LOAD MODEL FOR THE INTERACTION BETWEEN DEBRIS FLOWS AND FLEXIBLE BARRIERS

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A new kind of mitigation measure against debris flows are flexible barriers. Compared to similar barriers against rockfall, where the impacting rock is well modelable by a rigid body, the interaction between the two-phase medium debris flow and the flexible barrier is quite unknown. It is therefore the aim to develop a load model that can be used for both dimensioning in practice and numerical simulation.

FLEXIBLE BARRIERS AGAINST DEBRIS FLOWS

The investigated barriers consist of ring-nets, spanned by support ropes with integrated brake elements (Fig. 1). They can be installed easily and efficiently up to 15 m width without and up to 30 m with posts. They are most appropriate to act as a debris flow barrier in a rather narrow torrent channel or – if combined to a series of barriers – as an alternative to traditional check dams. Depending on the local conditions of an installed barrier, the benefits are trapped sediment volumes, decreased debris flow energy or river bed stabilization.
The load bearing principles are taken from analogue rockfall barriers. Applied against debris flows, their granular material is restrained but water and small particles are let through. The remaining load originates from the impact of the granular phase. A new research project now develops a load model that can be used for an optimized design of such barriers. It consists of an extensive experimental programme and corresponding numerical simulation.

Fig. 1 Filled 12 x 4 m field (left) and 30 x 30 cm laboratory (right) barrier.

EXPERIMENTAL PROGRAMME

Because there is only few information on the capabilities of flexible barriers against debris flows corresponding full-scale field tests are mandatory to validate the developed load models. The test facility is located in the Illgraben (Canton Valais, Switzerland) with an average

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frequency of 5-6 large debris flows per year. In the three debris flow seasons 2005, 2006 and 2007 several barriers were and will be tested. So, the design of such prototype barriers and their structural details can be reviewed and optimized over the time. The filling process is documented through a laser measuring the actual flow height at the barrier, a video camera inclusive illumination for nightly events recording the whole process and integrated load cells in the support ropes measuring the acting rope forces.
Beside the field tests more than 50 small-scaled laboratory tests were conducted on a chute. Significant parameters like flow and material composition, flow height, velocity and the filling process are documented and then scaled to reality. The laboratory tests enable a reproducibility of single experiments allowing a statistical spread analysis. Furthermore, parameter studies on the impact forces and retention volume influenced by the barrier stiffness, mesh opening, basal opening etc. can be conducted.

NUMERICAL SIMULATION

The Finite Element software FARO (Volkwein, 2005) has been written to simulate flexible rockfall barriers. It now also can be used to simulate above ring-net barriers against debris flows (Fig. 2) by applying single forces on the element nodes or by using inertial effects of an increased net mass combined with an initial velocity.

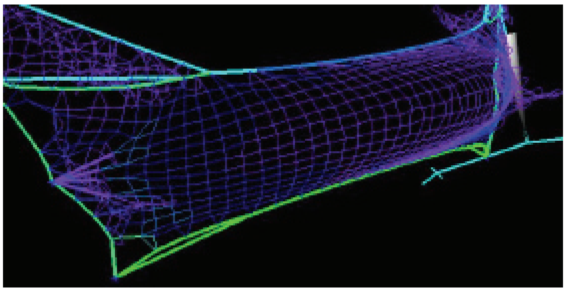

Fig. 2 Finite Element model of the field barrier.

LOAD MODEL DISCUSSION

Based on the data described above we now perform numerical simulations using FARO to evaluate the usability of different load models. E.g. for granular debris flows, the load approach by Rickenmann (1999) can be used. For watery debris flows or muddy events, above approach has to be adjusted to model the resistance the barrier is mobilizing against the debris correctly. There are now different approaches we have to select and/or to combine for a proper resistance quantification: (a) pressure on the proportionate ring-net area as portion of the channel cross section area; (b) active earth pressure scaled to dynamic impact forces using the obtained scaling factors from the laboratory tests; (c) back-calculation from the measured rope forces in the field; (d) impulse, kinetic energy of the impacting and retained masses.

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