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Pile Driving Analysis for Pile Design and Quality Assurance

Introduction

Dynamic measurements are often used to predict the capacity of a pile in the form of (a) pile driving formulae that relate the pile set per blow to the capacity of the pile or (b) analytical methods such as the Case method that predict the pile capacity from the accelerations and strains measured at the pile head. However, accurate prediction of pile capacity remains a challenge due to the complex response of piles during driving, prevailing uncertainties in the response of piles under static loading conditions post driving, and uncertainties stemming from simplifications made in the development of existing formulae.

For this study, a fully integrated pile driving control system (PDCS) prototype was developed that collects, processes, and analyzes dynamic data. To develop pile driving formulae, advanced and realistic soil models that explicitly consider important parameters, such as soil and pile variability, were used to accurately simulate the hammer-pile-soil system during driving and to predict the capacity of piles under static loading conditions after driving. The integrated PDCS collects dynamic data through sensors and modules during pile driving operations. The system conforms to all requirements specified in the pertinent ASTM standard (ASTM D4945). The PDCS uses wireless signals for the transmission of data collected in a PC located at a suitable distance from the driving operation. The PDCS can estimate the capacity of a single pile using existing dynamic methods, e.g., the Case method, or through the pile driving formulae developed at Purdue University.

Findings

Comparisons between the capacities predicted using the pile driving formulae developed at Purdue and existing formulae, including the modified-Gates formula used by INDOT, for several well-documented case histories of full-scale instrumented driven piles have revealed that the pile driving formulae developed at

Purdue perform better on average than other formulae. As a result, an intelligent QA/QC program for piling can use this new tool for a subset of routine piling projects, reserving other approaches for larger projects.

Implementation

The PDCS has been subject to very limited field testing (development was done in the laboratory). Additional testing is necessary to determine the robustness and reliability of the first integrated PDCS prototype. An ideal testing scheme would be to test the system for a variety of hammer systems, pile types, and soil profiles and to compare the capacities predicted from the PDCS using the Case method and the pile driving formulae to capacities measured in fully instrumented static load tests.

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