APPLICATION OF GEOELECTRICAL METHODS FOR IDENTIFICATION OF SOIL LAYER

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doi:10.5937/jaes0-29022

Cite article:


Online access of full paper is available at: www.engineeringscience.rs/browse-issues
APPLICATION OF GEOELECTRICAL METHODS FOR IDENTIFICATION OF SOIL LAYER

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INTRODUCTION

Landslide is a geological event caused by the movement of rock or land mass that can be defined as the displacement of slope-forming material, which is the original rock as well as the other material that is moving with the gravity. The factors that influence landslides are soil layer, slip surface and saturated soil. Mapping or determining the landslide area is done by identifying several parameters that can trigger landslide. The geophysical method that can be used to analyse soil layer is resistance type of geoelectrical. Variations of each rock or soil layer resistance below the measuring point can be obtained from the measurements of current and potential differences. The research site is located East Aceh district, Indonesia. Geoelectrical measurements using Wenner-Schlumberger electrode configuration. Based on geological information, field observation and geophysical measuring results, the area is dominated by clay, sand and gravel material. Lithology of clay dominates the underside of the surface (until the depth of ± 30 meters. Water that is held in sand lithology causes saturation of the sand. This is because there is a layer of clay under the sand which has low permeability or even impermeable properties. Saturated sand lithology can lead to contact between particles and has the potential to weaken it, causing soil movement

Key words: geoelectrical, soil layer, Wenner-Schlumberger configuration

GEOELECTRICAL METHOD

Geoelectrical method is one of the geophysical survey methods to identify the surface of the ground using the properties of rock electricity. The properties of the elec-
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Tricity is the resistivity type. A resistivity geoelectrical survey is generally used for shallow exploration (approximately 500 meters below the surface). The basic principle of this method is to inject a high voltage electric current into the ground through two current electrodes. Furthermore, the potential difference is measured using two electrodes, then the transmitted current and difference of the measured potential can be known its resistivity value of existing rocks below the surface. Thus, resistivity value can be used as a reference to the type of rock below the surface. Geoelectrical surveys are describe into two, sounding and mapping. Sounding is a survey to identify changes in the rock resistivity to the vertical direction. This method of measurement is commonly called the VES (Vertical Electrical Sounding). The mapping method itself is the identification of changes of the surface rock resistivity to the lateral direction. The illustration of a potential equilibrium line that occurs due to a current injection is shown at two current points (A and B current electrode) on the ground surface indicated by the fig 1.

Figure 1: The pattern of the flow and the potential of an ECG between the two current electrodes and the opposite polarity (Bahri (2005) in Kanata, P. and Zubaidah, T. (2008))

The potential difference between the M and N potential electrodes caused by the current injection on the A and B electrodes is indicated by the following equation,

$$\Delta V = V_M - V_N$$  \hspace{2cm} (1)

$$\Delta V = \frac{-p}{2\pi} \left( \frac{1}{AM} \cdot \frac{1}{BM} \cdot \frac{1}{AN} \cdot \frac{1}{BN} \right)$$  \hspace{2cm} (2)

$$p = \frac{2\pi}{l} \left( \frac{1}{AM} \cdot \frac{1}{BM} \cdot \frac{1}{AN} \cdot \frac{1}{BN} \right)^{-1}$$  \hspace{2cm} (3)

So,

$$p = k \frac{\Delta V}{l}$$  \hspace{2cm} (4)

With I current in Amphere, $\Delta V$ potential difference in volts, $p$ resistivity type in ohm meter and $K$ as the geometry factor of the electrode in meters. So it gets,

$$k = 2\pi \left( \frac{1}{AM} \cdot \frac{1}{BM} \cdot \frac{1}{AN} \cdot \frac{1}{BN} \right)^{-1}$$

This measurement used Wenner-Schlumberger electrode configuration. This configuration is a constant configuration with a space rule system which is where the $n$ factor for this configuration is a comparison of the distances between the C1-P1 (or C2-P2) electrode with a space between P1 (Fig 2).

If the distance between the potential electrodes (P1 and P2) is a then the distance between the current electrode (C1 and C2) is $2n + A$. The resistivity determination process uses 4 electrodes placed in a straight line. Telford, W.M. et al. (1990) and Reynold (1997) in Sugito et al. (2010) provides the resistivity value of different types of rocks and water as seen in Table 1.

