Research Highlight

Next Generation Liquefaction Susceptibility Database: Expansion of the Laboratory Component to Leverage Pacific Northwest Soils

Project # NCTR-1186

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Abstract (*up to 300 words*)
Liquefaction hazard assessments for transportation and other applications typically follow a three-step process: (1) estimate liquefaction susceptibility, (2) evaluate liquefaction triggering or cyclic softening, and (3) evaluate the potential for instabilities or large displacements. Current susceptibility models are largely deterministic and often result in conflicting outcomes as a result of varying datasets forming the basis for the models, varying criteria by which the available data was interpreted during model development, and varying intents of the models. The Next Generation Liquefaction (NGL) Project provides a research infrastructure within which it is possible to effectively gather, organize, and disseminate large datasets that can lead to the development of new models addressing each of the three steps in a typical liquefaction hazard evaluation.

This project represents a joint effort of UCLA and OSU, in coordination with the Southwest Research Institute, to follow up on the data resources and research needs identified in a recent PEER-funded Workshop on Liquefaction Susceptibility (Stuedlein et al. 2023). We propose to develop a new generation of susceptibility models by (1) extending the NGL database to include new data resources (combinations of in situ and cyclic laboratory test data), (2) proposing indicators of fundamental soil behavior to distinguish granular materials that can exhibit strength and stiffness reductions from excess pore pressures that occur during cyclic loading (“liquefaction”) from moderate to high plasticity soils which maintain a significant portion of their static strength during earthquake loading (cyclic softening), and (3) developing models to predict the probability of such indicators given input parameters that may include CPT soil behavior type index, soil plasticity test results, or monotonic undrained shear tests results. The

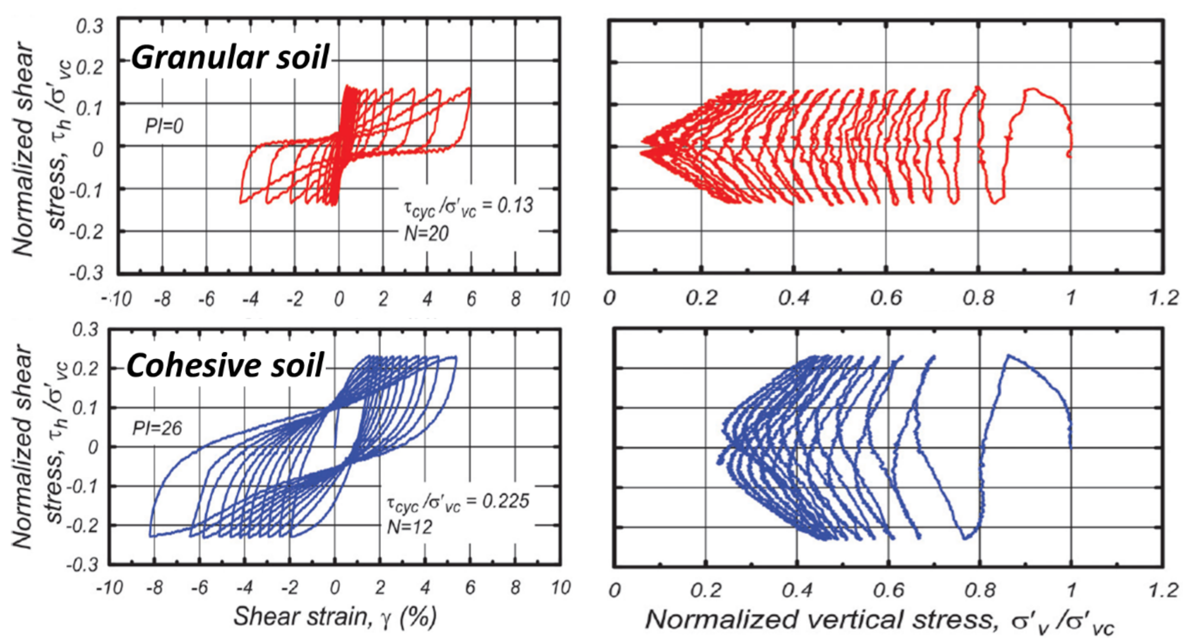
aim is for these models to characterize "material susceptibility" or "inherent susceptibility," which is needed for the first step of a liquefaction hazard assessment.

Deliverables

Project data bundles will be collected and uploaded to the NGL database (Brandenberg et al. 2020). Cyclic test data interpretation procedures will be developed as Jupyter notebooks and made available through DesignSafe. A report documenting the data, the data interpretation procedures, and the resulting models will be published in the PEER report series.

Research Impact

Workshop participants reported broad support for this probabilistic approach in the development of future susceptibility models. PEER's PBEE framework is being used in the development of new performance-based design and assessment procedures and there is general agreement that future developments will also be probabilistically-oriented. The development of future probabilistic liquefaction susceptibility models which can fit within the PEER framework has the potential to dramatically advance the current state-of-practice in probabilistic liquefaction hazard analysis. Once this project is completed, sufficient data will be available to formalize a probabilistic liquefaction susceptibility model leveraging both in-situ and cyclic laboratory data to bound the likelihood of liquefaction triggering given the probability that a particular stratum can liquefy based on its fundamental hysteretic behavior.



Caption: Plots of cyclic test results on granular and cohesive soils illustrating different behaviors including "pinching" near origin of stress-strain loops (left figures) and loss of effective stress from pore pressure generation (right figures). Figure adapted from Kramer and Stewart (forthcoming) using test data from Dahl et al. (2014).