Simple method to determine and optimize sediment rates passing a series of check dams

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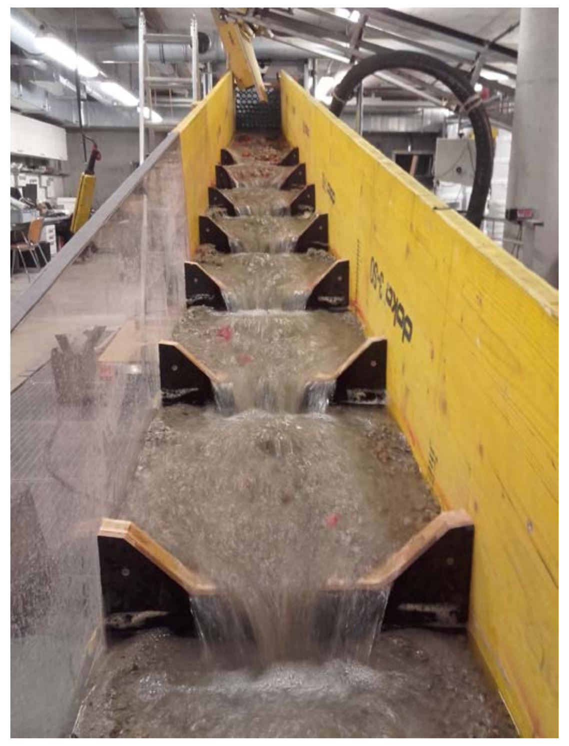
Introduction

A series of check dams works as a measure for sediment management in torrential channels. Besides the main function to stabilize the channel bed, the construction of a series of check dams offers a dosing function to bed load transport. The temporary changing effects of deposition and erosion are on the one hand sustaining the sediment connectivity and offer on the other hand intermittent sediment storage volumes.
A simple calculation method was derived to determine the sediment storage volumes and to formulate construction rules in a further step.

Basics

34 experiments were performed in a rectangular flume on a physical scale of 1:30 and a variation of the following parameters:

- *check dam spacing/height*
- *grain size distribution*
- *discharge Q (2 l/s, 3 l/s and 4 l/s)*
- *volumetric sediment concentration varying from 0,05 to 0,30*
- *flushing experiments just with water*

