



Continuous control of slow movements in landslides

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Slow movements of large landslides are difficult to notice, but they can produce damage in existing structures at long term conditions.

One of the tools to consider in this case is the tuning of the early warning and evacuation systems when the movement accelerates and become catastrophic.

In order to be effective and reliable, the warning system requires a deep knowledge of the landslide behaviour including its mechanism, the cause factors and the prediction of its evolution in the future.

In 1996 the Landslide of Vallcebre became a natural laboratory to this kind of investigation. Sixteen boreholes were performed in order to define geological conditions of the landslide and to obtain undisturbed samples and install a monitoring network.

Some boreholes were equipped with both wire extensometers and open piezometers which perform automatic and continuous measurements of displacement and water table levels respectively. In addition to that, other boreholes included inclinometers to define the location of the slip surface.

In November 2004 two new boreholes were carried out to increase the instrumentation network. A group of three closed piezometers were placed in each new borehole. They were installed in closed sections and isolated, in order to measure pore water pressure directly instead of water table. That will allow to determine if a vertical component of the water flow exist.

Simultaneously, from the beginning, a monitoring of the movement using a precision Global Positioning System (GPS) was carried out. 30 points were positioned on the landslide surface to complete the measurements of the inclinometers and wire extensometers. The measurements show that the different parts of the landslide move

simultaneously but with different velocities.

At present a model of the behaviour of the displacement pattern has been attempted (Corominas et al. 2005) using simple constitutive laws. Using fitting methods it has been proved that it is possible to reproduce, using the piezometric level records, the velocities of the displacement. That will constitute the basis for the future warning system.

Reference:

Corominas, J., Moya, J., Ledesma, A., Lloret, A., Gili, J.A. (2005). Prediction of ground displacements and velocities from groundwater level changes at the Vallcebre landslide (Eastern Pyrenees, Spain). *Landslides* (2), p. 83 - 96.