Research Project Highlight

Establishing Bridge Column Capacity Limit States through Modeling and Simulation

TSRP Topic S1 - Bridge & other transportation systems: Development of fundamental knowledge

Principal Investigator
Sashi K. Kunnath, Professor of Civil Engineering, UC Davis

Research Team
Jin Zhou, Graduate Student Researcher, UC Davis

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Abstract
Shakecast, a software tool used by Caltrans since 2008, uses near real-time ground shaking maps generated by USGS in conjunction with predictive seismic demand models and component/system capacity models to predict the likely damage to all bridges in the vicinity of the event. While the development of demand models has seen considerable progress, there is a significant gap in the ability of the Shakecast platform to correlate demands with component and system capacity limit states, particularly for older non-ductile California bridges. It is the goal of this project to address this gap by developing a range of capacity limit states for classes of pre-1990 Caltrans bridge columns through rigorous modeling and comprehensive simulations.

The current inventory of pre-1990 Caltrans bridge columns has been classified into suitable subsets based on bridge type (single or multi-column bent), cross-section shape, transverse and longitudinal reinforcement detailing. Capacity limit states for each column type are being established by examining critical response parameters under different loading protocols. Material strains in the core, cover concrete and reinforcing steel are monitored and damage states are defined based on strain limits and then correlated with global response measures such as drift and ductility. For example, the initiation of cracking, spalling of concrete, bar buckling, etc. are associated with well-defined strain states in the material. The calibration of limit states will be validated using an existing database of over 80 columns with axial load ratios comparable to Caltrans bridge columns and reinforcing details that classify them as components with limited ductility. Results from the numerical simulations will be compiled and the full range of damage states (from minor damage up to collapse) for each column type will be developed. The overall methodology is schematically displayed in Figure 1.

Deliverables
A PEER report as well as conference and journal papers summarizing the methodology utilized to develop the column capacity limit states and highlighting research outcomes will be prepared after completion of the project.

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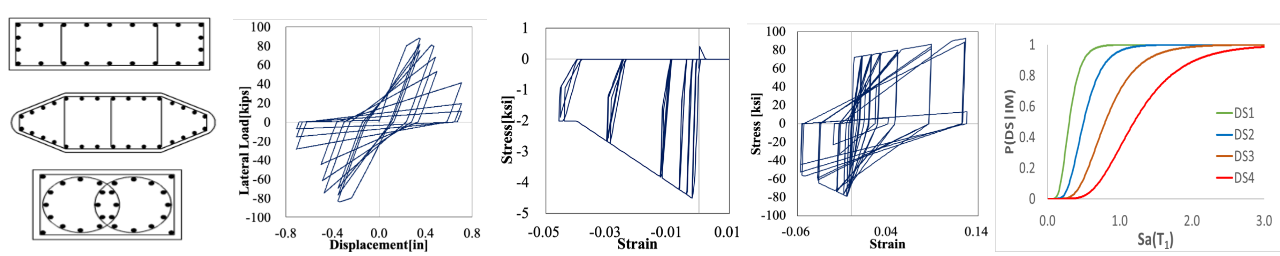
Research Impact

Project outcomes will enhance the capability of Caltrans to rapidly estimate damage to their bridge inventory following an earthquake to facilitate the planning, management and mobilization of emergency response. Highway bridges comprise a critical component of California's infrastructure and transportation network. The deployment of emergency response following a major seismic event is essential to post-earthquake recovery. In addition to enhancing emergency response capabilities following an earthquake, the establishment of capacity limit states will complement ongoing Caltrans efforts to develop probabilistic seismic demand models for a range of bridge types and consequently support and enhance planning decisions at Caltrans for effective allocation of resources (such as prioritizing retrofit needs for deficient bridges) for improved seismic safety. It is acknowledged that the damage state of a bridge system can be controlled by other factors. However, Caltrans practice requires that inelastic action be limited to column elements and that the superstructure and foundation remain undamaged. Hence the development of column capacity limit states is an important first step in the enhancement of the Shakecast platform.

Project Image



(a) (b) (c) (d) (e)

Figure 1: (a) Sample pre-1990 cross-sections; (b) Force-deformation response; (c) Material response: concrete; (d) Material response: reinforcing steel; (e) Sample fragility functions

PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu