Damage Control

BY MARIA BLACKBURN

In the Irish Bayou of New Orleans after Hurricane Katrina.

With fearsome fury, hurricanes bring punishing winds and deadly storm surges—but there are relatively easy steps you can take to protect life, limb and property.

WHEN THE STORM FORMED somewhere off the coast of the Bahamas, it was just another tropical depression—one of 100 or so created around the world each year as a mass of thunderstorms with a cyclonic wind circulation at its core. Many of these depressions never develop into significant tropical storms.

This one was different.

Fueled by warm ocean water, its winds increased and it gained power quickly. By the time Hurricane Katrina slammed into the Gulf Coast on Aug. 29, 2005, it was a force to be reckoned with. Among the communities in its path was the small town of Diamondhead, Miss. Here, tornadoes and winds of 135 miles per hour howled through the streets, uprooting trees and sending some more than 20 feet in the air. The gusts tore off roofs and exposed homes and businesses to hours of soaking, devastating rain. On the south side of

Diamondhead, an unprecedented 26-foot storm surge pushed the waters of Bay St. Louis over its banks, flooding streets, destroying more than 350 homes and leaving survivors clinging to rooftops and praying for rescue.

When the rain and wind ceased and the flood-

In the wake of Hurricane Katrina's destruction, Raymond Sheehy's storm-resistant house escaped virtually unscathed.

waters receded, the damage was colossal. Katrina killed some 1,836 people and caused an estimated $81 billion in property damage, making it the costliest disaster in U.S. history. In Diamondhead, half of the town's 5,000 homes were destroyed, leaving thousands homeless. The tidy, planned community with its quaint Hawaiian street names looked as if it had been whirled through a blender.

Raymond Sheehy was one of the lucky ones. The 82-year-old not only survived the hurricane, but his home, located only seven miles from the Gulf Coast, was virtually untouched. However, he would be the first to say that luck didn't protect him from the ravages of Hurricane Katrina.

Careful planning did.

Hurricane protection figured into nearly every aspect of the 3,000-square-foot single-story house that Sheehy built in 1995. To avoid flooding caused by a storm surge, the U.S. Air Force retiree situated the house on a hill 70 feet above sea level. Aware that hurricane winds usually blew from the southeast, he placed few windows on that side of the house and flanked all of the windows with manual wooden "hurricane" shutters that could be closed and latched before a storm. Sheehy cleared all of the pine trees from his land because of their tendency to uproot during a storm. And to ensure that his roof would protect him and his wife, Pat, from the elements, he exceeded standard mitigation practices by using extra trussing to tie the roof and the walls together; he also covered the roof surface underneath the shingles with extra-thick plywood.

When Hurricane Katrina swept through town, the house didn't move an inch. In fact, the only damage to Sheehy's home occurred when a neighbor's pine tree toppled over onto his roof and damaged a small section of an aluminum ridge vent.

"When you walk around disasters like I've done, you don't want to live it," says Sheehy, who witnessed Atlantic hurricanes during his childhood in New Orleans, and South Pacific typhoons while working as a communications officer for the Federal Emergency Management Agency (FEMA). "People who have undergone hurricanes and typhoons have a tendency to be more cautious. The newer people who move here don't tend to think about it. I see them building houses, especially friends of mine, and I say, 'Why don't you do this to protect your home in a hurricane?' They tell me, 'I'm not worried about it.'"

Sheehy's response is always the same. "When the time comes," he says, "you're going to worry about it."

PEOPLE WHO LIVE ON THE

North Atlantic Ocean and Eastern Pacific Ocean call them hurricanes. Those on the Western Pacific Ocean coasts call the storms "typhoons." And in the Southwest Indian Ocean, these low-pressure systems are known as "cyclones." Whatever one calls them, the fact remains that these intensely destructive storms have been devastating coasts worldwide for centuries.

More than 20,000 people died when the Great Hurricane of 1780, the deadliest Atlantic hurricane on record, plowed through the Lesser Antilles in October 1780. Specifics on the hurricane's strength are not known, but the highest winds on Barbados during the storm are estimated to have exceeded 200 mph; the furious gales stripped the bark from trees before downing every tree and destroying every house on the island. A 25-foot storm surge on Martinique caused 9,000 deaths. Just offshore, about 4,000 French soldiers drowned when their fleet of 40 ships from the American Revolutionary War capsized. Other areas affected by the hurricane included Puerto Rico, Hispaniola (the Dominican Republic and Haiti) and Bermuda.

