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# Experimental Study On The Performance Of Submerged Breakwater As Shore Protection Structure

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**Abstract.** In this study the efficiency of the submerged breakwater as shore protection structure has been investigated experimentally. To investigate the performance of the submerged breakwater, experiments are conducted in a two dimensional wave flume which is 21.3m long, 0.76m wide and 0.74m deep. This whole experimental set-up is carried out at the Hydraulics and River Engineering Laboratory of Bangladesh University of Engineering and Technology. A set of experiments are conducted at a still water depth of 50 cm with a fixed rectangular submerged breakwater of three different heights (30 cm,35 cm and 40 cm) for five different wave periods (1.5 sec,1.6 sec,1.7 sec, 1.8 sec, 2.0 sec) in the wave flume mentioned before. The type of wave breaking and the position of wave breaking are simultaneously recorded with a digital video camera. Effects of breakwater height and length along the wave direction on wave height reduction are analyzed. This analysis is expected to serve to assessment the wave height reduction due to submerged breakwater as a shore protection structure. It is clearly seen from this experiment that a submerged breakwater is very effective in reducing the transmitted waves. For same wave period higher breakwater can reduce the incident wave height more than the smaller breakwater. From the experimental investigations it is found that relative breakwater width, B/L ( B is the breakwater width and L is the wave length) and relative breakwater height, $h_s/d$ ($h_s$ is the breakwater height and d is the still water depth) are the important parameters for reducing the wave height. As the relative structure height $h_s/d$ increases, reduction of incident wave increases due to breaking caused by the breakwater. As the relative breakwater width B/L increases, the reduction of wave height also increases.

**Keywords:** Submerged breakwater,wave,shore protection

## 1. Introduction

Coastal zone is a dynamic area of natural change and of increasing human use. They occupy less than 15% of the Earth's land surface; yet accommodate more than 50% of the world population (it is estimated that 3.1 billion people live within 200 kilometers from the sea). With three-quarters of the world population expected to reside in the coastal zone by 2025, human activities originating from this small land area will impose an inordinate amount of pressures on the global system. Coastal zones contain rich resources to produce goods and services and are home to most commercial and industrial activities.Coastal zones are generally extremely important to the functioning and well being of many nations: they are often the most developed and resource-rich zones of the country and have often been (and in some cases still are) the site of conflicts, including wars. Protection against the sea level rise in the 21st century will be especially important, as sea level rise is currently accelerating. Changes on sea level have a direct response from beaches and coastal systems, as we can see in the succession of a lowering sea level. Shore protection work is usually provided to protect an exposed beach line; to stabilize existing beach, restore eroded beach, or to create and

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stabilize artificial beaches. The protection work in general includes: Seawalls, Sea dikes, Revetments, Bulkheads, Jetties, Groins, Sand dune, Beach Nourishment and Sand Bypassing, Shore-connected Breakwater, Offshore Breakwater, Tetra pods etc. The main purpose of this paper is to study on different aspects of submerged breakwater for shore protection. This paper considers the feasibility of using inflatable, submerged, moored structures as breakwaters. Submerged or low-crested breakwaters function by provoking wave-breaking and by allowing some wave transmission so that a milder wave climate is obtained in lee of the submerged structure, although it is not as mild as if the structure was emerged. The sediment transport capacity behind the breakwater will also decrease, which means that sand will accumulate in a manner similar to an emerged structure with a slightly smaller length. They can be used continuously or, when not in use, deflated and out of the way.

## 2. Experimental Work

The whole experimental work is carried out in a two dimensional wave fume where a breakwater is placed at 800 cm far from wave generator. Different types of wave periods are being generated by this wave generator. The transmitted waves are absorbed by a wave absorber placed at the end of the wave fume. Six measuring tapes are used to measure the water level in six different locations. Fifteen experimental runs are carried out in the laboratory to verify the water surface level.The experimental set-up is shown in Fig. 1.

