LAPORAN PENELITIAN

“Experimental Study On Floating Breakwater Anchored By Piles”

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Experimental Study on Floating Breakwater Anchored by Piles

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Abstract: Floating breakwaters are applied in order to minimize material cost but still can reduce wave height. In this paper we investigated floating breakwater anchored by piles based on experimental study in the laboratory with model scale 1 : 13. Two types of floating model were tested with several combination wave height, wave period and surface water elevation to determined transmission coefficient. This experimental study proved that floating breakwater with piles can prevent wave height up to 27 cm. The physical model shows that ratio of depth to wave length is less than 0.6 and ratio of model width to wave length is less than 0.3. It is confirmed that if those ratio less than those value the transmission coefficient is higher than 0.5. The result also shown that the first type model of floating breakwater can reduce wave height to 60.4 % while the second one can reduce up to 55.56 %.

1 INTRODUCTION

Ports, dockyard, housing and other coastal facilities are important to support human activities especially in Indonesia whereas 70% are ocean. Coastline is vulnerable to coastal erosion due to strong waves action, therefore coastal protection structure is an important infrastructure to developed utmost against several conditions. Most of breakwater types that has been built in Indonesia is Rubblemound Breakwater type. This type can reduces wave up to 90% (Madsen and White, 1976) with transmission coefficient 0.1 and appropriate for all coastlines, but this structures has several disadvantages such as: they are large structure, difficult to build, deep foundations, and has expensive material cost. Therefore, a floating breakwater was investigated to overcome these problems. Research on floating breakwater has been developed in many countries before this century. At 1930 a floating breakwater is placed in Aomori port in Japan to test its capability to withstand waves (Cheng, et.al, 2013). In China several floating breakwater types has been designed and studied, a variety of flexible and rigid floating breakwater has been carried out and analysed for its stabilization structure and also its mooring configuration. In Indonesia, several floating breakwater research also carried out by Coastal Research Centre from Indonesian Ministry of Public Work and Housing. The floating breakwater consisted of several module with separations and most of mooring configurations are installed with steel cable to foundations, however when this design was built there was a problem with its stability (Gumilang and Kurniadi, 2016). In this research we proposed a floating breakwater anchored by piles to stabilize the structure. Floating body is flexible to water level but the mooring configurations are rigid with pile. The purpose of floating breakwater is to reduce wave height of wave transmitted (Ht) passed the breakwater. Wave transmission coefficient (Kt) is defined by following equation with Hi is incident wave. Transmission coefficient should be small enough as it represents the effectiveness of breakwater.

2 EXPERIMENT STUDY

Floating breakwater experiment was conducted at Ocean Engineering Laboratory, Institute Technology Bandung (ITB). The wave flume is 40 m long, 1.5 m high and 1.2 m wide. Bed was flat with smooth concrete material. Revetment with 1:10 slope and made from rubber was located at the end of the wave flume use to absorb wave reflection. The wave flume is provided with a piston type wave maker, this wave maker can generate monochromatic waves for shallow water with waves height ranging from 0.05 cm up to 0.33 cm. This wave flume system also

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provided with peilschaal, wave probe and a computer to connect with wave probe (Fig.1).

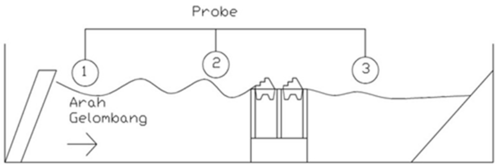


Figure 1: Wave flume system and model configuration.

2.1 Model Scale

The principle of the use of scale model consists of the possibility to reproduce the real problem (the 'prototype') on a smaller scale in such a way that the phenomena in the scale model are similar in model and prototype. This similarity regards various aspects : (i) geometric similarity (ii) kinematic similarity (iii) dynamic similarity. A geometric similarity are based on Froude Number which can be derived by stating that the model and prototype the ratio between inertia and gravity force has to be the same. The scale of a parameter is defined by the ratio between the prototype value and the model value of this parameter. The parameter for defining scale in this research is water depth and maximum wave height based on data at South Java coastal area. Depth at prototype is 900 cm while depth at wave flume is 70 cm. Therefore the geometric scale model defined in Eq (1) where nL is scale, Lp is prototype length and Lm is model length.

$$nL = \frac{Lp}{Lm} = \frac{900}{70} = 12{,}86 \approx 13 \qquad (1)$$

While the scale is 1:13, dimensions for floating breakwater models are shown at Table 1.

