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# Experimental study of mooring system and pile system on floating breakwater reviewed from the transmission coefficient

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## Abstract

The main problem in the Indonesian Ocean, especially along the west coast of Sumatra to the south coast of Java, is wave height. High sea waves can damage coastal areas. One method of mitigating this issue is the use of breakwaters, which function as wave energy dampers in specific areas. Large wave impacts can be reduced by decreasing the incoming wave energy so that waves approaching the coast have less energy. Therefore, a wave breaker construction is necessary to break and transmit wave energy effectively. This study aims to determine the transmission coefficient (Kt) value through physical model testing. The results from the physical model test indicated a transmission coefficient of 0.621 with the MU1A d50 L137 draft10 f0167 A010 test model /*Regular Wave*. The research findings suggest that a floating breakwater with a mooring system, placed at a depth of d50 with a draft of 10 cm (half submerged), can dampen wave energy when affected by regular waves, demonstrating its effectiveness in wave energy reduction.

**Keywords:** Floating breakwater, Mooring system, Physical model, Pile system, Transmission coefficient.

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## 1. Introduction

The main problem in the Indonesian Ocean, especially in the west coast of Sumatra to the south coast of Java, is the height of the waves. The height of the sea waves can damage the coastal areas. One method of overcoming the coast is the use of breakwaters, where the structure functions as a wave energy damper in certain areas. The onslaught of large waves can be dampened by reducing the energy of the incoming waves, so that the waves that head towards the coast have less energy. For this reason, a wave breaker construction is needed that functions to break and transmit wave energy. Various types of breakwaters have been known, namely rubble mound breakwater, caisson breakwater, composite breakwater, and floating breakwater [1].

*Floating breakwater* has advantages compared to other types of structures, namely that the structure can be used in soft ground conditions [2] and sea depths of more than 10*feet* [3]. *Floating breakwater* produces minimal interference to water circulation, sediment transport, and fish migration [4] effectively dampens waves less than 2 meters [5] this structure can also be easily moved and reassembled with a different layout to another location [3, 6, 7] does not cause *scouring* [2]. However, *floating breakwaters also* have disadvantages, including being less effective in reducing waves for short waves. Practically, the upper limit of the wave period is 6 seconds with a frequency of 1.6 radians/second; if the mooring structure fails, it will cause a disaster [4] and this structure requires high maintenance costs compared to conventional breakwaters [5].

*A floating breakwater reduces* wave energy by absorbing the wave through its interaction with the wave. Studies on wave transmission and reflection have been conducted by several researchers, both with physical and numerical models on various types of floating breakwaters with different wave characteristics, types of *breakwater*, and the geometric shape of the structure under review. Broadly speaking, there are four types of floating *breakwater*: *pontoon, tethered float, mat,* and *box* [2].

Study *floating breakwaters usually* focus on their performance, namely the ability of the structure to dampen waves (transmission coefficient), the stability of the structure and mooring system in various wave conditions, structure configuration, and location depth [8]. Research conducted by Ofuya [9] with three variations of pontoon draft (s/d), it was shown that wave transmission through the pontoon was greatly influenced by the height of the incoming wave (Hi), wavelength (L), width of the structure (B), depth of water in front of the structure (d), and pontoon draft (s). The transmission coefficient value will reach a minimum at B/L = 0.55 and relative depth (s/d) 0.27. Research by Priadi [10] on floating breakwater pontoon type shows that the pontoon draft(s) will have a significant influence on the transmission coefficient value if it exceeds one-third of the water depth. Dirgayusa and Yowono [11] studied wave transmission through horizontal pipe arrangements, and it was found that the longer the pipe used, the smaller the wave transmission. Additionally, the smaller the diameter of the pipe used, the smaller the wave transmission that occurs.

The research principles of Dirgayusa and Yowono [11] were further studied by Walukow [12] in a series of horizontal plates, it can be seen that the wave transmission that occurs in the floating breakwater plate series ranges from 29% (B/L=0.90) to 94% (B/L=0.15). The energy transmitted by this type of PGT is influenced by the incoming wave parameters (H, L), structure length (B), water depth (d), and distance between plates (s). The longer the plate used, the smaller the wave energy transmitted. The shallower the waters, the smaller the wave energy transmitted.

Heng [13] researched a *floating breakwater stepfloat* type with specifications of 80 cm long, 25 cm wide, 13 cm high, and piled with a pile system at a depth of 20 cm. Heng reported that this type of breakwater can reduce waves by 50-70%. Sujantoko et al. [14] studied the effects of mooring rope angle and water depth on its tension in a floating breakwater porous saw type. It was found that the greater the angle of the mooring rope, the greater the tension experienced by the mooring rope and the *floating breakwater*. This type provides a smaller mooring rope tension compared to the pontoon type. The dynamic behavior of *floating breakwater* types of porous saws has also been studied by Sujantoko Djatmiko et al. [15] it can be seen that the movement surge, *pitch*, and *yaw* are not affected by side waves, so the value of *Response Amplitude Operators* (RAO) is very small, almost approaching zero. Movement of the floating breakwater only affects movements of *heave* and *roll*.

