

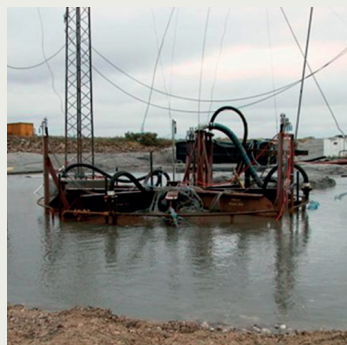
Installation: Frederikshavn



The bucket foundation during construction



Bucket foundation being prepared for installation



The bucket foundation at full penetration



Successful completion of the project

The Project

In November 2002, a prototype of the Universal Foundation's suction bucket was installed to support a Vestas V90 3MW turbine in Frederikshavn, Denmark. This project was delivered by MBD Offshore Power (today, Universal Foundation) and ELSAM (today, DONG Energy) in cooperation with the Aalborg University in August 2002.

Design Brief

The suction bucket was designed to be the foundation structure for a Vestas V90 3MW wind turbine which was to be sited in 4m of water in close proximity to the harbour at Frederikshavn, Denmark. At the time of installation, the Vestas V90 was one of the largest wind turbines in existence and was itself only a prototype design. The foundation had to support the 80m, 264 tonne turbine and withstand the dynamic forces created by the 3 MW generator and blade set when operating at full power (approximately 16.1 rpm).

Technical Specification

The top part of the foundation is supported by a tubular centre column that is connected to a steel bucket by flange-reinforced stiffeners. Overall stabilisation results from the soil pressures at the skirt and the vertical bearing capacity of the bucket. The bucket has a diameter of 12m, a height of 6m and a total weight of 135 tonnes. Total internal displacement is 679 cubic metres.

Monitoring and Analysis

An extensive test and monitoring campaign was established around the foundation and turbine in the Frederikshavn project. Before installation, a soil analysis was undertaken and an intelligent computerised control system

developed to ensure efficient and optimum penetration. In so doing, any tilting that occurred during the penetration operation could be corrected quickly ensuring that the transition piece would be level and ready to receive the wind turbine without additional remedial measures. The suction bucket method was first trialled at a specialist testing facility and then using bucket foundation models on site. These models allowed the soil strength to be investigated to assess whether the foundation structure would buckle or misshape during installation. Since installation numerous tests have been continuously performed including ambient and free vibration testing which are monitored using the Digitexx Data Streamer PDAQ Premium at Aalborg University.

Quotes

Universal Foundation's Technical Director, Søren A. Nielsen said: "The Frederikshavn project was a major kick-off project that was crucial to the commercialisation of the technology. Today, the foundation and Vestas V90 turbine continue to be amongst the most monitored and tested components in the wind industry. Comprehensive data logs of the foundation / turbine interaction have been collected, analysed and used as references in numerous academic publications. The resulting DNV certified design procedure continues to form the backbone of our engineering approval processes and will ensure that the design is taken from a concept through to full commercial deployment in the future."