2022年度共同利用研究報告書

2023年03月05日

所属・職名 九州大学大学院・工学研究院　社会基盤部門・博士課程学生
ムハマッド　ヌルジャティ　ヒダヤット

		整理番号	2022a025	
1.研究計画題目	エッジAIとIoTを活用したEWSの構築			
2.新規・継続	新規			
3.種別	若手・学生研究			
4.種目	短期共同研究			
5.開催方法	ハイブリッド開催			
6.研究代表者	氏名	ムハマッド　ヌルジャティ　ヒダヤット		
	所属部局名	九州大学大学院・工学研究院　社会基盤部門	職名	博士課程学生
7.研究実施期間	2022年10月15日(土曜日)～2022年10月15日(土曜日)			
8.キーワード	エッジAI、IoT、土砂災害、EWS（早期警報システム）、数理サステナベーション			
9.参加者人数	127人			

10.本研究で得られた成果の概要

The occurrence of rainfall-induced landslides is observed worldwide every year, costing many lives and damage to properties. Researchers have developed various methods to identify the areas that are susceptible to landslides during heavy rainfall and used embedded sensors within soils to monitor the slope movement and deliver an early warning. However, most of those Early Warning Systems (EWS) use expensive and complex configurations, which require a constant power source along with a data transmission grid to continuously transmit data to the server, where it will be analyzed. With the development of advanced sensor technology, monitoring and analyzing of data are becoming more extensive and comprehensive. Therefore, the development of a new integrated data-driven real-time monitoring and early warning system to deal with "instantaneous data" is crucial.

In this research, an EWS was successfully developed in the laboratory. The system uses low-cost sensors and a sustainable power supply so that the sensors and Internet of Things (IoT) devices can function smoothly. Three types of sensing devices were used to collect data during the laboratory tests, namely moisture sensor, acceleration sensor, and pore water pressure sensor. These sensors were embedded in the soil slope model to obtain the governing parameters before and during the occurrence of a slope failure. Based on the data collected from the sensors, the slope failure mechanism was investigated.

The research is already in the second phase of implementation in the field. The EWS was deployed in the field to evaluate the results obtained in the laboratory. Sustainable solar power-controlled batteries were used to supply the required power for the system to operate under any conditions of weather. LPWA (Low Power Wide Area) technology was also used in our EWS in addition to the conventional Wifi router for data transmission. LPWA consumes less power than WiFi and also is a free data transmission system because it uses a frequency similar to the radio signal. Therefore, a low-cost EWS could be realized. Thus, the LPWA-based system can be installed even in remote areas with limited Internet and WiFi access.

The developed EWS meets the requirement of the SDGs (Sustainable Development Goals). The results of this research will be published in international conferences and reputed international journals.

Short-Term Joint Research 2022

The IMI Short-Term Joint Research 2022

1. Reference No.	2022a025	
2. Research topic	Building EWS with Edge AI (Artificial Intelligence) and IoT (Internet of Things)	
3. New/Continuing	New	
4. Type	Short-term joint research	
5. Event	International Workshop	
6. Research representative	Name	Muhammad Nurjati Hidayat
	Department	Department of Civil Engineering, Graduate School of Engineering, Kyushu University
7. Research period	2022-10-15 to 2023-03-31	
8. Keyword	Edge AI, IoT, sediment-related disaster, EWS (Early Warning System), Mathematical Sustainnovation	
9. No. of participants	127	
10. Organizing Committee	1. Hemanta Hazarika (Professor, Kyushu University) 2. Yasuhide Fukumoto (Professor, Kyushu University) 3. Nguyen Thi Hoai Linh (Researcher, Kyushu University) 4. Yan Liu (Former Doctoral Student, Kyushu University) 5. Yusaku Isobe (CEO, IMAGEi Consultant Corporation) 6. Naoto Watanabe (Director, KFC Ltd.) 7. Tsuyoshi Tanaka (Technical Expert, Tokyo City University) 8. Sugeng Wahyudi (Section Manager, NITTOC Construction Co., Ltd.) 9. Haruichi Kanaya (Professor, Kyushu University) 10. Yoshifumi Kochi (President, K's Lab Inc.) 11. Masanori Murai (Senior Engineer, Shimizu Corporation) 12. Kazuaki Tanaka (Associate Professor, Kyushu Institute of Technology)	
11. Publication	1. Yurika Taguchi, Hazarika Hemanta, Vilayvong Khonesavanh, Hidayat Muhammad N., Particle Image Velocimetry (PIV) Analysis to Delineate Mechanism of Rainfall Induced Landslides. (2023). In the annual meeting of the 2022 JSCE Western Branch Research. 2. Muhammad N. Hidayat, et. al. Evaluation of Landslide Triggering Mechanism in a Slope with Vertical Cracks under Rainfall Condition. (2023). The 2nd International Conference on Construction Resources for Environmentally Sustainable Technologies (CREST 2023).	

