

Low Slope Roofing Systems The University of Wisconsin Madison

Madison, Wisconsin – December 2-3, 2025

Roof decks and wind design

presented by

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Definition

International Building Code, 2024 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



Definition

International Building Code, 2024 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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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 "nonnailable" (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



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 (<u>Link</u>)

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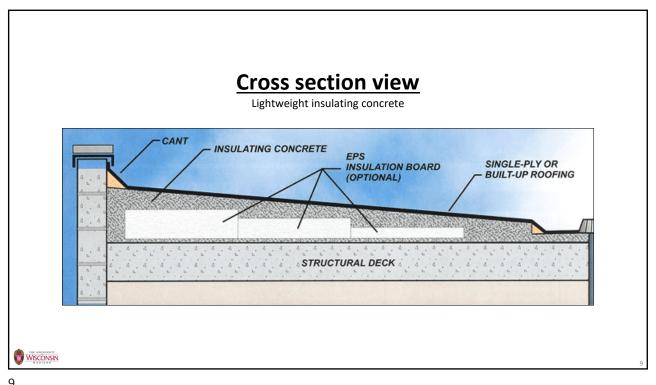
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Lightweight insulating concrete



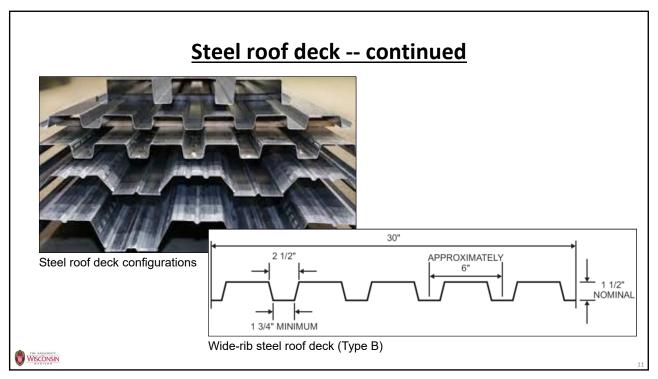
- Noncombustible
- Nailable
- Poured in place
- Two types:
 - Lightweight aggregate
 - Lightweight cellular
- NRDCA 100: aggregate (Link)
- NRDCA 175: cellular (<u>Link</u>)
- Drying & venting considerations

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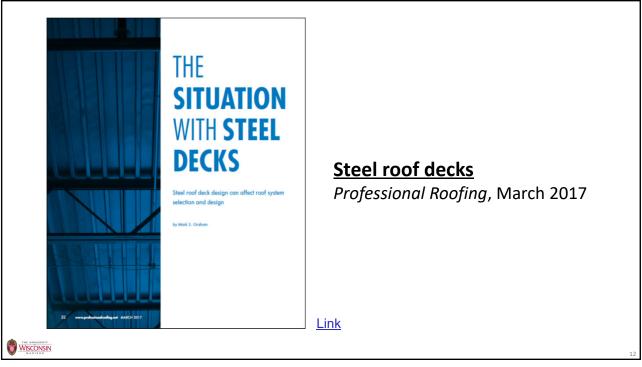


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Steel roof deck Noncombustible Mechanical fasteners Multiple profiles/spans Prime painted and galvanized Two strength types: 40 KSI (previously 33 KSI) 80 KSI ANSI/SDI SD-2022, "Standard for Steel Deck"



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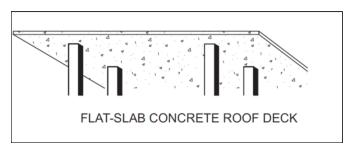
Structural concrete



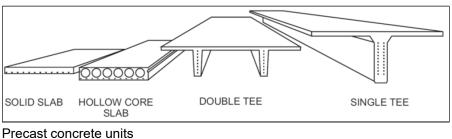
- Noncombustible
- Non-nailable
- Composition types:
 - Normal weight (150 lbs./ft³)
 - Lightweight (90-110 lbs./ft³)
- Construction types:
 - Cast-in-place (incl. post tensioned)
 - Precast-prestressed
- Curing and drying considerations

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Structural concrete -- continued