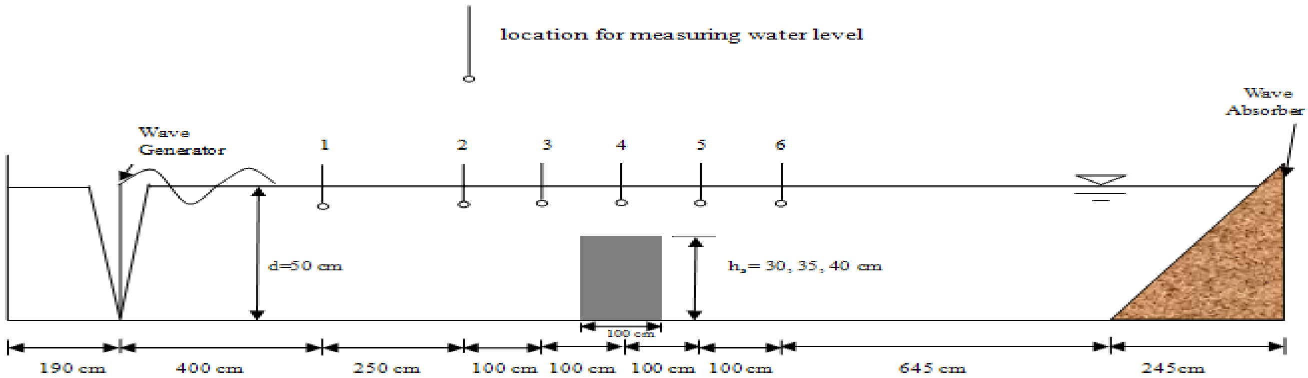


Fig.1: Experimental Set-up

To investigate the water surface profile wave height is measured before and after passing the submerged breakeater at different locations. 6 measuring tapes are placed in different locations on the glass suface of the flume to measuring the water level at desired points. Three measuring tape are placed in the offshore side for measuring the incident wave, one is placed over the breakwater and last two are placed behind the breakwater. Measuring location 1 is at 400 cm, measuring location 2 is at 650 cm, measuring location 3 is at 750 cm, measuring location 4 is at 850 cm, measuring location 5 is at 950 cm and measuring location 6 is at 1050 cm from the wave generator.

## 3. Results and Analysis

### 3.1. Water surface profile

Water surface profile at 10 seconds interval for 60 seconds for 15 different run conditions is being analyzed in this analysis. Fig.2 to Fig. 4 shows the variation of water level with time for a particular wave period 1.6 sec. The high energy of incident wave is reduced drastically because of the breakwater. Maximum reduction of wave height occurs for maximum value of $h_s/d$ for the same wave period. When breakwater height is set as such that $h_s/d=0.8$ (breakwater height=40 cm) the incident wave height of 15 cm for T=1.6 sec reduces to 6 cm after breaking over the breakwater. With fixed submerged breakwater of 35 cm height when $h_s/d$ becomes 0.7 then the incident wave height reduces from 12 cm to 7 cm for the same wave period. As the wave height reduces from 12 cm to 9 cm when the breakwater height is reduced to 30 cm ($h_s/d=0.6$). Thus for T=1.6 sec breakwater having $h_s/d=0.6$ reduces 25% of incident wave height, whereas breakwater having $h_s/d=0.7$ and 0.8 decreases incident wave height up to 42% and 60% respectively.

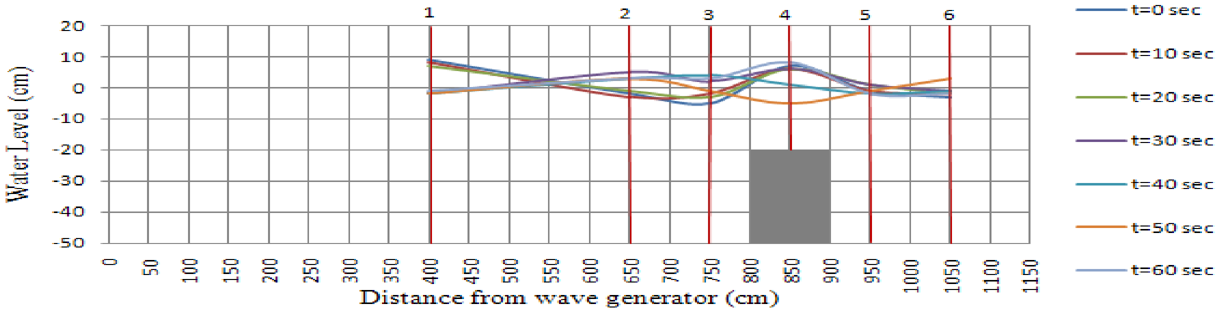


Fig. 2: Water surface profile along the wave flume when T=1.6 sec and $h_s/d=0.6$

