

ESSENTIAL FACILITIES DESIGN CONSIDERATIONS

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BE108, 1 LU / HSW



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Learning Objectives

1. Discuss the applicable Building Codes (IBC and FBC), Existing Building Codes (IEBC and FEBC), ASCE-7, and ICC 500 applicable to the minimum performance requirements for component and cladding systems/assemblies in Risk Category IV Essential Facilities.
2. Discuss the process for obtaining the minimum design loads required to prevent catastrophic failure of building components and cladding, while complying with IBC and FBC requirements to preserve the safety and welfare of occupants.
3. Discuss the difference between building minimum design pressures and the maximum design pressures of tested assemblies.
4. Discuss the component and cladding missile impact requirements that apply to wind-borne debris regions.
5. Discuss case study, components and cladding system warranty coverage and expectations.

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

IBC 2021 PREFACE (*the section no one reads*)

- **INTRODUCTION** – International Building Code (IBC) establishes minimum requirements for building systems using prescriptive and performance-related provisions.
- **DEVELOPMENT** – This code is intended to establish provisions that adequately protect public health, safety and welfare; that do not unnecessarily increase construction costs; that do not restrict the use of new materials, products or methods of construction; and that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

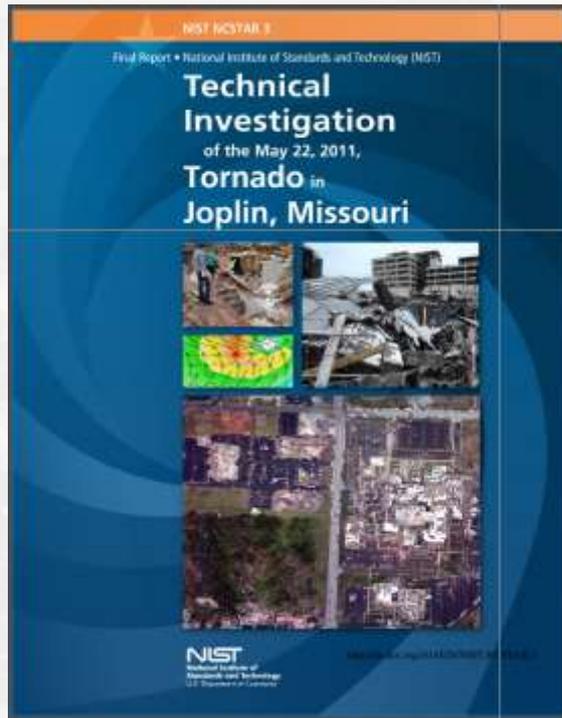
Joplin, Missouri. May 22nd. 2011



Essential Facilities Design Considerations (Building Enclosure/ Components & Cladding)

“Due Diligence”

The care that a reasonable person exercises to avoid harm to other persons or their property.

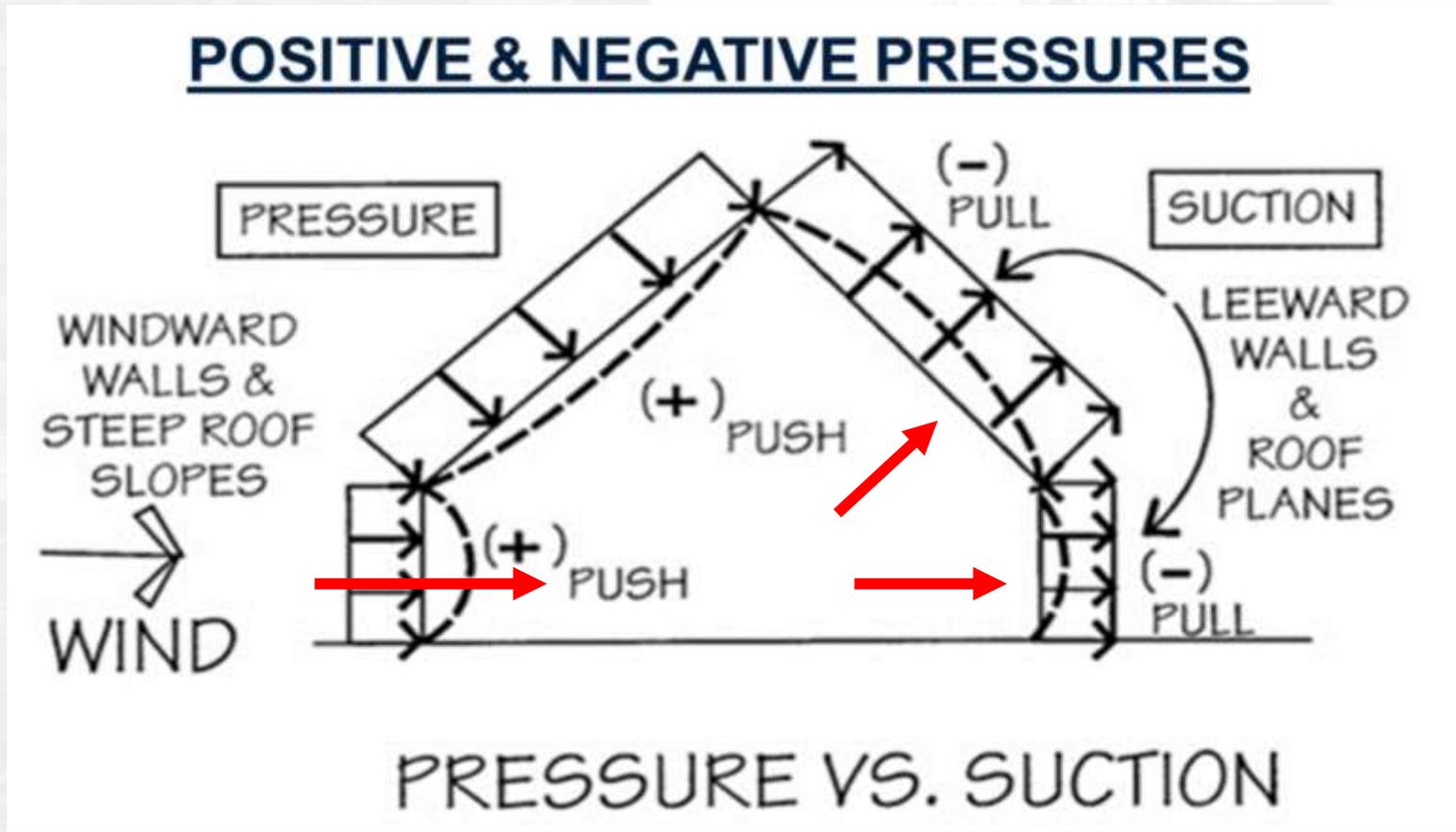


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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

How do we begin?

- Fully understand the structures component & cladding *minimum design pressure requirements.*
- How high must the bar be set to achieve the required Owners Project Requirement (OPR)?
 - Depends on the IBC/FBC/ICC Code Minimum Requirements, facilities mission critical and value to the client.
 - How long can the owner cease operations of the facility in case of a catastrophic wind event?

St. John's Regional Medical Center Joplin, Missouri. May 22nd. 2011



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

What is a Risk Category?

- You must determine the Building Risk Category (IBC/FBC 1604.5 - I, II, III, IV) first. It is a crucial initial step in establishing the appropriate **minimum design performance requirements**.
- IBC 1604.5 Risk Category. Each building and structure shall be assigned a risk category in accordance with table 1604.5....

Hurricane Michael Florida October 2018



Structures in higher Risk Categories are designed to withstand more severe environmental loads to ensure they ***remain operational*** during and after extreme events

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

2021 IBC/ 2020 FBC – Table 1604.5 Risk Category of Buildings and Other Structures Risk Category III

Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:

- Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300.
- Buildings and other structures containing one or more public assembly spaces, each having an occupant load greater than 300 and a cumulative occupant load of these public assembly spaces of greater than 2,500.
- Buildings and other structures containing Group E or Group I-4 occupancies or combination thereof, with an occupant load greater than 250.
- Buildings and other structures containing educational occupancies for students above the 12th grade with an occupant load greater than 500.
- • Group I-2, Condition 1 occupancies with 50 or more care recipients.
- • Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment facilities.
- Group I-3 occupancies.
- Any other occupancy with an occupant load greater than 5,000.^a
- Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV.
- Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that:
 - Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and
 - Are sufficient to pose a threat to the public if released.^b

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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

2021 IBC/ 2020 FBC – Table 1604.5 Risk Category of Buildings and Other Structures

Risk Category IV

Buildings and other structures designated as essential facilities, including but not limited to:

- Group I-2, Condition 2 occupancies having emergency surgery or emergency treatment facilities. ←
- Ambulatory care facilities having emergency surgery or emergency treatment facilities.
- Fire, rescue, ambulance and police stations and emergency vehicle garages
- Designated earthquake, hurricane or other emergency shelters.
- Designated emergency preparedness, communications and operations centers and other facilities required for emergency response.
- Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures.
- Buildings and other structures containing quantities of highly toxic materials that:
 - Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and
 - Are sufficient to pose a threat to the public if released.^b
- Aviation control towers, air traffic control centers and emergency aircraft hangars.
- Buildings and other structures having critical national defense functions.
- Water storage facilities and pump structures required to maintain water pressure for fire suppression.

