FIU | Wall of Wind
NHERI Experimental Facility

Scope of Work

Roof Underlayment Performance in Extreme Wind Events

Florida Department of Business and Professional Regulation

Florida Building Commission

And

Laboratory for Wind Engineering Research (LWER), Extreme Events Institute (EEI)

Florida International University (FIU)

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1. Introduction

Underlayment systems are a critical component of steep-slope roofing assemblies, especially in High-Velocity Hurricane Zones (HVHZs) such as Miami-Dade and Broward Counties in Florida. While roofing tiles provide the primary barrier against environmental exposure, their vulnerability to detachment during extreme wind events shifts the responsibility of waterproofing to the underlayment. Thus, the ability of underlayments to resist uplift forces and prevent water intrusion becomes central to the building's resilience during hurricanes.

Tile roofing systems in High Wind Zones are designed primarily as water-shedding assemblies, where the performance of the underlayment is critical for maintaining building integrity after tile displacement (FRSA-TRI, 2023). The effectiveness of a tile roof system during extreme events depends not only on tile attachment but also on the correct specification and installation of compatible underlayment and flashing systems.

Recent code evolutions recognize this role, but questions remain regarding the adequacy of both traditional nailable underlayments and modern self-adhered (peel-and-stick) membranes under extreme conditions. These uncertainties are particularly pronounced within HVHZ areas, where differing enforcement practices further complicate underlayment system design and acceptance.

2. Literature Review

The Florida Building Code (FBC 8-24) identifies Miami-Dade and Broward Counties as High Velocity Hurricane Zones (HVHZ) and mandates the use of secondary water barriers (SWBs) beneath steep-slope roof coverings. Outside the HVHZ, self-adhered membranes applied directly to the deck are permitted. Within the HVHZ, although the FBC allows direct-to-deck applications, Miami-Dade County's product approval process and Notices of Acceptance (NOAs) have historically required an additional mechanically fastened underlayment beneath self-adhered membranes. This regulatory distinction has led to significant differences in construction practices across the state, despite increased acceptance of self-adhered membranes in industry practice and research studies as a potential alternative to traditional two-layer systems.

ASCE 7-22 specifies design wind speeds of 170–180 mph (3-second gusts) for HVHZ regions, producing uplift pressures that can exceed –90 psf on roof components and cladding. These intense pressures, particularly along edges and corners, necessitate resilient underlayment systems capable of resisting both suction and uplift forces. To verify roof system performance, ANSI/FM 4474-2020 prescribes static uplift testing protocols that simulate differential pressures expected during hurricane events, establishing performance benchmarks critical for steep-slope applications in extreme wind zones.

Previous studies by Smith et al., (2014) documented the vulnerability of roofing systems following tile detachment, emphasizing that the underlayment becomes the primary defense against water intrusion. Earlier generations of underlayments, typically composed of mechanically fastened felt, often failed under uplift forces, leading to extensive interior damage. Prior experimental studies, by Prevatt et al., (2011) demonstrated that clay tile assemblies installed over direct-to-deck self-adhered membranes can achieve comparable or superior uplift resistance relative to traditional two-ply systems, with failure modes typically involving membrane rupture or adhesive delamination rather than nail pull-through (Prevatt et al., 2011).

It is worth noting that Silvers (2023a; 2023b), has commented on a perceived reluctance within Miami-Dade County to fully embrace self-adhered membranes without a mechanically attached base sheet. His commentary suggests that self-adhered membranes offer superior resistance to wind uplift and water intrusion, and that broader acceptance could align HVHZ practices with advancements seen in other Florida counties. However, as this viewpoint originates from an industry advocate, it's important to consider potential biases and the absence of peer-reviewed validation.

Industry guidance documents, such as the FRSA–TRI Florida High Wind Concrete and Clay Tile Installation Manual (7th Edition), recognize both single-ply self-adhered underlayment systems and traditional two-ply assemblies as viable methods for tile roofing in high wind regions. The manual stresses the importance of correct underlayment selection, minimum material thickness standards (e.g., 40 mil minimum for self-adhered membranes), and compliance with approved uplift resistance ratings to ensure long-term system performance (FRSA-TRI, 2023).

3. Problem Statement

While the Florida Building Code allows both mechanically attached underlayments and self-adhered membranes as secondary water barriers, inconsistencies remain in their implementation across Florida. Outside the HVHZ, self-adhered membranes applied directly to the deck are permitted and incentivized through insurance credits. Within the HVHZ, although the FBC allows direct-to-deck applications, Miami-Dade County's product approval process and Notices of Acceptance (NOAs) have historically required an additional mechanically fastened underlayment beneath self-adhered membranes.

This regulatory distinction has led to significant differences in construction practices across the state. Despite updates in the 8th Edition of the FBC, Miami-Dade continues to enforce the combined installation of the nailed and adhesive underlayments. This inconsistency raises critical questions about the adequacy of single-ply peel-and-stick membranes in HVHZ conditions, where design pressures can reach or exceed –90 psf under wind speeds of 170–180 mph.

