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THE EFFECT OF SQUARE MODEL SUBMERGED BREAKWATER ON WAVE REFLECTION

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ABSTRACT
Wave reflection is the reflection of waves that occurs when incoming waves hit a wall or barrier. The issue of wave reflection is very important in the design of coastal and harbor structures in particular. The water in the port pool should be calm so that the ship can dock. To get peace in the port pool, a building must be made that can absorb energy or destroy wave energy. A breakwater is a building that functions to absorb or destroy wave energy. One form of the breakwater is the sinking breakwater. The submerged breakwater is a breakwater in which the damped wave is allowed to pass over the construction. The aim of this research is to understand the wave reflection with an asymmetrical arranged square submerged structure. This research was conducted with a sinking square-shaped breakwater model. The model is arranged asymmetrically to see the effect of changing wave reflection on the square-shaped breakwater. The results of this study indicate that the reflection coefficient has an effect on the submerged breakwater model which is arranged asymmetrically. The closer the model is to the water surface, the greater the reflection coefficient value. Likewise, if the model is further away from the water surface, the reflection coefficient value will decrease. This is because the incoming waves are transmitted more than reflected by the height of the structure (model) used.

Keywords: Wave Reflection[1], Submerged Breakwater[2], Square Model[3]

1 INTRODUCTION

Wave reflection is the reflection of waves that occurs when incoming waves hit a wall or barrier. The issue of wave reflection is very important in the design of coastal and harbor structures in particular. The water in the port pool should be calm so that the ship can dock. To get peace in the harbor pool, a building must be made that can absorb energy or destroy wave energy. A breakwater is a building that functions to absorb or destroy wave energy. One form of the breakwater is the sinking breakwater. The submerged breakwater is a breakwater in which the damped wave is allowed to pass over the construction. The aim of this research is to understand the wave reflection with an asymmetrical arranged square submerged structure. This research was conducted with a submerged square-shaped breakwater model. The model is arranged asymmetrically to see the effect of changing wave reflection on the square-shaped breakwater. The results of this study indicate that the reflection coefficient has an effect on the submerged breakwater model which is arranged asymmetrically. The closer the model is to the water surface, the greater the reflection coefficient value. Likewise, if the model is further away from the water surface, the reflection coefficient value will decrease. This is because the incoming waves are transmitted more than reflected by the height of the structure (model) used.

The use of submerged breakwater has recently been widely used (Pina, 1990). In addition to the breakwater function produced by previous researchers, another function of the submerged breakwater is to reduce wave energy coming to the shore through the wave reflection mechanism. The reduction in wave height depends on the size of the wave reflection coefficient. The reflection coefficient of the submerged breakwater tends to increase as the slope gradient of the submerged breakwater gets steeper.

1. THEORETICAL BASIS

a. Wave Reflection

Wave reflection is the reflection of waves that occurs when incoming waves hit a wall or barrier. The reflection phenomenon can be found in the harbor pond. Reflection of waves is determined by different coefficients for different types of buildings. The magnitude of the ability of a building to reflect waves is given by the reflection coefficient, which is the ratio between the reflection wave height Hr and the incident wave height Hi:

$$X = Hr/Hi \qquad (1)$$

With:

X = Reflection Coefficient

Hr = high wave reflection (m)

Hi = high wave come (m)

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The building reflection coefficient is estimated based on model tests. Reflection coefficients for various building types are presented in Table 1

Tabel 1: Reflection Coefficient

Building Type	**X**
Vertical wall above the top of the water	0.7 - 1.0
Vertical walls with submerged peaks	0.5 - 0.7
Pile of stones with slanted sides	0.3 - 0.6
Pile of concrete blocks	0.3 - 0.5
Vertical buildings with energy absorbers (given holes)	0.05 - 0.2

Vertical and impermeable walls reflect most of the wave energy. In such a building the reflection coefficient is X = 1 and the reflected wave height is equal to the incident wave height. The wave in front of the vertical wall is the superposition of the two waves with the same period, height and wave number but in opposite directions.

