LOGIC
Journal of Engineering Design and Technology
Vol. 19 No.3 November 2019; p. 131 - 138

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs.pnb.ac.id/index.php/LOGIC

THE EKSPERIMENTATION STUDY OF WAVE TRANSMISSION TROUGH TYPE OF HOLLOW CUBE BREAKWATER

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Abstract. Erosion that occurs in break water by wave sand currents is a serious problem along coastal and inland shore [1]. This study aimed to assess the effect of the model height (Hm) and the pole density on the model on the reduction of the wave height and on the relationship between the non-dimensional parameter. The research was experimental with 2D physical model simulation which was conducted in the laboratory of Marine Engineering Faculty, Hasanuddin University. Several of configurations of Hollow-type breakwater models were made with different densities and model heights. The model scale use was 1:10 for the three model variations ((M1KB, M2KB, and M3KB) with the variations of the periods and of the wave height, at 0,25 m water depth. The research results indicated that the parameters which showed significant effects were the model height and the model density. These parameters showed the transmission coefficient (K_t) which tended to decrease while the value of the density and model height tended to increases respectively. The value (Kr) also showed an increased response to the increasing value of ψ. This is consistent with the theory that the closer the structure cross-sectional series to the in-coming waves, the greater the response of the reflection wave height. Hence, the is non regression equation which showed the relationship between the non-dimensional parameter ψ with K_t and K_r, was produced $K_t = m.e^{-n\psi}$ and $K_r = p.\ln\psi + q$ where $\psi = \zeta.\frac{H_i}{L}$; m and n respectively 0,6882 and -4,818; p and q respectively 0,046 and 0,3493.

Keywords : Breakwater Hollow Cube Type, Non-dimentional Parameter (NDP), Transmission Coefficient (K_t)

1. INTRODUCTION

One problem that arises along with the development of coastal areas is the occurrence of coastal erosion. Coastal erosion influenced by natural and non-natural factors. So that the damage to the beach is not getting worse, there needs to be handling, one of which is by making a breakwater which aims to reduce the wave energy so that there is a reduction in energy so that it does not cause damage when the waves arrive on the coast. Breakwater buildings are made to protect the coast from wave attacks that have the potential to cause erosion and also protect certain areas from experiencing sea level fluctuations with short periods [1].

So that the damage to the beach is not getting worse, it needs treatment, one of which is by making a breakwater which aims to reduce the wave energy so that there is a reduction in energy so that it does not cause damage when the waves arrive on the coast [2].

Breakwater structures are designed to protect the coast from wave attacks that have the potential to cause erosion and also protect certain areas from experiencing sea level fluctuations with short periods. Pile of stone breakwater (Rubble mound) is a flexible construction wherein the outermost layer is called layer protection (armor layer) which is useful for protecting breakwaters from wave attack. The use of rubble mound breakwater in deep waters will certainly cost a very high (not economical) [3].

Various laboratory scale physical model studies have been done before in the coastal protection. Development of a numerical model for calculating reflections of irregular waves for a cascade breakwater with perforations on some of its walls. The numerical model is then verified by testing the physical model in the laboratory [4].

Testing of the perforated breakwater model, where the structure is a massive structure starting from the bottom to the top of the breakwater with the perforation part at the top [5].

The breakwater model consists of impermeable wave barriers that are installed starting on the surface of the water and extended to some distance below the surface of the water [6].

On the basis of the above, the study of wave transmission through hollow cube type breakwater is carried out as an alternative breakwater for coastal protection. Breakwater in question is in the form of hollow cubes that are printed from concrete. To find out the effectiveness of the performance of the above breakwater, an approach is carried out by testing the physical model of hollow cube type breakwater in the laboratory. This reseacrh aimed to assess the effect of the model height (Hm) and density (ζ) pole on the model of the wave height reduction and gain exposure dimensionless parameter.

2. METHODS

2.1 Research Design

This experiment is a physical test in a 2-D wave channel equipped with wave drive with a flume length of 18.45 m, a width of 1.23 m and a height of 1.22 m. At the end of the channel there is a tilted wave absorber that serves to absorb and reduce wave reflection. This research will use a hollow cube with the arrangement of the pillars of concrete molds as a wave barrier that forms a breakwater. Variation model height is 0.125 m, 0.25 m and 0.375 m, while variations in density are 0.68, 0.64 and 0.59. The model scale use was 1:10 for the three model variations ((M1KB, M2KB, and M3KB) and of the wave height, at 0.25 m water depth as shown in table 1.

