Experimental study of wave transmission in slope crest floating breakwater

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Abstract. Studies on floating breakwater become increased in the past two decades. Researchers proposed some types of floating breakwater which is among them the Pi-type model. The performance of this model is still under development. In this study, a new model is made by modifying the PI-type breakwater by two slopes in the crest from the centreline down to both sides of the model, named slope crest floating breakwater (SCFB). A series of regular waves in intermediate water depth was generated to evaluate the performance of the model reducing transmission waves to shoreward. It was found that transmission coefficient ranging from 0.31 to 0.86. An empirical formula has been proposed to calculate the transmission coefficient for practical purposes. Further study is required to simulate wave transmission through various model dimensions. Furthermore, wave force measurement is also required.

1. Introduction

In the past decade, floating breakwater (FB) has been developed both in research and engineering application. The advantage of FB over conventional rubble-mound breakwater in reducing wave and costs under specific conditions such as short wave period, large water depth and poor seabed condition. McCartney [1] categorized FB into box, pontoon, mat and tethered float.

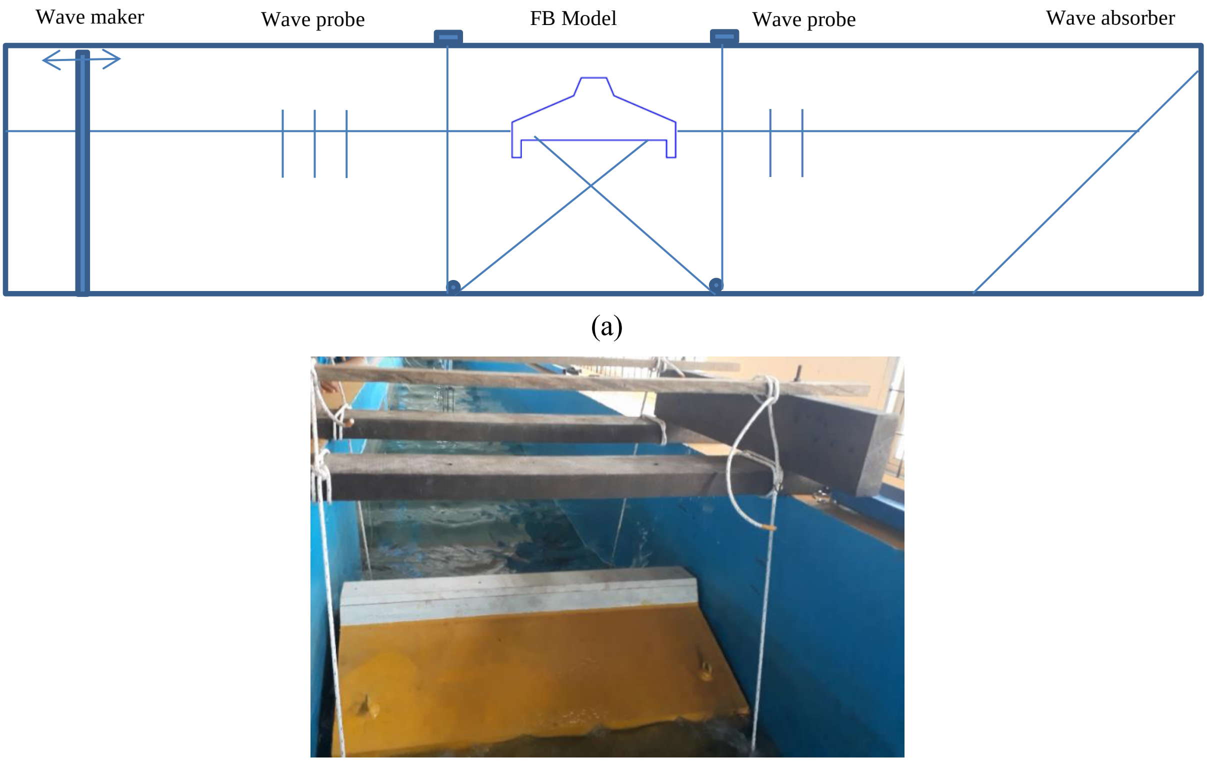
PI-type floating breakwater was introduced by Gesraha [2] by improving a floating rectangular breakwater. A growing number of companies over the world have patented shapes of PI-breakwater [3]. The performance of floating breakwater is mainly expressed by both transmission and reflection coefficient. Transmission coefficient defined as the ratio of transmitted to incident wave height, while reflection coefficient defined as the ratio of reflected to incident wave height.

