WIND DAMAGE ON LOW SLOPE ROOFS FROM HURRICANE KATRINA

By Cheri Panasik, PhD and André Desjarlais

Buildings located in hurricane-prone zones must meet higher code-rated specifications. Over the years, the industry continues to see a trend toward an increase in requirements for buildings to withstand higher wind speeds, leading to revised codes and guidelines. Many building owners depend on specifiers, inspections, and roof consultants to determine which roof system is appropriate for their building, and to ensure that specifications are followed. In hurricane-prone zones, tighter fastening patterns, concrete decks, and high-wind-rated systems are often specified to ensure the best wind endurance.

Hurricane Katrina

Wind damage investigations provide insight to roof system performance and adherence to codes and other guidelines. Collecting wind damage data and determining ways to improve wind resistance allow manufacturers to continuously improve and enhance roof systems.

Hurricane Katrina struck on August 29, 2005, producing more destruction than any other hurricane in U.S. history. Many organizations conducted wind-damage investigations shortly after the hurricane made landfall. Several buildings investigated were over 200 feet tall; thus, it was evident that the damage to the roof system was caused by the wind and not flooding. Witnesses interviewed also confirmed this to be the case. The authors of this article and others

Photos 1 and 2 – Impact of reduced fastening patterns.

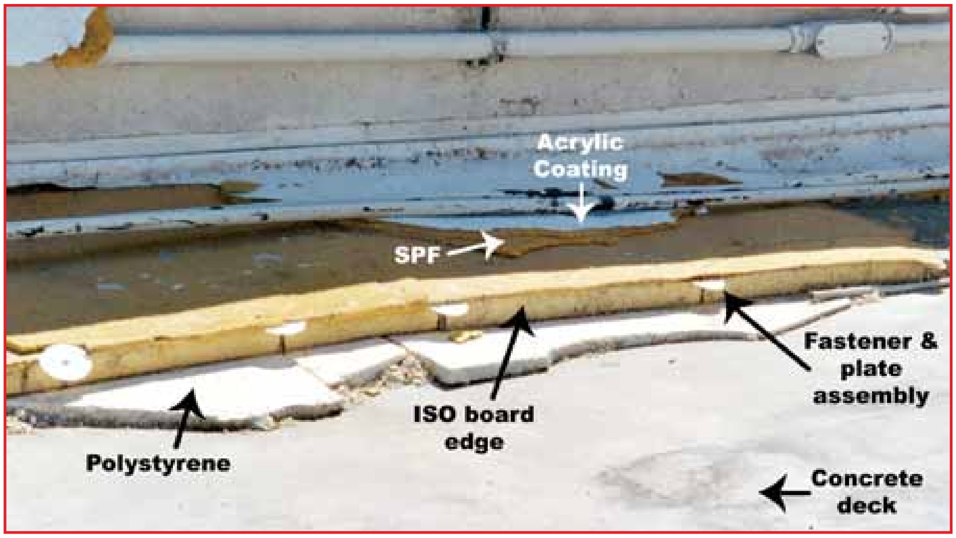

Photo 3 – Cross sectional view of roof system.

participated in Hurricane Katrina wind-damage investigations and made the following observations.

The investigation team inspected several types of low-slope roofs, such as SPF, SBS, BUR, and metal. The team found some of the same issues as seen in previous hurricane investigations. Some damaged membrane and edge details were not secured according to standard fastening pattern guidelines. An extreme example of this issue was found on a waterfront hotel in Biloxi, Mississippi. The SPF roof was only five years old and blew off during Hurricane Katrina; however, the fastening pattern used did not match any prescribed method (see *Photos 1* and *2*).

