Scope of Work

Wind-induced loads on roof overhangs

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)

Project Leader: Ioannis Zisis, PhD, Associate Professor, Co-Director, Lab. Wind Engineering Research, Extreme Events Institute, an FIU Preeminent Program, Florida International University

1. Introduction

An overhang is an unenclosed continuation of the roof surface. Particularly on low-rise residential applications, overhangs may be open or covered by a soffit and may be cantilevered or supported. Most of the foundational belief about overhangs seems to suggest that overhangs extend no more than 2 feet, whereas, in Florida, overhangs are often much longer and are necessary for energy efficiency and livability in this semi-tropical climate. Overhangs in Florida can be cantilevered 6-ft or more, or supported, as on a terrace or porch, for 10 to 12 feet or more.

ASCE 7-16 [1] provides methods for analysis of the loads on overhangs, both for main wind force resisting systems (MWFRS) and component and cladding (C&C) loads, but the commentary fails to provide any information as to the maximum length of overhang for which this analysis is valid.

ASCE 7-16 section 30.9 states that the pressure on the bottom covering of the roof overhang is the external pressure coefficient on the adjacent wall surface. This particular assumption was adopted more recently in the ASCE 7 (2016). In earlier versions of the ASCE 7 (2010) [2], the overhang pressures considered the net pressure applied on these elements from simultaneous contributions from both the top and bottom surfaces of the overhang.

Moreover, this may be an adequate assumption for a 2-foot overhang, but the pressure on the bottom surface of a 4-ft or 6-ft or 12-ft overhang is not a simple one-to-one wall-to-overhang pressure equivalent. The research that was done for canopies (ASCE 7-16 section 30.11), suggests that this is not the case [3-5]. Most importantly the research that led to the revised provisions of ASCE 7-16 did not consider any building model with roof overhangs.

This research could clarify how the pressures on the wall affect the overhang and for what distance, and at what point does the wall pressure cease to affect the overhang and the more direct wind loads on the overhang control, as though for an open building.

2. Relevance to Florida Building Code [6]

Chapter 16 – Structural Design

Section 1609 – Wind Loads

1609.6 Alternate all-heights method.

3. Tasks

Task 1

A detailed literature survey on the research topic will be carried out. Wind-induced loads on overhangs have been studied in Atmospheric Boundary Layer (ABL) wind tunnels in the past. All these studies used small-scale models that were instrumented with pressure taps to capture the wind effects on the building envelope. The smaller scale that was used did not allow in most cases to instrument the models with a large number of pressure taps therefore providing a less precise representation of wind pressures or suctions in smaller areas, such as roof corners, edges and ridgelines. Most importantly, the limited space within the model and close to the overhang detail made it extremely challenging to place an adequate number of pressure taps on both overhang surfaces (i.e. top and bottom). Measuring the net effect is the key objective of this research proposal and of paramount importance on developing reliable design recommendations that can be incorporated in building codes and wind standards.

The objective of this task is to identify the limitations of the previous studies, better understand how these limitations affect current codes and standards and design an effective and efficient test campaign in task 2.

Task 2

The knowledge gained in task1 will be used to design the experimental protocols and models in this task. The tests will be carried out at FIU's Wall of Wind (WOW) facility (Figure 1). The 12-fan WOW is the largest and most powerful university research facility of its kind and is capable of simulating a Category 5 hurricane – the highest rating on the Saffir-Simpson Hurricane Wind Scale [7]. In 2015, the National Science Foundation (NSF) has designated the Wall of Wind as one of the nation's major "Experimental Facilities" (EF) under the Natural Hazards Engineering Research Infrastructure (NHERI) program as a distributed, multi-user national facility that provides the natural hazards research community with access to research infrastructure. The WOW EF is managed by FIU's Extreme Events Institute (EEI).

Figure 1 - NHERI 12-Fan Wall of Wind Experimental Facility: (a) Intake side, (b) Open jet test-section side.