b. Breakwater

Wave breaker is a building that functions to break sea water waves thereby reducing the energy in sea water waves. The breakwater structure can be made of massive or rigid structures and flexible structures in the form of live plants, rubblemounts and floats. So far, breakwater can be used as a tool in defending coastal damage. The form of the breakwater is divided into 4 parts, namely:

1. Slant side breakwater

2. Upright side breakwater

3. Mixed breakwater

4. The breakwater sinks

The following is an example of the oblique and vertical side break breakwater which can be seen in Figures 1 and 2

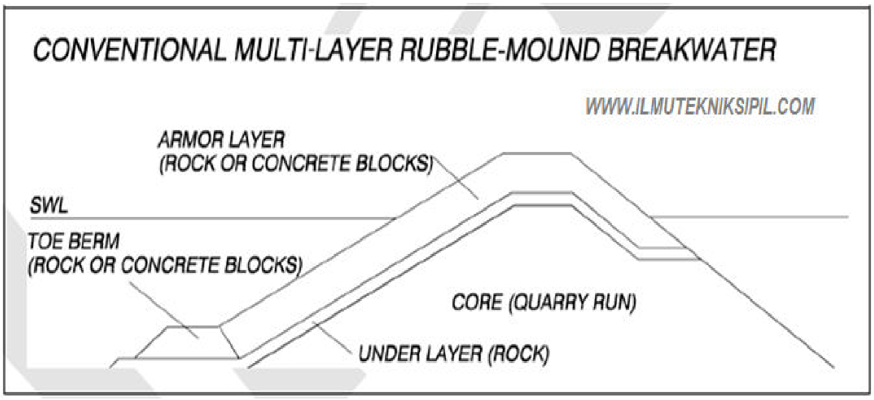

Figure 1. Beveled side breakwater

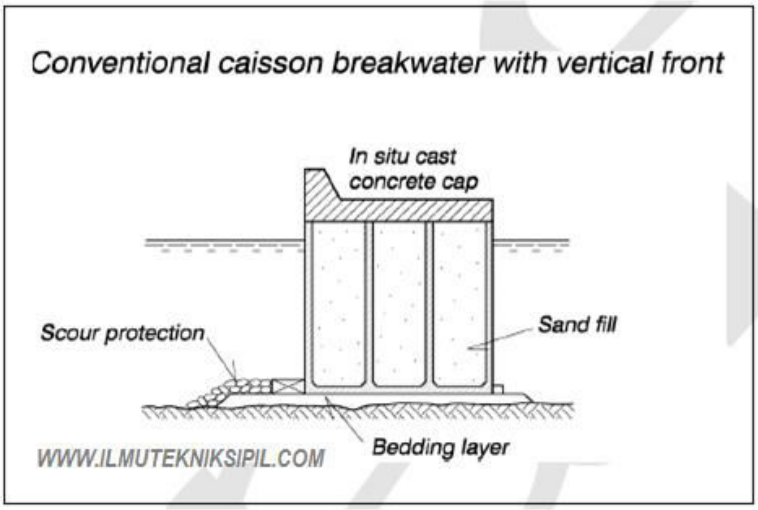

Figure 2. Upright side breakwater

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Basically, the breakwater as an energy damper consists of four types (Triatmojo, 1999):

a. A submerged breakwater is a breakwater where the damped wave is allowed to overturn the construction.

b. Non-submerged breakwater is a breakwater that is hit frontally by the wave during the construction so that the wave immediately breaks when it hits the construction

c. A floating breakwater is a breakwater that is made to float on the surface of the water so that the kinetic and dynamic energy is simultaneously damped by construction

d. Floating (submerged horizontal plate) is a breakwater that is built to float in the water in the form of a plate-shaped construction

2 METHODOLOGY

The research conducted was experimental research in the form of laboratory studies. The literature study is carried out by examining previous studies, specifically related to wave reflection. The research materials used in the laboratory are wood as a model making material, acrylate as a model holder, aluminum glue, rulers, gauges and writing tools.

Research Instruments

1. Digital cameras are used to take pictures directly when doing research in the laboratory
2. The ruler is used to read the wave height in front of the model and behind the model
3. Aluminum glue is used to glue the model with acrylate
4. Stroke is used to adjust the scale of wave generation
5. Other equipment: pens and paper.