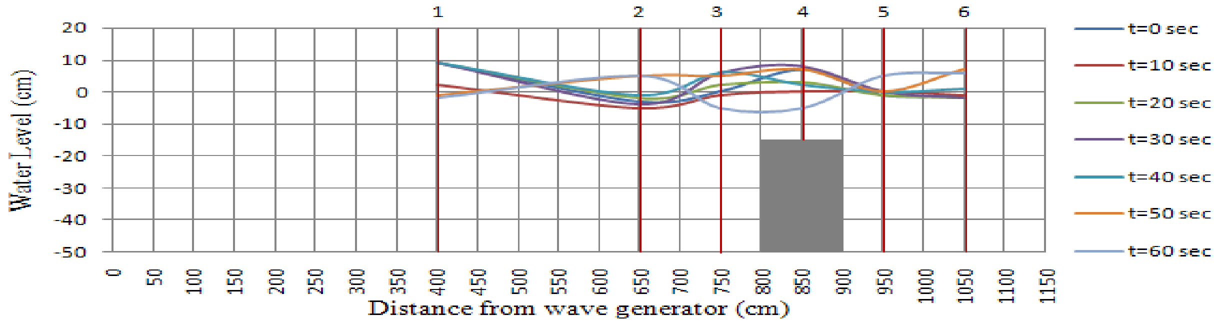


Fig. 3: Water surface profile along the wave flume when T=1.6 sec and $h_s/d=0.7$

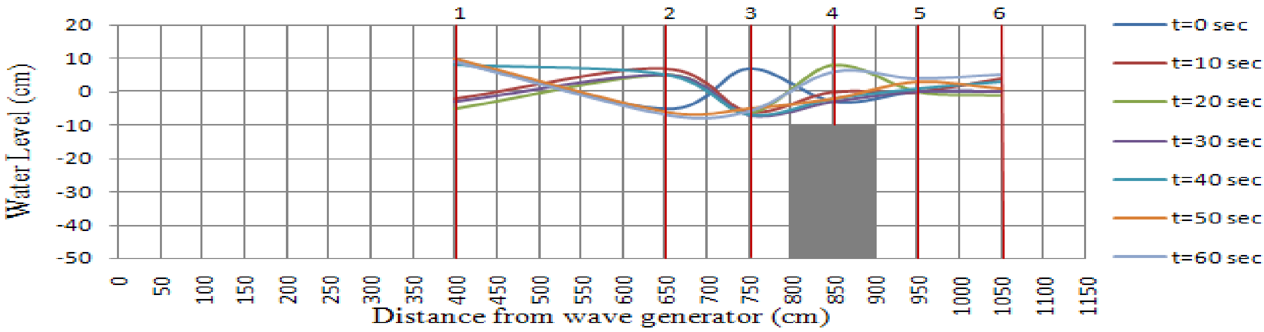


Fig. 4: Water surface profile along the wave flume when T=1.6 sec and $h_s/d=0.8$

By analyzing for all the wave periods it is clearly found that maximum reduction of wave height is being occurred by wave breaking over or behind 40 cm breakwater in a still water depth of 50 cm i.e. when the ratio of $h_s/d=0.8$ for all wave periods. Installation of rectangular fixed submerged breakwater of this type shows maximum efficiency by reducing wave height about 60-65%. Wave height is reduced about 40-50% when $h_s/d=0.7$ and about 25-30% when $h_s/d=0.6$.

Again for a particular ratio $h_s/d$ the reduction of wave height due to breaking occurs more for lower wave periods than for the higher wave periods among the five different wave periods 1.5 sec, 1.6 sec, 1.7 sec, 1.8 sec and 2.0 sec. When $h_s/d=0.8$, the wave height reduces 55% and 64% for T=2.0 sec and 1.5 sec respectively. Similar trend is being followed when $h_s/d=0.6$ and 0.7.

