

# Metal Roof Systems in High-Wind Regions

**Purpose:** *To describe practices for designing and installing metal roof systems that will enhance wind resistance in high-wind regions (i.e., greater than 90 miles per hour [mph] basic [gust design] wind speed).*<sup>1</sup>

## Key Issues

Damage investigations have revealed that some metal roofing systems have sufficient strength to resist extremely high winds (Figure 1), while other systems have blown off during winds that were well below design wind speeds given in ASCE 7. When metal roofing (or hip, ridge, or rake flashings) blows off during hurricanes, water may enter the building at displaced roofing; blown-off roofing can damage buildings and injure people. Here is general guidance for achieving successful wind performance:

1. Always follow the manufacturer's installation instructions and local building code requirements.
2. Calculate loads on the roof assembly in accordance with ASCE 7 or the local building code, it is recommended to use whichever procedure results in the highest loads.
3. Specify/purchase a metal roof system that has sufficient uplift resistance to meet the design uplift loads.
  - For standing seam metal panel systems, the 2009 International Building Code (IBC) requires test methods UL 580 or ASTM E 1592. For standing seam systems, it is recommended that design professionals specify E 1592 testing, because it gives a better representation of the system's uplift performance capability.
  - For safety factor determination, refer to Chapter F in standard NAS-01, published by the American Iron and Steel Institute.
  - For through-fastened steel panel systems, the IBC allows uplift resistance to be evaluated by testing or by calculations in accordance with standard NAS-01.



**Figure 1.** *This structural standing seam roof system survived Hurricane Andrew (Florida, 1992), but some hip flashings were blown off. The estimated wind speed was 170 mph (peak gust, at 33 feet for Exposure C).*

- For architectural panels with concealed clips, test method UL 580 is commonly used. However, it is recommended that design professionals specify ASTM E 1592 because it gives a better representation of the system's uplift performance capability. When testing architectural panel systems via ASTM E 1592, the deck joints need to be unsealed in order to allow air flow to the underside of the metal panels. Therefore, underlayment should be eliminated from the test specimen, and a 1/8 inch minimum between deck panel side and end joints should be specified.
- For safety factor determination, refer to Chapter F of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07).

This fact sheet addresses wind and wind-driven rain issues. For general information on other aspects of metal roof system design and construction (including seam types, metal types, and finishes), see the "Additional Resources" section.

<sup>1</sup> The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 116 mph for Risk Category II buildings.



- For copper roofing testing, see “NRCA analyzes and tests metal,” Professional Roofing, May 2003.
  - For metal shingles, it is recommended that uplift resistance be based on test method UL 580 or 1897.
  - Specify the design uplift loads for field, perimeter, and corners of the roof. Also specify the dimension of the width of the perimeter. (Note: For small roof areas, the corner load can be used throughout the entire roof area.)
4. Suitably design the roof system components (see the “Construction Guidance” section).
  5. Obtain the services of a professional roofing contractor to install the roof system.

## Metal Roofing Options

A variety of metal panel systems (including composite foam panels) are available for low-slope (i.e., 3:12 or less) and steep-slope (i.e., greater than 3:12) roofs. Metal shingles are also available for steep-slope roofs. Common metal roofing options are:

**Standing-Seam Hydrostatic (i.e., water-barrier) Systems:** These panel systems are designed to resist water infiltration under hydrostatic pressure. They have standing seams that raise the joint between panels above the water line. The seam is sealed with sealant tape (or sealant) in case it becomes inundated with water backed up by an ice dam or driven by high wind.

Most hydrostatic systems are structural systems (i.e., the roof panel has sufficient strength to span between purlins or nailers). A hydrostatic architectural panel (which cannot span between supports) may be specified, however, if continuous or closely spaced decking is provided.

**Hydrokinetic (i.e., water-shedding) panels:** These panel systems are not designed to resist water infiltration under hydrostatic pressure and therefore require a relatively steep slope (typically greater than 3:12) and the use of an underlayment to provide secondary protection against water that infiltrates past the panels. Most hydrokinetic panels are architectural systems, requiring continuous or closely spaced decking to provide support for gravity loads.

