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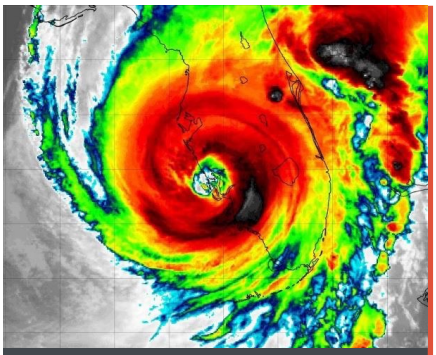

While climate scientists are hesitant to predict an increase in number of potentially dangerous storms annually, State of Florida statistics show this may well be the case. Of the 37 hurricanes that made landfall on Florida since 1950, 15 occurred in 2021-2022 alone. Six of those 15 were considered "major," that is, Category 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale.

HURRICANES AND PUBLIC SAFETY FACILITIES: A VIEW FROM GROUND ZERO

Based on a presentation given by Todd Sweet, AIA, LEED AP, Sweet Sparkman Architecture and Interiors, Sarasota, Florida, at the Station Design Conference, May 25, 2023.

INTRODUCTION

Data shows that hurricanes are becoming more intense, a phenomenon ascribed to our warming planet. In addition, the typical "season" for hurricanes is lengthening, while their threat widens to include regions outside the norm. Global climate models indicate that this trend will continue, with higher wind speeds and greater storm surges, bringing new levels of damage to persons, structures, and economies.[1] As a result, the Center for Climate and Energy Solutions cautions, "communities in both coastal and inland areas need to become more resilient."[2]

This paper looks at this situation from an architectural perspective centered on Florida, providing an overview of what the oft-hit state is doing to meet this challenge through aggressive building codes and using examples of some of its most severe storms, including the historically catastrophic Hurricane Ian. It also looks at lessons learned and changes expected and required to create a new level of resilient structures able to stand up to nature's worst.

Of special note is what all this means for public service buildings such as fire stations and what can be done to further the goal of getting first responders and other necessary personnel back in action as quickly as possible in times of intense need.

1. How Climate Change is Fueling Hurricanes, Reuters, September 20, 2022, https://www.reuters.com/business/environment/how-climate-change-is-fueling-hurricanes-2022-09-20/
2. Hurricanes and Climate Change, Center for Climate and Energy Solutions, https://www.c2es.org/content/hurricanes-and-climate-change/

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Largo Fire Station #43

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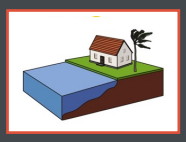
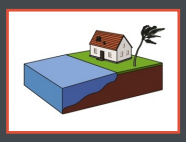
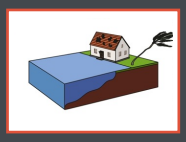
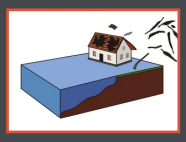
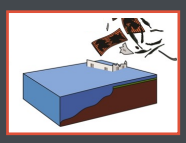
CODIFYING SAFETY

Florida developed the nation's strongest statewide building code after Hurricane Andrew in 1992 destroyed tens of billions of dollars' worth of property and exposed weak construction practices that left many structures unable to withstand the Category 5 storm.[3] First taking effect in 2002 and updated every three years, the Building Code, which encompasses volumes for residential, energy conservation, existing building, and building standards, currently is in its 7th Edition.

Like much change, there has been pushback from individuals and organizations such as building trade groups that want limited or no mandatory rules at all; anti-regulatory state legislators; and officials who want to avoid anything that might hurt home sales and reduce concomitant tax revenue.[4]

Still, the Florida Building Commission has held firm, guided, perhaps, by the simple fact that the codes work.

	Category	Sustained Winds	Types of Damage Due to Hurricane Winds
	1	74-95 mph	Will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Power outages that could last a few to several days.
	2	96-110 mph	Will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage, uprooted trees will block numerous roads, and near-total power outages expected that could last from several days to weeks.
	3 (major)	111-129 mph	Devastating damage: Well-built framed homes may incur major damage or removal of roof decking and gable ends; downed trees will block numerous roads. Electricity and water will be unavailable for several days to weeks.
	4 (major)	130-156 mph	Catastrophic damage: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months.
	5 (major)	157 mph	Catastrophic damage: Most framed homes will be destroyed, with total roof failure and wall collapse; fallen trees and powerlines will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Oceanic and Atmospheric Administration

3. Hurricane Damage Would Be Less Extensive with Stronger Building Codes; Florida's codes rank high, but those of Texas, Mississippi and Alabama are low, Scientific American, June 15, 2021, https://www.scientificamerican.com/article/hurricane-damage-would-be-less-extensive-with-stronger-building-codes/

4. Why Storm-Prone States Continue to Balk at Tough Building Codes, Insurance Journal, March 9, 2018, https://www.insurancejournal.com/news/national/2018/03/19/483773.htm

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Longboat Key Fire Station #92

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"We can clean this up in a month," said home co-owner Russell King. "But other folks, I don't know. Look at what these people suffered."

