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INVESTIGATION OF COASTALOCK™ PERFORMANCE ON A BREAKWATER SLOPE WITH POROUS CORE

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1 INTRODUCTION

Hard stabilization methods have traditionally been employed to mitigate coastal erosion. Concrete armour is widely used due to its high level of dependence, robustness, ease of production and cost effectiveness (Cooke et al., 2020; Pikey and Cooper, 2012). It is inevitable that coastline ‘armouring’ will continue to rise because of the growing human population and urbanization, desire for and value of coastal property, opposed to predicted climate change (Chapman and Underwood, 2011). The environmental impact of such 'armouring' on coastal systems can be detrimental, resulting in a degradation or destruction of habitats and the loss of ecologically trivial species (Gittman et al., 2015).

The Coastalock™, a single-layer armour unit, aims to blend coastal protection with marine habitat creation. This armour unit is designed to mimic inter- and sub-tidal habitats, with chemical composition of substrate and micro and macro features that provide niches for various species. The key feature of Coastalock™ is the cavity that is integrated into the design, that caters to diverse marine life needs depending on its orientation (ECOncrete Tech Ltd., 2019). Coastalock™'s hydraulic performance is under research. Preliminary tests conducted in the Hydraulic Engineering Laboratory (HEL) of the Technical University of Delft (TUD) on a 2V:3H impermeable slope in deep water conditions highlighted that with tight placement of the units significant pressure gradients across the top layer led to damage. The introduction of spacings between units for enhanced permeability improved stability significantly (Gutiérrez et al., 2023). A redesign of the unit was proposed incorporating protrusions to enforce the spacings between the blocks (Molenkamp, 2022).

This research focuses on evaluating the influence of a porous core on the hydraulic performance of a Coastalock™ armour layer, specifically assessing its stability, overtopping, and reflection on a 2V:3H breakwater slope in deep water conditions—from the toe to just below the crest. A pivotal aspect of this research is the investigation of the impact of protrusions on the hydraulic performance. Furthermore, the study explores the influence of different toe configurations, aiming to comprehend the vulnerability of the armour layer to sliding. Toe scour falls outside the scope of this study.

2 METHOD

For this project, a physical model testing program was set up and executed in the 2D wave flume of the HEL of TUD. Ultimately, all the data is processed and a final report is made.

3 MODEL TEST SET-UP AND TEST PROGRAM

First, the model units were arranged with armour layer spacings of 0%, 10%, and 20%, reducing the percentage of the number of blocks across the slope width. Positioned on a 2V:3H slope and supported by a fixed beam, these units were placed on an underlayer chosen to align with preliminary research (Gutiérrez et al., 2023). Without existing prototype, the model core size was set at a $D_{n50} = 3.89$ mm, about half the size of the underlayer. This size was expected to lead to negligible viscous scale effect related to core permeability. Subsequently, model protrusions were fixed to the sides of the units, leading to armour layer spacings of 10% and 22.5%, and tested. Additionally, for both types of protrusions, the fixed toe was replaced with an alternative foreshore (see Fig. 2 Left) designed to accommodate a loose rock toe berm. This berm was positioned on a fixed underlayer composed of either filter material or adhered shell sand.

Each test series employed 1000 irregular waves derived from the JONSWAP spectrum, with the steepness varying between 2% and 4%. Testing began with 500 shake-down waves. Wave heights were progressively increased, starting at $\frac{H_s}{\Delta D_{n,Coastalock}} = 1.79$, until the capacity of the wavemaker was reached at $\frac{H_s}{\Delta D_{n,Coastalock}} = 4.49$, or when failure was observed. The water level was kept constant.

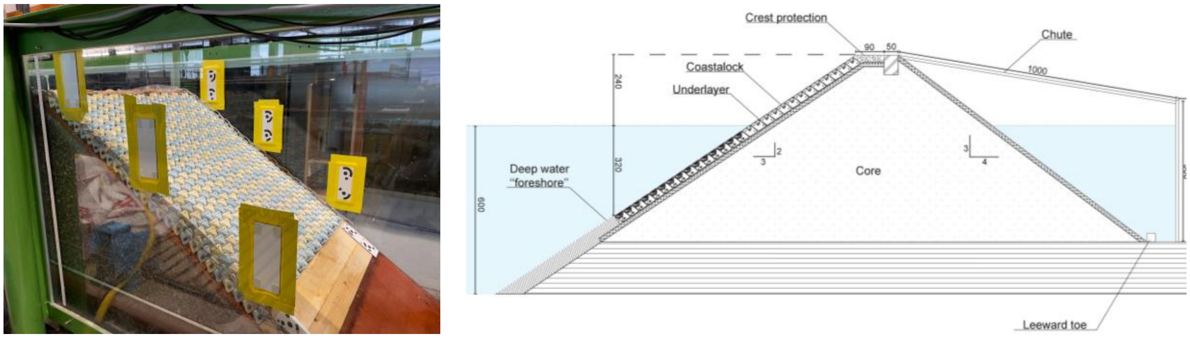

Figure 1. Left: Deep water set-up with fixed toe beam. Right: Cross-section of the deep water set-up

The study investigated wave characteristics and reflection using two sets of three wave gauges placed at the wave generator and upstream of the structure. Overtopping discharge was captured with a chute, and a dedicated wave gauge measured average overtopping volumes. Video-based inspection utilized two GoPro's—one for fixed-angle photos and the other for side-view videos. Detailed elevations of the slope were measured for tests series with protrusions under 4% steep waves, using a structure-from-motion technique. Over 60 photos were acquired per designated test run and processed with Agisoft Metashape photogrammetry software, resulting in detailed 3D models for grid-based assessment of armour unit elevation change with sub-millimeter accuracy.

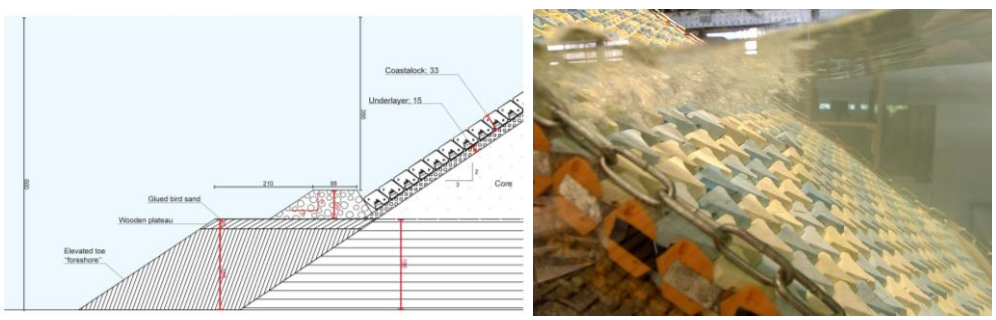

Figure 2. Left: Cross-section of loose rock toe berm. Right: Pressure induced uplift of the armour layer during wave attack

4 RESULTS

All test runs have been successfully completed, with data processing underway. The results and conclusions on the performance will be presented during the final presentation.

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