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Numerical Study of the Characteristics of Surface Waves Generated by Submarine Landslides

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Abstract

Surface waves generated by landslides in the dam reservoir regions are important in dam design and study of landslides in the dam lake area. This type of waves can produce flooding in the dam lake region and large run-up heights on the dam body. The impacts of this flooding and run-up, can lead to significant damages along the shore line of the lake and on the dam itself. In this paper, numerical study of the characteristics of the impulse waves generated by submarine landslides is presented. The study aims to evaluate the effects of landslide shape, and turbulence models on the impulse wave characteristics. The volume of fluid (VOF) technique is used to track the free surface of water and beach solid movements. Simulated results show the complex flow patterns in the lake due to occurrence of a submarine landslide in terms of the velocity field and free surface profiles. Hydrodynamic forces applied to the sliding materials are computed, which are used by geotechnical engineers to study the stabilization of the slope. Simulation results are in close agreement with the experimental observations.

Keywords: Submarine Landslide, Wave Run-up, Fluid Structure Interaction, Turbulence Models, Large Eddy Simulation

1. INTRODUCTION

Surface waves generated by landslides in the dam reservoir regions are important in dam design and study of landslides in the dam lake area. This type of waves can produce flooding in the dam lake region and large run-up heights on the dam body. The impacts of this flooding and run-up, can lead to significant damages along the shore line of the dam lake and on the dam itself. This is the reason of paying much attention by coastal and geotechnical engineers to study this problem and overcome its consequences.

Empirical studies of water waves generated by underwater landslides have been conducted by Wiegel [1], Iwasaki [2], Heinrich [3] and Watts [4]. Iwasaki [5, 6] conducted a wide variety of numerical studies for water waves generated by solid underwater landslides of various geometries using the linear shallow water wave equations. Harbitz [7] also used the linear shallow water wave equations to model the Storegga landslide as a sliding solid block generating waves. The results of their numerical results were not satisfactory, because of neglecting vertical acceleration in the shallow water model, especially in the generating zone where depth changes rapidly. Das et al. [8] and Basu et al. [9] performed numerical modeling of wave induced by submarine landslide for different landslide shapes (triangle, rectangle, and half ellipse) using turbulence models. They used an identical prescribed velocity for all geometries, which was measured by experimental work. So their numerical and experimental results were not in good concurrence. This emphasizes that different coupled velocities must be applied for different geometries. In other words, landslide velocity should be computed based on transient interaction between landslide movement and displacement of water body.

The above studies show that surface waves generated by underwater landslides are governed by several parameters related to the landslide geometry and kinematics. One important characteristic of these landslides is propagation of the generated wave. Predicting this wave propagation pattern is of prime importance for assessing risks and magnitude of flooding in coastal and dam lake areas. Hence, an effective numerical procedure is required for simulating the flow patterns of the generated waves, that takes into account all the strong nonlinearities that are involved in this transient phenomenon. Also forces and moments applied to the body of landslides should be clearly known to study the measures required for stabilization of the shoreline by geotechnical engineers.

The present study aims to evaluate the effects of landslide geometry and turbulence model on wave characteristics. Five different type of geometry in cross section are used: a triangle, a rectangle, a half ellipse, a half circle and a circle, all having the same area and density. The circular landslide contains two type of motion: sliding on the shoreline and a rotation along its center, while others have only the sliding motion.