ABSTRACT

Abou-Jaoude, Grace G. Ph.D., Purdue University, December 2006. Assessment of Static Pile Design Methods and Non-Linear Analysis of Pile Driving. Major Professor: Rodrigo Salgado.

Pile foundations are used to transfer loads from the superstructure to deep layers in a soil deposit. Depending on the installation method, piles can either preserve the original soil density and stress state to a certain degree (e.g., bored piles), or induce changes that cannot be easily quantified, leading to greater challenges in obtaining accurate estimates of pile resistance (e.g., driven or jacked piles). Scientific advances in pile analysis have been made in recent decades but their implementation in the estimation of axial capacity has been slow. The modeling of the pile driving process has been traditionally carried out using the one-dimensional wave equation analysis based on empirical factors to control the static and dynamic resistances developed in the soil. Considerable effort has been spent in the past decades to develop models that eliminate the use of these empirical constants. The present research focuses on extending the traditional wave equation analysis to incorporate the proper rheological soil behavior during driving.

The analysis incorporates all damping effects induced in the soil and considers the impact of shear modulus degradation on pile drivability. The pile/soil interaction system is described by a mass/spring/dashpot system where the properties of each component are derived from rigorous analytical solutions or finite element analysis. The outcome of this research is an algorithm that can be used to predict pile displacement and driving stresses. Field experiment results are used to validate the numerical simulation.

The major contributions of this work are the proper modeling of the physical problem in pile driving by accounting for the non-linear soil behavior and separately modeling all damping effects. The new rheological models show, as expected, that sustained loads remain in the pile after a blow. Pile displacement is accurately predicted when compared to field test results. The resistance curves along the pile shaft and base properly reflect the nonlinear soil behavior. Given the complexity of the pile/soil interaction problem in pile driving and the limitations of the one-dimensional wave equation analysis, the present research should be viewed as an effort towards finding a more general solution based on a continuum analysis.