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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Hurricane-induced tornadoes

- Nearly 70% of landfalling hurricanes (1948-2000) spawned at **least 1 tornado**
- 40% of landfalling hurricanes spawn **more than 3 tornadoes**
- Some hurricanes produce tornado “outbreaks”
 - – Hurricane Beulah (1967):141
 - – Hurricane Ivan (2004):120
 - – Hurricane Frances (2004): ...101
 - – Hurricane Rita (2005):90
 - – Hurricane Camille (1969):80
 - – Hurricane Katrina (2005):43

HURRICANE ANDREW AT PEAK INTENSITY CAT 5



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Saffir-Simpson Hurricane Wind Scale

Category Winds Summary

- Cat 1 = 74-95 mph = very dangerous winds will produce some damage
- Cat 2 = 96-110 mph = extremely dangerous winds will cause extensive damage
- Cat 3 = 111-129 mph **devastating damage** will occur
- Cat 4 = 130-156 mph **catastrophic damage** will occur
- Cat 5 = 157 + mph **catastrophic damage** will occur

Hurricane Michael Florida October 2018



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Tornado Enhanced “F” Scale Damage Indicators

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

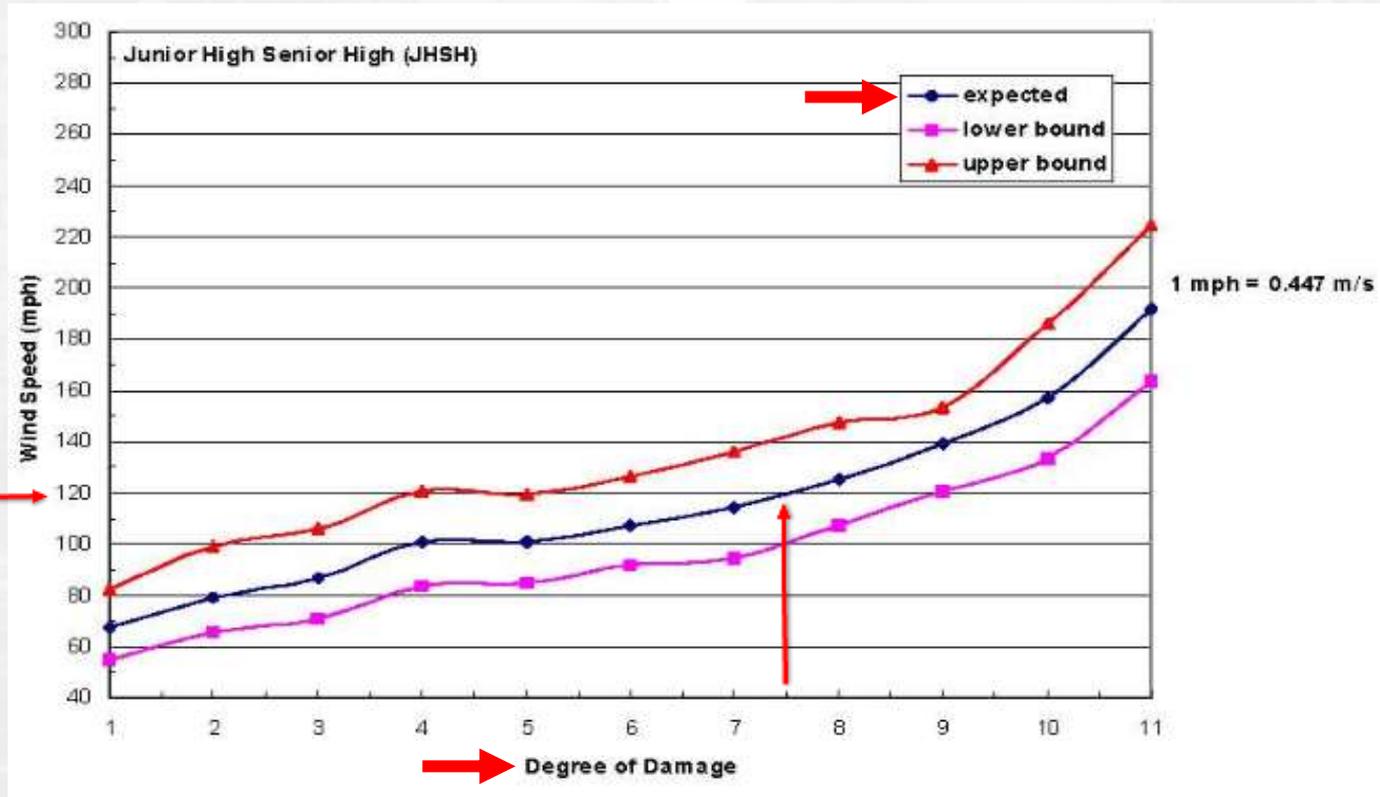
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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Enhanced “F” Scale Damage Indicators



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Enhanced “F” Scale Damage Indicators

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	68	55	83
2	Loss of roof covering (<20%)	79	66	99
3	Broken windows	87	71	106
4	Exterior door failures	101	83	121
5	Uplift of metal roof decking; significant loss of roofing material (>20%); loss of rooftop HVAC	101	85	119
6	Damage to or loss of wall cladding	108	92	127
7	Collapse of tall masonry walls at gym, cafeteria or auditorium	114	94	136
8	Uplift or collapse of light steel roof structure	125	108	148
9	Collapse of exterior walls in top floor	139	121	153
10	Most interior walls of top floor collapsed	158	133	186
11	Complete destruction of all or a large section of building	192	163	224

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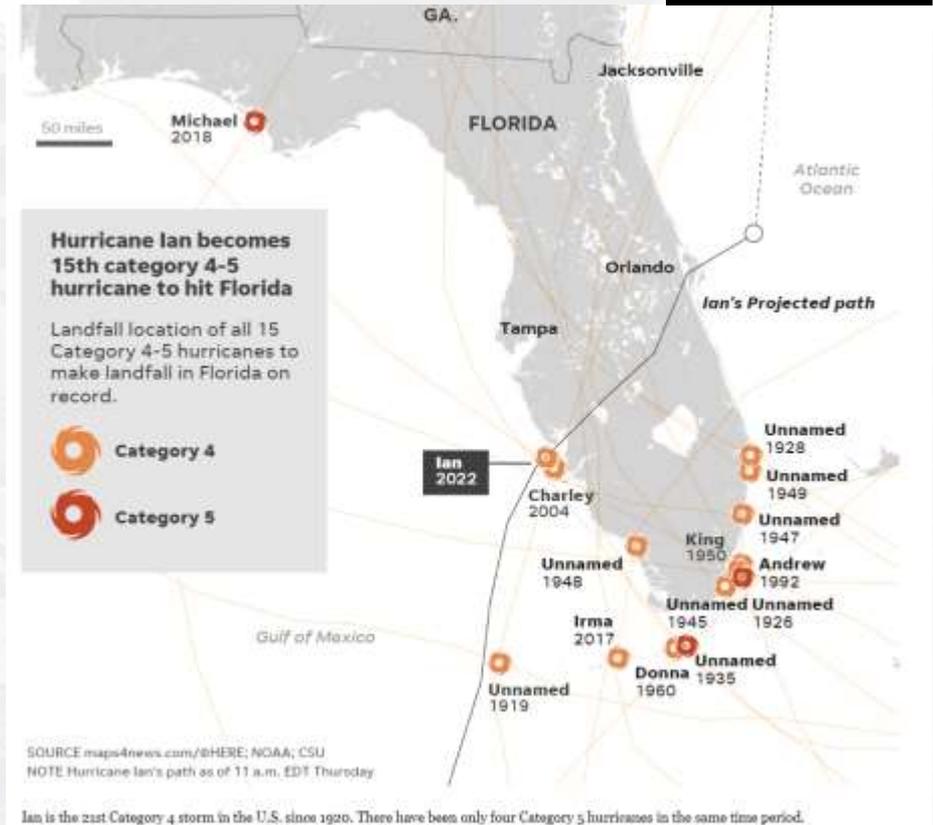
Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



IBC 2021/FBC 2020 – Section 423 Storm Shelters

- **423.1 General** – This section applies to the construction of storm shelters constructed as separate detached buildings or constructed as rooms or spaces within buildings for the purpose of providing **protection from storms, tornadoes and that produce high winds, such as hurricanes, during the storm.** This section specifies where storm shelters are required and provides requirements for the design and construction of storm shelters. Design of facilities for use as emergency shelters **after the storm** are outside the scope of **ICC 500** and shall comply with **Table 1604.5 as a Risk Category IV Structure.**



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



IBC 2021 – Section 423 Storm Shelters.

- **423.2 Construction** – Storm shelters shall be constructed in accordance with this code and [ICC 500](#) and shall be designated as hurricane shelter, tornado shelters, or combined hurricane and tornado shelter. Building or structures that are also designated as emergency shelters shall also comply with [Table 1604.5 as Risk Category IV Structures.](#)



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



IBC 2021 – Section 423 Storm Shelters

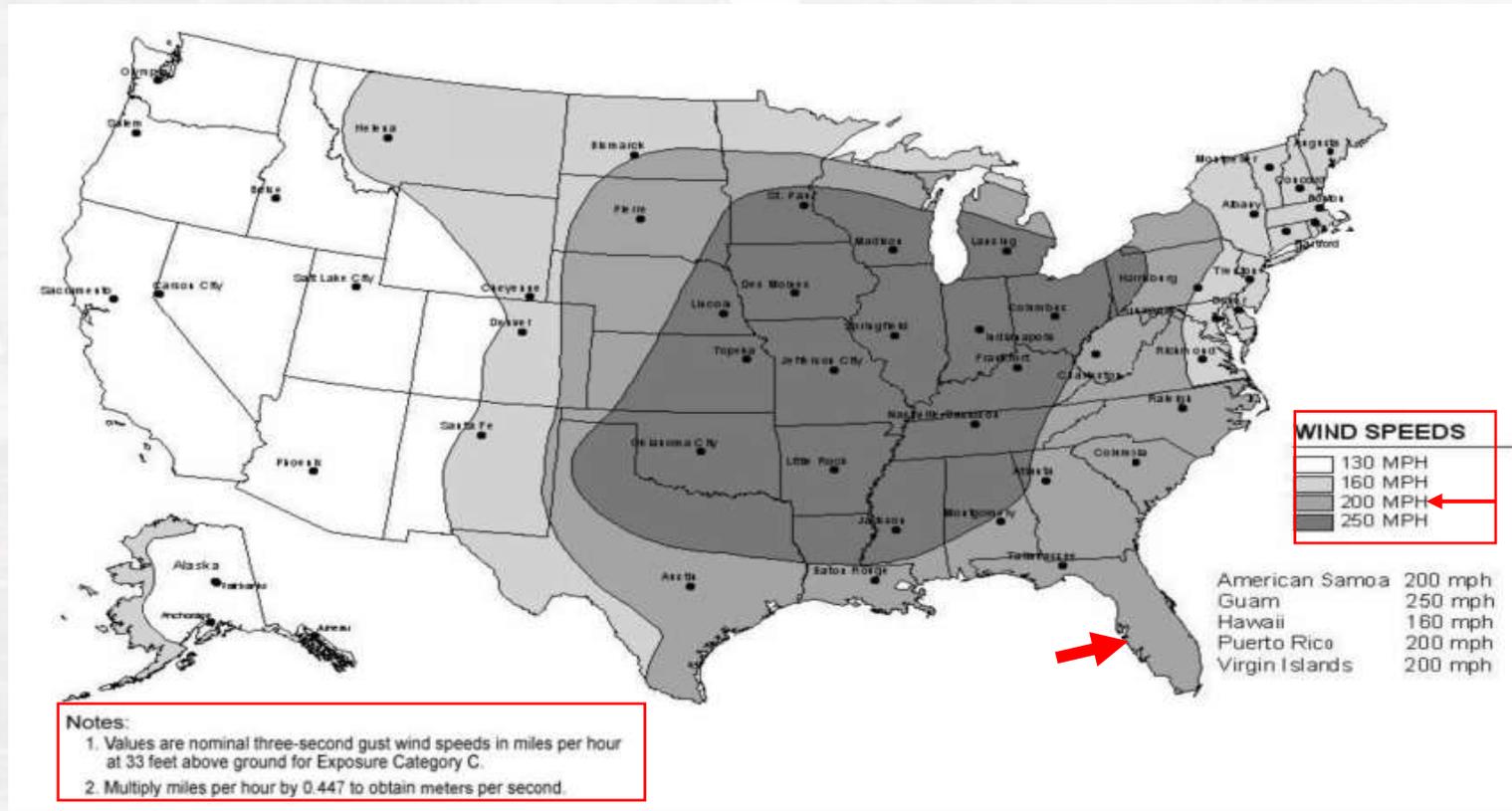
- **423.4 Critical Emergency Operations** – In areas where the shelter design wind speed for tornados is accordance with Figure 304.2(1) of ICC 500 is 250 mph, 911 call stations, emergency operation centers and fire, rescue, ambulance and police stations shall comply with table 1604.5 as a Risk Category IV structure and shall be provided with a storm shelter constructed in accordance with ICC 500.



