1. **Project Title:**

**Determination of Soil Parameters of Subsurface to be Used in Slope Stability Analysis in two Different Precipitations Zones of Sri Lanka.**

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

3. **Name of Project Leader:** Mr. A A Virajh Dias;
   BSc(Civil)Eng, PGDip, CEng., (MPhil in Earth Sciences – pending )

   **Affiliation:**
   Additional General Manager,
   Natural Resource Management & Laboratory Services / Centre for Research & Development
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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 May 2015.

7. **Report**

1) **Progress in the project:** -

   A. Collected 06 number of UDS soil samples; 18 number of disturbed soil samples from the two selected precipitation zones

   B. Soil classification test (LL, PI, PI, Gradation): Unconsolidated Undrained Triaxial Test and Consolidated Undrained test was conducted for two sets of samples

   C. Study on rainfall history back to 25 years and identify observations of extreme rainfall scenarios during that period – still continuing

1. A heavy rain is the main cause for landslide activation in hilly areas of Sri Lanka. No records of landslides occurred during dry season or under any seismicity are found in Sri Lankan history. Geology, hydro-geology, rainfall precipitation and ground slope are natural causes, while improper land use practices and man-made activities also account for landslide activation.

2. The test results as plotted below shows that E50 increases with effective confining pressure.

   ![Fig 1: Relationship of effective confining pressure and soil module E50](image)

3. Two soil samples can have the same dry density but different structures, like loose or dense, and thus have different moduli (Briaud, J L, 2001). Water content also impacts moduli. At low water contents the water binds the particles, increases the stress and suction between the particles and leads to a high soil moduli.
4. Table 1: Slope failures in two different precipitation zones along the road section

<table>
<thead>
<tr>
<th>Rainfall Precipitation Zone</th>
<th>E50 (at EC 100kPa - 120kPa) kN/m²</th>
<th>e_o</th>
<th>Number of landslides / slope failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1: Balangoda to Bandarawela</td>
<td>39,286</td>
<td>0.838</td>
<td>09 nos of slope failures identified</td>
</tr>
<tr>
<td>Zone 1: Koslanda Landslide</td>
<td>41,957</td>
<td>0.810</td>
<td>one major landslide across the road</td>
</tr>
<tr>
<td>Zone 1: Gampola to Nuwara Eliya</td>
<td>35,182</td>
<td>0.937</td>
<td>07 number of slope identified</td>
</tr>
<tr>
<td>Zone 1: Watawala Landslide</td>
<td>10,714</td>
<td>1.15</td>
<td>one major landslide across the rail road</td>
</tr>
<tr>
<td>Zone 2: Colombo and sub regions</td>
<td>56,900</td>
<td>0.788</td>
<td>Newly formed earth cutting</td>
</tr>
<tr>
<td></td>
<td>25,723</td>
<td>0.640</td>
<td>Newly formed earth cutting</td>
</tr>
<tr>
<td></td>
<td>11,909</td>
<td>1.348</td>
<td>Newly formed earth cutting</td>
</tr>
</tbody>
</table>

5. Laboratory determination of shear strength characteristics was done using the UDS samples of residual formations and the discrete boundary shears. The multistage consolidated undrained triaxial tests and direct shear test were conducted and showed that the fine-grained residual soils from the formation have an average effective cohesion, C’, of 4kPa to 8 kPa. The effective angle of internal friction, $\phi'$, is having a range of 29° to 35°. However, at the boundary loss of strength is indicated by an average effective cohesion, C’, of 0kPa and effective angle of internal friction, $\phi'$ is having a range of 14+1°. No metric suction effect has been considered these evaluations and the stability.

2) Planned future activities or Statement of completion of the Project

1. January 2011 to December 2013: 60% completed
   a. Evaluation of Soil Conditions at Site(Parametric Study). Several locations for soil sampling will be selected in both areas. This will be done so that different main soil types existing in the area are represented. The following comparisons will be 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

ii. January 2013 to December 2013

b. Selected sites where back analysis of slope failure can be carried out satisfactorily due to the availability of sub surface data will be identified. During the study period the slope failures will be closely monitored and in such occurrences back analysis will be performed and the above parameters will be compared.

c. Evaluation of Hydro-geological consideration and understanding the mechanisms of failures
d. Conducting one day seminar on design parameters for slope stabilization in the hill country of Sri Lanka

iii. January 2014 to December 2014


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

4) Results (resent Outputs):

One case study- completed ; Statistical and scientific evaluation of laboratory findings