Resilience and the Impact on Roofing

Provider Number: A001

Course Number: #S23RIR

Presenter: Brian P. Chamberlain, CSI, SPRI, IIBEC

Date: March 29, 2023

Collaboration Partner

Solutions From the Ground Up

Learning Objectives

At the conclusion of this educational activity, the learner will be able to:

1. Learn the definitions of Resilience and how these definitions from organizations differ.

2. Review of standards and how they can be used to go beyond the building code.

3. Case examples of real-world projects that incorporate a redundancy with consideration of worse case weather events.

4. Offer a check list on what to consider based on specific concerns by the building owner and/or the use of the building.

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Introduction

Defining Resiliency

Oxford Languages defines resilience as…

1. The capacity to recover quickly from difficulties, toughness.
2. The ability of a substance or object to spring back into shape; elasticity.

Resiliency

Right now, there are many definitions of resiliency, depending on organizational or industry specific perspectives.

- Preparation for terrorism
- City infrastructure
- Whole building and surrounding terrain
- And a Building Systems Focus

All have the basic premise: If a sever event should occur, the resulting damage is minimized with the goal to get all activities back to normal ASAP.

Department of Homeland Security - DHS

Eighteen Critical Infrastructure Sectors Identified in 2009

Food & Agriculture	Banking and Finance	Chemical
Commercial Facilities	Communications	Critical Manufacturing
Dams	Defense Industrial Base	Emergency Services
Energy	Government Facilities	Information Technology
Healthcare & Public Health	National Monuments	Nuclear Facilities
Postal & Shipping	Transportation System	Water

When essential building or infrastructure systems are damaged, a ripple effect spreads and disrupts a communities' ability to function.

Defining Resiliency

Contributors

U.S. Government Agencies
- DHS
- NIBS
- National Academy of Science
  - NOAA
  - White House Conf.

Non-Governmental Organizations
- ICC
- USGBC
- Resilience Building Coalition

The Canadian Government
- Canadian Research Council- NRCC

Trade Associations
- BOMA
- AIA

Defining Resiliency

US Department of Homeland Security and Federal Emergency Management Agency

The Ability to Adapt to Changing Conditions and **<u>Withstand and Rapidly Recover</u>** from Disruption due to Emergencies

The Key Phrase

" Withstand and Rapidly Recover"

Is Now Shaping The Resilience Discussion

Super Dome, New Orleans, LA

The Building Industry Report on Resiliency

A Coalition of the AIA and NIBS (National Institute of Building Standards) Plus 19 other Members and Code Agencies.

Develop "Whole-systems Resilient Design"

ASCE, NIST, NRCA, ERA, IIBEC and others.

- Develop Codes and Policies to Advance Resiliency
- Provide Guidance Beyond the Baseline-Safety Codes

Performance-based design set performance goals that are more stringent than the minimum standards required in current model codes and standards.

Code & Standards

Buildings & Other Structures: minimum performance criteria for design-level hazard events.

Accounts for: wind (non-tornadic), snow, seismic & fire events

Each Code Cycle: Improve Health & Safety of the Occupant & the Surrounding Enviroment

Champlain Towers South
Surfside, FL - 2021

Miami-Dade Fire Rescue Department

New York City, NY - 2022

Ronemus & Vilensky

Boise, ID - 2017

Rapid Aerial

Resiliency

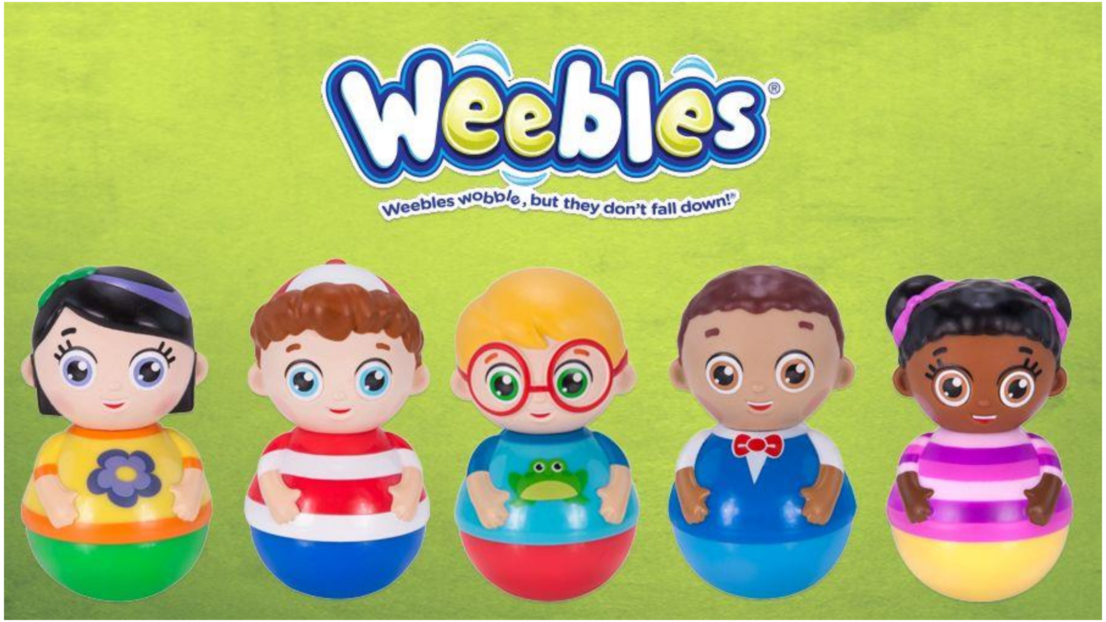
Thomas Lee Smith’s definition:

“Wind-resilient building: A building that is capable of resisting damage from wind and wind-driven rain; furthermore, if damaged, the building can be readily repaired so that important functions are maintained during and/or after a windstorm.”

Laverne Dalgleish, executive director of the Air Barrier Association of America, once said about the industry in general:

“This is not rocket-science…it’s worse.”

Resiliency



Weebles – (Source: Jazwares)

Options for Determining Uplift

Where to start?

Uplift Resistance – Adoption by State

ASCE 7 edition	States
2016	AL, AK, CA, CT, FL, GA, HI, ID, MD, MN, MS, MT, NE, NH, NJ, NY, ND, OK, OR, PA, RI, SC, SD, UT, VA, WA, WV & WY **Total 28 States**
2010	AR, IN, IA, KY, LA, ME, MA, MI, NC, NM, OH, TN, TX, VT & WI **Total 15 States & DC***
2005	0
Version adopted by Local Governments	AZ, CO, DE, IL, KS, MO, NV **Total 7 States**

International Code Council (January 2023)

*District of Columbia

ASCE 7-2005

$$q_z = 0.00256 \times K_Z \times K_{Zt} \times K_d \times V^2 \times I$$

ASCE 7-2010

$$q_z = 0.00256 \times K_Z \times K_{Zt} \times K_d \times V^2$$

I = Importance Factor was incorporated into V (Ultimate Winds)

ASCE 7-2016

$$qz = 0.00256 \times K_Z \times K_{Zt} \times K_d \times K_e \times V^2$$

K_e = Ground Elevation Factor

ASCE 7-2022

$$qz = 0.00256 \times K_Z \times K_{Zt} \times K_e \times V^2$$

K_d was moved to Design Wind Pressure Calculations

Increasing Uplift Requirements

"Safety Factor"

ASCE 7

Does Not mention one for Cladding

Minimum IBC criteria is to meet the calculated uplift without a safety factor.

Increasing Uplift Requirements

"Safety Factor"

Industry use of a Safety Factor

Apply the SF to the <u>results</u> of ASCE

ASCE result = 45-psf x 2 = 90-psf

Agencies that use this method

Roof Wind Designer by NRCA, MRCA, & NERCA	FM PLPDS* 1-28

ASTM D6630

*Property Loss Prevention Data Sheets

Increasing Uplift Requirements

"Safety Factor"

Industry use of a Safety Factor

Apply the SF to the Rated Assembly <u>by dividing</u>

Rated assembly = 90 psf / 2 = 45 psf

Agencies that use this method	
Miami-Dade Building Code Compliance Office	State of Florida

Increasing Uplift Requirements

Increasing local wind speed

Two Steps Greater Local Ultimate Wind Speed

EF5 Tornado (250-mph)

Saffir-Simpson Hurricane Category	*Basic 3 – sec gust wind speed**
Cat 1	82-108 mph (37-48 m/s)
Cat 2	108-130 mph (48-58 m/s)
Cat 3	130-156 mph (58-70 m/s)
Cat 4	156-191 mph (70-85 m/s)
Cat 5	> 191 mph (> 85 m/s)

Example Buildings

Data Centers

Storm Shelters

Internal Pressures

Openings in buildings can over pressurize the roof

Getting Carried Away: Example:

Project Parameters: Dimensions: 2000-sqs (400’x500’) **Building Height:** 50-ft

Wind Load (ASCE 7-10)

- Basic wind speed: 120-mph (Vult) **increased to 160-mph**
- Occupancy Category: IV
- Exposure: D
- Enclosed
- Safety Factor 2
- Assembly uplift rating listed in FBC Product Approvals

Results

Zone 1: 167-psf

Zone 2: 281-psf

Zone 3: 422-psf

Assembly in Zone 3 must have passed **844-psf** following ANSI/FM 4474 uplift testing

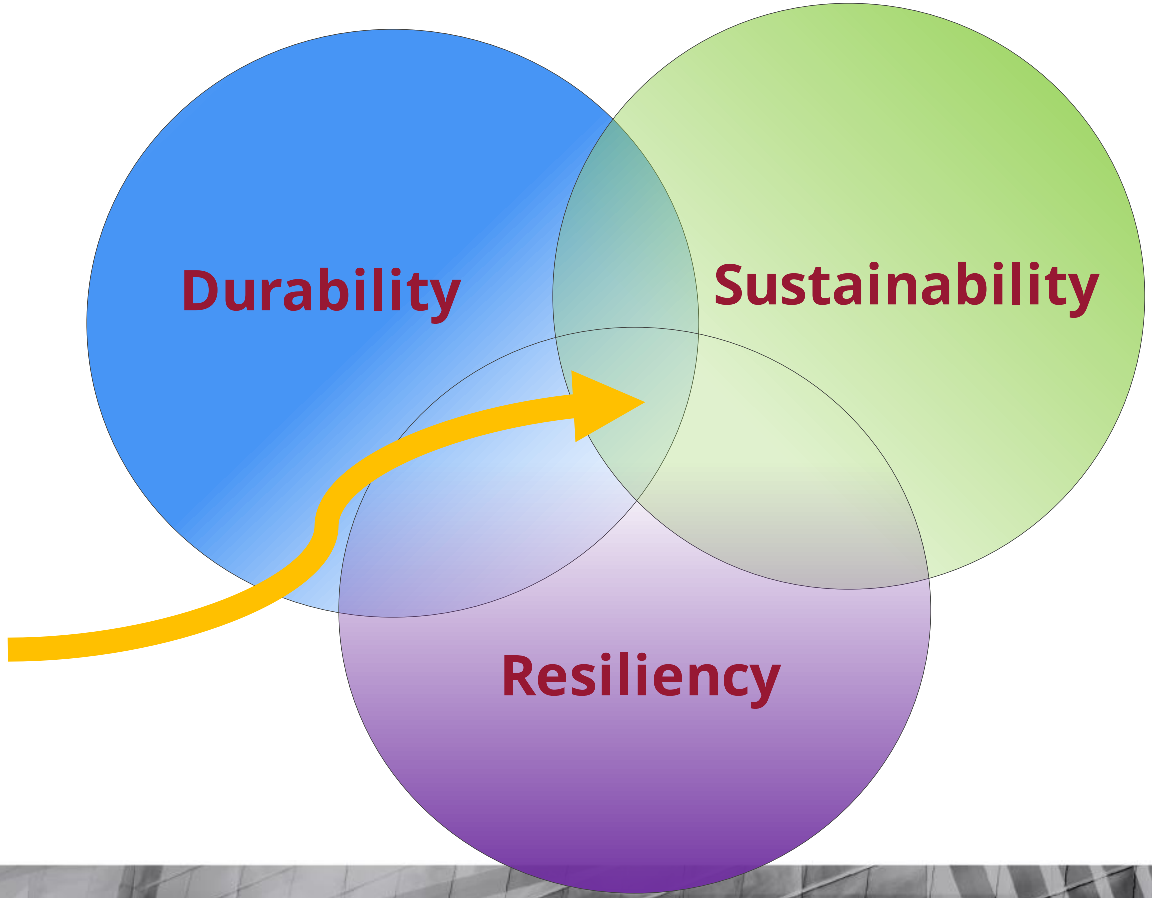
Roof Design total safety:

x4 + an additional 40-mph

Five Factors

- Durability
- Training
- Sustainability
- Resiliency Design
- Cost

The Goal



Including

- Materials/ Assemblies
- Training & Installation
- Testing & Standards

Definitions of Terms

Durability:

This includes products, roof assemblies, and training so when the installation is complete, it could exceed the building code

Sustainability:

Roof design considerations beyond durability, which includes environmental concepts such as cradle-to-cradle, life cycle assessment, on material, energy savings, & recyclability, etc.

