Date of Submission	30th March, 2018

IPL Project, IPL-155 Annual Report 2017

1 January 2016 to 31 December 2017

1. **Project Title:**
   Determination of Soil Parameters of Subsurface to be Used in Slope Stability Analysis in two Different Precipitation Zones of Sri Lanka.

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

3. **Name of Project Leader** :

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Core members of the Project

Eng.(Ms) S. S. I. Kodagoda(BSc(Hons)Eng,MEng.,CEng,- Geotechnical Engineer
Ms H.M.J.M.K. Herath(BSc(Geology Special).- Engineering Geologist
Eng.(Ms) M A S N Mallawarachchi (BSc Eng(Hons)-Civil Engineer

4. **Objectives:**
   Determination of critical and other important insitu soil parameters for various soil types that are present in two different precipitation zones in Sri Lanka and comparison of the same. The selected two precipitation regions are based with:
   (a) Heavily precipitated zone in wet zone with annual average rainfall above 4000mm
   (b) Wet zone with annual average rainfall between 2500-3000 mm

5. **Study Area**:
   a. Heavily precipitated zone in wet zone with annual average rainfall above 4000mm-Watawala, Nawalapitiya
   b. Wet zone with annual average rainfall between 2500-3000 mm Haldummulla, Haputale, Ratnapura, Kalawana

6. **Project Duration**:
   Originally proposed project duration is January 2010 to end December 2011. However, due to the requirement of further study project period extended until June, 2019)

7. Report

7.1 Progress in the project: -

The comparison of soil module E50 of residual soil slope failures in two different rainfall precipitation zones is an experimental study to formulate a relationship between the potential slope failures quantify shear strength characteristics of soils which could be easily discussed on scenarios of the first time occurrence failures and repetitive failures in residual soil formation. However, number of failures were recorded in rock or interface of rock-soil conditions. Therefore, nineteen locations were selected along with the UDS samples for the determination of initial moisture content, initial void ration, dry density,

shear strength parameters and secant modulus of E50. All triaxial samples were 70mm diameter and 140mm height and tested under isotropic consolidated undrained (CIU) triaxial compression state with pore water pressure measurements for the determination of stress strain parameters of soil. All testing were conducted at the Advanced Soil Testing Laboratory at the CECB Laboratory Services, Central Engineering Consultancy Bureau, in Colombo.

7.2 Planned Future Activities or Statement of Completion of the Project

7.2.1 January 2011 to December 2016:

Evaluation of Soil Conditions at Site(Parametric Study). Several locations for soil sampling selected in both areas. The following comparisons were made.

i. Comparison of lab and insitu parameters: cohesion and friction angle
ii. Comparison of all the above parameters of each soil type
iii. Determination of possible values for parameters mainly for the critical of them such as cohesion and friction parameters for each soil type in both regions
iv. Comparison of values obtained in above and study the variation
v. Publications

7.2.2 January 2017 to June 2019

a. Determination of possible values for parameters mainly for the critical of them such as cohesion and friction parameters for each soil type in both regions
b. Comparison of values obtained in above and study the variation
b. Evaluation of Hydro-geological consideration and understanding the mechanisums of failures
c. Conducting one day seminar on design parameters for slope stabilization in the hill country of Sri Lanka

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

Project proponents of development projects and residents in landslide prone areas, professionals, academics, design groups, planners

7.4 Results (resent Outputs):

The study on evaluation of E50 (secant modules) is an experiment setup to understand the behaviour of interface of rock under changing stress conditions at site due to various reasons such as prolong period of rainfall precipitations, movement of soils, unloading effects and re-loading effect caused by deposition. Therefore, it is advised to explore more sample representation in a detail study before the comparison or evaluation of the interdependence of sub coefficients of soils. Therefore, further tests are recommended with more representations of soil samples and also widening the range of test parameters to verify the interdependence capacity of soil parameters and to make it applicable over a wide range of actual failures of residual soils under prolong period of saturation. Sample interpretation of data and method of tabulation of results are given in fig 1 and Table 1.