12. Overview of the result obtained in this study

An Early Warning System (EWS) was successfully developed in the laboratory. The system uses low-cost sensors and a sustainable power supply so that the sensors and Internet of Things (IoT) devices can function smoothly. Three types of sensors were embedded in the soil slope model to obtain the governing parameters before and during the occurrence of a slope failure. Based on the data collected from the sensors, the slope failure mechanism was investigated.

The research is already in the second phase of implementation in the field. The EWS was deployed in the field to evaluate the results obtained in the laboratory. Sustainable solar power-controlled batteries were used to supply the required power for the system to operate under any conditions of weather. LPWA (Low Power Wide Area) technology was also used in our EWS in addition to the conventional Wifi router for data transmission. The LPWA-based system can be installed even in remote areas with limited Internet and WiFi access.

As part of the project's activities, an international workshop was held. The workshop was conducted in a hybrid format (face-to-face and online). 127 people from six different countries (Japan, India, Malaysia, Vietnam, Taiwan and China) attended the workshop. Four speakers were invited, one of them is Dr. Thuy from Vietnam.

Dr. Thuy involved in various activities during her visit in Japan. Those activities are meeting and discussion with IMI project members, laboratory visits, meeting and discussion with other experts, site visit to EWS for monitoring landslide in Chikushino city, and delivering lecture in the workshop.

The goal of the international workshop was to bring together experts in geotechnical engineering, applied mathematics, applied geology and mud flow disaster to discuss the process of slope hazard mitigation in the era of data science and artificial intelligence (AI).

The workshop was organized by the Institute of Mathematics for Industry (IMI), Kyushu University and the Asian Regional Technical Committee No. 1 (AsRTC1), International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), and supported by the Global Society for Smart Geo-Sustainnovation (GLOSS), Fukuoka.

The workshop opened the new opportunities of collaborative research on slope disaster prevention from interdisciplinary perspectives.

Result Report of the Short-Term Joint Research

The occurrence of rainfall-induced landslides is observed worldwide every year, costing many lives and damage to properties. Researchers have developed various methods to identify the areas that are susceptible to landslides during heavy rainfall and used embedded sensors within soils to monitor the slope movement and deliver an early warning. However, most of those Early Warning Systems (EWS) use expensive and complex configurations, which require a constant power source along with a data transmission grid to continuously transmit data to the server, where it will be analyzed. With the development of advanced sensor technology, monitoring and analyzing of data are becoming more extensive and comprehensive. Therefore, the development of a new integrated data-driven real-time monitoring and early warning system to deal with "instantaneous data" is crucial.

In this research, an EWS was successfully developed in the laboratory. The system uses low-cost sensors and a sustainable power supply so that the sensors and Internet of Things (IoT) devices can function smoothly. Three types of sensing devices were used to collect data during the laboratory tests, namely moisture sensor, acceleration sensor, and pore water pressure sensor. These sensors were embedded in the soil slope model to obtain the governing parameters before and during the occurrence of a slope failure. Based on the data collected from the sensors, the slope failure mechanism was investigated.

The research is already in the second phase of implementation in two locations. One is at Chikushino city, Fukuoka prefecture and the other is at Kyushu University Ito Campus. The EWS was deployed in the field to evaluate the results obtained in the laboratory. Sustainable solar power-controlled batteries were used to supply the required power for the system to operate under any conditions of weather. LPWA (Low Power Wide Area) technology was also used in our EWS in addition to the conventional Wifi router for data transmission. LPWA consumes less power than WiFi and also is a free data transmission system because it uses a frequency similar to the radio signal. Therefore, a low-cost EWS could be realized. Thus, the LPWA-based system can be installed even in remote areas with limited Internet and WiFi access.

The developed EWS meets the requirement of the SDGs (Sustainable Development Goals). The results of this research will be published in international conferences and reputed international journals.

These research activities are the results of collaboration with government organizations and industries. As a part of the project activities, an international workshop was held on November 25, 2022, in a Hybrid format, where 127 people from six different countries attended.

