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Monitoring, modelling and mitigation of the Moscardo landslide (Eastern Italian Alps)

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In the Carnian Alps, a large rotational slide causes relevant risk for a stream damming, which is threatening with a debris flow phenomena roads and socio-economic activities of the Paluzza village.
The landslide involves an estimated volume of 1 million m^3 of *colluvium* and has been monitored with inclinometers, electric piezometers and GPS since year 2004.
The velocity of deformation measured that is similar in several sectors of the landslide, averages 1 cm per month. The shear surfaces are localized at a depth of 10 and 60 m. while the groundwater table is constant throughout the year despite a cumulative rainfall of the area that usually reaches 2000 mm.
Basing on the results collected by the monitoring network the next task was to simulate the mass slope movement in a numerical way in order to estimate the stabilization effect obtained by different kind of designed countermeasures works. The simulation was carried out using FLAC 4.0 program (with creep option). Elasto-visco-plastic model of the medium in the slide zone was assumed, which allowed the recognition of the failure processes and the determination of the relation between time and displacements. A 10 years displacement trend, starting from 2006 was simulated. Numerical model was built and validated on the basis of the data coming from geological investigations, the results of inclinometric measurements and the GPS surveys data.

The simulation and forecasting prove that the actual situation of the slope is not dangerous. However, the constant rate displacement indicates, that the countermeasures are necessary in order to allowing to restrict and stabilize the slope. Therefore, remedial measures were proposed and their efficiency tested in numerical way. Two kinds of countermeasures were considered, namely: drainage and retaining wall. The drainage was designed in two forms – as a system of vertical holes (wells) located in the middle part of the slope and as the system of horizontal drainage holes. The retaining wall was located about 50 m above the slope base and reaches the slip surface. The numerical simulation allowed to check the effectiveness of the above proposals mentioned. All the simulation trials were successful in terms of the stabilization of the slope with the exception of the one in which the horizontal drainage holes were used. This research shows that an accurate and well planned multidisciplinary approach can help the decision makers in the choice of the most effective engineering solution for the mitigation of the landslide hazard.