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Study of Corossion Potential in Subsoil Resistivity

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ABSTRACT

The degradation of a substance or its qualities as a result of a reaction with the environment is known as corrosion. Corrosion is a natural process that can take place in almost any substance, but it is most commonly linked with metal. The resistivity of the soil is the one variable that has the most significant impact on the pace of corrosion. Metal that is buried in soils with a low resistivity will, in most cases, become anodic, whereas metal that is buried in soils with a high resistivity will, in most cases, become cathodic. In order to prevent and protect the corrosion of buried metallic structures by underground soil, a soil resistivity field study carried out at Merauke District. The results of the research and interpretation of soil resistivity data that have been carried out can be said that the subsoil structure of the three measurements was identified as topsoil, silty soils, sandy soils, and clayey soils. Sandy and clayey soils that have low soil resistivity values between 2.22 – 11.3 Ωm have the potential to be highly corroded. Topsoil which has a high soil resistivity of 590.0 Ωm can pose a danger if the existing mud causes the water content of topsoil to increase.

Keywords: Corrossion, Subsoil resistivity, Water content

1. INTRODUCTION

The degradation of a substance or its qualities as a result of a reaction with the environment is known as corrosion [3]. Although it can happen to almost any substance, corrosion is most frequently linked to metal. Metallic corrosion is a naturally occurring process in which the environment's chemicals or electrochemical reactions cause the surface of a metallic structure to oxidize or reduce to a corrosion product like rust. Ion migration away from the surface of metallic structures attacks the surface, causing material loss over time. Given enough time, material loss can result in a sizable area reduction, which in turn lowers a given metallic element's structural strength. A failure will occur when corrosion eventually eliminates enough of the structure's strength.

Although the corrosion mechanisms involving buried metallic structures are extensively recognized, it is not always simple to anticipate with accuracy how much metal will be lost over time in the soil [5]. The great majority of square shaft and round shaft helical anchors and piles have calculated service lives that are typically 50 to 75 years or more than the structure's design life. Additional precautions must be taken to preserve steel foundation goods in very corrosive soils and places with stray currents, such as around DC trains and underground transmission pipelines. In these situations, active safety measures like sacrificial anodes are used.

In order to prevent and protect the corrosion of buried metallic structures by underground soil, a soil resistivity field study carried out at Merauke District, Province of Papua.

2. SOIL RESISTIVITY

The one factor that has the biggest impact on corrosion rate is soil resistivity. It is challenging to manage the environment so that there is only one variable due to the interdependence of other factors including the hydrogen-ion concentration, soluble salts, and overall acidity. In general, the rate of corrosion increases as resistivity decreases. Metal buried in soils with low resistivity is typically anodic, whereas metal buried in soils with high resistance nearby is typically cathodic.

Moisture content has a significant impact on resistivity, as illustrated in Figure 1 (Romanoff, 1957)[2]. A fully dry soil has an incredibly high resistance. For instance, whereas clayey soils that retain water have low resistivity and are often corrosive, sandier soils that rapidly drain away water are typically non-corrosive. Because the backfill soil has a higher moisture content than native earth, it will typically be more corrosive. Additionally, backfill material frequently never resolidifies to the same extent as native soil, allowing for greater water penetration and retention.

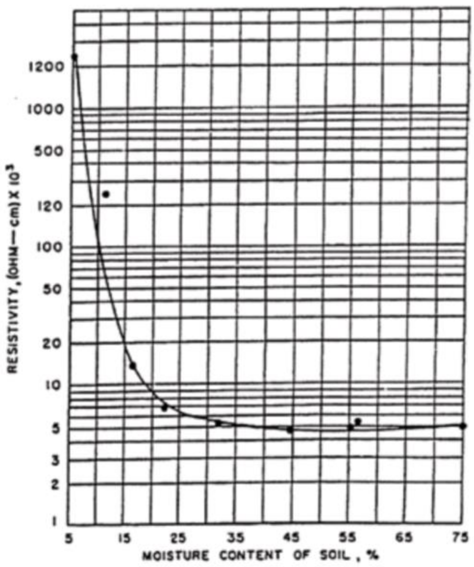

Figure 1. Effect of Moisture on Soil Resistivity.

