CRCA
CHICAGO ROOFING CONTRACTORS ASSOCIATION

Roofing Week in Chicago

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Chicago Area Chapter IIBEC International Institute of Building Enclosure Consultants

Roofing & New Wind Uplift Requirements in 2018's Codes

NRCA

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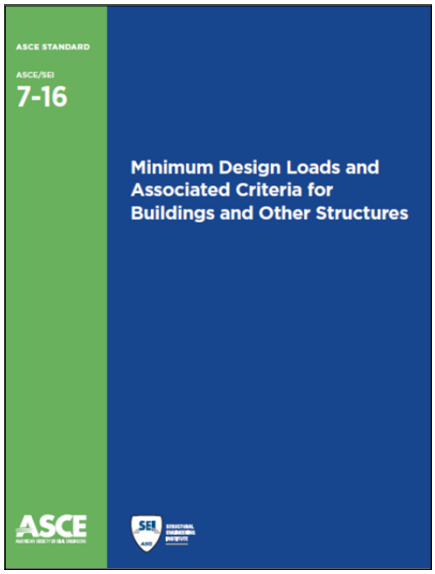

- Provisions: 402 pages
- Commentary: 417 pages

- Soft cover
- Electronic file (PDF)

www.asce.org

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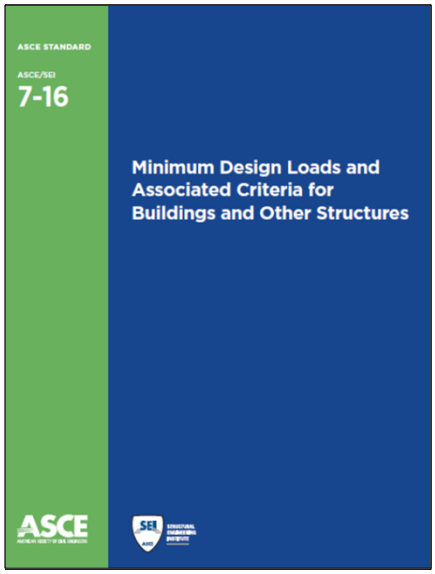

Wind loads:

Ch. 26—General requirements

Ch. 27—Buildings-MWFRS (Directional procedure)

Ch. 28—Buildings-MWFRS (Envelope procedure)

Ch. 29—Appurtenances & other structures

Ch. 30—Components and cladding

- Part 1: Enclosed and partially-enclosed (low-rise)
- Part 2: Simplified method (low-rise)
- Part 3: Enclosed and partially-enclosed
- Part 4: Simplified method (60 ft. < h ≤ 160 ft.)
- Part 5: Open buildings
- Part 6: Parapets & rooftop equipment

Ch. 31—Wind tunnel procedure

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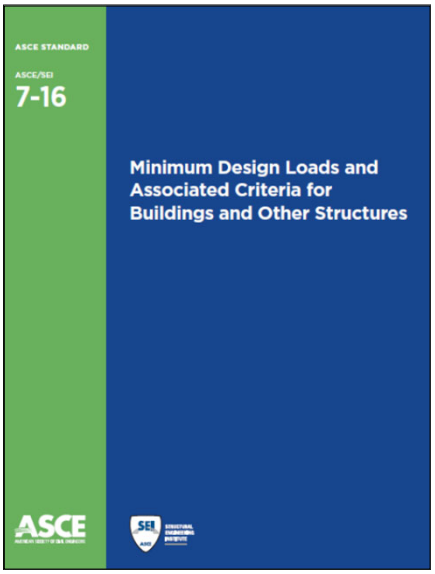
ASCE 7 is referenced in the International Building Code (IBC)



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Comparing IBC editions to ASCE 7 editions

IBC	ASCE 7
IBC 2006	ASCE 7-05
IBC 2009	ASCE 7-05
IBC 2012	ASCE 7-10
IBC 2015	ASCE 7-10
IBC 2018	ASCE 7-16
IBC 2021	ASCE 7-16

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International Building Code, 2018 Edition

