

Geotechnical / Structures

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Project Title:

Generation-2 Fragility Models for
California Highway Bridges

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Generation-2 Seismic Bridge Fragility Models - Production Analytical Components

Development of Production Models for Concrete Box-Girder Bridges.

WHAT IS THE NEED?

Major earthquakes can severely disrupt transportation networks. Immediately after an earthquake, the California Department of Transportation (Caltrans) emergency managers and decision-makers need to understand field conditions to coordinate the response and to dispatch bridge inspection resources. Since 2008, Caltrans has used the ShakeCast alerting system to provide early situational awareness to emergency managers. ShakeCast uses a combination of ground-shaking maps developed in near- real time by the United States Geological Survey, coupled with pre-calculated bridge fragility relationships, to rapidly estimate the bridge damage. Fragility relationships are statistical models describing the probability that a specific level of shaking will induce varying degrees of bridge damage, ranging from minor spalling of concrete to complete bridge collapse. The first-generation fragility models, developed in the early 1990s and used in the current ShakeCast platform, have several limitations that affect their usefulness for emergency response and planning applications. Most importantly, the models do not address substantial variations in bridge performance associated with the full range of bridge types, configurations, and design eras existing in California. In addition, the bridge damage state definitions are not clearly associated with the identification of post-earthquake emergency repair needs and available traffic capacity, and they provide only a qualitative sense of damage for the entire bridge, with minimal details about quantitative engineering metrics or where the damage might be located.

WHAT ARE WE DOING?

This phase integrates coordinated internal and contract



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research to characterize California's bridge inventory and conduct extensive analytical modeling. Internally, we are developing a bridge taxonomy based on seismic relevant design features, synthesizing Department data to assign each bridge to a class and generate component capacity limit state (CCLS) models in collaboration with Caltrans experts. Under contract with Georgia Tech, we are creating representative analytical models for each bridge class, performing hundreds of thousands of nonlinear finite element simulations to derive probabilistic seismic demand models (PSDMs). Finally, we integrate PSDMs with CCLS models to produce component and system level fragility models, which will underpin ShakeCast alerting and inspection prioritization.

WHAT IS OUR GOAL?

The goal of this project is to develop a new generation of more accurate and more useful bridge fragility models for incorporation into Caltrans' ShakeCast earthquake alerting system and to support seismic reliability evaluations of the state bridge inventory.

WHAT IS THE BENEFIT?

Successful development and deployment of improved fragility models into ShakeCast will facilitate a more effective post-earthquake emergency response where incident commanders, decision makers, and field inspectors have excellent situational awareness early in the response-operations timeline. Additionally, these same tools will improve planning capabilities by providing a uniform basis to assess the seismic reliability of California's bridge inventory over a full range of hazard levels. Together, the improved fragility models within ShakeCast will provide for faster post-earthquake emergency response and restoration of network mobility. It will also support planning decisions into the most effective allocations of capital resources for improved seismic safety and a more reliable transportation network.

WHAT IS THE PROGRESS TO DATE?

Research activities have completed, and the team is preparing the final report for submission. This project has continued under Task 4608.