

# USING THE NEW ANSI ROOF EDGE STANDARD TO MAKE A BETTER ROOF

BY JOHN B. HICKMAN

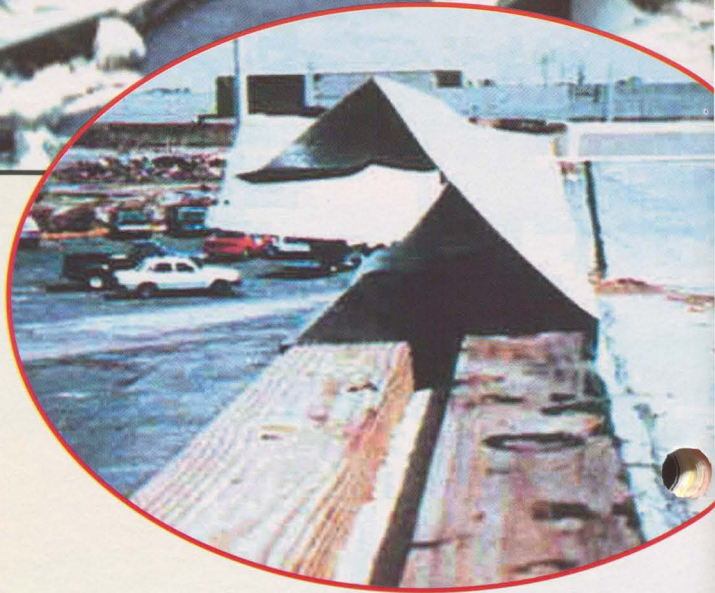


Figure 1: Roof collapse after Hurricane Andrew (Courtesy R. Edwards).

Figure 2: (Inset) Poorly secured coping destroyed by wind (Courtesy Factory Mutual).

## THE ANSI/SPRI ES-1-98 STANDARD

After six years of work, SPRI, the association of sheet roofing and component manufacturers, achieved approval of the industry's first comprehensive standard for roof edge design. ANSI/SPRI ES-1-98, Wind Design Standard for Edge Systems Used With Low Slope Roofing Systems, was approved in November 1998 by ANSI, the American National Standards Institute. SPRI's Roof Edge Detail Committee developed the new standard. That group included representatives of RCI, the National Roofing Contractors Association (NRCA), roofing manufacturers, and the insurance industry.

ANSI/SPRI ES-1-98 is the first industry-sponsored roof edge design standard. Its wind force provisions are based on ASCE 7-95, the National Wind Design Standard. Minimum metal thicknesses and corrosion considerations are also part of the new standard. A "Commentary" section explains the engineering behind its mandatory provisions. The purpose of this paper is to explore this standard and show how it may be used for better roof design.

## REASONS FOR DEVELOPING THE STANDARD

### Hugo/RICOWI

Ten years ago, Hurricane Hugo slammed into Puerto Rico and Charleston, SC. Winds reportedly exceeded 150 mph and were accompanied by torrential rain. According to Factory Mutual,<sup>1</sup> Hugo "caused \$194 million (1990 dollars) in damage to 11,075 insured properties." Shortly after Hugo, a group of individuals representing various roof-related associations formed RICOWI, the Roofing Industry Committee on Wind Issues (now "Weather Issues") with Charles Goldsmith, AIA, as its chairman. RICOWI's purpose was to foster research and communication aimed at mitigating the effects of hurricanes and strong winds on roof-related building damage.

Immediately, RICOWI established 19 priorities for study. "Roof Edge Detailing" was the number two priority on that list. Subsequent hurricanes and storms have increased awareness of the need for better roof edge design.

Investigators have found that relatively simple steps in edge system securement can potentially head off millions of dollars worth of windstorm damage. The Institute for Business and Home Safety (IBHS), an insurance association, has listed "adequate attachment of commercial edge metal" among its top four most wanted improvements for disaster-resilient structures.<sup>2</sup> Each year, about 80% of construction litigation involves water damage and most of that is a direct result of wind and water leaks at the roof edge.

### Structural Formulae

Most critical parts of a building are designed using precise structural formulae and codes. In a blow, these parts generally survive. Edges don't. Yet they are the first defense the roof has against the wind. Once the edge goes, so does the rest of the roof.

It doesn't take a hurricane to rip up a roof edge. Last November, Des Moines was hit by a windstorm that damaged the roofs of a number of schools. The local paper said, "Some schools scrambled to send students home because of ripped up roofs... Van Roekel [a school principal] said that the edging along the roof line blew off, allowing wind under a rubber membrane."<sup>3</sup>

### Inadequate Standards

Prior to the development of ANSI/SPRI ES-1-98, rules of thumb, local practices, and the suggestions of a few roof edge manufacturers guided edge design advice. The Factory Mutual Research Corporation (FMRC) Property Loss Prevention Data Sheet 1-49<sup>4</sup> has been accepted by some as a standard, but its advice is largely prescriptive and is not based on the latest wind design standards. Some have avoided FM 1-49 because it was never intended to be a national standard outside the FMRC organization, and it requires that testing be done only at FMRC's laboratories. The need for a national design standard for roof edge details has become acutely apparent to the roofing industry.

### Specifiers Seek Guidance

Many specifiers see the need for better roof edge design. Without a code or national standard to back them up, it is difficult for them to defend a specification when a contractor urges

the use of a cheapened detail because "it is just as good as" the one specified by the designer. It is even difficult to defend specification of the edge of a reputable manufacturer. With no standard, it is difficult to compare the merits of different designs. ES-1-98 is that standard.

### How To Use the Standard To Improve a Roof

ANSI/SPRI ES-1-98 is a comprehensive work providing rules for wind design, choice of materials, and other design parameters such as nailer coverage. Its wind pressure provisions, while based on the latest wind engineering, are easy to follow and quickly

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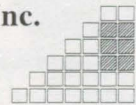
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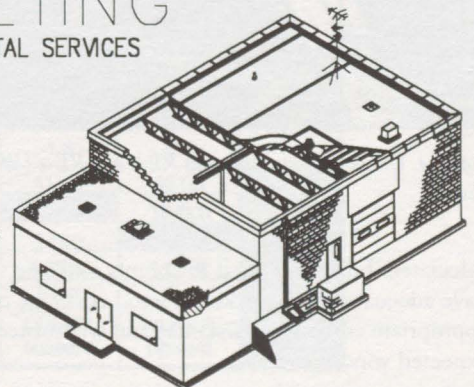
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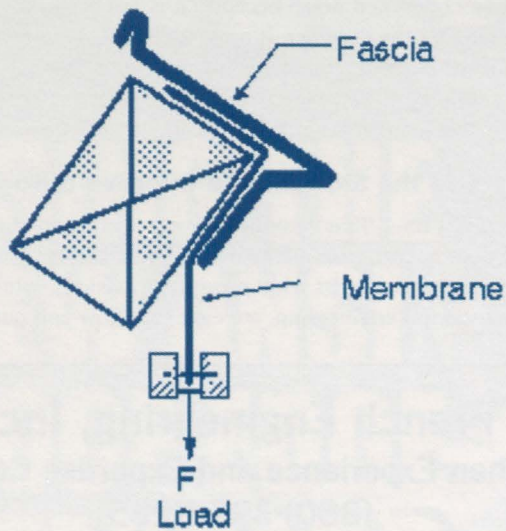


