ANALYSIS OF GROUNDING PERFORMANCE FOR DIFFERENT BIO FILLER MEDIUM EFFECT

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For my beloved mother and father

Norrzillah Binti Mohd Saaid and Abdul Karim Bin Ihwan,

and my lovely family

Thank you for your support, guidance and love

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Bismillahirrahmanirrahim...

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ABSTRACT

The importance of grounding system is when any fault current due to the power system problem, or lightning, can allow that dangerous current passes through the earth. Although with current specification and standardization right now is sufficient, there is no harm to try to improve the performance of the grounding system continually. Thus, the primary purpose of this project is to design and develop a new ground rod prototype with new soil composition. This new soil composition is used bio-material which then will be used as a main material for the grounding medium. The grounding rod will have a two design which is based on the previous research data. There is no any major or significant change on the ground rod except the is of the small electrode at the bottom of this copper rod. The small electrode is designed into the position of horizontal and vertical and then combine with the small ground grid rod which can increase the current dispersion. The performances analysis for the grounding system was based on two main assessments which are the soil resistivity and ground rod resistance. The results show that the vertical ground rod is performing better compared to the horizontal ground rod in term of ground rod resistance. Besides, it shows the depth of the ground rod buried will affect the ground rod resistance significantly. As a conclusion, pineapple leaves filler shows better medium for enhancing the grounding system performance compared with coir filler due to lower lower grounding resistance. Copper sulfate was able to reduce the ground rod resistance value temporarily although for a short duration.

ABSTRAK

Pentingnya system pembumian adalah ketika berlakunya mana-mana arus salah disebabkan system kuasa yang bermasalah atau kilat, dapat membenarkan arus berbahaya itu melalui bumi. Walaupun dengan spesifikasi dan penyeragaman yang mencukupi, tiada masalah sekiranya ingin mencuba untuk meningkat prestasi sistem pembumian. Jadi tujuan utama projek ini adalah untuk mereka dan mencipta prototaip rod pembumian dengan komposisi tanah baru. Komposisi tanah baru ini menggunakan bahan bio yang mana kemudian akan dijadikan sebagai bahan utama perantara pembumian. Rod pembumian ini akan mempunyai dua reka bentuk yang bersaskan dari penyelidikan yang lepas. Ia tidak akan mempunyai sebarang perubahan yang besar pada rod pembumian melainkan terdapat elektrod kecil di bawah rod pembumian itu. Elektrod kecil itu direka dalam posisi mendatar dan menegak dan kemudian dicantumkan pada rod grid kecil dimana ia boleh meningkatkan penyebaran arus. Analisis prestasi untuk pembumian system adalah berdasarkan dua penilaian utama iaitu ketahanan tanah dan rintangan rod pembumian. Keputusan menunjukkan bahawa rod pembumian menegak melakukan dengan lebih baik berbanding rod pembumian mendatar dalam terma rintangan rod pembumian. Selain itu, ia menunjukkan kedalaman rod pembumian yang ditanam akan mempengaruhi rintangan rod pembumian dengan ketara. Sebagai kesimpulan, pengisi daun nenas menunjukkan medium yang lebih baik untu meningkatkan prestasi sistem pembumian berbanding pengisi sabut kelapa disebabkan rintangan pembumian yang rendah. Kuprum sulfat telah berjaya mengurangkan rintangan rod pembumian buat sementara walaupun untuk tempoh yang singkat.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

These project aims are to develop a new soil composition by mixing a bio material with several other materials to improve the grounding system performance by reducing the resistivity of soil. Soil resistivity is one of the main factors that determined if the grounding system is good or not. Grounding is the practice of providing a good electrical connection between metallic parts, structures or electrical circuits and a metallic system usually buried in the earth. To simplify, soil resistivity is a measure of how much the soil resists the flow of electricity. It is a critical factor in the design of grounding systems that rely on passing current through the earth's surface.

