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Geotechnical/ Structures

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Project Title: New Near-Fault Adjustment Factors for Caltrans Seismic Design Criteria (SDC)

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New Near-Fault Adjustment Factors for Caltrans Seismic Design Criteria (SDC)

This research aims to update near-fault adjustment factors for use in bridge design.

WHAT WAS THE NEED?

Recordings from past earthquakes reveal that ground shaking near a rupturing fault can cause significantly more damage than shaking at greater distances. Since 1992, the California Department of Transportatiion (Caltrans) has increased the design response spectrum at locations within 15 km of a fault to account for the potential severity of shaking. Caltrans has made only minor modifications to these near-fault increases using period-dependent adjustment factors since their inception.

Additionally, under severe earthquake ground motions, structures respond in the inelastic range. Therefore, further refinement of the near-fault adjustment factors is necessary, based on recent earthquake events, to better account for the effects of inelastic response

WHAT WAS OUR GOAL?

The research aimed to update near-fault adjustment factors for bridge design based on recent findings from a statewide seismic hazard model that incorporates near-fault effects and a study on inelastic structural response resulting from near-fault input motions.

WHAT DID WE DO?

The research utilized the existing statewide Probabilistic Seismic Hazard Analysis (PSHA) results, with and without fault rupture directivity, from the Directivity-Based Intensity Measure Interactive Maps at the Natural Hazards Risk and Resiliency Research Center (NHR3) at the University of California, Los Angeles (UCLA). The study aimed to assess directivity amplification factors based on distance from fault and structural periods, for earthquake magnitudes ranging from

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6.5 to 8.5 and distances up to 300 km. The team developed adjustment factors for both elastic and inelastic response spectra at two ductility demand levels, considering a range of pulse periods. In addition, numerical analyses were performed to evaluate the seismic performance of two long-span bridges subjected to scaled ground motions incorporating the developed adjustment factors for two return periods (975 and 2,475 years), with results compared to those without directivity effects.

WHAT WAS THE OUTCOME?

The research was completed on the following main tasks:

1. Directivity Effect Assessment: Utilized the NHR3 Directivity-Based Intensity Measure Interactive Maps to assess directivity effects, focusing on identifying the threshold distance and developing amplification factors based on return periods, magnitudes, and spectral periods. The deliverables included recommendations for updating Caltrans Near-Fault Adjustment Factors, primarily focusing on simplified modifications to the current SDC 2.0 criteria. The project produced multiple models, including updated simplified adjustment factors dependent on distance and period, a magnitude-dependent model for enhanced accuracy, and a publicly available site-specific interactive online tool.

2. Nonlinear Time History Analyses of Bridgers: Conducted Nonlinear Time History Analyses (NTHA) on 3D bridge models to investigate the significant influence of ground motion directivity and directionality on the seismic responses of three-span long-period ordinary bridges. The findings showed that neglecting directional effects could lead to inaccurate seismic demand estimates, and recommend that seismic bridge design incorporate target spectra with directivity amplification factors and account for ground motion directionality, moving beyond simplified SDOF elastic analysis based on the equal displacement rule.

WHAT IS THE BENEFIT?

This research aims to refine the near-fault adjustment factors used in bridge design, incorporating the latest findings from seismic hazard models and studies on inelastic structural response to near-fault motion. By improving the accuracy of these factors, the research will enhance the safety and performance of bridges near faults, providing a more reliable representation of the potential severity of ground shaking.

LEARN MORE

The final report will be available online soon.
The directivity-based intensity measure interactive maps developed by UCLA and used in this study are publicly accessible at https://www.risksciences.ucla.edu/nhr3/california-directivity

IMAGES

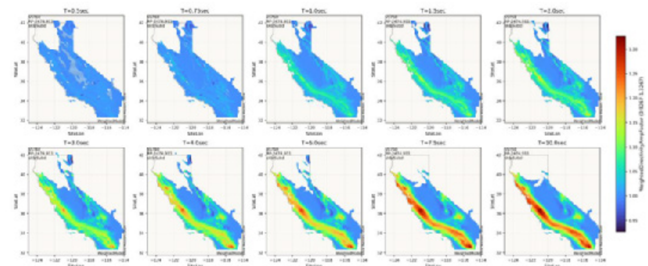

Image 1: Directivity-amplification factor for sites in dataset (Vs30 = 760 m/s, return period = 2,475 years)