ProTek® : Understanding Codes for Windborne Debris

Mike Gilbert, CDT
Brand Manager

July 2010

YKK AP America Inc. is a registered provider with the American Institute of Architects Continuing Education Systems. Credit earned upon completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available upon request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Thank you!

1-Hr Understanding Building Codes and Wind Borne Debris Mitigation

Learning Objective

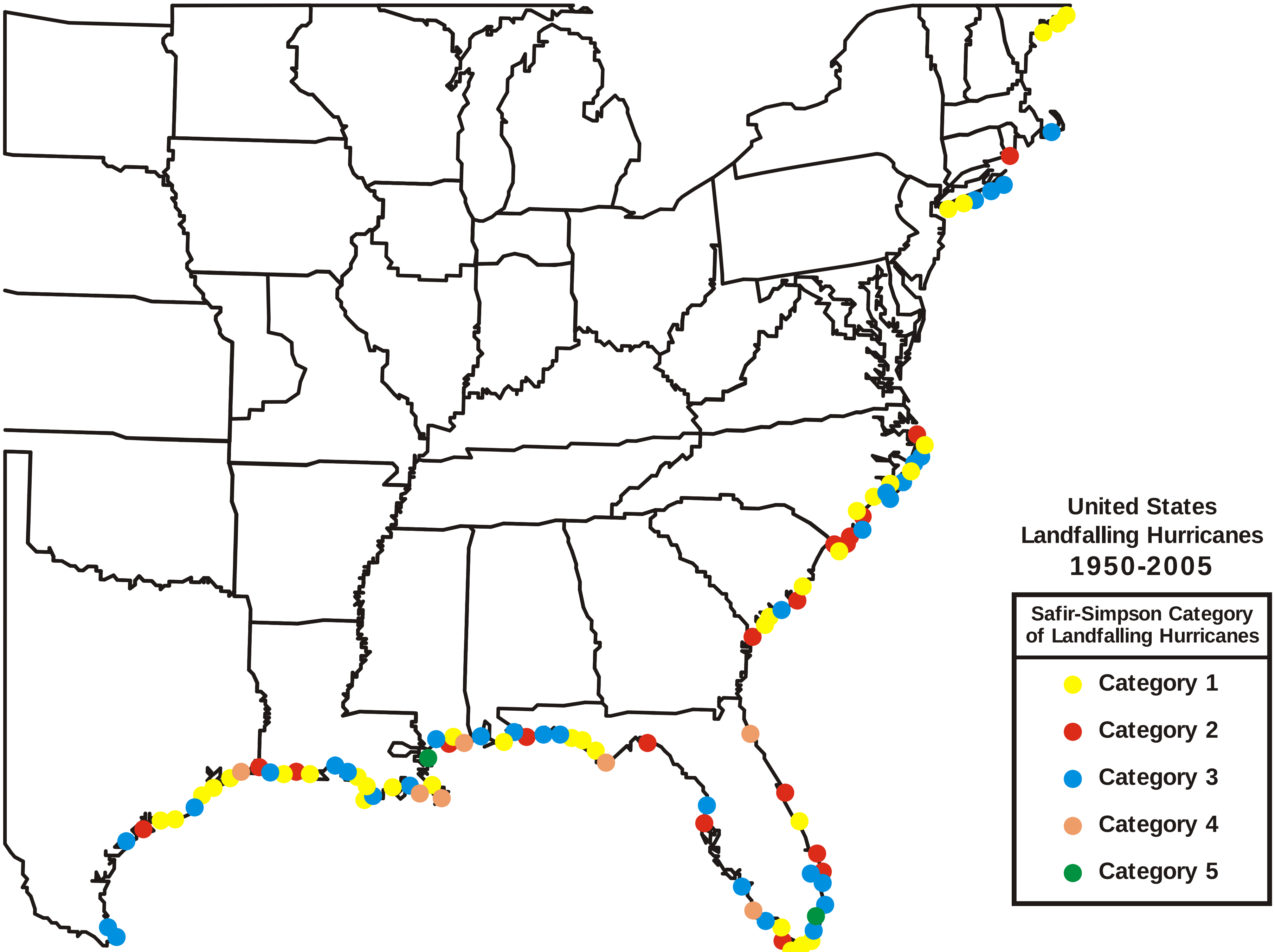
Using the ASCE7 Standards and the detailed information provided in this seminar, the participant will be able to make more educated decisions when designing projects that must the stringent building requirements of hurricane prone areas.

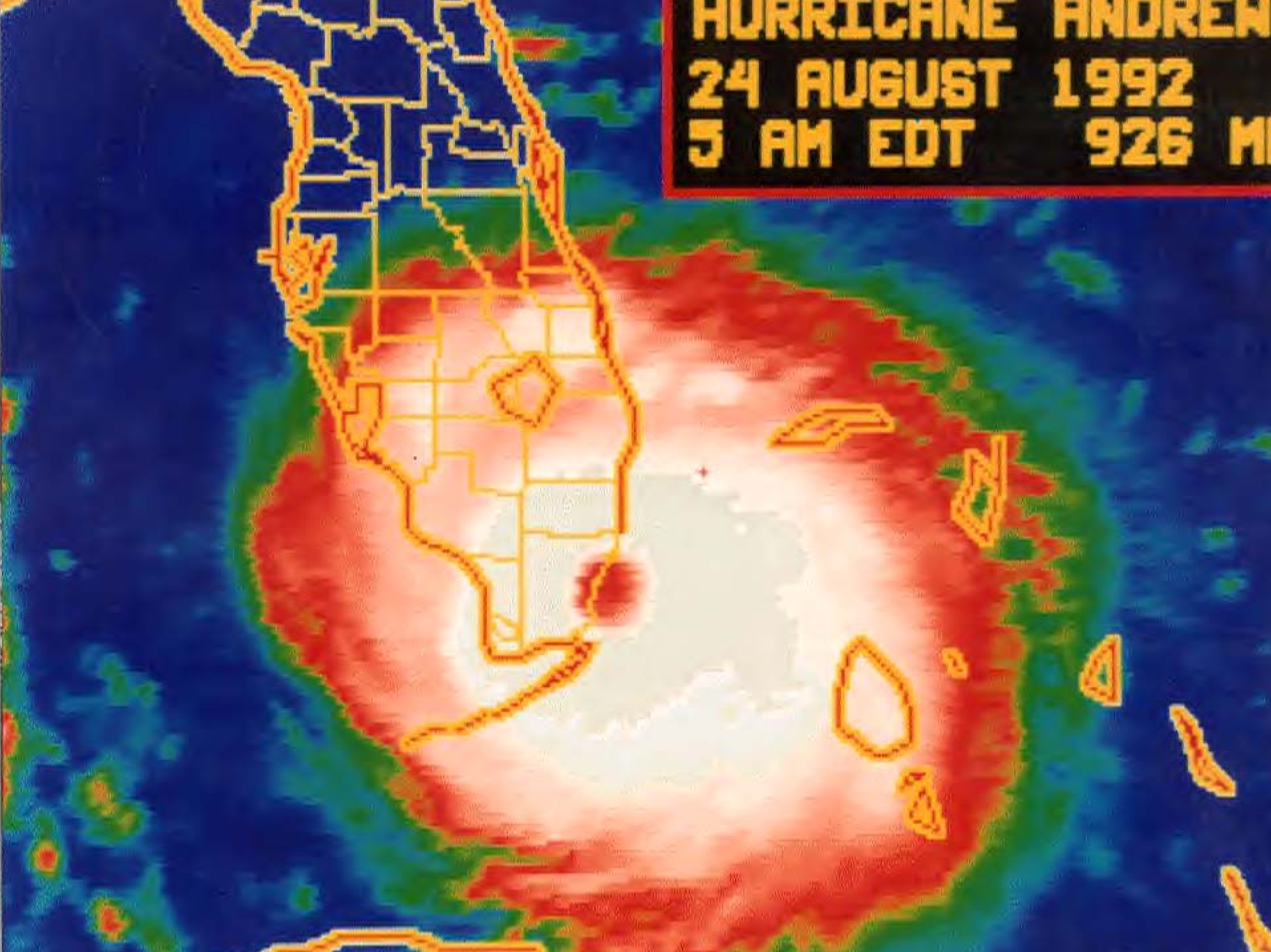
Hurricanes

- Classifications
- History
- Power of a Hurricane
- Bldg Codes React
- Code Requirements
- Recent Storms
- Product Testing
- Glazing Systems

Hurricane Classifications
Saffir-Simpson Scale

- Category One: 74-95 MPH
- Category Two: 96-110 MPH
- Category Three: 111-130 MPH
- Category Four: 131-155 MPH
- Category Five: Greater than 155 MPH


United States
Landfalling Hurricanes
1950-2005
Safir-Simpson Category
of Landfalling Hurricanes
Category 1
Category 2
Category 3
Category 4
Category 5