Figure 3: Membrane Pullout Test

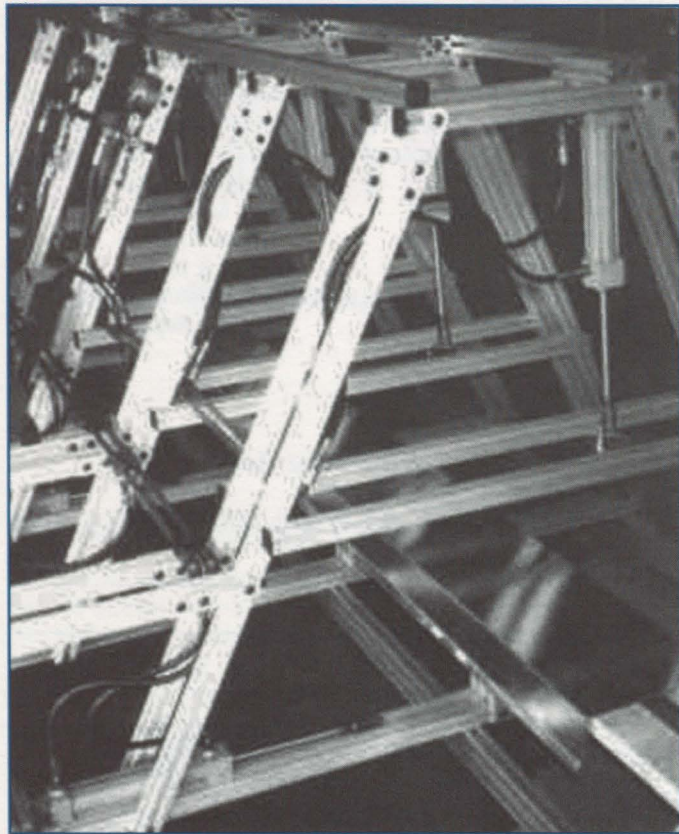


Figure 4: Device for performing tests RE-2 and RE-3 (W. P. Hickman Co. photo).

calculated. Edges designed to comply with the standard will have adequate metal thickness, good coverage of nailers and appropriate corrosion resistance, and will protect the roof from expected windstorms.

The standard considers such factors as building location, building use, building environment, corner regions, substrates, and nailer coverage. It also helps a designer to decide which metal pairs to use and what thicknesses to specify.

### Appliances

Frequently, an edge detail that would have served well is compromised by the use of appliances such as signs or lightning rods that are subsequently attached to the edge. ES-1-98 requires that these be eliminated or isolated to avoid corrosion and other problems.

### Testing

The heart of the document is its test protocols. There are three tests that may be required, depending upon the edge design. There are two blow-off tests, one for coping and one for fascia. There is also a membrane pullout test for those fascia systems that are intended to terminate ballasted or mechanically-attached roofing membrane systems.

### Membrane Pull-Out (Test RE-1)

The protocol for this test requires that the membrane be pulled at a 45° angle. A 100-pound resistance passes this test. See Figure 3.

### Blow-Off Tests (Tests RE-2 and RE-3)

The Standard requires static tests of full-length sections of roof edge. Full-length assures that all of the components will be stressed as they would be in the field. Test RE-2 for fascias is rather straightforward. Test RE-3 for copings is complicated somewhat by the requirement that a coping be tested simultaneously in horizontal and vertical directions and that the test be run twice, once against the top and face and once against the top and back leg (inboard face). The forces on the coping must be applied in the exact ratio of design pressures calculated for the top and the faces. We shall work examples of these calculations.

Figure 4 shows one embodiment of the testing apparatus for RE-2 and RE-3. It is a hydraulically operated device built by W.P. Hickman Company. Other roof edge manufacturers and at least one national testing laboratory have similar devices at this writing.

## WORKED EXAMPLES

Worked examples show the ease with which the Standard can be used. Worked calculation sheets appear on pages 23, 25, and 26. (For full understanding, readers should obtain a copy of the standard and refer to the pages and tables mentioned herein. For a copy, contact SPRI at 617-444-0242.)

### Example 1: Atlanta Hotel

Consider a 95-foot (30 m) high, suburban, conference-type hotel building in Atlanta. Attachment 1 from the ANSI/SPRI ES-1-98 is a basic wind speed map of the USA. This should be used to determine wind speeds.

Basic Wind Speed from the map is 90 mph

The "Exposure" for such a building, according to the definitions given on Page 3 of the Design Standard, is Exposure B. At 90 mph, the velocity pressure, ( $q_z$ ), for a 95-foot structure is 20 pounds per square foot (psf).

$$\text{Velocity Pressure} = 20 \text{ psf}$$

The Importance Factor (see ES 1-98 Table 1 and Table 3) would be that of a Category III building (occupancy by more than 300 people in one room). The importance factor (I), is 1.15 for this building.

$$\text{Importance Factor Multiplier (I)} = 1.15$$

Velocity Pressure is multiplied by the Importance Factor Multiplier to obtain an Adjusted Velocity Pressure:

$$\text{Adjusted Velocity Pressure} = 20 \times 1.15 = 23 \text{ psf}$$

Obtain Pressure Coefficients ( $G_Cp$ ) from Table 5. These are -2.3 in the vertical direction and -1.8 horizontally. The following design force is calculated:

$$\begin{aligned} \text{Vertical Design Pressure: } & -2.3 \times 23 \text{ psf} = -53 \text{ psf} \\ \text{Horizontal Design Pressure: } & -1.8 \times 23 \text{ psf} = -41 \text{ psf} \end{aligned}$$

In this case, a coping must be tested to withstand 41 psf outward force and 53 psf uplift force. If the coping had 4" legs and a width of 18", the cap would be required to withstand an upward

force of:

$$1.5 \text{ sq. ft./ft} \times 53 \text{ psf} = 80 \text{ lb/ft}$$

and outward forces of:

$$.33 \text{ sq. ft./ft} \times 41 \text{ psf} = 14 \text{ lb/ft}$$

on each face.