MEXICO BEACH, FLORIDA

GILCHRIST, TEXAS

PROOF OF PREPARATION

The photos below show two homes that once were part of vibrant communities. One hurricane later, each stood virtually alone amid debris. Like many newer homes, the structures shown were designed and built after Hurricane Andrew and the institution of stronger building codes. Put to the test, they stood when others failed.

2018 – Hurricane Michael

Built by its owners "for the big one,"[5] the Mexico Beach, Florida, home went even beyond code, fashioned by poured concrete reinforced by steel cables and rebar, with additional concrete bolstering the corners of the house. As reported in the New York Times, the space under the roof was minimized so that wind could not get underneath and lift it off. The home's elevation, on high pilings, was meant to keep it above the surge of seawater that usually comes with powerful hurricanes, and its construction was designed to withstand 250 mph winds. (A storm that carries winds of more than 157 mph is considered a Category 5 hurricane.)

"We can clean this up in a month," said home co-owner Russell King. "But other folks, I don't know. Look at what these people suffered."

Obviously, the owners were more than prepared. The only major damage involved the loss of the siding that wrapped around a stairway providing access to the elevated house, as well as the stairs. But that was by design: The architect reportedly used breakaway walls that would tear free without ripping off any more of the structure.

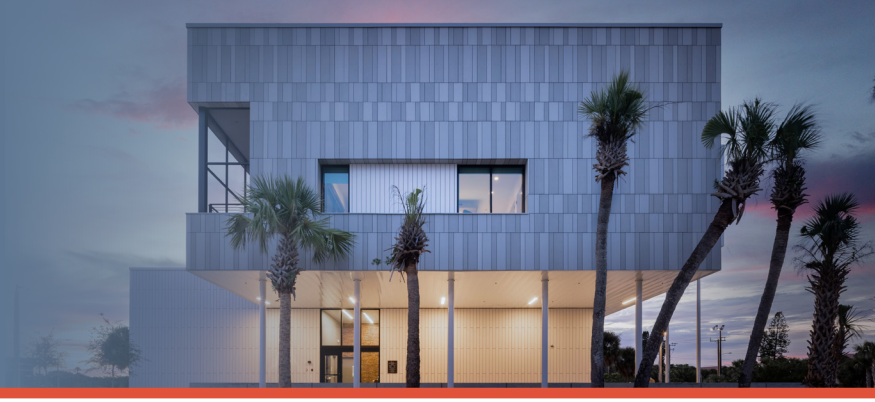
2008 – Hurricane Ike

Having lost one house to a hurricane, the owners of the Gilchrist, Texas, home shown built a new one on the same beach with a better chance of surviving a storm.[6] Built to code while other, older homes in the area were not, the house was elevated 14 feet, where others were not raised or elevated nearly as high, according to Aran & Franklin Engineering (A&F). Hurricane Ike exceeded the 100-year flood levels, and with storm surge at almost 20 feet, the older homes could not withstand that volume of water pushing on their walls and foundations and were reduced to rubble.

"It looked like somebody had dropped a bomb," said homeowner Warren Adams. "If my house wasn't there, I wouldn't have been able to recognize where I was even at."[7]

5. Among the Ruins of Mexico Beach Stands One House, Built 'for the Big One', New York Times, October 14, 2018, Hurricane, https://www.nytimes.com/2018/10/14/us/hurricane-michael-florida-mexico-beach-house.html
6. Case Study: Last House Standing, Aran & Franklin Engineering, https://aranfranklin.com/project/case-study-last-house-standing/ September 18, 2008,
7. Their House Survived Ike, But It's The Only One left, CNN, https//www.cnn.com/2008/US/09/18/ike.last.house.standing/

