WIND UPLIFT SOLUTIONS:

Increasing the Durability of Roofing Systems

By Reinhard Schneider

Hurricane damage to low-slope roofs is often extensive. As a result, building codes and wind design guidelines are changing. New solutions to wind uplift problems are being introduced that allow building owners and specifiers to design and build highly durable, standard-compliant, cost-effective roofs, regardless of where their buildings are located.

Standards in a State of Flux

In January 2006, Factory Mutual (FM), a leading global commercial insurer, made significant changes to its testing standards for wind uplift resistance in fully adhered membrane roofing systems. The change was prompted by the losses FM experienced during the 2004-2005 hurricane seasons. FM announced higher standards for uplift-resistance ratings for FM-insured buildings located in high-risk areas, such as the coastal hurricane regions and the Caribbean islands. Ratings standards applicable for inland, low-risk areas were also increased, but less dramatically.


Hurricane Charley. Severe wind damage with weak bond between membrane and insulation. Photo, courtesy of Tecta America.

Ironically, most of the damage incurred was not caused by weak or inadequate wind-uplift requirements. Rather, more than 80 percent of the severe-weather-related roof failures were due to workmanship issues or noncompliance with existing standards. Very few roofs failed when they were installed according to FM guidelines and the designer's specifications.

Meanwhile, in April 2006 and September 2007, the Roofing Industry Committee on Weather Issues (RICOWI) released data on its inspections of 93 low-sloped and 91 steep-sloped roofs in Florida in the immediate aftermath of hurricanes Charley, Ivan, and Katrina in 2004 and 2005. (The reports are available for free download at **www.ricowi.com.**

RICOWI investigators found that installers did not always use the required number of roof fasteners, particularly at the perimeter, where system attachment is most critical. In addition, the roof-edge details often failed to comply with the current ANSI ES-1 standard, and some edge protection features were missing. In other cases, rooftop equipment was not properly attached to equipment curbs, resulting in projectiles that caused membrane punctures. These mistakes often occur after the architect's plans are approved and equipment is installed by roofing nonprofessionals.

Using the RICOWI findings, the roofing industry has argued that the wind uplift failure issue is one of compliance and not of design, testing, or standards. Very few roofs failed when they were installed according to FM guidelines and the designer's specifications.

The changes in FM's standards caught the industry off guard and slowed the approvals process, forcing many manufacturers and designers to specify new systems that did not meet the full intent of the updated FM Class 1-90 standard. In most cases, this occurred in buildings not insured by FM, in which designers specified an FM Class 1-90 rated roof.

Many architects use FM 1-90 as the default requirement in their specifications. However, there are some who question the need for such a rigorous standard. "You are basically overdesigning with the FM 1-90," said an architect with almost 30 years of experience in roof design and installation. "When 85 percent of the projects are not FM insured but still call for FM 1-90, there is a disconnect."

Part of the roofing industry's reaction to FM's changes has been to increase its reliance on ASCE-7. This has prompted FM to change some of the details in the Class I standard. Due to concerns expressed by a coalition of roofing industry trade groups, FM Global will now allow prescriptive enhancements where a Class 1-90 roof system is specified in a non-hurricane-prone area.

Meeting FM's New Requirements

FM's wind uplift requirements are based on American Society of Civil Engineers ASCE-7. FM recommends higher standards and safety factors than those required by code. There are actually several calculations that go into the wind design process, which is based on the original ASCE-7 standard for building envelope pressures. Building location, enclosure, height, ground roughness, and other factors all enter into the wind uplift equation. A common misconception in the design community is that 1-90 represents winds up to 90 mph. In fact, the standard requires that the roof system withstand 90 lbs per square foot (psf) of wind uplift tested pressure.

In general, designing for 90 psf is only needed in high-wind areas and high-rise buildings, which make up a small portion of roof installations. However, 1-90 is now the *de facto* standard, and it is used in up to 80 percent of roofing specifications, whereas 75 or 60 psf would be adequate and more cost effective.

Currently, for building design pressures up to 45 psf that are using an FM safety factor of 2, FM requires that the roof assembly withstand the following tested differential ultimate pressures (See *Table 1*).

roofing membranes. (For more information on peel stops, visit **www.spri.org**.)

