Slope Failures Evaluation and Landslides Investigation Using 2-D Resistivity Method

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ABSTRACT

Slope failure is a complex phenomenon that may caused to landslides. Buildings and infrastructure such as transportation facilities and pipelines located within the boundaries of a landslide can be damaged or destroyed. Slope failure classification and various factors contributing to the instability using 2-D resistivity survey conducted in Selangor, Malaysia are described. Six 2-D resistivity survey lines with 5 m minimum electrode spacing using Pole-dipole array were performed. The data were processed using Res2Dinv and surfer10 software to evaluate the subsurface characteristics. The 2-D resistivity results show that the subsurface consist of two main zones. The first zone was alluvium or highly weathered with resistivity value of 100-1000 Ωm and depth of >30 m. This zone consists of saturated area with resistivity value of 1-100 Ωm and boulders with resistivity value of 1200-7000 Ωm. The second zone with resistivity value of >7000 Ωm was interpreted as granitic bedrock. The study area was characterized by saturated zones, highly weathered zone, highly contain of sand and boulders that will trigger slope failure in the survey area. On the basis of the case examples described, 2-D resistivity method is categorized into desirable and useful method in determination of slope failure and future assessments.

Keywords: Slope failure, landslides, 2-D resistivity, saturated, boulders

INTRODUCTION

Landslides and slope failure are always related to hilly areas and restricted essentially to the urban area. Development for tourism and residential is still rampant in these areas. The prevalence of failures is due to a combination of few factors; i.e. topography, climate, geology and land use. Some countries have similar soils but different rainfall patterns, or similar rainfall but different land use. Urban development including used of steep natural slopes for housing and road are potentially caused unstable areas.

The purpose of resistivity survey is to determine the subsurface resistivity distribution by taking measurements on the ground surface. True resistivity of the subsurface can be estimated (Figure 1). The ground resistivity is related to various geological parameters such as mineral and fluid content, porosity and degree of water saturation in rock. Variations in electrical resistivity may indicate changes in composition, layer or contaminant levels (Telford and Sheriff, 1984).
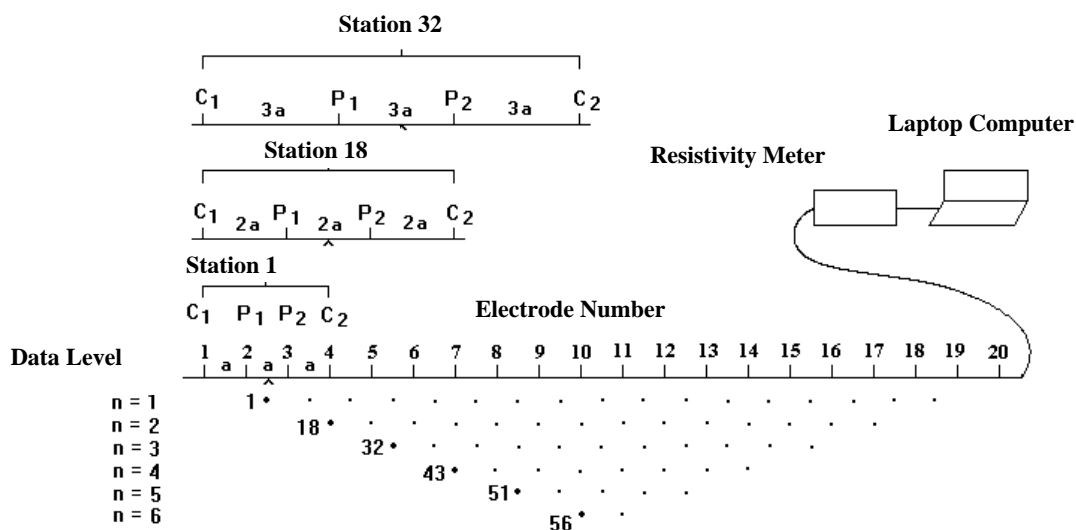

Figure 1: The arrangement of electrodes for a 2-D electrical survey and the sequence of measurements used to build up a pseudo section (Telford and Sheriff, 1984).

