GROUNDING ROD DESIGN EVALUATION FOR RESIDENTIAL USAGE

AHMAD NURDIN IKHWAN BIN MOHD NOR

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BACHELOR OF ELECTRICAL ENGINEERING

(INDUSTRIAL POWER)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

"I hereby declare that I have read through this report entitle "*Grounding Rod Design Evaluation for Residential Usage*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : ………………………………

Supervisor's Name : Dr. Farhan Bin Hanaffi

Date :

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AHMAD NURDIN IKHWAN BIN MOHD NOR

A thesis submitted in fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power) with Honors

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical Engineering

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2017

I declare that this report entitle "*Grounding Rod Design Evaluation for Residential Usage*" is the result of my own research excepts as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

Signature	: …………………………….
Name	: Ahmad Nurdin Ikhwan Bin Mohd Nor
Date	:

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To my beloved mother and father

For their endless love, support and encouragement

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ABSTRACT

Grounding of electrical installation is primarily concerned to ensure safety. The main purpose of grounding is to channel the fault current straightly to earth during fault condition. In order to create a good grounding system, the value of ground resistance must be reduced as low as possible. Otherwise, current may flow through to personal or damage electrical equipment instead of flowing through grounding system. The aim for this project is to study coconut husk efficiency as additive material for soil treatment in order to improve soil resistivity. Besides that, the galvanized steel rod electrode is investigated as alternative to copper steel rod to reduce the theft activity. In order to determine the good grounding, the experiment has been conducted on 6 different type of installation which is copper steel rod electrode, galvanized steel rod electrode without added with coconut husk and galvanized steel rod electrode added with coconut husk in different type of installation. The different type of installation is by added coconut husk with different weight which is 1kg, 1.5kg, 2kg and added coconut husk layer-by-layer with local soil. The treatments are done to enhance the performance of the galvanized steel rod in grounding system compared with copper rod. It shown grounding system performance such as grounding resistance gives better result compared to the conventional rod. Furthermore, the soil resistivity was reduced due to the ability of coconut husk that store water. Thus, it will lead improvement of grounding system.

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ABSTRAK

Sistem pembumian bagi pemasangan elektrik adalah untuk memastikan keselamatan. Tujuan utama system pembumian adalah untuk menyalurkan arus berlebihan terus kebumi semasa keadaan tidak normal berlaku. Dalam usaha untuk mewujudkan sistem pembumian yang baik, nilai rintangan tanah perlu dikurangkan serendah mungkin. Jika tidak, arus elektrik boleh mengalir melalui sesiapa sahaja yang telah menyentuh peralatan elektrik yang rosak dan bukannya mengalir melalui sistem pembumian. Tujuan projek ini adalah untuk mengkaji kecekapan sabut kelapa sebagai bahan tambahan untuk rawatan tanah dalam memperbaiki kerintangan tanah. Selain itu, keluli bergalvani rod telah disiasat sebagai alternatif kepada rod keluli tembaga untuk mengurangkan aktiviti kecurian. Untuk menentukan sistem pembumian yang baik, eksperimen telah dijalankan dengan 6 jenis pemasangan yang berbeza iaitu keluli tembaga, keluli bergalvani rod tanpa ditambah dengan sabut kelapa dan keluli bergalvani rod ditambah dengan sabut kelapa dalam jenis pemasangan yang berbeza. Jenis pemasangan yang berbeza itu ialah dengan menambahkan sabut kelapa tersebut dengan berat yang berbeza iaitu 1kg, 1.5kg, 2kg dan sabut kelapa telah ditambahkan lapisan demi lapisan dengan tanah tempatan. Rawatan telah dilakukan untuk meningkatkan prestasi keluli bergalvani berbanding dengan rod tembaga. Ia membuktikan prestasi sistem pembumian seperti pembumian rintangan memberikan hasil yang lebih baik berbanding rod konvensional. Tambahan pula, kerintangan tanah telah dikurangkan disebabkan oleh keupayaan sabut kelapa yang menyimpan air. Oleh itu, ia akan membawa penambahbaikan sistem pembumian.

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LIST OF ABBREVIATION

DET	Digital Earth Tester
UTeM	Universiti Teknikal Malaysia Melaka
GI	Galvanized
GPR	Ground potential rise

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In this modern era where electrical supply has become the basic needs in human life, grounding system cannot be avoided to be discussed as it is one of the most important part in electrical system. When working on the electrical installations, the earth or ground is one of the compulsory safety requirements. Grounded electrical system can protect the human life by diverting dangerous fault current to the ground. The grounding system is a conductive connection between an electrical circuit to the grounding electrode or to a point on the grounding electrode system. The grounding electrode is a rod driven into earth as a the actual device that establishes the electrical connection to the earth [1]. In order to ensure the fault current flow through the grounding electrode, the resistance of grounding electrode itself should be lower compared to the main circuit connection. Besides that, there are some various factors that effects the resistance to earth which is the connection of the system, the size and shape of the earth conductor and the resistivity of the soil [2].