Table 1. Arrangement of the pillars of concrete molds

Model	Relative Density (ζ)	Model Height (*Hm*)
Model 1	0,68	0,125, 0,25, 0,375
Model 2	0,64	0,125, 0,25, 0,375
Model 3	0,59	0,125, 0,25, 0,375

The series of simulations performed in this study is to place a hollow cube type breakwater model in the center of the flume equipped with a measuring instrument in front of and behind the model and then the wave is generated as shown in Figure 1 and 2. Simulation parameters consist of density (ζ), model height (Hm), water depth (d). While the parameters observed were the incident wave height (Hi), wave reflection (Kr), wavelength (L), density of each model (ζ), model height (Hm) and wave transmission (Kt).

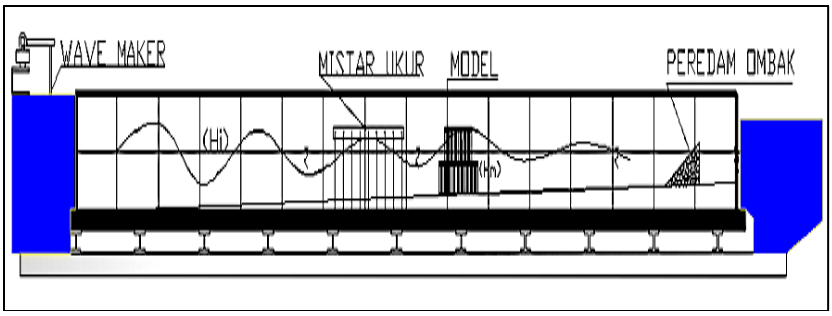

Figure 1. Wave channel 2-D

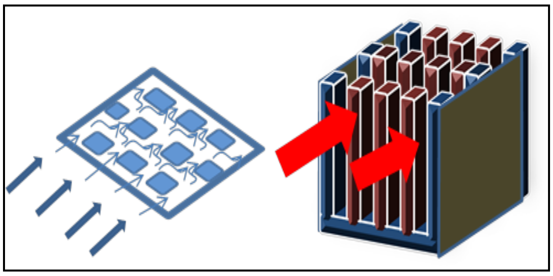

Figure 2. Model sketches

Model simulation procedure is as follows:

1. Perform equipment calibration (setting pulleys for periods and wavelengths, strokes for height and fast wave propagation, and setting the position of breakwater hollow cubes) for recording wave heights (H).
2. After the component is ready, the wave simulation starts without a model by generating waves with power levers on the wave generator control.
3. Then proceed to install the model in the middle of the wave flume
4. The height of the incident wave is measured in front of the position of the model at 9 points
5. Procedures 1 to 5 continue repeatedly on the other models for each model, with variations in density, number of layers, distances, stroke parameters for wave height, fully for the wave period and fixed water depth.

2.2 Research Stages

The stages of the research can be seen in Figure 3.

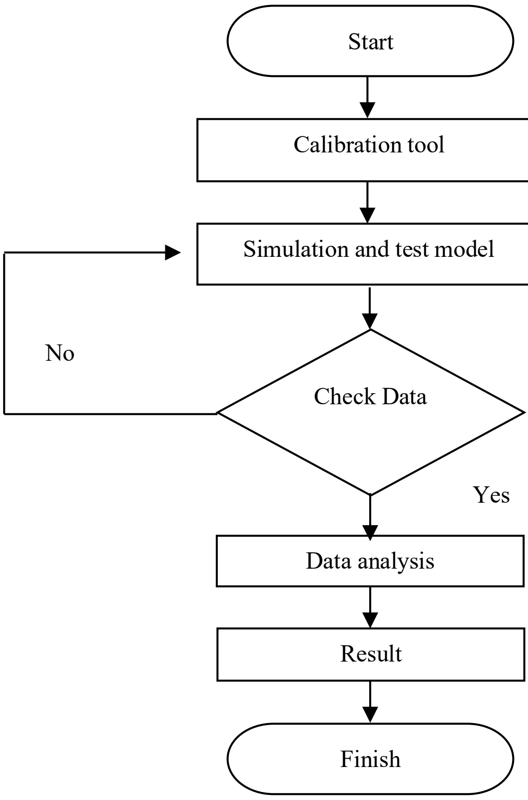

Figure 3. Flowchart of research stage

2.3 Dimension analysis

The data obtained is processed using dimensional analysis to obtain relationships between parameters that will produce dimensionless numbers. The dimension analysis method used in this study is the Langhaar method [7].

