Wave Energy Attenuation Levels Based On Various Coastal Building Scenarios

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Abstract. The abstract should summarize the contents of the paper in short terms, i.e. 150-250 words. The research aims to determine the level of wave energy attenuation in various coastal building scenarios.Data collection was carried out at wave frequencies of 1Hz, 2Hz and 3Hz. The variables measured involve the values of wave current speed, wave height, and water volume that passes through the embankment. Six different embankment models were used to create a variety of experimental scenarios, allowing research to compare the effectiveness of each model. Data is taken through a measurement process at a predetermined frequency for each embankment model. Measurements include wave current speed, wave height, and volume of water passed through. Appropriate measurement tools are used to obtain accurate and relevant data, ensuring research results are reliable.The results showed that among the six embankment models evaluated, one particular embankment model stood out as the most effective. This model achieved an effectiveness level of 84.09%, with a minimum wave current speed reaching 0m/s, and the volume of water passing through the embankment was recorded at 100ml. These findings provide insight into the potential effectiveness of certain dike models in attenuating coastal waves. In this research, it was found that embankment model five was more effective in reducing wave energy because apart from the percentage value of effectiveness being greater, the current speed value was smaller and the value of the volume of water passing through the embankment was small compared to the others.

Keywords: Wave Energy Attenuation; Embankment Model; Effectiveness

1 Introduction

Several coastal areas in Indonesia have carried out engineering to reduce the risk of coastal damage caused by large wave energy. If large wave energy occurs, even though it does not cause a tsunami, it can pose a risk of flooding or high tides for coastal (land) areas [1]. The impact of flooding or inundation quickly results in inundation by masses of water moving at a certain speed. Therefore, the construction of embankments is very necessary for coasts that are at risk of flooding and tsunamis. The construction of embankments in tsunami-prone areas is important to protect people who live and carry out

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activities on the coast from the dangers of large waves that arrive before they have time to evacuate. However, before construction is carried out there are several things that need to be considered and re-evaluated so that other impacts do not occur. According to [2], the construction of embankments has an impact on changes in coastal typology which affects hydrodynamic patterns. So changes in hydrodynamic patterns by the construction of embankments have an impact on increasing currents and causing abrasion in other parts of the water.

The earthquake with a magnitude of 7.5 M that occurred in Palu City on September 28 2018 caused a tsunami wave at Talise Beach with a height of 10.73 meters to hit the beach, leveling houses, washing away various objects, and destroying the coastal area of Palu Bay. Even though the height of the tsunami waves in the Talise coastal area was lower because the area was relatively flat, the impact of the tsunami on the Talise coastal area was heavier than the impact of the tsunami in the Tondo area [3], this incident prompted the local government to build embankments along Talise Beach to reduce the energy. large waves and reduce damage to the coast.

Several studies on efforts to attenuate wave energy have examined the simulation of wave attenuation by mangrove forests [4]. Mangrove forests can function to reduce long waves and short waves. Apart from that, research on the effectiveness of wave energy attenuation due to floating breakwaters is reviewed from physical scenarios and numerical studies which aim to determine how effective energy attenuation is based on the magnitude of the transmission coefficient of floating breakwater structures that have been designed in such a way [5].

Research on mitigation measures by building embankments due to tidal floods in Pekalongan Regency, Central Java [6]. This research has the same goal, namely how to overcome and ensure that damage caused by wave energy is minimized so that it can protect the people who live and often carry out activities in coastal areas. Previously, research had been carried out on physical scenario simulations of the attenuation levels of Tetrapod and Dolos breakwaters, where this research aimed to determine the level of energy attenuation in broken stone breakwater buildings with tetrapod and Dolos protective layer structures using variations in sea level conditions in the laboratory. [7]. Therefore, it is necessary to carry out this research to see the effectiveness of embankments in reducing big wave energy by using various coastal building scenarios and carrying out laboratory-scale simulations. This research aims to determine the level of wave energy attenuation in each scenario model so that it can help future analysis in making coastal buildings that are effective and efficient to use and can minimize damage to the beach.

2 Materials and methods

2.1 Design of Wave Generating Equipment and Beach Buildings

The design of a wave generator (Fig.1) is carried out using a rotary machine so that it can produce waves in the water in the aquarium and use a dimmer to regulate the current and voltage on the dynamo so that the wave speed can be adjusted. Designing beach buildings with various scenarios (Fig.2) to determine the level of attenuation of currents and waves.

