University of Washington Pin Pile Study

Abstract

The focus of this study was to increase our understanding of the testing and performance of small diameter steel pipe piles, or pin piles. Pin piles are a cost-effective and efficient foundation solution for transferring light structural loads to shallow bearing strata. The economic value of pin piles means engineers are more inclined to rely on local standards of practice instead of using load tests; this often leads to overly conservative foundation designs. This study involved testing of three 2-inch pin piles, each driven to a specific driving criterion of 1, 4, and 8 inches of penetration per minute of driving with a 90-lb pneumatic jackhammer. Static load tests were conducted until a plunging failure was reached. The results were then analyzed by both the Tangent-Line and Davisson method. Dynamic load tests were also performed using a homemade 370-lb drop hammer and a Pile Dynamic Analyzer (PDA) which collected the data. The data however, is still currently being analyzed with the Case Pile Wave Analysis Program (CAPWAP). Although the dynamic analysis is incomplete, results from the static load tests indicate an ultimate bearing capacity in the range of 10-14 kips, which is an increase of 2-6 kips compared to local standards of practice.

Introduction

In the late 1970's, Shannon & Wilson, Inc. learned of a method being used in Sweden in which small diameter steel rods were driven into soft soils and used to transfer structural loads to shallow bearing strata. Shannon & Wilson, Inc. adapted this method and introduced the concept of pin piles to the Seattle area. Through a series of load tests, Shannon & Wilson, Inc. invented a driving criterion which correlated penetration resistance with bearing capacity. They found that a pin pile could be designed for a working capacity of 4 kips if a nominal 2 inch steel pipe was driven to a resistance of equal to or less than 1 inch of penetration per minute of driving, when using a 90 pound jackhammer. Shannon & Wilson, Inc. compiled their findings and in 1980 presented their paper at the ASCE Convention and Exposition in Portland, Oregon. The objective of this study was simply to improve our understanding of the performance and testing of pin piles.

Pin Pile Study

Three 2-in pin piles were driven at a test site on the west bank of the Duwamish River, located near the West Seattle Bridge. The test site primarily consisted of soft to medium stiff, low plasticity sandy silt, increasing significantly to a very stiff sandy silt at about 20 feet below the ground surface. For performance evaluation purposes, the pin piles were driven to 1, 4, and 8 inches of penetration per minute of driving using a 90-lb pneumatic jackhammer. This provided a basis for quantifying the relationship between driving criteria and bearing capacity. All three pin piles reached their desired driving criteria at an elevation of about 19-21 feet below the ground surface. Steel reaction beams were constructed over the pin piles using drilled and grouted micropiles as anchors, from

which static load tests were performed to failure. Failure consisted of plunging the piles anywhere from 3-6 inches. The static load tests were conducted using a calibrated, 220 kip load cell which monitored the loading conditions. Four Linear Variable Displacement Transducers (LVDTs) were placed on top of the pin pile cap and used to monitor displacements up to 1/1000 of an inch. All of these measurements were then received and amplified by a signal conditioner and then digitized by an HP Data Logger, all of which were displayed real-time through a laptop. Telltales such as dial gauges and laser levels were also used to monitor the LVDT recordings and anchor pile movements, ensuring that everything was working properly. Table 1 outlines the results of the static load tests and demonstrates the range of bearing capacity values, given the various driving criteria.

Table 1: Static Load Test Results

Pin Pile #	Penetration Resistance in/min	Ultimate Bearing Capacity (kips)	
		Tangent-Line Method	Davisson Method
1	1	13.8	13.3
2	4	10.5	9.5
3	8	10.5	*

** Unable to interpret value*

Although highly effective, static load tests are often too expensive and labor intensive for use in everyday pin pile projects, which prompted this study to explore other testing methods. Dynamic testing seemed appropriate due to its widespread acceptance and popularity with larger piles. Each pin pile was tested using the Pile Dynamic Analyzer (PDA) program. The dynamic tests were performed by striking the top of each pile with a homemade 370-lb hammer which fell 30-40 inches. To raise the hammer above the pile, our study used a three part block and tackle system. A major concern was that the drop height would not be sufficient enough to overcome the friction between the pulley and rope, resulting in an insufficient hammer drop. A stand alone radar unit was positioned directly over the hammer to measure its velocity, which in turn was used to quantify efficiency. After ensuring that the hammer was in fact sufficient, the induced stress wave was then measured using strain gauges and accelerometers linked to the PDA software. Testing was successful and all initial indications of the data are good, but the data is still being analyzed with the Case Pile Wave Analysis Program (CAPWAP).

Conclusion

The goals of this project were relatively simple in that we wanted to better understand the testing and performance of pin piles. Even though the dynamic analysis is currently incomplete, the results of the static load tests, and previous graduate work findings on this topic, seem to indicate two main points. The first is that static load tests are only as good as the equipment used, especially when it comes to measuring the loading conditions. A recently calibrated load cell should always be used as the main measuring device. The second point is that our current understanding of the bearing capacity of pin piles is conservative. Without a load test and given the current accepted driving criterion,

a design bearing capacity of 6 kips seems to be appropriate for use with nominal 2 inch, schedule 80 pin piles.

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