Date of Submission	21 April, 2024

IPL Project (IPL-268) Annual Report Form

Period of activity under report from 1 January 2023 to 31 December 2023

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

3. Name of Project leader: Changdong Li

Affiliation: China University of Geosciences, Wuhan

Contact: postal address: No. 388 Lumo Road, Wuhan, China;

Fax: 027-67883507;

Phone: +86 15327198910;

Email: lichangdong@cug.edu.cn

Core members of the Project:

Prof. Changdong Li/ China University of Geosciences;

Dr.Yong Liu/ China University of Geosciences;

Ms. Jingjing Long /China University of Geosciences.

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, China

6. Project Duration:

2022.1-2025.12

7. Report

1) Progress in the project

A representative hydrodynamic pressure-driven landslide in study area is chosen as the examples, combined with the field investigation and data collection, the landslide geological model which is sensitive to dynamic pressure is constructed. The temporal-spatial evolution law of landslide seepage key characteristic parameters is revealed under the hydrodynamic conditions, such as different precipitation intensity, duration and reservoir water level variation. Aiming at the hydrodynamic pressure-driven landslides with unique law of geological structure evolution and mechanical strength degradation, a Physics-Informed Data Assimilation (PIDA) method is proposed for displacement forecasting. The method can integrate the mechanism models with multi-source observation data to update the model parameters and modify the model prediction trajectories. The novel PIDA method can improve the prediction ability of physical forecasting model, and settles the matter that the mathematic model ignores the physical significance of landslide dynamic deformation process.

In the physical mechanism model of landslides, the sliding zone deterioration (SZD) index can be calculated based on deep displacement data and the related external inducing factors; the Boussinesq equation is utilized to recognize the infiltration line of the sliding zone, and the dynamic parameters of shear strength are obtained by the SZD index; and the slice method and the residual thrust method are used to calculate the thrust inside the landslide. Based on the PIDA method, the dynamic update of the shear strength could be accomplished according to the deviation of the displacement. The utilization of self-adaptive dynamic parameters improves the adaptability of the model, and better consistency with the change in the landslide before it slides is observed. The PIDA model not only possesses a physical mechanism meaning but also incorporates the monitoring data and external inducing factors. It can estimate the state variables of the prediction model and the SZD index, resulting in the reduction of the uncertainty and deviation of the shear strength, which successfully reduces the structure error of the model and improves the accuracy of the prediction. Overall, this model offers a brand-new idea and method for the analysis and prediction of the hydrodynamic pressure-driven landslides.

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

In future work, the geo-mechanical model of landslide considering the controlling structure, dynamic seepage and strength deterioration will be constructed to study the dynamic response law of stress field and strain field of landslide with multiple effects of hydrodynamic conditions. The landslide strain field response model will be constructed under the framework of multi-parameter linkage

evolution rules. The critical instability state identification model of landslide will be proposed, the critical instability threshold system of landslide will be established, and the landslide starting criterion based on the threshold system of landslide will be constructed.

3) Project Beneficiaries:

The project focus on the key scientific problems about the initiation mechanism and criteria of hydrodynamic pressure-driven landslides in China Three Gorges Reservoir area, which is the fundamental work to construct a reliable and effective landslide early warning system and serve the major strategic needs of national disaster prevention and mitigation.

4) Results

[1] Li C, Long J, Liu Y. et al. (2021) Mechanism analysis and partition characteristics of a recent highway landslide in Southwest China based on a 3D multi-point deformation monitoring system. Landslides. https://doi.org/10.1007/s10346-021-01698-2

[2] Long J, Li C, Liu Y. et al. (2021) A multi-feature fusion transfer learning method for displacement prediction of rainfall reservoir-induced landslide with step-like deformation characteristics, Engineering Geology, 106494. https://doi.org/10.1016/j.enggeo.2021.106494.

[3] Liu, Y., Long, J., Li, C., & Zhan, W. (2024). Physics-informed data assimilation model for displacement prediction of hydrodynamic pressure-driven landslide. Computers and Geotechnics, 167. https://doi.org/10.1016/j.compgeo.2024.106085.