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Transmission and reflection waves on breakwater curtain wall

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ABSTRACT

Breakwaters are needed in harbor pools to get calm waters so that ships can board/unload passengers and load and unload goods safely and comfortably. The curtain wall breakwater is one of the material-efficient breakwaters when compared to the fill type breakwater. This research aimed to ascertain the influence of the wall's depth on the curtain wall breakwater, as well as the steepness of the incident wave, on the transmission and reflection wave values. This research was conducted with a physical model on the wave channel. Based on the results of the study indicate that the more profound the submerged wall relative to the depth (h/d) of the curtain wall breakwater, the lower the value of the wave transmission coefficient (K_t) and the higher the wave steepness (H_i/L) value of the incident wave, the lower the wave transmission coefficient value too. The reflection wave coefficient (K_r) is the opposite.

ABSTRAK

Pemecah gelombang sangat dibutuhkan pada kolam pelabuhan untuk mendapatkan perairan yang tenang sehingga kapal dapat naik/turunkan penumpang dan bongkar-muat barang secara aman dan nyaman. Pemecah gelombang dinding tirai merupakan salah satu pemecah gelombang yang hemat material jika dibandingkan dengan tipe pemecah gelombang tipe urugan. Tujuan penelitian ini adalah mengetahui pengaruh kedalaman dinding pada pemecah gelombang dinding tirai dan kecuraman gelombang datang terhadap nilai gelombang transmisi dan gelombang refleksi. Penelitian ini dilakukan dengan model fisik pada saluran gelombang. Berdasarkan hasil penelitian menunjukkan bahwa semakin dalam dinding terendam relative terhadap kedalaman (h/d) pemecah gelombang dinding tirai maka nilai koefisien gelombang transmisi (K_t) semakin rendah dan semakin tinggi nilai *wavestepness* (H_i/L) dari gelombang datang makanilai koefisien transmisi gelombang semakin rendah juga. Adapun koefisien gelombang refleksi (K_r) berlaku sebaliknya.

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1. Introduction

Some time ago, the variation of the breakwater type was identical to the gravitational type breakwater [11]. The dimensions of gravity breakwaters, such as embankment type breakwaters, will increase according to the depth of the water, starting from the base of the foundation (substructure) of the breakwater, whose dimensions increase significantly so that a large amount of breakwater construction material is required [4-6, 10, 11]. Rubble mound type breakwater, the width and weight of the breakwater structure will increase with increasing water depth and require soil bearing capacity under a good/strong breakwater foundation [10, 17, 20].

One solution to address the problems/weaknesses of a gravity-type breakwater, e.g., embankment-type breakwater, which has large dimensions and a heavy structure that increases according to the depth of the water, is a breakwater with the bottom structure in the form of a pole [14]. One type of breakwater with a bottom structure in the form of a pole is a curtain wall breakwater [8]. Curtain Wall Breakwater is often referred to as curtainwall pile breakwater (CPB), or piles support skirt breakwater (PSSB).

The construction of the curtain wall breakwater allows currents and waves to enter and leave the port pool through the bottom of the breakwater wall so that the water circulation in the harbor pool is relatively good. Fish and other organisms can enter and leave through the curtain wall breakwater so that this type of breakwater is considered an environmentally friendly breakwater [3-6, 12]. The condition of the soil structure at the location of the breakwater placement in the form of a soft soil structure with hard soil structure at depth, a curtain wall breakwater can be a choice with a pile structure [15].

Many types of research on breakwaters with the bottom structure form a pillar similar to a curtain wall breakwater. [9, 19] conducted research on caisson breakwaters with a pile bottom structure, [18] conducted a study to find the transmission coefficient formula on several breakwaters where one type of breakwater was a wall type with a pile-bottom structure, [15] conducted a curtain wall research by proposing a friction coefficient consisting of hydrodynamic characteristics, [13] conducted a numerical study on the pile structure breakwater to obtain wave transmission and reflection [13]. [7] conducted a study on multilayered curtain wall breakwaters to find the wave transmission-reflection coefficient, and [5-6] researched transmission waves and reflection waves on curtain wall breakwaters. Previous researchers have not researched curtain walls with variations in H/L (wave steepness) of incoming waves from 0.00970 to 0.02848.

