

INVESTIGATION OF STILLING WAVE BASIN AS AN OVERTOPPING DEVICE-TYPE WAVE ENERGY CONVERTER

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This research aims to ensure that a coastal protection structure where the promenade works as a Stilling Wave Basin (SWB) generates energy while it protects the coastline against flood. As recently expressed by top European heads of state, climate change is the largest challenge. Traditional non-renewable energy sources such as oil, coal, etc. pollute the environment by releasing hazardous gasses into the atmosphere. Research indicates that environmental contamination's consequences range from global warming to sea level rise (Zhang, 2022). According to the IPCC 5 report, a 30cm rise in sea level is predicted to affect European coasts in the medium and long term. It is anticipated that the rise will cause flooding.

Natural and geographical circumstances are considered for the design of coastal protection structures. These conditions are changing rapidly due to global warming. The structures are quickly becoming inadequate through the rapid change in sea level (Hinkel et al., 2014). Therefore, the coasts are in danger with the existing structures, in the future. Consequently, structural enhancements must be made to guarantee coastal safety. In this regard, the crest modification is a common approach for structural improvement. However, because it is critical to preserve coastal aesthetics in urban regions, increasing the crest height is not always feasible. For this reason, it is crucial to minimize crest modifications. The "Stilling Wave Basin" concept decreases wave overtopping by keeping the crest height constant. The concept includes a seaward and a landward storm wall, with a basin in between. Wave overtopping is allowed in the basin. Thereby, the energy of the overtopping wave is dissipated in the basin. Thus, the landward overtopping is minimized preserving the crest height.

In the SWB concept, the basin is additionally considered as a reservoir of a wave energy converter. These structures are known as Overtopping Device (OD) Wave Energy Converters (WEC). Fundamentally, the systems are based on the idea of generating electricity from the potential energy of the water in the reservoir. The accumulated wave in the basin is discharged to the sea through a drainage orifice. A hydraulic turbine is placed in the orifice to generate electricity from the potential energy. Wave energy is the most energy-dense renewable source. Each year, 32,000 TWh of wave energy is anticipated to reach shorelines all over the world. (Mork, 2010). Developing a wave energy converter system which is integrated with a coastal protection structure is essential, considering the amount of energy that hits the shorelines.

Small-scale physical model tests are performed to investigate SWB as an OD WEC. The experiments are done in the Wave-Current flume of the Maritime Engineering Laboratory (LABIMA) at Florence University (abbreviated as 'LABIMA-WCF') in Italy. The model is tested under irregular wave conditions for two different water depths. In total, one hundred twenty-six tests are performed for different geometric configurations of the SWB.



Figure 1 - Sketch of Stilling Wave Basin as an OD WEC

The flow rate of accumulated water in the basin is used to evaluate power potential. The flow rate is determined by calculating the empirical seaward and landward overtopping differences at 3.5m and 3.8m water depths. For each scenario, two alternative wave conditions are examined. The obtained overtopping flow rates are used to calculate potential power generation. The study determines the power potential in front of the wall, the potential in the basin, and the turbine potential. The correlation between the SWB design parameters and power potential is investigated for two separate water depths and two distinct wave conditions. The optimal design configurations are determined within the safety limitations. The limitations are designated in the consideration of the EurOtop Manual. Furthermore, an optimal relation is defined between the number of turbines and the length of the SWB.

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