

PAPER • OPEN ACCESS

A Study on the Use of Powder Zeolite as Backfill Material for Single Rod Grounding System

To cite this article: H B H Sitorus *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1125** 012075

View the [article online](#) for updates and enhancements.



The banner features a decorative top border with a repeating pattern of red, white, and blue diagonal stripes. On the left, the ECS logo is displayed in green and blue, followed by the text 'The Electrochemical Society' and 'Advancing solid state & electrochemical science & technology'. To the right of this text is a logo for the 18th International Meeting of the Solid State Ionics Society (IMCS18). The main text of the banner reads '239th ECS Meeting with IMCS18', 'DIGITAL MEETING • May 30-June 3, 2021', and 'Live events daily • Free to register'. On the right side, there is a red button with the text 'Register now!'. The background of the banner is a collage of images including a person's face, a laptop, and abstract digital network patterns.

ECS The Electrochemical Society
Advancing solid state & electrochemical science & technology

239th ECS Meeting with IMCS18

DIGITAL MEETING • May 30-June 3, 2021

Live events daily • Free to register

Register now!

A Study on the Use of Powder Zeolite as Backfill Material for Single Rod Grounding System

H B H Sitorus¹, D Permata² and A Wicaksono²

¹ Electrical Engineering Department, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ), Indonesia

² Electrical Engineering Department, Faculty of Engineering, Universitas Lampung (Unila), Indonesia

hbhstr@gmail.com, hbh.sitorus@upnvj.ac.id

Abstract. One way to reduce the value of grounding resistance is to replace the electrodes' backfill material with other materials such as; gypsum, charcoal powder, and bentonite. In this paper we report the use of zeolite powder as a backfill material to bury the electrodes of the grounding system. The purpose of this research is to compare zeolite and pure soil to be used as a backfill material. The type of electrode used is a single rod electrode. The parameters measured were grounding resistance, rain intensity, moisture and pH of the backfill material. Measurements were taken every day for 30 days. It was found that zeolite as a backfill material is better than pure soil which is often used so far. It is seen that the resistance value of grounding system using rod that buried in zeolite as a backfill material is lower than a half of the resistance value of grounding system when using pure soil as a backfill material. From this research it was also found that the moisture of the backfill material was higher by using zeolite than pure soil.

Keywords: Grounding, zeolite, backfill, electrode, resistance

1. Introduction

A reliable grounding system is needed to protect all electrical equipment both during normal conditions and in fault conditions. The grounding system provides a line for the flow of electric current to the earth, so that the touch voltage and step voltage that arise are still within a safe tolerance for humans around the equipment. The touch voltage and the step voltage arising on electrical system equipment are determined by the amount of ground resistance [1]. A low ground resistance value is not easy to obtain because it depends on various types of soil conditions. In reducing ground resistance, it must consider several factors that affect soil resistance, namely soil moisture, temperature, soil characteristics, and chemical composition in the soil [2].

The effect of soil moisture is dominant in reducing ground resistance. Grounding electrodes embedded in moist soil will make the grounding system resistance value is lower and more stable. In recent decades researchers have explored the appropriateness of the use of backfill material to minimize the grounding system resistance. The backfill material often used include gypsum, charcoal



powder, and bentonite [2]–[7]. The backfill material is expected not only to reduce the grounding system resistance but also to keep it low for a long time without much fluctuation. The backfill material from the soils tends to make the grounding resistance in fluctuating according to weather conditions. In the rainy season the grounding resistance tends to decrease, while in the dry season it tends to rise.

This paper presents zeolite powder used as a backfill material. The type of electrode used is a single rod electrode. The single rod electrode was buried using zeolite as a backfill material, then the grounding resistance value was measured every day for one month. In addition to the grounding resistance value, rain intensity, humidity and pH of the backfill material are also measured. These measurements are carried out to obtain the effect of rain intensity and humidity on changes in grounding resistance. As a comparison, soil is also used as a backfill material. Finally, we compare the grounding resistance value in a single rod grounding system using zeolite and soil as backfill materials.

2. Experimental Setup

2.1. Material

Zeolites are formed from volcanic ash that settled millions of years ago. The properties of zeolite minerals vary greatly depending on the type and content of zeolite minerals. Zeolites have a hollow structure, usually these cavities are filled with water and cations that can be exchanged and have a certain pore size. Zeolites are hydrated alumino silicate compounds consisting of SiO_4 and AlO_4 tetrahedra bonds that are connected by oxygen atoms to form a skeleton. In the zeolite skeleton, each Al atom is negative and will be neutralized by bonds with easily interchangeable cations. The easily interchangeable cations present in the zeolite skeleton influence the absorption process and thermal properties of zeolites. In addition to the type of cation, the absorption ability of zeolites is also influenced by the ratio of Si / Al and the geometry of the zeolite pores, including the inner surface area, pore size distribution and pore shape [8]. The physical form of zeolite can be seen in Figure 1.



Figure 1. Zeolite powder

Zeolites have chemical properties including dehydration, absorption, ion exchange, catalysts, and filters or separators. In general, there are three activation processes that can be carried out on natural zeolites, namely physical activation by heating and scaling down, chemical activation with acids and chemical activation using alkalis [9].

2.2. Measurement

2.2.1. Rain Intensity Measurement. The measurement of rain intensity aims to determine the effect of rainfall intensity on the reduction in grounding system resistance. The rain intensity measurements were carried out using the Hasper Der Werduwen method, with measurements setup is shown in

Figure 2. The rain that falls is collected in a standard rain gauge and measure its height in millimeter after every one hour. The rain intensity gauge is placed close to the ground hole where a single rod electrode is buried. The rainfall collected will be measured in mm and then the volume and intensity of the rain is calculated according to the Hasper Der Weduwen method [10].

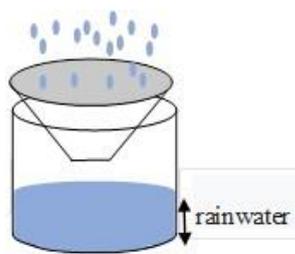


Figure 2. Rain intensity measurement

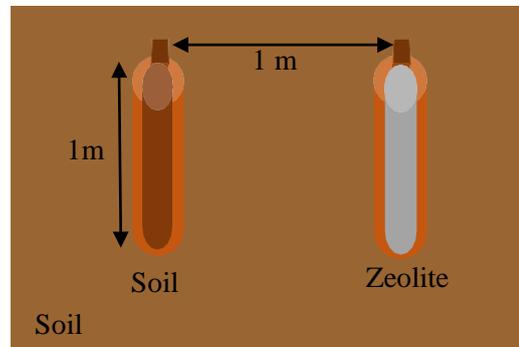


Figure 3. Arrangement of the grounding electrodes buried in backfill material

2.2.2. *Grounding Resistance Measurement.* The measurement of grounding resistance on a single rod electrode is carried out using the 3 point method [10]. The holes where the electrodes are buried is made with a depth of 100 cm and a diameter of 10 cm. Two holes are provided, namely for electrodes buried in zeolite and soil as backfill material in respectively. Figure 3 shows the arrangement of grounding electrodes. The first electrode is buried in the first hole with zolite as a backfill material and the second electrode is buried in the second hole with pure soil without additives as a backfill material. Each hole requires approximately 8 kg of backfill material. The measurement of grounding resistance is carried out by using the Earth Tester Kyoritsu Model 4105A with a three point method. The measurement settings for grounding resistance can be seen in Figure 4.

