Mass Movement Displacement Monitoring for SABO Works Maintenance

Giulia BOSSI, Matteo MANTOVANI and Gianluca MARCATO*

CNR-IRPI – National Research Council of Italy, Research Institute for Geo-Hydrological Protection, Italy
*Corresponding author. E-mail: gianluca.marcato@irpi.cnr.it

INTRODUCTION

Deep-seated Gravitational Slope Deformations (DGSD) are mass movements with volumes exceeding one million cubic meters. The main difference between the so-called large landslides and DGSD is that for the former it is possible to identify a well-defined sliding surface, while the latter are characterized by a more complex dynamic. DGSD are, in fact, large portions of mountain flanks, which sometimes extend from the ridge down to the valley floor, that suffers for viscous deformations (creep). Despite their considerable frequency in the Alpine regions, DGSD are still poorly investigated and many aspects related to the rheological behavior and their kinematics, remain unresolved. This is linked to the vastness of the phenomena, usually covering several km^2, that requires a large number of monitoring points to characterize its superficial displacements pattern; moreover, the slip surface may be at 100m of below ground surface so it is difficult and costly to drill a borehole for inclinometers.

Aim of this work is to demonstrate that the deformations induced by the DGSD, despite their extremely slow evolution, can cause significant socio-economic damages and hazardous conditions.

STUDY AREA

The study area is located the Autonomous Province of Bolzano (Italy), in the higher part of Passirio stream valley. The basin upstream the DGSD covers an area of $85km^2$ with peak discharge in the Passirio of about $43m^3/s$. The area has the typical morphological characteristics of the alpine area, with traces of glacial phenomena and recent gravitational remodeling. The slope of Ganderberg affected by a DGSD covers an area of about $4.7km^2$, and is predominantly oriented toward south-west. The mass movement develops for more than 1200m, from the crown at 2250-2450m to the valley floor located at 1170-1300m a.s.l. In order to decrease bed erosion since 2000 several (66) check dams were realized along the Passirio stream. The presence of these check dams guarantees also the stability of larger secondary landslide of several hundreds of m^3 that could detach from the toe of the DGSD and dam the river. The check dams were designed considering the landslide activity and for this reason the wings are independent from the weir to guarantee the deformability, and therefore the durability, of the structure.

In 2007 to assess the state and of activity and the kinematics of the DGSD, a GNSS (Global Navigation Satellite System) network, consisting of 20 benchmarks, was deployed over the unstable slope and located on wing of the check dams. Static relative positioning approach was used to locate with the highest degree of accuracy the position of each benchmark within the reference topographic frame. From 2010 to 2016, 8 surveys have been carried out. The variability of the coordinates of each benchmark in terms of planar and vertical component was used to measure the displacement sustained by the check dams among successive reading. The horizontal displacements range between 4-8cm/year whereas the SABO check dam uplift is between 0.5-3cm/year.