## 3.2. Effect of relative breakwater width on wave damping

This analysis presents the effect of relative breakwater width, B/L (B is the width of the breakwater along the wave direction and L is the wavelength) on wave damping i.e. wave height reduction, $H_b/H_i$ ($H_b$ is the breaking wave height and $H_i$ is the incident wave height) for three different relative breakwater heights $h_s/d$ = 0.6, 0.7 and 0.8. Wavelength L is measured for five different wave periods T (1.5, 1.6, 1.7, 1.8 and 2 sec) by using the equation ($L=gT^2/2\pi$ × co-efficient of transition wave length). In Fig. 5 to Fig. 7 it is clearly visible that for a particular relative breakwater height as B/L increases $H_b/H_i$ decreases that means the reduction of wave height due to breaking occurs more. The relative wave height for wave breaking $H_b/H_i$ is decreased from 0.714 to 0.583 when $h_s/d$= 0.6, decreased from .667 to .615 when $h_s/d$ = 0.7 and decreased from 0.368 to 0.333 when $h_s/d$ = 0.8 for increasing B/L from 0.247 to 0.354.For $h_s$ /d=0.6 and B/L=0.25

reduction of wave height due to breaking is 20% whereas for the same breakwater wave height reduction becomes 35% as the relative structure width B/L becomes 0.35. The trend is similar for $h_s/d$=0.7 and 0.8. Again for any value of B/L, the breaking wave height $H_b$ decreases more with respect to the incident wave height, $H_i$ for higher value of $h_s/d$. This means that, the breakwater reduces the transmitted waves as the breakwater width (B) increases or the wave length (L) decreases. The above mentioned behavior could be attributed for two reasons. First, the increase of the breakwater width causes the increase of the friction between the breakwater surface and the transmitted waves, causing more wave energy loss. Second, as the wave becomes short, the water particle velocity and acceleration suddenly change and the turbulence caused due to this sudden change causes dissipation in the wave energy. Also, from Fig. 5 to Fig. 7, it is also found that, $H_b/H_i$ decreases as $h_s/d$ increases. This may be attributed to the decrease in the transmitted wave energy due to decreasing the area which water path through.

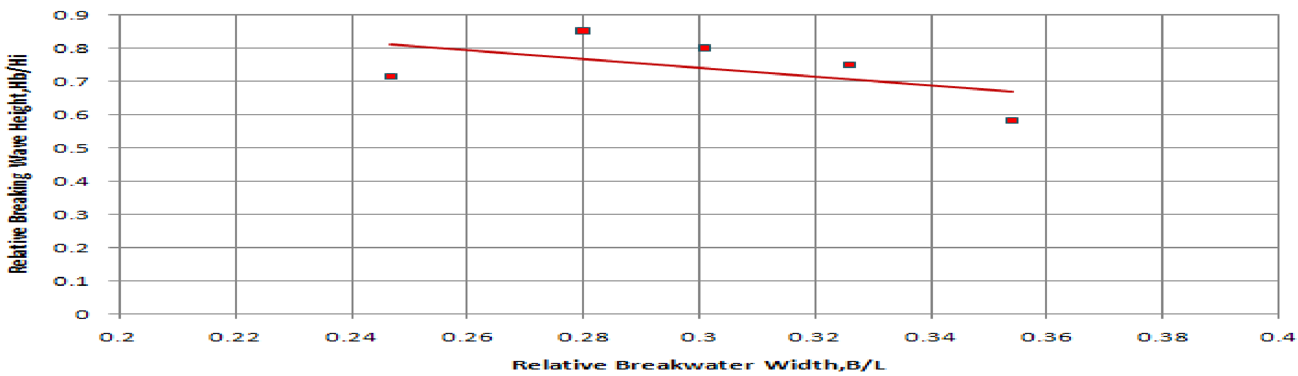


Fig. 5: Effect of relative breakwater width on wave height reduction for $h_s/d$= 0.6

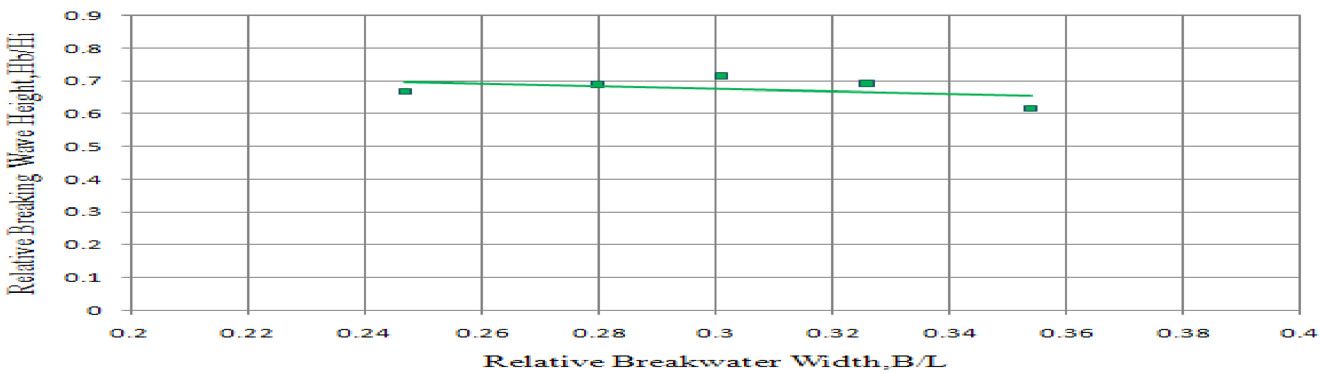


Fig. 6: Effect of relative breakwater width on wave height reduction for $h_s/d$= 0.7

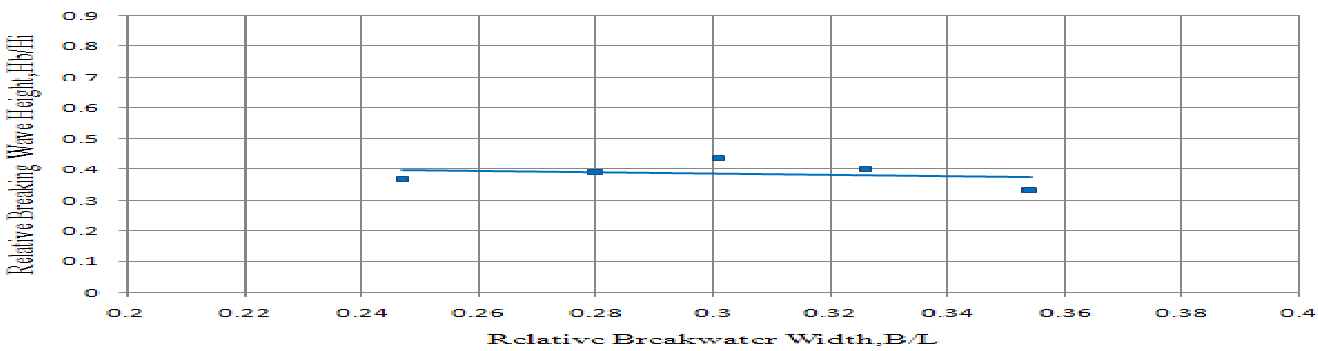


Fig. 7: Effect of relative breakwater width on wave height reduction for $h_s/d$= 0.8

## 4. Conclusions

The main drawn conclusions from this study can be summarized as follows:

- It is clearly seen from this experiment that a submerged breakwater is very effective in reducing the transmitted waves.
- Analyzing the water surface profile it is clearly found that for same wave period higher breakwater can reduce the incident wave height more than the smaller breakwater. For wave period T=1.5 sec wave height reduction is 42% when breakwater of 30 cm high is used but breakwater reduces the wave up to 50% and 64% when its height is increased to 35 cm and 40 cm respectively for same wave period.
- As the relative structure height $h_s/d$ increases, reduction of incident wave also increases due to breaking caused by the breakwater. When B/L is 0.3 reduction of wave height is 25% for $h_s$=30 cm. But, when breakwater height is increased to 35 and 40 cm reduction of wave height is increased to 32% and 59% respectively for the same B/L.
- As the relative breakwater width B/L increases, the reduction of wave height also increases.For relative breakwater height $h_s/d$, when B/L is equal to 0.25 reduction of wave height due to breaking is 20% whereas when it increases to 0.4 breakwater can reduce the wave up to 32%.

## 5. References


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