RESEARCH
PROJECT CAPSULE [24-1GT]
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TECHNOLOGY TRANSFER PROGRAM

Evaluation and Incorporation of Site and Laboratory Variability into LRFD Design of Pile Foundations—Phase 2

JUST THE FACTS:

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36 months

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POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used / Implementation Potential

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PROBLEM

Geotechnical engineering typically involves designing on natural geomaterials (e.g., soil and rock), which are considered non-homogenous and highly variable materials resulting from inherent variation during soil deposition and subsequent changes (Figure 1). Geotechnical variability is a complex phenomenon that results from many disparate sources of uncertainty such as spatial variability due to natural geologic deposits, equipment and operator measurement variations, statistical errors due to limited information, and model bias (Figure 2). Due to the horizontal and vertical spatial variation of soil properties at the site, it is anticipated that the resistance' variance of geotechnical infrastructural components varies greatly. In-situ/laboratory testing is typically conducted at a known spacing, which might be close or far from the main geotechnical component. This variability issue is exacerbated by the fact that the accuracy and dependability of the measured data sets to be used in the design are occasionally unknown and uncontrolled. Therefore, geotechnical engineering frequently works with a variety of uncertainties that, if not properly accounted for in the design, can result in either an under design that can lead to the failure of geotechnical structures or an overdesign that incurs additional costs.

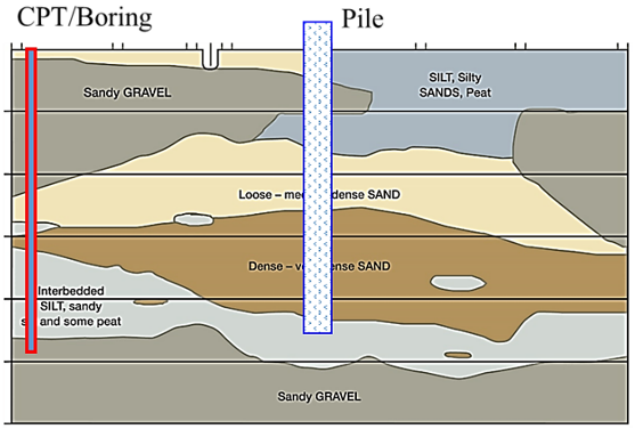

Figure 1. Spatial soil variability

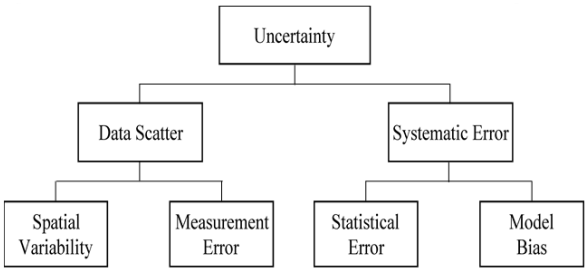

Figure 2. Source of geotechnical uncertainty

OBJECTIVE

The main objectives of this research are to evaluate the different sources of geotechnical site variability and to quantify the effect of spatial site variability of soil properties; number, type, and quality of lab/in-situ test methods; number and type of pile load tests, location and distribution of soil borings /in-situ test methods, and gap characteristic between soil borings/ in-situ tests for inclusion in the load and resistance factor design (LRFD) and analysis of deep foundations.

METHODOLOGY

To achieve the objectives of this study, the research team will conduct the following tasks. These tasks have been separated into two phases for this study.

Work Plan for Phase I

- Conduct a comprehensive literature review on relevant published works.
- Identify project sites from DOTD archives with multiple soil borings and/or multiple CPT tests as well as plan for conducting multiple soil borings and/or CPT tests for new project site, in order to evaluate the site variability.
- Evaluate the spatial variability of selected project sites using geophysics methods, such as the electric resistivity (ER) survey to fill the gap between the soil boring and CPT tests.
- Evaluate the spatial variability of soil type and design parameters for the identified sites in Task 2 using available special interpolation techniques, and compare the interpolated spatial variability with geophysics survey.
- Evaluate the effect of number and type of measurements and lab/in-situ testing methods on the reliability of geotechnical design parameters.
- Incorporate the special site variability (both vertically and horizontally) into LRFD design of piles using the semi-variogram approach. Conduct an analysis here for soil boring/lab tests and CPT data separately and combined.
- Implement the specific site variability into LRFD design of piles using Bayesian analysis method (based on site variability and/or pile load tests).
- Explore the possibility of evaluating and implementing the spatial site variability into LRFD design of piles using probabilistic analysis.
- Evaluate the effect of locations and distribution of soil borings/CPT tests within specific site reliability analysis for LRFD pile design.
- Evaluate the potential use of machine learning (ML) and finite element (FE) analysis to assess site variability.
- Evaluate the effect of number of static/dynamic tests on LRFD resistance factors.
- Perform a risk assessment.
- Develop a rational approach/optimize model and guidelines to implement all factors of site variability into LRFD design of piles.

Work Plan for Phase II

- Incorporate the Phase I tasks into LRFD design of pile foundations.
- Prepare a final report with guidelines and recommendations

IMPLEMENTATION POTENTIAL

It is anticipated that the findings of this research study will provide DOTD engineers with better methodology and techniques on how to evaluate/quantify the spatial site variability taking into considerations the various sources and aspects of site variability. The findings of this research study are expected to provide the recommended resistance factors (Φ) needed for implementing the effect of spatial site variability into LRFD design methodology for safe analysis and design of bridge foundations and other infrastructures. Supplemental guidelines will be provided on how to incorporate the effect of spatial variability into geotechnical LRFD.