Lessons Learned from 2004 Florida Hurricanes

Even as we continue to view images of hurricane devastation in part of the Gulf Coast and Eastern North Carolina, 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 in Louisiana and Mississippi, but last summer, Hurricanes Bonnie, Charlie, 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 and 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 become more energy efficient they also are more susceptible to damage," said Andre Desjarlais with the Oak Ridge National Laboratory in Tennessee and member of the RICOWI team. He noted that this belief was not found to be true, however, because it turns out that more energy efficient buildings are also better designed structures.

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

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's role involved determining whether energy efficient roofing materials, advocated by the federal agency, will also work well in severe wind events.

To investigate Category 4 Hurricane Charley following its landfall Friday, Aug. 13, 2004, near Punta Gorda, seven teams of investigators were deployed to conduct 90 inspections from Aug. 18-21. To investigate Category 3 Hurricane Ivan after landfall Sept. 16 near the Florida/Alabama border, another five teams were deployed to conduct 75 additional inspections from Sept. 22-25.

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 -- mechanical, adhesive and ballasted -- but all combinations of membrane and attachment types were not available in the field. The

team studied approximately 24 single ply roofing systems and was limited by what was available for inspection and the 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. None of the roofing systems investigated were immune from damage, but 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 clip installation. During the wind event, an intensely high clip load occurred and eventually a pull-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 come down."

"The issue of fastener corrosion was seen over and over again," he continued, noting that coastal specifications should specify fasteners with coatings that are unaffected by the salt air environment.

Windblown missile damage to roofs was significant,, according to Desjarlais. Membrane damage was typically limited to punctures from lightening rods and wire that swung in the typhoon-speed winds and whipped the membrane with sharp metal edges. Some poorly attached 2,000-pound HVAC units rolling over the roofs and also punctured membranes in a few cases. But panels and parts of the HVAC were more commonly

blown off the units by the wind and across roofs because the equipment was not properly tied down either during installation or following ongoing 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 small stones covering them 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 can remain during the hurricanes often determined the fate of the roof and, in some cases, the entire structure. Some roofing membranes were compromised 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 100 times 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; and 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 the previous storm. Furthermore, one of the on-site indications was that many of the roofs seen there by the inspections 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 windblown phenomenon caused cleats to deforms and disengagement of the edge metal.

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 contributed to expansion of edge damage into field.

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

On closer inspection, the edge metal gauge and nailer securement was also less than currently recommended by FM Global LPDS 1-49 and ANSI/SPRI ES-1, and the lack of enhanced perimeter base sheet fastening contributed to propagation of edge damage into 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 a hostile atmosphere along the coast.

Addressing the consistent failure of roofing clips and fasteners, Garrigus explained, "It really boiled down to workmanship and proper application of materials."

The roofing systems performed acceptably in cases where the proper fasteners and roofing components were applied in accordance to the manufacturers requirements, Garrigus observed.

In nearly 95 percent of the cases studied where roofing system failure was seen, the problems were because of poor workmanship and substituted 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 used to replace J-bolts or other proper fasteners used to secure nailers. In addition, the nails were often spaced improperly and at less frequency along the roof's perimeter than what was called for by the manufacturers of the edge or roofing system. And in other cases, the common nails were completely rusted away.

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

The education of entire building teams also would benefit the wind resistance of roofing assemblies by minimizing the deleterious effects created from building pressurization as seen during the 2004 Florida hurricane season. The effects compromised openings in buildings can have on both the roof and the structural integrity of the building were catastrophic in many cases and therefore building teams need to install impact resistant doors and windows to seal the interior from the balloon effect that pressurization has on a building.

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 possible roofing systems in the path of the storms. A full report on every roof inspected is set to be released in October.

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- ☐ TFM (Today's Facility Manager) Web site