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The Investigation of Submerged Breakwater Influence on Its Coastal Profile Behind

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Abstract. The submerged breakwater is one coastal erosion countermeasure. Even the breakwater height is below the seawater surface, and it may reduce the wave height in a certain amount. The less wave height makes the coastal behind breakwater will be protected. This research performed the investigation of submerged breakwater influence by using the physical model. It used the wave flume, which has a dimension of 4.0 x 0.25 x 0.08 m (LxHxW). Due to the small flume, the research objective is to investigate the submerged breakwater influence on its coastal profile behind. The breakwater variations are on its width and freeboard height. The wave has a 2.0 cm high and 0.71 second period. The sediment particle has 0.2 - 0.3 mm diameter, and the profile slope is 1:4. After several incoming waves, the profile change behind the breakwater was measured and analysed. The results showed that the wider of a breakwater and the smaller of freeboard height would make the smaller change on coastal profile behind.

Keywords: submerged breakwater, wave flume, coastal profile

1. Introduction

The wave action influences the beach line. The beach line may become advanced (sedimentation) or retreat (erosion) due to the movement of an incoming wave from the offshore. The little wave will push the sediment to onshore and collected on the beach. The beach line will advance and experienced sedimentation. The big wave will take the sediment on the beach to the offshore direction and collected on the deeper area. The beach line will retreat and experienced erosion. Mostly, erosion will give a bad impact on the environment and human living. One countermeasure technique to overcome the erosion is by using the breakwater.

One type of breakwater is the submerged breakwater. The submerged breakwater has the elevation crest below the water level. The structure will not become visible during high or normal seawater level and emerge during low sea water level. The wave may pass the crest of the submerged breakwater. The function of a structure is to reduce the incoming wave energy so that the beach is protected from erosion due to the incoming wave [1]. The less energy behind a breakwater will influence the beach profile behind it.

Many research about the submerged breakwater had been conducted, such as [2-6]. In general, the results show that the performance of submerged breakwater is depended on 1) the crest width of structure; 2) the freeboard height of structure; 3) the porosity of structure. The research results still have many variations so that the research about the submerged breakwater is still important to be conducted. The research attempt to examine the change of beach profile behind a submerged breakwater. The variation of width and freeboard height of submerged breakwater was examined by utilising the model experiment.

2. Methodology

The research utilised the model experiment in The Hydraulic and Coastal Laboratory Faculty of Engineering at The University of Mataram. It used the small wave flume, which has a dimension 4.0 m long, 0.08 m width, and 0.5 m height, as depicted in Figure 1.

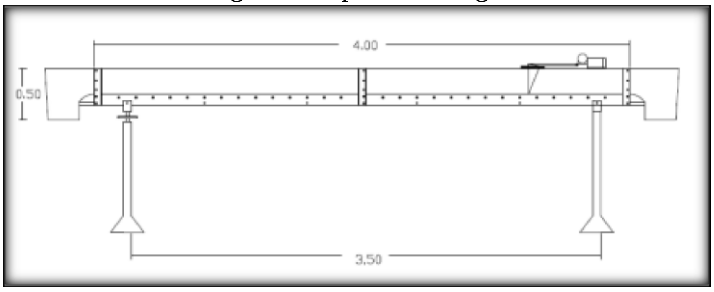

Figure 1. The wave flume

The beach profile model was be made from artificial sand which has diameter 0.2 – 0.3 mm. The profile has slope 1:4 with 17 cm height and 76 cm length. It was be built at the end of wave flume. Figure 2 shows the dimension of the beach profile model.

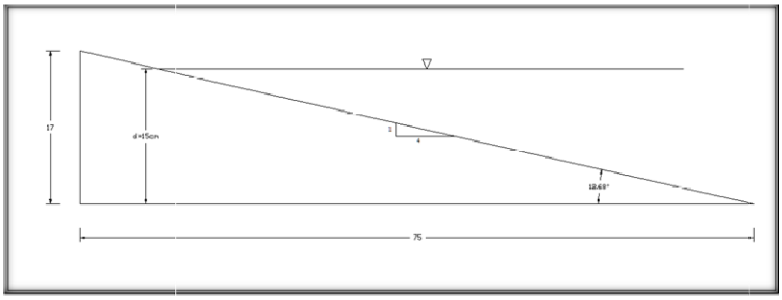

Figure 2. The beach profile model

The submerged breakwater model is made from the artificial concrete beam. The model has the dimension variation of width and freeboard height. There are three sizes of width and three sizes of freeboard height, and then it makes nine experiment models. The models are written in Table 1 and depicted in Figure 3. The wave parameter only uses one kind, i.e. 2.0 cm of wave height and 0.71 sec of wave period.

