Investigation for Foot Protection Diameter of Bored Pile by Resistivity Exploration Method

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ABSTRACT

The possibility of using resistivity to measure the foot protection diameter of a bored pile was investigated. Both laboratory experiments and on-site experiments were conducted using a four-pole electrode arrangement. In the laboratory experiments, we investigated the relationship between the resistivity and the exploration depth for determining the boundary position of dissimilar soil strata. With the results, we developed a measuring method that uses in situ resistivity. The on-site tests confirmed that the resistivity was extremely effective for measuring the hole diameter, including the foot protection.

KEY WORDS: Resistivity; Pile foot protection; Bored pile; Soil cement.

INTRODUCTION

In the approximate half-century since the bored pile construction technique was developed in the early 1960s, a variety of construction techniques have emerged that have brought a steady trend of increasing higher load-bearing capacities. However, in contrast to the technological innovations that have accompanied these increasing bearing capacities, quality management often adheres to conventional methods, and quality innovation has clearly lagged behind current boring capabilities. The reason for this is thought to be because previously there were no doubts about the soundness of the solid mass formed at the tip of the bored pile for foot protection, and nobody had any doubts that uniform solid masses for foot protection were being constructed according to design specifications. Similarly, strength management only extended as far as checking the raw liquid strength of the cement milk as mixed at the mixing plant (Copita, 2011). However, in recent years, it has no longer been possible to ignore the fact that dirt gets mixed into the foot protection liquid, and research has started examining methods for predicting the strength when this is taken into account (Tuchiya and Kuwabara, 2013). This is because there has been a growing awareness of the importance of quality management of foot protection as bearing capacities of bored piles have increased with the development of drilling blades with expansion mechanisms that have enabled the construction of larger foot protection bulbs. Against this background, methods for checking the shape of the foot protection bulb by using borehole sonar (Nakamura et al., 2006) and methods for checking the strength of a soil-cement mixture sampled from the foot protection immediately after construction have been developed (Technical Committee on Quality Control of the Hardened Foot Protection Part of High Bearing Capacity Piles, 2014). Furthermore, the importance of process management for soil stabilization, such as by mixing for uniformity, is being revised anew by treating the foot protection liquid as soil cement (BCJ and BL, 2018).

Although the foot protection liquid is now viewed as a soil cement, its uniformity has not yet been clarified. If it were determined that the foot protection liquid was a non-homogeneous material, then the sampling position would become an important problem. Furthermore, the biggest problems with current quality management are that the strength of the foot protection can only be checked after construction, that sampling of unconsolidated materials is only suitable for test piles, and that the sampling position is currently left up to each individual construction method. Furthermore, no testing techniques have yet been developed that extend to the diameter of the foot protection bulb.

The authors have focused on the resistivity exploration method, which is a type of physical method, and began research into methods of measuring the foot protection diameter during pile construction (Kodama et al., 2018, 2019). We have previously reported the results of checking the applicability of this technique through various laboratory and on-site experiments.

RESISTIVITY EXPLORATION METHOD

Resistivity, also known as specific electrical resistance, is a numerical value that represents how difficult it is for electricity to flow. The resistivity exploration method determines soil properties from the electrical resistance distribution when direct (or alternating) current is passed through soil. The scope of usability of the resistivity exploration method is extremely broad, including geological surveys for tunnels, fault investigation, rock property surveys, cavity investigation, and groundwater level investigation (Nakazato et al., 1999). Furthermore, it has long been used for detecting sand strata during soil surveys.

As shown in Fig. 1 (SEGI, 1998), resistivity is found by assuming a