The Identification of Hard Bottom Surface Structure using Correlation of Geoelectrical Resistivity Methods and SPT Data as Preliminary Studies for Laying the Foundation at Passing Cross Sumatera Toll Road, South Lampung Station

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Abstract
The planting of the upper pass foundation on the Sumatera toll road construction project in South Lampung requires proper planning in terms of both technical and safety aspect. Generally, in principle, the foundation should be able to reach soil layers, or in case the hard soil is not easily found, the compaction or soil recovery. To find out the geological condition below the soil surface, related to the planting and construction of the foundation, it is necessary to investigate and identify the geological structure of the area. The method used to identify the subsurface methods and the Standard Penetration Test (SPT). The resistivity geoelectrical method utilizes a variety of resistivity values for each rock, while the SPT method uses the amount of resistance (N) per depth of soil penetration in its process. The result of the investigation using these two parameters will then be correlated with the geological conditions of the research field to determine the hard surface structure. Hard layer on the research field had resistivity values above 250 $\Omega$ and N-SPT values is above 50, identified as a fine sand layer containing gravel breccia sandstone and granodiorite stones. The subsurface hard layer can be found from a depth of 0-25 meters at the research field.

1. Introduction
Planting of Upper pass foundation in Sumatera toll road construction station project located in South Lampung requires proper planning in terms of both technical and safety aspect. The significant number of failures of building construction in recent years is caused by the exploitation of the utilization of the ability of the land which exceeds the carrying capacity of the land itself [1]. The symptoms can be observed from the shifting of the foundation from the initial position, the cracking of the foundation structure and the worst impact is the building collapse. Generally, in principle, the foundation should be able to reach soil layers, or in case the hard soil is not easily found, the compaction or soil recovery [2]. To find out the geological conditions below the soil surface, related to the planting and constructing the foundation, it is eminent to investigate and identify the geological structure of the area [3].

Estimation of underground rock layers in the two-dimensional study area was carried out using geoelectrical resistivity method with Wenner configuration. It aims to identify the subsurface structure of the research location [4,5].
The geoelectrical resistivity method is one of the geoelectrical methods that is often used in shallow explorations, used in the exploration of springs, the state of subsurface structures and can also be used as a support for exploration of mining materials [6–8]. In the geoelectrical method survey will be obtained the value of the potential difference, current strength and rock resistance type [9,10]. In geoelectrical measurements of type resistors, usually, two C-current electrodes are used on the surface. The amount of potential at point on the surface will be affected by the two electrodes (Figure 1) [11, 12].

![Figure 1. Two current electrodes and an isotropic homogeneous earth surface potential](image)

Potential at the point $P_1$ caused by the current from the electrode $C_1$ and $C_2$ is:

$$V_1 = \frac{I \rho}{2\pi r_1} \tan V_2 = -\frac{I \rho}{2\pi r_2}$$

potential difference at the point $P_1$ due to current $C_1$ and $C_2$ to be:

$$V_1 + V_2 = \frac{I \rho}{2\pi} \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

Likewise the potential arising at the point $P_2$ due to the current from the electrode $C_1$ and $C_2$, So that the potential difference between points $P_1$ and $P_2$ written as:

$$\Delta V = \frac{I \rho}{2\pi} \left( \frac{1}{r_1} - \frac{1}{r_2} \right) - \left( \frac{1}{r_3} - \frac{1}{r_4} \right) = \frac{I \rho}{K}$$

or

$$\rho = K \frac{\Delta V}{T} \rightarrow K = \frac{2\pi}{\left( \frac{1}{r_1} - \frac{1}{r_2} \right) - \left( \frac{1}{r_3} - \frac{1}{r_4} \right)}$$

Where $K$ is a geometry factor that depends on the arrangement of electrodes.

The SPT method (Standard Penetration Test) is one of the geotechnical methods to measure the mechanical properties of soil by using a hammer punch and measuring the number of traps per depth of penetration [13]. The SPT test consists of a test of beating a thick wall split tube into the ground, accompanied by a measurement of the number of blows to insert a split tube as deep as 300 mm vertically. In this fall load system is used a hammer weighing 63.5 kg which is dropped repeatedly with a high falling 0.76 m. The testing is divided into three stages, which are 150 mm in length for each stage. The first stage is recorded as a stand, while the number of blows to enter the second and third stages is summed to get the value of punch N or SPT resistance which is stated in the number of blows 0.3 m [14].

