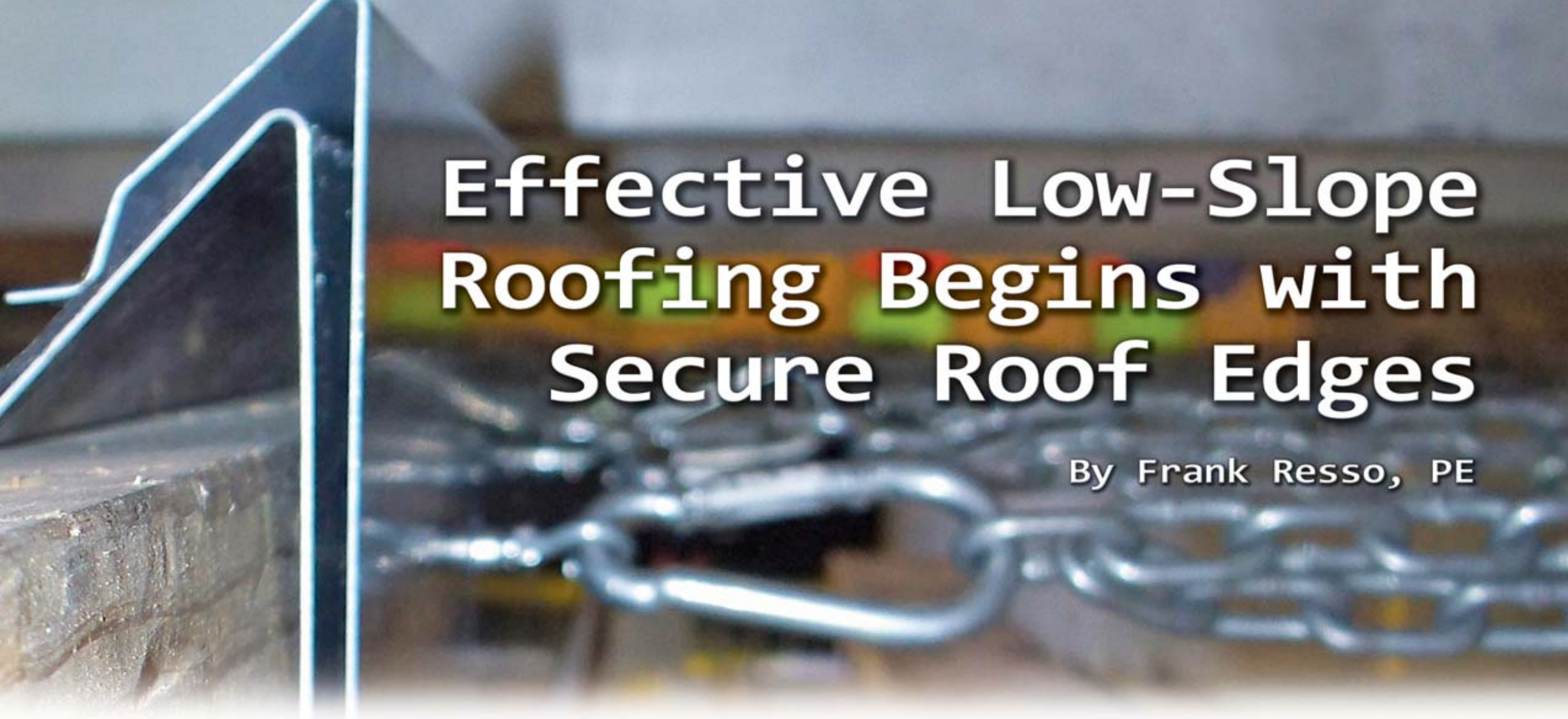

Effective Low-Slope Roofing Begins with Secure Roof Edges

By Frank Resso, PE

THE IMPORTANCE OF EDGE-SECUREMENT SYSTEMS

The edge of every low-slope roof can become the cause of serious waterproofing and roof system failures. Poor detailing of perimeter securement systems can lead to water ingress and, ultimately, failure of the complete roof system. FM Global Loss Prevention Data Sheet 1-49 cites a study of insured losses involving built-up roofing (BUR), showing that 59% of the cases occurred because the perimeter membrane securement failed. Further, the Roofing Industry Committee on Weather Issues (RICOWI), a nonprofit industry and research organization assisted by Oak Ridge National Laboratory, has consistently observed similar consequences in each of its Wind Investigation Reports, which date back to Hurricanes Charley and Ivan in 2004. One such RICOWI report states, “The studies reinforced the need for secure roof edges, and codes that require secure roof edging to be enforced.” Another report references insurance industry estimates that show wind-related events result in more than half of all insured disaster losses, which totaled over $300 billion between 1988 and 2007.

In spite of building code requirements for performance testing of edge metal systems, these instances of roof damage and failure due to insufficient edge securement serve as evidence of the lack of adequate design, construction, and code enforcement prevalent in the industry