International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

https://gssrr.org/index.php/JournalOfBasicAndApplied/index

Reduction of Soil Type Resistance with Grant Gypsum Additives as a Narrow Land Grid-Rod Grounding Media on Clay Soil Texture

I Made Suartika[a*], I Nyoman Budiastra[b], I Gusti Ngurah Janardana[c], I Gede Ari Aditya[d], Ni Wayan Swasti Sukma Agustini[e]

[a,b,c,d,e]Electrical Engineering, Udayana University, Jl. Raya Campus Unud, Jimbaran City, Bali, Indonesia
[a]Email: madesuartika@unud.ac.id, [b]Email: budiastra@unud.ac.id, [c] Email: janardana@unud.ac.id, [d]Email: aditya.2205541132@student.unud.ac.id, [e]Email: agustini.2205541033@student.unud.ac.id

Abstract

The area of land where the grounding is located affects the selection of the type of grounding. Narrow land not all types of grounding can be installed. One way that can be done is by applying additive media to reduce the soil retention value. Gypsum additives will be tested in this study. The purpose of this study is to determine the effectiveness of gypsum additive media in the Grid-Rod grounding system of narrow land with clay soil texture and maintain the stability of the resistance value of soil types so that it remains low. The method used in the analysis is a descriptive quantitative method where the results of soil resistance measurements before and after treatment will be used to calculate the grid-rod grounding resistance to obtain a value of < 5 ohms on narrow clay soil texture. The results of the study were obtained by applying gypsum additives to clay soils effectively reducing the resistance value of soil types from 32.65 ohm-meters to 17.85 ohm-meters or a decrease of 46.15%. The application of gypsum additives in clay soil can maintain the stability of the soil type resistance value which results in the stability of the grounding resistance value at a value of < 5 ohms during the dry season so that it is safe for equipment and humans around the distribution substation equipment.

Keywords: Grounding; Gypsum; Clay soil.

Received: 5/15/2025
Accepted: 7/1/2025
Published: 7/12/2025

** Corresponding author.*

1. Introduction

The resistance of large soil types can be lowered by the application of additives. Some of the additives that are widely used are charcoal, salt, bentonite. The texture of the soil is influential to obtain a small grounding resistance value. The texture of the clay soil is dense with a soil type resistance of > 20 Ω-meters. This study was carried out by applying gypsum additive media to the texture of narrow loam soil for grid-rod grounding system. Some existing studies, such as studies on grounding systems in narrow areas of calcareous soil, have resulted in an optimal mesh system of 0.6472 ohms in dry conditions and 0.4383 ohms in wet conditions, an optimal grid system of 0.6269 ohms in dry conditions and 0.4314 ohms in wet conditions[1]. Research on grounding systems on calcareous soils is only the plate grounding system, and the multi grid-rod grounding system[2]. Based on the problems mentioned above, it is important to carry out continuous research to complement the diversity of existing soil textures, namely in the texture of clay soils so that the effectiveness of applying gypsum additive media to clay soils to reduce soil resistance is known.

2. Materials and Methods

2.1 Literature Study

2.1.1 Chemical treatment of soil

The resistance value of the soil type is relatively high, the addition of chemical substances or additives to the soil. Some types of additives naturally contained in the soil tend to be conductive and reduce the resistance of the soil type. The latest materials that can be used to reduce soil resistance are bentonite, marcionite and gypsum[3,4].

2.1.2 Gypsum

Gypsum contains two molecules consisting of *CaSO4* and *2H2O*. Gypsum can be divided into two, namely *anhydrite* and *dehydrate*. Gypsum *anhydrite* is formed from 32.6% lime (Ca), 20.9% H2O and 32.6% sulfur (S). The use of gypsum does not cause pollution in both the air and the soil, in addition to its relatively low price, fireproof, and resistant to deterioration caused by biological factors and resistant to chemical substances. In previous studies, it has been shown that gypsum can be used to lower the value of soil resistance, the increase in weight of gypsum is directly proportional to the decrease in the value of soil resistance[3,5].

2.1.3 Different arrangements of earthing electrodes

The arrangement of earthing electrodes can be divided into several types, namely:

1. Grounding with vertically arranged electrodes
2. Grounding with horizontally arranged electrodes
3. Radial shaped arranged earthing
4. Arranged grounding in the shape of a ring (circle)

5. Grid-shaped structured grounding
6. Grounding of plate shapes

The arrangement of the electrodes usually adjusts to the type of soil in the area where the grounding system will be installed[6].

