AIA25

Coastal Performance

0000CP23

Thursday, June 5th, 11-12 pm

1 LU|HSW

AIA25 Conference on Architecture & Design

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Introductions

Alex Howell

Architectural Consultant with Andersen Windows

With a background in design, Alex has been collaborating with architects locally in the Cape Cod market for the past 8 years and now nationally as well, picking up the MN and Chicago markets as of last year. Alex's goal is to be an asset to her architects and designers by assisting them in anything they may need to have a successful project. With her knowledge in the products, her markets and design trends, she helps her customers in finding window and door solutions that meet their clients wants and needs.

ANDERSEN® WINDOWS & DOORS

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Course / Learning Objectives

- Describe how wind forces act upon different parts of a building, and how those forces are impacted by factors such as topography, height, and adjacent buildings
- Define building code requirements for impact resistance, wind pressure, and opening protection
- Describe the methods of opening protection that can be used to meet code requirements
- Describe how ASTM E1886 is used to test windows and doors for impact resistance
- Explain how wind load requirements are determined for windows and doors using ASTM E1886, E1996, and South Florida TAS

Challenges of Coastal Environments

- High winds and extreme winds
- Wind-borne debris
- Moisture intrusion
- Other considerations:
  - Corrosion
  - Thermal comfort and energy efficiency
  - Aesthetics

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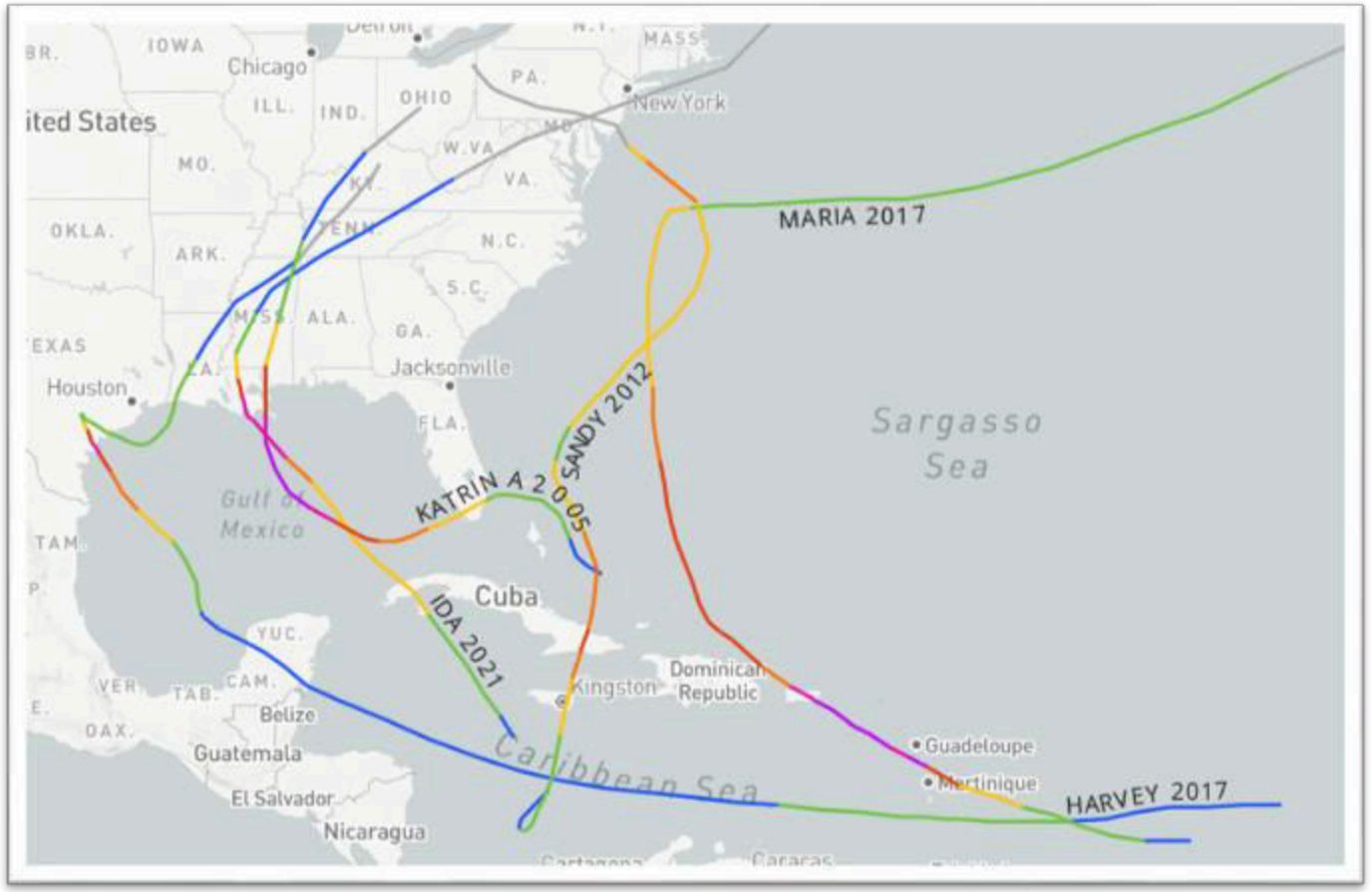
Destructive Hurricanes and Storms on the Rise

- Katrina (2005) $186 Billion
- Harvey (2017) $149 Billion
- Maria (2017) $107 Billion
- Sandy (2012) $82 Billion
- Ida (2021) $79 Billion
- Michael (2018) $25 Billion

Source: https://news.bloomberglaw.com/insurance/hurricane-ian-set-to-rank-in-top-10-costliest-us-storms-chart?context=article-related Accessed date: 10/1/2024

*This data does not reflect the impact of Helene or other 2024 hurricanes.



Source: https://coast.noaa.gov/hurricanes/#map=3.07/32.32/-57.3&search=eyJzZWFyY2hTdHJpbmciOiJREEgMjAyMSIsInNlYXJjaFR5cGUiOiJzdG9ybWlkcyIsIm1hdGNoIjoiZXhhY3QiLCJjYXRlZ29yaWVzIjpbIkg1IiwiSDQiLCJlMyIsIkgyIiwiSDEiLCJUUyIsIlREIiwiRVQiXSwieWVhcnMiOltdLCJtb250aHMiOltdLCJlbnNvIjpbXSwicHJlc3N1cmUiOnsicmFuZ2UiOlswLDEwMzBdLCJpbmNsdWRlVW5rbm93blByZXNzdXIlIjp0cnVlfSwic3Rvcm1JRHMiOiIyMDA1MjM2TjIzMjg1LDIwMTcyMjhOMTQzMTQsMjAxNzI2ME4xMjMxMCwyMDEyMjk2TjE0MjgzLDIwMjEyMzI0MTcyODEiLCJidWZmZXJVbml0IjpbIk1pbGVzIl0sInNvcnRTZWxlY3Rpb24iOnsidmFsdWUiOiJ5ZWFyc19uZXdlc3QiLCJsYWJlbCI6IlllYXIgKE5ld2VzdCkifSwiYXBwbHlUb0FPSSI6ZmFsc2UsImlzU3Rvcm1MYWJlbHNWaXNpYmxlIjp0cnVlfQ==
Accessed date: 10/1/2024

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Coastal Requirements for Windows & Doors

- Hurricane Andrew, August 1992
- 175 mph wind gusts
- $25 billion damage

Source: https://eoimages.gsfc.nasa.gov/images/imagerecords/78000/78948/andrew_goe_1982234-236_lrg.jpg Accessed date: 10/1/2024

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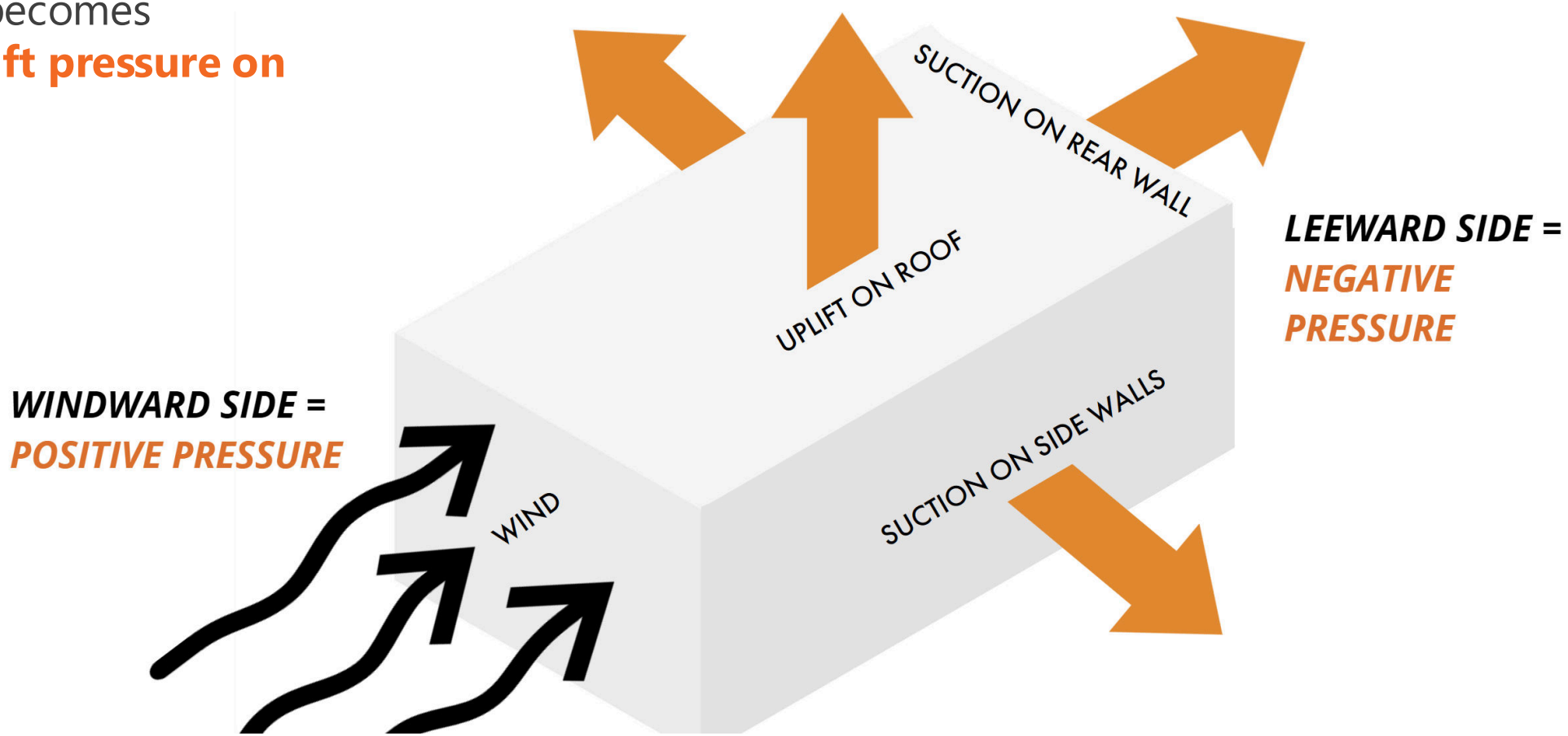
How Wind Forces Act on Buildings

When building becomes pressurized, **uplift pressure on roof increases**.