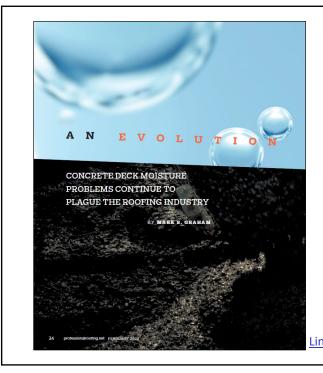


Cast-in-place concrete roof deck



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Concrete roof deck moisture

Professional Roofing, February 2020

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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 (<u>Link</u>)

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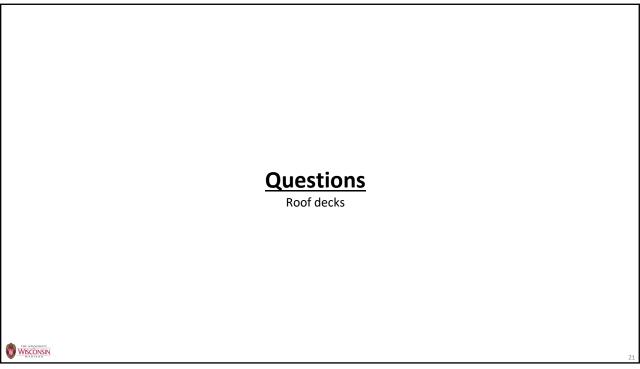
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A Roofing Contractor's "acceptance" of a roof deck should be limited to:

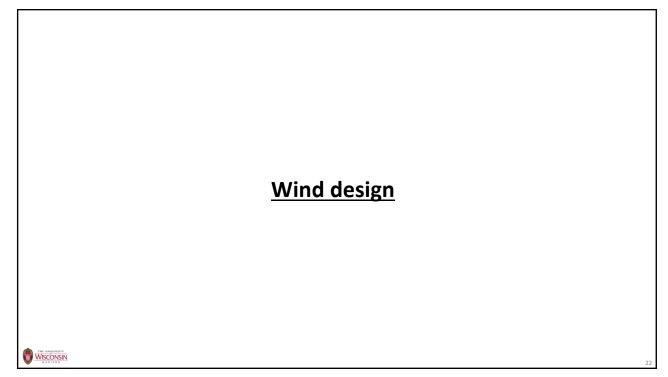
- Cleanliness: Broom clean (maybe "leaf-blower clean")
- No visible surface moisture

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

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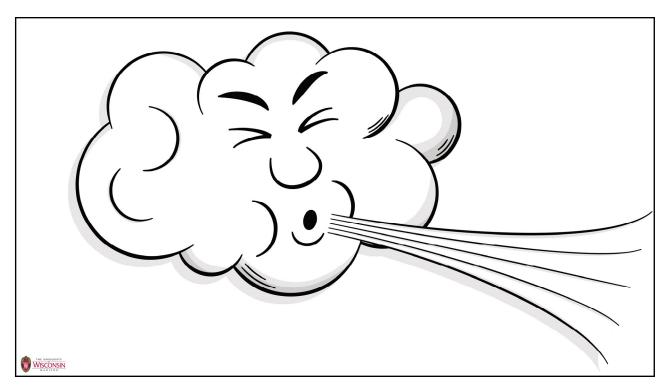
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Wind design... high winds, hurricanes and tornados



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Beaufort wind scale

Force	Wind Speed (mph)	Description	Characteristics
0	0-1	Calm	Smoke rises vertically
1	1-3	Light air	Direction of smoke drift
2	4-7	Light breeze	Wind felt of face; leaves rustle
3	8-12	Gentle breeze	Wind extends a light flag
4	13-18	Moderate breeze	Small branches are moved
5	19-24	Fresh breeze	Small trees in leaf begin to sway
6	25-31	Strong breeze	Large branches in motion
7	32-38	Near gale	Whole trees in motion
8	39-46	Gale	Breaks twigs off trees
9	47-54	Severe gale	Slight structural damage occurs
10	55-63	Storm	Trees uprooted; structural damage
11	64-72	Violent storm	Wide-spread damage
12	73-83	Hurricane	See Saffir-Simpson Hurricane Scale
	,3 63	Harricanc	See Sum Simpson Hurricane Scale

