Low Slope Roofing Systems
The University of Wisconsin Madison
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Roof decks and wind design

presented by

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
Rosemont, Illinois

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Definition

International Building Code, 2021 Edition

Roof deck: The flat or sloped surface constructed on top of the *exterior walls* of a building or other supports for the purpose of enclosing the *story* below, or shelter an area, to protect it from the elements, not including its supporting members or vertical supports

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Definition

International Building Code, 2021 Edition

Roof assembly: A system designed to provide weather protection and resistance to design loads. The system consists of a *roof covering* and *roof deck* or a single component serving as both the roof covering and the *roof deck*. A roof assembly can include an *underlayment*, a thermal barrier, insulation or a *vapor retarder*.

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Steel roof deck

Steel roof deck on steel joists on steel beams

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A roof deck….

- is a building's structural component of the roof assembly
- must be capable of safety supporting the design dead and live loads, including the weight of the roof system, and any additional loads that may be required by the applicable building code
- also provides the substrate to which roof systems are applied
- are categorized as either noncombustible (steel, concrete) or combustible (plywood, OSB, wood planks, wood boards)
- can also be categorized as "nailable" (attachment) or "non-nailable" (adhesion)

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Types of roof decks

- Cementitious wood fiber panels
- Lightweight insulating concrete
- Steel
- Structural concrete (cast-in-place, precast-prestressed and post-tensioned)
- Wood panels (plywood, OSB)
- Wood planks and wood boards

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Cementitious wood fiber panels

- Noncombustible
- Nailable
- Available as a composite product with rigid bord insulation
- NRDCA 600, “Guidelines for the Application of Cementitious Wood Fiber Roof Deck Systems (Link)

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Lightweight insulating concrete

- Noncombustible
- Nailable
- Poured in place
- Two types:
  - Lightweight aggregate
  - Lightweight cellular
- NRDCA 100: aggregate (Link)
- NRDCA 175: cellular (Link)
- Drying & venting considerations

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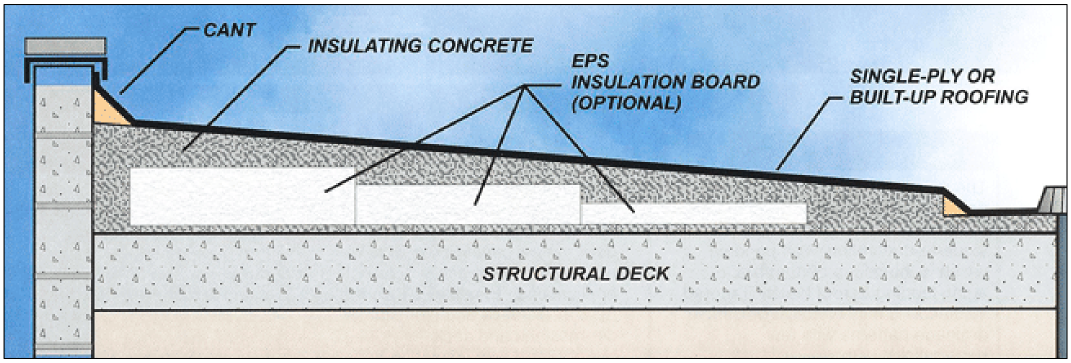
Cross section view

Lightweight insulating concrete



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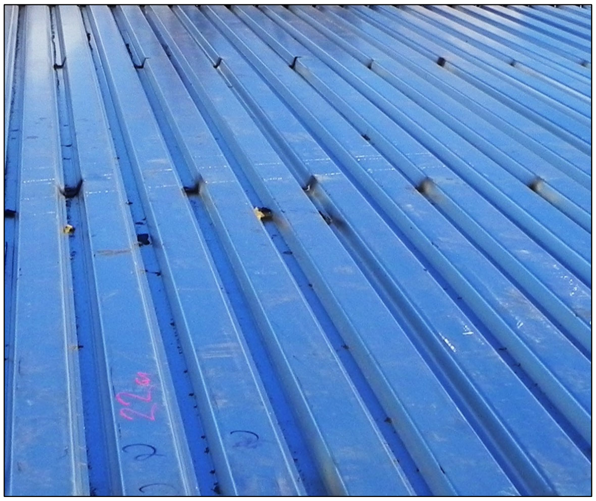
Steel roof deck



