Interim Report for Project Entitled:

Behavior of Aluminum Screen Enclosures in Strong Winds
PO Number AB3DBA

Performance Period: 10/10/2014 – 6/30/2015

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DRAFT

Presented to the

Florida Building Commission
State of Florida Department of Business and Professional Regulation

by

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1. Applicable Sections of the Code (and Referenced Documents)

- 1622.1, Florida Building Code—Building
- Chapter 20 (Aluminum), Florida Building Code—Building
- 2010 AAF Guide to Aluminum Construction in High Wind Areas

2. Description of the Issues

- During the 2013-2014 research cycle, the Aluminum Association of Florida (AAF) requested a study on the comparative performance of two screen enclosure systems. The first system was based on signed and sealed, site-specific plans obtained from building code departments in NE Florida. This 'generic' system was based on conventional design practice, which is believed to represent the majority of designs outside of the HVHZ in Florida. The second system was identical to the 'generic' system except that the design conformed to requirements set forth in the 2010 AAF Guide to Aluminum Construction in High Wind Areas
- Both systems were tested in the full-scale test facility at the IBHS research center. Neither system exhibited the type of catastrophic failure observed in the 2004 hurricane season, however loss of screens, local buckling and material yielding were observed in isolated sections. AAF subsequently released a technical bulletin addressing these issues in the AAF Guide
- There are outstanding questions about the wind loading characteristics of the screen enclosure systems. Design pressure coefficients originate from a two interrelated studies performed at Clemson University and Virginia Tech (Reinhold 1999). The limited scope of the 2013-2014 testing did not allow for direct measurement of area-averaged pressures and reactions. Boundary layer wind tunnel modeling is being conducted to investigate this issue
- A companion study (Corrosion of roofing and screen enclosure fasteners) will assess the effect of corrosion on typical fastening systems used in screen enclosures systems

3. Statement of Work

- Coordinate with stakeholder groups (e.g., Aluminum Association of Florida, Insurance Institute for Business & Home Safety) to finalize the testing matrix for the boundary layer wind tunnel modeling
- Conduct boundary layer wind tunnel modeling of typical screen enclosure systems found on Florida homes to provide baseline results that can be compared with findings from the Virginia Tech and Clemson University studies performed in the early 2000s
- Interpret results, determine if the problem requires action (or not), and produce a report that explains the results and implications for the Code

4. Deliverables

- Interim report by February 15, 2015 – Interim progress report detailing the current status and progress toward completing the work described above. In addition, the Interim report will be presented to the Commission's Structural Technical Advisory Committee at a time agreed to by the Contractor and Department's Project Manager
- Final report by June 1, 2015 providing technical information on the problem background, results and implications to the Code. In addition, the final report will be presented to the Commission's Structural Technical Advisory Committee at a time agreed to by the Contractor and Department's Project Manager

- Recommendation(s) that may require revision to future edition of the FBC will be analyzed using the criteria outlined in the currently adopted code modification form

5. Summary of Activities

The investigator convened a stakeholder meeting to finalize the project scope for the boundary layer wind tunnel (BLWT) experiments on January 20, 2015. Attending were representatives of the Aluminum Association of Florida (Tom Dowd, Mike Driscoll, Gary Hartshorn, David Johns, David Miller), JBD Code Services (Joe Belcher), the Insurance Institute for Business & Home Safety (Anne Cope, Tim Reinhold, Murray Morrison), and the Chair of the Structural TAC, Jim Schock.

The group prioritized three principal activities:

- A validation study of the Texas Tech Wind Engineering Research Field Laboratory (WERFL) low-rise building to verify similarity of experimental configurations between the University's BLWT and others around the world. WERFL has been the subject of dozens of studies since the 1990s. Data may be accessed at the NIST Aerodynamic Database (http://fris2.nist.gov/winddata/index.html)
- A validation study of the Reinhold et al. (1999) 1:24 geometric scale experiments that underpin the current load provisioning in the Code. These include quantification of wind loading on three enclosure shapes (monoslope, gable and hip), both freestanding and attached to a host structure. The experimental design employed a high-frequency force balance to measure peak base reactions, which were then normalized by a referenced velocity pressure to calculate the pressure coefficient values (GCp) that are used in the Code.
- Characterization panel loading using miniature load cells that affix a roof or wall panel to the 'cage.' The second thrust evaluates main wind force resisting system (MWFRS) loads (multi-axis loading of the entire structure that is resolved into base reactions, or equivalent out of plane loads that cause shear and uplift). This approach will enable quantification of component and cladding loads of individual panels, and in particular, provide new data to hone our understanding of the roof structure loads.

6. Remaining Tasks

There are three series of tests planned:

Series 1. Validation study using the WERFL building in Exposure C terrain. We will build a 1:24 scale model of the 30 ft x 40 ft plan building and install pressure taps following the configuration tested by the University of Western Ontario as part of the NIST Aerodynamic Database (HO et al., 2003). The model will be 3D printed, tapped, and connected to a Scanivalve pressure scanning system and compared against the literature to ensure the experimental configuration produces consistent results with established measurements (including the full-scale test facility in the IBHS Research Center, which was utilized in the FY2013-14 study)

Series 2. Comparative study of the MWFRS loads obtained from a high frequency force balance during the Clemson experiments. Models will sit on a rigid frame that is supported by an ATI Industrial Automation Nano25 six axis load cell. Three roof types (monoslope, gable and hip) will be tested with and without the host structure. Quasi-static theory will be applied to estimate GCp values, after appropriately converting for gust duration, height and exposure. At least three different wind directions will be evaluated (parallel to ridgeline, perpendicular to ridgeline, cornering).

Series 3. C&C load characterization of roof and wall panels. The rigid models will be replicated/modified to incorporate load measurements systems for individual panels to characterize peak loads occurring on the individual panels. The priority will be to measure roof loading, particularly to better understand how air communication affects the uplift loads

Model construction and tunnel commissioning will take place during the remainder of February and the entire month of March. Series 1 is scheduled for April 2-13. Series 2 will be performed During April 23-May 8. Series 3 will be performed during May 18-22. Findings will be distributed to the stakeholder groups following completion of series for comment. The draft final report will be circulated the final week in May to receive additional comments. The final report will be submitted June 1, 2015.

7. References

- Ho, T.C.E., D. Surry and D. Morrish, 2003: NIST/TTU Cooperative Agreement – Windstorm Mitigation Initiative: Wind Tunnel Experiments on Generic Low Buildings, BLWT-SS20-2003, University of Western Ontario. Available at http://fris2.nist.gov/winddata/uwo-data/uwo-data.html

- Reinhold, T.A., J. Belcher, D. Miller and C. Everley, 1999: Wind loads on screen enclosures. Clemson University Wind Load Test Facility Report