International Journal of Offshore and Polar Engineering
Vol. 13, No. 3, September 2003 (ISSN 1053-5381)

Comparative Behavior of Laterally Loaded Groups of Bored and Driven Piles in Cohesionless Soil

Michael W. O'Neill*
Department of Civil and Environmental Engineering, University of Houston
Houston, Texas, USA

An-Bin Huang
Department of Civil Engineering, National Chao-Tung University, Hsinchu, Republic of China

ABSTRACT

The lateral load performance of 2 pile groups, one consisting of driven displacement piles, the other of bored piles, is described. The effect of installing the piles is to reduce the soil stiffness within the bored pile group, making the soil less efficient in resisting lateral pile movements than in the driven pile group. Structurally, however, the bored piles were more resistant to flexural loading. The net effect was that the system of bored piles was stiffer than the system of driven displacement piles.

INTRODUCTION

Engineers are often faced with the need to analyze groups of laterally loaded piles (driven or bored), for example, for conditions that involve seismic or wave forces, and ice or vessel impact. If the piles are closely spaced, the loading of adjacent piles influences the lateral response of a given pile. An aim of this paper is to demonstrate that lateral pile response is also influenced by the installation of adjacent piles. Current design approaches include neglecting lateral group effects completely, using simple prescriptions for soil subgrade modulus reduction based on small-scale tests, applying published charts derived from the Theory of Elasticity, and the use of software that models the piles with finite elements or as beam-columns defined by finite difference equations. In the latter case, the soil resisting pile motion is modeled using *p-y* curves, which are nonlinear relations between local pile movement and unit soil reaction. This is the approach to modeling pile groups that will be considered here.

To model group effects, the soil resistance values (p) in a family of *p-y* curves for a given pile or a subgroup of piles (usually a row) can be reduced by a constant factor to simulate group action. This scaling factor is termed the *p*-multiplier. Reducing all p values for all single-pile *p-y* curves for a given pile in a group using a *p*-multiplier serves 2 purposes. It softens the response at all values of deflection, and it reduces the ultimate passive capacity of the supporting soil.

Most software that uses *p*-multipliers allows users to specify their values, which are usually chosen based on analyses of past full-scale loading tests on driven piles, centrifuge tests on driven or jacked piles, or 3-dimensional finite element simulations performed without consideration of the means of pile installation. Usually, distinct *p*-multipliers are specified for each row of a matrix-type pile group, but not for each pile on the row individually. Rollins et al. (2002), for example, deduced *p*-multiplier values of 0.82, 0.61 and 0.45 for the front, middle and back rows of a 3-row group of driven piles in clay.

However, none of the existing information contains guidance on whether *p*-multipliers should be assumed to be equivalent for driven and bored piles. For example, the installation of new bored piles in a granular soil might reduce the effective stresses in the soil mass surrounding the piles already in place, while the opposite effect might occur with driven displacement piles. It seems self-evident, then, that the effects of construction should have an influence on *p*-multipliers.

Two full-scale groups of instrumented piles were constructed and loaded by essentially having one group react against the other under large-amplitude, quasi-static loads. One group consisted of bored piles 1.5 m in diameter, while the other consisted of driven, circular, hollow closed-toe prestressed concrete piles 0.8 m in diameter (Huang et al., 2001). *p*-multipliers were evaluated from these tests by using simple system identification techniques to infer *p*-multipliers for each type of pile group. The procedure that was used was generally as follows:

1. Single piles identical to the group piles were subjected to free-head static lateral load tests. A family of *p-y* curves for each statically loaded reference pile was generated from soil data using well-known criteria. These criteria are resident in many design-level computer codes and are easy for the designer to implement.
2. The "standard" *p-y* curves determined in Step 1 were adjusted to cause computed and measured load-deformation relations at the head and along the length of loaded reference piles to match up to a reasonable level of precision. In this step, a series of site-specific and construction-method-specific *p-y* curves were thus generated.
3. The *p-y* curves from Step 2 were then modified by introducing *p*-multipliers that were varied row by row until a match was achieved between the measured and predicted group cap deflections and rotations using the pile group simulation program FLPIER (Hoit et al., 1997).

*Cullen Distinguished Professor: Passed away on August 2, 2003.

Received February 12, 2003; revised manuscript received by the editors July 1, 2003. The original version (prior to the final revised manuscript) was presented at the 13th International Offshore and Polar Engineering Conference (ISOPE-2003), Honolulu, Hawaii, USA, May 25–30, 2003.
KEY WORDS: Piles, sand, foundation, construction, Taiwan.