Soil Enhancement Material using Palm Oil Ashes (POA) for Grounding Purposes

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***Abstract*—In this study, we present our work on the application of palm oil ashes (POA) as backfill to be used in an earth grounding grid system. The backfill is implemented while considering certain high soil resistances in certain areas. In this project, we used POA as material as well as copper tape, aluminum tape, and galvanized steel as microgrids. The size of the microgrid is 1 square meter and is buried 1 meter into the ground. Two microgrids of each conductor type were assembled. One of the microgrids was installed with the POA as backfill and the other without backfill as a reference point. Fall-of-potential was used to measure soil resistance. The data collected show that the galvanized microgrid added with POA produced the best result with an improvement of almost 17%–23% compared with its reference point. This is followed by copper microgrid with almost 9%–13% improvement. Meanwhile, the aluminum microgrid had the worst performance with a resistance increment of just 1%–3%.**

***Index Terms*—Backfills; Grounding Earthing; Palm Oil Ashes.**

I. Introduction

During electrical fault or lightning, grounding systems protect living creatures, such as humans, and electrical equipment, by providing low impedance paths. By having low impedance, the discharge current can be quickly disbursed into the earth. In recent years, newspaper reports on the theft of cable activities from substations, telecommunications towers, and power system networks have been published, and the number of theft cases has increased over the years. This activity affects the continuity of the system supply, disrupts service and customer convenience, and brings great economic losses to utility companies. To overcome this problem, finding an alternative grounding conductor is necessary. Hence, we propose the replacement of copper with galvanized steel and aluminum as a grounding material. A grounding system not only depends on the effectiveness of the electrode alone, but also on the resistance of the soil. The usage of grounding additive material as backfill is expected to improve the performance of copper, galvanized steel, and aluminum for grounding systems. The diameter of galvanized steel is 10 mm, and the size of copper tape and aluminum tape is 25 mm × 2.5 mm. As for the galvanized steel the size we used were 10mm diameter.

II. Background Study

Martinez [1] described a resistance reduction additive (RRA) to reduce and maintain the reduced resistance of a ground electrode over time. The RRA employed consisted of a mixture of inorganic salts, some of which were residues from industrial mineral processing plants in Chile. The chemical characteristics of the mixture were described, along with the results of measurement of electrical resistance of ground electrodes over time without and with RRA treatment. The results showed a decrease in resistance to ground with an increase in the quantity of RRA [1].

Meanwhile, Kostic [2] reported the results of an experimental research related to the improvement of the electrical properties of grounding loops, in which bentonite and waste drilling mud were used as backfill materials. The use of this material led to a significant reduction in the grounding resistance and the maximum touch voltage, especially during drought periods. Corrosive testing was also conducted.

A method of reducing ground resistance using a water-absorbent polymer was introduced by Yamane [3]. Experiment results showed the long-term stability of ground resistance and compressive strength under both dry and wet conditions.

A portable grounding system used for different electrical equipment and portable machines was designed and implemented by Hassan [4]. Experiments were performed for different sizes. Results showed that the resistance of earth channel can be decreased to 2.5Ω by laying eight blocks inside pits and connecting all of them using copper rope.

III. Methodology

A. Preparation of Microgrid Grounding using Copper, Aluminum, and Galvanized Steel

The first step involved the preparation of the microgrids. Microgrids were selected instead of a larger grid because of limited land at the testing area. The grids were made using copper tape, aluminum tape, and galvanized steel. Figure 1 shows the design of the galvanized steel microgrid and Figure 2 shows the completed microgrids. For each conductor type, two microgrids were assembled: one microgrid was used for grounding without additive and another was used with additive. The size of the microgrids was 100 mm × 100 mm.

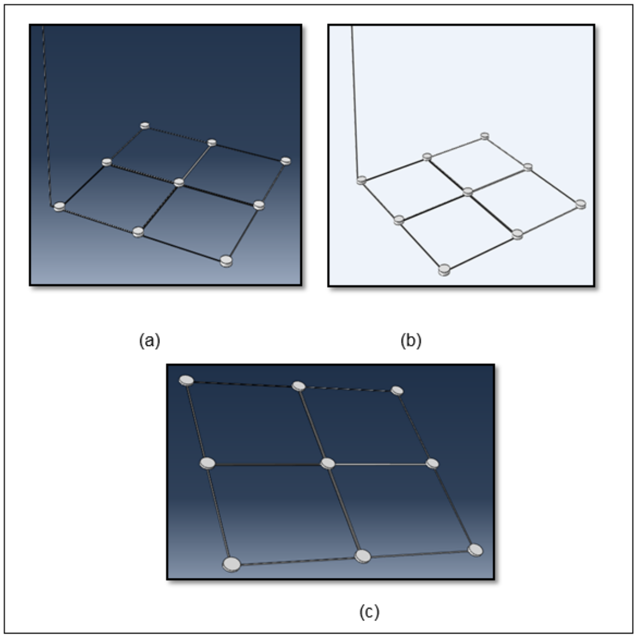

Figure 1: Aluminum grounding grid design with CATIA. (a) Aluminum grid without additive, (b) Aluminum grid with additive, (c) Design of aluminum grid base.

Figure 2: Actual microgrids.

