Some Surprising Results: Wind Tunnel Testing of Low-Slope Edge Metal

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Much of the damage that happens to roofs during high-wind events starts at the perimeters and corners. This means that the edge metal system at the roof-to-wall interface is critical to a roof's success during wind events. The roofing industry is well aware of this phenomena; investigating roof damage after high winds has been taking place for decades. This issue is so important to the roofing industry that an organization was formed to investigate, learn, and provide insights and recommendations so the industry can improve the performance of edge metal installed at roof-to-wall interfaces. This organization, RICOWI–the Roofing Industry Committee on Weather Issues–was formed in 1990 specifically to "identify and address important technical issues related to the cause of wind damage." Much has been learned from these investigations and full credit goes to RICOWI for spearheading this effort! This photo from RICOWI's investigation of Hurricane Michael shows the importance of the roof-to-wall interface.

Codes and guidance in the industry

The International Building Code (IBC) requires edge metal systems to be tested to determine their resistance to wind loads. This parallels the requirements for roof assemblies to be tested to determine wind resistance.

If you're not specifying or installing edge metal that's been tested–and meets or exceeds the design wind pressures–you certainly should be. Specifically, Section 1504, Performance Requirements, of the IBC requires that edge metal be tested according to ANSI SPRI ES-1 (ES-1). This requirement has been in the IBC since 2003–for 20 years.

FM Global's Loss Prevention Data Sheet 1-49, Perimeter Flashing, (LPDS 1-49) provides a wealth of information about edge metal, as well as flashings, gutters, wood nailers, and other perimeter components. Importantly, LPDS 1-49 is not a building code requirement! Remember, FM Global is an insurance company; they provide guidance through their LPDSs to help their clients' buildings perform well in order to protect the buildings and their occupants and contents. There's a wealth of information to be gleaned from LPDS 1-49. Check out all of FM's data sheets. And if you are working on an FM-insured building, designing the edge metal system is done through FM's RoofNav portal.

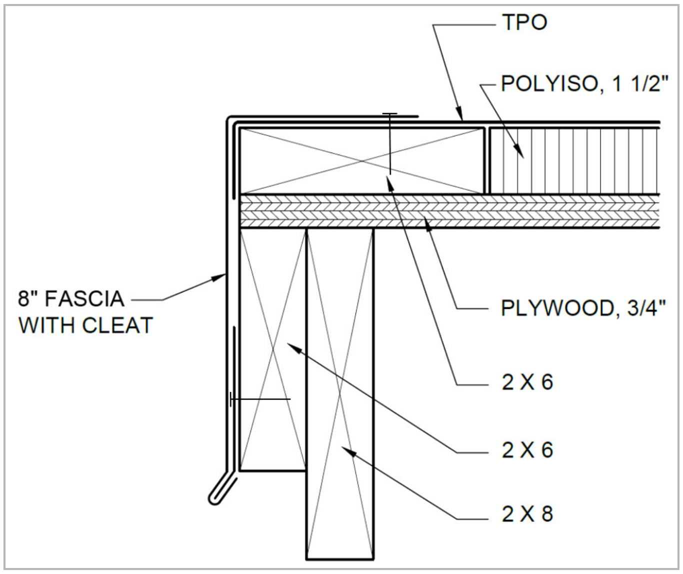
Back to the IBC requirements. IBC requires testing edge metal according to ES-1, and similar to roof systems, there are a number of Approval Listings for both contractor-fabricated and premanufactured edge metal systems that provide their wind resistance capacity. Siplast's perimeter edge metal systems are found here on our website. These systems have been tested according to ES-1, and Approval Listings are available. There are also many contractor-fabricated edge metal systems; the National Roofing Contractors Association's certification program includes a number of Approval Listings. It's worth mentioning that Approval Listings are used not only for IBC compliance, but may also be used for FM or Miami-Dade compliance.