Typically, one or both of the following two procedures are used to evaluate soil resistivity: (1) on-site testing using the Schlumberger method, or (2) sending a soil sample to a lab for a soil box resistivity test. The Schlumberger configuration used on-site in accordance with SNI 2018:2012 is the preferred practice[4]. The Schlumberger arrangement is suggested because it is relatively simple to measure the average resistivity of a substantial amount of earth. The soil box resistivity test is not advised since it necessitates the collection of numerous samples in order to provide an accurate map of the soil resistivities in a specific area. Additionally, the soil box test takes a lot longer to complete than the four-pin procedure. Table 1 is provided as a guide for estimating a soil's corrosion potential based solely on resistivity (Checker, 1986)[1].

Table 1. Soil Corrosion Potential Based on Soil Resistivity

Soil Resistivity (ohm.m)	Description
0 - 20	Very Corrosive
20 - 50	Corrosive
50 - 100	Moderately Corrosive
100 - 250	Midly Corrosive

250 - 500	Relative Less Corrosive
500 - 1000	Progressively Non-Corrosive

3. Resistivity Of Soil As Measured In The Field

The soil resistivity investigation is carried out at the location of the corrosion potential estimation point listed in Table 2. Determination of the location of the investigation point has several conditions that must be met, including :

a. There is a relatively flat location with a slope ranging from 0 - 5°.
b. Location has a minimum area of ± 250 m^2 for a length 200 – 400 m with an estimated depth of up to 70 – 130 m from the ground surface.
c. Measurements were made when it was not raining.
d. Measurements around the river or beach, the direction of the stretch must be parallel to the beach or river. If this condition cannot be met, then the direction of strain must be perpendicular to the object that affects it.
e. The direction of strain measurement should be sought that is not influenced by objects that can affect the accuracy of the measurement (such as railroads, pipelines, power lines).

Table 2. Soil Resistivity Coordinates

No.	Points	Coordinates X	Coordinates Y
1	SR1	475647	9195214
2	SR2	475611	9195119
3	SR3	475639	9195075

4. Interpretation Of Soil Resistivity

The measurement data in the site is then processed with IP2Win software so that it can show the results in the form of a curve with the interpretation of soil layers and soil lithology, in general from the research area. Data interpretation based on the results of computer analysis can be seen in Figure 2, Figure 3, and Figure 4.

The apparent resistivity value (a) is a measurable quantity that can be determined from field measurements. Once the apparent resistivity value change is understood, the real resistivity value may be calculated. In this research, researchers analyzed field data using Moscow State University's IP2Win program. The table from the figure shows the error matching, the field curve with the standard curve. Other available information includes N (code (sequence number) of soil resistivity layer), ρ (the value of the soil resistivity, ohm-m), h (thickness of soil layer, m), d (depth of boundary plane between layers, m), and Alt (elevation of the boundary plane, m).

A. Soil Resistivity 1 (SR1)

The SR1 measurement has soil that is colored red. The track length on the SR1 measurement is 100 m. The curve of the results of field data processing can be seen in Figure 2. There are four layers of data interpretation results with different resistivity values. The graph in the image shows three colors, namely blue, red, and black. Black is the result of field measurements, red is the result of synthetic data from processing, and blue is the layer at each depth. The interpretation of the resistivity values of SR1 is as follows.

a. First layer : A layer of soil with a resistivity value of 88.30 Ω.m at a layer depth of 0.00 – 0.59 m below the ground surface. This layer is interpreted as a layer of top soil which is silt.
b. Second layer ; A layer of soil with a resistivity value of 1446.00 Ω.m a thickness of 0.59 – 1.77 m below the ground surface. This layer is interpreted as a sand layer.

c. Third layer : A layer of soil with a value for resistivity of 11.30 Ω.m at a layer depth of 1.77 – 48.50 m below the ground surface. This layer is interpreted as a layer of sand that can function as an aquifer or groundwater-carrying layer.

d. Fourth layer : A layer of soil with a resistivity value of 2.22 Ω.m at a layer depth of 48.50 – 100.00 m below the ground surface. This layer is interpreted as a clay layer or rock layer with poor groundwater quality.