Besides, the new design of ground rod will be developed. This ground rod will determine how the leakage current will be discharged into the soil by analysis the soil resistivity and ground rod resistance value [1]. The ground rod usually connected to the wire by using grounding clamps. This wire will be connected with a lightning rod and also all conductive objects which are known as bonding. It is necessary to install the grounding system because it can protect human body and also electrical equipment if the electrical fault occurred.

As shown in the title of this project, by developing new soil composition and using it with the new design of ground rod, the outcomes of the results will use to find the best composition of soil and ground rod design. The resistivity of the soil and ground rod resistance value will be determined by using specific method that will be discussed later.

1.2 Problem Statement

Grounding system is compulsory for electrical power system and a must have system on every single building in the world. The reasoning behind is because it works as a protection for the electrical appliances, machines, devices and the most important thing is human life. The grounding system will provide low impedance path for the current to dissipated securely in the soil whenever lightning strikes or even fault occurs.

However, there is a concern regarding of the grounding system which is ground potential rise (GPR). Some induced current or voltage caused by the lightning can cause this GPR occurring at the various part of the building. These phenomena will cause side flash over human being, equipment and others cause by the rise of step voltage and touch voltage [2]. To overcome the problem, a new soil composition and ground rod will be developed. In Malaysia, there are many bio-material that can be recycled and used as a filler. These materials can be used attempt to improve the existing grounding system by letting the fault current to absorb and flow totally to ground with minimal resistance as possible.

1.3 Objectives

i. To develop a new soil composition by implementing a bio-filler with several other materials for the medium in the grounding system.
ii. To design and develop a new type of ground rod.
iii. To analyse the grounding performance of these new soil composition with the new type of ground rod.

1.4 Scopes of Study

To bring this project to completion as well to achieved the stated objective, several scopes need to be follow-on such as:

i. There will be two difference bio-materials are selected.
ii. There will be at least two types of a new grounding electrode that will be designed.

iii. In this project, a two type of bio-material which consider as waste materials that can easily found in Malaysia will be processed into a smaller particle and then used as the main filler.
iv. An analyse will be made in order to compare which type of these fillers have the low resistivity value.
v. Others factor such as moisture will be taken into consideration.
vi. There will two main measurements will be taken which is soil resistivity and ground rod resistance.

1.5 Expected Result

This project is expected to have results based on testing works as follow:

i. This two bio-filler will help to reduce the soil resistivity of local soil which can be used for grounding purpose.
ii. The new ground rod which has two design will have different soil resistivity and ground rod resistance.
iii. There will be a fluctuation in data measurement due to the external factor such as temperature, weather condition, and contents of the local soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

All the articles, journals and thesis about the grounding system from the studies that have been accomplished by those researchers and professionals, are used for the literature review and also as a guide to complete this project. In this chapter, the topic is to discuss and review the previous project such as soil resistivity, grounding electrode resistance, the design of the electrodes, measurement method and others which are related to the grounding system. The intention is to see the previous procedure and also the results data which can be compared and used to achieve the objective of this project.

2.2 Soil Resistivity

Soil resistivity is widely applied either in electrical engineering or civil engineering. Generally, soil resistivity is to detect soil type, water contents of soil, dry density of compacted soil, salinity, porosity and chemically contamination of soil etc. However, in electrical engineering, soil resistivity mainly is to measure the soil resistance that resists the flow of electricity. The less resistance value on the soil, the easier overcurrent to be discharged to the ground. Moreover, soil physical properties such as water content, soil structure and chemical properties can alter the electrical resistivity of the soil. Through the electrical resistivity, the results can be changed during soil characterization [3].

2.3 Soil Structure and Characteristics

When developing a good earthing system, the part need took into the consideration is the structures and characteristics of the soil because it is one of the factors to get a low resistivity. Thus, many researchers have studied the effects of soil on the earthing system to identify whether various types of soil influence the earthing system or not [4]. Therefore, based on the guide IEEE 80 [5, 6], they acknowledge and agree that when a grounding electrode buried in the ground, they found that the top layer of the soil gives a greater resistivity value compared to soil beneath or it may also be influenced by the factor of the cold and hot weather.

