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Transition of Soil Strength During Suction Pile Retrieval in Sand

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The main objective of this study is to help establish a procedure for the safe retrieval of suction piles from the seafloor. Field tests on suction pile retrieval were conducted in sandy seafloor soil. The measurements include the relationship between the applied positive pressure inside the pile and the resulting pile movement. They have been used to calculate the mobilized effective soil friction angle ratio, which describes the reduction of the interface friction between pile and soil during retrieval. The mobilized effective soil friction angle ratio is then expressed as a function of a nondimensional parameter that is composed of various factors affecting the suction pile behaviors during retrieval.

INTRODUCTION

In recent years, suction piles have been used with great success in offshore locations due to their significant advantages over conventional piles (Hogervorst, 1980; Larsen, 1989; Senepere and Auvergne, 1982). Wider use of suction piles in the near future is then expected. Almost all suction piles constructed to date are designed as permanent structures, but it may be necessary to retrieve such piles for many reasons, such as misalignment of the pile axis during installation, reuse of the piles at different locations, restoration of the seafloor for environmental concerns, etc. The literature indicates there has been successful removal of offshore foundations using pressures greater than the outside ambient water pressure (Broughton and Davies, 2002; Broughton et al., 2002).

The Daewoo E&C Co., Ltd. conducted a series of field tests on suction pile installation and retrieval inside Onsan Harbor, near the city of Ulsan in southeastern Korea during the summer of 2001 (Bang and Cho, 2003; Cho et al., 2002). The soil in this area was found to be silty sand with some shell fragments and is classified as SM according to the Unified Classification System. The objectives of the field tests were to provide data for further validation of the analytical solution for installation (Bang and Cho, 2000) and for calibration of the analytical solution for retrieval of suction piles (Jones, 2003). In order to include the effects of pile dimensions and the aspect ratio, piles of different diameter were utilized. The piles were made of steel and concrete. For each pile, 2 to 4 nearly identical tests were conducted to reduce uncertainties in test result interpretation. This paper concentrates on the behavior of steel suction piles associated with sandy seafloor soil.

FIELD TESTS

Fig. 1 shows a photo of various suction piles used for field tests. Fig. 2 shows a steel suction pile 1.5 m in diameter and 5.0 m in length. The entire field tests were conducted from a self-elevating platform (SEP) barge, 39.5 m × 39.5 m and 2,300 tons in displacement tonnage (Fig. 3). The water depth at the test site was approximately 15 m.

Fig. 4 shows the schematic cross-section and attachments associated with the suction pile. For installation, the necessary suction pressure inside the pile for penetration the seafloor was generated through a Venturi pump attached at the top of the pile; for retrieval, the pump was bypassed.

The water pressures were measured by piezometers (pluck-type vibrating wire sensor with built-in RTD temperature sensor) installed near the inner and outer top of each suction pile. The water pressure difference outside and inside the pile could thus be instrumented directly from the water-pressure measurements, regardless of the height of the tide. Also, a tilt meter (Electro Level tilt meter with biaxial electrolytic tilt sensors) installed at the top of the pile monitored the inclination angles in 2 perpendicular directions. The pile embedment depth was measured by 2 wire-crack extensometers. All instruments were connected to a laptop computer through a data control box. Each set of data was recorded every 3 s.

After each pile had completely penetrated the seafloor, the pile retrieval test was conducted by directly pumping water into the

Fig. 1 Various suction piles

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