In this study using primary data and secondary data. Primary data is in the form of direct observations from the field, namely photos when taking the materials used in the study. Meanwhile, secondary data is in the form of incoming wave height reading data, transmitted wave height and all data generated after reading. Figures 3 and 4 are an arrangement of models with an accrellite length (B) of 100 cm and Figure 5 is an arrangement of models with an accrellite length (B) of 200 cm

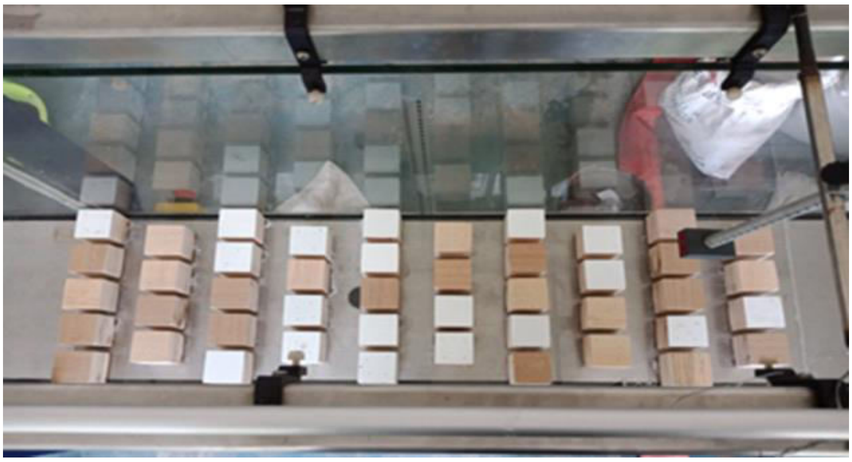

Figure 3: Arrangement of square models in the channel

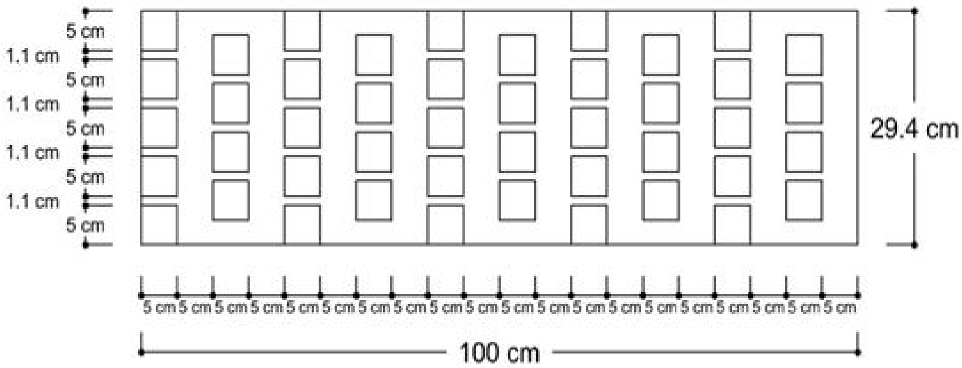

Figure 4: Top view of the model (B = 100 cm)

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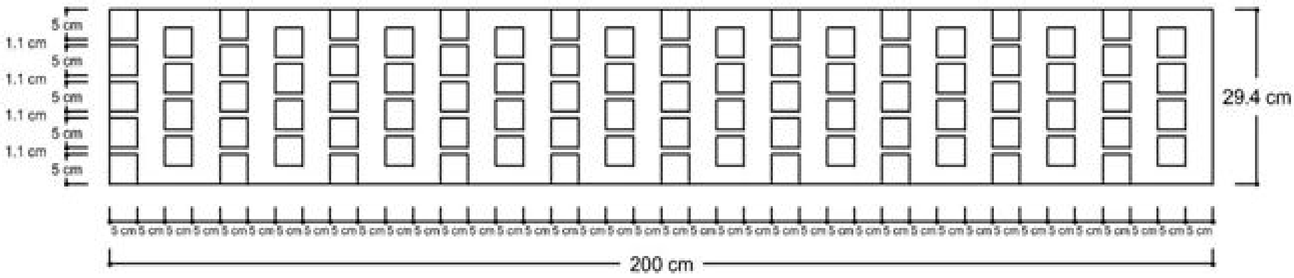

Figure 5: Top view of the model (B = 200 cm)

The data collection technique is in the form of literature study, direct observation in the laboratory in the form of reading the wave height in front of and behind the model. The data analysis technique used is descriptive analysis systematically and accurately regarding facts and situations related to the object of research. Then the data are organized and concluded according to the research variables related to wave reflection. In this study, using an asymmetrical arrangement of a square breakwater. Determination of the arrangement of the model is adjusted to the size of the channel in the laboratory.