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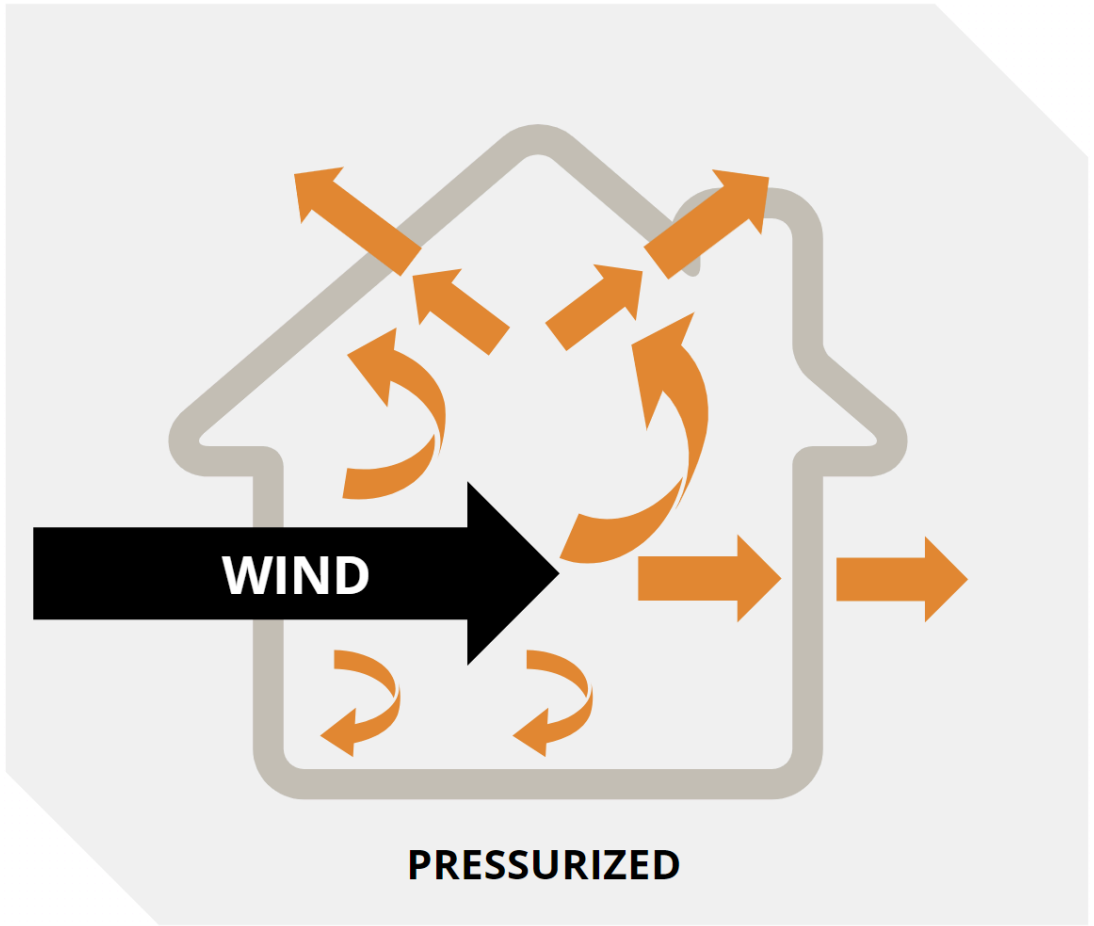
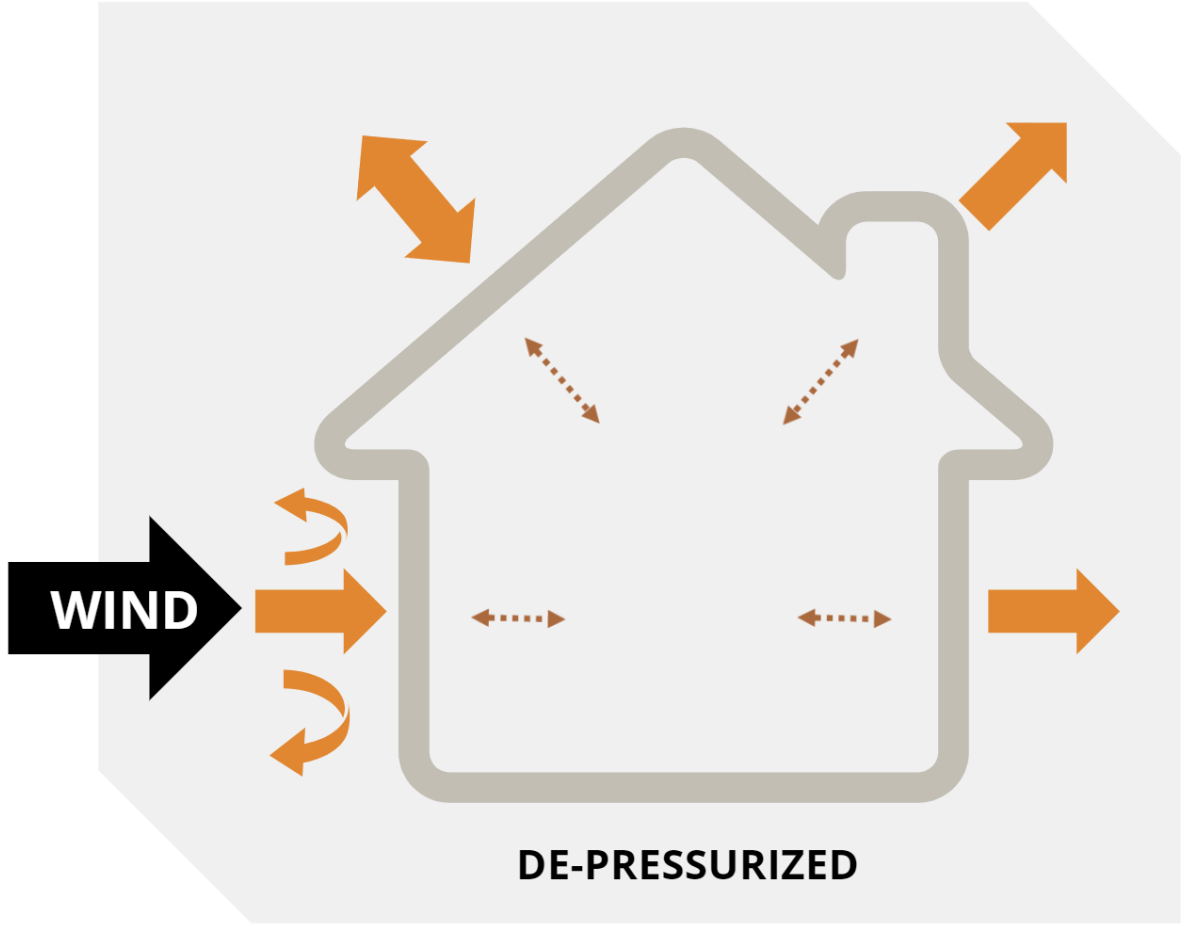
Why Protect Openings?