The type of material that usually use for earth rods is solid circular copper, molecular bonded clad steel, stainless steel, and galvanized steel. Grounding performance and the resistance to earth are significantly influenced by soil resistivity. Soil resistivity depends to the composition of the soil. Soil resistivity is essentially electrolytic in nature that effected and varies with the type of soil, moisture content of the soil, chemical composition and the concentration of salts dissolved in the contained water. Besides that, the geological formation of soil also must be considered because the soil resistivity also

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varies with the stratification of soil. The method that uses for measure the soil resistivity is Wenner four-probe method. This method are driven the four test spikes to a depth of up to 1m with the same spacing between electrodes in meters along the straight line and the depth not exceeding 5% of their spacing between electrodes. [3] After the rod electrode was installed, to know the resistance value of the ground resistance are obtained by using fall of potential 61.8% method.[4]

1.2 Problem Statement

All grounding system requires the lowest resistance value to improve performance of the grounding system. The fault current needs the lowest resistance path to the ground in order to protect personal and electrical system. There are several factors that affecting the resistance of electrode which is type of installation, soil resistivity, size of grounding conductor and shape of the grounding conductor. Besides that, soil resistivity is the most factors that determined the performance of ground electrode system in context of the resistance to the earth of any ground electrode. The soil resistivity depends upon type of soil, moisture content, temperature, salt content and depth of soil [2]. Furthermore, the moisture content of soil is the greatest effect on soil resistivity [5]. The higher of moisture content, the lower of soil resistivity. The moisture content of soil will increase with depth while soil resistivity decrease with depth. Since the soil resistivity is lower, thus the ground resistance also becomes lower. In order to reach the moisture part in soil, the depths of ground electrode must be increase. By increase the depth of ground electrode, it may make very costly and can damage the rod with forced it into the hard ground [6]. Therefore, this problem can be solving by using soil treatment method. Based on BS72430:1998, the additive material that usually use for soil treatment is bentonite but it is expensive [3]. So, as an alternative method, coconut husk can be used as an additive material for soil treatment. The coconut husk is the water absorbent polymer that has the ability to hold or

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store water. Thus, the moisture content will increase and the soil resistivity will decrease. As copper is having high value in scrap metal, the number of theft is increased. This theft activity will cause the services company will suffer losses in term of cost. Alternative conductor such as galvanized, aluminium and steel is an option to reduce the theft but the performance needs to consider. Therefore, the ground electrode used in this project is galvanized steel as alternative to copper grounding rod. However, the performance of the galvanized steel as grounding rod need to be analyzed in term of grounding resistance in order to provide same level of protection as copper rod .

1.3 Project Objectives

The objectives of this project are:

1. To study coconut husk efficiency as additive material for soil treatment in order to improve soil resistivity.
2. To evaluate the performance of galvanized steel rod electrode with different type of additive material configuration.
3. To compare the performance of galvanized steel rod electrode with coconut husk and copper steel rod electrode in terms of grounding resistance.

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1.4 Project Scope

The scopes of the research are:

1. The location of this experiment is at the vicinity of Faculty of Electrical, UTeM.
2. Type of rod is vertical galvanized steel rod electrode (hollow rod) and type of additive material is coconut husk.

3. The installation for ground electrode at site will be done with 6 different type of installation which is vertical copper steel rod electrode, vertical galvanized steel rod electrode without added with coconut husk and vertical galvanized steel rod electrode added with coconut husk in different type of installation. The different type of installation with coconut husk is by added coconut husk with different weight which is 1kg, 1.5kg, 2kg and added coconut husk layer-by-layer with local soil.
4. The duration for this experiment is 7 weeks by collecting data of ground resistance.
5. In this project, coconut husk had been used as water absorbent polymer in order to reduce soil resistivity and improve the resistance of earth electrode.
6. The method that had been used to measure the soil resistivity is Wenner method while for the ground electrode resistance is fall of potential method based on BS 7430:2011 and IEEE Std 81-2012.
7. Digital earth tester (Megger 4TD2) was used to measure the soil resistivity and ground resistance.

