Ground Penetration Radar Obseravtions at Kahagolla Landslide and Evaluation of Potential Failure Mechanism

Dissanayake SW, Pathirana GPNA, Sandaruwan MKS, *Abeysinghe AMKB, Premasiri HMR and Weerawarnakula S

Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka
*Corresponding author – amkb@uom.lk

Abstract

The term landslide is used to describe a wide variety of processes that result in the perceptible downward and outward movement of soil, rock and vegetation under gravitational influence. The material may move by falling, sliding, spreading, or flowing. Landslide disaster is caused to produce a significant impact to the economy of the country and caused to create number of social and enviromentalimpacts. This research was forced on studying the methods that can be used for evaluating the potential mechanism of Kahagolla landslide by applying geotechnical and geophysical techniques. The study was based on slow moving landslide located near the Kahagolla Estate. It belongs to Haputhale District Secretariate divisionin Badulla district.This study involves the use of Ground Penetrating Radar (GPR) and existing borehole information.GPR, technique used for defining underground structure, providing a time effective survey that yield high resolution data making it suitable for shallow and deep subsurface analyzing. The results were validated using the available borehole information. The GPR survey information revealed a close relationship with the borehole data. Hence, an optimum combination of GPR survey and borehole drilling can be proposed for cost controlling in landslide monitoring and instrumentation programme. After interpretation of GPR observations, could identify some of active slip surfaces and their depths from the ground surface.

Keywords: Ground Penetration Radar, Landslide monitoring, Slope stability

1. Introduction

A landslide is a geological phenomenon which includes a wide range of ground movement describe a movement such as rock falls, deep failure of slopes and shallow debris flow. The term therefore describes a movement of a mass of rock or soil from a higher point to a lower one. A complete definition of a landslide event could be the following: "movement of soil or rock controlled by gravity uperficial or deep with movement from slow to rapid but not very slow which involves material which make up a mass that is a portion of the slope or the slope itself"[1].

In the central hills of Sri Lanka, landslide have been one of the major and wide spread natural disasters that strike life and property repeatedly and occupy a position of a major concern.

Out of ten landslide prone districts, Badulla is one of the most affected areas. With the torrential rainfall in the central part of the country, many landslide incidents have been occurred.

1.1 Study Area

This study area is based on an unstable slope that is to be analyzed using GPR technique which is situated near the Kahagolla Estate. It belongs to Haputhale DS division in Badulla district. The average elevation of the location is about 1430m from the MSL. The main landslide body extends about 650 m with not very much steep in slope. However, just below the landslide, some community buildings and infrastructures exist while a stream and a drain channel drained adjoining this landslide. As the landslide get activated (slow movement) during heavy rains, tension cracks can also be seen clearly on the main road. It is reasonable to assume that, this is a rotational type [2,3] deep seated failure.

2. Methodology

Identification of the site condition was the first step of the project. The background information on the monitoring landslide was gathered through a literature survey. Further details were gathered using available borehole investigations that had already been conducted by the National Building Research Oraganization (NBRO).

2.1 Field Test Procedures

In the first site visit we recognized what instruments are in their, position of that place and also the evidence of surface movement, geological conditions, reasons for landslide initiation, the existing mitigatory measures and finally the problematic nature NBRO was confronted with during their mitigation process. In the second site visits we observed subsurface geological formation, water table, cracks, slide surface, bed rock

Figure 1 - Site location and GPR survey lines

and slide surface through the GPR instrument. After gaining Raw data, we analyzed it by means of software named GPRSoft.In that software we could interpret water table and subsurface soil layers.

