THE NEW INSTALLATION OF THE U-OSCILLATING WATER COLUMN BREAKWATER IN THE PORT OF SALERNO FOR THE WAVE ENERGY EXPLOITATION

Alessandra Romolo, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, aromolo@unirc.it
Vincenzo Fiamma, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, vincenzo.fiamma@unirc.it
Giovanni Malara, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, giovanni.malara@unirc.it
Valentina Laface, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, valentina.laface@unirc.it
Antonino Simone Spanò, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, antoninosimone.spano@unirc.it
Bruna Timpano, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, bruna.timpano@unirc.it
Elena Valentino, Port System Authority of the Central Tyrrhenian Sea , Salerno – Italy, e.valentino@adsptirrenocentrale.it
Gianluigi Lalicata, Port System Authority of the Central Tyrrhenian Sea , Salerno – Italy, g.lalicata@porto.salerno.it
Fausto Caputo, Port System Authority of the Central Tyrrhenian Sea , Salerno – Italy, f.caputo@porto.salerno.it
Felice Arena, Natural Ocean Engineering Laboratory (NOEL), Mediterranea University of Reggio Calabria, ITALY, arena@unirc.it

INTRODUCTION

This article describes the characteristics of a U-Oscillating Water Column plant, named also REWEC3 (REsonant Wave Energy Converter), that has been realized in the Port of Salerno (Italy). The objective of the infrastructure is to enlarge the port basin area by taking advantage of the most recent developments in the field of caisson breakwaters. The building of the caissons was completed in 2022, when a monitoring activity started of three active chambers. In the paper, a general overview of the U-OWC device and of monitoring activity of active cells is given in conjunction with an initial expected U-OWC plant performance.

Key words : U-OWC, port, prototype, wave energy.

THE U-OWC TECNOLOGY: INNOVATION and PROPERTIES

The U-OWC caisson breakwater is composed by a chamber containing a water column in its lower part and an air pocket in its upper part. The air pocket is connected to the atmosphere via a duct hosting a self-rectifying air turbine. A REWEC3 includes a vertical U-shaped duct for connecting the water column to the open sea (for this reason it is known also as U-OWC). The working principle of the system is quite simple: by the action of the incident waves, the water inside the U-shaped duct is subject to a reciprocating motion, which induces alternately a compression and an expansion of the air pocket. The pressure difference between the air pocket and the atmosphere is used to drive an air turbine coupled to an off-the-shelf electrical generator connected to the grid. The main feature of the U-OWC is the possibility of tuning the natural period of the water column in order to match a desired wave period through the size of the U-duct. This property introduces substantial improvements useful in the perspective of wave energy exploitation.

PROJECT LAYOUT: PROJECT OF THE NEW U-OWC FOR SALERNO'S PORT

The port of Salerno, located in the gulf of the Tyrrhenian Sea, is registered in the class of II category of seaports. It is one of the major domestic ports and plays an important role in the industrial and commercial system of the Central and South Italy. The Port of Salerno covers an area of 1,700,000 m², 500,000 m^2 of which on land, and it comprises 5 docks (Figure 1). In 2020, almost 26×10^6 tonnes of goods and more than 3 million passengers passed through the port. Since the traffic is supposed to increase in the future years, several improvements of the infrastructure have been planned. In this context, the widening of the port entrance has been carried out through the European Regional Development Fund (ERDF) "Grande Progetto: Logistica e Porti. Sistema Integrato" to allow access, transit, and docking of larger cruises. In particular, the outer breakwater has been extended by 200 m, by including the REWEC3 plant so that it can be employed both for protection and for energy harvesting purposes. Four caissons have been constructed to extend the breakwater, three of which are REWEC3 (Figure 2). Each of three REWEC3 caissons comprises 10 active chambers, for a total number of 30 chambers to be equipped with the optimized Power-Take Off (PTO) units.

The three caissons have the same geometrical characteristics, i.e. 39.20m long and 22.50m wide, being the active part of the device characterized by the inner chamber and the vertical duct which width is 4m and 2m, respectively. The duct opening is located 2m below the m.w.l. and the water depth at the installation position is around 11.40m (Figure 2). The height of the air pocket is 6m with respect to the m.w.l. and the air in the chamber is connected to the atmosphere via an opening with a diameter of 0.75 m.

The active part was designed with the objective of maximizing the average annual energy absorbed by plant, considering the specific wave climate conditions of the site. The passive part of the caisson, i.e. all the chambers apart from the U-duct and the inner chamber, comprises the stabilizing elements filled with sand and was designed for ensuring the global stability in extreme conditions.

