Numerical Study of Solitary Wave Interaction with a Slotted Barrier

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ABSTRACT

The interactions between a solitary wave and a submerged, vertical, fixed slotted barrier are investigated numerically. Two various locations of slotted barrier are considered by varying the vertical distance from the structure to the free surface and the floor. Numerical results are calculated by a well-validated two-dimensional volume of fluid (VOF) type model, named COBRAS (COrnell BReaking And Structure), based on the Reynolds-Averaged Navier-Stokes (RANS) equations and the $k$-$\varepsilon$ turbulence closure solver. In particular, the active wave absorption inflow boundary is incorporated to avoid re-reflection and reduce the computational cost. Experiments had been conducted to measure the free surface motion as a means of model calibration for the case of impermeable barrier. Fairly good agreements at both pre- and post-breaking stages are observed. Then, the numerical results are employed to illustrate the vortex shedding in details for different porosities and locations of the target structure.

KEY WORDS: Solitary wave; submerged; slotted; breakwater; vortex shedding; RANS model.

INTRODUCTION

Numerous available types of breakwater are commonly constructed along the coast to dissipate wave energy for protecting the shoreline as well as maintaining the activities and economies of local residents against the impacts from waves and currents before they arrive at the coast. In particular, for decades, submerged coastal structures are widely used due to the rise of environmental awareness. Therefore, it is of interest to understand the wave-structure interactions for design purposes and engineering applications.

Among various forms of breakwater, wave barriers are suggested as an alternative in considering cost effectiveness and less environmental impact. With the advantages of exchanging water circulations and sediment movements, wave barriers in the form of thin, rigid, vertical and surface-piercing are sometimes built around the world (see Kriebel, 1992; Rageh and Koraim, 2010). Over the past decades many extensive researches have been performed to exhibit the wave reflection and transmission on the periodic wave scattering by solid (e.g. Wiegel, 1960; Liu and Abbaspour, 1982) and slotted barriers (e.g. Issaicon et al., 1998; Huang, 2007) using either experimental or numerical approach. The design of coastal structures relies on the understanding of dynamical interaction between the structure itself and the induced flow fields, yet few works have been done for the flow dynamics under the wave-barrier interaction. Under solitary wave attack, Liu and Albanna (2004), Lin et al. (2005) and Wu and Hsiao (2010) respectively consider a surface-piercing, bottom-standing, fully submerged solid barrier to examine the vortex shedding in the vicinity of the structure. However, the information for the flow dynamics combined a solitary wave interaction with a slotted barrier is relatively rare.

The primary objective of this paper is to extend the previous work done by Wu and Hsiao (2010), which perform the solid/non-porous cases, to further investigate the porous effect of the barrier via using a two-dimensional volume of fluid (VOF)-type numerical model named