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Editorial

Research on Landslide Hydrology and Hydrogeological Disaster Monitoring

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1. Introduction

The triggering of landslides is strongly related to hydrological processes, as variations in soil moisture content and pore water pressure affect variations in soil mechanical properties [1]. Unsaturated soil hydrology and soil mechanics are strongly coupled. The infiltration of rainfall and snowmelt can increase the weight and pore water pressure of the soil and decrease the strength of the slope material [2,3]. Conversely, drainage, evaporation and transpiration decrease the pore water pressure and enhance the soil strength. Therefore, during landslides triggering, monitoring and modeling of pore water pressure and water content assist in analyzing hydromechanical behavior and predicting post-failure displacement [1,4,5].

This Special Issue includes publications that combine multidisciplinary techniques in monitoring and modeling to conduct stability analysis and risk assessment of natural and engineering slopes. The topics cover several important issues: (1) monitoring hydrogeological conditions in landslide-prone slopes; (2) understanding failure and deformation mechanisms under hydrological extremes of unprecedented rainfall; (3) developing, parameterizing, applying and analyzing uncertainties of hydro-mechanical models. Moreover, these studies focus on exploring the effects of interactive soil hydrology and landslide mechanisms under the influences of several natural environmental changes and anthropic activities, such as climate change, reservoir water level management and ecological effects.

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2. Summary of the Special Issue

The first paper [6] presented a new method for predicting landslide deformation under the influences of both rainfall infiltration and reservoir water level fluctuation (RWL), using the Shuping landslide in the Three Gorges Reservoir area as an example. The study utilized the least squares support vector machine (LSSVM) model, optimized by particle swarm optimization (PSO), to predict the landslide displacement. The input variables of the model included rainfall data from the previous month and two months, RWL, change in RWL from the previous month and the displacement from the previous half-year, which were used to build relationships with the landslide displacement. In addition, the study developed backpropagation (BP) and PSO-LSSVM models for comparative analysis. The proposed PSO-LSSVM model showed the most satisfactory performance for all three monitoring stations, indicating its reliability in predicting landslide displacement.

The second paper [7] used the Differential Evolution Markov chain Monte Carlo method (DE-MC) for inverse parameter estimation of in situ measured soil moisture. The DE-MC approach was validated through a synthetic numerical experiment and then applied to in situ measured soil moisture in an earthquake-induced landslide deposit. The landslide material featured coarse texture with a high fraction of sand and gravel, making it susceptible to reactivation under extreme rainfall. The numerical study revealed the equifinality phenomenon in the modeling of soil hydrology, meaning that posterior soil hydraulic parameters could express a similar soil water characteristic curve (SWCC) and hydraulic conductivity function (HCF), even with different values of soil hydraulic parameters. The application of DE-MC to the real case study of a landslide deposit resulted in satisfactory performance in simulated soil moisture content. The DE-MC approach significantly reduced uncertainties in specified prior soil hydraulic parameters and provided a well-constrained posterior evaluation of soil moisture dynamics to support slope stability analysis.

The third paper [8] proposed a discrete element rainfall infiltration model using discrete element software (PFC3D) for roadside slopes. This model integrated moisture transfer, intensity attenuation and infiltration forces into the calculation of the moisture field. By applying this model to a road slope in Nanping City, Fujian Province, China, the distribution law of water content, the functional relationship between shear strength and soil water content and the permeability at different times were obtained. The model was verified by comparing the simulated results of water content with field monitoring data, and the simulation error was lower than 10%. The model was further validated by modeling the variation in pore water pressure in a retaining wall on 12 May 2022. The performance of the proposed model was compared with two other models, i.e., the saturated water content model and seepage force model, and the comparison showed that the proposed model best matched the observation data.

The fourth paper [9] focused on seepage analysis on a road slope of fill embankment on an expansive soil foundation in Baoshan City, Yunnan Province, China. The expansive soil was heterogeneous due to the existence of weak intercalations and large fissures, which caused low strength and high permeability. The rainfall infiltration could further reduce the strength of the weak interlayer and large fissures and increase pore water pressure at the sliding surface. The infiltration-induced pore water pressure propagation was the main factor in triggering the embankment landslide. Based on the direct shear test, the functional relationship between shear strength and water content can be quickly obtained. Based on geological investigation and laboratory testing, a FORTRAN program was developed to consider the special moisture absorption and softening characteristics of expansive soil. The numerical simulation focused on quantifying the influence of absorption and softening on the hydromechanical processes in a slope composed of expansive soil. Finally, this paper put forward the reinforcement method of the high-fill embankment slope on the soft expansive soil foundation, which was proven to have a good reinforcement effect through calculation analysis and field practice.

The fifth paper [10] introduced a displacement prediction method for a tailings dam in Fujian Province, China. Due to the impact of rainfall, phreatic line and self-change on the deformation of the tailings dam, the displacement data were affected by both internal and external factors. Aimed at this problem and background, this study proposed the attention-mechanism-based LSTM network model, in which the attention mechanism module gave different probability weights to the hidden layer of LSTM. The model had the following advantages: it more adequately used input variables by taking the long-term dependence of the time series into consideration. The results showed that rainfall and changes in the phreatic line (i.e., fluctuation in groundwater level) would accelerate the tailings dam deformation process. The model considered the time lag to better reflect the delayed impact of external factors on the dam deformation. Compared with a single LSTM model, the inclusion of more informative input variables and the long-term dependence of the time series improved the prediction accuracy of the dam displacement.

3. Conclusions

This Special Issue aimed to highlight and discuss topics related to Landslide Hydrology and Hydrogeological Disaster Monitoring. The five published papers included in this

Special Issue address the importance of developing innovative monitoring and modeling systems for better quantification of subsurface hydrology and landslide occurrence. Future works should be more oriented towards an increasingly enhanced combination of field observations (e.g., in situ monitoring includes rainfall, groundwater level, soil moisture content, revisor water level, deformation of slopes, etc.), numerical modelling methods (e.g., Discrete Element model, LSTM, etc.) and parameterization algorithms (e.g., MCMC, PSO, LSSVM, etc.) for more reliable monitoring and prediction of the landslide hydrology processes.

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