Effect of Pipe Diameter Variation on Transmission of Porous Breakwater

A M Syamsuri¹, D Suriamihardja², M A Thaha³, T Rachman⁴

¹Doctor, Department of Civil Engineering, Hasanuddin University, Makassar Indonesia
²Professor, Department of Geophysics, Hasanuddin University, Makassar Indonesia
³Professor, Department of Civil Engineering, Hasanuddin University, Makassar Indonesia
⁴Lecture, Department of Marine Engineering, Hasanuddin University, Makassar Indonesia

Email: syamsuriandimakbul@yahoo.co.id

Abstract. The porous breakwater is a breakwater designed in a transitional sea with an upright position in the direction of the waves that protect the coastal area from erosion and abrasion as it is caused by wave energy. This study aims to determine the effect of pipe diameter and depth variation on wave transmission in porous breakwaters and to analyzing the parameters that affect the transmission coefficient on wave dampers. It was conducted at the Hydraulic Laboratory of the Faculty of Engineering, Hasanuddin University, Gowa. It uses an experimental-based method with a model. The resulting waveform consists of three variation periods (T; 1.0 s, T; 1.1 s, T; 1.2 s) and two water depth variations (d; 36 cm, d; 28 cm). The results of the study indicated that the parameters that influence the transmission coefficient (Kt) are wave height (Hi), wavelength (L), wave period (T), water depth (d), and pipe diameter (Ø).

1. Introduction
Breakwater construction can be divided into 2 (two) types, offshore and shore breakwaters. The shape and characteristics of the breakwater vary as well as the ability to reduce waves produced. One of the essential aspects of constructing structures is that breakwaters protect the coast and preserve the marine ecosystem. Accordingly, several research ideas emerged for protection and preservation along the Indonesian coastline. One of them is the wave absorber structure currently undergoing research development, the porous breakwater. In addition to minimizing wave reflection, it is expected that the porous breakwater will be useful in reducing wave transmission.

In our study, we used pipe media in the breakwater structure to add the dimensions of the friction plane to the pipe hole's surface to analyze the parameters of the dimensions of the walls relative to the diameter of the pipe holes. Hence, it is expected to be more effective in reducing incoming waves. Besides, this research also develops a breakwater building structure being useful and efficient and more economical in using the material as a wave absorbing device.

2. Literature Review
Essential parameters for describing water waves are the wavelength, the wave height, and the air's depth over which they propagate. Other parameters, such as the effect of speed, can be determined from the
three primary parameters above. As for the meaning of some of the above parameters, wavelength (L) is the horizontal distance between two successive wave crests or highs [1,2]. It can also be said to be the distance between two wave valleys (gT2). The wave period (T) is the time taken by two successive wave crests/valleys to pass through a certain point. Wave velocity (celerity) (C) is the ratio between the wavelength and the wave period (L/T), and Amplitude (a) is the vertical distance between the crest / highest point of the wave or the valley / lowest point of the wave, and the calm water level (H/2).

2.1. Classification of Wave Theory
Based on the water depth where the waves spread, it can be classified into 3 (three) categories: shallow, transition, and deep-water waves. The three types' limitations are based on the ratio of depth and wavelength (d/L). The end of their use can be seen in Table 1 [1,2].

| wave category      | d/L  | 2πd/L  | Tanh(2πd/L) |
|--------------------|------|--------|-------------|
| deep water         | > 0.5| > π    | ≈ 1         |
| transition water   | 0.05 - 0.5 | 0.25 - π | Tanh(2πd/L) |
| shallow water      | < 0.05 | < 0.25 | 2πd/L       |

Waves can be classified based on the ratio of wave height and wavelength. In this classification, it is known as small and finite-amplitude waves. Airy developed small amplitude waves, so it is known as Airy’s wave theory. This theory is derived based on the assumption that the ratio of wave height to length or depth is minimal. In contrast, the finite-amplitude wave theory considers the magnitude of wave height ratio to size and depth. 2π