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CHAPTER 2

LITERATURE REVIEW

2.1 Grounding system

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The grounding system is the important elements in electricity. The definition of grounding system is the connection of main electrical circuitry to the earth. The earth is a large conductor which can be considered as a reference or zero potential. Ground electrode is the equipment that use in between of the connection main electrical circuitry to the general mass of earth. The main purpose of grounding is to isolate the electricity supply from a fault situation by channel the fault current straightly to earth and capable of carrying the maximum expected fault current [2] and to limit the potential difference of neutral for system stability, allow for operation of relays and the system protection devices and also for personnel safety [7]. Besides that, the primary purpose of grounding is to avoid the effects of excessive currents that produced underground fault conditions by disconnected a system or equipment from the source of energy otherwise it will cause damage to property and to protect against danger to life through shock [3]. However, the grounding systems must operate continuously in order to ensure the personnel safety from shock, prevent the electrical equipment from damage and to avoid the property losses when the abnormal condition occurs in electrical system. The examples of abnormal condition are lightning strike and phase to ground fault [8]. In order for the fault current to flow through earth electrode, the resistance of earth electrode itself should be lower compared to the main circuit connection.

Furthermore, the grounding sytem have five categories which is TN-S, TN-C, TN-C-S, TT and IT [2]. In Malaysia, the grounding system that usually use in residential buildings is TT network system. The TT network system is a system with independent of the source earth which is used earth electrode that installed at the house. The TT network systems have two earth electrode installations. First earth electrode installation is at the supply system and second is at electrical appliances are connected directly to earth [9]. The requirement for earth electrode for installation protected by RCDs of sensitivity 100mA and lightning arrestor earth electrode from Suruhanjaya Tenaga 10 ohm [9]. Figure 2.1 shows the arrangement of connection earthing installation in TT network systems.

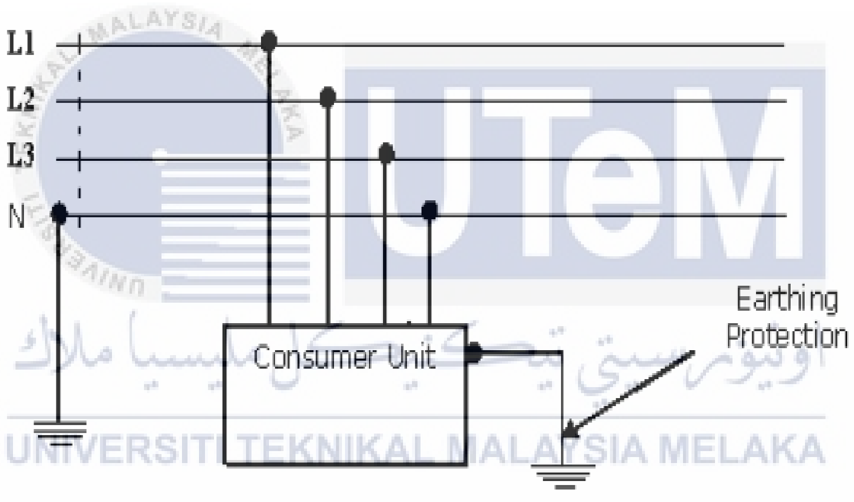

Figure 2.1 : The arrangement of the connection earthing installation in TT network system [9].

2.2 Ground Resistance

There are three basic components in the ground resistance. The basic component is resistance of the earth or ground electrode itself, the contact of earth electrode with the soil and resistance of the soil around the earth electrode [10]. There are several factors that affect the resistance to earth and fault current capacity of the buried conductor should be considered when design the earthing system. The factors are resistivity of the soil in which the grounding conductor is buried, size and shape of the earth conductor, and the type of connection system [2].

2.2.1 Soil Resistivity

Resistivity is a basic parameter to measure the characteristic of conductive for material [7]. Soil has its own particular resistivity that effects the implementation of earthing system, known as soil resistivity [4]. The definition of soil resistivity is a measure of how far a volume of soil will resist an electric current. The electric current that flow in the soil will be highly electrolytic which depends by the transport of ions that dissolved in moisture [11]. Unit measure that usually for soil resistivity is ohm-meter.

Besides that, there are two types of soil which is uniform soil and non-uniform soil. Normally, the uniform soil are rarely exists and the non-uniform soil can be categorized by horizontal layers and vertical layers. The elements that consist in soil structure are solid, liquid and gas. A mineral and organics matter is usually included in the solid phase of normal soil. The liquids phase is the water solution in the soil and the air between the solid particles is the gas particles [12]. However, the soil resistivity depends upon and can change with such as type of soil, temperature, moisture, mineral content, compactness and depth.

Figure 2.2 shows the geological structure of soil with different range of soil resistivity based on horizontally layered soil and vertical layered soil. Before designing the grounding system, there are two factors should be considered which is local soil resistivity and geological structure. These factors will make the grounding device are properly design according to the actual conditions of resistivity, soil structure and requirement for the grounding resistances of earthing system[12].