Resiliency:

The roof assembly design to deal with a sever natural event with the intent that any damage requires minimum repairs or disruption to the operation of the building

Training

NRCA: ProCertification®

Manufacturers

- Single-Ply
- Modified
- BUR
- Metal
- Foams & Coating
- Etc.

Training

Types of Training Programs

- New Applicator Training
- Certifications based on materials
- Installation Type & Method
- Classroom and Hands On

Training

Experience Applicator Training

- Refresher
- Advanced installation methods
- Time saving options
- New Technology

Job-Site Assistance

<u>Recommended training once a year</u>

Membrane Durability

Membrane History

Early 1980’s, two EPDM membranes where popular.

Today 250 types of membranes, including TPO, PVC, EPDM, Reinforced, Non-Reinforced, Fleece/Felt Backed membranes.

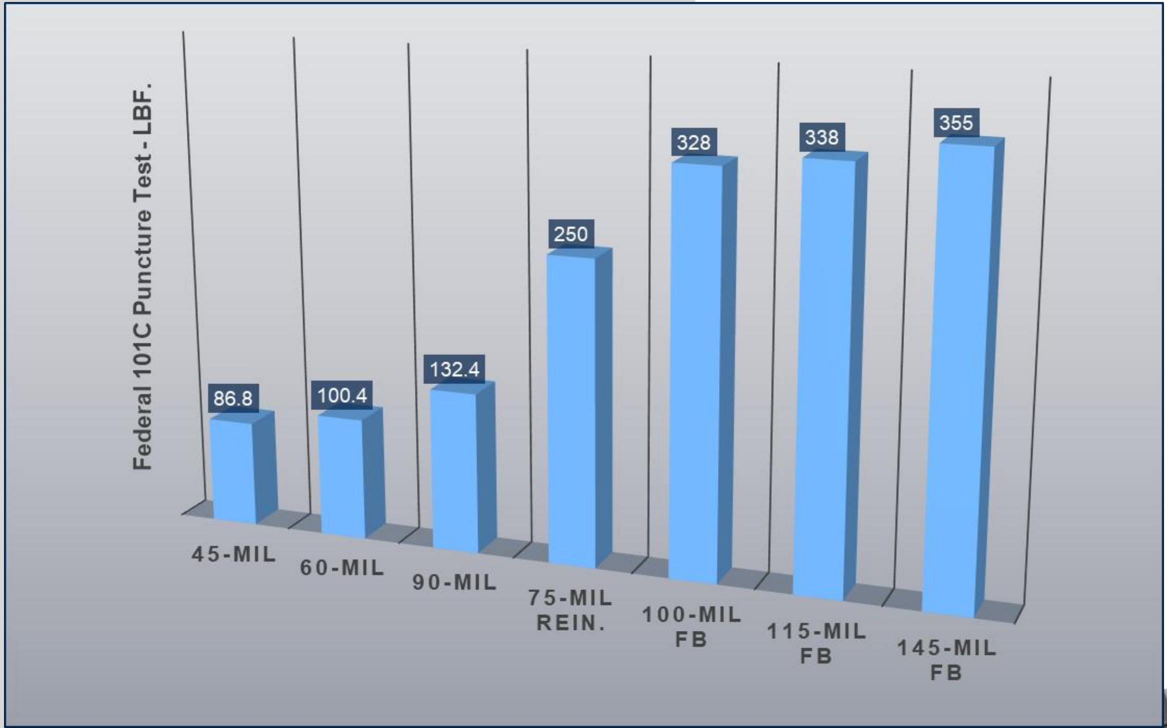
Add on the changes with modified, BUR, etc.

Roof System Components

- Securements: Fasteners & Adhesives
- Air Barriers & Vapor Retarders
- Insulation: Polyisocyanurate, Extruded Polystyrene, Expanded Polystyrene, Mineral Wool & Lightweight Insulated Concrete
- Cover Boards
- Adhesives
- Membranes

Physical Properties

“Thicker Is Better”



Adhesive Options for Membrane

Standard Bonding Adhesives

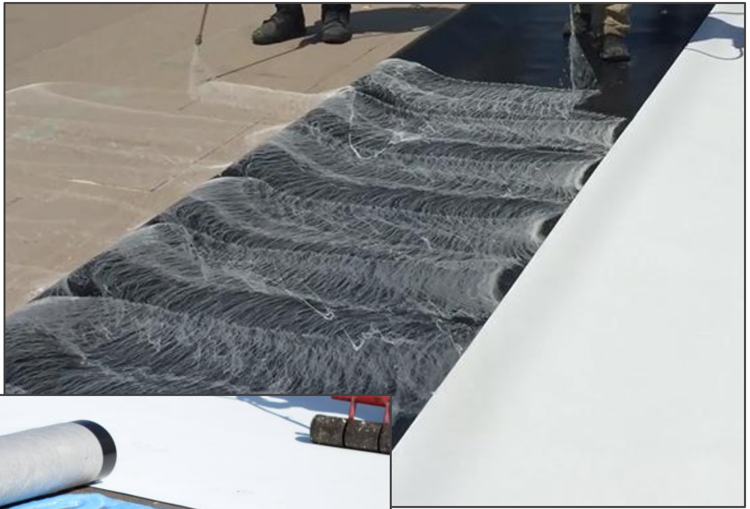
- Non-VOC compliant
- Solvent-based

Low-VOC Adhesives

- < 250 g/l VOC
- Utilize different solvents
- Could be water-based

VOC-free Adhesives

- Zero VOC
- Urethane Adhesives



Commercial Roof Cover Board Choices

- Increased Hail Resistance
- Increase Fire Performance
- Increased Wind Uplift

HD Polyiso Cover Boards

Gypsum Cover Boards

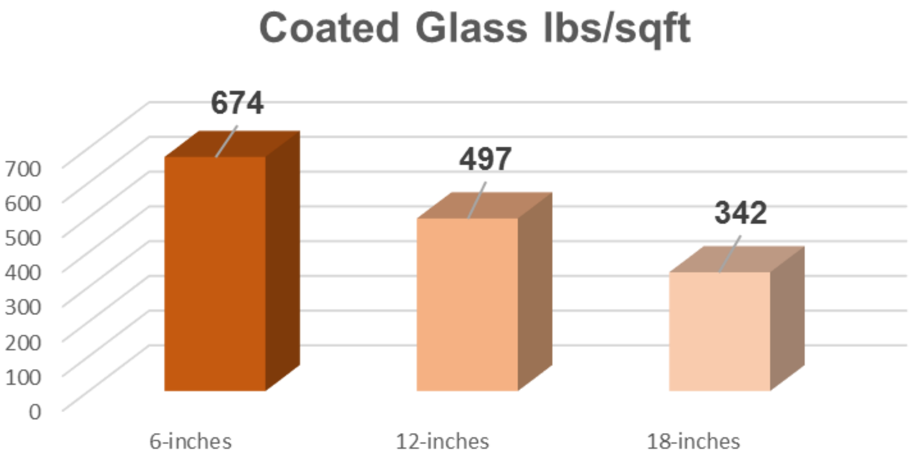
Recycled Cover Boards

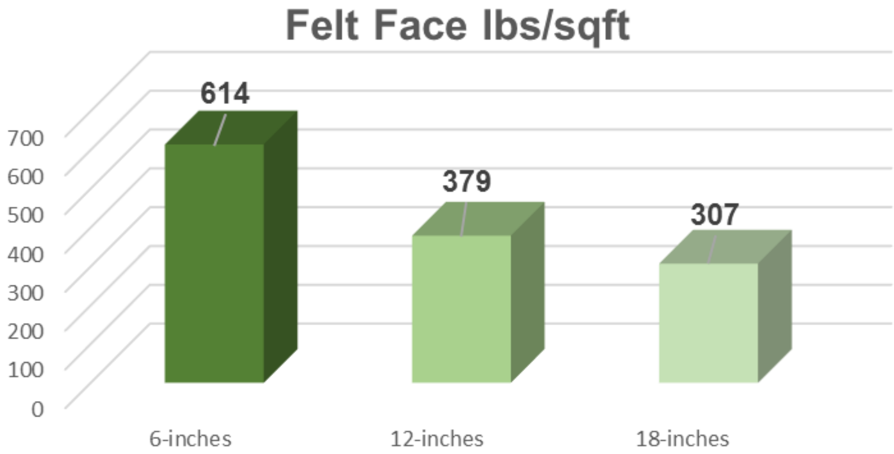
Air Barriers & Vapor Retarders

Prevents air and moisture from migrating into roofing system

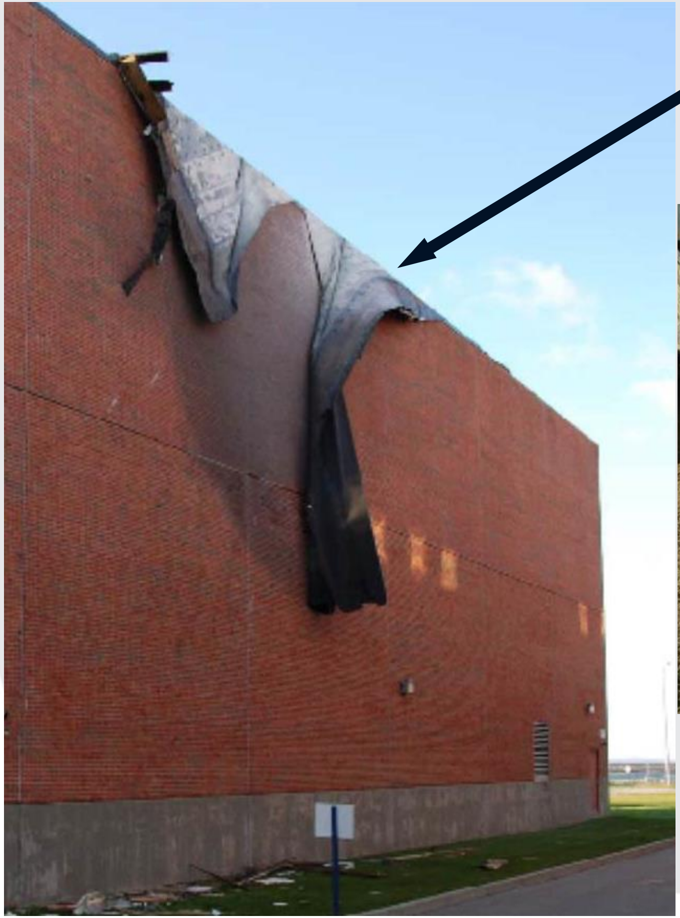
- Controls vapor movement from potential condensation
- Sealed correctly can assist in saving energy
- Some products can be used as a temporary roof

