MULTI-HAZARD RISK ASSESSMENT OF A BRIDGE-ROADWAY-LEVEE SYSTEM

Alexandros Nikellis [a], Kallol Sett [a] and Teng Wu [a]

[a] University at Buffalo, The State University of New York

Introduction

- Framework for multi-hazard risk assessment of civil infrastructure
- Spatially distributed system:
  - Transportation system (e.g., bridges, road sections)
  - Levee system
- Quantification of:
  - Life-cycle losses
  - Recovery time

Challenges in extending PBEE in spatially distributed systems

- Hazard characterization
  - Scenario based seismic hazard maps
  - Correlation due to seismic hazard (correlation function between different IMs does not exist)
- Damage correlation on the components of the system
  - Fragility curves for the bridges, the levee, the road section (Probabilistic simulation)
- Very computationally expensive to solve a large system

Novelties

- Include correlation of damage of the bridges in the analysis
  - Bridge specific fragility curves
- Quantify the losses of a system with three different but interdependent networks
- Probabilistic multi-hazard risk assessment for the system:
  - Earthquake
  - Flood
  - Wind (Future, considering long-span bridges)

Conclusions

- The levee system generates the highest losses
- The bridges generate higher losses than the road sections
- The retrofit of the bridges (steel jacketing of the pier) does not significantly reduce the losses of the network
- Losses related to flood are not significant
- The recovery time for the levee system is the longest
- The road sections require more time to recover than the bridges
- The retrofit of the bridges does not significantly reduce the recovery time of the system
- The recovery time related to flood is not significant

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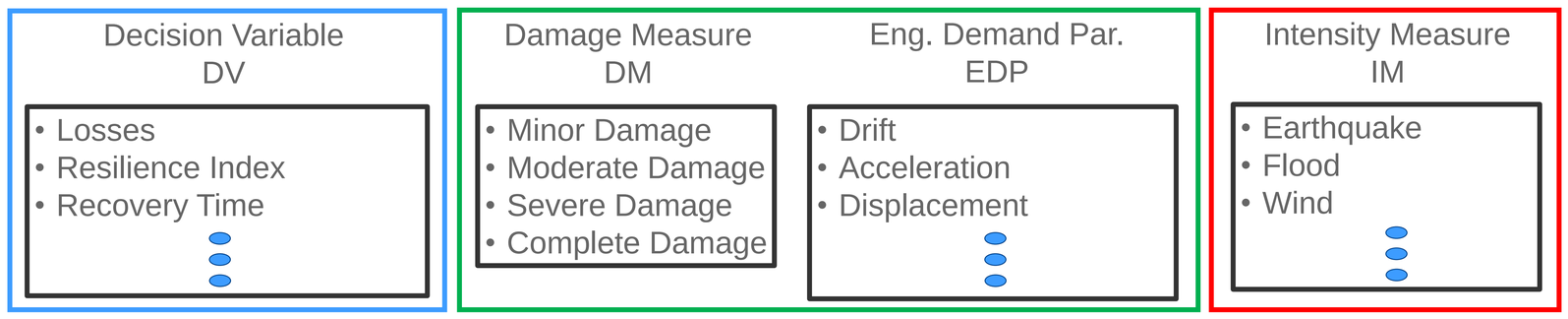
References

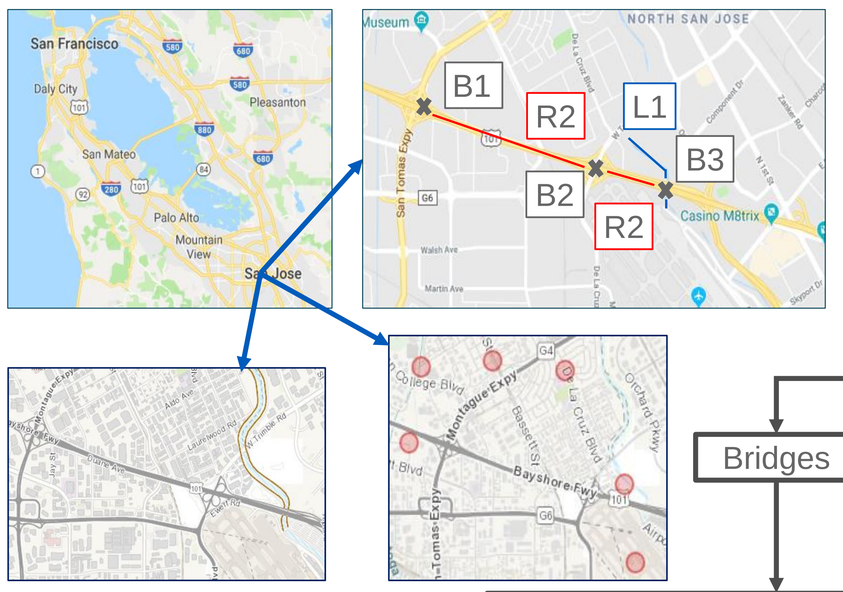
1. Mangalathu, S. (2017). "Performance-based grouping and fragility analysis of box-girder bridges in California", Ph.D. dissertation, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA.
2. Boulanger R.W., and Idriss I.M. (2016). "CPT-Based liquefaction triggering procedure", Journal Geotechnical Geoenvironmental Engineering, 142(2): 04015065.
3. Kwak D.Y., Stewart J.P., Brandenberg S.J., Mikami A (2016). "Characterization of seismic levee fragility using field performance data", Earthquake Spectra, 32:193–215.
4. Stergiou, E. C., and Kiremidjian, A. (2010). "Risk assessment of transportation systems with network functionality losses", J. Struct. Infrastructure Eng., 6(1–2), 111–125.
5. Jayaram, N., and Baker, J.W. (2009). "Correlation model for spatially distributed ground-motion intensities", Earthquake Engineering Structural Dynamics, 38:1687–1708.
6. HAZUS-MH. (2003). "Multi-Hazard Loss Estimation Methodology: Earthquake Model", Department of Homeland Security, FEMA, Washington, DC.

