Metal Roof Systems in High-Wind Regions

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HURRICANE IKE RECOVERY ADVISORY

Purpose: To recommend 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] gust design wind speed). This Advisory is applicable to residential and commercial/industrial buildings and critical facilities.

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, which 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.

> 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.

> 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.

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, thus requiring continuous or closely spaced decking to provide support for gravity loads.

> This Recovery Advisory 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:
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> ***Architectural Sheet Metal Manual*** (Sheet Metal and Air Conditioning Contractors National Association, 2003: http://www.smacna.org/bookstore
>
> ***Copper and Common Sense*:** http://www.reverecopper.com/candcs.html
>
> **Copper Development Association:** http://www.copper.org/publications/pub_list/architecture.html
>
> **Metal Construction Association:** http://www.metalconstruction.org/pubs
>
> ***Metal Roofing Systems Design Manual*** (Metal Building Manufacturers Association, 2000, http://www.mbma.com/display.cfm?p=44&pp6&i=47
>
> **National Institute of Building Sciences, Whole Building Design Guide:** http://www.wbdg.org/design/env_roofing.php
>
> ***The NRCA Roofing Manual*:** Metal Panel and SPF Roof Systems (National Roofing Contractors Association, 2008, http://www.nrca.net/rp/technical/manual/default.aspx

Some hydrokinetic panels have standing ribs and concealed clips (Figure 1), while others (such as 5V-crimp panels, R-panels [box-rib] 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 therefore also require a relatively steep-slope and the use of an underlayment. Metal shingles are available that simulate the appearance of wood shakes and tiles.

Key Issues

Damage investigations have revealed that some metal roofing systems have sufficient strength to resist extremely high winds (Figure 2), 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) blow off during hurricanes, water may enter the building at displaced roofing; blown-off roofing can damage buildings and injure people. Guidance for achieving successful wind performance is presented below:

1. Always follow 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, whichever procedure results in the highest loads.

3. Specify/purchase a metal roof system that has sufficient uplift resist resistance to meet the design uplift loads.

- For standing seam and through-fastened metal panel systems, the 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 (available online at: http://www.professionalroofing.net/article.aspx?id=266).

- 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.

- For architectural panels with concealed clips, test method UL 580 is commonly used. However, it is recommended that design professionals specify E 1592 because it gives a better representation of the system's uplift performance capability. When testing architectural panel systems via 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

Figure 1. 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.

Figure 2. 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, Exposure C at 33 feet).

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, available on-line at:

FEMA 488: http://www.fema.gov/library/viewRecord.do?id=1444

FEMA 489: http://www.fema.gov/library/viewRecord.do?id=1569

FEMA 549: http://www.fema.gov/library/viewRecord.do?id=1857

1/8” minimum gap between deck panel side and end joints should be specified.

For safety factor determination, refer to Chapter F in standard NAS-01.

- For copper roofing testing, see “NRCA analyzes and tests metal,” Professional Roofing, May 2003 (available online at: http://www.professionalroofing.net/article.aspx?id=266).
- 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 below).

5. Obtain the services of a professional roofing contractor to install the roof system.

Construction Guidance

- Consult the local building code 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 1 and 3). For enhanced underlayment recommendations, see Technical Fact Sheet No. 19 in FEMA 499, *Home Builder’s Guide to Coastal Construction Technical Fact Sheet Series* (available online at: http://www.fema.gov/library/viewRecord.do?id=1570). Fact Sheet 19 pertains to underlayment options for asphalt shingle roofs. For metal panels and tiles, where Fact Sheet 19 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).
- Where the basic (design) wind speed is 110 mph or greater, it is recommended that two clips be used along the eaves, ridges, and hips. Place the first eave clip within 2 to 3" of the eave, and place the second clip approximately 3 to 4" from the first clip. Figures 1 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, it is recommended that Type 316 stainless steel clips and stainless steel screws be used in lieu of the much more malleable copper clips.

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.

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.

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.

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.

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.

- When clip or panel fasteners are attached to nailers (Figures 5, 6, and 7), detail the connection of the nailer to the nailer support (including the detail of where nailers are spliced over a support).
- When clip or panel fasteners are loaded in withdrawal (tension), screws are recommended in lieu of nails.
- For roofs located within 3,000' of the ocean line, 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" 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.

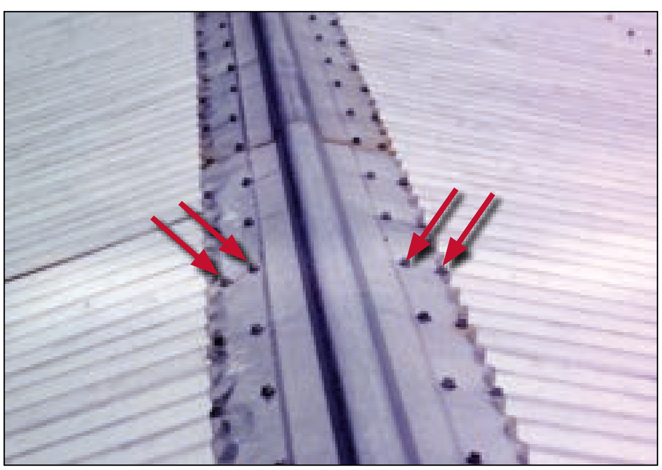

Figure 8. The ridge flashing on these corrugated metal panels had two rows of fasteners on each side of the ridge line.

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.

Critical Facilities

For metal roofs on critical facilities in hurricane-prone regions (as defined in ASCE 7), see the recommendations in FEMA 543, Section 3.4.3.4 (available online at http://www.fema.gov/library/viewRecord.do?id=2441). (For facilities located outside of hurricane-prone regions, see Section 3.3.3.4.) For load calculation recommendations, see Section 3.3.1.2.

For metal roofs on hospitals in hurricane-prone regions, see the recommendations in FEMA 577, Section 4.3.3.8 (available online at http://www.fema.gov/library/viewRecord.do?id=2739). (For hospitals located outside of hurricane-prone regions, see Section 4.3.3.7.) For load calculation recommendations, see Section 4.3.1.2.

Sustainable Design

Cool Roofs: Use metal roofs with a solar reflectance Index (SRI) equal to or greater than 78 for low-slope and 29 for steep-sloped roofs. The higher solar reflectance will reduce the heat-island effect (thermal gradient differences between developed and undeveloped areas), minimizing the impact buildings have on microclimate and human and wildlife habitat. Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, greenhouse gas emissions and air pollution, heat-related illness and mortality, and water quality (http://www.EPA.gov/heatisland).

Recycled Content: Use metal roof systems with recycled content. Many roofing products have recycled scrap content generated both from consumer and industrial users. Recycled content is defined in the International Organization of Standards (ISO) document, ISO 14021 (http://www.iso.org/iso/catalogue_detail?csnumber=23146). Using recycled products reduces impacts from extraction and processing of new materials.

For further information pertaining to sustainable design aspects of metal roofing, see: http://www.metalconstruction.org/design.