2.1.4 Soil Classification

Soil classification is a way of collecting and classifying soils based on the similarity of morphology, physics, chemistry, and mineralogic properties and characteristics, then given names so that they are easy to recognize, remember, understand and use and can be distinguished from each other. From a technical point of view, soils can be grouped into the following groups: *gravel*, *sand*, *silt* and clay [6,7,8].

2.2 Research Design

The deesain from the research will be used as a reference in treating the soil by applying gypsum additives as shown in the figure below,

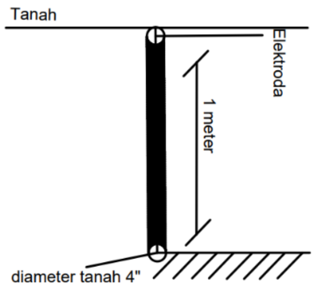

Figure 1: Earthing Electrodes with Gypsum Additive Addition

2.3 Research Flow Chart

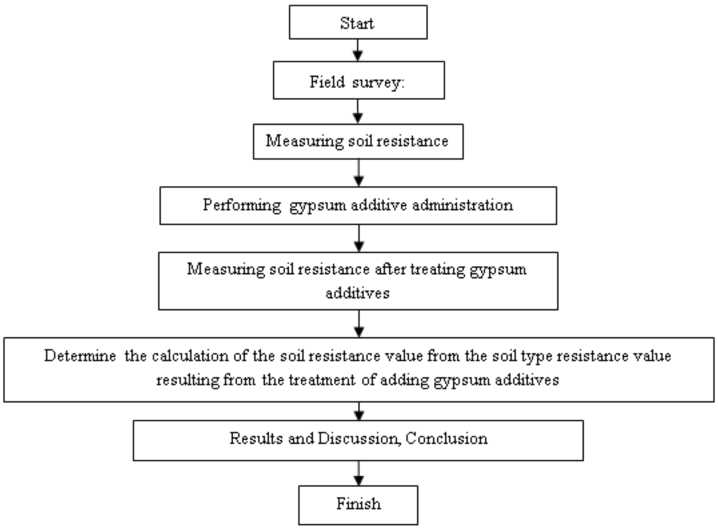

Figure 2: Research Flow Chart

2.4 Data Analysis

The data was analyzed quantitatively descriptively.

3. Results and discussion

3.1 Measurement Results

Based on the measurement results, soil resistance in clay soil is 0.26 Ω so that the highest soil type resistance is 32.65 Ω-meters. Meanwhile, the clay soil resistance after being treated with gypsum additives became 0.14 ohms so that the soil type resistance was 17.58 Ω-meters. Soil retention after being treated with gypsum additives decreased by 46.15%. This means that the application of gypsum additives to clay soils to reduce the resistance value of soil types is quite effective in the construction of earthing systems, especially in the construction of grounding systems in soils that have a large soil resistance value.

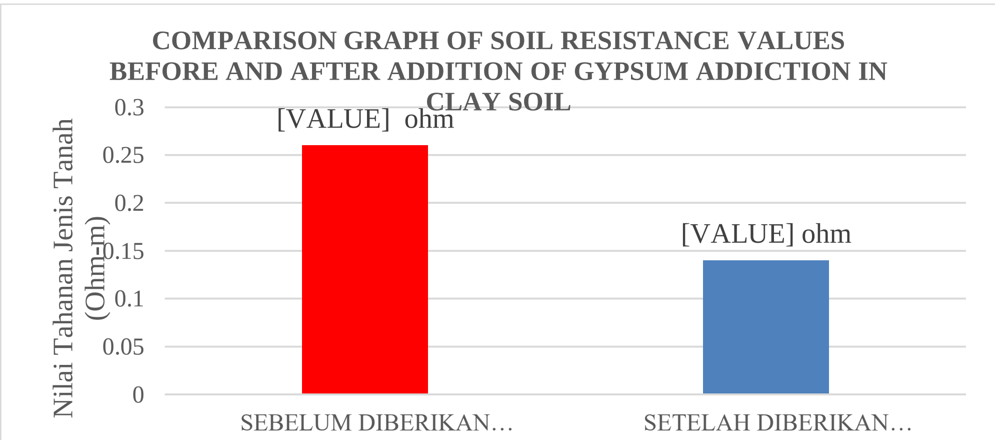

Figure 3: Comparison Chart of Soil Resistance Values Before and After Gypsum Treatment

