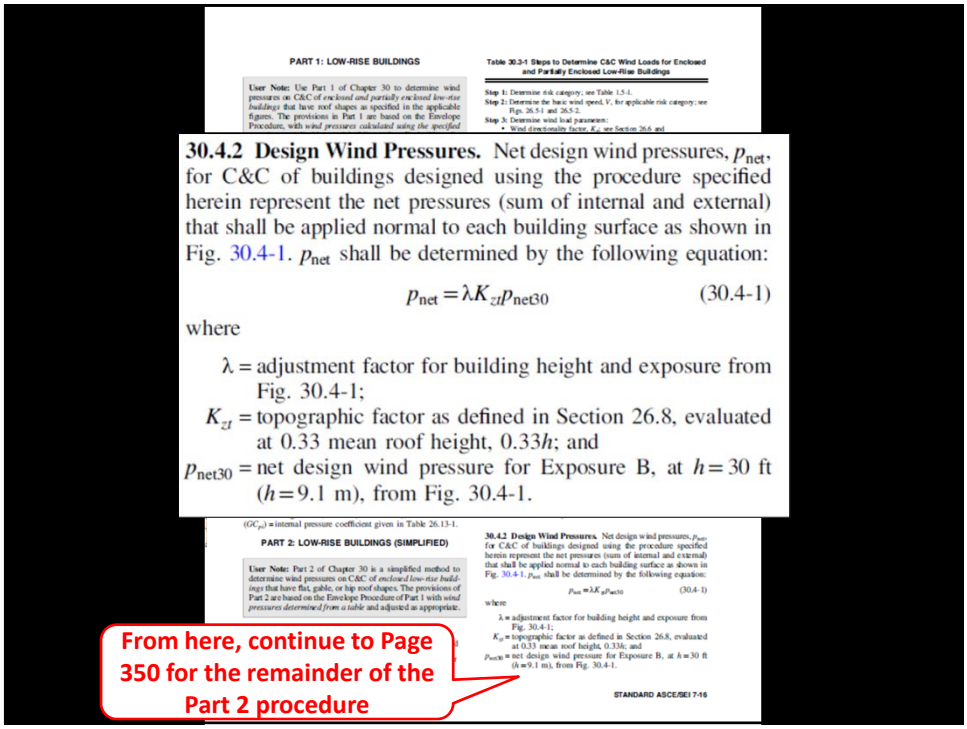
PART 1: LOW-RISE BUILDINGS
30.4.2 Design Wind Pressures. Net design wind pressures, p_{net}, for C&C of buildings designed using the procedure specified herein represent the net pressures (sum of internal and external) that shall be applied normal to each building surface as shown in Fig. 30.4-1. p_{net} shall be determined by the following equation:
$p_{net} = \lambda K_{zt} p_{net30}$ (30.4-1)
where
λ = adjustment factor for building height and exposure from Fig. 30.4-1;
K_{zt} = topographic factor as defined in Section 26.8, evaluated at 0.33 mean roof height, 0.33h; and
p_{net30} = net design wind pressure for Exposure B, at $h = 30$ ft ($h = 9.1$ m), from Fig. 30.4-1.
PART 2: LOW-RISE BUILDINGS (SIMPLIFIED)
From here, continue to Page 350 for the remainder of the Part 2 procedure

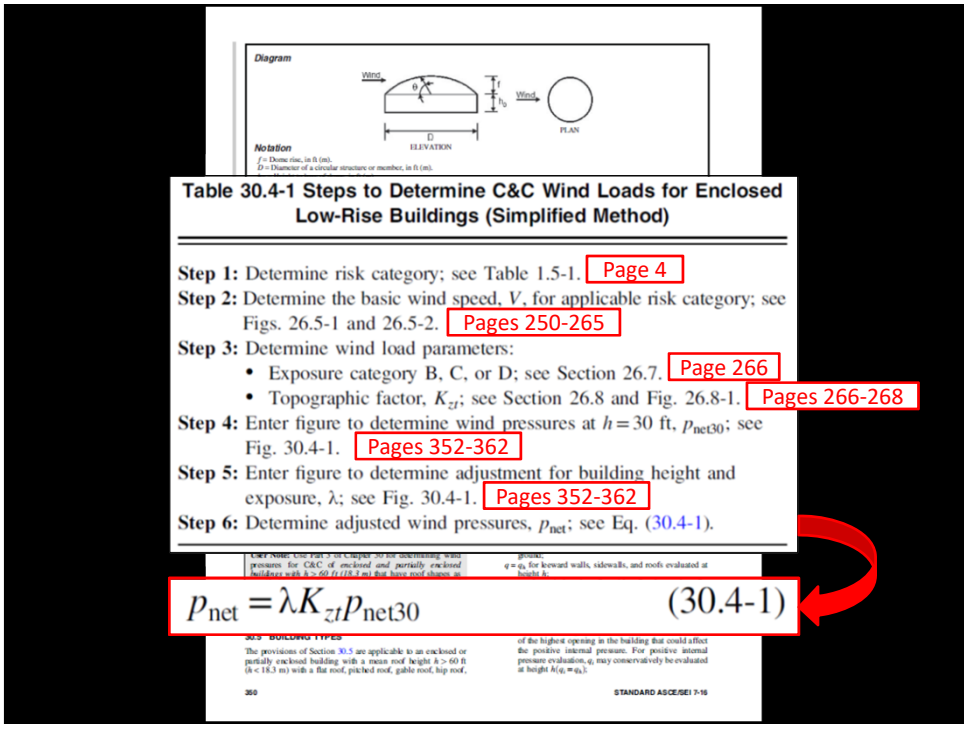
Diagram
Wind
ELEVATION
PLAN
Notation
Table 30.4-1 Steps to Determine C&C Wind Loads for Enclosed Low-Rise Buildings (Simplified Method)
Step 1: Determine risk category; see Table 1.5-1. Page 4
Step 2: Determine the basic wind speed, V, for applicable risk category; see Figs. 26.5-1 and 26.5-2. Pages 250-265
Step 3: Determine wind load parameters:
• Exposure category B, C, or D; see Section 26.7. Page 266
• Topographic factor, K_{zt}; see Section 26.8 and Fig. 26.8-1. Pages 266-268
Step 4: Enter figure to determine wind pressures at $h = 30$ ft, p_{net30}; see Fig. 30.4-1. Pages 352-362
Step 5: Enter figure to determine adjustment for building height and exposure, λ; see Fig. 30.4-1. Pages 352-362
Step 6: Determine adjusted wind pressures, p_{net}; see Eq. (30.4-1).
$p_{net} = \lambda K_{zt} p_{net30}$ (30.4-1)

Table 1.5-1 Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent low risk to human life in the event of failure	I
All buildings and other structures except those listed in Risk Categories I, III, and IV	II
Buildings and other structures, the failure of which could pose a substantial risk to human life	III
Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure	
Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released[a]	
Buildings and other structures designated as essential facilities	IV
Buildings and other structures, the failure of which could pose a substantial hazard to the community	
Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released[a]	
Buildings and other structures required to maintain the functionality of other Risk Category IV structures	

[a]Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower Risk Category if it can be demonstrated to the satisfaction of the Authority Having Jurisdiction by a hazard assessment as described in Section 1.5.3 that a release of the substances is commensurate with the risk associated with that Risk Category.

