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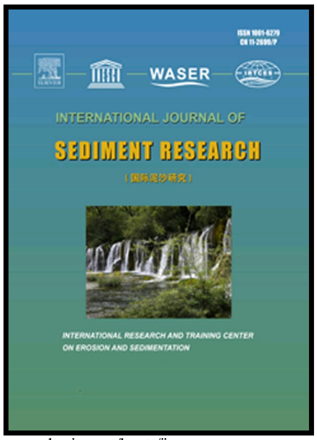

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Effect of bed load supply on sediment transport in mountain streams

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Abstract:

Mountain streams with their tributary torrents build the upper part of the fluvial network. They are important regarding the transfer of sediment from headwaters to lower basins. Channels are typically steep with wide grain size distributions, ranging from fine sand up to large boulders, and a stabilized bed surface. Mountain streams often are supply-limited with respect to mobile bed load, which needs to be addressed when bed load transport equations are applied to such streams. To better understand supply limitation, laboratory experiments highlighting the effect of bed load supply on incipient motion and bed load transport rate are discussed. Experimental tests were done in which fine bed load was supplied to a previously armored channel bed, with flow conditions ranging from one-third to twice the critical discharge for the bed surface. At flows not exceeding the critical discharge, the time series of the bed load transport rate at the downstream model boundary featured consistent patterns which are attributed to distinct phases: (i) a temporal lag, (ii) an equilibrium state, and (iii) a post-supply phase. Bed load transport occurred even at flows distinctly below that for incipient motion of the bed surface. But, with the mass of total bed load outflow approaching the supply amount, the mass did not exclusively consist of supplied grains. The coarser the supplied bed load, the more sediment was mobilized from the bed surface. At higher flows, processes differed. Total bed load outflow exceeded the supply amount and the break-up of the armor layer caused a refining of the bed surface.

Key words: Bed load transport, Bed load supply, Mountain stream, Experimental modeling

1 Introduction

Bed load transport in mountain streams has become a progressively investigated phenomenon within the last decades, since it has increased in importance for several fields of hydraulic engineering, e.g., river engineering, eco-hydraulics, hydropower utilization, flood protection, and, correspondingly, hazard mitigation. Mountain streams feature relevant topographical and morphological differences from their lowland counterparts (Montgomery & Buffington, 1997), such as (i) overall steep and locally variable channel gradients; (ii) wide grain size distributions; (iii) large, immobile boulders, or channel spanning bed forms which feature high stability; and (iv) low relative flow depths. Summarizing, the riverbed of mountain streams is often poorly sorted and segregated into a variety of structures. The mobility of individual grains is variable and strongly affected by (i) hiding and protrusion (Bathurst, 2013; Bunte et al., 2013), (ii) presence of immobile boulders (Ghilardi et al., 2014; Yager et al., 2007), (iii) clustering (Church et al., 1998; Hassan & Church, 2000; Lamarre & Roy, 2008), and (iv) supply conditions (Yager et al., 2012b).