Technical Basis for the Need to Update Guidance on Liquefaction Evaluation for Nuclear Power Plants

K. Ulmer[1], T. Weaver[2], and J. Stamatakos[1]

[1]*Center for Nuclear Waste Regulatory Analyses (CNWRA®), Southwest Research Institute®, San Antonio, Texas*

[2]*U.S. Nuclear Regulatory Commission*

Current guidance from the U.S. Nuclear Regulatory Commission (NRC) that addresses earthquake-induced liquefaction evaluation is contained in Regulatory Guide 1.198: "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites." This guide was published in 2003 and is generally based on the findings in NUREG/CR-5741: "Technical Bases for Regulatory Guide for Soil Liquefaction." The guidance in these documents is based on outcomes of the 1996 NCEER and 1998 NCEER/NSF workshops (Youd et al., 2001) and focuses on deterministic, semi-empirical methods, although analytical methods and probabilistic approaches are acceptable if they are sufficiently formulated. Since the NCEER/NSF workshops, liquefaction researchers have developed more probabilistic liquefaction evaluation methods. These advances allow us to explicitly evaluate liquefaction hazards using performance-based procedures to facilitate making risk-informed decisions. However, differences in assessed liquefaction hazard using newer methods was a driving force in a recent National Academy of Sciences study on assessing earthquake-induced liquefaction (National Academy of Sciences, Engineering, and Medicine 2016). Research initiatives of the Next Generation Liquefaction (NGL) project, through the Pacific Earthquake Engineering Research (PEER) Center, are working to address some of the National Academy's study recommendations. In this presentation, we evaluate the limitations associated with deterministic analysis procedures from Youd et al. (2001) through comparison with several case history examples. Specifically, we demonstrate that the current semi-empirical methods are constrained by the case history database from which they were derived, and that geotechnical conditions at some nuclear power plant sites may not be constrained within the case history database, limiting the applicability of existing semi-empirical models in evaluating liquefaction hazards. We also present challenges associated with using a single peak ground acceleration in liquefaction evaluations for demonstrating that the target performance goal has been achieved. We discuss the difficulties researchers and practitioners may face in formulating more probabilistic approaches because characterization of the epistemic uncertainty represented by different models is not yet well understood. Finally, we summarize our current research efforts in coordination with the NGL project which aims to resolve these issues in order to develop the technical bases for future liquefaction guidance that is consistent with a risk-informed and performance-based regulatory framework.