UNPROTECTED



PROTECTED



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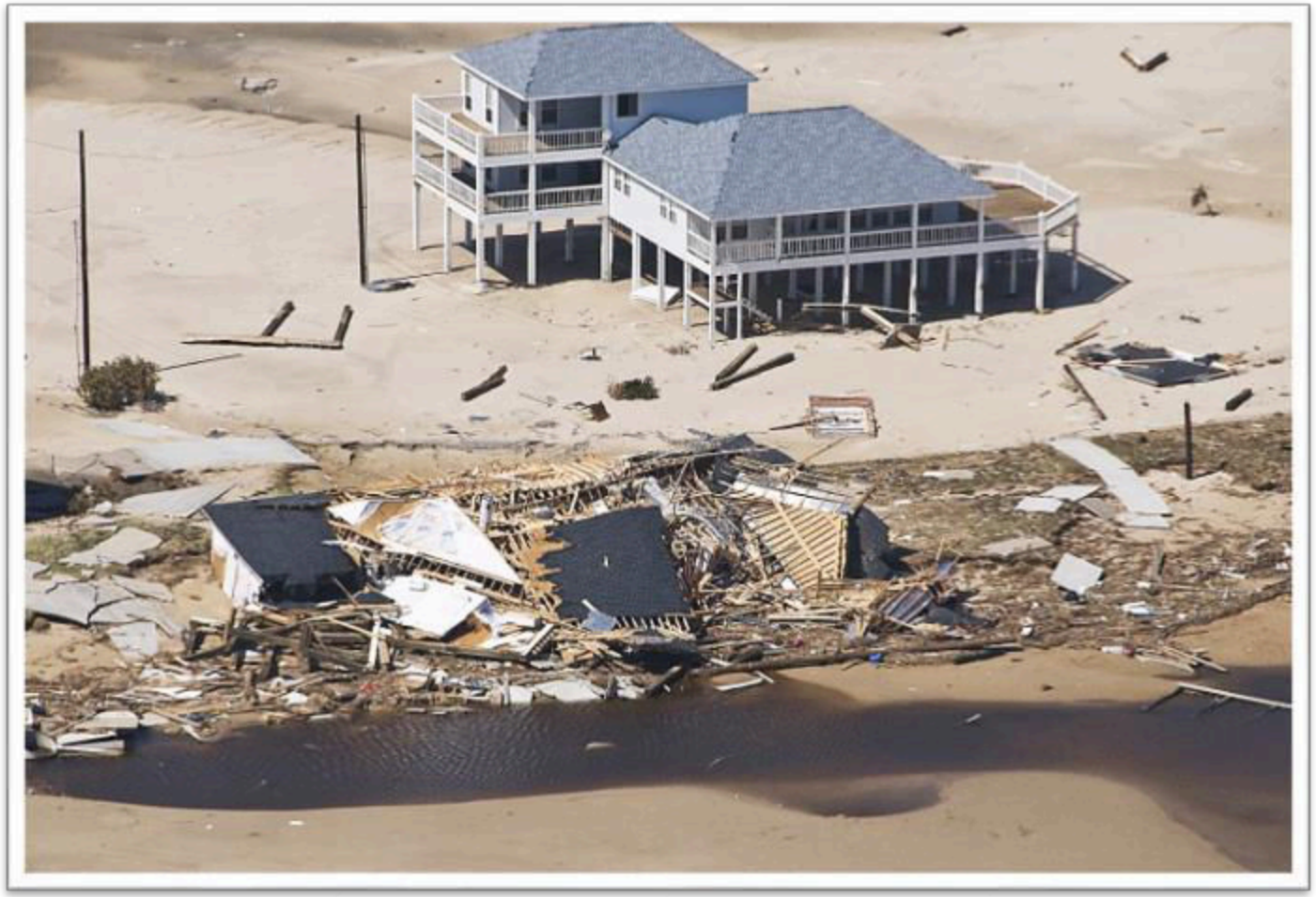
Why Protect Openings?

Which house was protected?



Crystal Beach, Texas on Sept 21, 2008 after Hurricane Ike. Photo Courtesy of FEMA ID 38764 by Patsy Lynch/FEMA.

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Wind Forces: Other Influencing Factors

- Height
- Building shape and irregularities
- Size and location of component
- Topography
- Presence of other buildings

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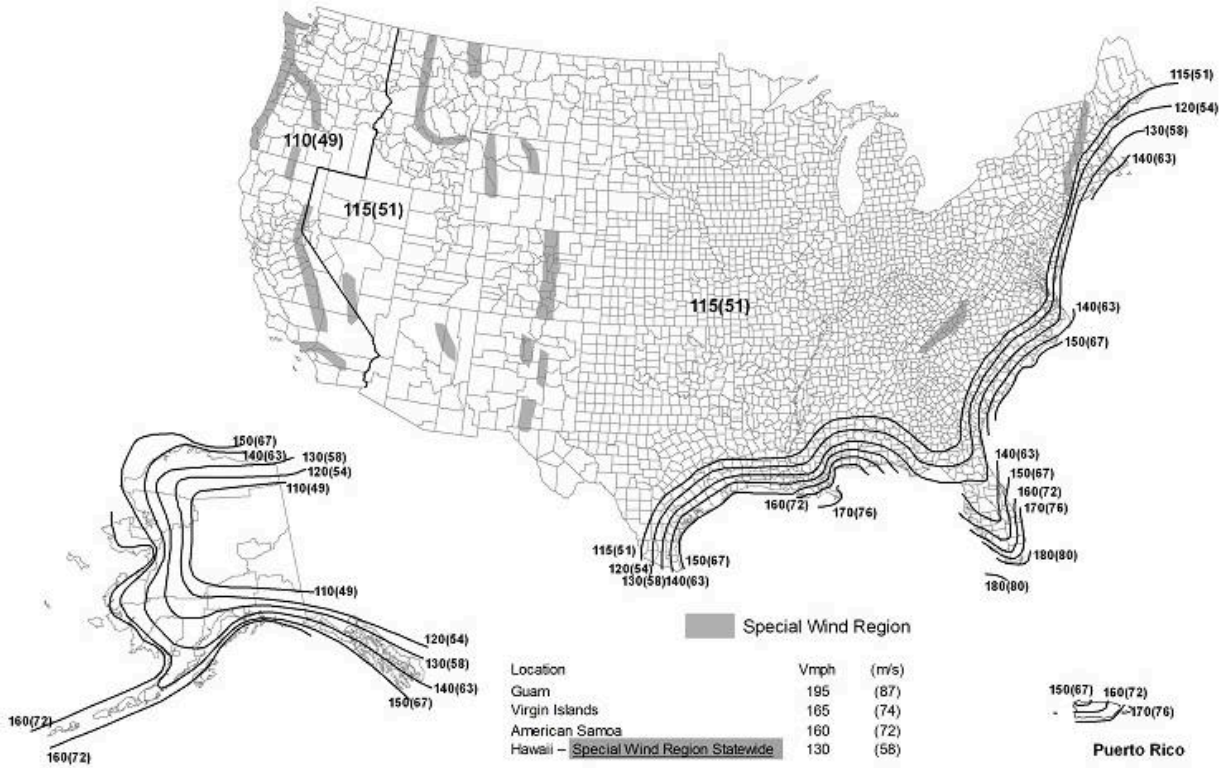
ASCE 7-16 Wind Speeds

FIGURE 1609A

ULTIMATE DESIGN WIND SPEEDS, V_{ULT}, FOR RISK CATEGORY II BUILDINGS AND OTHER STRUCTURES



Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).

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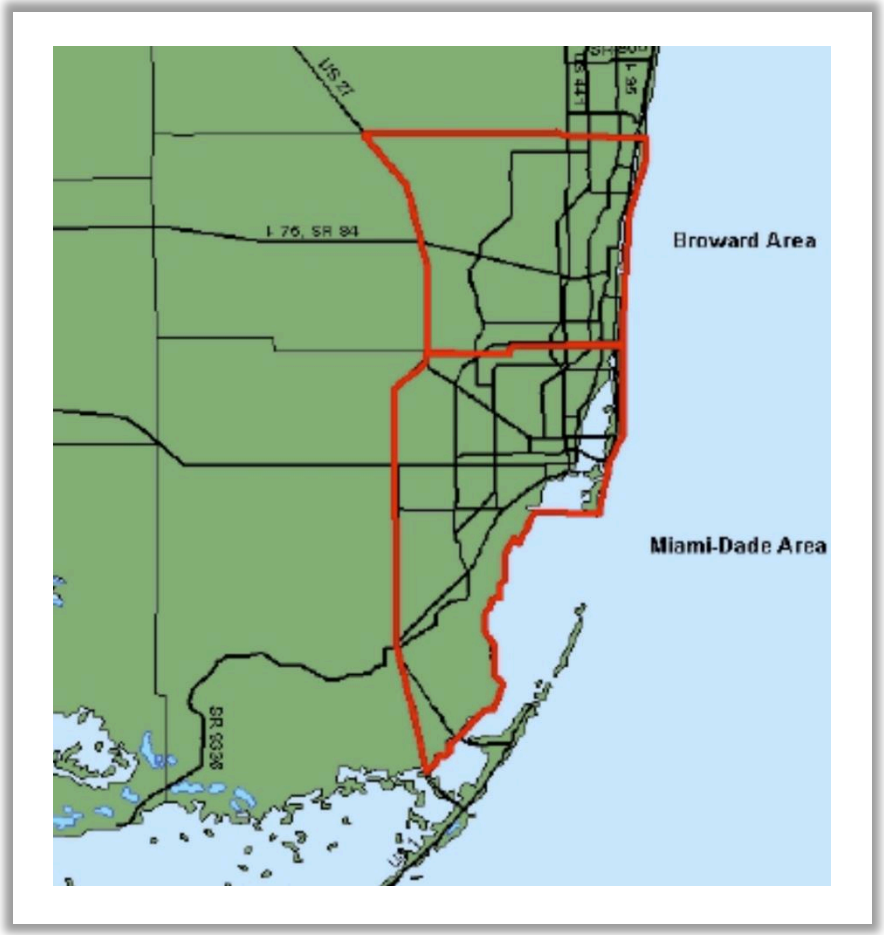
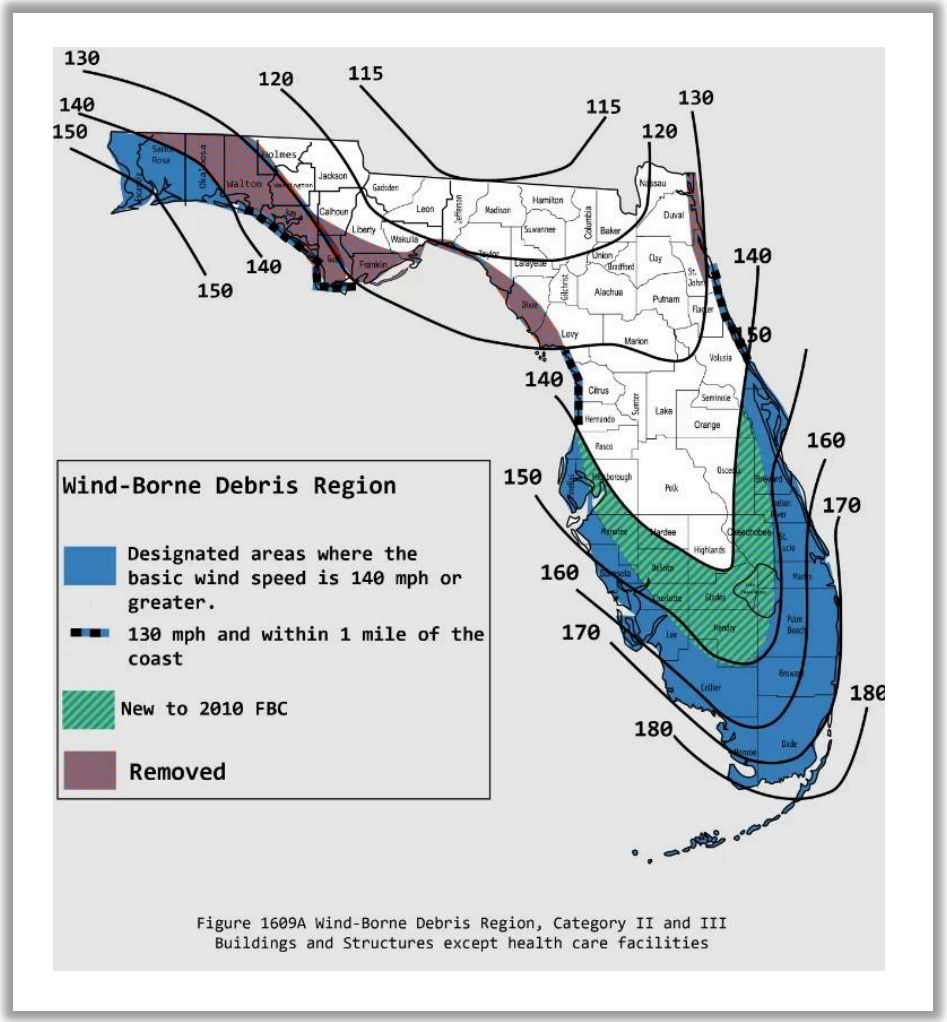
High-Velocity Hurricane Zones



