Experimental Study of Wave Impact Forces on Pervious Pipe Breakwaters

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ABSTRACT

In this study, the wave impact on highly-pervious pipe breakwaters is investigated by a physical experiment conducted in a 21-m wave flume, with a combination of positively placed pervious pipe obstacles and an impermeable embankment. The wave impact force on the protected coastal structures was effectively mitigated and attenuated. The process of wave impact is very complicated; involving strongly nonlinearity and transient effects, and the effect of wave impact is one of the important factors on the safety and/or destructions of coastal structures. This study addresses highly pervious dense pipe with small apertures, which can be beneficial for convection and interchange of seawater within the harbor district, and furthermore, perform effectively in wave absorption. The problems of random wave impact on the highly pervious perpendicular pipe obstacles were also investigated. Physical experiments were carried out with regular and irregular waves under various conditions. The results showed that, a pervious pipe obstacles placed vertically in the front of an impermeable embankment can effectively mitigate and attenuated the wave impact.

KEY WORDS: Irregular waves; pervious pipe breakwater; wave reflection; wave transmission; wave impact force.

INTRODUCTION

Increasing attenuation on the preservation of nature landscapes has led to the recent emphasis on hydrophilic facilities. Amenity-oriented policy was subsequently enforced to promote the comprehensive development of port and harbor facilities, and many constructions are underway, using the ecological engineering method. Offshore structures, such as breakwaters and seawalls, reduced huge wave forces and have been designed and constructed to produce hindrances for the waves and ensure urban safety. Many submerged breakwaters called “sub-dikes,” which include square, trapezoid, and triangular forms, are being extensively investigated and analyzed as impermeable embankments to provide protection. In recent years, many scholars have studied various offshore-submerged breakwaters, including the varying external forms and/or shapes, permeability, quantity of submerged obstacles, and the interval between two obstacles, and changes in wave conditions.

Regarding the studies of wave impact forces acting on different wave-structures, many scholars believe that: in addition to enhancing the efficiency of energy dissipation structures, they also expect to reduce the impact of waves on the structures, either by forcing the incoming waves to break before approaching or by implanting so-called screen breakwaters. Losada (1997) study experimentally the effects between permeable submerged breakwaters conducted by different gravel sizes with harmonic evolution of monochromatic waves as they propagate over the porous breakwaters, and shown that the porous breakwater increases the effective relative depth and decreases the relative wave height. Bai and Eatock Taylor (2009) studied the interactions of fully nonlinear wave with fixed and floating vertical cylinders and flared structures by higher-order boundary element model with domain decomposition technique. The horizontal hydrodynamic force on a floating truncated cylinder is reduced significantly compared with the wave force on a comparable fixed truncated cylinder. Moreover, with increase in cylinder radius, the dimensionless vertical force at the same frequency is smaller. Kisaçik, Troch and Van Bogaert (2010) studied the breaking wave impact on a vertical wall with horizontal cantilevering slab. They indicated that the highest impact pressure and forces were measured in breaking waves with a small air trap, and the horizontal part of the scaled model is more exposed to impact waves than the vertical part. Also, the variation of wave period (T) has a rather limited effect. Li and Lin (2012) studied the fully nonlinear wave-body interactions for a stationary floating structure under regular and irregular waves; they discussed and compared the effects of water depth, wave height and period on the variation of forces and moment. They indicated that the maximum forces and moment by irregular waves increase rapidly with relative wave height and the average values are less than those induced by regular waves. Akız et al. (2011) investigated the prediction of geometrical properties of perfect breaking waves on composite-type breakwaters by artificial neural networks.

A variety of laboratory tests have been performed by Bea et al. (1999) to study the wave force on decks of offshore platforms, and applied the results from laboratory testing and associated analyzing to the study the