

IPL Project (IPL-267) Annual Report

1. Project Number and Title: IPL- 267 The Collaboration of the debris flow early warning system between Vietnam and Taiwan

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, 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. Preparedness

3. Name of Project Leader

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4. Objectives (5 lines maximum)

Study and develop a smart and real-time debris flow early warning system in mountainous areas of Vietnam.

Pilot study in Sapa is to support the early warning of this natural disaster for authorities and local people.

5. Study Area

In recent years, Lao Cai province has experienced an increase in the frequency and magnitude of

landslides and debris flow due to complex geological factors, high precipitation, rapid urbanization, construction, and agriculture. Laocai is a mountainous province between the Northeast and Northwest regions of Vietnam. Several large-scale deep-seated landslides and debris flows happened during 2020-2025.

We focused on the Sapa area and other districts in Lao Cai province. Sapa Town belongs to the geology of Hoang Lien National Park, which is composed of metamorphosed sediments and a granitic intrusion. Due to the thick weathered crust, this area has a high-risk zone of landslides triggered by various activities such as climate, geological, and human activity factors.

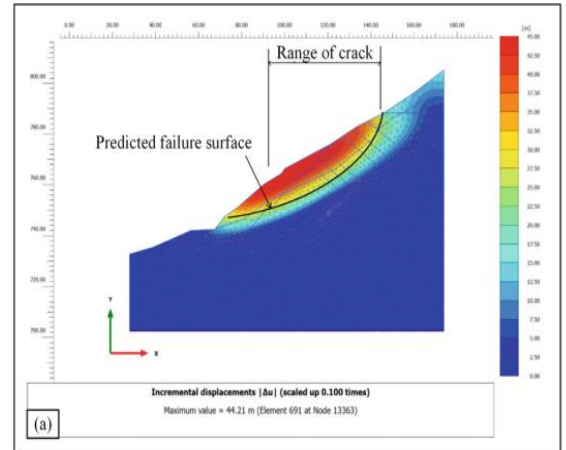
6. Report

1) Progress in the project (30 lines maximum)

- Our target is to study the mechanism of deep-seated landslides in Sapa and Lao Cai provinces. We developed a method to study the deep-seated landslide in Sapa. Deep seated landslide was examined based on comprehensive laboratory testing and back analysis data by using 2D and 3D FEM method. After that, we can evaluate the slope's stability and assess the effectiveness of countermeasures to reduce landslides. We will discuss the outcome of this target through some case studies below:
 - a) In the northwestern area of Vietnam, a deep-seated landslide occurred near the new Mong Sen bridge in Trung Chai commune, Sapa town, Laocai province in 2020. The geological conditions, laboratory tests, and stability analysis were conducted to understand the failure mechanism. Prof. Lan, Dr. Dinh and Dr. Nghia published a paper "Characteristics and Remedy Solutions for a New Mong Sen Deep-Seated Landslide, Sapa Town, Vietnam," in Progress in Landslide Research and Technology, Volume 1 Issue 2, 2022 to discuss the reason of failure. The analysis showed that cutting activities during road construction contributed to the sliding of the sloping soil mass [5].



Fig. 3 Morphological changes of the slope by time and landslide views: a before road construction on October 30th, 2019; b during road construction on October 27th, 2020; c crack on local road 155; d crack on head scarf at zone 1; e crack along slide body at zone 1, and f head scarfs at different stages at zone 2



Morphological changes of the Mong Sen deep-seated landslide

Predicted failure surface for Mong Sen deep-seated landslide

- b) 3D slope stability was conducted to estimate the slope failure surface. The study outcomes were utilized to establish correlations between slope stability (i.e., the factor of safety and probability of failure) and the change in PWP condition and to identify the slope failure moment presented by Dr. Lan and his colleagues [6].

