IDENTIFICATION OF SLIP SURFACE USING 2D RESISTIVITY METHOD, CASE STUDY IN PIDADA, BANDAR LAMPUNG

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Abstract: Landslide is a disaster that occurs influenced by morphology, lithology, geological structure, hydrogeology and land use factors. Pidada Urban Village, Panjang District, Bandar Lampung is an area with morphological conditions in the form of hills with steep slopes. Based on data from the Center for Volcanology and Disaster Mitigation (PVMBG) in January-October 2019, the research area in Panjang District has the potential for medium-high mass movement. Criteria for the occurrence of landslides are steep slopes, the presence of slip surface below the surface of water saturated soil and the amount of water content that comes from rain water that seeps into the ground. One of the geophysical methods that can detect skid fields is the 2D Resistivity Method of Wenner-Schlumberger Configuration. Through this method it is known that areas that have high water content are indicated by low resistivity values. In this study, measurements were carried out on the slip area in a landslide prone area. After measuring the 2 lines, depth of the slip area of the study area was obtained.

Keywords: slip surface, landslide, resistivity

I. BACKGROUND

Bandar Lampung is a densely populated urban area consisting of land and water with several plateaus and mountains that lie in Bandar Lampung City [1]. Based on the Geological Map of Tanjungkarang Sheet [2], the geological condition in Bandar Lampung City is under the influence of Lampung-Panjang fault/ active fault. The existence of the fault is reflected in the morphological conditions in the form of hills with steep slopes. Lithology that dominates Bandar Lampung area is the former coastal sediment and rivers which are scattered around the Lampung Bay and around Tanjung Karang are dominated by weathered soil resulting from young volcanic activity from the Lampung Formation which is generally in the form of tuff rock. This geological condition creates the risk of terrestrial disasters, one of which is the land movement/ landslide.

Pidada Urban Village, Panjang District, Bandar Lampung City is an area with morphological conditions in the form of hills with steep slopes. Based on data from the Center for Volcanology and Disaster Mitigation (PVMBG) in January-October 2019 [3], the research area located in Panjang District

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has the medium-high potential mass movement. On Sunday, February 24, 2019 night, heavy rain triggered a landslide on Pidada Urban Village, Panjang District, Bandar Lampung [4]. The disaster caused land in the hilly areas fall and uproot a number of trees. According to data from the Bandar Lampung City Disaster Management Agency (BPBD), 2 houses in the area were affected and 2 other houses were severely damaged and the walls were broken down [5].

Landslide is a movement down or out of a slope by the mass of the soil or rocks making up the slope, or mixing both of them as a razor material, due to disturbance of the stability of the soil or rocks making up the slope [6]. Landslide is a disaster that occurs influenced by morphology, lithology, geological structure, hydrogeology and land use factors.

One of the factors that cause landslides which is very influential is the slip surface or shear surface. In general, lands that experience landslides will move above the slip plane. One method that can be used to investigate slip fields is the resistivity method [7]. The resistivity method is non-environmentally damaging, relatively inexpensive and able to detect subsurface structure. Therefore, this method can be used to survey landslide-prone areas, especially to determine the thickness of layers with a potential for landslides and lithology of rock layers beneath the surface.

Measurement of the resistivity method is done in 2 lines namely resistivity mapping and resistivity sounding. Resistivity mapping is intended to determine the horizontal distribution of soil layers and resistivity sounding to determine the distribution of rock conductivity vertically. In this study the Wenner-Schlumberger configuration is used, this configuration is a combination of resistivity mapping measurements using the Wenner configuration and resistivity sounding using the Schlumberger configuration. When compared with the Wenner configuration, the Schlumberger configuration has a penetration depth of 10% greater [8].

The identification of slip surfaces and subsurface structures in landslide prone areas of Pidada Urban Village, Panjang Sub-District was carried out as an effort to monitor landslides and disaster mitigation recommendations. This investigation utilizes the resistivity method with the Wenner-Schlumberger configuration.

II. MATERIALS AND METHODS

The study was conducted in August to October 2019 in Pidada Urban Village, Panjang District, Bandar Lampung City with a Wenner-Schlumberger configuration resistivity method.