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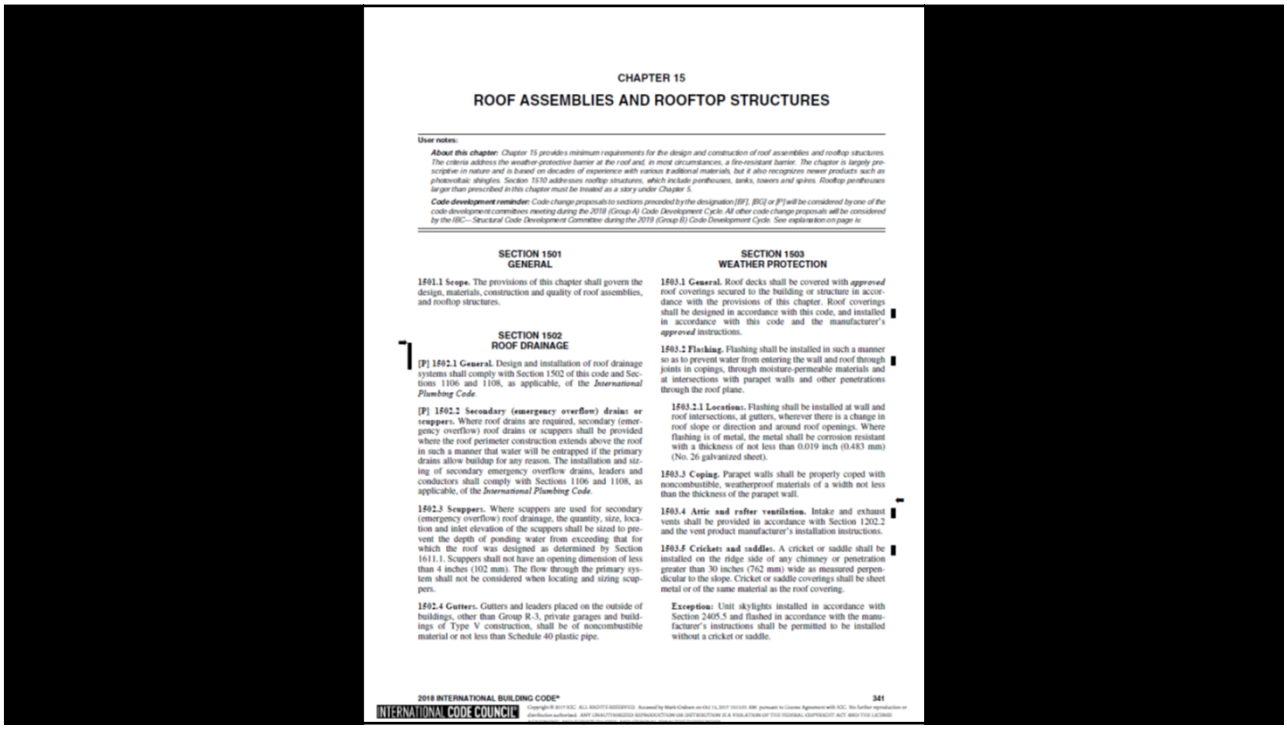

CHAPTER 15

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.

