8TH INTERNATIONAL CONFERENCE ON HYDRO-SCIENCE AND ENGINEERING

STABILITY ASSESSMENT OF THE RIVER CHANNEL BEDFORM

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This paper presents the results of monitoring of meander cute cut-off in send-bed river. The cut-off was made as narrower than the natural river channel, and the weir on the old riverbed was constructed at the height of average water level, and thus enabling further development of the cut-off. A 3.6 km long reach was monitored, located in the lower section of an alluvial watercourse with an average annual discharge of Q_{avg}=550 m^3/s, average sediment transport of $Q_{s.avg}$=250.000 tons/year, and an average longitudinal slope of S=0.00001. The river-bed material is uniformly graded sand of characteristic grain size of d_{50}=0.35 mm and d_{90}=0.40 mm.

Hydrologic-hydraulic data were collected on 24 control cross-sections on ten occasions during one year. The water levels were recorded using RTK-GPS, and data on the bedform, velocity profiles and discharges were collected using 4 beam broadband ADCP with frequency of 1200 kHz. Measurements were performed during low, medium and high flows. On a section somewhat longer than the cut-off itself, a 1-d morphodynamic model was constructed by using HEC-RAS 4.0 software. The paper gives an overview of the methodology of data collection and the results of estimated bedforms by using various methods of sediment transport calculation. The calculated bedforms were compared to the measured data. Parameters used for the evaluation of different methods of bedform prediction are hydraulic depth $\overline{h}$, river channel level and width of the water surface *B*.

The calculation of river bedforms was made through the quasi-dynamic 1-d morphodynamic model for a period of one year. There were also surveys of the river bed on cut-off in this period, and thus calculated and measured bedforms could be compared. The dynamic boundary conditions were recorded discharges at the upstream boundary and recorded water levels on the downstream boundary, and estimated incoming sediment load on the basis of the existing sediment load curve. The bedforms were calculated for several methods of sediment transport calculation: Ackers-White, Engelund-Hansen, Laursen, Meyer-Peter-Muller, Toffaleti and Yang. Hydrologic and hydraulic characteristics of the monitored watercourse are in the range of validity of all mentioned methods, but it should be emphasized that the Meyer-Peter-Muller method is valid predominantly for gravel river bed material. The paper also presents a sensitivity analysis for a certain morphological parameter in the numerical model. The sensitivity analysis was performed for: incoming sediment load, river bed material, sediment specific gravity, particle settling velocity and water temperature.

Sensitivity of the model to incoming sediment load was analysed for a wide range of quantity, so that the share of a particular sediment fraction ranged from 0.03 to 10 times more than the actual share of that fraction. Sensitivity of the model to river bed material was analysed through variations of the grain size distribution curve: uniformly graded curve with d_{50}=0.35 mm, uniformly graded curve with d_{50}=2 mm, and the natural distribution curve. The natural sediment specific gravity is 2.6, and during tests it varied from 1 to 4. Furthermore, sensitivity analysis was performed to different sediment settling velocity methods (Rubey, Van Rijn, Toffaleti and Report12 method), and for water temperature.

Sensitivity analysis indicate that the 1-d numerical model (1a) is largely sensitive to the incoming sediment rate, sediment specific gravity and settling velocity, and (1b) is relatively insensitive to grain size distribution curve and water temperature. Test results for settling velocity pointed out that (1c) model could not perform calculations for the Toffaleti method, and that (1d) output results are similar for the Rubey, Van Rijn and Report12 methods. For further morphodynamic model calculations, the Report12 method was selected as the reference settling velocity method.

The results of the 1-d morphodynamic model after one year of simulation, in relation to different methods of sediment transport, were inter-compared and compared to the measured bedforms. The distribution of bed shear stresses at the time of weir construction (initial moment) shows equal shear stress distribution along upstream and downstream sections of the cut-off (τ_0 = 0.6 Pa), and a sudden increase within the cut-off (range $2.5 < \tau_0 < 6$ Pa). Weir construction on the old riverbed caused flow diversion into the cut-off, on the basis of which one could expect significant bed degradation in the cut-off as well as simultaneous aggregation downstream from the cut-off. Such river bed changes are visible in the numerical model as well, so it is concluded that (2a) the mathematical model generally provides a realistic trend of morphological changes along the observed reach. Regarding the different sediment transport methods, it is shown that (2b) the Meyer-Peter-Mueller method is unacceptable for the monitored watercourse.

Comparison of model results and measurements for the hydraulic depth $\bar{h}$ indicates that (2c) Engelund-Hansen and Ackers-White methods gives the highest discrepancy from measurements, and that (2d) Yang method gives too high erosion at the beginning of the ditch, and that (2e) the Laursen method provides relatively better estimates of bedforms than the Yang and Toffaleti methods. Finally, it is concluded that (2f) none of the methods of the morphodynamic model show a widening of the bed in the monitored period or (2g) an increase of the hydraulic depth $\bar{h}$ upstream from the cut-off. Mentioned morphological changes are a result of erosion process of transverse to the flow, which may indicate the need of 2-d morphodynamic model utilisation in the analysed case.

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