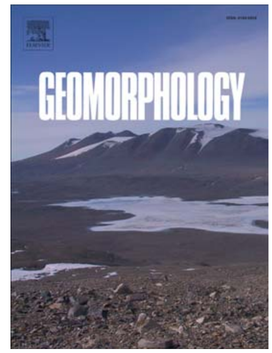

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PII: S0169-555X(17)30296-9
DOI: doi:10.1016/j.geomorph.2017.07.020
Reference: GEOMOR 6083

To appear in: *Geomorphology*

Received date: 10 March 2017
Revised date: 25 July 2017
Accepted date: 25 July 2017

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Available online at www.sciencedirect.com

ScienceDirect

Geomorphology 00 (2017) 1–31

Geomor-
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Analysis of mechanical-hydraulic bedload deposition control measures

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Abstract

During floods, the bedload transport of steep headwaters can exceed the hydraulic transport capacity of milder downstream reaches where settlements are often situated. Therefore, sediment retention barriers are typically installed upstream of such sensible areas. These barriers trigger bedload trapping via two control mechanisms, either hydraulic or mechanical. Both deposition controls, pertaining to instream sediment trapping structures, are analyzed experimentally in this study. Bedload trapping by hydraulically controlled barriers is prone to sediment flushing, i.e., the remobilization of formerly deposited sediment, in particular when the barrier is simultaneously under- and overflown. In this case, the remobilization rate is close to the bedload transport capacity of the nonconstricted channel. Mechanical deposition control by screens is in turn sensible to the grain size. Thus, both deposition control concepts may fail, and bedload may be transported downstream at a rate corresponding to the transport capacity of headwaters, thereby endangering urban areas. This study shows that the combination of both deposition control concepts is suitable for improving the control of bedload retention. With this combination, undesired sediment flushing of upstream deposits in the channel caused by insufficient hydraulic control is prevented. Furthermore, the uncertainty related to the estimation of the representative grain size in the design of mechanical control barriers is reduced.

Keywords: bedload; check dam; sediment flushing; sediment trap; self-emptying

1. Introduction

Heavy rainfalls such as those that occurred in Switzerland in the year 2000 can mobilize large amounts of sediment in the catchment areas of steep mountain rivers (Swiss Federal Office for Water and Geology FOWG, 2002). The high channel gradient in combination with flood discharges can transport considerable amounts of sediment toward downstream reaches, where the grains gradually deposit with decreasing channel slope (D'Agostino and Lenzi, 1999). The transported sediment is essential for the natural ecomorphological pattern of downstream river reaches, but this sediment represents a substantial factor of risks regarding flood protection planning (Surian and Rinaldi, 2003; Gabbud and Lane, 2015; Simoni et al., 2017). In August 2005, the Swiss locality of Bristen witnessed such flood-driven sediment deposits in the village center, causing severe structural damage; and many similar cases have been reported for the same flood event (Bezzola and Hegg, 2007; Bezzola, 2008). These undesired excessive deposits in urban areas can be prevented, e.g., by the installation of instream sediment traps. These structures typically comprise a permeable sediment check dam with openings that limit the downstream bedload transport in the case of floods (Leys, 1976; Zollinger, 1983; Piton and Recking, 2016a).