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Wind design for roof assemblies: ASCE, FM, IBC and UL

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Specifying a wind speed warrantee, in itself, is not proper wind design…

...in fact, it is usually evidence of incomplete, inadequate or improper design

Topics

- Reference documents
- Code requirements
- Fundamentals
- ASCE 7
- Roof Wind Designer
- Wind resistance:
  - Low-slope roof systems
  - Asphalt shingles
- Additional resources

Reference documents – "the acronyms"

Wind design

American Society of Civil Engineers (ASCE)

- ASCE 7, "Minimum Design Loads for Buildings and Other Structures"

International Code Council (ICC):

- *International Building Code* (IBC)

FM Global:

- Loss Prevention Data Sheet 1-28, "Design Wind Loads"
- Loss Prevention Data Sheet 1-29, "Roof Deck Securement and Above-deck Roof Components"

Reference documents -- continued

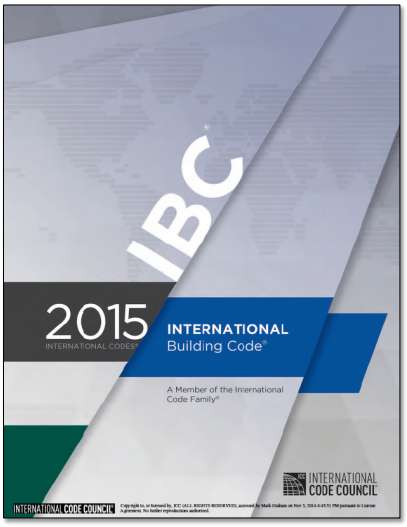
Wind design

FM Approvals (a subsidiary of FM Global)

- Approval classifications: 1-60, 1-90, 1-120, etc.
- RoofNav (www.roofnav.com)

Underwriters Laboratories (UL):

- Fire classifications: Class A, Class B and Class C
- Wind classifications: Class 30, Class 60, Class 90
- Impact (hail) classifications: Class I to IV
- Online certifications directory (www.ul.com)



The Code establishes minimum requirements for building construction (and reroofing)

IBC 2015:

- Ch. 15-Roof Assemblies
  - Sec. 1511-Reroofing
- Ch. 16-Structural Design
  - Sec. 1609-Wind Loads

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.

1504.1.1 Wind resistance of asphalt shingles. Asphalt shingles shall be tested in accordance with ASTM D 7158. Asphalt shingles shall meet the classification requirements of Table 1504.1.1 for the appropriate maximum basic wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D 7158 and the required classification in Table 1504.1.1.

Exception: Asphalt shingles that are not included in the scope of ASTM D 7158 shall be tested and labeled to indicate compliance with ASTM D 3161 and the required classification in Table 1504.1.1.

1504.2 Wind resistance of clay and concrete tile. Wind loads on clay and concrete tile roof coverings shall be in accordance with Section 1609.5.

1504.2.1 Testing. Testing of concrete and clay roof tiles shall be in accordance with Sections 1504.2.1.1 and 1504.2.1.2.

1504.2.1.1 Overturning resistance. Concrete and clay roof tiles shall be tested to determine their resistance to overturning due to wind in accordance with SBCCI SSTD 11 and Chapter 15.

1504.2.1.2 Wind tunnel testing. Where concrete and clay roof tiles do not satisfy the limitations in Chapter 16 for rigid tile, a wind tunnel test shall be used to determine the wind characteristics of the concrete or clay tile roof covering in accordance with SBCCI SSTD 11 and Chapter 15.

1504.3 Wind resistance of nonballasted roofs. Roof coverings installed on roofs in accordance with Section 1507 that are mechanically attached or adhered to the roof deck shall be designed to resist the design wind load pressures for components and cladding in accordance with Section 1609.

1504.3.1 Other roof systems. Built-up, modified bitumen, fully adhered or mechanically attached single-ply roof systems, metal panel roof systems applied to a solid or closely fitted deck and other types of membrane roof coverings shall be tested in accordance with FM 4474, UL 580 or UL 1897.

1504.3.2 Structural metal panel roof systems. Where the metal roof panel functions as the roof deck and roof covering and it provides both weather protection and support for loads, the structural metal panel roof system shall comply with this section. Structural standing-seam metal panel roof systems shall be tested in accordance with ASTM E 1592 or FM 4474. Structural through-fastened metal panel roof systems shall be tested in accordance with FM 4474, UL 580 or ASTM E 1592.

Exceptions:

1. Metal roofs constructed of cold-formed steel shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in Section 2210.1.
2. Metal roofs constructed of aluminum shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in Section 2002.1.

1504.4 Ballasted low-slope roof systems. Ballasted low-slope (roof slope < 2:12) single-ply roof system coverings installed in accordance with Sections 1507.12 and 1507.13 shall be designed in accordance with Section 1504.8 and ANSI/SPRI RP-4.

1504.5 Edge securement for low-slope roofs. Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except V_{ult} wind speed shall be determined from Figure 1609A, 1609B, or 1609C as applicable.

1609.5 Roof systems. Roof systems shall be designed and constructed in accordance with Sections 1609.5.1 through 1609.5.3, as applicable.

1609.5.1 Roof deck. The roof deck shall be designed to withstand the wind pressures determined in accordance with ASCE 7.

1609.5.2 Roof coverings. Roof coverings shall comply with Section 1609.5.1.

Exception: Rigid tile roof coverings that are air permeable and installed over a roof deck complying with Section 1609.5.1 are permitted to be designed in accordance with Section 1609.5.3.

Asphalt shingles installed over a roof deck complying with Section 1609.5.1 shall comply with the wind-resistance requirements of Section 1504.1.1.

1609.5.3 Rigid tile. Wind loads on rigid tile roof coverings shall be determined in accordance with the following equation:

$$M_a = q_h C_L b L L_a [1.0 - G C_p] \qquad \textbf{(Equation 16-34)}$$

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 1603.1.8 shall be indicated on the *construction documents*.

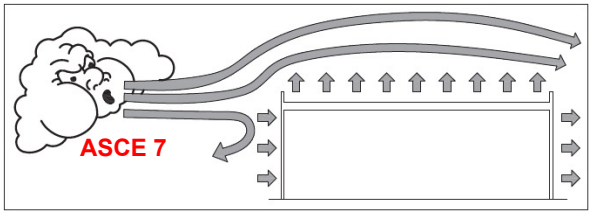
1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force-resisting system of the structure:

1. Ultimate design wind speed, V_{ult}, (3-second gust), miles per hour (km/hr) and nominal 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).

IBC requirements -- Summary

- BUR, MB, single ply (except ballasted), metal panels and edge metal
  - Design for loads (ASCE 7)
- Ballasted single ply
  - Design using ANSI/SPRI RP-4
- Asphalt shingles:
  - Design using wind speed
- Tile:
  - Design for loads (uplift moment)

The fundamental concept



Wind creates pressures/forces
on building elements

Fundamental premise

Wind resistance ≥ Design wind load

FM or UL rating ≥ ASCE 7

Safety factor

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

Designation: D6630/D6630M – 16

Standard Guide for
Low Slope Insulated Roof Membrane Assembly Performance[1]

This standard is issued under the fixed designation D6630/D6630M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide lists test methods intended to establish a minimum level of performance for insulated roof membrane assemblies, and lists pertinent design guidelines and installation methods in a unified manner. Material tests and evaluations are included with and without roof insulation.

1.2 It is not possible to establish a precise correlation between laboratory tests on roof assemblies and natural weathering due to variations in geographical climate, design, mate-

7.3.7 Wind uplift forces should be determined according to ASCE-7. Roof system wind uplift resistance shall have a minimum 2.0 factor of safety. For ballasted single ply roofs use ANSI/SPRI RP-4 for determining their wind uplift resistance.

responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

D450/D450M Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing

D1079 Terminology Relating to Roofing and Waterproofing

D2523 Practice for Testing Load-Strain Properties of Roofing Membranes

D4434/D4434M Specification for Poly(Vinyl Chloride) Sheet Roofing

D4637/D4637M Specification for EPDM Sheet Used In Single-Ply Roof Membrane

D4798/D4798M Practice for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Xenon-Arc Method)

D4799/D4799M Practice for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials

D5635/D5635M Test Method for Dynamic Puncture Resistance of Roofing Membrane Specimens

D5849/D5849M Test Method for Evaluating Resistance of Modified Bituminous Roofing Membrane to Cyclic Fatigue (Joint Displacement)

D6754/D6754M Specification for Ketone Ethylene Ester Based Sheet Roofing

D6878/D6878M Specification for Thermoplastic Polyolefin Based Sheet Roofing

E96/E96M Test Methods for Water Vapor Transmission of Materials

E631 Terminology of Building Constructions

2.2 *ASCE Standard:*

ASCE-7 Minimum Design Loads for Buildings and Other Structures[4]

[1] This guide is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.20 on Roofing Membrane Systems.

