Utilization of Simulated Ground Motions in the U.S. Hazard and Design Maps

Sanaz Rezaeian

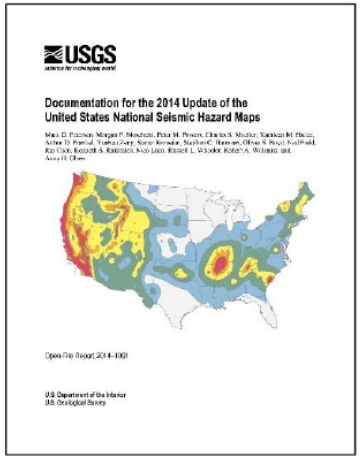
Research Structural Engineer

U.S. Geological Survey (USGS), Golden, CO

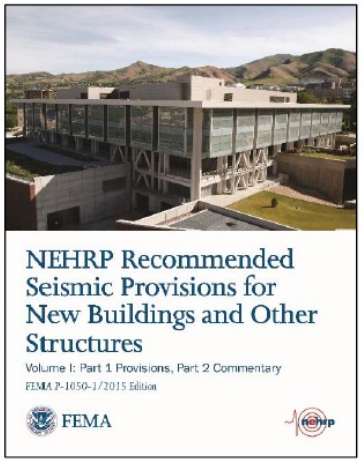
QuakeCORE GMSV Workshop, 31 Aug 2016, Taupo, New Zealand

U.S. Building Codes:

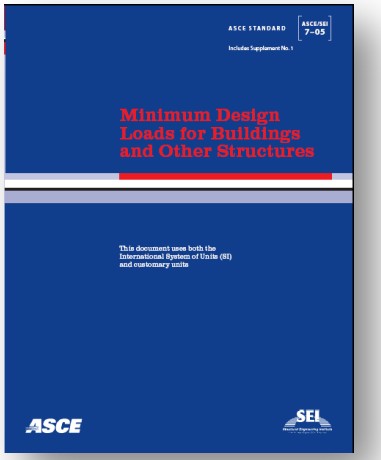
USGS National Seismic Hazard Model (NSHM)



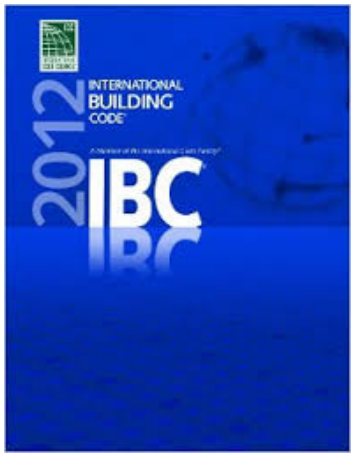
+ Site-Specific Ground Motion Procedures of …



ASCE-7 Committee



FEMA Code Resource Support Committee



Simulations in ASCE 7:

- ASCE 7 procedures permit the use of simulated ground motions. However, rigorous validation needed for engineers to gain confidence in simulations

ASCE 7-10, 16.1.3. (seismic response history procedures):

"…Appropriate acceleration histories shall be obtained from records of events having magnitudes, fault distance, and source mechanisms that are consistent with those that control the maximum considered earthquake. Where the required number of appropriate recorded ground motion records are not available, appropriate simulated ground motion records shall be used to make up the total number required…."

Upcoming updates to ASCE 7:

- Another way that ASCE 7 may utilize simulations may be through Project 17

ASCE 7-16	• 2014 USGS NSHM • Updated NEHRP Site Coefficients
ASCE 7-22	• Project '17 (including removal of site coefficients) • 2017*/2020* USGS NSHM (including NGA-East) • …

(Table Courtesy of Dr. Nicolas Luco)

- **Project 17:** a joint USGS-BSSC effort to develop consensus among practicing engineers and earth science communities engaged in formulating the rules by which next-generation seismic design value maps will be developed.
  - 2020 NEHRP Recommended Provisions for New Buildings and Other Structures
  - ASCE 7-22 Minimum Design Loads Standard
  - 2024 series of I-Codes, e.g., IBC (International Building Code)

Project 17:

- Initially identified 13 issues as important for consideration in the next-generation of design value maps (4 were selected as primary issues due to limited budget and resources):