Wave transmissions under PI-type floating breakwaters have been studied in a series of works based on numerical simulation and laboratory experiments. The presence of protruded plate downward results in increased added mass and damping coefficients. The surge and pitch added mass coefficient tend to be maximal at the long wave extreme [2]. The transmission coefficient decreases with an increase in relative plate height. The transmission coefficient decreases from unity in the long wave limit to zero at the point of complete reflection, where the breakwater acts as a complete vertical barrier. Rahman et al. [4] proposed a new type floating breakwater and compared its transmission coefficient with that of PI-type breakwater. PI-type gave smaller transmission coefficient than proposed model in relatively long wave.

PI-type floating breakwater reduces incoming wave due to reflective effect of vertical wall. In this study, modification is done by making slope crest instead of flat crest PI-type floating breakwater here in after called as Slope Crest Floating Breakwater (SCFB). This idea based on study of trapezoidal FB [6]. The aim of this modification is to increase dissipation wave due to run up and rundown on the slope crest. Performance of proposed model compare to PI-type breakwater in term of transmission and reflection coefficient.

2. Methods

Physical model was tested experimentally on a 24 m long, 1.0 m wide and 1,2 m deep wave flume of the Coastal and Environmental Laboratory of the Faculty of Engineering Hasanuddin University which is equipped with a flap-type wave maker. The sidewalls of the wave flume are made of concrete with a smooth coating which is not affected the fluid flow. The facility is equipped with a computer-driven, servo-controlled, piston-type wave maker, manufactured by HR Wallingford. Mount stone diameter 2.0-3.0 cm was placed in the opposite end of the wave flume to absorb the incoming wave. Fig. 1 shows the experimental setup. SCFB model was made by 1.0 cm thickness plywood with fibre reinforced plastic in the outer layer for the watertight. Weights were added inside the model to get the designated draft. The model was placed in the middle of flume tank and was tighten on the floor by four ropes. Table 1 shows model dimension and Fig. 2 shows its definition. In this study, regular waves were generated for 90 seconds for each run. Incident and transmitted waves are measured by using three and two wave probes (manufactured by HR Wallingford) in sea side and lee side of the model, respectively. The three wave probes were used to minimize the effect of reflected wave by model on wave measurement. All wave probes were calibrated in the morning, noon and afternoon to get the accurate measurement. Calibration process was conducted according to description in user manual of wave probe. Wave height and wave period are selected as the typical wave condition by considering a geometrical model scale number of 25 based on Froude scaling. Environmental condition parameters are listed in Table 2.



(a)

(b)

Figure 1. Experimental setup (not in scale). Model and facility layout (a); Wave attack the model (b).

Table 1. Model dimension.

Parameter	SCFB Model
Width, 2*a*	0.75 m
Length, *L*	0.95 m
Height, *t*	0.24 m
Draft, *h*	0.026 m
Weight, W	34.2 kg

Table 2. Environmental condition.

Parameter	Value
Wave period, *T*	1.0 s; 1.41 s; 1.73 s; 2.0 s
Wave height, *H*	0.02 m ~ 0.17 m
Water depth, *d*	0.5 m; 0.6 m; 0.7 m
Water density, ρ	1000 kg/m^3

