Project Title: Improve highway safety by reducing the risks of landslides

Recipient/Grant (Contract) Number: Carnegie Mellon University, Grant #: 69A3552344811

Center Name: Safety21 National University Transportation Center for Promoting Safety

Research Priority: Promoting Safety

Principal Investigator(s): Jiang Li Morgan State University

PI Contact: Jiang.Li@morgan.edu

Project Partners:

- Maryland Department of Transportation

Research Project Funding: $600,000.00

Project Start and End Date: 07-01-2023 to 06-30-2024

Project Description:

Geologic hazards including slope failures, landslides, mudflows, debris flows, etc. and hydrological hazards related to floods and stormwater surge can be destructive to transportation infrastructure and threaten property and human life along the highway and roads. Landslides alone cause thousands of deaths and many billions of dollars in damage every year. Morgan State University team proposes a multi-phase (multi-year) project focusing on safety of transportation infrastructure systems by preventing geohazard, specifically slope failure and landslides and minimizing impacts of geohazard. This project will employ an integrated approach of geotechnical and AI/Machine Learning methods for assessing conditions of geotechnical assets, such as cut slopes and embankment of the DOT SHA and delineating landslides and high-risk areas. The objectives (tasks) of the proposal include: (1) with AI/Machine Learning approaches assess the risks of landslides based on soil/rock types, weather conditions, mechanical properties of slope materials, and the status of existing retaining structures along the selected highway sections, using Maryland as case studies, (2) identify and map the high-risk areas based on controlling factors such as geometry and mechanical properties of soil or rock, and triggering factors, including gravitational and hydraulic forces, using available survey data, remote sensing and LIDAR data and other factors like transportation modes, (3) design and test protocols for real time monitoring at selected sites in consultation with DOT SHA staff, and (4) recommend strategies for reducing the risks of landslides with real-time monitoring for the high-risk areas, and improving the safety of the transportation infrastructure. All the methods and strategies can be transferred to other states or regions with similar geological conditions and engineering configurations. Phase 1 of this project will primarily cover task 1 and part of task 2. This project will primarily complement ongoing projects sponsored by the Maryland DOT SHA (see more information in TRID) led by Zhuping Sheng. Dr. Jiang Li has experience in both transportation research and environmental hazards. The former focuses on the mechanical behavior of road subgrades and the latter addresses the geological or hydrological hazards that may adversely affect the regional transportation infrastructure and traffic safety. As PI Dr. Li will coordinate the efforts in collaboration with MDOT/SHA and advise other faculty and postdoctoral research associates and graduate students to carry out the project. The team includes Co-PIs, Zhuping Sheng, Oludare Owolabi and Yi Liu who are currently conducting research supported by MDOT SHA, which provides a strong foundation for future collaboration with the partner MDOT SHA and others for technical transfer. This program includes a summer internship program with two students and one graduate team for development of future workforce in transportation safety in cooperation with MSU AI/ML program led by Dr. Owolabi. Students will also participate in exchange programs and deployment partners symposium and other activities. Through this project the MSU team is expected to expand collaboration with CMU and other partner institutes via faculty meetings, seminars, national summit, and other venues, which provides great opportunity for professional development.

Outputs:

The following are expected outputs for the Phase 1 of the proposed project: 1 to 2 Journal articles on methodology and case studies, 4 to 5 conference presentations at professional conferences and technical meetings, GIS coverages of detail delineation of selected landslides, Initial set up of database of geotechnical properties of soils, 1 training workshops for SHA staff and other professionals in transportation safety and disaster management, AI/ML models for landslides risk assessment with physical models (modified or new)

Upon the completion of the whole project, the following deliverables are expected: Maps of landslides risks and make them accessible through DOT SHA or UTC; Curricular materials (methodology, case studies of landslides, monitoring protocols and more) for classroom teaching for slope stability analysis and risk assessment of landslides and improvement of transportation safety. Protocols for monitoring of slope movement and failure as well as warning systems, and Guidelines for mapping risk areas and the real-time monitoring and alarm system for high-risk areas in cooperation with DOT SHA.

Outcomes/Impacts:

Besides advance in research and teaching related to transportation safety and disaster management, the project is expected to bring broad positive impacts on transportation system in the following aspects: Reliable assessment of landslide risk could help with preventive maintenance to avoid slope failures, assuring safe and reliable roadways and saving costs by reducing the impacts of potential failures. Early detection of slope failure with warning and monitoring systems, especially those recurring landslides sites could help to take measures to minimize damage to the infrastructures and provide safe routing to avoid injury to vehicle occupants. Research findings will help policy makers to improve the roadway design standards and secure resources to assure long-term safety of transportation systems under climate change. Research results, including assessment approaches and design protocols, are transferable to other states and regions with similar geological and hydrological conditions and roadway designs. In addition, this project will support initiatives that enhance doctoral achievement in the STEM and non-STEM disciplines for under-represented students of color and provide educational opportunities for student assistants to gain knowledge and experience for civil and environmental engineering. Faculty and researchers will participate in the Black Engineer of the Year Awards STEM Conference, reaching out to students, professionals, entrepreneurs, and employers in science, technology, engineering, and math fields.