This study aimed to determine the effect of wall depth on the curtain wall breakwater and the steepness of the incident wave on the transmission and reflection wave coefficients. Research on transmission and reflection waves on curtain wall breakwaters is carried out using a physical model on a wave channel equipped with a wave generator and a damper. The wave height was measured with a wave probe to record wave data with variations in the depth of the curtain wall and wave steepness (wave steepness). Ahmed and Schlenkhoff, in 2014, researched numerical investigation of wave interaction with double vertical slotted walls. Both walls have an impermeable top and bottom with a 50% permeable center. The spectrum of the height of the incident wave, transmission, and reflection wave is calculated using Equation 1 and Equation 2 [16].

$$K_r = \frac{H_r}{H_i} \quad (1)$$

Where H_r = reflection wave height; H_i= incoming wave height

$$K_r = \frac{H_t}{H_i} \quad (2)$$

Where H_t = transmission wave height; H_i= incoming wave height.

The incoming wave strikes a barrier in the form of a pile of rocks, sloping walls, and is permeable (passing water/porus), then the magnitude of the reflection wave height is smaller than the incident wave height. Reflection waves that occur are incomplete or partial reflection waves characterized by waves that have an upper and lower envelope of waves, causing a wave envelope. The wave envelope can be shown in Figure 1. The H_i value can be found using Equation 3, and the H_r value can be found using Equation 4 [2].

$$H_i = \frac{(H_{max} + H_{min})}{2} \quad (3)$$

$$H_r = \frac{(H_{max} - H_{min})}{2} \quad (4)$$

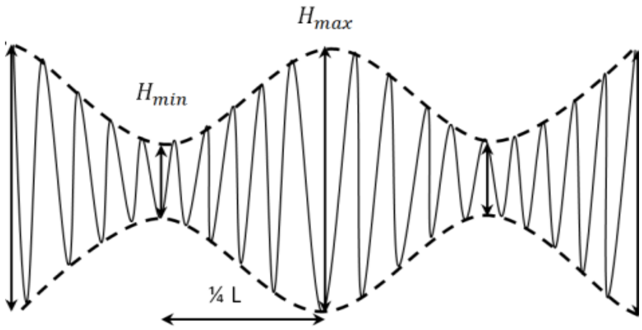

Figure 1. The instantaneous displacement of the water surface and the wave envelope on a partial standing wave

2. Research Methodology

2.1. Research Material

The research material is in the form of a wave channel equipped with a wave generator (wave generator), damper (wave absorber), and wave height meter (wave probe). The channels and equipment belong to the Hydraulics and Hydrology Laboratory, Center for the Study of Engineering Sciences (PSIT) Universitas Gajah Mada Yogyakarta with the following wave channel specifications:

Acrylic glass wall	: 10mm
Channel width	: 0.30 meters
Total length	: 15.0 meters
Channel height	: 0.45 meters

The wave channel and the placement of the model and wave probe can be shown in Figure 1 and Figure 2.

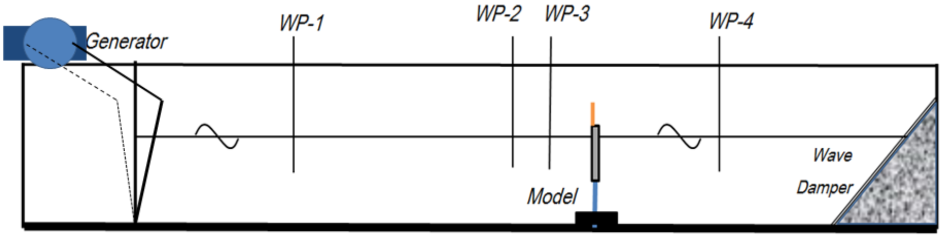

Figure 2. Wave channel sketch

Where, WP = wave probe, WP-1 to measure (incoming wave), WP-2 and WP-3 (reflection wave), and WP-4 (transmission wave). WP-3 is placed on the reflected wave at $^1/_4$ L wave, and WP-2 is placed on L wave; when the wave hits, the model gets the wave crest position, then on WP-2 the wave crest position. The wave channel is shown in Figure 3.

Figure 3. Wave channel

In addition to the wave channel when equipped with a wave generator (wave generator) complete with a stroke, and variator, a wave probe connected to a WTM (water tide meter)-800 & a computer, a model of a curtain wall breakwater, and a camera/video (for research documentation). The wave generator consists of a propulsion engine, a flap board equipped with a handlebar, a wave damper at the rear end of the flap, a stroke, and a variator, as shown in Figure 4.