B. Site Installations

The grounding system was installed at Universiti Kuala Lumpur (Malaysian Spanish Institute) at Kulim Kedah. The holes to be occupied by 1 m^2 micrograms were dug using a backhoe. A total of six holes were dug, and copper micrograms were buried in two holes. One of the grids was buried without the palm oil ashes (POA) and another was buried with POA as an additive, as shown in Figures 3 and 4, respectively. The quantity of the POA added per hole was approximately 90 kg. This process was then repeated for all micrograms using aluminum tape and galvanized steel. Once all the grids were installed, the holes were reinstated to their original conditions. All six holes were arranged in one line. Additional details can be seen in Figure 5. The depth of the holes was 1 m.

Figure 3: Microgrid installation without additive.

Figure 4: Microgrid installation with additive.

C. Site Measurements

Upon installation, the grounding resistances of the micrograms were periodically measured at each site. The fall-of-potential method [5] was used for measurement. For site measurements, the earth tester used was a Megger DET4TC, which injected an alternating current (AC) of known magnitude into the system being tested and measured the voltage developed across it, as shown in Figure 6. Induced by the current supply, AC flows and electrical potentials are created around the electrode under test and the auxiliary current stake. A fall of voltage could occur owing to certain resistances of the tested grounding. The voltage measure method is shown in Figure 6. Empirical testing showed that with suitably positioned stakes, this method can be shortened by placing the potential stake at a distance of approximately 62% between the electrode being tested and the current stake.

Figure 5: Six holes arranged in a straight line.

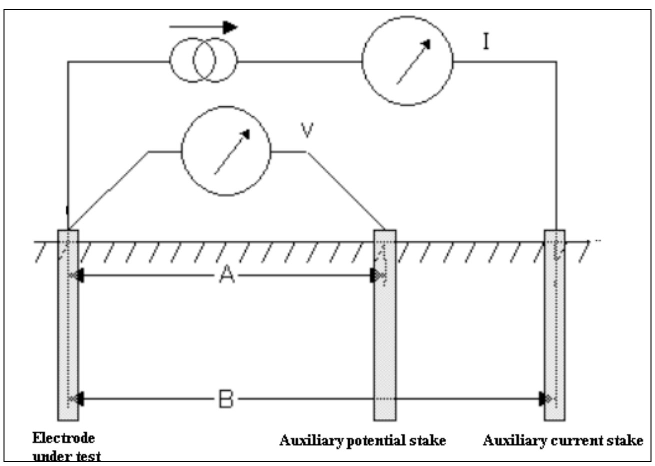

Figure 6: Schematic for the three-terminal resistance measurement.

IV. Results

Table 1 shows the result of resistance for each grounding grid starting from week 1 of installation. The result seems positive because most grids with POA show lower resistance than those without additives. The most desirable result obtained is from galvanized steel. The average resistance of grids with POA is 14.33Ω, whereas that without additive is 17.2Ω, which indicates a 17%–23% improvement. As for the copper grid performance, improvement in resistance is also observed. The grounding resistance without additive is 19.3Ω, and that with additive is about 17.3Ω, indicating a 9%–12**%** improvement.

Table 1
Resistance Measurements at Sites

Date	Grid Material	Without POA (Ω)	With POA (Ω)	Improvement (%)
Week 1	Copper	19.7	17.2	12.69
	Aluminum	19.5	19.7	-1.03
	Galvanized steel	17.2	14.33	16.69
Week 2	Copper	19.3	17.3	10.36
	Aluminum	18.3	17.3	5.46
	Galvanized steel	18	14.02	22.11
Week 3	Copper	19.3	17.4	9.84
	Aluminum	18.4	18.6	-1.09
	Galvanized steel	17.8	13.63	23.43
Week 4	Copper	20.1	18.2	9.45
	Aluminum	19.8	20.54	-3.74
	Galvanized steel	18.2	13.87	23.79

Meanwhile, the results of aluminum grid with POA is not as expected because the resistance is higher by only 1%–4%, even though the early stages showed good performance by having lower resistances at 17.3Ω and 18.3Ω with and without additives, respectively.

When POA is added, a galvanized steel grid still shows the best performance, with resistance of 14.33Ω. This is followed by copper with 17.3Ω, and aluminum with 18.3Ω. The reading of aluminum did fluctuate with the lowest resistance at 17.3Ω and the highest at 19.8Ω. The results for galvanized steel and copper gave consistent results.

V. Discussion And Conclusion

Adding POA as backfill improved soil resistance. Out of the three materials, galvanized steel grids had the best performance. Copper came in second place, which is surprising because it is expected to have the best performance. This result currently cannot be explained because, fundamentally, copper is a better conductor than zinc. Based on the authors' understanding, the galvanization protected the steel very well. However, once the zinc corrodes, the steel rusted.

For future improvements, short-, mid-, and long-term corrosion tests should be conducted on the material so as to ensure that the corrosive effects are minimized after POA is added. Further studies can also be conducted by connecting several grids in a parallel circuit. Based on circuit theory, the resistance can be reduced when connected in parallel. By using this method, industrial requirements resistance can thus be achieved. Finally, data collection should be done in the long term to obtain a sufficient data sample. In doing so, more accurate data can be obtained to support the use of POA as backfills.

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