SPF System

The SPF roof system of a 350-foot-tall waterfront hotel in Biloxi, Mississippi, consisted of a white acrylic coating; 1/2-inch-thick, 4-ft by 8-ft ISO insulation; and expanded polystyrene fastened to cast-in-place concrete using screw anchors (*Photo 3*). Three screws with plastic roofing plates were used to fasten each 4-ft x 8-ft board and the rest of the required fasteners were

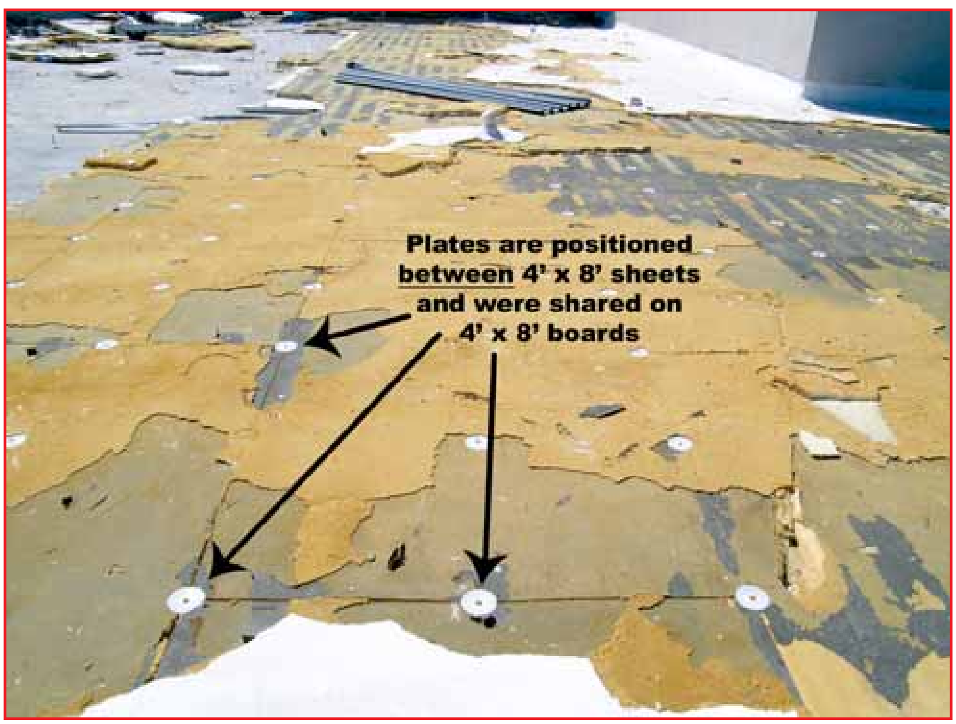

Photo 4 – Three screws with plastic roofing plates were used to fasten each 4-ft by 8-ft board at edges.

not installed (*Photo 4*). Additional fasteners were placed between each 4 x 8 board, thus not following any prescribed fastening pattern. The corner of each board was secured by fasteners that were installed between the board corners with the plastic plate straddling three ISO boards (see *Photo 5*).

Insulation fastening should be installed a minimum of six inches from the edge of the insulation board and never shared between boards. Perhaps an inspection by a qualified inspector during roof construction could have detected and stopped such a fastening pattern. As a result of the fastening mistakes, over 50% of the roof was blown off, leaving only the screws and plates secured to the concrete deck.

Photo 5 – Fasteners were driven between ISO sheets, shared by adjacent boards.

SBS System

An SBS roof on a waterfront hotel constructed in 1999 performed well until damaged by exhaust equipment (see *Photo 6*). The building was 36-feet-tall and located in Biloxi, Mississippi. The SBS membrane had a granular surface. Two and three-fourths-inch-diameter plate assemblies, spaced ten inches apart, were fastened into lightweight concrete. Five percent of the membrane was damaged. Thirty percent of the wood nailer was detached. The expansion joint was exposed. Damage initiation evidence showed that the exhaust equipment was detached from its location and blew across the length of the roof, damaging the membrane as it was dragged along. The damage seemed to be due solely to the exhaust equipment cutting and tearing the membrane.

