International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8, Issue-4S February, 2019

Study of Wave Dissipation Relationships with Large Volume Overtopping

Muhammad Arsyad Thaha, Rita Tahir Lopa, Muhammad Syahril

Abstract. A lot of researches have been conducted to develop effective wave-retaining beach structures that can minimize wave energy and deliver positive benefits. Waves also generate energy that can be used. Now ocean waves have been used as energy sources for electricity generation. The purpose and objective of this research is to consider the development of energy generation breakwater technology, to identify the parameters that affect the magnitude of the dissipation wave in the tilting wave energy catcher, and to determine the effect of freeboard height (Rc) and the slope of the test model (θ) on tilt wave energy catcher for its large stability overtopping wave volume. In accordance with experiments conducted in the laboratory using a test model, the test results showed that the parameters that affect the magnitude of wave overtopping in hypotenuse breakwaters are wave period (T), incoming wave height (Hi), freeboard height (Rc), and the front side slope of the structure (tan).

Keywords: Dissipation, Overtopping wave, Wave energy, breakwater

I. INTRODUCTION

Overtopping is termed as the volume of water, which exceeds the crest of coastal structures. The energy from the incoming wave is dissipated by breaking, friction, infiltration or is reflected while the rest of the kinetic energy is converted into potential energy. When the slope is not too long or the crest is not high enough, this conversion is not total and the freeboard is topped. Consequently, some water pass over the crest. This phenomenon is made into good use by converting the wave energy to electricity using breakwaters and this technology is termed as Overtopping Wave Energy Converter (OWEC)[1-2]. Over the years, there have been many types of OWEC proposed and researched upon. According to Kofoed (2002), sea power is the first overtopping device for wave energy conversion in the world whereas Wave Dragon (WD) which was developed in Denmark is world's first grid-connected floating WEC [3]. Another WEC device introduced was TAPCHAN (Tapered channel), with 350 kW capacity which utilized the natural topography of a gradual narrowing wave run-up channel and a reservoir with a 3m water head over the mean sea level [3-4]. Nonetheless, TAPCHAN was highly dependent on coastal topography.

Thus, in order to resolve this dependency issue, the Sea Slot-Cone Generator (SSG), which is an overtopping wave energy converter that could be coupled with traditional coastal engineering structures, was proposed. Margheritini, Vicinanza and Frigaard (2009) stated that SSG was more robust and able to collect more wave water under large wave-height conditions [5]. In addition, this technology is economical because it is suitable to be incorporated with a breakwater, thence this brought about Overtopping BReakwater for Energy Conversion (OBREC). The first full-scale prototype of the OBREC installed in the port of Naples (Italy) in 2015 consisted of a rubble mound breakwater with a reservoir designed to capture the wave overtopping from a frontal ramp in order to convert it into potential energy [6].Ünsalan(2016) stated that even for a modest sea state, an economically justifiable energy can be obtained by a modification of the existing breakwaters. Accordingly, many researches involving implementation of OBREC around the world has been conducted [7]. In order to evaluate the capability of Malaysian waters in handling the overtopping wave parameters, Ahmad et al., (2016) conducted a numerical simulation using CFD-flow 3D. The results obtained revealed that the optimum crest freeboard for adapting to Malaysia waters is 1.2 m which correlated in averaging 0.798 kW m–1 output power [8]. Troch et al., (2014) studied the overtopping behavior of the steep low-crested structures, which is positioned in between that of mildly sloping dikes and vertical walls and that of structures with zero crest freeboards and relatively large crest freeboards. From their research, they proposed formulas for wave overtopping at vertical walls subjected to non-impacting waves and at structures with zero crest freeboard [9]. Liu, Han, Shi and Yang (2017) found that the upper sloping angle and the opening width of the lower reservoir both have significant effects on the overtopping discharges [10]. However, there was no study done on the factors affecting the amount of dissipation wave in the tilting wave energy catcher. Therefore this research focused on the parameters that influence the magnitude of the wave catcher wave energy dissipation on the hypotenuse as well as the effect of high freeboard (Rc) and the slope of the test model (θ) at catcher hypotenuse wave energy in the stability of the large volume of wave overtopping.

II. METHODOLOGY

The type of research used is physical modeling experimental in the laboratory. As for the definition of the experiment, it is observation under artificial conditions wherein the condition is created and regulated by the researcher.

Revised Manuscript Received on February 05, 2019.

Muhammad Arsyad Thaha, Civil Engineering Department, Hasanuddin University, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia.

Rita Tahir Lopa, Civil Engineering Department, Hasanuddin University, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia.

Muhammad Syahril, Civil Engineering Department, Hasanuddin University, Jl. PerintisKemerdekaan Km. 10, Tamalanrea Indah, Tamalanrea, Kota Makassar, Sulawesi Selatan, 90245, Indonesia.

Thus, physical model research is a research conducted by making replicas of systems in smaller sizes so that certain simulations / treatments can be carried out in a controlled manner with the aim to investigate the effect of several parameters and the relationship between research parameters. For this study, the variable investigated is the discharge of overtopping waves (q) which is expected to be affected by the wave period (T), the incoming waves (Hi), height of freeboard (Rc), and the slope of the front side of the structure (tan θ). An undistorted model of geometric shapes between models and prototypes were replicated but at a scale of 1: 20. In this study, it is assumed that the planned water depth of 6 m and a depth which is operated in the wave flume are 30 cm. Besides that, modifications of coastal protection building were done in order to forms the hypotenuse to equip it with a reservoir which is located on top of the building. The function of the reservoir is to catch the wave overtopping on the front side of the model. The waves were caught in the reservoir in the form of overtopping discharge will produce a difference in water level between the reservoir with sea level which can then be used to generate power. Figure 1 depicted the setup of the model for this research. In this study, the wave height in front of the model is measured at nine points. The height of the overtopping water in the reservoir is measured at the back the model for several time variations. Similar measurement method was done for the variation of wave height and wave period for each type of model. Height variation and the wave period is obtained by changing the stroke position and variator. The values of the parameters varied are tabulated as in Table 1.

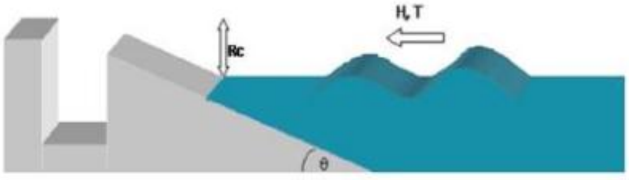


Fig. 1 Sketch of the beach protection model as a catch of wave energy

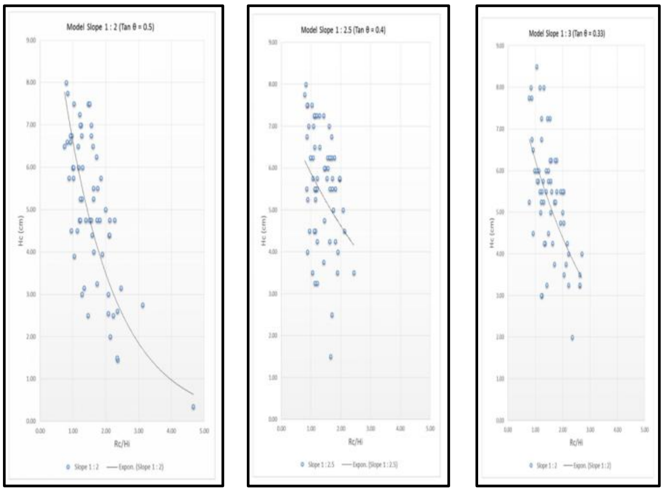
Table.1 Value variation of the parameters

