Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 158 (2016) 200 – 205

Procedia Engineering

www.elsevier.com/locate/procedia

VI ITALIAN CONFERENCE OF RESEARCHERS IN GEOTECHNICAL ENGINEERING – Geotechnical Engineering in Multidisciplinary Research: from Microscale to Regional Scale, CNRIG2016

A simple approach for evaluating slope movements induced by groundwater variations

Enrico Conte[a], Antonello Troncone[a,*], Antonio Donato[a]

[a]*Department of Civil Engineering, University of Calabria, Rende, Italy*

Abstract

Landslides reactivated by groundwater variations are usually characterized by low displacement rate with deformations essentially concentrated within a narrow shear zone above which the unstable soil mass moves like a rigid body. A simplified method was recently proposed by Conte and Troncone [1] for a preliminary evaluation of the mobility of these landslides. In the present study, this method is extended by incorporating a calibration procedure for a direct evaluation of some parameters which are difficult to obtain experimentally. Some case studies are analysed to validate the present approach.

Peer-review under the responsibility of the organizing and scientific committees of CNRIG2016

Keywords: active landslides; groundwater fluctuations; landslide mobility; sliding-block model

1. Introduction

Active landslides are often controlled by groundwater fluctuations which in turn are related to rainfall. The mobility of these landslides is therefore characterized by alternate phases of rest and motion according to the weather conditions. In particular, a rising groundwater level (as it occurs in wet periods) can cause a reactivation of the landslide or, if it is moving, an acceleration of the motion. On the other hand, a groundwater level reduction (as it occurs during dry periods) attenuates the landslide velocity and can bring the unstable soil mass to rest. The main type of movement experienced by these landslides is a slide with a velocity of order of some centimetres per year, so that

* Corresponding author.
E-mail address: antonello.troncone@unical.it

Peer-review under the responsibility of the organizing and scientific committees of CNRIG2016
doi:10.1016/j.proeng.2016.08.429

they can be defined as slow-moving landslides. Generally, deformations are concentrated within a thin shear zone located at the base of the landslide body, in which the soil shear strength is at residual condition owing to the high strains accumulated [2]. The soil above the shear zone is on the contrary affected by small strains and it is often characterized by a displacement profile essentially constant with depth. In the engineering practice, the changes in the groundwater regime and slope stability are usually dealt with in an uncoupled manner using different theoretical approaches which are generally based on the limit equilibrium method [3,4]. However, the limit equilibrium method is in principle unable to analyse active landslides for which a realistic prediction of the displacements is required rather than a calculation of the safety factor. Numerical modelling can obviously provide a better understanding of the complex mechanisms of deformation that occur in a slope [5]. Considering that in the slow-moving landslides the viscous component of deformation should be very important [6-8], an elasto-viscoplastic constitutive model is often incorporated in the numerical methods [9-12]. However, these methods are generally very expensive from a computational viewpoint. In addition, a significant number of material parameters need to be evaluated when advanced constitutive models are adopted. Simplified methods were also proposed to perform readily an approximate assessment of the landslide velocity on the basis of the groundwater level changes measured at some piezometers installed in the slope [1,13-19]. In these methods, it is generally assumed that the landslide body behaves like a rigid block sliding on an inclined plane. In the present paper, this assumption is maintained and the method proposed by Conte and Troncone [1] is used because of its simple applicability. In fact, the method is completely analytical and requires few parameters as input data. As an extension, a calibration procedure is incorporated in the original version of the method, for a direct evaluation of some parameters which are difficult to obtain experimentally. Some case studies documented in the literature are analysed to assess the capability of the present approach to predict the landslide mobility induced by groundwater variations.

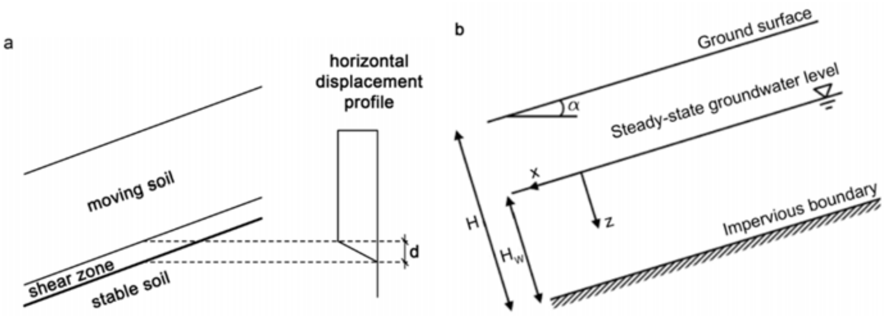

Fig. 1. a) Slope model considered in the present study; b) infinite slope with water seepage parallel to the ground surface.

2. Method of analysis

The slope model considered by Conte and Troncone [1] refers to the scheme shown in Figure 1a. Specifically, the landslide is assumed to be a translational infinite slide with deformation concentrated in a narrow shear zone above which the soil mass essentially moves like a rigid body. The slope is subjected to a water seepage parallel to the ground surface (Fig. 1b). Under these assumptions, the equation of motion takes the form [1]:

$$\frac{dv}{dt} + \lambda v = \chi \left[u(t) - u_{c} \right] \tag{1}$$

where $v(t)$ is the landslide velocity in the direction parallel to the slope, $u(t)$ describes the changes in pore water pressure (with respect to the steady-state condition) at the failure surface, and u_c is a critical threshold for $u(t)$, which is introduced to establish whether or not the landslide body moves. Specifically, motion occurs when $u(t)$ exceeds u_c. On the contrary, if $u(t)$ is smaller than u_c at every time, the landslide body is at rest. The expression of u_c is: