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Grouted Connections for Offshore Wind Turbines

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ABSTRACT

For offshore wind turbines (OWTs) the design of connections of parts of the support structure is an essential and limiting topic. Within this paper some specific issues of grouted connections between tubular structural members are described with a focus on the peculiarities of offshore wind turbines in contrast to "conventional" offshore support structures and monopile foundations especially. Intermediate results of the ongoing research project "GROW- Grouted Structures for Offshore Wind turbines" are presented.

KEY WORDS: Grout; Connection; Wind Energy; Offshore; Wind Turbine; Support Structure; Monopile; Joints

INTRODUCTION

Within the last few years, a number of offshore wind farms have been put into operation in European countries like Denmark, the UK and the Netherlands. They all have in common that they are situated in shallow water, i.e. less than 25m and relatively close to the shore. For many of these projects the foundations are designed as driven monopiles. Peculiarities in context with wind turbines are the predominant bending loading in combination with high cycle fatigue loading induced by the rotor and waves. The diameter of these piles usually lies in a range of 4 to 5 m. The connection between the foundation piles and the tower of the wind turbine is executed with an overlap connection of these two tubular members filled with high performance grout. For the combination of these factors no comparable experience could be derived from constructions of the offshore oil & gas industry. Further applications of grouted connections for OWT support structures for deeper water are pile sleeve connections of jacket or tripod structures where the grout is used to connect piles and support structure.

Germanischer Lloyd (GL) is taking part in a joint research project named GROW together with the industry partners *SIAG AG* and *Oevermann GmbH* and lead by the *Institute for Steel Construction, Leibniz Universität Hannover* (Germany). The aim is to investigate the applicability of existing standards and guidelines such as the GL Guideline (2005) and to improve the existing design approaches and calculation tools. Within this project, some large-scale models will be tested at the University's laboratories against in the fatigue and ultimate limit state. Previous work was done at the Universities of Aalborg (Denmark) and Hannover (Schaumann et al, 2007). The project "GROW" is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and will end up in September 2009.

STATE OF THE ART IN CONSTRUCTION

The support structure of an OWT – in contrast to oil & gas platforms – is not a completely individually designed construction, but a small series product within a wind farm. Typical projects that have been built in recent years or which are currently being planned consist of 50 to 100 units. In the future, larger projects are expected to be executed.
For this reason, the structural design is tended to be simplified in order to reduce construction time and especially installation time offshore – onshore preinstallation of as many components as possible is a prequisite.

Up to now, most offshore wind farms have been set up in quite shallow waters up to 25 m. Two basic foundation concepts have been applied in almost all the projects – driven steel monopiles and prefabricated slab foundations made of reinforced concrete. Here, monopiles have been considered to be suitable for greater water depths so far compared to the concrete foundations. Both concepts are combined in general with a tubular steel tower with the nacelle of the turbine mounted on top.

Typical monopiles have a diameter of 4 to 5 meters which is limited by the size of currently available driving equipment. The piles are prefabricated onshore. The length of the pile could be calculated from the height of the access platform over sea level plus water depth and required embed length in the soil. 50 m is a typical size for the length of a monopile foundation. Therefore road transport would be a costly option and a prefabrication yard with harbour access should be the preferred solution in order to reduce costs.

The grouted connection is linking the piles after their installation with the upper parts of the support structure. A second tube with a slightly different diameter is placed on top of the pile and the annulus between the two tubes is filled with grout. The upper tube is the main part of the