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The behavior of large diameter rock-socketed piles under lateral loads

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ABSTRACT: Large diameter rock-socketed piles have been extensively used in the foundation of platform and offshore engineering. Behavior of the large diameter rock-socketed CFST (concrete filled steel tube) piles under lateral loads is studied based on field tests and numerical analysis for piles for a port. The CFST piles are 2800 mm in diameter and 40m in length, with 5.2m socketed into the rock. The horizontal capacity and deformation of the large diameter rock-socketed piles is analyzed from the measured results of displacement and internal force of piles. The interactive behavior of pile-rock and the influence of backfilled sand on horizontal capacity are also discussed. Using FEM considering the properties of the pile-soil interface, the test results are simulated numerically and the design of a reasonable socketed length is studied.

KEY WORDS: large diameter, rock-socketed, CFST piles, horizontal capacity, pile-soil interface, load test, FEM

INTRODUCTION

Large diameter rock-socketed piles have been extensively used in the foundation of platforms and offshore engineering in China (Zhang, 1995; Cao, 1999; Xu, 1999). Therefore increasing importance has been attached to the study of bearing capacity of large diameter rock-socketed piles under offshore conditions, especially the bearing capacity and deformation of subaqueous rock-socketed piles under lateral loads. Due to the complexity of offshore environment and construction workmanship, and large lateral loads on offshore platforms, the mechanism of subaqueous rock-socketed piles under lateral loads has become one of the major research interests in offshore engineering.

Although there is much literature on lateral loaded rock-socketed piles (Simic, 1989; Hunter etal, 1992; Reese, 1997; Zhang etal, 2000; Ng etal, 2001; Nip etal, 2005), little research has been conducted into the behavior of large diameter rock-socketed piles, especially on the subaqueous rock-socketed concrete filled steel tube piles (CFST piles) under lateral loads.

In this paper, the behavior of the large diameter rock-socketed CFST piles under lateral loads is studied based on field tests in the port of Majishan and numerical analysis. Futhermore, a reasonable socketed length for rock-socketed CFST piles is proposed and the influence of a steel casing and backfilled sand is also discussed. The results can provide a valuable reference for engineering design and construction.

ANALYSIS OF FIELD TESTS

Introduction of field tests

Majishan port is located in the northeast of Zhoushan archipelago in the East China Sea, where the hydrological and geological conditions are very complex at the port site. The depth of the sea is more than 30 meters, and the loads of wave, tide, and underset are very large. In order 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 2800mm in diameter and 20mm in tube thickness. The filled reinforced concrete pile is 40m long, with 30m in seawater and about 5.2m socketed into the rock of the seabed. The diameter of the socketed part of the concrete pile in rock is 2600mm. During the construction process of the pile, four reinforced concrete casing boxes were placed on the seabed firstly, which filled by the sand and gravel to steady the steel tubes. Then the 2800mm diameter steel tubes were piled through the sand into No.VII layer. The boring in the steel pipes was completed on a steel platform, and the filled concrete was cast in place finally.

Since the berth is to be subjected to large lateral load in design, a lateral load test of pile foundation was conducted to check the safety. 8 piles located in the east section of the berth were chosen for the load test. The layout of the test piles is illustrated in Fig.1. In the field test, 2 piles signed as S3 and S4 were tested under lateral loads, while 4 adjacent piles were used as the reaction, which are signed as M1 to M4. The other two piles in Fig.1 signed as C1 and C2 are stable datum piles for lateral displacement observation. All of the 8 piles were covered by backfilled sand within reinforced concrete boxes during construction in order to stabilize the piles. During the lateral load tests, S3 and S4 were loaded along the axes A and B.

The geological profile at the S3 and S4 pile locations is shown in Fig.2. According to site investigation, the foundation can be stratified into 5 layers:

(1) filled gravel layer (No.I1): gray, saturated, loose, with gravel diameter ranging from 6mm to 60mm, 1.5m in layer thickness.

(2) filled coarse sand layer (No.I2): yellow, saturated, medium-dense, fine-grained, 5.0~8.5m in thickness.