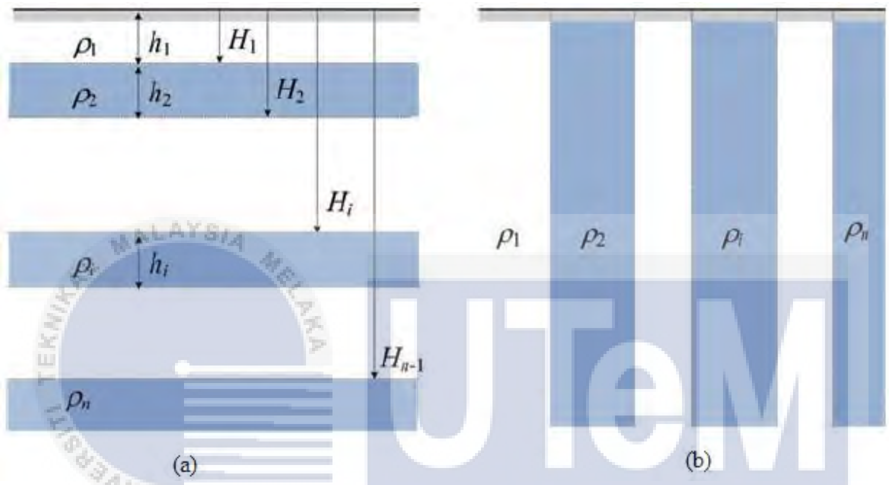

Figure 2.2: Type of non-uniform soil which is horizontally layered soil (a) and vertically layered soil (b)[12].

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Figure 2.3 shows the relation between added salt, moisture content and temperature with the resistivity. The highest effect on resistivity is the moisture content of the soil especially in the case of absorbent and permeable soils and rock [5]. Soils have the ability to retaining the moisture. The resistivity will reduces with increasing the percentage of moisture content in soil and it depends on the rainfall. During the monsoon, the resistance will be lower than dry season. The soil resistivity will become high when the moisture level is really low or nearly zero in soil especially in desert area or area with hardly any rainfall over the year [6]. Therefore, the electrode should be driven at the depth at which the moisture does not vary by the season to avoid the fluctuation. Since the moisture content of the soil increases with depth, thus the soil resistivity will decrease [6]. The location for grounding system should be chosen where the moisture content is ideally continuously within the range of 15% to 20% [2]. Besides that, the soil resistivity will slowly increase with decreasing temperatures and on the frozen soil the resistivity can be exceptionally high. The variation in soil temperature will also make the soil resistivity change. The soil temperature depends on effect of insolation, geothermic activity and air temperature [6]. However, the salt content can usually added by the human activity for lowering the soil resistivity and it was found that by adding the salt solution was effectively decrease the value of soil resistance. By addition salt content into soil, it only gives impermanent effects to soil resistivity [13]. Therefore, the level of moisture content and mineral salts in soil is the factors that affect the effectiveness of soil resistivity.

Besides that, the figure 2.4 shows the different type of soil with its conductivity and resistivity. In the grounding system, there are many types of soil that can be used. The soil resistivity can affect the ground resistance value. According to standard BS7430, there are several type of soil is arranged in descending order of resistivity:

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a) Gravel and stones
b) Dry sand
c) Damp and wet sand, peat
d) Clay and loam mixed with varying proportions of sand, gravel, and stones.
e) Clay, loamy soil, arable land, clayey soil, clayey soil or loam mixed with small quantities of sand
f) Wet marshy ground

Besides that, the location should be avoided if possible such as any very stony ground, dry sand, chalk, whinstone, limestone, granite, gravel and all locations where virgin rock is very close to the surface [2].

