# RELEVANCE OF THREE-DIMENSIONAL STABILITY ANALYSIS FOR TWO LANDSLIDES IN CENTRAL ITALIAN ALPS

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The design of landslide remediation requires a careful analysis and modelling of the deformation mechanisms occurring in the slope. In some cases, the classical two-dimensional (2D) stability calculation may lead to erroneous estimate of the slope safety margin and therefore to a too much conservative design of stabilization works.

Two different lanslides, both located in the Central Italian Alps, have been back-analysed using 2D and three dimensional (3D) limit equilibrium methods, showing the importante of 3D effects in the estimate of safety factor necessary for a proper design of intervention.

## THE LANDSLIDE ON THE VRIDEL CREEK

As a consequence of heavy spring rainfalls, a landslide in wheathered phyillites, located in the Valle dei Mocheni in Southeastern Trentino, began to move in early May 2002 at a rate of about 5 cm/day, thus interrupting the circulation on a road crossing the slope. In order to prevent additional movements of the road as soon as possibile, a tied-back shear pile retaining wall was designed and installed. Nevertheless, the landslide continued to displace at approximately the same rate.

Therefore, more careful geotechnical and geophysical investigations were carried out to characterize soil profile and properties and to undestand the basic sliding mechanisms and to select a more appropriate remedial.

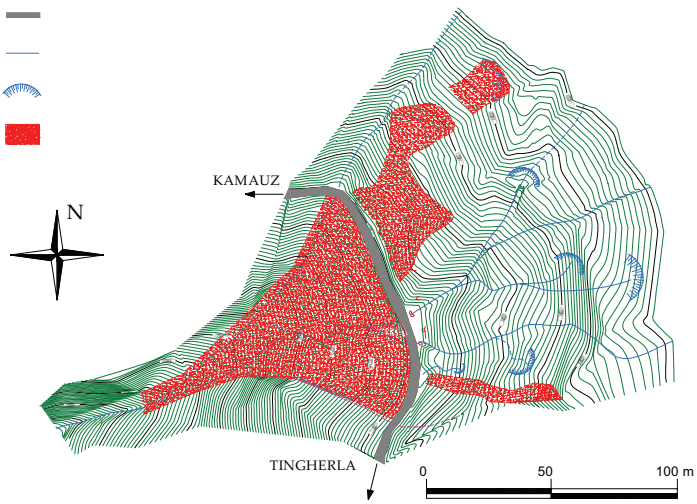


**Fig. 1**. Planimetric view of Vridel landslide.

A planimetric view of the landslide is provided in Figure 1: note that the slope is funnel-shaped with the sliding mass costrained by two lateral rock outcrops to flow down at higher rate. Site investigations showed the two outcrops sloping in the subsoil from the borders to the centre of the landslide. Along with the middle longitudinal cross section the shearing surface was detected at relatively shallow depth in the wheathered pyhillites, whose shear strenght, under realistic pore pressure distributions in the mass,

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did not seem to justify the relatively high slope angle, around 30°.
Traditional 2D limit equilibrium analysis showed, in fact, extremely small and unreasonable safety factors not in accordance to the observed stability condition. 3D effects were therefore considered through a more suitable 3D stability analysis, whose results allowed to select new and effective stabilitation works.

## THE IDRO LANDSLIDE

This landslide, located at the southwestern border between Trentino and Lombardia, is much larger than the previous one and it is still continuously moving at very small rate. The landslide, whose presence is known since many decades, is hanging above the Chiese river, the bayou of the Idro Lake. Since the margin of safety of the landslide is relatively small, the water level in the lake is maintained relatively low in order to reduce the risk of flooding due to the possible valley occlusion caused by slope failure. This situation has an increasing negative economical and phsycological impact on the population of the villages facing the lake.

To investigate the nature of the sliding phenomenon for the selection of the type of remediation, comprehensive geophysical and geotechnical investigations were very recently carried out. Landslide monitoring has been and is still performed through classical inclinometers, installed up to relevant depths, and by using the satellite radar interpherometry. Piezometeres were also installed in the boreholes.

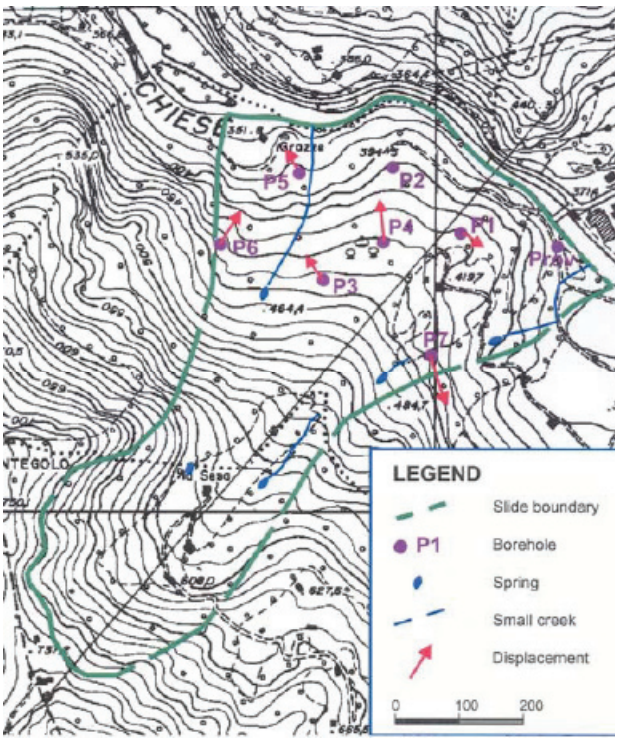
The soils forming the sliding mass are composed by a heterogeneous mixture of gravel and sand in a matrix of silt and clay. The relative percentages of different components is relatively constant with major concentration of fines in some deeper thin layers, where shear banding is concentrated as shown by the inclinometric measurements recorded so far.

Figure 2 depicts the landslide shape and the direction of relevant movements. The latter form a non-zero angle with the longitudinal slope axis of symmetry, suggesting that the landslide was divided into two turning out bodies.

According to the relevant mass movements, geophysical tests recognized the presence of a ridge inside the landslide, dividing the groundwater flow into diverging directions.

To design stabilization interventions, consisting mostly of large drainage wells, 3D stability analysis have been performed, showing, again, the importance of 3D effects in the evaluation of safety factor of the sliding mass.

**Keywords:** Landslides, Stability analysis, Stabilization interventions.

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