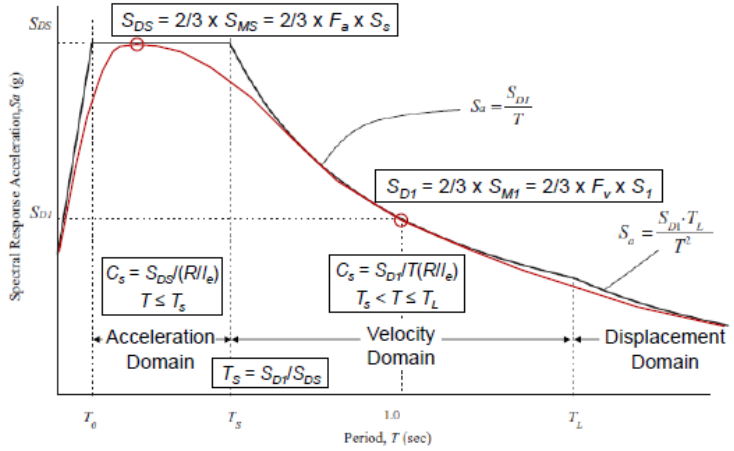
1. Timing for Updated Map Publication
2. Design Value Conveyance
3. Balancing Precision and Uncertainty
4. Acceptable Collapse Risk Definition
5. Collapse Risk Definition
6. Maximum Direction Ground Motion Components
7. Multi-Period Spectral Values
8. Duration as a Mapped Parameter
9. Damping Levels
10. Vertical Motion Parameters
11. Use and Definition of Deterministic Parameters
12. Basin Effects
13. Use of 3-D Simulation to Develop Long Period Parameters

Issue 12 was combined into issue 7: Presently, well defined models necessary for inclusion of basin effects are available for the Puget Sound region, and under development for the Los Angeles region, but many other regions have such basins. The Planning Committee believes that explicit inclusion of these effects in some regions, and exclusion elsewhere, can be problematic for implementation and enforcement of the building code requirements.

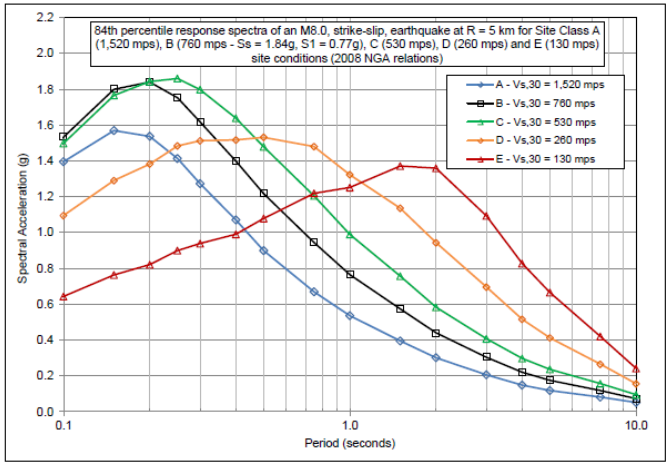
Issue 13 was not directly combined with other issues, nor was it rejected. The Planning Committee has no objection to USGS using such simulations to inform its development of the maps and notes that this will likely be very helpful in the inclusion of basin effects, should the Project 17 Committee elect to proceed with inclusion of these effects.

Multi-Period Spectrum:

ASCE 7 Design Spectrum based on Ss and S1:



Kircher study showing that the spectral shape varies:

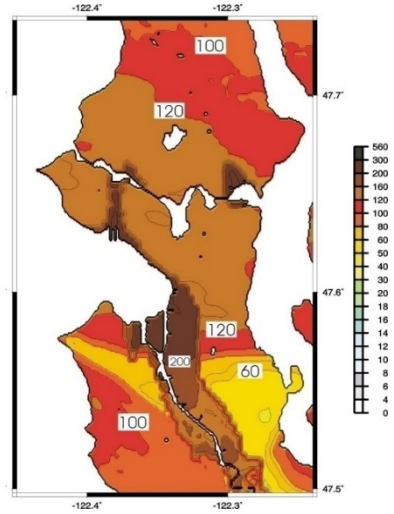


- **Solution:** USGS to develop maps for more periods and site-classes in addition to the Ss and S1 value maps at BC site-class.
- **At long periods:** due to the questionable accuracy of GMPEs, multi-period spectra can benefit from utilizing simulations

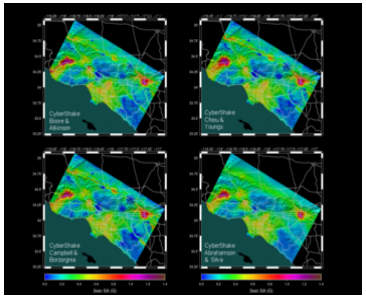
Urban Seismic Hazard Maps (USHM):