2.2 Data Retrieval

The data used in this study are current speed data, wave height, wavelength data, and water volume data, which are taken in the treatments carried out respectively in different scenarios. The work procedure in data collection is as follows Preparing measuring instruments after connecting the drive board to the rotary machine and then determining the beach building to be used. Connecting the dimmer to the rotary machine and electricity and adjusting the speed of the drive board through the dimmer after that measuring the wave height, wavelength and current speed simultaneously and measuring the volume of water passing through the barrier embankment. Repeating the procedure until all the beach building scenarios were tested.

2.3 Data Processing

Calculate the volume of water mass passing through the boundary to obtain the runoff momentum that reflects the energy passing through the coastal building scenario.

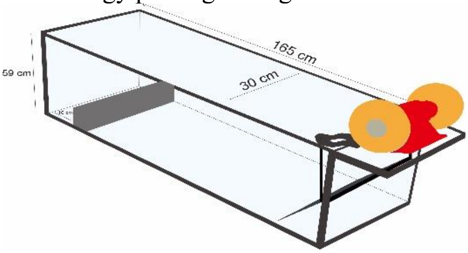

Fig. 1. A figure of aquarium and rotary machine.

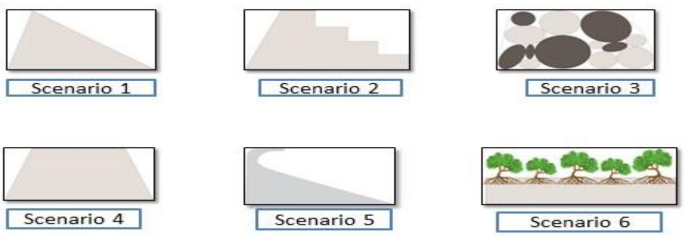

Fig. 2. A figure of scenario model

2.4 Calculating the effectiveness of the shore structures scenario

The calculation of the damping level of the coastal building is done by comparing the current velocity before and after passing through the coastal building scenario. By using the equation:

$$Effectiveness = \frac{V'}{V} \times 100\% \quad (1)$$

Where V is Flow Speed Before Engineering and V' is Current Speed After Engineering

3 Results and Discussion

3.1 Result

In this research, a miniature simulation of coastal damping with various types of coastal buildings is made. The wave generator in this miniature is designed using a movable drive board. To adjust the rate of movement of the drive board, the voltage entering the system is adjusted with a potentio meter (dimmer). The drive board can move to produce currents and waves in the aquarium so that the movement of the drive board can be adjusted to produce frequencies of 1 Hz, 2 Hz, and 3 Hz so that the amount of wave energy can be compared. The results of data collection at a frequency of 1 Hz can be seen in Fig 3.

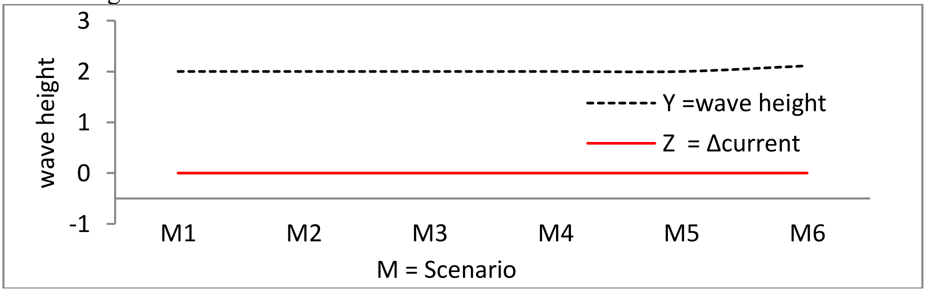

Fig. 3. Graphical representation of 1 Hz Frequency

Fig. 3 shows that embankment model 1 to embankment model 5 has a wave height value of 2 cm with a current speed of 0 m/s, while embankment model 6 produces a wave height value that increases to 2.11 cm and a current speed value of 0.00062 m/s. The results of the 2 Hz frequency data collection can be seen in Fig. 4.