today. The International Building Code (IBC) includes specific requirements for performance testing of edge metal systems, which, if properly applied and enforced, could dramatically reduce losses during wind events. Since the 2003 code cycle, the IBC has required the following performance and testing requirements for edge securement of flat roofs:

> **1504.5 Edge securement for low-slope roofs.** Low-slope membrane roof system metal-edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with ANSI/SPRI ES-1, except the basic wind speed shall be determined from Figure 1609.

Notwithstanding the clear code requirement that has been adopted in some similar form by each state building code, it unfortunately remains an exception, not the rule, when an American National Standards Institute/Single Ply Roofing Institute (ANSI/SPRI) ES-1 tested edge metal system is specified and installed.

Figure 1 – Hurricane Charley, 2004: Edge flashing damage initiates roof blow-off. Photo courtesy of RICOWI.

ANSI/SPRI ES-1 2003, WIND DESIGN STANDARD FOR EDGE SYSTEMS USED WITH LOW-SLOPE ROOFING SYSTEMS

The ES-1 standard includes an analytical procedure to determine the required resistance of an edge-securement system for a specific project application, as well as three test methods to quantify the ultimate capacity of a particular edge-securement device or system.

The first test method, RE-1, is known as the “membrane pull” test and is one of two required test methods for fascia and gravel-stop systems. This