Source:https://www.researchgate.net/publication/228851071_A_statistical_procedure_to_forecast_the_daily_amount_of_warm_season_lightning_in_South_Florida
Accessed date: 10/1/2024



Source: https://www.floridabuilding.org/fbc/wind_2010/flyer_wind_january2012.pdf
Accessed date: 10/1/2024

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Building Code Requirements

Windows and doors in wind-borne debris regions must meet two seperate requirements:

- Design Pressure requirements

- Opening protection requirements:
  - Impact resistant glass
  - Storm panels
  - Shutters

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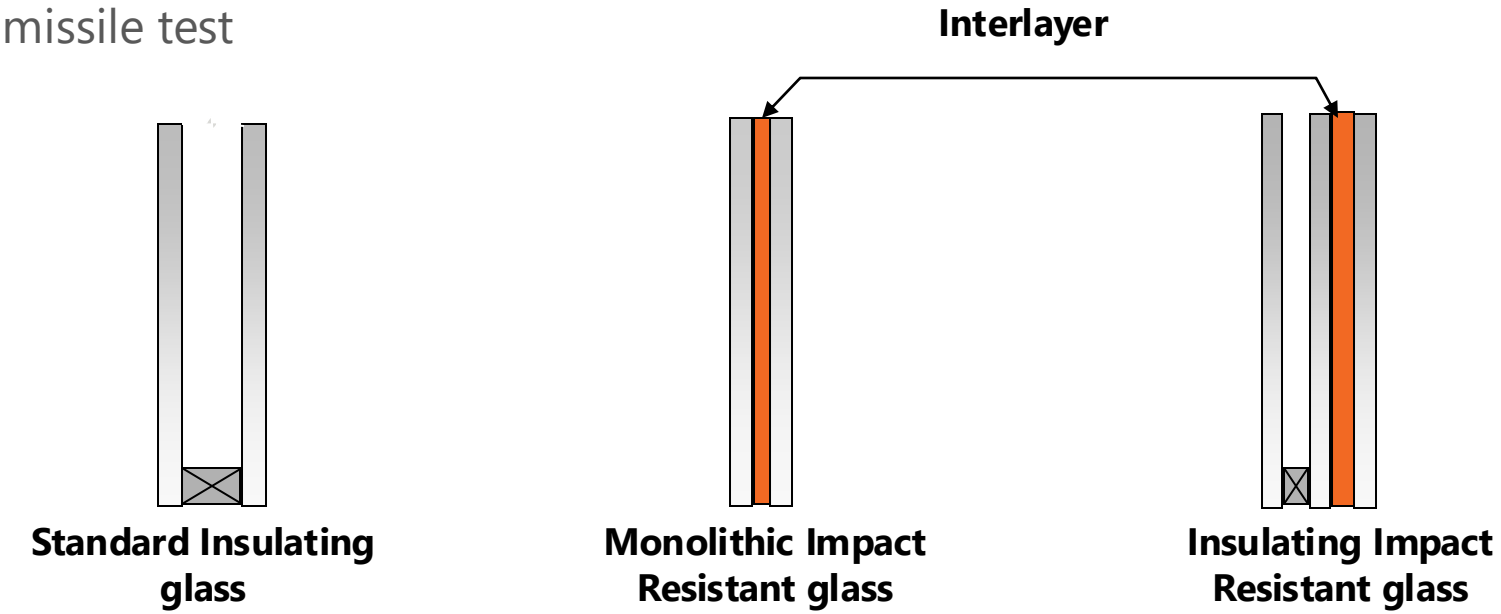
Impact Resistant Glazing Materials

Monolithic laminated

- Use restricted by energy code requirements
- Interlayer material options include:
  - Polyvinyl butyral (PVB), engineered plastic, PVB/Polyester/PVB, and poured in place resin
  - Sentry Glass Plus (SGP), innerlayer
  - *Total interlayer thickness = .090” to pass large missile test

Insulating laminated

- Same interlayer options used with monolithic
- Designed to also meet energy code requirements



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Product Enhancements

Other sash and frame component upgrades:

- Glazing bead, sealant location
- Hinges
- Sash & frame reinforcement

Lock System
Materials
Multiple locks

Installation Methods
Type and location

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Opening Protection Options

Physical protection

- Storm shutters
- Screens
- Storm panel
- Wood structural panel
  - Wind speed < 130 MPH
  - Mean roof height ≤ 33′
  - Precut panels - 7/16″ thick, ≤ 8′ long
  - Engineered anchors

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Opening Protection Options

These methods of opening protection require manual or electrical operation, or manual installation prior to the high wind event.

Automatic Rolldown Shutters

Awning Shutters

Bahama Shutters

Accordion Shutters

Storm Panel Shutters

Plywood Shutters

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Source for all images: https://www.aoml.noaa.gov/hrd/shutters/index3.html Accessed date: 10/1/2024

Test Standards

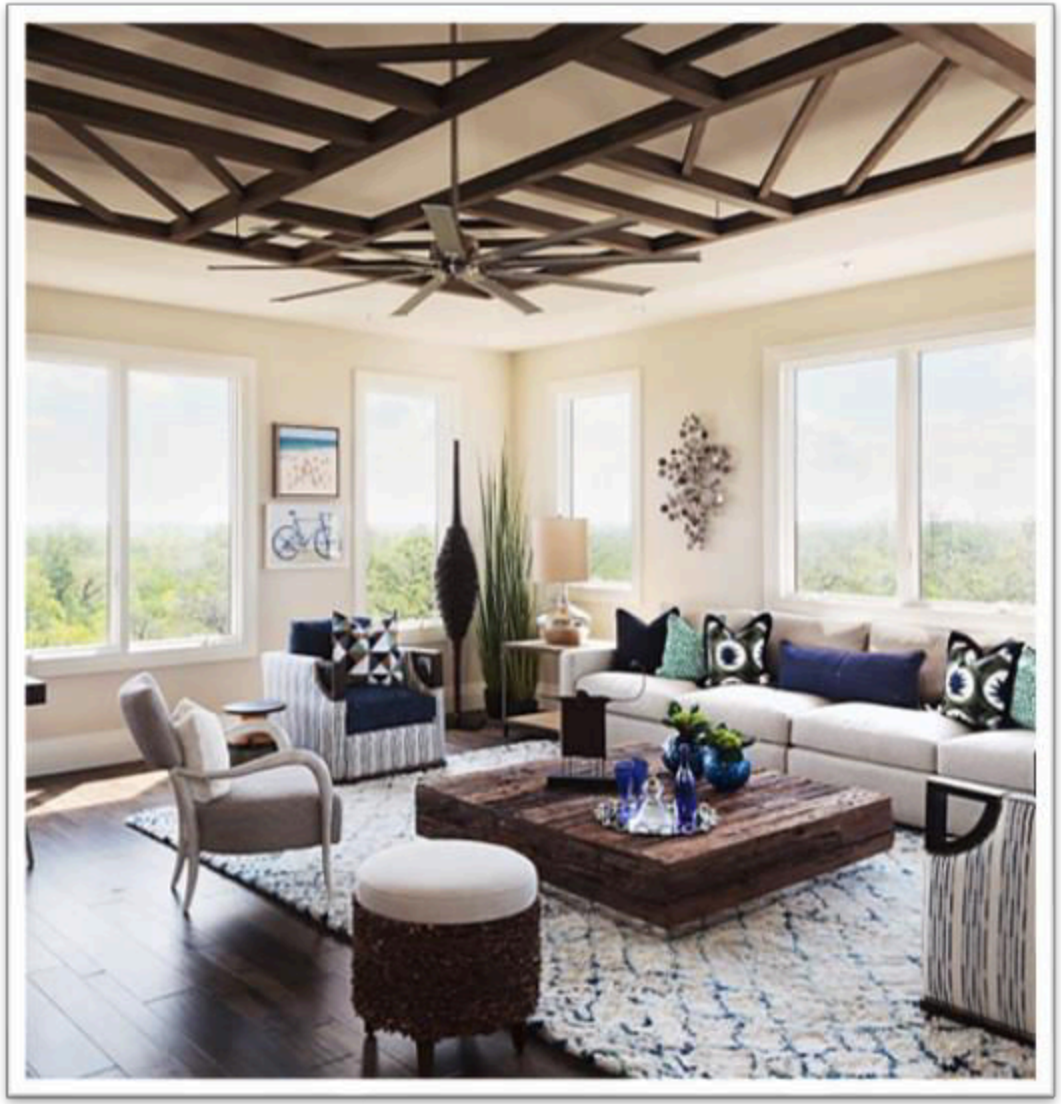
ASTM Wind-Borne Debris Test Method E-1886 and Specification E-1996