The Galveston Hurricane of 1900 was a Category 4 storm (see sidebar) that devastated nearly all of the buildings and bridges of the Texas city,

10 OF THE WORST HURRICANES IN WORLD HISTORY

Here's a brief look at the 10 worst hurricanes, typhoons and cyclones recorded worldwide over the last 300 years:

1. 1922 Swatow Typhoon, China Six days after the typhoon was spotted near the Caroline Islands in the Pacific Ocean, it hit the Chinese city of Swatow on Aug. 2, 1922, with winds of 100 miles per hour and a tidal wave that swept over 50,000 people. One of the deadliest typhoons ever to hit the northern Pacific, it killed some 60,000 people.

2. 1882 Bombay Cyclone, India This deadly storm, which began over the Arabian Sea as a result of a hurricane in progress, hit near Bombay, India, on June 6, 1882, and killed more than 100,000 people

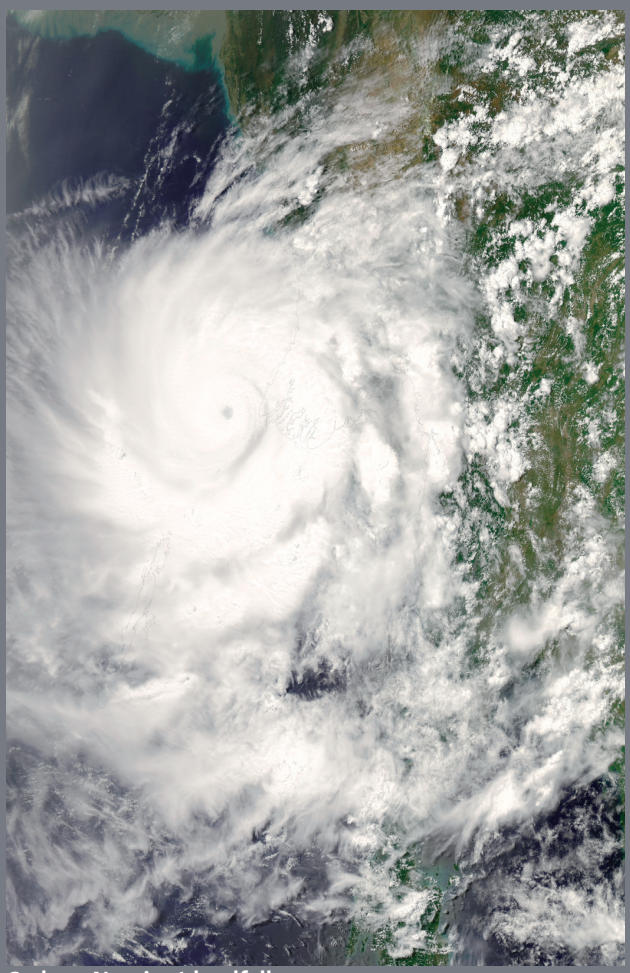
3. The 1991 Bangladesh Cyclone, Bangladesh On April 29, 1991, this powerful tropical cyclone struck the Chittagong district of southeastern Bangladesh with winds of around 155 mph. The storm forced a 20-foot storm surge inland, killing some 138,000 people and leaving as many as 10 million people homeless.

4. The Great Backerganj Cyclone of 1876, Bangladesh Formed over the Bay of Bengal on Oct. 27, 1876, this cyclone had a maximum wind speed of 136 mph and a surge of 45 feet. It killed about 200,000 people, half of whom died in the storm surge; the remainder succumbed to famine and disease following the storm.

5. Super Typhoon Nina, 1975, China One of the largest recorded typhoons in history and the second deadliest hurricane in the Pacific, this August 1975 storm made landfall in Taiwan with winds of up to 155 mph. The storm weakened as it made its way to China and missed most of the major cities, but its heavy rainfall caused the collapse of 62 dams, killed more than 100,000 people and caused $1.2 billion in damage.

6. 2008 Cyclone Nargis, Myanmar The worst natural disaster in the recorded history of Burma, Cyclone Nargis developed over the Bay of Bengal and gathered strength to attain peak winds of 135 mph. The storm made landfall on May 2, 2008, killed more than 138,000 people and caused damages estimated at more than $10 billion.

