Date of Submission	1st February, 2016

IPL Project (IPL 200) Annual Report 2015

1 January 2015 to 31 December 2015

1. **Project Title:**

An Assessment of the Rock fall Susceptibility Based on Cut Slopes Adjacent to Highways and Railways.

2. **Main Project Fields** - Technology Development
   Category B. Hazard Mapping, Vulnerability and Risk Assessment

3. **Name of Project Leader** : **Ms. H.M.J.M.K. Herath -** B. Sc.(Special Science degree in Geology), M. Sc (Water Resources Management)

Affiliation: **Engineering Geologist**, Natural Resource Management & Laboratory Service,, CENTRAL ENGINEERING CONSULTANCY BUREAU (CECB)

Contact: No 11, Jawatta Road, Colombo 5, Sri Lanka; Tel: +94 11 2505688
Fax: +94 11 2598215 ; Email: jmkherath@yahoo.com

Core members of the Project

Eng. (Ms)E M T M Ekanayake – B.Sc (Hons) (Earth Resource Engineering)
Eng. J A D N A Jayasooriya – B.Sc(Hons) (Civil Eng); PG.Dip(Transport Eng-reading)
Eng.(Ms) S. S. I. Kodagoda- B.Sc (Hons)Eng, M.Eng., CEng,- Geotechnical Engineer
Eng. A A Virajh Dias – B.Sc(Civil Eng); CEng, PG.Dip; MASCE,MIESL

4. **Objectives:**

Rock fall from cuts slopes adjacent to roadway and railways are significant during heavy rains in mountainous terrains. The main objective of the project is

- Recognition of the Gravity of rock fall hazard from cut slopes adjacent to highways and railways during heavy rainfalls
- Carrying out appropriate improvements for rock fall hazard assessment by introducing appropriate Rockfall Hazard Rating System (RHRS)

5. **Study Area**:

Two locations along Kandy – Nuwara Elliya highway, Sri Lanka and two locations along Sri Lanka railway Main line (Colombo to Badulla, Sri Lanka)

6. **Project Duration**:

Three years (July, 2015 to July 2018)

7. Report

7.1 Progress in the project: - Introductory Remarks

The historic perspective provided by the study team or the data collector is an important element of the preliminary rating of the Rockfall Hazard Rating System which was originally developed by the Oregon State Highway Division (Pierson et al. 1990). Past rockfall activity is a good indicator of what to expect in the future.

Figure 1: large boulder falling records; Kandy – Nuwara Elliya road

Most observed road associated slope failures were recorded as rock-soil composite failures. Therefore, road associated failures were categorized under common geological terms such as (1)soil and rock slump, (2) rotational slides in homogeneous soil seated on bedrock (3)translational slides and slip along plane of weakness, (4) planer failures in foliated rock slopes, (5) wedge failures along foliated or jointed surfaces, (6)complex form due to geological setting(rock –soil). In addition, the following information were also gathered during rockfall inventory study to support the RHRS; (1) Location of rockfall activity; (2.) Frequency of rockfall activity; (3.) Time of year when activity is highest; (4.) Size/quantity of rockfall per event; (5.) Physical characteristics of rockfall material; (6.) Where rockfalls have come to rest; (7.) Available accident history; (8.) Opinion of rockfall cause (9.)Frequency of ditch cleaning/road patrol and (10.) Estimated cost of maintenance response

7.2 Planned future activities or Statement of completion of the Project

July-December, 2015:	Identification of sampling locations and field work – Completed
January 2016- December 2016:	Laboratory and Field testing, data collection, back analysis; Numerical evaluation of data
January 2017 to December, 2017:	Development of advanced method of assessments, conducting in-situ testing, back analysis and modeling of case studies; verification and sensitivity assessment.
January, 2018- June 2018:	Finalizing the design approaches for evaluation and design of cut slope stabilization in roadway and railways in hill country slopes.

7.3 Beneficiaries of Project for Science, Education and/or Society

The beneficiaries of this project would be the road trace designers, engineering consultant and other professionals, academics, planners and people residing in landslide prone areas in the hill country of Sri Lanka.

7.4 Results (resent Outputs):

a. Data Collection and Field Survey Work

The slope survey provides an opportunity to document the historic rockfall activity.