In China, researcher [7] that has studied the characteristic of soil resistivity under meteorological condition in Haikou City. Three types of soils have been selected which is ash, sand and clay. The duration of the experiment is from January 2014 until March 2015 in spring, summer, autumn, and winter. The observation method used is by applying WENNER method (quadrupole method) for soil resistivity measuring. The result from the experiment as shown in Table 2.1 and Table 2.2 show that soil resistivity is not only influenced by soil type, but also by natural factors such as temperature, precipitation, and humidity. However, even with those factors, clay is still the soil with lower resistivity values follows by sand and ash.

Table 2.1: Soil resistivity and humidity relation of different soil properties

Soil	Spring		Summer		Fall		Winter	
	Resistivity (Ωm)	Humidity (%)	Resistivity (Ωm)	Humidity (%)	Resistivity (Ωm)	Humidity (%)	Resistivity (Ωm)	Humidity (%)
Ash	333.00	4.20	432.84	6.9	460.83	8.5	424.92	4.55
Clay	84.40	6.88	52.76	12.94	68.73	18.25	58.87	6.75
Sand	203.02	3.95	176.63	11.04	184.94	15.39	214.87	6.18

Table 2.2: Soil resistivity and temperature relation of different soil properties

Soil	Spring		Summer		Fall		Winter	
	Resistivity (Ωm)	Temp (℃)	Resistivity (Ωm)	Temp (℃)	Resistivity (Ωm)	Temp (℃)	Resistivity (Ωm)	Temp (℃)
Ash	333.00	25.76	432.84	28.54	460.83	25.50	424.92	18.29
Clay	84.40	26.08	52.76	29.77	68.73	26.36	58.87	18.86
Sand	203.02	25.89	176.63	28.89	184.94	25.69	214.87	18.60

Other than that, according to the previous research done by researcher [8] shows that the size of the grain soil can affect the characteristic of the soil. The critical breakdown electric field of the soil sample with larger grain size is lower than that of the soil with smaller grain size. It is more difficult to cause electric breakdown of soil with higher density. The particles of soil with higher density have tighter contact and smaller size of air voids among soil particles. Thus, it is difficult to develop into continuous discharge channels for the soil with higher density, which leads to a higher critical breakdown strength. This shows soil with higher density is difficult to disperse the current compare with the soil with lower density. Also, with the increment of the salinity of soil, the critical impulse breakdown electric field intensity of the soil decreases which mean the more water content in a soil, the reduce of resistivity in the soil.

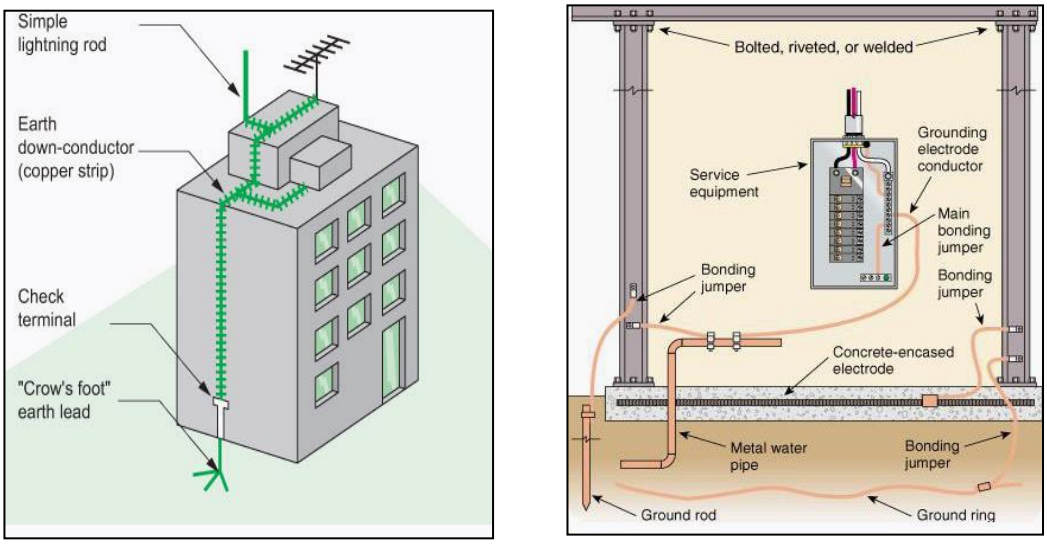
Another research was done by researcher [9] studied the characteristic value of electrical resistivity for different types of soil which shown in Table 2. From the Table 2, the lowest average value of ground resistivity is 30 Ωm which is boggy soil and the highest value of average ground resistivity is 2000 Ωm which is stony and rocky soil. This show boggy soil is easily discharge the electricity compare to stony and rocky soil. The data also can support the research done by researcher [8] which the type of soil which has a lower density such as boggy soil has lower resistivity values compare to the soil such as stony and rocky soil which has higher density and resistivity values.

