DAM-BREAK ON A MOVABLE BED IN PRESENCE OF AN INITIAL BED DISCONTINUITY: LABORATORY EXPERIMENTS AND SIMULATIONS WITH A MULTI-LAYER SHALLOW WATER MODEL

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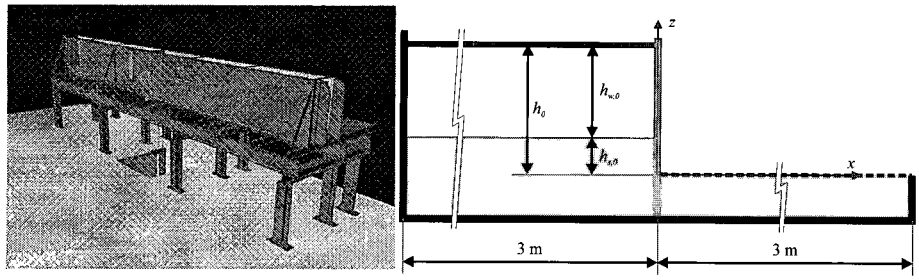
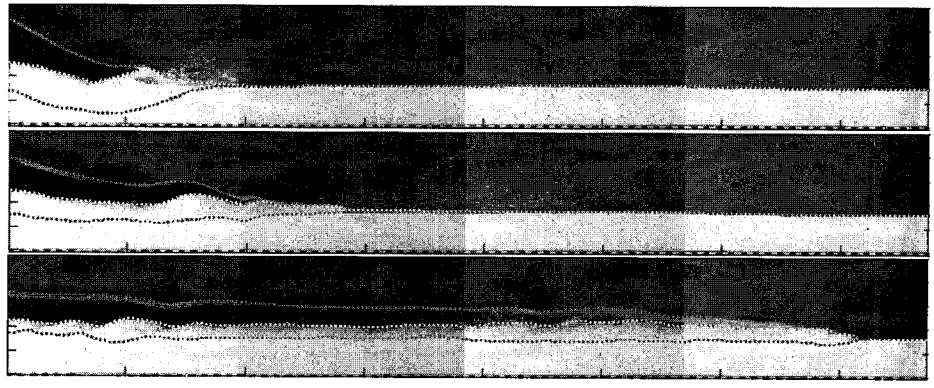
A series of laboratory experiments were performed, simulating the propagation of idealised dam-break waves over movable beds in the presence of an initial bed discontinuity at the dam location. The experiments were performed in a new dedicated flume. They were first exploited during the IMPACT European project as a benchmarking procedure for the validation of a range of simulation models. This paper presents the flume and the experiments. Observations are then faced against simulation outputs using an original one-dimensional multi-layer shallow water model.

The amount of sediment material entrained by catastrophic floods as resulting from dam or dike failures may be huge. Through friction, inertial effects and momentum exchanges with the fluid phase, erosion of bed material may in turn significantly affect the flood wave development in terms of arrival time of the wave front and envelope of maximum attained flood levels. Modelling accurately geomorphic changes associated with dam-break flows is thus important. For the validation of numerical models and the testing of conceptual descriptions, modellers are seeking reliable experimental data for idealised configurations with a low degree of uncertainty and a good reproducibility.

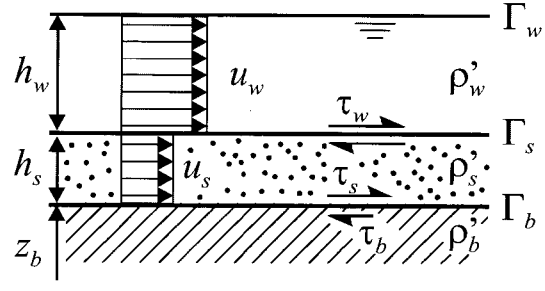
We present a series of idealised laboratory dam-break experiments in a straight prismatic flume. Idealisation towards instantaneous dam collapse provides a well-defined initial-value problem for numerical models. The investigated configuration exhibit a discontinuity of the bed profile across the dam, the upstream bed levels being higher and providing a rough analogue to reservoirs partially filled with sediments. Two types of bed material were used: sand and light PVC pellets. Initial test conditions are summarised in the below figure. Tests were performed in a new flume designed at the Civil Engineering Department (Fig. 1), 6 m long, 0.25 m wide and 0.7 m high., equipped with a narrow gate rapidly moving downwards. As opposed to a rising gate used in previous experiments, the direction of gate movement was chosen here to provide better initial conditions.



Instrumentation of the tests mainly involved fast digital imaging through the transparent side-wall. To guarantee a sufficient degree of detail with the limited resolution of the camera(s), identical tests were repeated in successive steps by translating the camera(s), and corresponding images were then rearranged and merged to form full flow mosaics over the entire flume length, as seen in the below figure for the PVC tests.

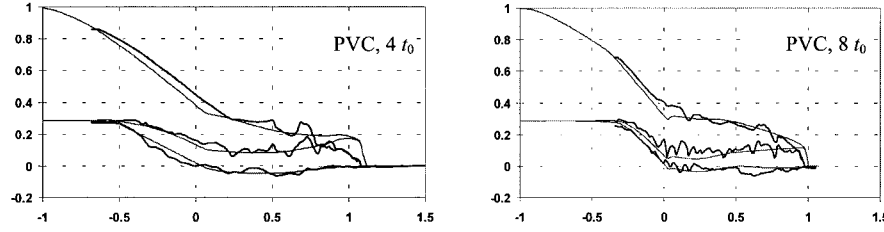


We then present simulation results obtained using a model based on a two-layer shallow water description outlined in the below figure, described in more details in Spinewine (2005).



In contrast with previous formulations, the bed and transport layer are now also characterised by distinct granular concentrations C_b and C_s. The main motivation for this postulate comes from the fact that erosion, associated with entrainment of material through

the bed interface, requires a dilatation of the granular matrix, hence a reduction of its granular packing, even for highly concentrated flows. This vertical expansion of the granular bed, requires a net supply of water relative to the grains, to counterbalance the increase of void fraction. The opposite occurs in case of deposition. The proposed model accounts explicitly for the related mass and momentum exchanges between the different flowing layers. The figure below shows sample comparisons of the model and experiments at selected instants.



SPINEWINE B. (2005) Two-layer shallow-water modelling of fast geomorphic flows and experimental validation on idealised laboratory dam-break waves. JFK Student Paper Competition, XXXI IAHR Congress, Seoul, September 11-16, 2005. Submitted

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