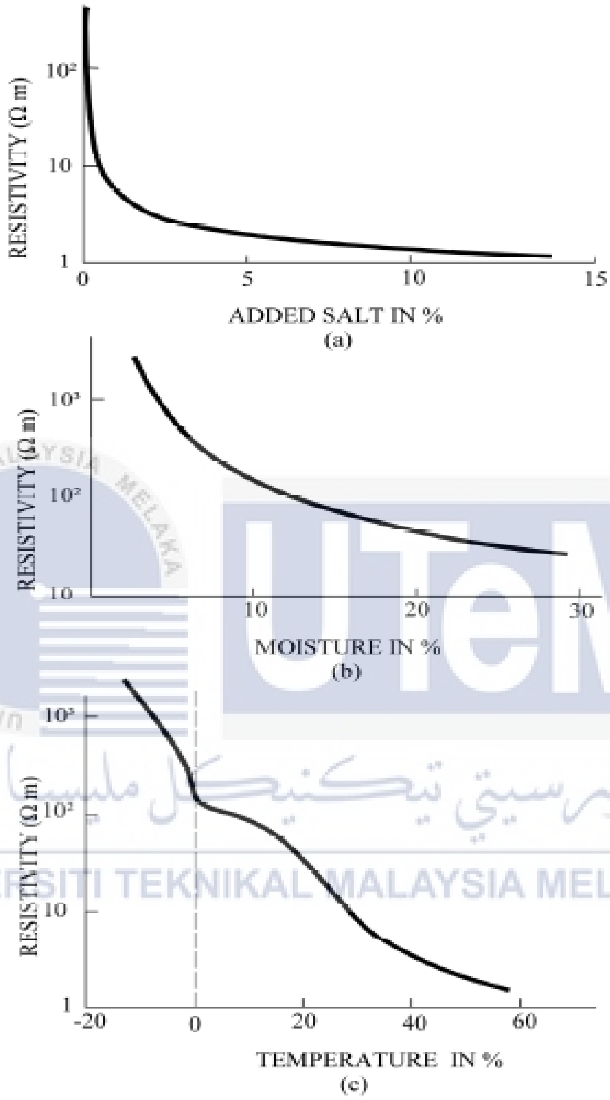

Figure 2.3: The variations of soil resistivity with salt, moisture and temperature [4]

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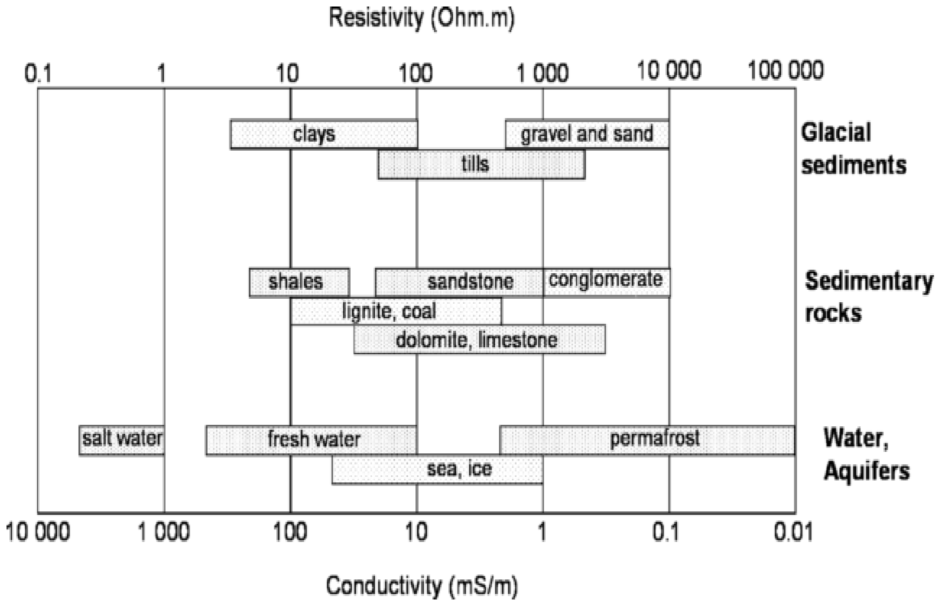

Figure 2.4: The type of soil resistivity depend on the type of soil [14]

2.2.2 Size and Shape Earth conductor

The type of driven ground rods generally consist of solid circular copper, molecular bonded clad steel, stainless steel, and galvanized steel. According to standard BS 7430, the diameter of copper and copper-clad steel rods are 9 mm, 12.5 mm and 15 mm. Galvanized and stainless steel rod, the preferred diameter is 16 mm. The length for the ground rod is 1.2 m for 9 mm rods and 1.2 m or 1.5 m for 15 mm rods [3]. By increasing the diameter of rod, it will lower the ground resistance value due the contact of conductor with soil. The value of ground resistance of galvanized iron rod with diameter 25 mm was lower than the diameter 15 mm by the single rod installation [15]. Table 2.1 shows the minimum sizes of components for ground electrodes according to BS 7430:1998.

Table 2.1: The minimum sizes of components for ground electrodes [3].

Electrode type	Cross-sectional area (mm^2)	Diameter or thickness (mm^2)
Copper strip	50	3
Hard drawn or annealed copper rods or solid wires for driving or laying in ground	50	8
Copper-clap or galvanized steel rods for harder ground	153	14
Stranded copper	50	3 per strand

2.3 Type of Grounding Electrode

There are several types of grounding electrode system which is single ground rod electrode, multiple ground rod electrodes and grounding grid [3].

2.3.1 Single Ground Rod Electrode

The single ground rod electrode is the simplest installation for grounding system. This type of installation will be done by driven the rod into the ground. The resistance of a single ground rod electrode can be calculated by using formula if the soil resistivity is known. The soil resistivity usually can be measured by using Wenner method. The resistance of the single ground rod electrode is given by the following equation:

$$R = \frac{\rho}{2\pi L}\left[\ln\left(\frac{8L}{d}\right) - 1\right] \tag{2.1}$$

From this equation, R is electrode resistance in unit ohms (Ω), ρ is soil resistivity in unit Ωm, L is the length of buried electrode in unit m and d is the diameter of electrode in unit m [3].