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

2020 ICC 500 ICC/NSSA STANDARD FOR THE DESIGN AND CONSTRUCTION OF STORM SHELTERS
FIGURE 304.2(1) DESIGN WIND SPEED, V_t , FOR TORNADOES



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



2020 ICC 500 ICC/NSSA STANDARD FOR DESIGN AND CONSTRUCTION OF STORM SHELTERS.

- **Section 304 Wind Loads**
- **Paragraph 304.1 General:** Wind loads from hurricanes, W_H , shall be determined in accordance with ASCE 7, Chapter 26 through 31, except as modified by this section.
- **Section 305 Debris Hazards**
- **Paragraph 305.1 Wind-borne Debris:** All storm shelters shall be designated for the impact loads of wind-borne debris in accordance with Section 305.1.1 through 305.2.2
- **Section 306 Storm Shelter Envelope Component Design and Testing**

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

IBC 1604.10 Loads on Storm Shelters.

- Loads and load combinations on storm shelters shall be determined in accordance with ICC 500

IBC 1609 Wind Loads

- 1609.1 Applications - buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.

Joplin, MO., May 24, 2011, St. John's Regional Medical Center shows the force of a 200 MPH tornado.



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



IBC– 1609.1.1 Determination of Wind Loads

- *Wind loads on every building or structure shall be determined in accordance with chapters 26 to 30 of ASCE 7.*
- The *type of opening protection required*, the basic design wind speed , V , and the exposure category for a site is permitted to be determined in accordance with ***Section 1609 or ASCE7.***
- Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

Joplin, MO., May 24, 2011, St. John's Regional Medical Center shows the force of a 200 MPH tornado.



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

- *ASCE 7-10*
- *ASCE 7-16*
- *ASCE 7-22*
- Minimum design loads and associated criteria for buildings and other structures



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26

Wind Loads: General Requirements

- **26.1 PROCEDURES**
- **26.1.1 Scope.** Buildings and other structures, including the *Main Wind-Force Resisting System (MWFRS)* and *all Components and Cladding (C&C) thereof, shall be designed and constructed to resist the wind loads determined in accordance with Chapters 26 through 31.* The provisions of this chapter define basic wind parameters for use with other provisions contained in this standard.
- **26.1.2 PERMITTED PROCEDURES**
- The design wind loads for buildings and other structures, including the MWFRS and **component and cladding elements there of, shall be determined using one of the procedures as specified in this section.** An outline of the overall process for the determination of the wind loads, including section references, is provided in **fig. 26.1-1.**

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26 Figure 26.1-1

Outline of Process for Determining Wind Loads

- **BUILDING, ENCLOSED**: A building that has the total area of openings in each wall, that receives positive external pressure, **less than or equal to 4 sq ft (0.37 m²) or 1% of the area of that wall, whichever is smaller.**
- **BUILDING, OPEN**: A building that has each wall **at least 80% open.**
- **BUILDING, PARTIALLY ENCLOSED**: A building that complies with both of the following conditions:
 - The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) **by more than 10%.**
 - The total area of openings in a wall **exceeds 4 ft² (0.37 m²) or 1% of the area of that wall** that receives positive external pressure, whichever is smaller, and the percentage of openings in the balance of the building envelope **does not exceed 20%.**

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26 Figure 26.1-1

Outline of Process for Determining Wind Loads

- **MAIN WIND-FORCE RESISTING SYSTEM (MWFRS):** An assemblage **of structural elements assigned to provide support and stability for the overall structure.** The system generally receives wind loading from more than one surface.
- **COMPONENTS AND CLADDING (C&C):** Elements of the building Enclosure that **do not** qualify as part of the MWFRS.

Moore, OK, May 26, 2013, extensive damage to the Moore Medical Building, the effect of the EF-5 tornado



Essential Facilities Design Considerations (Building Enclosure/ Components & Cladding)

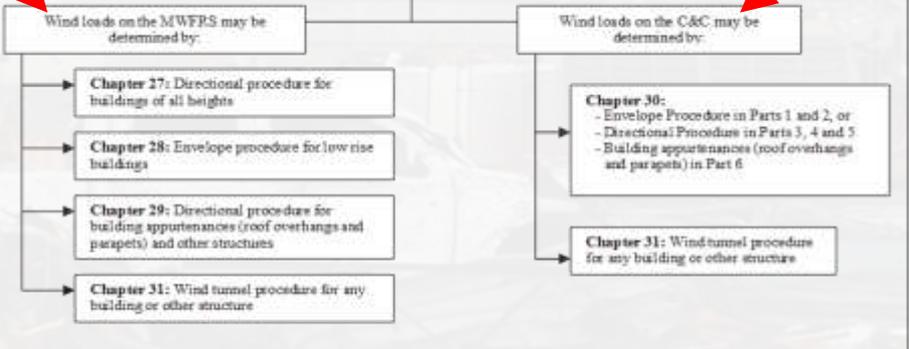
ASCE 7-16 Chapter 26 Figure 26.1-1

Outline of Process for Determining Wind Loads

CHAPTER 26 WIND LOADS: GENERAL REQUIREMENTS

Chapter 26- General Requirements: Use to determine the basic parameters for determining wind loads on both the MWFRS and C&C. These basic parameters are:

- > Basic wind speed, V , see Figure 26.5-1A, B or C
- > Wind directionality factor, K_d , see Section 26.6
- > Exposure category, see Section 26.7
- > Topographic factor, K_{zt} , see Section 26.8
- > Gust Effect Factor, see Section 26.9
- > Enclosure classification, see Section 26.10
- > Internal pressure coefficient, (GC_p) , see Section 26.11



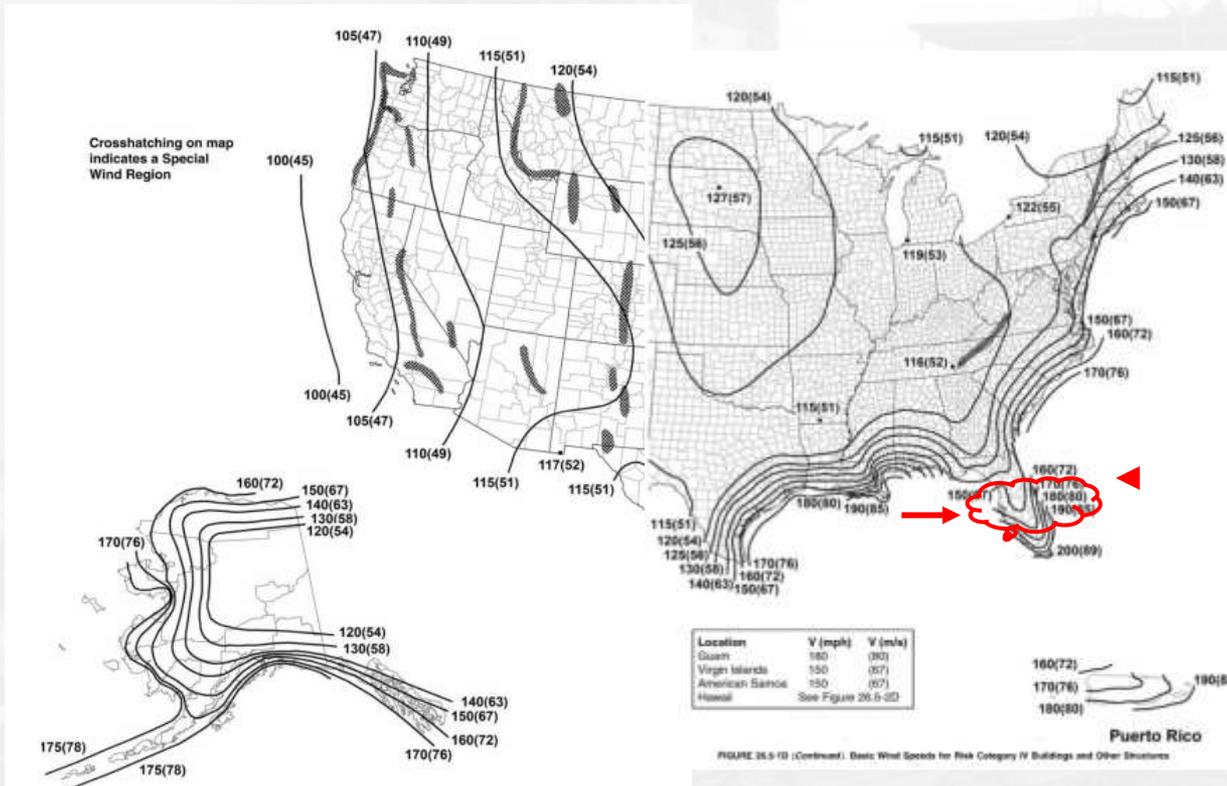
MAIN WIND-FORCE RESISTING SYSTEM (MWFRS): An assemblage of **structural elements assigned to provide support and stability for the overall structure.** The system generally receives wind loading from more than one surface.