The effectiveness of a wave retaining structure can be assessed by examining the amount of wave energy transmitted through it; the smaller the reduction in wave energy, the higher the wave transmission coefficient. The formulation of the wave transmission coefficient relationship model is derived by analyzing measurements of transmitted and incoming waves based on test variables, namely the height and period of incoming waves, the arrangement and type of the structure, the mooring system of the floating breakwater, and the pile system of the floating breakwater.

## 2. Method

### *2.1. Research Location*

The research was conducted at the Wave Laboratory, Ocean Engineering, Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, Indonesia.

### *2.2. Model Planning and Scale Floating Breakwater*

Physical model design *floating breakwater* must be done as well as possible so that it can truly represent the characteristics of the actual prototype. Therefore, what must be done in designing a structural model is to determine the dimensional scale between the prototype and the physical model by referring to the laws of geometric similarity, dynamic similarity, and kinematic similarity. In addition, the weight scale is also considered because it will affect buoyancy (*buoyancy*). Based on this, a scale of 1:50 is obtained as shown in Table 1 and Table 2.

**Table 1.**
Prototype and Model Dimensions *Floating Breakwater.*

| Dimension | Prototype | | Model | |
|---|---|---|---|---|
| | **1** | **2** | **1** | **2** |
| Length (m) | 55,00 | 55,00 | 1,10 | 1,10 |
| Width (m) | 30,00 | 15,00 | 0,60 | 0,30 |
| Height (m) | 10,00 | 10,00 | 0,20 | 0,20 |

**Table 2.**
Prototype and Model Parameter Scales Floating *Breakwater.*

| Parameter | Prototype (m) | Model (m) |
|---|---|---|
| Wavelength (m) | 10,00 | 0,20 |
| | 5,00 | 0,10 |
| | 2,50 | 0,05 |
| Water Depth (m) | 25,00 | 0,50 |
| | 40,00 | 0,80 |

The model *floating breakwater* in this test is designed using a steel plate as the basic material. The selection of the basic material of the model is based on considerations of strength, manufacturing process, and ease of obtaining. The printing of the model shape is done based on the scaling that has been made and adjusted to the laboratory dimensions.

Model *floating breakwater*, which has been designed, before the laboratory test is carried out, calibration is performed. Calibration is conducted to adjust the mass distribution to match the desired mass distribution. The parameters for determining the mass distribution include the location of the center of mass (*center of gravity*, CG) and the radius of gyration of the structure. Additionally, buoyancy (*buoyancy*) is reviewed to assess the total mass of the model. The model will be declared valid if it has been calibrated and has the same dimensions as the scaled structure. In this model, a tolerance value of 5% of the targeted value is used.

*2.3. Configuration Floating Breakwater*

The behavior of wave transmission and wave reflection is influenced by the arrangement of the floating *breakwater to* the direction of the wave. Therefore, in this study, the arrangement was varied to understand the extent of the influence of the arrangement of the floating *breakwater on* the efficiency of wave transmission and reflection. In this study, the arrangement of the placement of the floating *breakwater is planned*, as shown in Figures 1 and 2.