Each model was be run three times, as long as 36 minutes for each run. Every 12 minutes, the change of beach profile was be recorded by using the plastic sheet on the transparent wall of wave flume. So, there are three times of taking results in each run. The 12 minutes run is same as the 1,000 number of waves (N = 1,000) based on its period.

Table 1. The experiment models

Model	Length (L)	Width (b)	Freeboard height (Rc)
	(cm)	*(cm)*	*(cm)*
A	8	2 *(1x)*	0.25 0.5 0.75
B	8	4 *(2x)*	0.25 0.5 0.75
C	8	6 *(3x)*	0.25 0.5 0.75

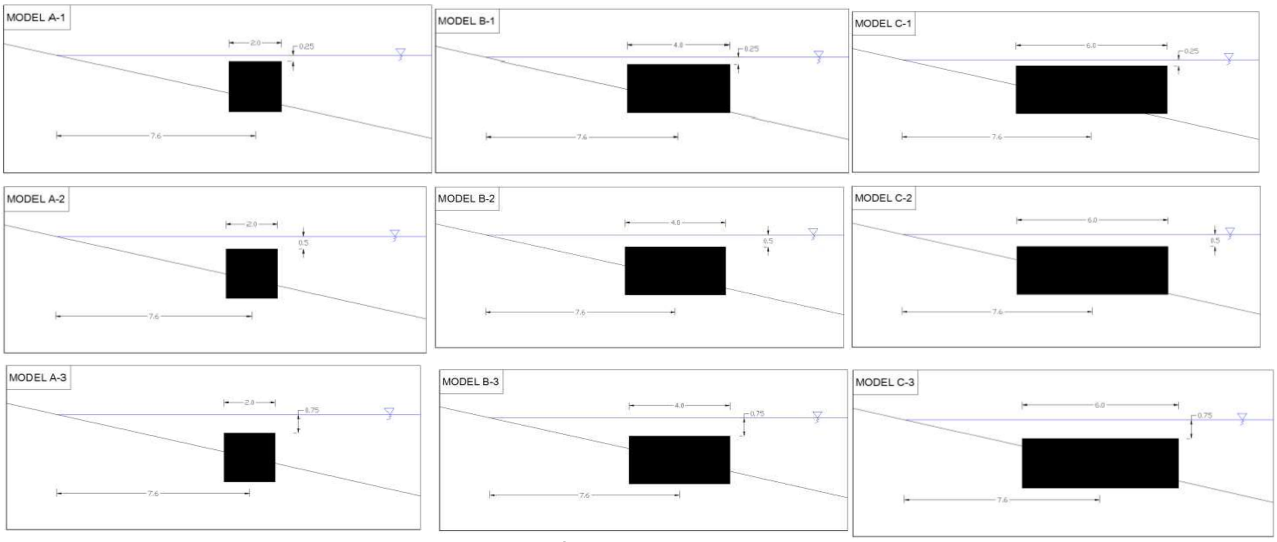

Figure 3. The variation of the submerged breakwater model

3. Results and Discussions

3.1. Consistency

This section shows the results consistency for three runs in each model. As an example, these are the results of Model A1, B1, and C1 in Figure 4. The erosion area between Run 1, Run 2, and Run 3 are the same for each model. It means the results of each model are consistent and good for analysing.

These results also show that there are the changing value of erosion area between first 12 minutes run (N=1,000) and second 12 minutes run (N = 2,000). However, all models show the same value between the second 12 minutes run (N= 2,000) and third 12 minutes run (N = 3,000). It means there is already stability condition between N = 2,000 and N= 3,000. Therefore, the results analysis is focused on the result of N = 3,000.

