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Interaction between opposite river bank dynamics

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Introduction

Although many studies regarding bank erosion and accretion can be found in the literature, it is not common to find works studying the interaction between opposite banks. Some existing morphodynamic models describe bank erosion as an event that depends on near-bank flow and bed topography, as well as on eroding bank properties. Most developed models do not include opposite bank accretion, with the exception of, e.g. Asahi et al. (2013) and Eke et al. (2014). . These models can represent opposite bank dynamics. Analyses of bank-to-bank interactions, showing for instance where the effects of depositing bank push are felt (where exactly opposite bank erosion occurs), are lacking. Observations by Nanson and Hickin (1983) on the Beatton River, in Canada, suggest that bank accretion is important for opposite bank erosion to occur, in addition to the magnitude and duration of hydrological events.

The present study focuses on the interaction between opposite river banks. The aim is to describe how bank accretion influences opposite bank erosion and whether there is a spatial lag in this interaction. This paper presents only some preliminary results.

Methodology

The work has three components. First, the impact of local bank accretion is analyzed, for different setups, initial and boundary conditions, in the laboratory. Second, a numerical model based on the Delft3D environment is used to integrate and interpret the laboratory results and to study some extra scenarios. Third, an analytical study is performed to further analyze the results and provide a simple mathematical description to identify the parameters governing bank-to-bank interaction.

This paper describes some laboratory observations.

Laboratory experiments

The laboratory experiments are carried out as a collaboration between UNESCO-IHE and Delft University of Technology (TU Delft) in the Environmental Fluid Mechanics Laboratory of TU Delft. The facility consists of a 7.00 x 1.20 m sand-bed flume with a horizontal bed (Fig. 1). A pump is recirculating the water, while the sediment input is accomplished via a funnel-shaped sediment feeder at the upstream boundary. The depth of the flume is 0.23 m, with a 0.18 m thick sand layer. The sand is graded with values of D_{10}, D_{50}, and D_{90} of 0.27 mm, 1.0 mm, and 1.48 mm, respectively, and a density of 2365 kg/m^3 (Singh, 2015). Four laser sensors are setup to record the bed topography at specified moments. Finally, a camera is located at a height of 1.50 m above the bottom of the flume to capture channel the evolution of the channel width throughout each experiment.

Figure 13. Sand-bed flume, with sediment feeder in the upstream and laser recorders.

Experimental Setup and Procedure

All the experiments are conducted on a straight excavated channel with a rectangular cross-section of dimensions 0.25 x 0.04 m, starting with a horizontal bed slope. The difference in the initial conditions between scenarios depends on the presence of groynes simulating local bank accretion, and the percentage of the channel width that is being obstructed by the groynes. In other proposed scenarios, opposite bank protection is present.

There are two boundary conditions to be observed. First, a constant discharge of either 0.50 l/s or 0.67 l/s. Sediment input is regulated in such a way that neither systematic erosion or deposition occurs at the upper boundary where the feeder is located

Before starting, the initial bed topography is recorded with the laser sensors. After the discharge is released, water level and channel width is recorded at seven cross-sections. The value of average surface flow velocity is determined by measuring the time in which a floating object travels a certain distance. The measurements of water levels, channel widths, and velocity are carried out several times throughout the experiment.

The duration of the experiments is based on preliminary tests and aims at reaching a state of equilibrium, reason for which it is 16 hours.

Preliminary results

The experimental test that is described here is characterized by low discharge (0.5 l/s) and a single groyne obstructing 20% of the channel width.

The evolution of the longitudinal bed profile at the channel centreline is shown in Fig. 2. The groyne is located at x =150 cm. The slope evolves with time to reach an equilibrium value. A sedimentation front is observed to linearly propagate along the channel.

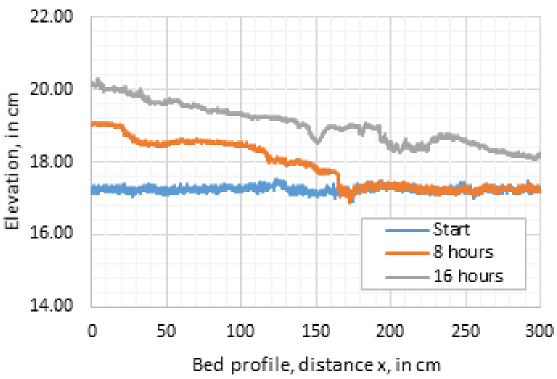

Figure 14. Bed topography profile after 0, 8, and 16 hours.

The test shows that opposite bank erosion does not occur right away, since it requires the formation of a bar downstream of the groyne for it to happen. Maximum bank erosion occurs at a certain distance from the groyne, showing a spatial lag in the process of bank-to-bank.

The slope is not continuous: at distance 150 cm, a scouring hole is visible, indicating the position of the groyne; between distance 160 cm and 190 cm bed aggradation is apparent, indicating the formation of a bar downstream of the groyne. Fig. 2 does not show changes in channel width, which happen during the entire experiment, as shown in Fig. 3, where traces of meandering start to become evident.

Figure 15. Channel-width evolution after 0 (left), 8 (middle), and 16 (right) hours.

Conclusions

Preliminary observations show that the erosion occurring at the bank opposite to a groyne occurs with a certain spatial lag and it is opposite to the deposition bar that forms downstream of the groyne.

A important limitation of the study is related to the relatively small length of the flume, in which the observed changes, and the rate at which they happen might be affected by the closeness of the boundaries. Another limitatoin that is worth mentioning is the way in which the sediment enters the flume at the upstream boundary. The results are not the same if the sediment input occurs at a point or if sediment is evenly distributed across the cross-section.

References

Asahi, K., Shimizu, Y., Nelson, J., and Parker, G. (2013) Numerical simulation of river meandering with self-evolving banks. Journal of Geophysical Reserach: Earth Surface, 118: 2208-2229.

Eke, E., G. Parker, and Y. Shimizu (2014) Numerical modeling of erosional and depositional bank processes in migrating river bends with self-formed width: Morphodynamics of bar push and bank pull, J. Geophys. Res. Earth Surf., 119, 1455–1483, doi:10.1002/2013JF003020.

Nanson, G. C., and Hickin, E.J. (1983) Channel migration and incision on the Beatton River. Journal of Hydraulic Engineering, 109(3): 327-337.

Singh, U. (2015) Controls on and morphodynamic effects of width variations in bed-load dominated alluvial channels: Experimental and numerical study. Trento, Italy, University of Trento. Doctor of Philosophy: 172p.