3. Results and Disscusion

By using Geko 60 antenna

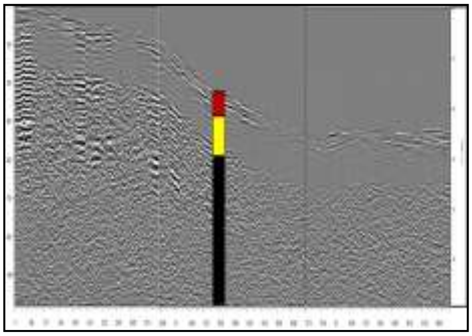

Figure 2 - Distance vs depth GPR graph along the road (A to B through BH-05)

0-3.3m-layer1

3.3-12.5m-layer 2

12.55m>Bed rock

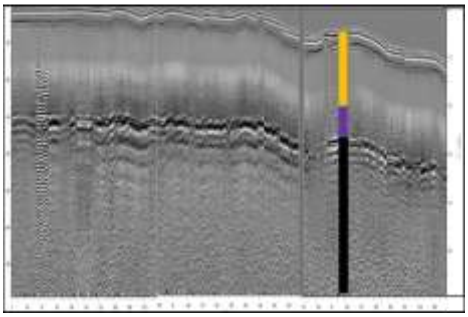

Figure 3 - Distancevsdepth graph along the slope(C-D-E through BH-02)

0-13.3 m layer 1

13.3-18.6 m layer2

18.6m>Bed Rock

Water Table

We could identify water table approximately at 4.75m by GPR instrument and it was same as the borehole data. We identified second layer in approximately closer to 13m and extend to 19m, so this is same as borehole data what we have.It was identified that below 19m moderately decomposed to fresh rock is found.

In second data file we took by moving GPR machine through tar road so we could identify there is few meter layer in there. Sometime it might be the compaction layer and after that we detected (11-12)m layer below the subsurface. After below that there is extended bed rock.

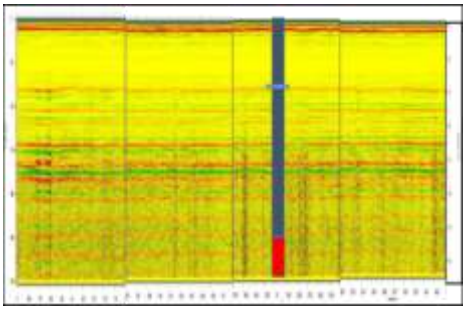

Figure 4 - DisatanceVs Depth graph along the slope(BH-05)

0-13.3 m layer 1

13.3-18.6 m layer2

Water Table

Landslides are complex structures exhibiting a wide variety of geological, geomorphological and hydrogeological properties. Investigation of such heterogeneous structures is one of the more challenging themes for near surface geophysics. The development of 2D and 3D geophysical techniques has aroused a growing interest for assessing the landslide volume, characterizing the physical properties of the landslide material and locating the groundwater flows within and around the slide. The choice of the techniques is clearly guided by the expected contrasts in physical parameters. Other parameters, like the required penetration depth, as well as the volume and the morphology of the landslide, may also have a significant effect on the survey strategy, including for economic reasons. Among these latter ones, the major difficulty of applying geophysical techniques to landslides is probably the complex relationship between the measured geophysical parameters and the desired geotechnical and hydrogeological properties, which prevents from giving a straightforward interpretation in terms of engineering properties. This review has tentatively pointed out the potentials and the limitations of Ground Penetrating Radar method.

Here we have three types of frequency emitting radar equipment. Firstly, we did survey by airborne equipment. It can find subsurface information up to 50-60 m depth. Hence, we did our survey along BH5 and BH2 area for identifying water table, soil layers and bed rock depths .The interpreted data from GPR survey were validated using borehole data. we could also clarify slip surface data by airbone survey data interpretation. Because of low resolution, we couldn't interpret any slip surface based on BH1 and BH5 ground survey. How ever But we could interpret water table, soil layers and bed rock based on these data.