3 RESULT AND DISCUSSION

a. Maximum and Minimum Wave Height

The maximum wave height is obtained by subtracting the reading of the wave height in front of the model, namely the peak height minus the trough height. And from the nine measurement points, the results are then selected the most maximum and minimum. Likewise for reading the nine points behind the model. Following are the results of the calculation of the maximum and minimum wave heights for accrellite lengths of 100 cm and 200 cm

Table 2. Maximum and minimum wave height for depth of 10 cm

Stroke	**Depth**	**Period**	**Wave Length**	**Hi**	**Hr**	**Kr**	**Hi/L**
	(cm	s	cm	cm	cm		
4			108	2.35	0.35	0.149	0.022
5	10	1.1	108	2.8	0.3	0.107	0.026
6			108	3.1	0.3	0.097	0.029
4			118	2.2	0.1	0.046	0.019
5	10	1.2	118	2.55	0.15	0.059	0.022
6			118	2.95	0.15	0.051	0.025
4			128	1.6	0.4	0.25	0.013
5	10	1.3	128	2.3	0.2	0.087	0.018
6			128	2.5	0.3	0.12	0.02

Table 3. Maximum and minimum wave height for depth of 15 cm

Stroke	**Depth**	**Period**	**Wave Length**	**B = 100 cm**		**B = 200 cm**	
	(cm	s	cm	Hmax (cm)	Hmin (cm)	Hmax(cm)	Hmin (cm)
4			133	2.7	2.1	1.9	1.8
5	15	1.1	133	3.6	3.2	2.8	2.4
6			133	4.2	3.7	3.1	2.4
4			145	3.1	2.4	2.3	1.8
5	15	1.2	145	3.4	2.9	2.6	2.1
6			145	4	3.5	3.4	3.1
4			158	2.8	2	1.9	1.3
5	15	1.3	158	3.2	2.3	2	1.4
6			158	3.9	3.4	3	1.9

Table 4. Maximum and minimum wave height for depth of 20 cm

Stroke	Depth	Period	Wave Length	B = 100 cm		B = 200 cm	
	(cm	s	cm	Hmax (cm)	Hmin (cm)	Hmax(cm)	Hmin (cm)
4	20	1.1	154	3.8	3.1	2.3	1.7
5			154	4.5	3.9	3.1	2.6
6			154	4.9	4.3	3.4	2.8
4	20	1.2	168	3.8	2.6	2.1	2
5			168	4.4	3.6	3	2.2
6			168	5.2	3.7	3.8	3.6
4	20	1.3	182	3.4	2.1	1.3	1.2
5			182	4	2.6	2	1.9
6			182	4.6	3.1	2.6	2.5

Tables 2, 3, and 4 show the results of the calculation of the maximum and minimum wave heights in front of the model with accrellite lengths (B) for 100 cm and 200 cm. There is a significant difference between the maximum and minimum wave heights with different accrellite lengths. The longer the accrellite (B) for the place to build the model, the lower the wave height that occurs.

b. Height Reflection Wave

The height of the reflection waves is obtained by using the formula, which is to subtract the maximum and minimum wave heights in front of the model then divide by two. To calculate the reflection coefficient, it is obtained by dividing the height of the reflection wave by the height of the incident wave. Tables 4 to 9 show that the reduction in the height of the reflection waves is influenced by the depth of the water in the submerged breakwater structure. Besides that, the accrellite length for the place to compile the model also greatly influences the height of the reflection waves.

