MORPHOLOGICAL EVOLUTION OF STEEP-SLOPED RIVER BEDS IN THE PRESENCE OF A HYDRAULIC JUMP: NUMERICAL AND EXPERIMENTAL ANALYSIS

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The present study focuses on a morphodynamic evolution of steep-sloped river beds driven by a sudden change in the flow regime from supercritical to subcritical, while the sediment supply upstream remains unchanged. From geomorphological and engineering points of view, it is interesting to characterise the response of the channel bed to such a transition of flow regime. This transition may take place when a sudden rise of downstream water level generates a subcritical condition in the downstream part of the stream. This rise could result for example from a sudden obstruction, or from the rapid closure of a gate on a check dam (Armanini et al., 2001) or a weir. From a hydrodynamic standpoint, the flow features a transition from low stage (supercritical flow) at the upstream reach to high stage (subcritical flow) at the downstream reach through a hydraulic jump. The sudden increase in water depth results in decrease in bed shear stress and sediment transport capacity, initiating sediment deposition.

Experiments were carried out in the UCL sediment flume with uniform non-cohesive sediment. Two measuring methods – a probe and a digital imaging system – are used to follow bed deformation and water profile evolution. Tests show that a sedimentation zone occurs in the region of reduced transport capacity downstream from the hydraulic jump, resulting in sediment accumulation forming a steep bore with a front slope comparable to the submerged angle of repose. Growing in amplitude when propagating downstream, this bore progressively takes over the transition of flow regime from super- to subcritical flow, and the hydraulic jump vanishes (Fig. 1). Progressively the water discontinuity is replaced by the bed discontinuity.

Keywords: Hydraulic jump; Sediment front; Steep slope; River beds; Geomorphology; Digital imagery; MacCormack scheme; Space and time-lag.

The numerical results are performed using the numerical model which has been developed by Leopardi (2001). This model is based on the explicit MacCormack scheme applied to two sets of equations: (a) Saint-Venant-Exner equations based on local equilibrium hypothesis of bed-load transport; (b) Saint-Venant-Exner equations with an additional dynamical equation taking into account non-equilibrium bed-load transport *(Iervolino et al., 2003)*.

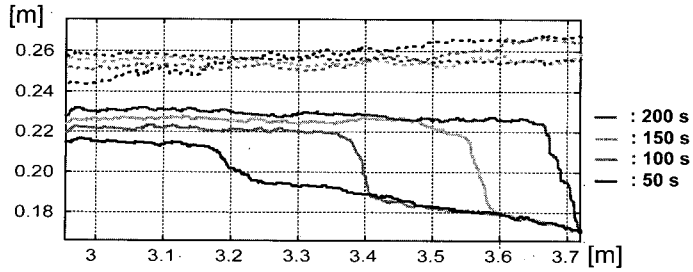

Fig. 1 Bed and water profiles derived from the digital images: front development, according to the time

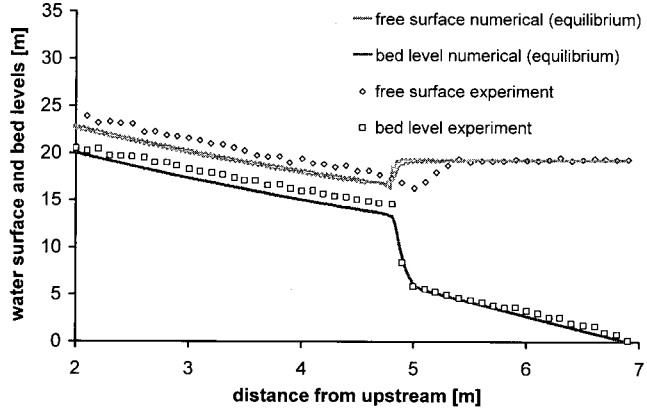

Fig. 2 Bed and water profiles (run 2) at time t = 640s

The results of these two numerical approaches were compared with measurements obtained from the two measuring methods (for instance, bed and water levels calculated by the equilibrium model are compared to the experimental data for a specific time in Fig.2). In general, observations compare rather satisfactorily with numerical profiles. The comparison shows also that the equilibrium model seems to be the best adapted to our study case. However it is expected that the dynamical model should be more accurate in practical situation when a boundary condition on solid discharge must be imposed at the downstream end.

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