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Composition of mixing gypsum additives as environmentally friendly material in tropical soil to reduce grounding resistance

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Composition of mixing gypsum additives as environmentally friendly material in tropical soil to reduce grounding resistance

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Abstract. Grounding resistance is directly proportional to the amount of soil type resistance. While soil type resistance is influenced by several things, namely soil structure, temperature, the effect of water content (moisture), and the effect of chemical content in the soil. The purpose of this study was to analyze the decrease in the value of earth resistance by adding additives in the form of gypsum without a mixture of soil and gypsum mixed with soil. The results showed that the value of grounding resistance with the addition of gypsum without soil mixtures had a higher resistance value than grounding resistance without the addition of additives. Grounding resistance with the addition of gypsum mixed with soil on average can reduce the value of grounding resistance by 153.56 ohms with 25% gypsum, 157.2 ohms with 75% gypsum and 169.91 ohms with 50% gypsum.

1. Introduction

Indonesia is located in the equatorial lane which has a high level of thunder days ranging from 100-200 days of thunder per year. The distribution of electrical power is transmitted through high voltage tranmission, then distributed through a 20-kV medium voltage to the center of the load. Construction of towers and distribution poles can be struck by lightning due to being open to nature so that lightning currents will reach a certain point of the object being struck which causes disruption of power distribution. The disturbances that occur will have the effect of reducing the voltage and stability of the power system, and will endanger humans and can damage electrical and electronic equipment. This can be maintained with a good grounding system [1].

A good grounding system has soil resistance values ranging from 1-5 ohms, but to get a low resistance value is quite difficult because it is influenced by soil type, temperature and humidity, soil electrolyte conditions and temperature. The grounding system must pay attention to several important things, namely the resistance to the grounding electrode, the resistance between the grounding electrode and the ground, the resistance from the ground around the grounding electrode. Resistance to grounding electrodes is usually ignored because the value of the electrode resistance is usually smaller than that of ground resistance [2]. The value of grounding resistance around earthed ground electrodes needs to be considered because a low soil type resistance value is needed as a support for the grounding system where the fault current will be channeled to the ground.

The type of resistivity value from the soil around the electrode is usually not directly obtained a low value, therefore to design a good grounding system it is necessary to do an assessment first on the grounding place to be used. Areas with high soil type resistance if they want to be used as grounding soil need to be treated on the soil so that the value of the earthen resistance is low. Reducing soil type resistance can be done in several ways, namely by modifying grounding electrodes to be planted in the soil and adding additives to the earthen soil [3].

In our previous research we carried out experiments using bentonite and zeolite additives as additives that can be used to reduce the soil resistivity values of various types, namely sodium chloride (NaCl), magnesium (Mg), copper sulfate ($CuSO_4.H_2O$), and calcium chloride ($CaCl_2$). [4,5] This study uses gypsum (calcium sulfate dihydrate) as an additive. Gypsum is used as an additive to reduce soil type resistance because it can absorb water and improve soil structure.

This study conducted an experiment on adding gypsum as an additive to the soil. Gypsum added to the soil was varied into four variations, namely gypsum without mixed with soil, and gypsum mixed with soil with a composition of 75% gypsum mixed with 25% soil, 50% gypsum mixed with 50% soil and 25% gypsum mixed with 75% soil. This study aims to observe the effect of adding variations in gypsum additives to a decrease in the value of soil type resistance. The expected results from this study are to obtain the best variation of additives which can reduce grounding resistance significantly

2. Literature review

2.1 Tropical Soil

Soil is a material composed of 8 granule-forming mineral elements and the largest percentage is oxygen reaching 46.6%, other elements are Si, Al, Fe, Ca, Na, K, Mg [6]. Mixing between gypsum and soil elements produces a compactness in neutralizing the resistance of stem electrode. So that this research can achieve the actual goals. The nature of the soil itself can be determined by research on the physical properties of the soil in the form of water content, volume weight, specific gravity, behavior of plasticity and elasticity in the soil and the size of its grain. The density of a soil also influences the behavior of the results of the research and compaction of the soil will cause the loss of water and air in the pore [5]. The following is given a table of the physical properties of the soil used before the soil is mixed with gypsum.

