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Impact of vegetation on stability of slopes subjected to rainfall – numerical aspect

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Recent years brought a significant development of soil bioengineering methods, considered as an ecological and economically effective measure for slope stabilization.

This work aims to show the advantages of the soil bioengineering solutions for a slope subjected to a heavy rainfall, with the help of a numerical model, which integrates most of the significant plant and slope features. There are basically two different ways in which vegetation can affect stability of a slope: root reinforcement (mechanical impact) and root water uptake (evapotranspiration). In the numerical model, the first factor is modelled using the Cam-Clay model extended for unsaturated conditions by Tamagnini (2004). The original formulation of a constitutive model is modified by introducing an additional constitutive parameter, which causes an expansion of the yield surface as a consequence of an increase in root mass in a representative soil element. The second factor is the root water uptake, which is defined as a volumetric sink term in the continuity equation of groundwater flow. Water removal from the soil mass causes an increase in suction in the vicinity of the root zone, which leads to an increase in the soil cohesion and provides additional strength to the soil-root composite.
The developed numerical model takes into account the above mentioned effects of plants and thus considers the multi-phase nature of the soil-plant-water relationship. Using the developed method, stability of some vegetated and non-vegetated slopes subjected to rainfall are investigated. The performance of each slope is evaluated by the time at which slope failure occurs. Different slope geometries and soil mechanical and hydrological properties are considered.

Comparison of the results obtained from the analyses of vegetated and non-vegetated slopes leads to the conclusion, that the use of soil bioengineering methods for slope stabilization can be effective and can significantly delay the occurrence of a rainfall induced landslide. On the contrary, vegetation removal can have serious consequences, especially on steep and forested slopes.