

A LARGE PERCHED BEACH SCHEME IN DEEP WATERS

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INTRODUCTION

Nowadays the need for creating land to establish new cities at more favourable locations, namely close to water, has increased. These new reclaimed cities are expanding more offshore, therefore facing severe and challenging wave conditions. Combining conventional coastal protection design (e.g. rock/concrete revetments) with these challenging conditions is expensive and non-attractive for visual, environmental and social aspects. Alternatives can be considered where hard and soft coastal protection measures are combined. Perched beaches are typically artificial beaches that are supported or partly protected at the offshore side by a (submerged) barrier. The advantages of such design schemes are that less dredged material is required than in a full "open" beach solution and less rock than in a full hard solution. At the same time, protected waters are created in front of the beach reducing the risk of significant loss of dredged material. There is a strong interaction between the barrier and the beach. The design of the barrier (quite exposed to wave action) not only depends on its standalone stability but also on the effect it has on the artificial beach, as related to the transmission performance, which is mostly influenced by the crest elevation. Moreover, water level setup and flushing are relevant aspects for safe bathing on a microtidal coast.

PROJECT DESCRIPTION

The Abo-Qir Port Expansion project consists of the expansion of the existing Abo-Qir port close to Alexandria, Egypt in the East Mediterranean Sea, creating a new terminal for solid and liquid bulk material and a new urban development called New Abo-Qir City. Due to the multipurpose function of the large reclamation also the aesthetics and the social use of the new urban development were important factors for the project concept. The sea frontage is bordered by a 6 km long rectilinear perched beach scheme on the exposed north west side (see Figure 1). The project was awarded by the Egyptian Navy to the Consortium of Contractors containing DIEG (part of the DEME-group) and GIECO (GD Consortium), who then appointed external consultant to develop the design.

DESIGN CHALLENGES

The main design challenges are posed by the water depth which varies along the toe of the submerged structure and has an average level of -16mCD with a maximum of -20mCD. Additionally, due to the project's location, extreme design conditions with waves up to $H_s=8\text{m}$ and $T_p=15\text{ s}$ are expected. Last but not least, the design solution considered, namely a perched beach

scheme has never been applied at this scale for these deep water and severe wave conditions. Thus, conventional design formulae and tools are not validated for this case with respect to the design of the beach.



Figure 1 - Project layout at Abo-Qir (Egypt)

DESIGN PROCESS

Due to the interaction between the barrier and the beach, the design of the two main elements is an integrated process. On top of this the design process has to consider constructability, safety and economical viability. Due to the lack of validated design tools and experience for such unique project, it was chosen to use various numerical tools and perform physical model tests (2D and 3D at appropriate scales) to verify both the structural stability and the morphodynamic response, using the latter ones to calibrate/validate the former ones.

PRELIMINARY STUDIES AND RESULTS

The first essential design step was the definition of the average and extreme wave climate (see Figure 2), which was based on a 43-year time series of hindcasted data from ERA5 model transferred nearshore and well calibrated with the ongoing wave measurements of two directional buoys at the project site.

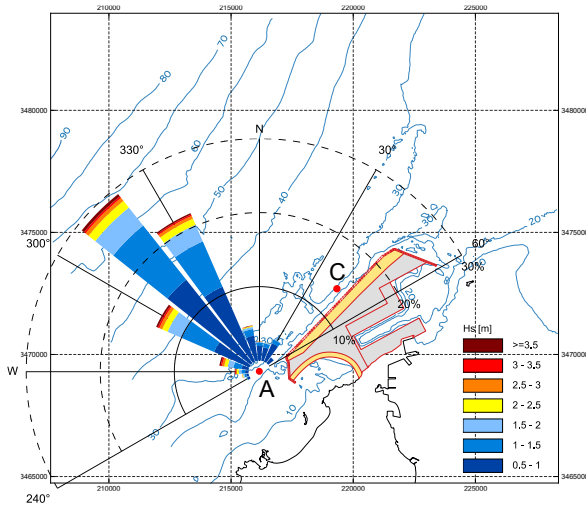


Figure 2 - Wave climate from ERA5 model

The preliminary design of the barrier was supported by small scale fixed bed 2D tests performed at DMC (NL) and at Roma TRE University (IT) to verify the armour stability, the transmission coefficient and setup with variable crest elevations (see Figures 3-5).