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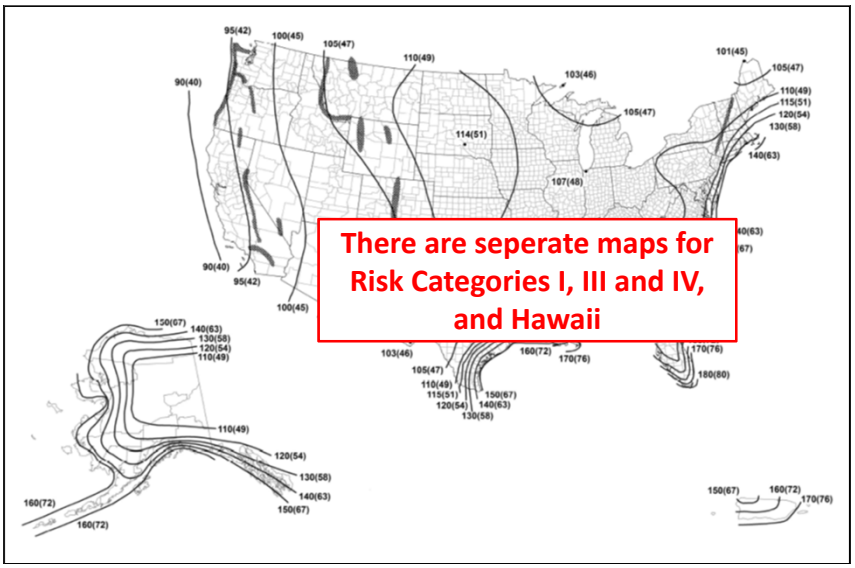


Figure 26.5-1B Basic Wind Speeds for Risk Category II Buildings and Other Structures

Table 26.6-1 Wind Directionality Factor, K_d

Structure Type	Directionality Factor K_d
Buildings	
Main Wind Force Resisting System	0.85
Components and Cladding	0.85
Arched Roofs	0.85
Circular Domes	1.0[a]
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Octagonal	1.0[a]
Round	1.0[a]
Solid Freestanding Walls, Roof Top Equipment, and Solid Freestanding and Attached Signs	0.85
Open Signs and Single-Plane Open Frames	0.85
Trussed Towers	
Triangular, square, or rectangular	0.85
All other cross sections	0.95

[a]Directionality factor K_d = 0.95 shall be permitted for round or octagonal structures with nonaxisymmetric structural systems.

26.6 WIND DIRECTIONALITY

The wind directionality factor, K_d, shall be determined from Table 26.6-1 and shall be included in the wind loads calculated in Chapters 27 to 30. The effect of wind directionality in determining wind loads in accordance with Chapter 31 shall be based on a rational analysis of the wind speeds conforming to the requirements of Section 26.5.3 and of Section 31.4.3.

26.7 EXPOSURE

For each wind direction considered, the upwind exposure shall be based on ground surface roughness that is determined from natural topography, vegetation, and constructed facilities.

26.7.2 Surface Roughness Categories. A ground surface roughness within each 45° sector shall be determined for a distance upwind of the site, as defined in Section 26.7.3, from the categories defined in the following text, for the purpose of assigning an exposure category as defined in Section 26.7.3.

Surface Roughness B: Urban and suburban areas, wooded areas, or other terrain with numerous, closely spaced obstructions that have the size of single-family dwellings or larger.

Surface Roughness C: Open terrain with scattered obstructions that have heights generally less than 30 ft (9.1 m). This category includes flat, open country and grasslands.

Surface Roughness D: Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

26.7.3 Exposure Categories.

Exposure B: For buildings or other structures with a mean roof height less than or equal to 30 ft (9.1 m), Exposure B shall apply where the ground surface roughness, as defined by Surface Roughness B, prevails in the upwind direction for a distance greater than 1,500 ft (457 m). For buildings or other structures with a mean roof height greater than 30 ft (9.1 m), Exposure B shall apply where Surface Roughness B prevails in the upwind direction for a distance greater than 2,600 ft (792 m) or 20 times the height of the building or structure, whichever is greater.

Exposure C: Exposure C shall apply for all cases where Exposure B or D does not apply.

Exposure D: Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance greater than 5,000 ft (1,524 m) or 20 times the building or structure height, whichever is greater. Exposure D shall also apply where the ground surface roughness immediately upwind of the site is B or C, and the site is within a distance of 600 ft (183 m) or 20 times the building or structure height, whichever is greater, from an Exposure D condition as defined in the previous sentence.

For a site located in the transition zone between exposure categories, the category resulting in the largest wind forces shall be used.

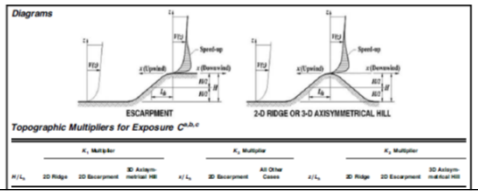
EXCEPTION: An intermediate exposure between the preceding categories is permitted in a transition zone, provided that it is determined by a rational analysis method defined in the recognized literature.

and Other Structures (Chapter 29). Wind loads for the design of building appurtenances (such as rooftop structures and equipment) and other structures (such as solid freestanding walls and freestanding signs, chimneys, tanks, open signs, single-plane open frames, and trussed towers) as specified in Chapter 29 shall be based on the appropriate exposure for each wind direction considered.

26.7.4 Components and Cladding (Chapter 30). Design wind pressures for C&C shall be based on the exposure category resulting in the highest wind loads for any wind direction at the site.

