Aftershock Seismic Vulnerability and Time-dependent Risk Assessment of Bridges

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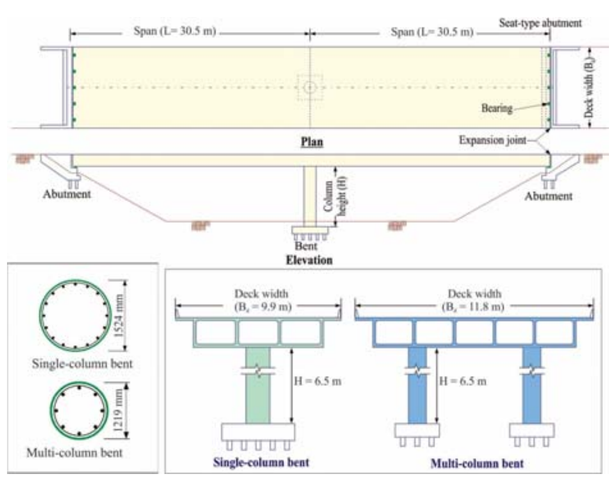
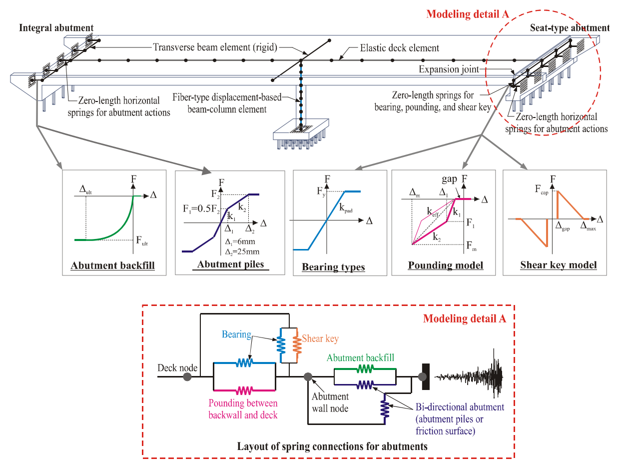
Abstract and Objectives

Decisions about the structural integrity and functionality of earthquake-damaged bridges is a critical step in post-event response and recovery. Currently, the California Department of Transportation (Caltrans) uses a set of bridge system-level damage states as the basis for classifying the post-earthquake operability of bridges. The damage states are based on the HAZUS classifications (minor, moderate, extensive and complete) and each one is assigned a "likely post-event traffic state". For example, a bridge that has been classified as having "moderate" damage is deemed "open to limited public traffic with speed, weight and lane restrictions". Despite HAZUS being the primary tool that is used to inform post-earthquake decisions regarding the partial or complete closure of bridges, the extent to which knowledge of residual structural capacity and time-dependent aftershock hazard and risk inform these damage-traffic-state relationships is unclear. Moreover, while there has been significant research on the seismic vulnerability and risk to bridges posed by mainshocks, recognized research to quantify the vulnerability and time-dependent risk in the aftershock environment is still in its infancy. The proposed research will implement the performance-based earthquake engineering framework to assess the aftershock vulnerability and time-dependent risk of earthquake-damaged bridges, with the goal of informing decisions regarding the appropriateness and timing of post-event closure (partial and complete).

Bridge Configurations and Numerical Modeling



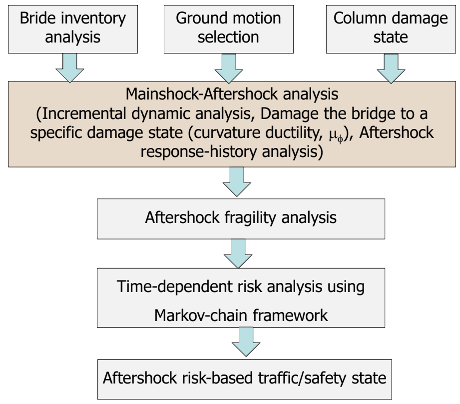
Selected Bridge Configurations

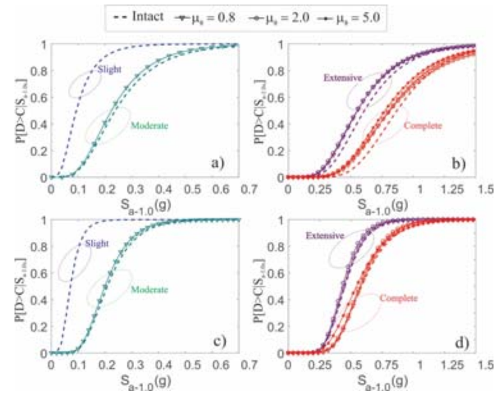


Numerical Modeling (Mangalathu, 2017)

Vulnerability of Bridges in Aftershock

- **Probabilistic seismic hazard analysis of the bridge site**
- **Selection of mainshock and aftershock ground motions**
- **Incremental dynamic analysis to generate the mainshock fragility curves**
- **Generate aftershock fragility curves for specific bridge damage states (slight, moderate, extensive and complete)**
- **Time-dependent risk analysis using Markov-chain approach**
- **Develop aftershock risk-based traffic/safety state classifications**





Mainshock-aftershock fragilities (top row: single column bent, bottom row: two column bent)

Potential Impact

- **The development of quantitative and comparable measures of aftershock bridge performance will ultimately lead to more informed post-earthquake decisions related to bridge closure, which has direct implications to the functionality and recovery of transportation networks.**
- **Modification of existing Caltrans damage-safety-state relationships.**

Reference:

Mangalathu, S. (2017). Performance based grouping and fragility analysis of box girder bridges in California. Ph.D. Thesis, Georgia Institute of Technology., Atlanta, USA