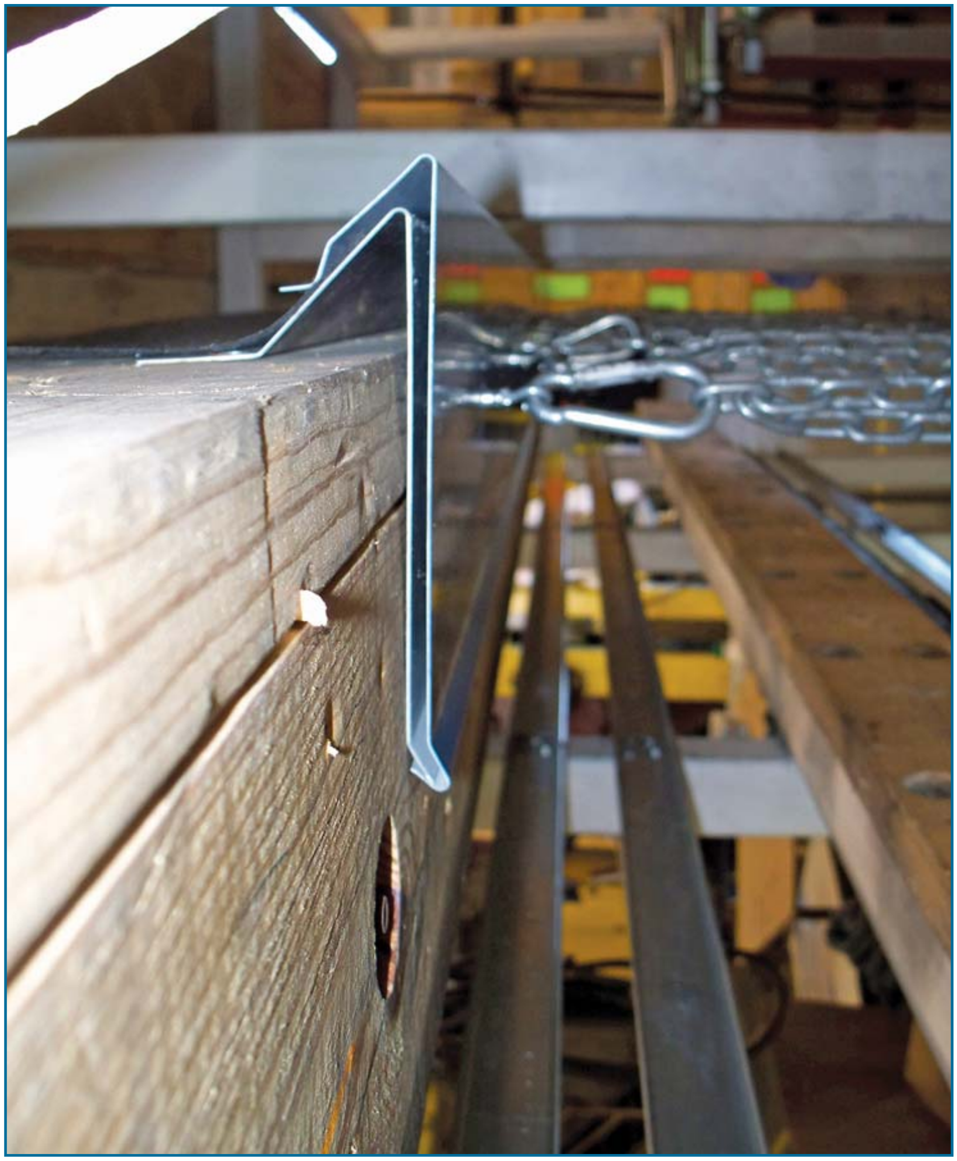

Figure 2 – RE-2 pull-off test for edge flashing. Photo courtesy of Hurricane Test Laboratory and IMETCO.

test originates from the observed failure mechanism of nonfully adhered membranes, which can separate from the edge securement and allow water ingress and membrane failure due to rapid air infiltration between the membrane and roof deck. Note that edge-securement systems for use with fully adhered roof membranes are exempt from this test method.

For the RE-1 test method, sample specimens of the edge-securement system and membrane are constructed per manufacturer or project details. The membrane is then pulled upward and away from the roof edge at a 45-degree angle. The edge-securement system is deemed to comply with the standard if it provides a minimum resistance of 100 pounds per linear foot for ballasted roof systems or a calculated load resistance based on fastener spacing and applied wind pressure for mechanically attached roof systems.

The RE-2 test method, “Pull-Off Test for Edge Flashings,” is also applicable to fascia- and gravel-stop-type systems defined as having an exposed horizontal component of 4 in or less. For this test method, a full-size specimen not less than 8 ft long is constructed and statically loaded in a manner that pulls the vertical leg of fascia or gravel stop in a horizontal, outward direction. The fascia is sequentially loaded with ever-increasing loads in accordance with the procedure of the test method. Prior to each increase in loading, the specimen is unloaded to simulate the cyclic and transient nature of wind pressures. It is often as the specimen is being unloaded and allowed to relax that many systems experience disengagement of the fascia from the anchoring cleat. For this method, the highest load achieved prior to system failure or disengagement is recorded as the ultimate blow-off capacity of the edge-securement system.

The last test method, RE-3, is the "Pull-Off Test for Coping." By definition, any edge-securement system for flat roof membranes with an exposed horizontal exposure greater than 4 in shall be tested in accordance with RE-3. Similar to the RE-2 method, full-size sample specimens are tested to failure. However, unlike the RE-2 method for fascia systems, the RE-3 method requires the wall coping system to be loaded simultaneously in both an upward direction (on the horizontally exposed face) and in an outward direction (on one of the vertically exposed faces). As there are frequently variations in both the exposed height and attachment method of each of the vertical coping legs, the RE-3 method requires each coping system to be tested twice—once while loading the outer vertical leg and coping top face, and once while loading the inner vertical leg and coping top face. The testing procedure is similar to the RE-2 method in that the copings are successively loaded with higher and higher applied static forces and are unloaded and allowed to relax between each successive loading. The lesser of the two resultant ultimate loads prior to failure or disengagement (either the outer or inner vertical leg loaded simultaneously with the top face) is recorded as the ultimate blow-off capacity of the coping system.

PROJECT DESIGN AND SPECIFICATIONS USING ES-1

Building codes require that edge-securement systems be performance tested to meet or exceed the wind loads prescribed by the code, but neither the International Code Council (the body responsible for the IBC) nor ANSI or SPRI provides a listing of "certified" testing agencies or maintains a registry of "approved" systems. Regarding the qualifications of those performing the test procedures and reporting the resulting system capacities, a credible recommendation would be to specify that "ES-1 testing shall be witnessed by, and test reports prepared and sealed by, a professional engineer acting on behalf of a third-party international accreditation service (IAS) ISO 17025-compliant testing laboratory." Although the code is nebulous as to what might constitute acceptance of an ES-1 test report, this measure of professional competence will certainly ensure a large measure of credibility for the submitted performance

Figure 3 – RE-3 pull-off test for copings. Photo courtesy of Hurricane Test Laboratory and IMETCO.

data. Considering the numerous manufacturers and fabricators who have already conducted ES-1 testing in accordance with the above suggested specification, the availability of systems capable of meeting the building code requirements is certainly substantial.

To use the ES-1 test results for project design and code compliance, it is first necessary to determine the applicable design wind loads to which the edge-securement system will be subjected. These loads are given in the ES-1 standard and are based upon the analytical design procedure outlined in American Society for Civil Engineers (ASCE) 7-02, "Minimum Design Loads for Buildings and Other Structures." When calculating wind loads acting on the edge-securement system at service-level loads, there are a number of key factors to note. First, the IBC wind speed map supersedes that of ASCE 7-02 and the ES-1 standard. However, through the IBC 2009 code cycle, the wind speed maps have remained identical to ASCE 7-02.

There are two other particular differences between ANSI/SPRI ES-1 and the provisions of ASCE 7-02. First, the directionality factor, Kd, for building components and cladding is given as 0.85 in ASCE 7-02 Table 6-4, while the ES-1 standard conservatively takes this factor to be 1.0. Secondly, ASCE 7 allows for a 10% reduction in the external pressure coefficient, GCp, for walls less than 60 ft high when the roof slope is less than 10 degrees (ref. ASCE 7-02, Figure 6-11A, Note 5). Again, the ES-1 standard conservatively ignores this potential reduction of the design outward wind pressure.

Perhaps the most important design consideration when applying the ultimate ES-1 test capacity to building code design service-level wind pressure is the (at best) vague reference to allowable stress safety

Figure 4 – Hurricane Charley, 2004: Coping blow-off. Photo courtesy of RICOWI.

factors or strength design load and resistance factors within the ES-1 standard and commentary. By studying the design example and commentary within the standard and from other sources, a designer may mistakenly assume that any tested edge-securement system that achieves an ultimate failure load in excess of the calculated design wind pressure is of sufficient strength for a given project application. However, this design methodology leaves no "reserve capacity" to account for variation in test values, equipment calibration, or—most important—construction tolerances, installer craftsmanship, and potential wind events that may exceed the design wind speed. Like every other material and system design analysis, it is imperative that the designer apply a factor to account for the potential "real-world" deviations from laboratory predictions. The SPRI ES-1 Task Force Committee has taken the official position that a