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2.3.2 Multiple Ground Rod Electrode

The multiple ground rod electrodes are the complex installation for grounding system. This type of installation will be done by increase the quantity of rod if the soil resistivity is not achievable using a single ground rod electrode. Besides that, this installation will lower the ground resistances and increase the amount of contact rod electrode with the surrounding earth. This type of installation will be done by more than one electrode is driven into the ground and connected in parallel to lower the resistance. The spacing of additional rods or spacing between the rod need to not less than the length of the rod. If the spacing between rods is too close together, the resistance will not be lowered. The resistance of the multiple ground rod electrodes is given by the following equation:

$$R_n = R\left(\frac{1+\lambda\alpha}{n}\right) \tag{2.2}$$

$$\text{In which } \alpha = \frac{\rho}{2\pi R s} \tag{2.3}$$

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From this equation, R is the resistance of one rod in isolation in unit ohms (Ω), ρ is soil resistivity in unit Ωm, s is the distance between adjacent rods in m, λ is a factor given in table 2.2, and n is the number of electrodes [3]. Table 2.2 shows the value factor λ for number of electrode.

Table 2.2: The factors for parallel electrodes arranged in line [3]

Number of electrode (n)	Factor λ
2	1.00
3	1.66
4	2.55
5	2.54
6	2.87
7	3.15
8	3.39
9	3.61
10	3.81

2.3.3 Grounding Grid

The definition of grounding grid is the system of horizontal ground electrodes. This system usually installed in one specific location such as at substation that consists of a number of interconnected, bare conductors buried in the earth and providing a common ground for electrical devices or metallic structures [16]. The main purposes of grounding grid are aimed achieving safety from dangerous step and touch voltage within a substation. Step voltage is the difference of 1 meter distance between the experienced by a person bridging in surface potential with the feet without contacting any grounded object. Meanwhile, touch voltage can be defined as potential difference at the point where a person standing between the surface potential and ground potential rise (GPR) which at the same time having a hand in contact with a grounded structure [16].

2.4 Measuring the Soil Resistivity

The most usually method that have been used to measure soil resistivity is four probe method or Wenner method. This technique was developed by Dr Frank Wenner of the U.S. Bureau of Standards. The fours probe must be installed in straight line at interval (a) and all at depth (b). The depth (b) of four probes should be not greater 5% of their interval (a). The two outer probes is the current electrode and the two inner probes is the potential electrode. When the current (I) is injected, it will passed between the two outer probes and the potential (V) between the two inner probes is measured with a potentiometer or high-impedance voltmeter. The resistance of the soil is determined by Ohm's law (R=V/I) and it's will display directly by instrument [2] [4].

The soil resistivity is given by the following equation:

$$\rho = 2\pi aR \quad (2.4)$$

From this equation, ρ is soil resistivity in unit Ωm, π is the constant 3.1416, a is the distance between the four probes in m and R is the reading from the measure instrument in unit Ω.

Besides that, by repeating the measurement with the different value of (a), the average resistivity to various depths may be found and the results will indicates whether any advantage is to gained by installing deeply driven electrodes in order to reach of lower soil resistivity. This is because the resistivity found applies to soil depth [2]. Figure 2.5 shows the arrangement for four probe method in measuring the soil resistivity.

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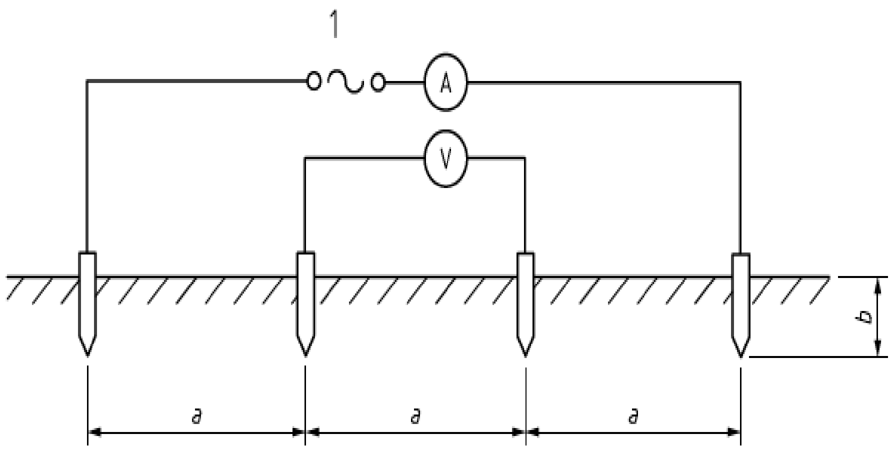

Figure 2.5: Shows the four probe method configuration [2].