Adhesive Testing Program (Polyisocyanurate)





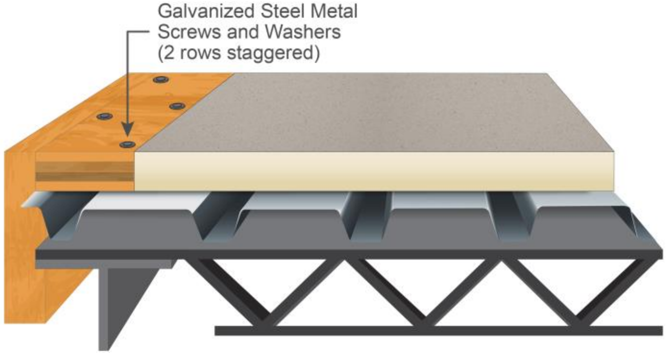
Midwest Roofer: Findings of Low-Rise Foam, MRCA & WJE research, 2020



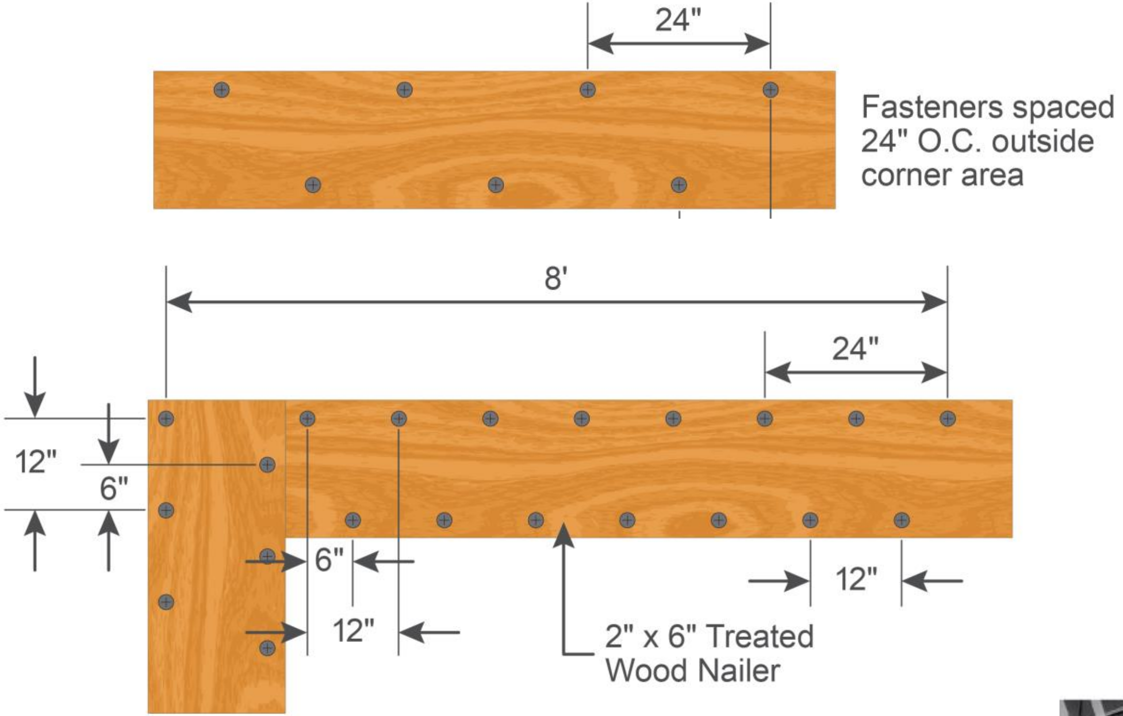
Wood Nailer Edge Failure

Wood Nailer Edge Failure

FM PLPDS* 1-49: Wood Nailer Securement



*Property Loss Prevention Data Sheet



First Line of Defense Against Wind

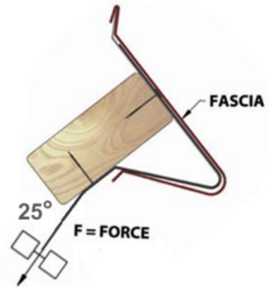
Metal Edging

Gutter Pulled Free

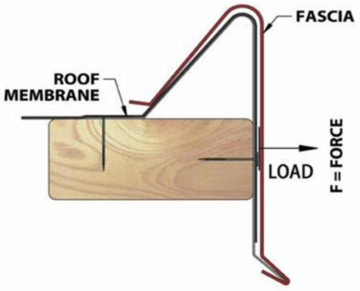
International Building Code (IBC)

Section 1504.5 Edge Securement for low-slope roofs.

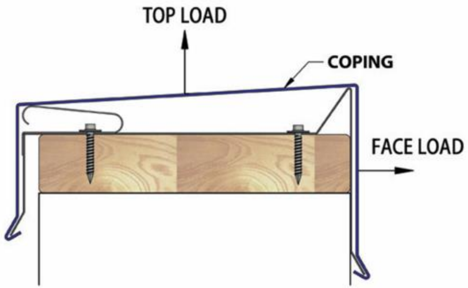
Low-slope membrane roof system metal edge securement
...tested for resistance in accordance with ANSI/SPRI ES-1...



Test RE-1

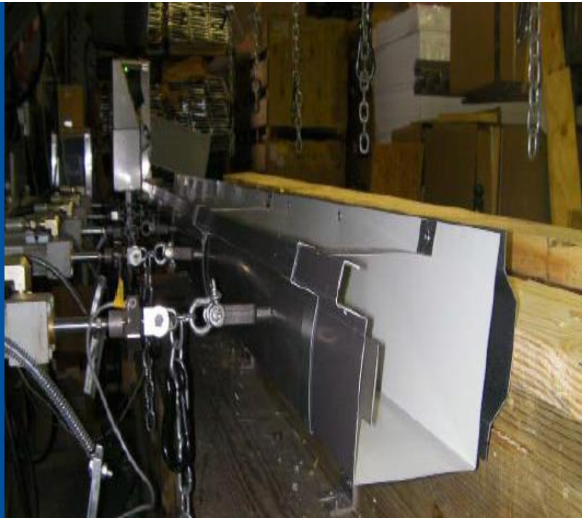


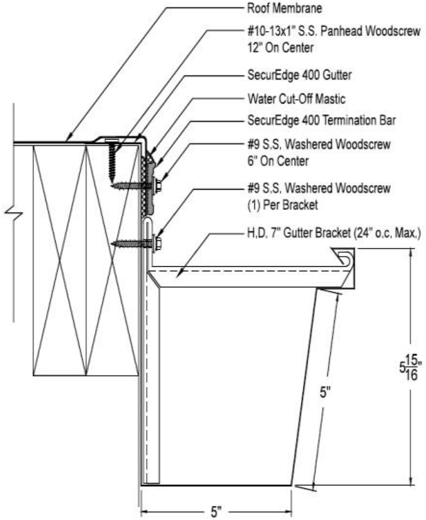
Test RE-2



Test RE-3

ANSI/SPRI GT-1 Standard





- Tests like ANSI/SPRI ES-1
- ANSI/GT-1 Standard has been adopted into the IBC 2021

Additional Accessories

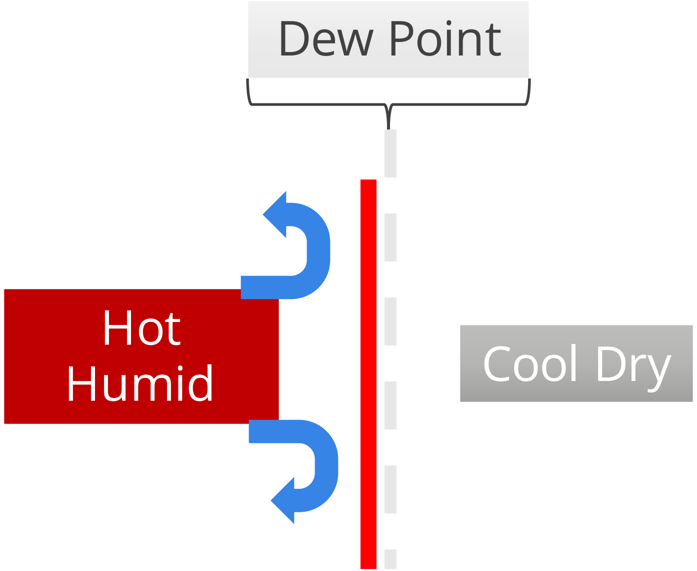
Pressure Sensitive Products

Tapered Insulation:

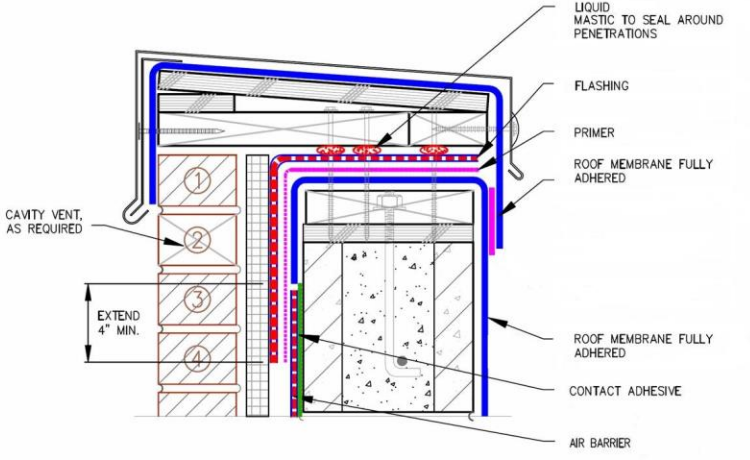
Locate roof drains where maximum deck deflection is anticipated

Vapor Drive / Air Leakage

Proper placement of a vapor retarder remains warmer than the Dew Point Temperature



Continuous air barrier need compatible materials at transitions



Roof to Walls

Solar Ready Roofs

The right components ensure the owner receives anticipated ROI

BEST PRACTICES

- Thicker membrane such as .090 mil or .080 mil
- Cover board attached with adhesives.
- Protection layer under any weighted solar panel racks or support systems.