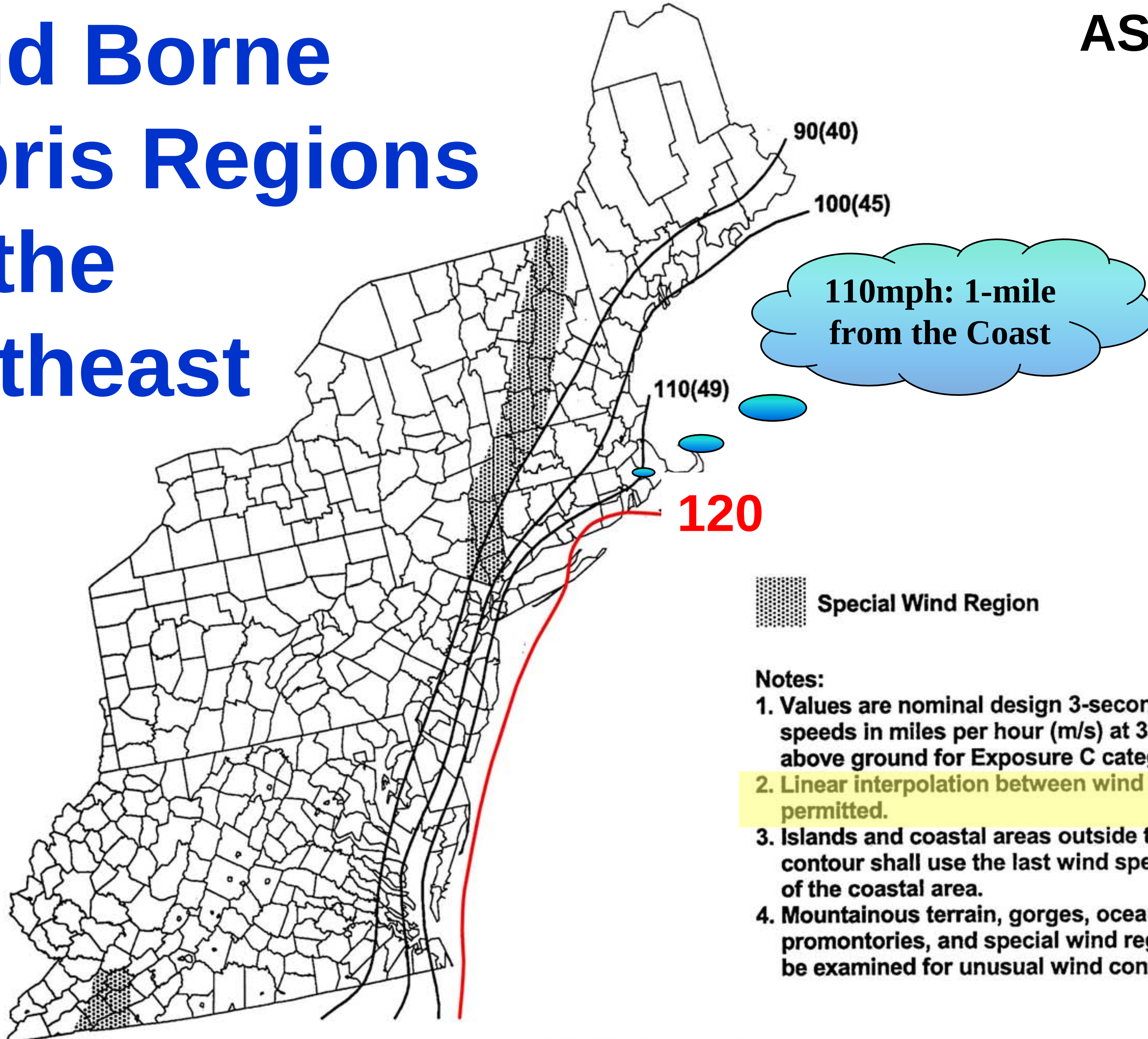

HURRICANE ANDREW
24 AUGUST 1992
5 AM EDT

Structural Requirements ASCE :

- The IBC & FL Building Codes reference ASCE 7 (American Society of Civil Engineers) to calculate a project's "Design Pressure" and define required protection from Hurricanes.
- **Hurricane Prone Regions** are defined as:
  - The U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed is greater than ***90mph***.
  - Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.
- **Wind Borne Debris Regions** are defined as those areas within the Hurricane Prone Regions located:
  - Within 1-mile of the coastal mean high water line where the basic wind speed is equal to or greater than ***110mph*** and Hawaii.
  - In areas where the basic wind speed is equal to or greater than ***120mph.***

Wind Borne Debris Regions for the Northeast

ASCE 7



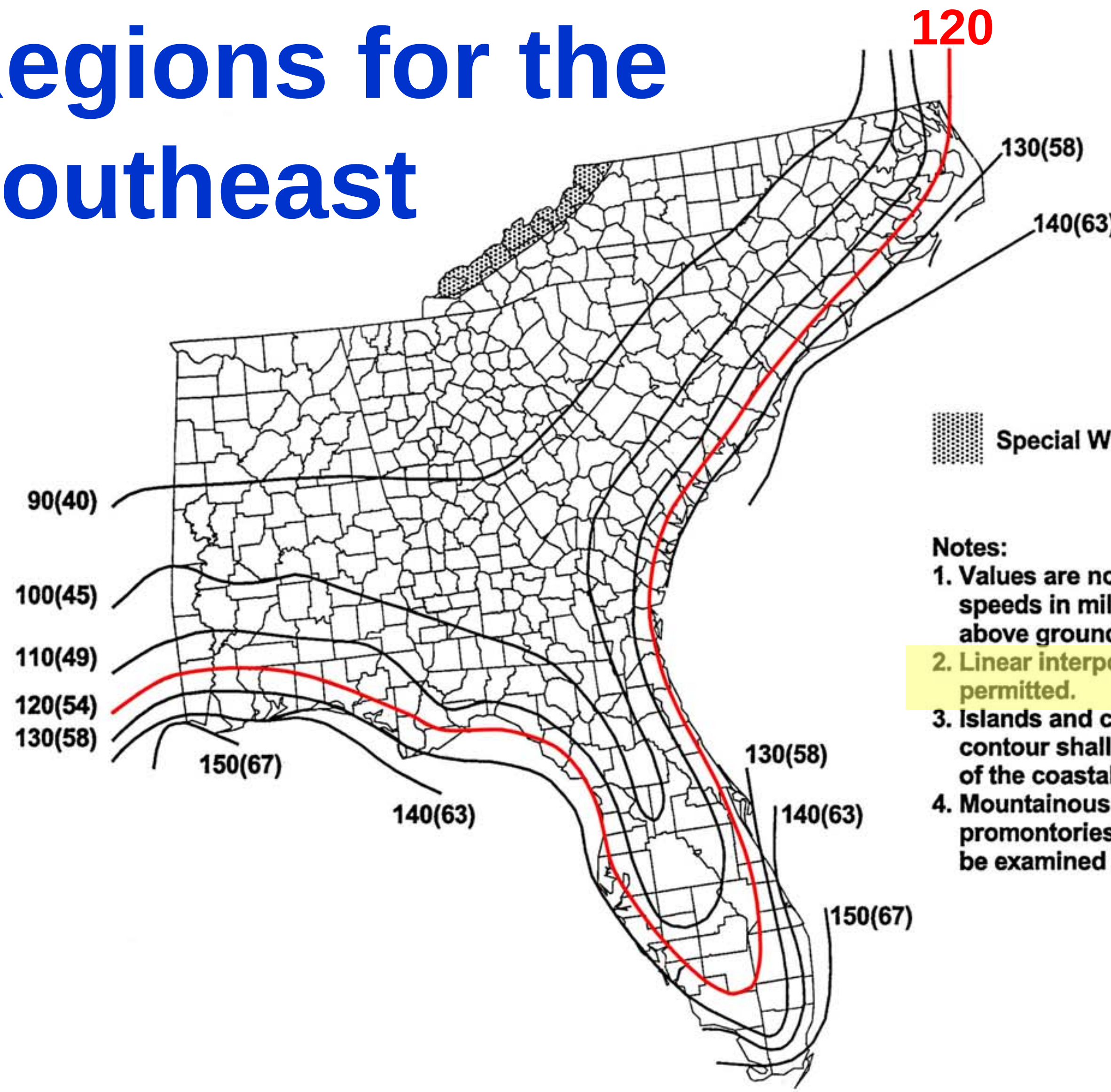
Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind 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.