Joint International Workshop Summary

On November 25, 2022, A Joint International Workshop was successfully held, which was organized by the Institute of Mathematics for Industry (IMI), Kyushu University, Fukuoka, Japan and Asian Regional Technical Committee No. 1 (AsRTC1), International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). This workshop was supported by the Global Society for Smart Geo-Sustainnovation (GLOSS), Fukuoka. More than 120 participants coming from six countries (Japan, India, Malaysia, Vietnam, Taiwan, and China)

attended the workshop both Online and face-to-face. The theme of this workshop was Towards the Thought Process of Slope Disaster Prevention in the AI Era.

The purpose of the workshop was to think beyond the conventional approaches such as using sustainable soft-type countermeasures and combining with those with the latest technologies such as Artificial intelligence (AI), Digital Transformation (DX), and the Internet of Things (IoT), to reduce the threat of natural hazard, especially the heavy rainfall-induced landslide disasters, which have been frequently occurring in recent years.

Four invited speakers delivered their presentations in two sessions. Each session was led by a chairman and was reviewed by respective expert. The details of the workshop program is given at the end of this report.

The workshop started with Dr. Masanori Murai, Shimizu Corporation, opening the workshop, before proceeding to invite Prof. Hemanta Hazarika, Kyushu University to give an official opening speech.

Session 1 of the workshop was chaired by Dr. Khonesavanh Vilayvong, Kyushu University. Lecture 1 was delivered by Dr. Hideaki Mizuno, Graduate School of Agriculture, Kyushu University. He talked on sediment-related disasters triggered by severe rainfall in Fukuoka Prefecture in 2017. Dr. Hideaki pointed out that the extremely rare and high rainfall intensity of over 80 mm/h for several hours in Asakura city and Hita city triggered landslides, debris flow, and led to disasters caused by driftwood. It was further pointed out that the erosion dam (Sabo dam) captured the sediment and driftwood, however, was unable to capture all because the amount of sediment and driftwood were more than anticipated.

Lecture 2 was delivered by Dr. Nguyen Thi Hoai Linh of IMI, Kyushu University. She spoke on the mineralization process in porous media using random walk with adsorption. In the lecture, Dr. Linh introduced the Random Walk (RW) with an absorption algorithm as a tool for styling the quantity of pore space. The developed algorithm could be used to study the particle flow distribution and the mechanism of the mineralization process on porous media. Also, the algorithm could be used to generalize artificial porous media samples.

Session 2 of the workshop was chaired by Dr. Babloo Chaudhary from the National Institute of Technology Karnataka (NIT K), Surathkal, India. The first lecture (Lecture 3) of this session was delivered by Dr. Thi Thanh Thuy Tran, Ho Chi Minh City, Vietnam. She spoke on the time-dependent reduction of soil strength and its implication in the prediction of time for slope failure. She introduced the creep-related problems of a slope at Krajang Lor Village, Magelang, Indonesia and introduced a mathematical formulation for predicting the slope failure using the time-dependent data collected from creep tests of soil samples.

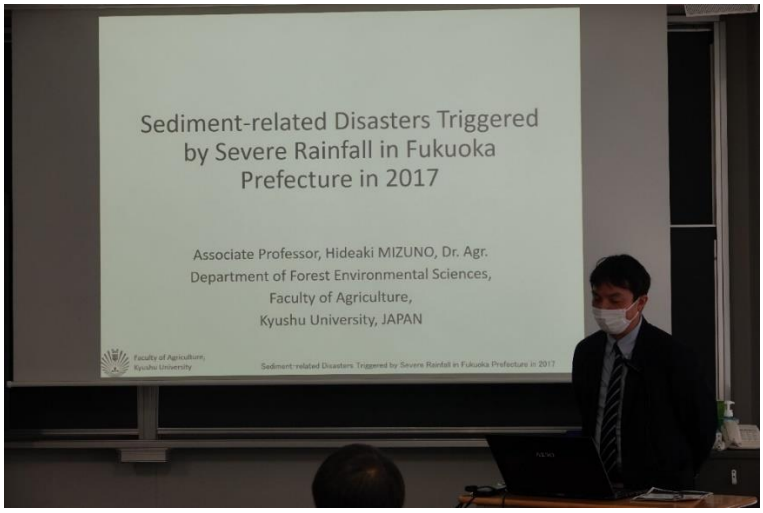
Lecture 4 was delivered by Dr. Kohei Araki, National Institute of Technology, Tokuyama College, Japan. In his lecture, Dr. Araki spoke on the derivation of SWCC and permeability coefficient from compaction test based on the Kitamura model. Dr. Araki explained a method to derive the soil-water characteristic curve (SWCC) and saturated permeability coefficient (kw) and degree of saturation (Sr) of unsaturated soils.

