Permeability Measurements from Routine On-the-fly CPT Sounding: Validation Against High-Quality VisCPT and In Situ Permeability Measurements

Derek Elsworth
Penn State University

Project Summary

Cone penetrometer testing (CPT) is a valuable tool for the rapid and continuous profiling of strength, deformability, density, stress-state, and cyclic mobility of soils. Despite the continuous refinement of cone-measured metrics for the determination of these soil parameters, no comparably validated method exists to determine continuous profiles of in situ permeability. This is especially prescient given the needs of the environmental services industry for the rapid and precise reconstruction of permeability fields for the design of contaminant containment and remediation systems. This project will evaluate the potential to determine in situ permeability profiles directly from routinely measured cone sounding metrics recorded on-the-fly. Prospective correlations between in situ field-scale permeabilities and penetration-induced pore pressures, cone end-bearing, and sleeve-friction will be developed and verified against high-quality field data, to be gathered in this study.

Specifically, we will:

- Fabricate *in situ* cone-deployable permeameters that examine the effects of penetrometer-induced disturbance on measured permeability magnitudes.
- Deploy these permeameters concurrently with the visual-CPT to gather unique ensemble data that link CPT sounding metrics with co-located measured permeabilities and visually observed fine-scale soil texture. Measure permeability magnitudes at unusually high spatial resolution and correlate these with direct visual observations of soil texture derived from the visual-CPT.
- Apply the ensemble data to establish correlations between on-the-fly CPT sounding metrics and permeabilities. And,
- Develop and refine models for mechanical and fluid transport behavior in the tip process zone that honor observed data *in situ*, and explain observed correlations.

CPT soundings, co-located with independent in situ measurements of permeability are meager. This study will add to these data, apply unusual constraint to permeability measurements through incremental permeability testing and visual identification of soil texture via the visual-CPT, and develop and explore CPT-permeability correlations through the directed use of model development and dimensional analysis. This work addresses an unresolved problem – that of rapidly determining *in situ* permeability profiles. Uniquely, this study hypothesizes, and provides preliminary evaluations, for the rigorous use of CPT sounding data to determine permeability profiles. The fidelity of these prospective relationships will be explored and refined using unusually well-constrained *in situ* measurements.

If affirmed, these proposed correlations will enable rapid and continuous profiling of soil permeabilities using standard cone metrics, that is currently not possible. Permeability profiles may subsequently be evaluated *a posteriori* from the wealth of piezocone data available, worldwide. Combined with the in situ visual identification of porosities and texture, and direct measurements of contaminant concentrations and fluid saturations, these ensemble techniques will provide an important tool to determine rates of migration of free-phase and aqueous components in unconsolidated porous media at spatial scales of relevance. This study will involve the training of graduate students and the findings will be disseminated in classes, presentations, and through publications.