METHODOLOGY

Six (6) 2-D resistivity survey lines were conducted in Selangor. Lines RL1-RL3 was conducted towards North-South direction as shown in while RL4-RL6 directed towards West-East (Figure 2). The length for all the 2-D resistivity survey lines were 200 m except for RL1 and RL4 is 300 m each. RL1 was located outside the collapsed area while RL2-RL6 located in the collapsed area. The protocol used for 2-D resistivity was Pole-dipole with 5 m minimum electrode spacing and the data was processed using Res2Dinv software.
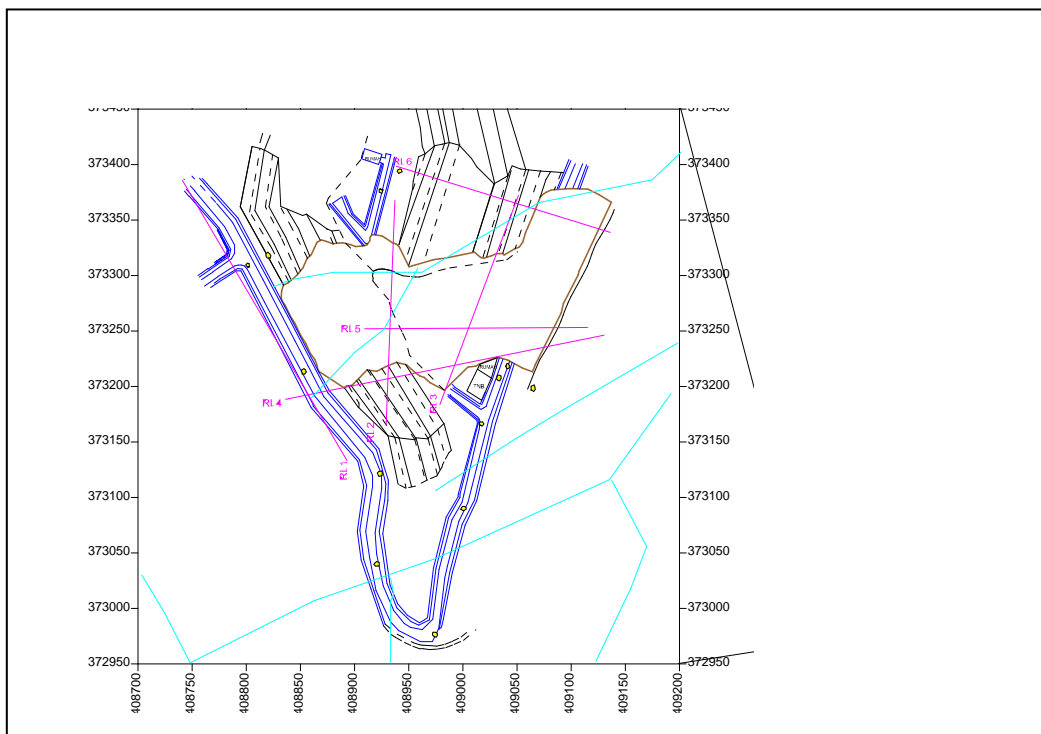

Figure 2: 2-D resistivity survey in Selangor, Malaysia

RESULTS AND DISCUSSION

From the 2-D resistivity method, the inversion model resistivity for potential area, RL1 (outside collapsed area) (Figure 3) shows there are 2 main zones. The first zone is alluvium or highly weathered with resistivity values of 100-1000 Ωm and depth of 70 m. This zone consists of saturated zone (1-100 Ωm) and boulders (1200-7000 Ωm). The second zone with

resistivity value of > 7000 Ωm which interpreted as granitic bedrock. A lot of small fractures can be seen around the study area as shown in Photo 1.
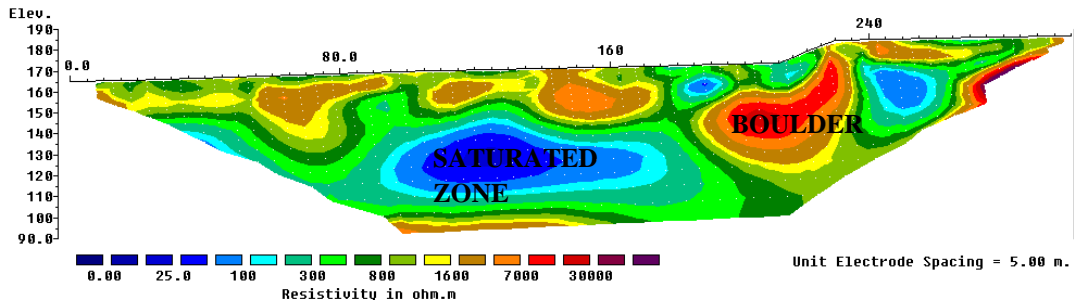

Figure 3: Inversion model resistivity in Selangor for RL1 (outside collapsed area).

