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Mandria landslide (Greece): a different approach in the determination of the kinematics of a deep-seated landslide

Stella Pytharouli (1) and Stathis Stiros (2)

(1) University of Strathclyde, Civil Engineering, Glasgow, United Kingdom (stella.pytharouli@strath.ac.uk), (2) University of Patras, Geodesy Lab., Civil Engineering, Patras, Greece (stiros@upatras.gr)

The Mandria landslide is a deep-seated landslide located close to the Polyphyton dam in Northern Greece. The landslide had been identified prior to the construction of the 105 m high earthfill dam, which was completed in 1974, but was considered to be of minor significance to the safety of the dam. During the impoundment of the reservoir the Mandria landslide was reactivated and open fissures of up to 2m length were observed. This led to a systematic geodetic monitoring of the landslide movement that continues up to-date. The dimensions of the sliding area are approximately 450m by 750m over a 150m height difference. The mass (minimum 10 million cubic metres) consists mainly of unweathered, fractured gneiss.

This study focuses on the kinematics and rheology of the Mandria landslide using geodetic data. In contrast to the neighbouring Alexis landslide, identified next to the Polyphyton dam, no geotechnical instrumentation was installed and no boreholes were drilled on the Mandria landslide. The only information on the landslide movement comes from the geodetic monitoring records.

The available data used in this paper consist of the movement of seven control stations located on the Mandria slide (561 epochs of measurements for each control point) and the daily values of the rainfall and the reservoir level fluctuations over a period of more than 23 years, from 1978 to 2001.

Signal analysis techniques were used to analyse the measurements. At a first step, the data were cleaned of any gross errors. Next, the trend of the displacements of each control point was approximated by a mathematical equation using least-squares and a particle swarm optimisation algorithm to achieve robust fitting. The principal component analysis was applied to identify similarities among the kinematic patterns of the control points. The third step involved spectral analysis using the Lomb periodogram as well as analysis in the time-frequency domain using the weighted wavelet Z-transform (both techniques suitable for the analysis of unevenly spaced data or data containing gaps) in an effort to detect periodicities present in the available data sets and possible correlations between the landslide movement and the rainfall and reservoir level variations.

It was found that all points share the same pattern of displacement, which characterises both short and longer records. The overall behaviour of the landslide can be described as viscoelastic and viscous or elastoviscous, with multi-annual periodic effects superimposed on the creep, as the results of spectral analysis indicate. The landslide seems insensitive to seasonal variations of precipitation and to annual fluctuations of the reservoir level, although the first filling of the reservoir is likely to have had an important role in its movement. This is consistent with previous studies stating no correlation between the velocity of a landslide and precipitation in case of crystalline rocks over periods of 90 years. For periods of up to 4 years, studies reveal that acceleration of movement has been observed over specific hydraulic loads. There is a lack of subsurface information, but the available data indicate that the landslide corresponds to a rigid mass dominated by brittle behaviour and internal shearing, with its kinematics controlled by thin mylonitic layers along low- and high-angle faults.