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Application of Bed Load Formulations for Dam Failure and Overtopping

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Abstract

The Enhanced HLLC scheme as a robust approximate Riemann solver is used for numerical modeling of three different test cases of mobile bed and stepped mobile bed in dam failure and dam overtopping conditions. The current research has been done in the frame of the finite volume method using shallow water equations along with the Exner equation for sediment continuity. The Ribberink, Wong and Parker formulations have been used for the modelling of bed load movement. A convenient approach based on the Boussinesq hypothesis is deployed for considering turbulence effects in the second case. The affections of stepped and slope condition for the flow bed are considered through a corrected version of the HLLC flux components. Finally, the model is applied for modelling overtopping in the third case. The results of the present model are relatively reasonable by comparing with the experimental data.

Keywords: HLLC Scheme; Stepped Bed; Shallow Water Equations; Sediment; Overtopping.

1. Introduction

All kinds of man-made structures such as dam might cause lots of risks depending on the dam location and operating condition. Therefore, Dam failure and overtopping risks are crucial challenges because of their huge effects on the downstream domain. There are three main methods for evaluating of dam failure and overtopping risks containing; studying of the last similar experiences, physical modeling and mathematical modeling. One of the most reasonable ways for studying the mentioned risks is the numerical modelling of waves induced by dam failure and also bed load movement or soil erosion. The numerical results include water surface and bed profiles in the various times after dam breaking or overtopping.

In the recent decades, the finite volume method has been known as one of robust discrimination methods for partial differential equations. After introducing of Godunov's scheme, some considerable activities have been done about waves modeling induced by dam failure and solving Riemann problem. One of the mentioned activities has been done by Harten et al. [1]. They proposed a Riemann solver assuming two separate waves known as HLL Riemann solver. Toro et al. presented a modification of HLL scheme named the HLLC Riemann solver assuming three separated waves considering the shear waves affection [2].

In order to extend HLL scheme to movable bed cases, Fraccarollo et al. studied rapid erosion in a rectangular flume using LHLL scheme as a Godunov-type scheme [3]. Simpson and Castelltort applied modified HLL scheme for solving shallow water equations and sediment continuity equation in the coupled approach using two test cases related to a dam

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