Table 2.3: Ground Resistivity for different types of soil

Type of soil	Ground resistivity $\rho[\Omega m]$	
	Range of values	Average values
Boggy soil	2-50	30
Adobe clay	2-200	40
Silt, sand and humus	20-260	100
Sand and sandy soil	50-3000	200
Peat	>1200	200
Gravel		
Stony and rocky soil	100-8000	2000
Concrete: 1 part cement + 3 part sand	50-300	150

2.4 Grounding System

Generally, any electrical power system needs an effective grounding system that can provide protection to equipment and safety to the people from the dangerous of faults that occurred in the electrical system. In the early 18th century, a German scientist, Calr August Steinheil discovered that a circuit is completed if it connected to the earth [10]. Therefore, researchers and engineers work together to build a grounding system that can protect the electrical system more efficient. This consist of lightning system and bonding system as shown in Figure 2.1.



(a) (b)

Figure 2.1: The overall system of grounding protection [11]. (a) Lightning protection system, (b) Bonding system

In the lightning protection system, the minimum design standard should follow NFPA 780 (Standard for the Installation of Lightning Protection Systems). For a material selection, copper may be superior to other metals in both corrosion and maintenance factors. A lightning protection system should only be connected to high quality, low impedance, and robust grounding electrode system [11]. The connection is from the lightning rod to earth down-conductors to the grounding rod.

For the bonding system, electrodes that are present, including metal underground water piping, structural building steel, concrete-encased electrodes, pipe and rod electrodes, plate electrodes, and the ground ring and all underground metal piping systems that cross the ground ring, are bonding together with the grounding electrode system. For complete bonding system, the grounding electrodes of separate buildings in a campus environment are bond together to create one grounding electrode system. Besides that, all indoor electrical systems, such as power, cable television, satellite television, and telephone systems, and outdoor metallic structures, such as antennas, radio towers, etc. also are bond together with the grounding electrode system.

2.5 Electrode Topology

According to studies conducted by researcher [12], the followings aspects were studied, different types of grounding electrodes influence the leakage current distribution and different soil structures influence the grounding electrode performance. The different shapes or a type of grounding system is one of the factors that influence the earthing system. This is because the voltage step is produced by the electrodes electrode lifespan and corrosion of underground facilities in the vicinity of the electrode. The different types of grounding electrodes will affect the distribution of current density that happens without thought. The distribution of leakage current is particularly useful in grounding system electrode design because corrosion concerns and water movement in soil [13,14].

However, by changing the size of the conductors and its current density can improve the lifespan of a grounding electrode. Therefore, several different types of electrode have been developed and used, namely:

- Ring-type electrode

- Linear electrode
- Star-type electrode
- Vertical grounding electrode

They also said that the shape of the electrode such as ring, linear horizontal, star and linear vertical normally release the density of leakage current in uniformly or horizontally into a layer of soil because these types of electrodes are symmetrical. By this, we can optimize the size of conductor used as the electrode, the appropriate shape and the most important is the electrode might to disperse the leakage current in uniform and large amount. Accordingly, the study focused on two type of grounding electrode and its impact on the earthing system, namely:

2.5.1 Linear-Type Electrode

This linear type electrode named as ocean electrode of linear type and the shape as shown in Figure 2.2. They have made a test on the electrode by injected 1250A of current to the grounding electrode to see whether the electrode are able to dispersed or release the leakage current to the ground and also to find out which parts on the electrode will release more current. So, the result are they found that the current coming out through the edges of the electrode is greater than the current at the middle because the point at the edge smaller than at the center of the electrode.

