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Analysis of Additional Bentonit and Salt for Improving the Resistance of Electrode Rods

R Pratama* and W S Saputra
Department of Electrical Engineering Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 207, Bandung 40154, Indonesia

*Reffky14@student.upi.edu

Abstract. Grounding is one way to assure the safety of the hazards and the damage caused by the incurring currents. A grounding system, according to the General Electrical Installation Requirements 2000: 11, is a connecting point of an electrical circuit or a carrier not part of an electrical circuit with an earthing earth. If there is any isolation damage to a tensioned electrical installation, the danger of touch tension can be avoided as the current continues to flow into the ground through the earthing or grounding system. This aims to analyze or know the value of soil type resistance, which later can be analyzed and used as a reference for planning an earthing. In addition, this discussion aims to determine the effectiveness of earthing system improvements using additives substance. To perform the data collection, it is done by direct measurement method in the field by using earth tester and other supporting tools, and recording the result of measurement using earth tester.

1. Introduction
Grounding is the most important factor for improving power system safety and electrical appliance, soil conditions influence for the value of resistance in the electrical grounding process [1]. Good grounding accordance with applicable standards which cannot be exceed 5 Ω. The factors affecting grounding resistance are soil type, soil salinity, soil temperature, and soil moisture. Soil moisture can be created and maintained by the addition of additive substances that are absorbing/adsorption for liquids and gases. The sample of additives including gypsum, charcoal powder, salt, zeolite, bentonite [1].

There is a significant difference between the ground without addition the additive substances in the form of salt with the addition of salt. The grounding system with the addition the addictive substances in the form of bentonite resulted a decrease in the value of earth resistance. Both types of the addictive substances can decrease the value of earth resistance [2].

In this research will discuss about the difference the value of earth resistance between the ground which added bentonit, salt and not given additive substances. This research will be made to the clay soil.

2. Method
2.1. Research method
The method used in the research "Analysis of additional bentonite and salt for improving the resistance of electrode rods" is a method with a qualitative approach, where the method used is a case study. Technique of collecting data in the form of data from measurement using earth tester with method "I".
2.2. Research process

In the research process, will be explained by the flowchart in figure 1:

![Flowchart]

**Figure 1.** Research Process.

2.3. Selection of the tools and materials used

For the first step, selection of tools and materials will be needed to help get the data of soil resistance measurement value:

2.3.1. Electrode Rod. Electrode rod or often called a grounding rod serves to drain the charge of electric current from the conductor cable to the grounding ground implanted in the ground.[3] The rod electrode used has a diameter of 1.5 cm and a length of 1.80 m can see in figure 2.

![Electrode Rod](image)

**Figure 2.** Electrode Rod.

2.3.2. Bentonite. Bentonite is a type of clay that mostly contains montmorillonite with minerals such as quartz, calcite, dolomite, feldspars, and other minerals [4]. Bentonite has properties can absorb water and hold water on the structure, consisting of tetrahedral layer and octahedral layer then the interlayer layer where the absorption of water occurs in the interlayer layer. In this interlayer layer there are water molecules and cations [5]. The sample of Bentonite can see in figure 3.
2.3.3. Salt. In chemistry, salt is an ionic compound consisting of positive ions (cations) and negative ions (anions), thus forming a neutral compound (without charge). Salt is formed from the reaction of acids and bases. There are many kinds of salt, among others, neutral salts, alkaline salts, acid salts [3,6]. Sample of salt can see in figure 4.

2.3.4. Earth Tester. The grounding measurement device used is Digital Earth Resistance Tester KYORITSU Model 4105A as shown in Figure 5. This tool serves to display the measured earth prison value with the following technical specifications [7,8]:

- Measurement range for ground resistance is 0 - 20 Ω, 0 - 200 Ω, 0 - 2000 Ω
- The terminal number 3 pieces are E, P and C.
Figure 6. Hole for Measurements.

