A 2D FINITE VOLUME SCHEME FOR HYBRID UNSTRUCTURED GRIDS

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The increase in catastrophic floods events observed in last decades has motivated a continuous research in developing numerical scheme in order to prevent those disasters. These models are useful to study the natural environments, the spreading of a flood along a river or the efficiency of some human interventions.

In order to describe the evolution of a flood in a river the best results are obtained modeling the main stream with quadrangular cells having their main direction parallel to flow direction. Anyway it can happen that a combination of unstructured triangular and quadrangular grid works more effectively, because this can fit the real topography at best.

As an example one can consider an abrupt change in channel width where two branches with constant cross section are connected by a narrowing. The best way to model the two arms is probably with regular quadrangular elements, but to use the same kind of cells all over the domain the cell surface in the downstream part must be much smaller than those of the upstream one.

In explicit schemes this causes a strong reduction in time step length, with Δt depending also on the size of the smallest cell in the grid. One possibility to keep cell size almost invariant is to model both arms with regular quadrangular cells of same dimension and to bring them together introducing some triangular cells. Thus the hybrid grid at the same time represents well the water flow and uses almost homogeneous cells, inducing a gain in computational time.

In literature there are a lot of second and higher order schemes for 2D structured grids, some second order scheme for triangular unstructured grids and a few schemes able to work simultaneously on triangular and quadrangular grids.

The present paper describes a numerical model obtained integrating the shallow water equations at second order in time by means of a Strang splitting approach. The advective part of the equation system is solved in space exploiting the rotational invariance and considering one augmented local Riemann problems across each side of the cell. The scheme is first order accurate in space and it allows to work with hybrid grids, built by triangular and quadrangular elements.

Thus the domain can be discretized as well as possible, following the main flow direction with quadrangular almost regular cells and maintaining quite homogeneous grid sizes. The former characteristic allows the scheme to work more effectively along the main flow direction and the latter helps in reducing computational time. The model can be easily applied to real environmental problems, with complex topography.

In order to check the numerical scheme, the model is tested on standard shocking test problems that allow an exact solution, as the 1D dam break and the oblique hydraulic jump. The objective of these tests is to verify that the numerical scheme is able to represent a shock, also working on hybrid unstructured grids.

The dam break test is carried out on a group of different meshes (Fig.1) to check the influence of the domain discretization on the results.

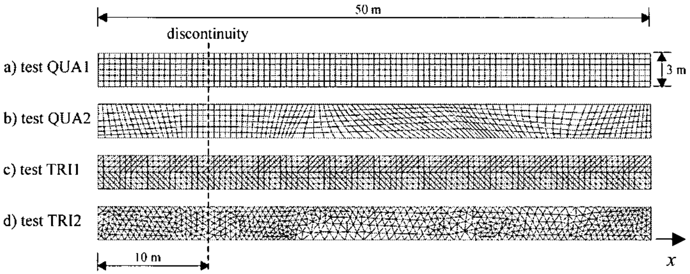

Fig. 1 Different grids used in the 1D dam break test.

The oblique hydraulic jump is a 2D test and here it is used to verify that the scheme is able to represent a bidimensional problem. The domain is modeled with an hybrid grid, made by quadrangular and triangular elements; this allows to model with a coarse mesh the whole domain and to refine the area involved by the oblique hydraulic jump (Fig.2).

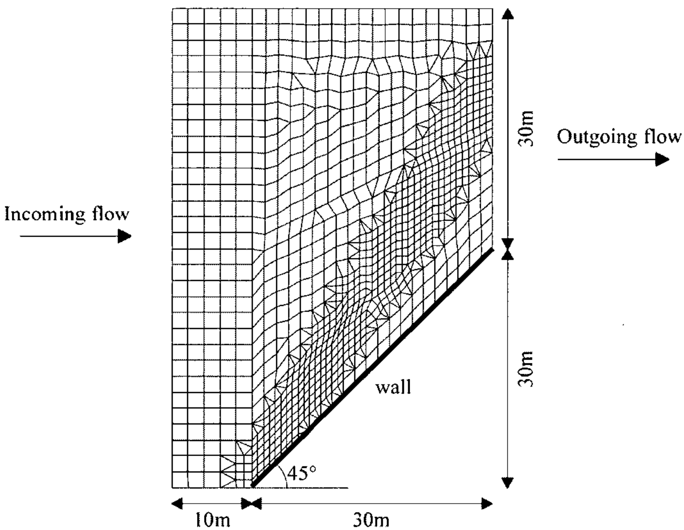

Fig. 2 Domain discretization for the oblique hydraulic jump test.