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Interaction of a railway tunnel with a deep slow landslide in clay shales

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Abstract

The *Varco d'Izzo* landslide system (Basilicata Region, Italy) develops at the suburbs of the city of Potenza, capital of the region, and is crossed by two transport infrastructures of local importance: the national highway Basentana and the national railway line. This paper is focused on the effects of slope movements on the railway tunnel which was built in the accumulation of an earthflow of the landslide system. The earthflow displacements were slow but continuous in the monitoring period 2005-2015 and in the order of one to several cm/year. They have led, not far from the railway tunnel area, to the eviction of a house, the dismantling of a pedestrian bridge, damages to roads and other structures. The tunnel was completely re-built in 1992 between two rows of piles, by the cut-and-cover method, after the previous tunnel had suffered severe damage due to the landslide. Available inclinometer data seem to suggest that, locally, the tunnel with its piles is hindering landslide displacements. In fact, measurements carried out in the vicinity of the tunnel, upslope from it, do not show a slip surface crossing the piles. On the other hand, landslide displacements are observed both farther, upslope from the tunnel, and downslope from it. The resultant of earth pressures acting on the tunnel is thus, probably, increasing with time. The distribution of landslide displacements around the tunnel until recent years is herein analyzed. Results of site surveys are reported. The causes of the current state of deformation of the tunnel, which was evaluated by laserscanning, are examined with the help of simplified calculations and FEM simulations.

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Keywords: landslide; tunnel; interaction; displacements; earth pressure

1. Introduction

Varco d'Izzo landslide system develops in an urbanized area at the eastern suburbs of Potenza, the capital of Basilicata Region. It is located in a slope facing the valley of Basento river that the geotechnical research group of

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University of Basilicata has been monitoring and studying for a long time. Many results have already been found and published for the adjacent Costa della Gaveta landslide [1,2,3]. More recently, attention has been focused on Varco d'Izzo landslide system and, in particular, on its interaction with man-made works. The highway and the railway, whose tunnel crosses the accumulation zone of an earthflow of the landslide system (Fig. 1), need frequent maintenance and continuous monitoring. The railway line is important for the whole region since it connects Potenza to the Tyrrhenian and Ionian coasts. The earthflow displacements, slow but continuous, are in the order of several cm/year upslope from the highway and of one cm/year in the accumulation. They have led, in the last years, to the eviction of a house, the dismantling of a pedestrian bridge, damages to roads and other structures.

The geology of the earthflow, which develops in Varicoloured Clays, has been studied by several authors among whom [4]; Di Maio et al.[5] reported results of a geotechnical investigation carried out in 2005 in the same zone, with six boreholes equipped with inclinometers. The authors analyzed data from other previous geotechnical investigations together with those of the 2005 investigation. All the experimental data were used to define the main geometrical and kinematic features of the landslide system. Calcaterra et al.[6] reported displacement time trends evaluated by inclinometers and by a network of permanent and non-permanent GPS stations still operative nowadays in the area under study.

The railway tunnel "Calabrese", 200 m long, crosses the accumulation. Its state of fissuring has significantly advanced in the last years, as will be described in the section 4. The tunnel can actually be considered an artificial tunnel, having maximum overburden of about 5 m. It was completely re-built in 1992 between two strutted sheet pile walls, by the cut-and-cover method, after the previous tunnel had suffered severe damage due to the landslide.

The interaction landslide-structure is thus characterized by the fact that the latter is constituted by different elements (piled walls and tunnel box structure) that were constructed in sequence and that also interact with one another. Most research studies available in the literature proposing methods for the evaluation of the stabilizing force that is provided in a landslide by a single row of piles (e.g. [7,8,9,10]) are thus not specifically useful for the studied case. Moreover, unfortunately, the literature is not very rich of comprehensive studies of landslide-tunnel interactions (see [11] and references therein) and most of them consider the case of circular, deep tunnels not reinforced by piles (e.g. [12, 13]).

In this paper, a preliminary analysis of the landslide-tunnel interaction in Varco D'Izzo earthflow is carried out by considering the results of inclinometer and GPS measurements, in-situ tunnel inspections, laser scanner surveys, simplified FEM calculations.

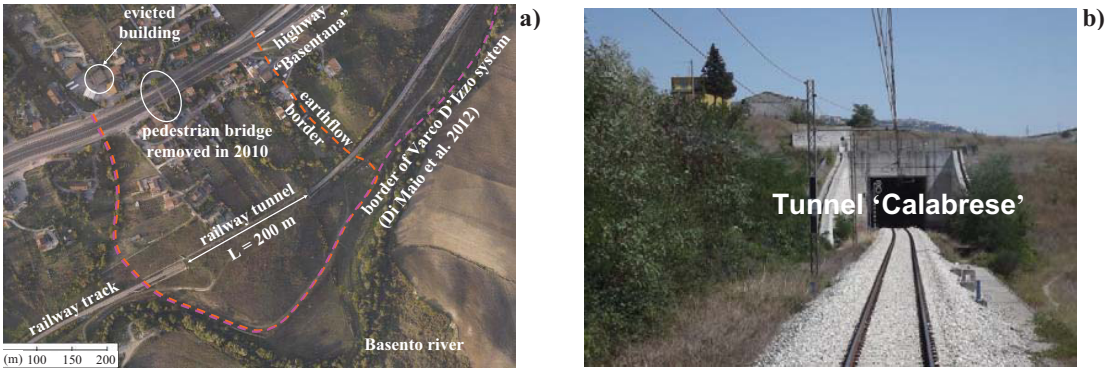

Fig. 1. a) Map with location of study area and railway tunnel, and with indication of main damages due to the landslide; b) Front view of railway tunnel "Calabrese".

2. Brief description of the earthflow and its kinematics

The landslide occurs in a clay shale formation of Upper Cretaceous - Oligocene, locally known as Varicoloured Clays, constituted by a succession of tectonized, chaotic, heterogeneous scaly clays. There are marly clays in the lower part of the formation and calcareous marls, calcilutites and calcarenites in the upper part. The accumulation is