Explanation:
TB1 = Holes not filled with additive substance with a depth of 125 cm
TB2 = Hole not filled with additive with a depth 90 cm
LB1 = Holes containing 5kg bentonite with a depth of 125 cm
LB2 = Holes containing 5kg bentonite with a depth 90 cm
LG1 = Holes containing 5kg salt with a depth of 125 cm
LG2 = Holes containing 5kg salt with a depth of 90 cm

2.5. Measurements using earth tester
In the use of earth tester tool in this research there are several ways as follows:

- Prepare the measurement tool.
- Plug the main electrode in the hole for measurement, then plug the number 1 and 2 auxiliary electrode. Distance 5 meter for auxiliary electrode number 1 and 10 meter for auxiliary electrode number 2 from the main electrode rod.
- By reason in this measurement using method “I”. So, the position of the main electrode with the 1 and 2 auxiliary electrodes shall be equal.
- Attach the red and yellow cables to the auxiliary electrode and green wire on the main electrode. Note that if there is dirt on clam wire or dirt on the electrode, must be cleaned first because that dirt can affect the measurement result.
- Then turn on the measurement limit button at 200 Ω because this research is done on clay type soil that having 100Ω res resistance value.
- After that push "PRESS TO TEST" button. If there are not many points and the measuring lights do not blink then there is no error on the cable or the tool. Then turn the "PRESS TO TEST" button to the right to hold the measurement results to help with the documentation process.
- At the Last, record the measurements that appear on the earth tester and repeat the measurements up to 24x on the next day with the same hour.

Figure 7. Measurement Using Method “I”.
3. Results and Discussion

3.1. Measurements result without added additive substance

In this measurement, no additive substance used. Because, the researcher want to knows how much soil resistance value before applying method how to improve the earth system by adding additive substance. Below is the result of the calculation without use of additive substance:

| Measurement | Time | Earth Resistance (Ω) |
|-------------|------|-----------------------|
|              |      | Depth 80 cm | Depth 110 cm |
| I           | 12.00 | 17.5     | 15.6     |
|             | 16.00 | 17.5     | 15.6     |
|             | 20.00 | 17.5     | 15.6     |
|             | 12.00 | 17.5     | 15.6     |
| II          | 16.00 | 17.5     | 15.6     |
|             | 20.00 | 17.5     | 15.6     |
|             | 12.00 | 17.2     | 15.1     |
| III         | 16.00 | 17.2     | 15.1     |
|             | 20.00 | 17.2     | 15.1     |
|             | 12.00 | 17.5     | 15.6     |
| IV          | 16.00 | 17.3     | 15.3     |
|             | 20.00 | 17.3     | 15.3     |
|             | 12.00 | 17.3     | 15.3     |
| V           | 16.00 | 17.3     | 15.3     |
|             | 20.00 | 17.3     | 15.1     |
|             | 12.00 | 17.3     | 15.1     |
| VI          | 16.00 | 17.3     | 15.1     |
|             | 20.00 | 17.3     | 15.3     |
|             | 12.00 | 17.3     | 15.3     |
| VII         | 16.00 | 17.3     | 15.1     |
|             | 20.00 | 17.3     | 15.1     |
|             | 12.00 | 17.3     | 15.3     |
| VIII        | 16.00 | 17.3     | 15.3     |
|             | 20.00 | 17.3     | 15.3     |

Average: 17.345833, 15.320833

Figure 8. Graphic measurement result without added additive substance.
Can be seen from the table 1 and figure 8, the value of soil resistance in the hole that is not added using salt or bentonit results at a depth of 80 cm has an overall average value of 17.345833 while at a depth of 110 cm has an average value of 15.320833 overall. The value of the grounding measurements without additive additions is bigger than the value of the PUll standard which requires under 5 Ω. Figure 9 is measurement result without added additive substance with earth tester.

**Figure 9.** Measurement result without added additive substance.

### 3.2. Measurements result with added bentonit

**Table 2.** Measurement result with added bentonit.

| Measurement | Time | Earth Resistance (Ω) |
|-------------|------|----------------------|
|              |      | Depth 80 cm | Depth 110 cm |
| I           | 12.00 | 6.6          | 4.8          |
|             | 16.00 | 6.6          | 4.8          |
|             | 20.00 | 6.6          | 4.8          |
|             | 20.00 | 6.6          | 4.8          |
|             | 12.00 | 6.5          | 4.8          |
|             | 16.00 | 6.5          | 4.8          |
|             | 20.00 | 6.6          | 4.8          |
|             | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| III         | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.5          | 4.6          |
|             | 20.00 | 6.5          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| IV          | 16.00 | 6.5          | 4.6          |
|             | 20.00 | 6.5          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.5          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| V           | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.5          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| VI          | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
|             | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| VII         | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             | 12.00 | 6.4          | 4.6          |
| VIII        | 16.00 | 6.4          | 4.6          |
|             | 20.00 | 6.4          | 4.6          |
|             |      | 6.454166     | 4.841666     |

Average
Figure 10. Comparison measurement results between without added additive substance and added bentonite at a depth 80 cm.

Figure 11. Comparison measurement results between without added additive substance and added bentonite at a depth 110 cm.

Can be seen from the table 2, figure 10 and figure 11, in contrast to the holes that are not added bentonite substances. In the non-additive holes and additive holes added to the depths of 80 cm and 110 cm there is a difference, wherein the bentonite added hole improves the resistance value of the soil. At a depth of 80 cm the hole added with bentonite has an average earth value of 6.454166 while the hole with added bentonite at a depth of 110 cm has an average value of 4.841666. Although holes with added bentonite can improve the resistance value of grounding resistance, but still have not reached the expectations of researchers who hope to achieve 2 or 3 $\Omega$. Figure 12 is measurement with erath tester.

Figure 12. Measurement result with added bentonite.
3.3. Measurements result with added salt

**Table 3.** Measurement result with added salt.

| Measurement | Time (h) | Earth Resistance (Ω) |
|-------------|----------|-----------------------|
| I           | 12.00    | 9.3                   |
|             | 16.00    | 9.3                   |
|             | 20.00    | 9.3                   |
|             | 12.00    | 9.3                   |
| II          | 16.00    | 9.3                   |
|             | 20.00    | 9.3                   |
|             | 12.00    | 9.2                   |
| III         | 16.00    | 9.2                   |
|             | 20.00    | 9.2                   |
|             | 12.00    | 9.2                   |
| IV          | 16.00    | 9.3                   |
|             | 20.00    | 9.3                   |
|             | 12.00    | 9.2                   |
| V           | 16.00    | 9.2                   |
|             | 20.00    | 9.3                   |
|             | 12.00    | 9.2                   |
| VI          | 16.00    | 9.2                   |
|             | 20.00    | 9.2                   |
|             | 12.00    | 9.2                   |
| VII         | 16.00    | 9.2                   |
|             | 20.00    | 9.2                   |
|             | 12.00    | 9.2                   |
| VIII        | 16.00    | 9.2                   |
|             | 20.00    | 9.2                   |
| Average     | 9.23     | 8.73                  |

**Figure 13.** Comparison measurement results between without added additive substance, added bentonit, and added salt at a depth 80 cm.
Figure 14. Comparison measurement results between without added additive substance, added bentonite, and added salt at a depth 110 cm.

Based on the measurements listed on the table 3, figure 13 and figure 14, the salt-added holes at depths of 80 and 110 cm can also decrease the resistance value of the soil such as holes with additional bentonite, but the result is still no better with the hole with additional bentonite which at a depth of 110 holes cm can improve the value of ground resistance up to 4.8 Ω. At a depth of 80 cm a hole added with salt can improve the soil resistance value by an average value of 9.23 and in a hole with a depth of 110 cm the average value is 8.73. It can be said that the hole with additional salt has not reached the value of ground resistance according to the rules of PUIL under 5Ω. Figure 15 is Measurement result with added salt.

Figure 15. Measurement result with added salt.

4. Conclusions

Based on the research "Analysis of Additional Bentonite and Salt for Improving the Resistance of Electrode Rods" which has been done, can be said as proving research on how to improve the earthing system. This study adds additives substance to improve the value of soil resistance. From the calculation results, it shows the difference of soil resistance value from the rod electrode directly implanted to the ground and the rod electrode which first added the additive substance in the hole. Besides added with additives substance, depth and soil type can also affect the value of grounding resistance.

Disadvantages possessed of the results from this study are not yet able to find out what effect on electrode rod which used in the next few years. Then, what is the effect on the surrounding environment.

This research is still not perfect, so it needs refinement in order to add ways to improve the value of soil resistance is better, simpler and lower cost. Some suggest that can be developed include the addition
of hole depth for measurement and also use of the other materials such as charcoal or gypsum, because bentonite price is too expensive for some people.

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