2.5 Measuring the Ground Resistance

The method that have been used to measure ground resistance is Fall of Potential Method. This method use two test probe which is potential probe and current probe. The distance (X) from ground electrode to the potential probe must 61.8% of the distance (D) from ground electrode to current probe. When the current (I) was injected, it will flow between a ground electrode and current probe. Then the voltage will measure between ground electrode and potential probe [4]. The ground resistance is determined by Ohm's law (R=V/I) and it's will display directly by instrument.

To make sure the accuracy of the first reading value of ground resistance, this procedure should be test [2]:

1. The positions of potential probe should be moved to 50% and 70% of the distance of ground electrode to current probe.
2. If the reading within ± 5% of the value from the 61.8% test then the first reading considered as correct value.

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3. Then, if the reading not within ± 5% of the value from the 61.8% test, the current probe much moves further away.

This procedure is to make sure the location of potential probe free from any influence from both ground electrode and current probe. Figure 2.6 shows the arrangement for the of Fall of Potential method in measuring ground resistance.

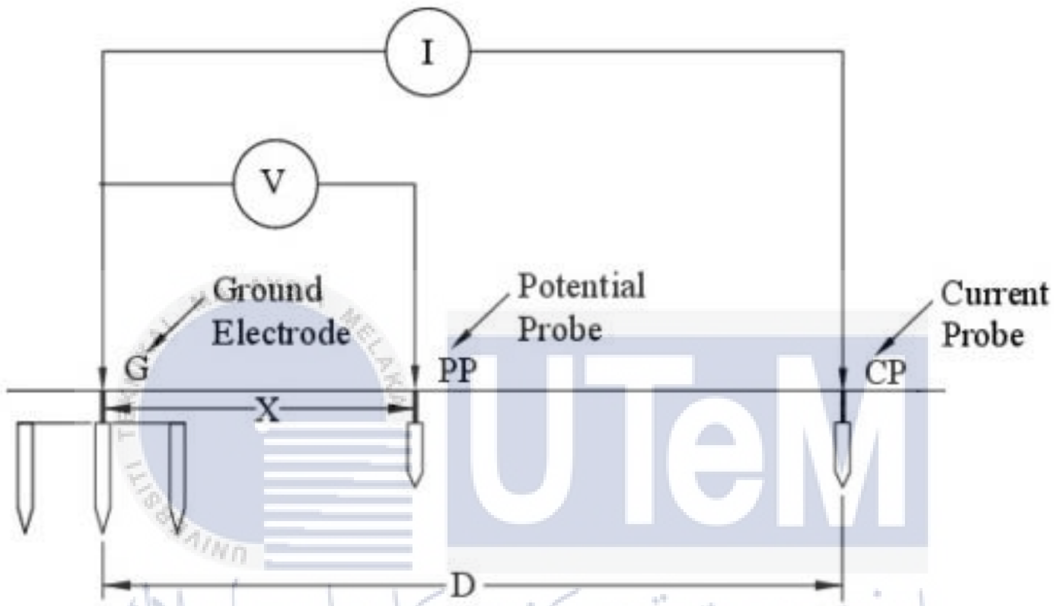

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Figure 2.6: Shows the Fall of Potential Method configuration [4]

2.6 Soil Treatment

Soil treatment is one of the methods to reduce the soil resistivity and also will reduce the ground resistance. The locations that usually have been used the soil treatment is at the high resistivity locations or on rocky ground for improve ground electrode contact resistance with respect to the general mass of ground. Soil treatment method needed the constant monitoring and replacement because from migration and leaching of applied chemicals over period of time will reduce the efficiency of soil treatment. According to standard BS 7430, there are several type of material with lower resistivity for soil treatment [3]:

1. A clay based material formed by decomposition of volcanic ash such as bentonite.
2. Concrete material
3. A conductive concrete or cement material.

Furthermore, the soil resistivity is the most important factor that must be considered in grounding system. In soil resistivity, the moisture content is the main role to determine whether the soil resistivity is high or low. If the soil resistivity is low, the ground resistance also will become low. According to N.H. Shuhada et al [17] based on measurement result, the bentonite can be used as grounding enhancement material to reduce the soil resistivity thus can reduced the grounding resistance. The soil resistivity without added bentonite of laterite soil is 82.1Ωm and peat soil is 130.9Ωm, thus the soil resistivity of peat soil is higher than laterite soil. This is because in context of water holding capacity. The laterite soil has a high of clay content than peat soil, thus it will affect the soil resistivity. The soil resistivity of both soils was changed when added with bentonite. The value laterite soil resistivity when added with 50g, 150g and 250g of bentonite is decreasing to 3.9%, 13.9% and 13.0% respectively.

