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Integrated geomechanics / geomatics approach to understanding the movement of a large, complex slowly moving landslide

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An integrated approach to landslide hazard monitoring and data interpretation has been developed. Based on geotechnical sensor data, numerical process simulation related to probable failure modes, a digital library of case histories and modelling results, and GIS tools, the approach is intended to support the data analysis and decision making of technical personnel. To improve the quality of the data derived from the numerical simulation tools for complex slopes, with variable sub-surface conditions and observed variation in displacement across the landslide surface and within the mass, a suite of tools to extract geometrical and geological data has been developed. Preliminary results from the work show that the tools identify progressive zonation of movement within the slope and simulate variable movement across and within the slope mass.

Geotechnical analysis using numerical simulation is required to assess the failure modes and the conditions that would trigger accelerating movement and failure of the slope. Analysis of instability of large complex slopes, by Agliardi et al (2001) and Eberhardt et al (2004) has shown promise. However, most geotechnical analyses for slopes are based on either modelling a two dimensional section cut through the sliding mass, or on modelling pseudo-rigid movement of a three dimensional solid on a geometrically simple surface (spherical or spoon-shaped). The analysis ignores the fact that large, active, slowly moving slopes rarely move as a single, cohesive mass, but rather display a variety of movement orientations and magnitudes at different locations across and within the slope.

Movement is affected by variable topographic influences as well as non-uniform undulations and curvatures of any localization interfaces (shear surfaces). These movements vary with time and are subject to directional perturbations and system error and drift. A key challenge in interpreting instrument data is the ability to differentiate between systematic error, noise and real changes. Numerical simulation of the Downie Slide, with varying assumptions of interface geometries has shown interesting results with respect to predicting the non-uniform surface response observed with the monuments installed on the landslide surface.

A critical step in the creation of three-dimensional landslide models is the definition of subsurface interfaces, material boundaries and shear zones. Accurate (although not necessarily precise) recreation of these surfaces in the model will dictate the level of reliability in the outcome. One of the challenges in slope stability monitoring relates to difficulties in resolving changing rock response with depth. Three different numerically simulated responses using three different, and reasonable, assumptions of material yield response (constitutive model) were generated to examine the Downie Slide: a large, complex, slowly moving landslide. It was found that the change in constitutive model resulted in significantly different modelling outcome, providing the opportunity to more effectively interpret the conditions at the sliding shear surface, 250m below ground surface.

The results of integrated numerical simulation and interpretation of geomechanics sensor data has proven the value that these two approaches have when they are applied together to a slope stability analysis problem.

Agliardi, F., Crosta, G., & Zanchi, A. 2001. Structural constraints on deep-seated slope deformation kinematics. Engineering Geology, 59, 83-102.

Eberhardt, E., Stead, D., & Coggan, J.S. 2004. Numerical analysis of initiation and progressive failure in natural rock slopes – the 1991 Randa rockslide. Int. J. of Rock Mech. And Min. Sci., 41, 69-87.