International Journal of Offshore and Polar Engineering (ISSN 1053-5381)
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Vol. 26, No. 1, March 2016, pp. 57–64; http://dx.doi.org/10.17736/ijope.2016.cg14

http://www.isope.org/publications/publications.htm

Scour Development Around Bucket Foundations

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A wind turbine foundation design without scour protection, especially for wind turbines in the North Sea, is a sensitive topic for most offshore developers. However, recent research shows that this concept is realistic if there is extended comprehension of the scour and backfill phenomena. The present paper shows the comparative results for monopile and bucket foundations through the use of experimental analysis and field scour surveys of bucket foundations installed offshore. The main findings show that the bucket foundation is a candidate for a design without scour protection that behaves like scour-protected monopiles in a variety of environmental conditions.

INTRODUCTION

The first issue for each present and future offshore wind farm is reducing the price of offshore wind energy to a competitive level compared to conventional energy sources with lower costs for fabrication and installation. The cost of offshore foundations for wind turbines accounts for around 30% of the total cost of offshore wind farms (Bakmar, 2009). Moreover, 6 to 10% of the total cost of the wind farms represents the investment in protection against erosion of the seabed around the classical monopile foundation, which represents 0.08 to 0.15 million € for one foundation (DHI, 2012). Therefore, reducing or eliminating these costs would be a positive quality for a foundation.

The present paper refers to the research on the behaviour of the bucket foundation (BF) in scour and backfill actions. The authors use an experimental approach to carry out the analysis. Additionally, offshore sites with BFs provide the survey results in order to support the outcome of the presented research. The BF concept presented in the research refers to the Mono Bucket foundation.

Mono Bucket Foundation Technology

Despite the comprehensive research on and use of the suction technology in the gas and oil industry, the BF is still a novel solution in offshore wind energy. This concept was used for the first time at the port of Frederikshavn, Denmark in 2002 as a mono-pad foundation (Mono Bucket foundation) following the bearing principles of a caisson. The foundation carries a 3 MW wind turbine from Vestas inside the harbour limits (Ibsen et al., 2005). The first offshore BF was then installed at the Horns Rev II site in 2009, followed by two more BFs installed at Dogger Bank in 2013, which are sites located in the North Sea. The BFs support three met masts collecting environmental data at the sites and proving the BF concept.

Received August 31, 2015; updated and further revised manuscript received by the editors November 3, 2015. The original version (prior to the final updated and revised manuscript) was presented at the Twenty-fifth International Ocean and Polar Engineering Conference (ISOPE-2015), Kona, Hawaii, June 21-26, 2015.
KEY WORDS: Bucket foundation, scour backfill, site investigation, experiment.

A shaft/leg transfers the loads from the supported structure to the suction caisson and into the foundation soil. Figure 1 illustrates the BF geometry. A multi-shell skirt cylinder makes up the suction caisson that will penetrate the soil and is sealed by the lid plate at the top. Depending on the type of soil, clay chambers may be used to increase the suction capacity in order to penetrate clay or layered clay-sand soils and maintain verticality during installation.

The ratio of the lid diameter D_b to the skirt length L_{sk} that is larger than 0.5, with target values usually around one, defines the specifics of the BF geometry as either a mono-pad or a multi-pad for jackets. The soil type and soil properties govern the ratio choice. The bearing capacity of the BF combines the principles of both a gravity-based foundation and a monopile (Houlsby et al., 2005).

The installation of suction caissons is divided into two stages: (1) the initial penetration of soil under the caisson's own weight to create a seal on the bottom ring; and (2) the application of suction pressure inside the caisson and in the clay chambers if necessary.

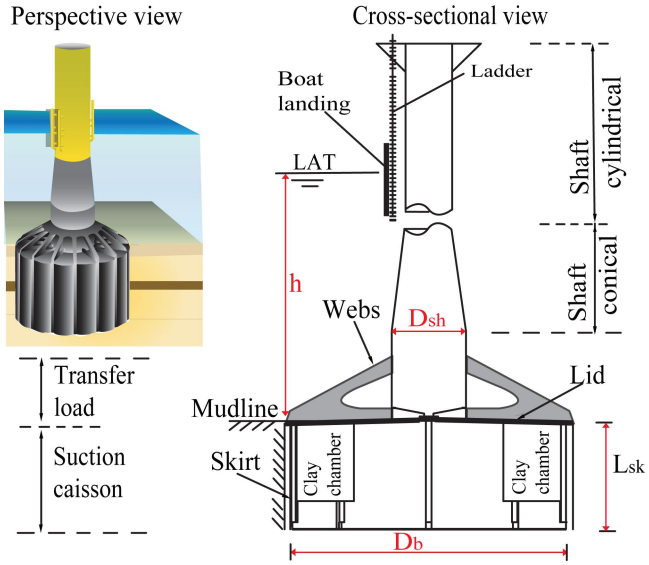

Fig. 1 Perspective and vertical cross-sectional view of Mono Bucket foundation