Damage detection in offshore wind turbine grouted connection by nonlinear harmonic identification

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Summary
To detect damages into the grouted joint of offshore wind turbines (OWTs), a Structural Health Monitoring (SHM) system based on fiber optic sensors and on a nonlinear damage detection methodology is proposed. The SHM system has been tested during fatigue tests on large scale grouted connection specimens. This work shows the possibility to obtain with such method relevant information concerning the structural health of grouted connections.

1. Introduction

The grouted connection of OWTs, which consists in the high performance grout-filled space between the two structural steel components of respectively the sleeve and the pile, is a critical structural part. In 2009-2010 engineers reported grouted connection failures causing slight and progressive settlement of turbines. The problem affected about 600 of the 988 monopile wind turbines in the North Sea, requiring further investigations concerning the design of the grouted connection [1]. Finding a monitoring solution for the grouted joint area is therefore of particular interest. Some monopile OWTs - such as some from the German offshore wind farm “Baltic I” [2] and Meerwind [4], as well as the Belgian wind farms “Belwind” and “Northwind” [5]- have been recently equipped with different instruments for monitoring the foundations and the grouted connection area.
In this paper, a SHM system based on fiber optic sensors and combined with a nonlinear damage detection methodology is proposed.

2. SHM and damage detection methodology

A fatigue test has been conducted on a large scale offshore wind turbine grouted connection specimen at the Institute for Steel Construction (LUH - Leibniz University of Hannover) within the project “GROWup”. For the monitoring of the grouted joint, fiber optic sensors (type Fiber Bragg Grating) have been installed on the external steel surface of the testing specimen. The sensors have been positioned in the shear key area, where failures are expected to occur.
The dynamic behavior of damaged grouted connection being nonlinear, with notably the presence of breathing (opening and closing) cracks, it becomes interesting to use nonlinear approach to detect damages [3]. This work shows the possibility to obtain - via nonlinear harmonic identification and the selection of a suitable damage indicator - relevant information concerning the health of grouted connections. It gives the results obtained - in terms of early detection, identification of severity, and localization of the damage.

3. References

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