Current edition approved July 1, 2016. Published August 2016. Originally approved in 2001. Last previous edition approved in 2008 as D6630 – 08. DOI: 10.1520/D6630_D6630M-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

ASCE 7-10, "Minimum Design Loads for buildings and Other Structures"

Fundamental pressure equation

ASCE 7-10, Equation 30.3-1

$$q_h = 0.00256\,(K_z)\,(K_{zt})\,(K_d)\,(V^2)$$

Where:

- K_d = wind directionality factor
- K_z = velocity pressure exposure coefficient
- K_{zt} = topographic factor
- V = wind speed (mph)
- q_h = velocity pressure (psf)

ASCE 7-10

Wind loads

- Ch. 26: Wind loads: General Requirements
- Ch. 30: Wind loads – Components & Cladding
  - Part 1: Low-rise buildings (h ≤ 60 ft.)
  - Part 2: Low-rise buildings (h ≤ 60 ft.) (Simplified)
  - Part 3: Buildings with h > 60 ft.
  - Part 4: Buildings with h ≤ 160 ft. (Simplified)
  - Part 5: Open buildings
  - Part 6: Building apprutenances and rooftop structures and equipment
- Ch. 31: Wind Tunnel Procedure

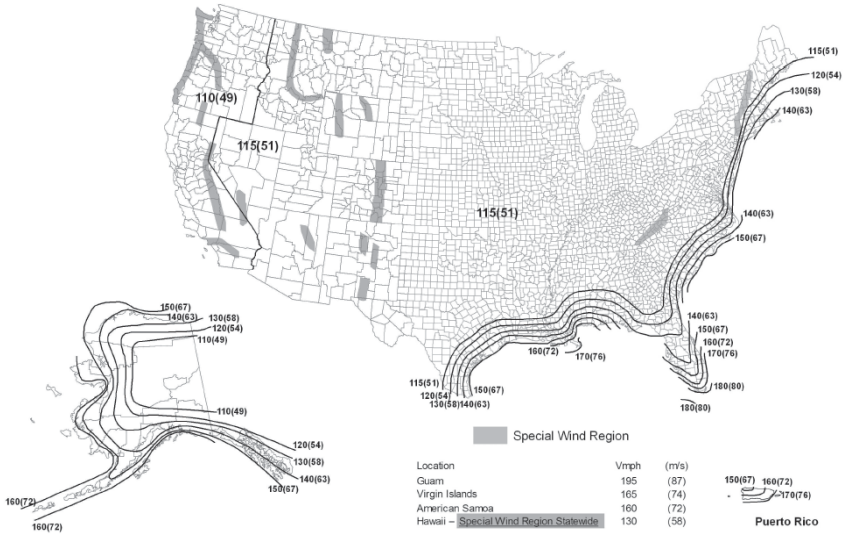
Design parameters

For the "Simplified procedures" (Part 2 and Part 4)

- Mean roof height (h)
- Enclosed building
- Wind-borne debris region (hurricane coastline)
- Regular-shaped building
- Topographical factor (K_{zt})
- Risk Category (Occupancy Category II most common)
- Basic wind speed (map)
- Exposure Category (Exposure C most common)
- Effective wind area (assume 10 ft^2)
- Wind zones (GC_p)

Basic wind speed

ASCE 7-10, Occupancy Category II Buildings



Pressure coefficients (GC_p)

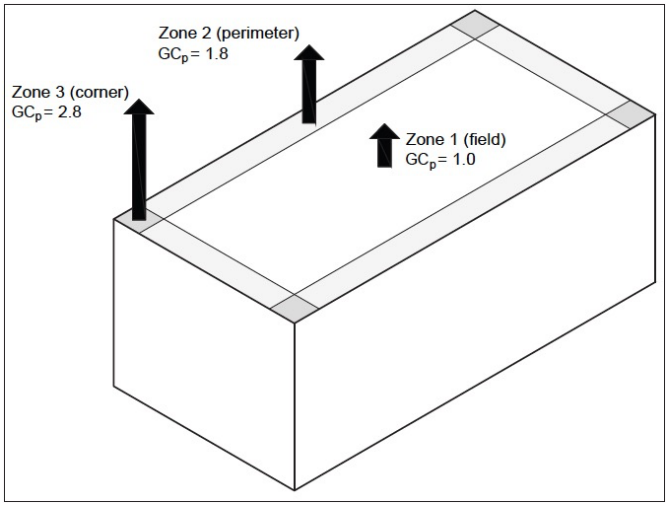


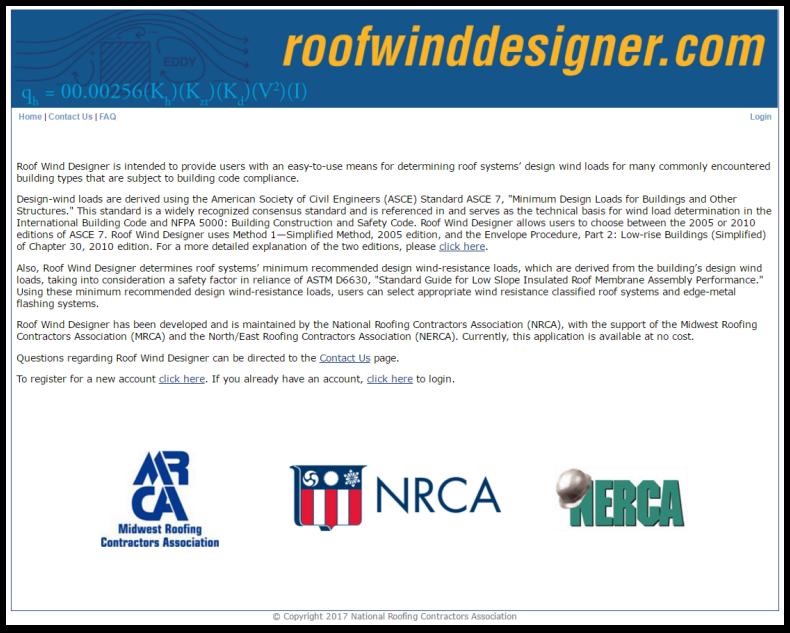
Illustration based upon ASCE 7-10, Fig. 30.4-2A ($\theta \leq 7°$); Effective wind area = 10 ft^2

ASCE 7-10

Strength design method vs. Allowable stress method

- ASCE 7-10 is based upon the strength design method
  - Increased wind speeds on map
  - Load factor of 1.6
- ASCE 7-10 allows for conversion of allowable stress design (ASD) method:

  ASD value = Strength design value x 0.6
- ASCE 7-05 and previous editions were based upon the ASD method

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$q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)$
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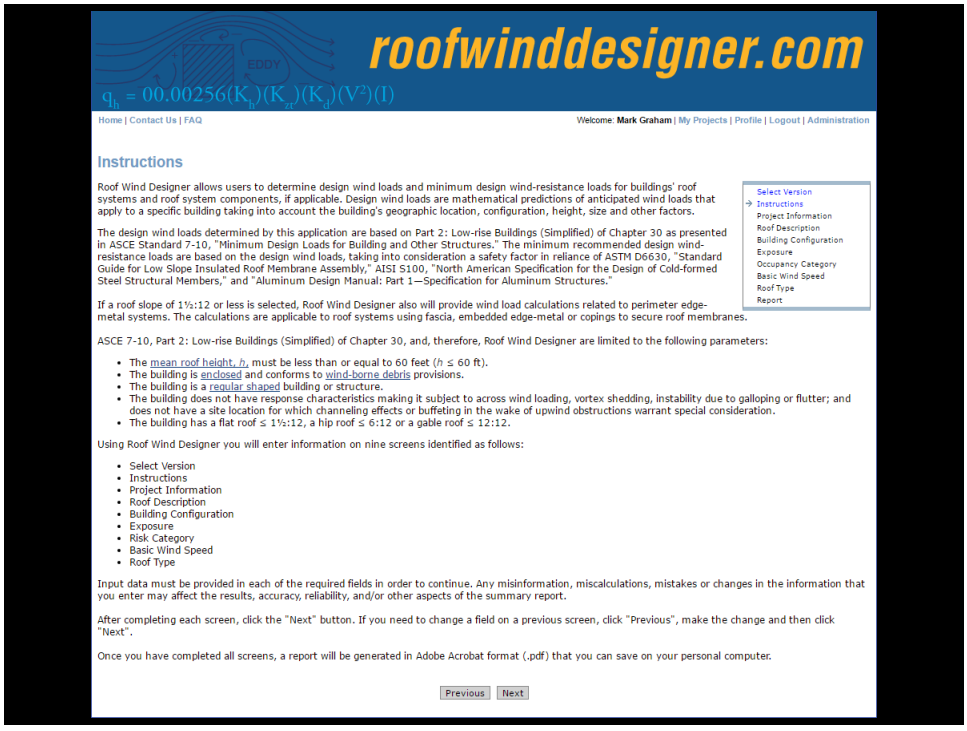
Select Version
Select the design version for this project.
ASCE 7 version *
ASCE 7-10
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report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Instructions
Roof Wind Designer allows users to determine design wind loads and minimum design wind-resistance loads for buildings' roof systems and roof system components, if applicable. Design wind loads are mathematical predictions of anticipated wind loads that apply to a specific building taking into account the building's geographic location, configuration, height, size and other factors.
The design wind loads determined by this application are based on Part 2: Low-rise Buildings (Simplified) of Chapter 30 as presented in ASCE Standard 7-10, "Minimum Design Loads for Building and Other Structures." The minimum recommended design wind-resistance loads are based on the design wind loads, taking into consideration a safety factor in reliance of ASTM D6630, "Standard Guide for Low Slope Insulated Roof Membrane Assembly," AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members," and "Aluminum Design Manual: Part 1—Specification for Aluminum Structures."
If a roof slope of 1½:12 or less is selected, Roof Wind Designer also will provide wind load calculations related to perimeter edge-metal systems. The calculations are applicable to roof systems using fascia, embedded edge-metal or copings to secure roof membranes.
ASCE 7-10, Part 2: Low-rise Buildings (Simplified) of Chapter 30, and, therefore, Roof Wind Designer are limited to the following parameters:
The mean roof height, h, must be less than or equal to 60 feet (h ≤ 60 ft).
The building is enclosed and conforms to wind-borne debris provisions.
The building is a regular shaped building or structure.
The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
The building has a flat roof ≤ 1½:12, a hip roof ≤ 6:12 or a gable roof ≤ 12:12.
Using Roof Wind Designer you will enter information on nine screens identified as follows:
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Risk Category
Basic Wind Speed
Roof Type
Input data must be provided in each of the required fields in order to continue. Any misinformation, miscalculations, mistakes or changes in the information that you enter may affect the results, accuracy, reliability, and/or other aspects of the summary report.
After completing each screen, click the "Next" button. If you need to change a field on a previous screen, click "Previous", make the change and then click "Next".
Once you have completed all screens, a report will be generated in Adobe Acrobat format (.pdf) that you can save on your personal computer.
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report


