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Granular Experiments on the avalanche mitigation structure 'Muehlauer Klamm', Innsbruck, Tyrol.

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Muehlau is a part of Innsbruck, the capital city of Tyrol. Several buildings in this area are endangered by avalanches. The avalanche path starts at a release area which spreads about 2.6 km^2 at an altitude of about 2300 m and finally enters a more than 1 km long gorge. In the catastrophic winter of 1951/52 an avalanche caused considerable property damage.

An analysis of several mitigation methods revealed that a retarding system of two mitigation structures in the lower avalanche path to be the most effective way to protect the area of Muehlau. This protection concept consists of a breaking dam at the lower part of the gorge as well as a deflecting structure further up.

In the years from 2002 to 2008 the avalanche breaking dam with a specific design was constructed. This construction is expected to decrease the destructive capability of catastrophic avalanches and to avoid any damage in the village. Fortunately, until now no avalanche reached this breaking dam. But due to the huge release area there is a potential of avalanches up to 250 000 m^3 volume.

To investigate the effect of the existing breaking dam and the second, planned, deflecting structure, laboratory experiments with granular media were performed. A 8m long and 1m wide chute with adjustable inclination was used. The topographic profile of the gorge was rebuilt in styrofoam in different scales and a mixture of polystyrol and glass beads served as a substitute material for the snow avalanche.

As a first step the effectiveness of the existing lower breaking dam was verified on a experimental scale of 1:100. It was shown that avalanche velocities were significantly reduced and the majority of the released volume was stopped by the dam.

For analysing the effect of the second deflecting mitigation structure, experiments with a model on a scale of 1:250 were performed. The planned building was installed in different positions along the path in order to find the most effective location.

Based on dynamic avalanche models, a Froude number greater than 3 was assumed for the real avalanche in the area of the retarding structures. In order to achieve scalability the same Froude number is assumed for model avalanche in our laboratory experiments. Accordingly the chute inclination was adjusted in order to gain matching avalanche velocities.

Several digital cameras were used to determine the velocities along the track and laser sensors on 2 positions provided information about the flow height of the avalanche. Optical speed sensors at 3 positions supplied further data of basal velocities. Comparing the velocities, the effectiveness of the new retarding structure with regard to its position could be checked. According to the experimental results, an optimal position of about 400m above the breaking dam was determined.

In a further step the effect of the structure with respect to its height was investigated. Therefore reflection dams with different heights were installed successively. The effect of reducing the dam height was investigated by comparing velocities and flow heights.