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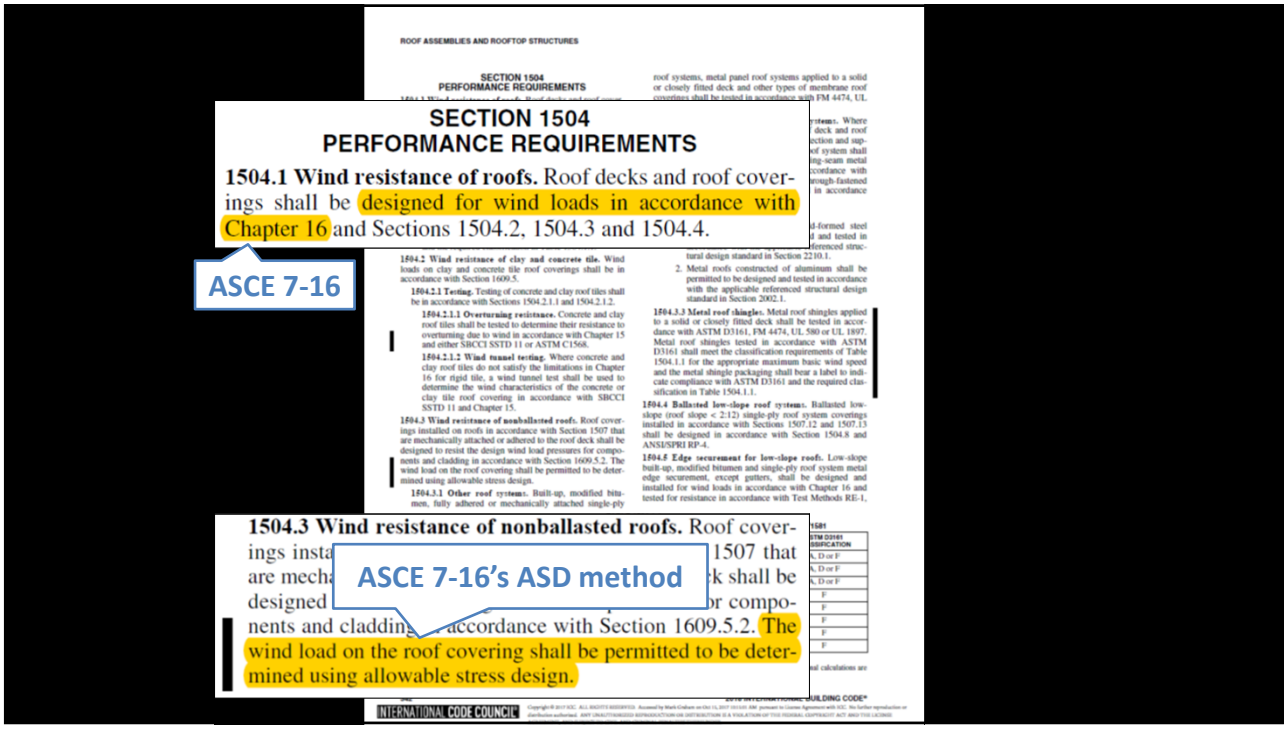

ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

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 … or components and cladding … 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

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Allowable stress design vs. Ultimate strength design

- ASD has been a traditional design method
- Ultimate strength design is not new
  - First implemented into ASCE 7 with the 2010 Edition
- What's the difference (as it applies to wind design)?
  - Different wind maps
    - V_{ULT} has higher basic wind speeds than V_{ASD}
  - Factors:
    - Ultimate strength design uses a "strength design pressure" (1.0W)
    - Allowable stress design uses a "allowable stress design load factor" of 0.6W

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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 Ponding 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 Application. 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 exceptments 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	50
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/m².