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Project Information
Roof Area Name *
Main roof area
Project Name *
Example calculation
Project Street Address *
123 Las Vegas Blvd
Project City *
Las Vegas
Project State *
Nevada
Project County *
Clark
Project Zip Code *
89119
Additional Comments
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Input the required information that identifies the project. This project information will be included in the Report.


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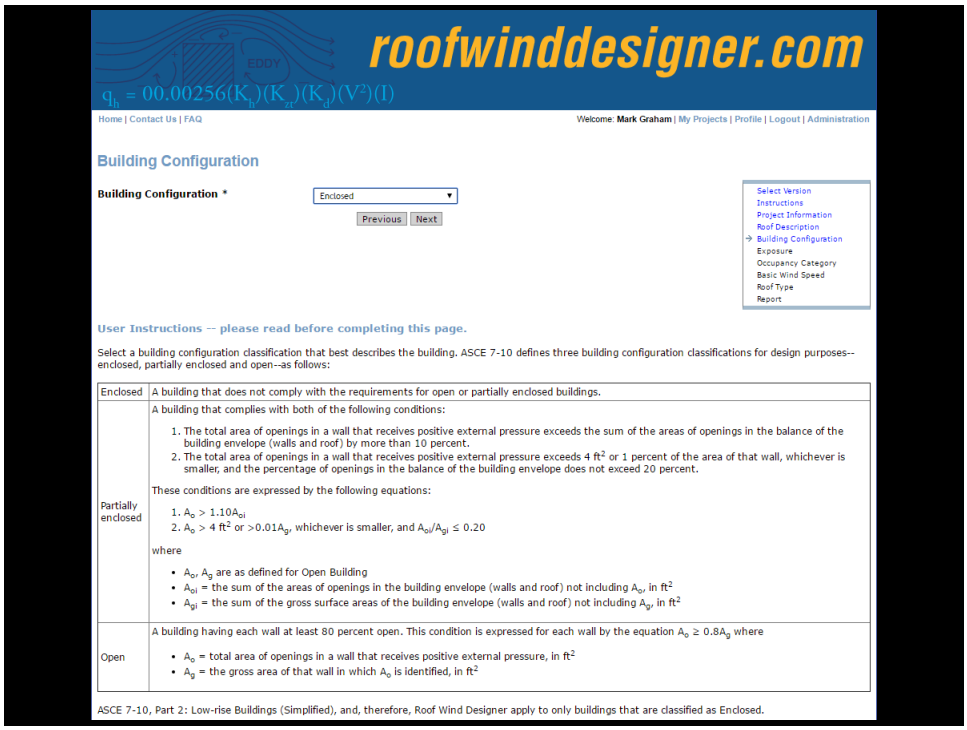
Roof Description
Roof Area Length (ft) *
200
Roof Area Width (ft) *
400
Mean Roof Height (ft) *
60
Roof Configuration and Slope *
Flat: 1½:12 or less
Parapet (minimum 36 inch high) *
Yes
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Roof description data input here will be used for calculation purposes and included in the Report.
Input the roof area's length and width dimensions rounding up to the next nearest 1 foot increment.
Next, select the roof area's Mean Roof Height. ASCE 7-10, Part 2: Low-rise Buildings (Simplified) of Chapter 30, and, therefore, Roof Wind Designer, is limited to roof areas where the mean roof height is 60 feet or less.
Next, select the roof configuration and slope. Roof Wind Designer is limited to a flat roof ≤ 1½:12, a hip roof ≤ 6:12 or a gable ≤ 1½:12.
Next, select whether any portion of the roof area perimeter includes a parapet. For the purposes of ASCE 7-10, Part 1: Low-rise Buildings of Chapter 30, parapets measuring a minimum of 36 inches above the roof system's surface may allow for decreased wind-load pressures in corner roof areas that are enclosed from the roof area's exterior by parapets.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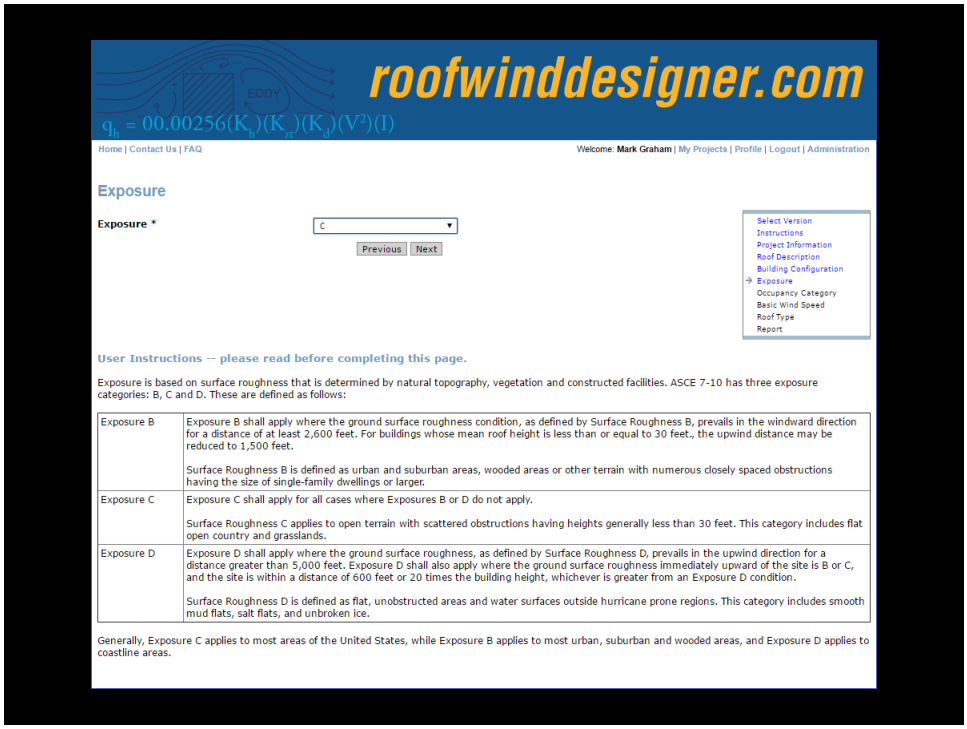
Building Configuration
Building Configuration *
Enclosed
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Select a building configuration classification that best describes the building. ASCE 7-10 defines three building configuration classifications for design purposes--enclosed, partially enclosed and open--as follows:
Enclosed
A building that does not comply with the requirements for open or partially enclosed buildings.
Partially enclosed
A building that complies with both of the following conditions:
1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.
2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft² or 1 percent 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 percent.
These conditions are expressed by the following equations:
1. $A_o > 1.10A_{oi}$
2. $A_o > 4$ ft² or $>0.01A_g$, whichever is smaller, and $A_{oi}/A_{gi} \leq 0.20$
where
• A_o, A_g are as defined for Open Building
• A_{oi} = the sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft²
• A_{gi} = the sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft²
Open
A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation $A_o \geq 0.8A_g$ where
• A_o = total area of openings in a wall that receives positive external pressure, in ft²
• A_g = the gross area of that wall in which A_o is identified, in ft²
ASCE 7-10, Part 2: Low-rise Buildings (Simplified), and, therefore, Roof Wind Designer apply to only buildings that are classified as Enclosed.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Exposure
Exposure *
C
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Exposure is based on surface roughness that is determined by natural topography, vegetation and constructed facilities. ASCE 7-10 has three exposure categories: B, C and D. These are defined as follows:
Exposure B
Exposure B shall apply where the ground surface roughness condition, as defined by Surface Roughness B, prevails in the windward direction for a distance of at least 2,600 feet. For buildings whose mean roof height is less than or equal to 30 feet., the upwind distance may be reduced to 1,500 feet.
Surface Roughness B is defined as urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.
Exposure C
Exposure C shall apply for all cases where Exposures B or D do not apply.
Surface Roughness C applies to open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country and grasslands.
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 feet. Exposure D shall also apply where the ground surface roughness immediately upward of the site is B or C, and the site is within a distance of 600 feet or 20 times the building height, whichever is greater from an Exposure D condition.
Surface Roughness D is defined as flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.
Generally, Exposure C applies to most areas of the United States, while Exposure B applies to most urban, suburban and wooded areas, and Exposure D applies to coastline areas.