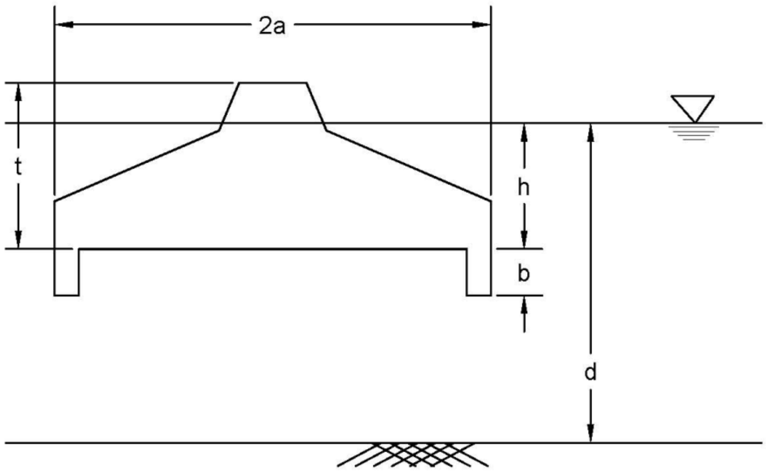
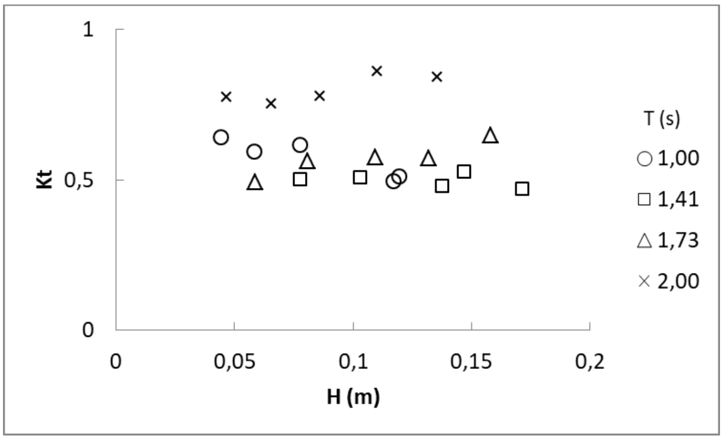


Figure 2. Model dimension.

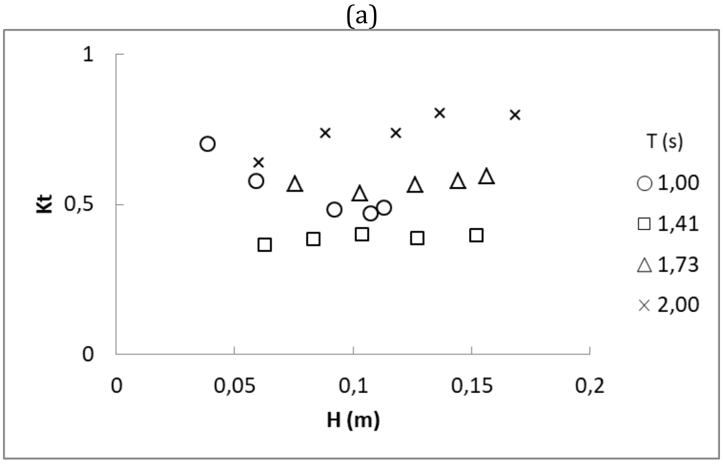
3. Results and Discussions

In this section, performance of FB will be discussed. The effects of environmental condition and model parameter were investigated by measuring incident and transmission wave.

Fig. 3 shows the effect of incoming wave on transmission coefficient. It is indicated that FB achieves smaller *Kt* at relative shortwave. However, it could not achieve its performance in relative bigger wavelength especially in deep water. This is due to heave motion allows the wave passing under the FB. Since the limitation of the previous study experimental data, comparison is done by collect some similar main dimension geometry of FB structure [3, 4]. Data was collected in laboratory to investigate 90.0 kg PI-shaped breakwater [4]. Another fourteen set data collected by Gesraha [3] to investigate PI-shaped breakwater for a/d = 0.3765, h/a = 0.3125 and b/a = 0.75 with additional numeric simulation. Fig. 4 shows the result of these experiments, where k is the wave number. It can be seen that the present study data relatively close to the numerical simulation result conducted by Gesraha [3].



(a)



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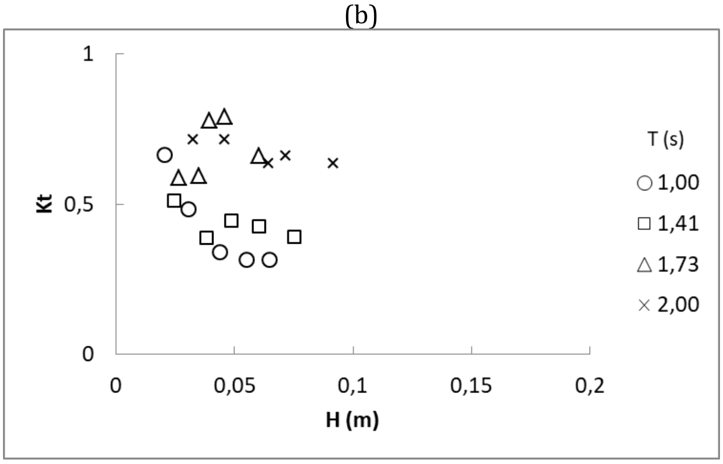

(c)

