Shingle Damage: In the Eye of the Storm

New research is trying to get a true measure of wind speeds and shingle damage in order to help model for hurricane damages.

Damage surveys following major wind events are critical for identifying potential problems with building codes, construction practices and building products.

In order for the surveys to be of value, it is necessary to know the wind speeds that caused — or did not cause — damage, since all design is based on the induced forces at particular wind speeds. This is more challenging than it may appear: wind speeds in the neighbourhoods where houses and other buildings have been damaged are rarely measured.

Usually, the only direct measurements of ground-level wind speeds are at airports or other weather stations. But these are sparsely spaced, are often far from where the hurricane makes landfall, and often do not function during the storm because of power outages.

Although ‘hurricane hunter’ aircraft measure wind speeds in the hurricane, these are far above ground and assumptions have to be made about what is happening down where the houses are. Hurricane hunters nevertheless provide valuable data for input to numerical models, which are getting increasingly better at predicting or estimating surface wind speeds.

Recently, there has been a significant effort to get portable anemometers into storms; at least three different groups are now making these measurements routinely. In the 2004-05 hurricanes, these groups tried to find the highest wind speeds in the hurricanes, since hurricanes are categorized by these speeds on the Saffir-Simpson Scale.

More recently, the emphasis has shifted to relating the speeds in open areas near the coast, where the highest speeds are found, to those in suburban neighbourhoods, where the majority of houses are.

**DIRECT OBSERVATION**

Photograph of tower belonging to the Florida Coastal Monitoring Program of the University of Florida, deployed in a suburban neighbourhood in Houma, Louisiana during Hurricane Gustav. This tower measured peak gust wind speeds of less than 80 mph. The house in the background was undamaged.
Hurricane Gustav was not a particularly powerful storm, although it is estimated to have caused upwards of US$10 billion in damage. And yet, despite the damages related to Gustav, its wind speeds were significantly lower than those used for design in this area. Measured peak gust speeds in Houma were about 80 mph, while the design speed for the region is 140 mph.

Much of Gustav’s damage was caused by flooding and storm surge. But wind damage also played a role, with much of the media attention focused on Baton Rouge. However, much closer to coast, where wind speeds are highest, the eyewall passed close to Houma, Louisiana, an area which had been hit by the 2005 hurricanes. This provided an opportunity to evaluate recent construction and measure wind speeds in typical suburban neighborhoods. University of Florida researchers, Drs. Forrest Masters and Kurt Gurley and their team positioned 5 portable towers in several neighborhoods in and around Houma and then waited for Gustav to arrive.

One of the advantages (for researchers) of a hurricane making landfall during the day is that you can see what is going on. And what we saw surprised us. Shingles were coming off everywhere, even in the weaker winds in the range of 40 to 60 mph prior to arrival of the eye of the storm. What was worse is that these failures appeared to be particularly bad for the new houses built since Hurricane Rita in 2005. When you can stand outside in the wind, effortlessly, and watch things coming apart, you know there is a problem.

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GUARANTEE FOR SUCCESS – LET US SHOW YOU HOW

Photograph of a recently-constructed house in Houma, Louisiana the morning after Hurricane Gustav made landfall. The general lack of debris indicates a relatively minor wind event, although one cannot see all of the shingles in the backyard that flew off from the front of the house. Note that this area had been evacuated and no one had yet returned to clean-up; we were the only people here except for Emergency Response Personnel.

As a result of these observations during the storm, the team decided to conduct a damage survey on the following day of more than 1,000 houses in Houma, in randomly chosen streets, but covering every quadrant of the city. It was apparent that shingle failure was the
only real issue in Houma, aside from the
downed power lines and trees, so our
damage survey focussed on this issue
alone. It seems that the problems were
primarily with new construction with
relatively high roof slopes and few trees
around. Preliminary analysis suggests
these failures may have been due to insuffi-
cient connection between the adhesive
on the underside of the shingle,
with the roof. This led to shingle tabs
flipping over and pulling the shingles
over the nail heads. The close-up photos
show this in detail:

Aside from direct costs associated with
the replacement of the roofing material,
other potentially more significant costs
can arise from these types of failures.
One is obviously water penetration,
while the other is more indirect, namely,
the costs associated with damage when
the shingles become wind bourne and
impact adjacent structures. Fortunately,
neither seems to have played much of a
role during Gustav because of the low
wind speeds. One wonders what would
have happened if the wind speeds had
been much higher.

To answer that question, we have been
conducting wind tunnel studies at the
University of Western Ontario on shingle
and roof tile flight in order to assess the
risk due to shingles impacting and pen-
etrating adjacent houses. We have found
several surprising facts, perhaps the most
important pertaining to the flight speeds
of the shingles. Typically, shingles can fly
at speeds in the range for 50% to 120%
of the undisturbed, upstream gust wind
speed. This is a large range and is due to
the nature of the turbulent wind gusts.
While the shingles do not fly faster than
the wind (actually they can, but there is
not space to explain that interesting fact
here), wind is actually accelerated above
the roof of the house. Since the shingles
are so light, they also accelerate quickly,
leading to these high flight speeds. What
this means, practically, is that they carry
a lot of energy and the potential to break
windows. They can also travel very far.
Just as important for answering the
question above, is to determine the flight
speeds which break windows, and such
research is currently being conducted
at the University of Florida using full-
scale impact tests. We have just begun to
link the data from these two types of
experiments.

As this research progresses we will be
able to link all of this observational data
in loss models which consider typical
neighbourhood layouts, shingle loss fre-
quencies (from damage surveys such as
these, sponsored by the Institute for Cata-
astrophic Loss Reduction), the flight dis-
tance data (from the wind tunnel tests),
and the full-scale impact test results to
develop probabilistic models for shingles
hitting windows and breaking them.
This is then linked to observed financial
costs associated with the broken win-
dows (due to water penetration and po-
tential subsequent roof or sheathing
failures due to internal pressurization)
so that expected losses versus wind
speed can be established. Relating storm
wind speeds in open areas near the coast
to wind speeds in the typical suburban
and urban neighbourhoods (from ob-
served tower data) is required for such
models. Of course, loss models already
distinct, but the point to be made here is
that it is of critical importance to incor-
porate all of this new information so that
they are based on the most accurate en-
gineering data available. These same data
are also critical for the development of
loss mitigation strategies, modifications to
building codes, identification of code en-
forcement issues, and improvements to
product tests. All of this starts by riding out
the storm to get that data accurately.

SHINGLES, HIGH WIND SPEEDS

Typical flight distances observed in wind
tunnel experiments. Note the great vari-
bility and that typical trajectories are
further than the distance between houses.

SHINGLE DISTRIBUTION PATTERN

Close-up photographs showing typical
shingle failures with the nails still in the
roof (left) and one of the shingles that
came off with two nail holes visible (right).

Close-up stroboscopic image showing a
single realization of shingle flight from
the roof of a house in a scale model wind
tunnel study. In this image, the shingle
fails in the lower right, gets caught up in
high speed flow at the roof edge, and ac-
celerates upwards, eventually moving
downstream with a speed higher than
the gust speed upstream of the house
that actually caused the failure.