Framework for multi-hazard risk assessment of civil infrastructure

$$\lambda(DV) = \int_{DM}\int_{EDP}\int_{IM} G(DV|DM)dG(DM|EDP)dG(EDP|IM)|d\lambda(IM)|$$

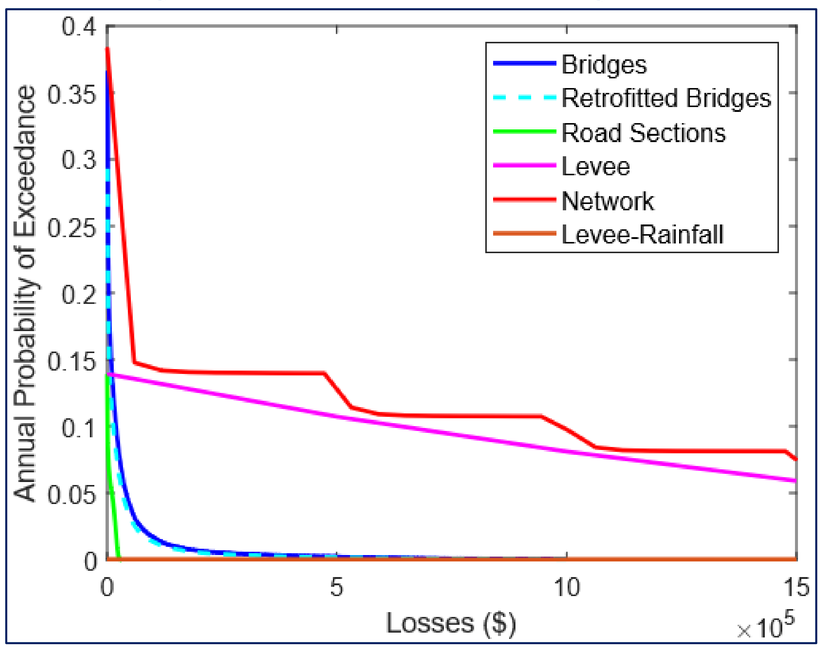


Selected infrastructure system

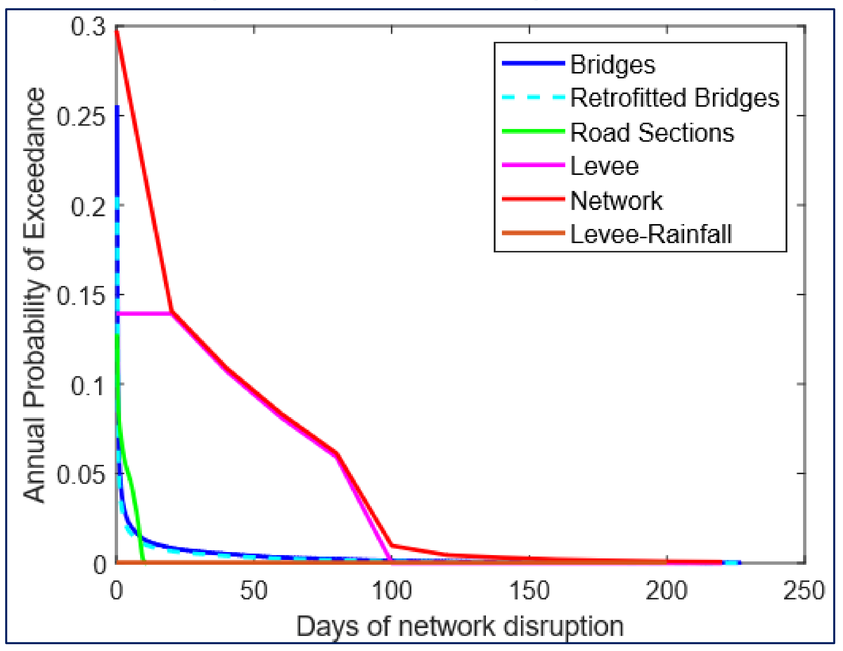


- Three bridges (construction characteristics of three design periods), two road sections, levee system
- Analysis of available CPT and SPT data using Kriging

Life-cycle losses to the system



Recovery time of the system



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Institute of Bridge Engineering
School of Engineering and Applied Sciences
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