Engineering Geology 116 (2010) 218–235

Contents lists available at ScienceDirect

Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Monitoring of the Beauregard landslide (Aosta Valley, Italy) using advanced and conventional techniques

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ARTICLE INFO

Article history:
Received 31 October 2009
Received in revised form 4 August 2010
Accepted 8 September 2010
Available online 16 September 2010

Keywords:
Monitoring
Deep-seated gravitational slope deformation
Radar interferometry
Beauregard dam

ABSTRACT

An advanced monitoring technique, based on radar interferometry and implemented by using a ground-based instrumentation (GBInSAR) has been applied for monitoring the Beauregard Deep Seated Gravitational Slope Deformation. This landslide is located in the Aosta Valley (on the Dora di Valgrisenche river), in northwestern Italy, and impinges on a 132 m high concrete arch-gravity dam. This is recognized to have relevant implications in terms of civil protection and poses important territorial and environmental issues.
The poor rock mass conditions of the left abutment slope were reported in the fifties, during dam construction. Since 2002, additional geological, hydrogeological and geotechnical investigations have underlined the presence of a deep seated shear zone up to 20 m thick, at the landslide toe. Continuous conventional monitoring over a time span of more than 50 years of both the slope and the dam has allowed to gain insights into the understanding of the behaviour of the basal portion of the slope, with very limited and uncertain point-wise displacement monitored in the upper sector.
The GBInSAR monitoring technique has allowed to obtain multi-temporal surface deformations of the upper portion of the landslide, discovering the presence of a main sector in motion, previously unknown, characterized by a total displacement of 45 mm over 4 months. The results of radar monitoring have been validated by comparing with topographic measurements carried out by an automatic total station on 4 targets located at the toe of the slope.

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1. Introduction

The investigations carried out since the Beauregard dam construction (between 1951 and 1960), located in Aosta Valley (northwestern Italy), have shown that a Deep Seated Gravitational Slope Deformation (DSGSD) is present on the left slope of the valley (Barla et al. 2006).

DSGSDs have been widely described by many authors (e.g. Zyschinsky, 1969; Ter Stephanian 1977; Hutchinson, 1988; Agliardi et al., 2001; Ambrosi and Crosta, 2006). Although defined in different ways, in general terms these are slope movements occurring on high relief slopes and with relatively small displacements (Agliardi et al., 2001).

The movements produce distinctive geomorphologic features including scarps, counterscarps, trenches, open tension cracks and grabens often associated with double crests and toe bulging. They appear to be best developed in rocks with marked strength anisotropy, particularly in metamorphic rocks such as shales, schists, phyllites, gneiss, and paragneiss (Hutchinson, 1988).

The surface deformations typically range from a few millimetres per year to several centimetres per year and are often close to the detection limit of conventional monitoring equipment (Bovis, 1990). Within the deformed mass of DSGSDs, the development of sudden and rapid secondary landslides (rotational and planar slides, falls, topples and flow-like movements) is a common feature.

Information regarding geometrical and geotechnical characteristics of DSGSDs at depth are usually lacking, making it difficult to distinguish and correctly understand their behaviour. The development of DSGSDs is strictly influenced by the presence of major tectonic features such as faults, fractures, shear zones and other structural lineaments (Agliardi et al., 2001; Ambrosi and Crosta, 2006).

Displacement monitoring of DSGSDs have generally been performed by means of conventional geotechnical monitoring techniques (inclinometers, extensometers, etc.) and topographic or GPS (Global Positioning System) surveys. The information thus provided is limited to a given number of points within the landslide area.

In large landslides such as DSGSDs, which are often characterized by different and complex movement patterns, single-point data are not sufficient to evaluate their kinematics and behaviour. Even if the instrumental and topographic measurements are carried out on extensive networks, there are difficulties in achieving spatial and

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doi:10.1016/j.enggeo.2010.09.004