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ANALYSIS THE EFFECTS OF THE DEGREE OF SATURATION ON THE SLOPES STABILITY USING MODELLING AND NUMERICAL SIMULATION

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ABSTRACT: Soil materials have been often considered in saturated condition for landslide analyses, in which back pore water pressure has been indicated to be a cause of the landslide. In this paper, numerical simulations are used to analyze the landslide process at the river bank from the viewpoints of unsaturated soil mechanics. A coupled hydro-mechanical model is adopted to numerically simulate the landslide process. For the mechanical behavior, the modified Barcelona Basic Model (BBM) is used in order to take into account the hardening and softening due to mechanical and hydraulic loading and unloading as well as to describe the shear strength via critical state line. Modified BBM allows the more realistic description of the behavior of soils, and particularly clayey soils in case these soils are not saturated. The numerical simulation using a modified BBM model is compared with the model, which does not account for the states of water saturation such as Drucker-Prager model. Both models are applied to the numerical simulation of the Red River bank in Vietnam. The evolution of displacements and the inelastic deformation during the infiltration process are discussed based on the simulation of dry to the rainy season with the changes of water level. With the model, the authors attempt to point out one of the possible causes leading to the instability of the river bank.

Keywords: Slope instability, Barcelona Basic Model, Elasto-viscoplastic model, Unsaturated soil; Red River

1. INTRODUCTION

Numerous landslides have occurred recently along the bank of the Red River, Hanoi, Vietnam (Fig.1). Reasons have been pointed out: featured geology profiles, the properties of the soil layers, the specific topography-geomorphology, the particularity of the hydrography profile, the characteristics of the flow in seasons, and human activities influencing the geo-environment [1]. The causes of landslides or soil topple at Red River should be studied in both global as well as local viewpoints. In several cases, landslides phenomenon in river bank is interpreted by the back-pore water pressure, when the river water level decreases rapidly inducing the pressure force from the body to the river. However, in many cases the water level of the river reaches far from the top of the river bank, the landslides are still occurring. These phenomena should be studied within the framework of partially saturated soil mechanics.

In order to analyze the stability of the slope, the relationship between stress and strain is calculated by a material model. The material model is described generally by a set of mathematical equations. The General Limit Equilibrium (GLE) method is afterward applied to calculate factors of safety via commonly used methods of slices (Bishop's simplified method, Ordinary method of slices) or mass methods (Culmann's method; Fellenius-Taylor method). Commonly used models presently are Mohr-Colomb model, Drucker-Prager model, Hardening model, Soft Soil model, Cam Clay model, etc. However, such classical models do not allow simulating the hardening or softening behavior due to wetting and drying process that occurs in reality.

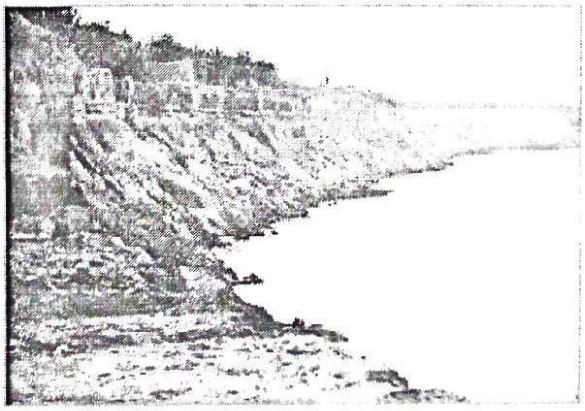

Fig.1 Red River bank landslide examples [2]

Red River is embanked majorly by clayey levees. Besides several concrete walls were built at the border of the city. In this paper, the stability of these levees depending on the dry and rainy season