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To cite this article: Ikah N P. Permanasari et al 2019 J. Phys.: Conf. Ser. 1127 012042

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Determination of The Type of Soil Using 2D Geoelectric Method And Laboratory Analysis for Landslide Area Cililin West Java

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Abstract. Landslide occurrence at Mukapayu ng, Cililin West Java with material movement downward slope as far as 500m and hit residential areas of the village Nagrog cause eighteen people died and ten homes were destroyed and twenty-three heads of families evacuated. 2D Geoelectric measurements and index properties of soil analysis has been conducted to determine the type of soil slope composing. From the results of resistivity measurements obtained that the material making up the slope dominated by a mix of clay and sand, in which the soil types are prone to landslides if triggered by the presence of water.

1. Introduction

Landslide is one of natural hazard that affect humans and their livelihood especially in the mountainous area[1]. A landslide is generally defined as the movement of rock, debris and soil down to slope driven by gravity and preconditioned by the landform. Landslides can be classified into different categories depending on the types of materials (earth, rocks and debris) involved and the types of movements (fall, topple, slide, spread and flow); for example, rock fall and earth flow. Steepness of slope, morphology, soil type and underlying geology are the most important factors for causing landslides[2,3].

The main aim of the present study is to test the capability of 2D resistivity inversion of individual vertical electrical soundings (VES) to investigate the type of soil composing. The VES is common method to determined the geoelectric parameters[4,5,6,7]. Special attention is paid to explain the reasons behind the so-called waterless area. Resistivity data are measured with the conventional Schlumberger array and processed and interpreted in both 2D manners. VES is based mainly on injecting electric current to the earth via two electrodes (current electrodes) and measuring the potential difference via two other electrodes (potential electrodes). This four electrode system has many types of arrays such as Schlumberger, Wenner and, Dipole–Dipole. The vertical resistivity sounding is based on the concept of a homogeneous, isotropic, layered horizontal earth model. VES is effective in ground water exploration, particularly for water table detection. For the 1-D case, where the subsurface is restricted to a number of horizontal layers, the linear filter method is commonly used to calculate the true resistivity from the measured apparent resistivity[8].

In this paper we measure the resistivity of the soil Cililin Landslides area to determine the type of soil slope composing and have conducted laboratory measurement to see the properties index of the upper soil.
2. Theoretical Background

The resistivity of a substance or material is defined as the electrical resistance between the two surfaces facing each other of cubic unit material. Thus the resistivity can be referred to as the barrier type of material. In the case of the conductive cylinder with resistance $R$, length $L$, and the surface area of the material $A$, the resistivity values can be determined by the equation:

$$\rho = \frac{RA}{L}$$

(1)

The SI unit of resistivity $\rho$ are ohm-meter (ohm. m). The resistivity is highly variable physical properties. Some minerals such as metals and graphite electric discharge via the flow of electrons. There are also minerals isolator which the electric current is carried through the rock via the ions in the water. Most rocks conduct electricity to the electrolytic process compared to electronic processes as usual[9].

![Figure1](image1.png)

Figure1. The Parameters Used To Define Resistivity

Equation (1) refers to the conduction of electricity, but this equation can also be used to describe the effective resistivity of rock that the resistivity of rock and resistivity of water through the rock pores. Effective resistivity can be expressed in terms of resistivity and the volume of water in the rock pores, according to the empirical equation

$$\rho = \alpha \phi^{-b} f^{-c} \rho_w$$

(2)

with $\phi$ is porosity, $f$ is the fraction of pores that contain water with a resistivity $\rho_w$. $a$, $b$ and $c$ are empirical constants. Water resistivity value may vary depending on the quantity and conductivity of the material that is passed the water[4].

3. Result and Discussion

Mukapayung Landslide area is located in Cililin West Java Indonesia, about 35 km from the center of Bandung City (Fig. 2). The altitude of this Mukapayung, Cililin landslide area is around 974 meters about the mean sea level while the relief is dominated by the mountainous area. Type of ground surface is dominated by sandy soil moist and the presence of some water flow along the field measurements. Geoelectric measurements and sampling was conducted along 64 meters. The slope of the ground in the measuring area reached 45 degrees with the surface uneven ground because there are many piles of former land avalanches. Local conditions can be seen in Figure 3
In general, the District Cililin morphology area is fairly steep hills with a slope between 15 ° - 30 °. But in some places several settlements located on a steep cliff with a slope of more than 40 °. Bedrock forming the slope by Geological Map Sheet Cianjur, West Java, consisting of lacustrine, while the upper part of weathering in the form of clay soil in the form of sand with a thickness of 4 to 6 meters.

And the topography of the area measurement are show in the figure 4 below:
Figure 4. Topography of the area

Geoelectric data retrieval using a Wenner-Schlumberger configuration with 16 electrode (see Figure 5)

Figure 5. Geoelectric measurement with Wenner-Schlumberger configuration

From the measurement results is known that the area is dominated by the type of soil that has a resistivity values in the range 2.9-400 ohm.m. directly before the measurement can be seen that the ground is sand and clay-type soil. Resistivity values that small can be caused by a large flow of rain water infiltration on the surface of the soil so as to reduce the resistivity values of the measurements. This can be seen in the flow of water between the datum point 24-28 and 44-48.
Surface soil sample (disturbed) were took and measure the properties index of from the laboratory measurement of soil showed that the soil type material of the sloe is clay sand and the water content is 45.3% (see table 1)

**Table 1.** Index properties of soil

| Measurement         | Result                  |
|---------------------|-------------------------|
| Water content       | 45.3%                   |
| Wet density         | 1.63 (t/m³)             |
| Dry density         | 1.12 (t/m³)             |
| Specific gravity    | 2.60                    |
| Void ratio          | 1.31                    |
| Porosity            | 0.57                    |
| Saturated deg       | 89.15%                  |
| Soil type           | Clay-sand               |

In clay soil the structure changes with the water content due to the swell-shrink dynamics of the material. Important role played in the reactivations of landslides by the dry seasons and then rainy periods. Dry periods can cause a deeper cracking in the soils, which may facilitate water infiltration during rainy periods[10]. When water comes to the clay soil, in the long run soil will be saturated and induced the landslide.

### 4. Conclusion

Based on the result of the measurement, real resistivity value range is at 2.96 to 910 ohm.m. Its surface is dominated apparent resistivity values 2.96 up to 177 ohm.m which is the sandy soil soaked with the flow of water in the ground two points of the field. The bottom layer of the soil is dominated by a mixture of sand and clay soil and there is a layer of high resistivity is> 910 ohm.m who suspected is a layer of sandstone boulders. This soil type is suspected of causing landslides during the certain
amount of water into the ground and saturate the soil. In line with the analysis from resistivity value, the index properties analysis shown that the upper soil type is clay sand that can induced the landslide when water gets into the soil.

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