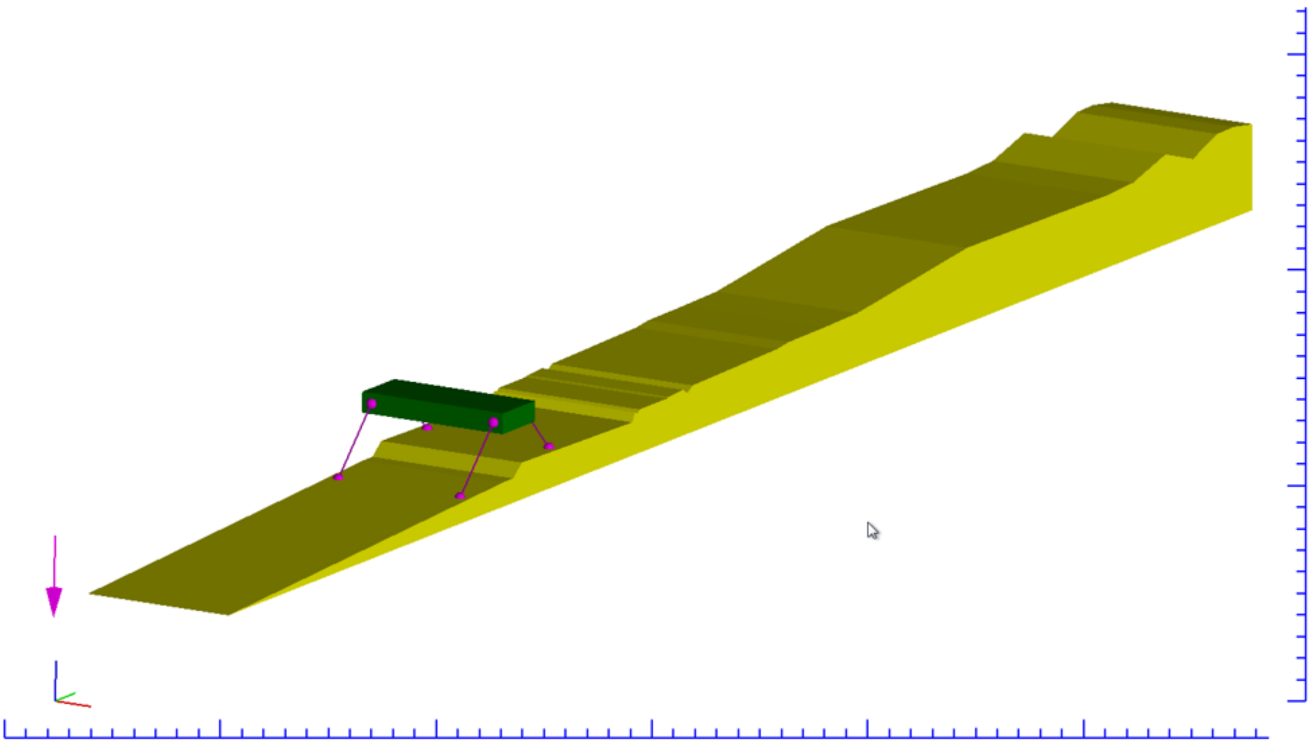

**Figure 1**.
Model Uji MU1A (110 x 60 x 20) *mooring system.*

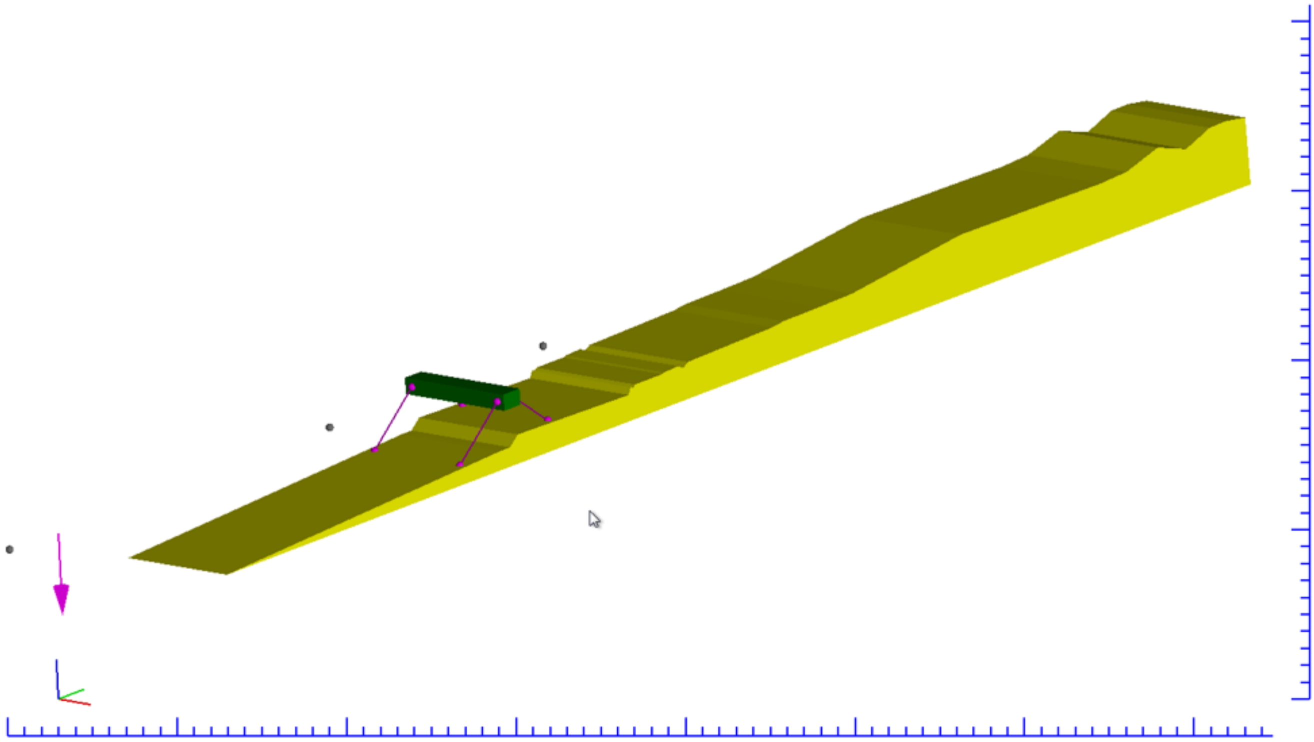

**Figure 2**.
Model Uji MU1B (110 x 30 x 20) *mooring system.*

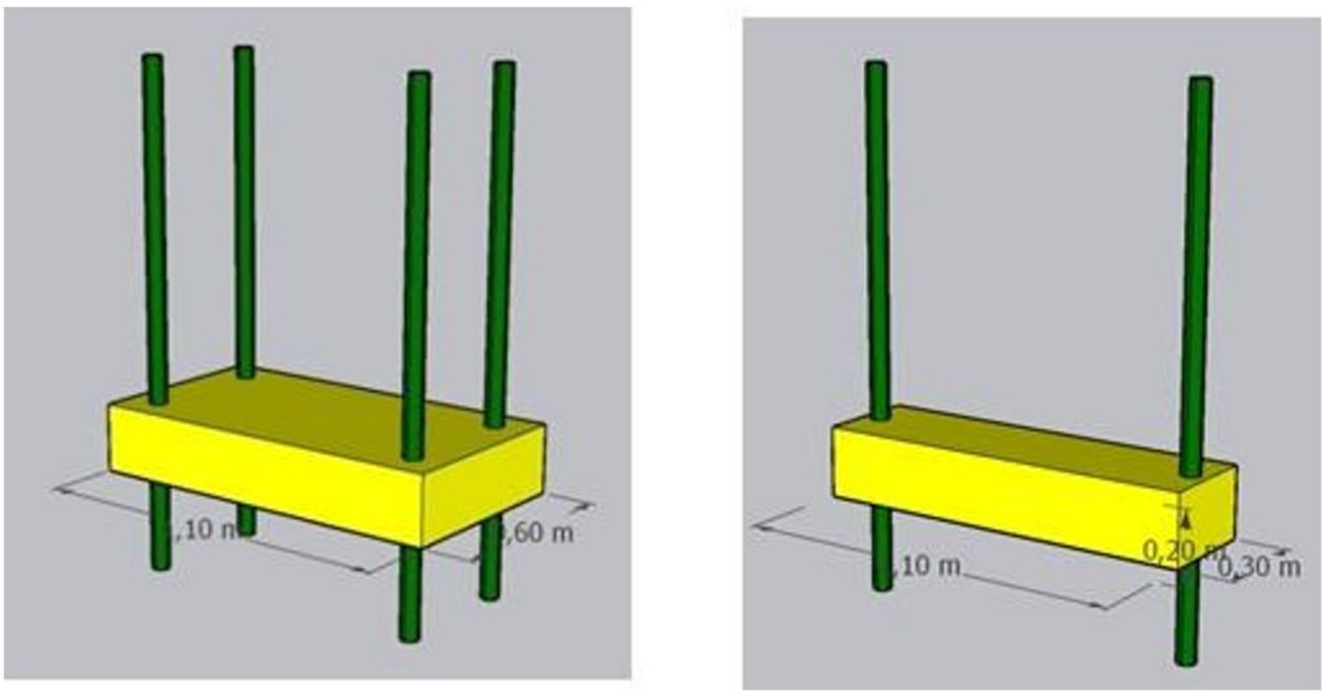


**Figure 3.**
*Pile System* on Test Models MU2A (110 x 60 x 20) and MU2B (110 x 30 x 20).

*2.4. Wave Flume*

The equipment used in this research is a Wave *Flume* (wave test pool) with a length of 40 m, a width of 1.20 m, and a height of 1.50 m, equipped with a plunger-type wave generator. The waves generated can be regular or irregular. The maximum wave height that can be generated is 0.2 m, with a wave period ranging from 4.0 to 8.0 seconds for regular waves. The irregular wave spectrum that can be generated includes Jonswap, Pierson-Moskowitz, ISSC, and ITTC, with a maximum wave height and period of 0.2 m and 8 seconds.

*2.5. Wave Probe*

*Wave Probe is* a wave height measuring tool. When the tool is immersed in water, the electrode measures the conductivity of the water volume. The conductivity varies proportionally with changes in water level elevation. In this study, four wave probes were installed (Figure 3). *The wave* type used in this experiment is the Water Tide Meter WTM-

902, made of stainless steel 304 and PTFE string AWG 30. The maximum sensor capacity is 800 mm, the resolution is 1 mm, and it has the ability to record 60 data points per second.