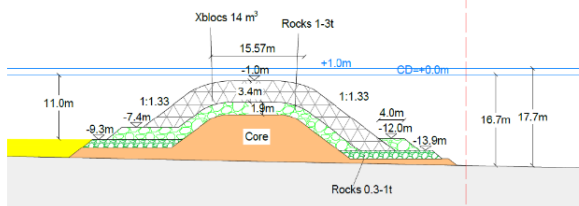


Figure 3 - Model cross section of the semi-submerged breakwater tested in the lab of Roma TRE University

The preliminary design of the beach was initially investigated with application of cross-shore numerical models (Sbeach, Xbeach) to observe the long-term response (10 years) of the profile under perpendicular wave attack. The reshaping of the construction slope occurs quite rapidly and the shoreline recession stabilizes after a few years (see Figures 6).

Moreover, given the occurrence of oblique waves and longshore transport, a one-line model has been used to show the shoreline reorientation and the required spacing between the groins. The numerical models have been validated with the transmission data from the early flume tests at the Roma TRE University and with some surveys of the open fill profiles from the ongoing works in the field.

DETAILED DESIGN

The detailed design will include 2D and 3D scaled physical model tests with a mobile bed to verify the beach and structural response of the preliminary design. These studies will be performed in the coming months and available results will be presented at the conference.

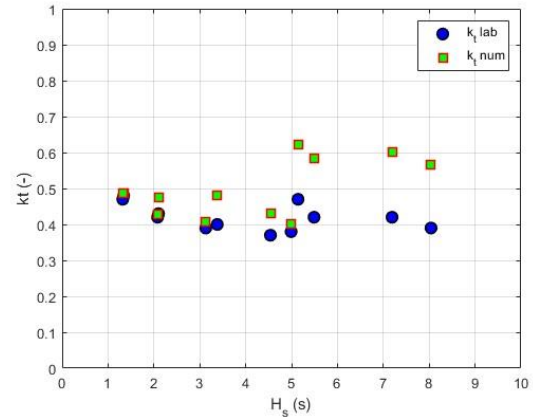


Figure 4 - Transmission coefficient K_t from physical model test and from numerical model Sbeach as function of incident wave height H_s ($R_c = -1.0$ mCD)

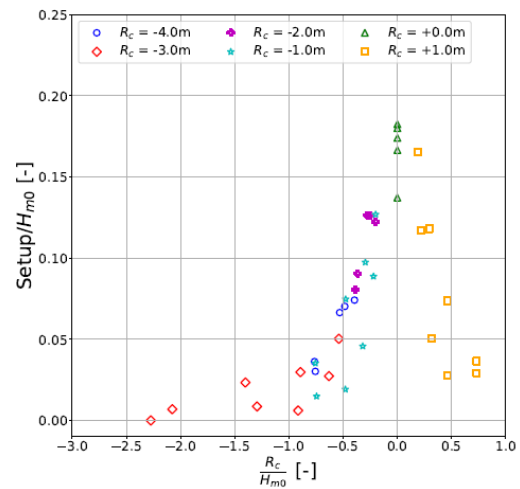


Figure 5 - Normalized average water level setup measured at model barrier rear side versus the relative freeboard R_c/H_{m0}

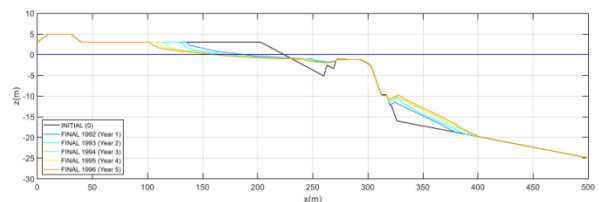


Figure 6 - Example of simulated Sbeach profile in 5 years