Introduction

The goal of the UGMS committee, since its inception in the spring of 2013, has been to develop long-period response spectral acceleration maps for the Los Angeles region for inclusion in NEHRP and ASCE 7 Seismic Provisions and in Los Angeles City Building Code. The maps are to be based on 3-D numerical ground-motion simulations, and ground motions computed using latest empirical ground-motion prediction equations from the PEER NGA project. The work of the UGMS committee is being coordinated with (1) the SCEC Ground Motion Simulation Validation Technical Activity Group (GMSV-TAG), (2) other SCEC projects, such as CyberShake and UCERF, and (3) the USGS national seismic hazard mapping project. Continued progress toward developing the maps was made in 2017, and this summary report highlights the accomplishments and future work.

Background and Motivation for Long Period Ground Motion Maps

This section was covered in the 2015 UGMS report and the reader is referred to that report for details.

UGMS Activities during 2017

SCEC, under the guidance of the UGMS, finished the development of the Beta version of the web-based lookup tool for MCE$_R$ ground motions, similar to the USGS tool for the national maps. SCEC and UGMS released the Beta version in October 2017. The MCE$_R$ response spectra obtained from the tool cover the greater Los Angeles region and thus provide a resource for cities and counties in the region.

The UGMS also continued to validate CyberShake using the data from the 1994 Northridge earthquake, and the committee examined differences in long period response spectra from the UCERF2 model used in the CyberShake simulations and UCERF3 model used by the USGS to develop the 2014 national MCER maps.

Presentations and Publication of UGMS Committee

A webinar, organized by the Structural Engineers Association of Southern California (SEAOSC), was given on October 26 by UGMS chair, C.B. Crouse, who reported the development of the tool and illustrated its use.

C.B. Crouse also gave a similar presentation at the COSMOS seminar on November 17, 2017, and at the American Association of the Advancement of Science in Austin, TX, on February 18,
2018. Although the Austin Presentation was in 2018, expenses were covered by SCEC under the 2017 budget for the committee.

A UGMS publication by Crouse et al. was submitted to the 11NCEE.

**UGMS Work Completed & Planned for 2018**

Based on comments received on the Beta version, SCEC, under the guidance of the UGMS finished the development of the web-based lookup tool for MCE$_R$ ground motions and officially release it on April 27, 2018.

C.B. Crouse also gave a UGMS presentation at the annual meeting of the American Association of the Advancement of Science in Austin, TX, on February 18, 2018. Although the Austin Presentation was in 2018, expenses were covered by SCEC under the 2017 budget for the committee. He also gave a similar presentation at the Los Angeles Tall Building Seismic Design Conference on May 4, 2018.

The Crouse et al. 11NCEE paper (attached) was accepted by the NCEE organizers.

During its November 8, 2017 meeting, the UGMS discussed additions to the look-up tool including deaggregation data (magnitude-distance and seismic source) and simulated accelerograms for regions within the City of Los Angeles where tall buildings are being constructed (i.e., downtown Los Angeles and to the west). The initial simulations would be for M~8 events on the San Andreas fault. A small subset of representative records would be extracted from the CyberShake files, and the short period motions would be added per the stochastic methods of Graves and Pitarka.

The UGMS will also consider developing companion look-up tools for obtaining: (1) Service Level Earthquake (SLE) response spectra per the 2017 Tall Building Initiative guidelines (TBI-2), and BSE-1E and BSE-2E response spectra per the ASCE 41-17 standard for the rehabilitation of existing buildings.

The next seismic code cycle has begun and will eventually result in the publication of the next editions of the NEHRP and ASCE 7 seismic provisions, slated for 2021 and 2022. Revisions to the current procedures to develop the ground-motion maps for the US were considered by the BSSC Project 17 committee and the decision was to stay with the current MCE$_R$ definition. The USGS is planning to use CyberShake results to recalibrate the NGA West2 equations to better account for the effect of basins. The UGMS will provide assistance to this effort.
Reference (Attached)


Acknowledgements

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Site-Specific MCE_R Response Spectra for Los Angeles Region based on 3-D Numerical Simulations and the NGA West2 Equations

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ABSTRACT

The Utilization of Ground Motion Simulation (UGMS) committee of the Southern California Earthquake Center (SCEC) developed site-specific, risk-targeted Maximum Considered Earthquake (MCE_R) response spectra for the Los Angeles region. The long period (T ≥ 2-sec) MCE_R response spectra were computed as the weighted average of MCE_R spectral accelerations derived from (1) 3-D numerical ground-motion simulations using the CyberShake computational platform, and (2) empirical ground-motion prediction equations (GMPEs) from the Pacific Earthquake Engineering Research (PEER) Center NGAWest2 project. The short period (T < 2-sec) MCE_R response spectra were computed exclusively from the NGAWest2 GMPEs. A web-based lookup tool was also developed so users can obtain the MCE_R response spectrum for a specified latitude and longitude and for a specified site class or 30-m average shear-wave velocity, V_S30. The tool provides acceleration ordinates of the MCE_R response spectrum at 21 natural periods in the 0 to 10-sec band.