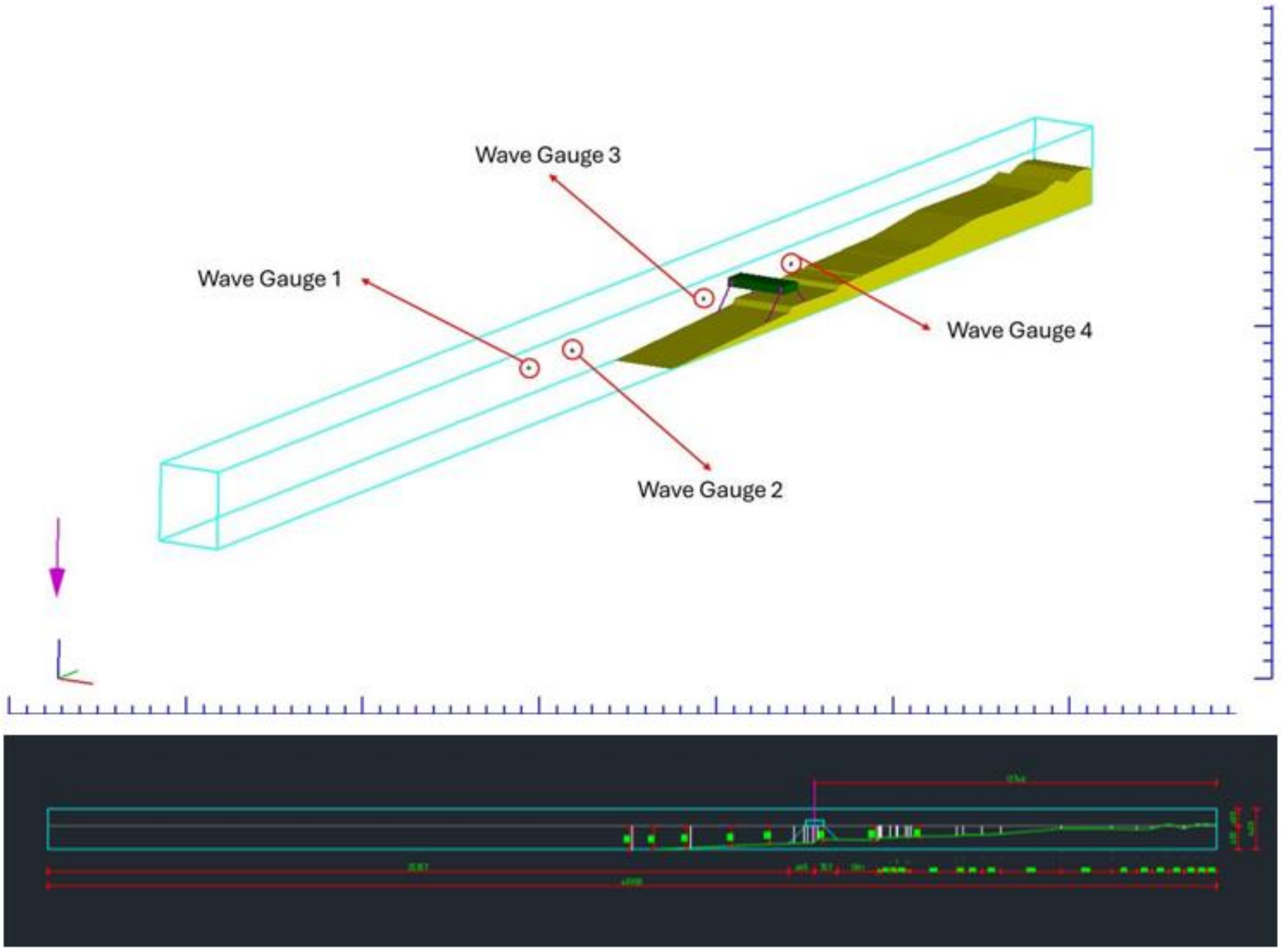


**Figure 4.**
Model Placement Position Floating Breakwater and Wave Probe on Wave Flume.

*2.6. Equipment Calibration*

In order to obtain physical modeling that matches the prototype conditions, it is necessary to carry out calibration to reduce errors during model testing. Because the function of the *wave probe greatly* influences the results of this test, the calibration process for the *wave probe* must be done. The calibration process is carried out by recording the position zero *point* from the *wave probe and* then recording the calibration by raising and lowering the *wave probe* 15 cm from the zero point position. After the calibration recording process is complete, the wave *probe* must be returned to its original position. This calibration is done to find the relationship between changes in the electrode immersed in water and changes in voltage recorded in the recorder.

*2.7. Model Testing*

Physical model testing was carried out to obtain wave transmission data for the floating *breakwater mooring system* and *pile system*. Testing was conducted on regular waves; the wave height range was determined to be between 10 and 20 cm, and the period range was between 0.5 and 3.0 seconds. Data recording takes time according to the wave period, with a minimum criterion of 10 waves [16] or 25 waves according to statistical rules; data collection takes at least 30 seconds to 1 minute. In this study, testing was carried out for 5 minutes in each model scenario. In the transmission test, the transmission coefficient Kt was calculated, which is the ratio of the transmission wave height (Ht) to the incoming wave (Hi).