Table 4: Reflection coefficient (h = 10 cm and B = 100 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	10	1.1	108	2.35	0.35	0.149	0.022
5			108	2.8	0.3	0.107	0.026
6			108	3.1	0.3	0.097	0.029
4	10	1.2	118	2.2	0.1	0.046	0.019
5			118	2.55	0.15	0.059	0.022
6			118	2.95	0.15	0.051	0.025
4	10	1.3	128	1.6	0.4	0.25	0.013
5			128	2.3	0.2	0.087	0.018
6			128	2.5	0.3	0.12	0.02

Table 5: Reflection coefficient (h = 15 cm and B = 100 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	15	1.1	133	2.4	0.3	0.125	0.018
5			133	3.4	0.2	0.059	0.026
6			133	3.95	0.25	0.063	0.03
4	15	1.2	145	2.75	0.35	0.127	0.019
5			145	3.15	0.25	0.079	0.022
6			145	3.75	0.25	0.067	0.026
4	15	1.3	158	2.4	0.4	0.167	0.015
5			158	2.75	0.45	0.164	0.017
6			158	3.65	0.25	0.069	0.023

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Table 6: Reflection coefficient (h = 20 cm and B = 100 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	20	1.1	154	3.45	0.35	0.101	0.022
5			154	4.2	0.3	0.071	0.027
6			154	4.6	0.3	0.065	0.03
4	20	1.2	168	3.2	0.6	0.188	0.019
5			168	4	0.4	0.1	0.024
6			168	4.45	0.75	0.169	0.026
4	20	1.3	182	2.75	0.65	0.236	0.015
5			182	3.3	0.7	0.212	0.018
6			182	3.85	0.75	0.195	0.021

Table 7: Reflection coefficient (h = 10 cm and B = 200 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	10	1.1	108	2.25	0.35	0.156	0.021
5			108	2.6	0.3	0.115	0.024
6			108	2.9	0.3	0.103	0.027
4	10	1.2	118	2.1	0.1	0.048	0.018
5			118	2.35	0.15	0.064	0.02
6			118	2.65	0.15	0.057	0.022
4	10	1.3	128	1.6	0.4	0.25	0.013
5			128	2.1	0.2	0.095	0.016
6			128	2.3	0.3	0.13	0.018

Table 8: Reflection coefficient (h = 15 cm and B = 200 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	15	1.1	133	2.5	0.3	0.12	0.019
5			133	3.1	0.2	0.065	0.023
6			133	4.05	0.25	0.062	0.03
4	15	1.2	145	1.85	0.35	0.189	0.013
5			145	2.75	0.25	0.091	0.019
6			145	2.95	0.25	0.085	0.02
4	15	1.3	158	2	4	0.2	0.013
5			158	2.45	0.45	0.184	0.016
6			158	2.35	0.25	0.075	0.021

Table 9: Reflection coefficient (h = 20 cm and B = 200 cm)

Stroke	Depth	Period	Wave Length	Hi	Hr	Kr	Hi/L
	(cm	s	cm	cm	cm		
4	20	1.1	154	2.65	0.35	0.132	0.017
5			154	3.7	0.3	0.081	0.024
6			154	4.4	0.3	0.068	0.029
4	20	1.2	168	2.8	0.6	0.214	0.017
5			168	3.6	0.4	0.111	0.021
6			168	4.65	0.75	0.161	0.028
4	20	1.3	182	1.95	0.65	0.333	0.011
5			182	2.8	0.7	0.25	0.015
6			182	3.35	0.75	0.224	0.018

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c. The relationship between the reflection coefficient and the steepness of the wave (Hi/L) in the square model(B = 100 cm dan B = 200 cm)

To see the change in wave height passing through a square submerged breakwater, the relationship that can be drawn is the steepness of the wave (Hi / L) to the reflection coefficient. This relationship is shown in Figures 6 and 7.

