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Comparative Study on Hydrodynamic Performance of Porous and Non-Porous Submerged Breakwater

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Abstract

The paper offers a novel comparative case study on the performance of solid versus porous breakwater physically modeled under similar laboratory and wave conditions. Unidirectional waves were generated in a two dimensional laboratory flume having dimensions of 21.3 m length, 0.76 m width and 0.74 m height. Keeping still water depth of 50 cm, waves with T=1.6 sec, 1.7 sec, 1.8 sec and 2 sec were generated from a piston type wave generator. At 800 cm from the wave generator, horizontally slotted submerged breakwater of 100cm width,75cm length and 40 cm height were constructed with varying porosities of n=0.4, 0.5 and 0.6. Water level data were collected at six different locations for 12 unique run conditions. Using the measured data different hydrodynamic coefficients were calculated which include transmission co-efficient K_t, reflection co-efficient, K_r and wave energy loss co-efficient, K_L. These co-efficient values were then, analyzed with respect to relative breakwater width (k.B), [where, k = wave number (2π/L), B = breakwater width] and porosity of breakwater. For the comparison, hydraulic performance of solid rectangular submerged breakwater of 40 cm height and 100 cm width was also reviewed which was modeled in the same laboratory under same wave condition of T=1.6,1.7 1.8 and 2.0 seconds and a still water depth of 50 cm. Experimental results from the porous breakwater and subsequent comparison of the results with solid breakwater indicate that, for transmitting less wave energy through the breakwater, maximum transmission co- efficient, K_t = 0.526 was obtained for porous breakwater with the lowest porosity (n=0.4) for T = 1.6 sec whereas for the solid breakwater maximum K_t= 0.5 was obtained for T=1.6 second. In terms of wave height, percentage wave height reduction was maximum 47% for porous breakwater whereas it was 68% for solid breakwater both at T=1.6 second. The hydrodynamic performance shows a significantly higher wave height reduction percentage for solid breakwater as anticipated by the physics of the interaction of the breakwater and the wave too. Besides, the position of wave breaking for different case scenario for both types of breakwater were recorded and analyzed which demonstrates that for porous breakwater waves tend to transmit through the slots and break at a certain distance beyond the breakwater whereas in case of solid breakwater, waves tend to break before or on the breakwater.

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Keywords: Breakwater; solid versus porous; laboratory study; transmission coefficient; wave height

1. Introduction

Coastal areas are commonly defined as the interface or transition areas between land and sea, which is diverse in function and form, dynamic and there are no exact natural boundaries that unambiguously delineate coastal areas.

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According to the 2003 distribution of population in relation to the distance from the nearest coastline, 20.6 percent of the world's population lives within 30 km of the coast, and 37 percent within 100 km [1]. As a result of migration to coastal areas, and in particular to coastal cities, the coastal population is growing at a faster rate than the world population; within the next 20 to 30 years, the coastal population is projected to be 3.8 billion. In context of Bangladesh, with a coastline of approximately 710 km and coastal areas of about one-third of the total area, consist of population of about 35 million

2. Literature Review

Liao et. al. [2] studied on the wave breaking criteria and energy loss caused by a submerged porous breakwater on a horizontal bottom. Results show that almost all tested waves can be triggered to break when the ratio of the estimated equivalent deep water wave height to the freeboard of the submerged breakwater is greater than 1. Kondo & Toma (1972) did experimental studies to find the effect of characteristics of incident waves and of the thickness of structure on wave reflection and transmission [3]. They concluded that the relative thickness (= B/L, where B = the width of the structure and L = wave length) of the structure has appreciable effects on reflected and transmitted wave energies. Their study has shown that the reflection coefficient reaches a maximum for B/L of 0.2 ? 0.25, then decreases as the B/L increases, and remains approximately uniform for B/L larger than about 0.6. Kakuno et al. (1992) did a theoretical and experimental study on scattering of small amplitude water waves in which they have found that wall with greater height tends to scatter the flow much than wall with lower height [4].

3. Methodology

3.1. Experimental Set-up

To investigate the performance of the proposed horizontal slotted submerged breakwater, experimental studies are carried out in a two-dimensional wave flume at the Hydraulics & River Engineering Laboratory of Bangladesh University of engineering and Technology. The flume is 21.3 m long, 0.76 m wide and 0.74 m deep where a breakwater is placed at 800 cm far from wave generator. The transmitted waves through the permeable breakwaters are absorbed by a wave absorber placed at the end of the wave flume. Six measuring tapes are used to measure the water level in six different locations and twelve experimental runs are conducted. The experimental setup is shown below in Figure 1. The laboratory flume and wave generator are shown in Figure 2.

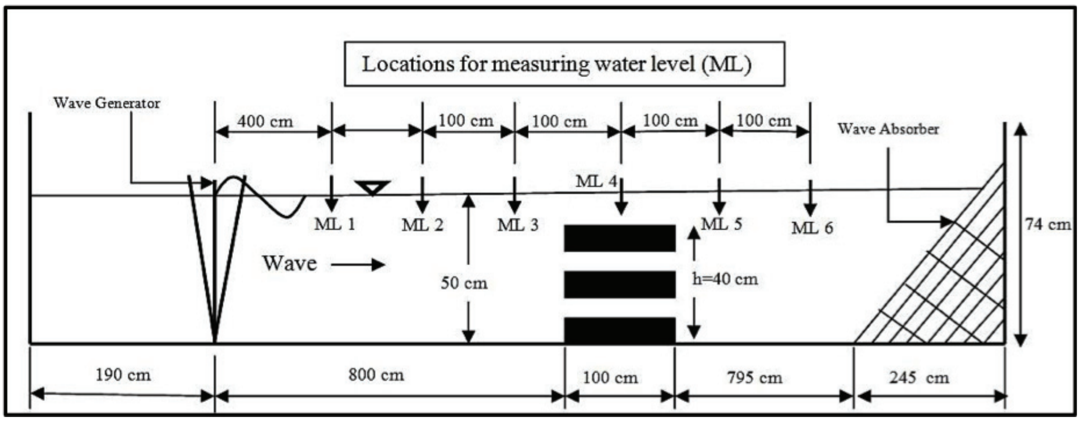

Fig. 1: Detail of the Experimental Setup