Investigation of Degradation Processes in Large-scale Experimental Tests by Structural Health Monitoring Techniques and Numerical Simulations

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Summary
Physical experiments on large-scale models are an appropriate and in many cases indispensable approach for gaining a profound understanding of the physically nonlinear behavior of foundations applied in offshore wind farms. In this contribution, the test facility and an experimental test set-up aiming at optimizing the reliability of structural health monitoring techniques are presented. The testing procedure and the model set-up have been developed by means of flexible computer aided design and numerical simulation approach developed within the joint project GIGAWIND *life* (BMWi, FKZ 0325575C). This contribution emphasizes the strategy and the numerical framework to ensure reasonable model set-ups. This shall fulfil demands in designing experimental tests and validating future numerical material models giving a broader insight into foundations' behavior offshore.

1. Introduction

Structural health monitoring (SHM) techniques for the observation and the assessment of the integrity of offshore support structures have to overcome several kinds of challenging issues. They have to identify changes in the structural behavior and assign them to potential damage under varying operational and environmental conditions. Large-scale experiments offer a good way to model a typical SHM system including sensors, data acquisition and algorithmic evaluation. In order to achieve a meaningful design the whole experiment should be analyzed numerically in advance.
Within the joint project QS-M Grout (BMWi, FKZ 03SX372) a large-scale test on a grouted joint, connecting the tubular steel members of a monopile and a steel tower, has been conducted. In this contribution, the strategy of the design and the test set-up are presented. A computer aided design model and a parameterized model for numerical analyses were applied to define the test set-up in Fig. 1.

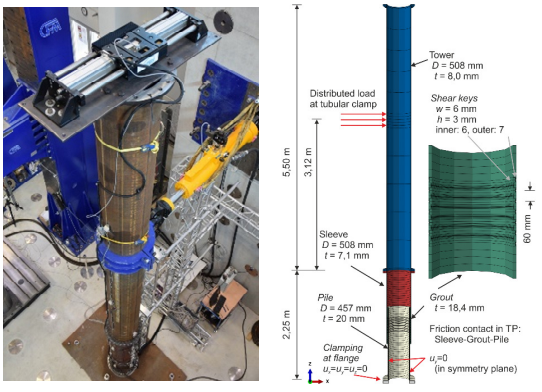

Figure 1: Experimental test set-up for damaging the grouted connection (left) and numerical model (right)

2. Evaluation of Results and Validation

In the design phase, numerical analyses of the dynamic behavior of the whole test set-up and the damaging behavior of the grout have been carried out. The predefined degradation of the grouted connection was observed during the test and accompanied by SHM measurements. In a parallel test approach, the behavior of the monopile foundation has been regarded within a foundation test pit assuring realistic offshore conditions in order to include the soil-structure interaction and to investigate the impact of varying environmental conditions. Here, fiber-optic strain gauges, see Fig. 2, and earth pressure transducers were applied in the soil.

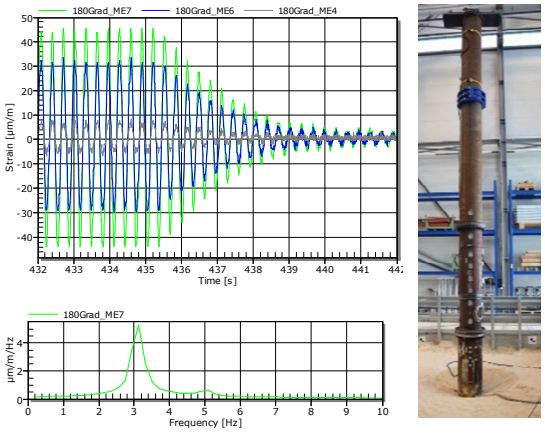

Figure 2: Fiber-optic strain measurements (left) at different depth of the monopile in the foundation test pit (right)

Measurements were compared to numerical estimations of deflections, stresses and grout damage. Thereby, a good insight into the damage behavior of the grouted connection could be achieved.