The coping is to be tested according to SPRI Test RE-3 run on straight lengths. Doubling fasteners in the corner region will be sufficient instead of testing corner assemblies if the straight length assembly passes RE-3. Note that, in testing the edge device, upward forces and outward forces on a face are to be applied simultaneously, and both face and back face tests are to be run.

If the perimeter were an edge flashing instead of a coping, it would need to withstand an outward design force of 54 psf. If the edge flashing had a 6" (0.5 sq. ft./ft) face, the design resistance would need to be:

$$0.5 \text{ sq. ft./ft} \times 41 \text{ psf} = 21 \text{ lb/ft.}$$

The edge flashing is to be tested according to SPRI Test RE-2 run on full lengths. Doubling fasteners in the corner region will be sufficient instead of testing corner assemblies if the full-length assembly passes RE-2. Furthermore, the edge flashing must be tested according to SPRI Test RE-1 to restrain a 45° pull of 100 pounds per foot if it is the termination of single-ply or modified bitumen membrane.

EXAMPLE 1: ANSI/SPRI ES-I-98 Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems						
LINE	Building Parameters	DATA				PAGE*
01	Building Description	Hotel				By:
	(City, State)	Suburban Atlanta, GA				
	Local Terrain, etc.	Suburban				Date:
	Type of Building	18" Coping w/ 4" Face				
02	Building Height at Eave.	95 ft.				
03	Exposure (Based on Local Terrain).	Circle One				Page 2
		A	B	C	D	
04	Importance Classification (from Table 1).	Circle One				Page 3
		I	II	III	IV	
05	Basic Wind Speed (from wind speed map).	90 mph				Page 7
06	Importance Factor (select Factor from Table 3 based on Line 04 above).	1.15				Page 4
07	Theoretical Velocity Pressure. Choose Table 4 Section Based on Exposure (Line 03). Enter Table 4 with Basic Wind Speed (Line 05) and Building Height (Line 02).	20 psf				Page 5
08	Design Velocity Pressure. Multiply Theoretical Velocity Pressure (Line 07) by Importance Factor (Line 06).	23 psf				
09	Pressure Coefficient Select from Table 5 based on Building Height (Line 02).	Horizontal	Vertical			Page 6
		-1.8	-2.3			
10	Design Pressure (Ignore negative). Multiply Line 08 by Line 09.	41 psf		53 psf		
11	Width of Top (Omit if Edge is Not Coping.)			18 inch		
12	Face Height	4 inch				
13	Height and Width in Feet. (Divide lines 11 & 12 by 12.0 to convert to ft.)	0.33 ft.		1.50 ft.		
14	Design Resistance. Multiply Line 10 by Line 13. Edge device must be tested to meet or exceed this force.	Face		Top		
		14 lbs./ft. outward		80 lbs./ft. upward		

\* Page number of ES-1-98

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A roof edge may be designed and tested to meet the above criteria, or one may be selected that has been previously certified to meet the minimum design requirements of this standard.

### Other Provisions of ES-1-98

The designer may specify a minimum thickness, or simply require the roof edge provider to comply with the standard. Frequently, dissimilar metals are used for the face and the cleats or retaining devices. Care must be exercised in selecting these materials. Allowable metal pairs are shown on Page 6 of the standard. Other pairs may be chosen, but only if they can be shown to provide satisfactory galvanic compatibility (Sec. 5.3 p.6).

The face of the coping must be tall enough to extend one inch below the top of the wall facing (Sec. 2.4 p.2). This provision of the standard is to prevent blowing rain from entering the building behind the facing material. If the coping is secured to a nailer, the attachment of the nailer must be sufficient to carry the loads calculated above. This requirement can be especially troublesome in retrofitting, because the condition of the nailer may not be known during the design process.