Some hydrokinetic panels have standing ribs and concealed clips (Figure 2), while others (such as 5V-crimp panels, R-panels [box-rib]

For observations of metal roofing performance during Hurricanes Charley (2004, Florida), Ivan (2004, Alabama and Florida), and Katrina (Alabama, Louisiana, and Mississippi, 2005), respectively; see Chapter 5 in FEMA MAT reports 488, 489, and 549.

For attachment of corrugated metal panels, see FEMA 55, *Coastal Construction Manual, Appendix K*, available online at: <http://www.fema.gov/library/viewRecord.do?id=1671>.

An advantage of exposed fastener panels (versus panels with concealed clips) is that, after installation, it is easy to verify that the correct number of fasteners was installed. If fastening was not sufficient, adding exposed fasteners is easy and economical.

and corrugated panels) are through-fastened (i.e., attached with exposed fasteners). Panels are available that simulate the appearance of tile.

**Metal Shingles:** Metal shingles are hydrokinetic products and require a relatively steep-slope and the use of an underlayment. Metal shingles are available that simulate the appearance of wood shakes and tiles.



**Figure 2.** This architectural panel system has concealed clips. The panels unlatched from the clips. The first row of clips (just above the red line) was several inches from the end of the panels. The first row of clips should have been closer to the eave.

## Construction Guidance

- Consult local building code requirements and manufacturer’s literature for specific installation requirements. Requirements may vary locally.
- Underlayment: If a robust underlayment system is installed, it can serve as a secondary water barrier if the metal roof panels or shingles are blown off (Figures 2 and 3). For enhanced underlayment recommendations, see Fact Sheet No. 7.2, *Roof Underlayment for Asphalt Shingle Roofs*. Fact Sheet 7.2 pertains to underlayment options for asphalt shingle roofs. For metal panels and tiles, where Fact Sheet 7.2 recommends a Type I (#15) felt, use a Type II (#30) felt because the heavier felt provides greater resistance to puncture by the panels during application. Also, if a self-adhering modified bitumen underlayment is used, specify/purchase a product that is intended for use underneath metal (such products are more resistant to bitumen flow under high temperature).



**Figure 3.** These architectural panel system have snap-lock seams. One side of the seam is attached with a concealed fastener. Although a large number of panels blew away, the underlayment did not.

- Where the basic (design) wind speed is 110 mph<sup>2</sup> or greater, it is recommended that not less than two clips be used along the eaves, ridges, and hips. Place the first eave clip within 2 to 3 inches of the eave, and place the second clip approximately 3 to 4 inches from the first clip. Figures 2 and 4 illustrate ramifications of clips being too far from the eave.
- For copper panel roofs in areas with a basic wind speed greater than 90 mph,<sup>3</sup> it is recommended that Type 304 or 316 stainless steel clips and stainless steel screws be used instead of more malleable copper clips.



**Figure 4.** These eave clips were too far from the panel ends. The clip at the left was 13" from the edge of the deck. The other clip was 17" from the edge. It would have been prudent to install double clips along the eave.

- When clip or panel fasteners are attached to nailers (Figures 5–7), detail the connection of the nailer to the nailer support (including the detail of where nailers are spliced over a support).



**Figure 5.** The panels blew off the upper roof and landed on the lower roof of this house. The upper asphalt shingle roof shown had been re-covered with 5V-Crimp panels that were screwed to nailers. The failure was caused by inadequate attachment of the nailers (which had widely-spaced nails) to the sheathing. Note that the hip flashing on the lower roof blew off.

- 2 The 110 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 142 mph for Risk Category II buildings.
- 3 The 90 mph speed is based on ASCE 7-05. If ASCE 7-10 is being used, the equivalent wind speed is 116 mph for Risk Category II buildings.