Table 1. Physical properties of soil used in research

Description		BOR 1 1,60 – 2,00
Undisturbed Sample		
Water Content	%	37,39
Density	gr/cm^3	1,47
Specific gravity (Gs)		2,57
Percent Lose No. 200	%	33,94
Atterberg Limit		
LL	%	51,33
PL	%	39,59
PI	%	11,75
Direct Shear Test		
Cohesion (c)	kg/cm	0,15
Internal Friction Angle (ϕ)	$\ldots^0$	26,54
Consolidation		
Cv	cm^2/s	0,132
Cc		0,129

Table 1 show the water content at the time of sampling includes a high-water content. Soil samples are taken at a depth between 1.6 m and 2 meters. Taken by undisturbed tube. From the results of this study it was stated that the clay content reached 33.94% and included clay sand.

2.2 Gypsum
Gypsum is a chemical that has the formula $CaSO_4.2H_2O$. Gypsum is claimed to contain 50% to 95% $CaSO_4$ (Calcium Sulfate Dehydrate) and in natural CaSO4 there are 23.5% sulfur and 29.4% calcium. The sulfur content of gypsum does not reduce the alkalinity of the soil (Alkalinity is the property in which substances form chemical salts when combined with acid) and the calcium content in gypsum does not affect the acidity (pH) of the soil [7]. The physical form of gypsum can be seen in Figure 1.

Figure 1. Gypsum powder

Gypsum as an additive used to change the chemical composition of the soil, which has a low solubility value that is not easily lost. Gypsum is a stone formed from the deposition of sea water, a mineral composed of calcium sulfate dehydrate with the chemical formula $CaSO_4.2H_2O$. Composition of Calcium Oxide (CaO) 32.57%, Water (H_2O) 20.93%, and Sulfur (S) 18.62%. This composition is expected to reduce gypsum resistance. Gypsum in the form of rock, formed because of two things, namely evaporation of ground water and deposition of groundwater itself. Climate change and oxidation reactions cause sulfur to turn into sulfuric acid in the soil containing $CaCO_3$ and forming gypsum. Gypsum is dissolved salt, hydrous calcium sulphate $CaSO_4.2H_2O$. The solubility rate is 2.6 grams of dm-3 in water at a temperature of 250 C and a pressure of 1 atmosphere. The arid and semi-arid soil causes gypsum to dissolve during the rainy season and tends to settle when the soil starts to dry out. [8].

The type of resistance (ρ) gypsum has different values depending on the surroundings. The research that has been done shows the resistance value of pure gypsum in the form of rocks in the amount of more than 800 ohm.m whereas for areas with wet soil conditions, it shows that gypsum has a high conductivity with a low resistance (close to 1 ohm.m) This is because the ions dissolved in water from material containing salt. [9]

2.3 Driven Rod Electrode
A good grounding system is very much determined by the type of soil that is good for determining the soil resistivity because not all types of soil have a good resistivity value, which is influenced by the density and contamination of the soil. To see grounding systems can be shown in various soil resistivity values for various types of soil. Table 2 shows the criteria for soil types and their resistivity values.

Table 2. Soil Type and Resistivity [10]

Soil Type	Resistivity (ohm-cm)
Clay, Garden Soil, dl	500-5000
Clay	800-5000
Mixture of clay, sand and gravel	4000-25000
sand and gravel	6000-10000
State, Rocky stone, dll	1000-50000

The results of the study in table 2 classify the criteria for soil types with resistivity values obtained in certain regions. Resistivity values are taken from measurements through samples from certain types of soil but it is possible to get results with conditions similar to samples taken.