2.2. Wave Transmission
Parameter of wave transmission is a transmission coefficient defined as the ratio of wave height behind the coastal construction and the destructive wave height.

\[ K_t = \frac{H_t}{H_i} \]  

Where:
- Kt: Wave transmission coefficient
- Ht: Transmission wave height
- Hi: Destructive wave height

2.3. Theory of Wave Damping
Waves that spread through an obstacle partly comes from wave energy will be destroyed through the process of friction, turbulence, and breaking waves. The rest will be reflected, dissipated, and transmitted depending on the characteristics of destructive wave (period, wave height, and wavelength), the type of coastal protection (smooth or rough surface), and protection dimension and geometry (slope, elevation, and obstacle width) and local environmental conditions (water depth and seabed contour) [3].

3. Method and Research

3.1. Location and Time
This study was conducted at the Hydraulics Laboratory, Department of Civil Engineering, Faculty of Engineering, Hasanuddin University. It was conducted for two months. Tools and materials used in this study consist of wave flume. It Performed on a wave channel measuring in length 15 m, wide 0.30 m, and 46 m effective depth. A computer equipped with wave reading software. Saw for cutting pipes and silicone glue. Measuring ruler to measure/find out the water level. Wave Monitor and probe 1, probe 2
to determine the wave's height before and after it hits the model. Pipes with diameters (d) 15 cm, 10 cm and 7.5 cm. Aggregate roughness that passes filter 40, freshwater, drawing sketch, silicon glue/fox.

![Figure 1. Variation pipes diameters](image)

### 3.2. Research Design
Scaling performed on the model is done by referring to the principle of Froude’s balance, and the determination of the geometry scale adjusted to the ability of the wave channel [4]. The scaling time will be adjusted to the length scale that will be made. The maximum wave height that can be raised is 6 cm, equivalent to the sea wave height. The test specimens made will be planned in 3 (three) types according to what will be expected in the research objectives.

### 3.3. Variables
For research, as mentioned earlier, the variables studied were destructive wave height (Hi), transmission wave height (Ht), wave period (T), porous holes diameter (d).

### 4. Results and Discussion
The calculation analysis of transmission wave height (Ht) and transmission coefficient (Kt) on the porous breakwater can be seen in the following table.

Based on figure 3, it can be concluded that in the 15 cm diameter model, the value of the transmission coefficient (Kt) will decrease with increasing wave steepness (Hi/L). For the effect of depth between models themselves, the value of the transmission coefficient (Kt) will get smaller with the smaller diameter of the model, as for the magnitude of the transmission value on the 15 cm diameter model at a depth of 36 cm, approximately 37-58%, while at a depth of 28 cm it ranges between 21-32%.

As figure 4, it can be concluded that in the 10 cm diameter model, the value of the transmission coefficient (Kt) will decrease with increasing wave steepness (Hi/L). For the effect of depth between the models themselves, the transmission coefficient (Kt) will decrease as the hole diameter model decreases until it reaches the value of wave steepness (Hi/L) in the range of 0.035. After passing this value, the Kt value will decrease with the decrease of the hole diameter [5]. The magnitude of transmission value at a 10 cm diameter model at a depth of 36 cm ranges from 17-39%, while at a depth of 28 cm ranges between 12-17%.