2.1 Tools and Materials

2.1.1 Research Tools

The tools used in this study include:

1. GF Instrument ARES 3000, used to read measurement results.
2. Four electrodes, consisting of two current electrodes C1 and C2 and two potential electrodes P1 and P2.
3. Roll meter, used to measure distance of the line and spacing between the electrodes.
4. Four wire coils, used to connect the electrodes with a geoelectric device.
5. Accu, used as a voltage source.
6. Three Handy talky (HT), Garmin 78 S Global Positioning System (GPS), to determine the position of the measurement point.
7. Hammer, to make stakes at each measurement point.
8. Jacob Staff, for elevation measurements.
9. One laptop unit, complete with software: Microsoft Excel, and Res2Dinv Software
10. Satu unit laptop, lengkap dengan perangkat lunak: Microsoft excel, dan Software Res2Dinv
11. Field notebooks and stationery.

2.1.2 Materials Tools

The materials used in this study include:

1. Regional Geological Map Tanjungkarang Sheet sourced from the Center for Geological Research and Development.
2. Google earth map, obtained from the Google Earth.
3. Secondary data, including data from the results of previous studies covering the geology of the study area from regional geological maps, other secondary data relating to the research area and literature as a theoretical basis.

2.2 Research Method

The first stage of this research is a literature study on the geology of research area regionally and locally, google earth maps, and historical landslide data in landslide prone zones. The second stage, a preliminary survey was conducted to find out the general condition and explore information at the research location such as topography and location of the population's housing. This was done to create a survey design in the actual location.

The third stage, 2D resistivity measurements were carried out, this measurement uses a 115 meter cable stretch with a 5 meter electrode

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distance. 2D resistivity measurements are carried out on 2 lines in areas with high potential hazard. 2D resistivity measurements using the GF Instrument ARES 3000, as well as for topography were obtained from GPS Garmin 78S elevation data and manual measurements with Jacob Staff. The measurement results obtained from the field in the form of data resistivity type stored automatically GF ARES 3000 Instruments. Then, this data processed using Microsoft Excel to get pseudo resistivity values (ρ pseudo) then the inversion process is done using Res2Dinv software.

Data interpretation is done by looking at characteristics of rocks and resistivity values obtained from the results of inverse least square modeling with Res2Dinv Software. Interpretation is done by correlating the 2D cross section of the Res2Dinv software data processing with the topography of the study area, as well as the geological data obtained on the Geological Map of the Tanjungkarang Sheet. The data generated from this modeling are information on the value of subsurface resistivity, thickness of subsurface material, composing lithology, and topography of study area.

III. RESULTS AND DISCUSSION

The study area is composed of lowland morphology and hills with an altitude 20 to 150 masl. Based on geological observations, Panjang district area is composed of lithology in the form of very thick sedimentary tuff. Based on Tanjungkarang Geological Sheet Map [2], the research location is located in Tarahan Formation (Tpot) with the composition of solid tuff, breccias with chert insertion.

Data collection in the study area was carried out on 2 lines using the Wenner-Schlumberger configuration with a length of 115 meters each. The first line with the transverse direction to the northeast. Point 0 measurement is located at coordinates E 535851 and N 9395722 with an elevation of 23 meters above sea level and an end point that is with a stretch 115 m located at coordinates E 535908 and N 9395820 with an elevation 64 meters above sea level. The second line with the transverse direction to the northeast. Point of measurement 0 is located at coordinates E 535873 and N 9395690 with elevation of 19 masl and the end point of 115 m is located at coordinates E 535987 and N 9395693 with elevation of 55 masl. The measurement map is presented in Figure 1 and the visualization of the research area is presented in Figure 2.

