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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Generation-2 Fragility Models for Steel Bridges, Part-2

Developing generation-2 fragility models for California steel bridges.

Geotechnical / Structures

MAY 2025

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

Task Number: 4285

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Completion Date: June 30, 2029

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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 task will complete the final phase of a continuing project

Caltrans

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to develop g2F seismic bridge fragility models, representative of major classes within California's bridge inventory, for incorporation into Caltrans' ShakeCast earthquake alerting system. This new task will develop additional models for steel bridge classes using the same robust methodology. Although steel bridges represent a relatively small proportion of Caltrans inventory (~10%), they are a critically important set as they are often located at high traffic-volume nodes in urban areas and water crossings. The seismic behavior of steel bridges, and damage to their components, are distinct from those of the concrete bridge classes. Thus, development of a consistent set of fragility models for steel-bridge classes is vital for comprehensive and uniform characterization of seismic risks for both response and planning applications.

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?

Contract setup in progress.