The Wind Whisperer

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Editor

Dr. Gregory Kopp, a professor of civil engineering at Western University, is a central figure in researching wind damage in aid of building safer homes.

Who has seen the wind? Dr. Gregory Kopp has.

Kopp is a professor in civil engineering at Western University in London, Ontario. His observations regarding the effects of wind forces on houses is a key factor in helping the Canadian property and casualty insurance industry advocate for building safer homes.

For more than a decade, Kopp has worked on the so-called Three Little Pigs project, which essentially replicates wind pressure and applies these forces to a full-scale house to see how it breaks. Kopp's research, funded in part by the Institute for Catastrophic Loss Reduction (ICLR), has provided the basis for recommendations the insurance industry can make to improve building codes.

Kopp, 45, has always been fascinated with wind and turbulence. A Winnipeg native, he studied mechanical engineering at the University of Manitoba. A professor convinced him to get his Master's degree at McMaster University in Ontario. He then went to the University of Toronto to complete his Ph.D. in mechanical engineering.

Kopp had an early interest in fluid mechanics and air turbulence. "Think of turbulence as smoke coming out of a stack on a cold winter day — you can see the vortices swirling, and the whirls are all in different scales," he says.

"It used to drive my wife nuts when we went camping and I would look at the smoke in the fire. That's always what I really loved."

Kopp's research evolved to an interest in the wind's forces after he applied for a position at Western University. The university had a Boundary Layer Wind Tunnel founded by Dr. Alan Davenport, a researcher who played an important role in the early founding of ICLR. Established in 1998 by Canada's P&C insurers, ICLR is an independent, not-for-profit research institute focusing on disaster loss prevention research and education.

"The ICLR was really instrumental in looking at houses," Kopp says. "I wouldn't have looked at houses otherwise. Very few engineers would, because they are not engineered structures. They are not as sexy, say, as a mile-long bridge or a super-tall building, so you tend not to get as many people looking at them. But from a disaster point of view and a societal point of view, when there are disasters, houses suffer disproportionately because they are not engineered."

Kopp's early work involved developing a wind pressure loading system that could be applied to a large-scale model house. "We knew we had to do full-scale houses to understand how they come apart," he says.

Very few engineers would look at houses, because they are not engineered structures. But in a disaster, houses suffer disproportionately because they are not engineered.

"The reason is that the materials in a house are quite variable. You are dealing with wood, which has knots and is bent and is put together by human beings, who are in a hurry. You put nails in, it cracks the lumber. Drywall is not an engineering material. You have the brick on the outside. So you have all of that variability, you don't know what all of these things do. To understand how a house comes apart, therefore, you have to build it full-scale."

How do you apply hurricane-force wind loads to a full-scale house for experimental purposes? It would cost about $30 million to build a wind tunnel big enough to encompass a full-scale home. "We thought for under $10 million, we could get this Three Little Pigs project, which was under budget at $7 million," says Kopp.

The pressure loading system at the core of the Three Little Pigs project is designed primarily around a system of 100 parts known as "pressure loading actuators." Each costs $20,000 to build for a grand total of $2 million. "We jokingly call it a vacuum cleaner," Kopp says. "It looks like a vacuum cleaner, but there is a lot of intelligence in the software that runs the thing."

If you see the device inside the lab in London, Ontario, it looks like a lot of different-sized airbags connected to the roof of a two-storey model home. A ladder takes you to roof level, where a number of 'vacuum cleaner' hoses are attached to the airbags.

"We are representing wind forces, so when wind moves over the surface of a building, it creates pressure on that surface," Kopp says. "We are just replicating those pressures. We can get up to about 20 kilopascals, 400 pounds per square foot. That's a huge structural load. That's the worst kind of load you could get in the worst hurricane possible. Hurricanes were foremost in our mind."

In fact, eye witnessing the destructive force of hurricanes allowed Kopp to see the practical application — and value — of his research. Kopp was at a pivotal moment in 2005, when he had to decide which of several research streams he might follow. At that point, Florida researchers asked him down to help them prepare instrumentation for observing Hurricane Dennis.

"I thought, 'Well, if I'm going to be breaking stuff in the lab, I really had better go and see what's happening out in the field.'" Kopp says.

"That was the first hurricane I was in. It changed my life. After that, I realized we have to jump into this [research] with both feet because it's important. It's going to make a difference to people's lives."

Hurricane Dennis hit the Florida Pandhandle as a Category 3 storm packing winds of between 120 mph and 125 mph. Just before the storm hit, Kopp was feeling the rain sting as he set up the instruments on the houses to measure pressures on houses and wind speed.

"I remember the emergency personnel had already left," Kopp says. "We were the last people there, setting up the towers. Then we were driving a big F-150 pickup truck at 80 miles an hour, and there are gusts of 80 or 90 miles an hour. It's a little frightening, because you know what can happen."

The crew members drove three hours away and bunkered down in a hotel. The next morning, they drove back to pick up their gear and start doing damage surveys.

"Dennis did a lot of damage there," Kopp says. "It was what I imagined Beirut would look like after the civil war there. There was a highrise building that just a concrete shell. A building beside it had been built to a higher standard: it had a couple of broken windows and that was it. You had these buildings side by side, so you could see the difference. You really got the sense of what mitigation can do."

Kopp's experiments indicate two ways to mitigate damage to a house in a hurricane. Essentially, if roof fasteners weaken and the roof flies off the house, the walls collapse. But even if one plywood sheathing comes off, the water entering the hole in the roof can destroy 80% of the home's contents, making the place a total write-off for insurers. Using more nails to connect the roof sheathing can help prevent damage to the roofs, Kopp's research shows.

"In the damage surveys, you rarely see broken lumber," Kopp says. "What you see are connections that have failed. That's why we focus on the nails, because that's what actually fails."

Kopp says a beer case worth of additional nails can make a big difference to the strength of the roof. Also, hurricane straps, thin pieces of steel that connect the roof to the walls, can be built into new homes for a cost of $200 or so.

"We're trying to effect these changes through the building codes," Kopp says. "ICLR and the insurance sector can play a big role in helping us get the research out there. They can say, 'These are the losses, here are the costs.'"

In the future, Kopp sees research being able to determine the impact of product endurance on the failure of connections. He also sees research evolving towards studying the effects of water. For example, if shingles fly off the roof, but the roof stays fastened, water damage can occur, causing significant insurance losses when the contents of the house get wet.