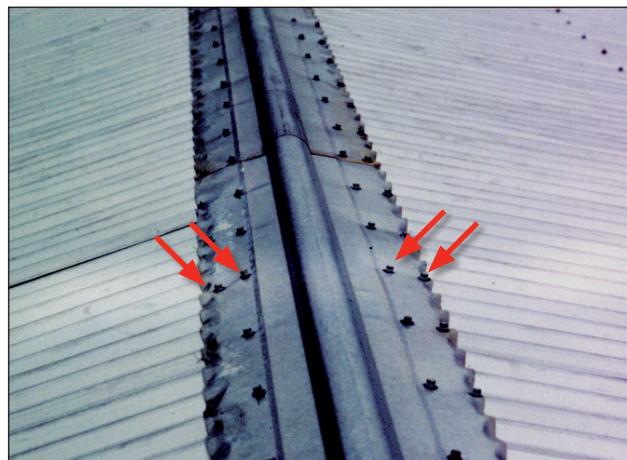
**Figure 6.** Blow-off of nailers caused these panels to progressively fail. The nailers were installed directly over the trusses. In an assembly such as this where there is no decking, there is no opportunity to incorporate an underlayment. With loss of the panels, rainwater was free to enter the building.

- When clip or panel fasteners are loaded in withdrawal (tension), screws are recommended in lieu of nails.
- For roofs located within 3,000 feet of the ocean line, 300 series stainless steel clips and fasteners are recommended.
- For concealed clips over a solid substrate, it is recommended that chalk lines be specified so that the clips are correctly spaced.
- Hip, ridge, and rake flashings: Because exposed fasteners are more reliable than cleat attachment, it is recommended that hip, ridge, and rake flashings be attached with exposed fasteners. Two rows of fasteners are recommended on either side of the hip/ridge line. Close spacing of fasteners is recommended (e.g., spacing in the range of 3 to 6 inches on center, commensurate with the design wind loads), as shown in Figure 8 in order to avoid flashing blow-off as shown in Figure 9.

**Figure 9.** The ridge flashing fasteners were placed too far apart. A significant amount of water leakage can occur when ridge flashings are blown away.



**Figure 7.** This residence had metal shingles that simulated the appearance of tile. The shingles typically blew off the battens, but some of the battens were also blown away.



**Figure 8.** The ridge flashing on these corrugated metal panels had two rows of fasteners on each side of the ridge line.



## Additional Resources

For general information on other aspects of metal roof system design and construction (including seam types, metal types, and finishes), see:

Copper and Common Sense, (<http://www.reverecopper.com>)

Copper Development Association, (<http://www.copper.org/publications>)

Metal Building Manufacturers Association, *Metal Roofing Systems Design Manual*, 2000, (<http://www.mbma.com/display.cfm?p=44&pp6&i=47>)

Metal Construction Association, (<http://www.metalconstruction.org/pubs>)

National Institute of Building Sciences, *Whole Building Design Guide*, ([http://www.wbdg.org/design/env\\_roofing.php](http://www.wbdg.org/design/env_roofing.php))

National Roofing Contractors Association, *The NRCA Roofing Manual: Metal Panel and SPF Roof Systems*, 2008, (<http://www.nrca.net/rp/technical/manual/default.aspx>)

Sheet Metal and Air Conditioning Contractors National Association, *Architectural Sheet Metal Manual*, 2003, (<http://www.smacna.org/bookstore>)

American Iron and Steel Institute, *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07), 2007, (<http://www.steel.org>)

American Iron and Steel Institute (<http://www.professionalroofing.net/article.aspx?id=266>)

FEMA MAT reports 488, 489, FEMA 543 (Section 3.4.3.4), 549, FEMA 577 (Section 4.3.3.8). (<http://www.fema.gov/library>).

International Organization of Standards (ISO), Document ISO 14021, (<http://www.iso.org>).

Professional Roofing, "NRCA analyzes and tests metal," May 2003, (<http://www.professionalroofing.net>)