Photo 1: Small fractures located at the collapsed area in Selangor.

Figure 4 shows the inversion model resistivity of RL2 and RL3 which has two main zones. The first zone is alluvium or highly weathered with resistivity value of 100-1000 Ωm and depth of 30-70 m. RL2 shows saturated zone while RL3 consists of alluvium or highly weathered zone. Boulders and fractures were located outside the collapsed area with resistivity value of 1200-7000 Ωm. Alluvium may consist of clay, sand and silt. Rainfall is also one of the factors that may cause to the instability of the slope. Seasonal nut high rate of rainfall, allowing part of the soil possibly to become fully saturated several times during wet seasons of any year. The study area is either decomposed volcanic rock (silt) or decomposed granite (silty sand) and both soils have high strength when unsaturated during dry season but

a low strength when fully saturated. The saturated zone, boulders and highly weathered rock

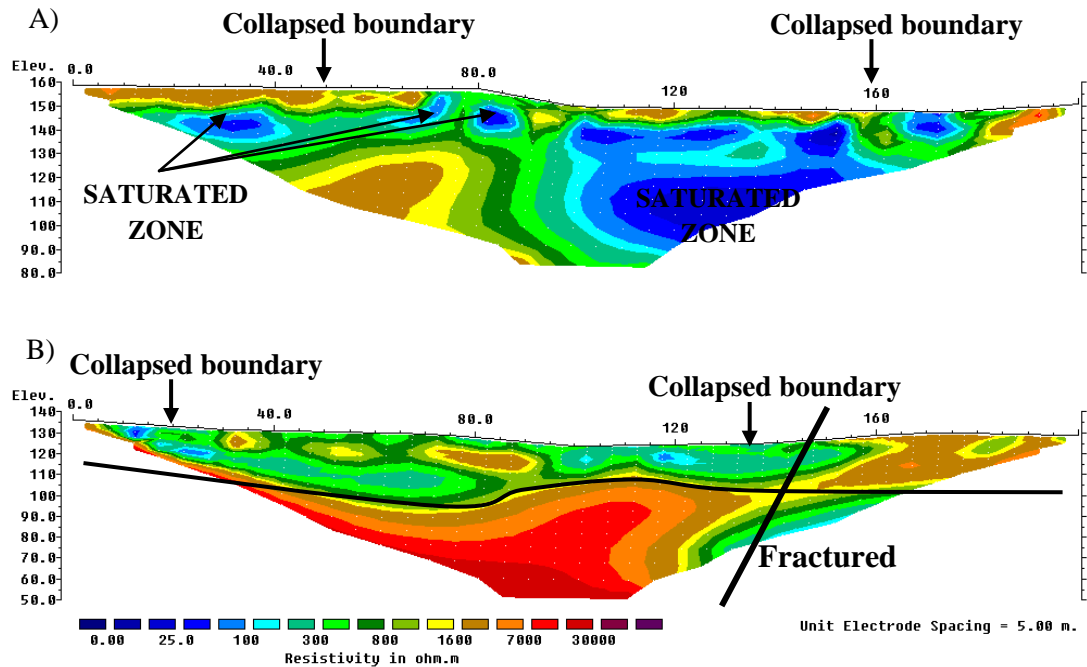will trigger the slope failure.

Figure 4: Inversion model resistivity in Selangor; A) LR2 and B) LR3.

Inversion model resistivity of RL4-RL6 shows two main zones (Figure 5). The first

zone with resistivity values of 100-1000 Ωm was interpreted as alluvium or highly weathered

rock with depth of 20-70 m. The zone consists of saturated zone and boulders with resistivity

