Simulations of Lateral Erosion in a Mixed Bedrock-Alluvial Meander

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1. Introduction

Most of the previous bedrock channel evolution models use shear stress or stream power of water flow as the deciding factor for lateral erosion. These models use shear stress/stream power erosion rule, and compose all relevant erosional processes into a single hydraulic parameter. These models ignored the effects of sediment transport in the channel. Some recent experiments and field studies have proposed sediment particle impact wear as an overriding factor for bedrock bank erosion (e.g., Fuller et al., 2016). Here, we implemented erosion model of bedrock bank into 2D physics-based morphodynamics model and reproduced the laboratory experiment results.

2. Methodology

2.1 Flume experiment

A laboratory scale experiment was carried out to inspect the interaction between sediment and banks of a bedrock channel. We used a Sine Generated Curve Shaped flume. The flume majorly consisted of weak erodible mortar. The length of the flume was 3 meters and width was 5 cm. The banks of flume were 10 cm high. The bed was covered initially with sediment. The initial alluvial thickness for bed was 0.5 cm. The grain size is 0.75 mm. The sediment used as an alluvial cover for bed was the same size as the sediment supplied as load. Flow discharge, channel slope, sediment feed rate, and grain size were kept constant throughout the experiment. The experiment was conducted for 4 hours.

2.2 Model

The governing equations for flow field and bed deformation in a mixed alluvial-bedrock channel are based on the numerical model proposed by Inoue et al (2016). In this study, we assumed that the lateral erosion rate in bedrock depends on a product of abrasion coefficient of bank with lateral bedload transport rate. We implemented the equations for bedrock bank erosion in the numerical model.

3. Results and Conclusions

In our experiment, the bank erosion occurred predominantly due to bed load abrasion. This shows that sediment supply can be one of the dominant factors causing lateral erosion in bedrock meander. In our experiment, the outer bank was eroded, but the inner bank was not eroded even if the sediment moved near the inner bank.

We compared the bank erosion width in left and right banks of simulation results with laboratory results. We found that our model could quantitatively reproduce the results. Our model could trace the bank erosion, and mimic the behavior of erosion in left and right banks.

References

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