The grounding system aims to obtain a low resistance value to channel fault current to the ground through a single rod electrode medium. Single rod electrodes are made of copper, steel profiles, which are influenced by the size, dimensions, and material of the rod electrodes. In general, rod electrodes use cylinders made of pure copper, bare copper rod and coated (copper-clad steel), stainless steel rod (stainless rod), copper wire inserted into galvanized pipe rods, copper plated steel. This study aims to determine the value of grounding resistance on clay to mixing gypsum with various compositions.

3. Experimental setup

The method used to determine the value in ground resistance by punching the ground with a depth of 1 m, where the stem electrodes are planted at a predetermined depth and diameter, then add the gypsum additive into the hole and mix it with the soil with the composition specified. Gypsum is varied before it is used as an additive in soil soils. There were five soil sources in this study, 100% gypsum, 75% gypsum, 50% gypsum, 25% gypsum and no gypsum as a comparison. Each grounding hole made in this study is illustrated as in Figure 2. The grounding electrode used is inserted into the grounding hole with a diameter of 10 centimeters and a depth of 1 meter. Next, each hole earth additive. The distance between the electrodes and the other electrodes is 50 centimeters.

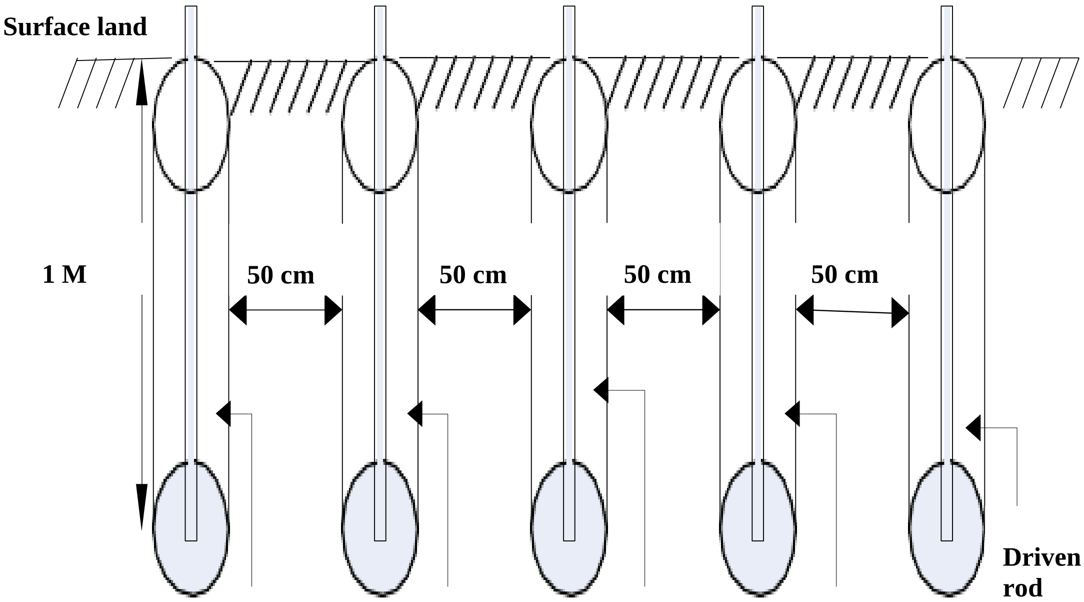

Figure 2. Set up designed to measure soil resistance mixed with gypsum

The composition of the mixture between soil and gypsum and the distance between 50 cm holes can be shown below :

1. Ground: 100%
2. Gypsum: 100%
3. Gypsum: 75%
4. Gypsum: 50%
5. Gypsum: 25%

Electrodes used in the type of electrode rod made from copper with a diameter of 0.015 m with a length of 1 m. The tip of the electrode will be planted into the ground as a point to touch the center of the electrode to the ground. To plant electrodes in a predetermined hole and be marked on holes that have been dug. There are 5 holes dug with a depth of 1 m, then hole 1 is filled with 100% pure soil without mixture and holes 2 to 5 are filled with mixing gypsum with a presentation value of 25% -75% as additives that have been smooth and not clot.

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4. Result and discussion

This research was started by making grounding holes and continued by mixing variations of gypsum with soil with variations of 100% gypsum, 75% gypsum mixed with 25% soil, 50% gypsum mixed with 50% soil and 25% gypsum mixed with 75% soil. The mixed mixture of gypsum is put into the grounding hole with a depth of each hole of 1 m and a diameter of 10 cm.

4.1 Results of Measurement of Grounding Resistance

4.1.1 Variation of Gypsum 100%. The graph in Figure 3 shows the resistance value with the length of the soil measurement as a sample without mixture with gypsum and the measurement of soil resistance values mixed with gypsum 100%.

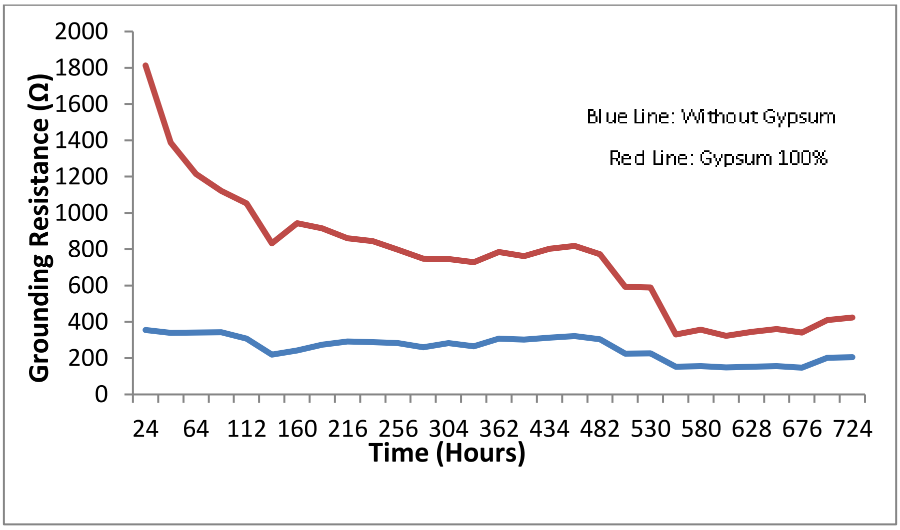

Figure 3. Grounding resistance of bentonite-mixed gypsum (100%)

Figure 3, it is seen that the value of grounding resistance with the addition of gypsum is very high at the beginning of the measurement. Gypsum density in the soil affects (decreases) the ability of gypsum to absorb water. This causes the value of grounding resistance to be high. After the location around the object of research experienced rain, grounding resistance with the addition of 100% gypsum began to decline. This decrease in the value of grounding resistance is because the gypsum in the grounding hole has absorbed the water and minerals found in the surrounding soil. The measurement data in the research from 538 hours to 732 hours showed the value of grounding resistance by adding 100% gypsum not much different from the grounding resistance without the addition of additives. This shows that grounding resistance with the addition of 100% gypsum does not differ much from the value of grounding resistance without the addition of additives

4.1.2 Variation of Gypsum 75%. In Figure 4, it can be seen that the value of grounding resistance with the addition of 75% gypsum is better than the value of grounding resistance without the addition of additives where the grounding resistance with the addition of gypsum is 75% lower than that of grounding without additives. The value of grounding resistance with the addition of 75% gypsum has decreased dramatically at the beginning of the grounding measurement to decrease with a research time of 130 hours. The decrease in the value of grounding resistance is due to the mixture of materials used as additives absorbing soil water and minerals found in the soil around the grounding hole.