26.8 TOPOGRAPHIC EFFECTS

26.8.1 Wind Speed-Up over Hills, Ridges, and Escarpments. Wind speed-up effects at isolated hills, ridges, and escarpments constituting abrupt changes in the general topography, located in any exposure category, shall be included in the determination of the wind loads when site



Topographic Multipliers for Exposure C[a,b,c]

K_1 Multiplier				K_2 Multiplier			K_3 Multiplier		
H/L_h	2D Ridge	2D Escarpment	3D Axisymmetrical Hill	x/L_h	2D Escarpment	All Other Cases	z/L_h	2D Ridge	2D Escarpment	3D Axisymmetrical Hill

26.8.2 Topographic Factor. The wind speed-up effect shall be included in the calculation of design wind loads by using the factor K_{zt}:

$$K_{zt} = (1 + K_1 K_2 K_3)^2 \qquad (26.8\text{-}1)$$

where K_1, K_2, and K_3 are given in Fig. 26.8-1.

If site conditions and locations of buildings and other structures do not meet all the conditions specified in Section 26.8.1, then $K_{zt} = 1.0$.

z = Height above ground surface at the site of the building or other structure, in ft (m).
μ = Horizontal attenuation factor.
γ = Height attenuation factor.

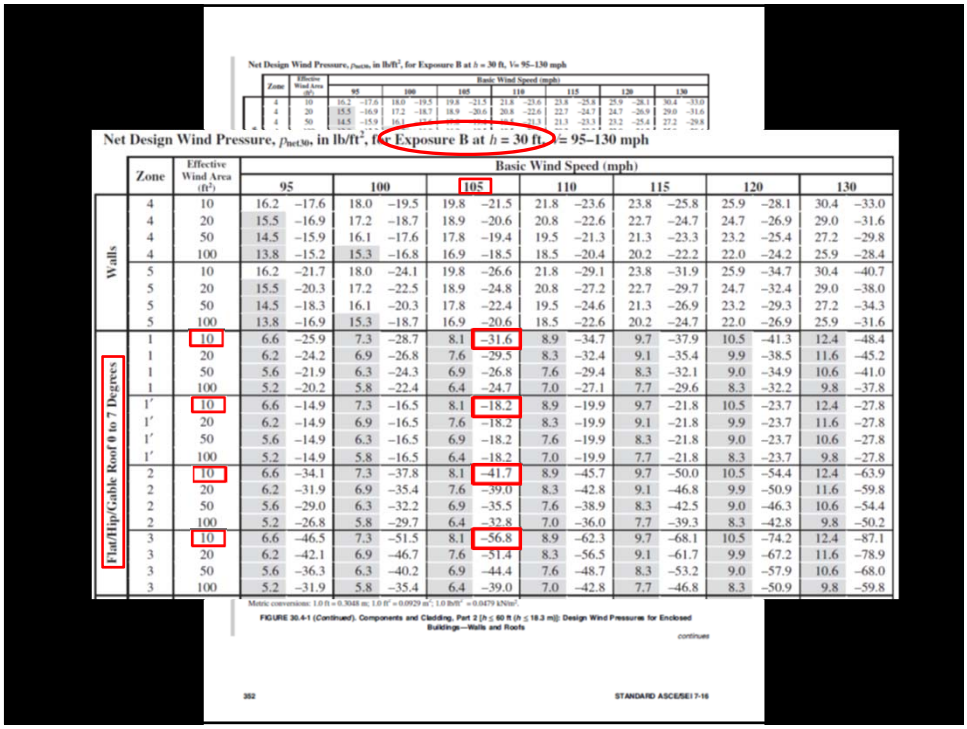
Equations

$K_{zt} = (1 + K_1 K_2 K_3)^2$
K_1 = determined from table below
$K_2 = (1 - |x|/\mu L_h)$
$K_3 = e^{-\gamma z/L_h}$

Parameters for Speed-Up over Hills and Escarpments

Hill Shape	$K_1/(H/L_h)$ Exposure B	C	D	γ	μ Upwind of Crest	μ Downwind of Crest
2D ridges (or valleys with negative H in $K_1/(H/L_h)$)	1.30	1.45	1.55	3	1.5	1.5
2D escarpments	0.75	0.85	0.95	2.5	1.5	4
3D axisymmetrical hill	0.95	1.05	1.15	4	1.5	1.5

FIGURE 26.8-1 Topographic Factor, K_{zt}



Net Design Wind Pressure, p_{net30}, in lb/ft^2, for Exposure B at h = 30 ft, V= 95–130 mph