- Noncombustible
- Mechanical fasteners
- Multiple profiles/spans
- Prime painted and galvanized
- Two strength types:
  - 40 KSI (previously 33 KSI)
  - 80 KSI
- ANSI/SDI SD-2022, “Standard for Steel Deck”

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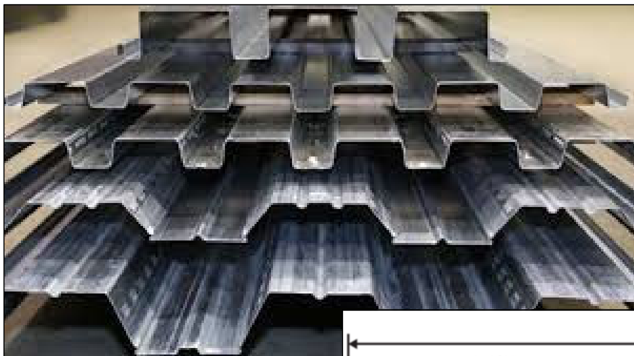
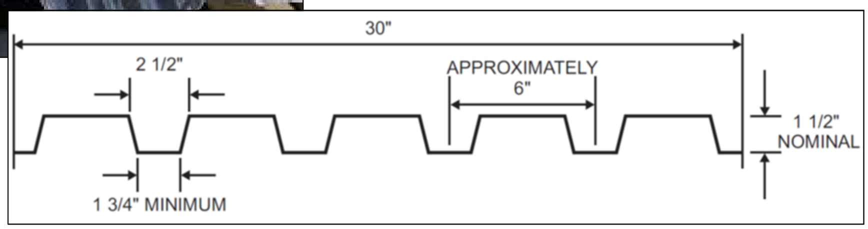
Steel roof deck -- continued



Steel roof deck configurations



Wide-rib steel roof deck (Type B)

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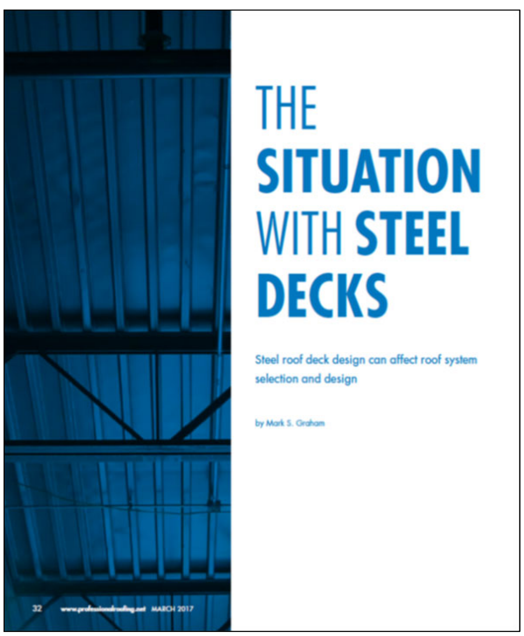

Steel roof decks
Professional Roofing, March 2017

Link

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Structural concrete

- Noncombustible
- Non-nailable
- Composition types:
  - Normal weight (150 lbs./ft^3)
  - Lightweight (90-110 lbs./ft^3)
- Construction types:
  - Cast-in-place (incl. post tensioned)
  - Precast-prestressed
- Curing and drying considerations

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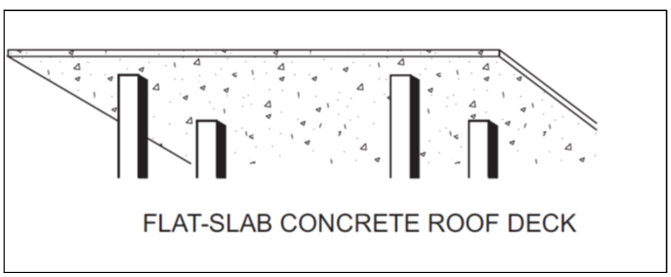
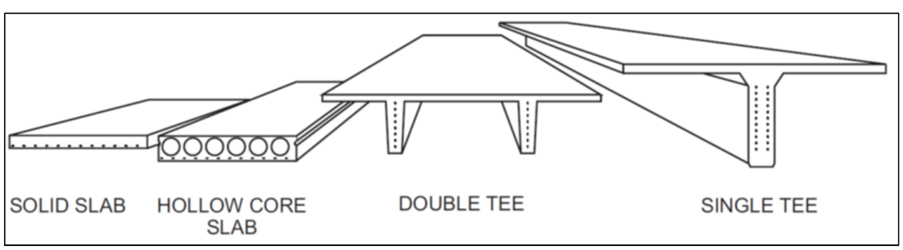
Structural concrete -- continued



