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Uplift Behavior of Under-reamed Anchors in Sandbed

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Under-reamed anchors are used in construction fields to provide increased pullout resistance that enhances the stability of various structures, including offshore structures. Under-reamed anchors are composed of a reamed plate part and a friction part. In this study, a series of laboratory model tests was carried out in sand to investigate the pullout capacity of an under-reamed anchor. Instrumentation was employed to determine the separated resistances undertaken by the shaft portion and the reamed plate of an under-reamed anchor. Based on the test results, it was found that the pullout resistances of the friction part and plate part of an under-reamed anchor were smaller than those of the friction anchor and the plate anchor, respectively.

INTRODUCTION

Ground anchors are reinforcing systems that are designed primarily to resist tensile loads, e.g., to ensure the stability of foundations and retaining walls, to restrain the buoyancy of tanks, to stabilize various types of offshore construction, and to decrease the possibility of tall structures overturning (Das, 1995; Hanna, 1982; Ostermayer, 1974). The number of studies that focus on under-reamed anchors is inadequate in contrast to the numerous investigations of shaft anchors and plate anchors.

This study investigates under-reamed anchors that ream the bottom of friction anchors for their potential to enhance the resistance of friction anchors. The use of an under-reamed anchor with a shafted anchor length of 3~5 m, a shaft diameter of 170 mm, and a reaming ratio (ratio of the diameter of the reamed section to that of the shaft) of 3, under dense and cemented sand, results in increased pullout resistance at a failure rate of at least 50% (Jones, 1997). Kim et al. (2001) observed that the uplift capacity is approximately twice the frictional resistance in the case of an under-reamed anchor composed of a fixed anchor length of 1.5 m, a fixed anchor diameter of 60 mm, and a reaming ratio of 2. However, as the aforementioned studies considered only total pullout resistance, further research is necessary in order to understand the contribution of the shaft friction and the under-reams on the resistance of an under-reamed anchor and the behavior of the surrounding soil.

Habib's Eq. 1, the summation of the frictional resistance and the bearing resistance of an under-ream, frequently overestimates the resistance of under-reamed anchors (Hong, 1999; Korean Geotechnical Society, 1992). The results of a study by the authors also showed that the resistance of the shaft portion and plate portion of an under-reamed anchor was smaller than those values for the friction anchor and plate anchor, respectively. This paper presents the results of model anchor tests performed to investigate the uplift capacity of an under-reamed anchor in sand:

$$T_{ug} = \pi \cdot D_1 \int_{Z_1}^{Z_1+L_1} \tau_z \cdot dz + \pi \cdot D_2 \int_{Z_2}^{Z_2+L_2} \tau_z \cdot dz + q \cdot A \tag{1}$$

where T_{ug} = ultimate pullout resistance (kgf); D_1 = diameter of shaft (cm); D_2 = diameter of bulb (cm); τ_z = frictional stress at depth z (kgf/cm^2); q = bearing stress of bulb area (kgf/cm^2); and A = effective area of bulb (cm^2).

DESCRIPTION OF TESTS

In this study, a series of laboratory model tests on under-reamed plate, and friction anchorages was performed in order to characterize the pullout resistance of each type of anchorage. Thus, the model tests results described in this paper present an excellent opportunity for further study of the real behavior of under-reamed anchors.

Model Tank and Preparation Method of Sandbed

A calibration chamber test has been used in a lot of research that investigated pile resistance and anchor behavior, and produced the results of fairly high accuracy because this test can simulate the stress level of the field in terms of the pressure calibration chamber and is relatively easy to manufacture and use (Ghaly and Hanna, 1994; O'Neill and Raines, 1991).

A tank 1.25 m deep, 1 m wide, and 1 m long was used for the model anchor tests in sand. Each model anchor was buried in the middle of the tank. As the tank diameter was over 11 times the plate diameter, no significant boundary effects on the anchor behavior were expected (Baligh, 1985). Plus, as the tank height was over 12 times the plate diameter, there was sufficient depth to form a deep failure mode that created a local closed bulb above the top of the plate (Ilamparuthi et al., 1999, 2002; Hsu and Liao, 1998; Ghaly et al., 1991; Su and Fragaszy, 1988).

A sand raining method was used to prepare the homogeneous sandbed. During the tests, the density of the sandbed was adjusted by changing the nozzle diameter of the perforated plate from which the sand particles freely fell. With repeated preliminary tests, reproducibility and repeatability were checked using 4 different sandbeds, 4 different pairs of nozzles and the proper dispersing systems.

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