Date of Submission	25th March, 2026

IPL Project (IPL-268) Annual Report Form

Period of activity under report from 1 January 2025 to 31 December 2025

1. **Project Number and Title:**

   Project number: 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

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   Core members of the Project:

   Prof. Changdong Li/ China University of Geosciences (Wuhan);

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

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

4. **Objectives** (5 lines maximum)

   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 (30 lines maximum)

During the reporting period, and throughout the full project duration (2022–2025), substantial progress has been achieved in revealing the initiation mechanisms and evolution processes of hydrodynamic pressure-driven landslides through the integration of advanced experimental, theoretical, and data-driven approaches.

A physics-informed deep learning framework (PMNN) has been successfully developed to quantitatively characterize the multi-physical coupling processes governing rainfall-induced landslides. By embedding fundamental geomechanical equations, including seepage, effective stress, and mass conservation laws into a multimodal neural network, the model enables accurate and physically consistent prediction of key state variables such as saturation, pore pressure, effective stress, and slope stability. The results significantly improve predictive accuracy and reveal the intrinsic coupling mechanisms among rainfall intensity, infiltration depth, and failure mode.

In parallel, systematic experimental investigations on weak interlayers and filled fractures have been completed. The influence of particle size distribution on shear behavior has been clarified through large-scale direct shear tests and microscopic analyses. The results demonstrate that particle gradation governs shear strength evolution via mechanisms including particle interlocking, lubrication effects, and stress chain reconstruction, providing a new micro-mechanical understanding of instability development in landslide slip zones.

Furthermore, the project has advanced the understanding of hydro-mechanical coupling processes in fractured geomaterials, particularly through studies on fluid-driven particle migration and hydraulic transmissivity evolution. These achievements collectively establish a multi-scale framework linking micro-scale mechanisms, meso-scale structural evolution, and macro-scale landslide instability.

Overall, the project objectives have been successfully achieved, and a comprehensive theoretical and methodological framework for hydrodynamic pressure-driven landslide initiation and evolution has been established.

2) Planned future activities or statement of completion of the Project (15 lines maximum)

The IPL-268 project (2022–2025) has been successfully completed, and all the planned objectives have been achieved.

The project has systematically revealed the initiation mechanisms and critical conditions of hydrodynamic pressure-driven landslides by integrating physics-based modeling, laboratory experiments, and data-driven approaches. A multi-scale understanding framework has been established, linking micro-mechanical processes, hydro-mechanical coupling behavior, and slope instability evolution.

The developed methods, including the physics-informed deep learning framework and experimental-based mechanical characterization, have demonstrated strong potential for application in landslide hazard assessment and early warning, particularly in reservoir areas such as the Three Gorges region.

Although the project has been completed, future work will continue to focus on extending and applying the developed models and theories to broader geological settings, enhancing their engineering applicability, and promoting their integration into practical disaster prevention and mitigation systems.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

The outcomes of this project benefit multiple domains, including scientific research, engineering practice, and disaster risk reduction.

From a scientific perspective, the project advances the fundamental understanding of hydrodynamic pressure-driven landslide mechanisms by integrating multi-physical coupling theory with data-driven methods, establishing a new paradigm for landslide research.

From an engineering perspective, the developed predictive models and instability criteria provide effective tools for landslide hazard assessment and early warning, particularly in reservoir areas such as the Three Gorges region, where hydrodynamic effects play a critical role.

From a societal perspective, the project contributes to improving disaster prevention and mitigation capabilities, supporting infrastructure safety, and reducing potential economic losses and human casualties associated with landslides. The methodologies developed in this project can also be extended to similar geological environments worldwide, enhancing their broader applicability and impact.

4) Results (15 line maximum, e.g. publications)

[1] Zhang, G., Li, C., Meng, J., Sun, X., Huang, D., Zhang, Z., Liu, Y. (2025). Investigating the rapid deterioration of mudstone structures in contact with water. *Journal of Rock Mechanics and Geotechnical Engineering*. https://doi.org/10.1016/j.jrmge.2025.09.022

[2] Li, C., Feng, P., Meng, J., Catani, F., Hellevang, H., Tang, H., Huang, D. (2025). Physics–informed deep learning for revealing the evolutionary characteristics of landslides induced by rainfall process. *Geophysical Research Letters*, 52(21), e2025GL117356. https://doi.org/10.1029/2025GL117356

[3] Ji, J., Li, C., Dong, C., Chen, W., & Li, B. (2025). Influence of Particle Size Distribution on Shear Behavior of Weak Interlayers: Insights from Filled Fractures Shear Tests. *Journal of Earth Science*, 36(5), 2341-2347. https://doi.org/10.1007/s12583-025-0182-9

Note:

1) If you will change items 2-6 from the proposal, please write the revised content in Red.
2) Please fill and submit this form to ICL Network <icl-network@landslides.org>
3) Reporting year must be one or two years (Maximum).