

COX, OREGON STATE UNIVERSITY

DHS Coastal Resilience Center

Research Project Work Plan

1/1/2016 – 12/31/2017

1. **Project Title.** Experimental and Numerical Study to Improve Damage and Loss Estimation due to Overland Wave and Surge Hazards on Near-Coast Structures

2. **Principal Investigators.**

Dr. Daniel Cox, (PI) Professor, Oregon State University

Dr. John van de Lindt (co-PI), Professor, Colorado State University

3. **Other Research Participants/Partners**

- Bill Coulbourne, Applied Technology Council
- Chris Jones, consulting coastal engineer; Chair, ASCE-7 Flood Loads

In addition to these Research Participants, we will have the following people involved in the End-User Transition:

- Eric Berman, HAZUS Program Manager at FEMA HQ
- Ed Laatch, FEMA Building Science Division
- Christina Lindemer, Coastal Engineer, FEMA Risk Analysis Branch, Atlanta GA
- Chad Berginnis, ASFPM Executive Director and CRC Advisory Board Member

4. **Short Project Description.**

This project will develop an accurate method to determine damage to buildings subjected to extreme surge/wave forces during hurricanes. The methodology will use large-scale hydraulic model testing combined with numerical simulations to improve existing risk software used by DHS/FEMA and to advance risk-based design methodologies to enhance coastal infrastructure resilience. The method will be consistent with other multi-hazard frameworks such as earthquake and wind engineering.

5. **Abstract.**

This project focuses on Theme 1 – Coastal Infrastructure Resilience; Topic 1a – Coastal Infrastructure Planning and Design. As building stakeholders seek to mitigate damage, risk to property and structure loss it is becoming apparent that existing design methodologies such as those outlined in the FEMA Coastal Construction Manual are inadequate to incorporate the range of building types, storm conditions, and potential for resulting damage. More effective decision support tools such as FEMA's HAZUS-MH rely on a framework of multi-hazard fragility curves to relate the hazard and affected buildings to compute/predict an expected level of damage and subsequent losses. Although there have been significant advances in this correlation for wind earthquake loading and some preliminary work for tsunamis, the coastal surge+wave response of structures remains poorly defined, primarily due to a lack of large-scale data and the complexity of the fluid/structure interaction modeling. This project will significantly improve HAZUS input fragilities for surge+wave through a robust experimental and numerical study of the interaction of surge and waves with near-coast structures. The overall goal of this project is to develop accurate fragilities for

near-coastal structures against overland surge and wave forces for input to HAZUS-MH such that they can be used in a design framework consistent with the risk-based methods used in wind and earthquake engineering. We outline these specific objectives to be completed in two years in order to provide (1) improved accuracy for surge+wave analysis in HAZUS-MH; and (2) innovative advances in risk-informed design methodologies to enhance coastal infrastructure resilience:

- **Objective 1:** Quantify wave forces on near-coast structures for a range of surge levels based on a mid-scale hydraulic model test program, and develop new predictive equations for horizontal and vertical forces.
- **Objective 2:** Develop the conditional probabilities (fragilities) for exceeding key thresholds which will be linked to damage levels available in HAZUS-MH.
- **Objective 3:** Illustrate next-generation risk-informed design for near-coast structures that have been shown to be vulnerable to hurricane surge and waves using the fragilities developed in (2). This will improve the ability of building occupants to return following the hurricane thereby improving the resiliency of the community.

This project will have a direct impact on estimating probable damage and loss of existing coastal infrastructure by providing improved load-response relationships to HAZUS-MH for surge+wave and develop a risk-informed framework for future engineering design of near-coast structures. While beyond the scope of this study, the results could also help improve the potential designs associated with the retrofit of existing structures funded through FEMA hazard mitigation grant programs and the implementation of improved coastal building codes.