Instrumentation and Monitoring of Mahawewa Landslide off Walapane

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Abstract: The instability of the slope area at Mahawewa, Walapane has been identified as a major threat to the people and properties of the vicinity since 1986. Therefore, National Building Research Organization has started a project of monitoring and stabilization of the slope, cooperating with the Japan International Cooperation Agency in 2010. Main involvement of this study was to do the monitoring part. It is mainly based on analysis of un-stabilization parameters of the area which measured using five instruments. That is horizontal movement at sub surface using Inclinometer, fluctuation of ground water level using Piezometers, characteristics of slip surfaces using Strain Gauges, movement of the surface using Extensometers and rainfall using Rain Gauges. In addition drill log data of the site, visual information of cracks generated and springs available were also used. Global Positioning System survey was carried out for preparation of a map in this particular area. Finally, according to the results and conclusions gained from monitoring of the landslide, a suitable mitigation method was proposed.

Keywords: Landslides, Slip surfaces, Ground water level, Slope stabilization, Rock slope instrumentation

1. Introduction

Landslide disaster causes a significant impact to the economy of the country and create number of social impacts.
The instability of the rock slope at Mahawewa in Walapane was identified as a major risk to the safety of the people and property. That slope is located behind the Padiyapallalla town in Nuwara Eliya district. It belongs to Kumbalgamuwa GN division. The initial signal of landslide was occurred in 1986, and then in 11th and 12th in January 2007, the problem has become severe and 3 landslides were monitored. Among them, one was activated by losing 18 lives and fully damaging 68 houses (http://www.wsws.org /articles / 2007/jan2007/sril-j31.shtml).

Mahawewa, Walapane area has some importance in economical, agricultural and sociological aspects. If the landslide will be activated again, it is highly affecting to the Walapane Hanguranketha main road and also it can destroy the Keerthi Bandara School situated on the extreme down slope (http://www.nbro.gov.lk/web, NBRO home page, Mitigation of landslides).

Therefore, after the 2007 tragedy, National Building Research Organization has started monitoring this landslide using instruments and some mitigating programme. This is the first time of doing such an instrumentation method for monitoring the landslide, Sri Lanka. There are 5 types of instruments have been installed such as,

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Inclinometer, Piezometer, Extensometers, Strain Gauges, and Rain Gauges (Fig1). Main involvement of this study was to do the monitoring part by analysing the relationships of slope stabilizing parameters which were measured using those instruments.

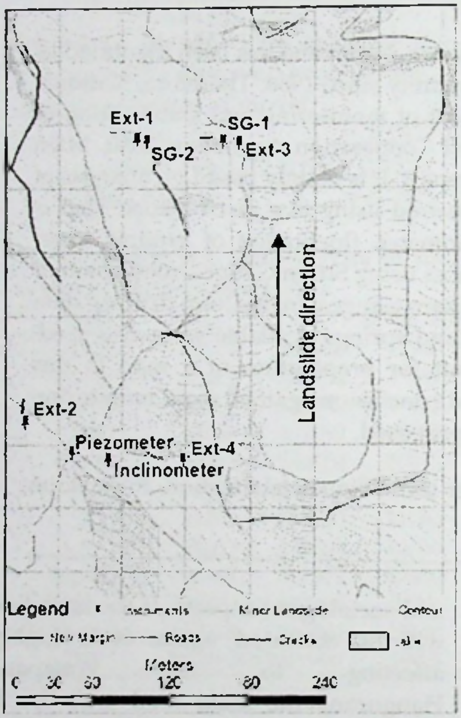


Figure 1: Instrumentation Location Map of Mahawewa Landslide

2. Methodology

Instrument installation and their particular locations were studied. Then one year data of all instruments were collected within suitable intervals. Data collection was done manually in Inclinometer once a month while data has been automatically recorded in other instruments at each half an hour or one hour.

Then, those data were analysed mainly based on the fluctuation of the basic parameters with the time or depth. First, data received from various instruments were tabulated in excel sheets as instrumental wise. Then, the best arrangements of data were explored for the convenience of the data analysing.

In addition to that, a Global Positioning System survey was conducted for the affected area to demarcate the boundary of the both past and current landslide, around the lake, along the cracks appeared and also at the location of instruments.

Finally, a suitable landslide mitigation method was proposed according to the monitoring data and failure mode.

3. Results

3.1 Geomorphology of the area

The landscape of Mahawewa is very much undulating with steep slopes of 15^0 to 35^0. There are two escarpments at the top area of the slope and near to that the whole area is filled with a colluvium deposit consisting of large size boulder (1 m to 5 m in diameter). There is an abandoned lake bellow the escarpment where still water level be observed.

3.2 Results of Extensometer (Ext)

Ext 01: Critical movement - 25/12/2010 to 10/01/2010. Lower portion from the Crack has relatively moved downward. Rate of movement is 7.56 mm per day.

Ext 02: Critical movement- 08/12/2010 to 09/01/2011. Rate of movement is 3.629 mm/day. Lower portion from the major boundary has moved downward.

Ext 03: Critical movement- 25/11/2010 to 09/12/2010. Rate of movement is 17 mm/day. Lower portion from the crack has relatively moved downward.

Ext 04: Critical movement- 27/11/2010 to 27/12/2010. Rate of movement is 1.3 mm/day. Low downward movement compare with the other movements.