Table 1: Dimension for Prototype and Model.

Dimension	Prototype (m)	Model (cm)
Length	10,4	80
Diameter	0,65	5
Width	14,3	110
Height	11,5	88,46 ≈89
Dimension	Prototype (m)	Model (cm)
Water Depth	9	70
Significant Wave Height	1	7,7
	2	15,4
	2,5	19,2

2.2 Floating Breakwater Configuration Model

2.2.1 Floating Breakwater Model 1

Floating Breakwater Model 1 consist of two rows of floating pontoons made from fiberglass. Each of these fiberglass pontoons was 46.5 cm long, 31 cm wide, 22 cm high with the A shape as shown in Fig. 2. Pile dimension was 42 cm high from foundation model. While foundation model was 93 cm long, 110 cm width, and 30 cm.

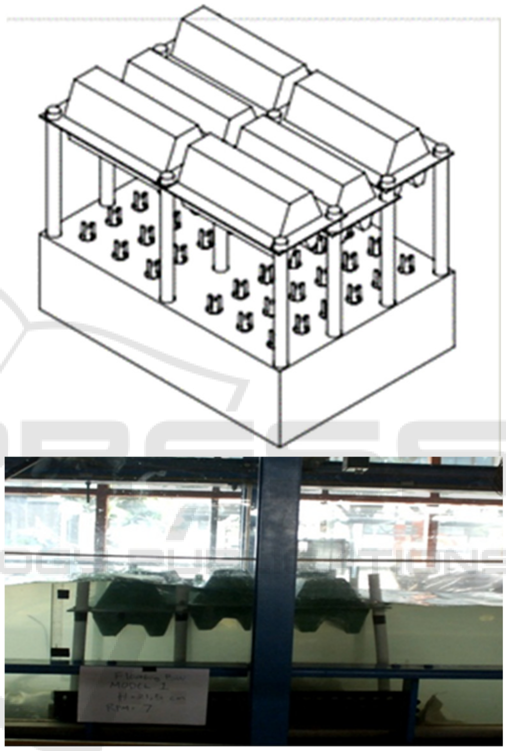


Figure 2: Floating Breakwater Model 1.

2.2.2 Floating Breakwater Model 2

Floating breakwater Model 2 shape was a modification from Model 1, but this model has a sawtooth design to prevent the wave (Fig.3).

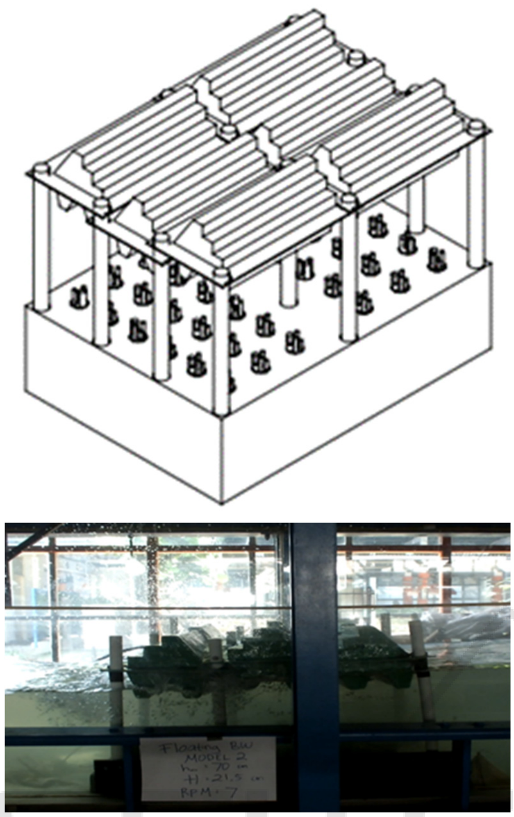


Figure 3: Floating Breakwater Model 2.