Dimensionless number (πj) can be stated:

$$\pi_j = P_1^{k_1} P_2^{k_2} P_3^{k_3} \ldots\ldots\ldots\ldots\ldots P_n^{k_n} \tag{1}$$

Where πj = product of dimensionless numbers with j = 1, 2, 3, ... n. if Pi has dimensions $M^{\alpha i}$, $L^{\beta i}$, $T^{\gamma i}$, then it can be written:

$$\pi_j = \left(M^{\alpha 1k1+\alpha 2k2+....+\alpha nkn}\right) * \left(L^{\beta 1k1+\beta 2k2+....+\beta nkn}\right) * \left(T^{\gamma 1k1+\gamma 2k2+....+\gamma nkn}\right) \tag{2}$$

πj is a dimensionless number if:

$$\alpha_1 k_1 + \alpha_2 k_2 + \dots\dots\dots + \alpha_n k_n = 0$$
$$\beta_1 k_1 + \beta_2 k_2 + \dots\dots\dots + \beta_n k_n = 0$$
$$\tau_1 k_1 + \tau_2 k_2 + \dots\dots\dots\dots + \tau_n k_n = 0 \quad (3)$$

3. RESULTS AND DISCUSSION

3.1 Wave Height (Hi), Transmission (Ht) and Reflection (Hr)

The recording of incident wave height (Hi), transmission (Ht) and reflection (Hr) of the experiments in the 2-D Laboratory at each observation point were taken from the maximum value of Hmax and the minimum wave height of Hmin. The transmission wave height (Ht) is the same as the incident wave height (Hi) but the transmission wave occurs behind the model. The waves came the about / hit an obstacle will be reflected in part the so-called reflection wave height (Hr) as shown for example in table 2.

Table 2. Results of the calculations Hi, Ht, and Hr by high variation models (Hm) and density models (ζ)

Type model	St	ζ	Hm	Wave lenght (L) (cm)	Hi (cm)	Ht (cm)	Hr (cm)
M1KBL1, T= 1,003	St1		12,5	130,928711	7,50	4,50	2,50
M1KBL1, T= 1,025	St2	0,68	12,5	134,909991	6,75	4,75	1,75
M1KBL1, T= 1,048	St3		12,5	139,052187	6,25	4,00	1,75
M2KBL1, T= 1,003	St1		12,5	130,928711	8,50	4,50	2,50
M2KBL1, T= 1,025	St2	0,64	12,5	134,909991	7,50	4,00	2,50
M2KBL1, T= 1,048	St3		12,5	139,052187	7,00	3,75	2,00
M3KBL1, T= 1,003	St1		12,5	130,928711	7,50	3,75	2,50
M3KBL1, T= 1,025	St2	0,59	12,5	134,909991	6,50	3,50	2,50
M3KBL1, T= 1,048	St3		12,5	139,052187	6,00	3,25	2,00

3.2 Transmission Wave Coefficient (Kt) and Reflection (Kr)

The comparison between transmission wave height (Ht) and incident wave height (Hi) is called the transmission coefficient (Kt). The comparison between the reflection wave height (Hr) and the incident wave height (Hi) is called the reflection coefficient (Kr). The amount of wave energy destroyed / muted is called the dissipation coefficient (Kd), for example as in table 3.

Table 3. The results of Kt and Kr calculations are based on variations in model height and model density (ζ)

Type model	St	ζ	Hm	Wave lenght (L) (cm)	K_t	K_r	K_d
M1KBL1, T= 1,003	St1		12,5	130,928711	0,58	0,33	0,09
M1KBL1, T= 1,025	St2	0,68	12,5	134,909991	0,58	0,26	0,14
M1KBL1, T= 1,048	St3		12,5	139,052187	0,64	0,28	0,08
M2KBL1, T= 1,003	St1		12,5	130,928711	0,53	0,29	0,18
M2KBL1, T= 1,025	St2	0,64	12,5	134,909991	0,53	0,33	0,16
M2KBL1, T= 1,048	St3		12,5	139,052187	0,54	0,29	0,12
M3KBL1, T= 1,003	St1		12,5	130,928711	0,50	0,33	0,17
M3KBL1, T= 1,025	St2	0,59	12,5	134,909991	0,54	0,38	0,12
M3KBL1, T= 1,048	St3		12,5	139,052187	0,54	0,33	0,13

3.3 Effect of NDP = (Hi / L) on Kt and Kr

Effect of wave parameters on the transmission coefficient (Kt) and reflection coefficient (Kr) used the dimension of the wave steepness dimensionless. The steepness of the wave (Hi / L) with respect to Kt and Kr for the simulation model height (Hm) and Model Density (ζ) as shown in Figure 4 and 5.

