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IPL Project (IPL – 265) Annual Report Form 2022

August 2022 to 31 December 2023

Project Title: **REVIEW OF ROCKFALL TRAJECTORIES OF CUT SLOPES OF ROADS USING A DISTRIBUTION MODEL APPROACH**

1. Main Project Fields - 1. Technology Development (database and hazard assessment)

2. Name of Project leader :

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Core members of the Project

Ms. J. M. K. Herath – BSc. (Geology Special), MSc. (Water Resources Management),

Mr. E.H.Navoda Premasiri – BSc. (Civil Eng.), AMIESL,

Mr. A. A. Virajh Dias – BSc. (Civil Eng.); MPhil (Earth Science); C.Eng. MASCE, MIESL

3. Objectives:

The objective of this research is to review the different patterns of failures and trajectories of cut slopes (rocks) of roads in hill country of Sri Lanka.

4. Background Justification:

A relatively high density road network is a significant observation in Sri Lanka's mountainous hill slopes and is the island at its most scenic, a land of emerald peaks and stupendous views of hillsides carpeted with tea and agricultural plantations and also graced by astonishing waterfalls. During recent past, it has been recognized that the rocky slopes associated in road construction are frequently affected by small to medium volume fragmental rock falls, especially initiation during high to medium rainfall events in hill country, Sri Lanka (Herath H.M.J.M.K et.al.,2018). The associated failures are usually recognized as; a) falls in rock blocks, topples often due to the lack of support of the underlying layer affected by planar sliding, b) wedge failure and rock fall after detachment of cutting face or in hanging rock faces, c) Large translational rock slide involving both soil and rock layers, d) planar rock slide along the mains structural setting and one or more combined setting meeting at once above. The project proponent, the Natural Resources Management and Laboratory Services of the CECB has already studied geotechnical features of landslides and rock slope failures and carries a many research finding which are needed to be organized in design standards, guidelines and policy framework under the World Center of Excellence on landslide disaster reduction during the period of 2014-2017, 2017-2020 and will be continued 2020 – 2023, in Sri Lanka.

5. Study Area: Mountainous area of Sri Lanka, covering the Central, Sabaragamuwa, and Uva, administrative provinces.

   Project Duration: Four years (January 2022–December, 2025) and will be extended to December, 2025

6. Progress:

1. Progress in the project:

August, 2022- December, 2023:

Slope segments of a cut slope of a road consist of various forms, geologically stable or unstable, including upper slopes that consist of soil, soil-rock composites, or rocky mountain slopes. Rock slopes are a natural phenomenon involving the displacement of rock through falling, toppling, sliding, and flowing, with materials usually depositing on the road stretch. Fragmentation in rocks due to the sequence of wetting and drying significantly aggravates the sliding potential. Similarly, soil and rock deformity, along with the reduction of interface frictional properties of slopes, can lead to limiting conditions or failure. The mountain slope closer to the road profiling and determination of hazard potential changes in nature along a road trace. Wedge failures, rockfalls, rolling of boulders, rock sliding failure, planar failure, and non-circular complex failures are some of the prominent patterns in rock slope engineering on a roadside. The initial field visits included various observations, understanding, and categorization of rock slope settings adjacent to road segments of the Kandy–Mahiyangana road in Sri Lanka. This activity also involved scrutinizing already available information, continuing data collection, and, in the event of new rockfalls, conducting site visits and field data verification. More than 30 new sample locations were studied, and observations were documented using standard field sampling methods, GPS records, photos, and histories of occurrences of failure (if recorded) or evidence.

January, 2023- December, 2023:

In the last year, substantial progress has been made in the determination of geotechnical characteristics of rock slopes, including the assessment of shear strength parameters and the interpretation of parametric variations in rock properties. This involved detailed field and laboratory investigations to accurately characterize the shear strength and other mechanical properties of the rock. Additionally, efforts have been focused on identifying and analyzing different modes of rock fall trajectories pertinent to our case model. This analysis has highlighted the importance of position-dependent modeling parameters such as friction and restitution coefficients, which are crucial for accurate simulation of rock falls. The ongoing work aims to refine these parameters to enhance the predictive capability of our models, thereby contributing to safer and more effective rock slope management strategies.

2. Planned future activities

January 2024 - December 2024:

(a) Preliminary interpretation of rock fall trajectories using Trajectory3D (or RocFall) to assess slopes at risk for rock falls, including energy, velocity, and "bounce height" envelopes for the entire slope.

(b) Writing a paper for the ICL Open book 2024/2025.

January 2025 - December 2025:

(a) Development of a terrain model based on a case record of a highway road section and the creation of a high-resolution digital elevation model.

(b) Conducting a full 2D (2D horizontal and 2D vertical) simulation model for rockfall based on the non-smooth contact dynamics method with hard contact.

(c) Further study on geotechnical characteristic of rock slopes, shear strength parameters and interpretation of parametric variation of rock properties in rocks.

(d) Simulation of various patterns of road cut-slope rockfall trajectories.

(e) Numerical verification, field verification, and detailed interpretation of the study.

(f) Writing a paper for the ICL Open book 2026/2027.

3. Project Beneficiaries:

Road sector/ Transportation planners

By gaining insights into rockfall trajectories, they can design more effective mitigation measures, improve road safety, and reduce maintenance costs. Further they can understand the importance of rockfall prediction and prevention strategies will aid in infrastructure planning and resource allocation, ensuring safer travel routes for the public.

Landslide professionals, academics, researchers,

Professional research groups can utilize the research findings to better understand the geotechnical properties of rock slopes, leading to more efficient and safer construction practices. The findings will contribute to the broader knowledge on rack fall trajectory, facilitating further research and development in the field of geotechnical engineering and rock mechanics.

People residing in landslide prone areas

Improve understanding of rock fall impact to public safety and to develop stricter guidelines and regulations for overall public safety and environmental protection. Ultimately, the public benefits from reduced risk of rockfall incidents, leading to safer travel and fewer disruptions on critical roadways.

4. Results of the overall study (Publications)

- Nimani S. Kulathilake L.K., Herath H.M.J.M.K.,Virajh Dias A.A.,(2018),Strength and Elastic Deformation of prominent load bearing Metamorphic rocks in Sri Lanka., Proceedings of the CECB symposium, Sri Lanka.
- Herath H.M.J.M.K., Jayasooriya J.A.D.N.A., Virajh Dias A.A.,(2018), Pairwise comparisons of Geological evidences in rockfall hazard rating system (RHRHS) for the evaluation of road based potential slope failures in Sri Lanka ,Proceedings of the CECB symposium, Sri Lanka