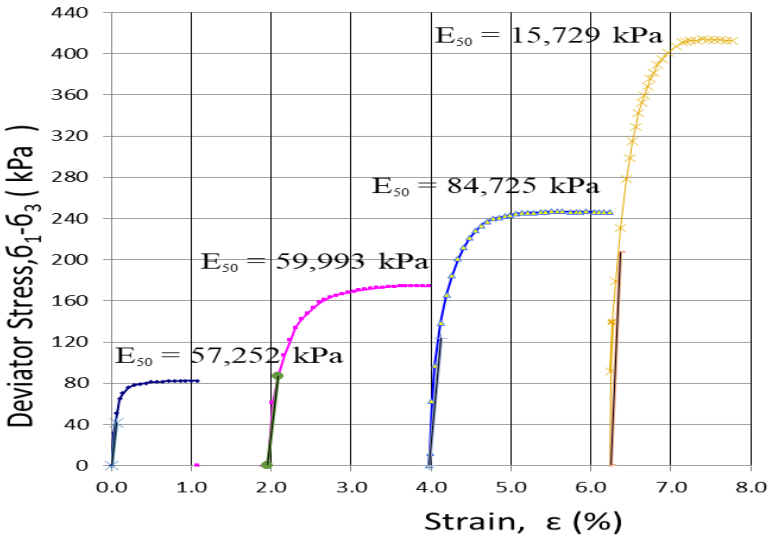

Fig 1: Interpretation/evaluation results : Sample plot : S160694, Brownish fine grained sandy clay

Table 1: Summary of shear strength parameters, densities, and elastic properties, degree of saturation and void ratio of selected residual soil samples tested at the laboratory.

Sample Reference	Landslide / Location Reference	MC (%)	Dry Density Mg/m³	Degree of Saturation	Void Ratio, e_o	CU Triaxial Test		Effective Confining Pressure(kPa)	E_{50}
						C' kPa	ϕ' deg		kPa
S130022	Loose, Reddish brown, fine to medium grains, soil with more sand, no impurities probably clayey silty sand	11.72	1.83	0.96	0.63	2	26	60	8,159
								100	31,767
								150	69,023
								200	62,754
S130026	Brownish silty sand	15.44	1.45	0.1	0.08	0	21	60	15,728
								100	25,297
								150	23,206
								200	43,091
S130121	Brownish slightly fine to medium grains, soil with more silt, no impurities, probably slightly sandy clayey silt	26.05	1.36	0.96	0.92	16	30	40	13,740
								80	55,607
								120	67,146
								160	155,470
								200	177,810
S140076	Dark brown fine to medium grain clayey sand	12.30	1.64	0.93	0.61	4	26	50	29,241
								100	69,317
								150	31,635
								200	23,957
S140077	Reddish brown fine to coarse clayey sand	26.05	1.78	0.94	0.48	0	30	50	24,323
								100	8,273
								150	9,936
								200	12,252

From the results presented, it can be observed that each void ratio function can only be applied for a certain type of residual soil (minimum to be satisfied with soil structure, moisture content, dry density gradation and LL, and PI). The results do not conclude a strong interdependence of eo and E50 with the shear strength characteristics due to the small sample size represented in this study. It seems that no universal void ratio function, which can be applied for all soils with their wide range of void ratios, exists.

8. Publications (Journal Papers and conference Papers)

1. "Soil Moduli E50 of Residual Soil Slopes, Sri Lanka"; A A Virajh Dias, L K N S Kulathilaka, W M J K Wendakoon & E M T M Ekanayake; Proceeding of the UNESCO – IPL Symposium, November, France, 2017.
2. "Comparison of soil modulus E50 of residual soil slope failures in two different rainfall zones"; Proceeding of the World Landslide Forum3 (WLF3), Beijing, China, 2-6 June 2014; Volume 1, Landslide Science for a Safer Geoenvironment, PP 135- 141.; Authors were M A S N Mallawarachchi, E M T M Ekanayake, S S I Kodagoda and A AVirajh Dias; ISBN 978-3-319-04998-4; Springer.
3. "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.

References

1. Briaud,J.l.,2001; Introduction to Soil Moduli, Geotechnical News, June 2001, BiTech Publisehers Ltd, Richmond, B.C.Canada, (geotwchnicalnews @bitech.ca).
2. Ekanayake, E M T M , Herath, H M J M K & Dias, A A Virajh (2015), Empirical Relationships of Elastic Modules and Uniaxial Strength of Intact Metamorphic Rocks of Sri Lanka; International Conference of Geotechnical Engineering(ICGE); PP 515 -518;
3. Fahey, M. (1999). Determining the parameters of a non-linear elastic model for prediction of ground deformation. Australian Geomechanics, Vol.34, No. 1, March, 39-59
4. Mallawarachchi, M A S N, Ekanayake, E M T M, Kodagoda, S S I and Dias, A A Virajh (2014), Comparison of soil modulus E50 of residual soil slope failures in two different rainfall zones; World Landslide Forum3 (WLF3), Volume 1, PP 135- 141..