374 2018 INTERNATIONAL BUILDING CODE®

INTERNATIONAL CODE COUNCIL

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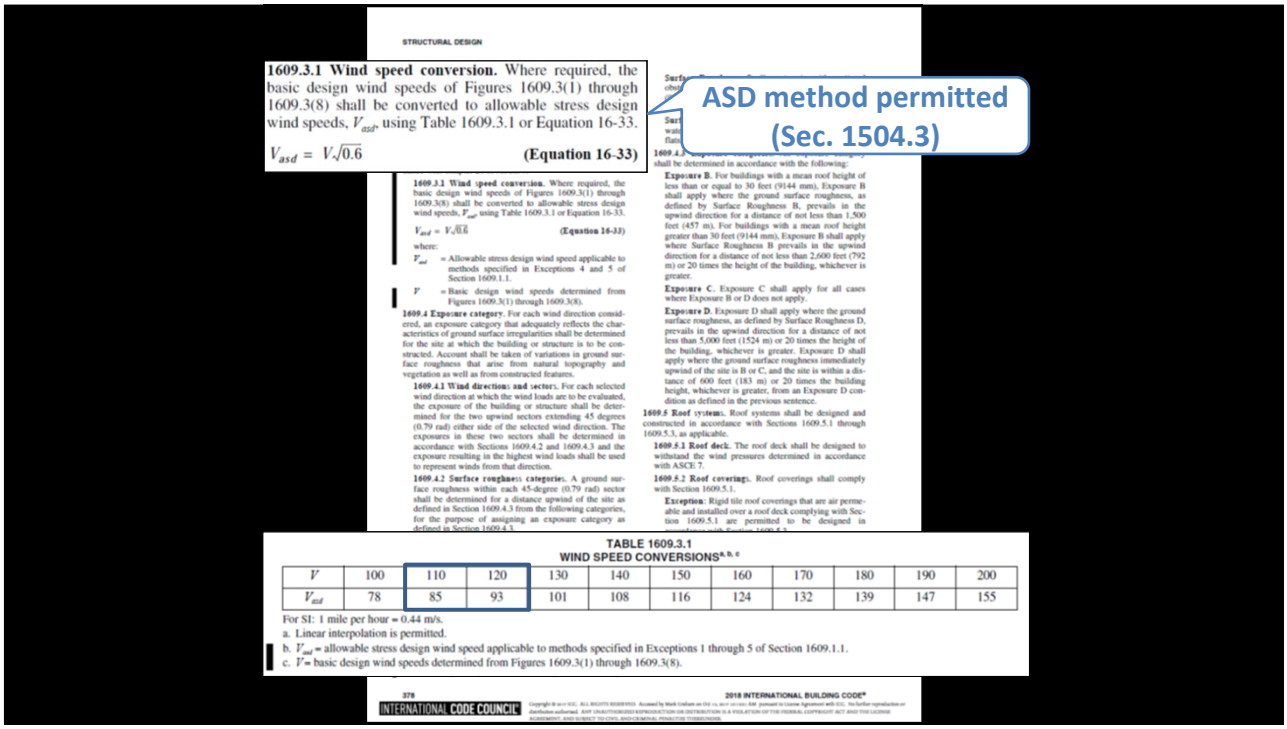

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With ASCE 7-10 and ASCE 7-16, there are four different Basic Wind Speed maps, based on Risk Category

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Basic wind speeds

Chicago:

ASCE 7-05:

- V_{ASD} = 90 mph (50-year return period)

ASCE 7-16:

- Risk Category I (MRI = 300 years): V_{ULT} = 100 mph
- Risk Category II (MRI = 700 years): V_{ULT} = 107 mph
- Risk Category III (MRI = 1,700 years): V_{ULT} = 114 mph
- Risk Category IV (MRI = 3,000 years): V_{ULT} = 119 mph

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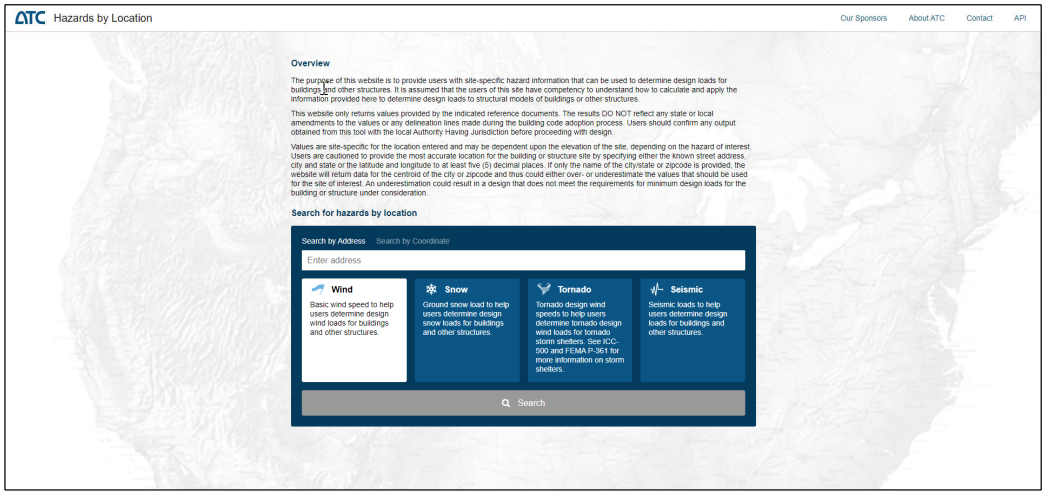
Applied Technology Council (ATC) hazards by location

www.hazards.atcouncil.org



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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

1602.1 Notation. The following notations are used in this chapter:

D = Dead load.