Figure 4. Wave, stroke, and variator generator engine

2.2. Tool Calibration

Waveprobes (wave height recording devices) and wave generators must be calibrated before being used to record wave heights. The calibration of the wave height recorder is carried out by comparing the results of the meter measurements on the pole with the recording results from the wave probe. The initial measurement of the wave probe with the submerged condition of the water surface is used as the initial position, namely the water depth is 0 mm, then it is lowered every 5 cm the size of the meter on the pole in a row with depth numbers 5, 10, 15, 20, 25, 30, 35, and 40 are then raised to the positions of 35, 30, 25, 20, 15, 10, 5, and 0 cm. Upon reaching these numbers, they are held for 5 seconds and go up/down to the following number within 5 seconds. The calibration activity of the wave probe connected to the WTM and computer to record wave height data is shown in Figure 5.

Figure 5. Water tub and wave probe with WTM and computer

The recording results from the wave probe are processed to obtain a regression equation used to adjust the recorded data to the actual value. This result is due to the instrument's accuracy, which may decrease somewhat along with the age of the wave probe. In the calibration of the wave generator, we look for the wave size (height, wave, and wave period) generated by the generator at the predetermined stroke and variator values. The wave generator consists of a wave generator, flap, stroke, and variator. The stroke rate variation used in this investigation is stroke number 13, with the variator varied according to the desired wave in the trial. This research was conducted with 3 (three) variations of the incident wave period (Ti), namely the incident wave period of 2.03 seconds, the incident wave period of 1.53 seconds, and the incident wave period of 1.18 seconds.

2.3. Curtain Wall Breakwater Model

The materials used in making the curtainwall pile breakwater (CPB) structure model are as follows: the upper part of the breakwater model in the form of a vertical wall is made of 10 mm thick acrylic with a width of 30 cm and a height of 50 cm which can be varied the depth of the sinking wall (h) with base guard height (t) of the rock pile. The structure of the model pole is round wood and is placed behind the model wall (attached), and the wood is painted. Walls and posts are reinforced with CPB model fasteners for stability. The sketch of the curtainwall pile breakwater (CPB) model and the concept of wave motion is shown in Figure 6.

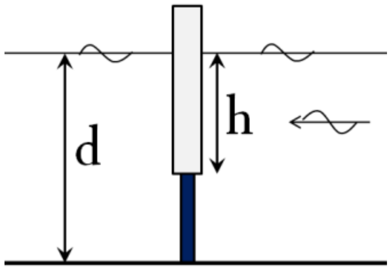

Figure 6. Curtain wall breakwater

Based on the literature review from previous research, it was found that the influential variables were: h (depth of the submerged wall), d (water depth), H_t (transmission wave height), H_r (reflection wave height), H_i (incoming wave height), and L (length wave). After conducting non-Dimensional analysis, the relationship is written as follows:

$$K_t = f\left(\frac{h}{d}, \frac{H_i}{L}\right) \quad (5)$$

$$K_r = f\left(\frac{h}{d}, \frac{H_i}{L}\right) \quad (6)$$

where K_t is wave transmission coefficient), K_r is wave reflection coefficient, and $\frac{H_i}{L}$ is wave steepness.

3. Results and Discussion

3.1. Antioxidant Activity of Mangosteen Rind Extract

The Curtain Wall Breakwater model test was carried out on the submerged wall depth (h/d) function relative to the water depth. The variation of the h/d parameters used is $\frac{h}{d} = 0;\ 0.10;\ 0.30;\ 0.50;\ 0.70.$ he test was carried out with the curtain wall breakwater model with variations of H/L waves. There are three variations of wave steepness with H/L parameters in the Curtain Wall Breakwater test, namely $\frac{H}{L} = 0.00970,\ 0.01697, 0.02848$. For each variation of the wave $\frac{H}{L}$ parameter during the CPB test, the h/d parameter variation was carried out, namely $\frac{h}{d} = 0;\ 0.10;\ 0.30;\ 0.50;\ 0.70$ with each variation being tested 3 times and one of the tests was taken which resulted in the value of equation (3).

The test of the Curtain Wall Breakwater model on the h/d parameter function is almost the same as the CPB model test on the h/d parameter function, as well as the way of processing/analyzing the data. Test the model to get the reflection wave coefficient (K_r) and transmission wave coefficient (K_t) from the curtain wall breakwater to the function parameter $\frac{h}{d}$ at condition $\frac{t}{d} = 0$ and condition $\frac{b}{D} = 1$. The transmission wave coefficient (K_t) of the curtain wall breakwater is shown in Table 1, and the reflection wave coefficient (K_r) is in Table 2.

Table 1. Relationship of K_t to parameter functions $\frac{h}{d}$ and $\frac{H}{L}$.