FIGURE 1609—continued
BASIC WIND SPEED (3-SECOND GUST)
MID AND NORTHERN ATLANTIC HURRICANE COASTLINE

ASCE 7

Wind Borne Debris Regions for the Southeast



Special Wind Region

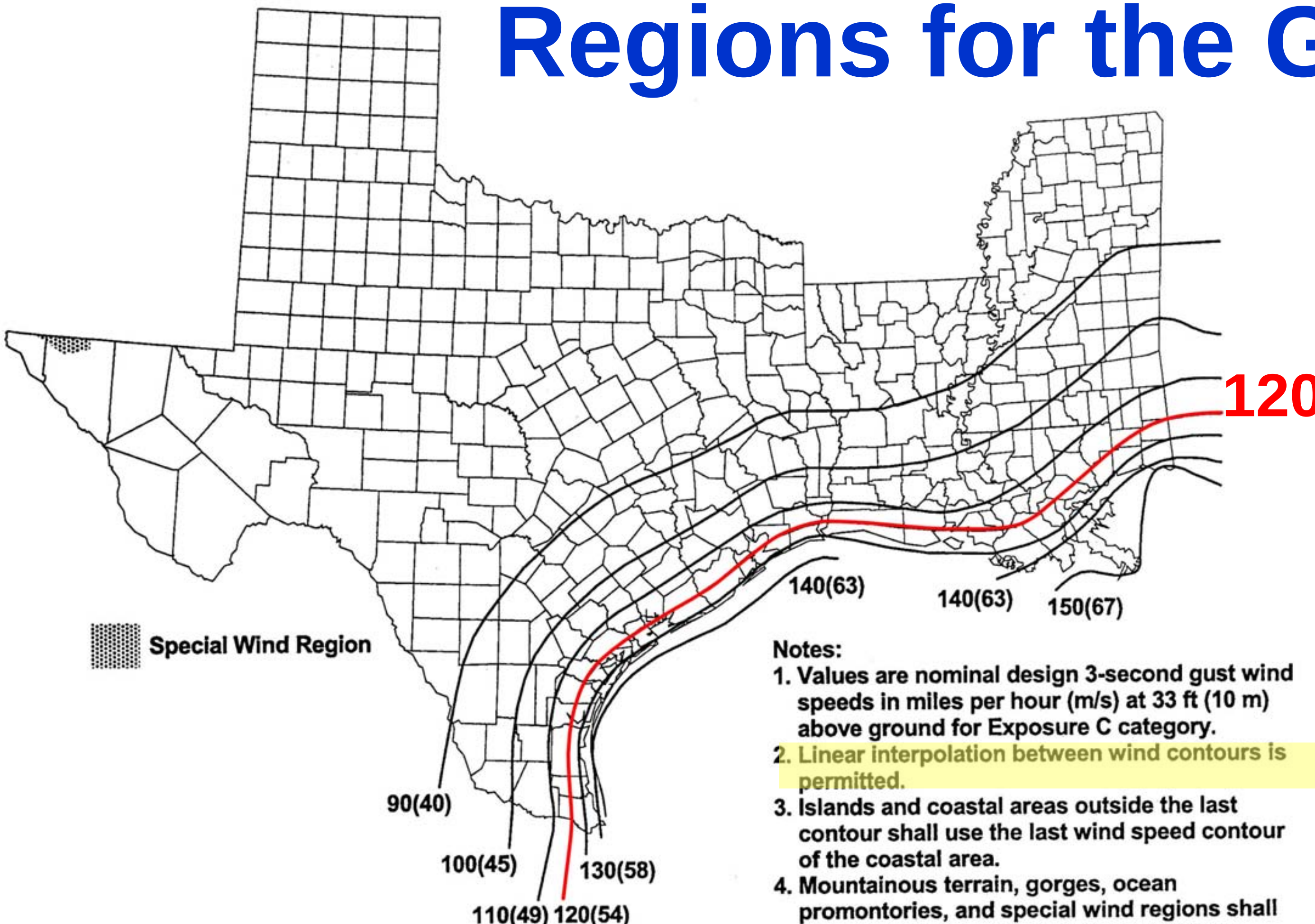
Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind 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.

FIGURE 1609—continued
BASIC WIND SPEED (3-SECOND GUST)
EASTERN GULF OF MEXICO AND SOUTHEASTERN U.S. HURRICANE COASTLINE

Wind Borne Debris Regions for the Gulf Coast

ASCE 7

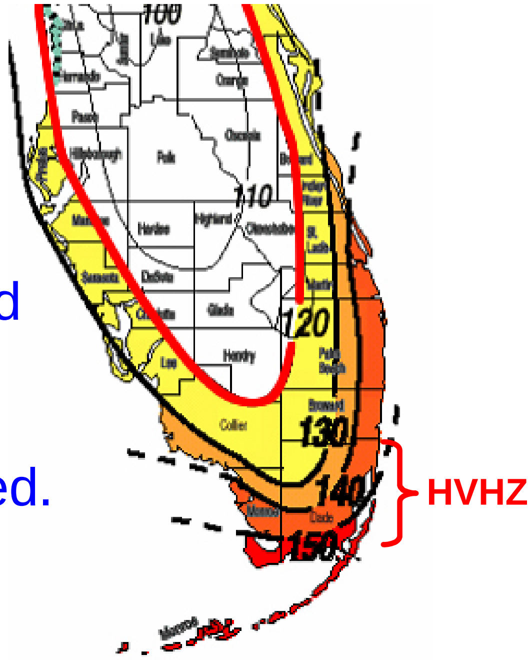


Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

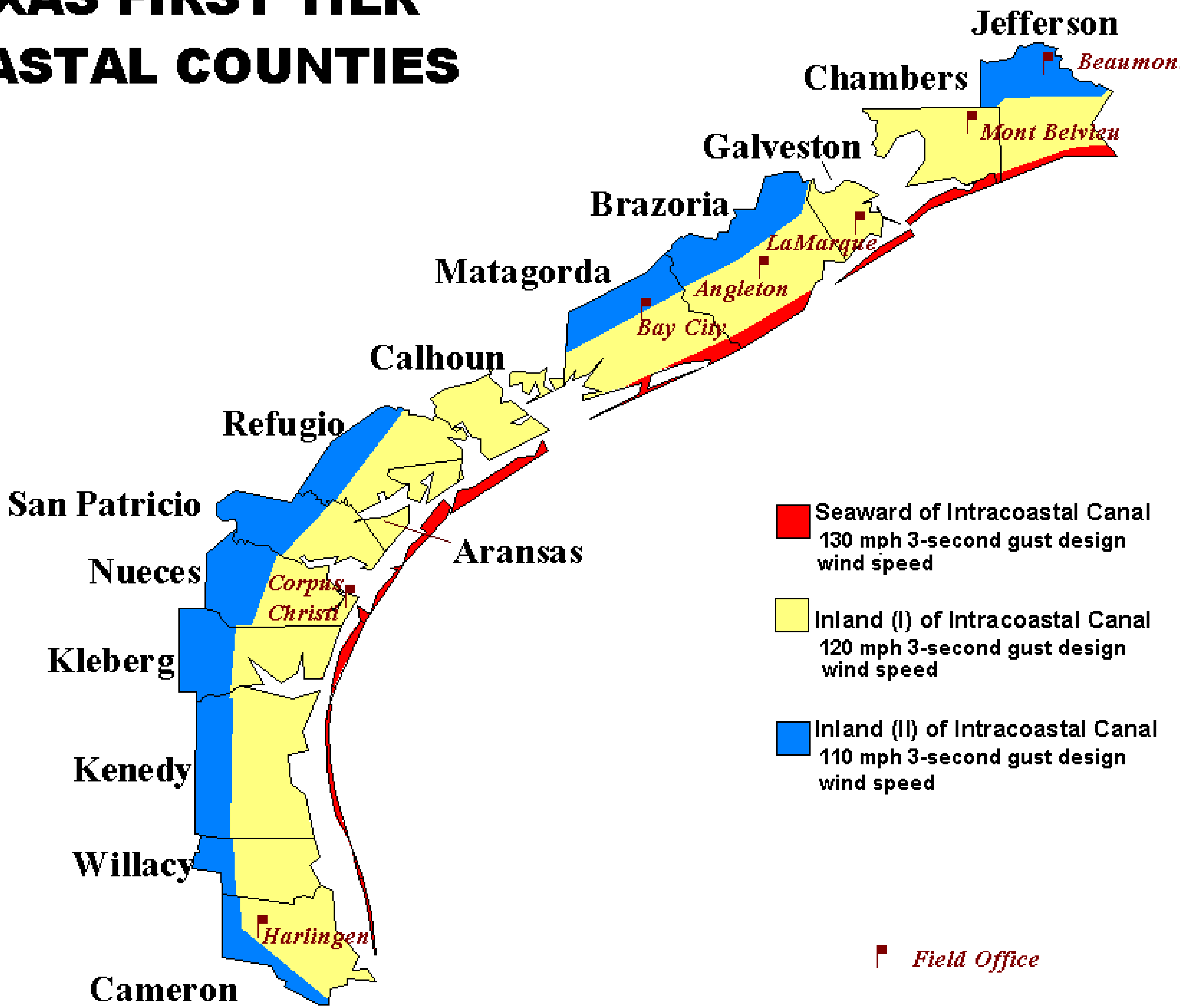
FIGURE 1609—continued
BASIC WIND SPEED (3-SECOND GUST)
WESTERN GULF OF MEXICO HURRICANE COASTLINE

High Velocity Hurricane Zone

- The Florida Building Code requires impact resistant systems for the HVHZ to be tested in accordance with:
  - TAS 201 Impact (Large & Small)
  - TAS 202 Air, Water, & Structural
  - TAS 203 Cycle Test (Positive & Negative)
- TAS 201 requires each lite of glass to be impacted twice to pass the large missile test.
  (ASTM E-1996 only requires one impact.)
- TAS 201 requires framing members to be impacted.
  (This is not a requirement of ASTM E-1996.)
- The Pass/Fail for TAS 201 is also more stringent than ASTM E-1996.
  - TAS 201 limits a tear in the interlayer to 5” and no wider 1/16”.
  - ASTM E-1996 states that a tear in the interlayer may not be longer than 5” and may not permit a 3” sphere to pass through.