Cast-in-place concrete roof deck



Precast concrete units

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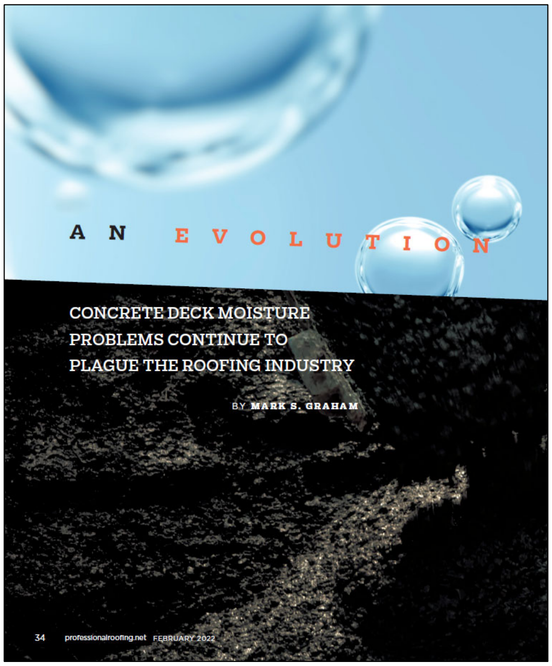

Concrete roof deck moisture

Professional Roofing, February 2020

Link

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Plywood and OSB panels

- Combustible
- Nailable
- Thickness and span
- Standards:
  - PS 1: Plywood
  - PS 2: OSB
  - APA PRP-108: Plywood or OSB
- APA Engineered Wood Construction Guide (E30): Roof Construction (Link)

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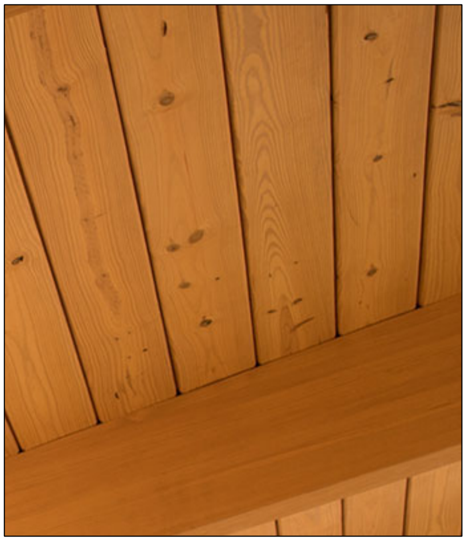
Wood plank and wood boards



- Combustible
- Nailable
- Wood planks: 2-5 inches thick with straight edges or T & G
- Wood boards: Less than 2 inches thick with square edges
- Species, thickness and span
- American Timber Council (ATC) *Timber Construction Manual*

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Other roof deck types

Sometimes encountered in reroofing

- Gypsum
  - Poured in place
  - Panels
- Thermal-setting fills
- Tile or masonry
- Various fills:
  - "Actinolite"
- Various composites
  - "Loadmaster"

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Additional considerations

Roof decks

- Deflection and smoothness
- Slope to drain
- Temporary weather protection
- Structural expansion joints & roof control joints
- Construction loading
- Deck "acceptance"

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A Roofing Contractor's "acceptance" of a roof deck should be limited to:

- Cleanliness: Broom clean (maybe "leaf-blower clean")
- No visible surface moisture

Any additional acceptance criteria is likely beyond a roofing contractor's expertise