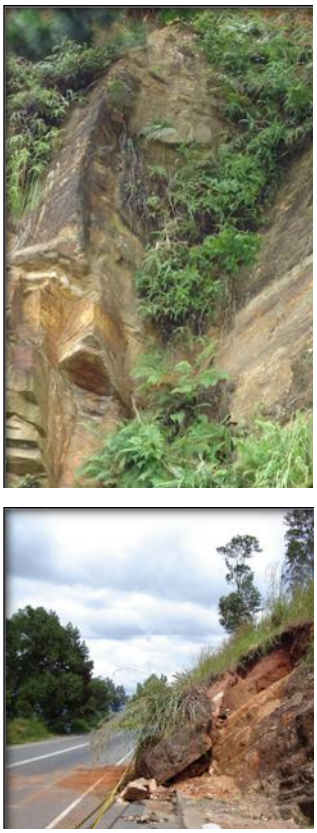
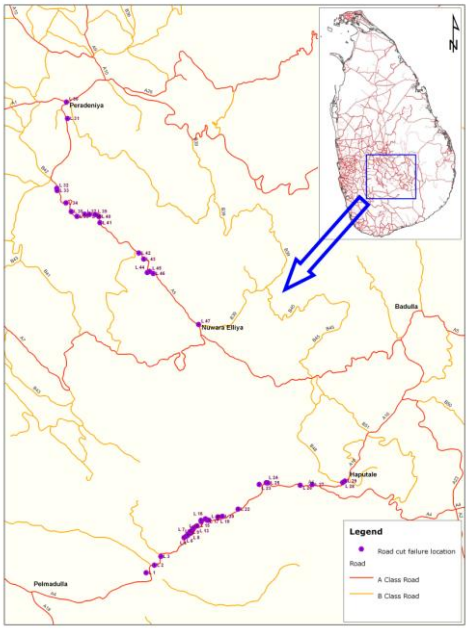


Figure 2: Failure along bedding, joint and fractures; Kandy – Nuwara Elliya road



Finger 3: Road inventory survey for rock fall hazard assessment

b. Observations and Interpretation of Data

1. Infinite slope failure is significant in dip slope with highly foliated, jointed and stratified rocks
2. Detachment of passive wedge, removal of earth cover and exposure of foliated rock to temperature has triggered slope instability than expected.
3. The purpose of the preliminary rating is to group the rockfall sections inspected during the slope inventory into three broad, more manageably sized categories such as “high”,” Moderate” and “low”.
4. A series of statistical interpretations were performed from the direct field data of earth cutting behaviour which is associated with various geological conditions at site.

5. Preliminary data plots and observations of shallow modes of rock/soil composite failure and limiting conditions prevailed at site is given in below

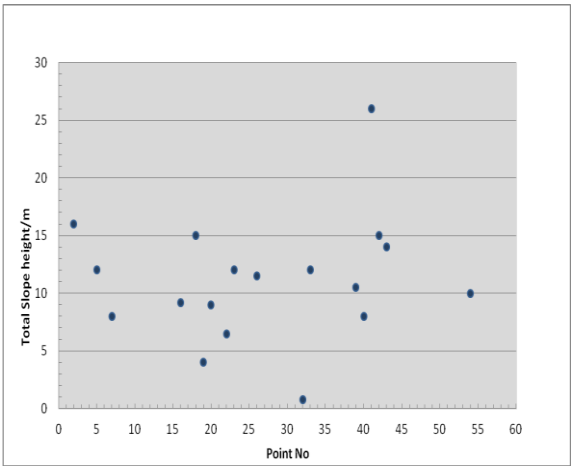


Fig 4: Statistical representation of foliated rock slope failures (road cutting sections only)

Shallow Modes of Failure	Description	Limiting Cutting Height
Infinite Slope Failure Mode	Critical in under dipping rock	0.8m
Composite Mode of Slope Failure	soil overlaying under-dipping rock slopes	Very low
Long-Term Stable Slope in Weathered Rock	Over-dipping rock slopes and moderately to highly weathered rock slopes only	5m single cut, 15m with berms

c. Slope Stability Considerations : Slope failure occurs when driving force exceed the resisting force. Factor of safety (FS) is defined as the ratio of resisting forces (or moments) to the driving forces (or moments). If FS $\leq$ 1, the slope will fail, if FS > 1, the slope is theoretically stable. Therefore, it is also important to recognize that this analysis considers only force equilibrium and assumes that all forces pass through the centroid of the wedge. This involves a series of calculations in which each significant parameter is varied systematically over its maximum credible range in order to determine its influence upon the factor of safety. Therefore, such approach provides a useful means of exploring a range of possibilities and reaching practical decisions on some difficult problems.

d. Publications (Journal Papers and conference Papers)

1. H M Janaki, M K Herath, S S I Kodagoda and A A Virajh Dias; Shallow Modes of Slope Failure in Road Earth Cuttings in Sri Lanka; World Landslide Forum 3; Beijing, China, 2014.

2. "Empirical Relationships of Elastic Modules and Uniaxial Strength of Intact Metamorphic Rocks of Sri Lanka"; Proceeding of the International Conference of Geotechnical Engineering(ICGE) 10th – 11th August 2015 in Colombo, Sri Lanka; PP 515 -518; Authors were E M T M Ekanayake , H M J M K Herath and A AVirajh Dias; ISBN 978-955-1411-01-5.

e. References

1. Pierson, L.A., Davis, S.A. and Van Vickle, R. 1990. Rockfall Hazard Rating System Implementation Manual. Federal Highway Administration (FHWA) Report; FHWA-OR—EG-90-01. FHWA, U.S. Department of Transportation.