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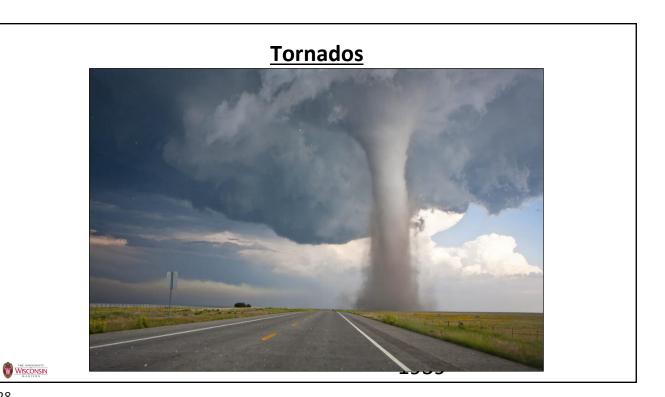
Helene (Sept. 26) 420 miles wide TIDA (2021) 247 miles **MICHAEL (2018) 212 miles 212 miles 212 miles

Saffir-Simpson Hurricane Wind Scale

Category	Wind Speed (mph)	Characteristics
1	74-95	Very dangerous winds produce some damage
2	96-110	Extremely dangerous winds will cause extensive damage
3	111-129	Devastating damage will occur
4	130-156	Catastrophic damage will occur
5	157 and higher	Catastrophic damage will occur



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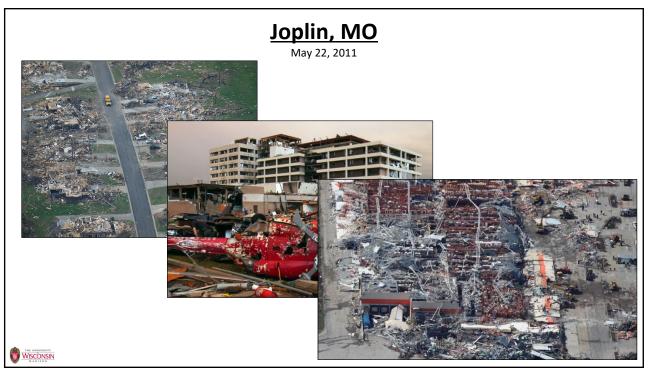


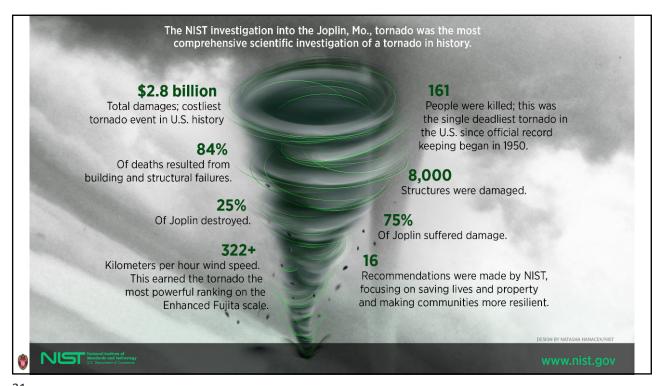
Enhanced Fujita Scale (EF scale)

Category	Wind Speed (mph)	
0	65-85	
1	86-110	
2	111-135	
3	136-165	
4	166-200	
5	Over 200	

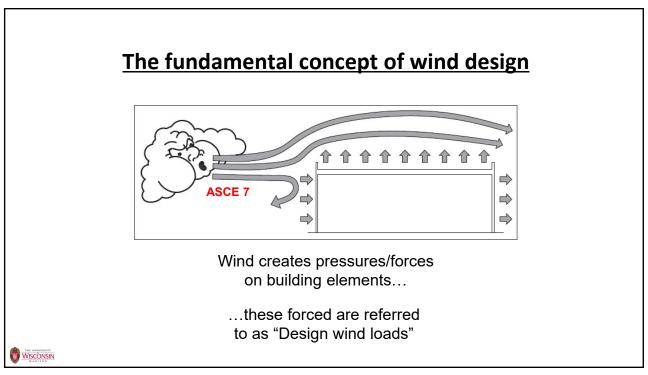
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The fundamental concept -- continued

