Experimental Research on the Wave Transformation over Submerged Structures with Sudden Depth Changes

Zhao-Bing Jiang, Jin-Yu Xu, Fei Shao
College of Field Engineering, PLA University of Science & Technology
Nanjing, China

ABSTRACT

The coral reefs can be simplified as submerged structures with sudden depth changes and the laboratory experiment here is conducted to investigate the influences of the submerged structures on incident waves. Both incident and diffracted wave amplitudes are detected to calculate the transmission coefficients. The results show that the transmission coefficients are not decided only by the ratio of submerged depth to wave amplitude or other dimensionless parameters. There are two different transmission coefficients corresponding to different wave breaking types, i.e., spilling or plunging in this paper. This means that wave breaking types dominate the transmission coefficient. The wave amplitudes have less effect on the transmission coefficients. But the wave with higher amplitude would be easier to break, and the breaking process would dissipate the wave energy to form less transmission coefficients.

KEY WORDS: Laboratory experiment; submerged structure; incident wave; transmission coefficient; bubble and vortex.

INTRODUCTION

Fringing reefs exist along coastlines in tropical and sub-tropical regions around the world. The majority of the energy in the tsunami wave or the ocean wave would be eliminated by coming across the reef barrier (Ferrario et al., 2014). The extended lagoons and steep flanks of most fringing reefs produce unique surf zone processes and they are the natural ports for the fishermen and the boats with small draft.

For the problems of the wave runup over the beach with a slope or over the steep offshore slope, some experimental results provide interesting information such as the relationship between the incident wave and the runup, which can be applied to practical situations to have a first guess of the excepted hazard (Synolakis and Deb, 1988; Liu et al., 1995; Roeber and Cheung, 2012).

Analytical solutions and numerical simulations with various methods are powerful and popular tools for its lower expenses comparison with the physical experiments. The linear incident wave diffracted by submerged structures with steep flanks, which can be simplified as vertical faces or sudden depth changes, was investigated systematically (Zheng et al., 2007; Zheng et al., 2006; Zheng et al., 2004). The analytical method was used for its accuracy and efficiency is higher than numerical methods and physical experiments. The incident wave is linear with finite or infinite depth determined by the ratio of the length of wave and the water depth. The method of separation of variables and the eigenfunction expansion matching was used to solve the diffracted wave for the existing of the submerged plate barrier with shallow water and vertical flanks.

Numerical methods including finite volume-finite difference hybrid model (Olabarrieta et al., 2011), Boussinesq model(Yao et al., 2012; Roeber and Cheung, 2012) and other models are developed to simulate the wave propagating over plate beaches or reef lagoons. Analytical methods, including Schwinger’s variational formulation (Black et al., 1971) and eigenfunction expansion matching method (Wu et al., 1995) and other methods, are classical and convenient methods to analyze the interaction between the waves and the marine obstacles.

The main purpose of this paper is to investigate the transmission coefficients and the wave characteristics over submerged structures with sudden depth changes in shallow water area. The remaining of this paper is organized as follows. Firstly, the experimental setup is described and the cases including wave parameters and structure arrangements are listed. Then the experimental results are compared with simple empirical fitting functions of others, and some discusses are presented. At last, the main conclusions drawn from this investigation are given.

EXPERIMENTAL SETUP AND CASES

Fig. 1 Snapshot of the wave flume

The laboratory experiment was conducted in a closed wave flume in the Ocean Hydraulics Laboratory, PLA University of Science and Technology, China. The flume is 30m long, 1.0m wide and 1.5m deep. The wave elevations are detected by wave gauges.

The snapshot of the partial wave flume is shown in Fig. 1 with 0.48m water depth. The experiment was designed to study the wave