Engineering Risk Analysis Group
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Master's thesis

Seismic Risk Assessment of Distributed Infrastructure Systems with Spatial Correlation: Case study Lima Water Distribution Network

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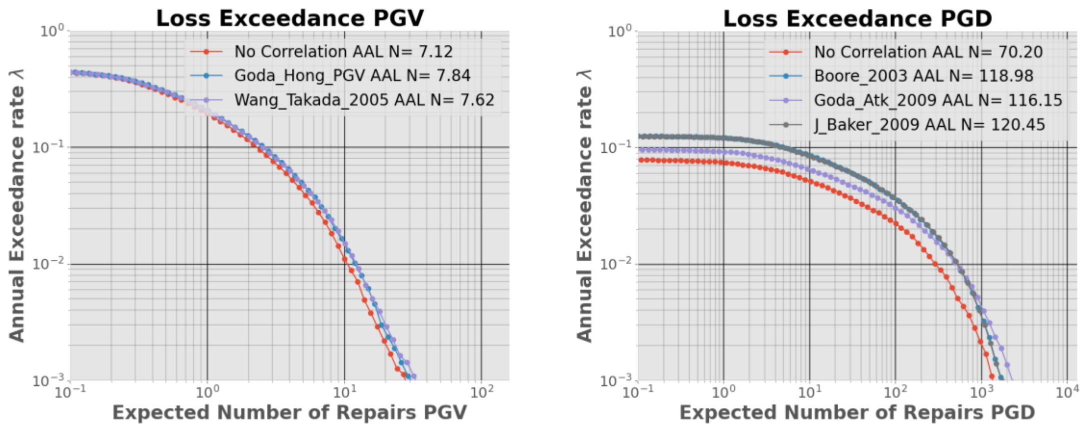
Background

Seismic risk assessment of distributed systems aims to quantify the consequences of Earthquakes (EQs) i.e. economic, physical, and social losses. This supports decision-makers in the context of preparedness and emergency response planning. Infrastructure systems are by nature spatially distributed. Therefore, they have spatial heterogeneity i.e. construction materials, age, soil conditions, and exposure. Spatially distributed systems require calculations of ground motion amplitudes at multiple locations, because there is a need to account for amplitudes of simultaneous events, and the effect of seismic waves traveling similar paths. This is not reflected on the typical hazard maps and has a direct impact on the estimation of expected losses.



The graph displays the loss exceedance curve for the number of failures associated with the ground motion amplitudes associated with PGV and PGD. The red curve plots the aggregated losses for the case with no spatial correlation, while the others show the effect of different spatial correlation models. The average annual loss (AAL) is used to summarize the results for each loss exceedance curve. The use of spatial correlation models shows an increase in the AAL.

Methodology

This thesis implements the steps of a general framework for seismic risk assessment to the case study of the Water distribution networks (WDN) in the city of Lima. This includes modeling hazard occurrence, analyzing propagation, and assessing component vulnerability and susceptibility. To illustrate the effect of spatial correlation on distributed systems, it also focuses on implementing spatial correlation of Intensity Measures (IMs) to assess the physical vulnerability of the WDN. Later, it uses these findings to estimate the reliability of system components (pipes) and compares the results following the implementation of different spatial correlation models.

Results

The outcomes show a strong dominance of failure associated with lateral spreading leading to ruptures, and leaks of buried pipes, which is also highly dependent on the local soil conditions. Last but not least, it illustrates how not accounting for the spatial correlation of seismic events leads to an underestimation of the physical damage and the components' reliability.

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