Prof. Takaji Kokusho of Chuo University, Japan, gave a summary of session 1 and Prof. Chandan Ghosh of the National Institute of Disaster Management, India, gave a summary of session 2. The workshop ended with closing remarks and a vote of thanks by Prof. Yasuhide Fukumoto of Kyushu University.

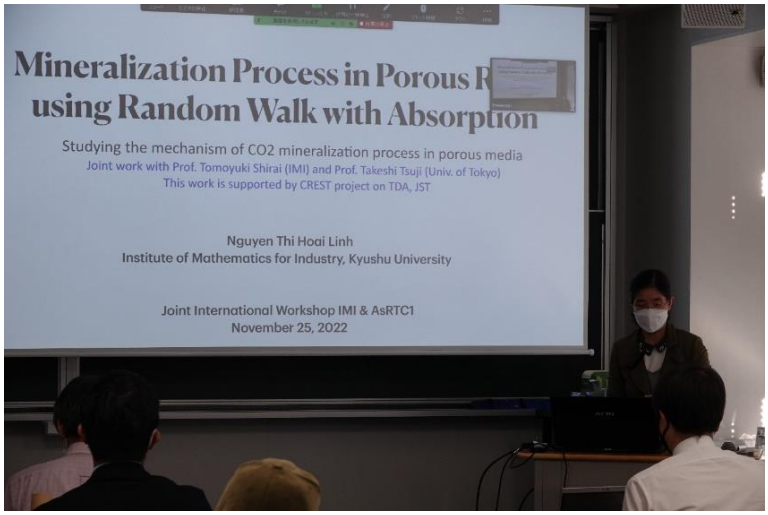
Picture 1. Dr. Murai opening the workshop

Picture 2. Workshop opening speech by Prof. Hazarika

Picture 3. Dr. Vilayvong chairing the first session



Picture 4. Dr. Mizuno delivering Lecture 1



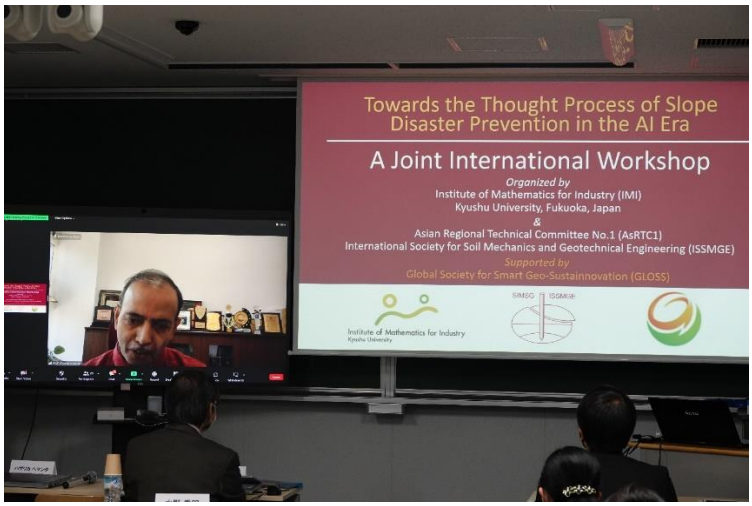
Picture 5. Dr. Linh delivering Lecture 2

Picture 6. Dr. Tran delivering Lecture 3 in Session 2, Chaired by Dr. Chaudhary

Picture 7. Dr. Araki delivering Lecture 4 in Session Chaired by Dr. Chaudhary

Picture 8. Prof. Fukumoto during the Q&A session

Picture 9. Prof. Kokusho delivering the review remarks for session 1



Picture 10. Prof. Ghosh delivering the review remarks for session 2

Picture 11. Closing remarks and vote of thanks by Prof. Fukumoto

Picture 12. Group photograph at the end of the workshop

Towards the Thought Process of Slope Disaster Prevention in the AI Era

A Joint International Workshop

Date : November 25, 2022
Onsite location : Room C513, West 1 Building
Ito Campus, Kyushu University, Fukuoka, Japan