Following implementation of new FM changes, only a few of the fully adhered specifications were approved, so many roof system manufacturers had to re-test. One way to meet the new FM requirements and increase the strength of the roofing assem-

Field of Roof	Perimeter Requirement	Corner Requirement
FM 1-90	FM 1-150	FM 1-255
FM 1-120	FM 1-195	FM 1-295
FM 1-135	FM 1-225	FM 1-330
FM 1-150	FM 1-255	FM 1-360

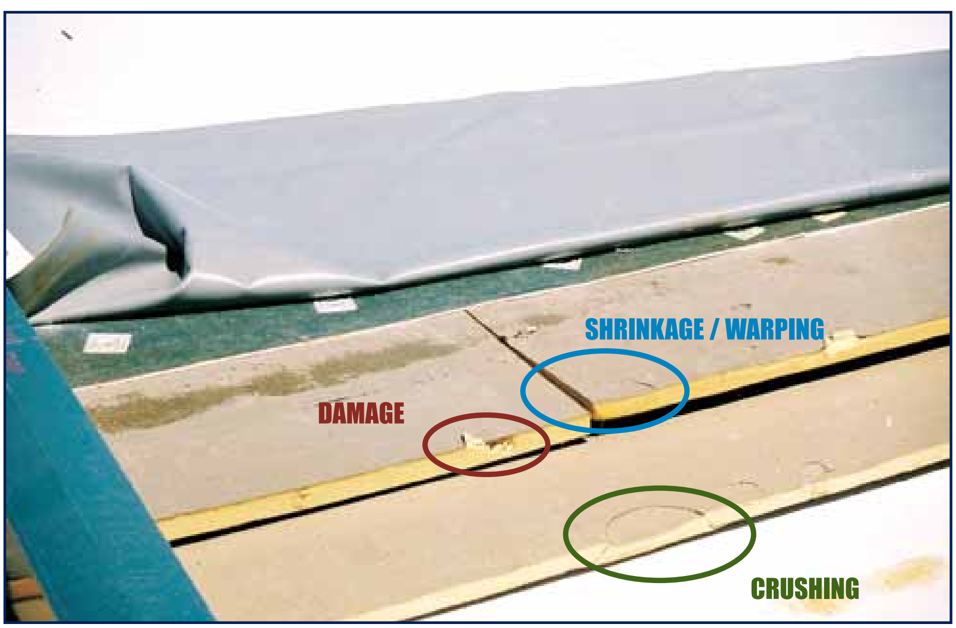
Table 1

bly is to specify a ½-in pre-primed, moisture-resistant gypsum coverboard fastened through the insulation to the roof deck. In recent testing, a three-ply built-up roof (BUR) with 1.5 in of loose-laid polyiso insulation achieved an impressive FM rating of 315 psf – 10 psf higher than the elevated corner pressures required for an FM 1-120 listing.

Similarly, a 45-mil, fleece-backed ethylene propylene diene monomer (EPDM) single-ply membrane fully adhered with water-based adhesive achieved 285 psf. A number of membrane manufacturers have tested various types of gypsum coverboards with their adhered membranes and have achieved a variety of high uplift results.

In addition, roof assemblies over 90 psf are tested to these pressures on a 12-ft x 24-ft uplift testing table. As noted in the chart, required uplift resistance at the corners of the roof is much higher than the field of the roof. This is because roof edges were the determining factor in failures, according to research done by FM and RICOWI.

The previous method of simply increasing the roof-field fastener count by fixed percentages for perimeter and corner areas of adhered systems is no longer accepted for FM field-of-roof ratings of 90 psf and higher. However, there are other methods of strengthening the edges and corners of roof systems, such as using a "peel stop" on



Damage to fragile insulation layer and evidence of cupping and bowing revealed after Hurricane Katrina. Photo courtesy of NOAA.

FM 1-29 Field of Roof Requirements

The FM requirements below 90 psf have changed slightly. For FM fully adhered membranes with ratings of 75 psf or lower, finding the perimeter and corner fastening rates by multiplying the field fastening rate is still acceptable. However, the new 1-29 Loss Prevention Data Sheet requirements are more stringent. In the past, the increase in fastener count was 50 and 75 percent for the perimeter and corner areas, respectively, for adhered membranes. In 2006, these values were increased to 50 and 100 percent, respectively, with minimum fastening rates required unless testing showed the uplift pressures could be resisted with fewer fasteners.

FM continues to work with the roofing industry, but its new requirements may still increase the costs of many roof systems. When the project requires FM approval, the specifier must design and install the roof to meet the Approval Guide, RoofNav, Loss Prevention Data Sheets 1-28, 1-29 and 1-49, as well as wind design and perimeter flashing requirements.

However, the designer can forgo the FM Class I rating for non-FM insured buildings. In this case, wind uplift requirements will be determined by a number of factors, including but not limited to: geographic area, locale, exposure factors, and the building design itself.