2.3 Laboratory Experiments

Three wave probes were installed 2 meter before and 2 meter after floating breakwater to measured wave height (Fig.4). Wave probe in this laboratory was measuring surface water elevation for each second therefore a zero up crossing analysis is needed. Wave probe number 1 is used as measurement for incident wave height while wave probe number 3 is for transmitted wave height. The design conditions of floating breakwater include several significant wave heights varies from 5 cm to 27 cm. Still water level design varies from 70 to 75 cm based on floating breakwater elevation.

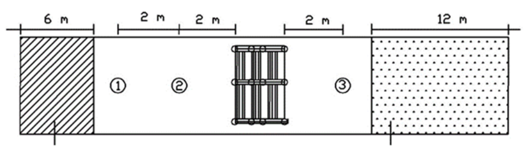
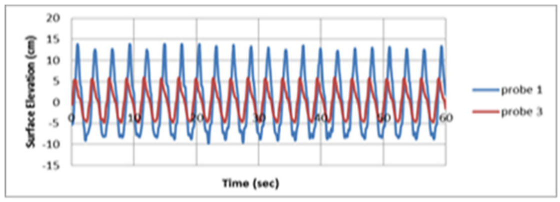
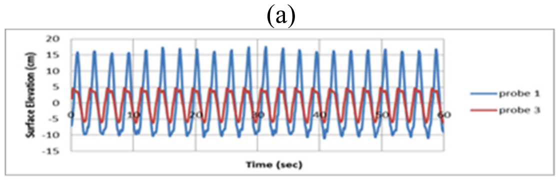


Figure 4: Wave Probe Positions and Model Configuration.

Surface water elevation from design variations were studied over two model floating breakwaters. Figure 5 shows the surface elevation from Wave Probe 1 and Wave Probe 3, this surface water elevation data are analysed for wave incident and transmitted wave. It can be shows that surface water elevation at Wave Probe 3 behind floating structure has reduced. At incident wave height above 20 cm with different water level it shows that this structure can reduce wave height significantly.



(a)



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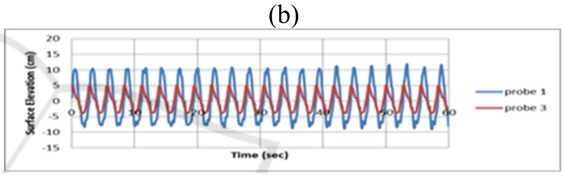

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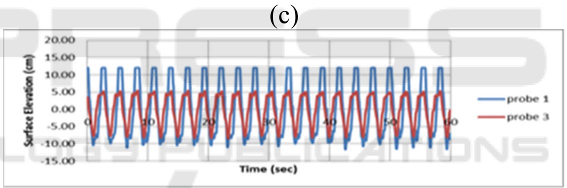

(d)

Figure 5: Surface Water Elevation at Probe 1 (blue line) and Probe 3 (Red Line). (a)Surface water elevation at Model 1 with water depth 70 cm and incident wave height 22.53 cm (b)Surface water elevation at Model 1 with water depth 75 cm and incident wave height 27.79 cm (c)Surface water elevation at Model 2 with water depth 70 cm and incident wave height 20.34 cm (d)Surface water elevation at Model 2 with water depth 75 cm and incident wave height 23.13 cm

3 RESULT AND ANALYSIS

Transmission coefficient and wave height reduction percentage were studied at several variation (Table 3). First variation with Model 1 at water depth 70 cm, at incident wave 6.908 cm yields the transmitted wave height 5.746 cm with the transmission coefficient 0.832 the wave height reduction is only 16.8%. While at the incident wave 22.532 cm the wave height reduction is 53.17%. The condition of model 1 at water depth 75 cm, the wave height reduction is up to 60.471%. Another condition with Model 2, the reduction percentage is lower than previous model. The sawtooth design could not reduce wave height significantly, this design yield higher reflected wave and the transmission coefficient higher than 1. The relationship between transmission coefficient and wave height shows at Figure 6. The bigger incident wave indicates the smaller transmission coefficient. It can be conclude that this floating breakwater structure effective at high wave condition. As floating breakwater body has 22 cm high, incident wave height less than 10 cm could not pass the structure therefore wave height reduction percentage below 20 % and reflected wave occurs. Non dimensionless parameter relation between Kt and Hi/L also indicated that this floating structure effective at high wave condition.