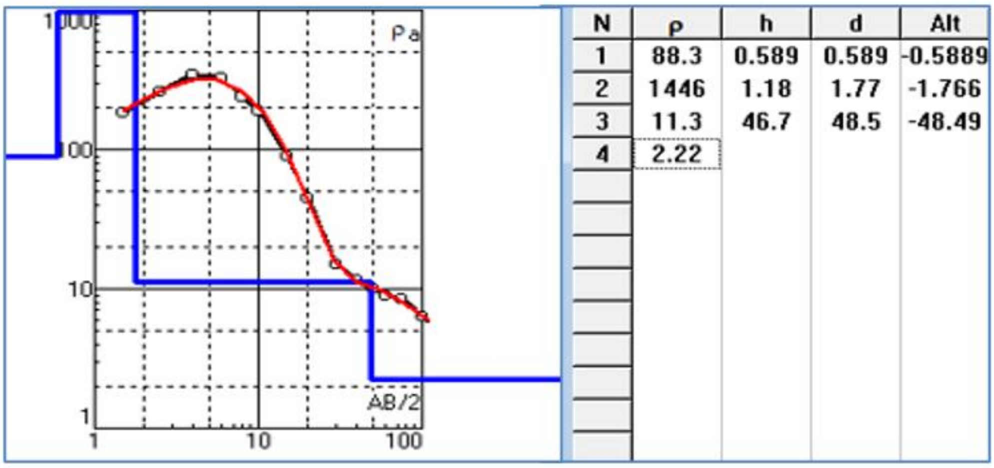

Figure 2. Data Interpretation Curve of SR1.

B. Soil Resistivity 2 (SR2)

The measurement on SR2 has the same soil as the measurement on SR2. The track length on the SR2 measurement is 150 m. The curve of the results of field data processing can be seen in Figure 3 below.

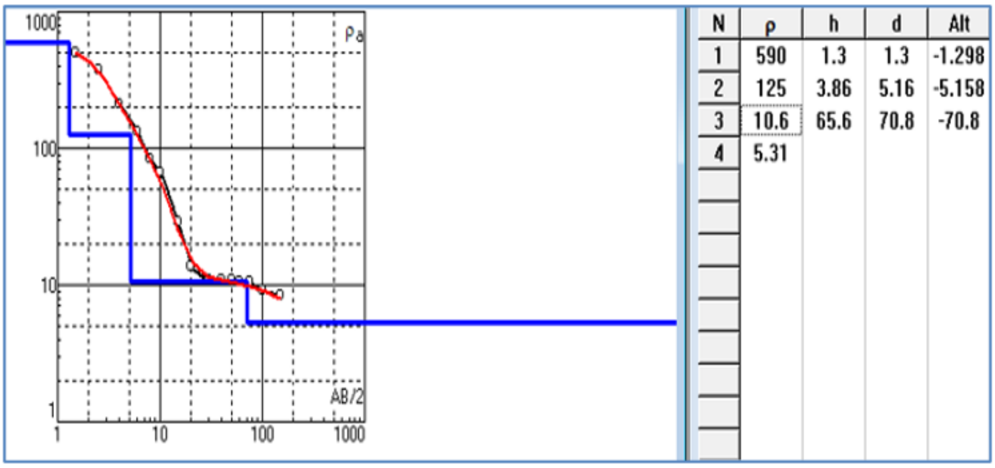

Figure 3. Data Interpretation Curve of SR2

The interpretation of the resistivity values of SR2 is as follows.

a. First layer : the soil layer with a resistivity value of 590.00 Ω.m at a layer depth 0.00 – 1.30 m below the ground surface. This layer is interpreted as a layer of top soil which is sand.

b. Second layer : the soil layer with a value for resistivity of 125.00 Ω.m at a thickness of 1.30 – 5.16 m below the ground surface. This layer is interpreted as a silt layer.

c. Third layer : the soil layer with a resistivity value of 10.6 Ω.m at a layer depth of 5.16 - 70.80 m below the ground surface. This layer is interpreted as a layer of sand that can function as an aquifer or groundwater-carrying layer.

d. Fourth layer : the soil layer with a resistivity value of 5.31 Ω.m at a layer depth of 70.80 – 150.00 m below the ground surface. This layer is interpreted as a clay layer or rock layer with poor groundwater quality.