Program

13:30 - 14:00 Onsite Registration

Opening Session: (Coordinator: Dr. Masanori MURAI)

14:00 - 14:10 Opening Remarks
Prof. Hemanta Hazarika (Chairman of AsRTC1; Professor, Kyushu University, Japan)

Session I: (Chairperson: Dr. Khonesavanh VILAYVONG)

14:10 - 14:55 Lecture 1
Dr. Hideaki Mizuno (Associate Professor, Kyushu University, Japan)
Sediment-related disasters triggered by severe rainfall in Fukuoka prefecture in 2019

14:55 - 15:40 Lecture 2
Dr. Nguyen Thi Hoai Linh (Post-Doctoral Fellow, Kyushu University, Japan)
Mineralization process in porous rocks using random walk with absorption

15:40 - 15:45 Review Remarks
Prof. Takaji Kokusho (Professor Emeritus, Chuo University, Japan)

15:45 - 16:00 Break

Session II: (Chairperson: Dr. Chaudhary BABLOO)

16:00 - 17:00 Lecture 3
Dr. Thi Thanh Thuy Tran (Engineer, Ho Chi Minh City, Vietnam)
Time-dependent reduction of soil strength and its implication in prediction of time for
slope failure

17:00 - 18:00 Lecture 4
Dr. Kohei Araki (Associate Professor, National Institute of Technology, Tokuyama College, Japan)
Derivation of SWCC and permeability coefficient from compaction test based on
Kitamura model

18:00 - 18:05 Review Remarks
Prof. Chandan Ghosh (Professor, National Institute of Disaster Management, India)

18:05 - 18:10 Closing Remarks and Vote of Thanks
Prof. Yasuhide Fukumoto (Professor, Kyushu University, Japan)

18:10 - 18:20 Group photo session

開催日：2022/11/25～2022/11/25

AI時代に求められる斜面防災の思考法 Towards the Thought Process of Slope Disaster Prevention in the AI Era｜共2022a025

カテゴリー：イベント　　タグ：若手研究　短期共同研究

開催概要

- **開催方法**：九州大学 伊都キャンパスとZoomウェビナーによる**ハイブリッド開催**
- **場所**：九州大学 伊都キャンパス ウエスト1号館 C棟 5階 **(W1-C-513 中講義室)**
- **主要言語**：英語
- **共催**：九州大学マス・フォア・インダストリ研究所,　AsRTC1, GLOSS
- **種別・種目**：若手・学生研究-短期共同研究
- **研究課題題目**：エッジAIとIoTを活用したEWSの構築
- **研究代表者**：ムハマッド　ヌルジティ　ヒダヤット（九州大学大学院・工学研究院　社会基盤部門・博士課程学生）
- **研究実施期間**：2022年11月21日（月）～2022年11月26日（土）
- **公開期間**：2022年11月25日（金）
- **研究計画詳細**：https://joint1.imi.kyushu-u.ac.jp/research_chooses/view/2022a025

プログラム

11月25日（金）

13:15-13:20　Onsite Registration

14:00 – 14:10　Opening Remarks

Prof. Hemanta Hazarika (Chairman of AsRTC1; Professor, Kyushu University, Japan)

14:10 – 14:55　Lecture 1

Dr. Hideaki Mizuno (Associate Professor, Kyushu University, Japan)
Sediment-related disasters triggered by severe rainfall in Fukuoka prefecture in 2019

14:55 – 15:40　Lecture 2

Dr. Nguyen Thi Hoai Linh (Post-Doctoral Fellow, Kyushu University, Japan)
Mineralization process in porous rocks using random walk with absorption

15:40 – 15:50　Break

15:50 – 17:00　Lecture 3

Dr. Thi Thanh Thuy Tran (Engineer, Ho Chi Minh City, Vietnam)
Time-dependent reduction of soil strength and its implication in prediction of time for slope failure

17:00 – 18:10　Lecture 4

Dr. Kohei Araki (Associate Professor, National Institute of Technology, Tokuyama College, Japan)
Derivation of SWCC and permeability coefficient from compaction test based on Kitamura model

18:10 – 18:15　Review Remarks

Prof. Chandan Ghosh (Professor, National Institute of Disaster Management, India)
Prof. Takaji Kokusho (Professor Emeritus, Chuo University, Japan)

18:15 – 18:20　Closing Remarks and Vote of Thanks

Prof. Yasuhide Fukumoto (Professor, Kyushu University, Japan)

18:20 – 18:30　Group photo session