COMPONENTS AND CLADDING (C&C): Elements of the building Enclosure that **do not** qualify as part of the MWFRS.

FIGURE 26.1-1 Outline of Process for Determining Wind Loads. Additional outlines and User Notes are provided at the beginning of each chapter for more detailed step-by-step procedures for determining the wind loads.



Essential Facilities Design Considerations (Building Enclosure/ Components & Cladding)



Recommended utilizing the ASCE 7 Hazard Tool site. The purpose of this website is to provide users with site-specific hazard information that can be used to determine design loads for buildings and other structures.

<https://asce7hazardtool.org/>



- Notes
1. Values are nominal design 3-s gust wind speeds in mph (m/s) at 33 ft (10 m) above ground for Exposure Category C.
 2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
 3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
 4. Mountainous terrain, gorges, ocean peninsulas, and special wind regions shall be examined for unusual wind conditions.
 5. Wind speeds correspond to approximately a 1.6% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00033, MRF = 3,000 years).
 6. Location-specific basic wind speeds shall be permitted to be determined using www.asce.org/wind/speed.

FIGURE 26.5-1D Basic Wind Speeds for Risk Category IV Buildings and Other Structures

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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Recommended utilizing the ASCE Hazard Tool. The purpose of this website is to provide users with site-specific hazard information that can be used to determine design loads for buildings and other structures. <https://asce7hazardtool.online/> The site will provide project/site specific wind speed.

Location
333 1st St SE, Saint Petersburg, Florida, 33701

Elevation: 0 ft with respect to North American Vertical Datum of 1988 (NAVD 88)

Lat: 27.757847

Long: -82.633852

Standard: ASCE/SEI 7-22

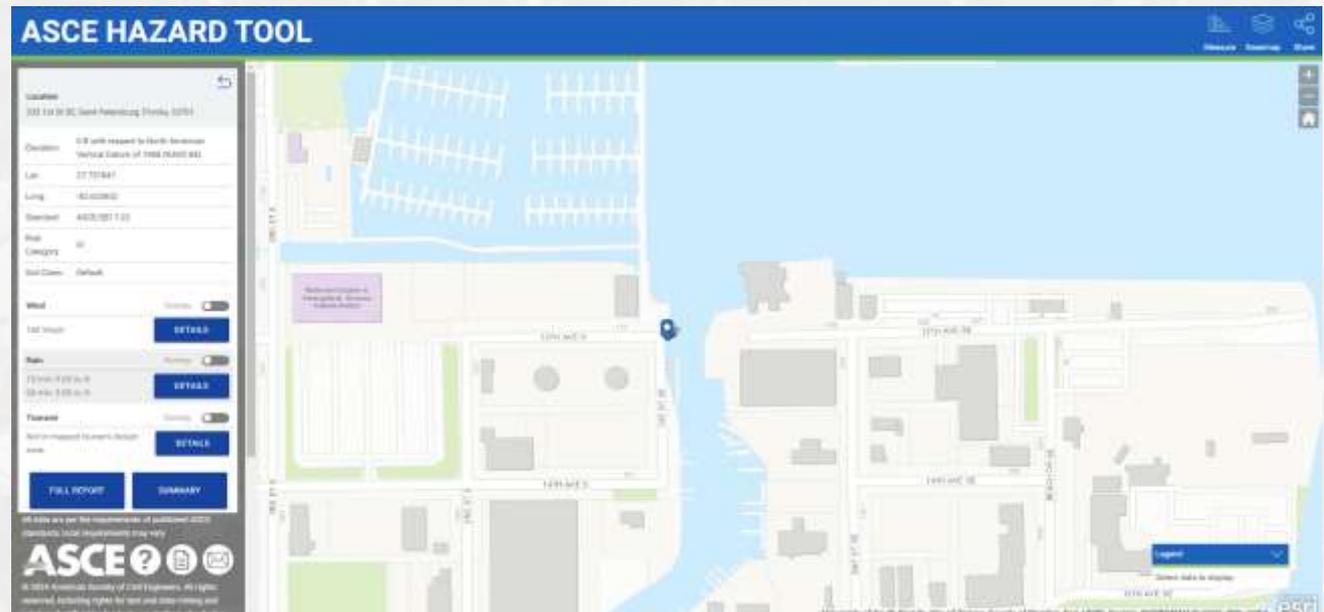
Risk Category: IV

Soil Class: Default

Wind: 160 Vmph **DETAILS**

Rain: 15 min: 9.05 in./h
60 min: 5.08 in./h **DETAILS**

Tsunami: Not in mapped tsunami design zone. **DETAILS**



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

COMPONENT & CLADDING WIND UPLIFT PRESSURES

CODE:
ROOF AREA DIMENSIONS (FEET):
MEAN ROOF HEIGHT FOR ROOFS:

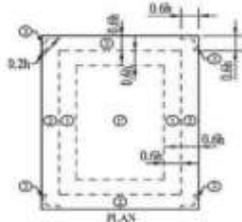
RISK CATEGORY:

EXPOSURE CATEGORY:
BASIC WIND SPEED (THREE-SECOND PEAK GUST, MPH):

ASCE 7-16 ; FLORIDA BUILDING CODE 2020
REFER ROOF PLAN
BUILDINGS 200, 500, 600, 700, 800: 20 FT
BUILDING 400: 25 FT
BUILDINGS 300: 30 FT
BUILDINGS 200, PORTION OF 500, 600, 700, 800: III
BUILDINGS 300, 400, PORTION OF 500: IV
C
155 MPH

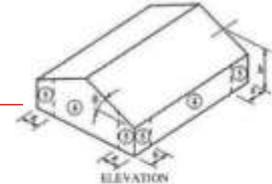
➔ NON-EHPA BUILDINGS

LOAD TYPE	ZONE	H = 20'
UNFACTORED LRFD	1*	-50.8
	1	-88.5
	2	-116.7
	3	-159.0
	4	-60.2
5	-74.3	



➔ EHPA BUILDINGS

LOAD TYPE	ZONE	H = 20'	H = 25'	H = 30'
UNFACTORED LRFD	1*	-50.8	-53.1	-55.3
	1	-88.5	-92.4	-96.3
	2	-116.7	-121.9	-127.1
	3	-159.0	-166.1	-173.2
	4	-60.2	-62.9	-65.6
5	-74.3	-77.6	-81.0	



PERIMETER ROOF EDGE SECUREMENT

ASCE 7-16 MINIMUM RECOMMENDED DESIGN WIND-RESISTANCE LOADS:

NON-EHPA: ZONE 2 (ROOF EDGE PERIMETER, VERTICAL LOAD DIRECTION): -116.7 PSF
 NON-EHPA: ZONE 3 (ROOF EDGE CORNERS, VERTICAL LOAD DIRECTION): -159.0 PSF
 NON-EHPA: ZONE 4 (WALL EDGE PERIMETER, HORIZONTAL LOAD DIRECTION): -60.2 PSF
 NON-EHPA: ZONE 5 (WALL EDGE CORNERS, HORIZONTAL LOAD DIRECTION): -74.3 PSF
 EHPA: ZONE 2 (ROOF EDGE PERIMETER, VERTICAL LOAD DIRECTION): -127.1 PSF
 EHPA: ZONE 3 (ROOF EDGE CORNERS, VERTICAL LOAD DIRECTION): -173.2 PSF
 EHPA: ZONE 4 (WALL EDGE PERIMETER, HORIZONTAL LOAD DIRECTION): -65.6 PSF
 EHPA: ZONE 5 (WALL EDGE CORNERS, HORIZONTAL LOAD DIRECTION): -81.0 PSF

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

IBC Chapter 24 – Glass and Glazing

- Chapter 24 establishes regulations for glass and glazing used in buildings and structures.
- Engineering and design requirements are included in this chapter for glazing that is subjected to *wind and snow loads*.
- Another concern of this chapter is glass and glazing used in areas where it is likely to be impacted by the occupants.

2404.1 Vertical Glass.

Glass sloped 15 degrees or less from vertical in windows, curtain and window walls, doors and other exterior applications *shall be designed to resist the wind loads due to basic design wind speed, V, in Section 1609 for components and cladding.*

Effects of Hurricane Wilma in Florida



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26.12 - Enclosure Classification

- **26.12.1 General.** For the purpose of determining internal pressure coefficients, *all buildings shall be classified as enclosed, partially enclosed, partially open, or open as defined in Section 26.2.*
- **26.12.2 Openings.** *A determination shall be made of the amount of openings in the building envelope for use in determining the enclosure classification.* To make this determination, each building wall shall be assumed as the windward wall for consideration of the amount of openings present with respect to the remaining building envelope.

Capital One Building in Lake Charles, LA.
before and after Hurricane Laura



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26.12 - Enclosure Classification

26.12.3 Protection of Glazed Openings

Glazed openings in ***Risk Category II, III or IV*** buildings located ***in hurricane-prone regions*** ***shall be protected*** as specified in this Section.

26.12.3.1 Wind-borne Debris Regions

Glazed openings ***shall be protected*** in accordance with ***Section 26.12.3.2*** in the following locations:

1. Within ***1 mi (1.6 km) of the coastal mean high-water line*** where the basic wind speed is equal to or greater than ***130 mi/hr*** (58 m/s), or
2. ***In areas where the basic wind speed is equal to or greater than 140 mi/hr (63 m/s).***



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASCE 7-16 Chapter 26.12 - Enclosure Classification

For Risk Category II buildings and structures and Risk Category III buildings and structures, **except health care facilities**, the wind-borne debris region shall be based on Fig. 26.5-1A and 26.5-2B.

- **For Risk Category III** health-care facilities, the wind-borne debris region shall be based on Figs. 26.5-1C and 26.5-2C.
- **For Risk Category IV** buildings and structures, the wind-borne debris region shall be based on Figs. 26.5-1D and 26.5-2D. Risk Categories shall be determined in accordance with Section 1.5.