Importantly, just because a contractor fabricates a shape that is similar or equal to one of NRCA's Approval Listings does not mean you've met the building code requirements. Demonstrating that what was fabricated is the same as the Approval Listing requires a contractor to be certified by NRCA's program. Contractor certification means that the contractor's shop is approved to fabricate the edge metal that is shown and was tested according to the Approval Listing. Additionally, contractor certification means the fabrication shop will be audited on a regular basis by UL or Intertek. It may feel like a technicality, but 3rd party audits provide surety that the edge metal meets the building code.

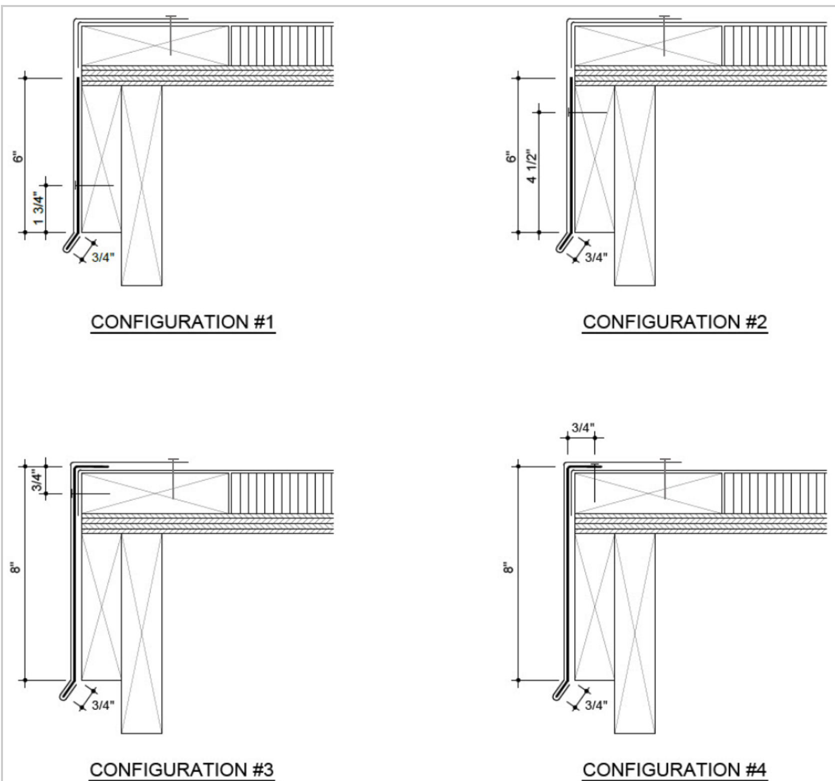
Because of the ES-1 test method, edge metal systems have greatly improved over the past couple of decades. However, damage still occurs during high-wind events, so there's more that can be done.

Wind tunnel testing

Full-scale wind tunnel testing was performed at FIU's Wall of Wind (WoW) in February 2022. Four full-scale wind tunnel tests were performed using a contractor-fabricated, 24-gauge steel, L-shaped edge metal system with an 8 in. face, 4 in. horizontal flange, and ¾ in. drip edge. The horizontal flange of the fascia was fastened into the wood blocking. This figure shows the generic edge metal detail used in the research.