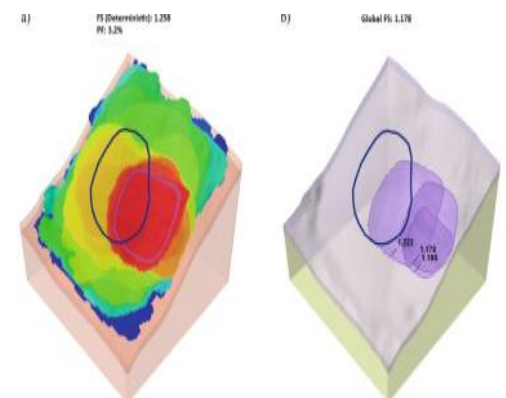
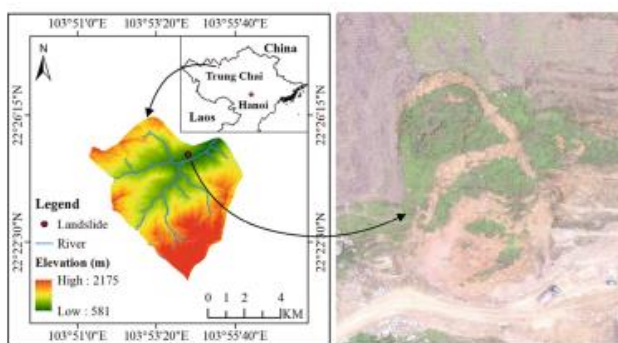


Fig. 4 The result of slope stability analysis using Slide3 in the dry season

Deep-seated landslide

3D model of stability analysis

- c) The deep-seated landslide happened due to excavation activity

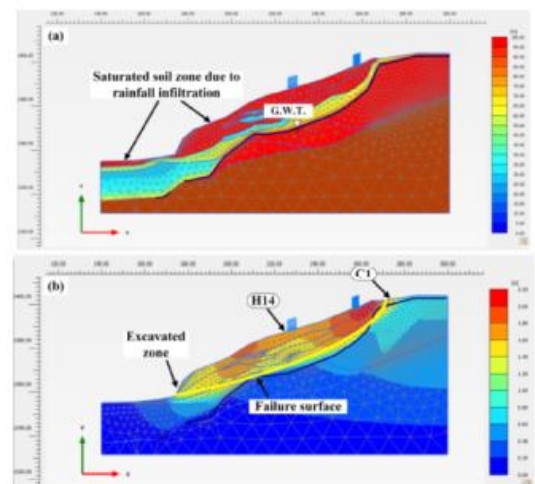
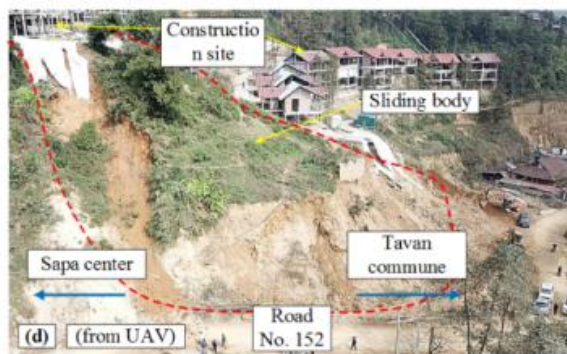


Fig. 13. Results of stability analysis using the strength reduction technique on January 7, 2020: (a) saturation; (b) incremental displacement of soil.

Failure surface of the Cau May deep-seated landslide in Sapa *Stablity analysis results by FEM (Plaxis) method*

The excavation to widen road No.152 at the slope toe and the construction of buildings at the top were attributed to unstable slope conditions. The numerical method from a commercial software was adopted to perform stability analysis in conjunction with seepage analysis during rainfall conditions. The predicted failure surface agreed with the observed failure at the site [4].

- The other target is to study the mechanism of Debris flow in Lao Cai province.

The debris flow occurred at 6 am on September 10th, 2024, in Nu Village, Bao Yen district, Lao Cai province, leaving 67 people dead and missing, destroying the village. We analyze this debris flow's causes, formation mechanism, and impact scope based on field surveys, rainfall analysis, and numerical simulations. The length of the debris flow (from the top of Con Voi Mountain to Nu Village) was 3.6 km. The affected area of the debris flow was about 21 ha. Intensive research has been done to investigate the debris flow mechanisms in Lang Nu, including field samples, lab tests, and a model to estimate head-scaft failure in Lang Nu. Lastly, Raams' model was applied to simulate the debris flow.



Debris flow disaster in Lang Nu, Bao Yen, Lao Cai on 10th Oct. 2025

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

-Workshop and conference:

The International Conference on Sustainability in Civil Engineering is held at the University of Transport and Communications (UTC) every two years, starting from 2016. After 5 times of organization, the Conference has become a prestigious destination, attracting the attention of experts and the scientific community worldwide. The proceedings of ICSCE will be published by Springer and will provide a comprehensive view of the latest advances in research and sustainable development [1].



