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STABILITY OF ESTUARINE GROYNE DURING OVERFLOWING LONG-PERIOD PRIMARY SHIP-INDUCED WAVES BASED ON LABORATORY EXPERIMENTS

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ABSTRACT

For the last two decades, significant damage to groyne structures has been observed in the German Elbe estuary. The main reason is the generation of primary ship-induced wave loading. The stern wave of the primary wave system appears as an overflowing over groyne, leading to damage at the crest and lee side of the structure due to the presence of high overflowing flow velocities (Melling et al., 2020). Therefore, overflowing flow velocities and damage were quantified by means of two different experimental setups; the flow experiments and the damage experiment.

The flow experiment involved testing scaled physical models under continuous free-flow conditions. A Particle Image Velocimetry (PIV) setup was used to capture flow velocities at the crest and lee side slope. A dimensionless flow velocity equation is obtained for overflowing flow over groyne structures. The damage experiment assessed the impact of overflowing waves at the crest and lee side on one of the scaled physical models. Measurements were conducted via Structure from Motion principles (SfM) and the damage is expressed in damage parameters S for varying wave heights and freeboard levels. This parameter describes the damage by width-averaged eroded area made dimensionless by the squared nominal stone diameter. Furthermore, the assessment considered the determination of the damage limits (initiation, intermediate, and failure) of a groyne structure for these waves.

The results revealed the relation between the wave height and the freeboard and damage. Furthermore, by regarding the flow velocity explicitly a more fundamental understanding, and more generally applicable design approach might be obtained. The insights gained from this research contribute to an enhanced understanding of groyne behaviour under overflowing long-period ship-induced waves. By highlighting the significance of the flow velocities for waves and freeboard levels, this study provides valuable information for optimizing the design and maintenance of estuarine groynes that are prone to these types of wave-induced loads.

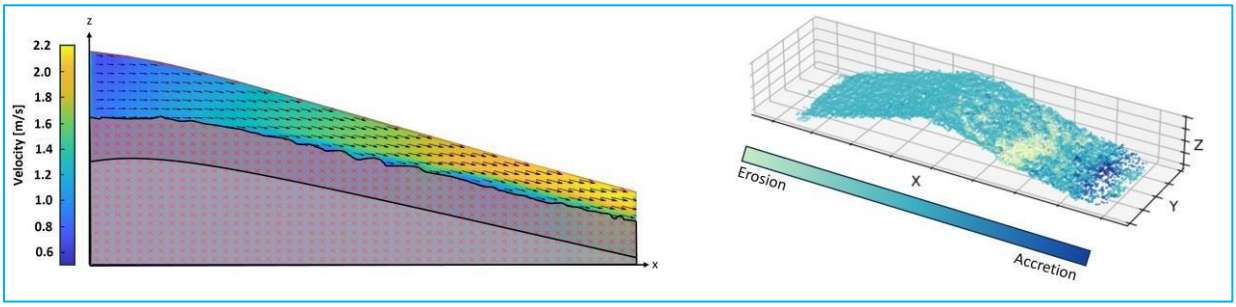

Figure 1. Left: Flow velocity field at crest and lee side of the physical model groyne via PIV measurements during the flow experiment. Right: Eroded positions at physical model groyne measured via SfM during the damage experiment.

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