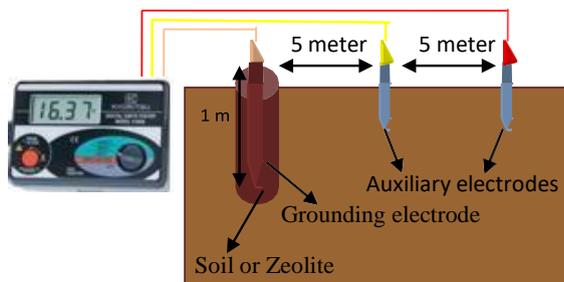


Figure 4. Arrangement of the grounding resistance measurement

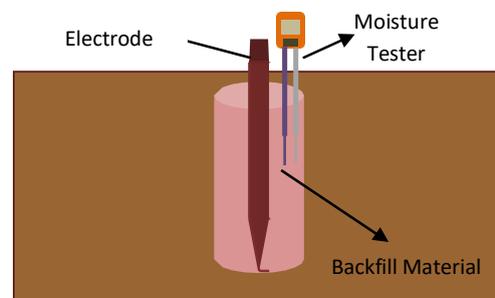


Figure 5. Measurement setup for moisture and pH tester

2.2.3. *Moisture and pH Measurement.* The measurement of humidity and pH is performed using a 2 in 1 moisture tester that can be used to measure moisture and pH of backfill material. The arrangement of moisture and pH measurements of the backfill material can be seen in Figure 5. The measurement of humidity and pH of the backfill material, the intensity of rain and grounding resistance are carried out twice a day, at 06.00 in the morning and at 16.00 in the afternoon for 30 days.

3. Results and Discussion

Figure 6 shows a comparative graph of the resistance of a single rod grounding buried in zeolite and pure soil as a backfill material. The value of grounding resistances on the first day until the 10th day fluctuates and tends to rise significantly. Starting on day 6 there is a tendency for an increase in grounding resistances for electrodes embedded in pure soil to be higher than those buried in zeolites.

On the 9th day there was rain with a very high intensity. The decrease in the grounding resistance on 10th day, both for electrodes buried in the zeolite backfill and in pure soil, are thought to be due to the high intensity of rain on day 9. On the 10th day there was a drastic reduction in grounding resistances with a decrease in percentage of 63%. Starting on day 10 there was a significant difference in the value of grounding electrodes buried in pure soils and zeolites. This proves that zeolites can absorb moisture better than pure soils.

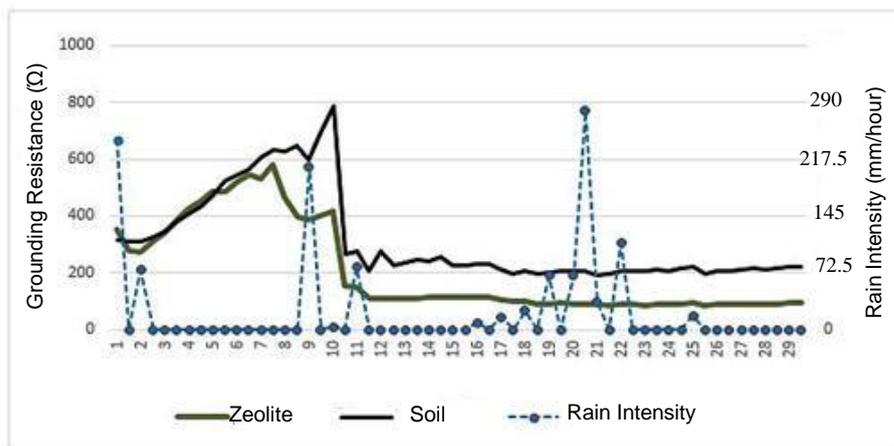


Figure 6. Variation of grounding resistances and rain intensities for 30 days Furthermore,

on the 10th to 15th day the grounding resistances tend to decrease even though the intensities of rain are zero at all times. On the 16th day until the 23rd day the intensities of rain fluctuated but they could not affect the earth resistance values. The grounding resistances tend to remain at all times. The measurement results of grounding resistance with rods buried in zeolite as backfill material for 30 days have been obtained, of which the lowest value is 86 Ω . Meanwhile for backfill materials using pure soil, the lowest value is 190 Ω . In other words, it can be written that the resistance value of grounding system using rod that buried in zeolite as a backfill material is lower than a half of the resistance value of grounding system when using pure soil as a backfill material.