Siesta Key Fire Station #13



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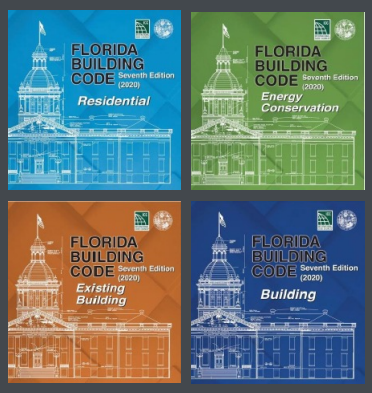
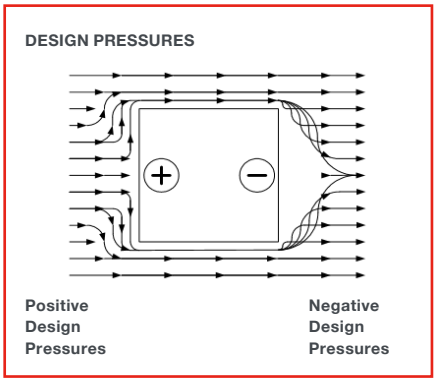


While the Florida Building Code continues to keep pace with changes in climate and environmental goals, many recent modifications have been energy-based. Thus, in addition to being strong, buildings need to be sustainable and consume less energy.



BUILDINGS ARE DESIGNED TO WITHSTAND BOTH POSITIVE AND NEGATIVE PRESSURES OR FORCE

Incorporating the most common structural elements of plywood shearwalls with bracket hold downs, high design pressure windows and doors, as well as a clip and strap fastening system that provided a continuous load path, the home was well suited to handle Ike's Category 2 winds, an A&F case study reports. Since it was elevated higher than FEMA required, it also resisted most of the water, as well, surviving with all structural elements remained intact.

The always evolving Florida building code

Significant changes in the most current volume of the Florida Building Code include a new wind map for Risk Category IV. This group includes structures such as fire stations, which are considered essential facilities whose failure could pose a substantial hazard to a community, and thus require higher reliabilities.[8]

Also, specific design wind speeds have been added under section 1620.2 for Risk Category IV buildings and structures located in High-Velocity Hurricane Zones (HVHZ). For instance, for Miami-Dade County, the Risk Category IV wind speed for the entire county is 195 mph. For Broward County, it is 185 mph.

While the Florida Building Code continues to keep pace with changes in climate and environmental goals, many recent modifications have been energy-based. Thus, in addition to being strong, buildings need to be sustainable and consume less energy.

Equally important is the protection of openings. Section 1609.1.2 requires that, in wind-borne debris regions, glazed openings in buildings be impact-resistant or protected with an impact-resistant covering meeting the requirements of ANSI/DASMA 115 (for garage doors and rolling doors) or TAS 201, 202 and 203, AAMA 506. ASTM E 1996 and ASTM E 1886, or an approved impact-resistant standard.

Other modifications include new wind load criteria for rooftop solar panels and higher design wind pressures on roofs of buildings with mean roof height ≤ 60 feet.

A WORD ABOUT WIND PRESSURE

Buildings are not designed to withstand just wind speeds. Buildings must be designed for wind load.

8. 2020 Florida Building Code, Building, 7th Edition, CHAPTER 16, STRUCTURAL DESIGN, https://www.floridabuilding.org/fbc/thecode/2020_7edition/ASCE_7-16_Fact_Sheet_final_2_column_format052820final.pdf

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Captiva Island Fire Station

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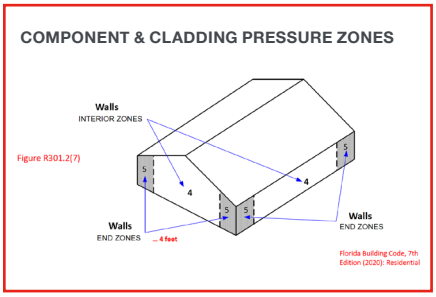
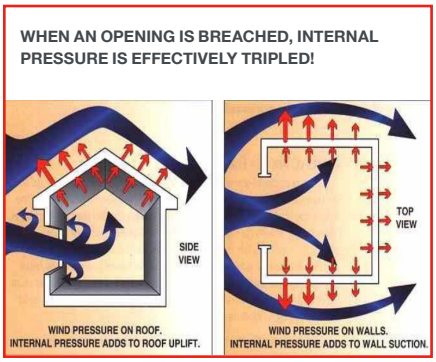
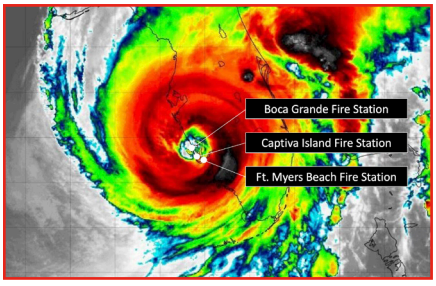
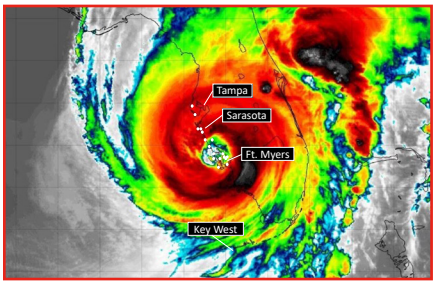