Roof Garden & Patios

Stormwater Management

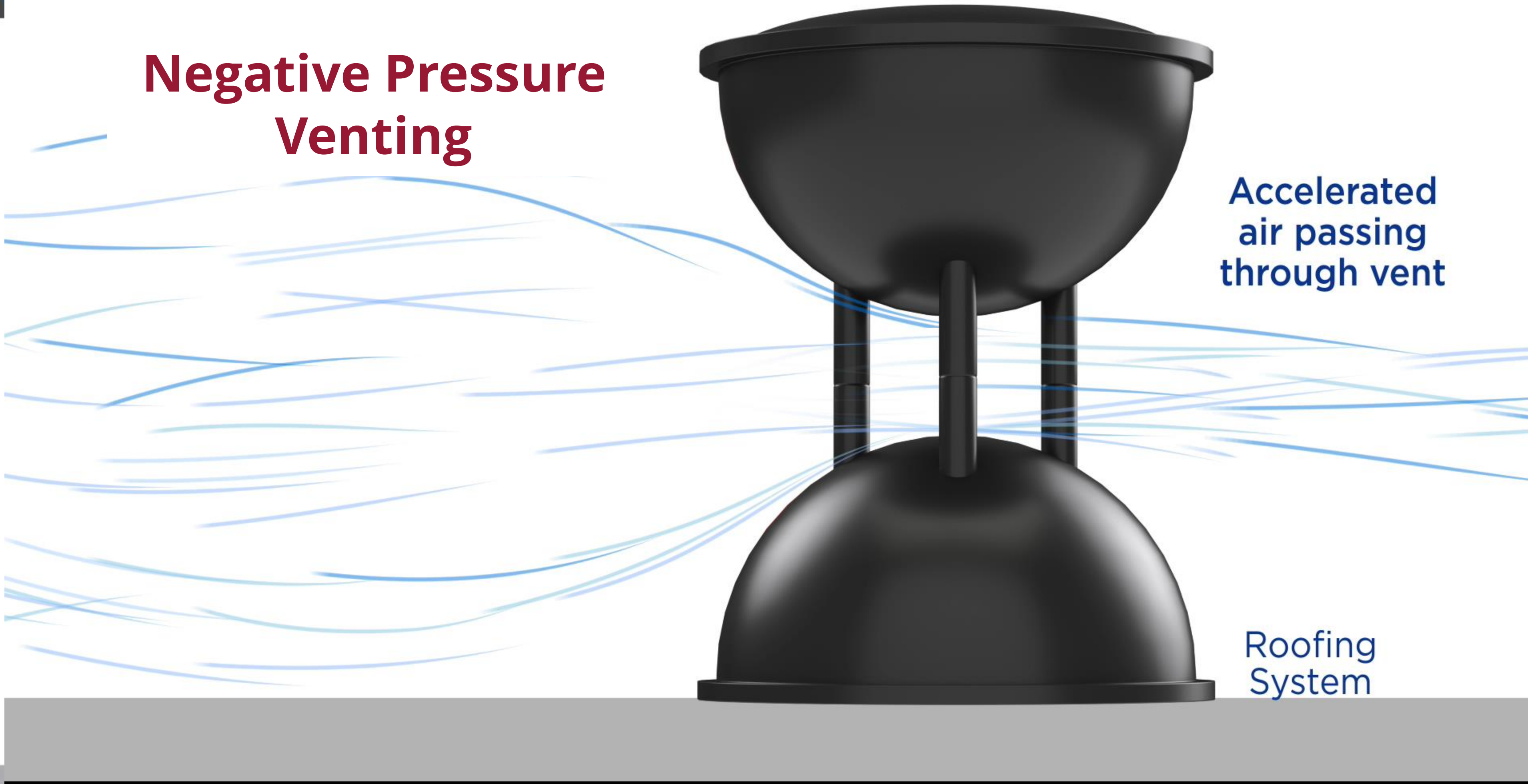
Urban Heat Island Effect

Healthy Living

Increased Amenity Space

Roof System Advancements

Negative Pressure Venting

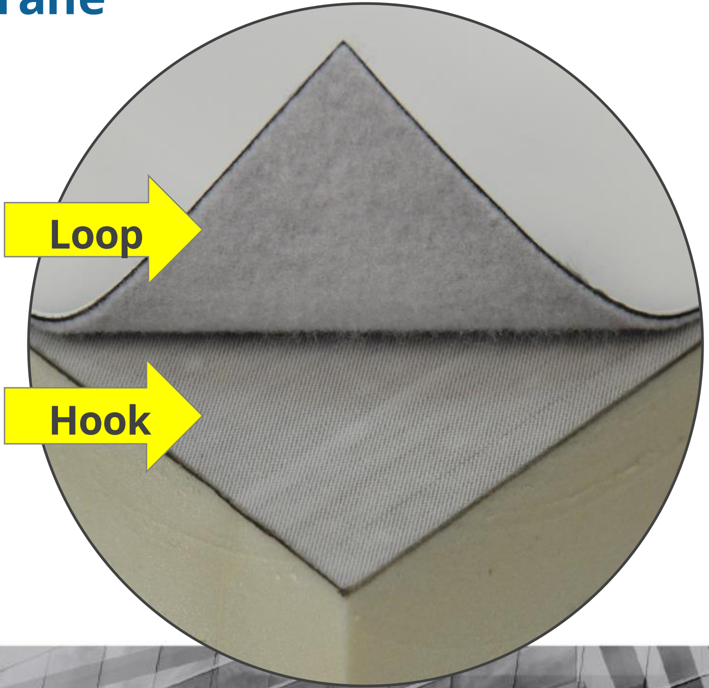


Another "Fully Adhered" Option

Utilizes hook and loop technology to "adhere" membrane

"Fully-Adhered" Membrane With:

- NO VOC's
- NO Odor
- NO Temperature Restrictions
- Uplift as great as 225-psf

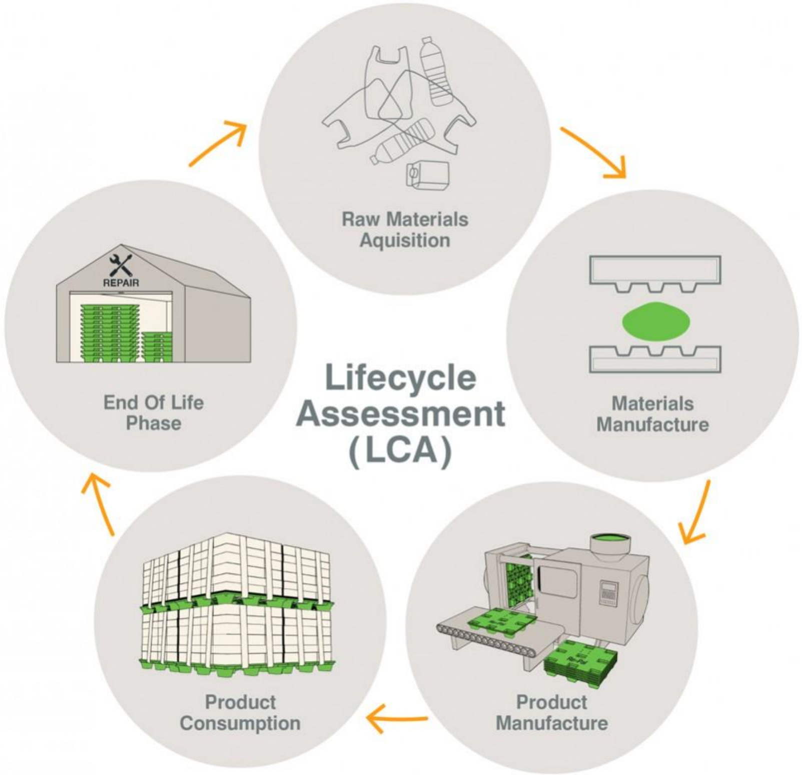


Sustainability:
Three Main Tenets

1. Minimize burden on the environment by using the earth's resources responsibly
2. Conserve energy by improving thermal efficiency
3. Extend roof lifespan by improving long term performance

Life Cycle Assessment

- Longevity of product life.
- Extending the lifespan of the assembly means fewer resources consumed during this time period.
- The product which is designed to last and perform the longest mitigates the impact on the environment.

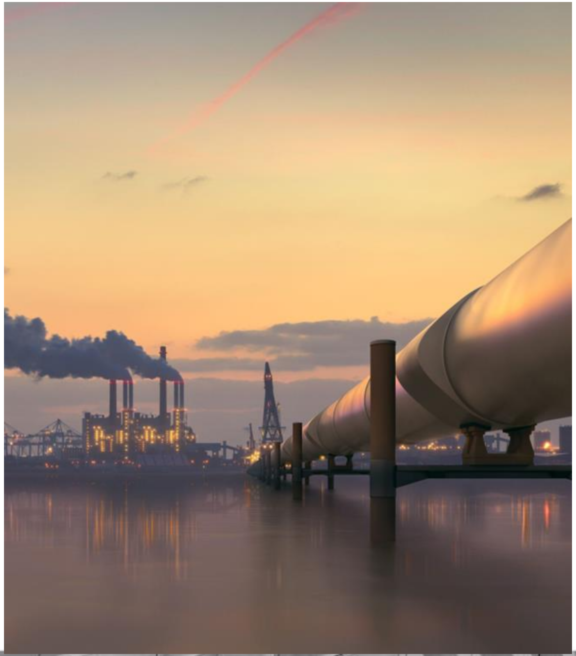


Managing Environmental Impact

Advances in technology improve sustainability efforts in the following ways:

- Reduction of construction waste
- Reduction of energy use
- Minimizing harmful fumes or chemicals
- Maximizing recycling

Meeting needs today without compromising the future generations to meet their needs.



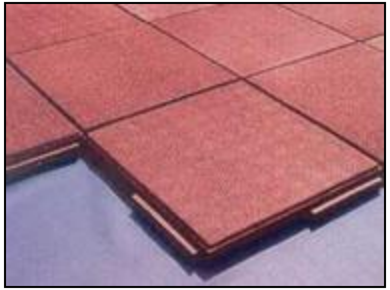
Pre-Consumer Recycling Roofing Materials

Pre-Consumer Recycling Roofing Product Examples:

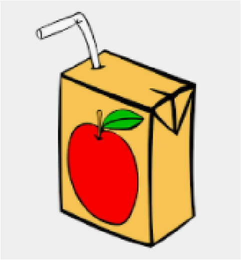
- EPDM = 5%
- TPO & PVC = 10%
- Insulation = up to 10%
- Metal = up to 15%
- EPS = up to 25%

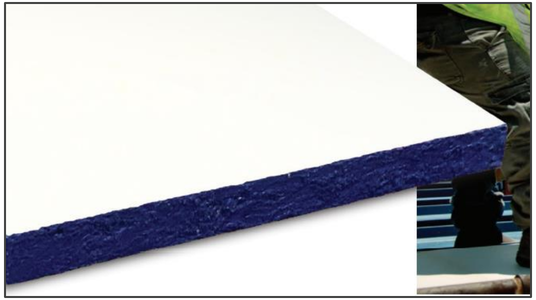
Recyclable Products

End use products for recycled EPDM.



