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EXTENDED ABSTRACT

Numerical Study of In- Site Tests for Pile Capacity Estimation

Mahdi Rojhani [a,*], Ali Fakher [b]

[a] *School of Civil Engineering, member of Institute of Modern Sciences and Technologies, Shahed University, Tehran, Iran*
[b] *School of Civil Engineering, University of Tehran, Tehran, Iran*

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1. Introduction

Pile capacity estimation by conventional design equations is not so accurate. Besides of uncertainty of geotechnical parameters and the defect of design equations, during pile installation, the soil is highly disturbed. In pile foundation projects, it is necessary to confirm pile capacity by in-situ tests. Many methods are proposed to perform in-situ such as static pile loading test, pile driving formulas based on penetration and rebound of the pile during driving, and wave equation method. Among these methods, the use of the pile driving formula is the easiest and the most economical method.(Randolph, 2003; Rosenvinge et al., 2004; Bullock, 2012; Likins, 2012; Rajagopal, 2012; Allin et al., 2015; Shooshpasha et al. 2016; Zhussupbekov, 2016; Salgado, 2017) Hiley formula is the only pile driving formula that uses pile rebound in combination with pile penetration for pile capacity estimation(Hiley, 1930). Static pile loading is the most accurate and also expensive test(Fellenius, 1975). Evaluation of capacity by wave equation method is newer than static loading and Hiley formula and with moderate accuracy and cost. In this research, by numerical simulating of the pile driving and pile loading, the results of the mentioned methods (Hiley formula, Wave equation, pile loading test) will be compared.

2. Methodology

In this study, the experimental research by the numerical modeling method was planned. The FLAC 3D software is used for numerical modeling and analysis of two types of models. First, pile driving has been simulated. Then the velocity and force of the pile's head are monitored to evaluate pile capacity by the Hiley formula and so wave equation method or Case method. Second, the pile has been loaded statically according to the pile load testing procedure to estimate pile capacity. During numerical modeling, many details such as mesh generation, dimensions of the model, appropriate constitute model of soil, boundary conditions, damping types, interface between pile and soil, loading conditions, and also verification of models and their results have been considered and discussed.

3. Results and discussion

In this paper, the Hiley formula has been evaluated using numerical simulation of pile driving and variation of penetration and rebound of pile (Fig. 1). Then, the pile capacity estimation using the Hiley equation based on penetration and rebound of pile was obtained from the numerical simulation. The pile capacity has also been calculated by the Case method using the force and velocity of the pile head obtained from the numerical simulation. In addition to numerical simulation of pile driving, a static pile loading test has been numerically simulated and its results have been used in the estimation of pile capacity(Khodaparast M, Fakher A, 1377). Finally, pile capacity values obtained by these three methods have been compared as shown in Fig. 2.

* Corresponding Author
E-mail addresses: m.rojhani@shahed.ac.ir (Mahdi Rojhani), afakher@ut.ac.ir (Ali Fakher).

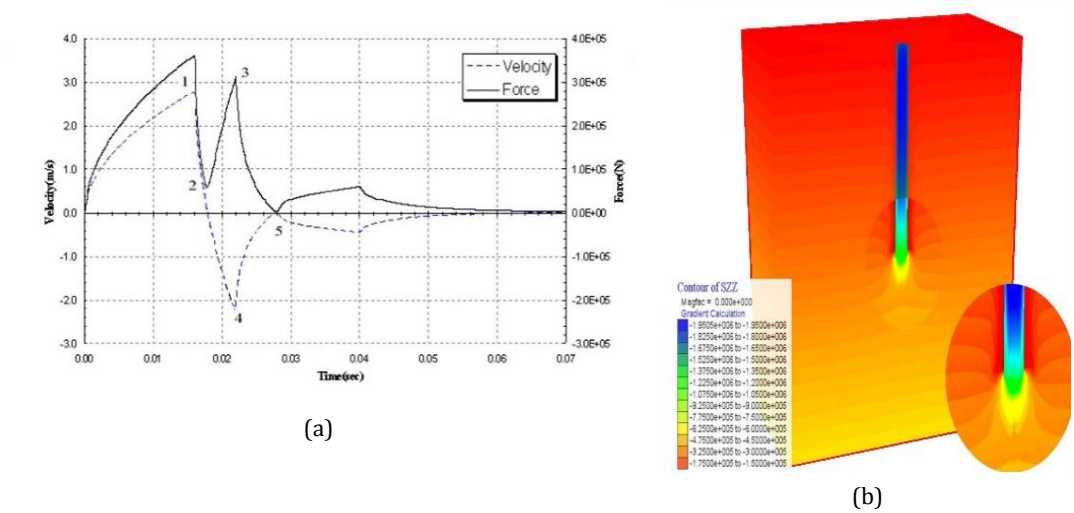

Fig. 1. Numerical modeling of pile Driving: a) Velocity and force of head pile during an impact, b) Szz stress counters during driving

