Proceedings of the Ninth (2010) ISOPE Pacific/Asia Offshore Mechanics Symposium
Busan, Korea, November 14-17, 2010

ISBN 978-1-880653-79-1: ISSN 1946-004X. www.isope.org

Experimental Study of Dynamic Response and Energy Absorption of Fixed Circular Cylindrical OWC Columns in Regular Waves

Yukitaka Yasuzawa and Yoshitaka Okumura

Department of Marine Systems Engineering,
Faculty of Engineering,
Kyushu University
Fukuoka city, Fukuoka, Japan

Department of Maritime Engineering,
Graduate School of Engineering,
Kyushu University
Fukuoka city, Fukuoka, Japan

ABSTRACT

Recently renewable energy has been recognized as the countermeasure against global warming and establishment of sustainable society. Therefore in the field of ocean engineering, development of energy converters including wave energy converter devices (Brooke, 2003) to extract energy from the ocean are active in the world. The authors have proposed a new type of floating wave power converter system with multiple columns (Yasuzawa and Nagashima, 2009). The wave power generation floating system is composed of deck structures and multiple columns underneath. Some columns are used as power generation units which are based on OWC (Oscillating Water Columns) principle and convert wave energy into electric energy, and the other columns have the function of buoyancy.

In the present study, dynamic response characteristics of the fixed cylindrical OWC column in regular waves are investigated as basic information before estimation of the floating system. Acrylic cylinder models of the OWC have been designed and manufactured, and the experiment has been performed in the wave tank in Ocean Energy Institute of Saga University.

In the experiment, amplitude of water level and pressure in the OWC have been measured to obtain energy absorption of the OWC. Horizontal shear force, vertical force, and pitching moment at the column root have been measured to clarify wave force acting on the columns simultaneously as well. The experiment has been conducted under several wave conditions and the columns with various dimensions to investigate frequency response and effect of column shape.

Finally efficiency of primary energy conversion of the OWC columns has been calculated for various conditions based on experimental results on amplitude of water level and pressure in the OWC by using some theories and discussed.

KEY WORDS: Wave energy; circular cylindrical OWC; floating structure; energy conversion.

INTRODUCTION

Recently it has become important to start an action against global warming and to control the consumption of the fossil fuel for reducing emissions of greenhouse gases such as carbon dioxide. Renewable energy has been paid attention these days. Wind power generation and solar photovoltaic generation have been already expanded in practical use under subsidy policy by the government.

On the other hand, generation cost and efficiency of wave power generation we are focusing on is not necessarily prior to those renewable energies at the moment. Therefore wave power generation hasn't been used commercially in Japan. However, it is said that there is wave power potential of 35,000,000kW around Japan, and this quantity is equivalent to about 1/3 of the Japanese total electricity consumption. Therefore if wave energy is harnessed stably and efficiently, the benefits are enormous.

OWC has been investigated because it is one of the promising candidates as wave energy converters. A single fixed cylindrical OWC or a diffraction problem of a single fixed cylindrical OWC device has been studied by numerically and experimentally (Evans(1982, 1997), Brendmo Falnes and Lillibekken (1996), Lee, Newman, and Nielsen(1996), Lopes, Ricci, Gato, and Falcao (2007)). Dynamic behavior of the OWC inside the cylinder has been getting made clear.

Based on the background above, we have proposed and started studying a new floating power generation structure which consists of a number of buoyancy columns, power generation columns and the deck structure as shown in Fig.1 (Yasuzawa and Nagashima, 2009). The proposed floating wave energy station has many circular cylindrical OWC columns hanging under a large deck structure. We call the structure system as multiple columned OWC system (MC-OWC system).

The external appearance of the floating structure is similar to a semi-submergible VLFS. Semi-submergible type structure is suitable for offshore installation from viewpoint of structural safety because the wave load is smaller against large waves. And mooring system of the structure is simpler than that wave energy field of a lot of point