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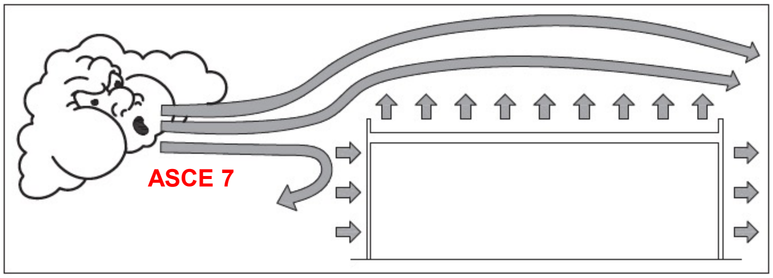
Questions

Roof decks

Wind design

The fundamental concept



Wind creates pressures/forces
on building elements…

…these forced are referred
to as "Design wind loads"

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The fundamental concept -- continued

A roof system needs to be able to "resist" the design wind loads acting on a building.

- Roof systems are tested for their "resistance" (attachment, adhesion):
  - FM Approvals classifications (FM 1-60, 1-90, 1-120, etc.)
  - UL classifications (UL Class 30, 60, 90)
  - Engineering analysis

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The fundamental concept -- continued

Design wind loads ≤ Tested resistance[*]

ASCE 7-16 ≤ FM Approvals classification or
UL classification[*] or
Engineering analysis[*]

[*] A "safety factor", typically 2.0 (i.e., 1/2 of tested resistance), is applied to account for variations in designs, materials, application and roof system aging/deterioration.

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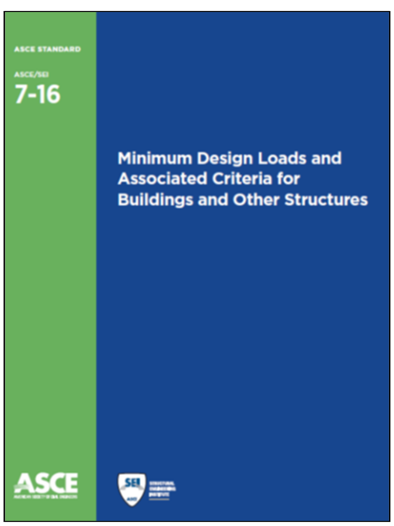
Design wind loads



ASCE 7-16, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures"

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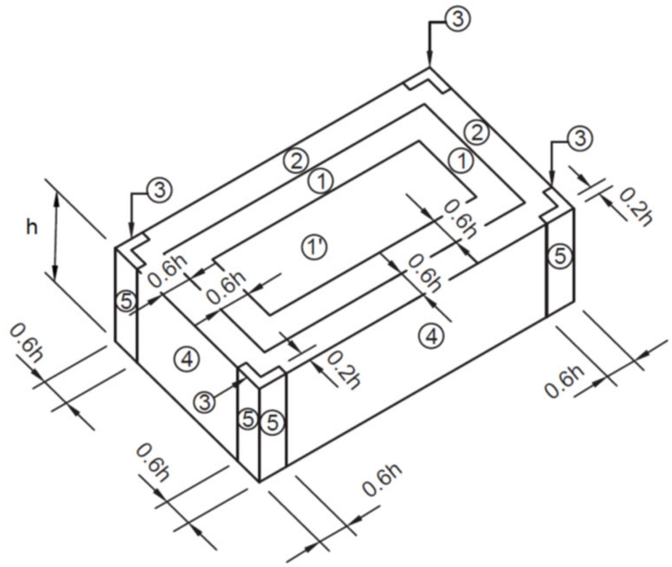
Roof zones

For buildings up to 60 high



Pressure coefficients (ASCE 7-16)

- Zone 1’: 0.9
- Zone 1: 1.7
- Zone 2: 2.3
- Zone 3: 3.2

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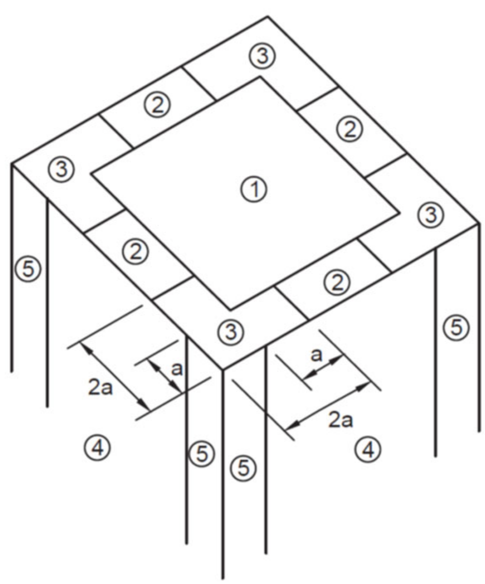
Roof zones -- continued