Architects and designers may also reduce project costs by specifying 75 psf or lower roof ratings if they are appropriate to the region and the individual project. Wind-load design guides based on ASCE-7 are available from NRCA (**www.nrca.net**) and SPRI (**www.spri.org**), as well as on FM's RoofNav Web site.

Adding Durability to Specifications

One strategy an architect can pursue to increase the roof performance is to add durability. This is defined as a combination of roof system "strength" and exemplary hail and foot-traffic resistance. By specifying a coverboard of any type—such as wood fiber, plywood, or gypsum—the designer adds durability to the roof system. A coverboard is defined as a relatively thin (1/4-in) semirigid board installed between the insulation and the roofing membrane. There are several commonly used coverboards from which specifiers may choose:

- Asphaltic board
- Plywood/OSB
- Mineral fiber board
- Wood fiber board
- Perlite
- Cellulose-reinforced gypsum
- Paper-faced gypsum
- Glass-mat gypsum

For years, the National Roofing Contractors Association (NRCA) has recommended the use of coverboards with polyisocyanurate (ISO) insulation to minimize problems with facer-sheet delamination, cavitation at the edge of the board, cupping or bowing of the board, shrinkage, and crushing or powdering. While fire and moisture resistance are generally understood, the added "strength" of a high-density coverboard bestows a number of benefits on the roofing system. These include increased hail, foot traffic, puncture, and wind uplift resistance.

In high winds, uplift pressures attempt to lift the membrane off the substrate first, and these forces eventually transfer to the roof components below the membrane—the insulation, fasteners, deck, and structural components of the building. These components work together to resist wind uplift. When one link is weak and fails due to high uplift pressures, performance of the entire system is compromised. Adhesively bonding a single-ply roof membrane to thermal insulations like ISO creates another weak link in the system. Roofs must withstand loads from construction and maintenance traffic, hail impact, wind uplift, and snow loads.

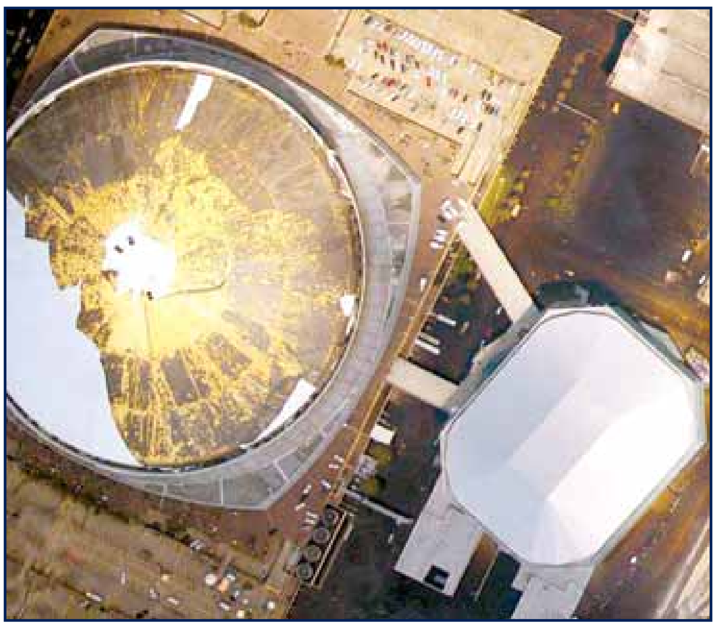
By specifying a coverboard, the architect is avoiding the weak link in most roofing systems. Attaching the coverboard through the insulation with fasteners, the roofing system can transfer uplift forces to the roof deck without stressing the relatively fragile layer of thermal insulation.

In areas where hailstorms are common, one major retail chain now specifies gypsum coverboard for all of its facilities to keep them operational. “At one of our Nebraska facilities, golfball-sized hail destroyed the single-ply roof,” says the manager of roofing programs for a retailer. “When we rebuilt the roof, we put ¼ in of glass-mat-faced gypsum board between the foam insulation and the membrane. When a similar storm hit, the membrane on our store’s roof was not fractured. We did a test cut on the roof and found that the gypsum board was unscathed and was ready for the next hailstorm.”

In these applications, the coverboard required high compressive strengths sturdy enough to protect the 16-20 psi foam insulation underneath from large hailstones, while maintaining enough flexibility to cushion the roof membrane above. In areas where hail is not an issue, foot traffic usually is, and most roofing warranties exclude damage from excessive traffic by maintenance crews and other nonroofing trades.

Considering all the benefits that a coverboard provides, the price of entry is relatively low, and without it, there can be adverse performance of the roofing assembly. According to one registered roof consultant who specifies glass-mat-faced gypsum on many of his projects, the coverboard “adds 5 percent to the cost but gives the roof 25 percent more life over the long run. It’s a return on investment that we’re more than willing to make.”