Developing and following a prescribed method to secure HVAC systems to curbs could reduce membrane damage during high winds. Year after year, roofing organizations cite findings of membrane failure solely due to being cut by a roof-mounted

Photo 6 – Developing and following a prescribed method to secure HVAC systems to curbs could reduce membrane damage from equipment dragged or thrown by the wind.

item breaking free and dragging along. Establishing robust fastening system requirements could reduce membrane damage.

BUR System

Several BUR systems performed well; however, the BUR and windows of a middle school building built in 1959 located in Di'Iberville, Mississippi, were unable to resist the hurricane. Ninety-five percent membrane damage and complete window blow-out allowed massive content damage. The membrane was a four-ply system with aggregate surfacing (*Photo 7*). It was mechanically attached with split-shank, sheet-metal barb nails in a three-per-square-foot fastening pattern in the perimeter zone. The roof deck was cementitious wood fiber and was secured to steel joists using sheet metal H clips fastened every eight feet on center.

Twenty-five percent of the edge nailer was detached. The system attachment substrate had 90% damage. Deck movement occurred in the southeast corner. The deck was detached from the secondary support. The sheet-metal H clips were corroded and pulled out of place from the steel bar joists. The base sheet split nail fasteners pulled out. The base sheet, membrane, and deck panels detached from the roof as uplift forces pulled H clips out of the steel joists. The remaining H clips were easy to lift and remove from the steel joists, thus not providing resistance to uplift forces (*Photo 8*). Numerous roof deck panels were displaced.

A roof-mounted air conditioning system landed on a covered walkway (*Photo 9*). Developing and following a prescribed method to secure such units to the roof could reduce damage from this equipment during high winds. The inside of the building and its contents were destroyed.

SUMMARY

Wind damage investigation findings indicate that although high-density fastening patterns are specified, they are not always followed, which can result in roof damage. In the past, the industry raised the requirement for the number of fasteners to increase fastener density in high-wind zones. However, improved performance will not be experienced unless the specified fastening patterns are followed. Good roof inspections during construction may prevent the use of low-density fastening patterns and thus increase performance by following codes

Photo 7 – This four-ply, aggregate-surfaced, BUR system suffered 95% membrane damage.

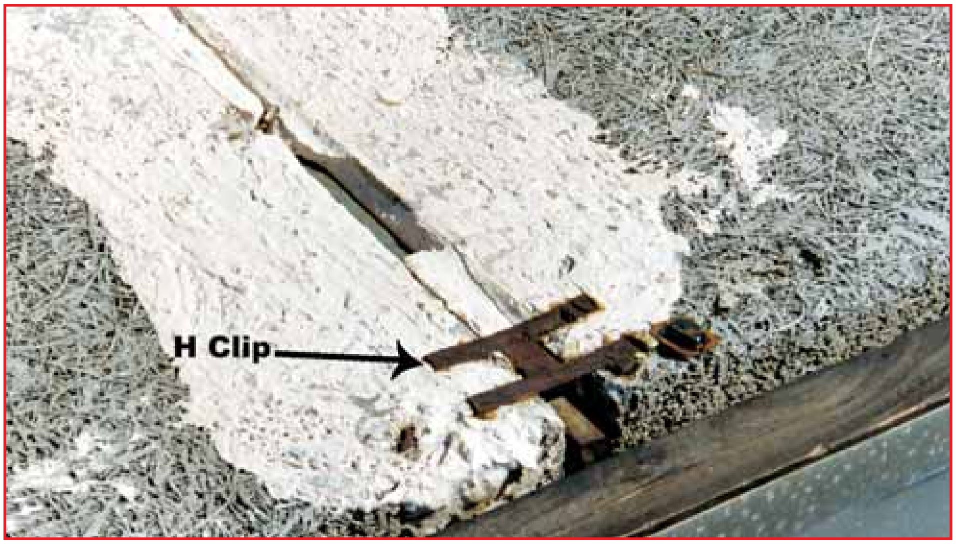

Photo 8 – The sheet metal H clips were corroded and easily pulled out of the steel joists, providing insufficient resistance to wind uplift forces.

and other guidelines. Many roofs did withstand Hurricane Katrina, as documented in observation reports. BUR, metal building, single-ply, and other types were among the many success stories. The two key issues of damage initiation observed were HVAC unit blow-off with little or no mechanical fastening to the supports, and non-conventional fastening patterns.