EXCEPTION: Glazing located over 60 ft.

(18.3 m) above the ground and over 30 ft. (9.2 m) above **aggregate-surfaced-roofs**, including roofs with **gravel or stone ballast, located within 1,500 ft.** (458 m) of the building shall be permitted to be unprotected.

Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

St. John's Regional Medical Center, Joplin, MO., May 24, 2011, Shows the Force of a 200 MPH tornado



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Essential Facilities Design Considerations

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St. John's Regional Medical Center, Joplin, MO., May 24, 2011, Shows the Force of a 200 MPH tornado



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

26.12.3.2 Protection Requirements for Glazed Openings

- Glazing in buildings requiring protection **shall be protected** with an **impact-protective system** or shall be **impact-resistant glazing**.
- Impact-protective systems and impact-resistant glazing shall be subjected to **missile test and cyclic pressure differential tests in accordance with ASTM E1996 as applicable**.
- Testing to demonstrate compliance with ASTM E1996 shall be in accordance with ASTM E1886.
- **Roof requirement:** ASTM D3746 Standard Test Method for Impact Resistance of Bituminous Roofing Systems,
- FM 4470 or TAS 114

ASCE 7-16 Chapter 26.12 - Enclosure Classification FBC 1515.2.4 Impact Resistance



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

ASTM E1996 - 17 - Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes



A 9 lb. wood 2 x 4 "large missile" is shot separately at both the window glass and sash frame in order to meet the necessary testing criteria.

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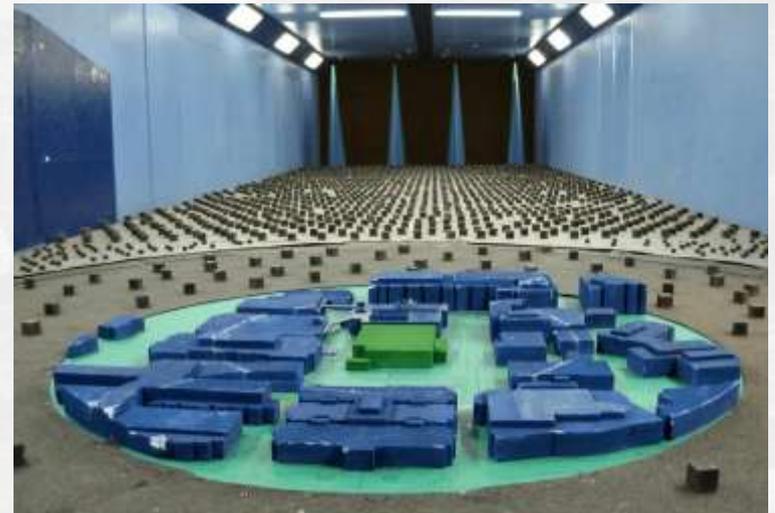
Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Roof System / Assembly Product Approvals

Sample: Miami-Dade NOA, FM Global Testing

- Maximum design -222.5 psf. with Olybond 500 and ISO and torch applied base sheet
- Pressure: -212.5 psf. with Olybond 500 and ISO and Permastic applied base sheet
- -195 psf. with Olybond 500 and ISO and securock and permastic applied base sheet (**see general limitation #9**).



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

Roof System / Assembly Product Approvals

Sample

- **General limitation #9** - the maximum designed pressure limitation listed shall be applicable to all roof pressure zones (i.e. Field, perimeters, and corners). **Neither rational analysis, nor extrapolation shall be permitted for enhanced fastening at enhanced pressure zones** (i.e. Perimeters, extended corners and corners). (When this limitation is specifically referred within this NOA, general limitation #7 will not be applicable.)
- **THE KISS OF DEATH!**

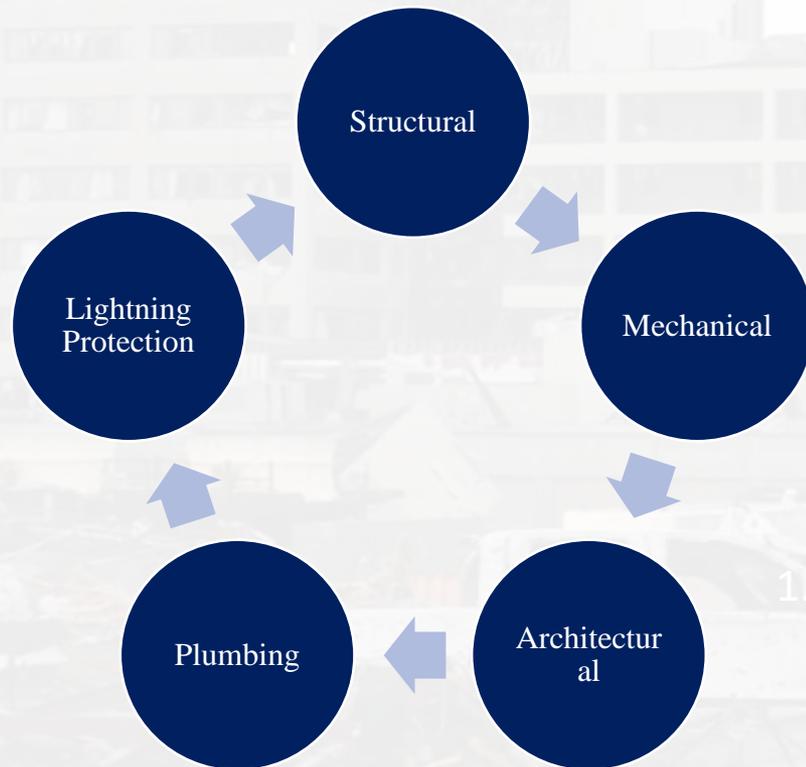


Roof System Case Study

- RAIN LOADS
- ROOF PENETRATIONS (Meeting ICC- 500, FEMA)
- PERIMETR ROOF EDGES (Meeting component and cladding requirements)



Roof Design Coordination



Rain Load	Wind Loads
Mechanical Equipment	MEP conduits Ducts
Architectural Finish (ceiling)	Telecom/ PV

1. The load(s) needs to be coordinated early in design and communicated to Structural Engineer.

- Any change in design needs to be communicated to Structural Engineer immediately

Project Manual Coordination

THE PROJECT MANUAL HIGHLIGHTS THAT ROOF DESIGN, ALONG WITH ITS SYSTEMS AND COMPONENTS, INVOLVES MULTIPLE DESIGN DISCIPLINES.

FOR EXAMPLE, **ROOFING FALLS UNDER DIVISION 7**, WHILE **STRUCTURAL ELEMENTS ARE COVERED BY DIVISIONS 3, 5, OR 6.**

REFLECTED CEILING PLANS AND BULKHEADS RELATE TO GYPSUM BOARD ASSEMBLIES IN **DIVISION 9**,

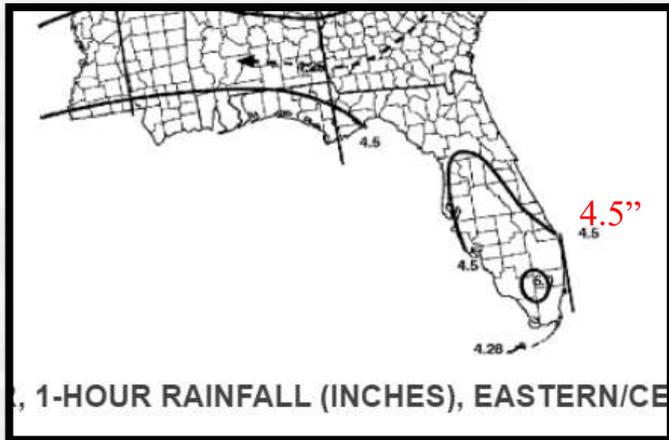
LIGHTING PROTECTION IS ADDRESSED IN **DIVISION 26**,

HVAC DUCTWORK IS PART OF **DIVISION 23**.

Rainfall Rate Requirements-ICC 500

303.1.1 Rainfall rate

For hurricane shelter roofs the rainfall rate shall be determined by adding 6 inches (152 mm) of rainfall per hour to the 100-year, 1-hour rainfall rate. The 100-year, 1-hour rainfall rate shall be determined from Figures 303.1.1 or approved local weather data.



For Hurricane shelters, size roof drains, scuppers, gutters for
4.5 inch + 6 inch = 10.5 inch rainfall



Rain Loads

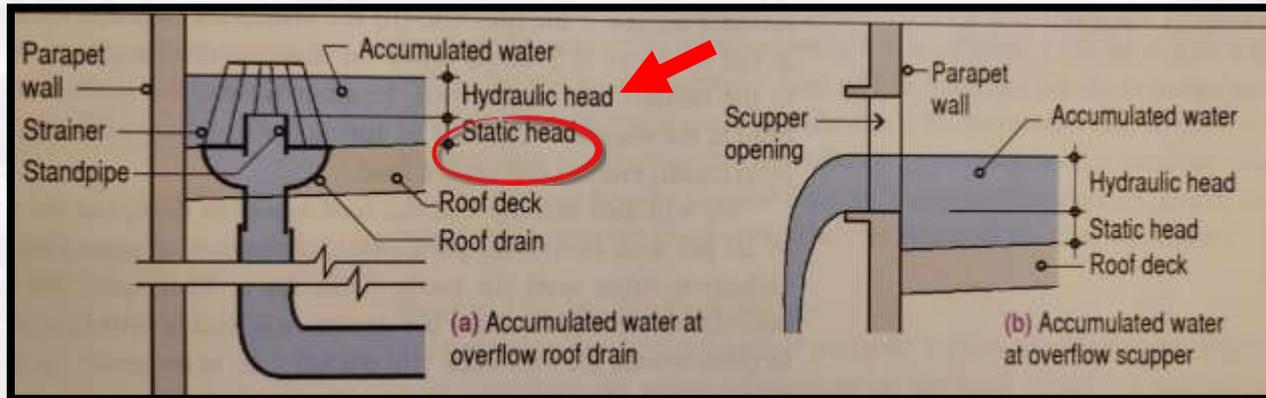
Rain loads are addressed in ASCE 7-22, Chapter 8.

$$R = 5.2 (ds + dh + dp)$$

ds= Static Head

dh= Hydraulic Head

dp= Ponding Head



The hydraulic head of water for roof drains/ scupper is the height of water above the inlet of a drainage element, required to cause water to flow out of roof drain/ scupper at certain rate.

