SPATIO-TEMPORAL ANALYSIS OF SCOUR AROUND JACKET TYPE OFFSHORE FOUNDATIONS UNDER CLEAR WATER AND LIVE BED CONDITIONS

Ramish Satari, Leibniz University Hannover, satari@hydromech.uni-hannover.de
Mario Welzel, Leibniz University Hannover, welzel@lufi.uni-hannover.de
Alexander Schendel, Leibniz University Hannover, schendel@lufi.uni-hannover.de
Insa Neuweiler, Leibniz University Hannover, neuweiler@hydromech.uni-hannover.de
Torsten Schlurmann, Leibniz University Hannover, schlurmann@lufi.uni-hannover.de

INTRODUCTION AND MOTIVATION

As an important contribution to the fulfilment of renewable energy targets, the offshore wind sector in Europe has grown significantly over the past decade (WindEurope 2021). Jacket structures are becoming more widely used as substructures for offshore wind turbines to accommodate the expansion towards greater water depth and to provide a stable basis for megastructures with hub heights > 200 m. However, there have been few studies (Chen et al., 2014; Baelus et al., 2018; Welzel et al., 2019; Welzel et al., 2020) that systematically address scour development at jacket structures. In addition, while the local equilibrium scour depth around pile foundations has been studied extensively in the past (e.g. Melville and Coleman, 2000; Sumer and Fredsøe, 2001; Schendel et al., 2020), there have been few studies on the development of spatial scour patterns, particularly around more complex offshore structures such as jackets.
In this context, this study aims to improve the understanding of scour development around jacket type offshore wind foundations. The main objectives are:

a) High resolution acquisition of the spatio-temporal evolution of the scour processes around a jacket structure under current only conditions.
b) Analysis of the scouring process around a jacket structure in clear-water and live bed conditions.
c) Evaluation of spatio-temporal scour pattern as a balance of eroded and accumulated volumes.

EXPERIMENTAL SETUP

Physical model tests in a scale of 1:30 were performed in the 3D wave-current basin of the Ludwig-Franzius-Institute, Leibniz university Hannover, Germany. The physical model of a generic jacket structure foundation type was printed in 3D and installed in the middle of the wave basin inside a sediment pit. A photograph of the experimental setup is shown in Figure 1. The spatial scour and erosion pattern were measured by using a high-resolution 3D laser scanner. Tests under current only conditions with a depth averaged velocity of 24.3 cm/s in clear water conditions as well as under live bed conditions with a depth averaged velocity of 41,7 cm/s have been conducted. In each test, the spatial scour pattern was measured after 15 min, 90 min and 420 min loading time. For the scour measurements, the wave basin had to be carefully drained to avoid any influences on the scour pattern. Subsequently, the bed topography measured with the 3D laser scanner. While time-consuming, this measurement procedure allowed a detailed look into the temporal evolution of spatial scour patterns. The test conditions are summarized in Table 1.

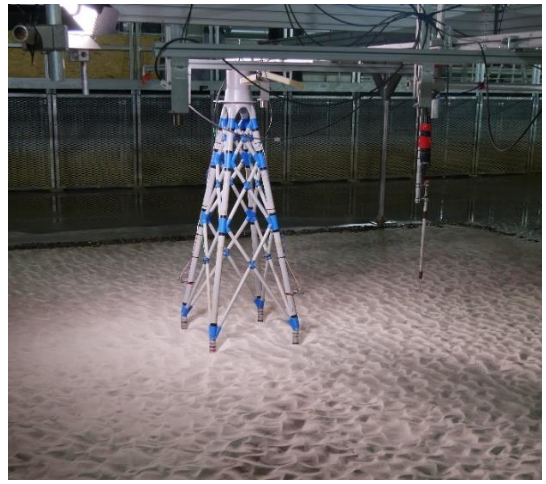

Figure 1. Photo of the experimental setup and the used Jacket structure.

Table 1 - Test conditions.

