

# **Evaluation of Wind Resistance of Vinyl Siding and Soffit Systems, and Performance During the 2017 Hurricane Irma**

**Submitted to:** Florida Department of Business and Professional Regulation

David O. Prevatt – PI – University of Florida

Date: 1 August 2018

As requested by the Structural TAC of the Florida Building Commission this provides a proposal, scope of work and estimated budget to investigate the performance of vinyl siding and soffit systems installed on residential structures during the 2017 Hurricane Irma.

## **Goals**

The goals of this research are the following:

1. To assess the extent of vinyl siding and soffit system damage to residential structures during the 2017 Hurricane Irma. The assessment will be based upon analysis of data collected by the University of Florida, augmented by data from others.
2. Comment upon the pressure equalization findings of installed soffit systems from previous UF research, particularly the implications to vented (perforated) materials.
3. Categorize the vinyl siding systems by age, manufacture and building code provisions based on information collected from the houses.
4. Develop typical failure mechanisms occurring within the vinyl siding and soffit systems, related to wind velocity (speed and direction) at the house.
5. Develop experimental research plan to subject a 12 ft by 12 ft vinyl siding system to apply spatially varying pressures using the SPLA in a multi-chamber pressure test setup. Coordinate test protocol with recent research findings.
6. Conduct tests on two vinyl siding systems to compare their wind resistance performance using the multi-chamber pressure test protocol against the ASTM D5206 standard test protocol that is currently used to evaluate their wind resistance.

## **Background**

The University of Florida's report on the 2017 hurricane season submitted to the Florida Building Commission, observed high numbers of premature failure of vinyl siding and soffit materials on residential building structures (Prevatt et al. 2018). The report assessed damage to houses, noting 347 out of approximately 800 structures had either vinyl siding or soffits, with various levels of damage occurring to them. Many of the failures resulted in costly water leakage to the interiors of the structures that damaged the structures and ruined the contents within the buildings.

The performance of vinyl siding was reported among all residential building performance finding the damage occurred throughout a large portion of the state of Florida. However, specific causes and failure mechanisms for vinyl siding and soffits were not identified as this was outside the report scope. However, the report recommended further studies to address the performance, particularly to understand whether newly installed vinyl siding on newer (post-2001) building failed prematurely during Hurricane Irma.

In previous research sponsored in part by the Florida Building Commission between 2008 and 2010, the University Florida addressed some issues for performance of vinyl siding and soffits. Those studies modeled under laboratory conditions water intrusion into residential wall cladding systems (including vinyl siding) (C Lopez et al. 2011) and structural performance of vented (perforated) soffits (C. L. Alexander et al. 2013). It is not certain whether any of the recommendations from the previous studies have been included into the current building code provisions. This proposal developed by the University of Florida (The Contractor) will offer a further study for consideration by the Florida Building Commission.

The evaluation of wind loading on discontinuous building cladding systems such as vinyl siding, soffits and discontinuous metal roofing systems is an area of active research by several organizations at present. There is evidence that current testing procedures that utilize uniform pressure on the test specimen to produce the design value PEFs may not be appropriate. Oh and Kopp (Oh and Kopp 2014) used an experimental test setup consisting of four pressure chambers to replicate the spatial and temporal variation of wind pressures on a vinyl siding specimen. By developing a numerical model this study clearly provided an approach to explain the physical mechanisms governing air pressure equalization. Miller et al. have furthered this work to practical implications suggesting that a test method is feasible using multiple test chambers (Miller et al. 2017).

#### **Current Test Methods for Vinyl Siding Systems**

The standard specification for rigid PVC/vinyl siding is ASTM D3679 (ASTM 2017) which recommends wind load testing per ASTM D5206 (ASTM 2013). This test standard utilizes a step and hold monotonically increasing test approach starting a 5 psf uniform pressure for 30 seconds and increasing in 5 psf increments each held for 30 seconds. The Wind Load Resistance Test Design Factors in Annex 1 of ASTM D3679 provide additional information regarding the provision of Pressure Equalization Factors (PEFs) for reducing the design wind load because vinyl siding systems are discontinuous, and they enable wind flow between the cavity and the exterior.