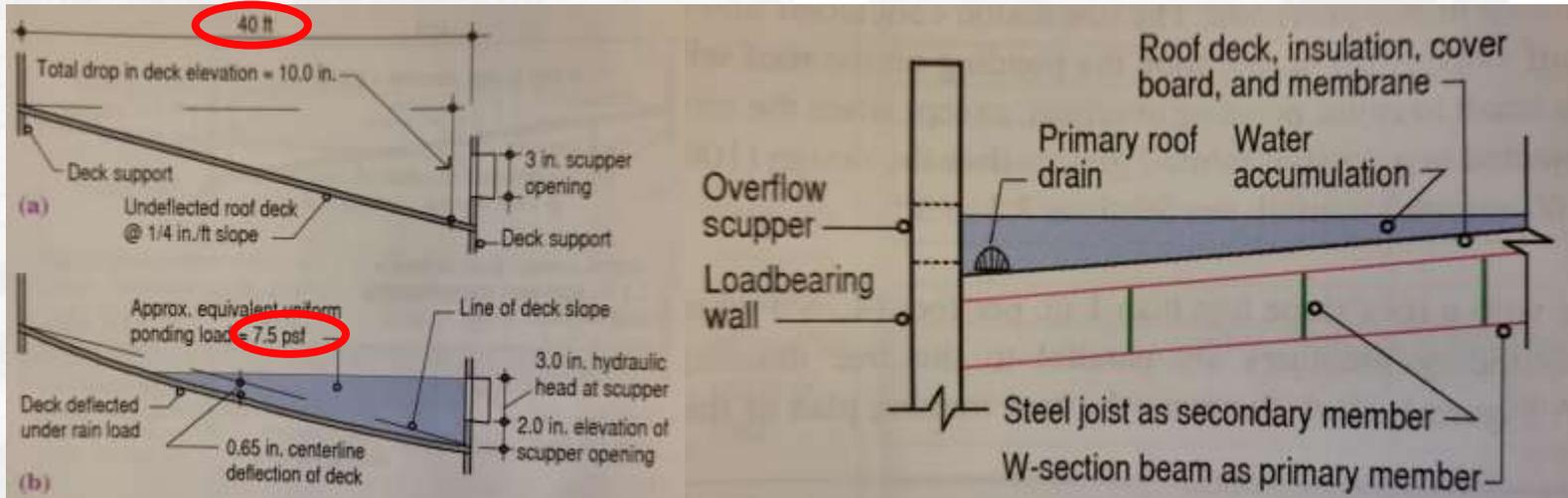
Source: Roof Drainage. Stephen Patterson, Madan Mehta

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Rain Loads

$$R = 5.2 (ds + dh + dp)$$



Source: Roof Drainage. Stephen Patterson, Madan Mehta

Plumbing codes provide methods to calculate water volume; for instance, (4 in.) of rain on a 100s.f x100 s.f (10,000-sf app.) roof results in (24,920 gal) of water.

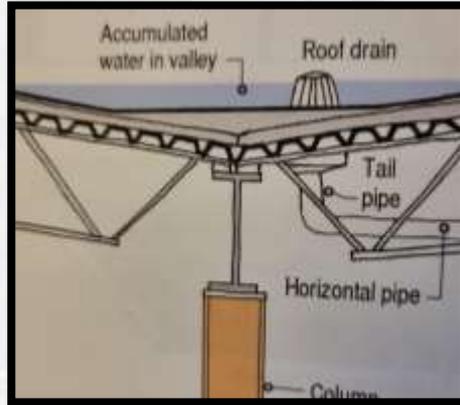
Gallons of water (4" rainfall)=10,000×4×0.623, Gallons of water=24,920 gallon

Gallons of water (4"+6" rain)= 10,000×10×0.623, Gallons of water=62,300 gallon(2.5 TIMES MORE LOAD)

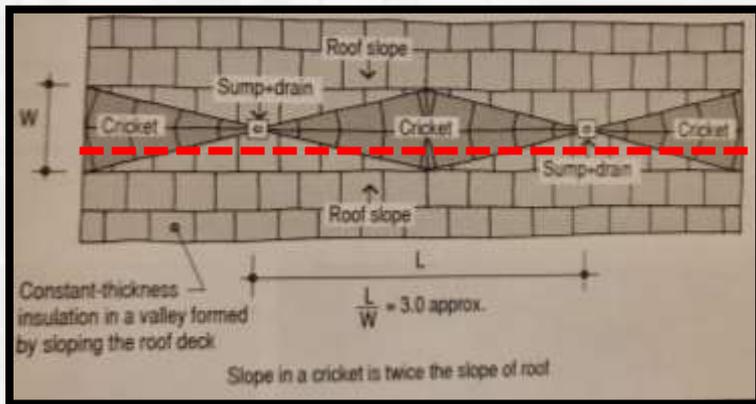
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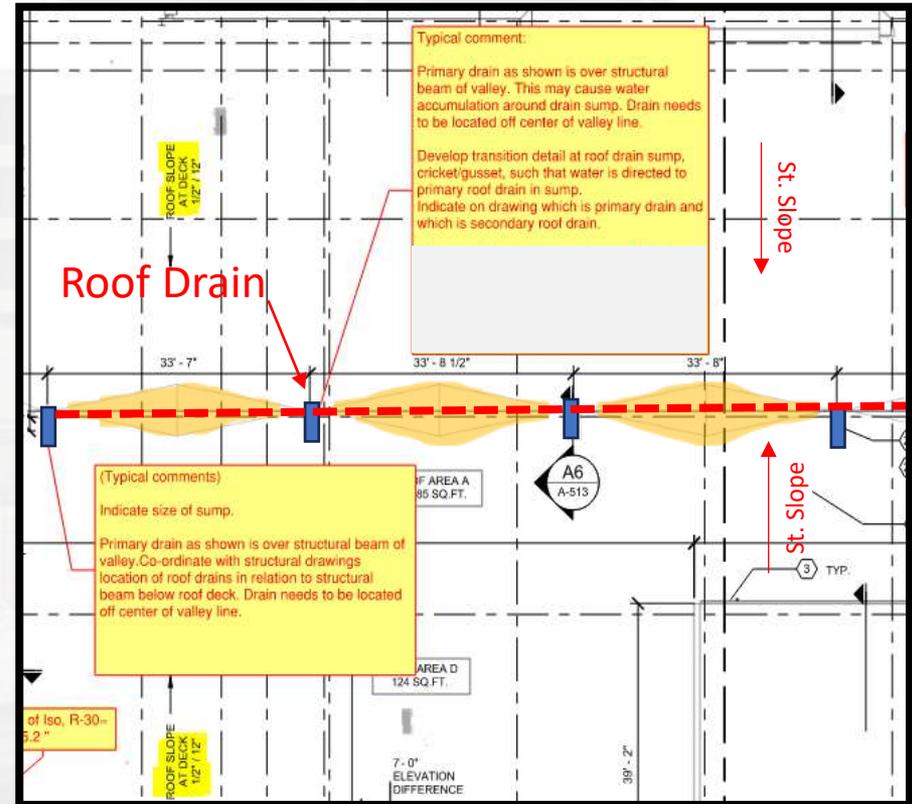
Roof Design Coordination



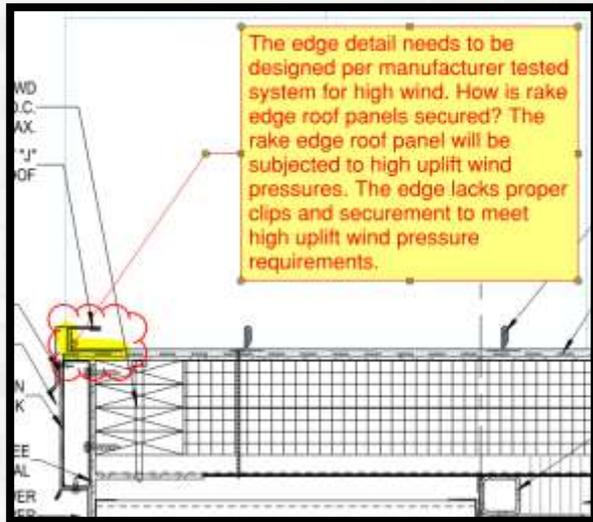
Source: Roof Drainage. Stephen Patterson, Madan Mehta



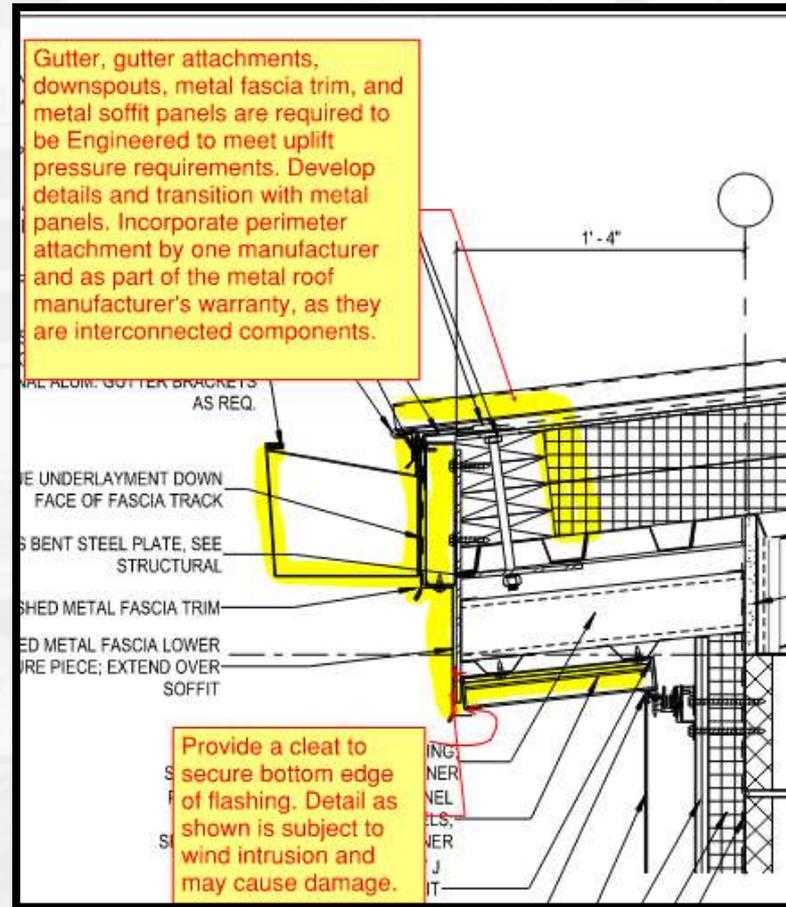
Source: Roof Drainage. Stephen Patterson, Madan Mehta



