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Debris-flow interaction with structures

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Introduction

For debris flows, the combination of high velocities and the capacity to carry large boulders, endangers human lives and infrastructures. For the design of mitigation measures a realistic design value of the expected impact pressure is required. Due to the destructive power of debris flows, real scale data are rare. For this reason a new monitoring barrier was built in the Gadria creek in South Tyrol, Italy, to measure the interaction between debris flows, the engineering structure, and the ground.

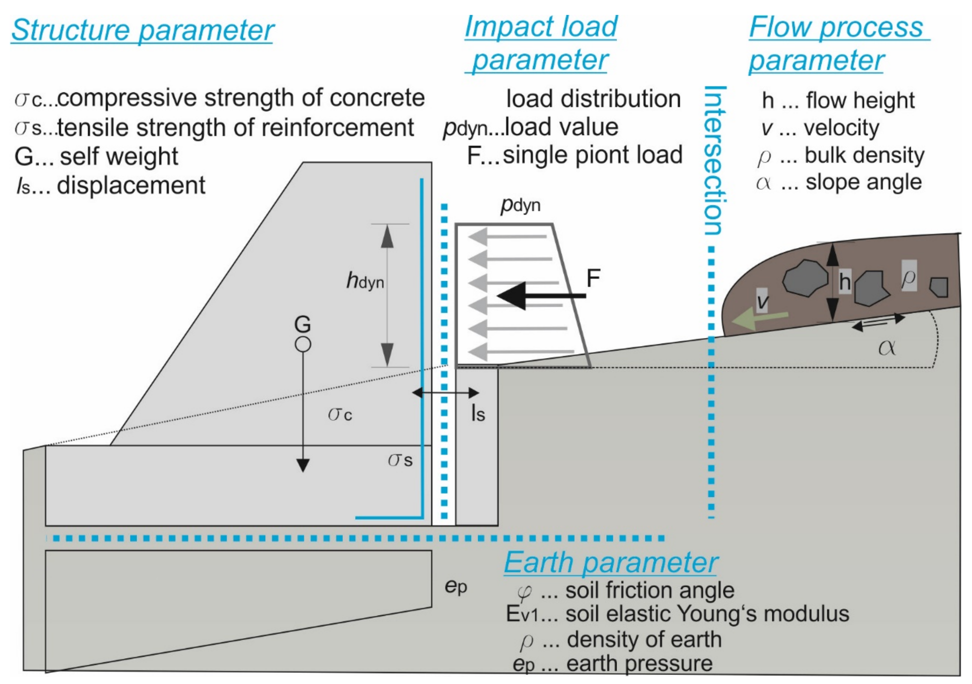


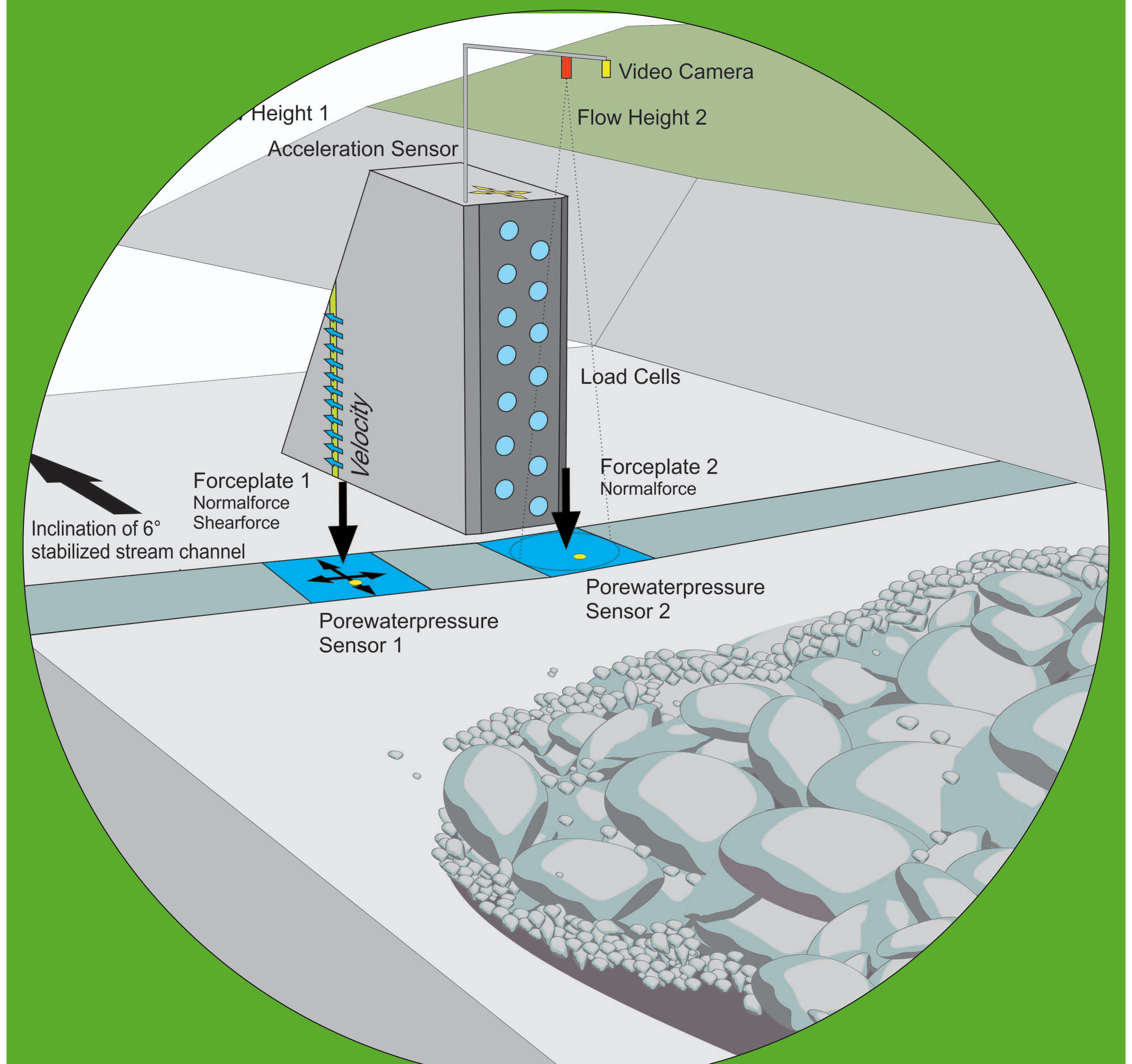
Fig.1: Schematic illustration of the interaction of debris flows with the monitoring barrier.

Monitoring barrier

The monitoring barrier consists of a single concrete element in the middle of the channel covered with steel plates with fourteen load cells at the front of the barrier. The load cells can measure impact pressures up to 2,000 kN. The sampling frequency of each load cell is set to 19,200 Hz. To measure the normal force one force plate was installed in front and one 2 m aside of the barrier, both recording with a sampling frequency of 2,400Hz. Additionally, ultrasonic sensors above the force plates are used to determine the flow height.

Fig.2: Debris-flow front in the Gadria torrent on July 26, 2019.

Confirmation of the Froude number dependence on the empirical coefficient for debris-flows impact force calculation. Furthermore, this indicate a problem of the hydrodynamic model in low Froude regimes.



In the three years of operation (2017 and 2019) five debris flows were recorded with a maximum flow depth between 1 to 2 m. The events showed densities from 1,500 to 2,500 kg/m³ and velocities up to 5 m/s at the front. Variations of flow depth go in line with normal stress and fluid pressure. We back-calculated the empirical coefficient α for the hydrodynamic impact model

$$F=\alpha v^2\rho \tag{1}$$

,where v is the velocity [m/s], ρ is the density [kg/m³] and the impact force F in [N].