	Zone	Effective Wind Area (ft^2)	Basic Wind Speed (mph) 95		100		105		110		115		120		130	
Walls	4	10	16.2	−17.6	18.0	−19.5	19.8	−21.5	21.8	−23.6	23.8	−25.8	25.9	−28.1	30.4	−33.0
	4	20	15.5	−16.9	17.2	−18.7	18.9	−20.6	20.8	−22.6	22.7	−24.7	24.7	−26.9	29.0	−31.6
	4	50	14.5	−15.9	16.1	−17.6	17.8	−19.4	19.5	−21.3	21.3	−23.3	23.2	−25.4	27.2	−29.8
	4	100	13.8	−15.2	15.3	−16.8	16.9	−18.5	18.5	−20.4	20.2	−22.2	22.0	−24.2	25.9	−28.4
	5	10	16.2	−21.7	18.0	−24.1	19.8	−26.6	21.8	−29.1	23.8	−31.9	25.9	−34.7	30.4	−40.7
	5	20	15.5	−20.3	17.2	−22.5	18.9	−24.8	20.8	−27.2	22.7	−29.7	24.7	−32.4	29.0	−38.0
	5	50	14.5	−18.3	16.1	−20.3	17.8	−22.4	19.5	−24.6	21.3	−26.9	23.2	−29.3	27.2	−34.3
	5	100	13.8	−16.9	15.3	−18.7	16.9	−20.6	18.5	−22.6	20.2	−24.7	22.0	−26.9	25.9	−31.6
Flat/Hip/Gable Roof 0 to 7 Degrees	1	10	6.6	−25.9	7.3	−28.7	8.1	−31.6	8.9	−34.7	9.7	−37.9	10.5	−41.3	12.4	−48.4
	1	20	6.2	−24.2	6.9	−26.8	7.6	−29.5	8.3	−32.4	9.1	−35.4	9.9	−38.5	11.6	−45.2
	1	50	5.6	−21.9	6.3	−24.3	6.9	−26.8	7.6	−29.4	8.3	−32.1	9.0	−34.9	10.6	−41.0
	1	100	5.2	−20.2	5.8	−22.4	6.4	−24.7	7.0	−27.1	7.7	−29.6	8.3	−32.2	9.8	−37.8
	1′	10	6.6	−14.9	7.3	−16.5	8.1	−18.2	8.9	−19.9	9.7	−21.8	10.5	−23.7	12.4	−27.8
	1′	20	6.2	−14.9	6.9	−16.5	7.6	−18.2	8.3	−19.9	9.1	−21.8	9.9	−23.7	11.6	−27.8
	1′	50	5.6	−14.9	6.3	−16.5	6.9	−18.2	7.6	−19.9	8.3	−21.8	9.0	−23.7	10.6	−27.8
	1′	100	5.2	−14.9	5.8	−16.5	6.4	−18.2	7.0	−19.9	7.7	−21.8	8.3	−23.7	9.8	−27.8
	2	10	6.6	−34.1	7.3	−37.8	8.1	−41.7	8.9	−45.7	9.7	−50.0	10.5	−54.4	12.4	−63.9
	2	20	6.2	−31.9	6.9	−35.4	7.6	−39.0	8.3	−42.8	9.1	−46.8	9.9	−50.9	11.6	−59.8
	2	50	5.6	−29.0	6.3	−32.2	6.9	−35.5	7.6	−38.9	8.3	−42.5	9.0	−46.3	10.6	−54.4
	2	100	5.2	−26.8	5.8	−29.7	6.4	−32.8	7.0	−36.0	7.7	−39.3	8.3	−42.8	9.8	−50.2
	3	10	6.6	−46.5	7.3	−51.5	8.1	−56.8	8.9	−62.3	9.7	−68.1	10.5	−74.2	12.4	−87.1
	3	20	6.2	−42.1	6.9	−46.7	7.6	−51.4	8.3	−56.5	9.1	−61.7	9.9	−67.2	11.6	−78.9
	3	50	5.6	−36.3	6.3	−40.2	6.9	−44.4	7.6	−48.7	8.3	−53.2	9.0	−57.9	10.6	−68.0
	3	100	5.2	−31.9	5.8	−35.4	6.4	−39.0	7.0	−42.8	7.7	−46.8	8.3	−50.9	9.8	−59.8

Metric conversions: 1.0 ft = 0.3048 m; 1.0 ft^2 = 0.0929 m^2; 1.0 lb/ft^2 = 0.0479 kN/m^2.

FIGURE 30.4-1 (Continued). Components and Cladding, Part 2 [$h \le 60$ ft ($h \le 18.3$ m)]: Design Wind Pressures for Enclosed Buildings—Walls and Roofs

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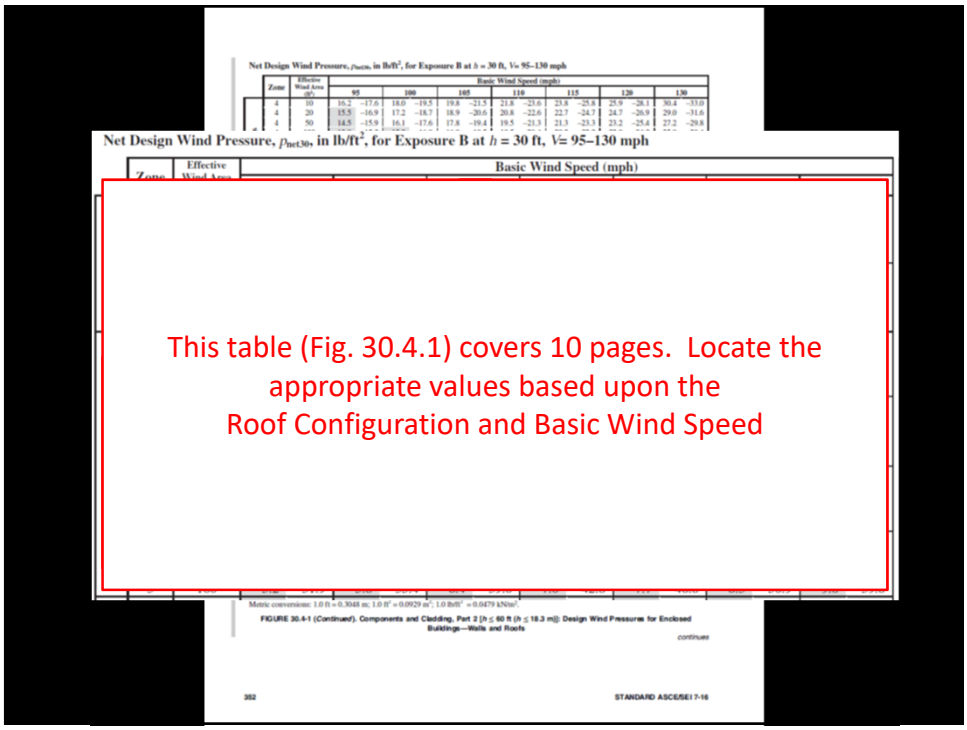