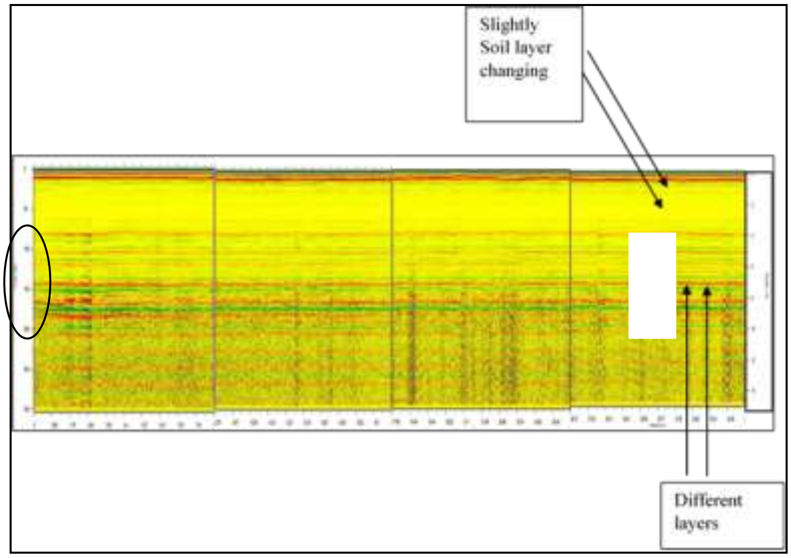

Figure 5 - Different layer changes (C-D-E survey line)

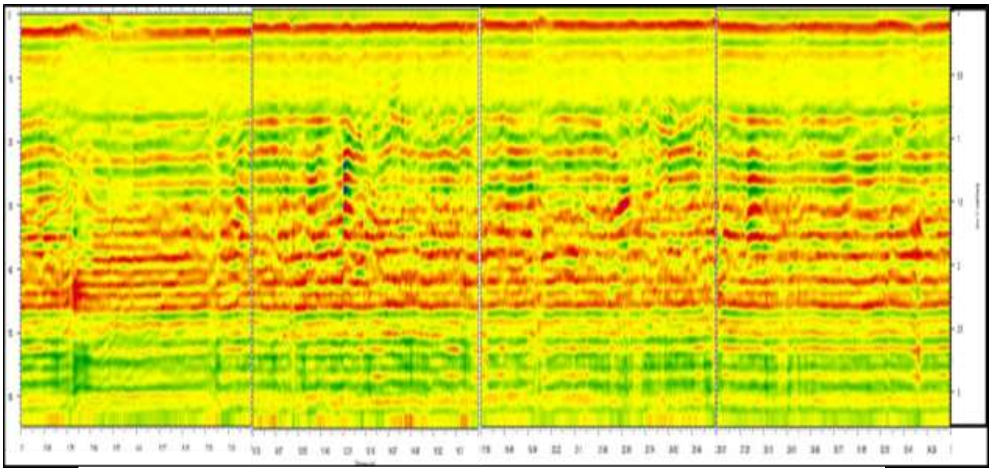

Figure 6 - Layer changes due to buried items (C-D-E Line)

These data were validated with borehole data. Then we turned into Ground Coupled Bowtie (GCB) 100 and Ground Coupled Bowtie (GCB) 300 to clarifying slip surface. GCB 100 has resolution about 50cm and penetrating depth up to 15m. GCB 300 has resolution about 16cm and penetrating depth up to 8m.

4. Conclusions

The research procedure was expected to identify the slip surface and the sub surface layers in the Kahagolla Landslide site. Data was obtained from the GPR instrument and along the slope of the site and along the road between 10 and 11 culvert.From the based on the results obtained from the data analysis, Following conclusions could be made:

- GPR instument can be recommended for identifying groundwater table,soil layers and bedrock.
- GPR reflecting frequency is highly affected by surrounding frequencies.
- In Kahagolla landslide, monitoring procedure suitable via instrumentation because there are lot of soil properties variation through the subsurface.Hence, we couldn't take clear image for identifying slip surface within the maximum depth capacity of the GPR.
- We have clear resolution for measuring depth upto 13m under our equipments.There is 13m-18m depth which couldn't be identified clearly so probaly a slip surface may be located within this depth range.

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