Engineering Risk Analysis Group
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Master's thesis

Probabilistic Seismic Risk Analysis for Residential Buildings in Lima and Callao, Peru

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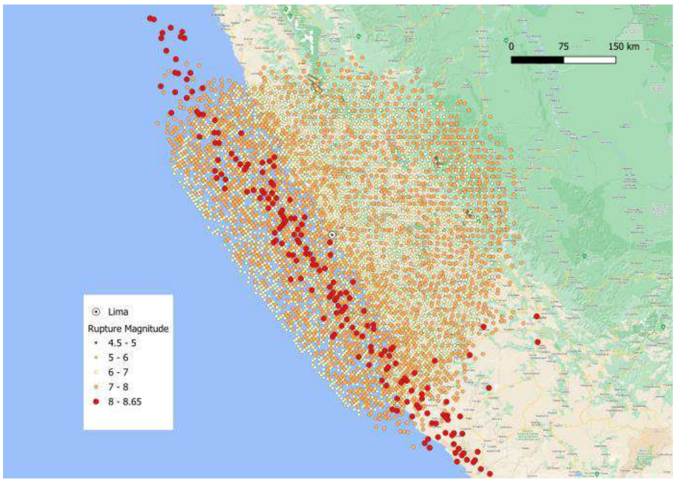
Background

Earthquakes have historically caused severe risks to human life and property worldwide. Notably, from 1900 to 2015, they were responsible for roughly 26% of all disastrous global losses and 2.3 million fatalities. Thanks to better construction codes and infrastructure, efforts to lessen earthquake damage have had some success; nonetheless, gaps still exist, particularly in less developed nations. Since earthquakes are caused by complex geological processes, they are processed as stochastic events with spatially distributed damage, and it can be challenging to assess earthquake risks accurately for insurance and financial planning purposes. Lima, Peru, is a crucial case study for risk assessment because of its active seismic zone, large population, poor building conditions, and susceptibility to seismic disasters.



The graph displays the magnitude and location of simulated earthquake ruptures in Lima and Callao in a time window of 100,000 years, applying the Probabilistic Seismic Risk Analysis approach using the OpenQuake engine.

Methodology

Using geotechnical data and historical records, this study models possible earthquake occurrences over a period of 100,000 years in Lima and Callao, Peru. It uses the probabilistic seismic hazard analysis method to calculate the potential ground movement resulting from each event. The shaking intensity for each seismic zone is evaluated using a logic tree of compatible Ground-motion models and Monte Carlo simulation to consider epistemic uncertainty. To determine anticipated damages and losses, the portfolio of residential structures with relevant attributes such as locality, number, material, and, most importantly, the damage state conditional on the ground shaking is introduced and combined with each simulated event. Losses are assessed in USD based on the damage ratio and the total replacement cost of each building.

Results

Losses and damage ratios are calculated for each event, and the accumulated losses are associated with their frequency of occurrence. Then, the analysis filters for a collection of events representing critical return periods, approximating the likelihood of experiencing a specific loss in a determined time window. Results emphasize how crucial uncertainty is to damage estimation, reflecting the large proportion of unreinforced masonry structures, which are sensitive to slight changes in the estimated intensity of ground shaking. The study assumes deterministic damage states per shaking intensity; thus, it only considers the uncertainty in the hazard part.

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