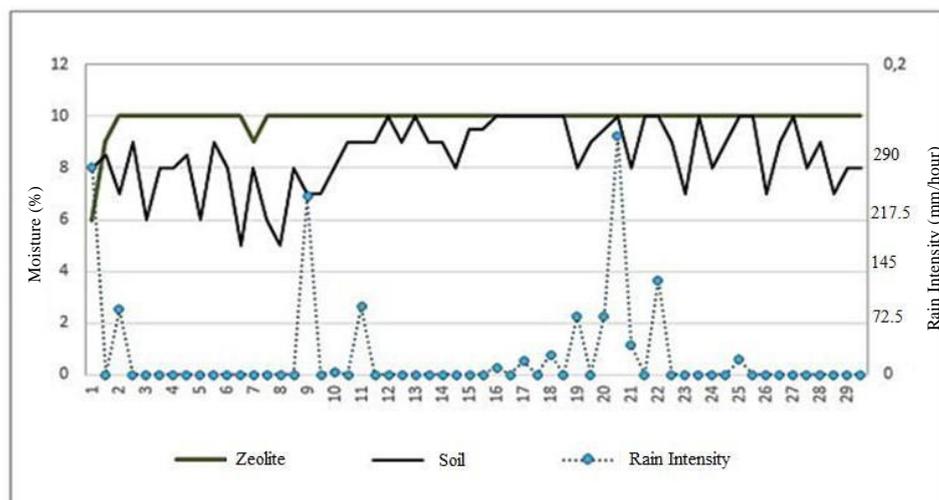


Figure 7. Variation of moistures of backfill materials for 30 days

Figure 7 shows the graph of the relationship of rainfall intensities to moistures of pure soil and zeolite. In this graph, it is seen that there are correlation between rainfall intensities and the moistures of backfill materials. The moistures of pure soil fluctuate below 10%, while the moistures of zeolite

are stable at 10%. However it could be assumed that the moistures of zeolite sometimes above 10%, but because of the measuring instrument used only able to measure up to the range of 10% so that the graph of moistures of zeolite as if they seen constant at values of 10%.

Figure 8 shows the measurement data for the acidities (pH) of the backfill material; zeolite and pure soil for 30 days. In the graph is seen that the pHs level of zeolites is almost always higher than the pHs of pure soils. In other words it can be written that the zeolite materials are more alkaline than pure soil materials, except on the 18th day and the 25th day. It is not clearly seen the cause of the increase in pH levels of the soil during these two days. There were only rain with low intensities on those two days. One conclusion can be obtained that the higher the acidity of the backfill material (the lower the pH level), the higher the earth resistance.

