Detection of the Soft Soil at the Slope Area using Geoelectrical Resistivity Method

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Abstract. The landslide occur commonly in the slope zone area. The landslide may cause the damage and lose the wealth. This research aimed to detect the soft soil zone of the landslide area using geoelectrical resistivity method. The geoelectrical resistivity survey was conducted using Wenner configuration with a total of 40 electrodes. Interpretation of the geoelectrical model was improved through the direct surface resistivity measurement. The geoelectrical resistivity model shows the relatively low resistivity value at the near surface. The low resistivity value indicates that the soil is not solid and it is possible the water seep to the pore of the soil. The relatively higher resistivity value indicates that the soil is relatively compact and thus, the water is relatively hard to enter the pore. The soft zone of the soil at the slope is clearly observed and possible to slide down whenever water intervene the soil condition.

1. Introduction
The surface of the earth does not always form a flat plane or have elevation differences between one place and another so that it forms a slope [1]. The slope is a land surface where there are two different surface heights of land, due to the earth's gravitational force so that the land that has a higher position tends to move down which is often called the ground collapse [2]. Land collapse is not only caused by gravity, but it is also generally caused by low ground holding forces, increased external loads or hydraulic conditions and high water content [3].

In the collapsing of the land especially in the slope zone, water contributes to all three of the above. Water has a big rule in adding the mass of the land so that the gravity force just a trigger in the slope failur. Water enters unsaturated soil through the infiltration of surface water and seepage of water in the soil. Soil layer due to inundation and heavy rain that occurs with a fairly long time triggers the collapse of the soil due to disruption of the equilibrium of the slope, which is caused by a variety of human and natural activities themselves [4].

The landslides cause the negative impact to all the life aspects. It is not only to collapse of the land cause material losses, but it can also cause the loss of life of living things including humans. Various attempts have been made to overcome these problems, namely by anticipating the occurrence of land collapse, for example by using a retaining wall. But even a retaining wall cannot solve this problem because there are still often construction failures on the retaining wall. Therefore a slope stability analysis is needed.

Geophysical method, especially the geoelectrical resistivity has been used in all aspects of the subsurface investigation. The geoelectrical resistivity has been used in the peat soil investigation in the coastal area of Siak River delta, Indonesia [5]. The geoelectrical resistivity was also performed in the
investigation of groundwater quality in terms of heavy metal content [6,7]. The geophysical method furthermore was used to investigate the geothermal investigation, which the geothermal potential can be imaged well [8].

In this research, the geoelectrical resistivity method will be examined to investigate the weak zone of the slope area. The geoelectrical resistivity of the surface survey is calibrated by the direct resistivity measurement to improve the geoelectrical resistivity interpretation.

2. Methodology

The location of the survey was on the hillside of the Hulu Kasok area, an artificial lake in Kampar, Indonesia. This location was chosen because this area is a famous geotourism in Kampar (Figure 1), so that the stability of slope should be detected as early as possible. An homemade resistivity meter was used with Wenner configuration. The total of data reading for each line was 190 data. The electrodes were spaced 2 meter to allow the higher intensity of resistivity reading.

The processing of the data used a Res2Dinv software. The Res2Dinv is a computer program that can automatically describe 2-dimensional subsurface models from geoelectric survey data. This program uses forward modeling techniques from pseudo resistivity data from the measurement results to get the inversion results or data that is by the actual situation. In the Res2Dinv software, the inputted data are \( a \) (the distance between the electrodes), the electrode position and \( \rho \) (resistance to the type of material). Then it will try to translate it in the form of 2-dimensional images that are adjusted to the data that has been inputted. This data will be processed several times until a small percentage of RMS errors are obtained. The RMS error value indicates the level of difference from the measurement of the material resistivity value to the actual material resistivity value [9]. The greater the value of the RMS error, the model obtained from the inversion process will be smoother. Smooth models with high RMS error values tend to be less representative of actual conditions in the field. The interpretation of the resistivity value distribution model for subsurface materials is carried out by considering the factors that affect the resistivity value of the material and its distribution patterns. These factors include rock type, composition and natural conditions [10].

3. Results and Discussion

Figure 1 shows the resistivity survey location. The survey location was conducted at the Hulukasok tourism area, Kampar, Indonesia. In the figure 1, it can be seen that the geoelectrical resistivity was conducted at the hilly side of the main road to the tourism location. The survey line 1 and line 2 was surveyed at the landside of the Hulukasok hill.

The Figure 2 shows the geoelectrical resistivity model for line 1. In the figure, the material on the slope surface below the 36.5 meter electrode position has relatively low resistivity of about 340 ohm.m. (colored green). This shows that the material making up the material is relatively porous, so that the electric current relatively easily flows. Types of rocks that may be sand, clay and mix of them. The material at a depth of 4 meters below the 28-35 meter electrode position has a relatively low resistivity of about 300-500 ohm.m (green). This shows that the constituent of the material is relatively porous too. Types of rocks that may be the same with the previous interpretation. The material at the surface to a depth of 5 meters below the beginning survey to 25 meter electrode position has a very high resistivity, which is greater than 1200 ohm.m (yellow / red). This shows that the compilers are relatively dense, making it difficult to pass an electric current. Possible rock types are sandstone or other compacted material such as metamorphic rock. From the description above, it indicates that on track 1 there will be no indication of possibility land collapse.
Figure 1. Google Earth snapshot of the study area

Figure 2. The geoelectrical resistivity model of line 1.
Figure 3. The geoelectrical resistivity model of line 2.

Figure 3 shows the geoelectrical model of line 2 that conducted at more step slope. In the geoelectrical model of line 2, the material on the surface is relatively higher resistivity value of more than 1500 ohm.m. This value is indicating that the material is relatively hard when it compare at the deeper depth below 37 m deep. At the slope zone, the resistivity value is relatively low of about less than 100 ohm.m. These value is indicating the material is relatively soft. It is due to the material filled by the higher moisture content which is high in porosity. However, in the geoelectrical model of the line 2, the possibility of landslide is relatively higher than the area at the line 1. This is because the line 2 consists of low resistivity value at the slope zone. When the heavy rain, the water is very possible to enter the soft zone, which cause the weight of the soil will increase drastically, and it is possible to be collapsed.

4. Conclusion
The geoelectrical resistivity survey has been successfully used to detect the weak zone of the slope area in Hulu Kasok, the artificial lake in Kampar, Indonesia. The geoelectrical resistivity model showed the low resistivity value which is indicating of the soft zone of soil at some zones of the geoelectrical resistivity. However, the possibility of slope failure is need to analysed with the other factors that influence the slope failure.

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