### Example 2, Florida High-Rise

Consider a 100-foot high hospital in downtown Lakeland, Florida. The unit is to have a 16-inch wide coping with 4-inch face and back leg. Refer to *Example 1* to follow the calculation steps. Enter the building identification, date, and designer's initials at the top of the worksheet. Line 02 shows the average building height at the eaves of 100 feet. Enter the coping width on Line 11 and face height on Line 12. This is the basic information needed to determine the forces on the coping. The calculation steps follow:

Referring to the Exposure classifications on Page 2 of ES-1, we see that Exposure "B" is appropriate for this hospital. Since a hospital is an essential facility, the Importance Classification is "IV" (Table 1 on Page 3 of ES-1). Circle these selections on lines 03 and 04 (bolded in the accompanying worksheet tables).

Examining the wind speed map on Page 7, note that Lakeland has a Basic Wind Speed of 130 miles per hour. Enter the wind speed on Line 05. Look up the Importance Factor (Table 3, Page 4), based on the Classification circled on Line 04. The value is 1.15. Enter it on Line 06.

Now we are ready to find the Theoretical Velocity Pressure (Table 4 on Page 5). Enter the appropriate figure from the Table for "Exposure B" (Line 03). A building 100 feet high (Line 02) and a Design Wind Speed of 130 mph (Line 07) gives a Velocity Pressure of 43 psf. Enter 43 on Line 07. Then multiply line 05 by Line 04 to get Line 08, "Design Pressure."

Pressure coefficients are obtained from Table 5, Page 6. These coefficients correct the theoretical velocity pressures of Table 4 to actual design pressures. No safety factors are needed here. The pressure coefficients themselves provide the recom-

Figure 5: Midwest school roof destroyed after edge failed in storm (courtesy Beavers & Associates).

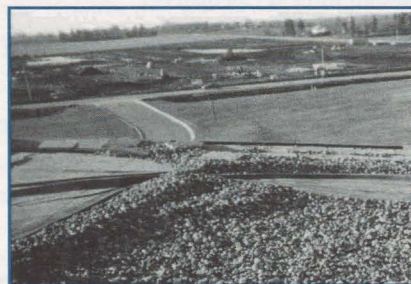


Figure 6: Florida high-rise destruction during Hurricane Andrew (photo ©1992 Roger Edwards).

mended values. Different values are needed for outward force (horizontal) and upward force (vertical). The building exceeds 60 feet, so we use the right hand column values: -1.8 for horizontal and -2.3 vertical. The negative sign denotes that the force is away from the building, tending to tear the edge device off. Enter -1.8 and -2.3 on Line 09.

We may ignore the minus sign if we remember that the force is always acting away from the building. Multiply the Design Velocity Pressure (Line 08) by the Pressure Coefficient (Line 09) to get Design Pressure (Line 10). The pressure is 90 psf horizontal and 115 psf vertical.

Divide Lines 11 and 12 by 12.0 to convert inches to feet. The 4-inch face is 0.33 feet high, and the 16-inch coping is 1.33 feet wide. Enter the results on Line 13.

The linear resistance we seek is found by multiplying the pressure (psf) by the height and width in feet to get pounds per linear foot (30 and 153) which are entered on Line 14. Test RE-3 (see Page 10) must result in at least 30 pounds per foot on the face and 153 pounds per foot on the top. Remember that the tests must be performed on a face and the top simultaneously. If the back leg dimension differs from the face, recalculate Lines 12-13 for the different back-leg height. That result will be the performance demanded of the back leg.



Figure 7: Roof and insulation blown off after edge system failed during Hurricane Hugo (W.P. Hickman Company photo).

The designer may properly place the burden of calculation on the roof edge provider by simply specifying that the edge comply with ANSI/SPRI ES-1-98.

The following examples will be followed in less detail. Refer to the example worksheets for calculation results.