Delegates attending the ICSCE 2024 in UTC



Prof. Chung delivered a keynote lecture at ICSCE 2024 with a paper 'Development of Multi-Spatial-Temporal Scale monitoring techniques for landslides early warning'



Prof. Lan and Prof. Chung co-chaired in Geotechnical Engineering section, mainly focused on landslide

-Collaboration on workshop and lecture:

In April 2025, Prof. Lan (UTC) and Prof. Chung contributed significantly to the "2025 Advanced Institute on Landslide Risks in the Mountains of Northern Mainland Southeast Asia" event in Thai Nguyen province, Vietnam. Professor Lan delivered a lecture titled "Debris Flow and Large-Scale Landslides Caused by Typhoon Yagi in Lao Cai Province." The lecture provided a comprehensive overview of the research methods used to study large-scale landslides and debris flows recently triggered by Typhoon Yagi. Prof. Chung presented a key lecture titled "Landslide Monitoring and Early Warning," discussing innovative technologies for detecting landslides, such as GNSS monitoring. After that, a field trip to the disaster-affected area by debris flow at Lang Nu, Bao Yen, and Lao Cai province complemented the lectures and encouraged collaboration among attendees to mitigate the effects of landslides in Vietnam and other countries.



Field trip study for all participants at the Lang Nu debris flow disaster

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

Prof. Chung's lecture in Vietnam has attracted many researchers on landslides and debris flows, especially the students at UTC and other universities. The monitoring of landslides and debris flows during the conference and workshop will be beneficial to Vietnamese researchers and students who are interested in landslide monitoring. This year, two bachelor students of UTC attended the GEOSAPA workshop in Sapa, organised by the Sapa government (<https://baolaocai.vn/hoi-thao-ky-thuat-ve-truot-lo-dat-da-va-tai-dinh-cu-post399894.html>).

The Lang Nu debris flow caused significant damage to people and property. Only 5 days later, we went to the site and helped the local people find new resettlement places. After that, we organized workshops on mudslides to explain the causes and mechanisms to the people to raise awareness, to respond to similar events, and to minimize damage to people in the future.

News:

+ <https://en.sggp.org.vn/landslide-devastation-lang-nu-hamlet-mourns-lost-lives-post112445.html>

+ <https://thanhvien.vn/de-khong-tai-dien-tham-hoa-nhu-lang-nu-185241003003203982.htm>

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

[1] ICSCE. 2024, "Proceedings of the 5th International Conference on Sustainability in Civil Engineering - Volume 2," Hanoi, 2025, vol. 2: Springer.

- [2] N. C. Lan et al., "Research on debris flow in Tra Leng, Quang Nam province, using Kanoko 1D software to develop appropriate countermeasures," in *Proceedings of Earth Sciences and natural resources for sustainable development*, Hanoi, 2024, vol. 1: Transportation publisher.
- [3] D. T. Nghia, N. C. Lan, N. Q. Tuan, and N. Q. Dinh, "*Assessment of a rock planar slide along an expressway in Vietnam*," *Journal of Mining and Earth Sciences*, vol. 66, no. 2, pp. 39-49, 2025.
- [4] T.-N. Do, L. C. Nguyen, S. S. C. Congress, and A. J. Puppala, "*Comprehensive Analysis and Rehabilitation of a Slow-Moving Landslide in Vietnam Using Laboratory and Field Measurements*," *Journal of Disaster Research*, vol. 19, no. 2, pp. 465-477, 2024.
<https://www.fujipress.jp/jdr/dr/dsstr001900020465/>
- [5] L. C. Nguyen, T.-N. Do, and Q. D. Nguyen, "*Characteristics and Remedy Solutions for a New Mong Sen Deep-Seated Landslide, Sapa Town, Vietnam*," in *Progress in Landslide Research and Technology*, Volume 1 Issue 2, 2022, I. Alcántara-Ayala et al., Eds. Cham: Springer International Publishing, 2023, pp. 403-413.
https://link.springer.com/chapter/10.1007/978-3-031-39012-8_8#DOI
- [6] B. Van Duong et al., "*Mathematical and Numerical Modeling of Slope Stability for the Mong Sen Landslide Event in the Trung Chai Commune, Sapa, Vietnam*," in *Progress in Landslide Research and Technology*, Volume 2 Issue 1, 2023, I. Alcántara-Ayala et al., Eds. Cham: Springer Nature Switzerland, 2023, pp. 193-207.
https://link.springer.com/chapter/10.1007/978-3-031-39012-8_8#DOI