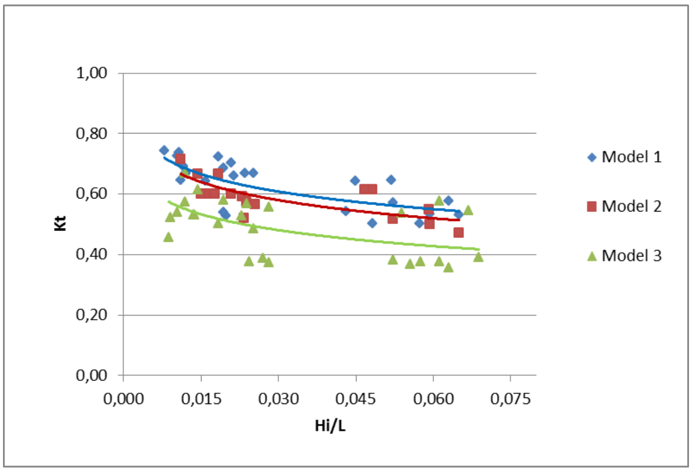

Figure 4. Relationship of Hi / L to Kt based on variations model height (Hm) and model density (ζ)

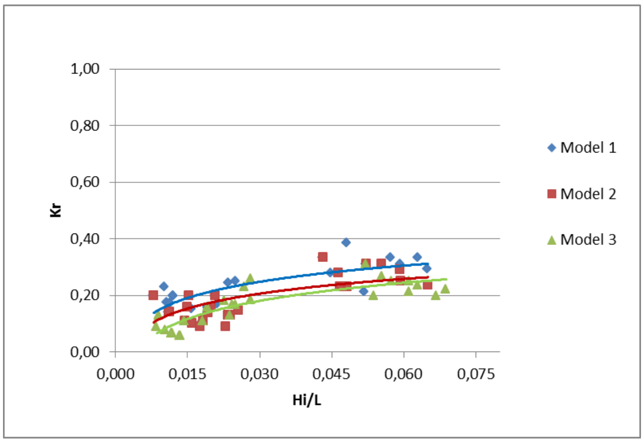

Figure 5. Relationship of Hi / L to Kr based on variations model height (Hm) and model density (ζ)

Based on Figure 4 and 5, shows the value of Kt has decreased significantly with the increasing value of Hi / L. Vice versa for the value of Kr has increased significantly. The change is influenced by the structure density of the model that is able to reduce the waves to be transmitted, as well as to reflect the waves again as the wave steepness that hits the structure increases.

3.4 Effect of NDP = $\zeta.\frac{H_i}{L}$ on K_t and K_r

Analysis of the relationship between the transmission coefficient (Kt) and the reflection coefficient (Kr) with $\zeta.\frac{H_i}{L}$ with a variety of relative and high density models to determine the effectiveness and influence of the characteristics of the model being made. The relationship ψ with the transmission coefficient (Kt) and reflection coefficient (Kr), where $\psi = \zeta.\frac{H_i}{L}$ as the X and Kt axis variables, Kr as the Y axis variable for each type of model, an graph is produced which is an exponential graph as in Figure 6 and 7 (based on the theory "If both progressive and standing waves propagate through an axis media, then the amplitude of the waves will decrease exponentially" [8].

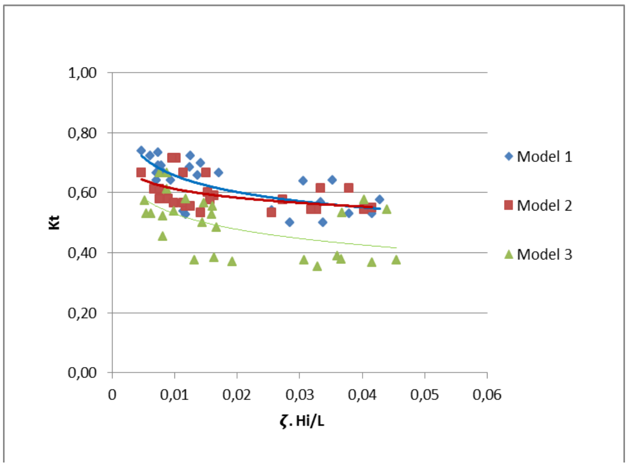

Figure 6. Relationship $\zeta.\frac{H_i}{L}$ with Kt for 3 variations in density and model height.

