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Sustainable Geotechnical Engineering - A Research Perspective

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Abstract

In this age of Anthropocene where human activities dominate the built and natural environments, geotechnical engineers have a strong role to play in mitigating the anthropogenic impacts on the environment because geotechnical engineering practice consumes close to 40% of the global energy consumption, depletes large amounts of sand, gravel, and stone reserves every year and adds to the problems of climate change and pollution. Sustainable practices in geotechnical engineering should take a 4-**E**'s approach in which sound **E**ngineering practices uphold the principles of triple bottom line, namely, **E**nvironment, **E**conomy, and **E**quity. Sound geotechnical engineering entails proper soil (material) characterization, sound analysis and design, and careful monitoring. In addition, sustainability assessment and considerations for resilience must be considered in the contemporary practice of geotechnical engineering.

In this presentation, a research philosophy is portrayed that upholds the 4-E's approach in geotechnical engineering. Excerpts from research on soil characterization, analysis, design, sustainability assessment, and resilience quantification are presented. It is first shown how a novel laser vibrometer technique can be used to improve results of bender element tests used for dynamic characterization of soil properties. Soil characterization also involves constitutive modeling and accounting for random spatial heterogeneity of soil properties. How a critical-state based soil constitutive model was developed for high-strain rate behavior of sand for application in blast analysis is shown. Further, the development of a semi-analytical soil structure interaction analysis framework with random spatial heterogeneity is demonstrated. The framework is then applied to nonlinear and dynamic analyses of offshore wind turbine monopile foundations based on which a design perspective for monopiles is developed. The framework is also applied to nonlinear dynamic soil structure interaction analysis with poroelastic soil. Further, finite element analysis of piled raft foundations is presented with a perspective on design. Design in geotechnical engineering should include the different uncertainties. A study on the development of resistance factor for LRFD of pile foundations is presented in which the different uncertainties are explicitly considered. Subsequently, life cycle assessment of pile foundations and a framework for resilience quantification in geotechnical engineering based on DPSIR framework are presented.