C. Soil Resistivity 3 (SR3)

The measurement on SR3 were carried out in areas adjacent to mud puddles. The track length at this point is 200 m, the results of data processing on SR3 obtained four layers. The results of the interpretation of SR3 are as follows.

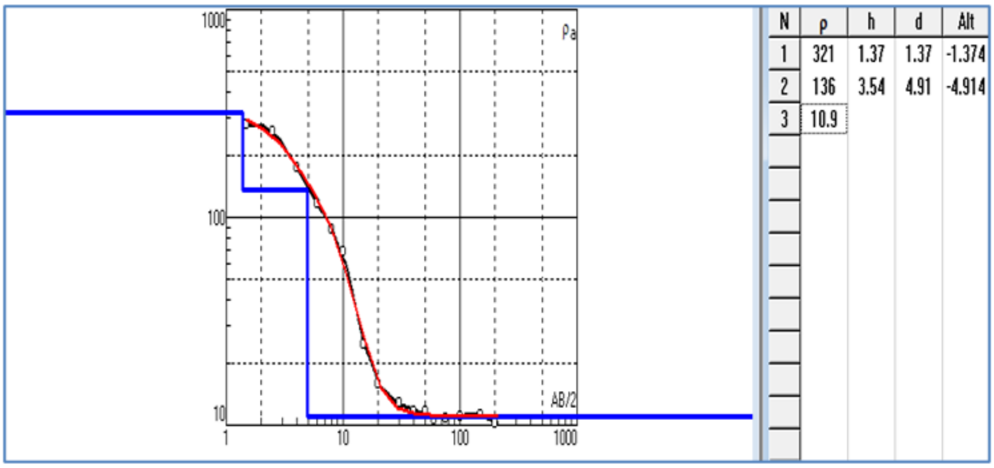

Figure 4. Data Interpretation Curve of SR3

a. First layer : the soil layer with a resistivity value of 590.00 Ω.m at a layer depth of 0.00 – 1.37 m below the ground surface. This layer is interpreted as a topsoil layer.

b. Second layer : the soil layer with a value for resistivity of 135.00 Ω.m at a thickness of 1.37 – 4.90 m below the ground surface. This layer is interpreted as a silt layer.

c. Third layer : the soil layer with a resistivity value of 10.30 Ω.m at a layer depth of 4.90 - 150.00 m below the ground surface. This layer is interpreted as a layer of sand that can serve as a groundwater-carrying layer.

The results of the corrosion potential investigation based on the soil resistivity value are given in Table 3.

Table 3. Results of Investigations on Corrosion Potential

Test	Depth (m)	Resistivity (Ohm.m)	Corostivity Potensial
SR1	0.0 – 0.59	88.3	Moderately Corrosive
	0.59 – 1.77	1446.0	Progressively Non-Corrosive
	1.77 – 48.50	11.3	Very Corrosive
	48.50 - 100	2.22	Very Corrosive
SR2	0.0 – 1.30	590.0	Progressively Non-Corrosive
	1.30 – 5.16	125.0	Midly Corrosive
	5.16 – 70.80	10.6	Very Corrosive
	7.80 – 150.0	5.31	Very Corrosive
SR3	0.0 – 1.37	590.0	Progressively Non-Corrosive
	1.37 – 4.90	135.0	Midly Corrosive

4.90 – 150.0	10.3	Very Corrosive

5. Conclusion

The results of the research and interpretation of soil resistivity data that have been carried out can be said that the subsoil structure of the three measurements was identified as topsoil, silty soils, sandy soils, and clayey soils. Sandy and clayey soils that have low soil resistivity values between 2.22 – 11.3 Ωm have the potential to be highly corroded. Topsoil which has a high soil resistivity of 590.0 Ωm can pose a danger if the existing mud causes the water content of topsoil to increase.

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