Tran-SET
Transportation Consortium of South-Central States

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Key Points

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$60,000

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Tran-SET
University of Texas at San Antonio

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$120,000

Coastal Bridges under Hurricane Stresses along the Texas and Louisiana Coast

Brief Project Description

While the United States (US) has made a significant investment to mitigate the risk of earthquakes, the investments to improve resiliency to hurricanes has lagged significantly. According to estimates by the National Oceanic and Atmospheric Administration (NOAA) the annualized cost of hurricane damage in the US is approximately $10 billion/year; in comparison the Federal Emergency Management Agency (FEMA) estimates earthquake damage to be approximately half that amount. The proposed research addresses this gap by studying methods to mitigate the risk to the transportation network from extreme weather events in one of the most important regions in the country in terms of population, economic activity, and transportation systems. As such, this study will develop a high-resolution model capable of simulating the response of bridge structures to hydrodynamic loads for hurricane design conditions (i.e. surge height, wave height, and frequency) expected in the Texas-Louisiana coast. This model will be calibrated using historical data from past hurricanes such as Katrina, and used to evaluate the vulnerability bridge structures in the Texas-Louisiana coast.

Problem Statement

Disruptive weather events in the Gulf Coast and Texas Triangle megaregions represent a very significant risk to the US economy. The societal cost of natural disasters can be significantly decreased through planning for resilience instead of accepting the risk and repairing the damage. For example, Padgett et al. (2009) indicates the cost of repairing and replacing bridges damaged during hurricane Katrina exceeded 1 billion dollars, and their review of the damage reports showed that this cost could have been significantly reduced by implementing relatively simple mitigation measures. The most severe damage consisted of superstructure collapse due unseating of the deck, which was induced by the combined actions of storm surge and hydrodynamic forces from waves. This type of failure was observed both in bridges with integral and non-integral supports, which shows that in some instances uplift forces were large enough to exceeded the weight of the superstructure and cause failure of the connection at the support. Studies that document damage from major hurricanes like those by Padgett et al. provide a valuable source of information to study the risk

to bridge infrastructure due to hurricanes. While documenting damage is important, and some of the empirical observations are useful, there is a need to develop scientific models capable of simulating fluid-structure interaction under the combined actions of storm surge and waves, so the risk can be quantified through a scientific rather than empirical approach. The proposed research addresses this gap by developing a new model to simulate complex interactions between bridges, storm surge, and waves. A model of this type will permit studying the effect of hydrodynamic forces characteristic of the Texas-Louisiana Gulf coast, which will help identify bridge structures with the greatest risk of collapse during hurricanes.

Objective

The main objective of this proposal is to develop a high-resolution model capable of simulating the response of bridge structures to hydrodynamic loads for hurricane design conditions (i.e. surge height, wave height, and frequency) expected in the Texas-Louisiana coast. This model will be calibrated using historical data from past hurricanes such as Katrina, and used to evaluate the vulnerability bridge structures in the Texas-Louisiana coast. The implementation phase will consist of developing a guide document for engineering professionals illustrating regions of greatest hazard and bridge support details most vulnerable to failure during large storms.

Intended Implementation of Research

The implementation phase of the project will consist of three different activities: (1) verify the results of the model using data from bridges damaged in past storms obtained the literature and from the Texas Louisiana DOTs, (2) producing a short document aimed at DOT and practicing engineers illustrating areas of highest hurricane hazard from hydrodynamic forces and bridge support details more susceptible to hurricane damage, and (3) a webinar/or presentation in a technical meeting presenting the results from the project.

Project results will be disseminated through outreach activities, technical conferences on disaster mitigation and resilience, and academic journal publications. Outreach materials will be posted in the project website to facilitate access from entities such as first responders and K-12, and community college instructors.

Anticipated Impacts/Benefits of Implementation

The proposed model will provide a means to study the vulnerability of bridge structures to natural hazards in terms of engineering demand parameters calculated with a rigorous scientific approach. The goal of developing a high-resolution model that can simulate fluid-structure interaction is to improve the understanding of the hydrodynamic forces that bridges experience during large storms, for different combinations of storm surge and wave forms in the Texas-Louisiana Coast. The proposed model will be used to study the level of damage associated with different type supports, and to identify new construction and retrofit schemes most likely to reduce the cost of repair. The model will be calibrated and used to evaluate the response of the three types of support conditions. This is an important step in developing the tools necessary to study and improve the resilience of bridge structures in the Texas-Louisiana Coast.

Weblinks:

http://transet.lsu.edu/research/research-in-progress/

https://rip.trb.org/View/1467306