

“Technical Research and Development for Road Policy Quality Improvement” Study Summary

No.	Title	Principal Researcher
No. 2023-2	Temporal and Spatial Enhancement of Advance Traffic Control Criteria for Localized Heavy Rainfall	Kyoto Univ. Prof. Kiyoshi Kishida

This study organized the outcomes of four research components into a technical framework for temporal and spatial enhancement of advance traffic control criteria under localized heavy rainfall by integrating road-specific sediment disaster warning critical lines, local rainfall prediction, a surrogate model for slope stability, and extraction of potentially hazardous slopes for road closure.

1. Backgrounds and Objects

Localized heavy rainfall and linear rainbands have increased the complexity of road slope disasters. Although conventional accumulated-rainfall criteria are easy to operate, they do not sufficiently reflect antecedent rainfall, soil moisture, site-specific topography and geology, or spatial rainfall distribution. This study aimed to enhance advance traffic control decisions both temporally and spatially, by improving slope stability evaluation, rainfall-risk assessment, rainfall forecast use, and identification of slopes requiring priority monitoring.

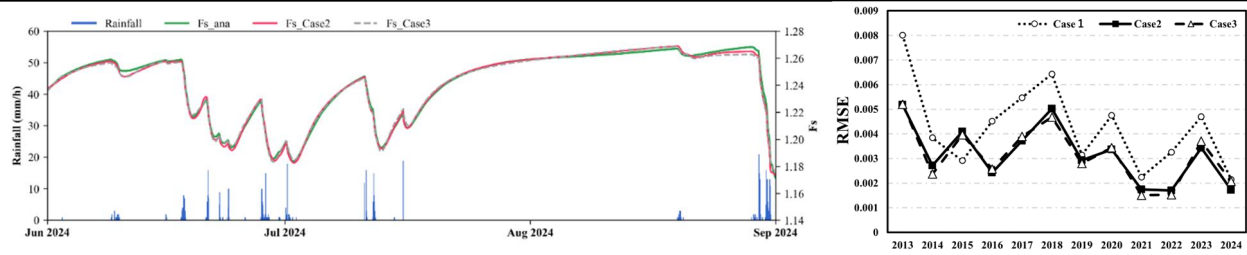
2. Activities in Research Period

The study was conducted at the Kannontoge section on National Route 9, the Takenokuchi section on National Route 28, and the Otani section on National Route 8. Four research items were addressed: 1) surrogate modeling of integrated seepage and circular-slip stability analysis, 2) development and evaluation of road-specific critical lines (road CLs), 3) development of a local rainfall prediction model, and 4) extraction of potentially hazardous slopes using topography, geology, rainfall history, InSAR time-series analysis, disaster records, and road slope inspection records.

3. Study Results

Figure 1 shows a representative result of temporal enhancement. At the Takenokuchi section on National Route 28, safety factor time histories obtained from integrated seepage and circular-slip stability analysis were learned and predicted using Long Short-Term Memory. The model achieved high accuracy, with both MAE and RMSE below 0.003. This result indicates that rainfall-induced changes in slope stability can be evaluated within a practical time frame and used as supporting information for reopening decisions and evaluation of countermeasure effects.

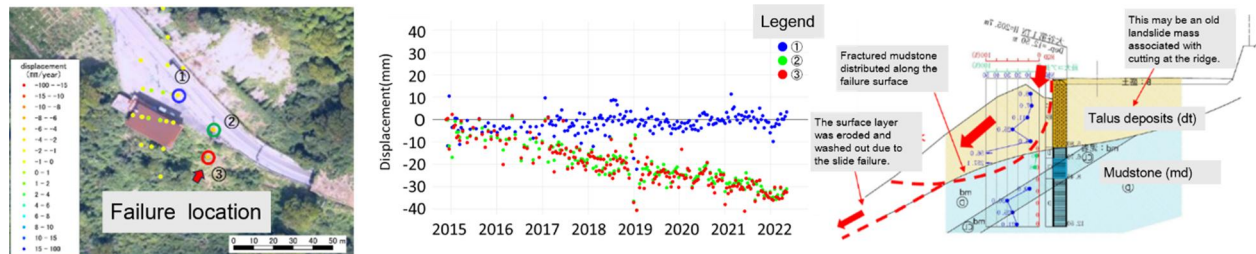
Figure 2 shows a representative result of spatial enhancement. At the Otani section on National Route 8, potentially hazardous slope extraction was validated by combining topographic and geological conditions, rainfall history, and InSAR time-series analysis. The method indicated slope locations that could cause road-disrupting failures. This result shows that InSAR is not a stand-alone traffic control trigger, but can support priority monitoring and countermeasure planning when combined with topography, geology, rainfall history, inspection records, field surveys, and expert judgment. The same approach was also applied to the Kannontoge section, where potentially hazardous slopes requiring continued observation were extracted. Thus, the method was shown to be applicable not only to verification of past disaster sites but also to identifying priority monitoring candidates in sections where failures have not yet become apparent.



(a) Example prediction by cumulative learning with weight transfer

(b) Change in RMSE

Fig.1 Example of LSTM prediction by cumulative learning with weight transfer at the Takenokuchi section.



(a) Failure location in 2022-Aug.

(b) InSAR analysis result

(c) Estimated failure mechanism

Fig.2 Example of potentially hazardous slope extraction at the Otani section on National Route 8.

4. Papers for Presentation

- 1) Miyazaki, Y. et al. (2025): Challenges and Innovations in Advance Traffic Control System Under Extreme Weather Events, Proceedings of ICTG 2024, Lecture Notes in Civil Engineering, Vol. 403, Springer.
- 2) Imiya, M., Miyazaki, Y., Koyama, T., Fujiwara, T. and Kishida, K. (2024): Time-series prediction of safety factors by machine learning based on seepage and circular slip analysis, Proceedings of the 64th Geotechnical Engineering Symposium, pp.138-143. (in Japanese)
- 3) Kuroda, S., Koyama, T., Asai, K., Miyazaki, Y., Yamaguchi, K. and Kishida, K. (2024): Comparison between radar-based analyzed/forecast rainfall and telemeter rainfall, Kansai Geo-Symposium 2024. (in Japanese)
- 4) Ishii, Y. et al. (2024): Landslide Risk Assessment along Roads by Using Radar-driven Land Deformation and Rainfall Data, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-3-2024, pp.231-237.

5. Study Development and Future Issues

Future work will standardize the organization of rainfall data, soil water index data, disaster records, non-disaster rainfall events, and field monitoring data, so that the road CL monitoring systems introduced at the Kannontoge and Takenokuchi sections can be expanded to other traffic control sections. Practical procedures for closure, continuation, and reopening decisions should also be developed by combining the accumulated-rainfall method, the CL method, and the CLfscst method. In addition, the procedures for extracting potentially hazardous slopes and evaluating safety factors of priority monitoring slopes should be organized as practical reference materials for road administrators.

6. Contribution to Road Policy Quality Improvement

This study contributes directly to road management decisions, including road closure, continuation and reopening, identification of priority monitoring slopes, and selection of locations requiring countermeasures. In particular, the installation of road CL monitoring systems at the Kannontoge and Takenokuchi sections made the outcomes available in a form that road administrators can check and use. The results of potentially hazardous slope extraction were also shared with the Road Disaster Prevention Liaison Council organized by the Kinki Regional Development Bureau, showing a concrete connection between the research outcomes and administrative decision-making.

7. References, Websites, etc.

No dedicated website is currently available. The research outcomes will be disseminated through the final report, research presentation meetings, and related academic conferences and technical meetings.