EXAMPLE 2: ANSI/SPRI ES-1-98 Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems				
LINE	Building Parameters	DATA		PAGE*
01	<b>Building Description</b>	<b>Hospital</b>		<b>By:</b>
	(City, State)	<b>Lakeland, Florida</b>		
	Local Terrain, etc.	<b>Downtown location</b>		<b>Date:</b>
	Type of Building	<b>16" Coping w/ 4" Face</b>		
02	<b>Building Height at Eave.</b>	<b>100 ft.</b>		
03	<b>Exposure</b> (Based on Local Terrain).	Circle One		Page 2
		A	B C D	
04	<b>Importance Classification</b> (from Table 1).	Circle One		Page 3
		I	II III IV	
05	<b>Basic Wind Speed</b> (from wind speed map)	<b>130 mph</b>		Page 7
06	<b>Importance Factor</b> (select Factor from Table 3 based on Line 04 above).	<b>1.15</b>		Page 4
07	<b>Theoretical Velocity Pressure.</b> Choose Table 4 Section Based on Exposure (Line 03). Enter Table 4 with Basic Wind Speed (Line 05) and Building Height (Line 02).	<b>43 psf</b>		Page 5
08	<b>Design Velocity Pressure.</b> Multiply Theoretical Velocity Pressure (Line 07) by Importance Factor (Line 06).	<b>50 psf</b>		
09	<b>Pressure Coefficient</b> Select from Table 5 based on Building Height (Line 02).	Horizontal	Vertical	Page 6
		<b>-1.8</b>	<b>-2.3</b>	
10	<b>Design Pressure</b> (Ignore negative). Multiply Line 08 by Line 09.	<b>90 psf</b>	<b>115 psf</b>	
11	<b>Width of Top</b> (Omit if Edge is Not Coping.)		<b>16 inch</b>	
12	<b>Face Height</b>	<b>4 inch</b>		
13	<b>Height and Width in Feet.</b> (Divide lines 11 & 12 by 12.0 to convert to ft.)	<b>0.33 ft.</b>	<b>1.33 ft.</b>	
14	<b>Design Resistance.</b> Multiply Line 10 by Line 13. Edge device must be tested to meet or exceed this force.	<b>Face</b>	<b>Top</b>	
		<b>30 lbs./ft. outward</b>	<b>153 lbs./ft. upward</b>	

\* Page number of ES-1-98

**EXAMPLE 3: ANSI/SPRI ES-I-98 Wind Design Standard for Edge Systems  
Used with Low Slope Roofing Systems**

LINE	Building Parameters	DATA	PAGE*
01	<b>Building Description</b>	<b>Motel</b>	<b>By:</b>
	(City, State)	<b>Miami Beach, FL</b>	
	Local Terrain, etc.	<b>Seaside</b>	<b>Date:</b>
	Type of Building	<b>8" Coping w/ 3" Face</b>	
02	<b>Building Height</b> at Eave.	<b>45 ft.</b>	
03	<b>Exposure</b> (Based on Local Terrain).	Circle One	Page 2
		A    B    C    D	
04	<b>Importance Classification</b> (from Table 1).	Circle One	Page 3
		I    II    III    IV	
05	<b>Basic Wind Speed</b> (from wind speed map)	<b>150 mph</b>	Page 7
06	<b>Importance Factor</b> (select Factor from Table 3 based on Line 04 above).	<b>1.00</b>	Page 4
07	<b>Theoretical Velocity Pressure.</b> Choose Table 4 Section Based on Exposure (Line 03). Enter Table 4 with Basic Wind Speed (Line 05) and Building Height (Line 02).	<b>65 psf</b>	Page 5
08	<b>Design Velocity Pressure.</b> Multiply Theoretical Velocity Pressure (Line 07) by Importance Factor (Line 06).	<b>65 psf</b>	
09	<b>Pressure Coefficient</b> Select from Table 5 based on Building Height (Line 02).	Horiz.      Vertical	Page 6
		-1.4          -1.8	
10	<b>Design Pressure</b> (Ignore negative). Multiply Line 08 by Line 09.	<b>91 psf</b>	<b>117 psf</b>
11	<b>Width</b> of Top (Omit if Edge is Not Coping.)		<b>8 inch</b>
12	<b>Face Height</b>	<b>3 inch</b>	
13	<b>Height and Width</b> in Feet. (Divide lines 11 & 12 by 12.0 to convert to ft.)	<b>0.25 ft.</b>	<b>0.67 ft.</b>
14	<b>Design Resistance.</b> Multiply Line 10 by Line 13. Edge device must be tested to meet or exceed this force.	Face          Top	
		<b>23 lbs./ft.</b> outward	<b>78 lbs./ft.</b> upward

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**EXAMPLE 4: ANSI/SPRI ES-I-98 Wind Design Standard for Edge Systems  
Used with Low Slope Roofing Systems**