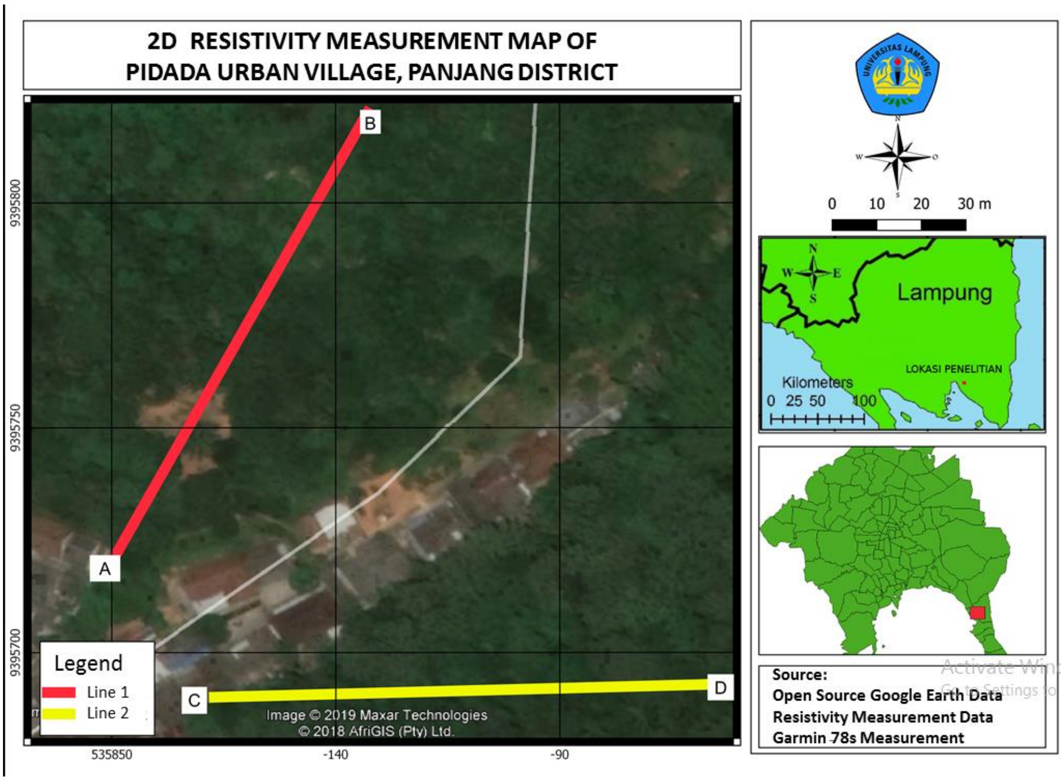

Figure 1. 2D resistivity measurement map of Pidada Urban Village, Panjang District.

Figure 2. Visualization of the Research area.

3.1 Analysis on Line 1

The results of processing for the first line, having a difference in height ranging from 41 m. The results of topographic data were obtained with GPS 78S, which then carried out elevation measurements with the Jacob Staff, so as to produce a type of inverse resistance model presented in Figure 3.

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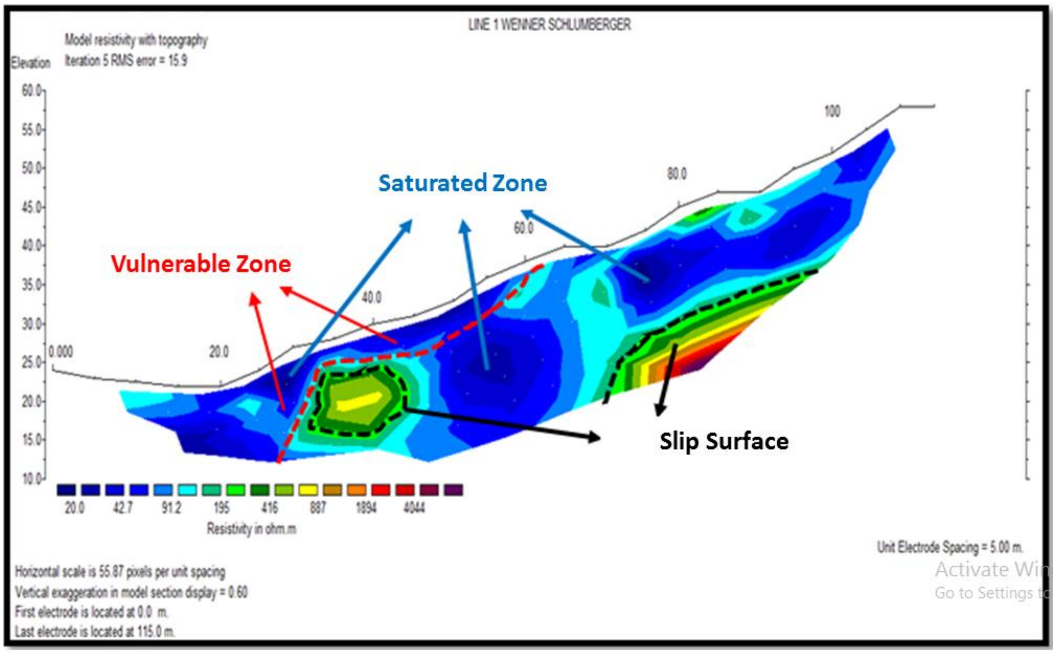

