

Lessons Learned from 2004 Florida Hurricanes

By STEVEN MOSCOWITZ

Even as we continue to view images of hurricane devastation remaining in the Gulf Coast and eastern North Carolina from 2005's storm season, roofing professionals

from RICOWI (Roofing Industry Committee on Weather Issues) and SPRI (Single Ply Roofing Industry) are in the final phase of analyzing data collected in Florida just after the 2004 hurricanes.

It may be a dim memory, given all that's happened since, but in 2004, Hurricanes Bonnie, Charley, Frances, Ivan, and Jeanne crisscrossed various parts of Florida, leaving virtually no portion of the state unscathed. Each presented a set of unique wind-event anomalies, allowing teams of RICOWI investigators to fan out over the storm-battered Sunshine State to examine a representative sampling of more than 50 single-ply roofing systems that either failed, were damaged, or remained intact.

"Many people claim that as buildings be-

come more energy efficient, they also are more susceptible to damage," said André Desjarlais, a member of the RICOWI team from the Oak Ridge National Laboratory in Tennessee. However, energy-efficient buildings are also better designed structures.

That was just one preliminary finding by RICOWI, but the emphasis of the mission was to formally document the performance and damage that occurred to roofing systems during substantiated hurricane-level wind speeds.



Pensacola School Building 1: RICOWI inspectors found pressurization and billowing at overhangs. There were cleat deformations and disengagement of edge metal. The cleat gauge was less than currently recommended by FM Global LPDS 1-49 and ANSI/SPRI ES-1. Corrosion reduced effective uplift resistance. Overhangs need to be designed and constructed to resist higher loads. (Source: André Desjarlais's Oak Ridge National Laboratory report, "RICOWI and its Investigations of Hurricanes Charley and Ivan")

About the Study

The RICOWI field performance investigations of roofing assemblies were specifically conducted on structures that were in the direct paths of Hurricanes Charley and Ivan.

The study was jointly funded by the roofing industry and the U.S. Department of Energy (DOE). The government was interested in determining if energy-efficient roofing installations, advocated by the federal agency, would exhibit favorable performance characteristics in the presence of hurricane-force winds.

Following its landfall on Friday, August 13, 2004, near Punta Gorda, seven teams of investigators were deployed to conduct 90 inspections from August 18-21. After Category 3 Hurricane Ivan, another five teams were deployed to conduct 75 additional inspections from September 22-25 near the Florida and Alabama borders.

David Roodvoets, RICOWI Wind Event coordinator, who is also a technical director for SPRI, headed the study.

All types of low-slope and steep-slope roofs were included in the study, including roofing systems with SPF, TPO, BUR, EPDM, and vinyl membranes, Roodvoets explained. Three attachment methods were studied – mechanically-attached, adhered, and ballasted – but all combinations of membrane and attachment types were not available in the field. The study was limited to approximately 24 single-ply roofing systems, restricted primarily by the available time allotted for data collection.

“The study was somewhat opportunistic for low-slope roofs. We tried to concentrate on essential facilities such as shelters, schools, hospitals, fire, municipal, and postal facilities,” Roodvoets said.

For purposes of comparison, the RICOWI teams of investigators selected geographic areas where significant damage occurred, as well as areas where damage was minimal. All roofing systems investigated sustained some damage, and patterns developed after analysis of the inspection reports.

Buildings closest to the ocean were not inspected because their structural integrity may have been compromised by water damage experienced during the storm surge. In many cases, the remains of coastline buildings were only evident by piles of rubble, and such remains were beyond the scope of the RICOWI study. This was because the focus was on roofing performance in a wind event and not a water event.

Roof System Performance

“Failure of roofing systems was because of system failure at the perimeter and punctures and tears from debris,” Roodvoets said. “The membrane attachment to the deck cannot resist the loads created when the perimeter securement fails, and this leads to progressive loss of membrane coverage.”

An example of such a catastrophic roof failure is a Port Charlotte office building that had a poorly installed roof. Investigators found that the roof system’s poor performance was the result of inconsistent edge metal clip installation. During the wind event, an intensely high clip load was demanded, and eventually a peel-off failure occurred to the membrane.

Desjarlais noted, “It’s a fair statement to say membranes themselves were not the major cause of failure. There were a lot of perimeter attachment failures. If you can’t hold the edge down, no matter what kind of roof you have, the whole thing is going to be subject to loss.”

“The issue of fastener corrosion was seen over and over again,” he continued, noting that coastal specifications should require fasteners with coatings that are unaffected by the marine environment.

Wind-blown missile damage to roofs was significant, according to Desjarlais. Membrane damage was typically limited to punctures from lightning rods and wire that swung during the hurricane and whipped the membrane with sharp metal edges. Some poorly anchored HVAC units rolling across the roofs also punctured membranes in a few cases. But panels and other components of the HVAC units were more commonly blown off because the equipment was not properly tied down either during installation or following periodic servicing.

On some single-ply systems, the damage was easier to locate, and this may be an advantage to those types of systems, Desjarlais revealed. Conversely, it was less obvious to determine damage on systems such as ballasted roofs, because the aggregate overburden can conceal the indicators of compromised performance.

