EMBANKMENT OVERTOPPING AND BREACH EVOLUTION MODELLING

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A numerical model based on an alternative formulation of one-dimensional shallow water equations and on sediment mass balance is presented. In momentum balance equation the source term has been analytically modified in order to avoid the explicit dependence on local bed slope (Valiani et al., 2001). This particular treatment leads to an improved numerical stability, in particular when irregular channel geometries are encountered. The proposed numerical model is therefore especially suitable for the study of alluvial rivers and natural channels in which abrupt changes in longitudinal profile slope are frequently present, and transversal cross sections are often complexly shaped.

Sediment mass balance is treated with the Exner equation, in which solid discharge is evaluated by means of a transport formula based on flow transport capacity.

For numerical implementation, the simple MacCormack scheme is adopted. It is an explicit finite-difference numerical scheme based on a predictor-corrector procedure, second order accurate both in time and space. Liquid and solid phase are related at every time step by a semi-coupled treatment.

In recent works the model has been widely tested on different kind of channel geometries and flow conditions (Schippa and Pavan, 2004). Various transport mechanism have been investigated, such as channel aggradation due to overloading; progressive bed erosion consequent to a check-dam failure; knickpoints migration; homogeneous washout of an earth embankment. The model showed to perform satisfactorily, even in presence of rapidly varied flow and transcritical conditions. A TVD algorithm has been added to the numerical scheme when an hydraulic jump occurs, as suggested by Garcia-Navarro et al. (1991), in order to avoid spurious oscillations in the numerical solution.

In this work the model is applied to breach formation in earth embankments subjected to overtopping. To this aim, a series of laboratory tests performed by Rozov (2003) has been considered. Experimental setup is shown in Fig. 1: an earth dam of homogeneous sandy material is built across a 100 m long flume, and a triangular-shaped reservoir is created at its upstream.

A pilot channel is prepared on dam's crest before the experiments begin, in order to force a central position for the breach, then its evolution is documented both by video recording and washout indicators time operation .

The model is applied to the physical scheme above described without insert any computational discontinuity between the reservoir and the dam. The flume has been subdivided in equally-spaced cross sections of known coordinates, providing a local reduction of space interval across dam's location. It is worth noting that the model does not need internal boundary conditions such as a reservoir depletion relation or a weir flow equation to compute the discharge through the breach.

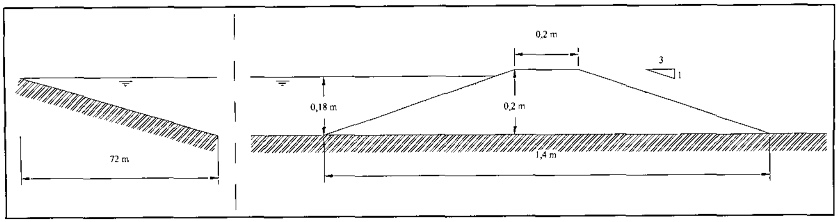

Fig. 1 Side view on flume.

Some uncertainties are encountered in the choice of the sediment transport formula, since most of available empirical formulae are not applicable to, or are untested in, the regime of flow conditions occurring during dam breaching. Breach enlargement process is addressed adopting a simplified erosion scheme, based on sediment mass conservation, and on proportionality between eroded mass and wetted perimeter (Lamberti and Schippa, 1994).

Numerical results compare favourably with numerical simulations output, demonstrating that the model can correctly address dam's washout and breach evolution problematic. A limit in the phenomenon reproduction can be noticed at the downstream toe of the dam, in which 2-D effects are dominant and cannot be completely captured by a model based on a one-dimensional set of equations.

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