Research Project Highlight

Validation and Utilization of Physics-based Simulated Ground Motions for Bridge Performance Assessment

TSRP Topic: Physical Simulation - M2

Principal Investigator
Farzin Zareian, Associate Professor, UC Irvine

Research Team
- Mayssa Dabaghi, Co-PI, American University of Beirut
- Jawad Fayaz, Graduate Student Researcher, UC Irvine
- Sarah Azar, Graduate Student Researcher, American University of Beirut

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Abstract
The overarching goal of this research is to develop and apply a methodology to validate synthetic ground motions obtained from physics-based simulation models intended for performance assessment and design of bridge structures. The main objective is to investigate if such synthetic motions lead to a bridge response that is consistent with the response obtained using statistically conforming recorded ground motions. The validation methodology will provide technical feedback to ground motion modelers on needed model enhancement, and bridge engineers on best utilization practices. The validation methodology is founded on comparing conforming groups of ground motion waveforms from recordings and simulations and their effect on a collection of structures that represent the engineering practices and application. The comparison considers the statistics of earthquake scenarios at the level of the seismic event and site parameters, the resulting waveform characteristics, and the subsequent structural responses. Regression models are developed at three levels (between structural responses and waveform characteristics, structural responses and event and site parameters, and waveform characteristics and event and site parameters). The validation process is guided by a statistical comparison of the models obtained from groups of recorded and simulated ground motions. The validation methodology is applied to CyberShake (ver. 15.12) simulations in the southern California region and estimates the column drift ratio of a representative set of bridge structures.

Deliverables
A PEER report and several conference and journal papers describing the validation methodology and guidance to the users on how to validate simulated ground motions for performance-based assessment of ordinary bridges.

Research Impact
The mainstream approach for designing and assessing structures to withstand impacts of seismic hazard is to utilize a set of selected and modified ground motions from past global recordings of seismic events. Such an approach does not allow the opportunity to embrace the advancements in ground motion simulation, resulting in waveforms tailored for the structures' location. A validated ground motion simulation method opens significant research opportunities to investigate seismic events' regional impact on essential components of distributed systems (e.g., highway bridges in a transportation system). The main hurdle in using simulated motions is the lack of consensus on the acceptable accuracy of the computed structural responses. Validation methods for simulated ground motions can

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be categorized into three main types. Type I validation methods are based on historic events; they show if ground motion waveforms obtained from replicating a single event at their respective recording stations have the same central value of response as their corresponding recordings. Type II validation methods focus on the similarity of trends in important parameters representing ground motion characteristics (e.g., peak ground acceleration, building response) with event and site parameters obtained from simulations and recordings. In contrast with Type I validation, Type II validation may utilize a population of past events to form the trends in ground motion parameters. Type III validation methods find the equivalency between simulated and recorded ground motions using established structural/earthquake engineering principles and statistical tools; similarity of response spectra is the cornerstone of such equivalency checks. The methodology presented in this research is of the Type II validation approach. The suggested validation methodology's main contribution resides in its ability to be tailored for the target simulation method and engineering application while founded on a set of established engineering principles and statistical tools.

Project Image

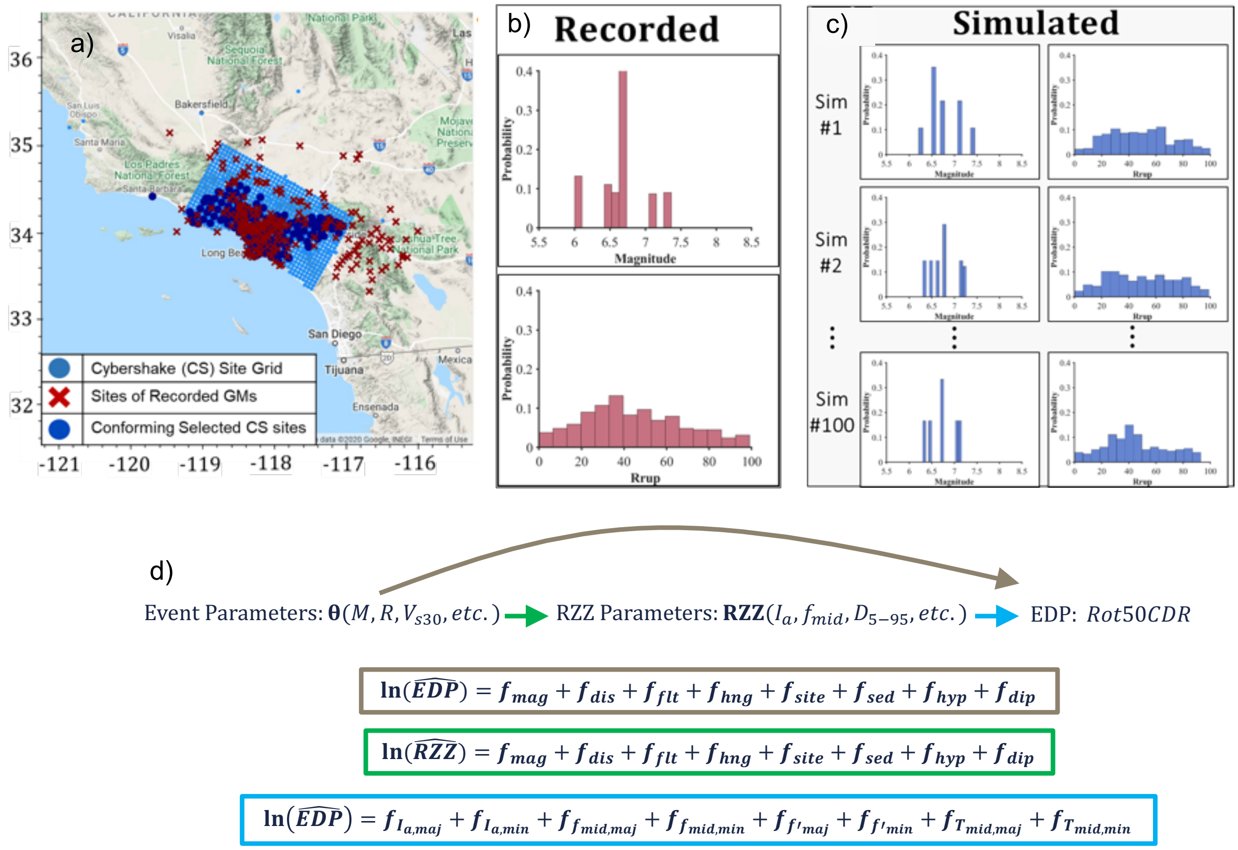

Figure. a) Sites of the selected recorded and simulated ground motions, b) histograms of Magnitude and Rrup of recorded catalog, c) histograms of Magnitude and Rrup of simulated catalogs, d) proposed validation methodology process.

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