For buildings greater than 60 high



Pressure coefficients

- Zone 1: 1.7
- Zone 2: 2.3
- Zone 3: 3.2

a = 10% of the least horizontal dimension, or
0.4 times the building height, whichever is smaller;
but not less than either 4% of the least horizontal
Dimension or 3 feet

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Example design wind load calculation using ASCE 7-16

Example: A low-rise office building (Risk Category II) is in Madison, WI. 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 7-16 Ult.	V_{ULT} = 105	29.5	51.2	67.6	92.0
ASCE 7-16 ASD	V_{ASD} = 90	17.7	30.7	40.5	55.2

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Example design wind load calculation using ASCE 7-16

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An FM 1-75 classification provides adequate resistance

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Considerations/Reminders

- Design wind loads should be determined by the building/roof assembly designer
- Taller buildings, higher wind pressures
- Increasing basic wind speeds, higher wind pressures
- Don’t confuse (basic) wind speeds, with pressures:
  - For example, FM 1-90 means 45 psf, not 90 mph
- Proper wind design is relatively complicated

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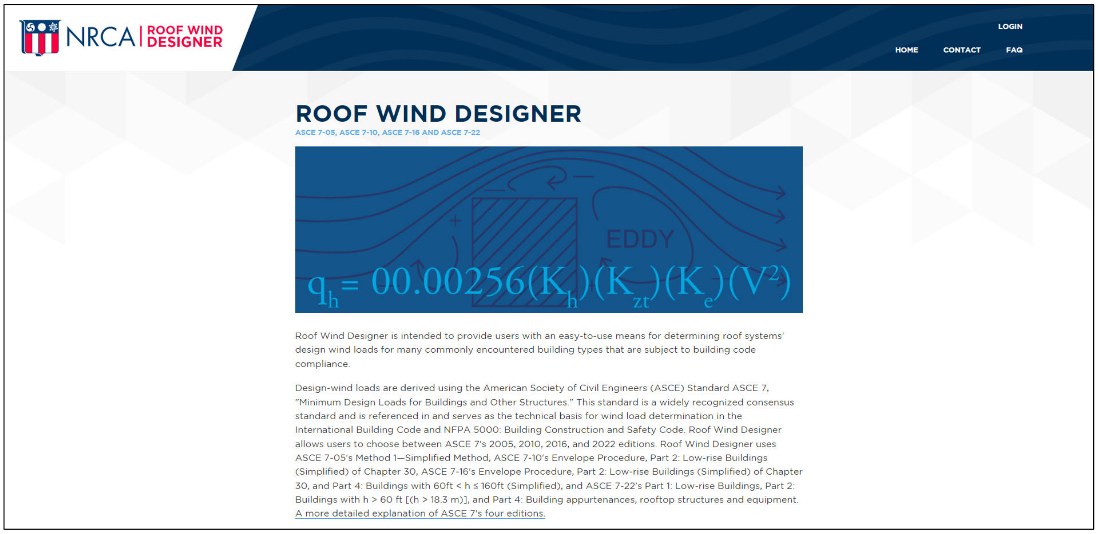
Roof Wind Designer

www.roofwinddesigner.com



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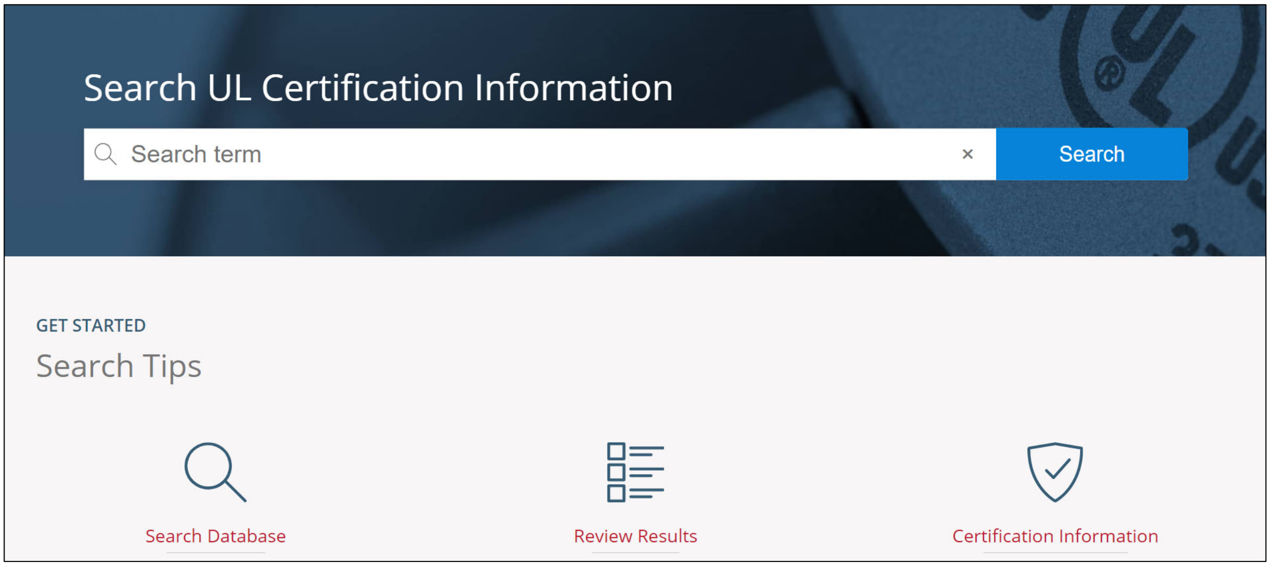
UL Product iQ

www.productiq.ulprospector.com



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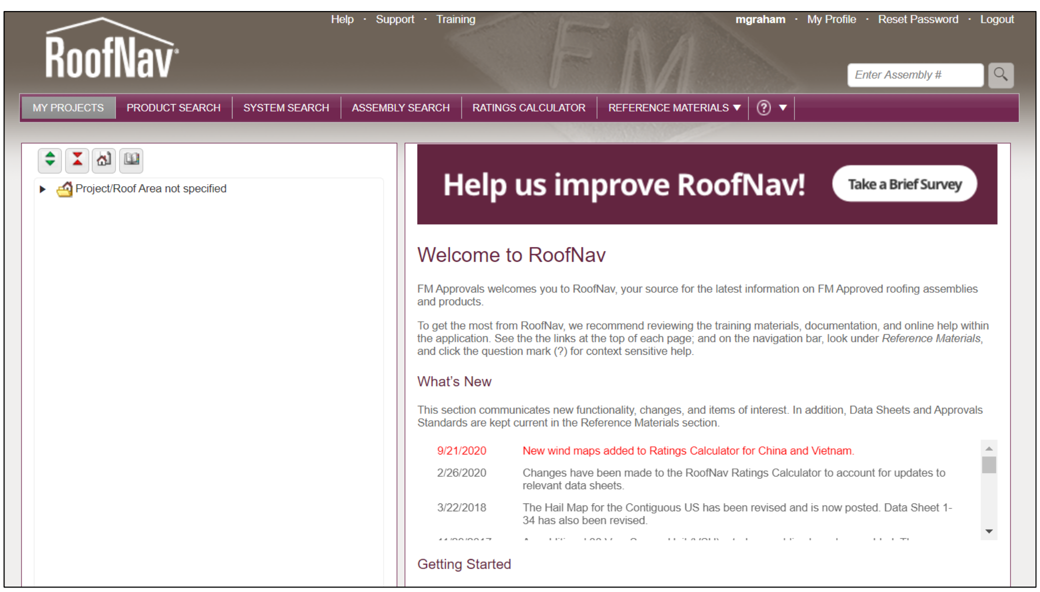
FM RoofNav