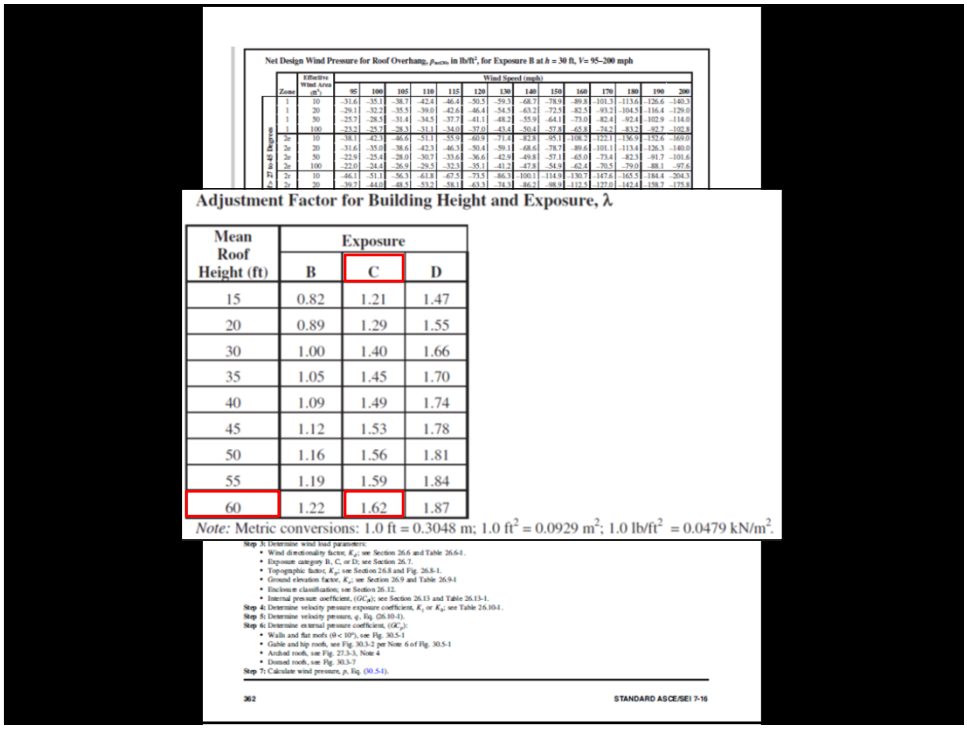

Net Design Wind Pressure for Roof Overhang, p_{net3}, in lb/ft², for Exposure B at h = 30 ft, V= 95–200 mph

	Zone	Effective Wind Area (ft²)	Wind Speed (mph) 95	100	105	110	115	120	130	140	150	160	170	180	190	200
Flat, Low-Slope ($\theta \le 7°$)	1	10	-31.6	-35.1	-38.7	-42.4	-46.4	-50.5	-59.3	-68.7	-78.9	-89.8	-101.3	-113.6	-126.6	-140.3
	1	20	-29.1	-32.2	-35.5	-39.0	-42.6	-46.4	-54.5	-63.2	-72.5	-82.5	-93.2	-104.5	-116.4	-129.0
	1	50	-25.7	-28.5	-31.4	-34.5	-37.7	-41.1	-48.2	-55.9	-64.1	-73.0	-82.4	-92.4	-102.9	-114.0
	1	100	-23.2	-25.7	-28.3	-31.1	-34.0	-37.0	-43.4	-50.4	-57.8	-65.8	-74.2	-83.2	-92.7	-102.8
	2e	10	-38.1	-42.3	-46.6	-51.1	-55.9	-60.9	-71.5	-82.8	-95.1	-108.2	-122.1	-136.9	-152.6	-169.0
	2e	20	-31.6	-35.0	-38.6	-42.3	-46.3	-50.4	-59.1	-68.6	-78.7	-89.6	-101.1	-113.4	-126.3	-140.0
	2e	50	-22.9	-25.4	-28.0	-30.7	-33.6	-36.6	-42.9	-49.8	-57.1	-65.0	-73.4	-82.3	-91.7	-101.6
	2e	100	-22.0	-24.4	-26.9	-29.5	-32.3	-35.1	-41.2	-47.8	-54.9	-62.4	-70.5	-79.0	-88.1	-97.6
	2r	10	-46.1	-51.1	-56.3	-61.8	-67.5	-73.5	-86.3	100.1	-114.9	-130.7	-147.6	-165.5	-184.4	-204.3
	2r	20	-39.7	-44.0	-48.5	-53.2	-58.1	-63.3	-74.3	-86.2	-98.9	-112.5	-127.0	-142.4	-158.7	-175.8

Adjustment Factor for Building Height and Exposure, λ

Mean Roof Height (ft)	Exposure B	Exposure C	Exposure D
15	0.82	1.21	1.47
20	0.89	1.29	1.55
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

Note: Metric conversions: 1.0 ft = 0.3048 m; 1.0 ft² = 0.0929 m²; 1.0 lb/ft² = 0.0479 kN/m².

Step 3: Determine wind load parameters:
- Wind directionality factor, K_d; see Section 26.6 and Table 26.6-1.
- Exposure category B, C, or D; see Section 26.7.
- Topographic factor, K_{zt}; see Section 26.8 and Fig. 26.8-1.
- Ground elevation factor, K_e; see Section 26.9 and Table 26.9-1
- Enclosure classification; see Section 26.12.
- Internal pressure coefficient, (GC_{pi}); see Section 26.13 and Table 26.13-1.

Step 4: Determine velocity pressure exposure coefficient, K_z or K_h; see Table 26.10-1.
Step 5: Determine velocity pressure, q_z Eq. (26.10-1).
Step 6: Determine external pressure coefficient, (GC_p):
- Walls and flat roofs ($\theta < 10°$), see Fig. 30.5-1
- Gable and hip roofs, see Fig. 30.3-2 per Note 6 of Fig. 30.5-1
- Arched roofs, see Fig. 27.3-3, Note 4
- Domed roofs, see Fig. 30.3-7

Step 7: Calculate wind pressure, p, Eq. (30.5-1).

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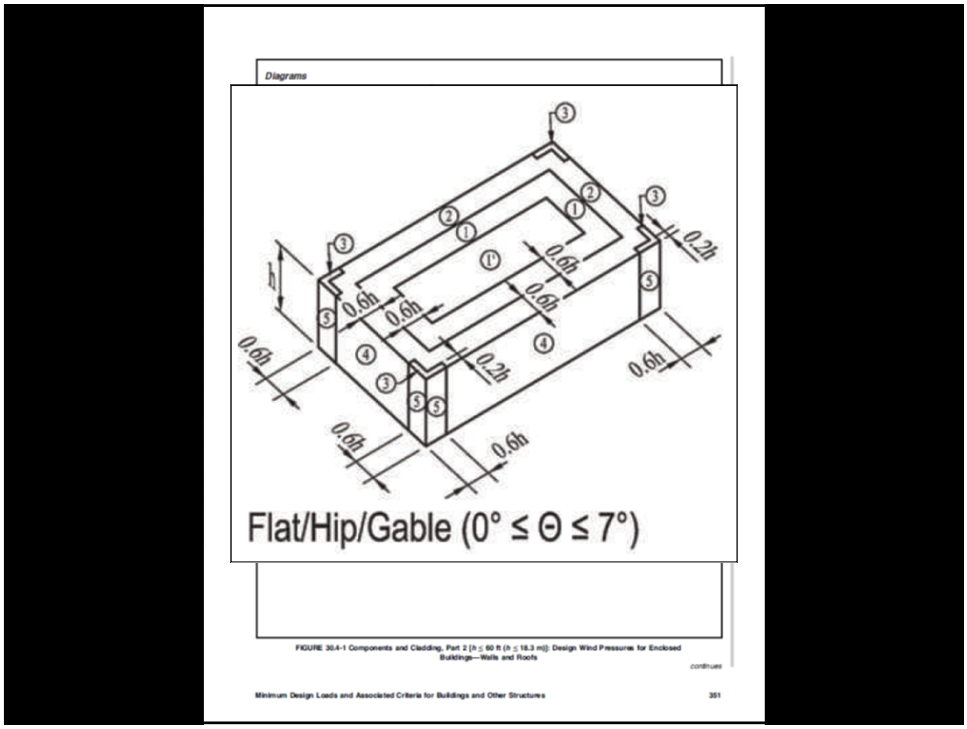
30.4.2 Design Wind Pressures. Net design wind pressures, p_{net}, for C&C of buildings designed using the procedure specified herein represent the net pressures (sum of internal and external) that shall be applied normal to each building surface as shown in Fig. 30.4-1. p_{net} shall be determined by the following equation:

