Executive Summary and Implementation

CPT-Based Pile Design

Research Objectives

- Determination of the bearing capacity of soils based on Bustamante and Frank (1997) and Bustamante and Gianeselli (1982).
- Determination of the settlement of piles based on Mayne and Niazi (2009)
- Find factors η and θ by comparing NDOT's CPT results and pile loading test results.
- Find correlations between the cone tip resistance and the end bearing/frictional resistance for typical Nebraskan soils (over consolidated soils).
- Implement the correlations in NDOT's piezocone penetration test (PCPT) device (Data Logger/Computer) so that the bearing capacity of pile is obtained "on-the-fly" with other outputs such as tip resistance, pore pressure, side friction, and soil classification.

Research Benefits

- Existing pile load test results will be used as a precise data for deriving more reliable pile bearing capacity evaluation.
- Accurate evaluation of bearing capacity of soils with unsurpassed high resolution (less than 2 in. data spacing) and accuracy will lead the way for optimum foundation design.
- Optimum design of pile foundation will ensure the design of resilient, economic and low maintenance transportation structures.
- High quality bearing capacity analysis may be used to evaluate the feasibility of potential upgrades of load rating of bridges.
- Easy to use spreadsheet will enable quick design

Principal Investigator

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Background

The geotechnical design of a pile foundation is concerned with the determination of the safe magnitude of an external load that the foundation can carry without jeopardizing the stability of the supported structure. In recent years, in-situ sounding tests are becoming a more attractive method to predict pile capacity due to the rapid development of testing instruments, improved understanding of their mechanics and interpretation, and cost efficiency. The cone penetration test (CPT) and its upgraded version, the piezocone penetration test (PCPT), are the most widely used in situ sounding tests to predict pile capacity.

Proposed Implementation by the Principal Investigator

The research results will be thoroughly documented so that NDOT engineers can use the results in determining the pile capacity. Furthermore, the result (correlations) of this research will be:

a) Implemented to the Data Logger or Computer of NDOT's PCPT system so that the equipment operators can obtain results without knowing the specific details of the analytical method, such that the bearing capacity of soil is computed for every 2 centimeters;

b) Coded with a spreadsheet (e.g. Excel) in the case the Data Logger/Computer of NDOR's PCPT system does not allow any modification of its software;

c) And transferred to NDOT engineers through a technology transfer workshop at the end of the project period; and

d) Ultimately, a new, easy, convenient and more reliable pile design technique for Nebraska soils will be used to design more robust, resilient, sustainable and economic highway structures.

Conclusion

This research report compared eight CPT-based and three PCPT-based methods for potential application of the best performer(s) by the Nebraska Department of Transportation (NDOT) to predict pile capacity. Several statistical as well as non-statistical comparison criteria were adopted. According to the evaluation output, the modified (calibrated) Tumay and Fakhroo (1982) method was found to be the best performer for H-piles, and the modified De Ruiter and Beringen (1979) method was found to be the best performer for pipe and precast prestressed concrete piles. For a complete design of pile foundations, the settlement criterion has to be incorporated. The settlement of pile foundations must not exceed a certain tolerable magnitude of settlement to ensure the safety of the structure supported. In this regard, this research project adopted the t – z curve approach to predict pile settlements. Several existing t – z curve approaches based on analytical and numerical techniques were assessed and their relative accuracy was investigated. An easy to use software for the computation of settlement was also developed.

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Final report is available at:
NDOT Research Website

Recommendations for Implementation

The research conducted in this project represents a step forward in the department's design practice of driven pile. CPT is recognized as a versatile and effective method of geotechnical investigation and has been used by the department for various soil mechanics and shallow foundation work. This research extends the application of the CPT to deep foundation analysis and design, which is the department's primary foundation type for bridge construction.

The NDOT Geotechnical Section plans to implement the work from this project in three primary practices:

(1) Conduct CPT testing when possible alongside traditional drilling exploration, which offers higher resolution information and time/cost savings;
(2) Use the CPILE design software developed from this project for pile bearing capacity design, which may offer more efficient foundation design; and
(3) Verify design CPT based design capacities through regiment of dynamic load testing which the department already conducts, and modify η and θ factors in the Nebraska CPT pile bearing capacity equations accordingly. This process will integrate the new design method and ensure reliable outcomes from the CPT based design.

This brief summarizes Project SPR-1(18) M076
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