www.RoofNav.com



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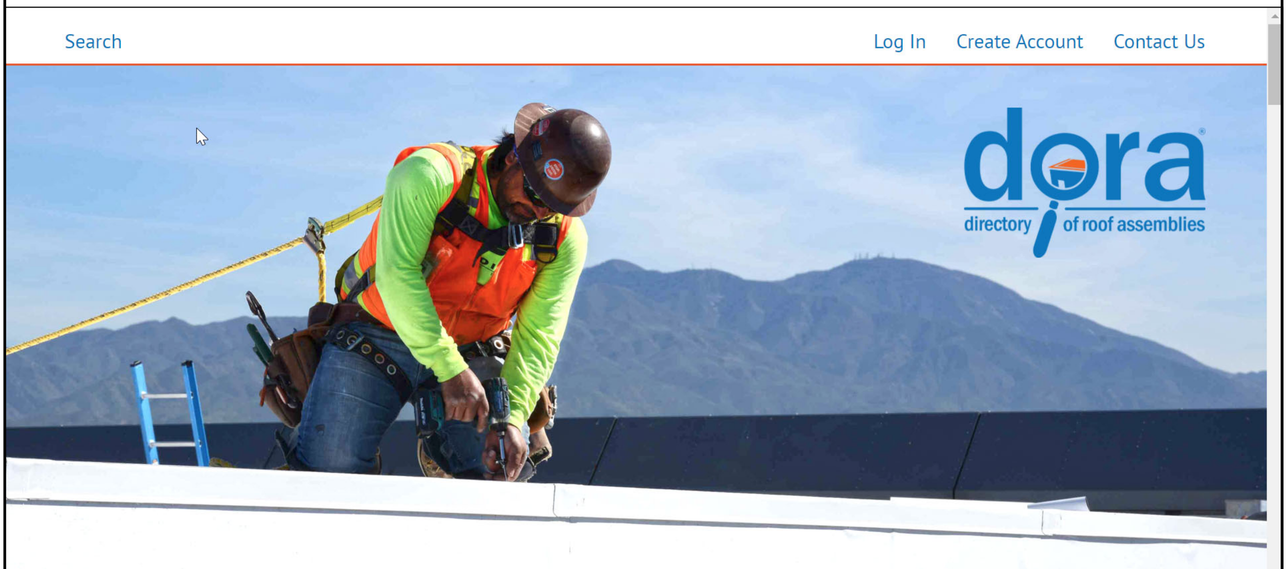
Directory of Roof Assemblies (DORA)

www.dora-directory.com



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Wind design for FM Global-insured buildings

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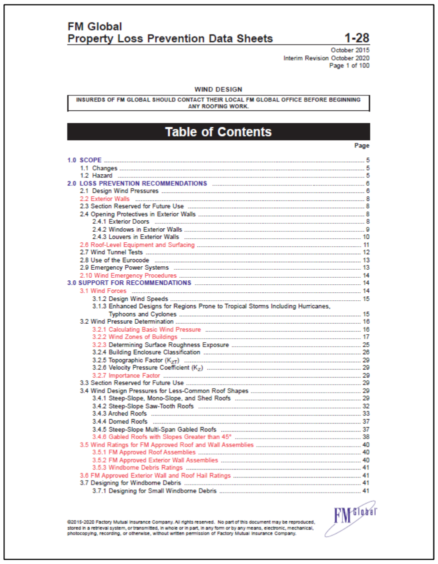
FM Global Loss Prevention Data Sheets

www.FMGlobalDataSheets.com


FM Global
Property Loss Prevention Data Sheets 1-28

October 2015
Interim Revision October 2020
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WIND DESIGN

INSUREDS OF FM GLOBAL SHOULD CONTACT THEIR LOCAL FM GLOBAL OFFICE BEFORE BEGINNING ANY ROOFING WORK.