$$p_{net} = \lambda K_{zt} p_{net30} \qquad (30.4\text{-}1)$$

So for our hypothetical example, where:

- Enclosed structure
- Risk Category II
- v = 105 mph
- Exposure C
- K_{ZT} = 1.0
- Mean roof height = 60 ft

Zone 1': p_{net} = 1.62 x 1.0 x (-18.2) = -29.5 psf
Zone 1: p_{net} = 1.62 x 1.0 x (-31.6) = -51.2 psf
Zone 2: p_{net} = 1.62 x 1.0 x (-41.7) = -67.6 psf
Zone 3: p_{net} = 1.62 x 1.0 x (-56.8) = -90.1 psf



For buildings with 60 ft. < h ≤ 160 ft.

ASCE 7-16, Chapter 30, Part 4

User Note: Part 4 of Chapter 30 is a simplified method for determining wind pressures for C&C *of enclosed buildings with* 60 ft < $h \leq 160$ ft (18.3 m < $h \leq 48.8$ m) that have roof shapes as specified in the applicable figures. These provisions are based on the Directional Procedure from Part 3 with *wind pressures selected directly from a table* and adjusted as applicable. Fig. 30.4-1 in Part 2 is referenced for buildings with $h \leq 60$ ft ($h \leq 18.3$ m) for all roof shapes and for the specified roof shapes when $h > 60$ ft ($h > 18.3$ m).

Final design wind pressure shall be determined from the following equation:

$$p = p_{\text{table}}(\text{EAF})(\text{RF})K_{zt} \qquad (30.6\text{-}1)$$

where

RF = effective area reduction factor from Table 30.6-2;
EAF = exposure adjustment factor from Table 30.6-2; and
K_{zt} = topographic factor as defined in Section 26.8.

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Table 30.6-1 Steps to Determine C&C Wind Loads for Enclosed Building with 60 ft < $h \leq$ 160 ft (18.3 m < $h \leq$ 48.8 m)

Step 1: Determine risk category of building; see Table 1.5-1. Page 4

Step 2: Determine the basic wind speed, V, for applicable risk category; see Figs. 26.5-1 and 26.5-2. Pages 250-265

Step 3: Determine wind load parameters:

- Exposure category B, C, or D; see Section 26.7. Page 266

Step 4: For flat, gable, hip, monoslope, and mansard roofs with $h \leq 60$ ft ($h \leq 18.3$ m), refer to the figures in Table 30.6-2 and determine roof and wall pressures directly from Fig. 30.4-1. Page 365 and Pages 352-362

Step 5: For flat and monoslope roofs with $h > 60$ ft ($h > 18.3$ m), see Table 30.6-2 to determine pressure on walls and roof, p_h. Pages 368-373

For flat, hip, gable, monoslope, and mansard roofs with $h > 60$ ft ($h > 18.3$ m) and roof slope $\theta \leq 7$ degrees, apply roof pressur Pages 368-373

For hip and gable roofs with $h > 60$ ft ($h > 18.3$ m) and all roof slopes $\theta > 7$ degrees, apply Fig. 30.4-1 with appropriate velocity pressure q_h.

Step 6: Determine topographic factor, K_{zt}, and apply factor to pressures determined from tables (if applicable); see Section 26.8. Pages 266-268