The current test methods make the simplification of applying a single uniform pressure to the siding systems, whereas realistic wind flows create spatially varying external pressures. How the vinyl siding behaves under such spatial pressures is unknown, although the assumption is that the uniform pressure test replicates the response to some extent.

In recent years, the wind loading, and testing of vinyl siding systems has been the focus of other organizations. In testing by Florida International University (Moravej et al. 2016) their report suggest that the current lower PEF value of 0.36 specified in ASTM D3679 may lead to the underestimation of loads for the design of details affected by local loads. This conclusion provided further support for the IBHS report on a full-scale building test at their wind load facility (Cope et al. 2012; Morrison and Cope 2015). In a follow-up study by the IBHS addressing fastener loads directly, the paper noted that there is a strong overall one to one correlation between the net outward loads calculated by applying the pressure load to the tributary area and the measured loads on the fasteners (Cope et al. 2014).

To the extent that some of the vinyl siding that failed during Hurricane Irma were approved based upon existing ASTM D 5206, they could be expected to have premature failure prior to attaining

the actual design loads. Research utilizing the existing UF database of failures may be able to determine the extent of these conditions.

Our research will focus on the following issues:

### **Scope of Work**

- a. The Contractor shall review the database summary and results from the 2017 Hurricane Irma and identify the structures and wind speeds related to vinyl siding and soffits failure.
- b. Review the previous University of Florida research report on wind resistance of soffit panel systems and report upon design requirements for evaluating wind loading on vented (perforated) soffit systems.
- c. Estimate the wind speed and direction at each home with vinyl siding/soffit/fascia failure, using local wind observations, and map to failure locations.
  - i. The Contractor shall contact other organizations involved in collecting post Hurricane Irma damage investigation on residential structures (FEMA, Vinyl Siding Institute, NIST) to augment the University of Florida damage assessment and performance data from additional surveys. Analyze damage assessment surveys to determine the extent of additional available information on the performance of vinyl siding and soffits in order to assemble a complete set of data on performance.
  - ii. Identify from the augmented database of surveyed houses, the locations of failed soffit and siding systems relative to the dominant wind direction and wind speeds causing failures. If possible, determine whether failures are caused by mean positive pressure fluctuations on the windward side or due to suction pressures on leeward location from accelerating air flows around the sides of the building.
  - iii. Conduct up to three days of field work to assess vinyl siding systems that failed, or did not fail but were in close proximity to systems that did fail with the intent of documenting in greater more detail dimensions and properties of typical vinyl siding systems, fastener schedules, etc. Work with local building officials to coordinate the deployment and gain access to target homes.
  - iv. Identify specific post-2001 installed vinyl siding and soffit materials and systems that were surveyed following Hurricane Irma, tracking down their manufacture and design specifications and performance.
- d. Convene an invited Advisory Panel to provide advice to the Principal Investigator. Invitations to participate will be extended to representatives from IBHS, FIU, Vinyl Siding Institute and UWO. Hold three conference calls during the contract period.

- e. Develop experimental test procedure that recreates wind loading on vinyl siding systems observed in the field. Coordinate this development with recent research findings from UWO and IBHS and Vinyl Siding Institute.
  - i. Conduct testing on representative samples of the observed vinyl siding systems using the appropriate test devices (Spatio-Temporal Pressure Loading Actuator SPLA or Dynamic Flow Simulator) to simulate the failure mechanisms observed in the 2017 post-hurricane damage survey.
- f. Report to the Florida Building commission a summary of the performance factors for vinyl siding systems, including recommendations of the modifications of existing test specifications if appropriate.
  - i. Provide interim report and presentation to the Florida Building Commission on or around 15 March 2019.
  - ii. Provide a final report and presentation to the Florida Building Commission on or around 15 June 2019.