ASTM E1886: Defines test method

- Defines devices and apparatus
- Defines procedures for reporting

ASTM E1996: Defines test specifications

- Missile type, size, weight and speed at impact, location, and number of strikes
- Pressure cycles
- Failure criteria



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Wind-Borne Debris Testing

The purpose of these tests is to simulate the effects of a hurricane or other high wind event:

- The **impact** of wind-borne debris
- The fluctuation of **wind toward and away from** windows and doors

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Test Standards

ASTM E-1996 - Missiles

Wind Zone	Wind Speed	Missile	Size	Velocity
Zone 1	110 to 120 mph	A	10 2g Steel Balls	130 ft/s (89 mph)
Zone 2	120 to 130 mph	B	2x4 @ 2 lbs.	50 ft/s (34 mph)
Zone 3	130 to 140 mph	C	2x4 @ 4.5 lbs.	40 ft/s (27 mph)
Zone 4	> 140 mph	D	2x4 @ 9 lbs.	50 ft/s (34 mph)
		E	2x4 @ 9 lbs.	80 ft/s

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Small Missile Impact Test

- 2 g steel balls (simulates roof aggregate)
- Applies to units 30’ to 60’ above grade
  - Measured to center of unit
- 30 balls are fired at each target in 3 groups of 10 balls each
- 3 test units, one target each unit, targets at center, corner and edge
- Impact speed = 130 ft/second (89 mph)

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Large Missile Impact Test

- Nominal 2x4 lumber (simulates large debris, tree branch)
- 9 lbs., 8 ft. for 120 mph wind zone & higher
  - Smaller size (4.5 lbs.) for 110 mph wind zone
- Applies to units up to 30’ above grade
  - Measured to center of unit
- 3 test units, one impact each
  - Targets: center and 6” from two corners
- Impact speed = 50 ft/sec (34 mph)

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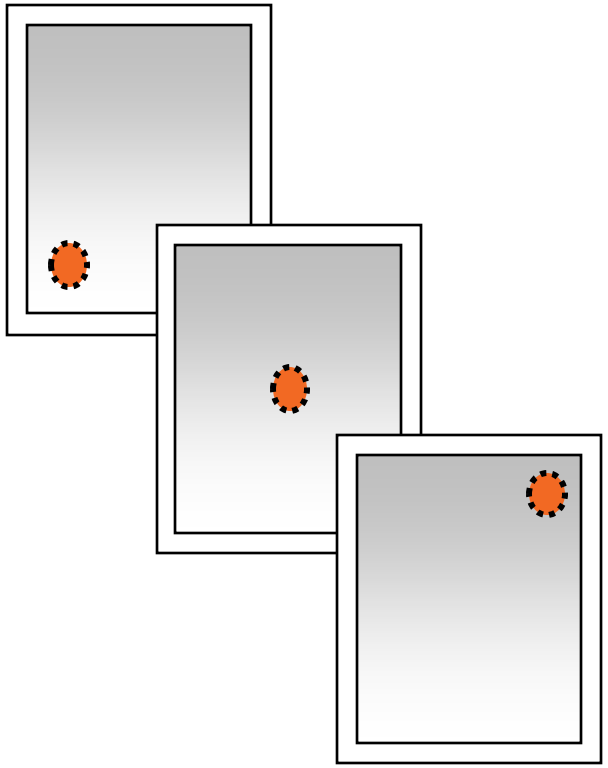
Missile Impact Locations

- Impacted in 3 places (targets) on the glass area of 3 individual units
- All 3 tested units must pass



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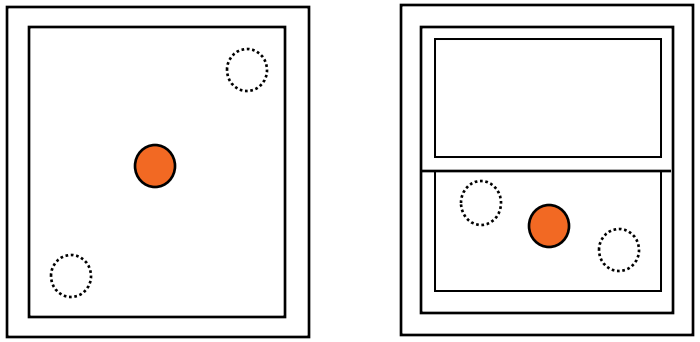
Large Missile Impact Test Comparison

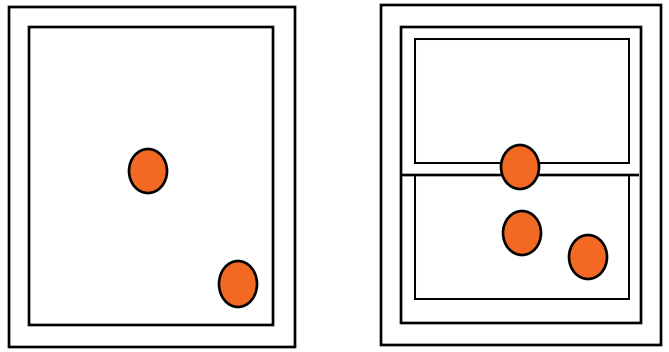
ASTM E1996

- Nominal 2x4 Lumber
- **Size varies for lesser wind zones**
- Length = 8 feet
- Weight = 9 lb.
- Speed = 50 f/s (34 mph)
- One impact
- No tear greater than 5" or an opening up to 3" in diameter



TAS 201

- S4S nominal 2x4 #2 Surface Dry Southern Pine
- **All wind zones**
- Length = 7 to 9 feet
- Total Weight = 9 lb.
- Speed = 50 f/s (34 mph)
- Two impacts
- No tear over 1/16" x 5"



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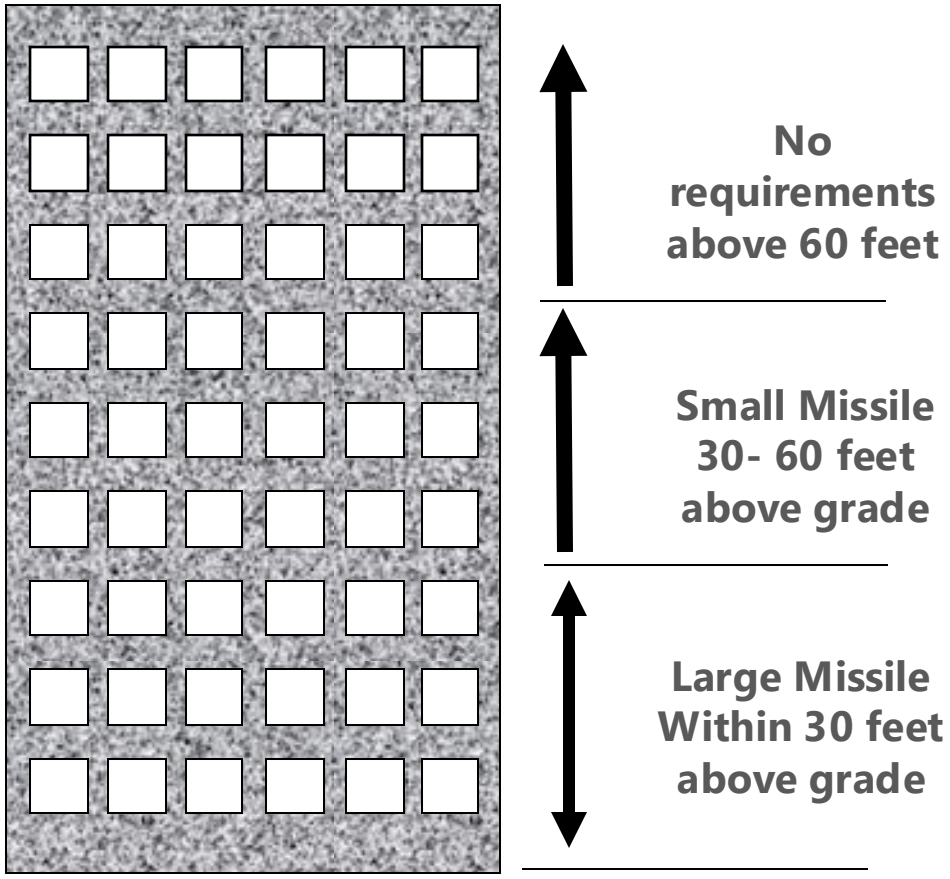
ASTM Impact Requirements

If product passes the Large Missile Impact test, small impact testing is not required.