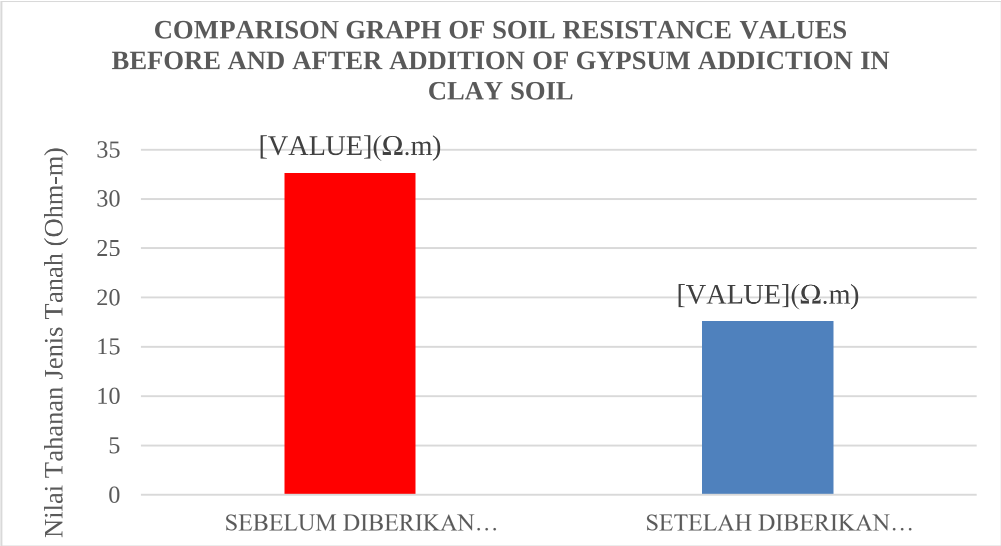

Figure 4: Comparative Graph of Soil Type Resistance Before and After Gypsum Additive Treatment

3.2 Analysis of the grounding resistance of the grid-rod system before being treated with gypsum additives

Calculating the value R_1

$$R_1 = \frac{32,65}{3,14x16}\left[L_n\left(\frac{2x16}{0,14}\right) + \frac{0,01x16}{\sqrt{4}} - 4,5\right]$$

$$R_1 = 0,65(5,43 + 0,08 - 4,5\ )ohm$$

R1 = 0.66 ohms

Calculating the value R_2

$$R_2 = \frac{32,65}{2.3,14.16.16}\left[L_n\left(\frac{4.16}{0,02}\right) - 1 + \frac{2.0,01.1}{\sqrt{4}}\left(\sqrt{16} - 1\right)^2\right]$$

$$R_2 = 0,0203[8,07 - 1 + 0,09]$$

$$R_2 = 0,14 \text{ ohm}$$

Calculating the value R_m

$$R_m = \frac{32,65}{3,14.16}\left[L_n\left(\frac{2.16}{1}\right) + \frac{0,01.16}{\sqrt{4}} - 4,5 + 1\right]$$

$$R_m = 0,65[3,47 + 0,08 - 4,5 + 1]$$

$$R_m = 0,0325 \text{ ohm}$$

Calculating grid resistance values

$$R_G = \frac{0,66x0,14 - 0,0325^2}{0,66 + 0,14 - 2x0,0325}$$

$R_G = 0,12$ ohm

3.3 Analysis of Grid-Rod System Grounding Resistance After Gypsum Additive Treatment

Calculating the value R_1

$$R_1 = \frac{17,85}{3,14x12}\left[L_n\left(\frac{2x12}{0,14}\right) + \frac{0,01x12}{\sqrt{4}} - 4,5\right]$$

$$R_1 = 0,474(5,14 + 0,06 - 4,5\,)ohm$$

R1 = 0.33 ohms

Calculating the value R_2

$$R_2 = \frac{17,85}{2.3,14.9.1}\left[L_n\left(\frac{4.1}{0,02}\right) - 1 + \frac{2.0,01.1}{\sqrt{4}}\left(\sqrt{9} - 1\right)^2\right]$$

