Usability Proof of Ordinary Portland Cement as a Grout Material for Offshore Wind Turbines

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ABSTRACT

The development of offshore wind turbines is constantly adjusted, in particular relating to economic aspects. Consequently, the substitution of a high-performance mortar grout typically used with an ordinary Portland cement grout could have significant economic benefits. Laboratory investigations were carried out using three different types of cements within the scope of this research. In addition, a high-performance grout material was used for the purpose of comparison. The laboratory test facility specially developed at the Institute of Building Materials Science (Hanover) was used to conduct the filling and execution tests. The investigations have shown considerable differences between the cement paste grouts applied and the high-performance mortar grout.

KEY WORDS: Offshore wind turbine; grouted joint; ordinary Portland cement grout; high-performance grout; usability proof.

INTRODUCTION

The development of offshore wind turbines is becoming more efficient and cost effective. To this end, the application of an ordinary Portland cement grout (OPC-grout) could be an economic advantage. Indeed, OPC-grouts are already used worldwide and extend not only in the oil and gas industry. However, the application of OPC-grout for offshore wind turbines in Germany is not usual and is only accepted in individual cases with respect to the certification body.

The objective of this research is to check the potential usability of OPC-grout in grouted joints for offshore wind turbines. Grouted connections are used to connect the foundation piles to the upper part of the substructure of offshore wind turbines (see Fig. 1). These connections are used to transfer loads from the wind turbine tower to the foundation pile. Grouted joints are tube-in-tube connections with tubes of different diameters. The annular gap between these two steel members is filled with a specialized high-performance concrete, mortar, or OPC, the so-called grout. Installation tolerances and imperfections can be compensated easily in this way. High-strength mortar grouts are generally used for grouted joints of offshore wind turbines in Germany (Anders and Erhardt, 2010; Schmidt et al., 2013). The loads from the tower are transferred by compression struts from the sleeve to the pile (Lamport, 1988; Lohaus et al., 2012; Fehling et al., 2013). The compressive strength of the grout has an important effect on the load-bearing capacity of the connection (Hordyk, 1996; Werner, 2013; Lohaus and Cotardo, 2014). The in situ assembly of grouted joints is challenging due to the harsh offshore conditions (Welham and Gilfrin, 1993; Lohaus and Werner, 2014). It is nearly impossible to check the material properties of grout inside a grouted joint after the filling process.

High demands are placed on the building materials of grouted joints with regard to the strength of the concrete in the early age, the processing of concrete, the flowing property, and the segregation stability (Anders, 2007; Anders and Erhardt, 2010).

A further basic requirement is a low risk of cracking (Billington and Tebbett, 1980; Billington and Woodward, 1980). There are additional requirements regarding the early age strength of the grout as a result of the time slot and the low temperatures in the depths of the sea. The maritime environmental conditions also place high demands on the building materials with regard to the durability properties. Offshore platforms, for example, are exposed to an aggressive and constantly high level of a mixture of salt water and air, especially in the so-called splash zone (Anders and Erhardt, 2010; Heins and Binder 2011). Requirements for the grout used, construction, structural design, and manufacturing process for offshore wind turbines can be found in standard regulations, for example, Det Norske Veritas, Germanischer Lloyd and the American Petroleum Institute (DNV, 2014; GL, 2012; API, 2014). In contrast to high-performance grout materials, the application of OPC-grout could lead to several problems.