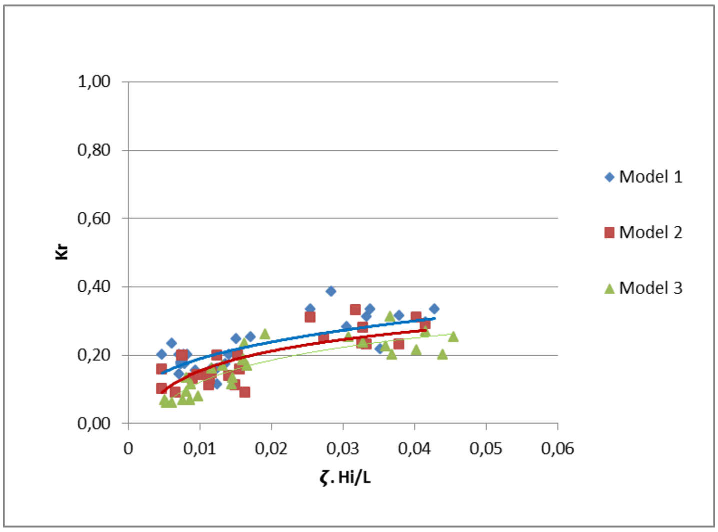

Figure 7. Relationship $\zeta.\frac{H_i}{L}$ with Kr for 3 variations in density and model height.

Based on Figure 6 and 7 for the type of model with variations in relative density and height of the model shows an influence on the steepness of the wave (Hi / L). The greater the density and height of the model, the greater the steepness of the wave so that the transmitted wave gets smaller and the greater the reflected wave.

If all the combined data is plotted in graphical form showing the relationship between ψ and the transmission coefficient (Kt) and the reflection coefficient (Kr) as in Figure 8 and 9.

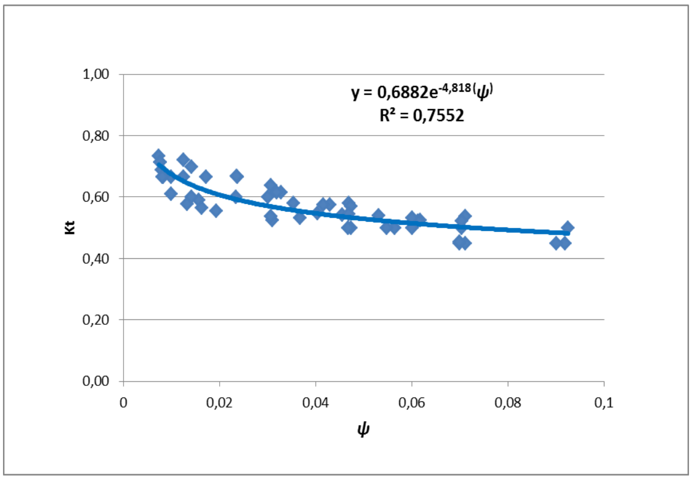

Figure 8. Relationship ψ with K_t

Figure 8 shows that the greater the value ψ the smaller the value of the transmission coefficient (Kt). This is in accordance with the theory, where the height of the wave that passes through an obstacle will decrease non-linear (exponential) with a reduced value of the smaller wave height. This experiment produces an equation of the dimensionless parameter relationship between ψ and Kt.

$$Kt = \frac{Ht}{Hi} = m.e^{-n\psi} \quad (4)$$

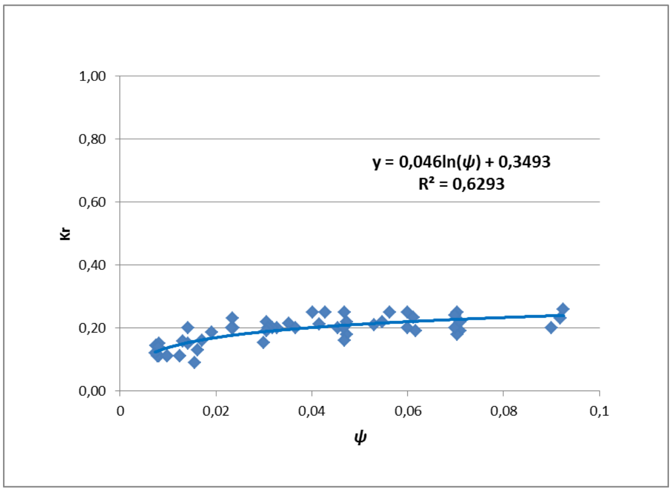

Figure 9. Relationship ψ with K_r

Figure 9 shows the greater the value ψ the Kr value also increased by a significant increase gradient. This is in accordance with the theory, where the closer the cross-section of the model that is subjected to a coming wave, the higher the wave height is reflected by the dimensionless parameter relation equation

