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Effects of vertical wall and tetrapod weights on wave overtopping in rubble mound breakwaters under irregular wave conditions

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ABSTRACT: *Rubble mound breakwaters protect the coastal line against severe erosion caused by wave action. This study examined the performance of different sizes and properties (i.e. height of vertical wall and tetrapod size) of rubble mound breakwaters on reducing the overtopping discharge. The physical model used in this study was derived based on an actual rubble mound in Busan Yacht Harbor. This research attempts to fill the gap in practical knowledge on the combined effect of the armor roughness and vertical wall on wave overtopping in rubble mound breakwaters. The main governing parameters used in this study were the vertical wall height, variation of the tetrapod weights, initial water level elevation, and the volume of overtopping under constant wave properties. The experimental results showed that the roughness factor differed according to the tetrapod size. Furthermore, the overtopping discharge with no vertical wall was similar to that with relatively short vertical walls ($\gamma_v = 1$). Therefore, the experimental results highlight the importance of the height of the vertical wall in reducing overtopping discharge. Moreover, a large tetrapod size may allow coastal engineers to choose a shorter vertical wall to save cost, while obtaining better performance.*

INTRODUCTION

The rubble mound breakwater is one of the most common breakwater types used for shore protection, which involves several tetrapod layers. One of the greatest influences on the design of a breakwater is the overtopping hydraulic procedure. The overtopping manual provides management guidelines on the analysis and estimation of the overtopping discharge volume to control flooding when breakwaters are subject to significant wave action. On the other hand, there has been little research on the role of the overtopping parameter in design. A few overtopping studies have been reported for seawalls (Owen, 1980; Goda, 1985), and more recently for rubble mound breakwaters (Aminti and Franco, 1988; Bradbury and Allsop, 1988; Goda, 1985). An extensive study was published by Van der Meer and De Waal (1993). Franco et al. (1994) established a formula for the overtopping discharge volume of vertical breakwaters. Franco (1993) also evaluated the effect of overtopping volumes on persons and cars behind the crown wall of a vertical breakwater. Saville and Caldwell (1953) researched the wave overtopping volumes and wave run-up height, whereas (Jensen and JuhI, 1987; Weggel, 1976; Van der Meer, 2002) analyzed the data of previous studies. Several formulae can be used to estimate the mean overtopping discharge at toe structures. On the other hand, it was not the aim of this study to calculate these formulae, rather, this study focused on the roughness influence factor, which

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can also be applied to wave overtopping estimations by Van der Meer (2002). On wave overtopping, previous studies tried to separate out these influences, but the findings were inconclusive Franco et al. (2009). The overtopping performance of different armor units for rubble mound breakwaters and the roughness influence factor was investigated experimentally by Bruce et al. (2009) but only a single tetrapod size was considered. The port of Busan is a vital gateway in Korea, connecting the country to the Pacific Ocean and Asia. This port is Korea's main port, handling approximately 40% of the country's overseas cargo, 80% of its container cargo, and 40% of Korea's national fishery production. Breaking waves play an important role in almost all coastal engineering issues Busan Port Authority (2011). A key function of breakwaters is to provide protection against waves in harbors and nearby channels, as well as currents and siltation. In South Korea's Busan Yacht Harbor (Fig. 1), breakwater rubble mounds have been studied. Rubble mound breakwaters in this area of the beach are the most suitable structures for this investigation, which were designed to test irregular waves. The hydraulic responses of a breakwater are one of the most significant factors for the design of rubble mounds. Another major factor for embedding the breakwater is the overtopping-related issue.

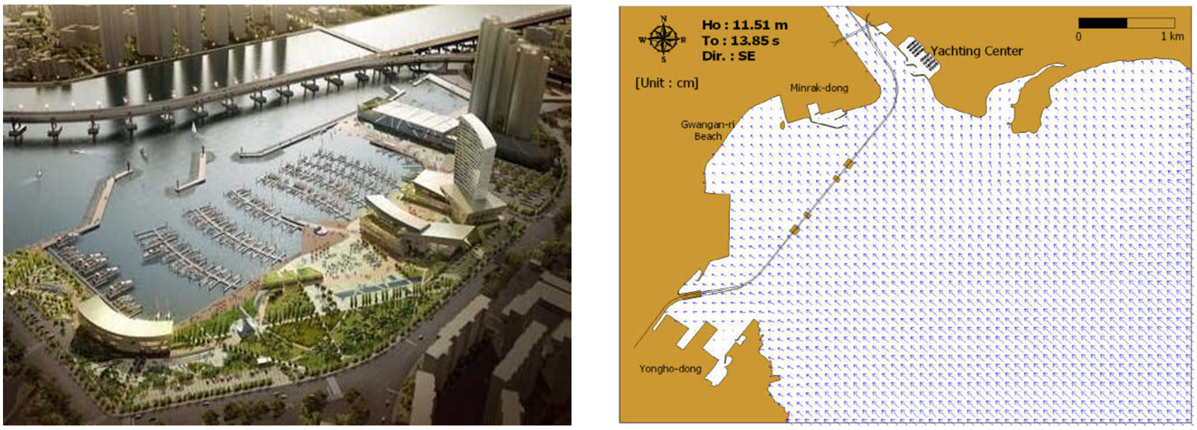

Fig. 1 Yacht harbor position, busan, south korea.

Pullen et al. (2007) suggested the installation of vertical walls on the rubble mound breakwater structure to reduce the overtopping discharge. They recommended that the vertical wall not be much higher than the armor crest level because wave forces on the wall will increase drastically if attacked directly by waves and not hidden behind the armor crest Pullen et al. (2007).

Model set-up

An extensive number of experimental tests in the wave flume located at coastal engineering research institute, Pusan National University, Busan, South Korea were conducted to achieve the main purposes of this study. The wave flume used in this study was a 30 *m* long rectangular channel with a transparent Plexiglas sidewall. The width and height of this flume were 0.6 *m* and 1.0 *m*, respectively. A foreshore with a front slope of 1:30 was constructed in the flume. The beginning of the foreshore was located 22.5 *m* far downstream from the wave generators. Fig. 2 presents a schematic (not to scale) view of the rubble mound physical model.

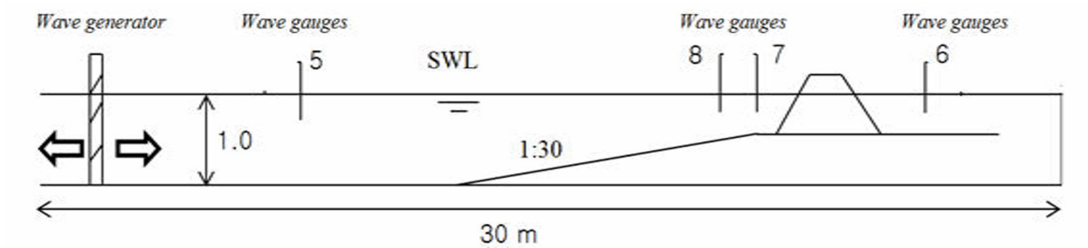

Fig. 2 Experimental setup.