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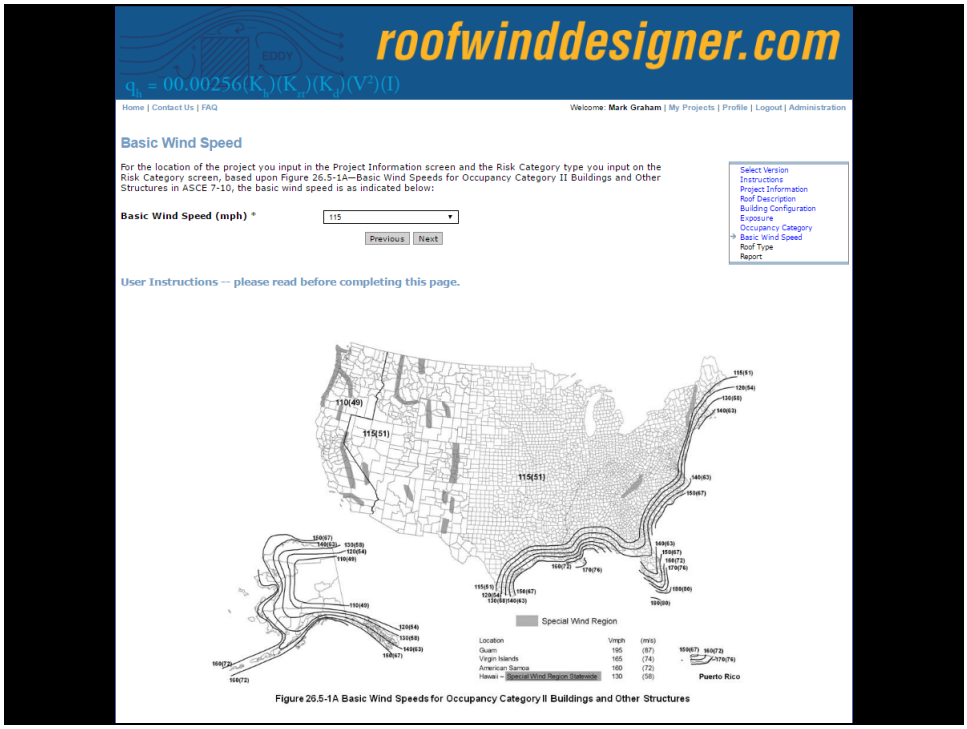
Risk Category
Risk Category *
II
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Risk Category is a categorization of buildings and other structures for determining design loads based on the risk associated with unacceptable performance. A building's risk category is determined by its occupancy. Part 2: Low-rise Buildings (Simplified) uses risk category to determine the applicable basic wind speed map. Input the risk category that most closely describes the occupancy type of the building being considered.
Risk Category is determined from the following:
Risk Category of Buildings and Other Structures
Risk Category
Buildings and other structures that represent a low risk to human life in the event of failure
I
All buildings and other structures except those listed in Occupancy Categories I, III and IV
II
Buildings and other structures, the failure of which could pose a substantial risk to human life.
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 their quantity exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
III
Buildings and other structures designated as essential facilities.
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 exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released 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.
IV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Basic Wind Speed
For the location of the project you input in the Project Information screen and the Risk Category type you input on the Risk Category screen, based upon Figure 26.5-1A—Basic Wind Speeds for Occupancy Category II Buildings and Other Structures in ASCE 7-10, the basic wind speed is as indicated below:
Basic Wind Speed (mph) *
115
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
110(49)
115(51)
115(51)
Special Wind Region
Location
Vmph
(mps)
Guam
195
(87)
Virgin Islands
165
(74)
American Samoa
160
(72)
Hawaii – Special Wind Region Statewide
130
(58)
Puerto Rico
Figure 26.5-1A Basic Wind Speeds for Occupancy Category II Buildings and Other Structures


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$q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)$
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Roof Type
Roof Deck Type *
Steel Deck
Roof Covering Type *
TPO
Previous
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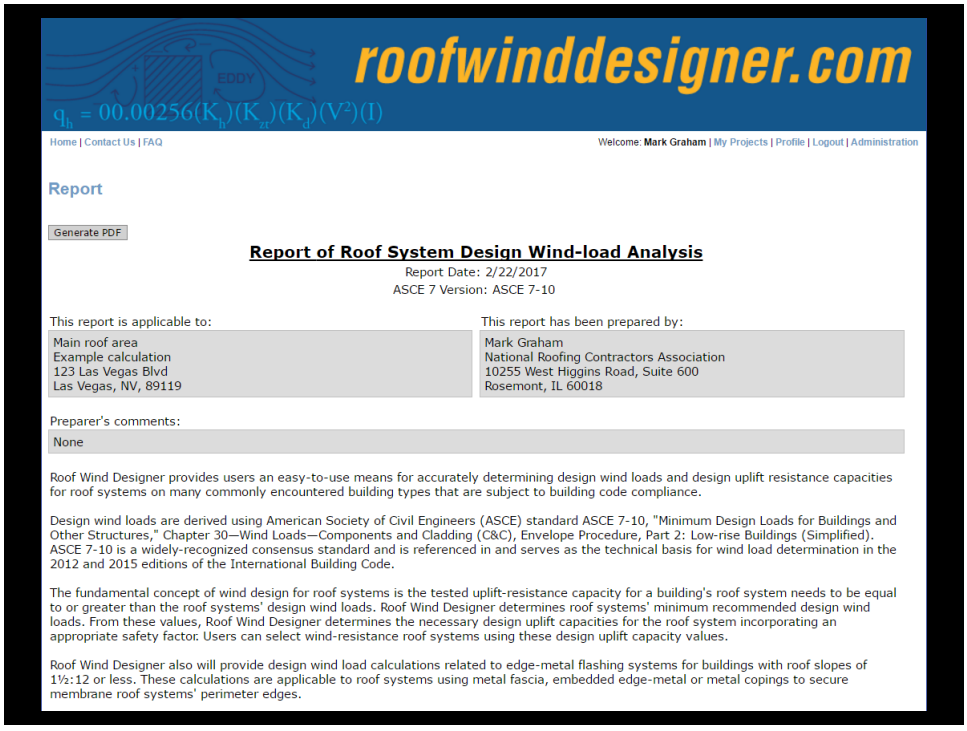
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report


roofwinddesigner.com
$q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)$
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Report
Generate PDF
Report of Roof System Design Wind-load Analysis
Report Date: 2/22/2017
ASCE 7 Version: ASCE 7-10
This report is applicable to:
Main roof area
Example calculation
123 Las Vegas Blvd
Las Vegas, NV, 89119
This report has been prepared by:
Mark Graham
National Roofing Contractors Association
10255 West Higgins Road, Suite 600
Rosemont, IL 60018
Preparer's comments:
None
Roof Wind Designer provides users an easy-to-use means for accurately determining design wind loads and design uplift resistance capacities for roof systems on many commonly encountered building types that are subject to building code compliance.
Design wind loads are derived using American Society of Civil Engineers (ASCE) standard ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures," Chapter 30—Wind Loads—Components and Cladding (C&C), Envelope Procedure, Part 2: Low-rise Buildings (Simplified). ASCE 7-10 is a widely-recognized consensus standard and is referenced in and serves as the technical basis for wind load determination in the 2012 and 2015 editions of the International Building Code.
The fundamental concept of wind design for roof systems is the tested uplift-resistance capacity for a building's roof system needs to be equal to or greater than the roof systems' design wind loads. Roof Wind Designer determines roof systems' minimum recommended design wind loads. From these values, Roof Wind Designer determines the necessary design uplift capacities for the roof system incorporating an appropriate safety factor. Users can select wind-resistance roof systems using these design uplift capacity values.
Roof Wind Designer also will provide design wind load calculations related to edge-metal flashing systems for buildings with roof slopes of 1½:12 or less. These calculations are applicable to roof systems using metal fascia, embedded edge-metal or metal copings to secure membrane roof systems' perimeter edges.

Wind Design for Roof Systems

ASCE 7-10 specifies wind design procedures for buildings and organizes them into two categories: main wind force-resisting systems, and component and cladding elements. Main wind force-resisting systems are the structural elements assigned to provide the support and stability for the overall building. Components and cladding are elements of the building envelope that do not qualify as part of the main wind force-resisting system. Roof systems and edge-metal flashing systems are considered components and cladding.

ASCE 7-10 provides two methods to determine minimum design load requirements for buildings: strength design method and allowable stress design (ASD) method. Design wind load calculations determined by the Envelope Procedure, Part 2: Low-rise Buildings (Simplified) method result in strength design values.

Roof systems and roof system components generally are designed using the ASD method. Because the ASD method's results often are used, a designer can adjust the strength design method's values to ASD method's values. A load-reduction factor is applied as a multiplier to the strength design values to determine the ASD values. ASCE 7-10 provides a load-reduction factor of 0.6 for this purpose, and the calculation is expressed as follows:

ASD value = Strength design value x 0.6

Roof Wind Designer determines design wind loads based upon the strength design method and then adjusts those values to the ASD method's values.

