# Numerical modelling of a creeping landslide using the finite element method: A case study

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**ABSTRACT**

In this study, a finite element based numerical method is considered to evaluate the creeping behavior of a creeping landslide induced by snow melt water. A novel 2D-Elasto-viscoplastic constitutive model is used to simulate the creeping behavior owing to groundwater level fluctuations of the Tomuro landslide of Gunma, Japan as a case study. Two new control constitutive parameters are incorporated in the numerical model for the first time to better understand the creeping behavior of a landslide. Such control constitutive parameters are estimated based on the relation between the total factor of safety, calculated by the various Limit Equilibrium Methods and Finite Element Method, and the field monitoring displacement rate of the Tomuro landslide. In addition, the snowfall precipitation is also considered during the calculation of total factor of safety using both limit equilibrium methods and finite element method. Others required material parameters for landslide simulation are obtained from the field investigation and laboratory tests of the collected blocked samples. The simulation results of deformation pattern and shear strain pattern are also discussed to understand the creeping behavior of the Tomuro landslide. Moreover, the predicted and measured time histories of horizontal displacement of the Tomuro landslide are compared for the validity of the proposed numerical model, and found in good agreements with each other.

**Keywords:** finite element simulation; groundwater fluctuation; new control constitutive parameters; creeping behavior; tomuro creeping landslide

## 1 INTRODUCTION

Creeping landslides are one of the major geotechnical hazards. Most of creeping landslide sites accommodate human settlement and agricultural fields, roads and highways, bridges and tunnels, nature conservation sites, and so on (Bhat et al., 2017a and 2014a). When the displacement rate of such landslides is suddenly increased and accelerated, it leads a huge mass failure, which damages human life, property, nature, and the environment. If a numerical approach to predict the creeping behavior of a landslide is possible, each damage can be prevented (Bhat et al., 2017a, and 2017b). Therefore, study of the creeping behavior of a landslide and associated Geotechnical hazard issues seems very important.

Creeping landslides are controlled by the groundwater fluctuations (e.g., Conte et al. 2014; Picarelli et al. 2004) therefore; groundwater fluctuations should be incorporated in the numerical simulation of such landslides (Bhat et al. 2017a and 2017b). However, most of previous numerical approach (e.g., Picarelli et al. 2004; Patton 1984) of soil creep and associated problems are focused on the laboratory creep tests (i.e., consolidation/oedometer test and triaxial test), which could not address the fluctuation of groundwater level. Based on the theoretical, experimental, and numerical models, a few researches (e.g., Bhat et al. 2016 and 2014b; Picarelli et al. 2004; Patton 1984) have tried to address these issues; but they are not fully understood, especially in relation to the displacement behavior of a creeping landslide. Huvaj and Maghsoudloo (2013) have simulated considering groundwater fluctuations in different phases to understand of displacement behavior of a slow-moving landslide, but the exact value of the deformation at any required point (location) couldn't be captured perfectly. Recently, a few researchers (e. g., Ishii et al., 2012; Conte et al., 2014; Fernández-Merodo et al., 2014) have proposed a FEM-based 2D-Elasto-viscoplastic constitutive model using the field instrumentation and monitoring results, but they are only considered the single control constitutive parameter, estimate based on the trial and error method, which could not control the displacement rate of the landslide, and also far to address the realistic field problem of creeping behavior of the landslide. Therefore, the main objective of this study is to address the above-mentioned problems using a new FEM-based numerical model, and to study the creeping behavior of Tomuro landslide induced by snow melt water as a case study.