12th Congress INTERPRAEVENT 2012
Grenoble / France – Extended Abstracts
www.interpraevent.at

INITIATION OF MOTION IN TORRENTS UNDER CONSIDERATION OF NATURAL BED STRUCTURES

A FLUME STUDY ON SELF STABILISATION AND DESTRUCTION

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INTRODUCTION

Bedload transport calculations at steeps slopes are rather challenging. Also, measured transport rates in gravel-bed rivers and boulder-bed streams may vary by several orders of magnitude. Steep headwater streams are characterized by a wide range of sediment sizes and temporally- and spatially-variable sediment sources. Bed morphology and channel structures may be influenced by the presence of large boulders, woody debris and bedrock constrictions. This can result in large variations in channel geometry, stream flow velocity and roughness (Hassan et al., 2005). Flow resistance in steep mountain streams with irregular bed topography includes both grain friction and important macro roughness (Chiari and Rickenmann 2011). Flows are typically characterized by low relative flow depths. Yager et al. (2007) demonstrated that accurately predicting bedload transport in steep, rough streams requires accounting for the effects of local sediment availability and drag due to rarely mobile, loose particles. The formation of step structures is regarded as the main stabilization process in steep open channels (Weichert et al. 2008). Beside macro roughness, knowledge about incipient motion conditions for natural bed structures is very important for an accurate prediction of bedload transport in torrents and mountain streams.

METHODS AND FIRST RESULTS

A laboratory flume for bedload transport experiments has been constructed at the Institute of Mountain Risk Engineering at the University of Natural Resources and Life Sciences, Vienna. The flume is 6 m long, 0.25 m wide and the inclination can be varied up to 25 %. Discharges up to 50 l/s are possible and bedload can be fed by a conveyor belt.

A systematic study on initiation of motion has been carried out. To generate a typical grain size distribution for torrents 55 pebble counts were analysed and a typical grain size distribution with a physical scale of 1:10 is generated (d_{30}=0.8 mm, d_{90}=22 mm and d_{max}=55mm). To increase the existing database on the development of natural bed structure the following experimental setup is used: Flume experiments are carried out at channel gradients varying from 9 to 21 %. Therefore the bed sediment mixture is built into the flume with a constant height of 0.25 m. Then a low flow discharge (close to incipient motion conditions) is applied until the bedload transport decreases. Then the discharge is increased stepwise until typical bed structures like step-pool sequences develop. Finally a constant discharge is applied until the bedload transport decreases towards zero. A typical duration of the experiment is 12 hours. To analyse the bed forms, a laserscan device is mounted above the flume to produce high resolution elevation models of the channel bed before and after the experiment. Finally the discharge is increased until the bed structures are destroyed. In order to collect information on transport rates and selective bedload transport at steep slopes, grains size analyses are performed at the channel outlet with high temporal resolution during the self stabilisation and destruction phase of the experiments at the channel outlet. Finally the channel bed is scanned again to identify immobile bed structures and determine the channel slope after each experiment. A photo of a flume experiment

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is shown in Figure 1. A self-generated step-pool sequence developed at a channel slope of 9 % is shown.

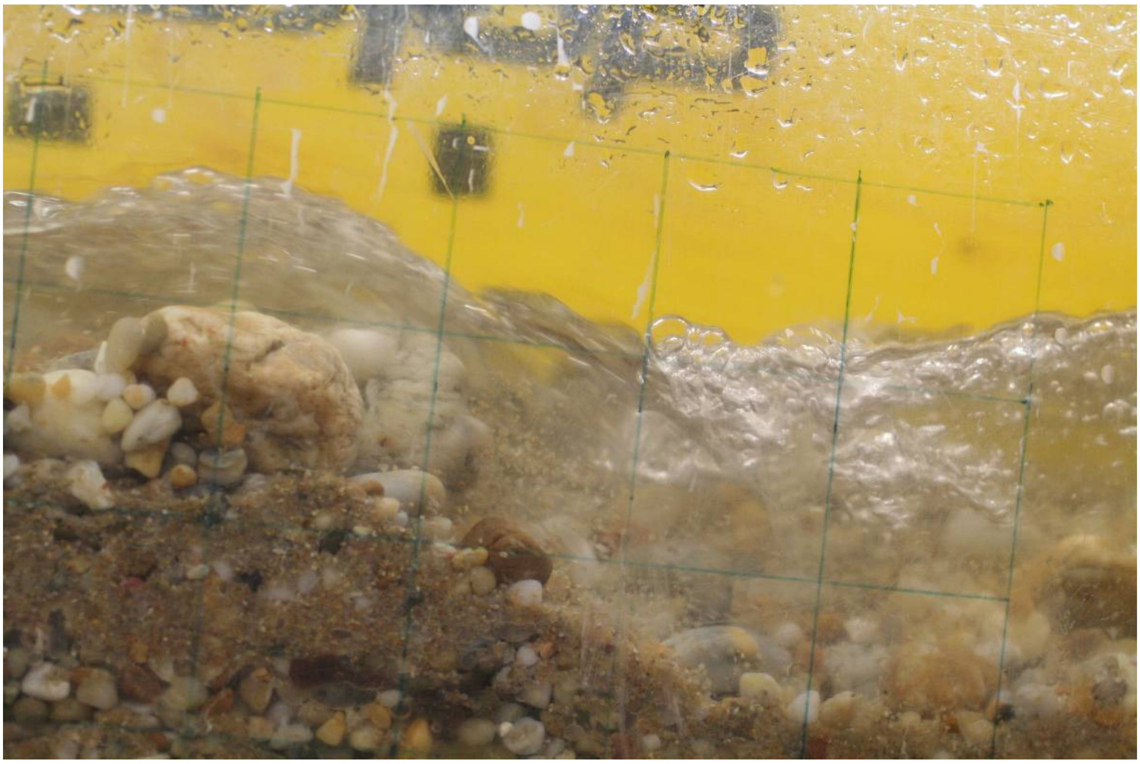

Fig. 1 Self-generated step-pool sequence at 9 % channel slope.

The results show the importance of bed structures for the self-stabilisation of steep channels. For the same channel slope the incipient of motion condition is increased significantly. No bedload transport occurs until a higher discharge is applied. Then the bed structures are (partly) destroyed and a flattening of the channel bed can be observed, causing increased transport rates. During some experiments the maximum grain size was not transported to the channel outlet, but a slow motion due to scouring was observed.

The aim of the study is to increase the knowledge on incipient motion conditions of natural bed sediment under the condition of self-stabilisation. The results are also used for the calibration of a hiding function for a more accurate prediction of grain sorting phenomena at steep slopes.

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Keywords: bedload transport, steep gradient, initiation of motion, selective transport, step-pool development