Design Wind Loads

To determine design wind loads on roof areas, ASCE 7-10 identifies three primary areas of differing wind loads on a roof area: roof area field, roof area perimeter and roof area corners. Within ASCE 7-10 these areas are designated as Zones 1, 2 and 3, respectively. Also, ASCE 7-10 identifies a dimension determined by calculation, referred to as "a," that defines the depth of the perimeter and corner zones from the roof area's edges.

Strength Design Method:

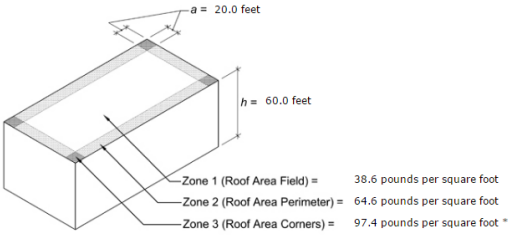
ASCE 7-10 uses three basic wind speed maps for different categories of building occupancies. These maps provide basic wind speeds that are applicable for calculating pressures and they are based on strength design. The strength design values determined for the roof area described by this report are as follows:

Zone 1 (roof area field):	38.6 pounds per square foot
Zone 2 (roof area perimeter):	64.6 pounds per square foot
Zone 3 (roof area corners):	97.4 pounds per square foot

Also, the calculated "a" dimension is as follows:

***a*:**	20.0 feet

Graphically, the strength design values are depicted as follows:



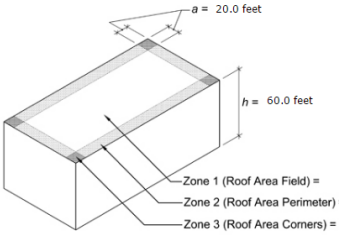
* ASCE 7-10, Part 3: Buildings with h > 60 ft., permits the design wind loads in Zone 3 (roof area corners) to be reduced to the value for Zone 2 (roof area perimeter) when a minimum 36-inch high parapet occurs at the two outside edges of the specific corner area where the design wind load is being reduced.

Adjustment of Strength Design to Allowable Stress Design (ASD):

To adjust the strength design values to ASD values, the load-reduction factor of 0.6 is applied. The ASD values determined for the roof area described by this report are as follows:

Zone 1 (roof area field):	23.1 pounds per square foot
Zone 2 (roof area perimeter):	38.8 pounds per square foot
Zone 3 (roof area corners):	58.4 pounds per square foot *

Graphically, the ASD values are depicted as follows:



Zone 1 (Roof Area Field) = 23.1 pounds per square foot
Zone 2 (Roof Area Perimeter) = 38.8 pounds per square foot
Zone 3 (Roof Area Corners) = 58.4 pounds per square foot *

* ASCE 7-10, Part 3: Buildings with h > 60 ft., permits the design wind loads in Zone 3 (roof area corners) to be reduced to the value for Zone 2 (roof area perimeter) when a minimum 36-inch high parapet occurs at the two outside edges of the specific corner area where the design wind load is being reduced.

FM Approvals' classifications

www.roofnav.com

FM 1-60 or Class 60:	30 psf allowable (field)*
FM 1-90 or Class 90:	45 psf allowable (field)*
FM 1-105 or Class 105:	52.5 psf allowable (field)*
FM 1-120 or Class 120:	60 psf allowable (field)*

And so forth…

*Includes a safety factor of 2.0

UL uplift classifications

www.ul.com, Resources: Online Certifications Directory,
Category Code: TGKX and TGIK

Class 15: 15 psf (nominal)*

Class 30: 30 psf (nominal)*

Class 60: 60 psf (nominal)*

Class 90: 90 psf (nominal)*

*UL's nominal values do not include a safety factor

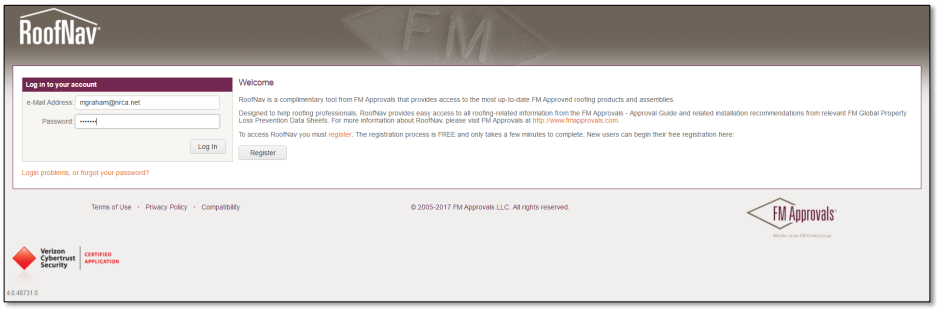
Back to the fundamental premise

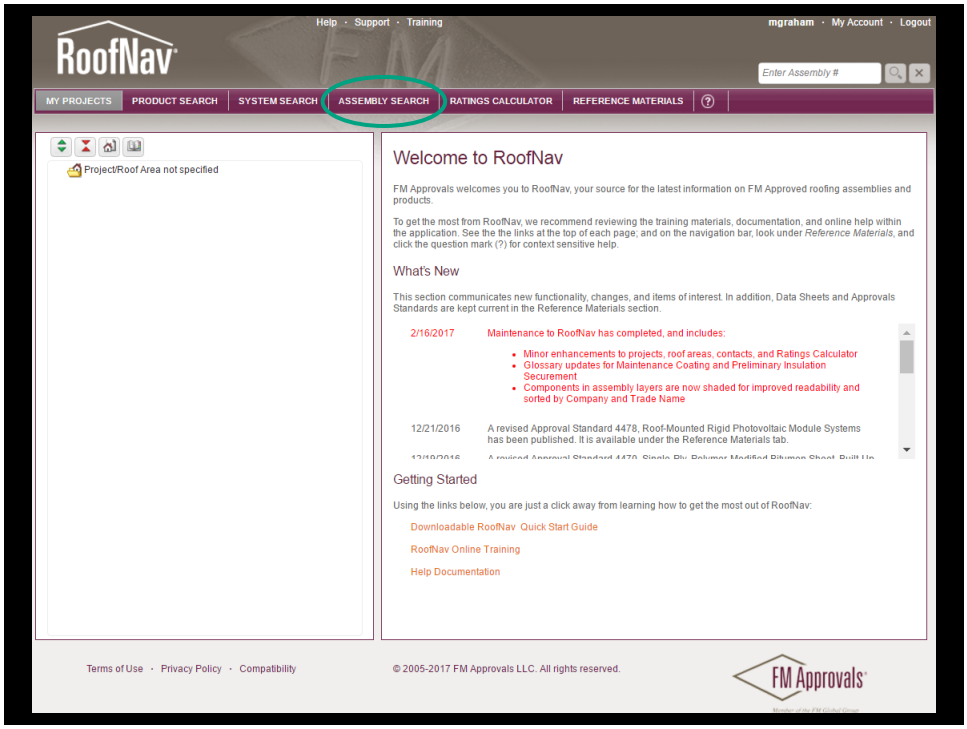
Wind resistance ≥ Design wind load

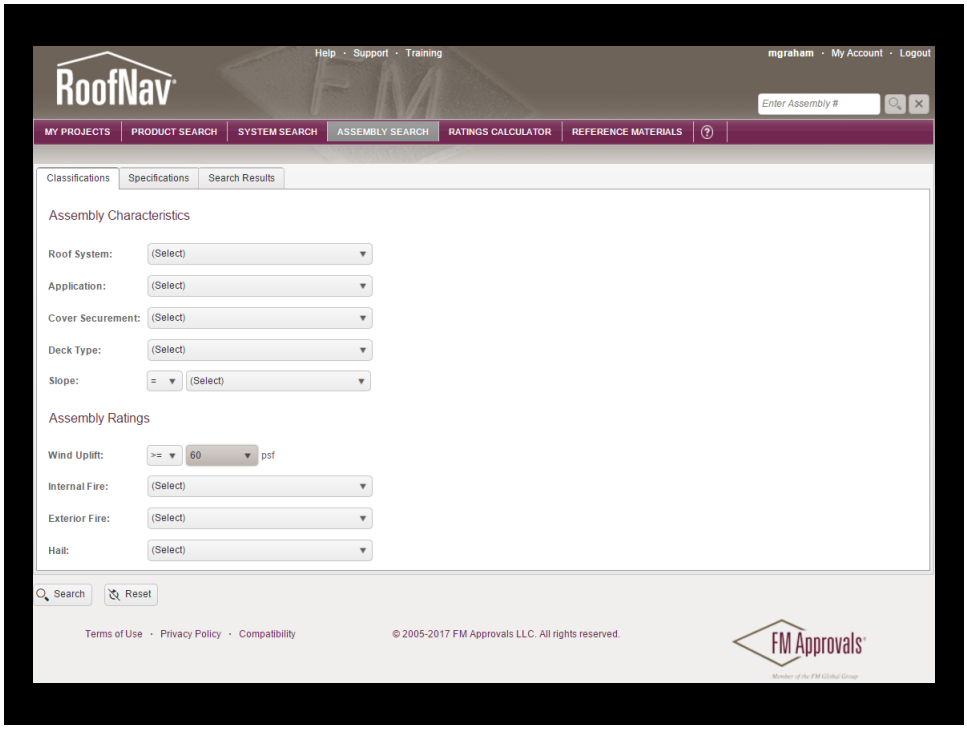
FM 1-60 (30 psf) ≥ 23.1 psf
or UL Class 60

