EXPERIMENTALLY VALIDATED FRAGILITIES FOR HURRICANE RESILIENCE OF TRANSMISSION SYSTEMS

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ABSTRACT

The electric power transmission infrastructure in the United States, especially in coastal areas, faces substantial risk from hurricanes. Considering the significant size of the transmission grid, the cost of upgrading the entire infrastructure to achieve acceptable performance levels against hurricanes would be extremely high. The objective of this research is to investigate a framework to reliably identify vulnerable transmission line systems and provide cost-effective retrofit solutions to reduce their likelihood of damage and loss of functionality during hurricanes and their recovery time following the event. For this purpose, this project will develop multi-dimensional fragility models for transmission tower-line systems using experimentally validated numerical models. This will enable characterization of the effects of various significant factors on the wind performance of these systems. Outcomes of this research will aid in minimizing societal disruptions due to loss of functioning of critical infrastructure and facilities caused by power outages. The project will actively engage stakeholders to facilitate technology transfer and implementation of novel design and retrofit solutions for transmission systems. The research findings will be integrated into courses at Ohio State University and Florida International University (FIU). In addition, underrepresented undergraduate and K-8 students will be trained in research on infrastructure systems to prepare the next generation of engineers to enhance the hurricane resilience of communities.

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The research will produce a state-of-the-art experimentally validated stochastic numerical framework to generate multi-dimensional fragility models for hurricane resilience enhancement of transmission systems. The research will involve a series of aeroelastic wind tunnel studies on the wind response of multi-span transmission systems at the National Science Foundation-supported Natural Hazards Engineering Research Infrastructure Wall of Wind (WOW) Experimental Facility at FIU. These novel sets of experimental data, together with high-fidelity three-dimensional nonlinear finite element models of tower-conductor-insulator-foundation systems, will provide new and critical insights into various complex wind-induced behaviors of these systems. The WOW tests will also enable characterization of dynamic boundary effects from neighboring spans. The multi-dimensional fragility surfaces, based on validated numerical models, will provide component- and system-level structural and functional failure probabilities for units of transmission tower-lines. The generated reliability models, combined with recovery models, will be integrated into optimization frameworks to provide optimal design and retrofit solutions based on hazard and environmental factors, which will facilitate optimal management of transmission systems against hurricane hazards to enhance their resilience in response to extreme events.