Proceedings of the Eighth (2008) ISOPE Pacific/Asia Offshore Mechanics Symposium
Bangkok, Thailand, November 10-14, 2008

ISBN 978-1-880653-52-4

Numerical Simulation of Wave Flow over the Spiral-Reef Overtopping Device

B.W. Nam, S.H. Shin, K.Y. Hong, S.W. Hong
Maritime & Ocean Engineering Research Institute, KORDI
Daejeon, Korea

ABSTRACT

In this paper, computational fluid dynamics (CFD) simulations are carried out for the purpose of finding the optimal design parameters of a spiral-reef overtopping device. In order to maximize the overtopping flow rate, geometrical parameters of the device were systematically examined in numerical computations. In all simulations, the commercial CFD program FLOW3D was used. In this study, regular waves with a period range of 4~6 seconds (which are very common in the Korean southern sea) are considered. In the first phase of the study, two-dimensional parameters including device ramp angle, ramp shape and draft were investigated. Fully three-dimensional CFD simulations were then conducted to understand wave flow over the device and the guide-vane effect on overtopping on it. The calculation results show different overtopping processes between 2D and 3D simulations, and optimal design parameters were identified based on numerical results. These findings can be incorporated in the design of an overtopping device to obtain better overtopping performance.

KEY WORDS: Spiral-reef overtopping device, CFD, overtopping discharge, ramp, guide-vane.

INTRODUCTION

There are many kinds of wave energy converters. They can be categorized as being one of three basic types; a movable body type, an oscillating water column (OWC) type and a wave overtopping type. The overtopping type makes use of the potential energy of overtopping water via water turbines.

Only a few overtopping wave energy converters have been studied. Among them, the Wave Dragon (Nielsen & Kofoed, 1997) is the most practical and pioneering model. It consists of two wave reflectors, a reservoir and a number of hydro turbines. The wave reflectors focus the incoming waves towards a ramp, and a reservoir captures the overtopping water above sea level. Low-head hydro turbines generate power by using the hydraulic head of the stored water. The Wave Dragon is a floating converter that is placed in an offshore area with a mooring line. Another new conception of the overtopping wave energy converter is the Seawave Slot-Cone Generator (Vicinanza & Frigaard, 2008). This converter has multiple reservoirs and a multi-stage turbine, which results in a higher overall efficiency compared to a single reservoir structure.

In this study, a spiral-reef overtopping wave energy converter (shown in Fig.1) was investigated. Spiral-reef overtopping devices are fixed circular-shaped structures. Consequently, the converter's performance is identical with respect to waves from all directions. The device is composed of a sloped ramp, an inner reservoir and substructures. The substructure is a mono-pile type or jacket type. On the ramp, guide-vanes are attached to reinforce wave overtopping. In the reservoir, the overtopping water is accumulated and drained out through a center hole.

In this study, basic research on the spiral-reef overtopping device was conducted using CFD simulations. The primary purpose of numerical simulations is to find an optimum device shape with respect to overtopping flow rate (discharge). For this purpose, two and three dimensional numerical simulations were conducted by using a commercial CFD program, FLOW3D. Firstly, flow patterns of the overtopping procedure were observed. Several geometrical parameters, such as draft, ramp shape, and guide-vane shape, were then changed and the effects of the parameters were systematically investigated through numerical simulation.

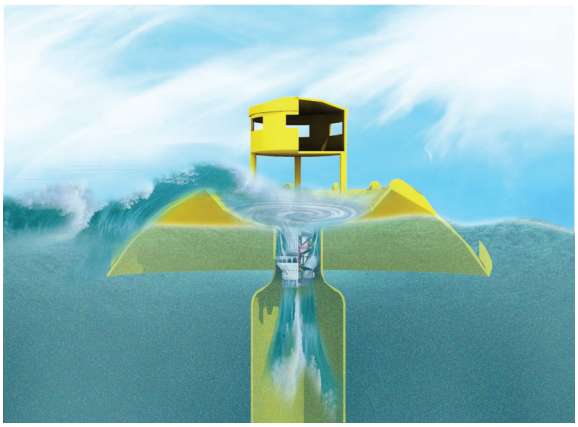

Fig.1 Spiral-reef overtopping wave energy converter

MAIN DESIGN PARAMETERS