THREE DIMENSIONAL MODELING OF SEDIMENT TRANSPORT IN A SHARPLY CURVED MEANDERING CHANNEL

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Natural meandering rivers are very complex in their water flow situation. The stream is characterized by being strongly three-dimensional due to the irregular channel topography. A flow through a bend is dominated by transverse secondary currents. These currents, the so-called helical flow, cause erosion on the outside of a river bend and tend to form a point bar at the inner part due to depositing sediments.

Sediment particles on a river bed are exposed to shear stress resulting from the friction of the water body with the river bed. The classical deviation of the shear stress balances all forces acting on an element of the river. A particle motion may be initiated by shear stress τ exceeding a critical value of the bed-shear stress τ_{crit}, which is a function of sediment and hydraulic parameters. Dey (Dey, Subhasish., 2001) carried out experiments to take the effects of a combined transverse and longitudinal sloping bed on sediment particle stability into account.

The shear stress induced by the water flow acting on sediment particles and the prediction of initial sediment movement are of central importance for numerical modeling. A three-dimensional numerical model is used to predict the temporal changes in bed topography in a sharply curved meandering channel. The numerical results are tested against the measurement data taken from a physical model study with steady flow conditions. Considering the stability analysis of a sediment particle, a new algorithm to calculate the incipient motion of sediment particles on generalized sloping fluvial beds (Dey, Subhasish., 2001) is introduced and implemented within the numerical model. Despite of the good results when predicting the deposition and formation of point bars, the erosion pattern is less well predicted.

The resulting bed level change of the physical model study after a duration time of $\Delta t=4h$ is illustrated by a contour map in Fig. 1. It shows a representative bend of the sharply curved meandering channel geometry. The experimental study shows a pool bar at the inner bank of the apex and a small erosion zone at the concave bank as well as a scour point at the convex bank upstream of the apex.

Fig. 2 illustrates the contour map of the bed level changes of the numerical simulations after the full simulation time of $\Delta t=4h$. One can see that the qualitative change in bed topography by the numerical simulation matches the measurements quite well. The computed bed changes predict a point bar at the convex apex of the bend which also occurs in the physical model. Considering the erosion, results achieved from the numerical model and measurements show the same characteristic trend as observed in the physical model.

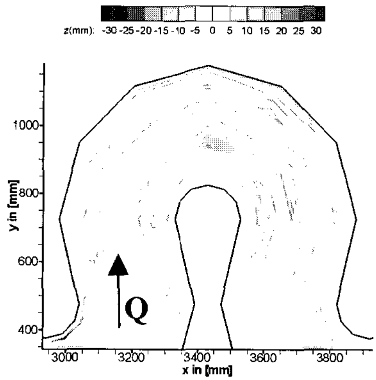

Fig. 1 Contour map of the bed level changes from the physical model study (Guymer, Ian and Dutton, Richard)

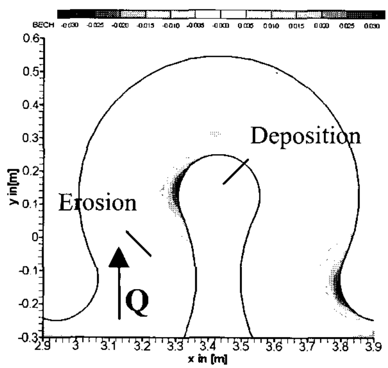

Fig. 2 Contour map of sediment transport calculations (Wildhagen, Jörn., 2004) conducting critical shear stress correction algorithm of Dey (Dey, Subhasish., 2001)

REFERENCES

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