The large test section of the WOW EF allows for testing of larger models. This advantage will be leveraged and will allow to incorporate a higher number of pressure taps on roofs and overhangs of low-rise building models. The more accurate geometry and the higher resolution of the pressure measurements will help the team acquire the needed amount of data required for the codification process in Task 3.

Task 3

In this last task, the data from the experimental task will be utilized towards the development of code-ready output by applying codification approaches worked successfully in the past. These consist of comparison, generalization and simplification of large quantities of data in order to produce simplified diagrams suitable for incorporation in building codes and wind standards.

More specifically, the large amount of pressure data collected in Task 2 will be analyzed to extract local and area-averaged design pressure coefficients. The analysis will follow the codification procedure that generates ASCE 7 format design curves [3-5, 8]. This will allow to compare the findings to the existing wind standards and building codes and to evaluate the adequacy of using existing wind design specifications for the design of various overhang geometries.

4. Deliverables

A detailed report will be submitted and will include the following:

Task 1:
- Summary of literature survey related to experimental studies on roof overhangs.
- Conclusions on geometric parameters for the large-scale models that will be tested at the WOW-EF facility.

Task 2:
- Description of the testing protocols and model parameters adopted in the WOW tests.
- Wind-induced pressure data acquisition from pressure taps.

Task 3:

- Analysis of pressure data and generated contour plots.
- Codification of pressure data and ASCE 7 format design curves.
- Comparison of current findings to existing Wind Standards and Building Codes of Practice.
- Recommendations for future studies and enhancement of wind design practices.

5. Contract Details

Personnel

PI: Ioannis Zisis, Florida International University, USA

Graduate Student: TBD, Florida International University, USA

External Collaborator: Ted Stathopoulos, Concordia University, Canada

Service Dates

This project shall start upon the execution of this purchase order, whichever is sooner, and end at midnight on TBD.

Method of Payment

A purchase order will be issued to FIU. The project shall not exceed $TBD (estimated ~$150k) and shall cover all costs for labor, materials, and overhead. Payment will be made for the work in lump sum after the final report has been approved by the Contract Manager, Program Manager, and the Florida Building Commission's Structural Technical Advisory Committee.

6. Financial Consequences

LWER at FIU 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 3 and 4, respectively, shall result in a non-payment of invoice until corrective action is completed as prescribed by the program or contract manager.

7. Contract Manager and Program Manager

The Contract Manager for this purchase order is Barbara Bryant and the Program Manager is Mo Madani.

8. References

[1] ASCE/SEI 7-16 (2017). Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, Reston, Virginia, USA.

[2] ASCE/SEI 7-10 (2013). Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers, Reston, Virginia, USA.

[3] Zisis, I. and Stathopoulos, T. (2010). Wind-induced pressures on patio covers. ASCE Journal of Structural Engineering, Vol. 136, No. 9, pp. 1172-1181.

[4] Candelario, J. D., Stathopoulos, T. and Zisis, I. (2014). Wind loading on attached canopies: A codification study, ASCE Journal of Structural Engineering, Vol. 140 (5).

[5] Zisis, I., Raji, F. and Candelario, J. D. (2017). Large scale wind tunnel tests of canopies attached to low-rise buildings, ASCE Journal of Architectural Engineering, Vol. 23 (1).

[6] Florida Building Code - Building, Sixth Edition (2017). International Code Council, ISBN: 978-1-60983-687-0

[7] Gan Chowdhury, A., Zisis, I., Irwin, P., Bitsuamlak, G., Pinelli, J.-P, Hajra, B., and Moravej, M. (2017). "Large-Scale Experimentation Using the 12-Fan Wall of Wind to Assess and Mitigate Hurricane Wind and Rain Impacts on Buildings and Infrastructure Systems." Journal of Structural Engineering, Vol. 143, Issue 7.

[8] Stathopoulos, T. (1979). Turbulent Wind Action on Low-rise Buildings. Ph.D. Thesis, The University of Western Ontario, London, Ontario, Canada.