Transportation Consortium of South Central States

Sustainability-based Long-term Management of Bridges under Multi-Hazard Exposure

Key Points

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17STOKS01

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Oklahoma State University

Funds Requested to UTC:
$55,000

Funding Source(s):
Tran-SET
Oklahoma State University

Total Project Cost:
$110,000

Brief Project Description

The purpose of this project is to formulate a sustainability-based management approach for bridges under multiple hazards. The considered hazards are primarily hydraulic related ones (e.g., floods, inundation, and scour) and seismic events, in addition to gradual deterioration due to corrosion in the sub-structure and super-structure.

Problem Statement

Bridges are crucial elements in transportation networks. During their service life, these structures are subjected to various types of natural hazards that can affect their safety and sustainability. In our region, tropical cyclones and intense precipitation, along with the resulting flooding and storm surge, have been especially hazardous to bridges. Moreover, with the increasing intensity of weather-related hazards driven by changing climate conditions and the increasing occurrence probability of damaging earthquakes, bridges in our region are subjected an ever-increasing threat due to the cumulative effects of natural hazards that they were not designed to withstand.

Given the severe social, economic, and environmental impact of bridge failure, optimum long-term management of these structures considering multi-hazard exposure is essential. These management activities should be formulated based on economic, environmental, and social sustainability metrics. However, available approaches for optimum management of these structures fail to properly consider (a) the cumulative effects of natural hazards, (b) the effect of changing climate patterns, and (c) the comprehensive integration of sustainability and resilience measures. The proposed research addresses these shortcomings by constructing a sustainability-based framework for the optimum management of bridges under multi-hazard exposure. The simulation-based framework will consider the uncertainties associated with performance prediction under gradual deterioration (e.g., corrosion in the sub- and superstructure) and sudden hazards in evaluating the bridge performance.

Objective

The main objective of the proposed research is to develop a sustainability-based framework for management of bridges under multi-hazard exposure. In more detail, the proposed research aims to:

(a) Develop a comprehensive integrated tool to assess the fragility and risk of failure for bridges under multiple hazards;
(b) Formulate an approach for optimal decision-making under uncertainty to establish optimum management activities of bridges considering sustainability and resilience metrics; and
(c) Establish a detailed guidebook for optimal sustainability-based management of deteriorating bridges.

Intended Implementation of Research

Upon the completion of the research, the PI will add a module to the "Reliability and Risk of Components and Systems" class related to sustainability-based risk management under extreme events, which will be heavily based on the research developed in this project. This will make sure that the developed approach is translated into classroom material to provide future engineers with the tools necessary to tackle transportation challenges facing our region.

For workforce development and implementation, PI Soliman plans to organize a research seminar during the 2018 Oklahoma Transportation Research Day based on the results of the investigation. Attempts will be made to organize similar workforce development and implementation activities in other Trans-SET states; potentially during the 2018 Louisiana Transportation Conference. Educational material will be printed and distributed to the attendees of the seminars. This material will include a step-by-step guidebook to apply the proposed methodology, ensuring the smooth transition of the proposed approach from research to implementation.

Anticipated Impacts/Benefits of Implementation

The developed framework could be implemented by bridge officials to manage the existing stock of deteriorating bridges allowing them to reduce the life-cycle cost and improve bridge sustainability. In addition, the anticipated impacts/benefits of this research are the following:

- Promote a better understanding of the system performance under multiple hazards. Accordingly, bridge managers can take corrective actions to prevent structural failures under extreme events, and subsequently reduce the economic and social disturbances arising from these events. Therefore, the proposed research has significant societal, environmental, and economic benefits.
- Use results for real-time decision-making by infrastructure managers for traffic control during natural disasters or disaster evacuation operations; which will reduce the adverse consequences of natural hazards.
- Assist infrastructure managers in making informed decisions regarding future rehabilitation, replacement, and/or retrofit activities considering different conflicting budgetary and safety constraints. Accordingly, a better budget allocation can be achieved and unnecessary expenditures on infrastructure management can be avoided. This will eventually improve the durability and extend the service life of existing bridge infrastructure.

Weblinks:

- Tran-SET's website (http://transet.lsu.edu/completed-research/)

- TRB's Research in Progress (RIP) database (https://rip.trb.org/view/1467365)