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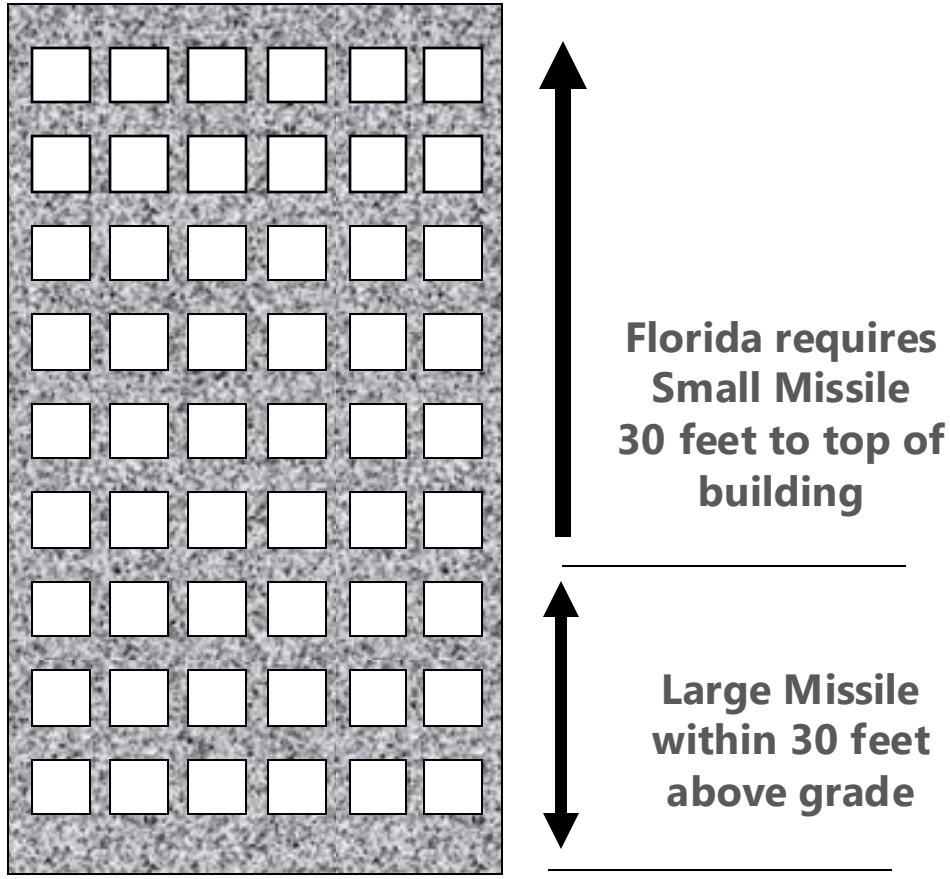

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Pressure Cycle Testing

ASTM E1996 Cyclic Pressure Test

- Simulates pressure fluctuation during high wind event
- The units must first pass missile impact test
- Must pass 4,500 cycles of positive & 4,500 cycles of negative applied pressure (shown in video)
- Pressures are % of rating the unit is being tested to achieve

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Pressure Cycle Testing

Cyclic wind pressure testing:

4,500 Positive Cycles

4,500 Negative Cycles

Design pressure increased each sequence

	Pressure Direction	Loading Sequence	% of Load Range	Number of Cycles
Positive	Inward Acting Pressure P_{max}=maximum positive wind pressure in accordance with specified wind calculation method	1	0.2 P_{max} to 0.5 P_{max}	3500
		2	0 to 0.6 P_{max}	300
		3	0.5 P_{max} to 0.8 P_{max}	600
		4	0.3 P_{max} to 1.0 P_{max}	100
Negative	Outward Acting Pressure P_{max}=maximum negative wind pressure in accordance with specified wind calculation method	5	0.3 P_{max} to 1.0 P_{max}	50
		6	0.5 P_{max} to 0.8 P_{max}	1050
		7	0 to 0.6 P_{max}	50
		8	0.2 P_{max} to 0.5 P_{max}	3350

P = psf design pressure

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Impact Test Criteria

Test Failure Criteria

- No tear or crack longer than 5″ x 1/16″ wide that air can pass through
- No opening that a 3″ sphere can pass through
- All 3 test units must pass impact and pressure cycle tests

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Structural Performance Testing

- Impact resistant units are tested to the same test standards as non-impact resistant units: ASTM E330
- Units are tested to 1.5 times the rated design pressure
    - **Example**: A unit rated at Performance Grade 50 must pass 75 pounds per square foot of test pressure
    - (50 x 1.5 = 75 psf)
- Performance Grade: identifies product tested for air, water and structural performance

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Air and Water Testing

Impact resistant units are tested to the same test standards as non-impact resistant units.

Water Penetration ASTM E547

- Unit sprayed with water while under pressure (psf)
  - Example: For a PG 50 rating, 7.50 psf is used. (Test pressure equals 15% of DP)
- Water is applied continuously in 5-minute cycles
- Amount of water penetration not measured – pass/fail rating
- Failure occurs if water passes into interior of room

Air Leakage ASTM E283

- Air measured in cubic feet per minute (cfm) per sq. ft. of unit. Maximum allowable leakage = .30 cfm/sq. ft.
- Air pressure is applied at 1.57 cfm (6.24 cfm for Heavy Commercial and Architectural window class)
- Pass/fail rating

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Test Reports

Intertek | Architectural Testing

SUMMARY TEST REPORT

Report Number: E3276.02-201-44
Test End Date: 12/17/2014
Report Date: 02/17/2015
Test Record Retention End Date: 12/17/2018

SERIES TESTED: Series 07 Clad Double Hung Vent with HMIG
MODEL TESTED 3466

NAFS-08/-11	Class R-PG55 Size Tested 1016 x 1981 mm (40.0 x 78.0 in.)-H
Test	**Results Summary**
Resistance to Air Infiltration	0.16 cfm/ft² (ASTM E283)
Resistance to Water Penetration	Pass at DP55 (ASTM E547)
Resistance to Structural Loading	Pass at DP55 (ASTM E330)
Forced Entry Resistance	Pass (ASTM F588)

ASTM E1886 / ASTM E1996	
Test	**Results Summary**
Impact	No rips, tears or penetrations, Missile D, Zone 4
Pressure Cycling	DP+55/-65 psf

REFERENCE:	See Intertek-ATI Report No. E3276.01-201-44 and E3266.02-201-18 for complete test results.

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Research and Innovation

Numerous efforts to improve testing requirements

Wall of Wind (WoW) at the International Hurricane Research Center, FIU Miami, simulates the effects of both wind and wind-driven rain.

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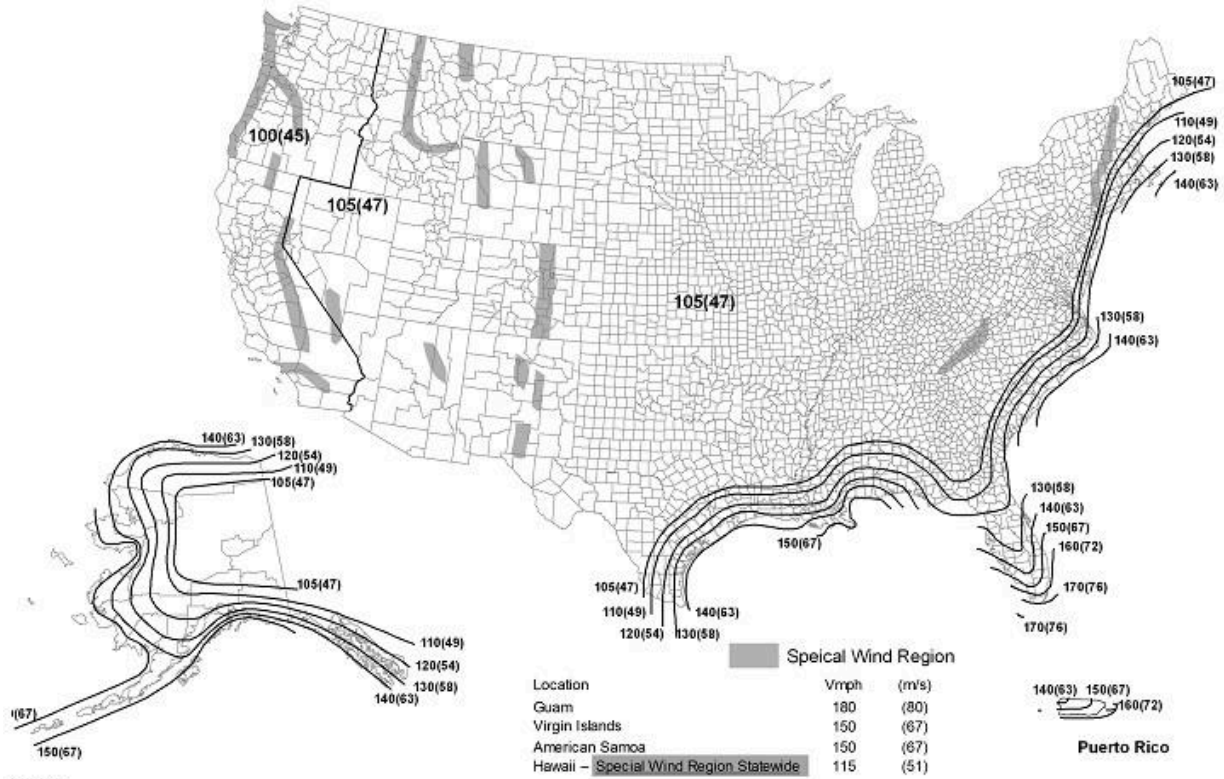
Determining Wind Load Requirements

What design pressure rating is required for windows and doors in a project with these characteristics?