Crushed Recycled Tumbled Glass





100% Recycled Cover Boards

Waste Reduction & Landfill Diversion

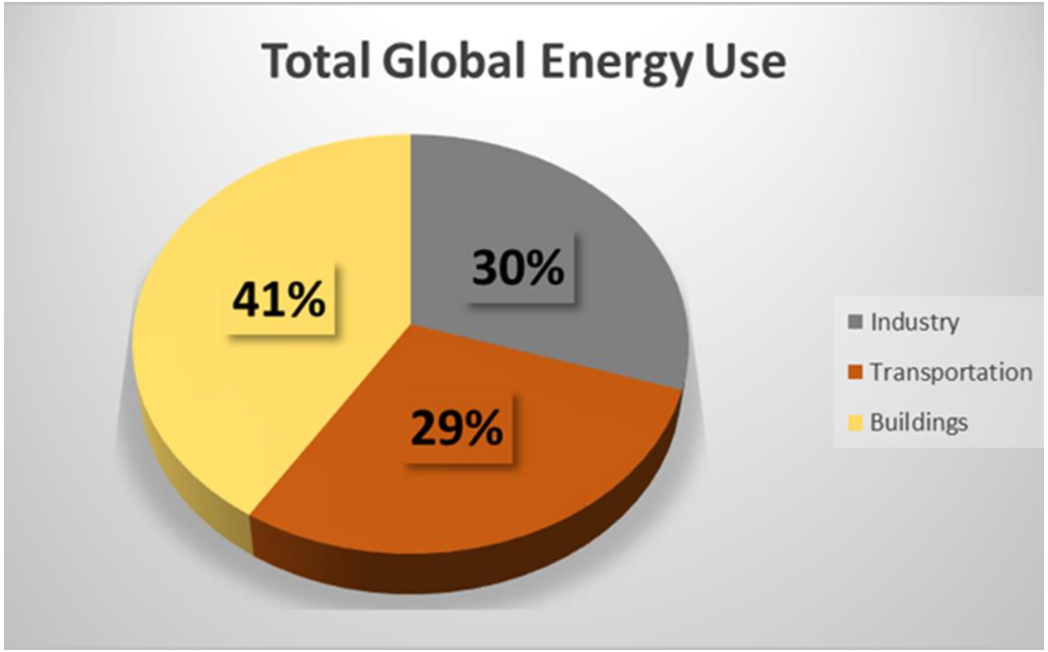
Insulation Recycling

- Polyisocyanurate
- Expanded Polystyrene (EPS)

Jobsite Recycling

- Packaging
- Recycling Guides

Energy


Total Global Energy Use
30%
41%
29%
Industry
Transportation
Buildings

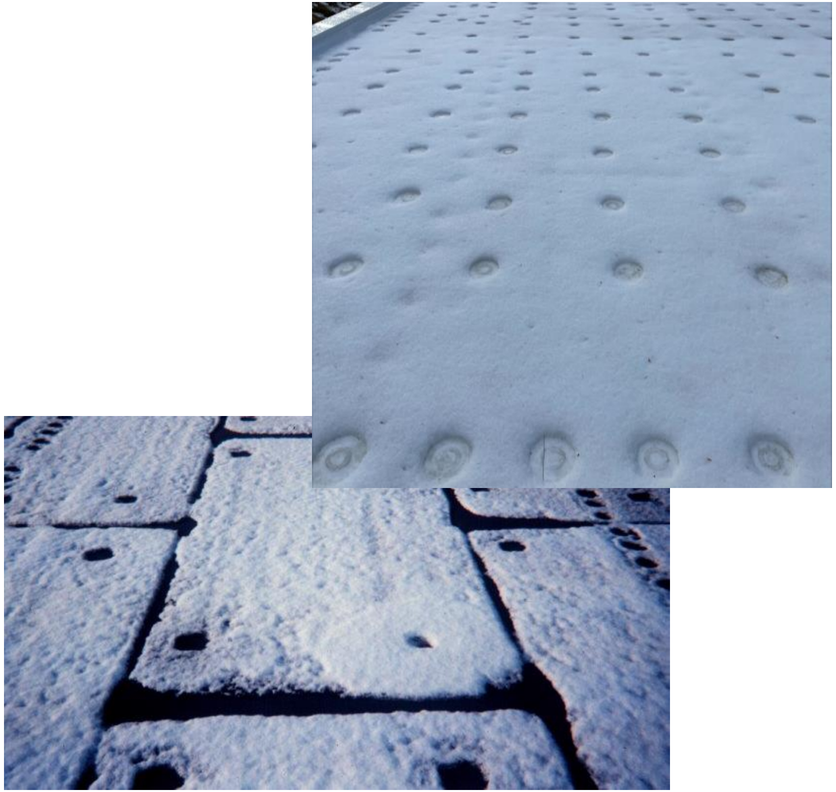
Minimum R-Value (Non-Residential, Above Roof Deck)

Zones	ASHRAE 90.1				ASHRAE 189.1					IBC – IECC				IGCC			
	2010*	2013*	2016*	2019*	2009	2011*	2014*	2017*	2020*	2012*	2015*	2018*	2021*	2012*	2015*	2018*	2021*
0	-	-	25	25	-	-	-	27.02	27.02	-	-	-	20	-	-	27.02	27.02
1	15	20	20	20	20	20	20	21.9	21.9	20	20	20	20	22.3	21.1	21.9	21.9
2	20	25	25	25	25	25	25	27.02	27.02	20	25	25	25	22.3	26.3	27.02	27.02
3	20	25	25	25	25	25	25	27.02	27.02	20	25	25	25	22.3	26.3	27.02	27.02
4	20	30	30	30	25	25	35	35.08	35.08	25	30	30	30	27.8	31.6	35.08	35.08
5	20	30	30	30	25	25	35	35.08	35.08	25	30	30	30	27.8	31.6	35.08	35.08
6	20	30	30	30	30	30	35	35.08	35.08	30	30	30	30	33.5	31.6	35.08	35.08
7	20	35	35	35	35	35	40	38.98	38.98	35	35	35	35	39	36.9	38.98	38.98
8	20	35	35	35	35	35	40	38.98	38.98	35	35	35	35	39	36.9	38.98	38.98

Building Insulation

INSULATION BEST PRACTICES

- Properly insulate building for its' climate zone.
- Increase R-value by specifying more insulation.
- Stagger insulation joints to reduce energy loss through gaps.
- Improved energy efficiency reduces pollutants.

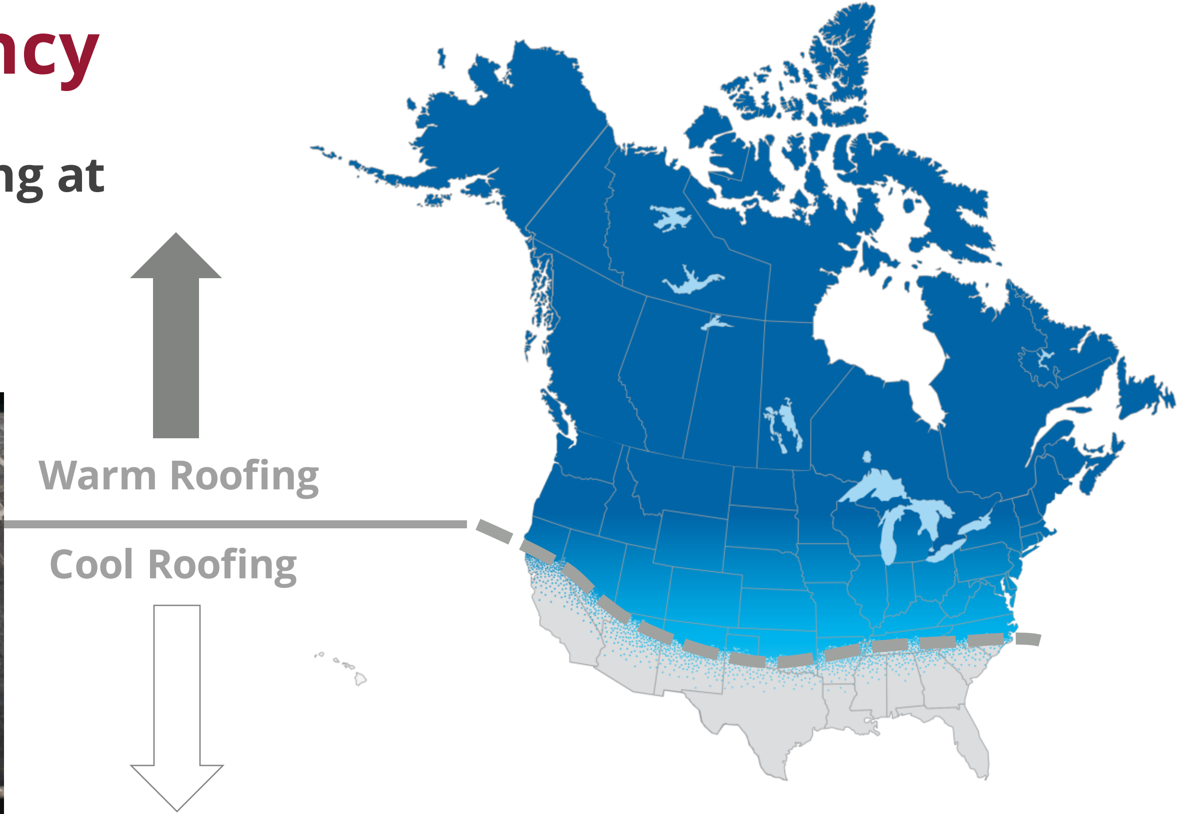


Thermal Loss of rigid insulation which has been mechanically fastened.

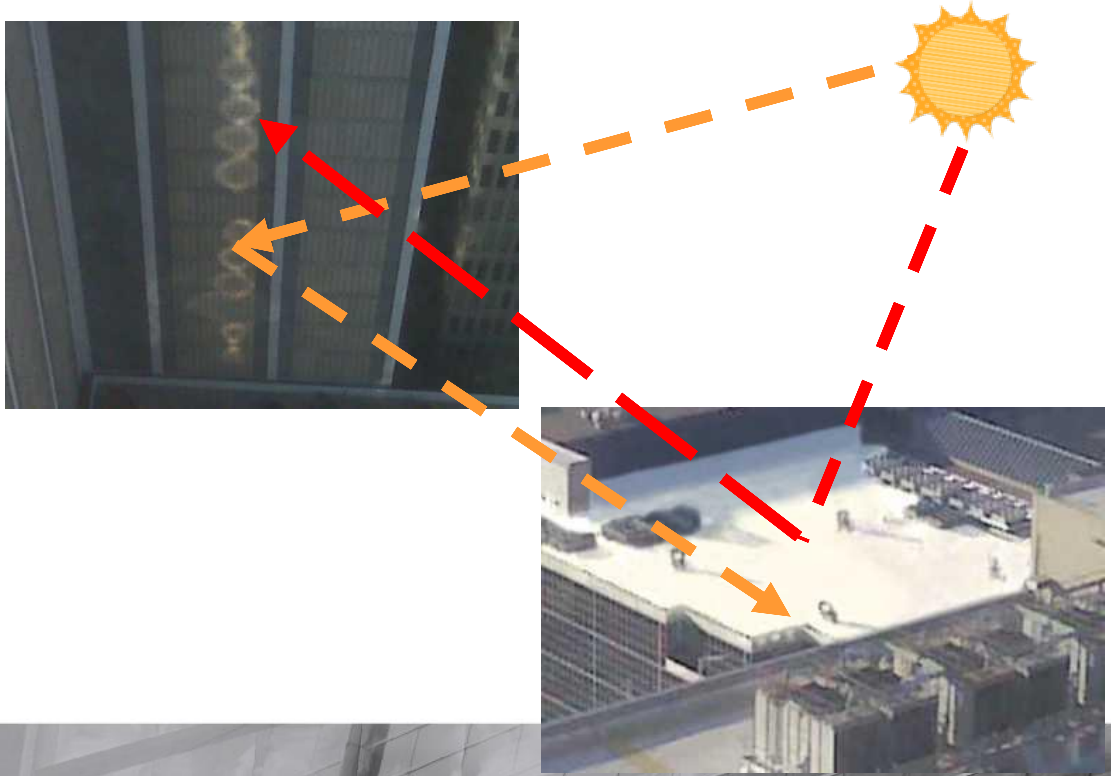
Energy Efficiency

Geography must be considered when looking at energy usage.

There is no "magic pill".