7. Calcutta Cyclone of 1737, India On Oct. 7, 1737, this cyclone destroyed nearly all of the thatched buildings in this city and killed 3,000 of the city's inhabitants, according to one report. Other reports from merchant ships indicate that the disaster was in fact an earthquake and tidal surge, which destroyed 20,000 boats in the harbor and killed 300,000 people.



Cyclone Nargis at landfall.

8. 1881 Haiphong Typhoon, Vietnam The most powerful storm of the Pacific, this cyclone struck on Sept. 15, 1881, and killed 300,000 people in Vietnam and surrounding areas.

9. 1839 Coringa Cyclone, India This storm made landfall with a 40-foot storm surge that killed 300,000 people, destroyed more than 20,000 boats and flattened the city.

10. 1970 Bhola Cyclone, Bangladesh The deadliest tropical cyclone ever recorded, Bhola struck Bangladesh and India's West Bengal in November 1970. A Category 3 hurricane with peak winds of 115 mph, it wiped out villages, destroyed crops and caused some 500,000 deaths, the majority from the 33-foot storm surge that flooded many of the islands of the Ganges River Delta.

SOURCES: Scienceray, Weather Underground

COURTESY FEMA

JOCELYN AUGUSTINO/FEMA

Above left, a special construction technique called "continuous load path" uses hangers and hurricane straps to stabilize a structure in severe weather, like that caused by Hurricane Katrina, which brought members of the U.S. Coast Guard out into the flooded streets for search and rescue operations.

which is located only 8.7 feet above sea level. Winds of more than 120 mph and a 15-foot storm surge knocked buildings off their foundations and pounded them to bits. Some 8,000 people—20 percent of the island's population—died in the storm, and more than 4,000 more succumbed when they were trapped under wreckage and could not be reached by rescuers.

In November 1970, the worst tropical storm in history, the Great Bhola Cyclone, struck the Ganges River Delta region of Bengal and East Pakistan and killed an estimated 500,000 people. It is believed that 90 percent of the population was aware of the cyclone before it made landfall—but only 1 percent sought refuge in fortified structures.

Each year an average of 11 tropical storms develop over the Atlantic Ocean. Lately that tally has been growing. The busiest hurricane season on record in the U.S. came in 2005, with 28 named storms and seven major hurricanes.

The resulting damages can be costly as well as destructive. In addition to punishing wind and rain, hurricanes also have tornadoes embedded in them; moreover, storm surges, which occur when winds push the sea into the land, can cause devastating floods. The average annual damage from tornadoes, hurricanes and floods in the United States is $11.4 billion, according to the National Oceanic and Atmospheric Administration.

During the last two decades, scientists have gained greater understanding about how hurricanes behave and that knowledge has drastically improved our ability to predict these acts of nature and fortify the property in their path. "We know more about the fury of hurricanes and how to protect ourselves from them," says Sheehy.

For homeowners, preparing for surges is largely about building homes at high enough elevations to remain safe. But there are lots of other steps people can take to make their homes resistant to hurricane winds and rain. Such efforts can be as extensive as a specially constructed foundation or as minor as the type of nail used to attach a roof shingle, says Mike Rimoldi, a construction specialist with the nonprofit Federal Alliance for Safe Homes. "Your house is only as strong as its weakest link," he says.

FOR SHEEHY, THE SPECIFICS

on his hurricane-resistant home came from a book published by FEMA called *Home Builder's Guide to Coastal Construction*. He had seen 750 houses built to the book's mitigation specifications when he was deployed to American Samoa in the South Pacific by FEMA. He recalls being impressed when only one of these houses was damaged after a 1991 storm, with 225-mph winds, slammed the island.

When Sheehy handed the book to his contractor in Diamondhead at the start of the project, the builder glanced at it and told him, "We already do this." Sheehy replied, "Not like this, you don't."

Sheehy's home has three reinforced laminated beams along the ceiling to enhance structural integrity and the roof's anchoring capacity. Traditionally, half-inch plywood is used to construct roofs, but Sheehy's roof is built with three-quarter-inch plywood attached to trusses that are 16 inches apart, rather than the usual 20 inches. In addition, he built a reinforced safe room in the center of the house that he and his wife refer to as a "scaredy hole." They use it as a place to store food and water, but in case of disaster the room has enough space for 12 people to safely wait out a storm.