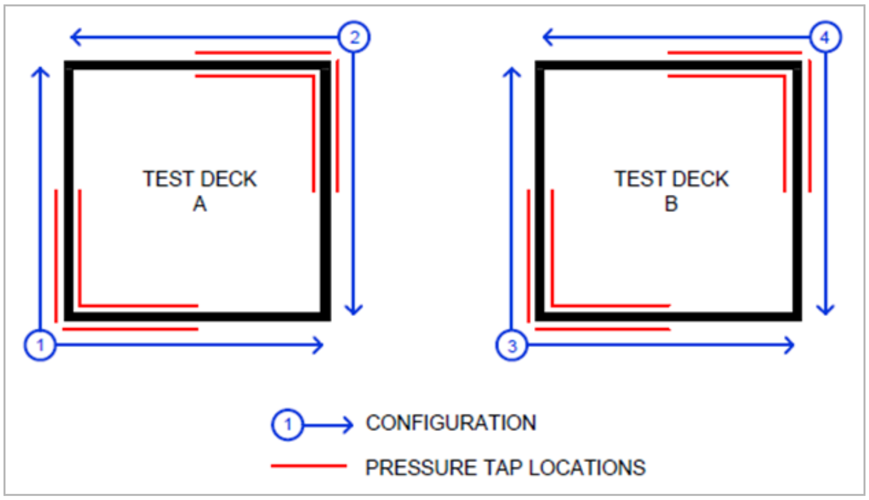


Two different 22-gauge steel cleat shapes were used—a 6 in. cleat and an 8 in. cleat with a 1 in. horizontal return (L-shaped cleats). Four different cleat-fastener locations were used—one low, one in the middle, and one high on the vertical surface, and one on the horizontal surface (Configurations #1, #2, #3, and #4, respectively). The figure below shows the 2 cleat shapes and 4 fastening locations used in this research.



The roof system consisted of a 1.5” layer of polyiso insulation and a 60-mil TPO membrane that was induction-welded to the substrate. Horizontal 2x6 wood blocking was installed at the perimeter of the roof deck. Additionally, a vertical 2x6 surrounded the test deck to provide a substrate for fastening the 2 lower cleat fasteners (as shown in Configurations 1 and 2).

Overall, two test decks, each with 2 of the cleat-fascia configurations, were built. This figure provides a graphical representation of the 2 test decks with the 4 configurations.



This photo shows one of the test decks in the wind tunnel.

Importantly, FIU’s WoW includes a turntable to which the test decks are mounted. The wind tunnel is capable of producing wind speeds up to 157mph in the free air stream, and the turntable allows the test decks to be tested at various wind directions. The maximum wind speed at the deck level was 134 mph.

Each of the test decks was tested at multiple wind directions until the edge metal failed. For this research, “failure” was when the fascia flipped up and onto the roof. This photo is an example of failure, as defined for this research.

Results

<u>Configuration #1</u> (6” cleat, fastened 1 ¾” above the drip edge) failed at a relatively low wind speed: 77 mph. The failure was due to the fascia’s drip edge disengaging from the cleat. Observation of the cleat showed the cleat-fascia disengagement at the low wind speed was due to the cleat being installed approximately ¼” too high–an installation error. This mis-alignment reduced the drip-edge engagement significantly. Note that the cleat remains in place. The photo below shows the failure mode.

Because this was a research project, the installation of the edge metal was performed under ideal conditions. And yet, even under ideal conditions, the short cleat was positioned slightly incorrectly, which led to failure at low wind speeds due to the disengagement of the drip edge.

Configuration #2 (6” cleat, fastened 4 ½” above the drip edge) failed at 134 mph. There was some fluttering of the fascia near the corner at lower wind speeds. The failure was, again, the result of the disengagement of the fascia drip edge from the cleat. Note that the cleat remains in place. There was little outward permanent deformation of the fascia and cleat system until failure occurred. The photo below shows the failure mode.

Configuration #3 (8” L-shaped cleat, fastened ¾” from the top edge of the vertical portion of the cleat into the face of the horizontal nailer) failed at 134 mph. Similar to configuration #2, there was some fluttering of the fascia near the corner at lower wind speeds. Again, the failure was the result of the fascia’s drip edge disengaging from the cleat. The cleat generally remained in place; the cleat furthest from the corner had minimal permanent deformation (before failure occurred), but was deemed to remain able to perform. The 2 photos below show the failure mode.