FM Approvals' RoofNav

www.RoofNav.com



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REFERENCE MATERIALS
Classifications
Specifications
Search Results
Assembly Characteristics
Roof System: (Select)
Application: (Select)
Cover Securement: (Select)
Deck Type: (Select)
Slope: = (Select)
Assembly Ratings
Wind Uplift: >= 60 psf
Internal Fire: (Select)
Exterior Fire: (Select)
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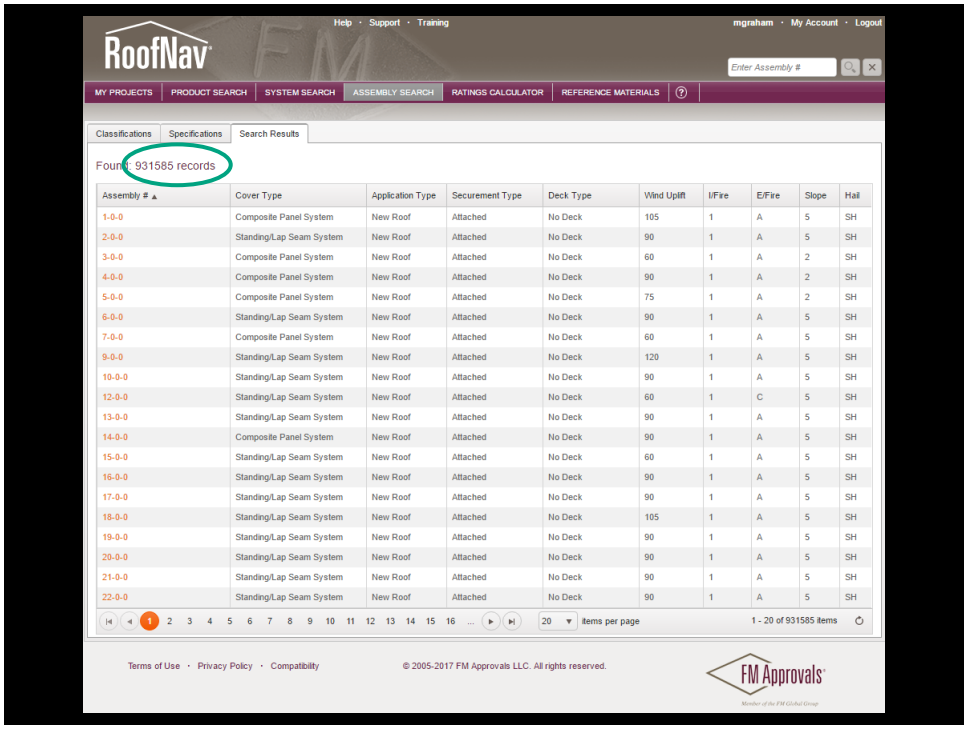
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Enter Assembly #
MY PROJECTS
PRODUCT SEARCH
SYSTEM SEARCH
ASSEMBLY SEARCH
RATINGS CALCULATOR
REFERENCE MATERIALS
Classifications
Specifications
Search Results
Found: 931585 records
Assembly # | Cover Type | Application Type | Securement Type | Deck Type | Wind Uplift | I/Fire | E/Fire | Slope | Hail
1-0-0 | Composite Panel System | New Roof | Attached | No Deck | 105 | 1 | A | 5 | SH
2-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
3-0-0 | Composite Panel System | New Roof | Attached | No Deck | 60 | 1 | A | 2 | SH
4-0-0 | Composite Panel System | New Roof | Attached | No Deck | 90 | 1 | A | 2 | SH
5-0-0 | Composite Panel System | New Roof | Attached | No Deck | 75 | 1 | A | 2 | SH
6-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
7-0-0 | Composite Panel System | New Roof | Attached | No Deck | 60 | 1 | A | 5 | SH
9-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 120 | 1 | A | 5 | SH
10-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
12-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 60 | 1 | C | 5 | SH
13-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
14-0-0 | Composite Panel System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
15-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 60 | 1 | A | 5 | SH
16-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
17-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
18-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 105 | 1 | A | 5 | SH
19-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
20-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
21-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
22-0-0 | Standing/Lap Seam System | New Roof | Attached | No Deck | 90 | 1 | A | 5 | SH
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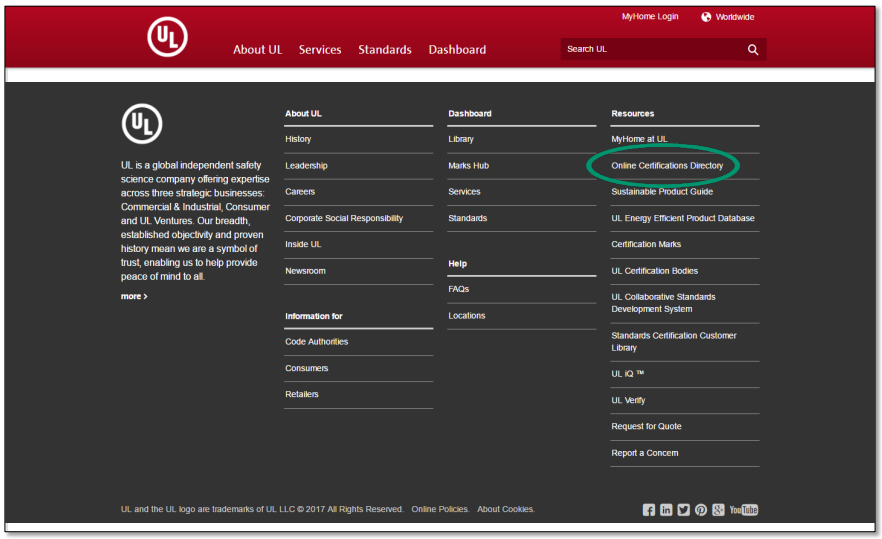

