Modelling of landslides using the material point method

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Abstract

Movement and failure mechanisms of slopes are generally categorised into four different stages: pre-failure, failure, post-failure and reactivation (Leroueil et al., 1996). The mechanical phenomena involved in these stages differ from each other. This makes an analysis of the entire deformation process very complicated to be performed. Conventional numerical techniques such as the finite element method (FEM) or the finite difference method (FDM), can be effectively used to predict the deformation processes occurring in the slopes in the pre-failure and failure stages under the assumption of small strains. However, serious numerical drawbacks could arise due to mesh distortions when large deformations occur, for example during the post-failure stage of landslides. As a consequence, these methods are unable to analyse the run-out process of landslides. Among the available numerical techniques, the material point method (MPM) is undoubtedly one of the most attractive to overcome the limitations of the traditional methods in the study of geotechnical problems involving large deformations. In this presentation, MPM is used to analyse the complete deformation process of natural slopes taking also into account the brittleness of soils, the progressive failure developing during the pre-failure stage and the characteristics of the post-failure movements. In this context, a novel procedure based on the results of direct shear tests is presented to reduce the effects of the mesh dependency on the numerical solution. This procedure is completely analytical and requires few parameters of simple experimental determination and with a clear physical meaning. Some landslides that occurred in Southern Italy are analysed using the proposed approach. The obtained results demonstrate that an adequate analysis of the slope deformation process, including the post-failure stage, can lead to a better understanding of the complex mechanisms that characterise the landslides. Moreover, a predictive analysis of this stage is very useful for assessing the risk associated with the landslide occurrence and establishing the most suitable measures for slope stabilization.

Biosketch

Dr Luigi Pugliese is Research Fellow in Geotechnical Engineering at University of Calabria. He obtained the Master's degree in Civil Engineering with specialisation in Geotechnical Engineering (summa cum laude) in 2016 and the PhD in Civil and Industrial Engineering with emphasis on Geotechnical Engineering in 2020, at University of Calabria. During the PhD, he focused his attention on the analysis of the post-failure stage of landslides using the Material Point Method (MPM), spending also a period at the research center Deltares, in The Netherlands. The research results were published in international journals and presented in national and international workshops. His current research interests concern slope stability analysis, landslide modelling, retaining wall and foundation design.
He achieved the National Scientific Qualification as Associate Professor in the Italian higher education system, for the disciplinary field of 08/B1 – Geotechnics.

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