D_i = Weight of ice in accordance with Chapter 10 of ASCE 7.

E = Combined effect of horizontal and vertical earthquake induced forces as defined in Section 2.3.6 of ASCE 7.

F = Load due to fluids with well-defined pressures and maximum heights.

F_a = Flood load in accordance with Chapter 5 of ASCE 7.

H = Load due to lateral earth pressures, ground water pressure or pressure of bulk materials.

L = Roof live load greater than 20 psf (0.96 kN/m^2) and floor live load.

L_o = Roof live load of 20 psf (0.96 kN/m^2) or less.

R = Rain load.

S = Snow load.

V = Basic design wind speeds, miles per hour (mph) (km/hr) determined from Figures 1609.3(1) through 1609.3(8) or ASCE 7.

W = Load due to wind pressure.

W_i = Wind-on-ice in accordance with Chapter 10 of ASCE 7.

Exception: *Construction documents* for buildings constructed in accordance with the *conventional light-frame construction* provisions of Section 2308 shall indicate the following structural design information:

1. Floor and roof dead and live loads.
2. Ground snow load, P_g.
3. Basic design wind speed, V, miles per hour (mph) (km/hr) and allowable stress design wind speed, V_{asd}, as determined in accordance with Section 1609.3.1 and wind exposure.
4. *Seismic design category* and *site class*.
5. Flood design data, if located in *flood hazard areas* established in Section 1612.3.
6. Design load-bearing values of soils.
7. Rain load data.

1603.1.1 Floor live load. The uniformly distributed, concentrated and impact floor live load used in the design shall be indicated for floor areas. Use of live load reduction in accordance with Section 1607.11 shall be indicated for each type of live load used in the design.

1603.1.2 Roof live load. The roof live load used in the design shall be indicated for roof areas (Section 1607.13).

following additional information shall also be provided, regardless of whether snow loads govern the design of the roof:

1. Flat-roof snow load, P_f.
2. Snow exposure factor, C_e.
3. Snow load importance factor, I_s.

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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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Noteworthy changes in ASCE 7-16

Compared to ASCE 7-10

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

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Comparing GC_p pressure coefficients

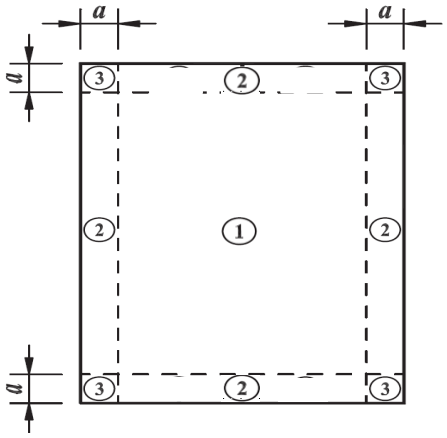
h ≤ 60 ft., gable roofs ≤ 7 degrees

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%

18

ASCE 7-10's roof zones

h ≤ 60 ft., gable roofs ≤ 7 degrees



a = 10% of the least horizontal direction, or 0.4h, whichever is smaller but not less than either 4% of the least horizontal dimension or 3 ft (0.9 m).

