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Behavior of Large-Diameter Rock-Socketed Piles Under Lateral Loads

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Large-diameter rock-socketed piles have been extensively used as the foundation of platforms and other offshore installations. In this paper, the behavior of large-diameter rock-socketed CFST (concrete-filled steel tube) piles under lateral loads is studied, based on field tests and numerical analysis. The CFST piles are 2800 mm in diameter and 40 m in length, with 5.2 m socketed into the rock. The horizontal capacity and deformation of large-diameter rock-socketed piles are analyzed from the measured displacements and internal forces of piles. The interactive behavior of pile-rock and the influence of backfilled sand on horizontal capacity are also discussed. Using the Finite Element Method (FEM) considering the properties of the pile-soil interface, the test results are simulated numerically. This shows that the stress concentration effect in the region near the bottom of the steel tube should be considered in the design, because the socketed part of piles bears most of the lateral load. The steel tube and backfilled sand are both effective in limiting the pile displacement under the working load. Parametric analysis shows there is an optional socketed length to improve the bearing capacity of piles.

INTRODUCTION

Predictions of the bearing capacity of large-diameter rock-socketed piles under offshore conditions, especially for the subaqueous rock-socketed piles under lateral loads, have attracted great attention among offshore engineers in China. One of the major reasons is that such a large-diameter rock-socketed pile has been extensively used as the foundation of offshore infrastructures in China. In general, 2 kinds of piles have been commonly used in underwater rock-socketed pile engineering, including drilled shaft and concrete-filled steel tube (or pipe) piles (CFST piles). CFST piles are constructed by driving a steel tube (or pipe) section into the soil/rock and filling the tube section with concrete (CBSC, 2007). The steel tube is placed on site for concreting and then works with the filled reinforced concrete. Therefore, CFST piles can be constructed more conveniently than others in offshore engineering, and also provide high bearing capacity and good bending resistance because of the cooperation between steel tube and filled concrete core (Gaythwaite, 2004).

Due to the complexity of offshore environments, construction workmanship and large lateral loads on offshore platforms, the mechanism of subaqueous rock-socketed piles under lateral loads has been intensively studied by offshore engineers. Numerous investigations of lateral-loaded rock-socketed piles are available in the literature. Among these, Reese (1997) extended the *p-y* method for the analysis of single piles by considering the nonlinearity of *p-y* curves and the bending stiffness of piles. Zhang et al. (2000) developed a nonlinear continuum method to predict the response of rock-socketed piles under lateral loading. These methods and field tests were applied in analyzing the lateral bearing capacity of piles supporting marine and civil structures, such as ports (Kim et al., 2009) and bridges (Zhang et al., 2000). All aforementioned studies have focused on lateral-loaded rock-socketed piles. To date, only little efforts have been devoted to the behavior of large-diameter rock-socketed piles, especially on the subaqueous rock-socketed CFST piles under lateral loads (Kwon et al., 2000; Na and Kundu, 2002).

In this paper, the behavior of the large-diameter rock-socketed CFST piles under lateral loads is studied, based on in-situ tests in the Port of Majishan. A 3D finite element analysis is also conducted for the prediction of bearing capacity of CFST piles. Further, an optimal socketed length for CFST piles is proposed for engineering design, and the influences of a steel casing and backfilled sand will be discussed.

FIELD TESTS

Introduction of Field Tests

Majishan port is located in the northeast of the Zhoushan archipelago in the East China Sea (Fig. 1), where the hydrological and geological conditions are complex at the port site. The water depth in the region is more than 30 m, and the loads of waves, tides and under sets are large. To satisfy the requirement of lateral bearing capacity of a 250,000 DWT port, large-diameter rock-socketed CFST piles were adopted as the foundation. The steel casing tube is 2800 mm in diameter and 20 mm in thickness. The filled reinforced concrete pile is 40 m long, with 30 m in seawater and about 5.2 m socketed into the rock of the seabed. The diameter of the socketed part of the concrete pile in rock is 2600 mm. During the construction, 4 reinforced concrete casing boxes were placed on the seabed first, which filled with the sand

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