MODELLING GROUND WATER RESPONSE TO CLIMATE INPUT FOR THE STABILISATION OF SLOPES BY ECO-ENGINEERING

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Although the stabilising potential of vegetation has long been recognised, eco-engineering attracts currently renewed attention for slope stabilisation, as it potentially is more cost-effective and sustainable than conventional engineering solutions. Slope stabilisation by eco-engineering relies on mechanical root reinforcement on the one hand and on the hydrological effects of vegetation on the other. The hydrological effects result from the influence of vegetation on different hydrological processes like infiltration, interception and evapotranspiration. The hydrological effects lead to changes in both the initial conditions and the hydrological response during a potentially triggering rainfall event. Therefore, the hydrological contribution to slope stabilisation cannot as easily be quantified as the mechanical contribution of root reinforcement that, although highly variable, relates directly and uniquely to the shearing resistance along a potential slip plane.

For the evaluation of the potential of slope stabilisation by eco-engineering it is necessary to simulate the hydrological effects of vegetation on the initial hydrological conditions and storm response. Eco-engineering approaches to stabilise the natural or man-made slopes will have to be studied by means of numerical models that are based on the best available physical process knowledge and that are thoroughly tested. In the framework of the ECOSLOPES project, this modelling approach was used to perform a parametric study on the hydrological and mechanical aspects of vegetation as part of eco-engineering measures. Three different slope geometries were defined with different subsurface schematisations and three different types of vegetation imposed on them. These slopes mimic existing research sides within the ECOSLOPES project.

For the hydrological modelling the finite element software package HYDRUS 2D was chosen to simulate the unsaturated-saturated zone hydrology in two dimensions. The initial hydrological conditions for each slope and vegetation cover were approximated by the steady state ground water levels resulting from the annual average rainfall and potential evapotranspiration rates. To model the hydrological influence of vegetation the potential evapotranspiration was partitioned into soil evaporation and transpiration which fractions were kept constant in time.

On top of these steady state ground water levels the ground water responses were modelled to design storms for summer and winter conditions (96hr, 20 year return interval) that were based on the Flood Studies Report (NERC, 1975). When transient rainfall was applied, changes from seepage faces to atmospheric boundary condition at every node per time step were possible and a patch was installed to account for this in the HYDRUS 2D model.

This analysis provides a consistent modelling approach to quantify the hydrological effects of eco-engineering for slope stabilisation. We will discuss its current possibilities and limitations in the light of our field and modelling experiences. The resulting changes in initial and transient groundwater conditions with changes in slope geometry, subsurface schematisation and vegetation type are shown. The subsequent influence on slope stability is discussed in the accompanying paper "Assessing the relative importance of root reinforcement and hydrology with respect to slope stabilisation by eco-engineering" by Van Beek et al. (2004).