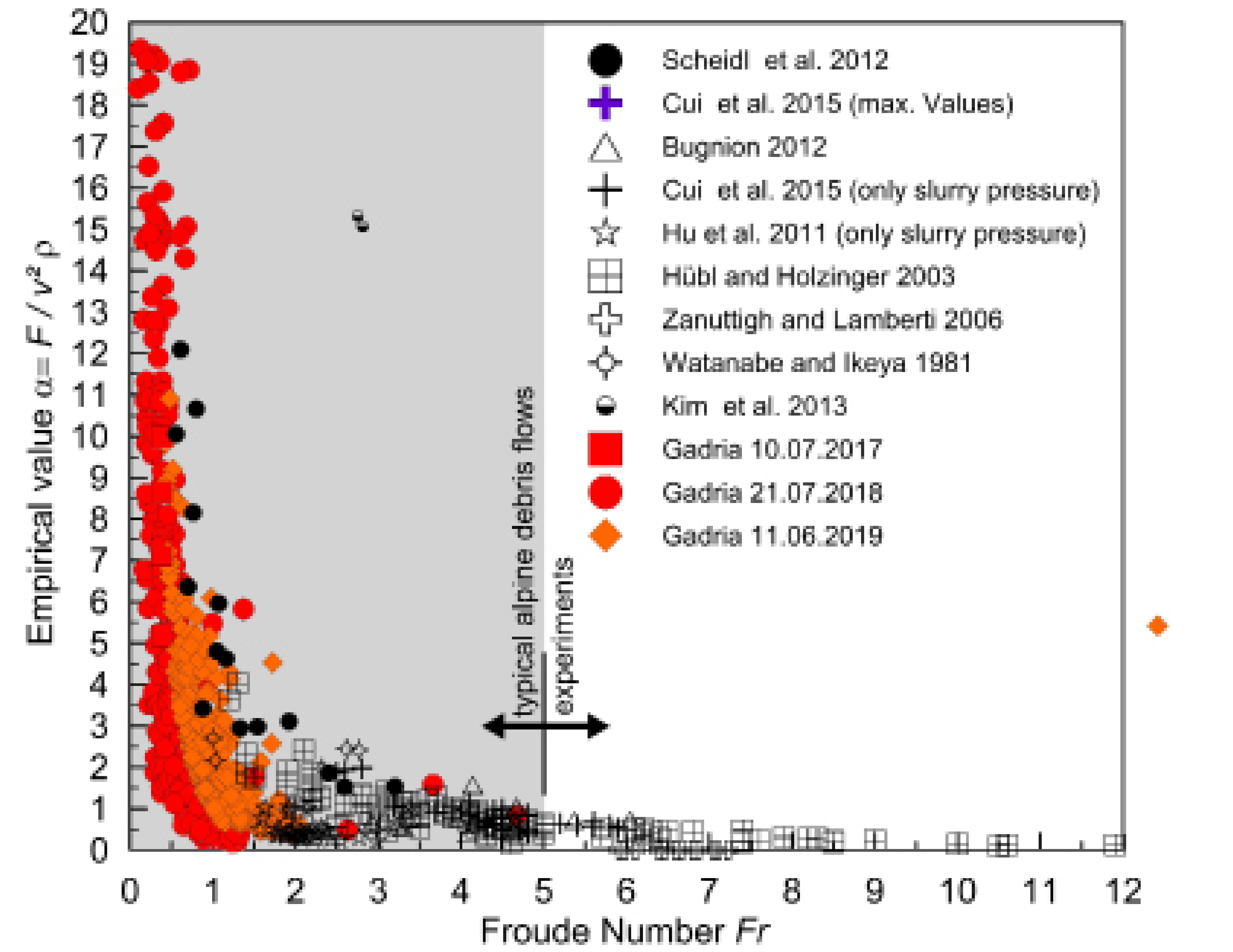


Fig.3: Data from previous studies based on small-scale experiments [Scheidl et al., 2013; Cui et al., 2015; Zanuttigh & Lamberti, 2006; Kim et al., 2013; Hübl & Holzinger,2003; Watanabe & Ikeya, 1981] and real-scale measurements [Bugnion et al., 2012; Hu et al., 111 2011] suggest a dependence of the empirical value on the Froude numbe. Measurements of three natural debris flow of the years 2017 to 2019 confirm the Froude number dependence.

The measurements of a natural debris flow underline that the empirical coefficient α of the hydrodynamic model does not perform well by low Froude regimes.Further in-situ real time measurements also will help to densify the database of real scale debris flows and improve hazard assessment.

Acknowledgement

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