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Boussinesq Model for Dam-Break Flow Analysis

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Abstract : Dams and reservoirs are perceived for their estimable alms to irrigation, water supply, flood control, electricity generation, etc. which civilize the prosperity and wealth of society across the world. Meantime the dam breach could cause devastating flood that can threat to the human lives and properties. Failures of large dams remain fortunately very seldom events. Nevertheless, a number of occurrences have been recorded in the world, corresponding in an average to one to two failures worldwide every year. Some of those accidents have caused catastrophic consequences. So it is decisive to predict the dam break flow for emergency planning and preparedness, as it poses high risk to life and property. To mitigate the adverse impact of dam break, modeling is necessary to gain a good understanding of the temporal and spatial evolution of the dam-break floods. This study will mainly deal with one-dimensional (1D) dam break modeling. Less commonly used in the hydraulic research community, another possible option for modeling the rapidly varied dam-break flows is the extended Boussinesq equations (BEs), which can describe the dynamics of short waves with a reasonable accuracy. Unlike the Shallow Water Equations (SWEs), the BEs taken into account the wave dispersion and non-hydrostatic pressure distribution. To capture the dam-break oscillations accurately it is very much needed of at least fourth-order accurate numerical scheme to discretize the third-order dispersion terms present in the extended BEs. The scope of this work is therefore to develop an 1D fourth-order accurate in both space and time Boussinesq model for dam-break flow analysis by using finite-volume / finite difference scheme. The spatial discretization of the flux and dispersion terms achieved through a combination of finite-volume and finite difference approximations. The flux term, was solved using a finite-volume discretization whereas the bed source and dispersion term, were discretized using centered finite-difference scheme. Time integration achieved in two stages, namely the third-order Adams Basforth predictor stage and the fourth-order Adams Moulton corrector stage. Implementation of the 1D Boussinesq model done using PYTHON 2.7.5. Evaluation of the performance of the developed model predicted as compared with the volume of fluid (VOF) based commercial model ANSYS-CFX. The developed model is used to analyze the risk of cascading dam failures similar to the Panshet dam failure in 1961 that took place in Pune, India. Nevertheless, this model can be used to predict wave overtopping accurately compared to shallow water models for designing coastal protection structures.

Keywords : Boussinesq equation, Coastal protection, Dam-break flow, One-dimensional model
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