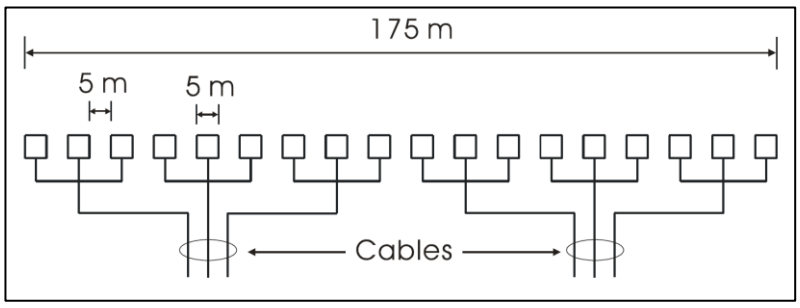


Figure 2.2. Ocean electrode of linear type

From Figure 2.3, it shows the graph of the current distribution of the ocean electrode is constantly increase when the number of the element also increases.

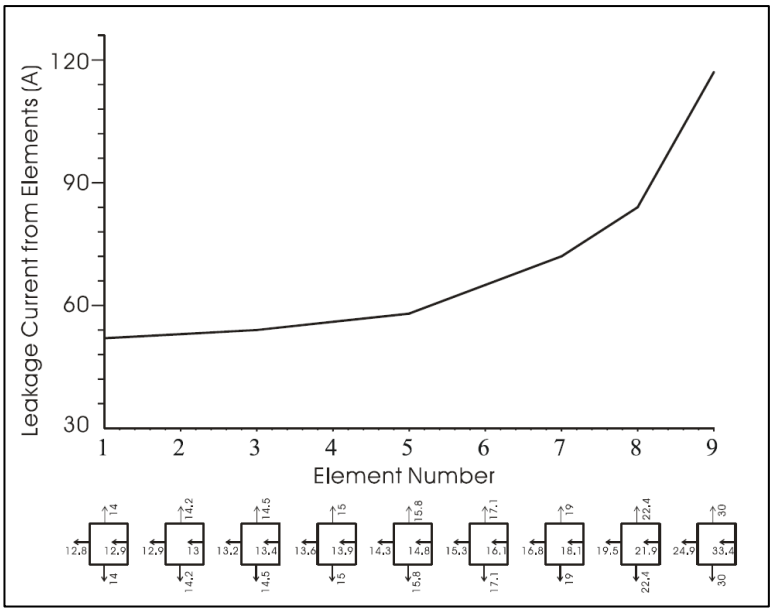


Figure 2.3. The current distribution of the ocean electrode

2.5.2 Star-Type Electrode

This type of electrode has been created with six arms star that looks exactly like a star and it usually fed at the center of this electrode as shown in Figure 2.4. They discussed that the leakage current coming out through the middle of the electrode is small compares to the leakage current come out at the electrode's arms. This happens due to the current density is located at the end of the electrode is 2.5 times than at center of the electrode. Also, the potential drop in each arm was 24%.

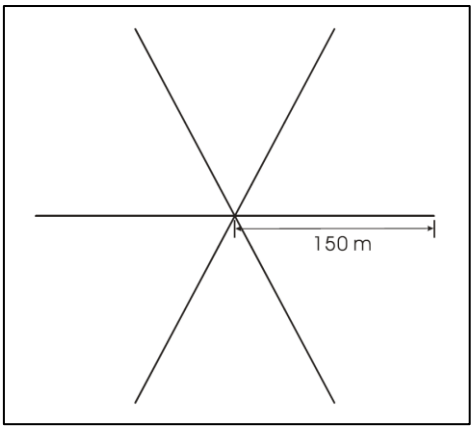


Figure 2.4. Star-type grounding electrode

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