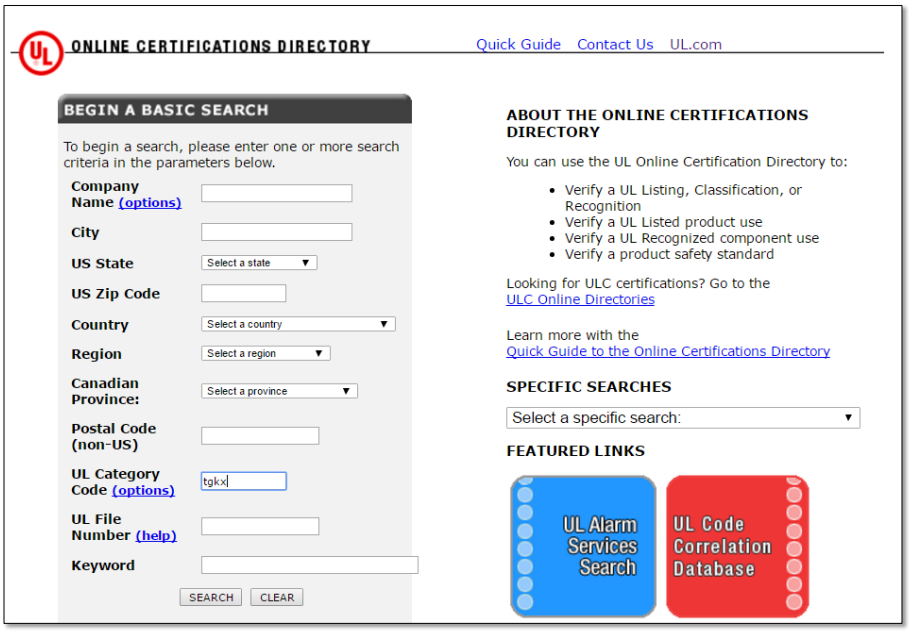

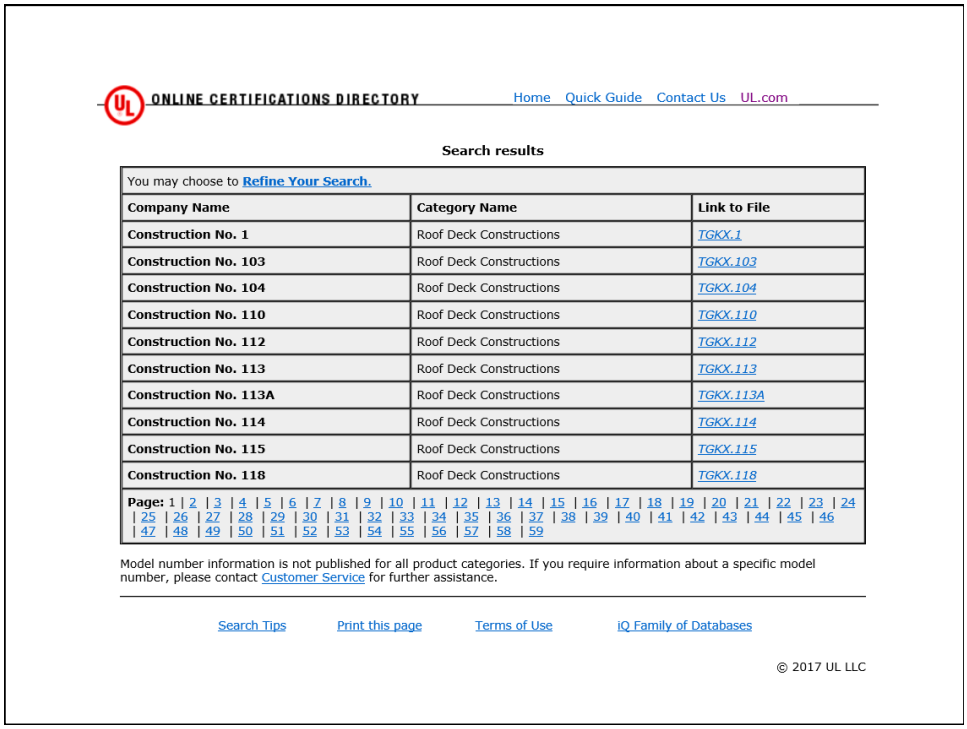

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Company Name	Category Name	Link to File
Construction No. 1	Roof Deck Constructions	*TGKX.1*
Construction No. 103	Roof Deck Constructions	*TGKX.103*
Construction No. 104	Roof Deck Constructions	*TGKX.104*
Construction No. 110	Roof Deck Constructions	*TGKX.110*
Construction No. 112	Roof Deck Constructions	*TGKX.112*
Construction No. 113	Roof Deck Constructions	*TGKX.113*
Construction No. 113A	Roof Deck Constructions	*TGKX.113A*
Construction No. 114	Roof Deck Constructions	*TGKX.114*
Construction No. 115	Roof Deck Constructions	*TGKX.115*
Construction No. 118	Roof Deck Constructions	*TGKX.118*

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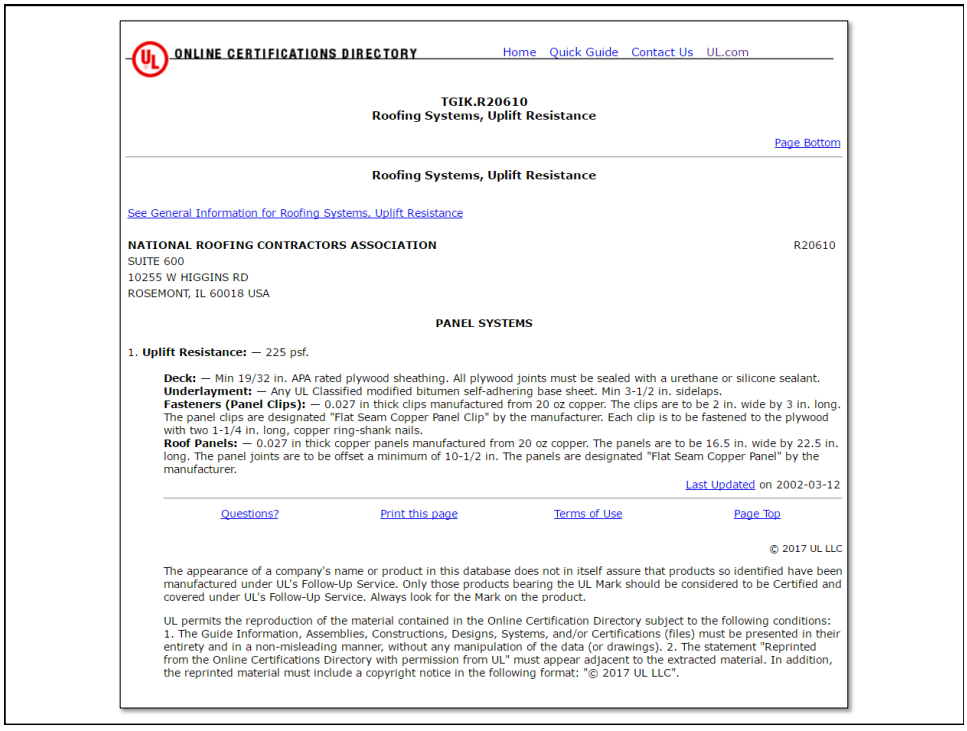

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TGIK.R20610
Roofing Systems, Uplift Resistance

Page Bottom

Roofing Systems, Uplift Resistance

See General Information for Roofing Systems, Uplift Resistance

NATIONAL ROOFING CONTRACTORS ASSOCIATION R20610
SUITE 600
10255 W HIGGINS RD
ROSEMONT, IL 60018 USA

PANEL SYSTEMS

1. **Uplift Resistance:** — 225 psf.

Deck: — Min 19/32 in. APA rated plywood sheathing. All plywood joints must be sealed with a urethane or silicone sealant.
Underlayment: — Any UL Classified modified bitumen self-adhering base sheet. Min 3-1/2 in. sidelaps.
Fasteners (Panel Clips): — 0.027 in thick clips manufactured from 20 oz copper. The clips are to be 2 in. wide by 3 in. long. The panel clips are designated "Flat Seam Copper Panel Clip" by the manufacturer. Each clip is to be fastened to the plywood with two 1-1/4 in. long, copper ring-shank nails.
Roof Panels: — 0.027 in thick copper panels manufactured from 20 oz copper. The panels are to be 16.5 in. wide by 22.5 in. long. The panel joints are to be offset a minimum of 10-1/2 in. The panels are designated "Flat Seam Copper Panel" by the manufacturer.

Last Updated on 2002-03-12

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Asphalt shingles

International Building Code, 2015 Edition

1504.1.1 Wind resistance of asphalt shingles. Asphalt shingles shall be tested in accordance with ASTM D 7158. Asphalt shingles shall meet the classification requirements of Table 1504.1.1 for the appropriate maximum basic wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D 7158 and the required classification in Table 1504.1.1.

Exception: Asphalt shingles that are not included in the scope of ASTM D 7158 shall be tested and labeled to indicate compliance with ASTM D 3161 and the required classification in Table 1504.1.1.

Basic wind speed

ASCE 7-10, Occupancy Category II Buildings

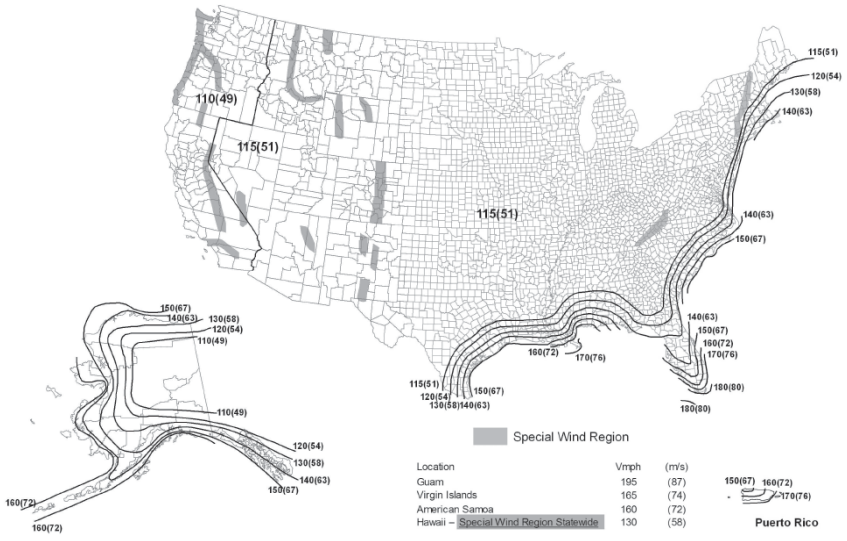
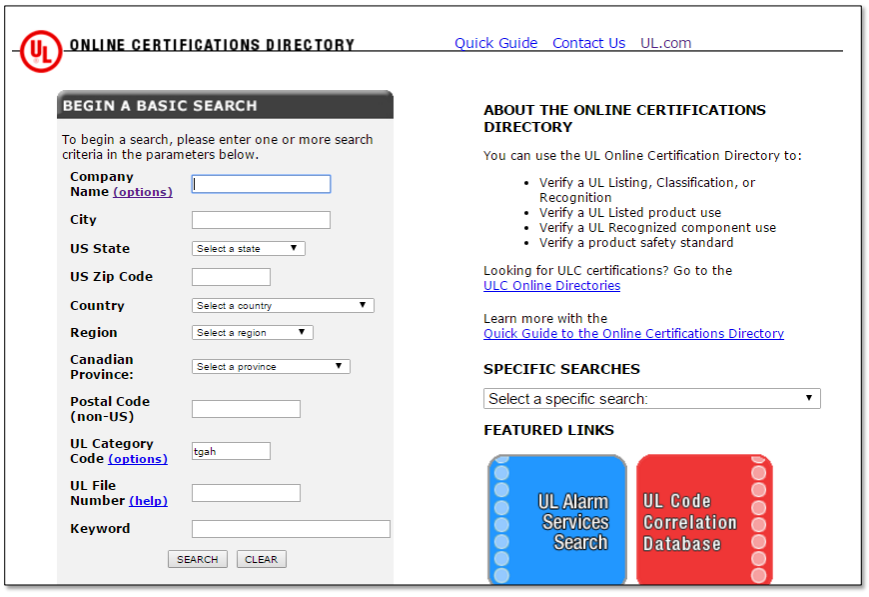


