

Investigation Of Coastalock Performance On A Breakwater With Porous Core

Lawniczak, A.D.; Hofland, Bas; Gutiérrez, J.; van den Bos, J.; van Gent, M.R.A.

DOI

[10.59490/coastlab.2024.806](https://doi.org/10.59490/coastlab.2024.806)

Publication date

2024

Document Version

Final published version

Citation (APA)

Lawniczak, A. D., Hofland, B., Gutiérrez, J., van den Bos, J., & van Gent, M. R. A. (2024). *Investigation Of Coastalock Performance On A Breakwater With Porous Core*. Abstract from 9th Conference on Physical Modelling in Coastal Engineering and Science, CoastLab 2024, Delft, Netherlands.
<https://doi.org/10.59490/coastlab.2024.806>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

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

LAWNICZAK, A.D.¹, HOFLAND, B.², GUTIÉRREZ, J.³, VAN DEN BOS, J.⁴, VAN GENT, M.R.A.⁵

1 TU Delft, the Netherlands, A.D.Lawniczak@student.tudelft.nl

2 TU Delft, the Netherlands, B.Hofland@tudelft.nl

3 EONcrete, Spain, jorge@econcretetech.com

4 TU Delft, the Netherlands, J.P.VandenBos@tudelft.nl

5 TU Delft, the Netherlands, M.R.A.VanGent@tudelft.nl

KEYWORDS: Breakwaters, Ecological Enhancement, Nature Inclusive Design, Armour Unit, Physical Modelling

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 (EONcrete 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 $\frac{H_s}{\Delta D_{n,Coastallock}} = 1.79$, until the capacity of the wavemaker was reached at $\frac{H_s}{\Delta D_{n,Coastallock}} = 4.49$, or when failure was observed. The water level was kept constant.

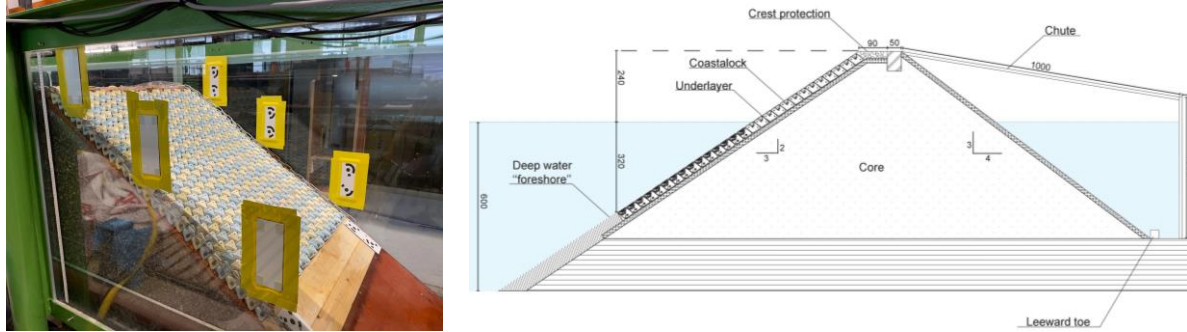


Figure 1. Left: Deep water set-up with fixed toe beam. Right: Cross-section of the deep water set-up

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.

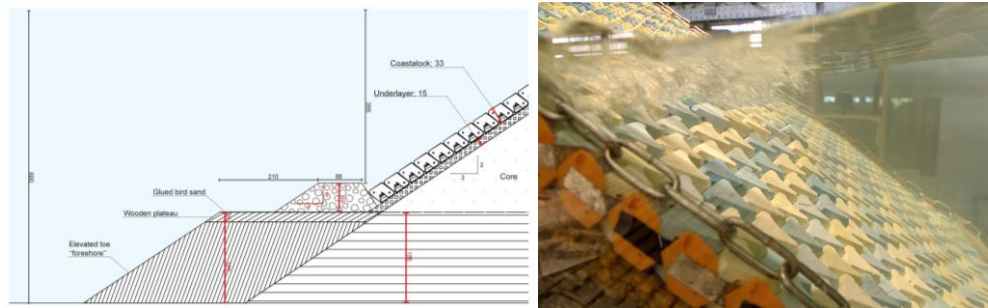


Figure 2. Left: Cross-section of loose rock toe berm. Right: Pressure induced uplift of the armour layer during wave attack

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.

REFERENCES

- Chapman, M., & Underwood, A. (2011). Evaluation of ecological engineering of “armoured” shorelines to improve their value as habitat. *Journal of Experimental Marine Biology and Ecology*, 400(1), 302–313.
- Cooke, S., Bergman, J., Nyboer, E., Reid, A., Gallagher, A., Hammerschlag, N., Van de Riet, K., & Vermaire, J. (2020). Overcoming the concrete conquest of aquatic ecosystems, *Biological Conservation*, 247.
- ECONcrete Tech Ltd. (2019). Coastallock: Technical product information.
- Gittman, R., Fodrie, F. J., Popowich, A., Keller, D., Bruno, J., Currin, C., Peterson, C., & Piehler, M. (2015). Engineering away our natural defences: An analysis of shoreline hardening in the us. *Frontiers in Ecology and the Environment*, 13(6), 301–307.
- Gutiérrez, J., Bezner, M., Molenkamp, A., Bos, J. v.d., Hofland, B., Leblanc, P., Rella, A., Rosenberg, Y., & Sella, I. (2023). PHYSICAL EVALUATION OF THE HYDRODYNAMIC STABILITY OF AN ECO-ENGINEERED ARMOURING UNIT. *Coastal Engineering Proceedings*, (37), papers.35. URL: <https://doi.org/10.9753/icce.v37.papers.35>
- Molenkamp, A. (2022). Hydraulic performance of Coastallock armour units, Master Thesis, Delft University of Technology. URL: <http://resolver.tudelft.nl/uuid:f45f0aaa-200d-4db9-9738-230ec8c46728>.

Pilkey, O., & Cooper, J. (2012). "Alternative" shoreline erosion control devices: A review, *Coastal Research Library*, 3, 187–214.