$$p = p_{\text{table}}(\text{EAF})(\text{RF})K_{zt} \qquad (30.6\text{-}1)$$

Determination of q_h is from Part 1: Low-rise Buildings ***(Not "simplified")***

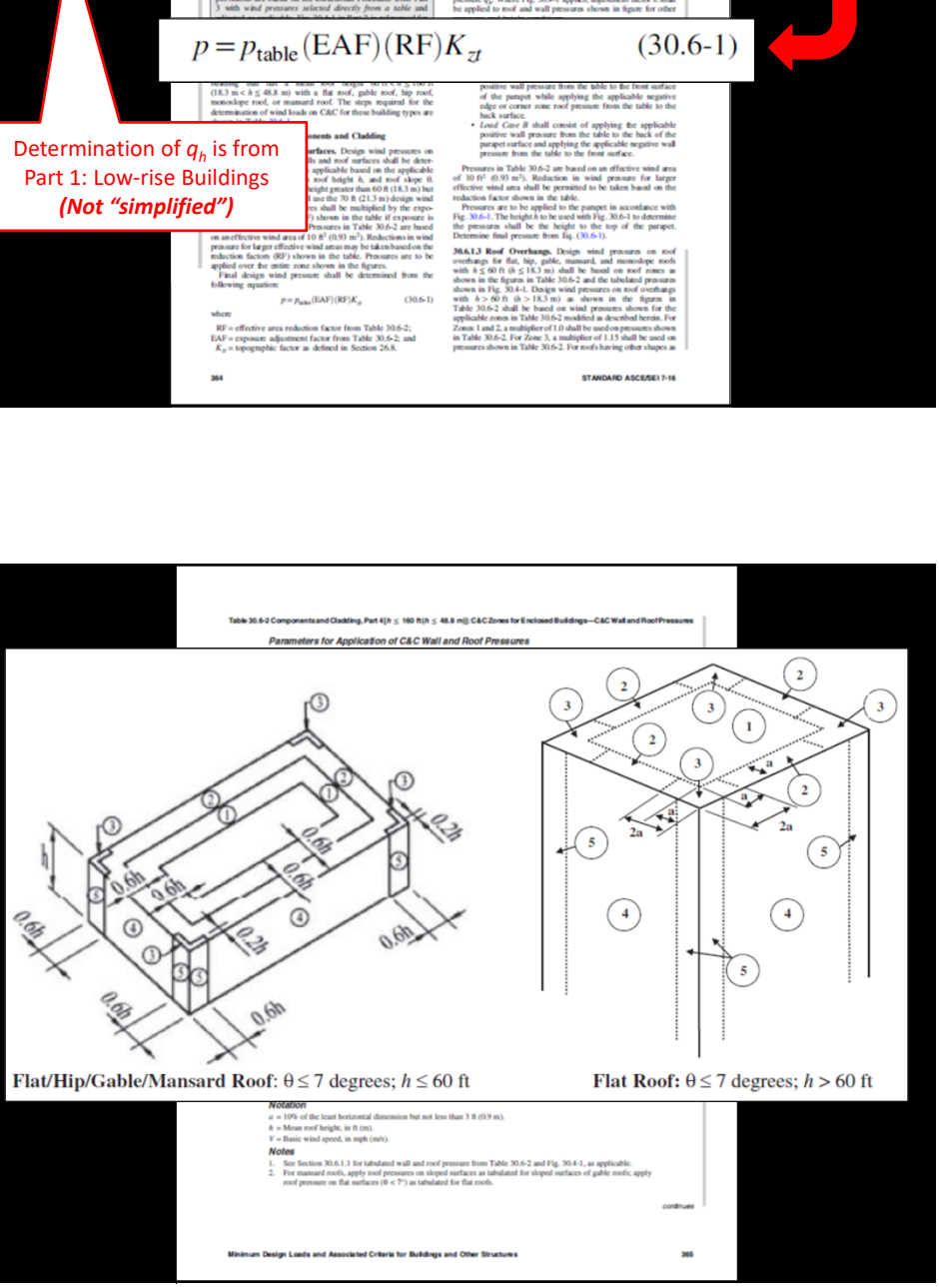


Table 30.6-2 Components and Cladding, Part 4(h ≤ 160 ft(h ≤ 48.8 m)): C&C Zones for Enclosed Buildings—C&C Wall and Roof Pressures

Parameters for Application of C&C Wall and Roof Pressures

Flat/Hip/Gable/Mansard Roof: $\theta \leq 7$ degrees; $h \leq 60$ ft

Flat Roof: $\theta \leq 7$ degrees; $h > 60$ ft

Notation

a = 10% of the least horizontal dimension but not less than 3 ft (0.9 m).

h = Mean roof height, in ft (m).

V = Basic wind speed, in mph (m/s).

Notes

1. See Section 30.6.1.1 for tabulated wall and roof pressure from Table 30.6-2 and Fig. 30.4-1, as applicable.
2. For mansard roofs, apply roof pressures on sloped surfaces as tabulated for sloped surfaces of gable roofs; apply roof pressure on flat surfaces ($\theta < 7°$) as tabulated for flat roofs.

continues

Minimum Design Loads and Associated Criteria for Buildings and Other Structures 365

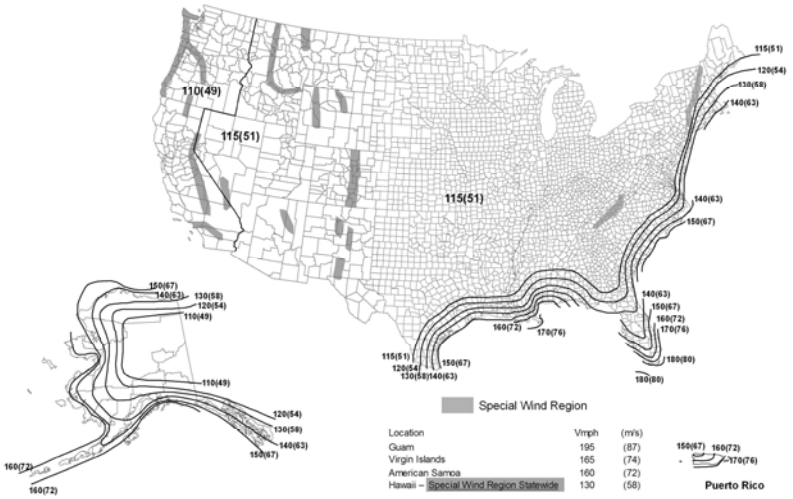
…so, it really is "simplified".

Noteworthy changes in ASCE 7-16

Compared to ASCE 7-10

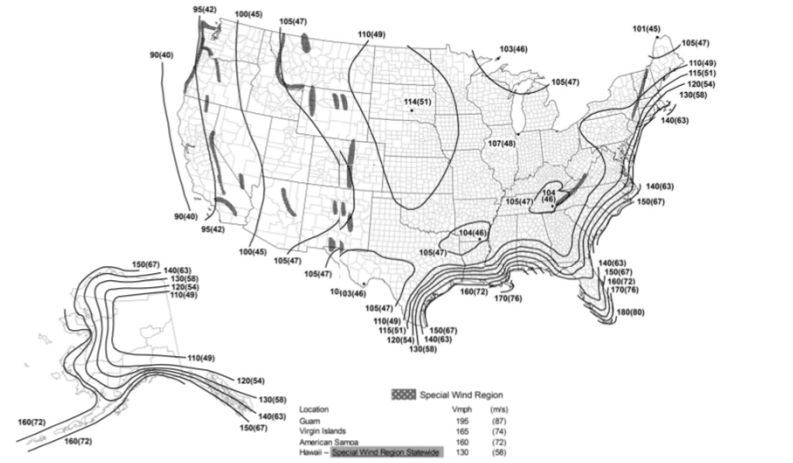
ASCE 7-10 basic wind speed map

Fig. 1607A--V_{ult} for Risk Category II Buildings



ASCE 7-16 basic wind speed map

Risk Category II Buildings



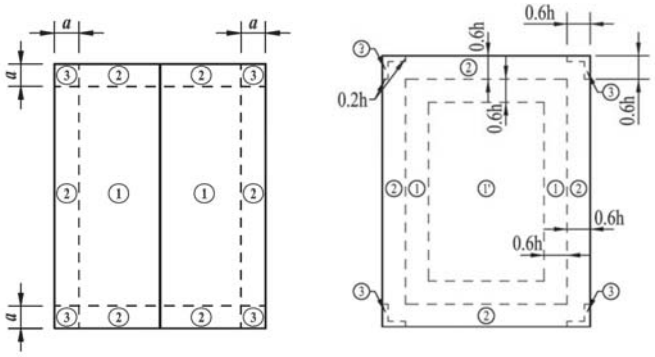
Comparing GC_p pressure coefficients

h ≤ 60 ft., gable roofs ≤ 7 degrees

Zone	ASCE 7-10	ASCE 7-16	Change
1'	n/a	0.9	-10%
1 (field)	-1.0	-1.7	+70%
2 (perimeter)	-1.8	-2.3	+28%
3 (corners)	-2.8	-3.2	+14%