LINE	Building Parameters	DATA	PAGE*
01	<b>Building Description</b>	<b>Equipment Shed</b>	<b>By:</b>
	(City, State)	<b>Near St. Louis, MO</b>	
	Local Terrain, etc.	<b>Farmland</b>	<b>Date:</b>
	Type of Building	<b>6" Fascia</b>	
02	<b>Building Height</b> at Eave.	<b>32 ft.</b>	
03	<b>Exposure</b> (Based on Local Terrain).	Circle One	Page 2
		A    B    C    D	
04	<b>Importance Classification</b> (from Table 1).	Circle One	Page 3
		I    II    III    IV	
05	<b>Basic Wind Speed</b> (from wind speed map)	<b>90 mph</b>	Page 7
06	<b>Importance Factor</b> (select Factor from Table 3 based on Line 04 above).	<b>0.87</b>	Page 4
07	<b>Theoretical Velocity Pressure.</b> Choose Table 4 Section Based on Exposure (Line 03). Enter Table 4 with Basic Wind Speed (Line 05) and Building Height (Line 02).	<b>22 psf</b>	Page 5
08	<b>Design Velocity Pressure.</b> Multiply Theoretical Velocity Pressure (Line 07) by Importance Factor (Line 06).	<b>19 psf</b>	
09	<b>Pressure Coefficient</b> Select from Table 5 based on Building Height (Line 02).	Horiz.      Vertical	Page 6
		-1.4          -1.8	
10	<b>Design Pressure</b> (Ignore negative). Multiply Line 08 by Line 09.	<b>27 psf</b>	<b>34 psf</b>
11	<b>Width</b> of Top (Omit if Edge is Not Coping.)		<b>xxx inch</b>
12	<b>Face Height</b>	<b>6 inch</b>	
13	<b>Height and Width</b> in Feet. (Divide lines 11 & 12 by 12.0 to convert to ft.)	<b>0.5 ft.</b>	<b>NA ft.</b>
14	<b>Design Resistance.</b> Multiply Line 10 by Line 13. Edge device must be tested to meet or exceed this force.	Face          Top	
		<b>14 lbs./ft.</b> outward	<b>NA lbs./ft.</b> upward

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### Example 3, Florida Low-Rise

Assume another Florida building. This time, it is a low-rise motel on the beach near Miami. The specification is for an 8 inch coping with 3 inch face and back leg. Notice that even though the wind zone is fiercer, the requirements are much less stringent. The reasons are: The building is not an "essential facility"; it is not a high-rise; the coping is smaller.

Since the building is on the waterfront, it qualifies as an "Exposure D" location. Being a motel, however, it is neither low hazard nor critical. For that reason, it qualifies for Importance Category II. The basic wind speed in Miami, from the map, is 150 mph. These factors lead to 23 and 78 pounds per ft.

### Example 4, Equipment Shed

In this example, we have an equipment shed. If it collapsed, there would be scant chance of loss of human life. Its Importance Category, therefore, is I, "buildings that represent low hazard to human life." Situated on a farm, it has an environment of open terrain with scattered buildings—clearly, "Exposure C." Even such a low risk building in America's "heartland" requires over 14 pounds per foot of horizontal resistance on the face.

### SUMMARY

These worked examples can give a sense of the forces that edge systems must resist. The forces developed through these examples require resistances on the faces of the edge devices of from 14 to 30 psf. The copings require uplift resistances of 78 to 153 psf.

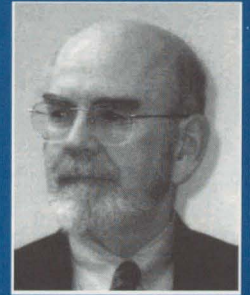
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2. IBES, 1998.
3. *The Des Moines Register*, p4A, Des Moines, IA, Nov. 11, 1998.
4. Property Loss Prevention Data Sheet 1-49, "Roof Edge...", Factory Mutual Corp., Norwood, MA, 1998. ■

### ABOUT THE AUTHOR

**John B. Hickman** is the Chairman and CEO of the W. P. Hickman Company, headquartered in Asheville, NC. Mr. Hickman holds a MS degree in Engineering from the University of Michigan. He is chairman of the Single Ply Roofing Institute's (SPRI) Edge Detail Subcommittee, and is SPRI's delegate to the Edge Detail Committee of the Roofing Industry Committee On Wind Issues (RICOWI). Mr. Hickman is a member of the Boards of Directors of RICOWI, the North Carolina Quality Leadership Foundation (NCQLF) and of The North Carolina Alliance for Competitive Technologies. He has served NCQLF as a Senior Quality Examiner. He is a member of CSI, RCI and NRCA and is a former Director of SPRI.



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