## 3. Results and Discussion

*3.1. Wave Transmission on Floating Breakwater Mooring System*

The determination of the transmission coefficient of the experimental results is based on the incoming wave energy. The results of the calculation of the transmission coefficient for floating breakwater mooring types for models MU1A and MU1B at a depth of d50 due to *regular waves* are shown in the following Table 3. Based on the table, there is a relationship between the transmission coefficient value Kt and changes in test parameters, namely the width and draft of the model. In general, the influence of the model parameters is almost constant when viewed from the width of the model. Reviewed from the mooring system consequence *regular waves*. It can be shown that at a depth of d50, it tends to have the smallest Kt value, namely 0.621 and 0.622, when compared to a depth of d80, namely 0.734 and 0.935.

**Table 3.**
Experimental Transmission Coefficient (Kt) d50 at Floating Breakwater Mooring System Consequence Regular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 28/11/2024 | MU1A d50 L137 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.906 | 12.099 | 11.603 | 10.461 | 0.902 |
| 2 | 29/11/2024 | MU1A d50 L137 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 9.802 | 11.464 | 11.731 | 9.814 | 0.837 |
| 3 | 29/11/2024 | MU1A d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.268 | 10.397 | 11.851 | 9.160 | 0.773 |
| 4 | 29/11/2024 | MU1B d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.096 | 10.860 | 11.823 | 9.536 | 0.807 |

**Table 4**.
Transmission Coefficient (Kt) Experimental d80 at Floating Breakwater Mooring System Consequence of Regular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 03/12/2024 | MU1A d80 L192 draft10 f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 21.586 | 19.359 | 23.598 | 30.697 | 1.219 |
| 2 | 03/12/2024 | MU1A d80 L192 draft10 f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 18.026 | 20.409 | 14.986 | 21.541 | 0.734 |
| 3 | 03/12/2024 | MU1A d80 L192 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 14.680 | 13.600 | 13.784 | 12.730 | 1.014 |
| 4 | 02/12/2024 | MU1B d80 L192 draftkosong f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 25.409 | 11.597 | 20.234 | 20.589 | 1.745 |
| 5 | 03/12/2024 | MU1B d80 L192 draftkosong f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 25.837 | 22.386 | 20.933 | 21.791 | 0.935 |
| 6 | 03/12/2024 | MU1B d80 L192 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 19.681 | 13.199 | 23.612 | 17.506 | 1.789 |
| 7 | 03/12/2024 | MU1B d80 L192 draftkosong f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 14.687 | 12.111 | 14.929 | 13.816 | 1.233 |
| 8 | 02/12/2024 | MU1B d80 L192 draft10 f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 15.133 | 13.038 | 17.220 | 25.789 | 1.321 |
| 9 | 02/12/2024 | MU1B d80 L192 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 15.993 | 12.282 | 15.899 | 13.379 | 1.295 |

The same is true if you look at the consequences of *irregular waves*. It can be shown that at a depth of d50, it tends to have the smallest Kt value, namely 0.773 and 0.807, when compared to a depth of d80, namely 0.995.

**Table 5.**
Experimental Transmission Coefficient (Kt) d50 at Floating Breakwater Mooring System Consequence Irregular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 28/11/2024 | MU1A d50 L137 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.906 | 12.099 | 11.603 | 10.461 | 0.902 |
| 2 | 29/11/2024 | MU1A d50 L137 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 9.802 | 11.464 | 11.731 | 9.814 | 0.837 |
| 3 | 29/11/2024 | MU1A d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.268 | 10.397 | 11.851 | 9.160 | 0.773 |
| 4 | 29/11/2024 | MU1B d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.096 | 10.860 | 11.823 | 9.536 | 0.807 |

**Table 6**.
Transmission Coefficient (Kt) Experimental d80 at Floating Breakwater Mooring System Consequence of Irregular Waves.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 03/12/2024 | MU1A d80 L192 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.689 | 11.072 | 11.314 | 10.352 | 1.022 |
| 2 | 03/12/2024 | MU1A d80 L192 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.343 | 10.482 | 10.434 | 9.679 | 0.995 |
| 3 | 03/12/2024 | MU1A d80 L192 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.364 | 10.766 | 11.242 | 10.303 | 1.044 |
| 4 | 03/12/2024 | MU1A d80 L192 draftkosong T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 11.896 | 10.793 | 12.624 | 12.891 | 1.170 |
| 5 | 03/12/2024 | MU1A d80 L192 draft10 T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 12.088 | 11.196 | 11.869 | 13.104 | 1.060 |
| 6 | 03/12/2024 | MU1A d80 L192 draft10 T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 11.113 | 10.200 | 12.814 | 12.706 | 1.256 |

Based on this, it can be explained that the construction *floating breakwater*, if applied in the field with a mooring *system*, will result in *regular wave* damping, providing a smaller *Kt*. In this case, it is important to consider the installation location of the *floating breakwater*. If the protected area from wave impact is a port, then the effects of wave reflection and transmission should be prioritized, as wave reflection can influence ship movement. When the reflected wave's timing coincides with the wave's natural period, wave resonance may occur, potentially disrupting ship stability. When used to reduce coastal erosion or abrasion, the reflection and transmission effects should be optimized to minimize the impact of wave reflection. The goal is to achieve a balance where wave reflection is maximized and wave transmission is minimized, ensuring the *floating breakwater* provides effective coastal protection.

