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Debris Flow Risk mitigation by the means of rigid and flexible barriers. Experimental tests and impact analysis

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Landslides triggered by rainfall occur in most mountainous landscapes. Soil slip and debris flow affect most of Alpine valley and represent one of the the main hazard in North Italy. Debris flows most often occur as a result of intense rainfall but there are also other triggering mechanisms such as snowmelt or dambreak failure. In a torrent catchment, debris flows often produce much higher peak discharges than "ordinary" floods under the same rainfall conditions. The peak discharges often exceed channel capacities on the fan, resulting in widespread sediment deposition on the fan and associated hazard to buildings, infrastructure and people.
Present study investigates rapid channelized debris-flow related to rainfalls in small alpine basins. Different geological and technical aspects that can control processes in order to support hazard zonation and risk mitigation. In particular, statistical analysis of debris flow occurrence highlighted the presence of basins with different retourning time depending to the lithology of the bedrock and the quantity of covers. These changes reflect also differences in materials and depositional stiles. These considerations turn out useful in term of hazard zonation and risk mitigation. Future mitigation systems could be based on the fact that in a relatively small area some basin can be affected frequently by debris flow occurrence, while others can be interested only for long returning periods.
Recently, especially in small basins, in order to control and mitigate debris and mud flows events, flexible barriers (such as net barriers) have been used. Noteworthy are the similarities between these barriers and the protections used for rock fall events. Whilst in Europe design and verification criteria for rock fall are universally recognized and applied, such criteria have not been implemented for debris flows. The need of new methods of certification of the barriers together with a good knowledge of the impact phenomena and the energy related to itself derives from two main fundamental considerations.
First, the different behavior of a debris flow and a rock boulder impacting a barrier. In fact unlike the impact of a falling rock on a net, that can be considered impulsive and punctual(time domain of few milliseconds), the interaction of a debris flow with a flexible barriers is complex and few studies were conducted to understand the dynamics of the impact and to develop a solid and useful design guideline together with new verification criteria.
Second, failure consequences. In case of large debris flow events a failure of the flexible barrier could led to more catastrophic effects. In fact whilst stopped, large solid volume in case of barrier collapse can be moved increasing the disruptive potential of the flow.
In order to clarify at best the impact phenomena, laboratory tests conducted in a small scale channel and results obtained. Following Iverson's scaling and dimensional analysis of debris flow, flows of water saturated sand were triggered in a 40 cm wide channel and 4 m long. At the bottom of the channel has been installed a barrier in order to measure the impact force of the generated flow.
Different types of barriers (in terms of rigidity and shape) have been used to analyze the impact energy of the flow and the amount dissipated by flexible barrier deformation and to investigate the consequences of a fast drainage. In fact, as shown in the tests, the water drainage induced by net barriers together with the absorption of energy due to high deformations rates reduces significantly the impact force and decelerates the flow.
Comparison between measurements and debris flow literature are also highlighted.