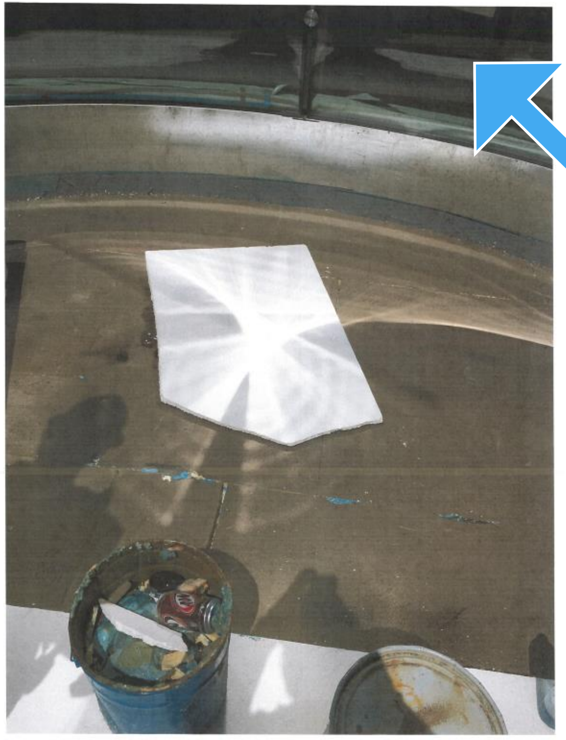


Deflection & Concentration of UV Loads



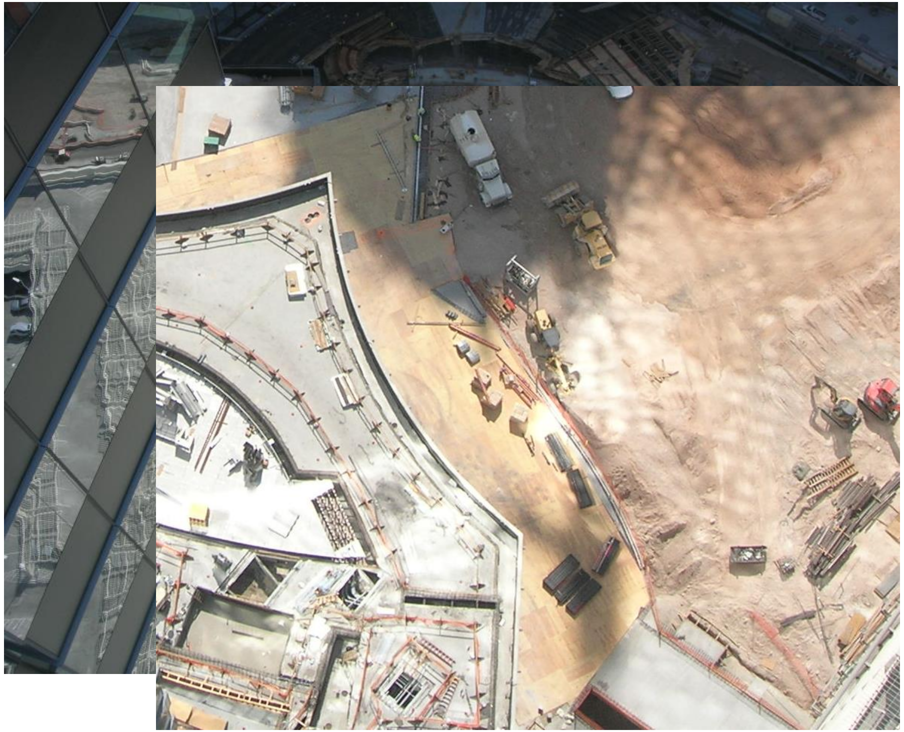
Unexpected Results

Next to a glass wall



Curved Glass

Unexpected Results



Unexpected Results

Swanky new Vegas hotel's 'death ray' proves inconvenient for some guests

By Brett Michael Dykes brett Michael Dykes – Wed Sep 29, 12:00 pm ET

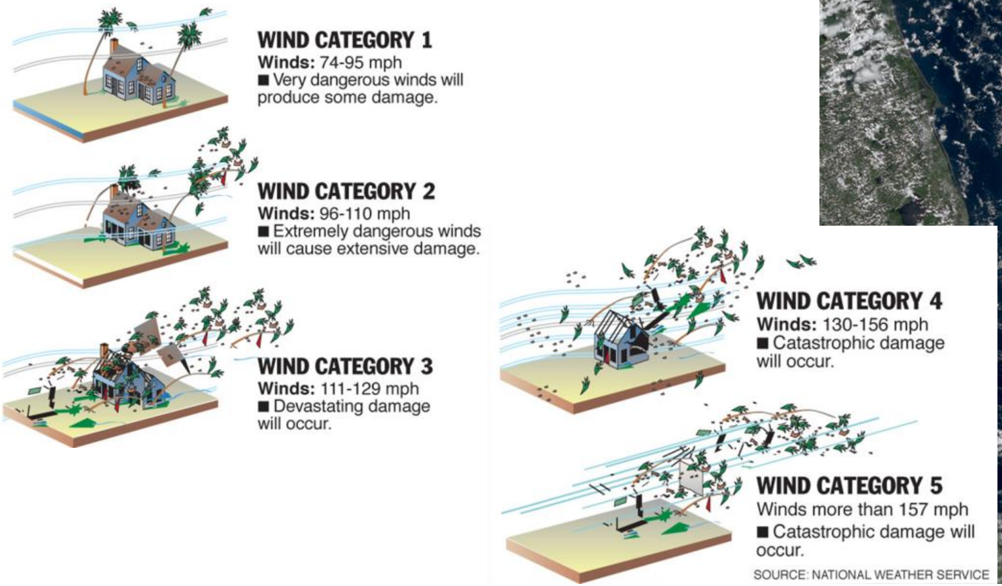
Vdara
Las Vegas, NV

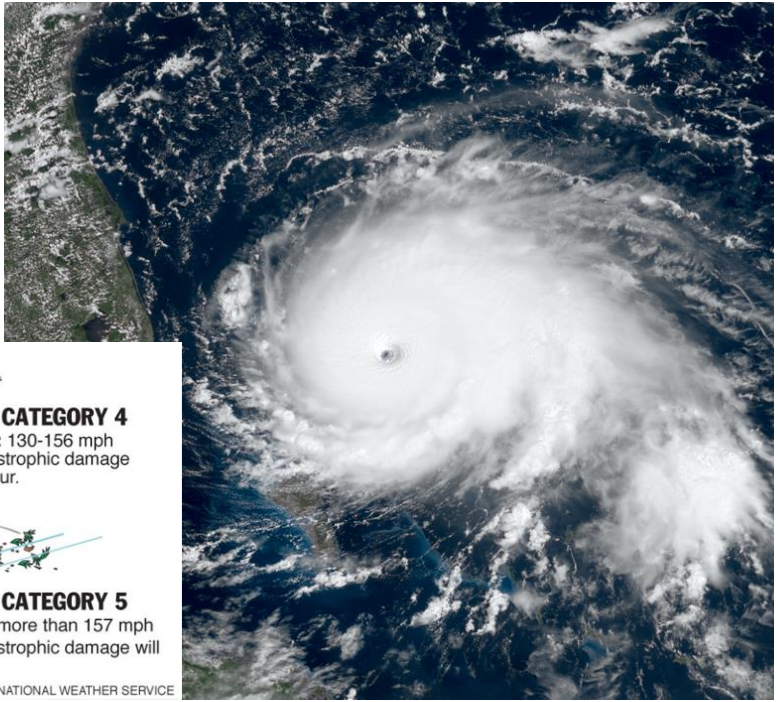
Unexpected Results

Walkie-Talkie London, England

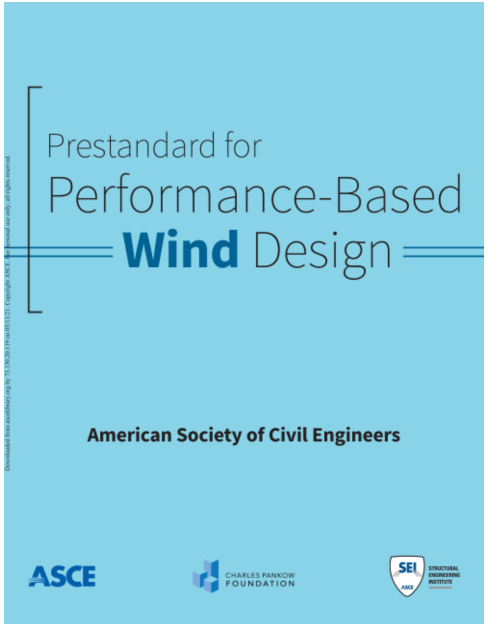
Museum Tower
Dallas, TX

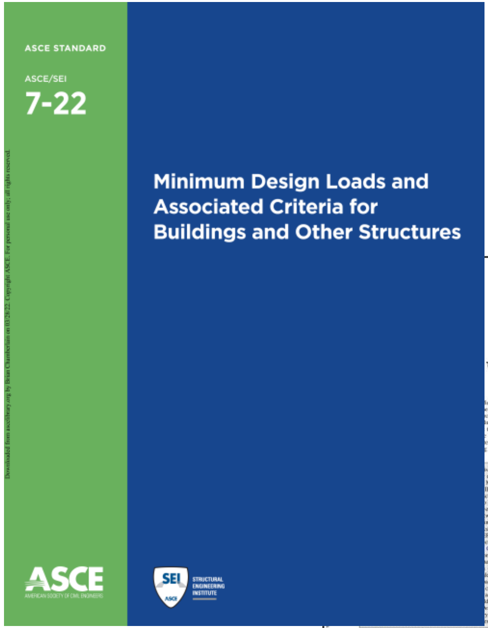
Resiliency


WIND CATEGORY 1
Winds: 74-95 mph
■ Very dangerous winds will produce some damage.
WIND CATEGORY 2
Winds: 96-110 mph
■ Extremely dangerous winds will cause extensive damage.
WIND CATEGORY 3
Winds: 111-129 mph
■ Devastating damage will occur.
WIND CATEGORY 4
Winds: 130-156 mph
■ Catastrophic damage will occur.
WIND CATEGORY 5
Winds more than 157 mph
■ Catastrophic damage will occur.
SOURCE: NATIONAL WEATHER SERVICE

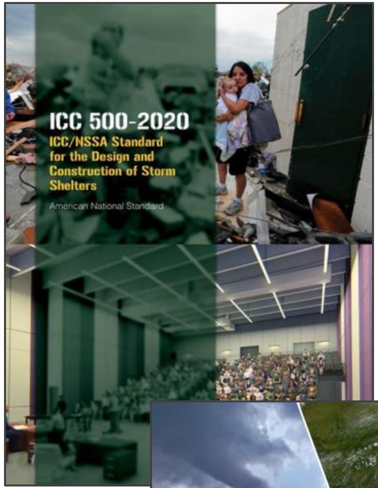


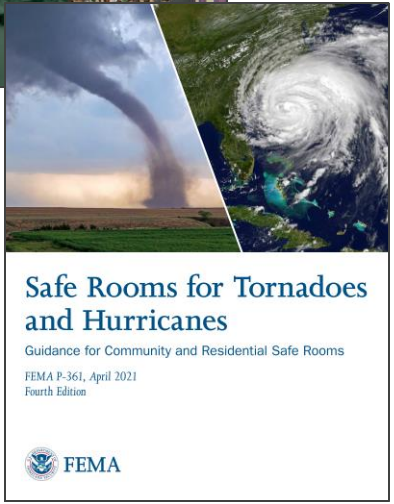
Standards


Prestandard for
Performance-Based
Wind Design
American Society of Civil Engineers
ASCE
CHARLES PANKOW FOUNDATION
SEI STRUCTURAL ENGINEERING INSTITUTE


ASCE STANDARD
ASCE/SEI
7-22
Minimum Design Loads and Associated Criteria for Buildings and Other Structures
ASCE
SEI STRUCTURAL ENGINEERING INSTITUTE


