

# Advanced Studies in Breakwaters and Coastal Protection

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Globally, mean sea level rise has been accelerating, populations living in coastal zones have been gradually growing, including in low-lying coasts, and the demands for deeper harbors have been quickly increasing to accommodate the future deeper-draft vessels that are being bought online by shipping companies. Specific regions around the world will also experience increasingly frequent and extreme storm events, which will inevitably lead to increased structural damage, beach/dune erosion, flooding, and saltwater intrusion, amongst other consequences. These are anticipated to have negative impacts on the economy, infrastructure, and lives. Adapted solutions that are safe and sustainable are required for the protection of coastal residents, ecosystems, coastal/harbor infrastructure, and the economy.

Breakwaters are commonly used for the sheltering of harbor basins and harbor entrances against waves, with different types being used depending on local characteristics (e.g., foundation conditions, water depths, wave climate severity), sizes and shapes of the area to be protected, amounts of large quarry stones, etc. They may be rubble-mound structures armored with rock or concrete armor units, vertical-front structures, or composite structures. Breakwaters have also been used in coastal defense schemes with the main objective of preventing shoreline erosion. In this case, detached breakwaters, reef breakwaters, and groins (similar to rubble mound breakwaters) are more commonly used.

This Special Issue on “Advanced Studies in Breakwaters and Coastal Protection” solicited original research on innovative methods and technologies for coastal and harbor protection structures, including findings on the effects of climate change and the needs for sustainable solutions, focusing on advanced studies (physical and numerical models, field observations, composite modeling, probabilistic approaches) for upgrading the reliability of existing structures in terms of safety and functionality, for the optimal design of new ones, and for improving measures to mitigate risks (e.g., warning systems and decision-support tools).

Eleven papers on these subjects were selected for this Special Issue, of which one is a case report [1], another is a technical note [2], and the remaining nine are applied research articles. The techniques used in the presented studies range from in situ measurements, in order to evaluate wave height reduction inside a port in Korea caused by the construction of a detached breakwater [1], to convolutional neural networks used to estimate overtopping discharge on several types of coastal structures [3].

Although most of the papers deal with scale model tests, there is one interesting example of a not-so-small-scale model built off the beach of Reggio Calabria [4], in Italy, at the Natural Ocean Engineering Laboratory, to study the wave impact on a vertical structure where a U<sub>O</sub>WC was installed.



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Overtopping was one of the most commonly studied phenomena in the papers, given its importance for safety matters related to breakwaters, namely, in face of climate uncertainty [2,3,5–7]. This Special Issue also features a paper that uses CFD modeling to assess the influence of the friction parameters on the overtopping response of a rubble mound breakwater under extreme wave attack [2] and another one [6] that uses a simpler numerical model for sea-wave propagation to illustrate the inclusion of such phenomena in the prototype of a forecast system.

Coastal protection against sea wave action is the subject of two papers. One paper uses scale model tests to assess the influence of seawall shape and position on a low-lying reef flat [8], whereas another paper combines scale model tests and numerical model simulations to evaluate wave transmission over rubble mound submerged breakwaters [9].

The Special Issue also contains a paper on the use of buffer blocks to dissipate the flow energy associated with tsunami events [10]. The goal of this procedure is to improve coastal protection from these events. Related to this type of energy dissipation, although at a different scale, is a paper on the hydraulic response and overtopping performance of the armor layer of a rubble mound breakwater made of single layer [5]. The shape of the artificial element, which looks like a small cube on top of a large one, promotes energy dissipation through the flow around the small cubes.

Finally, it includes a compelling paper that illustrates, using practical examples, how the potential effects of climate changes on coastal structures can be analyzed by the owners or designers of such structures [11].

We hope that readers will enjoy and learn from these papers as much as we have.

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