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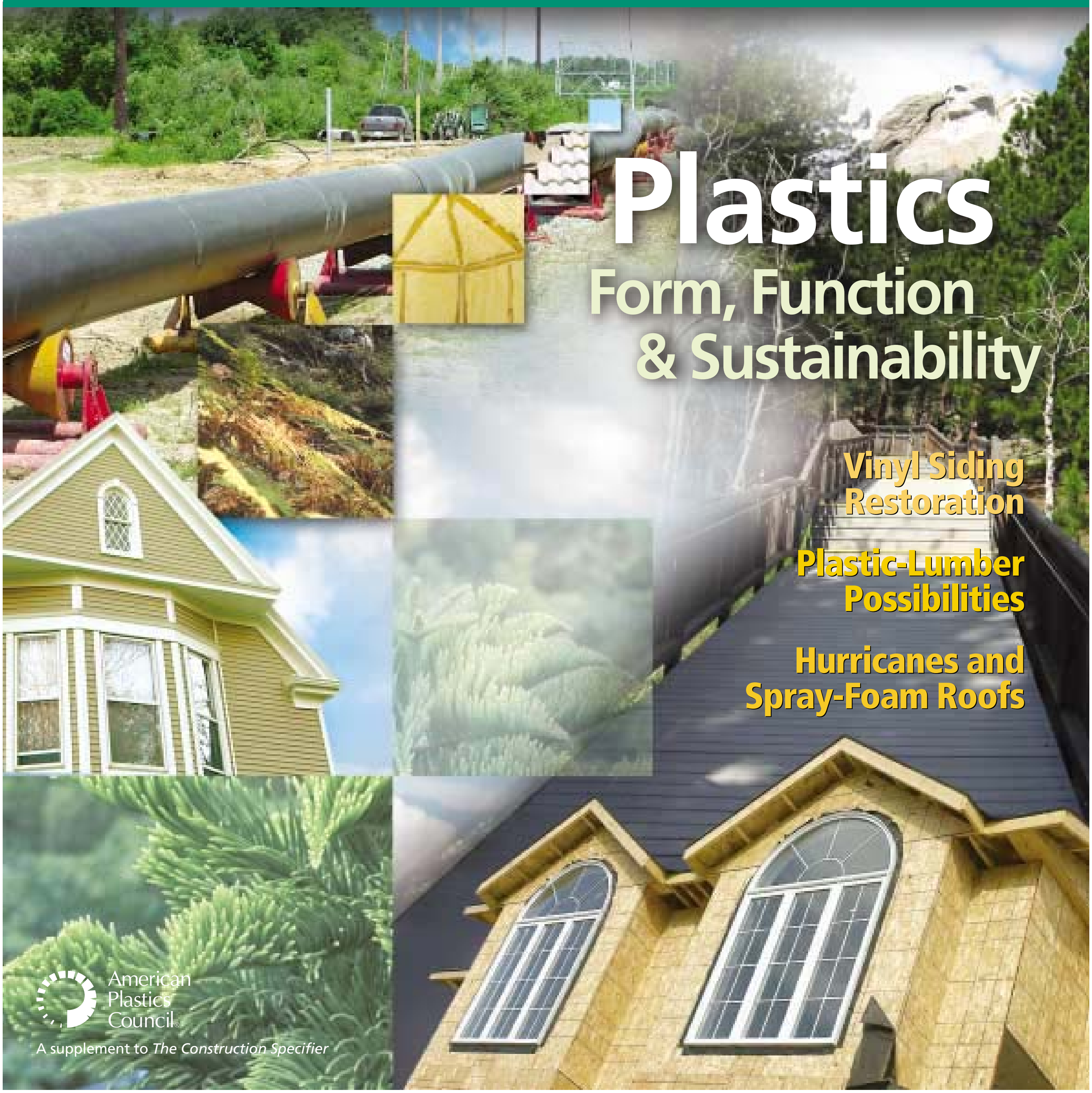

Plastics
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Hurricanes and Spray-Foam Roofs

American Plastics Council

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Photos courtesy Gene Whiting, John Howley, Roger Morrison, and Tom Kelley (2001 Company).

Shelter from the Storm

SPF and the hurricanes of Florida

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Before 2004, Florida enjoyed more than a decade free of the ravages and destruction of major hurricanes. Unfortunately, things changed drastically that summer when four major storms swept across the state. On August 13, Charley, a Category 4 hurricane packing 225-km/h (140-mph) winds, slammed into the Gulf Coast area around Punta Gorda, made its way through Orlando, and finally exited near Daytona Beach. Along the way, it destroyed buildings, tore off roofs, and caused related damage that will take years to repair. Before the state could catch its breath, Hurricane Frances (a Category 2 storm with 177-km/h [110-mph] winds) hit Palm Beach on September 3, exiting into the Gulf of Mexico near Tarpon Springs, and then re-entering the panhandle region close to Tallahassee. Three days later, Hurricane Ivan—the most wayward storm of all—struck near Pensacola, went up into Georgia, and exited into the Atlantic, before turning 180 degrees into the Gulf and returning to hit the coast again a week later. On September 26, the season's final storm hit, as the Category 3 Hurricane Jean took essentially the same route as Frances—often destroying what its predecessor did not.