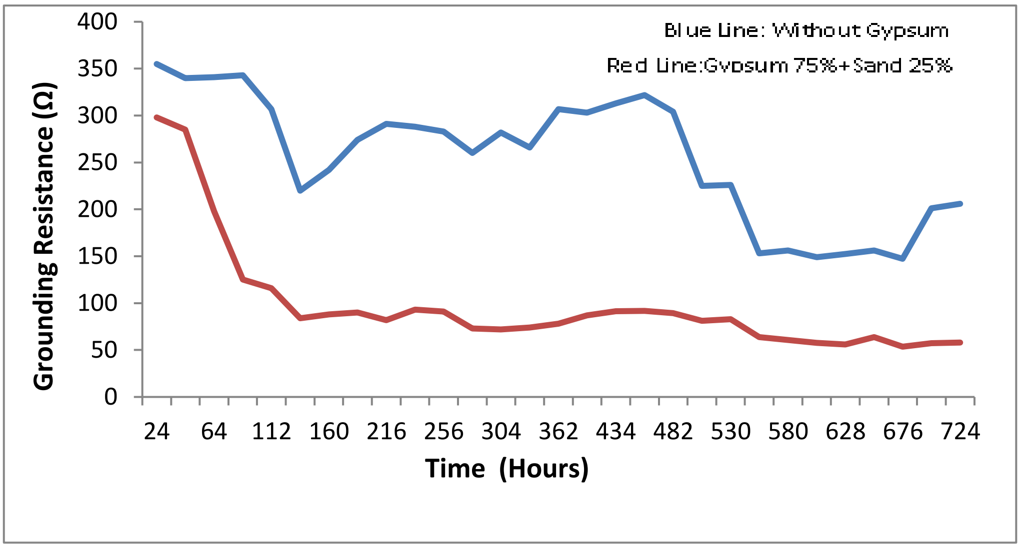

Figure 4. Grounding resistance of bentonite-mixed gypsum (75%)

4.1.3 Variation of Gypsum 50%. Figure 5, it can be seen that the value of grounding resistance with the addition of 50% gypsum is better than the value of grounding resistance without the addition of additives. This is because the mixture of 50% gypsum material and 50% soil is able to absorb water better than the soil without the addition of additives. The measured grounding resistance values from 556 hours to 732 hours of planted electrodes did not undergo significant changes. This shows that the mixture of 50% gypsum and 50% soil has reached a saturation point in reducing ground resistance where the lowest value of grounding resistance is measured at 51.8 ohms.

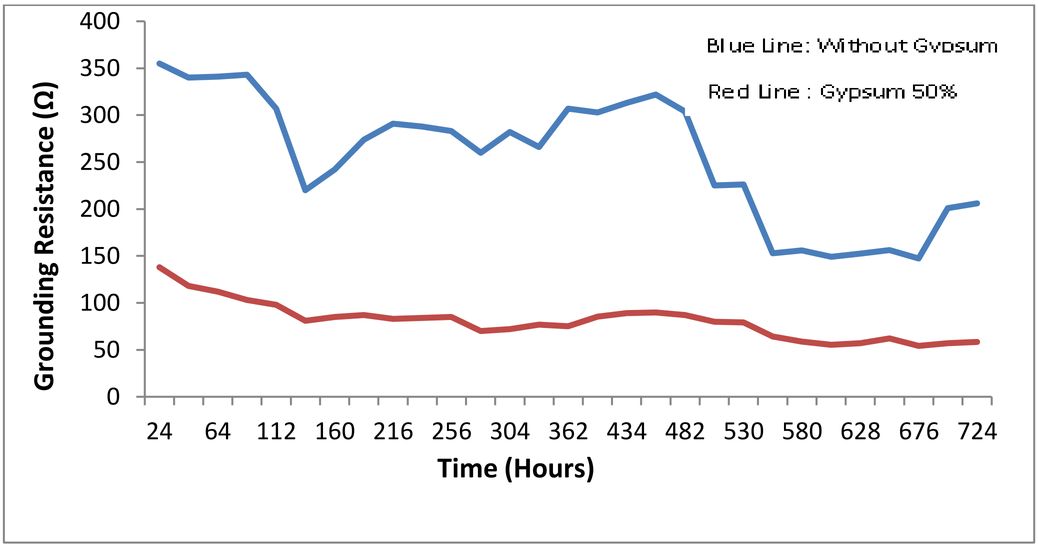

Figure 5. Grounding resistance of bentonite-mixed gypsum (50%)