Variables	Variation value
Freeboard height(*Rc*)	12.5 , 10 , 7.5 (cm)
Model slope (*tan θ*)	0.33 , 0.4 , 0.5
Wave height (*H*)	6, 7, 8 (cm)
Wave period (*T*)	0.6, 0.7, 0.8, 0.9, 1.1, 1.2, 1.3 (s)

III. RESULTS AND DISCUSSION

Relationship between Rc / Hi and Hc For Each Model

Based on the results of data processing obtained, a comparison of the height of the freeboard and wave height (Rc / Hi) and height dissipation waves is described in graphical form by taking Rc / Hi as variable X and height of wave dissipation as an axis variable Y for each type of model, graph as in Figure 2(a) to Figure 2(c) are produced. Analyzing the graphs, it is seen that increasing with the value of Rc / Hi resulted in shorter dissipation wave height.



(a) (b) (c)

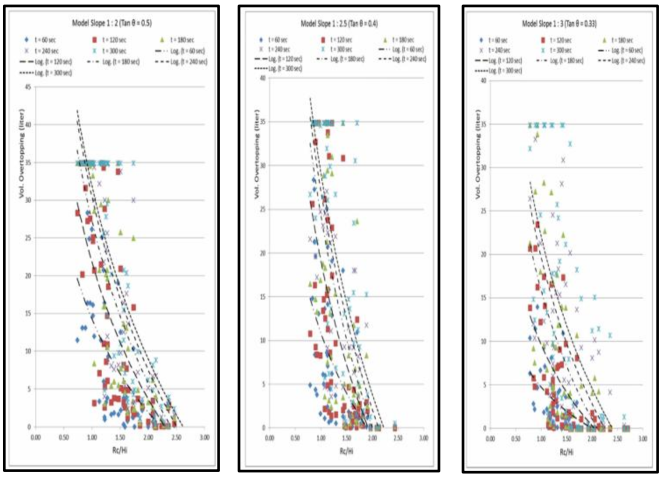
Fig. 2 R_c / H_i and H_c Relationship Graphics Slope for a) 1: 2 b) 1:2.5 c) 1:3

Relationship between Rc / Hi and Volume Overtopping For Each Model

Line graphs as presented in Figure 3(a) to Figure 3(c) represented the data of the height of the freeboard and wave height (Rc / Hi) and volume overtopping, line. Based on the graphs, it was proven that there existed an inversely proportional relationship between Rc / Hi and overtopping volumes. Greater value of Rc / Hi, reduced the volume generated overtopping.

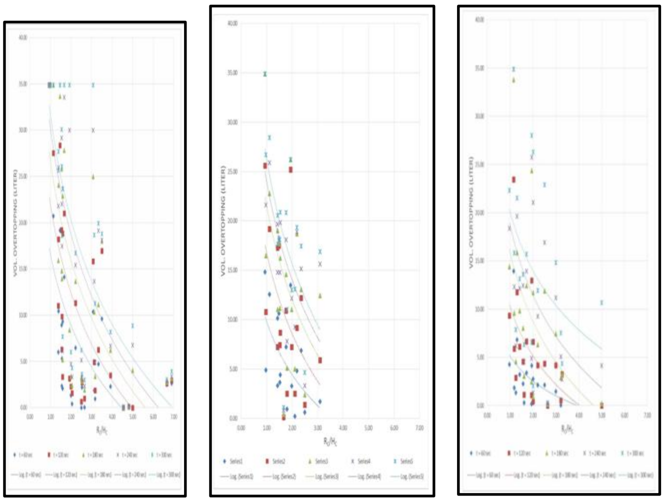
Relationship between Rc / Hc and Volume Overtopping For Every Model

Figure 4(a) to Figure 4(c) depicted the results of freeboard high and height of wave dissipation (Rc / Hc) on the volume of overtopping. Based on the graph, it is deduced that the relationship between Rc / Hc and overtopping volumes is also inversely proportional since the greater the value of Rc / Hc , the lower the volume of generated overtopping.