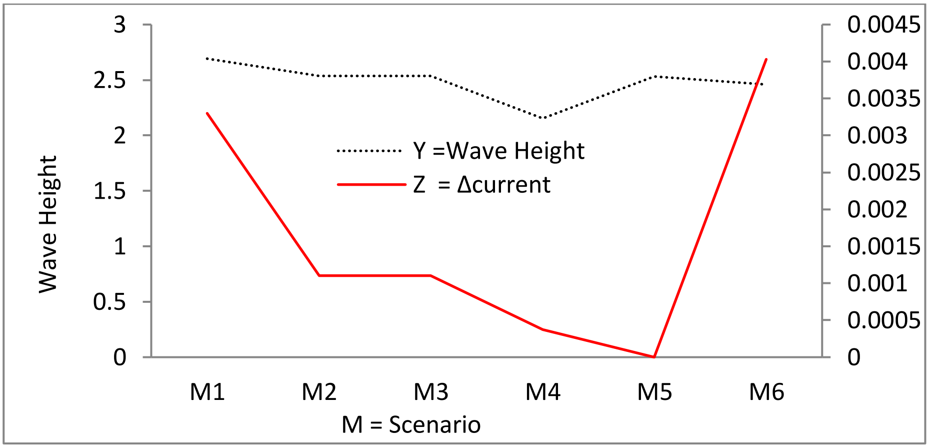

Fig. 4. Graphical representation of 2 Hz Frequency

Fig. 4 shows the results of the scenario 1 model, the resulting wave height value is 2.69 cm with a current speed of 0.0033 m/s. In scenario 2 the wave height value is reduced to 2.53 cm and the current speed value is reduced to 0.0011 m/s. In scenario 3 the wave height value is 2.53 and the current speed value is 0.0011 m/s. On embankment 4 the wave height value was reduced to 2.15cm and the current velocity value was also reduced by 0.00037 m/s. In the scenario 5 model, the wave height value increased to 2.53 cm with a current speed of 0 m/s. In the scenario 6 model, the wave height increases again to 2.46 cm with a current speed of 0.0040 m/s. The results of data collection at a frequency of 3 Hz can be seen in Fig. 5.

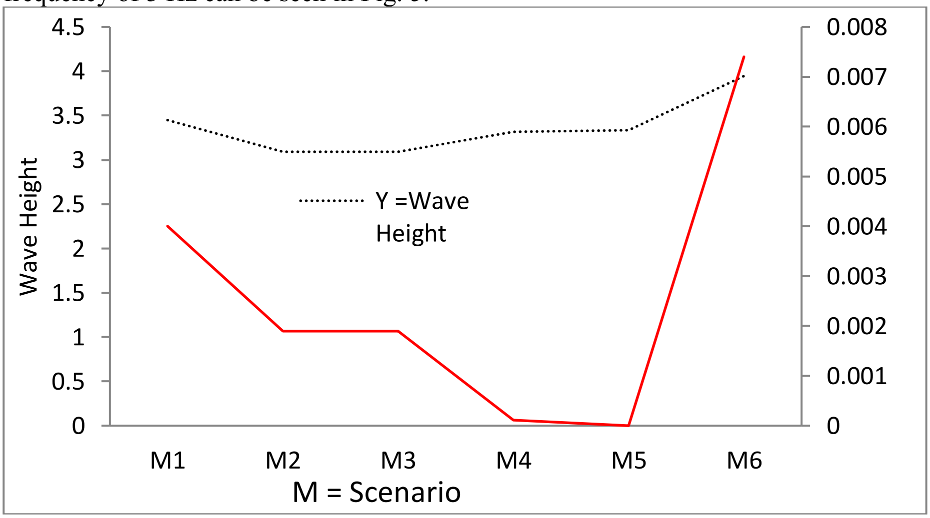

Fig. 5. Graphical representation of 3 Hz Frequency

Based on Figure 3.3 shows the results of the scenario 1 model resulting in a wave height of 3.45 cm with a current speed of 0.004 m/s. In the scenario 2 model, the resulting wave height value increases to 3.09 cm and the current speed decreases to 0.0019 m/s. In the scenario 3 model, the wave height value is 3.09 cm and the current speed is 0.0019 m/s. In the scenario 4 model, the wave height value increased to 3.31cm with a current speed of 0.00011 m/s. In the scenario 5 model, the wave height value is reduced to 3.13 cm with a current speed of 0 m/s. In the scenario 6 model, the wave height increased to 3.94 cm with a current speed of 0.0074 m/s.
Comparison of this frequency value affects the current speed value on the effectiveness of the scenario where to get the effectiveness value, equation 1 is used, the results of which can be seen in Table 1.

Table 1. Table captions should be placed above the tables.

Scenario	1 Hz	2 Hz	3 Hz
MODEL 1	0%	0%	7,31%
MODEL 2	0%	57,14%	57,14%
MODEL 3	0%	57,14%	57,14%
MODEL 4	0%	50,30%	57,14%
MODEL 5	50%	72,72%	84,09%
MODEL 6	0%	11,11%	50%

Based on Table 1, the scenario model that has a greater effectiveness value is the embankment model 5 which at a frequency of 1Hz produces 50% while the other embankments have 0% effectiveness, when the frequency increases to 2 Hz, the effectiveness of scenario 5 increases to 75.72% while scenario models 2 and 3 only have an effectiveness value of 57.14%, scenario model 4 has a value of 50.30% while the embankment model 6 is only 11.11%, at a frequency of 3.
In addition to processing data using equation 1, one of the steps to determine the effectiveness of the scenario carried out in this study is to calculate how much water passes through the embankment with the resulting current speed. The results of the volume of water passing through the embankment can be seen in the Fig. 6.