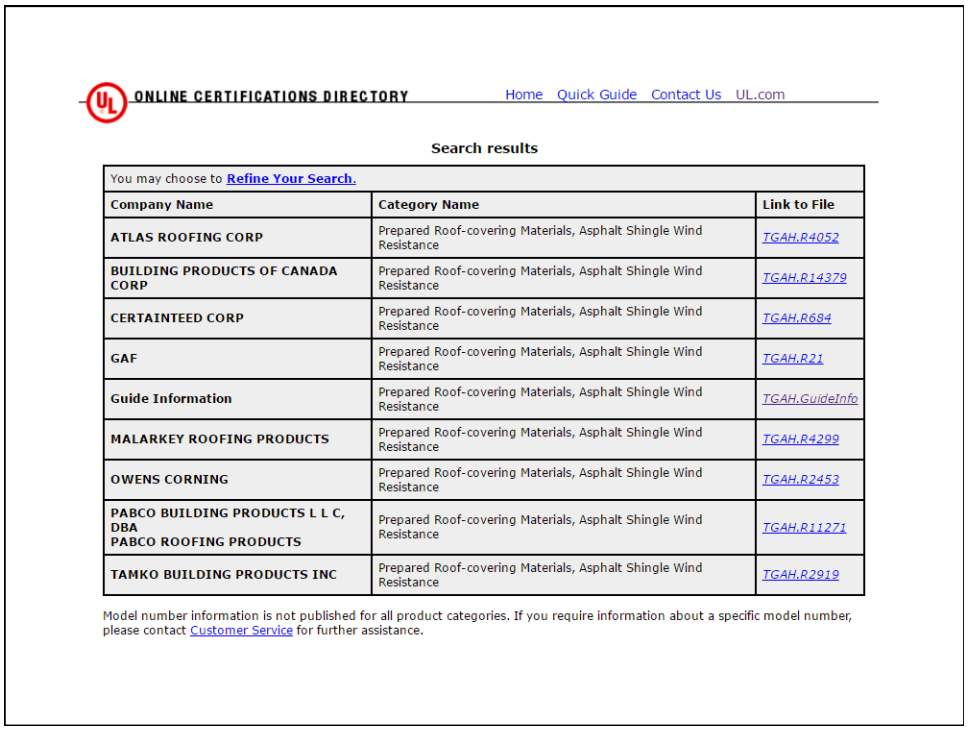
TABLE 1504.1.1
CLASSIFICATION OF ASPHALT SHINGLES

MAXIMUM BASIC WIND SPEED, V_{asd}, FROM FIGURE 1609A, B, C OR ASCE 7	MAXIMUM BASIC WIND SPEED, V_{asd}, FROM TABLE 1609.3.1	ASTM D 7158[a] CLASSIFICATION	ASTM D 3161 CLASSIFICATION
110	85	D, G or H	A, D or F
116	90	D, G or H	A, D or F
129	100	G or H	A, D or F
142	110	G or H	F
155	120	G or H	F
168	130	H	F
181	140	H	F
194	150	H	F

For SI: 1 foot = 304.8 mm; 1 mph = 0.447 m/s.

a. The standard calculations contained in ASTM D 7158 assume Exposure Category B or C and building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.





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ATLAS ROOFING CORP	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R4052
BUILDING PRODUCTS OF CANADA CORP	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R14379
CERTAINTEED CORP	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R684
GAF	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R21
Guide Information	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.GuideInfo
MALARKEY ROOFING PRODUCTS	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R4299
OWENS CORNING	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R2453
PABCO BUILDING PRODUCTS L L C, DBA PABCO ROOFING PRODUCTS	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R11271
TAMKO BUILDING PRODUCTS INC	Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance	TGAH.R2919

Model number information is not published for all product categories. If you require information about a specific model number, please contact Customer Service for further assistance.

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TGAH.R4052
Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance

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Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance

See General Information for Prepared Roof-covering Materials, Asphalt Shingle Wind Resistance

ATLAS ROOFING CORP R4052
SUITE 800
2000 RIVEREDGE PKY
ATLANTA, GA 30328 USA

Class H asphalt shingles, designated "Stormmaster Slate,""GlassMaster 25,""Pinnacle 35,""Pinnacle 45,""Ultra Pro,""Chalet,""Stratford,""StormMaster LM," and "StormMaster ST".

Last Updated on 2015-06-09

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Comparing FM 1-28 to ASCE 7-05 and ASCE 7-10

Example: A manufacturing building located in New Orleans, LA. The building is an enclosed structure with a low-slope roof system and a roof height of 33 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 (Field)	Zone 2 (Perimeter)	Zone 3 (Corner)
FM 1-28 (without SF)	v = 120	43	72	108
ASCE 7-05 (without SF)	v = 120	38	63	95
ASCE 7-10 Strength design	v_{ULT} = 150	59	99	148
ASCE 7-10 ASD (without SF)	v_{ASD} = 116	35	59	89

Closing thoughts…

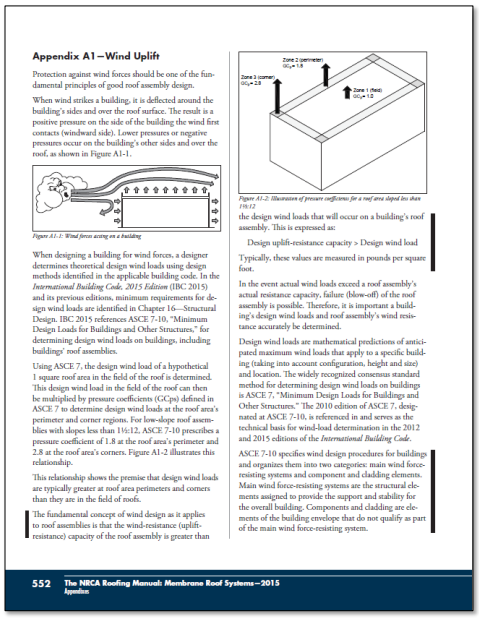
- Be cautious when you see a wind speed warrantee specified
- Remember the fundamentals
- Design wind loads (ASCE 7) are required to be shown on Construction Documents
- Use www.RoofWindDesigner.com
- FM or UL wind-uplift resistance ratings
- Asphalt shingles (only) are designed using wind speed and wind resistance classification
- Tile: Consult tile manufacturer

Additional references

Professional Roofing, March 2007

Additional references

The NRCA Roofing Manual: Membrane Roof Systems-2015 (July 2016 Update)



Appendix A1—Wind Uplift

Protection against wind forces should be one of the fundamental principles of good roof assembly design.

When wind strikes a building, it is deflected around the building's sides and over the roof surface. The result is a positive pressure on the side of the building the wind first contacts (windward side). Lower pressures or negative pressures occur on the building's other sides and over the roof, as shown in Figure A1-1.

Figure A1-1: Wind forces acting on a building

When designing a building for wind forces, a designer determines theoretical design wind loads using design methods identified in the applicable building code. In the *International Building Code, 2015 Edition* (IBC 2015) and its previous editions, minimum requirements for design wind loads are identified in Chapter 16—Structural Design. IBC 2015 references ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures," for determining design wind loads on buildings, including buildings' roof assemblies.

Using ASCE 7, the design wind load of a hypothetical 1 square roof area in the field of the roof is determined. This design wind load in the field of the roof can then be multiplied by pressure coefficients (GCpi) defined in ASCE 7 to determine design wind loads at the roof area's perimeter and corner regions. For low-slope roof assemblies with slopes less than 1½:12, ASCE 7-10 prescribes a pressure coefficient of 1.8 at the roof area's perimeter and 2.8 at the roof area's corners. Figure A1-2 illustrates this relationship.

This relationship shows the premise that design wind loads are typically greater at roof area perimeters and corners than they are in the field of roofs.

The fundamental concept of wind design as it applies to roof assemblies is that the wind-resistance (uplift-resistance) capacity of the roof assembly is greater than

Figure A1-2: Illustration of pressure coefficients for a roof area sloped less than 1½:12

the design wind loads that will occur on a building's roof assembly. This is expressed as:

Design uplift-resistance capacity > Design wind load

Typically, these values are measured in pounds per square foot.

In the event actual wind loads exceed a roof assembly's actual resistance capacity, failure (blow-off) of the roof assembly is possible. Therefore, it is important a building's design wind loads and roof assembly's wind resistance accurately be determined.

Design wind loads are mathematical predictions of anticipated maximum wind loads that apply to a specific building (taking into account configuration, height and size) and location. The widely recognized consensus standard method for determining design wind loads on buildings is ASCE 7, "Minimum Design Loads for Buildings and Other Structures." The 2010 edition of ASCE 7, designated as ASCE 7-10, is referenced in and serves as the technical basis for wind-load determination in the 2012 and 2015 editions of the *International Building Code*.

ASCE 7-10 specifies wind design procedures for buildings and organizes them into two categories: main wind force-resisting systems and component and cladding elements. Main wind force-resisting systems are the structural elements assigned to provide the support and stability for the overall building. Components and cladding are elements of the building envelope that do not qualify as part of the main wind force-resisting system.

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Appendix

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Personal website: www.MarkGrahamNRCA.com


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