COMPARISON OF TWO-DIMENSIONAL FINITE VOLUME SCHEMES FOR DAM BREAK PROBLEM ON AN IRREGULAR GEOMETRY

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Shallow water equations have become a common tool for modeling environmental problems involving unsteady flows in waterways. The non linear character of the equations means that numerical methods must be used to obtain solutions to practical problems which include discontinuities in the solution. Many authors proposed numerical schemes for the integration of shallow water equations in one- and two-dimensional domains and recently many shock capturing finite volume schemes have been widely implemented, owing to their capacity to simulate various types of flow even in the presence of discontinuities. Although there are many schemes, in literature there are few comparison tests.

This paper compares the performances of some finite volume schemes applied to two-dimensional shallow water equations to solve dam-break problems. Differently set up models have been implemented such as HLL, HLLC , Roe's first and second order upwind schemes, and MacCormack's second order space centered scheme with the TVD artificial viscosity term. For each scheme several difficulties have been adequately treated such as the correct implementation of the source terms. The performances of the numerical methods have been investigated simulating two examples from literature with the presence of an irregular geometry and comparing the results obtained both among themselves and with experimental data.

The first simulated test was conducted at the Waterways Experiment Station (W.E.S. 4.1) (U.S. Army Corps of Engineers, 1961) and concerns a dam-break wave with instant breakup of a partial breach causing the flow to cross an abrupt constriction. In Fig. 1 water levels in the middle of the breach, computed by means of all analyzed schemes, are compared with the experimental data at time t = 90 s. In this case, despite not introducing any internal conditions in the constriction of the breach, the numerical results computed by the various schemes succeed in reproducing the phenomenon in a satisfactory way and the discrepancies with the observed data have a value of the error norm less than 0.06. It is interesting to underline that the computational time of the first order schemes is about 30% of the second order schemes.

The second test concerns a dam-break in a channel with a bump (CADAM, 2000). This test is particularly onerous due to its characteristics which involve the simulation of the wave front, rapid change of flow regime, and the treatment of the source term in order to simulate the water at rest (Fig. 2). The results of both first and second order schemes are in good agreement with experimental data and all the schemes fulfill the condition of water at rest until water wave reaches the pool. The values of the error norm prove to be very similar for all the schemes and about 0.28; moreover, the difference among the schemes does not exceed 3%. As regards mass conservation, the first order schemes present a variation of 0.08% whereas the second order 6%.

Hence the numerical solutions of all the schemes present a good agreement with the experimental data and the discrepancies between the obtained solutions are irrelevant from a technical point of view. Moreover, the first order schemes are less expensive in computational time, simpler to implement and they fulfill mass conservation.

These considerations lead to prefer the first order schemes also in the dam break over an irregular geometry.

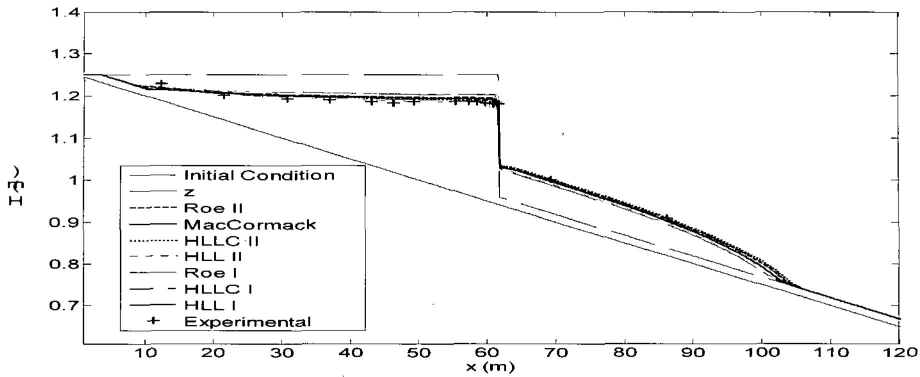

Fig. 1 Test 1. Water surface profiles at time t = 90 s in the middle of the channel computed by all the schemes and compared to experimental data.

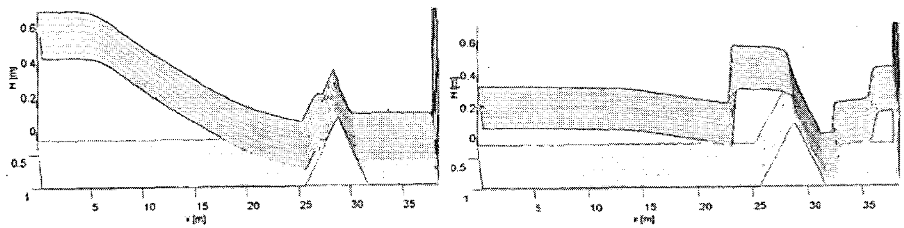

Fig. 2 Test 2. Water surface elevation at times (a) t = 3.5 s and (b) t = 10 s

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