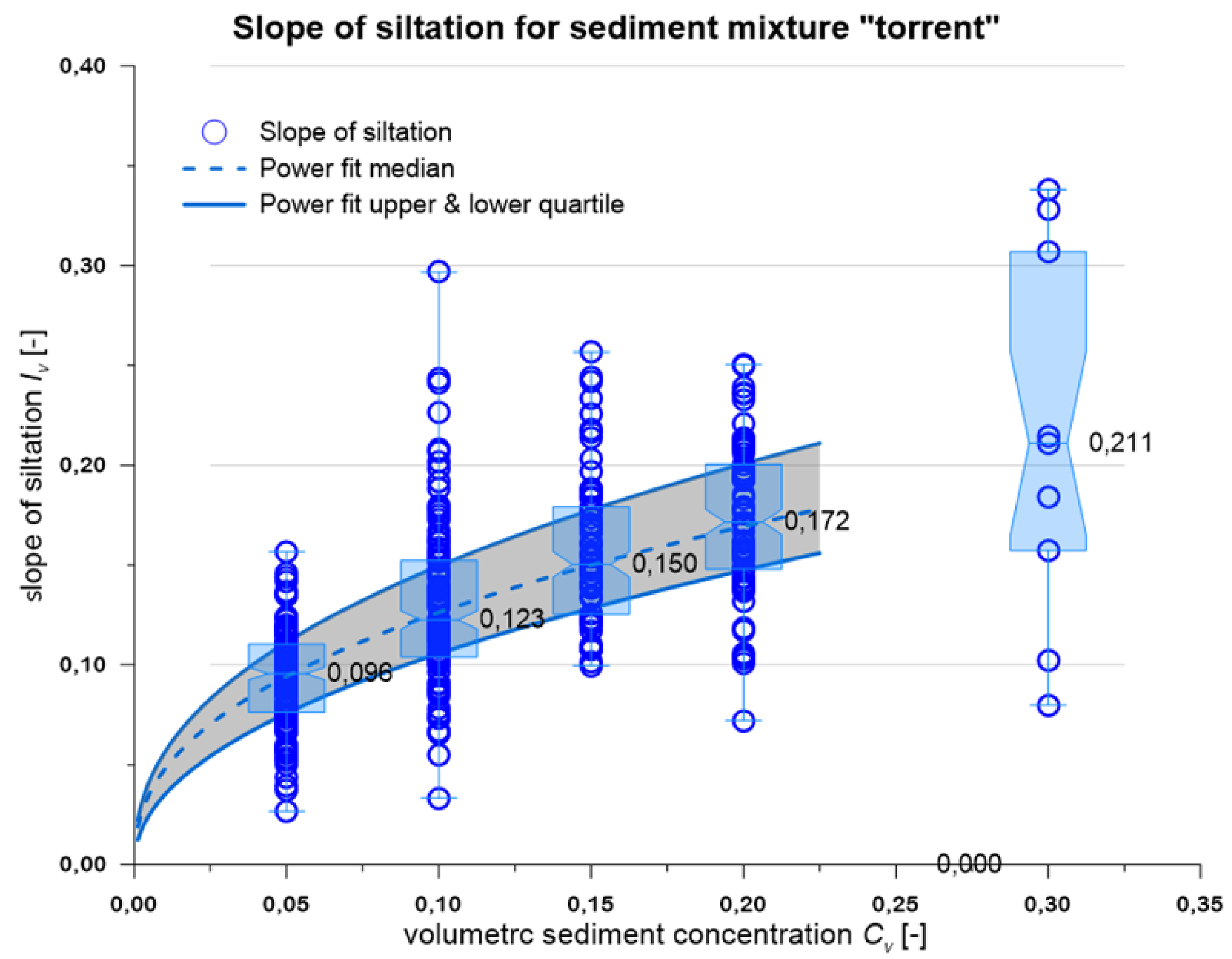


Experimental flume

Experimental results

- The main influence on the siltation slope φ_v is caused by the volumetric sediment concentration c_v
- A larger average grain diameter increases the siltation slope φ_v
- Increasing the volumetric sediment concentration c_v by 0,10 increases the slope of siltation φ_v by 5 %, irrespective of the grain size distribution, the distance between check dams and the discharge of the fluid- sediment- mixture.
- The deposit volume changes in dependence of the siltation slope φ_v, pure water flushing offers potential sediment storing volume