(a) (b) (c)

Fig.3 Graph of Rc / Hi Relations and Volume Overtopping Slope a) 1: 2 b) 1:2.5 c) 1:3

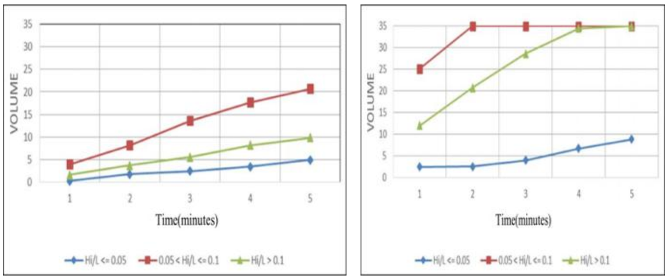


(a) (b) (c)

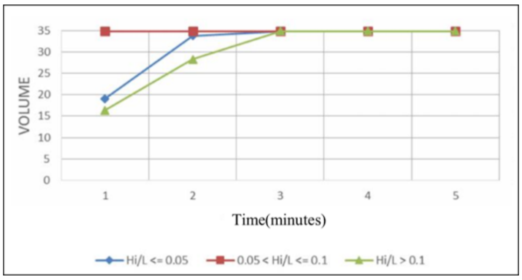
Fig. 4 Graph of R_c / H_c Relations and Volume Overtopping Slope a) 1:2, b) 1:2.5, c) 1:3

Increased Volume Overtopping Wave

The increase in overtopping volume is measured in order to determine the stability of volume overtopping. Based on processing results data obtained over time for wave overtopping volume and the value of the magnitude of steepness wave (Hi / L), it can be divided into 3 sections which are 1. Hi / L <= 0.05, low steepness level, 2. 0.05 <Hi / L <= 0.1, medium steepness level, and 3. Hi / L> 0.1, high steepness level. With reference to Figure 11 till Figure 13, it was found that the amount of volume overtopping produced were different. In the model slope of 1: 2 with a value of Rc equals to 12.5, 10 and 7.5, showed that the magnitude of the volume of overtopping were different from the first minute of the incoming wave. Furthermore, it is also seen that the wave with medium slope height had overtopping volume larger than others. Model slope 1: 2.5 showed in Figure 14 to Figure 16 revealed that a wave with a low steepness provided greater overtopping volume. However, for the model with the value of the volume scale Rc = 7.5 wave with low steepness and medium steepness had the same overtopping volume. While the waves with high steepness provided smaller overtopping volume. On models with a slope of 1: 3 as shown in Figure 17 to Figure 19, it was found that the steepness of the wave with high levels did not produce the volume of overtopping against the breakwaters.

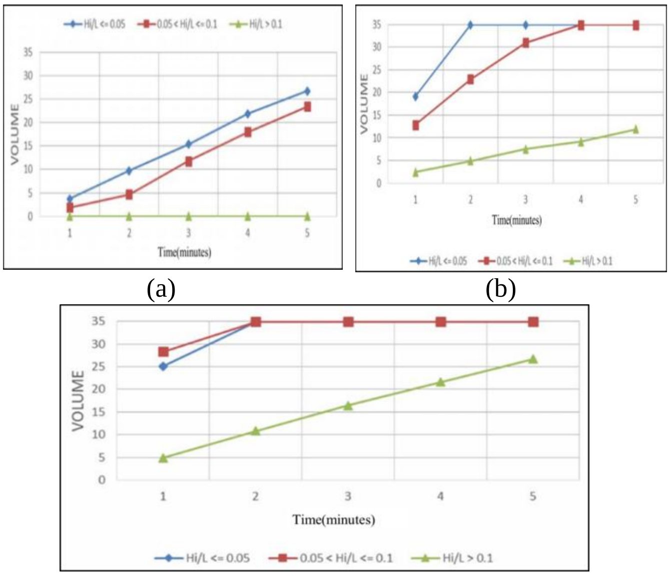


(a) (b)



(c)

