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Experimental Research on Overtopping Flow Thickness and Secondary Wave Conditions Over Sloping Breakwater

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ABSTRACT

In this paper, a physical experiment is conducted to investigate the wave overtopping flow thickness on the crest of slope breakwater and the generated secondary waves behind the slopping breakwater. The relationship between the relative overtopping flow thickness, secondary wave height transmission coefficient and non-dimensional mean wave overtopping rate or the relative crest level are proposed. The experimental results could provide reference to practical engineering design and validations for associated numerical model.

KEY WORDS: slope breakwater, mean overtopping, wave overtopping flow thickness, secondary wave

INTRODUCTION

Breakwater is a kind of important sea defense to prevent the coastal area or harbor from hitting by tides and waves. Sloping breakwater is one of the most common structure types of all. If the design embankment top elevation is low, waves will cross over the crest top in a great deal and to generate wave overtopping flow, and wash or even destroy the crest, and then come into a series of new waves behind the breakwater in the harbor. The new waves, which are called “secondary waves”, have lots of influence on the berthing stability of the ships. Lots of researches pointed out that the strength of wave overtopping can be measured by the wave overtopping discharge, and then has the direct influence on the overtopping flow on the crest and secondary waves.

Most of the typical sloping breakwaters do not set up seawalls or set up lower crest seawalls, in which case the overtopping is commonly apparent, and water discharge will be large and then form overtopping flow on the crest. So the study about the wave overtopping flow thickness and velocity is necessary. Schuttrumpf and Oumeraci (2005) divided the whole process of the waves over sea dikes into five domains: wave parameters at the toe of the sea dike, wave transformation on the seaward slope up to the breaking point, wave run-up and wave run-down on the seaward slope, wave overtopping on the dike crest, and wave overtopping on the landward slope. They studied the conditions of the wave overtopping in these five domains in detail and proposed the formulas about the thickness of wave flow and velocity.

Furthermore, waves cross over crest and then become secondary waves behind the breakwater. They have big influence on the wave conditions in the harbor. However most of the studies about the secondary waves are concentrated on the submerged dikes. Gu (1994) gives the transmission coefficient formulas about sloping submerged dikes, vertical and rectangular submerged dikes, and semicircular submerged dikes. Chinese code of design and construction of breakwaters (1998) gives the empirical formulas about the transmission coefficient of rubble mound submerged dikes. Ge et al.(2010) experimentally studied the variation of the significant wave height, significant wave period and wave spectrum for secondary waves over breakwaters with relatively water depth. So the researches about the secondary waves over the breakwaters are mainly concentrated on the influencing factors such as wave parameters and section scales.

As to the wave overtopping discharge, lots of researches offer many empirical formulas applicable to real projects and study. At present, the main methods by irregular waves in and abroad included the proposed formula by the Chinese Code of Hydrology for Sea Harbour (called as Standard method (1998), VDM method which is commonly used in European countries (2002), and Owen method (1980, 1982, 1991) and so on. The proposed formulas can calculate the mean overtopping rate and single wave overtopping in the case of single or complex slope, breast wall or not.

Considering that the formulas about the wave overtopping is relatively mature, and the wave overtopping flow thickness and secondary waves have direct relationship with the overtopping discharge, establishing the relationship between the wave overtopping flow thickness, secondary waves and overtopping discharge will be more convenient for application and has good meanings for project design.

Although many numerical models were developed to study the wave overtopping on seadikes or breakwater (such as Hsieh et al. 2010, Tuan and Oumeraci 2010), experimental method is one of the most important methods for the evaluation of the wave overtopping problems because of its complex. So with physical experiments, this paper preliminarily studied the wave overtopping discharge over a sloping breakwater, the wave overtopping layer flow thickness on the crest and secondary waves behind the breakwater. Then the relationships between relative layer thickness of wave overtopping flow, secondary wave height transmission coefficient, secondary wave period and non-dimensional mean overtopping discharge or the relative crest level are established. The experimental results could provide reference to practical engineering design and validations for associated numerical model about the wave overtopping on the crest.