- USHMs provide additional ground motion information not included in NSHM

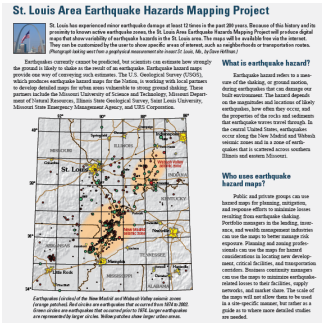
Seattle



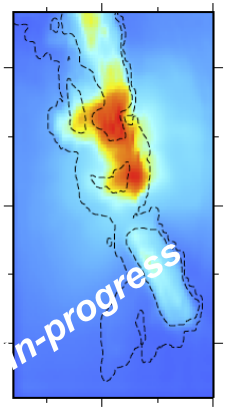
Los Angeles (Cybershake)



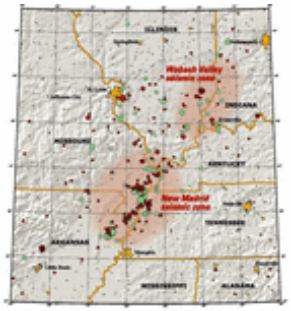
St. Louis



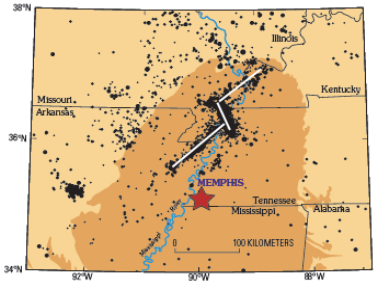
Salt Lake City



Evansville, IN



Memphis

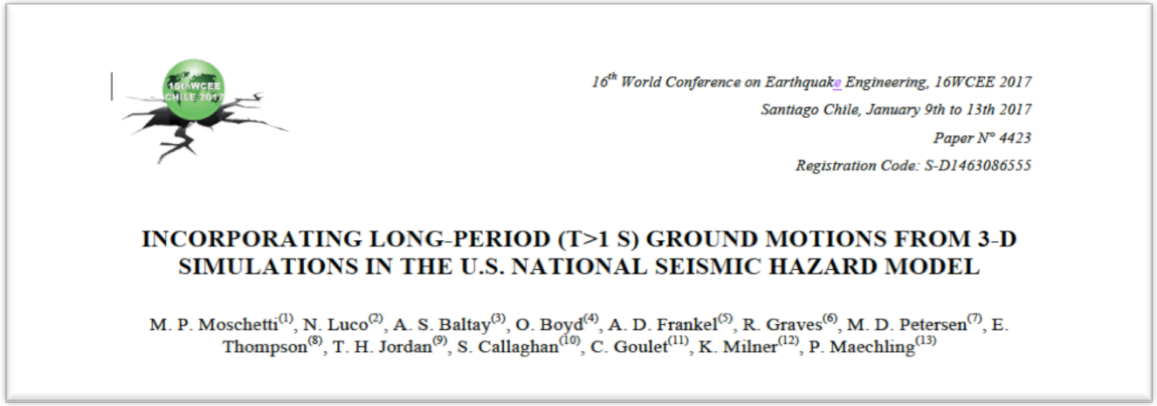


Multiple classes:

- 3-D simulation-based ground-motions
- Near-vertical propagation of S-waves to account for non-linear soil effects
- Vs30 amplification factors

Urban Seismic Hazard Maps (USHM):

- A USGS working group initiated by Morgan Moschetti to compile existing USHMs and to develop recommendations on the utilization of USHMs in the NSHM
  - Recommendations on source and ground motion model details.
  - What is the future role of USHMs within the USGS?
  - How should the USGS vet and incorporate USHMs produced by external groups?
  - How can locations of future USHMs be identified and prioritized within the USGS?
  - …
- WCEE conference paper: sensitivity study of amplification-based method for incorporating SCEC CyberShake simulations into NSHM



16th World Conference on Earthquake Engineering, 16WCEE 2017
Santiago Chile, January 9th to 13th 2017
Paper N° 4423
Registration Code: S-D1463086555

INCORPORATING LONG-PERIOD (T>1 S) GROUND MOTIONS FROM 3-D SIMULATIONS IN THE U.S. NATIONAL SEISMIC HAZARD MODEL

M. P. Moschetti[1], N. Luco[2], A. S. Baltay[3], O. Boyd[4], A. D. Frankel[5], R. Graves[6], M. D. Petersen[7], E. Thompson[8], T. H. Jordan[9], S. Callaghan[10], C. Goulet[11], K. Milner[12], P. Maechling[13]

Next:

More on UGMS/Cybershake
by Christine Goulet