DRISI
CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Generation-2 Seismic Bridge Fragility Models - Production Analytical Components

Developing generation-2 fragility models for California concrete slab bridges, and scoping and performing risk-reduction studies for steel bridges (Part-1).

Geotechnical / Structures

MAY 2025

Project Title:
Generation-2 Fragility Models for California Highway Bridges

Task Number: 4608

Start Date: October 1, 2024

Completion Date: October 31, 2025

Task Manager:
Qiu Zheng
Research Engineer
Qiu.Zheng@dot.ca.gov

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.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

WHAT ARE WE DOING?

This new project extends prior research on the development of a new generation of more accurate and more useful seismic fragility models for California bridges. The prior work provided models for concrete box-girder bridge types. This contract extends the initiative to complete models for other concrete bridge classes and initial scoping studies for steel bridges using the same, now proven, methodology. The new fragility models will be incorporated into Caltrans' ShakeCast earthquake alerting system to support emergency response, risk mitigation planning, and seismic reliability evaluations of the state bridge inventory.

WHAT IS OUR GOAL?

Improve Caltrans' ShakeCast earthquake alerting system to support emergency response, risk mitigation planning, and seismic reliability evaluations of the state bridge inventory.

WHAT IS THE BENEFIT?

A more effective post-earthquake emergency response where emergency managers, decision makers, and field inspectors have excellent situational awareness early in the response-operations timeline. Additionally, these same tools will improve transportation-system planning by providing a uniform basis to assess the seismic reliability of California's bridge inventory over a full range of hazard levels. Both applications will preserve and protect human life and safety as well as achieve significant long-term cost savings by reducing manageable earthquake-related fatalities, facility damage and transportation-network downtime along with associated liabilities.

WHAT IS THE PROGRESS TO DATE?

In collaboration with the research team, the Caltrans Task Manager has transferred methodologies and infrastructure from the prior team, finalized inventory characterization of representative bridges, and delivered required data. The research team has since adapted these methods and implemented infrastructure tailored to the task's specific bridge configurations. Next, the team will initiate production simulations.