### *3.2. Wave Transmission Floating Breakwater Pile System*

On the *floating breakwater pile system*, it can be seen that the empty draft MU2B d50 model provides better wave attenuation than other models (Table 7). The lowest wave transmission is obtained at the value due to a regular *wave*. In Tables 7 and 8, it is known that the greatest wave attenuation occurs at a transmission coefficient of 0.653.

**Table 7.**
Experimental Transmission Coefficient (Kt) d50 at Floating Breakwater Pile System consequence Regular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | | Ht Current (cm) | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 18/11/2024 | MU2A d50 L137 draftkosong f0125 A0025 (Regular Wave) | 2.5 | 5 | 0.125 | 8.000 | 1.868 | 0.860 | 3.396 | 3.593 | 1.058 |
| 2 | 18/11/2024 | MU2A d50 L137 draftkosong f0167 A0025 (Regular Wave) | 2.5 | 5 | 0.167 | 5.988 | 3.980 | 5.297 | 5.383 | 4.017 | 0.746 |
| 3 | 18/11/2024 | MU2A d50 L137 draftkosong f0250 A0025 (Regular Wave) | 2.5 | 5 | 0.250 | 4.000 | 2.625 | 3.137 | 1.881 | 2.905 | 1.545 |
| 4 | 18/11/2024 | MU2A d50 L137 draftkosong f0125 A005 (Regular Wave) | 5 | 10 | 0.125 | 8.000 | 5.128 | 3.089 | 7.322 | 8.102 | 1.106 |
| 5 | 18/11/2024 | MU2A d50 L137 draftkosong f0167 A005 (Regular Wave) | 5 | 10 | 0.167 | 5.988 | 8.102 | 11.107 | 11.368 | 8.362 | 0.736 |
| 6 | 18/11/2024 | MU2A d50 L137 draftkosong f0250 A005 (Regular Wave) | 5 | 10 | 0.250 | 4.000 | 6.279 | 5.925 | 5.023 | 6.661 | 1.326 |
| 7 | 18/11/2024 | MU2A d50 L137 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 18.839 | 12.614 | 21.573 | 14.098 | 0.653 |
| 8 | 18/11/2024 | MU2A d50 L137 draftkosong f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 11.391 | 12.625 | 11.682 | 11.919 | 1.020 |
| 9 | 18/11/2024 | MU2A d50 L137 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 11.671 | 12.775 | 13.332 | 13.706 | 1.028 |
| 10 | 26/11/2024 | MU2B d50 L137 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 15.698 | 16.562 | 21.468 | 15.244 | 0.710 |
| 11 | 26/11/2024 | MU2B d50 L137 draftkosong f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 13.045 | 14.738 | 7.557 | 15.086 | 1.996 |
| 12 | 26/11/2024 | MU2B d50 L137 draft10 f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 15.008 | 16.441 | 21.289 | 14.798 | 0.695 |
| 13 | 26/11/2024 | MU2B d50 L137 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 12.588 | 6.121 | 15.165 | 13.656 | 0.900 |

In theory, if the structure is a *floating breakwater*, the wider the Kt value will tend to decrease because the distance traveled by the wave is longer, so that the resulting wave reduction is also greater. Based on the data above, it is known that the effect of the relative structure width on the transmission coefficient is inversely proportional. This means that the wider the structure, the smaller the transmission coefficient will be. These results are in accordance with research conducted by Heng [13].

**Table 8.**
Transmission Coefficient (Kt) Experimental d80 at Floating Breakwater Pile System consequence Regular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 21/11/2024 | MU2A d80 L192 draftkosong f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 21.261 | 21.024 | 25.632 | 32.994 | 1.219 |
| 2 | 25/11/2024 | MU2A d80 L192 draftkosong f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 14.978 | 19.027 | 26.356 | 37.525 | 1.385 |
| 3 | 21/11/2024 | MU2A d80 L192 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 12.528 | 20.345 | 13.807 | 20.589 | 0.679 |
| 4 | 25/11/2024 | MU2A d80 L192 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 19.715 | 19.113 | 26.464 | 37.626 | 1.385 |
| 5 | 25/11/2024 | MU2A d80 L192 draftkosong f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 10.590 | 19.818 | 13.343 | 11.857 | 0.673 |
| 6 | 21/11/2024 | MU2A d80 L192 draftkosong f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 12.809 | 11.531 | 14.161 | 13.066 | 1.228 |
| 7 | 25/11/2024 | MU2A d80 L192 draftkosong f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 10.321 | 13.117 | 15.369 | 14.615 | 1.172 |
| 8 | 22/11/2024 | MU2A d80 L192 draft10 f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 18.095 | 17.019 | 25.026 | 34.550 | 1.470 |
| 9 | 22/11/2024 | MU2A d80 L192 draft10 f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 12.753 | 6.830 | 12.176 | 18.880 | 1.783 |
| 10 | 22/11/2024 | MU2A d80 L192 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 12.094 | 10.792 | 13.334 | 13.974 | 1.236 |
| 11 | 25/11/2024 | MU2B d80 L192 draft10 f0125 A010 (Regular Wave) | 10 | 20 | 0.125 | 8.000 | 17.249 | 19.846 | 25.713 | 35.247 | 1.296 |
| 12 | 25/11/2024 | MU2B d80 L192 draft10 f0167 A010 (Regular Wave) | 10 | 20 | 0.167 | 5.988 | 10.411 | 17.578 | 12.912 | 21.010 | 0.735 |
| 13 | 25/11/2024 | MU2B d80 L192 draft10 f0250 A010 (Regular Wave) | 10 | 20 | 0.250 | 4.000 | 11.903 | 12.608 | 14.320 | 14.320 | 1.136 |