Configuration #4 (8” L-shaped cleat, fastened ¾” from the outer edge of the horizontal portion of the cleat into the horizontal nailer) failed at 134 mph. This configuration began to flutter at relatively low wind speeds. This is not surprising given the vertical portion of the cleat was not fastened. Fluttering increased as wind speeds increased. This configuration had more outward permanent deformation than the other 3 configurations (before failure occurred); again, this was not surprising given the location of the fastener. The failure mode was two-fold; the nearest-to-the-corner portion failed due to the fascia disengaging from the cleat. And, the furthest-from-the corner portion failed because the fascia and cleat flipped up and onto the horizontal portion of the roof. The fascia and cleat did not stay together, so it is unknown if the cleat disengaged first or if the fascia-cleat flipped up together first. Regardless, where the cleat flipped up, the roof edge is exposed to potential weather infiltration. The photo below shows the failure mode.

Observations

A number of observations can be made based on the 4 configurations used in this research.

- Except for the mis-aligned cleat, each of the configurations failed at 134 mph. The location of the cleat fastener was deemed to not be a critical factor in this research.
- In all cases, the failures were the result of the fascia's drip edge disengaging from the cleat.
- Fastening the cleat on the vertical face led to little outward permanent deformation in Configurations #1, #2, and #3.
- Configuration #4 had outward permanent deformation of the edge metal system that, in the field, would likely have been considered great enough to require repair and/or maintenance of some kind. This was not surprising given the cleat fastener location on the horizontal flange of the L-shaped cleat.

Contractor-fabricated edge metal

For contractor-fabricated edge metal systems, the following suggestions are provided.

- Use L-shaped cleats. L-shaped cleats provide a way to ensure the fascia's drip edge is properly aligned with the cleat. This will help with quality control and quality assurance in the field. Configurations #3 and #4 used L-shaped cleats.
- Using longer drip edges (i.e., longer than ¾") will help increase the possibility of proper drip edge-to-cleat engagement; therefore reducing the possibility of cleat disengagement. This is especially true when the cleat is not self-aligning. Tom Smith recommended this in 1990 in a paper titled, "Hurricane Hugo's Effects on Metal Edge Flashings," from the International Journal of Roofing Technology, NRCA, Rosemont, IL.
- For wall systems that only include a single nailer at the top of the wall, this research suggests that fastening into the face of the nailer (i.e., high on the cleat) provides equivalent wind resistance to failure. However, because high nailing of the cleat can lead to permanent outward deformation, fastening lower on the cleat is suggested.
- Fasten the cleat as low as reasonably possible to prevent outward deformation (similar to Configuration #1).
- To stiffen the full system (especially if a longer drip edge is used), one possibility is to use cleats that are 2 gauges thicker than the fascia. Industry practice is to use a cleat that is one gauge heavier than the fascia. Using a 2-gauges-thicker cleat in the corner zones can provide benefits where the highest wind loads occur. Because the failure mode is cleat disengagement, adding more fasteners to the cleat (for example at 3" on center versus 6" on center) does not provide additional wind resistance.

Pre-fabricated edge metal

While this research was performed on contractor-fabricated edge metal, the use of prefabricated edge metal provides a ready-made solution for the suggestions provided for contractor-fabricated edge metal.

- Prefabricated edge metal includes a cleat with pre-punched holes (to properly locate fasteners) that is designed to fit tightly to the fascia. Because these pieces are pre-fabricated as a system, the drip edge and the cleat are aligned and fit together properly. Therefore, there is little room for misalignment during installation. In addition, the pre-punched holes in the cleat provide an allowance for thermal movement and ensure correct fastener placement and spacing. And the fasteners are included!

- ➢ The fascia and cleats used for prefabricated edge metal oftentimes are stronger and stiffer, providing exceptional wind resistance. This is accomplished by using heavy gauge materials for the fascia and extruded aluminum for the cleat. Siplast's Paraguard Extruded Edge AT HG Fascia is a great example.
- ➢ There are many shapes and designs of premanufactured edge metal. Siplast's Paraguard Extruded Edge AT Fascia is intended to be fastened high on the cleat (similar to Configuration #3) for those installations that include only a single or double wood nailer at the top of a wall.

This research was presented at IIBEC's 2023 Annual Trade Show and Convention in Houston on March 6. Contact IIBEC at https://iibec.org/ or Siplast at BuildingScience@Siplast.com for more information.