Introduction

The UGMS committee was formed in the spring of 2013 with the goal of utilizing the CyberShake simulation platform to improve the determination of long period ground motion in the Los Angeles region for use in seismic design. Details of the CyberShake methodology are provided in Graves et al. [1] and Wang & Jordan [2], and the computational process is described by Callaghan et al. [3]. The CyberShake probabilistic seismic hazard model used here (CS-LA15.4) simulated the ground motions for ~40,000 fault ruptures of moment magnitude M ≥ 6 in Southern California from the Uniform California Earthquake Rupture Forecast, UCERF2 [4], generating ~440,000 pairs of orthogonal horizontal component time histories for each of 336 regional sites. This ensemble is large enough to sample the aleatory variability of the rupture process, including hypocenter and slip variations [5]. The time histories were computed using the high-resolution 3-D crustal model CVM-4.26 [6]. Other details on the background and motivation for the project can be found in Crouse and Jordan [7].

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MCE_R Response Spectra for Southern California

As described in Crouse and Jordan [7], MCE_R response spectra were computed separately for the NGA West2 GMPEs and the CS-LA15.4 model by following the site-specific procedures for probabilistic and deterministic seismic hazard analysis (PSHA and DSHA) in Chapter 21 of the ASCE 7-16 standard. Initially, these spectra were computed for 14 sites outside and within the basins of the Los Angeles region to obtain indications of the characteristics and differences in the spectra. The GMPE-based MCE_R response spectra were computed by substituting the values of the basin-depth terms, Z_{1.0} and Z_{2.5} (the depths to the tops of the layers with shear-wave velocities of 1.0 km/sec and 2.5 km/sec), taken from CVM-S4.26, and the V_{S30} value from Wills et al. [8], into the Abrahamson et al. [9], Boore et al. [10], Campbell and Bozorgnia [11], and Chiou and Youngs [12] GMPEs.

Based on MCE_R response spectra computed from the two approaches, the UGMS committee developed an averaging procedure to combine the spectra in the period band, 2.0 to 10 sec. The procedure is illustrated in the logic tree shown in Figure 1.

The final MCE_R response spectra are the weighted geometric average of the MCE_R response spectra from the NGA West2 GMPEs and from the CyberShake simulations; the weights assigned to each vary depending on the natural period, T, with the MCE_R response spectra from the NGA West2 GMPEs receiving all the weight for T < 2.0 sec. As T increases, the weights for the MCE_R response spectra from the NGA West2 equations decrease, and the weights for the CyberShake MCE_R response spectra increase such that, for T ≥ 5.0 sec, the weights are equal. An additional requirement, namely that these “averaged” MCE_R response spectra cannot be less than the MCE_R response spectra from NGA West2 equations, was imposed to account for the underestimation of the CyberShake MCE_R response spectra at T < ~ 3 sec. A color-coded plot of the “averaged” 5-sec MCE_R spectral accelerations for the region is presented in Figure 2, which also shows the locations of the 336 sites where the CyberShake motions were simulated.
The decision to compute the final MCE$_R$ response spectra as the weighted geometric average of the MCE$_R$ response spectra from the NGA West2 GMPEs and the CyberShake simulations, rather than weight the total mean hazard curves from both approaches (which was initially considered because it is the standard approach), was as follows. The MCE$_R$ response spectra from weighting the hazard curves were not much less than the MCE$_R$ response spectra from the simulations at deep soil basin sites, where the simulation-based MCE$_R$ response spectra were significantly greater than the GMPE-based MCE$_R$ response spectra by up to a factor of ~2. Because the simulations were generated from a linear model, the concern was that they overestimated these site ground motions due to nonlinear responses in the local soils and within the fault zones generating the motions. Limited 1-D nonlinear site-response analysis conducted...
by the UGMS indicated that the long period motions would be reduced, and further reductions might be expected from nonlinear response within the fault zone [13, 14]. Thus, weighting the MCE\textsubscript{R} response spectra was a convenient way to judgmentally account for nonlinear effects and produce smoother looking final MCE\textsubscript{R} response spectra that were not significantly greater than the GMPE-based MCE\textsubscript{R} response spectra. This latter observation was considered important to gain acceptance and use of the MCE\textsubscript{R} response spectra by the structural engineering community, which would be reluctant to accept such spectra if they were significantly greater than MCE\textsubscript{R} response spectra from the traditional site-specific approach using the NGA West2 GMPEs.

**Web-Based Lookup Tool**

A web-based lookup tool, similar to the USGS lookup tool, was developed by SCEC under the UGMS direction and released for public use in early 2018. The web address to access the tool is as follows: [https://data2.scec.org/ugms-mcerGM-tool_v18.4](https://data2.scec.org/ugms-mcerGM-tool_v18.4). This tool enables users to obtain the MCE\textsubscript{R} response spectrum for a specified latitude and longitude and for a specified site class or \( V_{S30} \). If either of these local geologic parameters is not known, the tool automatically selects a default value of \( V_{S30} \) from Wills et al. [8]. The Summary output consists of a table of acceleration ordinates of the MCE\textsubscript{R} response spectrum at multiple natural periods in the 0 to 10-sec band; a plot of the spectrum is also included. The Detailed output also presents the simulation-based and GMPE-based MCE\textsubscript{R} response spectra; values of SDS, SD1, SMS, and SM1, per the requirements in Section 21.4 of ASCE 7-16, are also listed, as well as the PGA\textsubscript{M}, per Section 21.5.

**References**