CHAPTER 32
TORNADO LOADS
32.2 DEFINITIONS
Minimum Design Loads and Associated Criteria for Buildings and Other Structures
353


ICC 500-2020
ICC/NSSA Standard for the Design and Construction of Storm Shelters
American National Standard


Safe Rooms for Tornadoes and Hurricanes
Guidance for Community and Residential Safe Rooms
FEMA P-361, April 2021
Fourth Edition
FEMA

ASCE 7-22 & Tornados

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

CHAPTER 32
TORNADO LOADS

Tornado Loads

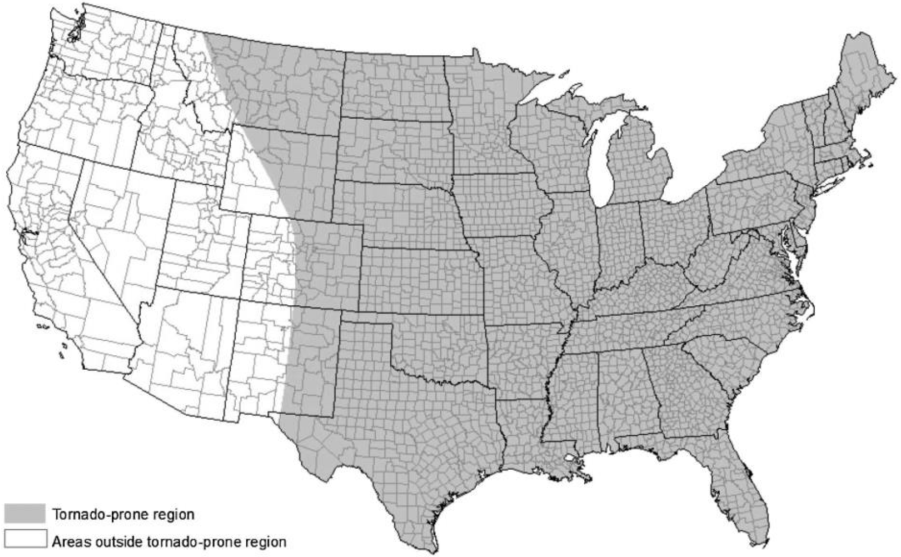
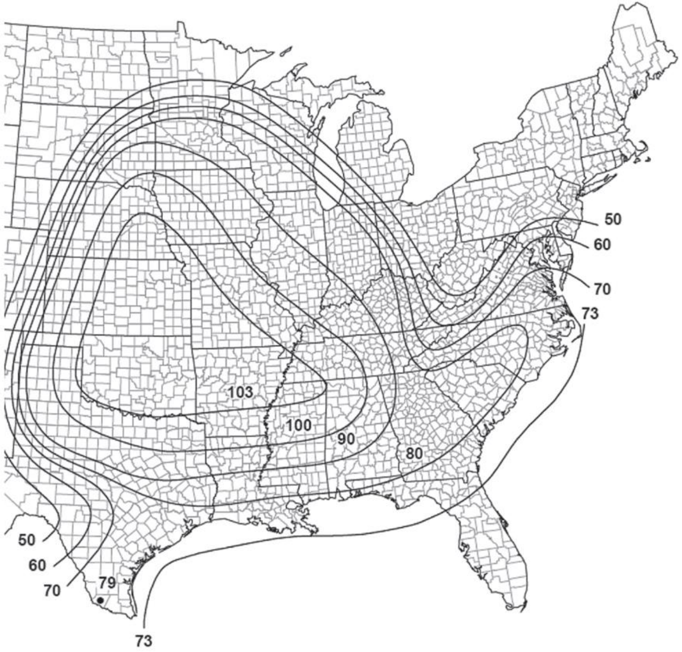


Figure 32.1-1. Tornado-prone region.



4. Islands, coastal areas, and land boundaries outside the last contour shall use the last tornado speed contour.
5. Tornado speeds correspond to approximately a 1.7% probability of exceedance in 50 years (annual exceedance probability = 0.00033, MRI = 3,000 years).
6. Location-specific tornado speed is permitted to be determined using the ASCE Tornado Design Geodatabase, available at the ASCE 7 Hazard Tool (http://asce7hazardtool.online) or approved equivalent.

Figure 32.5-2D (*Continued*). Tornado speeds for Risk Category IV buildings and other structures, for effective plan area of 40,000 ft^2 (3,716 m^2).

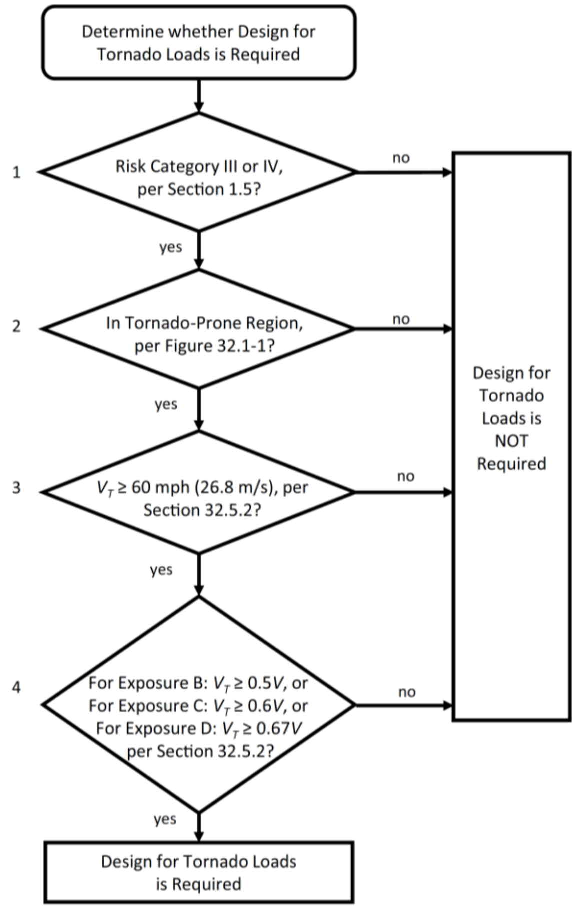


Figure 32.1-2. Flowchart of process for determining when design for tornado loads is required.

Hospital: Risk Category IV

Chicago, IL

ASCE 7-22 Wind Speed: 119-mph

Effect Plan Area: 40,000 sqft

Tornado Wind Speeds (Vt): 82-mph

Risk Category III or IV **(Yes)**

In Tornado-Prone Region **(Yes)**

Vt ≥ 60-mph **(Yes)**

Exposure B: 82-mph ≥ 59.5-mph **(Yes)**

Exposure C: 82-mph ≥ 71.4-mph **(Yes)**

Exposure D: 82-mph ≥ 79.7-mph **(Yes)**

Tornado Loads

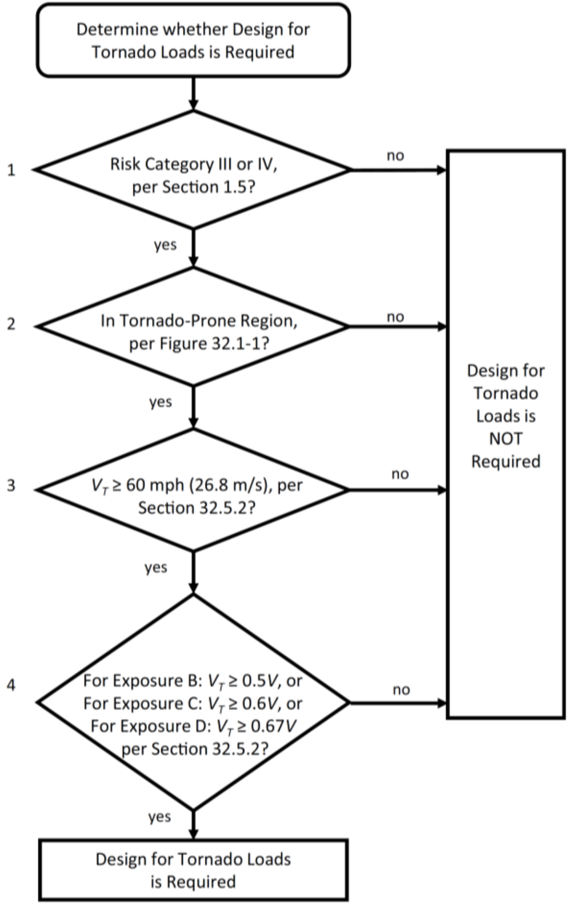


Figure 32.1-2. Flowchart of process for determining when design for tornado loads is required.