When Katrina hit, residents in the area lost power for 21 days. Sheehy kept his diesel generator running and

never even had to turn off the air conditioning. In the days following the storm, his home sheltered not only a few neighbors, but several members of the state highway patrol. "There were some reports of looters so we were happy to have their patrol cars parked out front," he says.

For Sheehy, the extra safety measures added $5,000 to the cost of building his $128,000 home—a prudent investment, he says. "The biggest thing we have to do is to get people to understand that anything they can do will help," he says.

HOMEOWNERS HAVE LONG taken steps to protect their homes from hurricanes, but "best practices" have changed over time.

As a child growing up in Florida in the 1970s, Rimoldi remembers racing through his home during a hurricane, opening and closing windows at his mother's direction as part of an ill-conceived effort to equalize the pressure inside and outside of the house and prevent structural damage from wind gusts. The builder, who teaches hurricane mitigation classes to contractors, shudders when he thinks of it now. "We were placing ourselves at so much risk by opening those windows during a hurricane," says Rimoldi. His counsel today: Close all windows and doors, cover them with shutters, and stay away from them during a storm.

Statewide building codes—like the one that became effective in Florida in 2002 in response to the devastation wrought by Hurricane Andrew, and in North Carolina, South Carolina and Louisiana in recent years—have helped bring to the fore the best practices for building new structures. And new and improved building materials featuring the latest technology are constantly becoming available to builders. That's a good thing, Rimoldi says, because the stakes are high. "You don't have to have your house totally blown away to suffer a lot of damage," he says.

Consider this scenario: Take a typical ranch-style home located just in from the coast, and expose it to a Category 1 hurricane with 74- to 95-mph winds. The wind pulls a few shingles off the roof or takes out a window, thereby causing a breech in the building envelope, the boundary separating the inside from the outside. For the next day or two, rain pours through the hole, drenching the insulation and walls, destroying furnishings and creating a potential mold problem that could require the homeowner to seek temporary housing for several months until the damage is repaired.

"It doesn't take a big hole in the roof or a lot of water to cause a lot of damage," Rimoldi explains. "If you've ever had a plumbing leak in your house, you know that one of those lines only has to run for a couple of hours and you have soaked furniture, flooring and drywall, and then you have to worry about mold."

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To retrofit a home in preparation for a hurricane, Rimoldi suggests strengthening the building envelope. First, if you are in need of a new roof, make sure that you install an enhanced roof covering material that's tested and approved for your location, as well as the wind speed and pressure it will be exposed to. "It doesn't matter whether it's shingles or tile," he says, as long as it's code approved.

Next, it's important to strengthen the connection where the roof eaves meet the top of your walls by using specially made metal connectors that are much stronger than nails. The wind uplift in a roof can easily be two to three times the force of gravity. "Testing and field studies show that having that little piece of metal in there as an enhancement makes a big difference," Rimoldi says.

Finally, cover all openings in the house—windows, doors, garage doors—to protect glass from breaking and doors from blowing in. "For windows, we stress that people use permanent shutters, the kind specifically made for windows, because when people put plywood up they don't always do it properly," he says. "If it gets blown off by wind, then you have a big sheet of plywood blowing through the neighborhood."

FOR YEARS, SCIENTISTS USED what they learned from surveying storm damage in the field to inform the best methods and products for hurricane protection. Now they can find more precise answers in the lab—thanks to full-scale testing of structures.

Seven years ago, Stephen P. Leatherman, professor and co-director of the Laboratory for Coastal Research at the International Hurricane Research Center, helped develop and build a storm simulator in Miami known as "The Wall of Wind"—the world's first full-strength hurricane machine. Using six 500-horsepower engines, the lab can produce winds of up to 120 mph. It has been used to test a variety of products and technologies and has generated some compelling data. "In a nutshell, we are gaining better understanding of how to keep a roof on," Leatherman says. "That's important because if you don't keep your roof on, everything is going to be lost."

