RESEARCH PROJECT CAPSULE [17-1GT]

August 2016

TECHNOLOGY TRANSFER PROGRAM

Verification and Implementation of Set-up Empirical Models in Pile Design

JUST THE FACTS:

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24 months

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TT-Fed/TT-Reg

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used Implementation Potential

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PROBLEM

Piles driven into saturated cohesive soils typically experience a time-dependent increase of pile resistance (set-up) after installation. Set-up contributes to the long-term resistance of the piles. Field observations show that pile set-up is significant and continues to develop for some time after installation, especially for fine grained soils (clays and silts).

An accurate assessment of pile set-up with time is very important in the design and construction of economical pile foundations in Louisiana. Pile set-up characterization using dynamic and/or static load tests requires re-striking the pile at different times after the end of driving (EOD). Re-striking in routine construction practice is often not practical or economical.

Incorporating pile set-up in the design of pile foundations can result in significant cost savings. The current engineering practice for design of piles in Louisiana is based on analyzing test piles 14 days after driving, and ignoring any pile set-up after that time period. A more reliable design methodology that accounts for the effect of time-dependent increase of pile resistance is needed.

OBJECTIVE

The primary objectives of this research include: performing static and dynamic load tests on newly instrumented test piles to better understand the set-up mechanism for individual soil layers, verifying or recalibrating previously developed empirical set-up models for piles driven in soft cohesive soils (prior LTRC Project 11-2GT), and developing an analytical methodology to estimate the duration of pile set-up.

Minor objectives include: developing a model to predict spatial distribution of excess pore water pressure due to pile driving, establishing a relationship between vertical shaft displacement and associated shear resistance by analyzing strain gage data from instrumented test piles, developing a method to predict the pile tip resistance at different axial tip displacements, and calculating the total and effective stress parameters (e.g., adhesion factor).

METHODOLOGY

DOTD and the researchers have identified the LA-1 bridge construction site (near Grand Isle and the Gulf of Mexico) as an appropriate study site, where four instrumented piles will be driven and several dynamic and static load tests will be performed. Test pile information for the site has already been obtained. At least one other bridge site for this study needs to be identified.

A comprehensive subsurface soil investigation program will be conducted for each selected site. Evaluation of soil layers and corresponding soil properties will then be possible. After developing instrumentation plan drawings based on the site investigations, sensors will be installed on test piles as approved by DOTD.

Strain gage measurements obtained at different depths along the length of a pile will allow for determination of load distribution. Dissipation of pore water pressure will be monitored with time by piezometers installed on the pile face. Pressure cells will be used to measure the increase of horizontal effective stress with time.

Strain gage data will be used to study stress-strain relationships for the axially loaded piles. An analysis of skin friction and end-bearing resistance with axial deformation will provide additional knowledge about how pile loads are transferred to the surrounding soil.

New models for estimating the duration of pile set-up and for predicting the spatial distribution of excess pore water pressure near the pile will also be developed. Since set-up continues as long as excess pore water pressure dissipates, the duration of set-up can be evaluated using soil consolidation theory and piezometer measurements.

IMPLEMENTATION POTENTIAL

The incorporation of any amount of set-up into pile design can result in significant cost savings. Through verification or re-calibration of previously developed empirical models, the research team may provide DOTD with an accepted pile design methodology that leads to reductions for pile length, pile cross-sectional area, and/or size of pile-driving equipment.

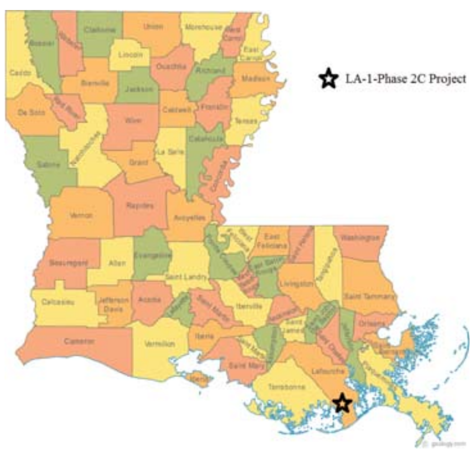

Figure 1
Location of pile set-up project in LA-1

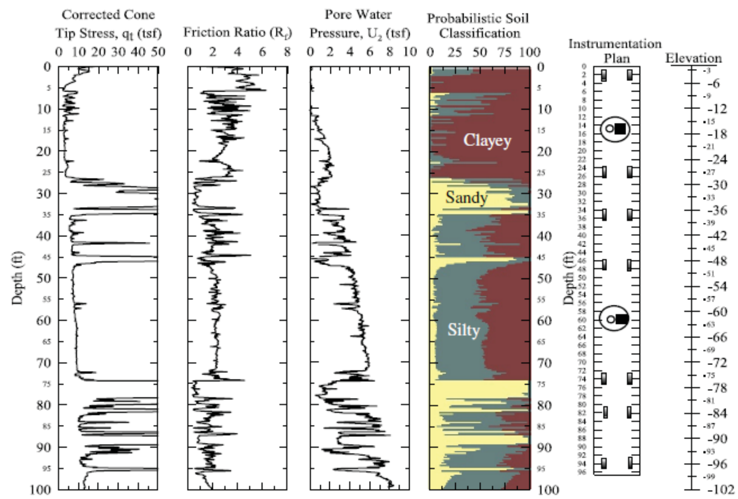

Figure 2
In-situ test results and instrumentation plan for TP-2C1 test piles at LA-1