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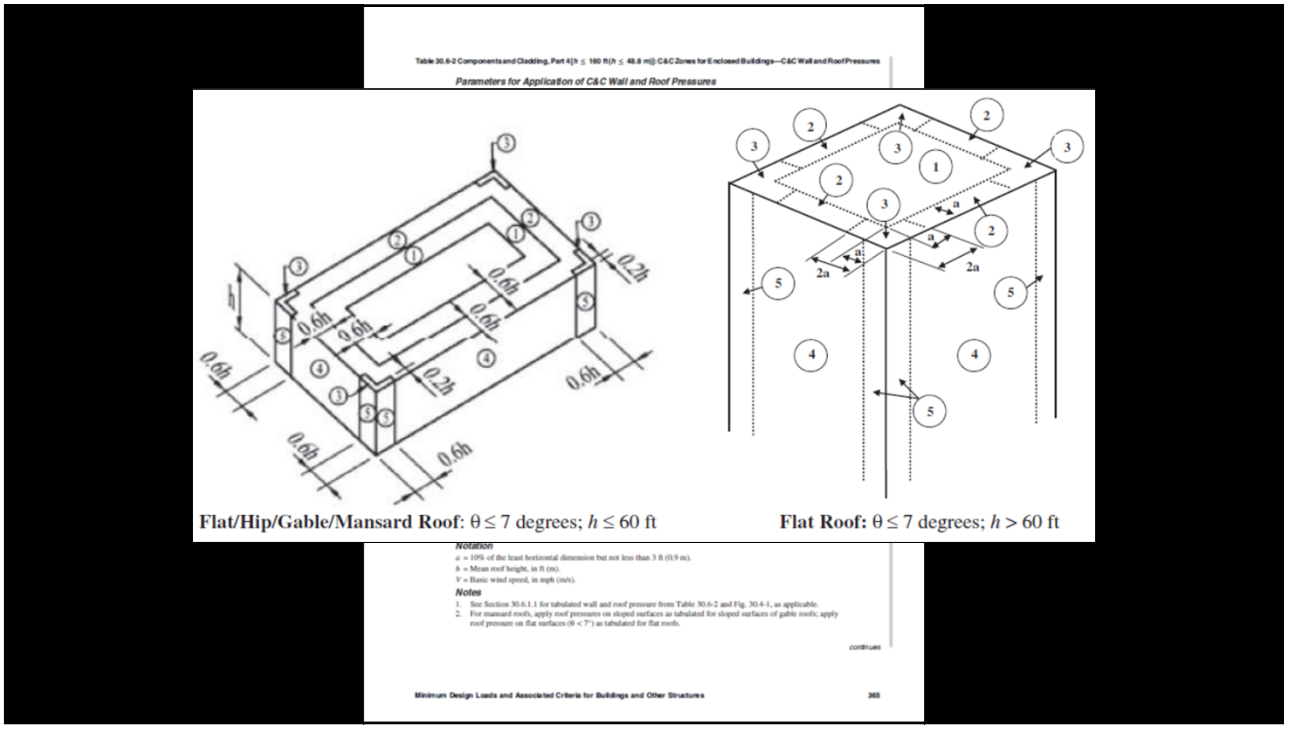

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Comparing ASCE 7-05, ASCE 7-10 and ASCE 7-16

Example: A low-rise office building (Risk Category II) in Chicago, IL. The building is an enclosed structure with a mean roof height of 60 ft. The building is in an open terrain area that can be 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	V_{ASD} = 90	--	24	40	58
ASCE 7-10 Ult.	V_{ULT} = 115	--	39	65	97
ASCE 7-10 ASD	V_{ASD} = 90	--	23	39	58
ASCE 7-16 Ult.	V_{ULT} = 105	30	51	67	92
ASCE 7-16 ASD	V_{ASD} = 90	18	31		

30 % increase

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Comparing ASCE 7-05, ASCE 7-10 and ASCE 7-16

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ASCE 7-10 Ult.	V_{ULT} = 115	--	39	65	97
ASCE 7-10 ASD	V_{ASD} = 90	--	23	FM 1-60	58
ASCE 7-16 Ult.	V_{ULT} = 105	30	51	67	92
ASCE 7-16 ASD	V_{ASD} = 90	18	31	FM 1-75 or FM 1-90	