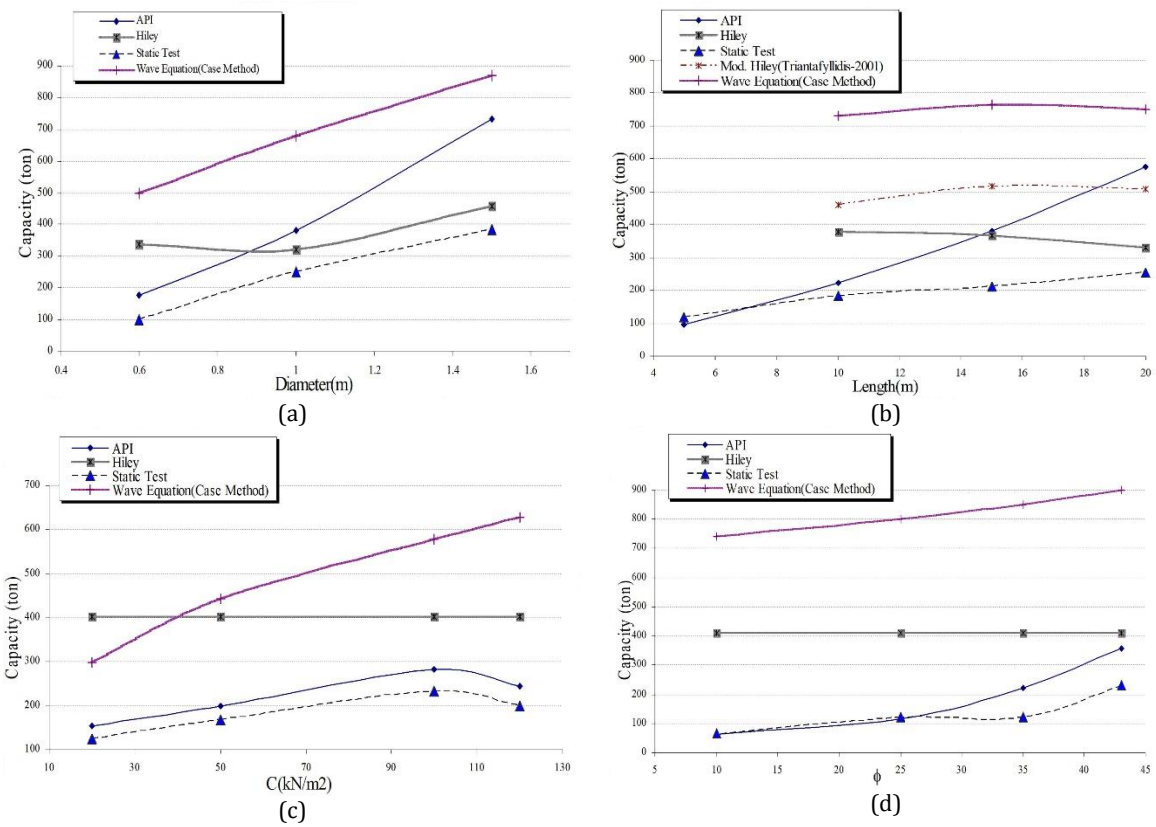

Fig. 2. Test setup: a) Diameter effect, b) Length effect, c) Soil cohesion effect, d) Soil friction angle (ϕ) effect

The results of numerical simulation have shown that the trend and also the amount of pile capacity estimation by pile loading tests have the best fit with the results of the design equation. The pile capacity estimated by the wave equation is usually overestimated. Because the soil strain due to wave propagation is low and elastic, and doesn't reach to plastic range. Also, the trend of the modified Hiley formula is in good agreement with the wave equation. The result of the Hiley formula is overestimated, but not as high as the wave equation results. The results of the Hiley formula are insensitive to friction angle, cohesion, and also modulus of elasticity of soil.

4. Conclusions

According to these results, the trend of capacity variation in static pile loading test modified Hiley formula, and Case methods are all, to some extent, in good agreement with the results of design equations. However, capacity values obtained from the Hiley formula and Case method are, almost in all cases, higher than capacity by static loading test and design equation(Triantafyllidis, 2001).

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