

Detailed subject :

Nowadays, many landslides triggered after rainfall events cause many damages and victims in urban area. On 21 March a landslide killed 12 people in Papua New Guinea. In December 2013, a landslide in the center of Lyon (2nd largest city in France) caused major damage to roads and the Lyon National Conservatory of Music.



Fig.1. 2 pictures of the Lyon's landslide

The complex hydromechanical behavior of soils is still not yet well understood. Due to this complexity, many kinds of material instability can develop inside the plasticity limit. Nevertheless, the second order work criterion allow a good description of these instabilities for the case of saturated soils [1]. But the development of instabilities of a soil layer in a saturation process is still not yet well understood.

In particular, the anisotropy of the capillary tensor is not described in general. In order to tackle this problem, it is proposed through this subject to revisit the concept of effective stress in unsaturated soils. A literature review will be made on a thermodynamic approach [2] and on the last advances with the DEM method [3]. Then, based on this literature, an improvement of the constitutive model developed at INSA de Lyon [4] will be proposed and implemented in a FEM code. Eventually, a discussion about the expression of the second order work criterion in unsaturated soils will be done [5]. A proper stability criterion will be deduced at the local scale (Gauss point) and at the boundary value problem scale in order to propose a generalized safety factor.

References:

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[2] O. Coussy : *Poromechanics*. Wiley, 2004.

[3] J. Duriez et R. Wan : Stress in wet granular media with interfaces via homogenization and discrete element approaches. *Journal of Engineering Mechanics*, 142(12), 2016. DOI : 10.1061/(ASCE)EM.1943-7889.0001163

[4] W. Arai, F. Prunier, I. Djéran-Maigre et F. Darve : A new insight into modelling the behaviour of unsaturated soils. *International Journal for Numerical and Analytical Methods in Geomechanics*, 37 :2629–2654, 2012. DOI : 10.1002/nag.2151.

[5] G. Buscarnera et C. di Prisco : Discussing the definition of the second-order work for unsaturated soils. *International Journal for Numerical and Analytical Methods in Geomechanics*, 36 :36–49, 2012.