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 7-22 ≤ 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 Minimum Design Loads and Associated Criteria for Buildings and Other Structures ASCE 7-22, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" ASCE STATEMENT PROPERTY OF THE PROPERTY OF

Roof zones

For buildings up to 60 high

Pressure coefficients (ASCE 7-22)

• Zone 1': -0.9

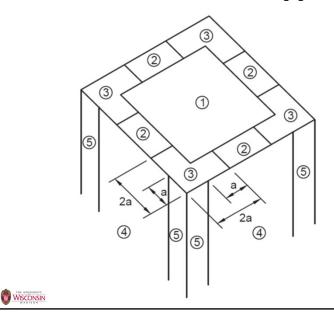
• Zone 1: -1.7

• Zone 2: -2.3

• Zone 3: -3.2

Roof zones -- continued

For buildings greater than 60 high



Pressure coefficients

• Zone 1: -1.4

• 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 7-22

Example: An auditorium building (Risk Category III) 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	Design wind pressure (psf)			
	speed (mph)	Zone 1' (Center)	Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corners)
ASCE 7-22 Ult.	V _{ULT} = 115	35.1	61.1	80.6	109.9
ASCE 7-22 ASD	V _{ASD} = 90	21.2	36.7	48.4	65.9



Example design wind load calculation using ASCE 7-22

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ASCE 7-22 ASD	V _{ASD} = 90	21.2	36.7	48.4	65.9

An FM 1-75 classification provides adequate resistance

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Tornado loads

ASCE 7-22 Chapter 32-Tornado loads

- Risk Category III and IV buildings
- Tornado-prone region
 - Generally East of the Rocky Mountains
- Use V_T
 - 16 maps based on risk category and "effective area"
- If design tornado loads are greater than design wind loads, use the design tornado loads as the basis for design



Example design wind load calculation using ASCE 7-22

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ASCE 7-22 ASD	V _{ASD} = 90	21.2	36.7	48.4	65.9
ASCE 7-22 Ult.	V _T = 93	25.0	37.1	43.1	58.5



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Example design wind load calculation using ASCE 7-22

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ASCE 7-22 Ult.	V _T = 93	25.0	37.1	43.1	58.5



Since tornado loads are less than wind loads, use wind loads

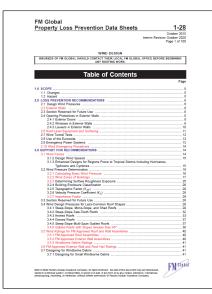
Wind design for FM-insured buildings

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FM Loss Prevention Data Sheets

www.FMGlobalDataSheets.com



FM 1-28, Wind Design

Design wind load determination

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FM Loss Prevention Data Sheets

www.FMGlobalDataSheets.com



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

Wind load resistance

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Comparing ASCE 7-22's design wind loads to FM 1-28's

Example: An auditorium building (Risk Category III) 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	Design wind pressure (psf)			
	speed (mph)	Zone 1' (Center)	Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corners)
ASCE 7-22 Ult.	V _{ULT} = 155	35.1	61.1	80.6	109.9
ASCE 7-22 ASD	V _{ASD} = 90	21.1	36.7	48.4	65.9
FM 1-28	V _{ASD} = 90	24	43	57	77



Comparing ASCE 7-22's design wind loads to FM 1-28's

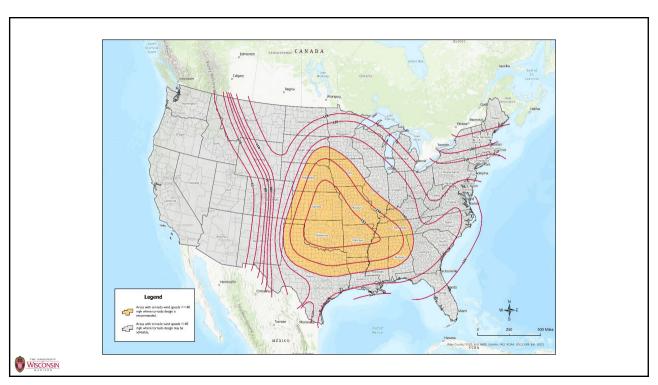
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	speed (mph)	Zone 1' (Center)	Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corners)
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ASCE 7-22 ASD	V _{ASD} = 90	21.1	36.7	48.4	65.9
FM 1-28	V _{ASD} = 90	24	43	57	77

FM 1-90

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FM's tornado design recommendations

FM 1-28, Sec. 2.11-Tornados

- Assume "partially enclosed" and Exposure C
- Avoid the use of windows
 - When windows are provided, use FM 4350 Level D or E impactresistant glazing
- Limit other exterior wall openings (e.g., doors)
 - Doors should open outward and have positive latching
- Do not use aggregate on roofs
- Consider full-time QAO during exterior wall and roof application



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Wind Design FM Global Property Loss Prevention Data Sheets

3.12.4.5 Design Wind Speeds and Wind Pressures

The guidance in this document is primarily for locations on the map in Figure 2.11.1 with wind speeds of 140 mph (62 m/s) and greater. If desired by the client or account team, design guidance can be given for locations on the map with wind speeds less than 140 mph (62 m/s).

Note: The cost increase to change from a 90 mph (40 m/s) design wind speed (as is the case with the majority of the central United States) to a higher tornado wind design will vary, depending on geography, the specific design criteria, percentage of windows, etc. Increased construction costs for components and cladding are expected in areas not normally designed for increased wind speeds. This cost increase could be as high as 50%.

Similar to what occurs with hurricanes, most tornado damage is much greater to the building envelope than to the building frame. Using an importance factor of 1.15 (based on ASCE 7-05), some larger structures designed for more typical code-required wind speeds (≥ 90 mph [40 m/s]), have experienced considerable damage to the building envelope, yet limited damage to the structural frame. One cost-effective approach would be to provide a limited increase in design strength for the building frame, but a considerable increase in resistance for the building envelope.



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FM Global's tornado design provisions are more stringent than IBC 2024's and ASCE 7-22's



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FM's design wind load determination method typically results in higher design wind loads resulting in the need for higher wind resistances compared to ASCE 7-22



Some considerations/Reminders

Designing for wind and tornado load

- Design wind and tornado 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 and tornado design is relatively complicated



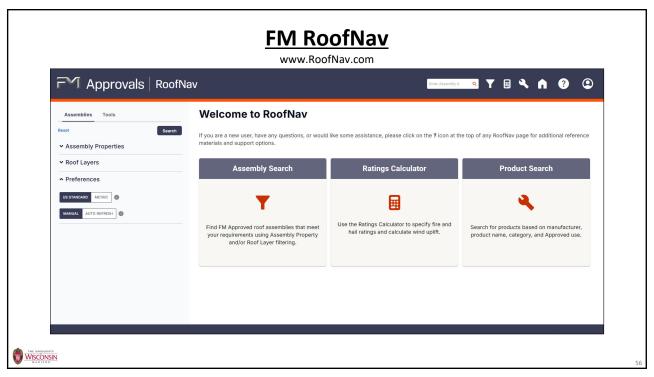
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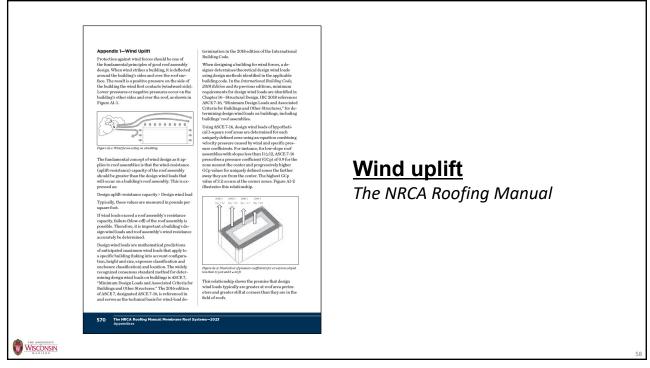


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Questions

Roof decks and wind design



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Mark S. Graham





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