Figure 3. Cross check of Line 1.

Based on Table 1 [9], line 1 can be divided into 3 layers, namely tuff sediment with a resistivity value 1-91 Ωm and the image in the modeling that is dark blue, sandstone with a resistivity value 91-250 Ωm and the image in the modeling sky blue to light green, and breccia with resistivity values > 250 Ωm with images modeling dark green to dark purple. The total penetration of the inverse resistivity modeling on line 1 reached 24 m with iteration 5 resulting in a root mean square error value of 15.9%, with a very deep tuff sediment thickness reaching 0-15 m depth.

Table 1. Resistivity value of rocks and minerals [9].

Resistivity material	(Ohm meter)	Resistivity material	(Ohm meter)
Topsoil	50-100	*Graphitic schist*	10-500
Loose sand	500-5000	*Slates*	500-500.000
Gravel	100-600	*Quartzite*	500-800.000
Clay	1-100	*Pyrite*	0,01-100
Weathered bedrock	100-1000	*Pyrrhotite*	0,001-0,01
Sandstone	200-8000	*Chalcopyrite*	0,005-0,1
Limestone	500-10.000	*Galena*	0,001-100
Greenstone	500-200.000	*Sphalerite*	1000-1.000.000
Gabbro	100-500.000	*Magnetit*	0,01-1000
Granite	200-100.000	*Cassiterite*	0,001-10.000
Basalt	200-100.000	*Hematit*	0,01-1.000.000

In general, soil tuff sediment types are very easy to absorb water, because the porosity value of this medium is very high, but the water holding capacity is very less, coupled with contact resistivity values that differ from breccias. The upper layers of the skid plane (imaged with a black dotted line) were detected suspected as a layer of weathered rock or vulnerable zones (imaged with a red dotted line) that is in the form of a layer of tuff sediment and sandstone which can become a zone saturated by water , in lane 1 there are water saturated zones at lengths of lines 27, 47, and 72 m with each depth ranging from 5, 12, and 8 m. if high rainfall allows water to accumulate in these layers, so that in the event of an avalanche of the layers that experience movement. In this first lane, the vulnerable zone area is right next to the settlement or located at the bottom of lane 1 and at the bottom of cross section 1 has a slope of> 30^o which makes this area prone to landslide disaster.

In general, tuff sediment types are very easy to absorb water, because the porosity value of this medium is very high, but the water holding capacity is very less, coupled with contact resistivity values that differ from breccias. The upper layers of the slip surface (imaged with a black dotted line) were detected suspected as a layer of weathered rock or vulnerable zones (imaged with a red dotted line) that is in the form of a layer of tuff sediment and sandstone which can become a zone saturated by water, in line 1 there are water saturated zones at lengths of lines 27, 47, and 72 m with each depth ranging from 5, 12, and 8 m. If high rainfall allows water to accumulate in these layers, thus causing these layers have movement. In this first line, the vulnerable zone area is right next to the settlement or located at the bottom of line 1 and at the bottom of cross section 1 has a slope of> 30^o which makes this area prone to landslide disaster.

3.2 Analysis on Line 2

The results processing for the second line, has a height difference 36 m. The results of topographic data were obtained with GPS 78S, which then carried out elevation measurements with a Jacob Staff, resulting resistivity inversion models are presented in Figure 4.