Although self-adhered membranes have gained broader acceptance as an alternative to traditional systems, their performance under realistic hurricane-force conditions has not been conclusively validated through full-scale testing. Addressing this gap is crucial for advancing resilient roofing practices across the HVHZ.

4. Objectives

The proposed study will utilize a full-scale hip-and-gable roof assembly, which will allow the symmetrical installation of the two main underlayment systems. The building apparatus will be subjected to realistic hurricane level winds at the Wall of Wind (WOW) Experimental Facility (EF) at Florida International University (FIU). The primary objectives of this study are to:

1. Conduct ramp-to-failure wind tests simulating HVHZ conditions, targeting uplift pressures at or exceeding –90 psf.
2. Document the sequence, location, and type of failures observed during testing.
3. Monitor wind-induced deformations on the underlayment system using state-of-the-art motion capturing equipment.
4. Produce a comprehensive experimental database to inform future technical discussions regarding the performance of underlayment systems in hurricane-prone regions.

5. Scope of Work

The project will be executed through the following tasks:

- **Task 1. Combined Roof Assembly Construction**

  A single full-scale hip-and-gable roof will be constructed in the Wall of Wind facility. The roof deck will be split along its centerline so that one half—both hip and gable planes—receives nailable felt or synthetic underlayment installed per FBC fastening patterns, and the other half receives self-adhered membrane applied directly to the deck. Certified installers will adhere strictly to manufacturer and FBC guidelines. By rotating the model on the turntable during testing, each side will be exposed to windward and leeward wind conditions, enabling direct comparison.

- **Task 2. Wind Uplift Testing**

  Each assembly will undergo ramp-to-failure wind tests. Wind speed will increase progressively until failure occurs, targeting the maximum Wall of Wind (WOW) wind speed (approximately 157 mph). High-speed video will capture the sequence and progression of failure events. In addition, a Vicon motion capture system will be employed to monitor real-time deformations of the roof surfaces during loading. The Vicon system will provide high-precision displacement measurements, complementing the visual observations and enabling detailed analysis of failure mechanisms.

- **Task 3. Failure Mode Analysis**

  Test footage and failed specimens will be examined to determine failure modes—such as nail pull-through or membrane rupture. A panel of experienced practitioners will correlate failure events with wind conditions, estimating uplift pressures and classifying each mode.

- **Task 4. Reporting & Recommendations**

  Findings will be summarized in interim and final reports that detail test procedures, uplift pressures, and failure analyses. Results will be presented to the FBC Hurricane Research Advisory Committee.

6. Staffing

Personnel

PI: Ioannis Zisis, Associate Professor, CEE, Florida International University, USA

Graduate Student: Mahmoud Abdallah, CEE, Florida International University, USA

7. Method of Payment

A purchase order will be issued to the Florida International University. This project shall start on date of execution of the purchase order and end at the midnight on TBD. This purchase order shall not exceed TBD (est. $120k; full-scale testing and 1 graduate student) and shall cover all costs for labor, materials and overhead. Payment will be made for the study after the Program Manager and the Florida Building Commission's Hurricane Research Advisory Committee have approved the final report. Additionally, the Contractor agrees to provide additional documentation requested by the Program Manager to satisfy all payment and audit requirements.

8. Deliverables

a. An interim report shall be prepared and delivered no later than TBD. The interim report shall contain the deliverables of Task 1 and 2 and any preliminary findings from Task 3; i.e. a detailed description of the testing protocols and model parameters adopted in the WOW-EF tests. In addition, the interim report shall be formally presented to the Florida Building Commission's Hurricane Research Advisory Committee at a time agreed to by the Contractor and Department's Program Manager. The due date may be extended with the approval of the Department of Business and Professional Regulation's ("Department") Program Manager.

b. A final report shall be prepared and delivered no later than TBD. The final report shall contain deliverables of the first three Tasks as discussed in Section 2. The final report shall be formally presented to the Commission's Hurricane Research Advisory Committee at a time agreed to by the Contractor and Department's Program Manager. The due date may be extended with the approval of the Department of Business and Professional Regulation's ("Department") Program Manager.

9. Financial Consequences

FIU LWER/EEI is solely responsible for the satisfactory performance of the tasks and completion of the deliverables as described in this Scope of Work. Failure to complete the tasks and deliverables in the time and manner specified in Sections 2 and 5, shall result in a non-payment of invoice until corrective action is completed as prescribed by the program or contract manager.

10. Program Manager

The Program Manager for this project is Mo Madani. Mo Madani's email address is Mo.Madani@myfloridalicense.com and his phone number is 850-717-1825.

References

Florida Building Code (FBC), 8th Edition. (2024). *Florida Building Code - Building*. Florida Department of Business and Professional Regulation, Tallahassee, FL.

American Society of Civil Engineers (ASCE). (2022). *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-22)*. American Society of Civil Engineers, Reston, VA.

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