Experiments using the simulator have shown that ring shank nails, which screw into wood, are more effective than smooth nails at keeping plywood secured to roofs. In addition, researchers have discovered that soffits, the area underneath the edge of a roof, need to be strengthened so they don't let in water during a storm. "Before we did our tests, a lot of people just thought soffits needed to be covered for cosmetic reasons," says Leatherman. "Instead of being covered, they need to act as more of a shield."

In October 2010, the Insurance Institute for Business & Home Safety (IBHS) opened a $40 million state-of-the-art research center in Richburg,

COURTESY IBHS

A member of the Institute for Business & Home Safety stands before one of 105 test fans that generated winds of about 100 mph. Above right: While the house without fortification collapsed after high winds, the fortified home remained intact.

S.C., that takes the technology Leatherman helped develop to new heights. Funded entirely by the insurance industry, the center features a 105-fan wind tunnel capable of generating Category 3 winds of 130 mph—and a 21,000-square-foot chamber, large enough to test one- and two-story structures, with rain capacity equal to 8 inches per hour.

"We've never had the ability to take full-sized structures with all of the real materials—shingles, siding and so forth—in their full-sized configuration and test them under realistic wind conditions," says the IBHS' Timothy Reinhold, senior vice president and chief engineer. "What we are trying to create in the lab are real-life settings."

For the next few years, IBHS is focusing on roofing and will be testing such products as roof covers, roof equipment for commercial buildings, secondary water barriers and flashing.

However, because all of the structures they will be testing will have walls, windows and doors, researchers also will have an opportunity to observe how these behave in hurricane conditions.

Already the scientists in the IBHS lab have made some interesting discoveries. While preparing a video to show the difference in how a hurricane-resistant structure and a non-mitigated structure performed in high winds, Reinhold's builders used current design specifications to strap together the second-story exterior walls with the second floor of the fortified structure. However, when both structures were exposed to 100-mph winds and their front doors were opened, the fortified structure's walls began expanding out like a balloon from the pressure, and it nearly blew away.

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>
> —Timothy Reinhold, IBHS chief engineer

"We found that it only took an extra $20 in strapping materials to secure the structure, but it made a big difference," Reinhold says. This was a modification that wasn't in any of the current design guides or building codes—something they never would have discovered without the lab.

"Looking at some of these systems issues is what we see as a real power of this facility," he says. "What we want to do is help people analyze homes so that we can put the right amount of strength in the right places."

SEVEN YEARS AFTER HURRICANE

Katrina came through Diamondhead, the small Gulf Coast town has mostly returned to normal. The debris has been cleared, trees have been replanted, and residents have rebuilt lost and damaged homes with stronger structures better suited to surviving wind, rains and flooding. People seem to have gotten the message that hurricane mitigation is important, Sheehy says. "If you go around Diamondhead now, I'd say 40 percent of us now have generators," he says.

But despite the fact that the most destructive storm in U.S. history is now behind him, Sheehy isn't about to let his guard down. Not long ago he replaced the original windows in his house with impact-resistant windows that can withstand the force of a 2-by-4 hurtling into them at a speed of 230 mph. And every other Sunday, he and his wife take turns running the generator for two hours just to make sure that it's working.

There are hurricanes coming, and Sheehy just wants to be prepared. "We skated this year, but after a big storm you usually have a lull," he says. "I think next year we are going to get hit."

COURTESY NOAA

Looking southeast in the eye of Hurricane Emmy.

Measuring Intensity

CATEGORY	SUSTAINED WINDS	POTENTIAL DAMAGE
1- Minimal	74 to 95 mph	Damage primarily to shrubbery, trees, foliage and mobile homes. No real wind damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.
2 - Moderate	96 to 110 mph	Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major wind damage to buildings. Considerable damage could occur to piers. Marinas flooded. Small craft may be torn from moorings.
3 - Extensive	111 to 130 mph	Foliage torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. Serious flooding at coast and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris.
4 - Extreme	131 to 155 mph	Many shrubs and trees blown down and most street signs damaged. Extensive damage to roofing materials, windows and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. Major damage to lower floors of structures near shore, due to flooding and battering by waves and floating debris. Major erosion of beaches.
5 - Catastrophic	Greater than 155 mph	Shrubs and trees blown down; considerable damage to roofs of buildings and all signs damaged or destroyed. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes.

SOURCES: National Oceanic and Atmospheric Administration, National Weather Service, National Hurricane Center