Chasing the Hurricane

Full-scale measurements, combined with laboratory testing of hurricanes, improve housing structures so that they can withstand nature's most powerful storms

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Damage to townhouses in Biloxi, Mississippi caused by Hurricane Katrina.

Humans build homes and Nature tests them. This has perhaps never been more true than in 2005, when three of the largest hurricanes on record tore up the coastal regions of the Gulf of Mexico. In 2004, four hurricanes made landfall in Florida, and 2006 introduced itself with tornado outbreaks that killed more the 20 people in the U.S. Midwest in early April. In Australia, 2006 saw the largest tropical cyclone on the eastern coast in three decades. Tropical Cyclone Larry was a Category 5 at its peak, with wind speeds estimated at 180 mph. Larry eventually made landfall with Category 4 wind speeds.

KEEPING AN EYE ON THE STORM

Houses are complex structures. There is wide range of shapes, sizes and construction methods, as well as variability in the materials and installation. There is also variability in the wind speeds and turbulence houses experience during storms. Thus, the damage resulting from extreme winds is also variable. This variability of damage makes it difficult to establish standard designs that can withstand a specified level of risk. Controlled testing is necessary and should be used with statistically-based, post-storm damage surveys. The link that ties controlled testing with damage surveys is the detailed measurements collected during storms.

A popular joke in the wind engineering community is that the best insurance to protect a house from a hurricane is to install instrumentation to measure the wind loads. Hurricanes are relatively rare events at any given location; recording measurements is therefore a difficult endeavour. The Florida Coastal Monitoring Program, led by Professor Kurt Gurley at the University of Florida, is making the act of recording wind loads easier with their portable, real-life experiments. They have placed instrumentation in more than 20 houses along the Florida coast and have six portable, yet robust, towers to measure the wind speeds near these houses. The towers are designed to sustain 200-mph gust wind speeds without overturning or sustaining damage. This active form of research, in which researchers go to the storm, eliminates the problem of waiting for an unpredictable amount of time to observe a rare event at a given location. The program, active for seven years now, is providing valuable information about wind speeds houses face during a storm, the wind loads, and damage to adjacent structures under nominally similar conditions.

WHEREWITHAL TO DAMPEN DAMAGE

Gurley and his team have been busy during the past two summers. They have chased storms and performed statistically-based damage surveys, capturing details of the damage, once the homeowners have their claims data. This comprehensive approach has helped lead to improvements in new house construction. Information the team collected, for example, led to an update to the Florida code in 2001, following the destruction caused by Hurricane Andrew in 1992. Gurley's subsequent research indicates the new houses are holding together better, code compliance is up, but that losses due to water penetration are still excessive.

David Henderson of the Cyclone Testing Station at James Cook University in Australia has done similar research. His work, based on the damage caused by Larry, has helped to analyze construction standards revised in the mid-'80s. Henderson found that older homes performed poorly under Larry's winds, even homes that had been retro-fitted for improvement (as a result of poor detailing).

If the 2004 Florida hurricanes proved it is possible to improve the resiliency of houses to wind, Hurricane Katrina illustrated there are still a number of problems concerning where and how houses are being built.

In Katrina, the two largest sources of losses were the storm surge, which devastated buildings right on the coast, and the levee failures in New Orleans, which led to extensive flooding. Wind damage, though widespread, was not as devastating; it accounted for roughly US$10-20 billion of the US$120 billion reported in total losses.

Wind speeds in coastal Mississippi were less than the design wind speeds, suggesting not much wind damage should have been observed. There were structural failures, but most damage resulted from cladding and roof cover failures. The cause of these failures seems to be poor attention to detail.

Townhouse complexes in particular did not fare very well. Stapling siding onto a structure, for example, is just not a good idea in a hurricane-prone region. Nails missing trusses was a big issue for buildings struck by Hurricane Andrew and this problem persists today.

The close proximity of many sources of debris (such as the shingles and siding), in combination with a lack of window protection, may have exacerbated the problems with the townhouse complexes. However, one positive observation can be made: there appeared to be limited wind damage in older neighbourhoods with mature trees.

Researchers set up a 10-metre-high tower just hours prior to Hurricane Dennis making landfall. This tower measured a three-second gust speed of about 120 mph as Hurricane Dennis' eyewall passed over Navarre, Florida.

Gregory Kopp (top left) participated in the Florida Coastal Monitoring Program a day before Hurricane Dennis made landfall. The grey "dishes" on the roof of the house are pressure transducers that collect information on wind loads affecting real houses during hurricane conditions. The houses are pre-wired so a team of four can set-up the "experiment" in about two hours.

DEMYSTIFYING DAMAGE BEHIND THE SCENE

Damage surveys indicate where the problems are and laboratory testing allows factors that are widely variable in the field to be examined in a controlled way. Modern wind tunnel testing of structures for wind effects began in the '60s with a study of the World Trade Center towers in New York. The approaches developed for that project led to new methods of experiments and analysis for wind loads along with the implementation of improved building codes and design protocols.

Forty years later, much has changed; still, wind tunnel tests represent the state-of-the-art in determining wind loads notwithstanding Professor Gurley's work. The other side of the equation – how strong the structure actually is – involves full-scale testing.

The Cyclone Testing Station, formed after Tropical Cyclone Tracy destroyed Darwin, Australia in December 1974, pioneered the first full-scale tests. These tests indicated the strength of complete structures and their component parts. In one important example, they showed that drywall provides sufficient resistance to the horizontal wind forces in framed construction.

A new research facility in London, Ontario, supported in part by the Institute for Catastrophic Loss Reduction (ICLR), is called the Three Little Pigs project. (See *Canadian Underwriter*, April 2006). It is expected to make a significant contribution by performing tests that will link accurate wind tunnel loading data with full-scale structural testing. The results are anticipated to close the loop on understanding and mitigating hurricane wind damage.

The result should be a more resilient housing stock, built to fend off the worst events that nature can throw at us.

Soil characteristics caused this tree to fall on a house in Picayune, Mississippi during Hurricane Katrina.

TREES: FRIEND OR FOE?

There is an ongoing debate about whether trees offer a net benefit or a net cost to homeowners and insurers. Anecdotal evidence from Katrina indicates there is a significant benefit to having many trees around, as they protect houses from the wind. The downside is that when a tree falls on a house, it is almost certain to cause significant damage. Also, risk of fire increases when trees are in close proximity to houses.

Tree blow-over was a significant issue in '03 during Hurricane Juan, which made landfall in Nova Scotia just west of Halifax. Millions of trees blew down, including about 400,000 in Halifax alone. This poses a serious challenge to the forestry industry: it needs to harvest the lumber quickly following a hurricane so that it does not go to waste.

Storm surge as high as 30 ft in Biloxi, Mississippi destroyed most of the structures right on the coast.

WILD WATER WEATHER

Katrina was really about the water - specifically the storm surge along the gulf coast and the flooding in New Orleans. The storm surge from Katrina was about 30 ft high in Biloxi, Mississippi. Even though the winds had diminished somewhat as the hurricane made landfall, Katrina's large size over the Gulf led to Category 5 surge levels.

Measurements contribute to preparing for and understanding natural catastrophes - which seem to be on the rise in both frequency and severity - but it is important to understand the variable reality of nature. One of Kopp's engineering colleagues, for example, said he would live in New Orleans because, now that it had been hit, it would not be hit again. But recall the area was hit by the storm surge of Hurricane Camille in '69, leading to similar destruction. So, as history does seem to repeat itself, an event like Katrina may likely strike again. CU