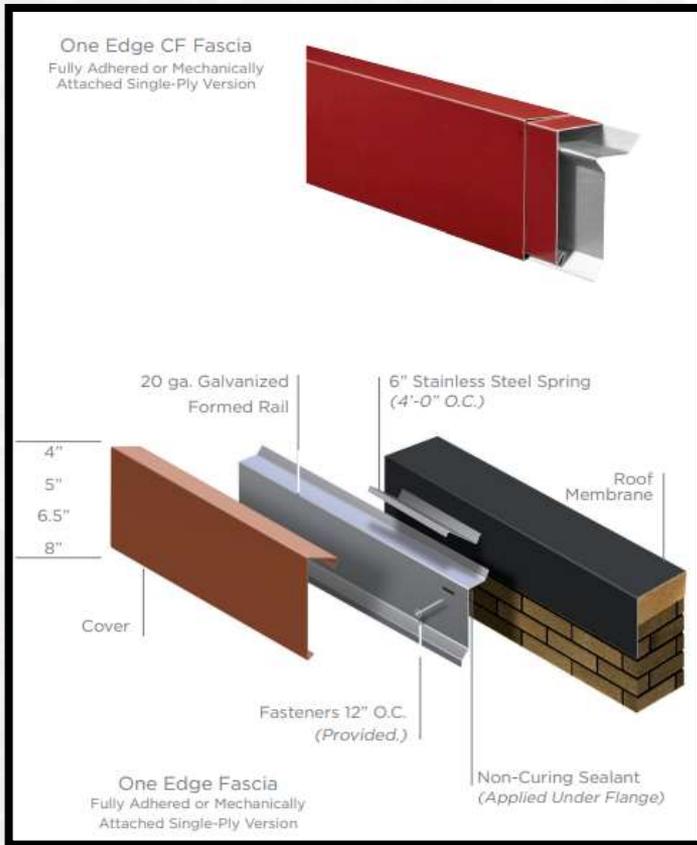
Roof Design Coordination



Source: Raymond



Roof Design Coordination

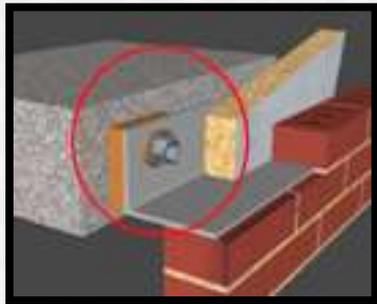


ES-1 Compliant Edge: Source Metal Era



GT-1 Compliant Gutter: Source Metal Era

Energy Codes Requirements



Energy code requirements and NFPA, fire requirements) in between structure

Ensure no air leakage at transitions.

Minimize thermal bridging at this interface

Typical Note: The air barrier is stopped at soffit (pen test method). The air from below soffit could easily intrude in to roof assembly through metal deck-side laps and other openings. Design a continuous air barrier per Energy code requirements. Specify appropriate air barrier material under deck or it could be detailed above deck also. Detail interface between wall air barrier and roof underlayment.

- MAX. LAP UNDERLAYMENT OVERLAP
- FLASHING
- EAVE ANGLE SUPPORT BY ROOFER
- AND
- why is roof underlayment stopped? suggest continue as shown around bent plate and interface with air barrier
- CONTINUE UNDERLAYMENT DOWN FACE OF FASCIA TRACK
- PRE-FINISHED METAL FASCIA TRIM
- CONTINUOUS BENT STEEL PLATE, IS STRUCTURAL
- PRE-FINISHED METAL FASCIA LOWER CLOSURE PIECE, EXTEND OVER SOFFIT
- 3/8" GALV. METAL STUD FRAMING SPACING PER DELEGATED DESIGNER
- PRE-FINISHED METAL SOFFIT PANEL OVER 1/2" GALV. HAT CHANNELS SPACING PER DELEGATED DESIGNER
- PRE-FINISHED METAL SOFFIT 2 CLOSURE TRIM MATCH SOFFIT PANELS, TYP.
- CONT. SEALANT WITH BACKER ROD, TYP.
- CONT. 7/8" GALV. ID FURRING, 3/4" DEEP, SEE RAINSCREEN ATT. SPEC
- ALUMINUM COMPOSITE METAL PANEL OVER HD SYSTEM, COLOR AS SCHEDULED
- 2" XPS RIGID INSULATION
- FLUID APPLIED MEMBRANE AIR BARRIER, TYP.

Control Layer Details Masonry Cavity Wall

Identify 4 control layers

- Water
- Air
- Vapor
- Thermal

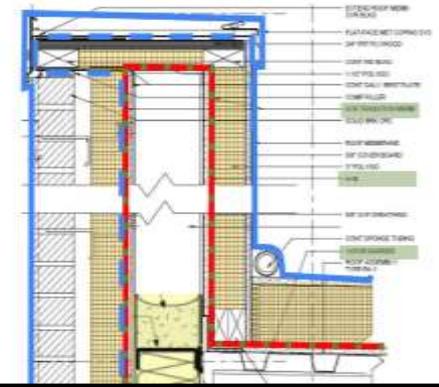


Image Source: Siplast

- MAINTAIN CONTINUITY OF AIR, WATER, VAPOR, THERMAL BARRIER- ROOF TO WALL
- AVOID THERMAL BRIDGING

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Roof Penetrations – ICC 500

306.6 Penetrations of storm shelter envelope by mechanical, electrical and plumbing systems

Penetrations through the *storm shelter envelope* of mechanical, electrical and plumbing systems, including piping and utility lines, larger than **3½ square inches** (2258 mm) in area for rectangular penetrations or **2½ inches** (64 mm) in diameter for circular penetrations, shall be considered openings and shall be protected in accordance with Section 306.4. Penetrations of the *storm shelter envelope* shall not degrade the structural integrity of the *storm shelter* and impact resistance of the *storm shelter envelope*.

Penetrations of the *storm shelter envelope* by hazardous gas or liquid lines shall have automatic shutoffs to protect against leakage due to movement of the utility line. The threshold movements for shutoff shall be as defined by the *applicable* codes and standards governing such utility lines.



Roof Penetrations – ICC 500, FEMA

IMPACT-PROTECTIVE SYSTEM. An assembly or device, subject to static or cyclic pressure and impact testing as detailed in this standard, installed to protect an opening in the *storm shelter envelope*.

FEMA B8.2.4.3

B8.2.4.3 Other Impact-Protective Systems

Impact-protective systems other than door and window assemblies include shutters, shields, and cowlings. Shields and cowlings are used to protect penetrations in the safe room envelope and openings at louvers, grates, grilles, plumbing vents, roof drains, emergency generator exhaust vents, and masonry control joints or precast panel joints that exceed tolerances in ICC 500 Section 306.4.3. Non-operable, permanently affixed shields and cowling that have been designed to resist design pressures may be excluded from pressure testing.

➤ Pressure test not required for non operable, permanently affixed Shields or Cowlings but Missile impact testing required.

ICC-500 Definition

306.4.1 Impact-protective systems

Impact-protective systems for use in the *storm shelter envelope* shall be tested for impact in accordance with Section 803 and static and cyclic pressure in accordance with Sections 804 and 805. Any changes to *listed impact-protective systems*, such as a change of glazing, shall require evaluation by the listing agency or retesting of the entire assembly.

Exceptions:

1. Window assemblies and other glazed openings where the opening is protected on the exterior side by an *impact-protective system* are not required to be tested for impact.
2. Window assemblies and other glazed openings where the opening is protected on the interior side by an *impact-protective system* are not required to be tested for impact and static and cyclic pressure.
3. Nonoperable, permanently affixed shields or cowlings designed to resist the design wind pressures are not required to be tested for static and cyclic pressure in accordance with Sections 804 and 805.



Source: FEMA

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Roof Penetrations – ICC 500

Roof Design Considerations for Penetrations:

- Must be rated for wind speed
- Rated for missile impact

Roof Penetrations:

- Roof drains
- Vents (greater than 2 1/2" Diameter)

Roof Considerations:

- Roof Hatches
- Roof perimeter edges, copings
- Penetration Enclosures
- MEP Units, Duct supports
- Lightning protections

TABLE 305.1.1 MISSILE SPEED FOR TORNADO SHELTERS

DESIGN WIND SPEED	MISSILE SPEED AND IMPACT SURFACE
130 mph	80 mph Vertical Surfaces 53 mph Horizontal Surfaces
160 mph	84 mph Vertical Surfaces 56 mph Horizontal Surfaces
200 mph	90 mph Vertical Surfaces 60 mph Horizontal Surfaces
250 mph	100 mph Vertical Surfaces 67 mph Horizontal Surfaces

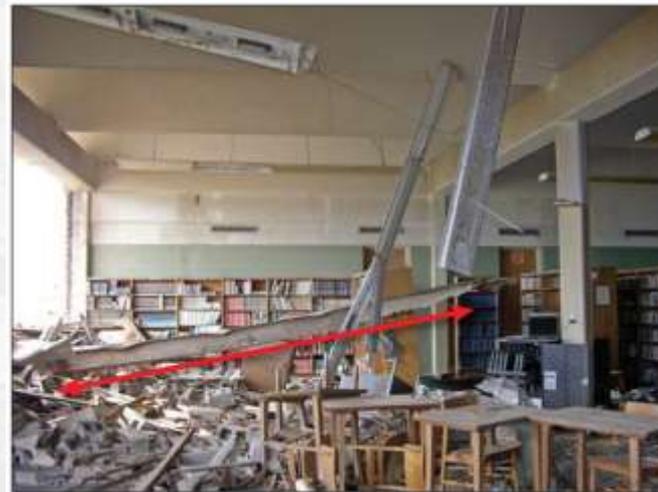


Figure B8-3.
Large debris: Steel
beam that blew into
a school
(Greensburg, KS, 2007
tornado)