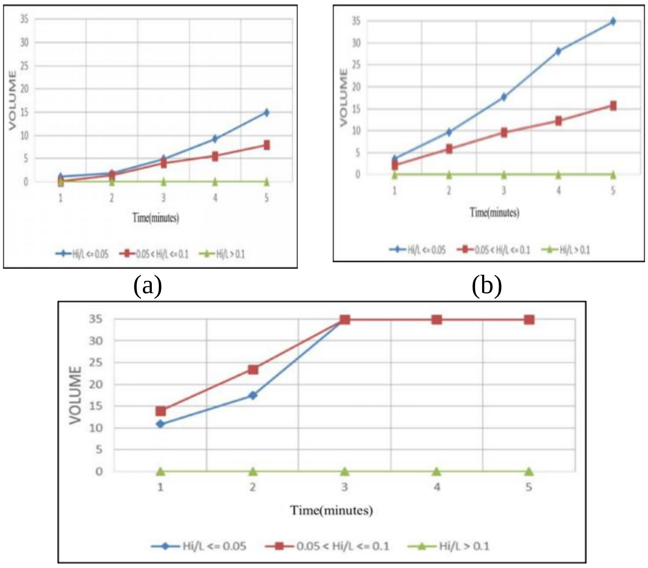
Fig. 5 Graph of Time and Volume Relationships in Model Slope a) 1: 2, R_c 12.5 b) 1: 2, R_c 10 c) 1: 2, R_c 7.5



(a) (b)

(c)

Fig. 6 Time and Relationship Graph Volume on Model Slope a) 1: 2.5, R_c12.5b) 1: 2.5, R_c 10 c) 1: 2.5, R_c 7



(a) (b)

(c)

Fig. 7 Time and Relationship Graph Volume on Model Slope a) 1: 3, Rc12.5, b) 1: 3, Rc10, c) 1: 3, Rc 7.5

IV. CONCLUSION

Based on these results, it can be concluded that:

1. The parameters that influence the magnitude of the wave overtopping breakwaters hypotenuse is the wave period (T), the incoming waves (Hi), height of freeboard (Rc), and the slope of the front side of the structure (tan θ).
2. The distance between the peak of the breakwater and the water level or Rc also affect the volume of overtopping. That is, the smaller the value, the greater Rc overtopping volume produced.

ACKNOWLEDGEMENT

The author would like to acknowledge Civil Engineering Department, University of Hasanuddin for unconditional support.

REFERENCES

1. S. Mehrangiz, Y. Emami, S.H.S. Sadigh, and A. Etemadi, International Journal of Smart Grid and Clean Energy **2**, 289 (2013).
2. A.F.D.O. Falcão, Renewable and Sustainable Energy Reviews **14**, 899 (2010).
3. J.P. Kofoed, Wave Overtopping of Marine Structures Utilization of Wave Ene, thesis, 2002.
4. E.Mehlum, in *Hydrodynamics of Ocean Wave-Energy Utilization* (Springer, Berlin, Heidelberg, 1986), pp. 51–55.
5. L. Margheritini, D. Vicinanza, and P. Frigaard, Renewable Energy 34, 1371 (2009).
6. P. Contestabile, F. Vincenzo, E.D. Lauro, and D. Vicinanza, Coastal Engineering Proceedings 1, 12 (2016).
7. D. Ünsalan, Scientific Bulletin of Naval Academy 19, 304 (2016).
8. M.F. Ahmad, M.A. Musa, A.Y. Maliki, O. Yaakob, K. Samo, and M.Z. Ibrahim, Journal of Environmental Science and Technology 9, 417 (2016).
9. P. Troch, J. Mollaert, S. Peelman, L. Victor, J.V.D. Meer, D. Gallach-Sánchez, and A. Kortenhaus, Coastal Engineering Proceedings 1, 2 (2014).
10. Z. Liu, Z. Han, H. Shi, and W. Yang, International Journal of Naval Architecture and Ocean Engineering 10, 651 (2017).