### **Motivation and Purpose**

The motivation for this research is to shed light on the apparent premature failure of vinyl siding and soffit systems during Hurricane Irma. The analysis of survey data is expected to show whether the appropriate siding and soffit systems were installed in the locations, whether they failed at or above the design wind pressures and whether there are any patterns within the construction or workmanship of the installations. Through the experimental testing, the research will advance current testing to include spatially non-uniform pressures. This test procedure if proved to be appropriate, will be a forerunner for future multi-chamber pressure testing on discontinuous siding and roofing systems.

## Anticipated Budget and Justification

The UF is a land-grant institution that is today a large public university offering a full spectrum of educational opportunities. The Engineering School for Sustainable Infrastructure and Environment is working with Auburn University in all tasks.

**Budget Estimate (\$46.8k Auburn / \$234.8k UF); Total \$254.1k**

### Auburn University Budget

Category	FY2019
Labor	\$26,210
Materials & Supplies	\$1,500
Travel	\$3,750
Subcontract	\$0
Overhead	\$15,356
Subtotal	\$31,460
Grand Total	\$46,816

### UF Budget Breakdown

UF Civil & Coastal Eng. Budget	FY2016
Faculty salary & fringe	\$17,109
TEAM Personnel	\$13,135
(2) Grad Student-Salary	\$41,888
(2) Student - Tuition	\$16,962
Student OPS	\$5,065
Materials & Supplies	\$30,000
Lab Usage	\$35,000
Travel	\$7,500
F & A @ 10%	\$16,666
Auburn U. Sub Award	\$46,816
Administration	\$4,682
UF Total Contract	\$234,823

## References

- ASTM (2013). "ASTM D5206-13 Standard Test Method for Wind Load Resistance of Rigid Plastic Siding." *ASTM International*.
- ASTM (2017). "ASTM D3679-17 Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Siding." *ASTM International*.
- C Lopez, FJ Masters, and S Bolton (2011). "Water penetration resistance of residential window and wall systems subjected to steady and unsteady wind loading." *Building and Environment*, 46(7), 1329-1342.
- C. L. Alexander, F. J. Masters, M. J. Morrison, and S. Bolton (2013). "Wind Resistance of Vented Vinyl and Aluminum Soffit Panel Systems." *Journal of Disaster Research*, 8(6), 1103-1113.
- Cope, A., Crandell, J., Johnston, D., Kochkin, V., Liu, Z., Stevig, L., and Reinhold, T. (2012). "Wind Loads on Components of Multi-Layer Wall Systems with Air-Permeable Exterior Cladding." *Advances in Hurricane Engineering*, American Society of Civil Engineers, 238-257.
- Cope, A. D., Crandell, J. H., Liu, Z., and Stevig, L. J. (2014). "Wind loads on fasteners used to attach flexible porous siding on multi-layer wall systems." *Journal of Wind Engineering and Industrial Aerodynamics*, 133, 150-159.

- Miller, C. S., Kopp, G. A., Morrison, M. J., Kemp, G., and Drought, N. (2017). "A Multichamber, Pressure-Based Test Method to Determine Wind Loads on Air-Permeable, Multilayer Cladding Systems." *Frontiers in Built Environment*, 3, 7.
- Moravej, M., Zisis, I., Chowdhury, A. G., Irwin, P., and Hajra, B. (2016). "Experimental Assessment of Wind Loads on Vinyl Wall Siding." *Frontiers in Built Environment*, 2, 35.
- Morrison, M. J., and Cope, A. D. (2015). "Wind performance and evaluation methods of multi-layered wall assemblies." *Structures Congress 2015. Proceedings*, 2735-2748.
- Oh, J. H., and Kopp, G. A. (2014). "Modelling of spatially and temporally-varying cavity pressures in air-permeable, double-layer roof systems." *Building and Environment*, 82, 135-150.
- Prevatt, D. O., Gurley, K. R., Roueche, D. B., and Wong-Parodi, G. (2018). "Final Report: Survey and Investigation of Buildings Damaged by Category II, III, IV and V Hurricanes in FY 2017-18 – Hurricane Irma 2017", University of Florida, Gainesville, FL.