$$R_2 = 0,3158[5,298 - 1 + 0,04]$$

$R_2 = 1,37$ ohm

Calculating the value R_m

$$R_m = \frac{17,85}{3,14.12}\left[L_n\left(\frac{2.12}{1}\right) + \frac{0,01.12}{\sqrt{4}} - 4,5 + 1\right]$$

$$R_m = 0,47[3,18 + 0,06 - 4,5 + 1]$$

$R_m = -0,12$ ohm

Calculating grid resistance values

$$R_G = \frac{0,33x1,37 - (-0,12)^2}{0,33 + 1,37 - 2(-0,12)}$$

$R_G = 0,2256$ ohm

The application of gypsum additives can reduce the number of electrode rods used, including:

1. The total length of the mesh conductor from 16 meters to 12 m or reduced by 4 meters.
2. The number of rod electrodes from 16 rods to 9 rods each 2 meters long.
3. The total length of the electrode *rod* from 16 m to 9 meters.

By reducing the number and length of electrodes in the grounding system, the addition of gypsum additives will be able to reduce the cost of purchasing copper electrode rods and can maintain the stability of the soil type resistance value which results in maintaining the stability of the grounding resistance value in the dry season of dry soil so that the safety of equipment and people around it will be safe.

4. Conclusion

The application of gypsum additives to clay soils is very effective in reducing the resistance value of soil types from 32.65 ohm-meters to 17.85 ohm-meters or a decrease of 46.15%.

Acknowledgments

We would like to thank Udayana University, the Faculty of Engineering, the Electrical Engineering Study Program FT. Unud and the team of research lecturers, students and the entire audience who have made this research a success.

References

[1] Arta, I W A P., Janardana,IGN., Wijaya, IWA. 2021. Analisis dan Desain Sistem Pembumian Gardu distribusi Pada Lahan Sempit tanah Berbatu. Jurnal Spektrum., Volume 8 No. 1 Maret 2021.

[2] Prinzler, MPQ., Partha, CGI., Janardana, IGN. 2020. Optimasi Perencanaan Sistem Pembumian Padea Rencana Pembangunan Gas Insulated Substation 150 kV Pecatu. Journal SPEKTRUM, Volume 7 N0. 1 Maret 2020. Jimbaran : Program Studi Teknik Elektro Universitas Udayana.

[3] Sukmadewi, NWDP. Janardana, IGN, Wijaya, IWA. 2021. Pemanfaatan Pencampuran Gypsum Dengan Kalsium Oksida Sebagai Zat Aditif Pada Sistem Pembumian. Jurnal Spektrum., Volume 8. No. 3 September 2021.

[4] Erliza, Y.,Muhammad A.,Yosi, A; 2018, Analisis Ketinggian Zat Aditif Pada Box Elektroda Batang Terhadap Resistansi Pembumian; Volume 8; Edisi 1; Palembang; Jurnal Teknik Elektro; Diakses Pada Hari Rabu, 18 November 2020

[5] Erliza,Y., Abdul, M., Faisal; 2019, Studi Perlakuan Terhadap Tanah untuk Menentukan Nilai Resistansi dan Tahanan Jenis Pembumian,Volume 3; Edisi 2; Palembang; Jurnal Surya Energi

[6] Suartika.2017,Sistem Pembumian (*Grounding)* Dua Batang Sistem Pengamanan Tenaga Listrik;Karya Tulis Ilmiah;Jimbaran Bali;Universitas Udayana

[7] Subardja, D., Ritung, Muhammad, A, Sukarman, E. Suryani, dan Subandiono, RE. 2016. Petunjuk Teknis Klasifikasi Tanah Nasional. Bogor. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian,

[8] Mahadewi, KM., Janardana, IGN., Wijaya, IWA,. 2019. Analisis Tegangan Langkah dan tegangan Sentuh Serta erencanaan Sistem Pembumian Pada Pembangunan Substation VVIP. Di Bandara Internasional I Gusti Ngurah Rai Bali. Journal SPEKTRUM Volume 6, No. 1 Maret 2019. Jimbaran: Program Studi Teknik Elektro Universitas Udayana.