value of 1-100 Ωm and 1200-7000 Ωm respectively. Second zone is granitic bedrock with
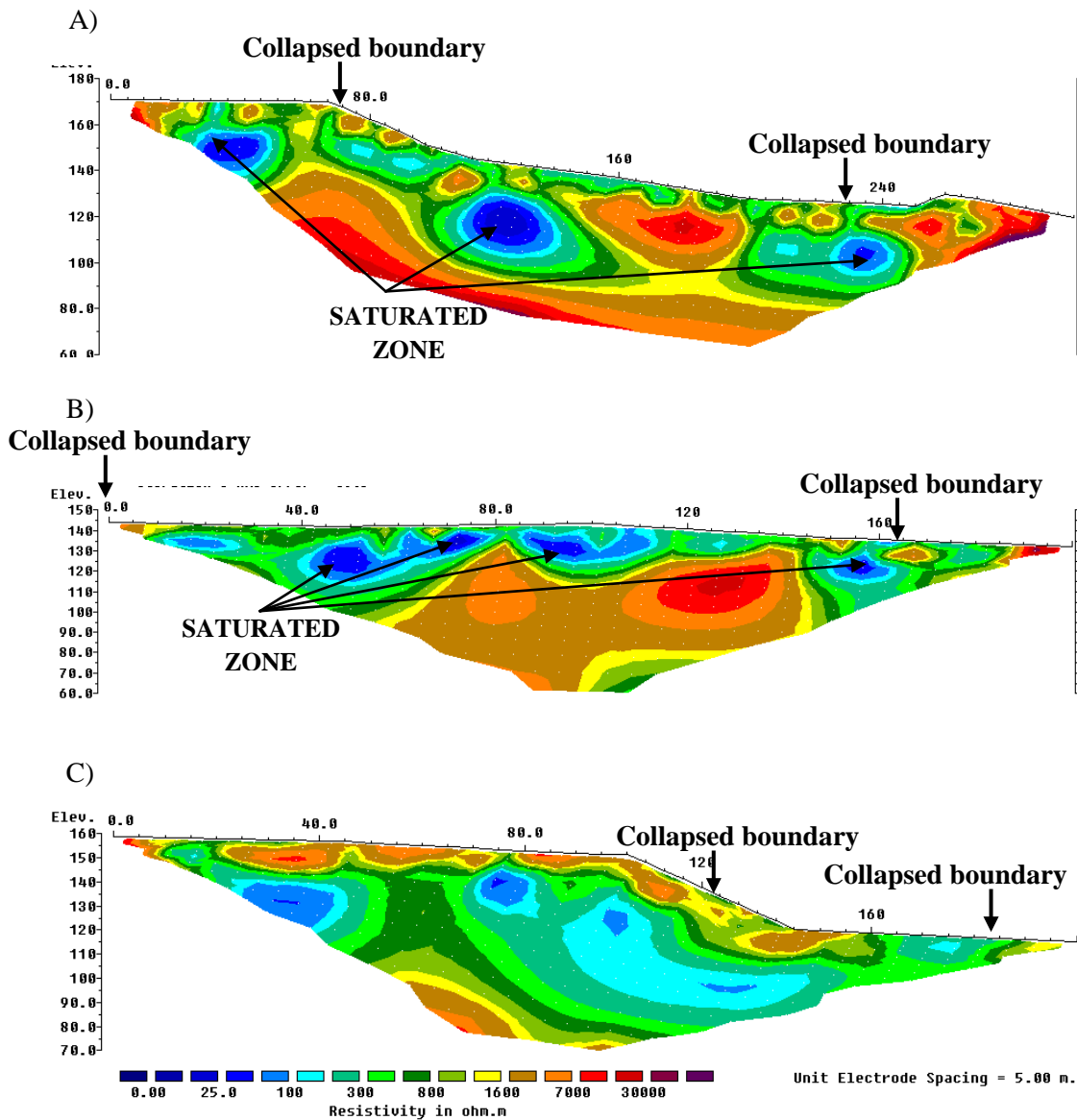
resistivity value of >7000 Ωm.

Figure 5: Inversion model resistivity in Selangor; A) RL4, B) RL5 and C) RL6.

Generally the results show that the study area consists of high resistivity value, it might due to sand. It was observed that the topsoil was characterized by isolated low resistivity materials that were identified as saturated zones, highly weathered zone and boulders. The saturated zone might be due to the present of Gapis River as shown in Figure 6. The higher the porosity will give higher permeability. Porosity can be a factor in permeability. Water flows quickly through material with high permeability. The Gapis River can be easily flow in the study area due to the sand contained. These low materials overlie the

