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PERFORMANCE ANALYSIS OF AN INNOVATIVE FIELD MEASUREMENT SETUP FOR WAVE OVERTOPPING AT A DIKE ON A SHALLOW FORESHORE

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1 INTRODUCTION

Low-lying countries typically have mildly-sloping beaches as part of their coastal defense system. Many countries in north-western Europe have coastal urban areas that rely on this type of defense system, which consists of a low-crested impermeable sea dike with a relatively short promenade, and a long (nourished) beach in front that acts as a very/extremely shallow foreshore as defined by Hofland et al. (2017). Along the cross-section of this hybrid beach-dike coastal defense system, storm waves are forced to undergo many transformation processes before they finally overtop the dike. These hydrodynamic processes include shoaling, sea-swell (SS) wave energy transfer to sub- (also infragravity or IG waves) and superharmonics via nonlinear wave-wave interactions, wave dissipation by breaking and bottom friction, reflection against the dike, wave run-up and overtopping on the dike, bore impact on a wall or building, and finally reflection back towards the sea interacting with incoming bores on the promenade. Due to breaking of the SS waves and growth of the IG waves on the shallow foreshore, the IG waves can become as important or even dominant at the toe of the dike (Hofland et al., 2017; Lashley et al., 2020), which influences the overtopping process (van Gent, 1999).

Field measurements of all these processes at the same time are very challenging but necessary since field observations do not suffer from scale nor model effects. Field data are therefore crucial to evaluate design methodologies, which rely on physical and numerical modelling. This paper presents the field setup and the design features of the innovative research dike, unique in the world, including a performance analysis.

2 FIELD MEASUREMENT SETUP

The field measurement site “Living Lab Raversijde” is located in Ostend, Belgium (Figure 1), where wind, waves, water levels, bathymetry and beach profiles are measured over 10 years (2021-2030). It consists of (1) offshore measurements using two collocated directional wave buoys and ADCP’s with a shallow sand bank in between to investigate the generation of IG waves; (2) three intertidal poles with collocated current and pressure sensors, and sediment suspension meters to measure the wave transformations and beach profile changes; (3) the research dike to measure the wave overtopping and impact on storm walls on the dike, and the wind. Topography and bathymetry surveys are also done on a yearly (offshore) and monthly (foreshore) basis.

Measuring wave overtopping at existing dikes has been reported before (Wenneker, 2016; van der Meer, 2019). However, in Belgium none of the existing dikes are in contact with the sea because of beach nourishments, requiring a different approach. The concept of the Research Dike Raversijde (RDR) (Figure 2) is to bring the dike and instrumentation closer to the sea (lower, at about the high tide level on the beach), and was designed so that every storm season on average 5 events can be measured. The RDR was constructed in 2021, and consists of 4 typical dike cross-sections, where the overtopping is measured at the dike crest and at the end of a promenade (both without and with a storm wall present where the impact forces are measured). At the conference, the design of the RDR will be presented in more detail, with a performance evaluation of the RDR based on the first measured storms during winters ’22-’23 and ‘23-‘24.

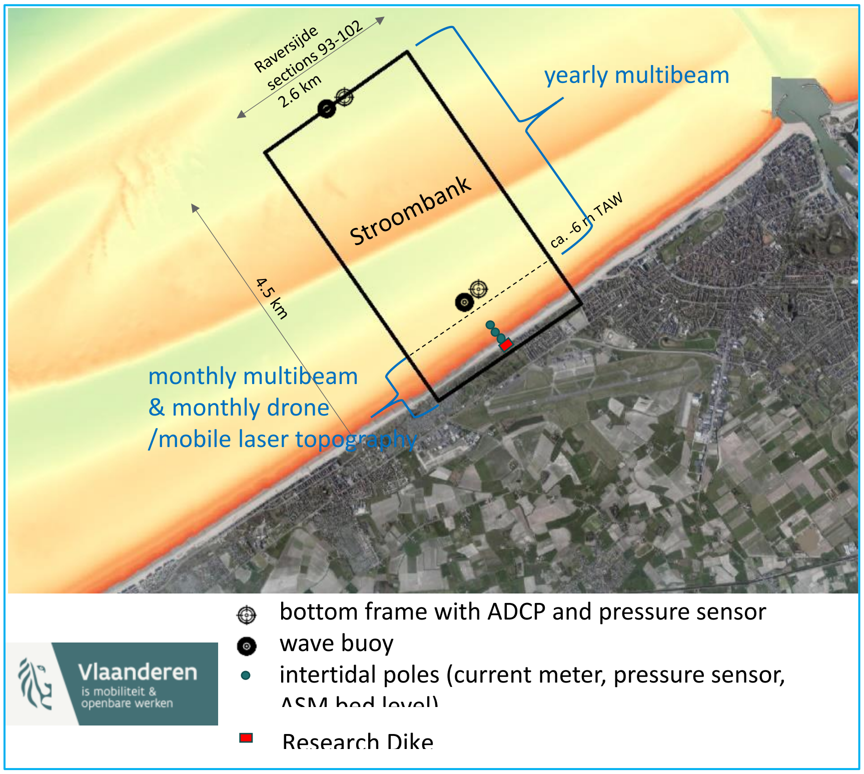

Figure 1. Offshore field setup of “Living Lab Raversijde”.

Figure 2. The research dike and intertidal poles at low tide (top left and bottom) and high tide (top right).

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