As figure 5, it can be concluded that at a diameter of 7.5 cm, the value of the transmission coefficient (Kt) will decrease with increasing wave steepness (Hi/L). For the effect of depth between models themselves, the transmission coefficient (Kt) will decrease with the decrease of hole diameter model until it reaches the value of wave steepness (Hi/L) in the range of 0.0250. After passing this value, the Kt value will decrease with the decrease of hole diameter (s) [6]. The magnitude of the transmission cost for a 7.5 cm diameter model at a depth of 36 cm ranges 10-20%, while at a depth of 28 cm ranges between 9-17%.
Table 2. Data of wave height at a depth of 28 cm

| Models | deep (d) | Period | Wavelength (L) | Stroke | Wave Height | Probe 1 | Probe 2 | Hi/L |
|--------|----------|--------|----------------|--------|-------------|---------|---------|------|
| 1.0    | 1.347    |        |                | 4      | Hmax 0.0122 | 0.0253  | 0.0253  | 0.0253 |
| 5      | 0.0188  | 0.0238 | 0.0056         | 0.0164 | 0.0252     | 0.0177  | 0.0252  | 0.0252 |
| 4      | 0.0155  | 0.0207 | 0.0078         | 0.0060 | 0.0210     | 0.0250  | 0.0210  | 0.0210 |
| 6      | 0.0217  | 0.0250 | 0.0094         | 0.0042 | 0.0214     | 0.0211  | 0.0214  | 0.0211 |
| 1.2    | 1.651    |        |                | 4      | Hmax 0.0103 | 0.0311  | 0.0207  | 0.0207 |
| 5      | 0.0188  | 0.0238 | 0.0056         | 0.0164 | 0.0254     | 0.0111  | 0.0254  | 0.0111 |
| 6      | 0.0264  | 0.0304 | 0.0079         | 0.0060 | 0.0282     | 0.0144  | 0.0282  | 0.0144 |

As Figures 6 and 7, it can be concluded that the largest transmission coefficient (Kt) occurs in models with a diameter of 15 cm at a depth of 36 cm.

Table 3. Data of wave height at a depth of 36 cm

| Models | deep (d) | Period | Wavelength (L) | Stroke | Wave Height | Probe 1 | Probe 2 | Hi/L |
|--------|----------|--------|----------------|--------|-------------|---------|---------|------|
| 1.0    | 1.413    |        |                | 4      | Hmax 0.0303 | 0.0697  | 0.0386  | 0.0386 |
| 5      | 0.0638  | 0.0901 | 0.0483         | 0.0434 | 0.0386     | 0.0386  | 0.0386  | 0.0386 |
| 4      | 0.0416  | 0.0638 | 0.0216         | 0.0126 | 0.0422     | 0.0386  | 0.0422  | 0.0386 |
| 6      | 0.0165  | 0.0242 | 0.0309         | 0.0173 | 0.0411     | 0.0382  | 0.0411  | 0.0382 |
| 1.2    | 1.876    |        |                | 4      | Hmax 0.0224 | 0.0129  | 0.0383  | 0.0383 |
| 5      | 0.0636  | 0.0901 | 0.0483         | 0.0434 | 0.0386     | 0.0386  | 0.0386  | 0.0386 |
| 6      | 0.0177  | 0.0242 | 0.0309         | 0.0173 | 0.0411     | 0.0382  | 0.0411  | 0.0382 |

in models with a diameter of 15 cm at a depth of 36 cm. In contrast, the smallest transmission...
coefficient (Kt) occurs in models with a 7.5 cm diameter at a depth of 28 cm. Also, conclusions can be drawn regarding the effect of its porosity on changes in the transmission coefficient. All models show the greater of wave steepness, the smaller the transmission coefficient value. However, some models offer a very significant change, and others relatively do not experience much change in Kt value. A model with a diameter of 15 cm at a depth of 36 cm and a diameter of 10 cm at a depth of 36 cm shows a significant change in Kt values. In comparison, the model with a diameter of 7.5 cm at a depth of 28 cm and 10 cm diameter at a depth of 28 cm shows a change is not significant Kt value.

5. Conclusion
The results of the study can be concluded that parameters that were affecting wave transmission include variations in pipe diameter (Ø), destructive wave height (Hi), wavelength (L), and water depth (d). The effect of variations in pipe diameter on the wave transmission in porous breakwaters is very significant. The smaller pipe diameter, the smaller of transmission waves produced, are more useful to reduce waves.

References

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