Figure 3. Transmission coefficient against wave height. (a) d = 0.7 m; (b) d = 0.6 m; (c) d = 0.5 m

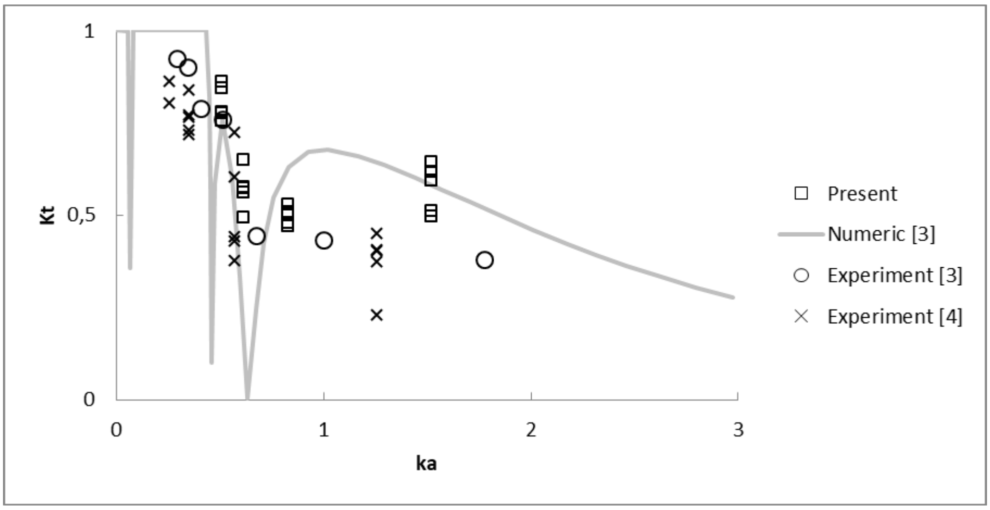

Fig. 4. Comparison of previous study coefficient transmission.

For the application purpose of the experimental result, empirical formula is proposed based on previous study non dimensional parameter of *ka*, *kd* and H/gT^2. By using multiple regression analysis, transmission coefficient is formulated as:

$$K_t = 0.73 - 0.5ka + 0.284kd - 26.4H/gT^2 \quad (1)$$

Fig. 5 shows the comparison of measured and calculated of transmission coefficient using this formula with the coefficient correlation and RMSE are 0.61 and 0.38 respectively.

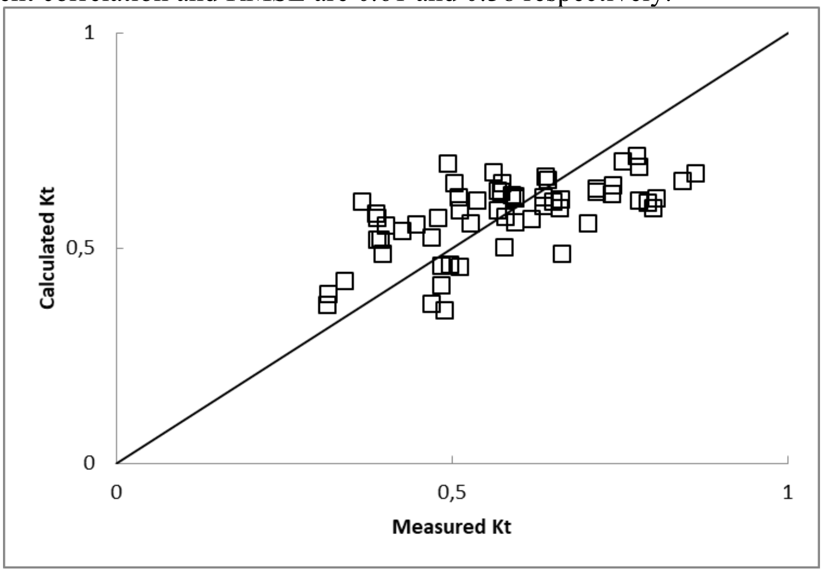

Fig. 5. Comparison of measured and calculated transmission coefficient.

4. Conclusions

Laboratory study has been conducted to evaluate the performance of modified PI-type floating breakwater (SCFB). The incident and transmitted wave height are measured by using three and two wave probes in front and behind of the model, respectively. There are sixty wave runs have been done to collect data with varying wave height, wave period and water depth. Transmission coefficient was found ranging from 0.31 to 0.86. An empirical formula has been proposed based on multiple regression analysis.

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