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

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

1. **What is the difference between a hydrokinetic metal roof system and a hydrostatic metal roof system?**
2. **How much does a metal roof move? The formula used to determine the estimated expansion of a metal roof panel is $AL = L \cdot \Delta T \cdot CX$. What does each component of the formula represent?**
3. **How is side-to-side thermal movement handled?**
4. **Aluminum panels are also used in the metal roof industry but are not as popular as coated steel panels. What two factors are most responsible for the difference in popularity?**
5. **Define the term "chalking" in regard to a metal roof.**
6. **Define the term "fading" in regard to a metal roof.**

Answers on page 26

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Answers to questions from page 25:

1. **Hydrokinetic roof systems are steep-sloped but not watertight. Hydrostatic roof systems are low-sloped but watertight.**

2. **AL = Change in length of metal panel.**

   L = The original length of panel.

   ΔT = The change in temperature.

   CX = The coefficient of expansion for the metal being used.

3. **By flexure at the side seam, since the roof panel width is only a few feet.**

4. **Cost and coefficient of expansion.**

5. **A release of pigment and filler as the resin breaks down from weathering.**

6. **Fade of coatings is a permanent color shift, generally with a loss of color intensity.**

REFERENCE:
Roof Technology and Science II (RCI educational program)

safety factor of 2.0 must be applied to the ultimate test value prior to comparing the system capacity to the applied design wind pressure. In effect, we are comparing one half of the tested system capacity to the full magnitude of the anticipated wind force. The newly published SPRI/FM4435/ES-1 (2010) standard now clarifies this design methodology by explicitly multiplying the design wind pressure by 2.0.

An excerpt from the RICOWI Executive Summary of the Hurricane Ike investigation should serve as an indisputable real-world lesson on the importance of performance testing, project design application, product submittal review, and building code enforcement:

> The major problems were most often caused by edge failure, leading to membrane dislodgement and/or punctures and tears due to flying debris. Since 2003, the International Building Code (IBC) has required that edge metal be designed and installed in accordance with ANSI/SPRI ES-1. Compliance with the standard could significantly reduce the damage from hurricanes.

Frank Resso, PE

Frank Resso, PE, is the director of engineering for IMETCO, Inc. (**www.imetco.com**) in Tucker, GA. For more than 13 years, he has been involved in project design and system selection, product development, testing, and approvals of metal roofing, wall panel, and edge-securement systems. Resso is a member of several professional organizations, including RCI, ASCE/SEI/AEI, and ASTM.

Proprietary Roof Bidding Examined by CA Assembly

An investigation into the process used by California public school districts in bidding reroofing projects has been conducted by the Assembly Accountability and Administrative Review Committee. It determined that statewide, the practice of what amounts to noncompetitive bidding is costing school districts $30 to $125 million each year.

The increased costs are "the product of aggressive marketing techniques by roofing manufacturers, a tendency of districts to stick with manufacturers hired by previous administrations, and a convenient reliance by district officials on the manufacturers to write project specifications," the legislative inquiry found.

State law requires competitive bidding in public projects, including schools, but there's little enforcement, industry experts said. Public agencies are allowed to specify particular brand name products but must also include an "or equal" clause that allows alternative manufacturers to be considered. The noncompetitive bids, often written as a "convenience" for the school district by a manufacturer, get around that clause by listing product requirements that are so specific that no other manufacturer could qualify.

Assemblyman Hector De La Torre, D-South Gate (Los Angeles County), chairman of the investigating committee that began the investigation after being tipped off by a whistle-blower, called it a "systemic breach of trust," saying he wants a fix that will survive the constant churn of district facility administrators and legislators. State officials don't believe kickbacks or other misconduct are part of the problem. The noncompetitive bidding is more a result of taking the path of least resistance and little or no oversight of the process.

— San Francisco Chronicle