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Improving Surfability Assessment along a Submerged Detached Breakwater at Praia da Vagueira, Portugal

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ABSTRACT

A case study aiming to improve surfing conditions over a submerged detached breakwater, intended to be placed in front of Praia da Vagueira (Aveiro, Portugal), was concluded in April 2022. The final results are revisited and refined by incorporating an alternative wave breaking line detection method, using the resulting eddy viscosity parameter from the COULWAVE numerical model. Preliminary results demonstrate good agreement with experiments and indicate the potential for a more detailed analysis, but further investigation is required.

1. Introduction

The Portuguese Environment Agency, I.P., and the LNEC, UAveiro, and IST Consortium collaborated in carrying out the characterization and feasibility study of a multifunctional submerged detached breakwater (SDB) in front of Praia da Vagueira (Aveiro, Portugal), which concluded in April 2022. A physical and numerical modeling study was developed to assess the influence of the SDB on surfing conditions in the area for three cases: the current situation (without SDB); with the SDB parallel to the coastline (SDB 0º); and the SDB with a 45º angle relative to the coastline (SDB 45º).

Estimation of wave breaking-related parameters, such as the Iribarren number and peel angle, requires accurately capturing the wave breaking line. Regarding the numerical study by Sancho et al., 2022, the employed wave breaking line detection method enabled capturing only a breaking region and not necessarily pinpointing a specific breaking line along the structure.

In this paper, we present an alternative method to more accurately capture the wave breaking line by taking advantage of the implemented ad-hoc wave breaking model in COULWAVE (Lynett et al., 2008).

2. Previous Physical & Numerical Results

The reduced physical model utilized by Sancho et al., 2022 consisted of a sandy mobile bed replicating the conditions of the prototype from the -12 m (HZ) bathymetric contour to the upper beach. On the numerical front, the COULWAVE model was applied at prototype scale, and the results from the reduced physical model were appropriately scaled for meaningful comparison.

In the context of assessing surfability, all tests were conducted for regular waves with wave direction of 296ºN, following the initial conditions specified in Table 1.

Table 1. Tested wave conditions at prototype scale.

H_0 (m)	T_0 (s)	Water Level (m (HZ))
1.5, 2 and 3	10 and 12	+2.17

Overall, the study indicated that the SDB 45º configuration was more favorable for enhancing surfing conditions.

3. Wave Breaking Line & Surfability Parameters: COULWAVE

The COULWAVE model enables the numerical solution of a depth-integrated model consisting of a set of weakly dispersive Boussinesq-type equations, incorporating physically consistent viscosity and vorticity terms as derived in Kim et al., 2009. These equations are coupled to a wave breaking mechanism identical to the one presented in Kennedy et al., 2000. The breaking scheme is based on an eddy viscosity approach, where the eddy viscosity ν is a component of an ad-hoc dissipative term and expressed as,

$$\nu = B h_t \eta \quad , \qquad (1)$$

where $h_t = h + \eta$ represents the total water depth, and B is a variable selected to ensure a smooth transition between breaking and non-breaking states.

Considering the SDB 45º configuration with H_0 = 2 m, T_0 = 12 s, and appropriate boundary conditions, the wave dynamics over the SDB were simulated for a computational domain of 2900 m in the longshore and 1670 m in the cross-shore directions, over 600 s total simulation time (Fig. 1). The available viscosity parameters were fixed to their default values, since an initial calibration attempt using physical model data showed no significant changes.

Using the output eddy viscosity quantity over space and time, the local maximum values were identified within a specified domain window for each time instant. These points were subsequently grouped into breaking lines by requiring them to be sufficiently close both in space and time. The results of this post-processing analysis are illustrated in Fig. 1. Comparison with physical model photographs shows good agreement with the detected breaking lines.

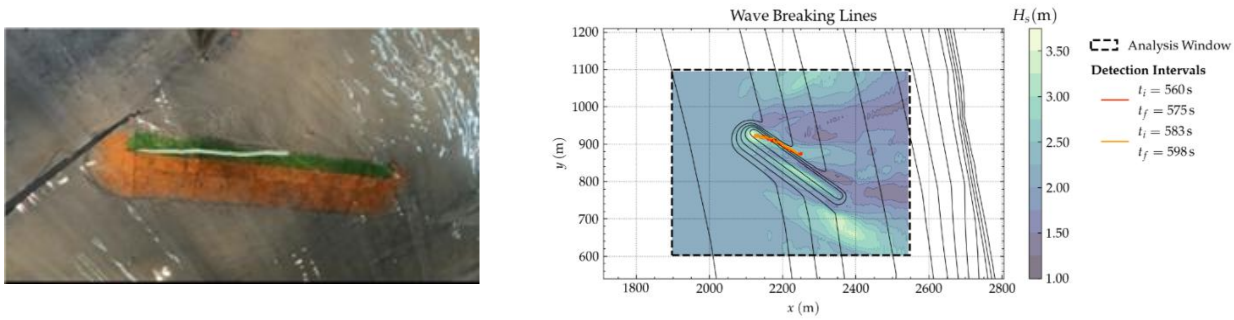

Fig. 1. Comparison between two examples of numerically detected wave breaking lines (right) and physical model photograph (left) for the SDB 45º configuration.

By interpolating the detected points, one can then determine the Iribarren number and peel angle over space, for each detected breaking line. For a more conclusive result, the results for each breaking line can be averaged, providing clearer results for the case study.

4. Conclusions

The present work showed an overall improvement in wave breaking line detection and holds the potential for a more consistent and detailed analysis of the surfability parameters along the SBD. However, it's important to note that, due to the nature of the numerical model in use, more detailed information on wave breaking along the structure, such as wave overturning patterns, cannot be directly simulated and can only be approached using fully 3D CFD models. Efforts to provide 3D analysis for the Praia da Vagueira case study are currently under consideration.

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References

Kennedy, A., Chen, Q., Kirby, J. and Dalrymple, R. (2000) 'Boussinesq Modeling of Wave Transformation, Breaking, and Runup. I: 1D', Journal of Waterway, Port, Coastal, and Ocean Engineering, 126(1).

Kim, D.-H., Lynett, P. J. and Socolofsky, S. A. (2009) 'A depth-integrated model for weakly dispersive, turbulent, and rotational fluid flows', Ocean Modelling, 27(3–4), pp. 198–214.

Lynett, P. J., Liu, P., Sitanggang, K. and Kim, D.-H. (2008) 'COULWAVE Code Manual: Cornell University Long and Intermediate Wave Modeling Package'. Available at: https://isec.nacse.org/models/coulwave_description.php.

Sancho, F., Freire, P., Neves, M., Oliveira, F., Mendonça, A., Fortes, C., Roebeling, P., Baptista, P., Brito, F. and Coelho, C. (2022) Characterization and feasibility study of a multifunctional detached breakwater in front of Vagueira Beach (Final Report). Lisbon.