$\frac{H}{L}$	Parameter $\frac{h}{d}$				
	0	**0.10**	**0.30**	**0.50**	**0.70**
0.00970	0.93	0.85	0.90	0.79	0.68
0.01697	0.88	0.86	0.80	0.73	0.62
0.02848	0.84	0.83	0.54	0.52	0.38

Statistical analysis of the data in Table 1 shows the relationship between the K_t value of the curtainwall pile breakwater (CPB) on the h/d and H/L parameter functions by using non-linear multivariate regression to obtain the equation line in Equation 7.

$$K_t = -0.8290\left(\frac{h}{d}\right)^{2,6560} - 479.93\left(\frac{H}{L}\right)^{2.20} + 0.9290 \quad (7)$$

with value $R^2 = 0.95$. Based on Table 1 and Equation 7, the graph of the relationship between the value of the transmission wave coefficient K_t of the curtain wall breakwater without basic protection to the $\frac{h}{d}$ and $\frac{H}{L}$ parameter functions is shown in Figure 7. The results of recording the wave probe and analyzing the results of the reflection waves are shown in Table 2, with variations in wall depth $\left(\frac{h}{d}\right)$ and wave steepness $\left(\frac{H}{L}\right)$.

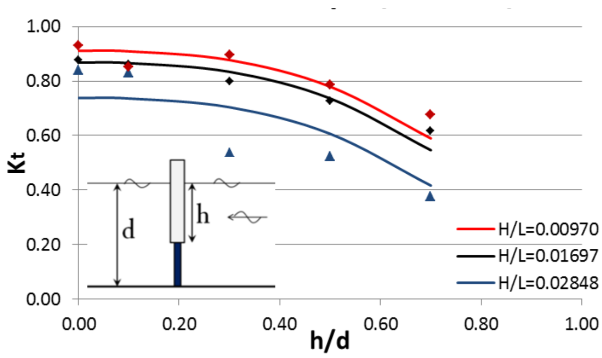

Figure 7. Relationship of K_t to function $\frac{h}{d}$ and $\frac{H}{L}$

Table 2. Relationship K_r to parameter functions $\frac{h}{d}$ and $\frac{t}{d}$

$\frac{H}{L}$	$\frac{h}{d}$				
	0	**0.10**	**0.30**	**0.50**	**0.70**
0.00970	0.35	0.33	0.34	0.40	0.58
0.01697	0.32	0.32	0.35	0.40	0.60
0.02848	0.32	0.35	0.47	0.47	0.78

Statistical analysis of the table data above for the value of K_r curtainwall pile breakwater (CPB) on the function of $\frac{h}{d}$ and $\frac{H}{L}$ parameters with non-linear multivariate regression obtained the equation of the line in Equation 8.

$$K_r = 0.6760\left(\frac{h}{d}\right)^{2.3240} + 37.2630\left(\frac{H}{L}\right)^{12.2590} + 0.3290 \quad (8)$$

with value R^2 = 0.96. Based on the data from Table 2 and Equation 8, the graph of the reflection wave coefficient value (K_r) of the CPB without the rock pile base protection against the function of the parameters $\frac{h}{d}$ and $\frac{H}{L}$ is shown Figure 8.

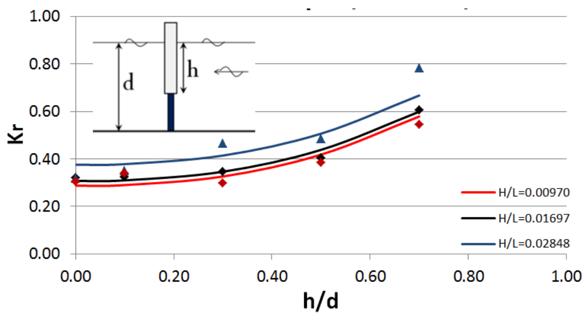

Figure 8. Relationship K_r to function *h/d* and *H/L*

4. Conclusions

The IC50 value produced from mangosteen rind extract is less than 50 ppm, which is classified as very strong. The best homogeneity was found in the F2 treatment. The peel-off gel mask in this study complied with the 1996 SNI on pH and viscosity. The best treatment for peel-off gel mask was F3 treatment with a preparation given 40g of extract and had the fastest average drying time compared to other treatments. Based on the results and discussion of the research above, it shows that the more profound the wall of the Curtain Wall Breakwater (*h/d*), the lower the value of the transmission wave coefficient (K_t) and the greater the wave steepness (*H/L*) of the incident wave, the higher the value of the transmission wave coefficient (K_t) is getting lower too. As for the reflection wave, the opposite applies. This value applies to small *H/L* values, namely in the region of the incoming wave that has not yet broken.

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