Research Project Highlight

Correlation of ground motion duration with spectral acceleration and implications for expected bridge performance

TSRP Topic: M1 - Improved characterization of GM & hazard intensity

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Abstract
Due to the critical nature of transportation infrastructure, design or evaluation of bridges often requires site-specific ground motions for input into nonlinear structural models. These site-specific ground motions are generally selected based on the magnitude, distance, and site condition of the recorded ground motion. A preliminary study found that duration and spectral acceleration are negatively correlated for large magnitude earthquakes recorded on soft-soil sites (Vs30<360 m/s). This means that if the target spectral acceleration is above average, then the average duration associated with that ground motion should be below average for the target scenario earthquake magnitude and distance. As duration has been shown to affect structural damage metrics as well as collapse capacity, ignoring duration correlation may result in overestimating the probability of loss of functionality or collapse for bridges. The objectives of the project are to (a) improve the characterization of ground motion duration and (b) evaluate how the improved characterization affects bridge fragilities used within the performance-based earthquake engineering (PBEE) framework. The research will focus on two bridge designs, a typical highway overpass and a major toll bridge.

Deliverables
This research will result in (i) a correlation model between ground motion duration and spectral acceleration, (ii) examples with two case-study bridges showing how appropriate selection of ground motions affects bridge failure probability and estimates of losses using the PBEE framework, and (ii) a PEER Report with findings and journal publications.

Research Impact
Accurate prediction of seismic performance of highway bridges is paramount for resiliency and the ability to plan for post-earthquake recovery, and these predictions are highly dependent on their input. Ground motion prediction equations (GMPEs) and duration prediction equations describe the

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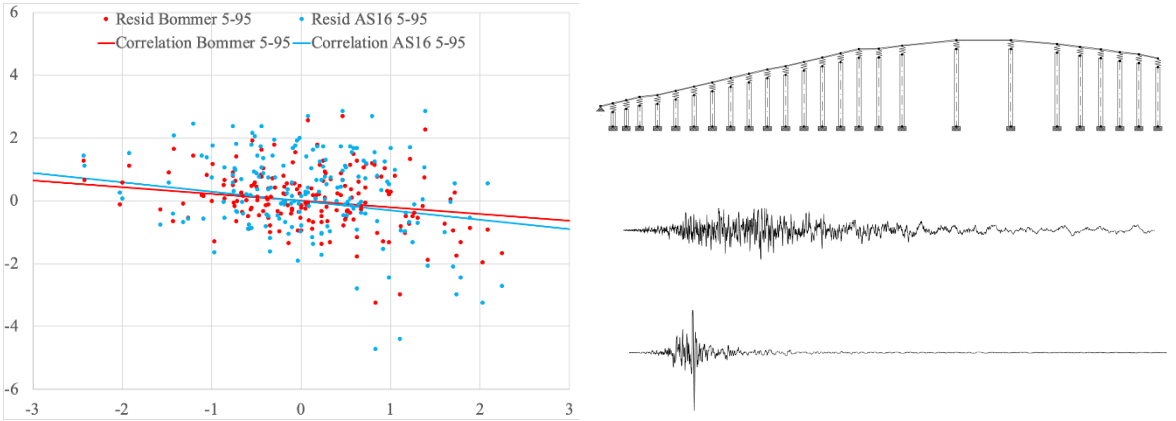
distribution of spectral acceleration and duration given a set of predictor variables such as magnitude and distance, but do not address the correlation between spectral acceleration and duration. From a preliminary study, if the correlation is not accounted for, the durations can be overpredicted on the same order as overpredicting the magnitude by one-half a unit. Numerous studies have shown that the duration of the selected ground motions can impact structural response and should be included in selection procedures, yet there are no clear guidelines on how this should be done. When duration is deemed to be important for the structural response, the state of the practice is to check the duration of the selected records against existing duration prediction models, but these models do not take into account the correlation with spectral acceleration, which may lead to a bias.

The research will allow engineers to select more appropriate records for use in analysis and design of structures and will demonstrate the impact of appropriately selecting for duration. Thus, the research will complement previous and ongoing research in bridge and transportation systems. Furthermore, the question of appropriate durations is especially relevant to high importance structures requiring time series analysis that are expected to experience nonlinear response in large events; this includes transportation infrastructure, tall buildings, geostructures, etc. Thus, the research can have broad impact and is of interest to structural engineering firms as well as geotechnical engineering firms.

Project Image



Left: Residuals of spectral acceleration at 1 second and D5-95 duration with correlation estimates for ground motion recordings from the NGA-West2 database for Mw>6, Repi<100 km, and Vs30<300 m/s. Right: Model of bridge with input ground motions of different duration.

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