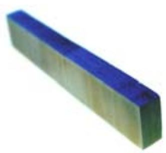
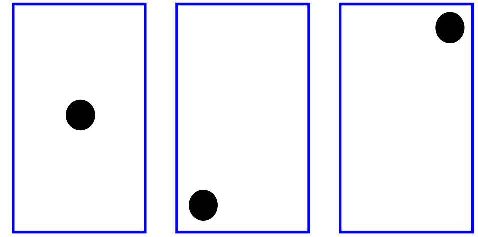
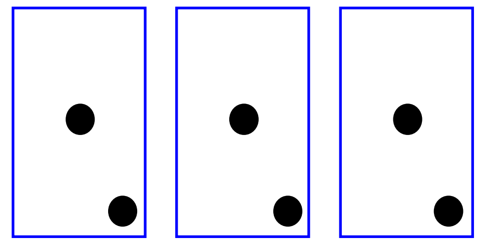


TEXAS FIRST TIER COASTAL COUNTIES

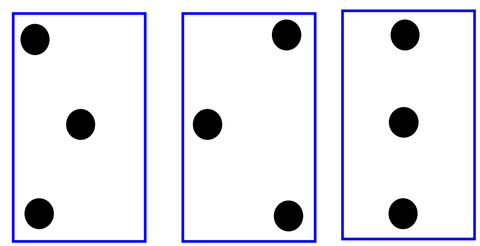
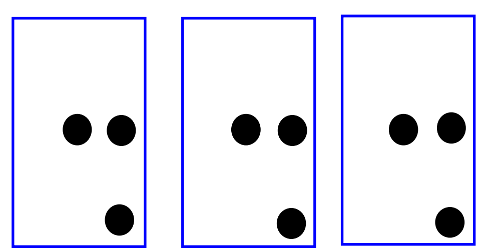


Impact Test Requirements

Large Missile (● Impact Location)

Missile			Impact Location	Pass/Fail
Missile  2” X 4” Lumber	ASTM E-1996	Level B 2lb @ 50 f/s Level C 4.5lb @ 50 f/s Level D 9lb @ 50 f/s Level E 9lb @ 50 f/s		**Pass/Fail** • No Tear Permitting a 3” Sphere to Pass Through • No Tear Longer than 5”
	TAS 201 (HVTZ)	9lb @ 50 f/s		**Pass/Fail** • No Tear Longer than 5” and 1/16” in Width

Small Missile (● Impact Location)

Missile			Impact Location	Pass/Fail
Missile  (10) 2 Gram Steel Balls	ASTM E-1996	2g @ 130 f/s		**Pass/Fail** • No Tear Permitting a 3” Sphere to Pass Through • No Tear Longer than 5”
	TAS 201 (HVTZ)	2g @ 130 f/s		**Pass/Fail** • No Tear Longer than 5” and 1/16” in Width

Cyclic Pressure Loading

Inward-Acting Pressure (Positive)

Range	Cycles
0.2P max – 0.5P max	3,500
0.0P max – 0.6P max	300
0.5P max – 0.8P max	600
0.3P max – 1.0P max	100
Total:	4,500

P max is the design wind pressure from the building code based on an unbreached building envelope.

Cyclic Pressure Loading

Outward Acting Pressure (Negative)

Range	Cycles
0.3P max – 1.0P max	50
0.5P max – 0.8P max	1,050
0.0P max – 0.6P max	50
0.2P max – 0.5P max	3,350
Total:	4,500

P max is the design wind pressure from the building code based on an unbreached building envelope.

Calculating Design Pressure in Accordance with ASCE 7

- **Method 1** allows for a simplified procedure as specified in section 6.4 for building meeting these requirements.
- **Method 2** allows for an analytical procedure as specified in section 6.5.
- **Method 3** allows for Wind Tunnel procedures as specified in section 6.6.

Design Pressure Calculations

(Old Method)

It used to be a very simple calculation:

$Velocity^2$ X 0.00256 = Design Pressure

Design Pressure Calculations

(Current Method)

Now, many other factors are used in the calculation to determine the required design pressure for all areas of the building.

- *Basic Wind Speed and Directionality*
- *Importance Factor*
- *Exposure Category*
- *Topographic Factor*
- *Gust Effect Factor*
- *Enclosure Classification*
- *Internal Pressure Coefficient*
- *External Pressure Coefficient*
- *Velocity Pressure*
- *Design Wind Load*

Design Pressure Comparison

- ***Example:***
  - *50' Tall Building*
  - *100' Minimum Width*
  - *120 mph Basic Wind Speed*

- ***Old Way:*** *120^2 X 0.00256 = 36.86 psf*

- ***New Way:*** *ASCE 7*
  - *Mid-Zone Positive = **+44.6 psf***
  - *Mid-Zone Negative = **-46.1 psf***
  - *Corner Zone Negative = **-77.8 psf***

Building Importance Factor
(ASCE 7)

- ***Category I:*** *Buildings & Structures that Represent Low Hazard to Human Life*
  - *Agriculture Buildings & Storage Facilities*
- ***Category II:*** *All Buildings & Structures Except Those Listed in Categories I, III, or IV*
- ***Category III:*** *Building & Structures Where More than 300 People Congregate (Schools are 250 or Greater)*
- ***Category IV:*** *Buildings & Structures Designated as Essential Facilities*
  - *Buildings that Contain Toxic or Explosive Material*
  - *Hospitals, Fire Rescue, Police*
  - *Communication Centers, Power Stations*
  - *Hurricane Shelters*

Building Exposures Categories

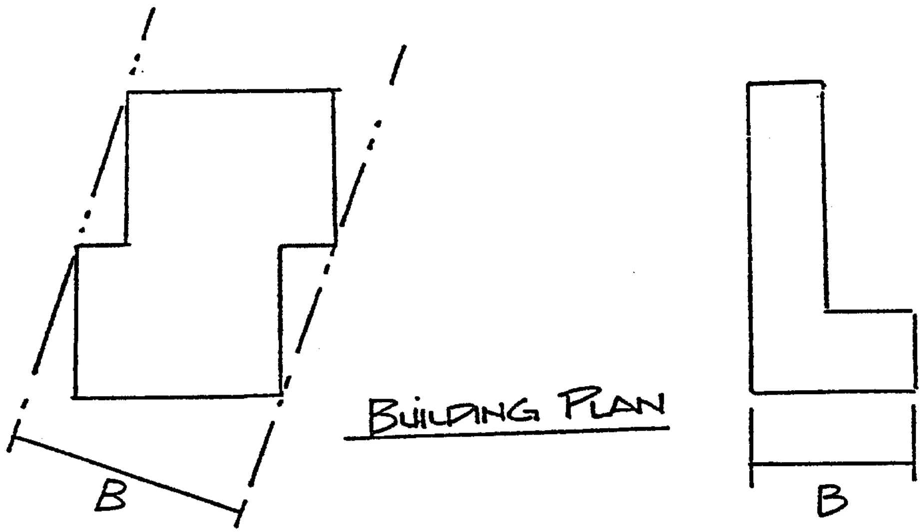
(ASCE 7)

- ***Exposure B:*** *Urban & Suburban Areas*
- ***Exposure C:*** *Open Terrain with Scattered Obstructions Less than 30 Feet Including Flat Open Country & Grasslands &* ***Shorelines in Hurricane Prone Regions***
- ***Exposure D:*** *Flat, Unobstructed Areas and Water Surfaces outside Hurricane Prone Regions. This Category includes Smooth Mud Flats, Salt Flats, and Unbroken Ice.*

Determine Minimum Building Width (Footprint)

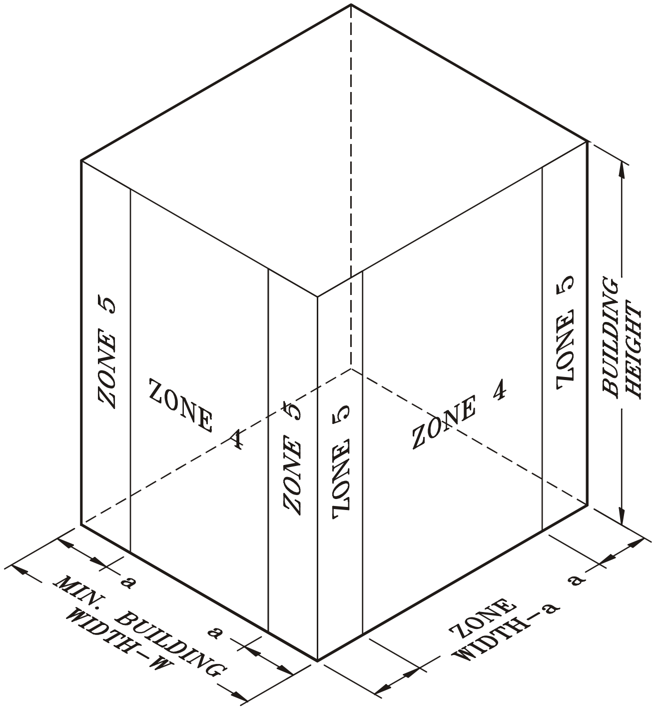
Least Width Of Building

This is the shortest distance between two parallel lines which contain the entire building floor plan.