Based on experiments, it can be shown that the wider the model arrangement, the better. *Floating breakwater* waves that will be reflected will be bigger. Likewise, if we look at the effects of an irregular *wave*, it can be shown that at a depth of d50, it tends to have the smallest Kt value, namely 0.841 and 0.82.

**Table 9.**
Experimental Transmission Coefficient (Kt) d50 at Floating Breakwater Pile System consequence Irregular Wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 26/11/2024 | MU2A d50 L137 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.609 | 10.735 | 11.945 | 10.234 | 0.857 |
| 2 | 21/11/2024 | MU2A d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.645 | 11.731 | 11.805 | 9.933 | 0.841 |
| 3 | 26/11/2024 | MU2B d50 L137 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 11.247 | 10.878 | 11.744 | 10.356 | 0.882 |

**Table 10.**
Transmission coefficient (Kt) experimental d80 at floating breakwater pile system consequence irregular wave.

| No | Date | Test Model | A input (cm) | Hi Input (cm) | f input (Hz) | T Input (s) | Hi Current (cm) | | Ht Current (cm) | | Kt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WP1 | WP2 | WP3 | WP4 | |
| 1 | 22/11/2024 | MU2A d80 L192 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 10.438 | 10.164 | 11.223 | 10.328 | 1.104 |
| 2 | 22/11/2024 | MU2A d80 L192 draftkosong T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 9.744 | 10.509 | 12.433 | 12.151 | 1.183 |
| 3 | 22/11/2024 | MU2A d80 L192 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 9.681 | 9.721 | 11.131 | 12.392 | 1.145 |
| 4 | 22/11/2024 | MU2A d80 L192 draft10 T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 11.140 | 10.742 | 12.943 | 12.332 | 1.205 |
| 5 | 25/11/2024 | MU2B d80 L192 draftkosong T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 8.954 | 10.086 | 10.979 | 9.545 | 1.089 |
| 6 | 25/11/2024 | MU2B d80 L192 draftkosong T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 10.182 | 11.374 | 11.602 | 12.745 | 1.020 |
| 7 | 25/11/2024 | MU2B d80 L192 draft10 T4 H02 (Irregular Wave) | 10 | 20 | 0.250 | 4.000 | 8.886 | 9.818 | 10.699 | 9.765 | 1.090 |
| 8 | 25/11/2024 | MU2B d80 L192 draft10 T6 H02 (Irregular Wave) | 10 | 20 | 0.167 | 6.000 | 9.843 | 11.193 | 11.783 | 13.378 | 1.053 |

## 4. Conclusion

In this research, the structure has been successfully designed as a floating *breakwater mooring system* and *pile system* which tested its wave transmission with experiments. Based on the experimental results, it can be concluded that the test model that can dampen the largest waves is the test model that has a smaller transmission value of 0.621 (MU1A d50 L137 draft10 f0167 A010 / Regular Wave). The results of the study indicate that the wave transmission coefficient (Kt) is greatly influenced by the size of the breakwater material, the type of wave (regular and irregular), and the model configuration used. Larger-sized materials (d80) tend to produce higher Kt values than smaller-sized materials (d50), indicating a greater ability to transmit wave energy. In addition, irregular waves provide higher Kt values than regular waves, indicating that more random or natural wave conditions allow more energy to pass through the structure. Model configurations with or without draft also affect the Kt value, where certain combinations produce more optimal damping performance. Overall, these findings indicate that the selection of material size and breakwater structure design must consider the dominant wave type to achieve maximum effectiveness in controlling wave energy.
The results of this study show that the smallest transmission coefficient is:

1. *Floating breakwater* with *mooring system*
2. *Floating breakwater placed* at a depth of d50.
3. *Floating breakwater* draft 10 cm (submerged 10 cm / half-submerged).
4. *Floating breakwater* consequence of *regular waves*.

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