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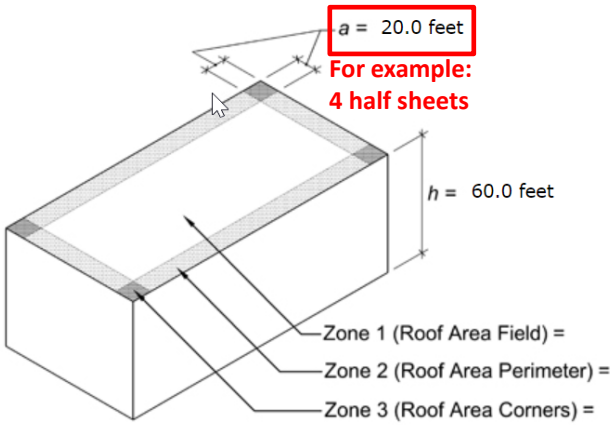
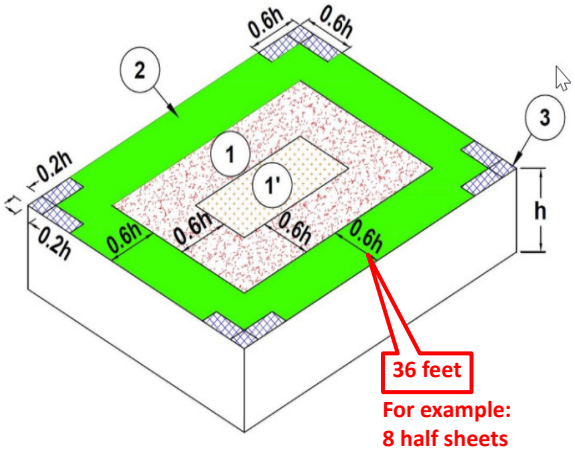
ASCE 7-16's impact on perimeter and corner zones



ASCE 7-05 and -10



ASCE 7-16

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ASCE 7-16's impact

- Higher wind loads (typically)
- New, more complicated zone layout
- Larger perimeter zones
- More fasteners (typically)
- More half sheets

There is a roof application labor impact associated with ASCE 7-16…

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RESEARCH+TECH

roofwinddesig

ASCE 7-05, ASCE 7-10 and ASCE 7-16

ASCE 7-16

Increased design wind-uplift loads may present challenges

by Mark S. Graham

24 www.professionalroofing.net MARCH 2018

Professional Roofing
March 2018

Link

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A few words on "safety factors"…

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Safety factor

A factor of safety is intended to address possible variances in load determination; normally anticipated variances in materials, including material aging and deterioration; and in application.

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A safety factor in wind design

- Use of a safety factor is not required by the Code
- FM Global assigns a SF = 2.0 in their ASD-based classifications
  - A FM I-90 classification has a maximum 45 psf uplift in Zone 2 (field)
- ASTM D6630 (a guide) suggest a SF = 2.0 based on ASD
- CSA A123.21 uses a SF = 1.5
- SPRI WD-1 suggests a SF = 2.0 for ASD and uses a SF = 1.0 in their Ultimate Design examples

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So, what is an appropriate/a reasonable safety factor for Ultimate Strength Design?

Since Ultimate Strength Design's loads are inherently higher than ASD's loads, in a sense, there is somewhat of an additional "factor addressing an additional level of safety" already built into wind design using Ultimate Strength Design

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Comparing ASCE 7-05, ASCE 7-10 and ASCE 7-16

Example: A low-rise office building (Risk Category II) in Chicago, IL. The building is an enclosed structure with a mean roof height of 60 ft. The building is in an open terrain area that can be categorized as Exposure Category C.

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ASCE 7-10 ASD	V_{ASD} = 90	--	23	39	58
ASCE 7-16 Ult.	V_{ULT} = 105	30	51		
ASCE 7-16 ASD	V_{ASD} = 90	18	31	41	55

65 % increase

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If a SF = 2.0 is applied to Ultimate Strength Design…

Comparing ASCE 7-05, ASCE 7-10 and ASCE 7-16

Example: A low-rise office building (Risk Category II) in Chicago, IL. The building is an enclosed structure with a mean roof height of 60 ft. The building is in an open terrain area that can be categorized as Exposure Category C.

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ASCE 7-16 Ult.	V_{ULT} = 105	30	51		
ASCE 7-16 ASD	V_{ASD} = 90	18	31		

FM 1-105 or FM 1-120

FM 1-75 or FM 1-90

A SF = 2.0 seems excessive for Ultimate Strength Design

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A safety factor of about 1.5 appears to be reasonable when using the Ultimate Strength Design method for wind uplift design

Mark S. Graham
CRCA/IIBEC-Chicago "Roofing Week in Chicago"
January 22, 2021

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The Designer has the authority/responsibility to determine an appropriate safety factor (if any)…
and it should be clearly indicated

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Questions…

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