Date of Submission	8th May, 2025

IPL Project (IPL-268) Annual Report Form

Period of activity under report
from 1 January 2024 to 31 December 2024

1. Project Number and Title

IPL-268 (2022) Title: Initiation mechanism and criteria for hydrodynamic pressure-driven landslides

2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(1) Technology Development

A. Monitoring and Early Warning

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

(4) Mitigation, Preparedness and Recovery

B. Mitigation

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Prof. Yong Liu/ China University of Geosciences (Wuhan);

Dr. Jingjing Long /China University of Geosciences (Wuhan).

4. Objectives:

The project aims to provide the disaster-forming mechanism of landslide induced by dynamic water, and the mechanical mechanism and its criterion of sliding initiation. The results and findings are expected to support the development of major landslide prediction theory with related technical system, and serve the major strategic needs of national disaster prevention and reduction.

5. Study Area:

Three Gorges Reservoir Region of Yangtze River, China

6. Project Duration:

2022.1-2025.12

7. Report

1) Progress in the project

A new computational method is proposed to calculate the water droplet–clay contact angles based on molecular dynamics analysis. We introduce an advanced computational framework based on molecular dynamics simulations. This framework leverages the coordination number (CN) differences of the water molecules and effectively eliminates the gaseous water molecules in the droplet equilibrium system. Additionally, our framework uses an alpha- shaped probe ball to accurately determine the three-dimensional (3D) coordinates of the droplet interface and utilizes a feed-forward neural network (FFNN) to optimize the objective function of the 3D-interface; this ensures highly accurate characterization of the interface contour and an accurate computation of θ. Our approach exhibits outstanding performance in typical clay mineral surface-water wetting systems; it significantly overcomes the limitations of the transformed cylindrical coordinate system algorithm and accurately captures the wettability variations under complex environmental conditions. This new θ computational framework provides crucial assistance for the in-depth exploration of the wettability characteristics of clay minerals in complex environments.

The accurate assessment of hydraulic transmissivity in rock fractures filled with particles is of great importance. We experimentally examine the fluid-driven particle migration behavior in filled fractures and its consequent impact on fracture transmissivity under various hydraulic gradients, normal stresses, and fracture apertures. We find that escalating hydraulic gradients not only intensify particle erosion through amplified fluid drag forces and hydro-mechanical coupling effects but also lead to an increase in the size of migrating particles, thereby augmenting pore clogging. The dynamics of erosion and clogging define four distinct migration phases within the filled fractures. Variations in normal stress and initial fracture aperture significantly alter the particle arrangement and the soil structure stability within the fractures, thereby modulating the progress of particle migration in response to hydraulic gradients. The pattern of particle migration in filled fractures dictates the development of the internal pore structure and normal deformation, ultimately affecting fracture transmissivity. We propose an empirical expression to encapsulate the comprehensive evolution of fracture transmissivity across different particle migration patterns. Our research advances the understanding of fluid-driven particle migration within filled fractures and provides a practical tool for the precise determination of hydraulic properties of fractured rocks amidst complex geological settings.

2) Planned future activities or statement of completion of the Project

In future work, the critical instability state identification model of landslide is quite important, the critical instability threshold system of landslide will be further examined. The landslide initiation criterion considering the physical-mechanical process will be studied.

3) Project Beneficiaries:

The project focus on the initiation mechanism and criteria of hydrodynamic pressure-driven landslides, which can be used to the landslide forecasting in the Three Gorges Reservoir area of Yangtze River, China. Also, the related method can be used in similar reservoir landslides.

4) Results

[1] Tan, J., Li, B., Li, C., Zhan, H., Zhou, J.‐Q., Tang, Y., Tang, H. (2024). Fluid‐driven particle migration and its impact on hydraulic transmissivity of stressed filled fractures. Journal of Geophysical Research: Solid Earth, 129, e2024JB029066. https://doi.org/10.1029/2024JB029066

[2] Meng, J., Li, C., Zhang, S., Hellevang, H., Xiang, L. (2024). New computational method for calculating of water droplet–clay contact angles: Based on molecular dynamics. Applied Clay Science, 252, 107343. https://doi.org/10.1016/j.clay.2024.107343.