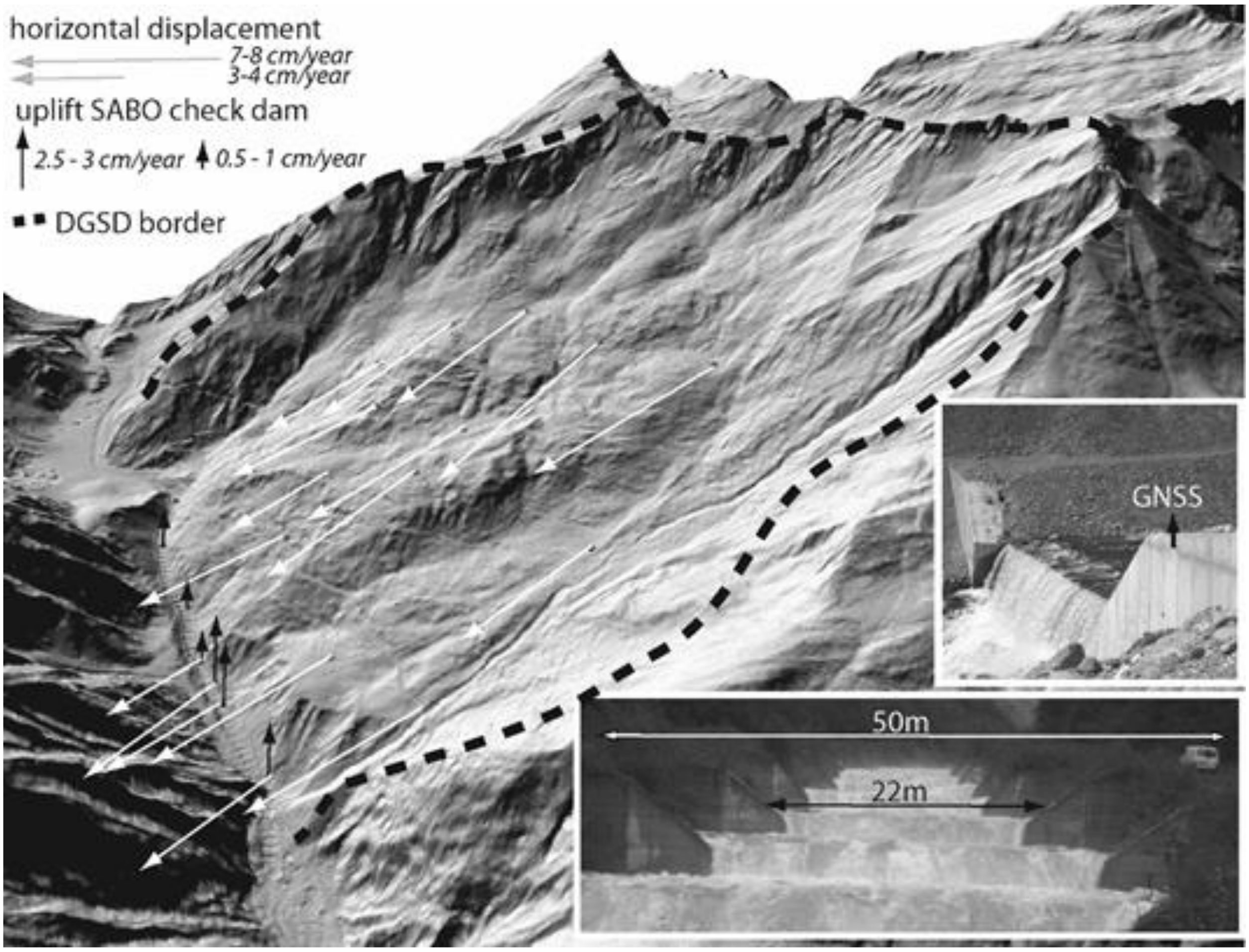

Fig. 1 GNSS displacements for the benchmarks in the Ganderberg site with two photos of the SABO check dams at the toe of the DGSD

RESULTS

The data recorded clearly indicate that the check dams are displacing under the thrust of the DGSD. In particular, all the benchmarks recorded a west-south-west planar displacement along with an upward shove. These results are consistent with the geomorphological interpretation that the creep band is located under the riverbed inducing talweg uplift thus exacerbating erosion. The monitoring data could also support structural health assessment for the SABO dams: the displacement vector associated with benchmarks deployed on the wings should be congruent with the transversal axis of the defense work. The eventual discrepancy between the vector and the axis could indicate a dislocation of the structure that could lead to localized erosion and eventually to the failure of the whole system. With monitoring it is possible to detect early signs of rotation and therefore rapid intervention to avoid major damage.

FINAL REMARKS

We demonstrated the usefulness of deformation monitoring for DGSD. These are often discarded due to their slowness and hence considered less hazardous. Indeed, these phenomena often are coupled with instability processes (i.e. falls, debris flows, slides) that lead to higher hazardous settings. In this context the dynamic relationship between SABO works and slow, massive, slope instability movements should always be considered both in the design and in the monitoring phases.

Keywords: SABO dam, GNSS monitoring, Deep-seated Gravitational Slope Deformation, structural effect