B = The Least Width for the Building

Determining Near Corner Zone Dimension “a”

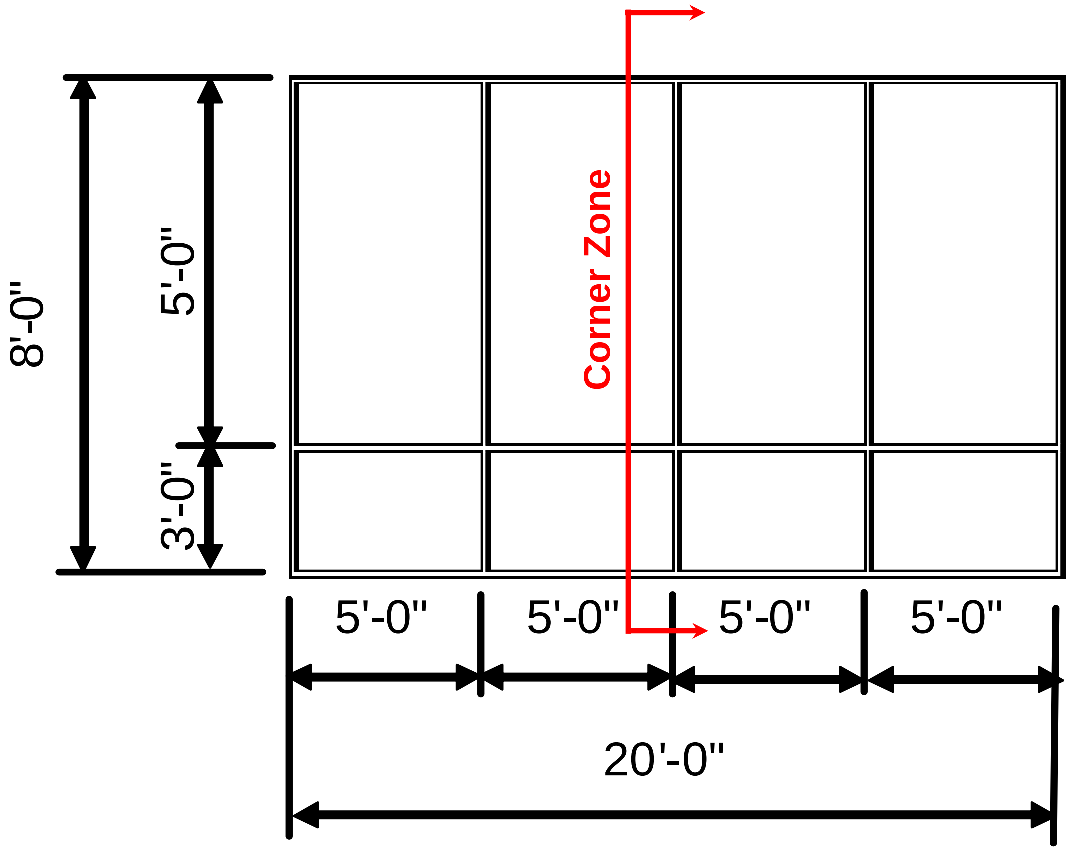


Dimension “a” = 0.10 X Minimum Bldg Width, But Not Less Than 3’-0”

ASCE 7

BLDG HEIGHT	IMPORTANCE FACTOR	WIND SPEED	POSITVE ZONES 4 & 5	MID-ZONE ZONE 4 NEGATIVE	NEAR CORNER ZONE 5 NEGATIVE
50'	II	120	32.8 psf	-35.9 psf	-40.9 psf
		130	38.5 psf	-42.1 psf	-48.0 psf
		140	44.6 psf	-48.8 psf	-55.6 psf
	III	120	37.7 psf	-41.2 psf	-47.0 psf
		130	44.2 psf	-48.4 psf	-55.2 psf
		140	51.3 psf	-56.1 psf	64.0 psf
100'	II	120	38.8 psf	-40.1 psf	-67.7 psf
		130	45.5 psf	-47.1 psf	-79.4 psf
		140	52.8 psf	-54.6 psf	-92.1 psf
	III	120	44.6 psf	-46.1 psf	-77.8 psf
		130	52.3 psf	-54.1 psf	-91.4 psf
		140	60.7 psf	-62.8 psf	-106.0 psf

System Requirements in Corner Zones



(15) Thus Mid-Zone
(4) Thus Corner-Zone

Intermediate Verticals May Require
Reinforcing @ for Corner-Zone Frames

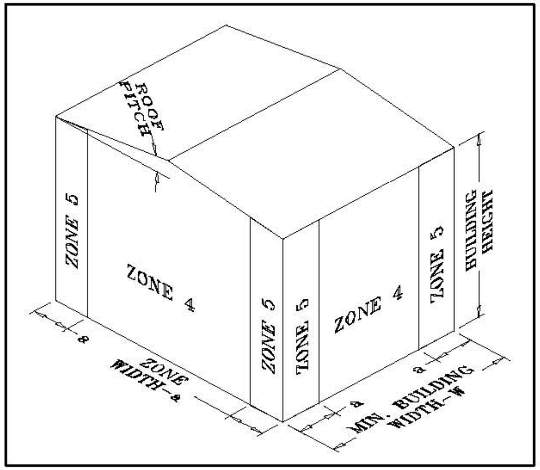
ASCE 7-98 WIND LOAD CODE FOR BLDGS UNDER 60 FEET HT., COMPONENTS & CLADDING

LOAD COMBINATIONS 2.4.1, PG 5, WORST CASE WIND LOAD

JOB : ______________________

CUST. : ______________________ DATE : __________

FN : ______________________ CONTROL #: __________



INPUT

60	BUILDING OVERALL HEIGHT FEET
100	MINIMUM BUILDING WIDTH,'W'
9.54	TYPICAL FLOOR TO FLOOR HEIGHT (OR WINDOW HEIGHT), 'H'
4.75	TYPICAL MULLION SPACINGS (OR WINDOW WIDTH), 'S'
B	EXPOSURE, SEC. 6.5.6, PG. 28, (A,B,C or D)
90	BASIC WIND SPEED MPH, FIG. 6-1, PAGE 34-38
II	IMPORTANCE FACTOR CATAGORY (I,II,III, or IV), TABLE 1-1, PG 4
Y	IS ROOF PITCH LESS THAN 10° ? (Y OR N)
N	PARTIALLY ENCLOSED BUILDING? (Y OR N)
N	WIND BORNE DEBRIS REGION? (Y OR N)
N	IMPACT RESISTANT WINDOWS? (Y OR N)
1.00	K_{ZT}, TOPOGRAGHICAL FACTOR, 6.5.7.2, PG. 29
0.85	K_D, DIRECTIONALITY FACTOR, TABLE 6-6, PG.61