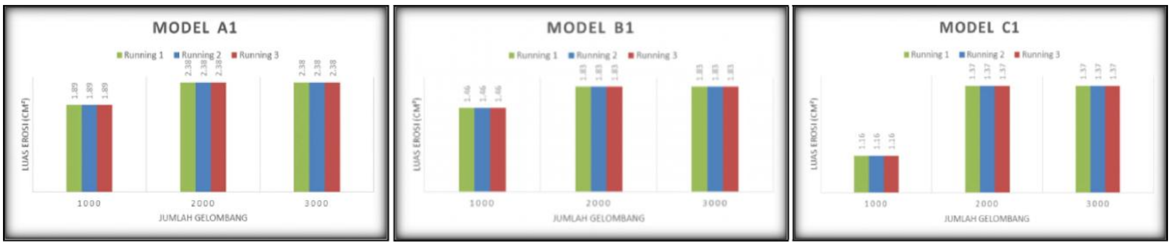

Figure 4. The results consistency in Model A1, Model B1, and Model C1

3.2. The influence of width (b) variation

The results comparison between Model A1-B1-C1; Model A2-B2-C2; and Model A3-B3-C3 will show the influence of submerged breakwater width. The width variation is b = 2 cm, 4 cm, and 6 cm respectively. The erosion area is the area below the initial slope line of the beach profile. Figure 5 shows the erosion area of Model A1 is 2.38 cm²; Model B1 is 1.83 cm², and Model C1 is 1.16 cm². Figure 6 shows the erosion area of Model A2 is 3.01 cm²; Model B2 is 2.58 cm², and Model C2 is 1.93 cm². Figure 7 shows the erosion area of Model A3 is 6.47 cm²; Model B3 is 3.33 cm², and Model C3 is 2.82 cm². It shows that the wider of a submerged breakwater, the smaller of erosion area.

The wider of submerged breakwater makes longer the interaction between the wave and the crest surface of the submerged breakwater. The wave energy is more reduced and becomes smaller the wave height behind the submerged breakwater, which is approaching the beach area. It can be concluded that the wider submerged breakwater is more effective to overcome the erosion of the beach area.

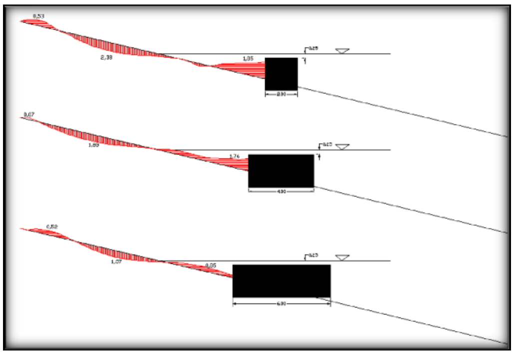

Figure 5.The erosion area of Model A1, B1 and C1 (with Rc=0,25 cm)

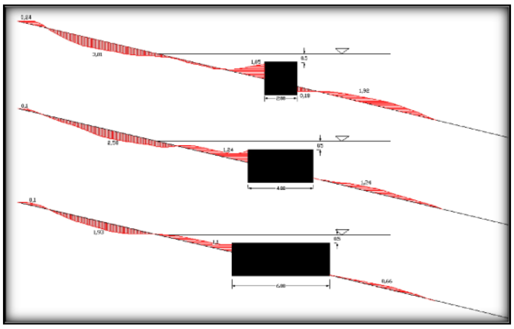

Figure 6.The erosion area of Model A2, B2 and C2 (with Rc=0,50 cm)

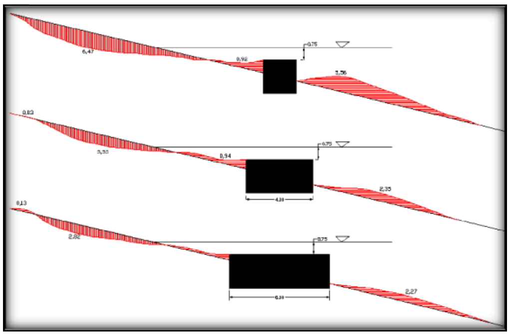

Figure 7.The erosion area of Model A3, B3 and C3 (with Rc=0,75 cm)

