Guidelines on Utilization of Simulated Ground Motions for Engineering Building Response Applications

Presented on behalf of task committee:

Ting Lin

Dept. of Civil, Environmental & Construction Engineering

Multi-Hazard Sustainability Research Group (HazSus)

Texas Tech University

SCEC5 GMSV Guidelines Workshop

December 6, 2019

Project Overview

- SCEC Award 19173: "SCEC Ground Motion Simulation Validation (GMSV) Guidelines on Utilization of Simulations for Engineering Building Response Applications"
- PI: Ting Lin, Texas Tech University
- Co-PIs: Sanaz Rezaeian, U.S. Geological Survey; Nicolas Luco, U.S. Geological Survey; Gregory G. Deierlein, Stanford University; Jack W. Baker, Stanford University; Farzin Zareian, University of California, Irvine
- Key Contributors: Jon Stewart, University of California, Los Angeles (EEII/GMSV); Christine Goulet, SCEC; Rob Graves, U.S. Geological Survey (Simulation); Phil Maechling, SCEC (IT); C.B. Crouse, AECOM (UGMS); Jon Heintz, ATC; Practicing Engineer Experts
- Proposal Category: Integration and Theory
- SCEC5 Science Priorities: 4d, 4b, 4c (GM, EEII, CS)

- Workshop (SCEC Award 19181 thanks to Sanaz Rezaeian & Jon Stewart to help with 19173 Task 3) Participants: All of you – Thank you!

Proposed Work

- As stated in the SCEC5 Science Plan Basic Question of Earthquake Science Q4, *realistic physics-based predictions of strong ground motions are among the highest long-term priorities of SCEC*. This research connects SCEC 1D and 3D ground motion simulations – specifically BBP and CyberShake – to practical applications for (a) code-based and (b) performance-based engineering analyses of building responses.
- The anticipated outcome will directly address one of the two action items from the GMSV Planning Workshop in August 2018, as follows:
  "Develop a white paper to describe how to use simulated motions for building response studies once a target response spectrum (e.g. UHS or CMS) is developed by some other process. The paper will include best practices, as we now understand them, and identify limitations to the methodology."
- To achieve this goal, we envision to form a committee led by the PI alongside the co-PIs listed on this proposal, a few practicing U.S. engineers, and SCEC ground motion modeler and IT representatives to (1) review prior SCEC GMSV research, (2) vet through engineering practice, **(3) convene an in-person meeting to identify gaps and develop consensus**, and (4) provide recommendations in the form of a position paper to translate SCEC ground motion simulations and GMSV research into engineering practice.

Task 1: Review prior SCEC GMSV research

From the survey questions in the February 2018 workshop with a range of stakeholders including ground motion modelers and engineering users, the top areas of interest based on collective ranking of importance are:

- What are some examples of using and validating SCEC seismogram simulations for building response analysis? Are they just for research, or for practice as well?
- How are seismogram simulations validated? What features (derived parameters) of the seismograms are used for validation? What are the challenges in validating simulations against recorded data? How are the simulations vetted for scientific research vs. engineering applications?

To bring research to practice, we will aggregate results, observations, and recommendations in a language relevant to the engineering community, specifically for building response applications. This will form the basis of the vetting materials provided to Task 2, the process outlined in Task 3, and a position paper described in Task 4.

Project Plans

- Task 2: Vet through engineering practice
- Task 3: Convene an in-person meeting to identify gaps and develop consensus
- Task 4: Provide recommendations to translate SCEC simulations and GMSV research into engineering practice

- The final deliverable will be a **position paper** with consensus recommendations in the journal, **Earthquake Spectra (EQS)**. This paper will describe what simulations are most useful for, what they can and cannot do, with best practices to guide engineering applications.
- We will also work towards citable SCEC data, recognizing contributions from SCEC Seismology and IT/CS/Special Projects teams by individuals like Rob Graves, Kim Olsen, Christine Goulet, Phil Maechling, Scott Callaghan, Fabio Silva, Edric Pauk, and Kevin Milner.
- We will provide additional engineering application examples with documented SCEC data product to encourage broader utilization of simulated motions in the engineering community.
- Finally, we will summarize our work via a SCEC report for submission by March of 2020.

EQS Guidelines Paper v1

EARTHQUAKE ENGINEERING PRACTICE

Guidelines on Utilization of Simulated Ground Motions for Engineering Building Response Applications

Ting Lin,[a] M.EERI, Sanaz Rezaeian,[b] Nicholas Luco,[b] M.EERI, Gregory G. Deierlein,[c] M.EERI, Jack W. Baker,[c] M.EERI, Farzin Zareian,[d] M.EERI, and Contributing Authors* M.EERI

This paper provides guidelines on the utilization of simulated earthquake ground motion time series for engineering building response applications based on research conducted in the Southern California Earthquake Center (SCEC) Ground Motion Simulation Validation (GMSV) Technical Activity Group. The emphasis here is on how to use simulated motions for building response studies once a target response spectrum is developed. The recent validation of ground motion simulations, especially for complex system response and site-specific spatial extent, provides the basis towards utilization. This work connects SCEC and other ground motion simulations to practical applications for code-based and performance-based engineering analyses of building responses. To illustrate the appropriateness of simulations for the intended usage, engineering application examples are demonstrated with documented SCEC data products. With this backdrop, we show what simulations are most useful for, what they can and cannot do, with best practices to encourage broader utilization of simulated motions in the engineering community.

Introduction

Simulated Ground Motions

Validation

Utilization

Guidelines and Recommendations

Guidelines Paper Presentations

- Introduction: Motivation and Objectives (Nico Luco)
- Guidelines and Recommendations (Greg Deierlein) – also handout/brief document for discussions
- Simulated Ground Motions (Sanaz Rezaeian)
- Justification: Validation (Farzin Zareian)
- Justification: Utilization (Ting Lin)

Thanks to all presenters and written contributions from Jack Baker and feedback from Jon Stewart
@10/2-11/20/2019: multi-PI web-conferences for paper development

Discussions:

Brief guidelines

Paper (if interested)

Plan: Target completion date of 2/29/2020

Guidelines for discussions (brief) – led by Greg Deierlein (next)

GUIDELINES AND RECOMMENDATIONS

SCOPE AND APPLICATIONS OF GUIDELINES

These guidelines pertain to the use of simulated earthquake ground motions for nonlinear response history analyses, where the simulated seismograms are used to supplement or replace recorded ground motions. In such cases, it is presumed that the ground motions are selected and scaled to ground motion intensity targets that are determined by seismic hazard analyses and/or building code requirements for one or more intensities. The ground motion intensity targets are typically based on some type of spectral acceleration (e.g., building code spectra, uniform hazard spectra, conditional spectra) combined with other parameters (e.g., characteristic parameters of the earthquake events governing the seismic risk, such as earthquake fault mechanism, magnitude, distance etc., along with other measures for earthquake duration, pulse characteristics, etc.). In such cases, simulated earthquake ground motions may be most useful in one or more of the following situations:

1. where the seismic hazard is dominated by conventional earthquake characteristics that are not represented well in available databases of recorded ground motions. This includes, for example, instances where the seismic hazard is dominated by large magnitude earthquakes at short distances, for which there are few available recorded ground motions. In such cases, conventional methods of selecting and scaling recorded ground motions to match the target site hazard measures, such as acceleration spectrum, significant duration, and near-fault velocity pulses, can result in significant scaling of ground motions that may not match well the magnitude, distance and other characteristics of the earthquake events that govern the seismic hazard.
2. where the site of interest has unique seismological characteristics that are not

1. Scope and Applications
2. Selection (and Scaling) of Simulated Ground Motions
3. Validation and Vetting of Simulated Motions
4. Documentation of Simulations