Zones

h ≤ 60 ft., gable roofs ≤ 7 degrees



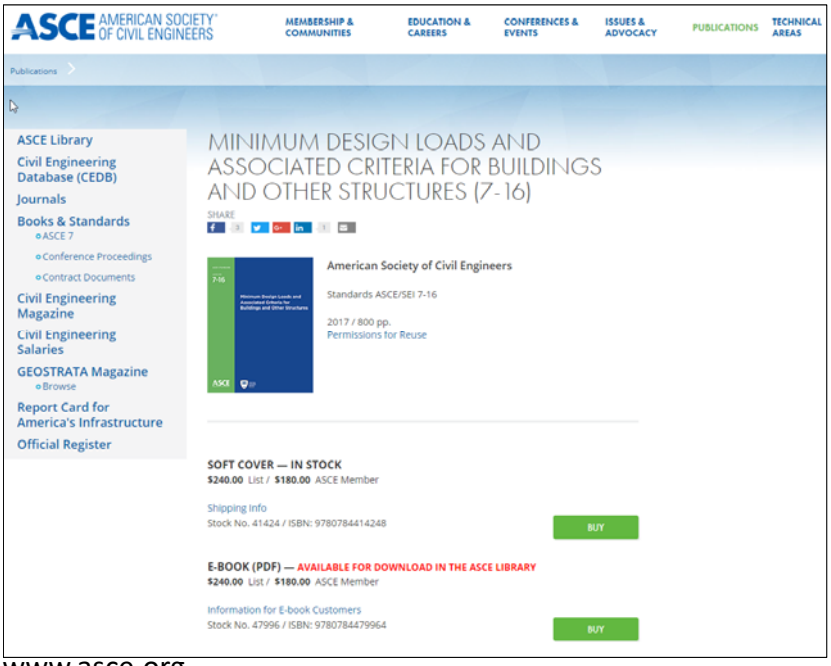
ASCE 7-10 **ASCE 7-16**

Noteworthy changes in ASCE 7-16

compared to ASCE 7-10

- Revised basic wind speed map
- Changes (and new) pressure coefficients
- Revised perimeter and corner zones

While center field pressures may be slightly lower, field, perimeter and corner uplift pressures will generally be greater



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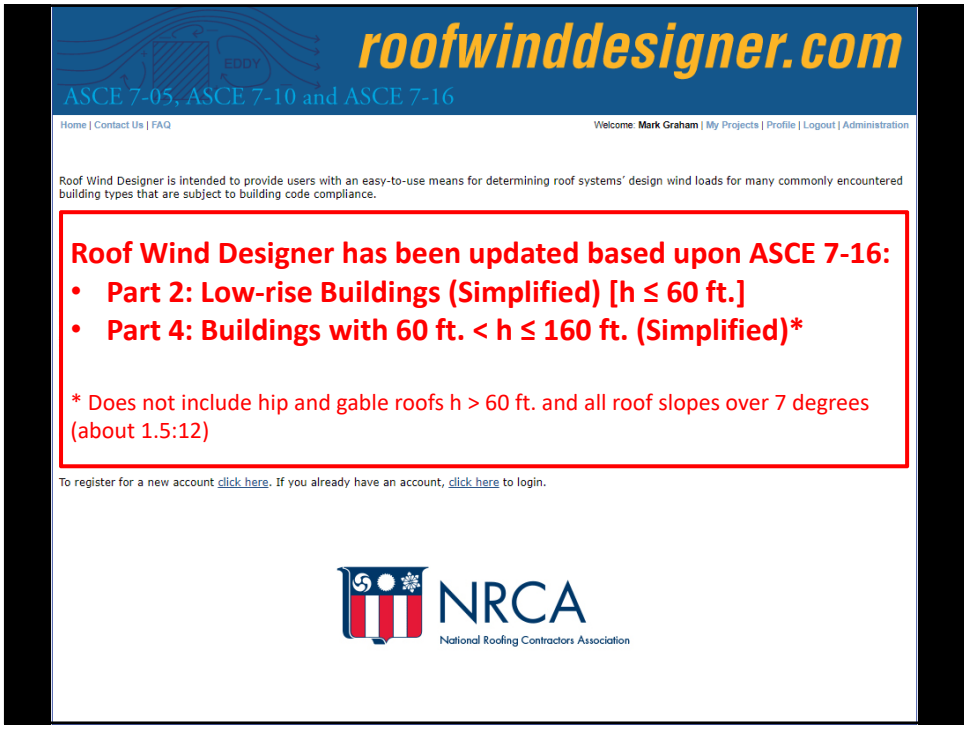

How the roofing industry will adapt to ASCE 7-16 remains to be seen….

FM Global has indicated they will update their FM 1-28 to be based on ASCE 7-16 (with modifications) by the end of the 2018.

Comparing FM 1-28 and ASCE 7-05, -10 & -16

Example: A manufacturing building is located in New Orleans, LA. The building is an enclosed structure with a low-slope roof system and a roof height of 35 ft. The building is located in an area that is categorized as Exposure Category C.

Document	Basic wind speed (mph)	Design wind pressure (psf)			
		Zone 1' (Center)	Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corners)
ASCE 7-05	120	NA	38	61	95
FM 1-28	120	NA	43	72	109
ASCE 7-10 Strength design	150	NA	59	96	148
ASCE 7-10 ASD	116	NA	35	59	89
ASCE 7-16 Strength design	150	47	81	107	146
ASCE 7-16 ASD	116	28	49	65	88

This comparison illustrates why it is important for Designers to include wind design loads in their Construction Documents (per IBC Sec. 1603.1)…

…It also illustrate why specifying a wind warrantee can create an uneven playing field. Unless the Designer indicates the wind design loads, which design method will the manufacturer use (e.g., in a competitive environment)?

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