Reducing the chance of building failure begins with site selection. The demand for waterfront structures often overwhelms location dangers when hotel or homeowners choose such locations. Building in non-hurricane zones is a wise decision, but many times not the selected option.

The second level of defense is codes and other guidelines. However, in order for the codes and guidelines to be effective, they must be followed. Buildings designed for high-wind areas must adhere to more stringent systems. Specifiers and roof consultants do well to ensure proper codes and other guidelines are specified. Building owners pay a higher cost for such wind resistance systems; however, they sometimes decide to forego the cost of the roof inspections during construction. Perhaps they believe the warranty will provide them with the protection needed to ensure proper roof integrity and assembly. If the roof fails within warranty, it is important to consider other costs the owner might have to endure. Injury, death, property content damage, and opportunity loss due to business down time are high impact items to review. Many believe the added inspection cost is well worth avoiding all of the issues listed.

Photo 9 – A roof-mounted air conditioning system landed on a covered walkway.

Test your knowledge with the following questions, developed by Donald E. Bush Sr., RRC, FRCI, PE, chairman of the RRC Examination Development Subcommittee.

1. **What is the major purpose of the structural roof deck?**
2. **In addition to the roof deck's structural function as the base for the roof system, what other design requirements must it satisfy?**
3. **As a basis for deciding whether to use a vapor retarder, what two calculations are needed?**
4. **A key factor about wind pressure is its exponential increase with wind velocity. If the wind velocity were doubled, how would it affect the wind pressure?**
5. **What four tests does UL conduct to determine roof-covering fire classification?**

Answers on page 24

ROOF KNOWLEDGE ASSESSMENT

Answers to questions from page 23:

1. **To resist gravity loads and lateral loads from wind and seismic forces.**
2.
   - **Deflection (prevents ponding of water and related drainage and structural problems).**
   - **Component – anchorage technique (prevents both delamination by wind uplift or horizontal movement and membrane splitting).**
   - **Dimensional stability (depends on the coefficient of thermal expansion/contraction).**
   - **Fire resistance (exterior and interior).**
   - **Surface character (continuous or jointed).**
3. **Location of dewpoint and the rate of vapor migration under the worst winter conditions. If vapor retarder/location is below dewpoint, do not specify a vapor retarder.**
4. **It would quadruple.**
5.
   - **Flame spread.**
   - **Flame exposure.**
   - **Burning brand.**
   - **Flying brand.**

Reference: ***The Manual of Low Sloped Roof Systems — 4th***

As demonstrated in damage investigations over the years, when a roof system is not constructed per recommended or required fastening patterns, it may not perform as needed. Increasing the system requirements when current requirements are not met will not improve performance unless requirements are followed. Real-time quality inspections conducted during roof construction can detour low-density fastening patterns, unsealed seams, and other quality issues. Roof systems are dependent on proper installation of all the components. Deteriorated substrate, wood nailers, and edge detailing also prove to have a critical impact on the performance of roof systems. Ensuring codes and other guidelines are followed will provide the foundation for a robust roof system. Inspections can help ensure adherence to these critical details.

Photo 10 – A Hummer comes in handy for Cheri Panasik (pictured) and André Desjarlais for Mississippi's post-Katrina landscape.

Dr. Cheri Panasik

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— CORRECTION —

The January 2007 cover of *Interface,* depicting the Minneapolis Central Public Library, and the accompanying two-page profile published in that issue failed to mention the main architect and the roof consulting company involved in that project. Architectural Alliance of Minneapolis designed the building and AMBE Ltd., also of Minneapolis, provided all waterproofing and roof consulting. Rosenquist Construction was a subcontractor for the green roof installation.