In the summer of 2004, four hurricanes ripped through the state of Florida. The high winds and resulting debris 'missiles' resulted in rampant damage, although many spray polyurethane foam (SPF) systems remained largely unscathed.

Roof decks encountering high winds can be damaged as a result of high-pressure differentials. When a door or window fails, this pressurization's effect on the roof increases, with dire consequences—the deck (and the roofing membrane) can quite literally blow up.

While the hurricanes were truly ferocious, they were also the best-documented storms in history. Dozens of investigative teams from organizations such as the Federal Emergency Management Agency (FEMA), Roofing Industry Committee On Weather Issues (RICOWI), and the National Roofing Contractors Association (NRCA) have provided insight into what materials and systems work—and which ones do not—when building hurricane-resistant structures.

Polyurethane foam protection

One assembly noted for its durability in storms is the spray polyurethane foam (SPF) roofing system. Many such roofs were able to survive unscathed or with minor surface damage. Steep sloped roofs where asphalt shingles or ceramic tiles had been covered with SPF also fared well. In many cases where roofs were partially repaired with SPF after Hurricane Frances, the foam was the only product remaining after Jean, a few weeks later.

Spray-applied as a liquid, SPF reacts and expands in place to form a firmly adhered, rigid, seamless mass of closed-cell foam. Based on small-scale wind uplift testing, SPF roofing systems have achieved very high wind uplift ratings. Due to the adhesive, compressive, and tensile strength of SPF, the typical mode of failure in small-scale testing (*i.e.* 3.6 x 7.3-m [12 x 24-ft] panels) is the fastening of the deck (*i.e.* screw pullout). Testing over re-cover panels has suggested the added stiffness and reduced profile of SPF roofing increases the wind uplift resistance of an existing membrane. As a result, SPF roofing systems are frequently installed over existing membranes such as built-up roofs (BUR) or modified bitumen (mod-bit).

Investigating SPF failures

Even with the added wind uplift resistance provided by SPF, some failures were reported and documented. Understanding how and why these problems occurred not only can help specifiers select materials more appropriately, but can also provoke discussion on further design considerations for heavy wind-prone areas.

Deck

Roof decks provide the structural support for the waterproofing and insulating components of the roofing system. Commonly constructed of concrete, steel, or plywood, these decks can fail as a result of high-pressure differentials (also known as 'pressurization').

When wind encounters an obstruction such as a building, air pressure tends to increase on the windward side relative to the leeward side. As wind passes over a roof, the velocity increases because the air must travel a greater distance. As air velocity increases, its pressure tends to decrease (similar to air passing over an aircraft wing)—thus, the air pressure atop the roof tends to be lower than the underside. When a window or door fails, this effect is exacerbated as the pressure within the building suddenly—and catastrophically—spikes, blowing up large sections of roof deck and the roof membrane with it.

Substrate

When installed as a re-cover, SPF roofing is applied directly to an existing membrane. While testing and field performance indicates the foam tends to increase wind uplift resistance of the combined system, should the underlying substrate or membrane be insufficiently attached/adhered, the total roofing system can still be vulnerable to blow-off.

The typical mode of substrate failure was a loosening of the windward edge followed by a peel-back of the membrane. Depending on the security of the underlying insulation, the peel-back can take the insulation boards with it. At some point in the peel-back process, the membrane typically ruptures, leaving the remaining substrate and SPF intact.

Substrate failures can be due to insecure edges and insufficient adhesion or fastening of the membrane and insulation boards to the deck. Membrane roof systems are highly dependent on the roof edge for their security, yet these edges are the most exposed detail on the roof. Furthermore, the pressure difference across the membrane tends to add extra uplift forces to the edge. Once the edge submits to these forces, a membrane peel-back is almost inevitable.

Roof edges are usually fabricated from metal and fastened to a wooden roof edge nailer with screws, nails, and/or cleats. The security of the metal edge is dependent on its stiffness, the quality and quantity of fasteners, and the security of the nailer.

Surface damage

Surface damage of SPF roof systems occurred due to the impact of wind-borne 'missiles' (such as tree limbs, broken tiles, and metal debris). Gravel scour occurred at windward roof corners and near roof protrusions and roof-mounted equipment in some cases. Little or no loss of waterproofing resulted from this damage due to the closed-cell properties of the SPF.

General observations

Generally, SPF roofs performed very well during the 2004 hurricane season in Florida. Failures were limited to deck and substrate failures and while surface damage occurred, it was not a cause of failure or leakage.

Substrate failure could be minimized or eliminated by improving edge and membrane security when installing SPF roofs. Possible improvements include the following considerations:

- The existing membrane should be removed a few feet in at roof edges and the SPF should be applied directly to the deck in these areas;
- In the field, the existing membrane should be refastened at the edges; and
- New flashing and edge metal should be installed during re-cover applications.

Ultimately, no SPF adhesive failures were observed or reported by the investigative teams, with many SPF roofs surviving largely undamaged. While gravel movement was present at windward corners, little or no gravel loss was observed. Slope roofs where shingle or tiles had been covered with SPF also fared quite well, and the application of foam as a temporary patch-and-repair method was very successful—often demonstrating better wind resistance than the original roofing system.

About the Authors

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