	Current velocity 10 cm above bed U_C [cm/s]	Shields Parameter θ [-]	Test duration [min]
T01	22.5	0.033	15
T02	22.5	0.033	90
T03	22.5	0.033	420
T04	38.8	0.084	15
T05	38.8	0.084	90
T06	38.8	0.084	420

RESULTS

To illustrate the differences in the spatial scour process between clear-water and live-bed conditions, Figures 2 shows the scour pattern around the jacket structure following Test T02 (clear-water) and Test T05 (live-bed). Overall, both flow conditions show local deep scour at the four main piles. For clear-water conditions, however, little influence of other structural elements (e.g., diagonal braces) is apparent in the scour pattern. The lee-wake vortices at the main piles locally provided a concise downstream scour development. Below the structure, or between the main piles, the topography was almost undisturbed.
In contrast, live-bed conditions led to distinct erosion and deposition patterns even below the jacket structure. The jacket structure also had an overall blockage effect that led to sediment redistribution globally around the structure. As such, significant erosion could be seen

laterally next to the structure, while sediment has accumulated downstream. In the further course of the experiments (Test T03), the local scour processes overlapped in clear-water conditions, which also resulted in a spatial scour pattern. In live-bed conditions, however, it is not the superposition of several local scour processes but the influence of the overall structure that leads to a spatially global scour pattern.

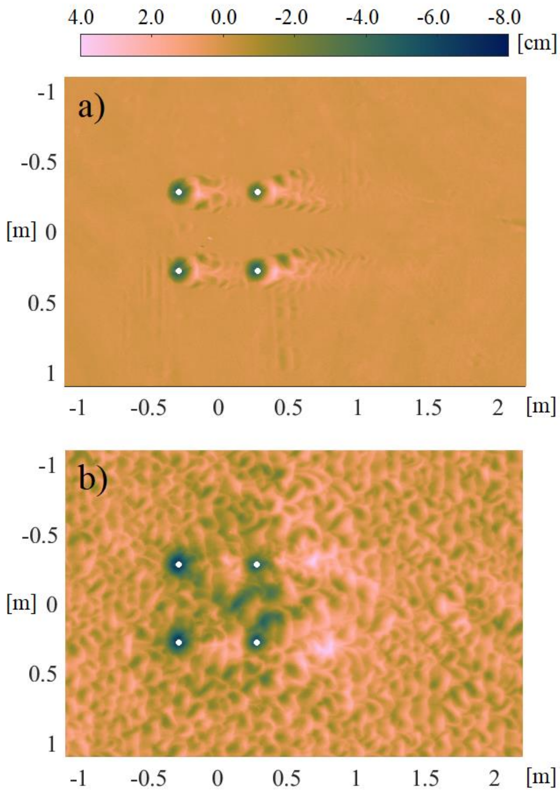

Figure 2. Scour pattern (a) after test T02 with clear water conditions and (b) after test T05 with live-bed conditions. Pink colors represent deposition, whereas blue colors represent scour.

Eroded and displaced sediment volumes are analyzed by using normalized volume numbers. The cumulative volume depth $D_{A,i}=(V_i/a_i)/D$ sets a volume V_i in relation to an area a_i and is further normalized by the diameter of the jacket's main piles (see Welzel, 2021). As expected, erosion volumes around the jacket were significantly larger in live-bed than in clear-water conditions. In both conditions, a peak of maximum erosion intensity emerged at distance of 1.2-1.25A, with A being the distance from the structure normalized with the jacket structure's footprint. This peak in erosion represents the local scour at the main piles. Over time, the difference in erosion volumes between the peak at 1.2A and the center of the jacket structure at 0.5A declines relatively, indicating an increasing importance of global erosion processes.

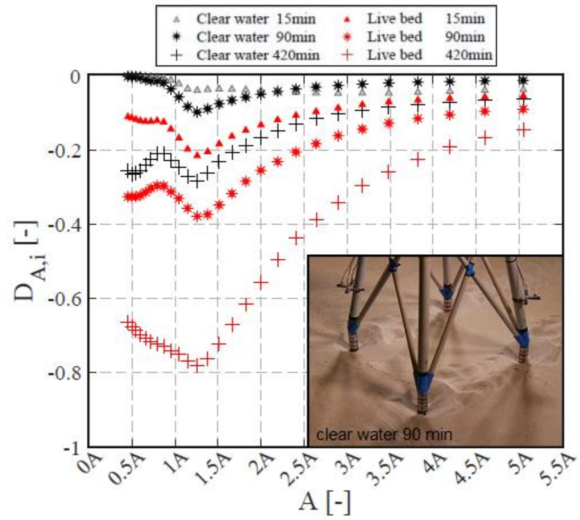

Figure 3. Spatio-temporal analysis of volume differences of eroded sediment for 15 min, 90 min and 420 minutes, investigated under 24.3 and 41.7 cm/s.

CONCLUSIONS

The study highlights the importance of distinguishing between global and local erosion processes when considering the spatio-temporal scour development at a complex jacket structure.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Deutsche Forschungsgemeinschaft (DFG – German Research Foundation) within the funded project SFB1463 – 434502799.

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