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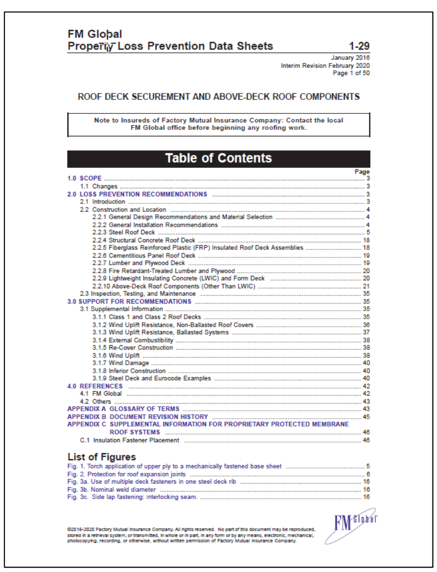
FM Global Loss Prevention Data Sheets

www.FMGlobalDataSheets.com


FM Global
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January 2016
Interim Revision February 2020
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ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

Note to Insureds of Factory Mutual Insurance Company: Contact the local FM Global office before beginning any roofing work.

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FM 1-29, Roof Deck Securement and Above-deck Roof Components

Wind load resistance

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Comparing ASCE 7-16's design wind loads to FM 1-28's

Example: A low-rise office building (Risk Category II) is in Madison, WI. 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 ASD	V_{ASD} = 90	17.7	30.7	40.5	55.2
FM 1-28	V_{ASD} = 90	24	43	57	77

FM 1-90

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FM Global's design wind load determination method typically results in higher design wind loads resulting in the need for higher wind resistances compared to ASCE 7-16

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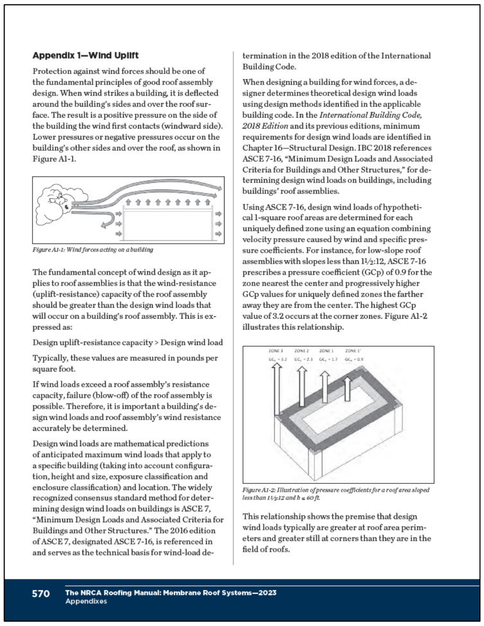

Appendix 1—Wind Uplift

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

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

If wind loads exceed a roof assembly's 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, exposure classification and enclosure classification) and location. The widely recognized consensus standard method for determining design wind loads on buildings is ASCE 7, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures." The 2016 edition of ASCE 7, designated ASCE 7-16, is referenced in and serves as the technical basis for wind-load determination in the 2018 edition of the International Building Code.

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, 2018 Edition* and its previous editions, minimum requirements for design wind loads are identified in Chapter 16—Structural Design. IBC 2018 references ASCE 7-16, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures," for determining design wind loads on buildings, including buildings' roof assemblies.

Using ASCE 7-16, design wind loads of hypothetical 1-square roof areas are determined for each uniquely defined zone using an equation combining velocity pressure caused by wind and specific pressure coefficients. For instance, for low-slope roof assemblies with slopes less than 1½:12, ASCE 7-16 prescribes a pressure coefficient (GCp) of 0.9 for the zone nearest the center and progressively higher GCp values for uniquely defined zones the farther away they are from the center. The highest GCp value of 3.2 occurs at the corner zones. Figure A1-2 illustrates this relationship.

ZONE 3 $GC_p = 3.2$
ZONE 2 $GC_p = 2.3$
ZONE 1 $GC_p = 1.7$
ZONE 1' $GC_p = 0.9$

Figure A1-2: Illustration of pressure coefficients for a roof area sloped less than 1½:12 and h ≤ 60 ft.

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

570 The NRCA Roofing Manual: Membrane Roof Systems—2023
Appendixes

Wind uplift

The NRCA Roofing Manual

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Roof decks and wind design

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Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
10255 West Higgins Road, 600
Rosemont, Illinois 60018-5607

(847) 299-9070
mgraham@nrca.net
www.nrca.net

Personal website: www.MarkGrahamNRCA.com
LinkedIn: linkedin.com/in/markgrahamnrca

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