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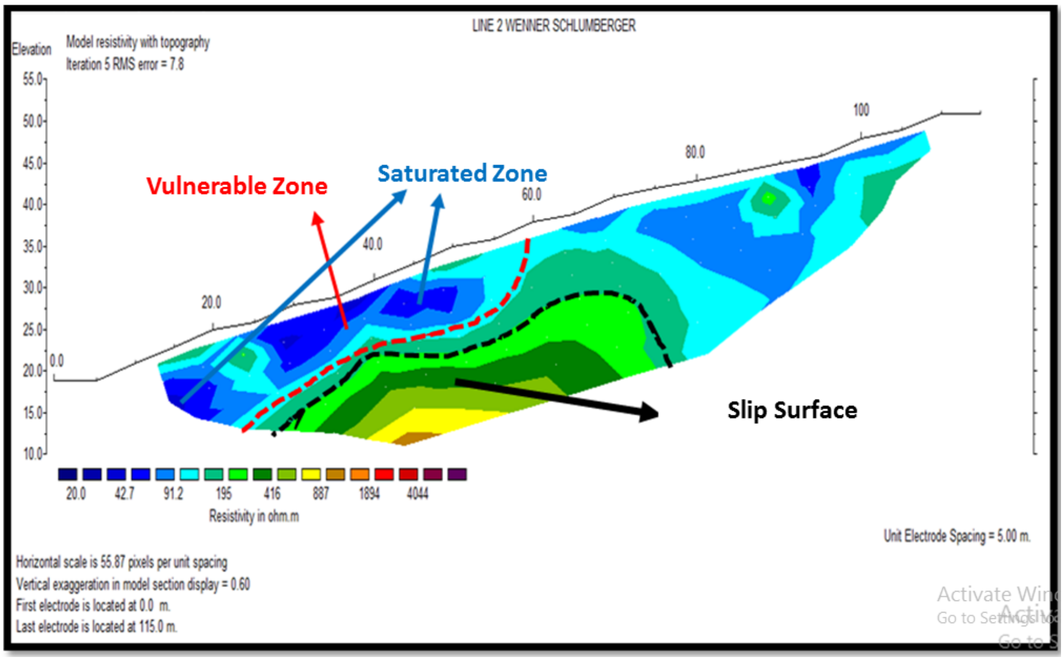

Figure 4. Cross check of Line 2.

Based on Table 1, line 2 can be divided into 3 layers, namely tuff sediments with resistivity values 1-91 Ωm with the image modeling dark blue, sandstone with resistivity value 91-250 Ωm with the image sky blue to light green, and breccia with resistivity value > 250 Ωm and modeling image dark green to deep purple. The total penetration of inverse resistivity modeling at line 1 is 24 m with iteration 5 resulting in a root mean square error of 7.8%, with a very deep tuff sediment thickness reaching 0-11 at a point of 0 line up to a range of 60 m, as well as thick tuff sedimentary layers in the range of 61-115 m.

Line 2 generally has the same characteristics of subsurface medium as Line 1. Layer of the slip surface is obtained between the contrast value of resistivity between two mediums which are close together. It is imaged with a black dotted line which is an area suspected as a layer of weathered rock or vulnerable zones imaged by a red dotted line in the form of a layer of sediment tuff and sand sand which can be a zone saturated by water, in this path 1 there is 3 water saturated zones at a length of 12, and 45 m with a depth of 5 and 6 m respectively. If high rainfall allows water to accumulate in these layers, thus causing these layers have movement. In this second line, the prone zone area is located right next to the settlement or is at the bottom of lane 1 and at the bottom of cross section 1 has a slope of> 30^{o} which makes this area a prone to landslide disaster, as evidenced by the occurrence of landslides in

February which caused a destroyed house. The location of the landslide or ground movement is presented in Figure 5.

Figure 5. Location of landslide on line 2.

IV. CONCLUSION

Through this method it is known that areas that have high water content are indicated by low resistivity values. In this study, measurements were carried out on the slip area in a landslide prone area. After measuring the 2 lines, information on the value of subsistence resistivity, thickness of subsurface material, lithology, and topography of the study area were obtained.

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