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学 位 論 文 要 旨
Dissertation Summary

氏　　名 (Name) Firman Husain

論　文　名:
(Dissertation Title) DEVELOPMENT OF A SEAWALL OF DOUBLE WATER CHAMBER TYPE FOR EFFECTIVE WAVE POWER EXTRACTION AND REFLECTED WAVE DISSIPATION

In the present study, a new type of seawall called a water chamber type is introduced. The water chamber model proposed here has two water chambers partitioned by two vertical curtain walls with different draft depths. This seawall is proposed for realizing the following two purposes: The first is to reduce reflected waves and also wave overtopping amount. And the second is to extract incoming wave energy for the utilization of electric power. Existence of the curtain wall triggers a pumping mode wave resonance in the chamber.

For expanding the function of the new seawall model and increasing the B/C performance, the newly proposed water chamber model is also examined as a wave extraction device. In this study, both the single and double water chamber types of seawall are examined as a wave energy extraction device, in addition to the function of a reflection wave dissipater. A special feature of this study is to apply a horizontal water turbine in the water chamber instead of an air turbine in the air chamber as used in the almost all previous studies for extracting the wave energy.

In order to realize the objectives described above, the thesis consists of seven chapters, including the first introductory chapter and followed by the conclusion of Chapter 7. In Chapter 1, the introduction related to this research was described; history of seawall, types of seawall and material construction include on content. The framework of this research was also discussed in this chapter. In Chapter 2, a theoretical analysis for solving the water wave boundary value problem around the coastal structure was described. Especially, the source distribution method is introduced to solve the water wave boundary value problem. In order to analyze the wave dissipation effect around the low reflective seawall, the damping wave model was introduced and developed. In Chapter 3, a theoretical procedure to find out an effective cross section of water chamber seawall was clarified. Theoretical considerations regarding the pumping or piston mode wave resonance in the water chamber was discussed precisely. In order to derive the rational design method of the single water chamber seawall, the governing parameter for describing dissipation effects of reflected waves was presented. In Chapter 4, effectiveness of the single water chamber seawall with guide vanes was mainly examined. The major interest is the ability of wave energy extraction rates as well as the dissipation function of the reflected waves from the seawall. In Chapter 5, in order to increase the ability of wave power extraction and dissipation of reflected waves, the double water chamber model comprised of two curtain walls was newly introduced. Especially, focusing on the wave amplifications of the piston mode resonance in the two chambers, various cross sections of the seawall were tested. Intending the wave power extraction device of

OWC type, the rational design method for effective cross section was examined extensively. In Chapter 6, firstly, in order to improve the effectiveness of the single water chamber model, an extension model to it with an addition of a new water chamber was proposed. By using various locations of the guide vanes mainly in the second water chamber, ability of wave energy extraction was examined extensively. The resultant dissipation effect of reflected waves was also discussed. In order to take much more advantage of the double water chamber structure of the seawall, a new allocation of the guide vane was further examined. As a preliminary study, the wave amplifications in the two chambers were examined for various cross sections of the seawall model. By adopting the optimum cross section of the double water chamber model, ability of wave energy extraction and dissipation of wave reflection were clarified.

Based on overall examinations and discussions of this study, the major conclusions can be summarized as follows:

1) The dissipation of reflected waves by a single water chamber model comprised of a front curtain wall and a rear vertical wall is strongly dependent on the two dimensionless parameters, i.e., the ratio of a wave length to a breadth of the water chamber and the one of a wave length to a draft depth of the curtain wall. The maximum dissipation takes place under the condition of piston or pumping mode wave resonance in the water chamber. A new length parameter expressing the water chamber is proposed for the rational design of the water chamber.

2) From the examination of the two different models of a single water chamber type with and without gap spacing around the guide vanes, it can be confirmed that the gap spacing is effective to activate rotations of the turbine. It is also seen that the wave reflection is comparatively large when the energy extraction device is mounted in the water chamber, especially for higher wave height conditions.

3) Wave energy extraction rate of the single water chamber model is about 18% at maximum. The rate becomes lower for higher wave height conditions. It may be caused by higher hydrodynamic resistance in the guide vane. The possible wave power in prototype scale is about 25kW for wave height H=2m and 65kW for H=4m.

4) A double-water-chamber type of seawall, in which a horizontal plate is attached to the lower end of a second vertical barrier, is more effective to reduce wave reflections and also wave amplifications in the two chambers as compared to the model without a horizontal plate.

5) Effective range of wave frequency for the dissipation of reflected waves becomes narrow with increasing the bottom channel height under the horizontal plate. However, wave height amplifications in the water chambers, especially in the second water chamber, magnified significantly. It may contribute the higher efficiency of wave power extraction with the use of OWC type device.

6) The new parameter for estimating the performance of the second water chamber of a double-water-chamber type with a horizontal plate was proposed. It can be used for the rational design of the new double-water-chamber type seawall.

7) According to the examinations of four different arrangements of guide vanes in the double-water-chamber model, which are extensions of the single water chamber model described above, the maximum efficiency of the extraction of wave energy is about 22%. For higher wave condition, the efficiency decreases as compared to the case of lower waves, that is about 12%. The higher fluid resistance around the guide vanes for the higher wave condition might be responsible for the reduction in efficiency. Although the efficiency of the proposed seawall is not enough, the structure plays a second role as a breakwater sufficiently, typically wave reflection Cr being about 0.3 in average for a wide range of wave period.

8) In order to take much more advantage of the double water chamber structure of the seawall, a new allocation of the guide vane was further examined. As a preliminary study, the wave amplifications in the two chambers were examined for various cross sections of the seawall model. It was confirmed that the double water chamber model with an overlapping part of the first vertical wall on the guide vane is optimum for wave amplifications in both the chambers.

9) The maximum efficiency of the wave energy conversion for the double water chamber model with an overlapping part of the first vertical wall on the guide vane is about 30%. For a higher wave height condition, the efficiency of wave energy conversion is a little bit decreased and the maximum wave power extraction rate is about 23%. Both the rates observed here are about two times as large as that of the single water chamber model. This optimal condition is closely related to the optimal wave amplification in the water chamber described above. It was suggested that the gap spacing below the first curtain wall and the overlapping structure of the first wall on the guide vane are important to increase the efficiency and wave amplifications in the water chambers.

10) The possible extraction of wave power in prototype scale for the overlapping model is about 50 kW for a wave height H = 2 m and 120 kW for H = 4 m in average.