3.3. The influence of freeboard height (Rc)

In the other hand, the results comparison between Model A1-A2-A3; Model B1-B2-B3; and Model C1-C2-C3 will show the influence of submerged breakwater freeboard height. The freeboard height variation is Rc = 0.25 cm, 0.50 cm, and 0.75 cm respectively. Figure 8 shows the erosion area of Model A1 is 2.38 cm^2; Model A2 is 3.01 cm^2, and Model A3 is 6.47 cm^2. Figure 9 shows the erosion area of Model B1 is 1.83 cm^2; Model B2 is 2.58 cm^2, and Model B3 is 3.33 cm^2. Figure 10 shows the erosion area of Model C1 is 1.16 cm^2, Model C2 is 1.93 cm^2, and Model C3 is 2.82 cm^2. It shows that the higher of a submerged breakwater freeboard, the bigger of erosion area.

The higher of submerged breakwater freeboard makes less interaction between the wave and the crest surface of the submerged breakwater. The wave energy is less reduced and becomes less change of the wave height behind the submerged breakwater, which is approaching the beach area. It is opposite with the width submerged breakwater, i.e. the higher of submerged breakwater freeboard is less effective to overcome the erosion of the beach area.

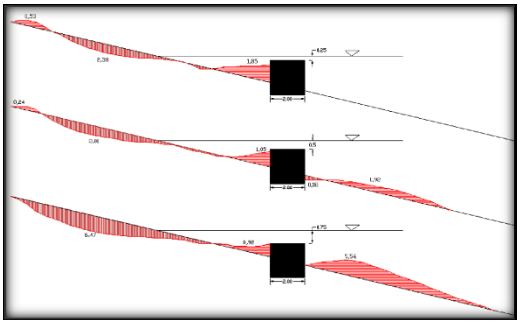

Figure 8. The erosion area of Model A1, A2 and A3 (with b = 2 cm)

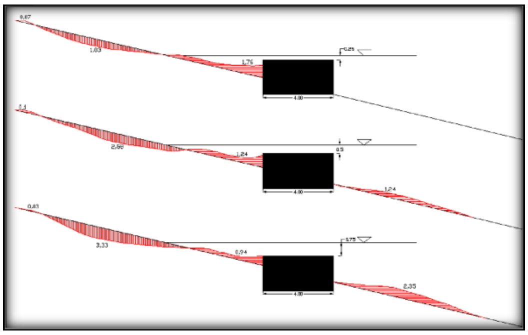

Figure 9. The erosion area of Model B1, B2 and B3 (with b = 4 cm)

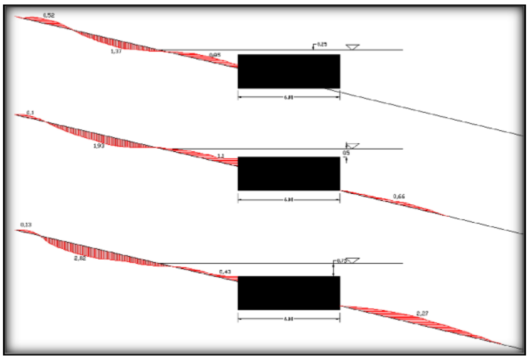

Figure 10. The erosion area of Model C1, C2 and C3 (with b = 6 cm)

From all of the results, it clearly shows that the Model C1 is most effective to overcome the erosion on the behind submerged breakwater. The Model C1 has the smallest erosion area, i.e. 1.37 cm^2. The Model C1 has bigger of width (b = 6 cm) and smaller of freeboard height (Rc = 0.25 cm).

4. Conclusion

The model experiment of the submerged breakwater has been conducted. The conclusion can be deducted as follows:

1. The wider submerged breakwater has smaller erosion area on beach area behind it. Therefore, the bigger submerged breakwater width is more effective to overcome the erosion problem behind the structure.
2. The bigger submerged breakwater freeboard height has bigger erosion area. Therefore, the smaller submerged breakwater freeboard height is more effective to overcome the erosion problem behind the structure.
3. Among the model variation, Model C1 is the most effective to overcome the erosion. Model C1 has the biggest width and the smallest freeboard height.

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