![Figure 2: The electrode arrangement of the Wenner-Schlumberger configuration](image)

**Table 1: Resistivity value of different types of rocks and water**

<table>
<thead>
<tr>
<th>Rock</th>
<th>Resistivity (Ohmmeter)</th>
<th>Water</th>
<th>Resistivity (Ohmmeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Covered</td>
<td>250-1700</td>
<td>Meteoric water</td>
<td>30-1000</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>30-215</td>
<td>Sea Water</td>
<td>0.2</td>
</tr>
<tr>
<td>Clay (Wet)</td>
<td>1-100</td>
<td>Saline water 3%</td>
<td>0.15</td>
</tr>
<tr>
<td>Sand (dry)</td>
<td>80-1050</td>
<td>Saline water 20%</td>
<td>0.05</td>
</tr>
<tr>
<td>Soil (40% clay)</td>
<td>8</td>
<td>Surface Water (Igneous Rock)</td>
<td>0.1-3000</td>
</tr>
<tr>
<td>Soil (20% clay)</td>
<td>33</td>
<td>Surface Water (Sedimentary Rock)</td>
<td>10-100</td>
</tr>
<tr>
<td>Clay (dry)</td>
<td>50-150</td>
<td>Ground Water (igneous Rock)</td>
<td>0.5-150</td>
</tr>
<tr>
<td>Tufaan sand</td>
<td>20-100</td>
<td>Ground Water (Sedimentary Rock)</td>
<td>1-100</td>
</tr>
</tbody>
</table>

**RESEARCH METHODS**

The research site is located in three sub-districts, Julok sub-district, Indra Makmu sub-district, and Nurussalam.
sub-district where all three are located in East Aceh district. Research location shown in the Fig 3.

According to Cameron, N.R. (1980) [2] The island of Sumatra suffered a clockwise rotation at the end of the Miocene which resulted in the direction of the geological structure being southwest-northeast on the Plio-Pleistocene. The rotation and changing direction of this structure occurs due to fault of the Indian Ocean Plate to the west of Sumatra. The West also resulted in the western part of the island being lifted, and the eastern side became more down. The decline of the eastern part resulted in the land of erosion in the west to the east and resulted in the eastern part having a vast area of clay, peaty and mangroves. In the early Miocene period, Transgressi caused the East Aceh region to be flooded and resulted in sedimentation and forming the formation of Peutu, Belumai and Baong. Later in the late Miocene to the Pleistocene there was a regression that resulted in the stopping of the sea sedimentation and the clastic sedimentation resulting in the Keutapang, Seurula and Julu Rayeu formations.

Site investigation is carried out before starting the geoelectrical work. The acquisitions is done for 4 days. The Total trajectory was 4 with a breakdown of 1-round 1150 m, the track 2 along 975 m, trajectory 3 and 4 along 1150 m. This geoelectrical acquisition uses the Wenner-Schlumberger configuration (Fig 2) which is a configuration with a system of space rules that Constant.

The data that has been compiled in the format of DAT in software ZondRes2D then set into mesh parameters and the initiations model. The initial model or model created is a homogeneous subsurface model. With a homogeneous model then the mathematical model or the resulting response data will have a different value with the data response result of the measurement.

To get a data response (calculated data) that has the same value as measured data (measured data), it needs to be done inversion. Below we show examples of the results of the inversion of geoelectrical data (Fig 4 and Fig 5).
Geoelectrical Result

From data that has been processed using ZondRes2D software, resistivity model is obtained as shown in Fig 6. The four trails above generally have a range of resistivity values from 1-250 ohm meters. On the 1 and 2 paths have a variation distribution of relatively similar resistivity values. As for the track 3 is dominated by the low resistivity value (blue color), the low resistivity value has a range of 1-10 ohm meters. Contrary to track 3, track 4 is dominated by high resistivity (red color), low resistivity value has a range of 50-250 ohm meter.

From geological information and acquired resistivity model can be interpreted that low resistivity value associated with the clay present in this area and the high resistivity value of the gravel association which is widely found. The Medium value range (color green) with a range of 10-50 ohm meters is possible associated with a water-saturated pebble and gravel contact with a clay. Thus, the subsurface lithology of the geoelectrical measuring track can be modeled like Fig 7.

The sand or gravel on the clay prevent water coming from the surface. While the clay has a low permeability properties or even impermeable so that the water unable to soak.
through its pores. This condition can cause the sand layer above the clay to experience high saturation of water. This high saturation condition can result in a weak contact between the sand particles. When the contact or the connective power between sand particles or gravel is weak, the area of slope will easily occur soil movement.

**CONCLUSION**

Based on geological information, field observation and geophysical measuring results, the area is dominated by clay, sand and gravel material. Lithology of clay dominates the underside of the surface (until the depth of ± 30 meters). Water that is held in sand lithology causes saturation of the sand. This is because there is a layer of clay under the sand which has low permeability or even impermeable properties. Saturated sand lithology can lead to contact between particles and has the potential to weaken it, causing soil movement.

**REFERENCES**