Image Source: FEMA P-361, 2021

Rooftop Equipment



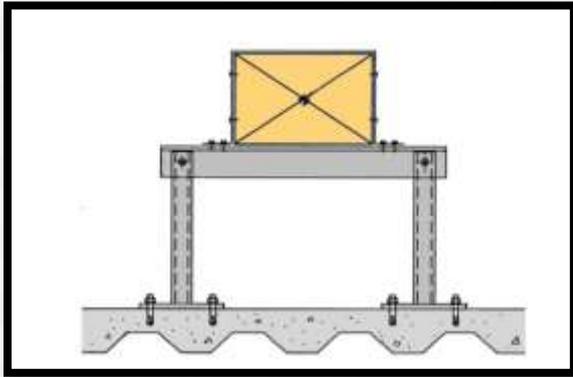
Source: Miro Industries



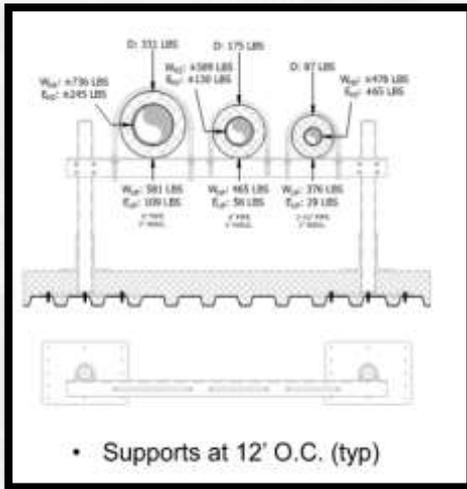
Source: FEMA

- Who is responsible for Roof Top Equipment design? *Architect, Structural Engineer, Mechanical, Owner.....*
- The design of rooftop equipment supports requires coordination among multiple trades and professionals.
- It is typically addressed as a **deferred submittal** in project documents, which can lead to it being overlooked.
- Additionally, evaluating wind and seismic loading on rooftop units is often neglected by many industries, owners, building officials, and inspectors.

Rooftop Equipment



Source: MEP academy



Source: Miro Industries

- Avoid roof top units and equipment's. Co-ordinate early in the design.
- If required, establish a Load path per ASCE requirements.
- Connect roof top equipment to the structure
- Provide X- bracing to frames as required.
- Install Roof Flashing



Source: Miro Industries

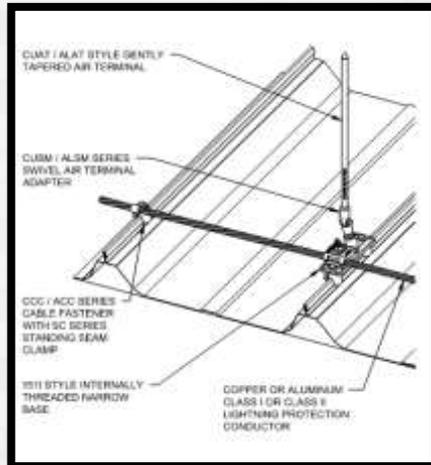


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Lightning Protection



Source: Harger

Lightning Protection is Typically Overlooked by Design professionals and Contractors.

Galvanic reaction between Dissimilar metals.

Lack of flashing for penetration lightning protection system through roofs.

1511.7.6.2 Installation of roof coverings. Lightning protection system components directly attached to or through the roof covering shall be installed in accordance with this chapter and the roof covering manufacturer's installation instructions. Flashing shall be installed in accordance with the roof assembly manufacturer's installation instructions and Sections 1503.2 and 1507 where the lightning protection system installation results in a penetration through the roof covering. When the roof covering manufacturer is unknown, installation shall be as directed by a registered design professional.

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All CYCLONE® products are third-party tested to meet ICC-500 2014 and FEMA P-361 to 250+ mph wind, including missile impact and labeling. They are engineered with a two-point deflection for ICC compliance and optimum safety, and fabricated from 3/16" carbon steel or schedule 40 steel pipe with industrial coating and SRI 88.2.



CYCLONE® STEEL HOUSING (CSH) (formerly CRV)

Provides a multiple penetrant pathway to the roof in tornado/hurricane-prone areas.

Paired with our RPH Exit Seals™ for a weather-tight solution.



CYCLONE® ROOF DRAIN (CRD)/ (COFRD)

Meets ASME, ANSI, ASPE flow rates.

Dome shaped to dampen shock to roof drain sump.

patent # US 10,907,398 B2



CYCLONE® ROOF HATCH (CRH)

Passed both the ASTM E330-14 uniform static A/P differential and Missile Impact Tests, demonstrating its resilience in hurricane/tornado-prone areas.

R-40 insulated lid



CYCLONE® WALL SHROUD (CWS) (formerly CWVSO)

Designed to protect interior/ exterior wall penetrations or roof deck of a safe room/storm shelter.

Access door for future repairs.



CYCLONE® VENT THROUGH ROOF (CVTR)

Can be custom designed for the thickness of the roof and height of the parapet.



CYCLONE® WALL DOWNSPOUT (CWS) (formerly CWV90)

Accommodates small piping and conduit for exterior walls.

Can also serve as a downspout nozzle for roof drain leaders.

NOTE: Testing documents are available upon request.

LET RPH BE YOUR PARTNER AND RESOURCE FOR ALL THINGS ROOF AND WALL PENETRATION PROTECTION FOR SAFE ROOMS AND STORM SHELTERS



935 Isom Road
San Antonio, TX 78216

800-994-0945
info@RPHproducts.com

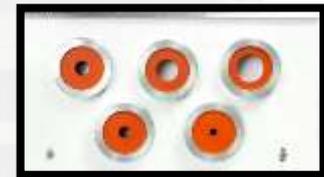
Source: RPH Products

SAFE ROOM/STORM SHELTER PROTECTION

CYCLONE® products meet strict standards for safe rooms/storm shelters, including ICC 500-2014 and FEMA P-361 codes. Third-party tested to withstand up to 250 mph winds with two-point deflection design for ICC compliance, they offer exceptional protection for the building and occupants in areas prone to high-wind events.



Source: RPH Products



Source: RPH Products



Source: RPH Products

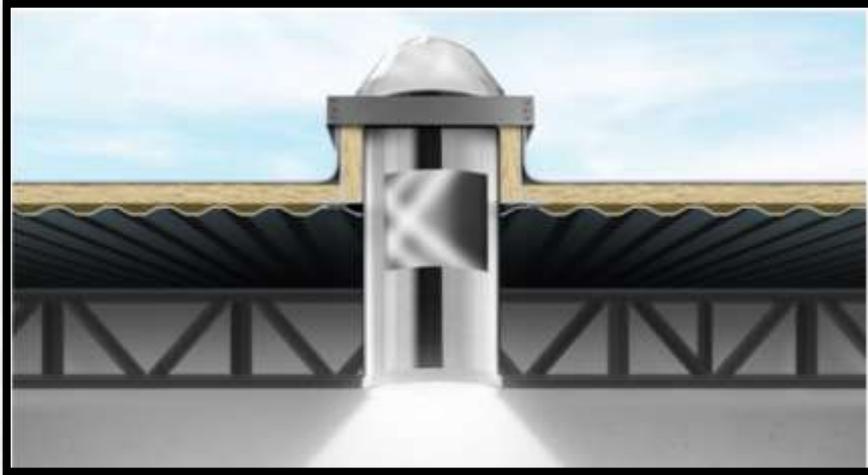


Source: RPH Products

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Storm Protection



<https://solatube.com/storm-shelters/>



Model: Solatube 750 DS-O Open Ceiling
FOR ICC 500/FEMA P 361 COMPLIANCE

Project: _____
 Location: _____
 Type: _____
 Product Specifications Appear in CSI Division 08, Section 08 62 23. For budgeting and quotations use only. Qty: _____

Model	Capture Zone	Transfer Zone	Delivery Zone
S750DS-O	[DPI] [PB] - [FC] [CCI]	[E]	[L2P]
1	2 2a	3 3a	4 4a 5 5a 6 7

1 Model

750 DS-O SoloMaster® Solatube 750 DS-O (21 in./530 mm Daylighting System) Open Ceiling



Capture Zone

2 Dome

DPI Acrylic Outer Dome + Polycarbonate Inner Dome (Required for High Velocity Hurricane Zones, FM™ and ICC 500/FEMA P 361)

2a Dome Options

B Security Bar (optional) **PB** Dome Edge Protection Band (Required for FM™ and ICC 500/FEMA P 361)

SK Dome Security Kit (optional)

3 Flashings

FC Curb Cap (Curb by Others) (FM Approved™) (Required for ICC 500/FEMA P 361)



3a Insulation Options

CCI Curb Cap Insulation (Required for ICC 500/FEMA P 361)

CI Curb Insulator (optional)

TIP Thermal Insulation Panel (optional)

* Only product that is FM approved. Must use Dome Polycarbonate (DP). It is required that a Dome Edge Protection Band (PB) be used with FM approved flashings.

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QA/QC Inspections & Testing



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Essential Facilities Design Considerations (Building Enclosure/ Components & Cladding)



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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)



Roof System Warranty



- **CAUTION READ THEM, READ THEM, READ THEM,** BEFORE YOU SPECIFY A MANUFACTURERS SYSTEM.
- Exclusions include – **ACTS OF GOD, HURRICANES, TORNADOS, MICROBURST.**
- **Question** – does anyone know of anything that can create a 120 mph wind other than one of the exclusions noted above?
- Non-leaking membrane blisters are not considered a warrantable claim.
- **Question:** what adverse effect will the trapped moisture have on the system fasteners or adhesives. Will it diminish the uplift “performance” of the assembly?
- The manufacturer employees do not practice engineering, architecture or consulting.
- **Question:** why do they write so many assembly letters attesting compliance of the systems signed by company engineers or employees?



Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

**Components & Claddings must perform
to the standards required for an
Essential Facility.
Failure can be catastrophic!**

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Essential Facilities Design Considerations

(Building Enclosure/ Components & Cladding)

This concludes The American Institute of Architects
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Contact our Business Development team for follow up:



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