$$Kr = \frac{Hr}{Hi} = p.ln\psi + q \quad (5)$$

Where :
Kt = wave transmission coefficient, Hi = coming wave height
Kr = wave reflection coefficient, Hr = reflection wave height
Ht = transmission wave height, Ψ = the Hollow Cube friction parameter = $\zeta.\frac{H_i}{L}$
ζ = density of hollow cube poles, L = wavelength
m and n = constants with values 0.6882 and -4.818, p and q = constants with values of 0.046 and 0.3493. In order to obtain the regression equation for the values of Kt and Kr.

$$K_t = 0{,}6882\ e^{-4{,}818\,(\psi)} \quad \text{with } R^2=0{,}7552 \quad (6)$$
$$K_r = 0{,}046\ln(\psi) + 0{,}3493 \quad \text{with } R^2=0{,}6293 \quad (7)$$

The equation obtained can then be used for planning the wave damping structure using a hollow cube type breakwater structure.

Based on the analysis and dimensionless relationship between the friction parameter (ψ) of the transmission coefficient (Kt) and the reflection coefficient (Kr), where the higher the value of ψ, the lower the value of Kt and the increasing value of Kr. The greater the value of Hi / L (increasingly steep waves) are the model of the Kt value tends to decrease, height models (Hm) also affect the high reduction of the wave through the transmission coefficient, where the higher the model, it tends to be the smaller the value Kt.
As well, the effect of pole density on the hollow cube model (ζ), where the closer the cube poles to the wavelength, the smaller the value of Kt. The effectiveness level of perforated skirt breakwater (PSB) in the long wave category shows the greater the draft breakwater (s), the smaller the transmission coefficient (Kt).

Whereas with the increase in value Kr, the value of Kr also increases with a significant increase in gradient. This is consistent with the theory, where high waves that pass hurdle will be reduced non-linear (exponential) with high reduction value of the smaller waves. A wave damper structure can also be said to be good if the reflection wave thereof is small enough so as not to adversely impact the area in front of it [1]. The same thing was expressed [8], if both progressive and standing waves propagate through a pivot media, the amplitude of the waves will decrease exponentially. Wave transmission depends on the depth of the barrier both at the front and rear of the breakwater while the wave reflection depends on the depth of the barrier at the front of the breakwater [6].

4. Conclusion and suggestion

4.1 Conclusion

Based on the results of research and data analysis that has been implemented, it can be concluded some points as follows:

1. The height of the model has a significant effect on the transmission coefficient (Kt) and the reflection coefficient (Kr), where the greater the value of Hm or the higher the model, the smaller the value of Kt and the greater the value of Kr. Similarly, the pole density ζ models affect the Kt and Kr, where the meeting of the pillars on the model of the transmission coefficient (Kt) is getting smaller and the reflection coefficient (Kr) increases.
2. The research of testing the hollow cube type breakwater model in the Laboratory obtained a dimensionless relationship between the friction parameter (ψ) of the transmission coefficient (Kt) and the reflection coefficient (Kr), where the higher the value of ψ, the lower the value of Kt and the increasing value of Kr and have the equation $K_t = m.e^{-n\psi}$ and $K_r = p.ln\psi + q$, where $\psi = \zeta.\frac{H_i}{L}$; m and n respectively 0,6882 dan -4,818; p and q respectively 0,046 dan 0,3493.

4.2 Suggestion

Based on the conclusion, the suggestion or recommendation from this research is as follows:

1. This research uses 2-D channels made of steel, so it is recommended to use 2-D channels made of glass, in order to facilitate the observation of data
2. This research did not carry out numerical validation of the hydrodynamic characteristics of the breakwater types.
3. Further research needs to be done with variations in the depth of the water in the channel

5. ACKNOWLEDGEMENT

Acknowledgement is given to the marine civil engineering University Hasanuddin for permission to use the Hydrodynamics Laboratory facilities

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