Table 2: Transmission Coefficient and Wave Height Reduction Percentage at Water Depth 70 cm.

Floating Breakwater	Water Depth (cm)	$H_{1/3}$ (cm)		Transmisision Coefficient (Kt)	Wave Height Reduction Percentage (%)
		Hi	Ht		
Model 1	70	6.908	5.746	0.832	16.816
	70	7.421	4.949	0.667	33.308
	70	22.532	10.550	0.468	53.178
Model 2	70	5.333	5.371	1.007	-0.722
	70	7.194	4.515	0.628	37.238
	70	20.348	9.041	0.444	55.566

Table 3: Transmission Coefficient and Wave Height Reduction Percentage at Water Depth 75 cm.

Floating Breakwater	Water Depth (cm)	$H_{1/3}$ (cm)		Transmission Coefficient (Kt)	Wave Height Reduction Percentage (%)
		Hi	Ht		
Model 1	75	7.000	8.646	1.235	-23.511
	75	7.665	5.025	0.655	34.449
	75	27.779	10.981	0.395	60.471
Model 2	75	7.209	7.617	1.057	-5.673
	75	8.164	5.476	0.671	32.922
	75	23.152	14.009	0.605	39.49

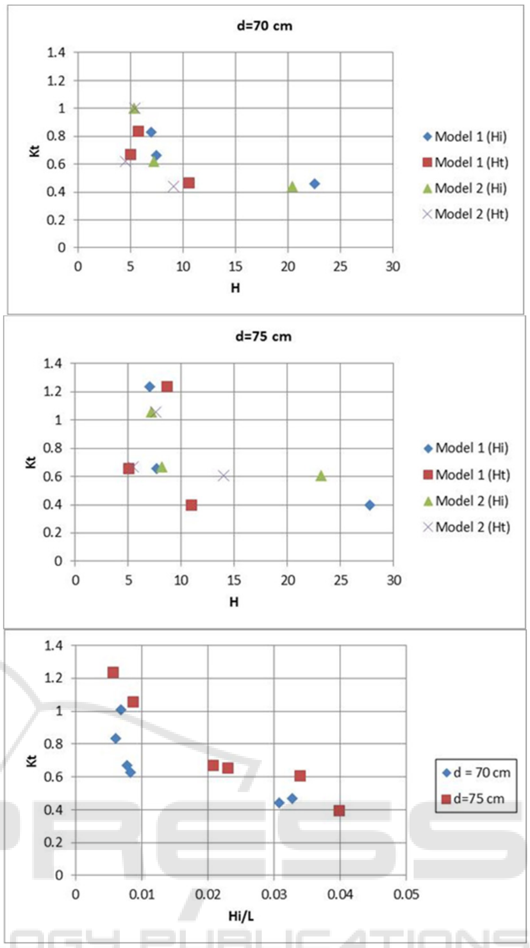

Figure 6: Relation between Transmission Coefficient, Wave Height and ratio Hi/L.

3.1 Wave Transmission Coefficient with d/L

Effect of water depth and wave lenght should be analysed in a non dimension relationship between wave transmission coefficient (Kt), relative depth (d), and wave period (T). Wave length (L) for shallow water is in Eq (2)

$$L = \frac{gT^2}{2\pi}\tanh\frac{2\pi d}{L} \qquad (2)$$

From Figure 7 shows T and Kt with various water depth. As wave period increases, the transmission coefficient also increases. An effective floating breakwater should have lower transmission coefficient, therefore it can be seen that this breakwater should placed in the lower wave period. Figure 8 and 9 shows non dimensionless between parameter Kt vs d/L at various condition. It can be seen that when d/L less than 0.3 and the transmission coefficient is higher than 0.5. Relationship between relative structure width (W) with transmission coefficient also studied here. From previous research by Cheng et al it is conclude that the smaller coefficient get the bigger W/L. Figure 10 shows similar result.

