Date of Submission	September 30th, 2022

IPL Project (IPL-244) Annual Report Form 2022

from 1 January 2019 to 31 December 2022

1. **Project Number and Title:**

IPL-244 (2019) Title: Evolution mechanism and control of landslides induced by sudden rainstorm.

2. **Main Project Fields**

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

(1) Technology Development

B. Hazard Mapping, Vulnerability and Risk Assessment

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides

(3) Capacity Building

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Mitigation

3. **Name of Project Leader**

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Core members of the Project:
Prof. Changdong Li/ Faculty of Engineering, China University of Geosciences (Wuhan), China.
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Mr. Wenqiang Chen/ Faculty of Engineering, China University of Geosciences (Wuhan), China.

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

The objectives of this project are to: 1) establish geological and meteorological coupled model for the analysis of sudden rainstorm-induced landslide; 2) investigate the threshold level of rainfall for sudden rainstorm-induced landslide; 3) reveal the formation and evolution mechanisms of sudden rainstorm-induced landslide; 4) propose the efficient and accurate landslide deformation prediction model.

5. Study Area

Baijiabao landslide, one of the most representative sudden rainstorm-induced landslides in Zigui basin, China Three Gorges Reservoir area.

6. Project Duration

2019 - 2022, 36 months

7. Report

1) Progress in the project (30 lines maximum)

A landslide susceptibility model based on a metaheuristic optimization algorithm (germinal center optimization (GCO)) and support vector classification (SVC) is proposed and applied to landslide susceptibility mapping in China Three Gorges Reservoir area. The results showed that rainfall and variation of reservoir water level are the mainly inducing factors for the landslides located in high susceptibility zone, such as Baijiabao landslide. Spatiotemporal deformation characteristics of Baijiabao landslide were investigated under sudden rainstorm and periodic reservoir water level conditions. A long period monitoring data was collected and analyzed, including GPS surface displacement, deep displacement via inclinometer, rainfall amount and reservoir water level. It turned out that all GPS sites displayed similar, step-like displacement trends, a shape that contrasted with the pulse-like annual trends of precipitation and reservoir water level. Multi-field information monitoring is useful to better understand the deformation and failure behavior of landslides. Therefore, a physical slope model was analyzed through multi-field monitoring to ascertain the failure mechanism of the slope. Multi-field monitoring can reveal the behavior of the slope model from different perspectives and offer new insights into the failure mechanism of the slope.

With consideration of the monitoring datasets and deformation characteristics, five popular machine learning methods, namely, particle swarm optimization–extreme learning machine (PSO–ELM), particle swarm optimization–kernel extreme learning machine (PSO–KELM), particle swarm optimization–support vector machine (PSO–SVM), particle swarm optimization–least squares support vector machine (PSO–LSSVM), and long short-term memory neural network (LSTM), are applied to the displacement prediction of Baijiabao landslide. The results show that PSO–KELM and PSO–LSSVM are recommended for their superior mean prediction accuracy and prediction stability. And multi-feature fusion transfer learning (MFTL) method, which applies the knowledge and skills obtained from the Baijiabao landslide scenario to improve the prediction capacity for other landslides, was proposed for landslides prediction because previous landslide displacement forecasting models yielded low prediction accuracy especially for mutational displacements. The results indicate that the MFTL method owns low prediction error and high reliability, as well as the positive generalization

ability in landslide prediction. This study paves the potential way for realizing the real-time, whole-process and accurate forecasting for sudden rainstorm-induced landslides.

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

With respect to the future activities, special focus will be paid on the deterioration mechanism of soil and rock mass under the action of periodic reservoir operation and rainfall through detailed multi-scale laboratory experiments. In addition, a multi-field characteristic monitoring system, and physical model experimental device and method for sudden rainstorm-induced landslide will further be developed to reproduce the formation process of rainstorm-induced landslide. Furthermore, the efficient and accurate deformation prediction model based on physical mechanism and mathematical model will be improved and widely applied in sudden rainstorm-induced landslides for landslide mitigation and prevention.

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

The above project related researches not only have expanded the understanding of evolution characteristics of rainstorm-induced reservoir landslides, but help to identify triggering factors of the deformation of reservoir landslide. Moreover, the proposed stability evaluation model for rainstorm-induced landslides and mapping method of regional susceptibility for rainfall-reservoir induced landslides could be implemented by technical/scientific agencies for the prevention and control of rainstorm-induced landslides in reservoir area, and thus provide guarantee for the sustainable development of society and economy of the regions threatened by rainstorm-induced landslides.

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

① Fang Kun, Miao Minghao, **Tang Huiming***, Jia Shixun, Dong Ao, An Pengju, Zhang Bocheng. Insights into the deformation and failure characteristic of a slope due to excavation through multi-field monitoring: a model test. Acta Geotech, 2022. (DOI: 10.1007/s11440-022-01627-0)

② Xia Ding, **Tang Huiming***, Sun Sixuan, Tang Chunyan, Zhang Bocheng. Landslide Susceptibility Mapping Based on the Germinal Center Optimization Algorithm and Support Vector Classification. Remote Sensing, 2022. 14. 2707. (DOI: 10.3390/rs14112707)

③ Wang Yankun, **Tang Huiming***, Huang Jinsong, Wen Tao, Ma Junwei, Junrong Zhang. A comparative study of different machine learning methods for reservoir landslide displacement prediction. Engineering Geology, 2022. (DOI: 106544. 10.1016/j.enggeo.2022.106544)

④ Long Jingjing, **Li Changdong**, Liu Yong, Feng Pengfei, Zuo Qingjun. A multi-feature fusion

transfer learning method for displacement prediction of rainfall reservoir-induced landslide with step-like deformation characteristics. Engineering Geology, 2021, 297, 106494. DOI: 10.1016/j.enggeo.2021.106494

Note:

1) If you will change items 2-7 from the proposal, please write the revised content in Red.
2) Please fill and submit this form by 30 March XXX (next year of the activity report) to ICL Network <icl-network@iclhq.org>
3) Reporting year must be one or two years (Maximum).