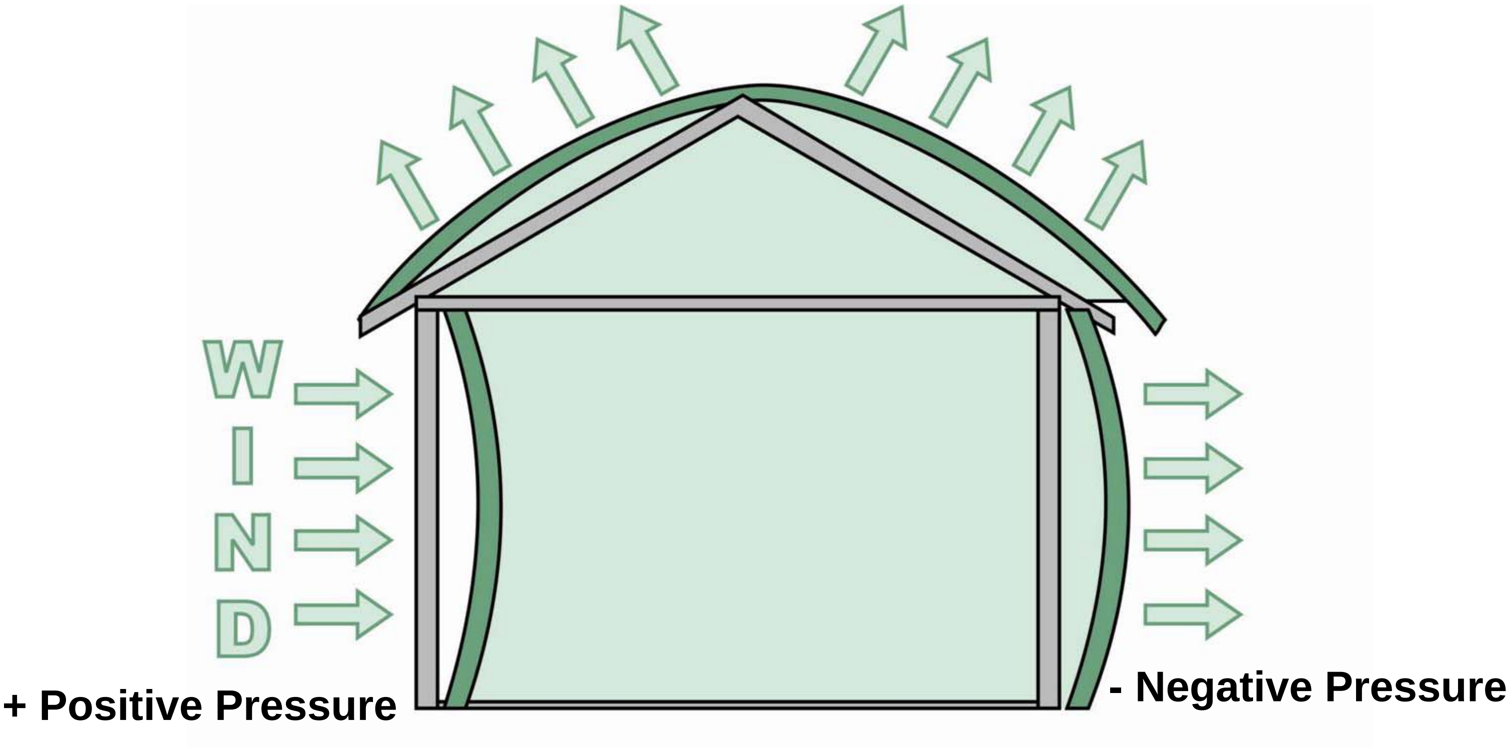
OUTPUT

0.18	GC_{pi} + , TABLE 6-7, PAGE 62
-0.18	GC_{pi} - , TABLE 6-7, PAGE 62
1	IMPORTANCE FACTOR, TABLE. 6-1, PG. 55, DEFINED IN TABLE 1-1, PG. 4
45.32	TRIBUTARY AREA ACCORDING TO ASCE, (THE GREATER OF SxH, OR $1/3xH^2$)
7	α, alpha, TABLE 6-4, PAGE 59
1200	Z_g, TABLE 6-4, PAGE 59
0.88	GC_p POSITIVE, ZONES 4 & 5, FIG. 6-5A, PG. 44
-0.98	GC_p MID-ZONE NEGATIVE, ZONE 4, FIG 6-5A, PG 44
-1.17	GC_p AT CORNER ZONE NEGATIVE, ZONE 5, FIG 6-5A, PG 44
10%	REDUCTION IN GCP VALUES BASED ON (ROOF PITCH) <10 DEG. (FIG. 6-5A NOTE 5. PG 44)
10.0	* ZONE WIDTH 'a', (THE LEAST OF [0.10 x W] OR [0.4 x HEIGHT], NOT LESS THAN 3.0 FT.)

VELOCITY PRESSURE	$Q_h = 0.00256*(\text{WIND SPEED})^2*K_h*K_{ZT}*K_D$	REF. EQUATION 6-13, PG 30
EXPOSURE COEFF.	$K_h = 2.01*(Z/Z_g)^{2/\alpha}$	REF TABLE 6-5, PG 60
DESIGN PRESSURE	$P = Q_h*[(GC_p)-(GC_{pi})]$	REF. EQUATION 6-18, PG 32

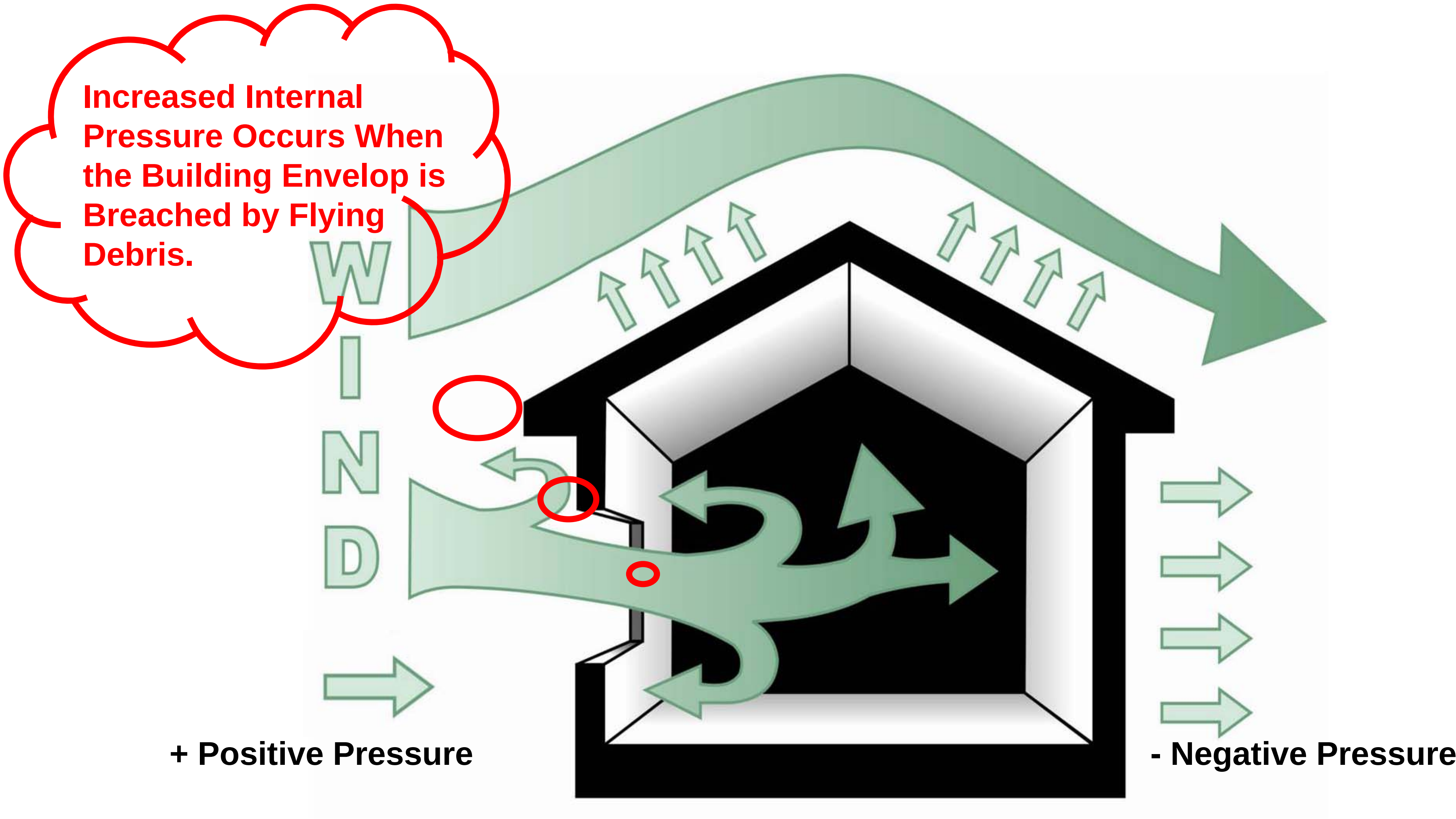
HEIGHT FEET	POSITIVE ZONES 4 & 5 PSF	MID-ZONE NEG. ZONE 4 PSF	NEAR CORNER NEG. ZONE 5 PSF	K_h	Q_h
60	14.7	-16.0	-18.5	0.85	15.05

Designing for Wind Pressure



This graphic illustrates the effects of wind forces on a building. The arrows indicate positive forces pushing on the surface and negative pressures pulling on the opposing side of the building. The wind forces impact and vary on every surface of the building. In most cases the pulling (-) forces are the higher loads.

Increased Internal Pressure



This graphic represents the effects of internal pressure when windows and doors fail. Wind enters and creates additional pressure that can lead to catastrophic damage to a structure.

Power of a Hurricane

ASCE 7 Requirements

- Protection from flying debris may be accomplished with either a shutter system (plywood or steel) or a glazing system designed and tested to resist the impacts.
- Buildings more than 45’ tall may **NOT** use wood shutters for protection from wind borne debris.

Plywood Shutters

Metal Shutters

Impact Resistant Glazing System

Will Plywood Provide Protection for Homes?

Yes!

Will Protective Glazing Systems Provide Protection for Buildings?


New Protective Glazing System
Old Glazing System
Security
Danger


Flying Debris

Yes!

Shutters Are Not Possible For Most Commercial Buildings.

Conventional Glazing & Protection

Standard Annealed/Tempered

- No Protection from Harmful Ultraviolet Light
- Easily Broken by Flying Debris
- Offers <u>No Protection</u>

Applying Mastic/Duct Tape to Standard Glazing

- False Sense of Security
- Easily Broken by Flying Debris
- Offers <u>No Protection</u>

