HYDROGEOLOGICAL HAZARD BY DEBRIS FLOW PHENOMENA IN RIO SPINI FAN IN TRENTINO

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INTRODUCTION

This contribution reports the results of a study on the hydrodynamic behaviour in relation to debris flow events of Rio Spini, a small tributary of Caldonazzo Lake in eastern Trentino (Italy). The river, subjected to debris flows, as verified by historical evidence, was an object in the past of torrent control measure with a classic "staircase" of check dams, of considerable size. The presence of a village has requested an increase in the degree of safety. To achieve this goal, in 2008 one of the largest dams in concrete was replaced by an open check dam, obtaining a relevant deposit basin. In a collaboration between the Mountain Basins Service of the Autonomous Province of Trento (Servizio Bacini Montani) and the University of Trento, Faculty of Engineering, the behaviour of the new torrent control structure against debris flow events has been investigated by the application of new computational tools, such as bi-dimensional mobile bed models.

CHARACTERISTICS OF THE BASIN OF THE RIO SPINI

The entire basin of the Rio Spini, as the entire mountainside of Caldonazzo Lake, is characterized by a substrate of phyllites. The whole area is also affected by a widespread sub-surface water movement; regarding land use, it is divided into two main sections: in the upper part of the basin there is mostly grassland and wooded area, while in the lower there are sparsely urbanized areas and agricultural crops. The analysis of the natural disasters (floods and landslides) that have occurred over the years within the basin (Service Archive and a specific database – Stock disasters of the Autonomous Province of Trento – ARCA Project) has shown that a large number of landslide/debris flow events with different degree of importance (estimated volumes from 50 to 16,000 cubic meters) have occurred.

HYDROLOGIC ANALYSIS AND EVALUATION OF UNSTABLE AREAS

The studies allowed to estimate the flood hydrograph with different types of modelling ("Piene_TN – Floods_Trento" and JGrass), testing the results. One of the most difficult aspects of the analysis of debris flow events is to estimate the volume of material potentially available in the basin: for a correct analysis is certainly required a great knowledge of the area and of its geomorphic processes, in order to identify critical areas.

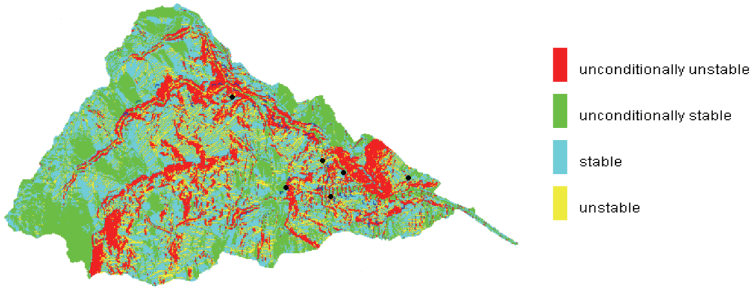

Fig. 1 SHALSTAB model application and back-analysis of landslides and unstable areas (blue points)

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Important to this evaluation is also the application of Hydrological/ Stability models based in particular on the morphological study of the basin. For this reason, the analysis was conducted using the model SHALSTAB. The calibration of the parameters for the modeling was carried out with a back-analysis of debris flow and landslide events occurred in the past (Fig. 1). Based on the identified unstable areas we have tried to make an estimate of the movable volume.

ANALYSIS OF THE PROPAGATION

The analysis of propagation of debris flow along the river Spini was carried out using the model TRENT2D, which is a two-dimensional code developed by the C.U.D.A.M. (University of Trento), that simulates debris flow with grain-inertial rheology on mobile bed. The version of the software TRENT2D used did not allow to model reaches where erosion can not occur (as the dam) and then, to study the quantity of debris material stopped by a traditional dam, the analysis of propagation was carried out for a section between two dams. The volume of sediment deposited in this reach was multiplied by the number of dams to obtain the total volume of solid material stopped by the "staircase" of check dams. Another important simulation performed by the two-dimensional model was the analysis of the behaviour of the deposit basin and of the new open check dam built in 2008. The behaviour of the open check dam was simulated with both the two-dimensional code TRENT2D and with the direct use of one-dimensional equations. The two-dimensional analysis allowed to assess the performance of the deposit basin, particularly with regard to the contribution of the solid material inside the mixture.
Finally, on the base of the outcomes of the previous analysis, we estimated the debris flow hydrograph coming out from the open check dam and studied the hazard of the flow in the urbanised area downstream. The results of the simulation of a severe debris flow events show that the sedimentation along the series of check dams is limited, because of the small space between two successive dams, which is not sufficient to stop the entire debris flow, but can only slow it down.
These traditional works have been built more in order to stabilize the river and less to stop a hypothetical event of debris flow.

Fig. 2 Traditional dams and the new open check dam on the Rio Spini

CONCLUSIONS

In order to assess the hazard of a mountain debris fan there are several calculating methods based on mathematical models of complex physical phenomena such as natural debris flows. These models are useful indicators of the degree of danger of a fan from torrential phenomena, but there are many factors difficult to quantify in the analysis: the quantification of sediment availability, the flow hydrograph, the effect of retention of traditional works and of more modern open check dam. The simulations carried out on works recently built up have however allowed us to verify the different behaviour of the torrent control structures and the level of protection.

Keywords: debris flow, silt dam, open check dam, two-dimensional modeling