bedrock produce unstable slope which trigger slope failure and may cause to landslides in the study area.
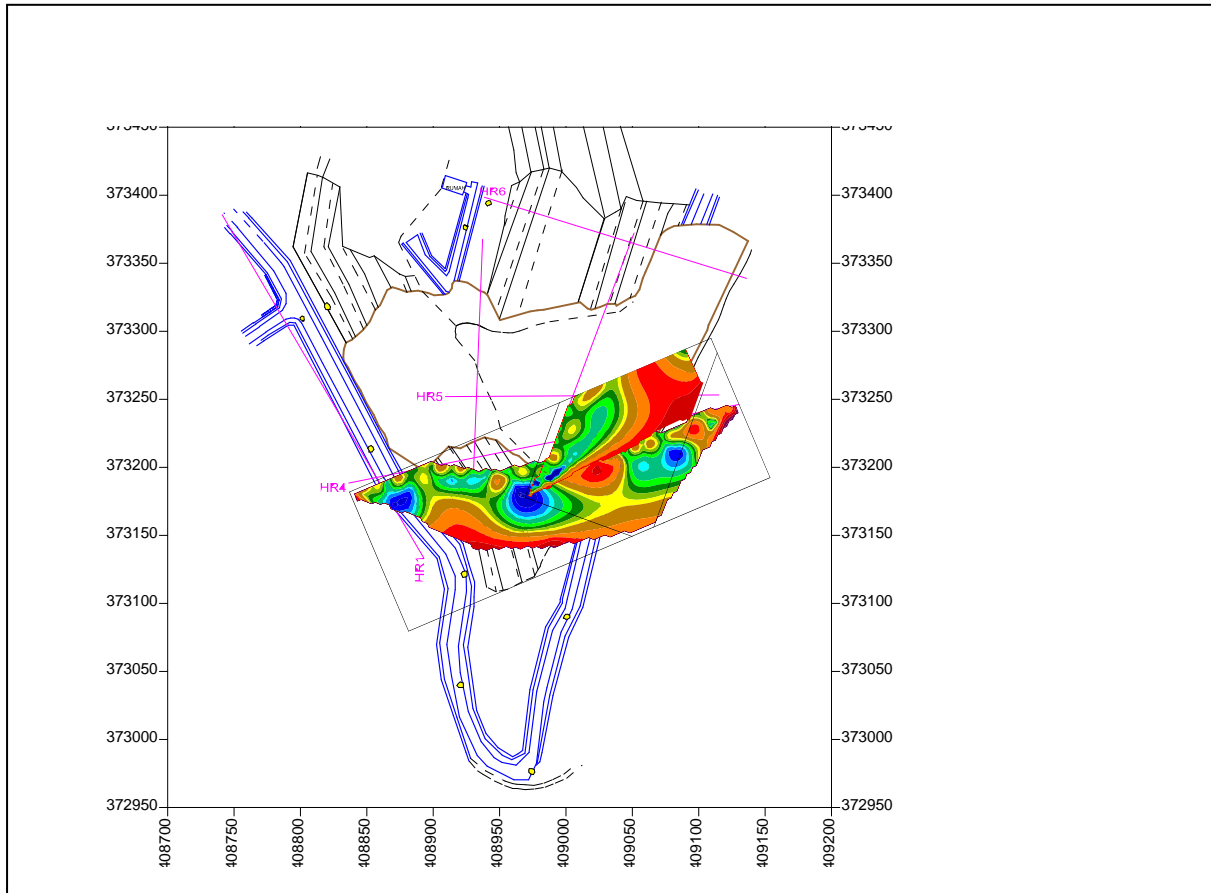

Figure 6: The arrangement of inversion model of resistivity with underground water from Gapis River.

CONCLUSION

The 2-D resistivity method has been carried out in Selangor, Malaysia. Six 2-D resistivity survey lines were carried out in order to identify the subsurface characteristic of slope failure. Results of inversion model resistivity indicates that the topsoil was characterized by isolated of low resistivity materials that were identified as saturated zones. The saturated zones, highly weathered zone, highly contain of sand and boulders will trigger slope failure in the survey area that finally may cause to landslides. Table 1 shows summarize of slope failure

evaluation using 2-D resistivity method. The 2-D inversion model resistivity has been correlated well with the geological map of Gapis River. Thus, the 2-D resistivity survey has provided valuable information on the subsurface characteristic and the results obtained may be useful for future slope instability investigation.

Table 1: Summarize of slope failure evaluation using 2-D resistivity in Selangor.

Category	Description
Zone	Two main zones with the first zone with 100-1000 Ωm was interpreted as alluvium or highly weathered rock. The zone consists of saturated zone (1-100 Ωm) and boulders (1200-7000 Ωm). Second zone is granitic bedrock with resistivity value of >7000 Ωm.
Fractured	Small fractured/ fault may caused to the earth movement.
Underground water	The flow of Gapis River contributes to low resistivity value which indicated as saturated zone.
Soil structure	Has high resistivity values due to the highly contained of sand and boulders.

ACKNOWLEDGMENTS

REFERENCES

Telford W.M and R.F. Sheriff, *Applied Geophysics*. Cambridge University Press, 1984.