Performance of a New Floating Breakwater

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Abstract. The need of floating breakwater is increased to protect harbour by wave storm. The study and development of some model have been done in the past decade. However, their model still not effective to protect harbour against wave period greater than 5.0 second. This study deals with performance of a new type floating breakwaters in terms of heaving motion and transmission coefficient. The result compare with heaving motion of PI-type floating breakwater. Heaving motion is evaluated by using seakeeper tools, while transmission coefficient is obtained through laboratory experiment. The results indicate that the performance of proposed model better than PI-type model in terms of motion and transmission coefficient.

1. Introduction
Human activities in the coastal area are increasing by years. Ports, shipyards and floating buildings along the coastline have an important role in supporting human activities at the coastal. In addition, some of these facilities are exist in a relatively higher water depth. Protection of these facilities against wave especially during bad weather condition is very important. Breakwaters are generally built as coastal structures that reduce wave energy so that beach erosion and harbour disturbance can be reduced. The construction can be built from rubble mound or imperial buildings that sit on piles of stone as a foundation.

The increase in human activities at sea encourages an increase in the need for broader waters of the port and is followed by greater water depths as well. This results in conventional breakwaters being ineffective in both technical and economical aspect. Furthermore, based on wave theory, it is known that wave energy is concentrated in the sea surface area and decreases towards the seabed. A floating body may experience movement at six degrees of freedom resulting in the structure being less effective in absorbing waves. These issues underlay so that research related to floating breakwaters has been increased in the last few years.

Floating breakwaters (FBs) classification has been discussed briefly by Dai [1] as: box-type, pontoon-type, frame-type, mat-type, tethered float type, horizontal plate type and other types. Among these types, box-type and pontoon-type breakwaters are the most common design and effective in protecting beaches by reflecting incoming waves. The shape can function effectively at FBs width ratios of one third of the wavelength. So it is less effective to absorb relatively long waves. Pontoon type breakwaters has been developed further by some researcher. Combination of several boxes or pontoons and frames produces frame type breakwater. It reduces wave energy through reflection, but also through flow interference by the frame. Laboratory test results show that reduction in incident wave height is effective for small width and wave length values. While Gesraha [2] introduce PI-type floating breakwater by adding upright curtains on two sides of pontoon-type floating breakwater.
Mathematical models [3, 4] and laboratory experiment [4] have been used to investigate movement, hydrodynamic forces and wave transmissions of pontoon-type floating breakwaters. The effect of the addition of two porous side plates on the performance of a rectangular breakwater has been studied by using mathematical model [5]. Model predictions of transmission coefficient for PI-type floating breakwater have been developed by Ruol [6] and Kolahdoozan [7]. The latter can be used for shallow and intermediate water depth.

One method used to reduce the movement of FBs is by anchor it to the seabed. However, water level fluctuations due to tides result in low tide conditions which are still less effective because the tension of the strap is reduced. For this reason, the development of the existing floating breakwater type is a challenge. One indicator for choosing the best performance is a model with relatively small heaving motion.

In this study, a new modified pontoon-type breakwater is developed. Damping effect on heaving motion is considered by making bottom part adopting the idea of floating body studied by Clauss [8]. Flat top of the design can be useful as berthing facility. Performance of proposed model compare to PI-type breakwater in terms of heaving motion and transmission coefficient. Figure 2 shows both models used in the experiment.

2. Methods
Heaving motions are analysed by using Seakeeper tools provide by Maxsurf software. A new floating breakwater model is evaluated in terms of transmitted wave coefficient ($K_t$). This value is obtained by experimental study 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 at Universitas Hasanuddin which is equipped with a flap-type wave maker. Incident and transmitted waves are measured by using three wave probes both in sea side and lee side of the model. Wave heights and wave period are selected as the typical wave condition by considering a geometrical model scale number of 25. Environmental condition parameters are listed in Table 2.

![Experimental setup](image)

**Figure 1.** Experimental setup

| Table 1. Model dimension |
|--------------------------|
| **Parameter** | **PI-type** | **New model** |
| Width, $B$ (m) | 0.4 | 0.4 |
| Height, $h$ (m) | 0.38 | 0.597 |
| Draft, $D$ (m) | 0.22 | 0.537 |
3. Results and Discussions
Freely motion of FBs characteristics is required to the performance of the breakwater can be evaluated in terms of coefficient of transmission and reflection.

In this section, two parameters are evaluated in terms of heaving motion and transmitted wave coefficient. Heaving motion is obtained by using Seakeeper tools provide by Maxsurf software. While transmitted wave coefficient is obtained from laboratory experiment.

3.1. Freely FBs Heaving Motion
Figure 4 shows relationship of dimensionless wave height $ka$ and RAO heaving motion of both models. It shows that proposed model has smaller peak amplitude heaving motion than PI-type model even both model has same displacement. This is due to the effect of bottom part reducing heaving motion.
3.2. Moored FBs Transmission Wave Coefficient

In order to examine the performance of FB in a quantitative way, the transmission coefficient is investigated further. Transmission coefficient \((K_t)\) is the ratio of transmitted wave height \((H_t)\) to the incident wave height \((H_i)\). The incident and transmitted wave height are measured by using 3 wave probes both in front and behind of the model. There are sixty waves run for each model as shown in Table 2. Figure 5 shows relationship between \(K_t\) against wave period (6.a) and wave steepness (6.b). These Figures show that \(K_t\) value greater than 0.5 is obtained at wave period greater than 1.3 s (6.5 s in prototype scale) which implies that both model are not effective at this wave incident condition. Proposed model has better performance due to smaller \(K_t\) than PI-type model especially at relatively small wave period.

4. Conclusions

A new model of floating breakwater has been evaluated in terms of vertical motion, transmission and reflection coefficient. Some wave parameters are generated to evaluate heaving motion of PI-type and proposed model. The numerical results show that proposed model has a smaller peak value of heaving performance than that of PI-type model at a particular wave condition. Furthermore, performance of proposed model has been achieved to transmit less wave height than PI-type model. Further experiments should be carried out for some width variation.
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References
[1] Dai, J., Wang, C.M., Utsunomiya, T. dan Duan, W., 2018. Review of recent research and developments on floating breakwaters. Ocean Engineering 158, pp. 132-151.
[2] Gesraha, M.R., 2006. Analysis of pi shaped floating breakwater in oblique waves: I. Impervious rigid wave boards. Applied Ocean Research, Vol. 28, pp. 327-338.
[3] Drimmer, N., Agnon, Y., and Stiassnie, M., 1991. A Simplified analytical model for a floating breakwater in water of finite depth. Applied Ocean Research 14, pp. 33-41.
[4] Fugazza, M. and Natale, L., 1988. Energy losses and floating breakwater response. Journal of Waterway, Port, Coastal and Ocean Engineering. Vol. 114, No. 2, pp. 191-205.
[5] Cho, I-H., 2016. Transmission coefficients of a floating rectangular breakwater with porous side plates. International Journal of Naval Architecture and Ocean Engineering, Vol. 8, pp. 53-65.
[6] Ruol, P., Martinelli, L. and Pezzutto, P., 2012. Limits of the new transmission formula for pi-type floating breakwaters. Coastal Engineering.
[7] Kolahdoozan, M., Bali, M., Rezaee, M., Moeini, M.H., 2017. Wave-transmission prediction of pi-type floating breakwaters in intermediate waters. Journal of Coastal Research 33 (6), 1460-1466.
[8] Clauss, G.F. and Birk, L., 1996. Hydrodynamic shape optimization of large offshore structures. Applied Ocean Research, Vol. 18, pp. 157-171.