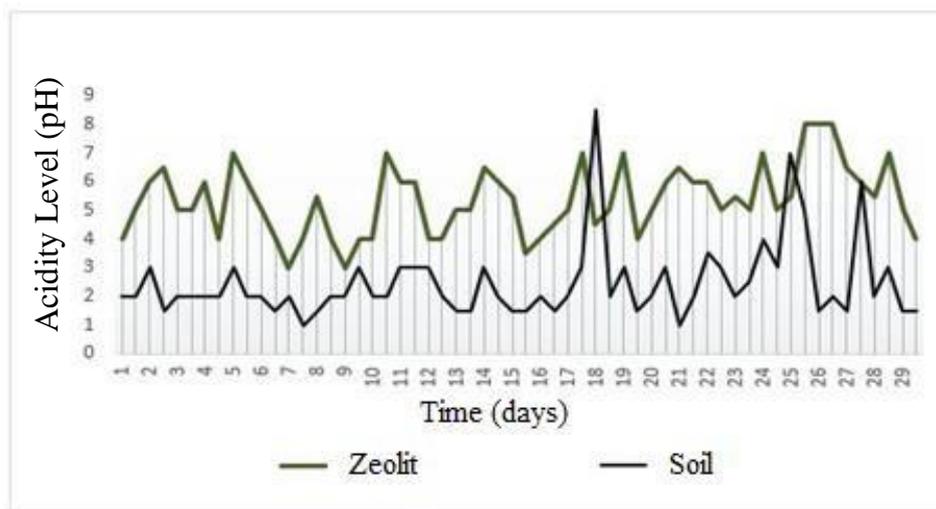


Figure 8. Variation of acidities (pH) of backfill materials for 30 days

4. Conclusion

This work has been carried out in order to look for the properties of zeolite as a backfill material in the design of grounding systems in electric power systems, specifically the ground value of earth. The work has also been done to see the relationship between rainfall intensity, humidity and pH level on ground values. It has been found that the resistance value of a grounding system using a single rod that buried in zeolite as a backfill material are lower than a half that of a grounding system when using pure soil as a backfill material. During 30 days measurements were obtained that the level of Humidity of zeolite was higher than that of pure soil. It is probably to be the reason why the grounding resistances of grounding system which uses zeolites as backfill material are lower than pure soils. Another thing that has also been obtained is that the higher the acidity of the backfill material (the lower the pH level), the higher the earth resistance.

References

- [1] IEEE Power Engineering Society, *IEEE Guide for Safety in AC Substation Grounding*, vol. IEEE Std 80–2000. .
- [2] Siow Chun Lim, Chandima Gomes, and Mohd Zainal Abidin Ab Kadir, “Electrical earthing in troubled environment,” *Electr. Power Energy Syst. Elsevier*, vol. 47, pp. 117 – 128, 2013.
- [3] Chandima Gomes, Mohd Zainal Abidin Ab Kadir, Chamath. L. Kottachchi, and Siow Chun Lim, “INDUSTRIAL WASTES AND NATURAL SUBSTANCES FO,” *Int. J. Electr. Eng.*, vol. 21, no. 2, pp. 39 – 47.
- [4] Siow Chun Lim, Chandima Gomes, and Mohd Zainal, “Behaviour of a New Material that Improves Ufer Grounding Practice,” *J Electr. Syst.*, vol. 12, no. 2, pp. 291–300, 2016.

- [5] Siow Chun Lim, Chandima Gomes, and Mohd Zainal Abidin Ab Kadir, “Characterizing of Bentonite with Chemical, Physical and Electrical Perspectives for Improvement of Electrical Grounding Systems,” *Int J Electrochem Sci*, vol. 8, pp. 11429 – 11447, 2013.
- [6] Siow Chun Lim, Chandima Gomes, and Mohd Zainal Abidin Ab Kadir, “Behaviour of a New Material that Improves Ufer Grounding Practice,” *J Electr. Syst.*, vol. 12, no. 2, pp. 291–300, 2016.
- [7] Nedim Hodžić *et al.*, “Examination of Adsorption Abilities of Natural and Acid Activated Bentonite for Heavy Metals Removal from Aqueous Solutions.”
- [8] F. Cakicioglu-Ozkan and S. Ülkü, “Diffusion Mechanism of Water Vapour in a Zeolitic Tuff Rich Clinoptilolite,” *J. Therm. Anal. Calorim.*, vol. 94, no. 3, pp. 699 – 702, 2008.
- [9] Grzegorz Jozefaciuk and Grzegorz Bowanko, “Effect of Acid and Alkali Treatment on Surface Areas and Adsorption Energies of Selected Minerals,” *Clays Clay Miner.*, vol. 50, no. 6, pp. 771–783, 2002.
- [10] IEEE Power and Energy Society, *IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System*, vol. IEEE Std 81™-2012..