The new FM requirements will continue to impact the cost and complexity of designing and building standard-compliant sys-



Durability and strength are major factors in wind uplift resistance.

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Test your knowledge of building envelope consulting with the following questions developed by Donald E. Bush Sr., RRC, FRCI, PE, chairman of RCI’s RRC Examination Development Subcommittee.

1. **How does the International Energy Conservation Code define an above-grade wall?**
2. **How does the International Energy Conservation Code define a basement wall?**
3. **How does the International Energy Conservation Code define a conditioned space?**
4. **How does the International Energy Conservation Code define a curtain wall?**
5. **How does the International Energy Conservation Code define fenestration?**
6. **How does the International Energy Conservation Code define a roof assembly?**
7. **How does the International Energy Conservation Code define a skylight?**

Answers on page 26

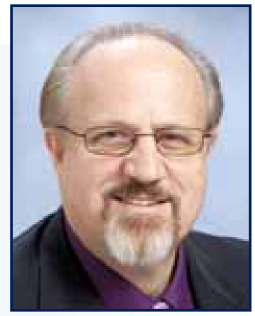
Answers to questions from page 25:

1. **A wall more than 50% above grade and enclosing conditioned space.**
2. **A wall 50% or more below grade and enclosing conditioned space.**
3. **An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent conditioned space.**
4. **Fenestration products used to create an external non-load-bearing wall that is designed to separate the exterior and interior environments.**
5. **Skylights, roof windows, vertical windows (fixed or movable), opaque doors, glazed doors, glazed block, and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials.**
6. **A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof covering, underlayment, roof deck, insulation, vapor retarder, and interior finish.**
7. **Glass or other transparent or translucent glazing material installed at a slope of 15 degrees or more from vertical.**

Reference: 2006 International Energy Conservation Code

tems. However, architects and builders have a solid option for increasing the strength of the assembly without overdesigning or breaking the bank. Deploying a preprimed, moisture-resistant gypsum coverboard to the roof deck adds durability to the system, making it more resistant to inclement weather and extending the life of the roof. The promise of delivering a superior product that exceeds standards and delivers positive return on investment should be a strong motivator for building industry professionals to seriously consider this approach.

Reinhard Schneider



Reinhard Schneider is the technical and product development manager for commercial roofing with Georgia Pacific Gypsum Corporation, LLC. A graduate of Kent State University's School of Architecture in Kent, Ohio, he practiced architecture internationally and in Ohio for 15 years before focusing his efforts on commercial roofing. For over 20 years, he has been involved in the development, manufacture, testing, and marketing of commercial roofing systems. He joined the Goodyear/Versico roofing division in Akron, Ohio, as marketing manager and had responsibilities for product development and contractor training. For the last nine years, Reinhard has been heading up the technical development of DensDeck at the Georgia Pacific Gypsum Corp., LLC. He has written several articles on roofing technology published in *Interface*, *RSI Magazine*, and *Roofing Contractor*. He is a member of RCI, AIA, RICOWI, and SPRI, where he chaired the Technical Committee.

RRCI Announces New Board

The Reflective Roof Coatings Institute (RRCI) held its third annual meeting in Las Vegas on Wednesday, February 20, 2008, prior to the IRE/NRCA conference. More than 60 roofing consultants, coatings manufacturers, and consultants from related industries attended the meeting, focused on "Monitoring Equipment — Gathering Data." A presentation by Tim Leonard of ER Systems, "Cool, Green and Sustainable Roofs," is available at **www.ersystems.com/content.php?content=presentations**. Penny Gift of Republic Powdered Metals, representing the RRCI Education Committee, previewed "Cool Stories for the Roofing Contractor," a presentation illustrating the benefits of reflective roof coatings in extending the life of roof systems while reducing energy consumption and demand for the building envelope.

Bill Kirn of National Coatings Corp. and outgoing president of RRCI, presented the "State of the Association" address and conducted the election of new board members and officers. Newly elected officers include President Bob Brenk, Aldo Products Co.; Vice President Penny Gift, Republic Powdered Metals, Inc. (RPM); Secretary Kate Baumann, Mule-Hide Products Co., Inc. New board members include Mitch Clifton, NCFI Polyurethanes; Tim Leonard, ER Systems; and Matt Lendzinski, Rohm & Haas Co., who will join Charlie Van Gelder of United Coatings Mfg. Co., and past-President Bill Kirn on the RRCI board of directors for 2008-2009.

For more information on the Reflective Roof Coatings Institute, visit **www.reflectivecoatings.org** or contact Ken Bowman, executive director, at 816-472-8870.