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

Research Notes

Incorporating System-Level Seismic Risk Assessment into Caltrans Risk-Based Seismic Design (CT-RBSD)

Research to improve Caltrans' performance-based bridge design procedures to enhance transportation network reliability and achieve more consistent bridge performance.

Geotechnical/ Structures

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Project Title: Incorporating System-Level Seismic Risk Assessment into Caltrans Risk-Based Seismic Design (CT-RBSD)

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WHAT IS THE NEED?

The California Department of Transportation (Caltrans) Risk-Based Seismic Design (CT-RBSD) procedure currently evaluates bridge seismic performance primarily based on single-column behavior. While this approach has provided useful insights, it does not fully account for other critical bridge components, particularly abutment seat widths and in-span hinge widths. Exceedance of these widths during seismic events can lead to unseating and potential bridge failure.

There is a need to shift from a single-component approach to a system-level evaluation in which bridges are analyzed as integrated systems of interacting components. Expanding the CT-RBSD methodology in this way enables more accurate estimation of seismic risk by accounting for component interactions, load redistribution, and the influence of individual elements on overall system behavior.

This framework improves the ability to identify vulnerabilities and assess seismic performance, supporting the development of more resilient bridge designs.

WHAT ARE WE DOING?

This research applies the CT-RBSD procedures to establish system-level seismic risk values for bridge evaluation by considering the behavior and interaction of key bridge components.

The study includes a review of existing research on the reliability analysis of multi-frame bridges, multi-column support bents, and other critical bridge components. Relevant data are compiled to characterize seismic fragilities of these systems.

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A framework is developed to integrate these components into the CT-RBSD methodology, supported by analytical simulations used to evaluate and validate the system-level risk assessment approach.

The study also produces guidelines and implementation tools to support integration of the expanded methodology into bridge design and assessment practices.

WHAT IS OUR GOAL?

The Caltrans Risk-Based Seismic Design (CT-RBSD) methodology is being integrated into bridge design practices to enable tailored seismic performance objectives and improved risk management for highway bridges. This approach enhances transportation network reliability and resilience while reducing lifecycle costs.

An initial phase of this effort developed a comprehensive CT-RBSD methodology and supporting implementation tools. The current work builds on this foundation by incorporating fragility relationships associated with abutment seat widths and in-span hinge widths into the CT-RBSD framework.

The research extends the methodology to evaluate system-level probabilities of bridge failure for multi-frame, multi-column bent, and multi-span bridge systems, moving beyond the current single-column-based approach. Analytical studies, simulations, and testing are used to support and validate the expanded framework.

The study also provides recommendations for updating the CT-RBSD procedure to incorporate a system-level seismic risk assessment approach for bridge design and evaluation.

WHAT IS THE BENEFIT?

Incorporating a system-level risk assessment into the CT-RBSD methodology aligns with the Caltrans Seismic Strategic Plan to improve the safety, reliability, and resilience of bridge infrastructure.

Evaluating bridges as integrated systems rather than isolated components enables more realistic and comprehensive seismic performance assessment.

The study supports improved bridge design and retrofit strategies across the transportation network by providing a more system-level basis for seismic risk evaluation.

WHAT IS THE PROGRESS TO DATE?

This project is set to start on June 1, 2026.