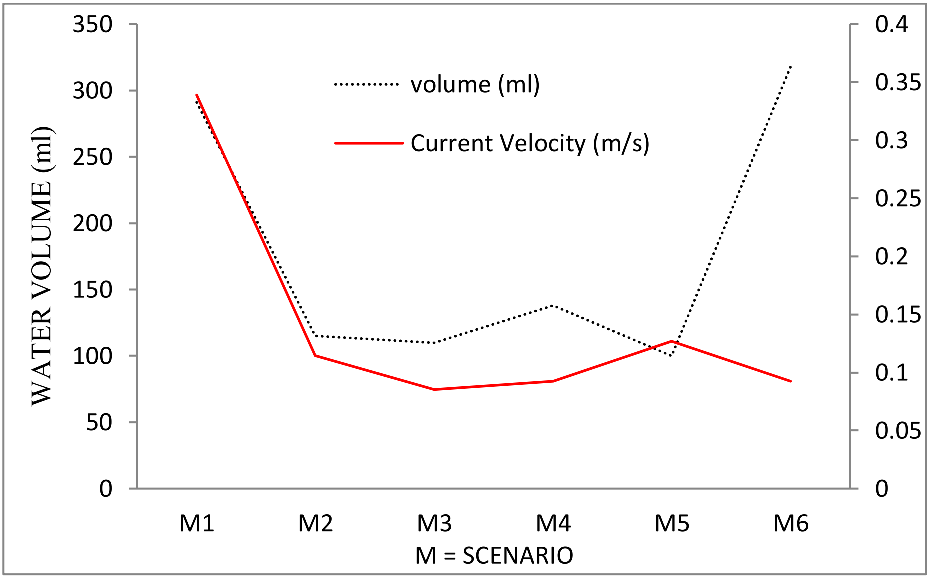

Fig. 6. Graphical representation of water volume

Based on Fig. 6, it is shown that in scenario 1, it can be obtained that the volume of water passing through is 291 ml with a current of 0.3390 m/s, in scenario 2, 115 ml of water volume is obtained with a current speed of 0.1146 m/s, in scenario 3, 110 ml is obtained with a current speed of 0.0853 m/s, in scenario 4, 138 ml of water volume is obtained with a current speed of 0.0926 m/s, in scenario 5, 100 ml of water volume is obtained with a current speed of 0.1268 m/s, and in scenario 6, 318 ml of water volume is obtained with a current speed of 0.0926 m/s. Hz the effectiveness of scenario model 5 again increases to 84% while embankment model 1 produces an effectiveness of only 7.31%, scenario models 2, 3 and 4 produce a value of 57.14% and scenario model 6 has a value of 50%.

3.2 Discussion

The scenarios used have different shapes. Scenario 1 has a shape like a right triangle or can be said to be revetment while scenario 2 has a shape like steps. As for scenario 3, it is made of a vertical arrangement of stones while scenario 4 has a shape like a wall that stands upright. In scenario 5, it has a sharp side shape and has a barrier above it and scenario 6 has the shape of a mangrove plant area. This is what compares the values of current speed, wave height and water volume. Scenario 5 can be said to be effective in reducing wave energy with the results of the percentage of attenuation rate reaching 84.09%, which in the research of [8]. Scenario 5 also produces a smaller current velocity value even though the wave height value is quite large, in calculating the volume of water passing through the runoff, scenario 5 produces a smaller water volume value than the other scenarios. This is because scenario 5 has a shape with a side and a wave barrier above it so that when the wave spreads the water can be dampened by the barrier and the wave energy is reduced when passing through the scenario. However, the construction of the embankment must be adjusted to the characteristics of the coast so that abrasion and erosion do not occur so that it is more effective in reducing waves. Other scenarios are also effective in reducing wave energy but the arrangement and placement of the scenario forms that need to be considered. For example, in scenario 6, it is necessary to pay attention to the arrangement of the tree planting which should not be parallel but the location of the trees should cover each other so that when water comes and passes through the scenario the water can be dampened and has no gaps. This is what affects the large current speed and the water passing through the scenario is quite a lot.

4 Conclusion

Based on the research results, it can be concluded that in scenario 1, a damping level percentage is 7.31%, in scenario 2, scenario 3 and scenario 4, a damping level percentage is 57.14%, in scenario 5, a damping level percentage is 84%, in 6 obtained a percentage of 50%. In this research, it was found that scenario 5 was more effective in reducing wave energy because apart from the percentage value of the attenuation level being greater, the value of the current speed was smaller and the value of the volume of air passing through the scenarios was smaller than the others.

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