- Residential structure
- Located in 140 mph wind speed zone
- Located on the coast in Exposure C
- Mean roof height = 45 feet
- Window size = 10 square feet

FIGURE 1609.3(3) BASIC DESIGN WIND SPEEDS, *V*, FOR RISK CATEGORY IV BUILDINGS AND OTHER STRUCTURES



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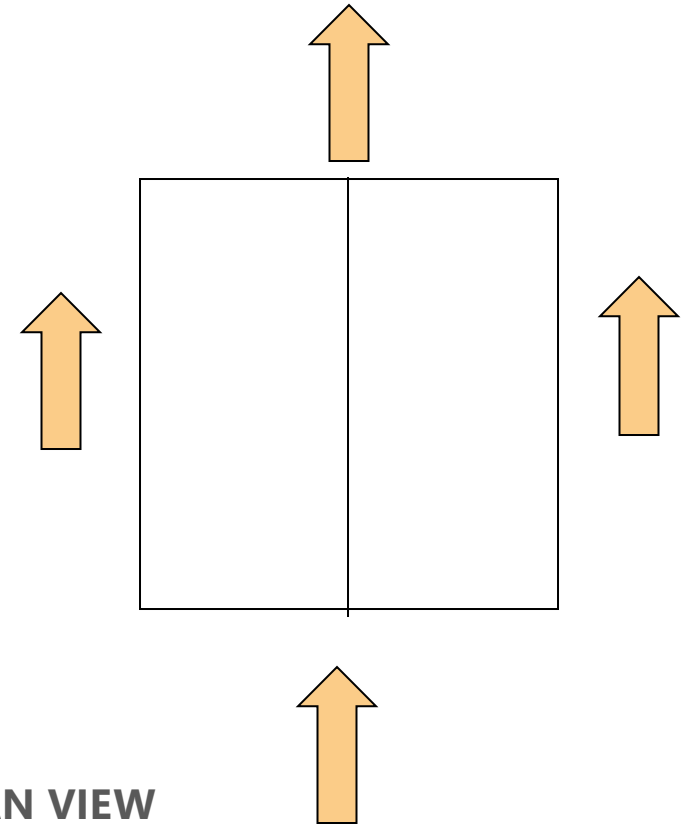
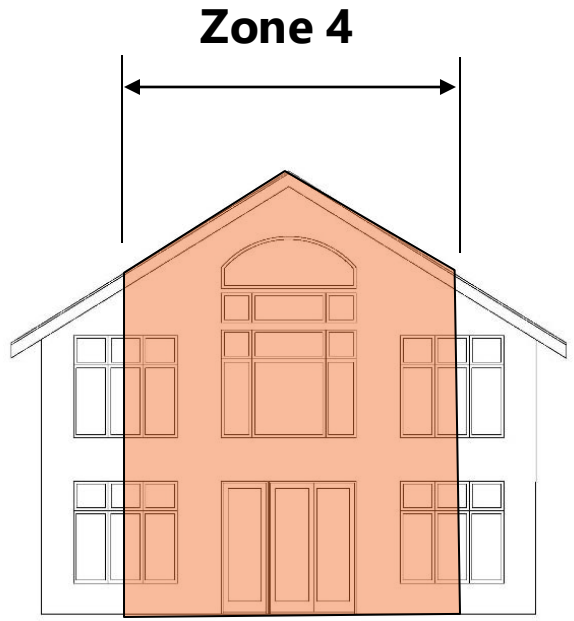
Wind Zones

Zone 4: Body of building



PLAN VIEW



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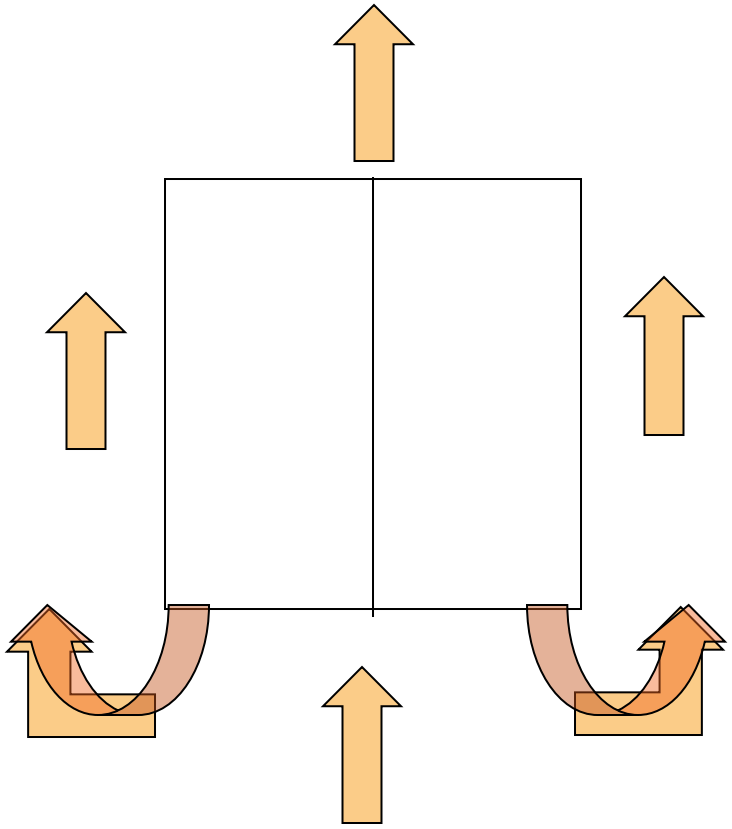
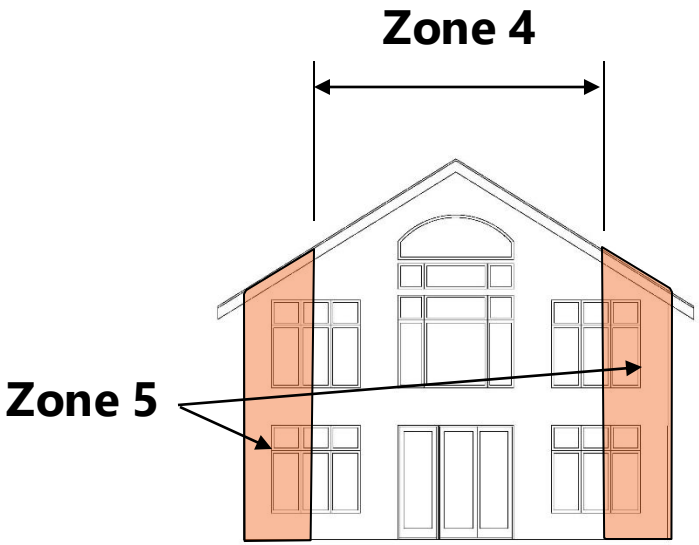
Wind Zones

Zone 4: Body of building

Zone 5: Corner zone





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Mean Roof Height

Distance from grade to halfway between the soffit and ridge of a gabled roof

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Exposure Categories

Exposure B: Cities & residential areas

Exposure C: Flat open areas

Exposure D: Open water > 5,000 ft across, Hurricane-prone regions

Exposure A: Deleted in ASCE 7-02, Applied to cities with tall closely spaced buildings.

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Design Pressure Example

Step 1: Go to Table R301.2(2) of the International Residential Code (IRC). Refer to the "Wall" section.

	ZONE	EFFECTIVE WIND AREA (feet^2)	ULTIMATE DESIGN WIND SPEED, V_{ULT} (mph)														
			110		115		120		130		140		150		160		17
Wall	4	10	13.1	-14.0	14.3	-15.0	15.5	-16.0	18.2	-19.0	21.2	-22.0	24.3	-26.0	27.7	-30.0	31.2
	4	20	12.5	-13.0	13.6	-14.0	14.8	-16.0	17.4	-19.0	20.2	-22.0	23.2	-25.0	26.4	-28.0	29.7
	4	50	11.7	-12.0	12.8	-14.0	13.9	-15.0	16.3	-17.0	19.0	-20.0	21.7	-23.0	24.7	-27.0	27.9
	4	100	11.1	-12.0	12.1	-13.0	13.2	-14.0	15.5	-17.0	18.0	-19.0	20.6	-22.0	23.5	-25.0	26.5
	4	500	10.0	-10.0	10.6	-11.0	11.6	-12.0	13.6	-15.0	15.8	-17.0	18.1	-20.0	20.6	-22.0	23.2
	5	10	13.1	-17.0	14.3	-19.0	15.5	-20.0	18.2	-24.0	21.2	-28.0	24.3	-32.0	27.7	-37.0	31.2
	5	20	12.5	-16.0	13.6	-17.0	14.8	-19.0	17.4	-22.0	20.2	-26.0	23.2	-30.0	26.4	-34.0	29.7
	5	50	11.7	-14.0	12.8	-16.0	13.9	-17.0	16.3	-20.0	19.0	-23.0	21.7	-27.0	24.7	-31.0	27.9
	5	100	11.1	-13.0	12.1	-14.0	13.2	-16.0	15.5	-19.0	18.0	-22.0	20.6	-25.0	23.5	-28.0	26.5
	5	500	10.0	-10.0	10.6	-11.0	11.6	-12.0	13.6	-15.0	15.8	-17.0	18.1	-20.0	20.6	-22.0	23.2

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Design Pressure Example

Step 2: Determine the adjustment factor.

To do this, identify the appropriate Height and Exposure Adjustment Coefficients in Table R301.2(3) for 45-foot mean roof height and Exposure C (on the shore). The adjustment factor = 1.53

TABLE R301.2(3)
HEIGHT AND EXPOSURE ADJUSTMENT COEFFICIENTS FOR TABLE R301.2(2)

MEAN ROOF HEIGHT	EXPOSURE		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

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Design Pressure Example

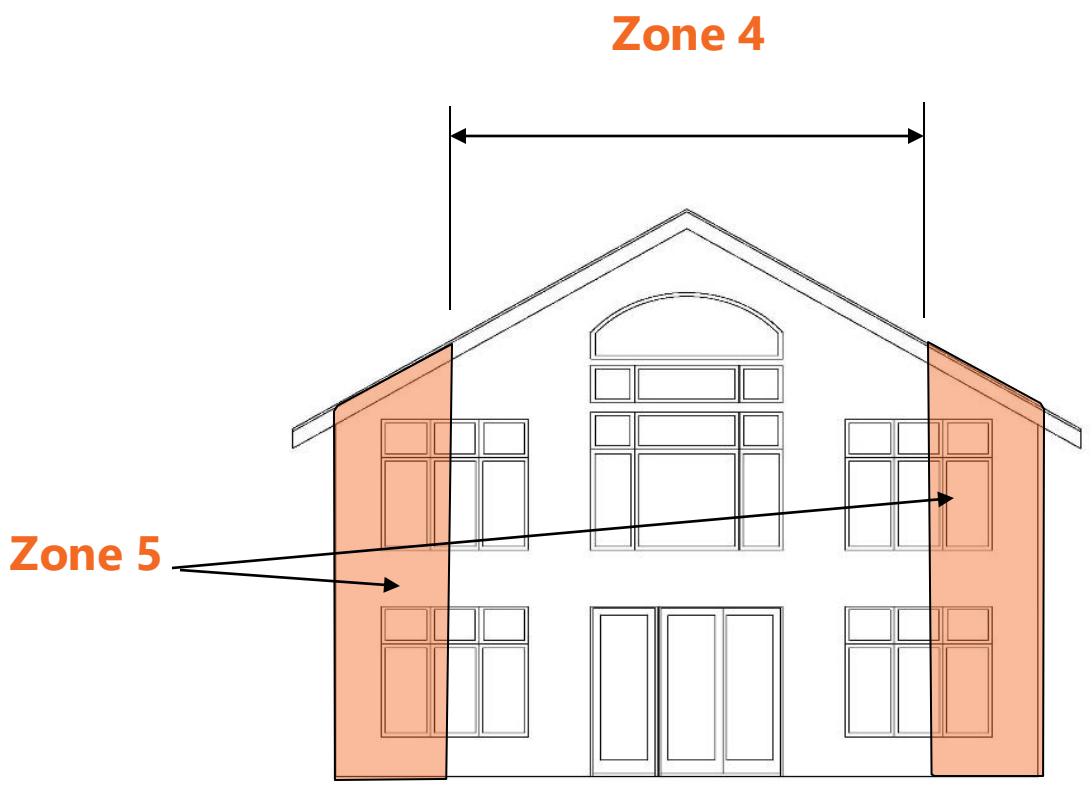
From Step 1:

Interior (Zone 4) design pressures

- 21.2 psf positive pressure
- (-)34.0 psf negative pressure

Corner (Zone 5) design pressures

- 21.2 psf positive pressure
- (-)43.0 psf negative pressure



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Design Pressure Estimating Tools

- Calculate design wind pressures for windows and doors
- Obtain site-specific wind speeds
- Calculate design roof-to-wall uplift loads

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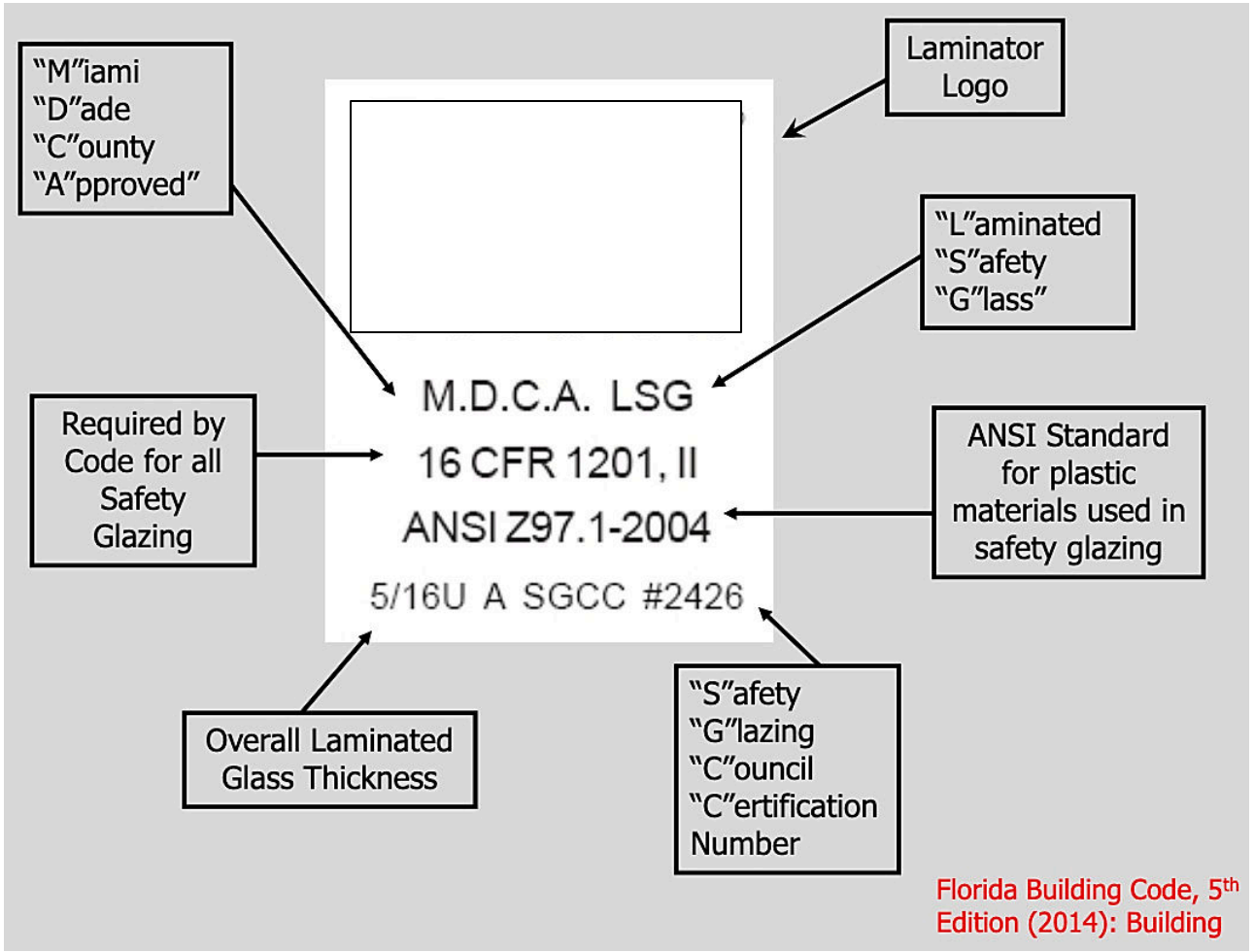
Florida Requirements

Products need to be identified in order to provide compliance with the wind loads. Florida has additional requirements for impact product identification.

- Each pane of tempered glass requires a permanent label that identifies:
  - Laminator
  - Overall glass thickness
  - Trade name of interlayer
- Label can be acid etched, ceramic fired, laser etched, embossed, sand etched, or of a type that cannot be removed



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Florida state government materials are in the public domain.

Florida Requirements

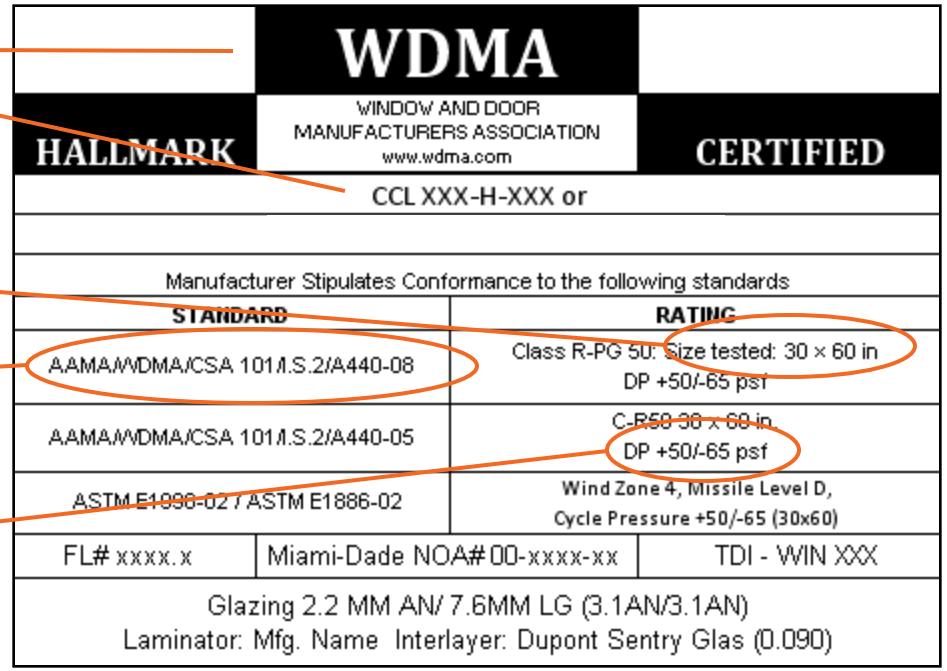
Temporary Label

Certification agency

Product Maximum Size

Test Standards

Positive & Negative rating



WDMA		
HALLMARK	WINDOW AND DOOR MANUFACTURERS ASSOCIATION www.wdma.com	CERTIFIED
CCL XXX-H-XXX or		
Manufacturer Stipulates Conformance to the following standards		
STANDARD	RATING	
AAMA/WDMA/CSA 101/I.S.2/A440-08	Class R-PG 50: Size tested: 30 × 60 in DP +50/-65 psf	
AAMA/WDMA/CSA 101/I.S.2/A440-05	C-R50 30 x 60 in DP +50/-65 psf	
ASTM E1996-02 / ASTM E1886-02	Wind Zone 4, Missile Level D, Cycle Pressure +50/-65 (30x60)	
FL# xxxx.x	Miami-Dade NOA# 00-xxxx-xx	TDI - WIN XXX
Glazing 2.2 MM AN/ 7.6MM LG (3.1AN/3.1AN) Laminator: Mfg. Name Interlayer: Dupont Sentry Glas (0.090)		

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https://www.wdma.com/index.php?option=com_content&view=article&id=38:wdma-hallmark-certification&catid=20:site-content&Itemid=141
Accessed date: 12/30/2024

Conclusion

Code requirements, testing, opening protection methods, and materials

- Air and Water Infiltration Tests
- Structural Wind Load Resistance Test
- Impact Test
- Pressure Cycling Test

- Methods of Protection
- Glass Options
- Physical Barriers

- Design Pressure Performance
- Product Labeling

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Going “Beyond Code”

Hurricane Michael

- Many homes damaged or destroyed were built before strict codes in place
- Design pressure in Mexico Beach is only 120 mph
- This newer home was built according to “Fortified Home” requirements

Source: https://www.tampabay.com/opinion/editorials/editorial-toughen-floridas-building-code-20181019/ Accessed date: 10/1/2024

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THANK YOU!