4.1.4 Variation of Gypsum 25% The graph in Figure 6 below shows the value of soil resistance with a variation of 75% addition of gypsum on the ground from the resistance value on the blue line of measurement of resistance to the soil. There was a significant decrease after measurement of 24 hours as shown in the graph in figure 6. From the various measurements made with the composition of soil and gypsum showing variations in soil and gypsum 25% far more significant the results obtained based on measurements for 724 hours.

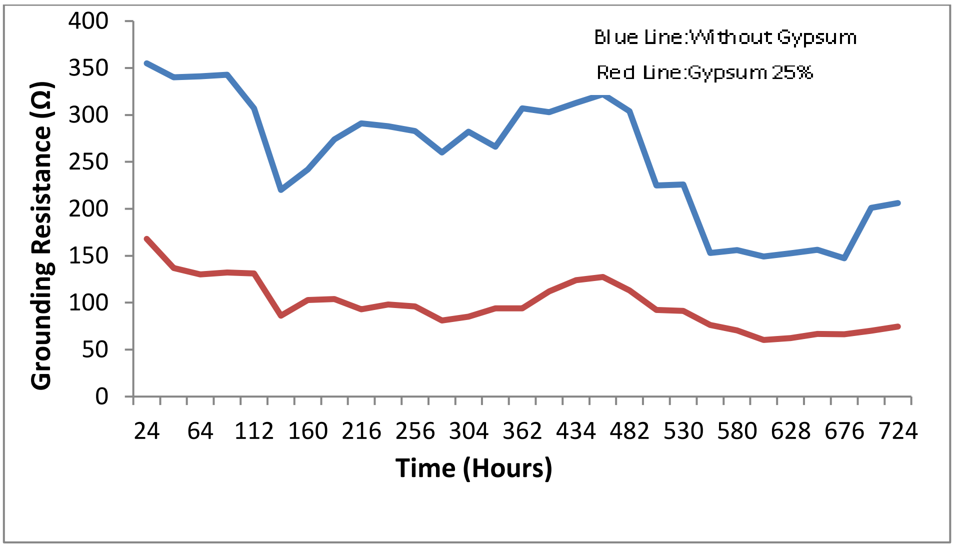

Figure 6. Grounding resistance of bentonite-mixed gypsum (25%)

The value of grounding resistance with the addition of 25% gypsum is better than the value of grounding resistance without the addition of additives where the value of grounding resistance with the addition of gypsum is 25% lower. This is due to the ability of the mixture of gypsum material 25% and soil 75% in absorbing water and minerals in the soil better, compared to soil without additives. The measurement data during the 732-hour study showed the lowest grounding resistance value obtained with the addition of 25% gypsum which was equal to 60.3 ohms. The data shows that 25% gypsum has reached its saturation point in reducing the value of grounding resistance. This is because the ability of 25% gypsum to absorb water and minerals around it has reached the maximum limit.

5. Conclusions

Based on the results of measurements of the value of earth resistance with the addition of gypsum, some conclusions can be obtained as follows:

1. Additional of gypsum as an additive to the soil can reduce the value of soil type resistance. In this study, Gypsum absorbs water and minerals contained in the soil so that the value of the resistance of its species decreases.
2. The value of grounding resistance with the addition of 50% gypsum in this study is the best among the other groundings where the addition of 50% gypsum on average can reduce the value of grounding resistance by 68.24%.
3. The value of grounding resistance with the addition of 100% gypsum has a value that is not much different from the value of grounding resistance without the addition of additives.

Acknowledgements

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