Hospital: Risk Category IV

Miami, FL

ASCE 7-22 Wind Speed: 189-mph

Effect Plan Area: 40,000 sqft

Tornado Wind Speeds (Vt): 73-mph

Risk Category III or IV **(Yes)**

In Tornado-Prone Region **(Yes)**

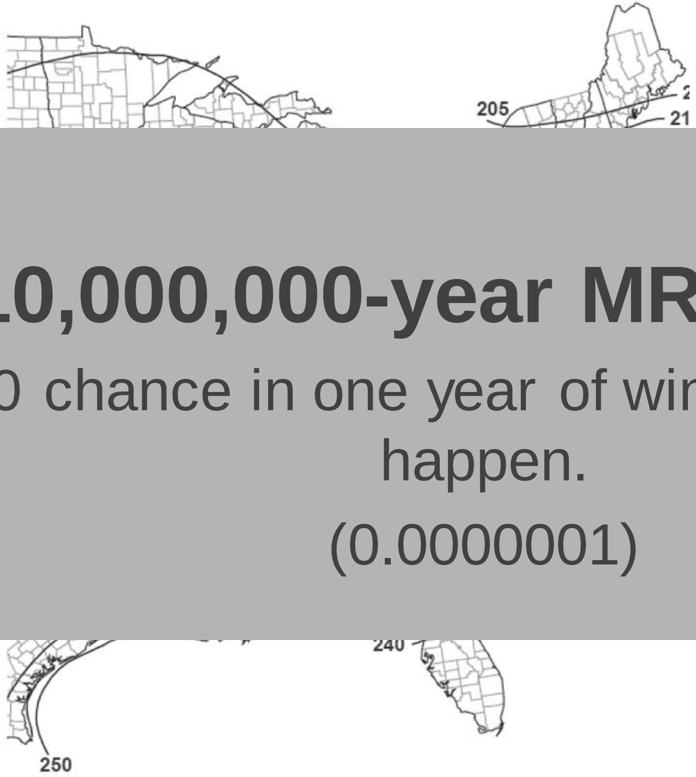
Vt ≥ 60-mph **(Yes)**

Exposure B: 73-mph ≥ 94.50-mph **(No)**

Exposure C: 73-mph ≥ 113.4-mph **(No)**

Exposure D: 73-mph ≥ 126.6-mph **(No)**

Wind Loads



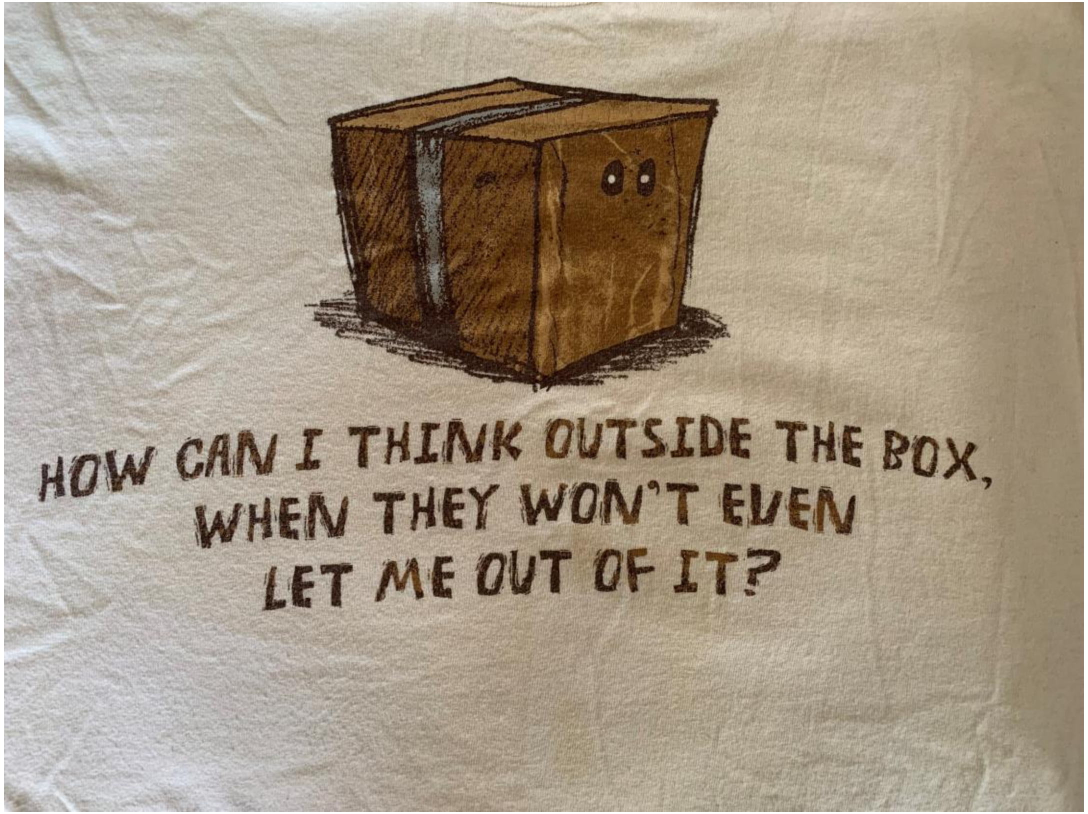
10,000,000-year MRI means

1/10000000 chance in one year of wind of this amount may happen.

(0.0000001)

4. Islands, coastal areas, and land boundaries outside the last contour shall use the last tornado speed contour.
5. Tornado speeds correspond to approximately a 0.0005% probability of exceedance in 50 years (annual exceedance probability = 0.0000001, MRI = 10,000,000 years).

Innovative Designing



Controlling the Failure Mode

Mid-West Data Center:
Concrete deck
Adhered vapor retarder
(attachment must meet pressures based on 250-mph)

Additional components (minimum code requirements)
Adhered insulation
Adhered cover board
Adhered membrane

Concern of Unexpected Failure Mode

Mid-West School:

- Steel Deck and structure
- Designed following ICC 500 “Storm Shelter”

Only one area of the school was required to meet these structural pressures

- “Is the roof assembly required to meet these “Storm Shelter” pressures?”
- “Since typical roof assemblies (cladding) only need to meet Allowable, Nominal or Service Pressures, by meeting “Storm Shelter” pressures will there be unexpected stress pressures not compensated on the structural?”

Resiliency Design

Improve Wind Performance

- Strengthen the Roof Deck
- Strengthen the Perimeter Edge (wood Nailers & Air Tightness)
- Use a Robust Edge System
- Incorporate an Air Barrier
- Robust Assembly with Durable Cover board

Design for the Elements

- Positive Drainage with Sufficient Number of Drains & Overflows.
- Increase Flashing / Skirting Height.
- Accommodate for an increased Snow-Load.
- Possible use of sensors for early alert of to activate Snow-Melting.

Redundancy

- Incorporate an Impermeable Roofing Membrane to serve as an Air Barrier / temporary Roof.
- Incorporate Secondary Drainage System at the bottom waterproofing layer (Air Barrier Level).
- Possible use of sensors for early alert of Water infiltration.

Redundancy can Assure Continuous Building Operation After a Catastrophic Event

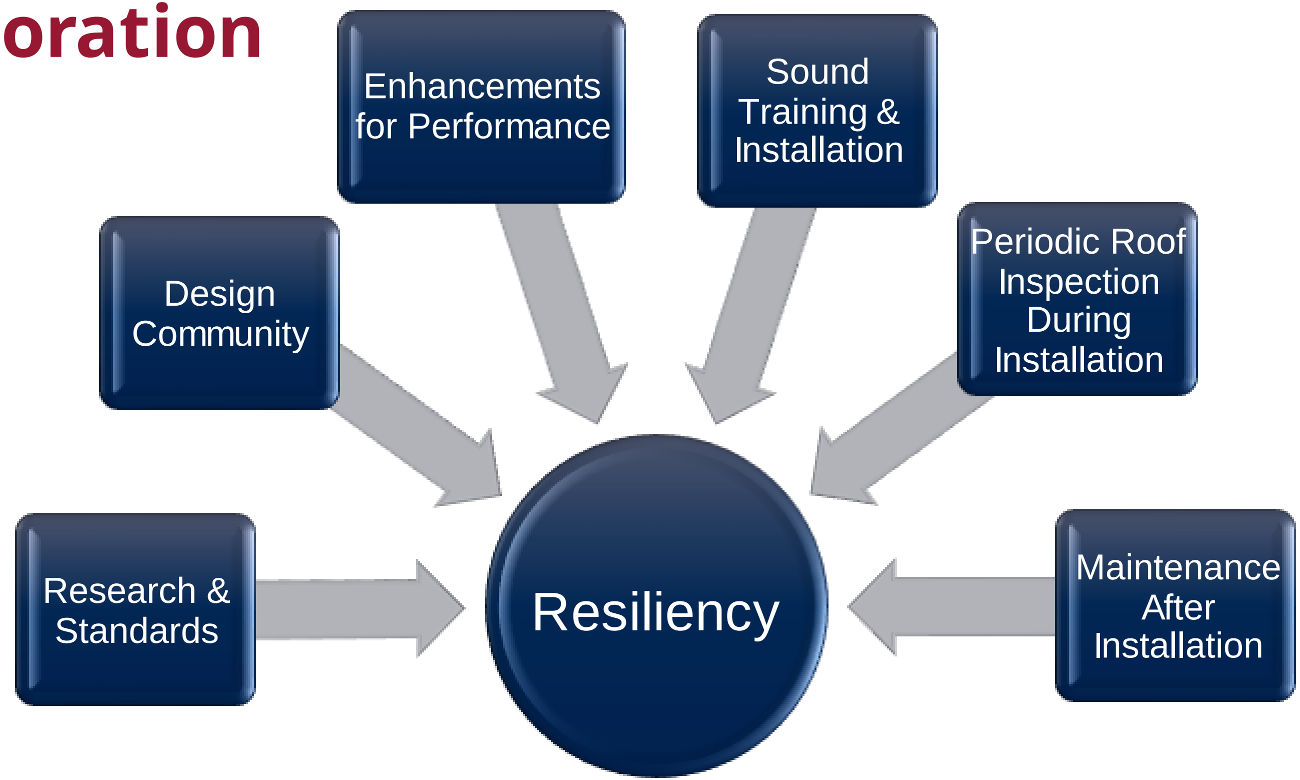
EPDM used as a secondary roof and air barrier

Chernobyl Nuclear Plant & Sarcophagus - Ukraine

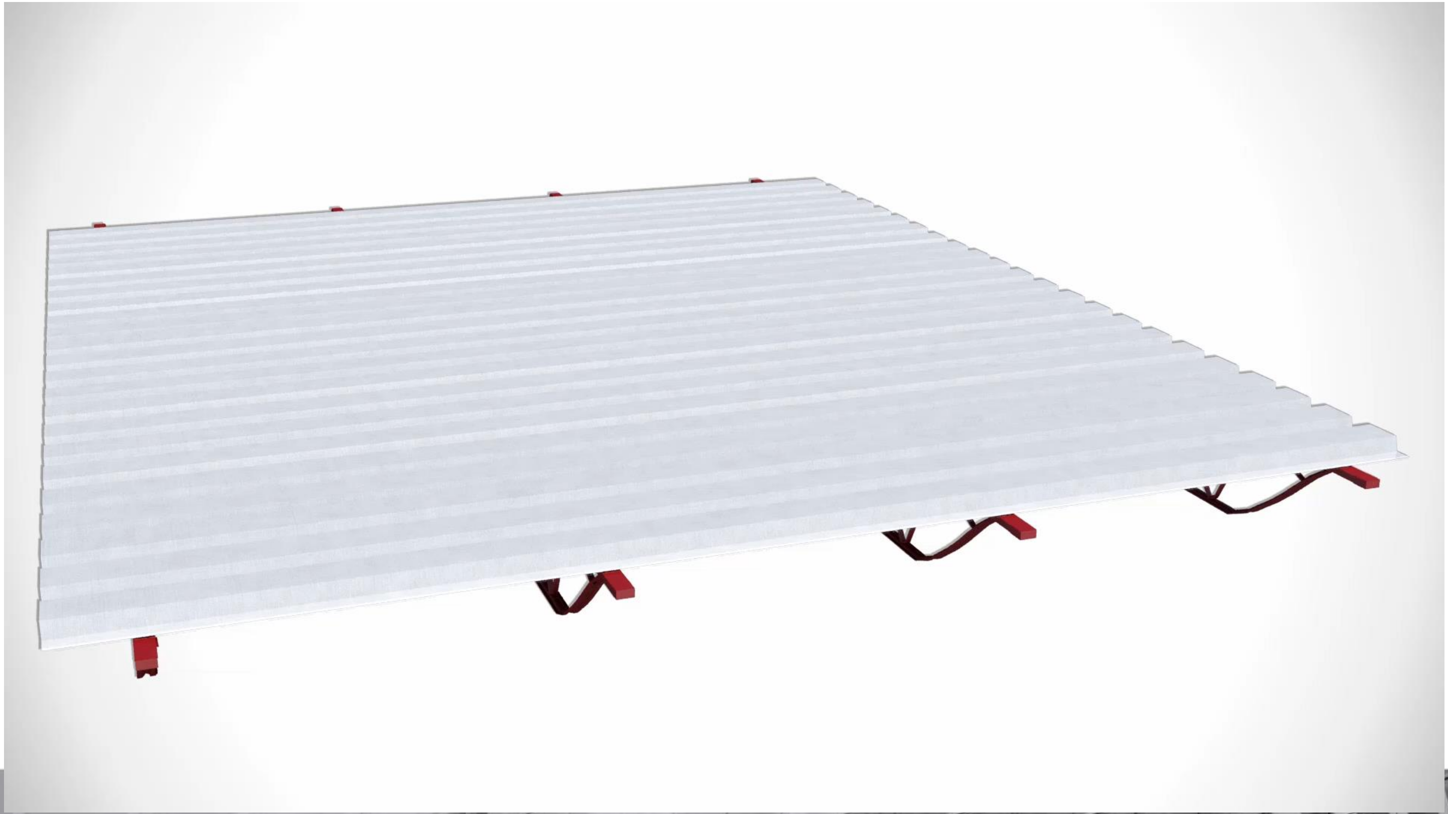
Principles for Resilient Design

- Redundant System = **More Resilient**
- Durability **Strengthen** Resilience
- Resilience **Anticipates** Interruptions
- Simplicity/Ease of Repairs **Quicken** the Recovery

Collaboration



Example: Durability, Sustainability, & Resilience



This concludes the American Institute of Architects
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Thank you for participating!

Questions?

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