Proceedings of the 9th International Conference on Physical Modelling in Coastal Engineering (Coastlab24)
Delft, Netherlands, May 13-16, 2024

Extended Abstract, DOI: 10.59490/coastlab.2024.759

SCOUR HOLE EVOLUTION NEAR A DETACHED LOW-CRESTED RUBBLE-MOUND BREAKWATER

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KEYWORDS: Scour, Low-Crested Structure, Rubble-Mound Breakwater

1 INTRODUCTION

Low-crested detached breakwaters are affected by coastal hydro- and morphodynamics, due to complex wave-structure-seabed interactions, which impact their stability, namely due to scour effects. The scour phenomenon has been under study in several mobile-bed physical model research studies (e.g., Fredsøe *et al.,* 1997, Sumer *et al.,* 2000 and Sumer *et al.,* 2005). However, scour phenomenon near detached rubble-mound breakwaters is still far from being well understood.

Therefore, the present research work comprises an innovative and comprehensive analysis of the local morphodynamics around a detached low-crested rubble-mound breakwater, with a special focus on the quantitative characterization of scour phenomena, namely the scour depth.

2 PHYSICAL MODEL

A 3D mobile bed physical model was built in the wave basin of the Hydraulics Laboratory at the Faculty of Engineering of the University of Porto, Portugal. The wave basin is 12 m wide, 28 m long and 1.2 m deep. The experimental setup consisted of a single geometric configuration featuring a porous seabed-placed breakwater. For the model layout, a foreshore slope of 1(V):20(H) was constructed in order to raise the breakwater structure and, consequently, create an erodible area nearby (Figure 1). The coastal structure was placed over an erodible layer with a thickness of 20 cm made of sand with the following characteristics: $d_{50} = 0.273$ mm and $\rho_s = 2650\ kg/m^3$. The experimental campaign encompassed the systematic examination of various hydrodynamic conditions, including various water levels (h), significant wave heights (H_s), and wavepeak periods (T_P). Furthermore, the influence of different geometric characteristics of the breakwater, such as crest freeboard(F), leeward slope ($\alpha = 1(V): 2(H)$), and crest height (d), were examined. The non-suspension sediment transport was the predicted mode for the experimental campaign. During the experimental campaign, wave trains of different lengths were reproduced to have a clear and representative assessment of the scour hole development and also scour holes near the detached breakwater as close to the equilibrium as possible. To provide precise quantitative insights into the scour phenomena, different measurement techniques were used, such as a laser scanner to measure the morphological changes near the structure, and several wave gauges placed in strategic positions in the domain to allow the characterization of wave conditions.

3 RESULTS

One of the noteworthy findings of this study is the scour phenomena predominantly observed in the trunk section of the low-crested detached rubble-mound breakwater (Figure 2). Additionally, a notable scour pattern was identified in the 45º quadrant of the seaward roundhead section. Importantly, it was observed that the precise location of the boundary between scour and accretion zones was not static but rather contingent on the prevailing maritime conditions. Furthermore, an intriguing revelation was made regarding the significant influence of the peak wave period (T_P), which appeared as a major maritime parameter contributing to the variance in scour depths, particularly in the trunk section of the low-crested detachedrubble-mound breakwater. This observation underscores the importance of considering realistic sea conditions, with a high probability of occurrence, in the existing formulations that quantify scour depth, during the design and assessment of coastal protection structures. Notably, during this experimental campaign, the plunging breaker phenomena did not occur. This can be attributed to the large crest width considered in the breakwater design. This observation is noteworthy, considering that previous experimental studies have identified the plunging breaker phenomena as the primary driver of scour holes in the leeward side of the roundhead section of a detached breakwater.

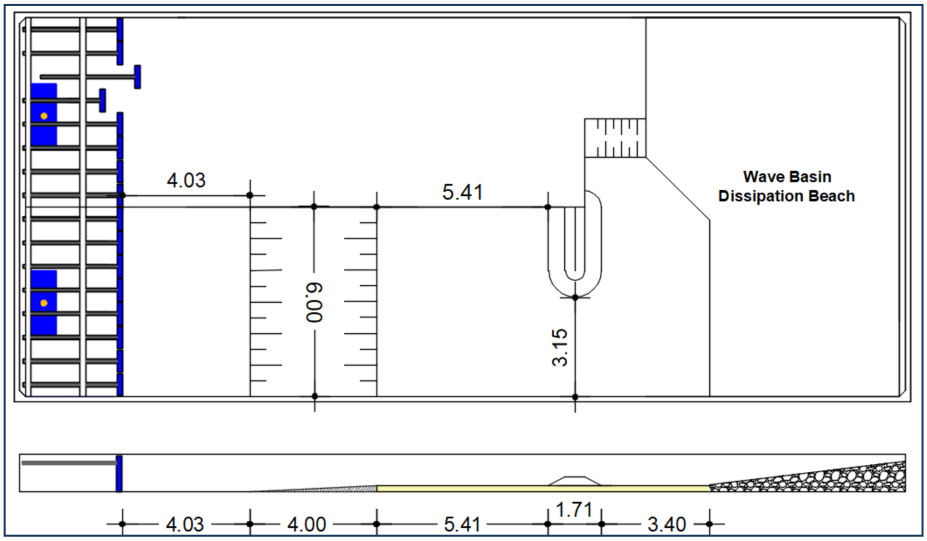

Figure 1. Physical model layout (dimensions in meters).

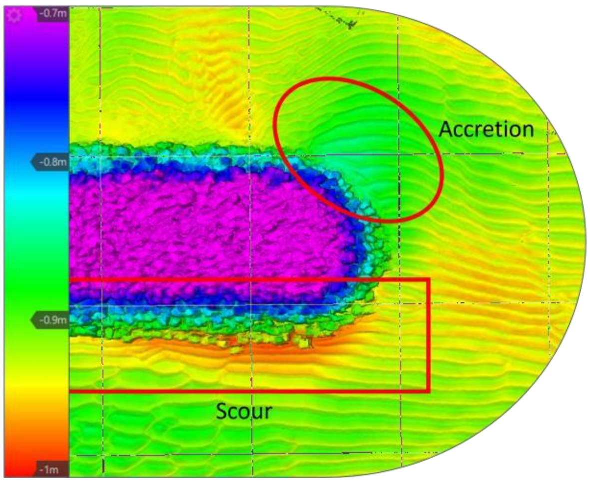

Figure 2. Morphological changes after 11 000 waves (Test condition: $H_s = 0.11\ m$; T_P =2.8 s).

4 CONCLUSIONS

In summary, this study enhances the understanding of scour phenomena around low-crested detached rubble-mound breakwaters. The scour phenomena predominate in the trunk section, therefore, this area, requires effective countermeasures against scour. The dynamic scour-accretion boundary in the roundhead section, influenced by maritime conditions, calls for adaptable protection strategies. The study highlights the significance of peak wave period as a critical factor already incorporated into scour depth quantification, reaffirming its relevance in the design process.. Notably, the absence of the plunging breaker phenomena challenges conventional assumptions. These findings contribute to a more comprehensive approach to structure design, maintenance, and research.

ACKNOWLEDGEMENT

The first author acknowledges funding in the form of a PhD scholarship grant by the Science and Technology Foundation (FCT), with reference 2021.06629.BD.

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