3.3. Results of Strain Gauge (SG)

First 6 months- Mainly two slip surfaces were identified at 13 m and 18 m depth bellow the location of SG2 (Fig 2). The slip surface at 13 m depth also can be detected at the 11 m depth bellow the SG1. This has a slow movement with the rain. The effect is varying up to 1m above the slip surface and varies with the rain fall.

Slip surface at 18 m depth bellow the SG2 has a rapid movement in whole time period. It has affection of 1 m above the slip surface and 2 m bellow the slip surface. The effect changes with the rain.

Second 6 months- New two slip surfaces are formed in shallow area with the depth of 4m and 10m bellow the SG2.

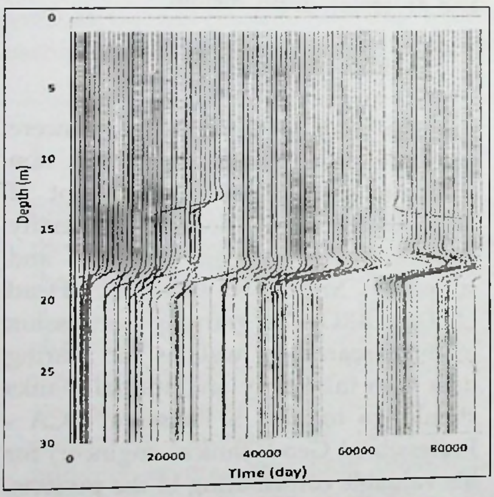
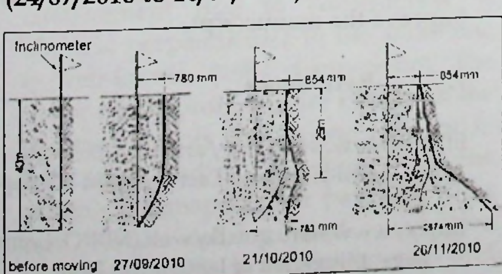


Figure 2: Strain Gauge 02 Graph (24/07/2010 to 10/01/2011)



3.4. Results of Inclinometer

At the end point of the Inclinometer there is a considerable horizontal movement even below that end point of 40m depth (Fig 3). A slip surface has been identified at 26m depth below that location.

Figure 3: Results of Inclinometer

3.5. Results of Piezometer

Average GWL at normal condition is 2.5m. In rainy season it is 1.75 m and in dry season it is 3m

3.6. Results of Water Gauge

ST 01 - The average GWL at normal condition is 4 m and during rainy condition it has been very close to the ground surface (1 m).

ST 02 - The average GWL at normal condition is 20 m and during rainy condition it is 12.5 m -10 m.

4. Discussions

By comparing the strain gauge and extensometer data with the rainfall got an idea of stabilization of the slope is rapidly changed with the rainfall. Because, even with the slight rain, slip surfaces of the unstable slope and cracks are moving with some extent.

Though some sort of problems with less number of instruments was encountered, a successful landslide monitoring could be achieved.

In the mitigation process it is required to quantitatively identified the rate of dewatering value for maintain the GWL well below to the deepest effective slip surface. To perform it, proper pumping arrangement has to be installed in order to calculate the rate of dewatering.

5. Conclusions

According to the monitoring the type of this landslide is a debris rotational slide, and rock falling only at the top area.
Mainly 2 slip surfaces could be identified by first 6 month data analysis of Strain Gauges and Inclinometer (Fig4). In next 6 months, newly formed 2 slip surfaces also could be defined (Fig5).

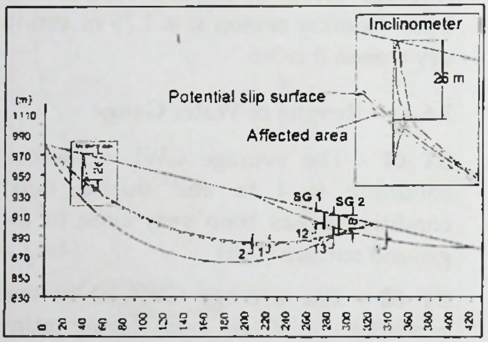


Figure 4: Potential Slip Surfaces Occured (24/07/2010 to 10/01/2011)

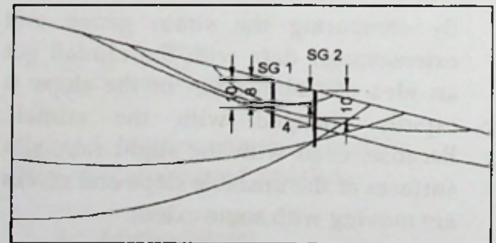


Figure 5: Newly formed Slip Surfaces (10/01/2011 to 14/06/2011)

According to the Piezometer and Water Gauge data GWL are as follows

Dry season -
Top of the slope - at 2.5 m depth
Middle area of the slope - 9.82 m depth

Rainy season-
Top of the slope - at 1.75 m depth
Middle area of the slope - 6.64 m depth

However the most critical factor of the landslide is the unfavourable GWL in slope area. Therefore, installation of a proper drainage method is essential.
It is better to insert horizontal drains up to the area of abandoned lake and reduce the GWL even below the main slip surface occurring 18 m depth below the SG2. Furthermore, to increase the feasibility of the project it can be introduced an agricultural water project from the removal water to the Kumbalgamuwa and Walapane community. In here, to distribute high quality water has to be introduced deep well system to prevent middle subsurface contaminated water entering. Inserting of proper surface drainage system is also essential. It can be done by having proper maintained ditches and diversion drain system.

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7. References

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