Inexpensive roof vent could prevent billions of dollars in wind damage

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(top) Engineering science and mechanics doctoral student Yihong Yang installs the V2T prototype roof vent in the Virginia Tech stability wind tunnel. Photo courtesy of Michael Miller, Virginia Tech Intellectual Properties. (bottom) One of the buildings on which the V2T roof system is in use is KnowledgeWorks in the Virginia Tech Corporate Research Center. Photo courtesy of Pat Johnson, Acrylife.

Hurricanes often lift the roofs off buildings and expose them to havoc and damaging conditions, even after the worst of the wind has passed. A local roofer, Virginia Tech faculty members from architecture and engineering, and a graduate student have devised an inexpensive vent that can reduce roof uplift on buildings during high winds, even a hurricane.

Low-sloped roof buildings around Wytheville, Va., where Virginia Tech alumnus Chuck Johnson and his brother, Pat Johnson, operate a roofing business, have sprouted foot-high plastic structures that look vaguely like alien technology – a flying saucer connected by three narrow columns to a dome.

Chuck Johnson, an irresistible pitchman, has also persuaded Travel Centers of America in South Carolina, the Gaston County government complex in North Carolina, a Nestlé's distribution center in Tel Aviv, Israel, and VTKnowledgeWorks in the Virginia Tech Corporate Research Center to use the revolutionary Venturi Vent Technology (V2T™), designed for membrane roofing systems.

Hurricane Andrew, which made landfall on August 24, 1992, resulted in $26 billion worth of damage. It was the first big event that created changes in the roofing industry, said Johnson. "Now, so many fasteners are required that roofing is very expensive and the integrity of the deck is compromised," he said. "Plus, if you ever have to take the roof off, you have to take it off in pieces and recycling the material is impossible. It's all very labor intensive."

But the Venturi Vent Technology system could revolutionize the way roofing is done, Johnson said. "We are using physics instead of mechanical fasteners or adhesives. The harder the wind blows, the better it works."

The physics is the Venturi effect. You know – wind forced through an opening speeds up. Covered porches create a breeze. Winds blow harder through mountain passes and between city buildings. Cars at any speed split the air, so when you crack the car window to get rid of cigarette smoke, the lower pressure outside sucks the smoke out the window.

Sitting at their kitchen table about six years ago, the Johnson brothers asked, “What if we could split the wind blowing over a roof and create a vacuum to suck the roof down instead of up?”

The result was V2T.

V2T splits the airflow, speeding up the wind that is forced through the vent (between the upper saucer and the lower dome), which drops the pressure and creates a vacuum. The saucer has a hole on the bottom and the columns are tubes from the saucer to the dome and the underside of the roof membrane. The wind pressure draws the air out of the saucer and from under the membrane, pulling the membrane down tight against the substrate. “The pressure being created under the membrane is lower than the uplifting pressure of the wind over the roof. The result is a low pressure condition that prevents the uplift and detachment of the roof membrane,” said Jim Jones, associate professor of architecture at Virginia Tech.

The Johnsons took their idea to Virginia’s Center for Innovative Technology (CIT), which referred them to Jones. “Their concept was a tube shaped vent that would rotate to catch the wind,” Jones said.

He saw that keeping up with changing wind direction could be a problem and decided to investigate whether the Venturi concept could be applied to an omni-directional design “so it wouldn’t matter which way the wind came from.”

Jones and his graduate student, Elizabeth Grant, started exploring the geometry of a pyramidal base with an inverted pyramid on top – like an hour-glass with a space in the middle for the wind to pass through. They presented that idea to Demetri Telionis, the Frank Maher Professor of Engineering Science and Mechanics, an aerodynamics expert, who suggested a similar but rounded shape – the dome and saucer. "Once we decided on the geometry, the fine tuning became Grant's thesis. She created a model with an adjustable distance between the dome and bowl and began wind-tunnel tests."

Grant was already an experienced architect and designer whose credentials included affiliation with the Roof Consultants Institute. She made the project her master's degree research with the other members of the design team as her thesis advisors.

With funding from Virginia's Center for Innovative Technology and the Johnsons' company, Acrylife, the team designed and built several prototypes – with different shapes, distances, and connecting columns, with the goal of enhancing the vacuum -- and tested them in Virginia Tech's stability wind tunnel, where winds can reach 150 miles an hour, and in the NASA full scale wind tunnel at Langley Air Force Base. These tests demonstrated the ability of the vent to generate low pressure that could be used to counter the uplifting forces from high winds.

View a clip of the V2T roof vent doing its job on a very windy day. [Quicktime] (Movie courtesy of Acylife.)

The team figured out how to take a force of nature and harness it, using geometry and physics, "So the very force that could destroy a building is used to save it," Grant said.

The height of the dome was partially dictated by consideration of rain and snow levels on a roof, Jones said. "The hole was placed in the bottom of the bowl to avoid admitting water. So with the hole in the top unit, the columns had to be hollow."

Jones said at least two questions remain to be answered. One is concerned with the spacing of the units. Although Johnson has a degree of confidence in the current spacing, he agrees. "It is important to verify this with testing in order to take out the guess work. We need to establish a set of rules that define where the units should be placed for each different roof type."

Jones suggests, "To maximize the economic benefits of the V2T, spacing should depend on a variety of factors, such as building geometry, parapet wall height, and infiltration rate through the roof deck; and therefore some further study is needed."

The second question, Jones said, is "What happens to the vacuum that holds the membrane down if there are cracks in the substrate or sub roof? We have scheduled a series of wind tunnel tests to better understand this situation as we begin to develop design guidelines for the system," Jones said.

Underwriters Laboratories testing, commonly known as UL testing, is also scheduled for June. UL testing is the standard for household and commercial products.

Meanwhile Acrysoft, with an introduction and funding from Virginia's Center for Innovative Technology, is developing hardware and software to provide real-time monitoring of the vent. A sensor board developed in conjunction with the Space Alliance Technology Outreach Program will measure the pressures created in the vent and the forces on and under the roof membrane, said Mark Howard, a partner at Acrysoft. "This information has not been available."

He said such data is critical to engineers. “They want this data before their company invests in a roof system,” said Howard. The sensor, along with cameras, will substantiate initial performance and provide long-term monitoring, “for example, in case there is a tear during an (air conditioning) AC repair or some other activity on the roof,” Howard said.

Although the Johnson brothers have been putting their systems on roofs, it would be better if it were provided to roofers by the manufacturers of the roof membrane materials as part of a complete roof assembly, said Chuck Johnson.

Source: Virginia Tech

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