New Strategy for Landslide Mitigation Considering Cost Sustainability

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INTRODUCTION

Structural countermeasure works for slope stability are costly and difficult to sustain in term of economic burden for local communities. In some cases, the cost correlated with the engineering activities could be compensated through the association of works that provide economic return on the long term.

In this work, we present the case study of a medium-size landslide located in the Eastern Italian Alps that has been monitored for more than a decade. The landslide intercepts a National Road but despite that no mitigation works have been implemented due to the economic shortage of the Municipality and conferment disputation between the national and local authorities. We propose to extract and convoy the water that flows above and within the slope in order to reduce the landslide displacements, then using the available 130m drop to produce hydroelectric power.

METHODS

The case study consists of a heart-shaped landslide that is located in the Upper Tagliamento River Valley (Friuli Venezia Giulia region, Italy). The landslide, that consist of two formerly distinct slope instability phenomena that now are interdependent, is crossed by the Rio Verde torrent. Near the crown of the instability phenomenon some springs are present.

The landslide has been monitored for more than a decade with piezometers, inclinometers (periodic and in place) and GNSS surveys. The monitoring system was also integrated with a thin plate weir that was installed in the Rio Verde to assess the discharge of the torrent.

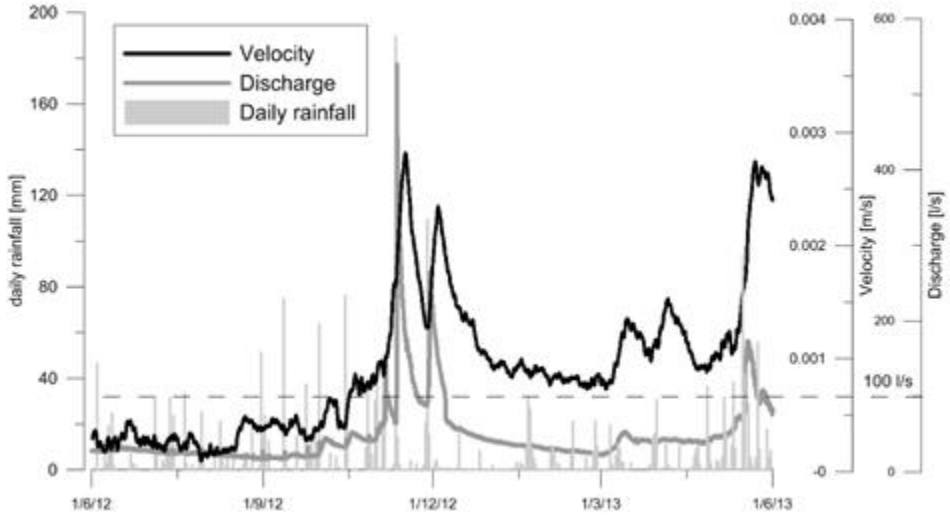

Fig. 1 Velocity of the landslide along the slip surface in comparison with the daily rainfall and the discharge in the Rio Verde – the dashed line represents the proposed plant's maximum discharge

RESULTS

Data support the hypothesis that the displacement pattern of the landslide is influenced by the water discharge of the Rio Verde rather than rainfall. The flow of the torrent erodes the toe of the landslide; besides the groundwater circulation near the slip surface transports the finer particles of the well graded soil that forms the landslide body. This suffusion induces displacements and sagging. The discharge originates from the springs and only on rare major rainfall events has a contribute from the upper basin due to the complex hydrogeology of the area. Between the velocity of the landslide along the slip surface and the discharge in the torrent, the Pearson test results with a correlation of 0.85. In (**fig. 1**) more than a year of monitoring data is represented, usually during autumn and spring snowmelt the aquifer that feeds the stream recharges and higher discharges are observed but the average flow is about 50 l/s.

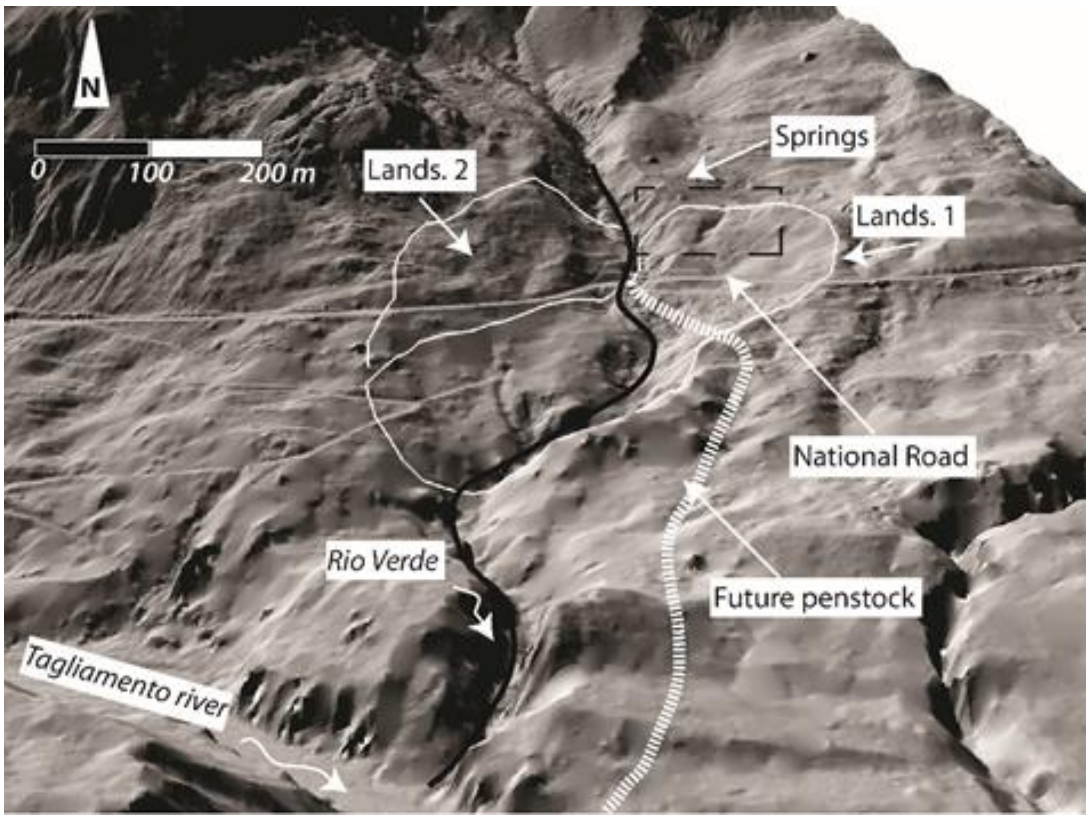

Fig. 2 Study area with possible intervention areas, capitation of water from the springs and buried penstock layout

CONCLUSIONS

Based on the available data, the possibility to intercept the water discharge from the springs and from the Rio Verde is a good option to reduce the mobility of the landslide. The average discharge of the stream is 50 l/s, we propose to intercept in the plant a maximum of 100 l/s and leave to flow in the Rio Verde the exceeding discharge that may occur during intense rainstorm, that has usually small duration. The opportunity to use the water subtracted by the system to produce energy through a small hydropower plant could help sustain economically the remediation project. The value of 100 l/s represent a balance between economic long-term sustainability and expected effect since based on monitoring when the water discharge is sufficiently low the movements of the landslide stop. Moreover, the countermeasure would produce lesser environmental impact than extensive engineering slope stabilization works.

Keywords: landslide mitigation, countermeasure works, hydropower, sustainable cost