Experimental results



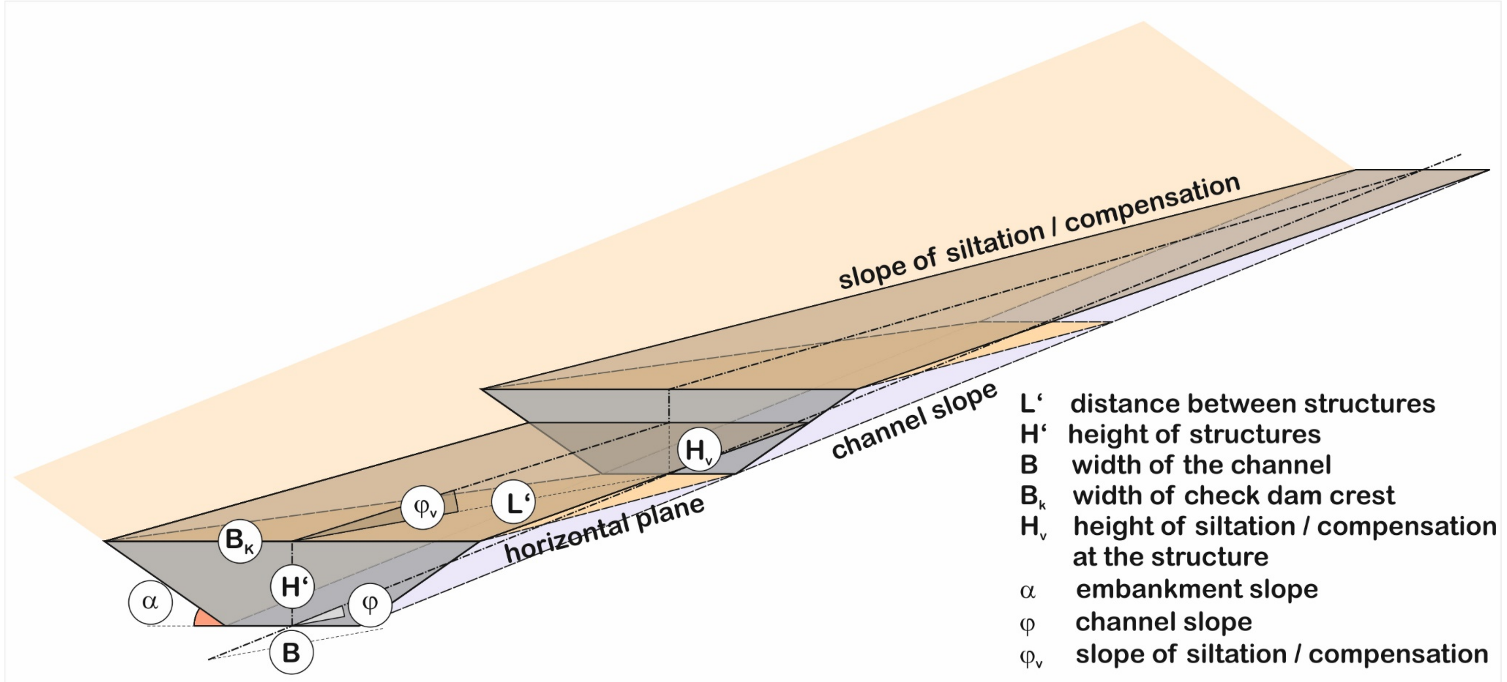
Varying slope of siltation due to the volumetric sediment concentration

Simple calculation method

…to calculate the variable and non-variable sediment storage volumes within a series of check dams of a trapezoidal-shaped torrent channel

Non-variable sediment storage volumes:
…naturally/artificially filled storage space in the back of a check dam up to the minimum compensation slope $\varphi_{v\text{-min}}$: deposited sediments are excluded from further sediment transport

Variable storage volumes:
…volumes changing due to the siltation slope $\varphi_{v\text{-max}}$: remobilizable sediments sustaining sediment connectivity



Basic assumptions for the calculation of deposited volumes

Calculation results

Constrains:

- Fluvial processes, no debris flows
- Minimum interspacing L'_{min}

$$L'_{min} \geq \frac{H_s}{\tan\varphi - \tan\varphi_{v-max}}$$

- Minimum check dam height H'_{min}

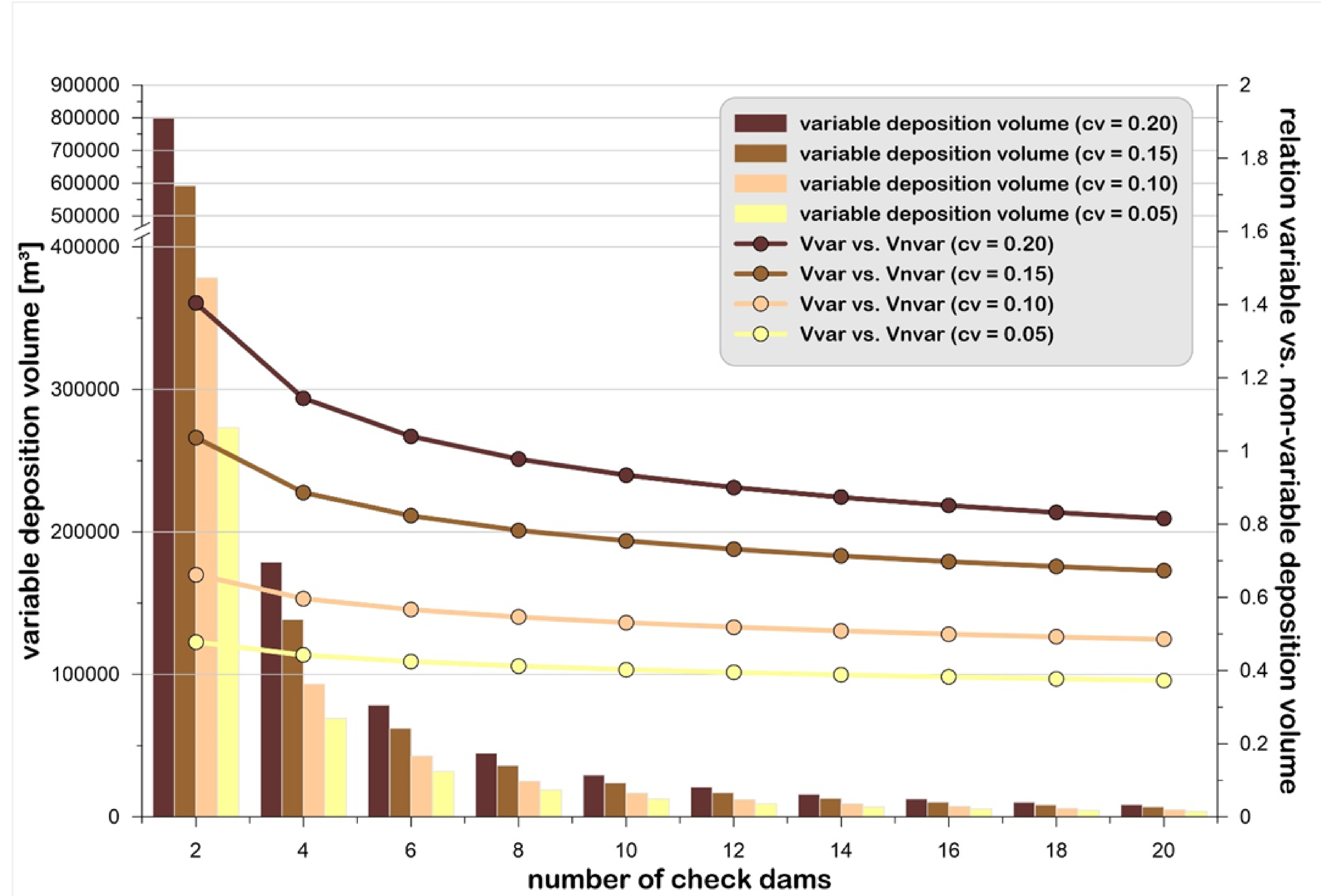
$$H'_{min} \geq L'_{min} \cdot \tan\varphi_{v-max} + H_s$$

Volume of temporary sediment deposition

Basic assumptions for the calculation

L = 400 m, H = 100 m, B = 5m, φ = 25%, α = 35°,
cv = 0.05-0.2

$\varphi_{v\text{-min}}$ = 2%, $\varphi_{v\text{-max}}$ = 10-17%,



Variable sediment storage volume for a given number of check dams

Conclusion

A series of check dams offers a natural sediment balancing strategy by dosing the sediment rates. Deliberately optimizing the constructive distances and heights of the buildings, these dosing effects can be artificially directed and used in cases of sediment management and torrential flood protection.

References
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