HURRICANE IAN LAND IMPACT ON FIRE STATIONS



HURRICANE IAN LAND IMPACT

Wind load is the wind pressure or force, in pounds per square foot, exerted on a building. There can be uplift wind load (which affects roof/horizontal structures), shear wind load (which is horizontal pressure that can damage walls), and lateral wind load (which can cause foundational issues).[9]

Loads are a primary consideration in structural design because they define the nature and magnitude of hazards and external forces the building must resist to provide reasonable performance throughout its useful life. The type and magnitude of design loads affect major decisions, such as material selection, construction details, and architectural configuration.[10]

As the following illustrations show, the science of design pressure incorporates both positive and negative pressures on the structure. It is important to note that whenever any opening is breached, internal pressure is effectively tripled.

In addition to wind speed and wind forces, other variables that affect design pressures on a building include the following:

1. Location of building
2. Size and shape of building
3. Terrain
4. Internal pressure factors
5. Size of opening
6. Building use

FIRE STATIONS IN THE EYE OF IAN

Hurricane Ian was one of the costliest and deadliest storms in Florida's history, covering an area 20-30 miles wide, with maximum sustained winds of 160 mph. In its wake, it left 160 fatalities and $135.9 billion in estimated total cost of damage to the United States due to high winds and storm surge, which reached 16 feet on Fort Myers Beach. All told, approximately 6000 buildings were destroyed across three Florida counties, with more than 20,000 receiving major damage.

Florida public service buildings that took the brunt of the Category 5 storm were those in Boca Grande, Captiva Island, and Fort Myers Beach.

9. Under Pressure: Wind Loads, Series Part 1, NICHIHA, https://www.nichiha.com/blog/under-pressure-wind-load-series-part-1

10. Structural Design Loads for the Home Inspector, InterNACHI, https://www.nachi.org/structural-design-loads-home-inspector.htm

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Sarasota County Fire Station #1

WHITE PAPER

CAPTIVA ISLAND (BEFORE)

CAPTIVA ISLAND (AFTER)

BOCA GRANDE (BEFORE)

BOCA GRANDE (AFTER)

Captiva Island

Captiva Island is located just offshore of Lee County in the Gulf of Mexico. As a barrier island, it has been impacted by a number of hurricanes, including Charley, in which it was seriously damaged.

When it came time to build a new fire station some eight years ago, those involved had to walk a fine line between the past and future, ensuring the structure blended in with the surrounding historic district, while incorporating the latest materials and features to help it withstand intense storms. Meeting both goals, the two-story, 9000-sq.-ft. station was completed in June 2015.

Fast forward to 2022 and results of efforts toward resiliency were in. While the structure received some damage, Fire Chief Jeff Pawul reported he was happy with how the station performed during the storm. The biggest hit was to the facility's roof, which would require replacement after wind lift compromised the metal fasteners. The electric locks on the doors failed, and several of the windows leaked. Flying debris smashed a window and gutters were ripped off. With the structure itself intact, the Chief praised the generator that ran 24 hours a day for 30 days to keep the fire station in operation immediately after the storm and provide undisrupted emergency service to the island.

Boca Grande

The Boca Grande Public Safety Building is an 11,000-sq.-ft. fire, EMS and sheriff's facility on a coastal island that has weathered three hurricanes in its 20-year history.

Factors contributing to its resiliency were a retention system for collecting heavy rains, Hardi-plank composite siding, double-wall construction for all sides, and impact-resistant glazing to withstand wind speeds of 144 mph. Large mahogany overhead doors were specially tested to meet stringent codes.