The number of N blows gives a clue about the relative density (density) in the field, especially sand or gravel soil and soil type resistance to penetration, this test is usually used for hard soils, the greater the value of N (number of punches) given the greater the value density of a material [15].

The value of N will determine the type of soil as follows [16].

1) Hard Soil  :  $N \geq 50$

2) Medium Soil :  $15 \leq N < 50$

3) Soft Soil   :  $N < 15$

The average N value is determined by the formula [16];

$$N = \frac{\bar{N}}{t/N_i}$$

Where the SPT test data is in the form of $t$ as a measured reference depth (30 cm), $N_i$ as the the thickness of the pulverized layer (cm) and $N_i$ the resistance value of each layer.
2. Research Method

The geoelectrical resistivity data collection process is carried out at the site of the Construction of the Cross Sumatra Toll Road (STA 64 + 500) located in the Village of Sinar Ogan, Tanjung Bintang, South Lampung Regency, Lampung Province. The geoelectrical data collection point is 5 lines (GL.1, GL.2, GL.3, GL.4, and GL.5) with a length of 192 meters for each track, while the electrode configuration used is the Wenner configuration.

While the Standard Penetration Test (SPT) data is 1D data totaling 2 drill points (BH-1 & BH-2), each drill point depth is 12 (BH-1) and 20 meters (BH-2).

The geoelectricity and SPT research area conducted at the construction site of the Trans Sumatra Toll Road in Lampung Province is in the Tanjung Karang geological sheet. Based on previous research, the formation of the study area was in the Kgdsn lithology group. The Kgdsn lithology group is a Sulan Granodiorite group consisting of granodiorite and tonalite rocks. Breakthrough rock with the age of Early Cretaceous to Middle-Cretaceous Mesozoic. Granodiorite is a plutonic igneous rock, formed by the magma-rich intrusion of silica, which cools in the batolite or is deposited beneath the surface of the earth [17].

After the data obtained from the measurement of the resistivity geoelectrical method and the SPT method are obtained, the next step is to model the resistivity data into a 2D model and then correlate it with the SPT data and the surrounding geological conditions to identify the hard structure below the surface of the research location.
3. Result and Discussion

From the research that has been done, the results of 2D resistivity modeling have been correlated with the SPT data on the five paths shown in Figure 5.

Figure 4. Research flowchart

Figure 5. 2D resistivity modeling and 2D N-SPT modeling
Table 1 Geological information based on the resistivity value of the research location

| Rock Lithology       | N-SPT | Category | SPT Index |
|----------------------|-------|----------|-----------|
| Silt Clay            | 17    |          |           |
| Fine sand contains   | 23    | Medium   |           |
| Gravel               | 53    | Hard     |           |
| Slit                 | >250  | Hard     |           |
| Breccia sandstone    | 1500  |          |           |
| Granodiorite         |       |          |           |

Table 2 Geological information based on the N-SPT value of the research location

| Rock Lithology       | Resistivity Value | Resistivity Index |
|----------------------|-------------------|-------------------|
| Silt Clay            | 1 - 162 Ωm        |                   |
| Fine sand contains   | 251 - 529 Ωm      |                   |
| Silt                 | 200 - 250 Ωm      |                   |
| Breccia sandstone    | 529 - 1115.5 Ωm   |                   |
| Granodiorite         | >1115.5 Ωm        |                   |

From the results of the modeling above, the results show that the hard surface subsurface has a resistivity value above 250 Ωm and the N-SPT value is above 50. The subsurface hard layer at the research location can be found at each measurement path starting from 0 - 25 meters depth according to the distribution pattern. The results obtained were then taken into consideration in the process of laying the upper foundation of the cross-Sumatra toll road (STA 64 + 500) provided that the foundation must be placed in a hard layer beneath the surface to avoid undesirable things in the future.

4. Conclusion

Correlation of resistivity geoelectrical methods and SPT data can identify subsurface hard layers for geotechnical purposes, namely as a preliminary study of laying foundations on crossing Sumatra's toll roads, while hard layers in the study location have resistivity values above 250 Ωm and N-SPT values above 50 identified as fine sand layers containing gravel, breccia sandstone, and granodiorite stones. The subsurface hard layer can be found from a depth of 0-25 meters at the research location.

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