Next Generation Liquefaction Database and Probabilistic Liquefaction Model Development

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Soil liquefaction and resulting ground failure due to earthquakes present a significant hazard to infrastructure around the world. On a site-specific basis, liquefaction evaluations are performed by first evaluating whether a given soil material exhibits a type of soil behavior in which large pore pressure generation and strength loss is possible (susceptibility analysis), followed by assessing whether the state of the soil and the potential future ground shaking at the site are likely to lead to such strength loss (triggering analysis), and finally by considering the potential consequences if liquefaction were to be triggered. The research performed in this study, which was conducted as part of the Next Generation Liquefaction (NGL) Project, aimed to improve all three steps in this modeling framework, but with an emphasis on the latter two. The NGL Project has database and modeling components, with the emphasis of this presentation on the modeling.

NGL modeling was undertaken by a supported modeling team (SMT). The susceptibility model solely considers soil type and behavior considerations and expresses results in a probabilistic manner instead of binary “yes” or “no” determinations common in previous models. The triggering model was developed in two phases. Initially, a Bayesian prior model was derived from a large inventory of laboratory data that was compiled by the SMT. This prior model provides a probability density function for liquefaction triggering conditional on the relative density of granular soils. That model is later adjusted through a Bayesian inference process, as described further below.

This model evaluates the probability that individual layers within a site profile, and ultimately the profile as a whole, express the effects of liquefaction triggering at the ground surface. Referred to as a manifestation problem, this approach is to evaluate triggering and susceptibility probabilities for each layer at a site, and to combine such results with information on liquefied layer depths, layer thicknesses, and soil type characteristics to predict manifestation probabilities. This analysis is empirical, using the NGL database within a Bayesian inference process. Outcomes of Bayesian inference are referred to as posterior distributions, and include both models for layer and profile manifestation, as well as updates to the triggering prior.

The most significant original contributions of this research relative to prior work are the separation of liquefaction triggering from manifestation in model development. In particular, the triggering analysis reflects fundamental understanding of soil behavior as derived from laboratory testing, while the manifestation model was empirically derived from case histories and uses physically meaningful parameters related to the full profile. A number of other innovations were introduced to make this modeling effort possible, including development of machine learning algorithms to layer site profiles, development of improved models for predicting fines contents from CPT sounding data, and improved routines for ground motion prediction at liquefaction sites from past earthquakes.

This presentation will cover the key aspects of the modeling innovations and an example application of the new models to a site in 千葉県美浜区 (Mihama ward, Chiba, Japan) that had varying liquefaction manifestations during the March 11, 2011 **M**9.1 東日本大震災 (Tohoku earthquake).