Sediment-trapping effectiveness of check dams with multiple debris-flow surges: Experimental study

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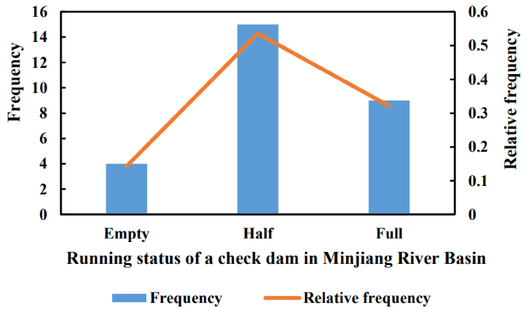
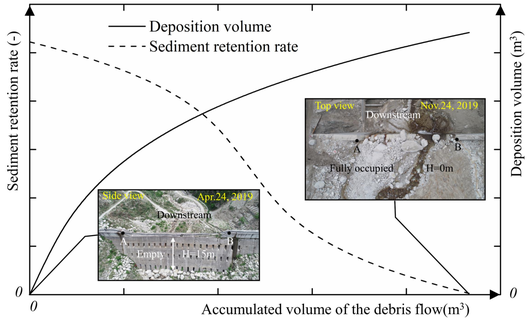
MOTIVATION

- Most of check dams are not empty, how to evaluate the remaining sediment retention capacity of these check dams?

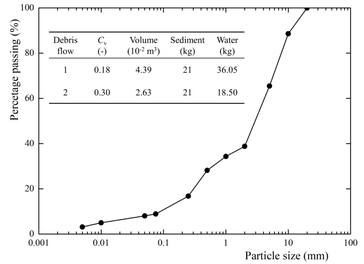


- The quantitative relationship between debris flow volume & deposition volume & sediment retention rate?



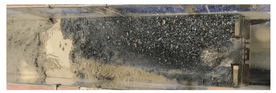
METHODS

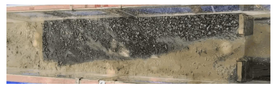
- The debris-flow sediment concentration (C_v) in this text is 0.18 & 0.30
- 4 kinds of check dams working conditions (Single dam (3 heights)+ double dams)
- Multiple debris flows cumulatively act on the check dams
- Measure the change of deposition volume by photogrammetry technology
- Measure the change of sediment retention rate by collecting tailings

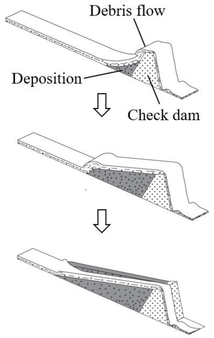


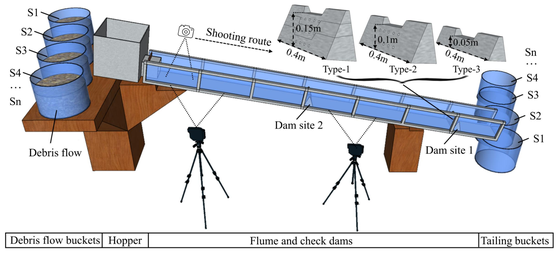
Debris flow	C_v (-)	Volume (10^{-2} m³)	Sediment (kg)	Water (kg)
1	0.18	4.39	21	36.05
2	0.30	2.63	21	18.50

- Deposition gradually development upstream & differential deposition in the cross section direction
- Flow regime: check dam and backwater control& deposition and dominant flow section control









Case	Check dam		Debris flow	
	Dam site 1	Dam site 2	C_v	n
Case1	Type-1	None	0.18	1-10
Case2	Type-2			1-8
Case3	Type-3			1-8
Case4	Type-1		0.30	1-10
Case5	Type-2			1-8
Case6	Type-3			1-8
Case7	Type-2	Type-2	0.18	1-14
Case8			0.30	1-14

RESULTS

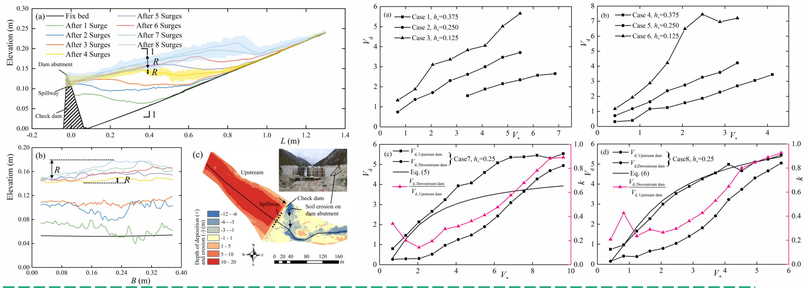
- With the increase in the volume of debris flow, the deposition gradually develops upstream. the empirical calculation formulas of deposition volume are proposed.

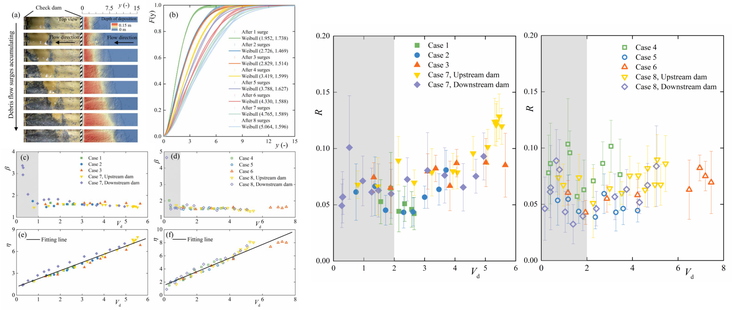
$C_v = 0.18$:

$V_d = 10.420 \cdot \exp(-3.156 \cdot h_* - 1.787 / V_*)$

$C_v = 0.30$:

$V_d = 22.547 \cdot \exp(-4.595 \cdot h_* - 1.654 / V_*)$





- The distribution of deposition along the flume was affected by deposition volume and sediment concentration of the debris flow surges, which could be described by the Weibull distribution.

$$F(y) = 1 - e^{-\left(\frac{y}{\eta}\right)^{\beta}}$$

$C_v = 0.18$, $\eta = 1.119V_d + 1.145$, $\beta = 1.594$

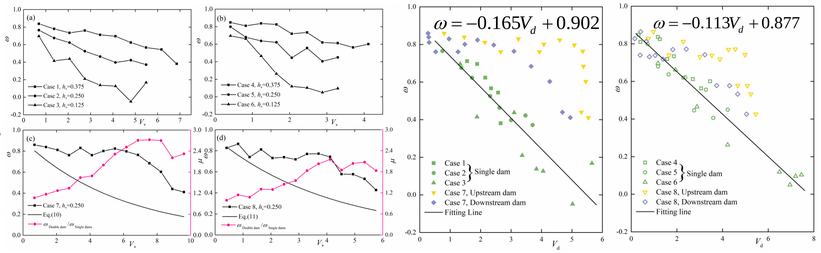
$C_v = 0.30$, $\eta = 1.038V_d + 1.507$, $\beta = 1.538$

- Deposition difference in cross section increase with the increase of deposition volume.

- Deposition development optimizes the hydraulic conditions of the debris flow and weakens the effectiveness of the check dam. The empirical calculation formulas of sediment retention rate are proposed.

$\omega = 0.903 \cdot \exp(-0.020 \cdot h_*^{-1.547} \cdot V_*)$,

$\omega = 0.922 \cdot \exp(-0.026 \cdot h_*^{-1.601} \cdot V_*)$



WHAT'S NEW?

- The deposition volume and sediment retention rate calculation formulas considering debris flow volume and dam height are proposed, which can provide a reference for the design of the height of the check dam.
- We have established a quantitative relationship between sand retention rate and siltation volume, which can provide a reference for evaluating the remaining sediment retention capacity of check dams not empty.
- We use the deposition volume , the distribution function and deposition difference in cross section to describe the deposition characteristics, which can better reflect the actual deposition than the deposition slope and promote the optimization of the design of the check dam.