Another factor affecting roof performance, which was anticipated, was intensely high-speed winds entering buildings through openings such as shattered windows and open doors. However tightly sealed a building remained during the hurricanes often determined the fate of the roof and, in some cases, the entire structure. Some roofing membranes were compro-



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Pensacola School Building 2: Cleat deformed, edge metal lifted, membrane peeled. Cleat gauge less than currently recommended by FM Global LPDS 1-49 and ANSI/SPRI ES-1. Corrosion of roof edge fasteners contributed to expansion of edge damage into field. (Source: André Desjarlais's Oak Ridge National Laboratory report, "RICOWI and its Investigations of Hurricanes Charley and Ivan.")

mised after walls or windows were damaged, providing uplift to the roof in excess of what the building was designed to endure.

Buildings built after Hurricane Andrew devastated Florida in 1992 performed much better than buildings with roofs installed before Andrew, according to Desjarlais.

The overall findings were that post-Andrew roof designs and installations performed well unless there were installation problems, internal pressurization from openings (typically created by failed accessories), perimeter detachment, or corrosion issues.

The Punta Gorda area also contained a significant amount of vinyl roofing membranes, which performed very well.

Before Hurricane Charley, the last recorded storm to make landfall in Punta Gorda was in 1943, and many of the older buildings there had been through previous storms. Furthermore, one of the on-site indications was that many of the roofs seen there by the inspection teams had been



poorly maintained. "What we saw was a lot of deferred maintenance that compromised the roofing system," Desjarlais said.

But not every roof on every building in the path of Hurricane Charley failed. A Punta Gorda Elementary School was well designed, and its roofing system installation and performance were both good. It remained intact.

The teams of inspectors assigned to the Florida panhandle in the wake of Hurricane Ivan found similar results. The roof on a

Pensacola school building was damaged. The key points that surfaced from the investigation were that damage was initiated by pressurization and billowing at overhangs. This pressurization phenomenon caused cleats to yield, compromising the attachment of the edge metal. Progressive failure then rapidly followed.

Other findings were that the cleat gauge was less than currently recommended by FM Global LPDS 1-49 and ANSI/SPRI ES-1. In addition, corrosion of roof edge fasteners

Pensacola School Building 3: Edge metal bent upward, nailers lifted, membrane base sheet torn around fasteners and peeled back. In this shot, the edge metal is bent upwards. The edge metal gauge and nailer securement are less than that currently recommended by FM Global LPDS 1-49 and ANSI/SPRU ES-1. Also, a lack of enhanced perimeter base sheet fastening contributed to propagation of edge damage into field area. (Source: André Desjarlais's Oak Ridge National Laboratory report, "RICOWI and its Investigations of Hurricanes Charley and Ivan.")



contributed to expansion of edge damage into the field.

A second school building inspected in Pensacola had damage and propagation. The edge metal was bent upward, nailers lifted, and the membrane base sheet torn around fasteners and peeled back.

On closer inspection, the edge metal gauge and nailer securement were also less than currently recommended by FM Global LPDS 1-49 and ANSI/SPRU ES-1, and the lack of enhanced perimeter base sheet fastening contributed to propagation of edge damage into the field area.

Lessons Learned

According to another RICOWI inspection team member, Peter Garrigus, vice president of engineering for Trufast Corp. in Bryan, Ohio, "Corrosion problems were due to the wrong roofing products" for the hostile atmosphere along the coast.

Addressing the consistent failure of edge metal roofing clips and fasteners, Garrigus explained, "It really boiled down to workmanship and proper application of materials." Roofing systems performed acceptably in cases where the proper fasteners and roofing components were applied in accordance with the manufacturers' requirements and industry standards established by FM and others, Garrigus observed. In nearly 95 percent of the cases studied where roofing system failure was seen, the problems were because of poor workmanship

and substandard materials, explained Garrigus, who had made similar observations during inspections conducted after Hurricanes Hugo and Andrew in years past.

In some cases, uncoated nails from local hardware stores were substituted for J-bolts or other proper fasteners to secure nailers. In addition, the nails were often



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spaced improperly and at less frequency along the roofs' perimeter than what was called for by the manufacturers of the edge or roofing system. And in other cases, the carbon steel nails were completely rusted away.

Garrigus believes roofs as poorly constructed as those that failed during hurricane-force winds would have failed in lower than hurricane-speed winds. To counter installation and material problems, he encouraged the trend of manufacturers offering contractor training programs be accelerated. Also, inspections during application – either by the system supplier or consultant – would further decrease system failures during high wind events.

The integrity of the entire building envelope would benefit from improved wind resistance in the design and installation of windows and doors to minimize their failure in high winds and reduce the deleterious effects created from building pressurization. The effect of compromised openings can result in excessive damage on both the roof and in the structural integrity of the

building. These losses can be catastrophic in many cases; therefore, building teams need to install impact-resistant doors and windows to safeguard the interior from the pressurization of the enclosure.

Many coastal property owners' housing docking and transportation operations simply left loading doors open in their warehouses and lost entire buildings. So, property storm planning is also an issue.

RICOWI's preliminary results were recently presented by Roodvoets and Desjarlais to SPRI. The earliest findings contained information about six types of roofing systems in the path of the storms. A full report on every roof inspected was released in October. 

Steven Moskowitz

Steve Moskowitz is the current president of SPRI (Single Ply Roofing Industry), and also vice president of technical and warranty services at Stevens Roofing Systems, Holyoke, Massachusetts. Moskowitz has been active in SPRI for 10 years. He has directed a number of key association committees and task forces for SPRI, such as the technical committee and the member services committee, and has served two terms on the board of directors. Moskowitz also led SPRI's fire testing task force.

