SCIENTIFIC NOTEBOOK 1227

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by

John Stamatakos

Southwest Research Institute®
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
San Antonio, Texas

Issued 8/26/2014

SCIENTIFIC NOTEBOOK 1227

INITIAL ENTRIES

12/4/2014 *Entry By: John Stamatakos*

Project number: 17860.11.002

Title: One Dimensional Site Response Analysis to Support NRC Review of the DOE Seismic Hazard Information for Yucca Mountain.

Contributors: John Stamatakos (JAS)

Objectives: The objective of this notebook is to document the spreadsheet calculations of seismic site response data provided by U.S. Nuclear Regulatory Commission (NRC) seismologist Dr. Tianqing Cao. Dr. Cao provided this data as part of the NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA®) review of the U.S. Department of Energy (DOE) Safety Analysis Report for Yucca Mountain. Specifically, this data was used to evaluate the DOE preclosure seismic response analysis used to develop seismic design inputs to the surface facilities area of the Geologic Repository Operations Area (GROA).

Special personnel training or qualification requirements: Seismology, Geology, Basic Statistics.

Identification of code(s) and software used: Microsoft Excel (current version is Version 10, but older versions were also used, especially Excel97). The Excel analysis was conducted on a standard PC running Windows 8, Windows 7, and Windows XP.

Description of hypothesis to be evaluated and/or list of objectives to be accomplished: This analysis builds on earlier geotechnical analysis described in Gonzalez et al., (2004). The work was to evaluate near-surface earthquake site response based on DOE borehole geophysical data collected after 2004 and compare the site response values to the DOE uniform hazard spectra provided in the Yucca Mountain Safety Analysis Report.

Summary of technical approach to be used in the analysis: These calculations were performed by NRC scientist Tianqing Cao, using SHAKE2000 and the time histories from two earthquakes: Sylmar and Umbria. SHAKE2000 is very similar to the program ProShake® (EduPro Civil Systems, 2001). These programs calculate the response of a semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves (Schnabel, et al., 1972). An equivalent linear procedure is used to account for the nonlinearity of the soil (Idriss and Seed, 1968). The details of this approach are provided in Gonzalez et al., (2004) and CNWRA Scientific Notebook 644.

The response output is the ground motion ratio (amplification or transfer function) between output on the surface of a site profile and input at the bottom of a profile. The approach used was to develop an array of spectral amplification functions to compare with the site amplification functions provided by DOE in DOE (2009) and the Yucca Mountain Safety Analysis Report, Section 1.1.5.2.7.2.

Data Inputs and Outputs:

1. The file **borehole_lith.xls** contains the soil property data for the borehole lithology used in the analysis. The borehole lithology (unit, thickness, depth) was obtained from the DOE description of these boreholes in SAR Section 1.1.5.2.7.2 and DOE (2009). V_S and Density values are derived for each unit based on Gonzalez et al., (2004), and are provided at the top of the Excel file. These data were passed to NRC scientist Tianqing Cao for the SHAKE2000 runs.
2. The resulting outputs are provided in the **Composite_1D_SR_Data.xls** file. This file has two tabs, one for the Umbria earthquake and one for the Sylmar earthquake. The resulting amplification functions for each borehole and the mean and standard deviation for the entire group of runs are also provided in this Excel file.

Conclusions

These calculations of the one-dimensional linear-equivalent site-response modeling confirm the DOE results provided in SAR Section 1.1.5.2.7.2 and DOE (2009). The calculations provided in this scientific notebook were for 26 borehole-specific lithologic profiles throughout the GROA using the SHAKE2000 code. Mean transfer functions based on the individual profiles for each of the additional 26 boreholes are bounded by the applicant's site response model.

References

EduPro Civil Systems. "ProShake." Version 1.11. Sammamish, Washington. 2001.

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Gonzalez, S.H., J.A. Stamatakos, K.R. Murphy, and H.L. McKague. 2004. "Preliminary Evaluation and Analyses of the U.S. Department of Energy Geotechnical Data for the Waste Handling Building Site at the Potential Yucca Mountain Repository." NRC ADAMS Accession Number ML083510698. San Antonio, Texas: CNWRA.

Idriss, I.M. and H.B. Seed. "Seismic Response of Horizontal Soil Layers." Journal of the Soil Mechanics and Foundations. Vol. 94, No. SM4. 1968.

Schnabel, P.B., J. Lysmer, and H.B. Seed. "SHAKE: A Computer Program for EarthquakeResponse Analysis of Horizontally Layered Sites." Report No. UCB/EERC–72/12. EarthquakeEngineering Research Center, University of California, Berkeley. pp. 102p. 1972.