Figure 1 - The configuration of the Port of Salerno, red areas indicate the location of the works : the West breakwater was demolished for a length of about 100 m, while the East breakwater has been extended of about 180 m by adopting REWEC3 caissons

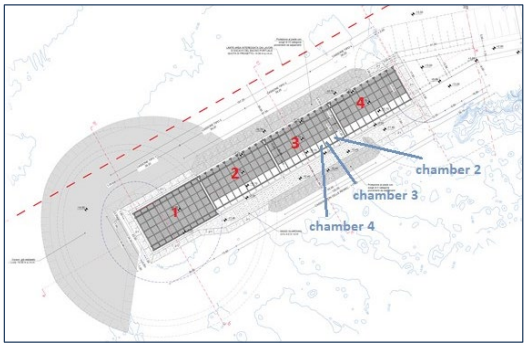

Figure 2 - Cross-section of a REWEC3 caissons (the 2, 3 and 4 of Figure 2) in the Salerno's project, at the center of the breakwater.

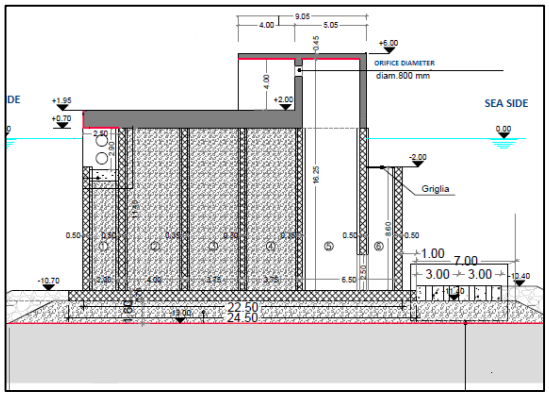

Figure 3 - Cross-section of a REWEC3 caissons (the 2, 3 and 4 of Figure 2) in the Salerno's project, at the center of the breakwater.

MONITORING ACTIVITY AND INITIAL RESULTS

To assess the behaviour in real conditions and to evaluate the performances of the plant a 1-year monitoring activity is planned. Data will be collected by pressure transducers and ultrasonic probes installed in three of the 30 active chambers corresponding to the centre of the enlargement (chambers 2,3 and 4 of figure 2). All the sensors are connected to the acquisition unit, placed in a control room realized in correspondence of the chamber n.3 and equipped with a workstation accessible remotely.

Thanks to the data collected the dynamics can be described by considering the water column displacement and the air chamber pressure, by which

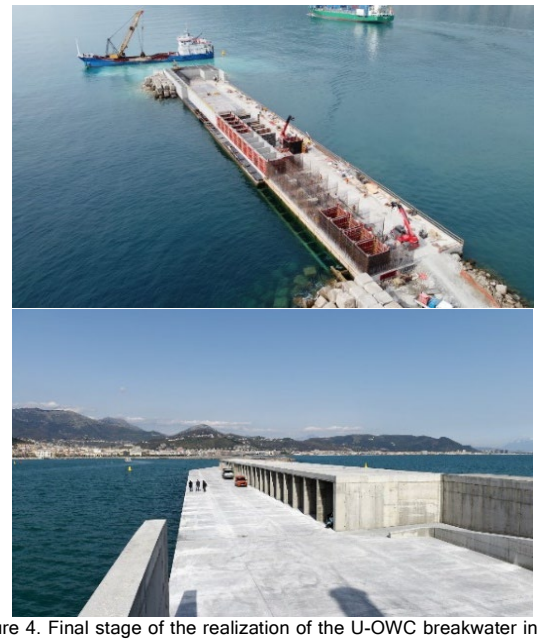

Figure 4. Final stage of the realization of the U-OWC breakwater in the Salerno's port.

the power absorbed by the plant and the power output that the system made available to the turbine can be computed, allowing the design of an optimal PTO and of the estimation of energetic performances of the REWEC3 plant.

Moreover, the article will show that the plant may absorb about 60-80% of the incident wave energy in a large variety of sea states available in the location under study.

The average absorbed power, Φ_p, by the single REWEC3 cell of the Salerno plan is showed for a recorded sea state in Figure 5.

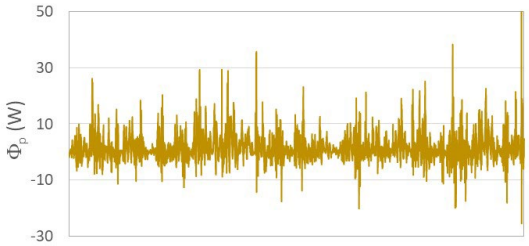

Figure 5. Absorbed power inside the single REWEC3 pneumatic chamber in Salerno during a record

REFERENCES

Arena F., Romolo A., Malara G., Ascanelli A.. 2013. "On design and building of a U-OWC wave energy converter in the Mediterranean Sea: a case study". Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering, OMAE2013, 2013, Nantes, France.

Arena, F, Romolo, A, Malara, G, Fiamma, V, & Laface, V. 2018. "Response of the U-OWC Prototype Installed in the Civitavecchia Harbour." Proceedings of the ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering. Volume 10: Ocean Renewable Energy. Madrid, Spain. June 17-22, 2018.

Boccotti P., et al.., 2007 "Caisson breakwaters embodying an OWC with a small opening-Part II: A small-scale field experiment", Ocean Engineering, 34(5-6), pp. 820-841.