Hurricane Ian, with sustained winds at this location of 150 mph and gusts of up to 200 mph, put all efforts to the test, as the storm blew in a rear door and breached the envelope. This, in turn, blew out an upper-story window, which landed on the front apron (though it subsequently was reinserted awaiting replacement). The interior suffered some water intrusion resulting mostly in damaged ceiling tiles and flooring. Most of the flooring, however, was intact and suffered only minor damage. The Modified Bitumen roof and the standing seam roof both were subsequently replaced. All the wall-

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Boca Grande Fire Station

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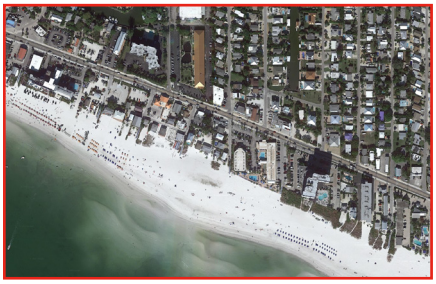

FORT MYERS BEACH (BEFORE)

FORT MYERS BEACH (AFTER)

mounted arm lights were blown off, and the rooftop AC units, though not affected by the storm surge, were impacted by flying debris. Significantly, having stored their apparatus in about 30 miles inland, they returned immediately after the storm to find the generator and all power on, enabling them to successfully service the island out of the station.

Fort Myers Beach

Fort Myers Beach on Estero Island is a seven-mile stretch on the Gulf of Mexico that took a direct hit during Hurricane Ian, leaving nearly every building on the barrier island damaged or destroyed. Among them was Fire Station #31, which suffered the loss of a fire truck and ambulance which were stored at the firehouse during the storm and extensive structural damage that eventually led to the building being condemned.[11]

Ironically, the decision to leave more than $1 million in gear on the island vs. moving it inland was a strategic one, intended to get help to residents faster should its bridges become inaccessible and first responders cut off. Thus, Station #31 moved its vehicles to the island station with the highest-grade elevation, where they later were rendered useless by a 16-ft. storm surge.

The Fire District is now in the design stages of a new Fire Administrative Facility and Station #32 to replace the loss of Fire Station #31. The new station design will reflect the lessons we learned from Hurricane Ian.

FUTURE CONSIDERATIONS

Each severe storm leaves behind knowledge that, hopefully, can work to mitigate the impact of the next. Our firm recently conducted site visits and interviews with fire personnel affected by Hurricane Ian in Boca Grande, Captiva Island, and Fort Myers Beach. Based on the feedback we received, we developed a list of reflections that will stay top of mind. They are:

1. Give more consideration to two-story fire stations to allow for as much space above the storm surge as possible.
2. Elevate the apparatus bays to the highest elevation the site allows.
3. If aesthetics are a concern, integrate double doors at the apparatus bays – an aesthetic overhead door and an industrial door backup.
4. Provide back-up utilities for water (storage tank or well) and electricity (generator or photovoltaic panels).

11. Fort Myers Beach Fire Dept. loses fire truck & ambulance to Hurricane Ian, firehouse condemned, NBC 2, November 6, 2022, https://nbc-2.com/news/2022/11/04/fort-myers-beach-fire-dept-loses-fire-truck-ambulance-to-hurricane-ian-firehouse-condemned/

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Sarasota County Fire Station #14

WHITE PAPER

Each severe storm leaves behind knowledge that, hopefully, can work to mitigate the impact of the next.

5. Roof Design:
   a. Standing seam metal roofs - select fasteners for maximum wind uplift for panels, gutters, and downspouts. Specify minimum 24 ga. mechanically rolled low profile seams.
   b. Low slope or “flat roofs” - consider wind vented roof systems.
6. Install windows that not only are laminated and insulated but also meet Missile E standards for enhanced impact protection.
7. Floodproof to a higher elevation.
8. Raise electrical outlets and consider sacrificial wiring/lighting below flood elevation.
9. Provide for proper hydrostatic relief venting to enable water to come and go, flowing through the facility.
10. Consider a saferoom to assure a core of operation following an event.

CONCLUSION

As climate conditions change, design and construction will – or should – change, as well. As hurricanes become more intense and more widespread over a longer period of time, all affected states and their governments must take note and take action.

Florida shows that stricter codes do work. They make a huge difference. And they should be acknowledged.

With or without that impetus, however, it is important for public service facilities in construction or under renovation to take every step possible to protect the structures and their personnel to promote a fast response to a storm disaster in their communities.

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Sweet Sparkman Architecture and Interiors is a multi-disciplinary architecture and planning firm specializing in community-oriented projects and high-end residential, as well as interior design. Since its beginning in 2002, the award-winning firm has designed and permitted more than two dozen fire facilities. For more information, visit www.sweetsparkman.com or call 941.952.0084.