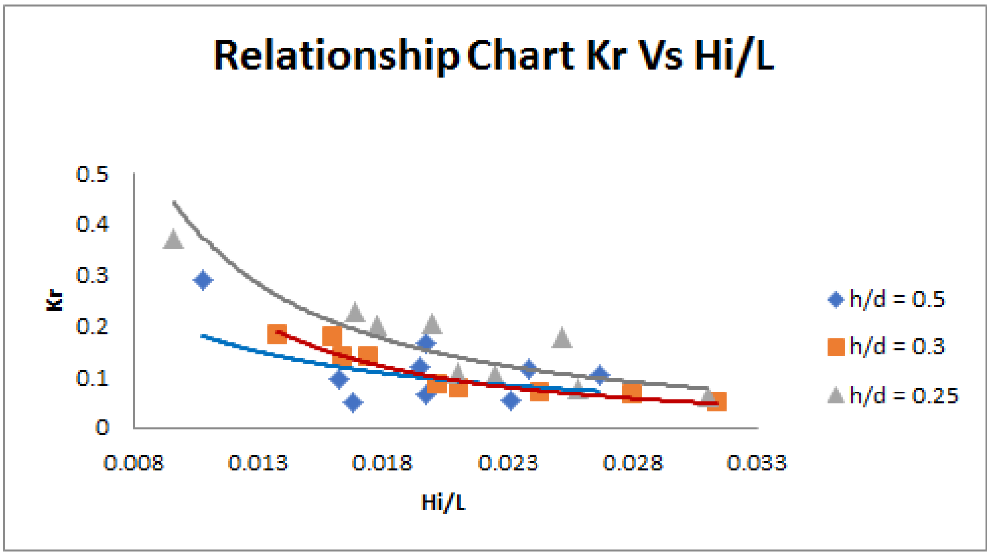

Figure 6: Relationship reflection coefficient and Hi/L (B = 100 cm)

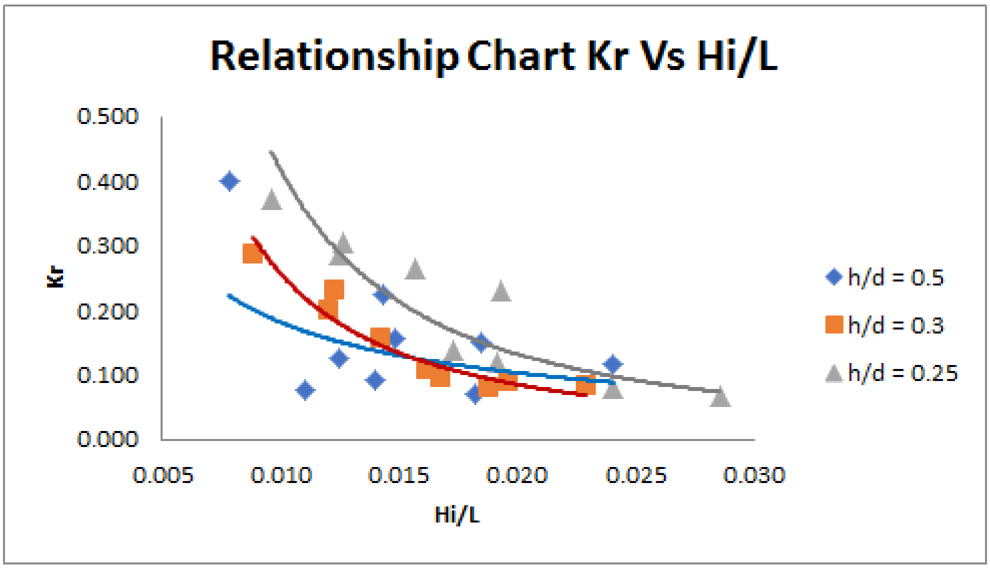

Figure 7: Relationship reflection coefficient and Hi/L (B = 200 cm)

Figures 6 and 7 show that the value of the reflection coefficient on wave steepness (Hi / L) is decreasing. The closer the model to the water depth, the greater the reflection coefficient that occurs. Then the reflection coefficient is also greatly influenced by water depth and the length of the model arrangement. In addition, the reflection coefficient is also influenced by the wavelength, where the longer the wavelength, the smaller the reflection coefficient

4 CONCLUTION

Based on the results of data processing and data analysis, it is found that the square model used as a submerged wave breaker which is arranged asymmetrically affects the reflection coefficient that corresponds to the depth of water and the length of the model (B). The closer the model is to the water surface, the greater the reflection coefficient value. Likewise, if the model is further away from the water surface, the reflection coefficient value will decrease. This is because the incoming waves are transmitted more than reflected by the height of the structure (model) used.

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