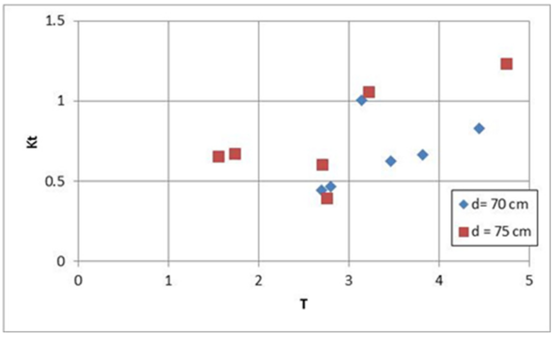

Figure 7: Relation between Transmission Coefficient (Kt) and Wave Period (T).

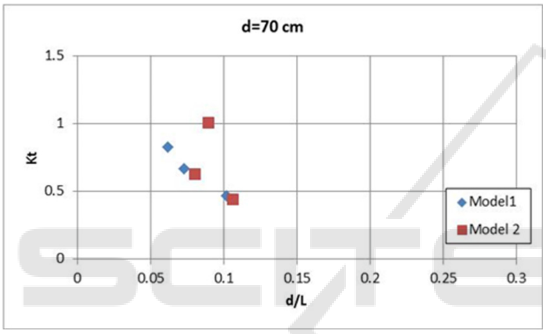

Figure 8: Relation between Transmission Coefficient (Kt) and d/L at water depth 70 cm.

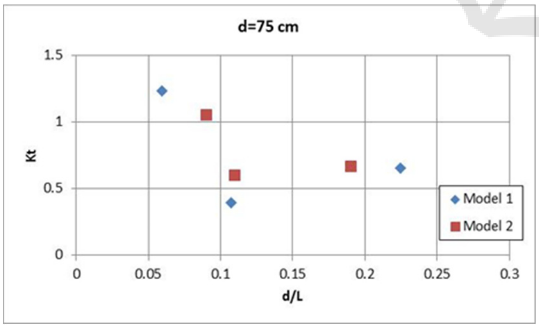

Figure 9: Relation between Transmission Coefficient (Kt) and d/L at water depth 75 cm.

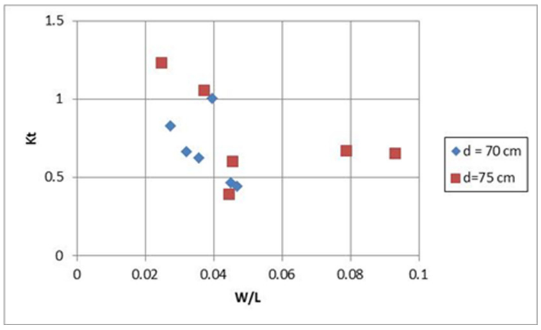

Figure 10: Relation between Transmission Coefficient (Kt) and W/L.

4 CONCLUSION

Wave transmission over floating breakwater anchored by piles have been investigated and analysed experimentally. This floating structure can reduce wave height at high condition up to 23 cm on scale 1:13 geometric scale.

From wave reduction percentage, Model 1 at water depth 70 cm can reduce 16% until 53% while at water depth 75 cm can reduce 34% until 60%. Model 2 can at water depth 75 cm can reduce 37% until 55% while at water depth 75 cm can reduce 32% until 39%.

REFERENCES

L.H. Cheng, C.Y.Fen, Y.H. Li, W.Y. Jiang, 2013. Proceeding of the 7th International Conference on Asia and Pacific Coasts.

O.S. Madsen, S. M. White, 1976. Reflection and Transmission Characteristics of Porous Rubblemound Breakwater. US Army Corps.

R. I. Gumilang, Y.N. Kurniadi, 2016. Jurnal Reka Racana Teknik Sipil Itenas.