Conventional Protection

Plywood Coverings

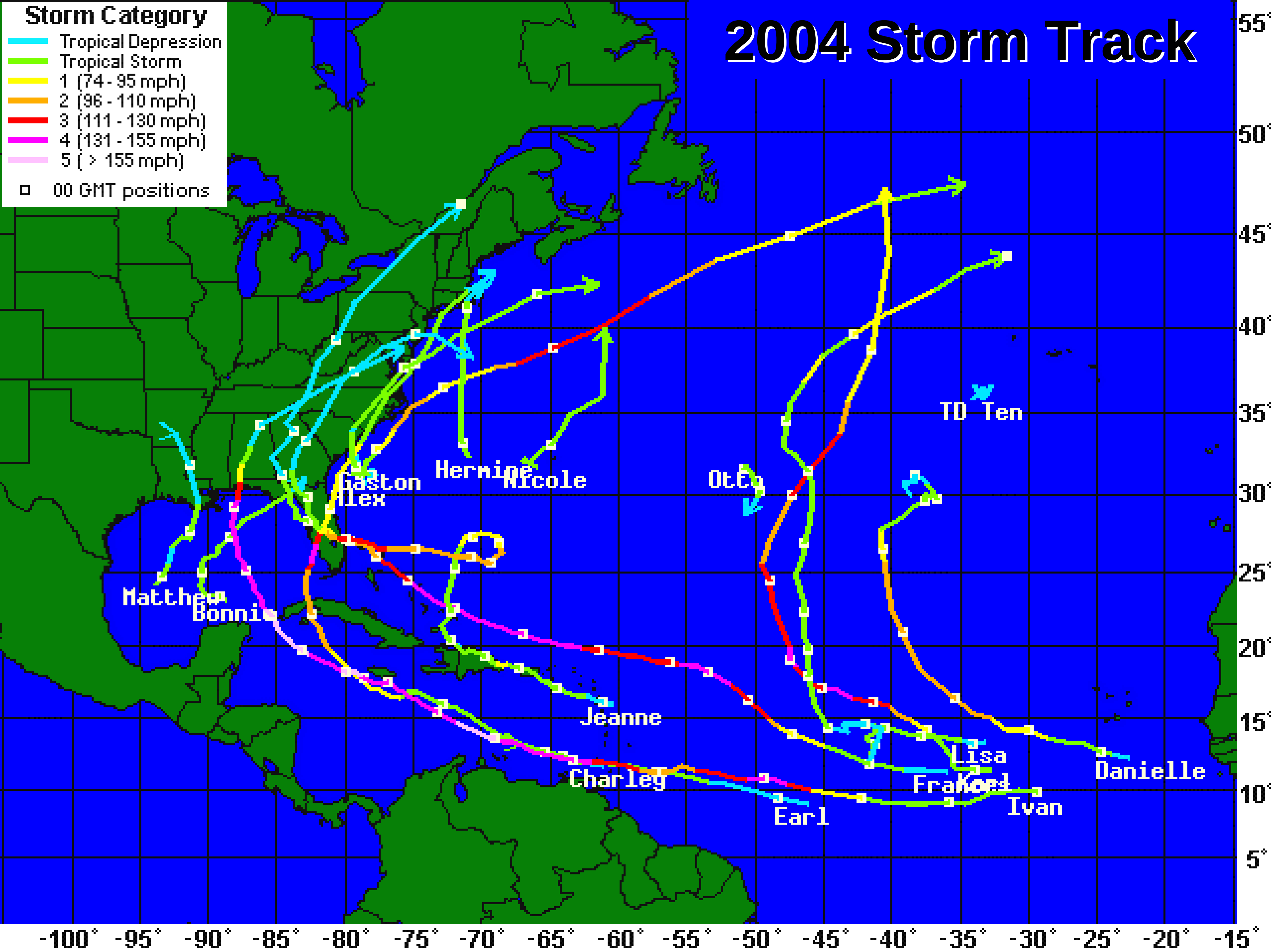
- Must be Stored or Purchased at Time of Need
- Must Be Installed as the Hurricane Approaches
- No Protection if Not Securely Anchored

Storm Shutters

- Must be Taken Out of Storage
- Must Be Installed as the Hurricane Approaches
- No Protection if not Securely Anchored
- Leaves Holes at Anchor Locations

Shutter Protection

Shutter Protection



2004 Storm Track
Storm Category
Tropical Depression
Tropical Storm
1 (74 - 95 mph)
2 (96 - 110 mph)
3 (111 - 130 mph)
4 (131 - 155 mph)
5 (> 155 mph)
00 GMT positions
Hermine
Nicole
Gaston
Alex
Otto
TD Ten
Matthew
Bonnie
Jeanne
Charley
Earl
Lisa
Frances
Karl
Ivan
Danielle
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
-100°
-95°
-90°
-85°
-80°
-75°
-70°
-65°
-60°
-55°
-50°
-45°
-40°
-35°
-30°
-25°
-20°
-15°

2004 Hurricanes

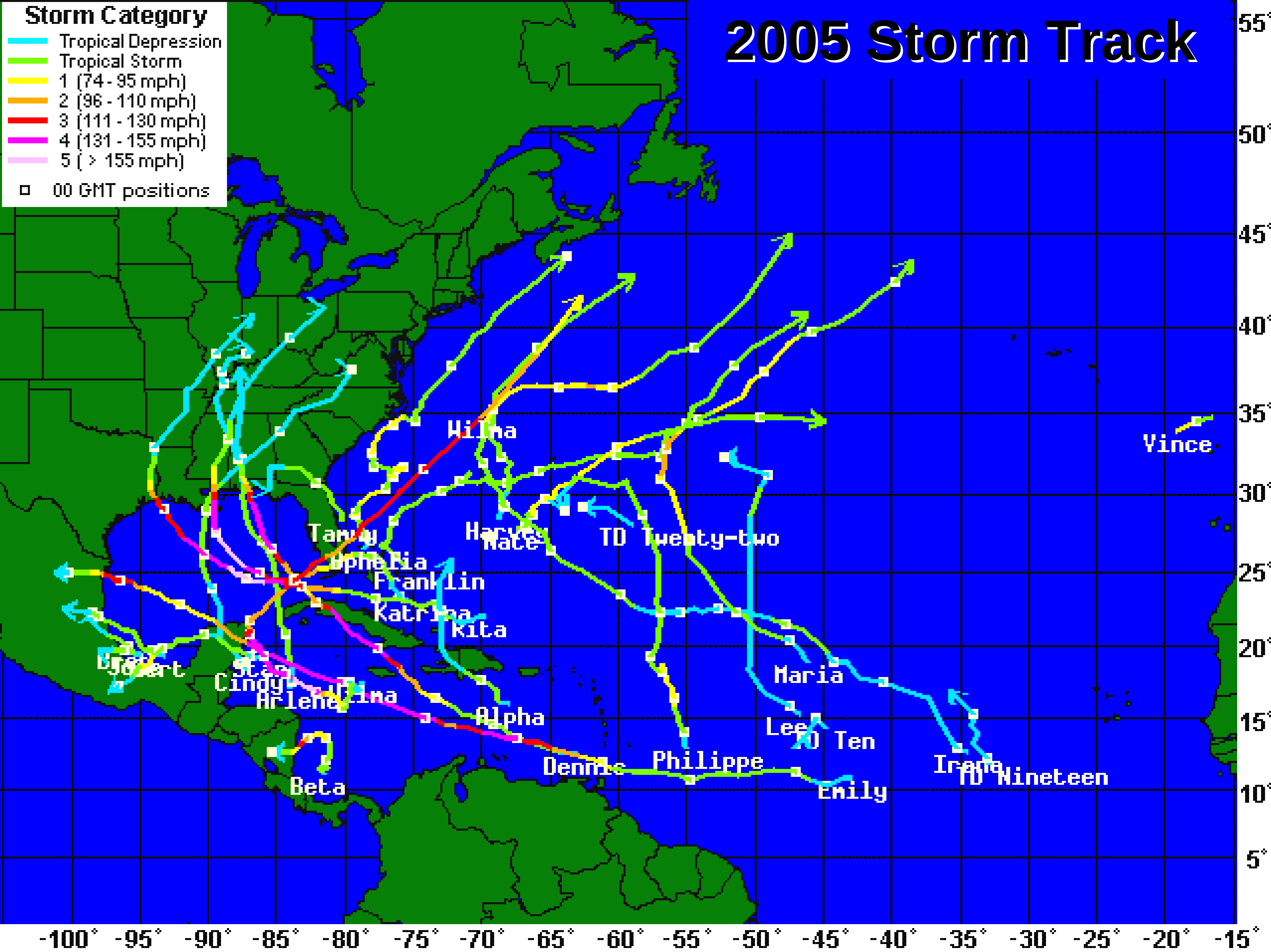

ICE
ICE


FNB







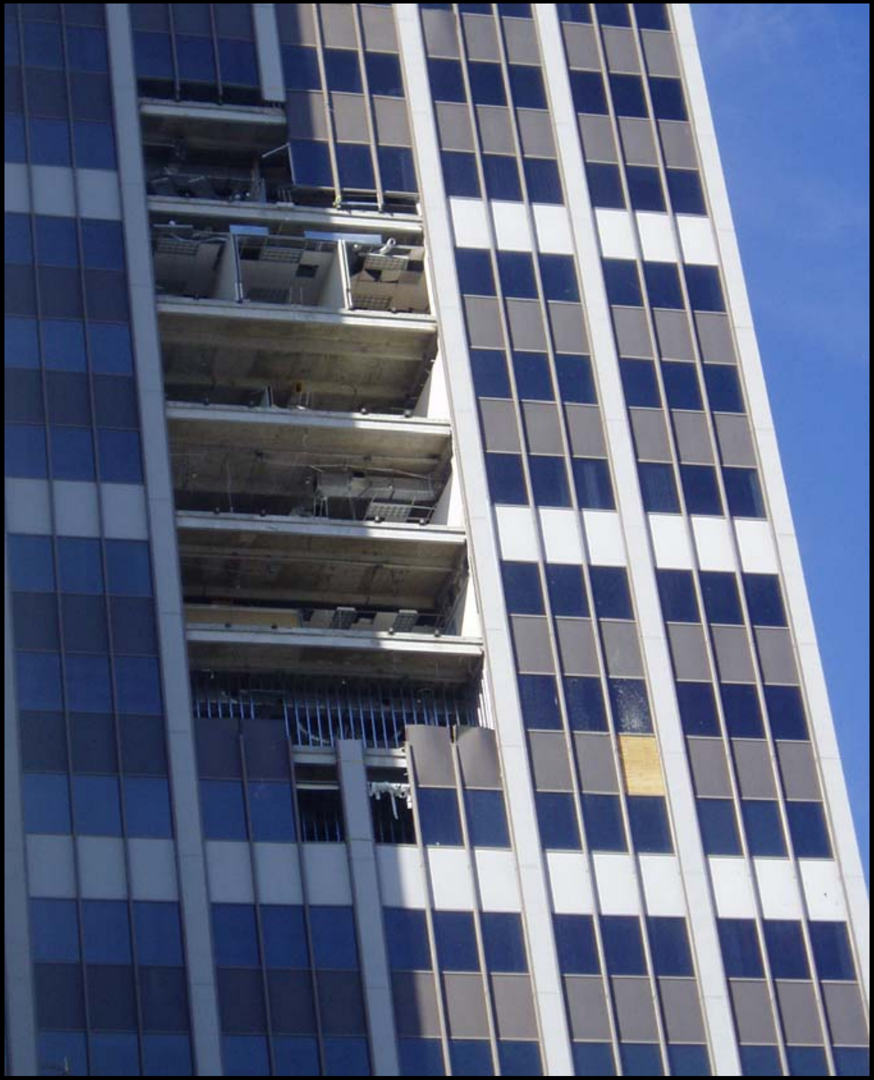

2005 Storm Track
Storm Category
Tropical Depression
Tropical Storm
1 (74 - 95 mph)
2 (96 - 110 mph)
3 (111 - 130 mph)
4 (131 - 155 mph)
5 (> 155 mph)
00 GMT positions
Wilma
Tammy
Harvey
Nate
TD Twenty-two
Ophelia
Franklin
Katrina
Rita
Vince
Maria
Alpha
Lee
TD Ten
Philippe
Dennis
Emily
Irene
TD Nineteen
Beta
Stan
Cindy
Arlene
Gert
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
-100°
-95°
-90°
-85°
-80°
-75°
-70°
-65°
-60°
-55°
-50°
-45°
-40°
-35°
-30°
-25°
-20°
-15°

2005 Hurricanes

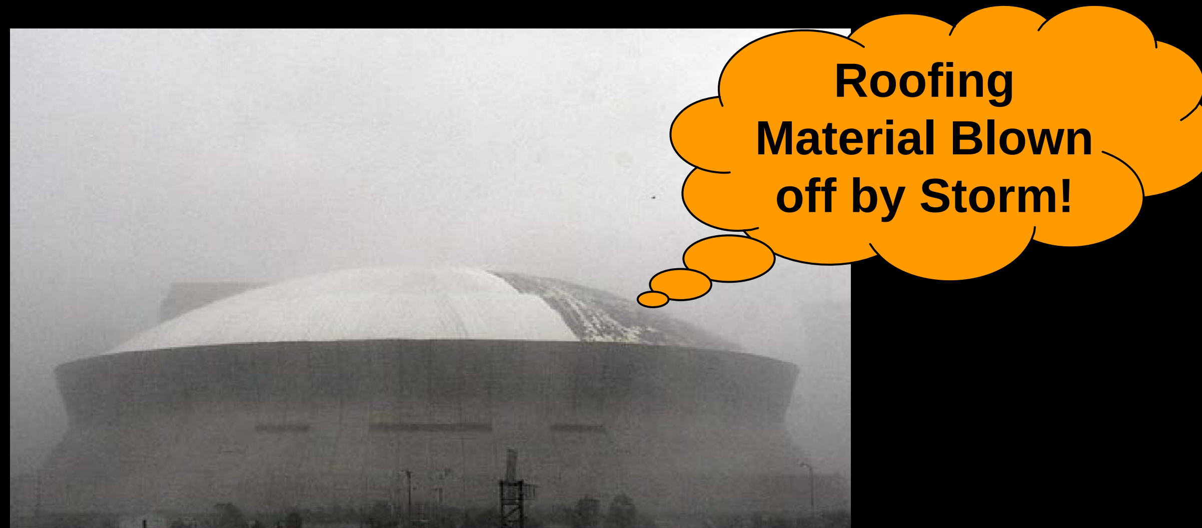

Damage from Flying Debris

Damage from Flying Debris

Damage from Flying Debris



Damage from Flying Debris


Roofing
Material Blown
off by Storm!


(AP PHOTO)

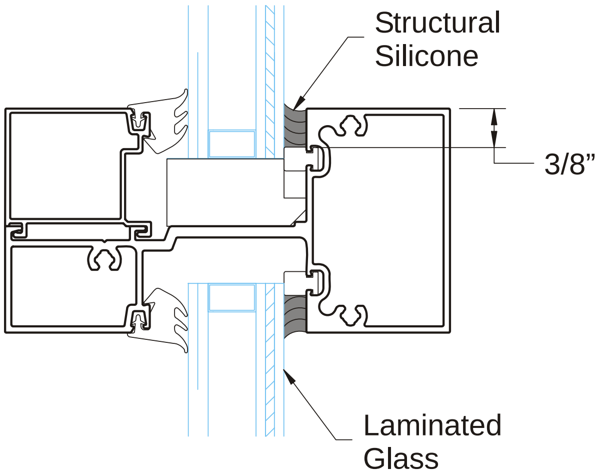
Impact Resistant Framing Systems

- The concept is to maintain the integrity of the building envelope by developing glazing systems that provide protection from wind borne debris without the use of shutters.
- Procedures have been established to test the ability of a glazing system to resist impacts from both large and small missiles and the strong buffeting winds associated with hurricanes.
- Test Labs have been licensed to conduct the test and to certify the results.

Large Missile Impact Test

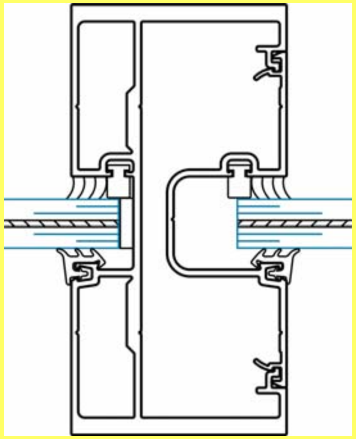
Test as a "Total System":

- The building codes require that the all of the components that make up a "protective glazing system" be tested together:
  - Framing System
  - Gaskets
  - Structural Silicone
  - Glass
  - Anchors
- "Total System" testing ensures that the glazing system will provide the desired level of protection.



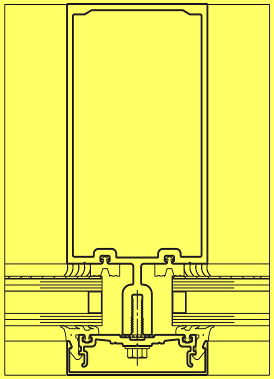
Glazing Systems

- Storefronts and Entrances:
  - Large Missile - Silicone Glazed
  - Small Missile - Dry Glazed
  - Monolithic & Insulated Glazing
  - Thermally Broken Option
  - Doors as Large as 8'-0" X 8'-0"
  - Hardware:
    - MS Locks & Exit Devices
    - Check with System Manufacturer
  - Design Pressures up to –90psf
  - Optional Water Resistant Thresholds



Glazing Systems

- Curtain Walls:
  - Large Missile - Silicone Glazed
  - Small Missile - Dry Glazed
  - Monolithic & Insulated Glazing
  - Thermally Improved
  - Glazed from Exterior or Interior
  - 4-Side Capture or 2-Side Silicone Glazed
  - Design Pressures up to -130psf



Glazing Systems

- Operable Windows:
  - Large Missile - Silicone Glazed
  - Small Missile - Dry Glaze
  - Monolithic & Insulated Glazing
  - Thermally Broken Options
  - Configurations:
    - Fixed
    - Casement & Projected Vents
    - Sliding
    - Single & Double Hung
  - Design Pressures up to -65psf

Glazing Systems

- Sliding Glass Doors:
  - Large Missile - Silicone Glazed
  - Small Missile - Dry Glaze
  - Monolithic & Insulated Glazing
  - Thermally Broken Option
  - Panels up to 4'-0" X 10'-0"
  - Configurations:
    - OX, OXO, OXXO
  - Design Pressures up to -120psf
  - Water Resistance up to 15 ~ 20psf

Building Structure

- The building itself must also be designed to meet the higher design pressures required to mitigate the damage from hurricanes.
- The building structure that the window, storefront, or curtain wall are anchored to must be capable of caring the higher loads that will be transferred through the glazing system anchors.

The Best Option Is Impact Resistant Glazing

Safety + Security

- ✓ Provides Protection from Flying Debris
- ✓ Large Missile Debris Does **NOT** Penetrate the Glass
- ✓ Building & Contents Protected from a Build up of Internal Pressure & Water Damage
- ✓ Always In Place (24/7 Protection)
- ✓ No Need to Allocate Valuable Space in the Building for Storage
- ✓ No Additional Labor Required to Install Shutters
- ✓ Not Possible to Shutter Large Openings
- ✓ Protects Household Furnishings from Damage and Fading Due to Ultraviolet Light
- ✓ Additional Security Against Burglary

THANK YOU VERY MUCH.
This concludes the AIA portion our our presentation today.

ARE THERE ANY QUESTIONS?

Mike Gilbert, CDT

- Cell Phone: (404) 451-1134
- Office Direct Line: (678) 838-6078
- Email: mikegilbert@ykk-api.com