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PREDICTION OF VELOCITY RATIO IN OPEN CHANNEL FLOW MEANDERING BED DEVELOPMENT TIME: FORMULATION AND RELATED EXPERIMENTAL TESTING

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As is well-known, substantial research has been carried out since many years on the nature of the equilibrium bed topography in meandering streams, and on the physical mechanisms leading to the bed deformation. By contrast, no efforts have been made to define the time-scale of the bed deformation process. As a result, at present, no predictions can be made regarding the duration of the bed development. Yet, as pointed out by Nelson and Smith (1989), p. 322: "Both the mechanism by which the channel adjusts to a perturbation from equilibrium and the time scale over which the adjustment takes place is of fundamental importance in many problems of concern to hydrologists and geomorphologists". Knowledge on the bed development time is also relevant to numerical modelers, who need to decide on the time-steps to adopt when discretizing the underlying time-dependent governing equations.

In this presentation the recent efforts by the authors on the topic of meandering bed development time are described. In agreement with the prevailing approach, it is assumed that the stream centreline follows a sine-generated curve; the banks are rigid. The flow is turbulent and sub-critical, and the flow width is much larger than the flow depth. The movable bed is flat at time $t=0$; at $t=T_b$, the bed reaches its equilibrium or developed state.

Dimensional and physical considerations are used to derive an expression for the duration of bed development, T_b. According to this expression, T_b is proportional to the square of the flow width and inversely proportional to the specific volumetric bed-load rate corresponding to the channel-averaged flow. The proportionality factor is found to be a function of only the stream initial deflection angle. The form of this function is revealed on the basis of a series of experimental runs carried out by the writers at Queen's University, in sine-generated meandering streams of varying sinuosity. In these tests, which started from a flat initial bed, the bed was allowed to deform under the action of the flow until a time sufficiently beyond the stage where equilibrium conditions appeared to have been reached. The flow was stopped at specified times to monitor the bed evolution with the passage of time.

Finally, it is shown that the equation resulting from the present work yields realistic predictions for the bed development time when applied to natural streams.

References

Nelson, J. M., and Smith, J. D. (1989a) “Evolution and stability of erodible channel beds.” River Meandering, S. Ikeda and G. Parker, eds., Water Resour. Monograph, Vol. 12, American Geophysical Union, Washington, D.C., 321-378.