ADVANCES IN 3D MODELING OF FREE-FORMING MEANDER FORMATION FROM INITIALLY STRAIGHT ALLUVIAL CHANNELS

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The present paper describes the current state of art when using computational fluid dynamics (CFD) for predicting free forming migration of meander bends. On the basis of the simulation of water and sediment flow in an alluvial channel, different algorithms and parameters are investigated. The simulation was started from an initially straight grid, with neither sediment feed nor any perturbation at the inflow boundary. The model computed the river bed evolution over a real time period of three days. The results were compared to a physical model study and showed that the three dimensional modeling of free forming meander is one step closer of having a universal predictor for alluvial channel migration.

The numerical model which was used in the present study is called SSIIM and was developed by Olsen (2004). It solved the time-depending Reynolds-averaged Navier-Stokes equations in three dimensions to compute the water flow. The k-e turbulence closure scheme (Rodi, 1980) was used and the SIMPLE method (Patankar, 1980) was applied for computing the pressure. The discretisation method was based on a finite volume approach. Simultaneously to these operations, the convection-diffusion equation for sediment concentration was solved. As boundary condition van Rijns' (van Rijn, 1984b) formula for the sediment concentration close to the bed was used. Additionally, the sediment continuity and empirical formulas (van Rijn, 1984a) were used to compute the bed load transport in order to predict the vertical changes in the bed morphology over time. The model used a three dimensional unstructured grid with a mixture of tetrahedral and hexahedral cells to model the geometry. To point out the changed in the bed morphology, the CFD program included an algorithm for wetting and drying (Olsen, 2000). This algorithm generated new cells in areas where erosion took place and let cells disappear where sediment deposited. Consequently the grid changed in shape and size over time as the geometry of the meandering river is formed.

The numerical model was setup in similarity to a physical model study performed by Friedkin (1945). The observation showed a meandering channel with a maximum meander amplitude and wavelength of about 3.0 m and 12 m respectively. The meandering evolution started downstream of the first third of the channel length. In addition to this one can see that the bend size grow with increasing longitudinal distance.

To continue the investigations of Rüther and Olsen (2003), the present study describes the progress made to enhance 3D modeling of free forming meander evolution. The results are depicted in Figure 1. From an initially straight alluvial channel with neither an initial perturbation nor sediment feed, the model computes the initiation and the migration of the meander bends. Hence, the program predicts the process of erosion and sedimentation as well as the lateral movement of the channel. The results matched the measurements of the physical model study concerning the meander amplitude and downstream growth. The meander wavelength was underestimated by around 30 %. The results showed that the modeling of free forming meander is still under research and additional investigations and developments have to be done. This would include an improved algorithm for the free water surface as well as better formulation for the shear stress on side slopes.

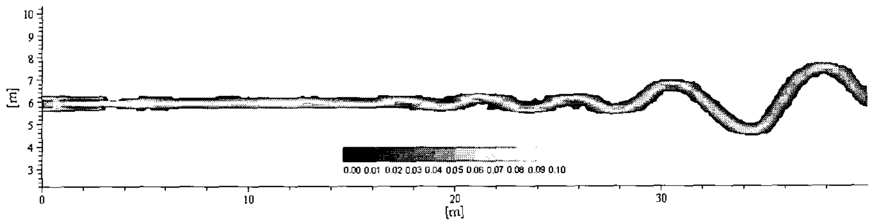

Fig. 1 Plan view of the computed depth when. (ζ_1 = 0.006 m and ζ_2 =0.012 m)

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