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Besisdes that, the value peat soil resistivity when added with 150g and 250g of bentonite is decreasing to 9.4% and 11.7% respectively. The peat soil resistivity was increase slightly when 50g of bentonite was added which is 0.15%. However, for the ground resistance of laterite soil without added with bentonite is 3.26Ω. When the laterite soil was mixed with bentonite, the ground resistance was decrease to 3.7% when added with 50g of bentonite. The value of ground resistance when added with 150g and 250g of bentonite is decreasing to 13.8% and 12.9% respectively. Besides that, the ground resistance of peat soil without added with bentonite was higher than laterite soil which is 5.21Ω. When the peat soil was added with bentonite, the value of ground resistance when added with 50g and 250g of bentonite is decreasing to 11.3% and 11.7% respectively. The value of ground resistance when added with 150g of bentonite is slightly decreased to 9.4%.

Next, according to Muhamad Emir [18] the average ground resistance of local soil without mixed with coconut husk ashes is 3.13Ω. When the local soil was mixed with coconut husk ashes the average ground resistances decrease to 32.6%. Besides that, the average of ground resistivity for local soil without mixed with coconut husk ashes is 78.65Ωm and when the local soil mixed with coconut husk ashes, the average ground resistivity decrease to 32.6%. Therefore, the ground resistance and ground resistivity of stainless steel grounding system without enhancement of coconut husk is greater than stainless steel with enhancement of coconut husk ashes.

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Besides that, according to Mohd Khairil [19] The average ground resistance of local soil without mixed with cow dung ashes for the sunny day is 1.54Ω and when the local soil was mixed with cow dung ashes the ground resistance decrease to 29.2%. Besides that, the average ground resistance of local soil without mixed with cow dung ashes for rainy day is 0.78Ω and when the local soil was mixed with cow dung ashes the ground resistance decrease to 53.8%. Therefore, the average ground resistance for rainy day is lower than sunny day due to effect of soil humidity. In overall, the ground resistance was lower when galvanized steel rod grounding system with cow dung ash compared to galvanized steel rod grounding system without cow dung ash.

By using the water absorbent material as an additive material in grounding system, it will help retaining the moisture content in soil around the ground electrode. Since the moisture content of the soil increase, thus the soil resistivity will decrease. Therefore, the performance of grounding system will be improve by the value of ground resistance is low. Table 2.3 shows the previous study about effective of bentonite, coconut husk ashes and cow dung ashes as an additive material for soil treatment in order to improve soil resistivity in grounding system.

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Table 2.3: The previous study on additive material for soil treatment.

Item / References	N.H. Shuhada et al [17]	Muhamad Emir [18]	Mohd Khairil [19]
Type of soil	Laterite and peat soil	Local soil	Local soil
Type of additive material	Bentonite	Coconut husk ashes	Cow dung ashes
Type of mixture	Added with 3 different quantity of bentonite which is 50g, 150g and 250g in different hole.	Coconut husk ashes mixed with local soil	Cow dung ashes mixed with local soil
Type of installation	1-ft long vertical of copper rod. The dimension of hole is 1.6ft depth and 6 inches width.	1ft long of vertical stainless steel rod. The dimension of hole is 1.6ft depth and 6 inches width.	1m long of vertical galvanized steel rod electrode.
Characteristic of additive material	Good water absorbent and can retain moisture content	Good water absorbent or to hold the water when rain	By increases the absorbency of the soil
Advantage of additive material	Able to reduce the soil resistivity and grounding resistance	Able to reduce the soil resistivity and grounding resistance	Able to reduce the soil resistivity and grounding resistance
Disadvantage of additive material	Due to hot and dry weather, when the bentonite shrunk forming a large air gap in the soil between the ground electrode with the ground medium will cause the rise of soil resistivity.	Migration and leaching of additive material over period of time will reduce the efficiency of soil treatment	Migration and leaching of additive material over period of time will reduce the efficiency of soil treatment

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2.7 Summary of the studies

The grounding system can be divided into two types which is grounding rod and grounding grid. Grounding rod was usually used in residential area while grounding grid was usually used in substation. The ground resistance of the grounding system is an important value for the safety of electrical system in the event of fault. When the value of ground resistance is low as possible, the fault current can easily flow to the earth without cause any damage to property and can protect person from exposed to the danger of critical electrical shock. Besides that, there are several factors were affected to ground resistance which is type of installation rod, size and shape of the earth conductor as well as soil resistivity. For this study, the soil resistivity is the most factors that affect the ground resistance value. Meanwhile, the soil resistivity depends upon and can change with such as type of soil, temperature, mineral content, moisture and depths. The moisture content is the important role to determine whether the soil resistivity is high or low. Therefore, to get the lower value of soil resistivity it must achieve the moisture part in soil deep for lowering the resistance of grounding system. However, in the rocky soil it was very costly and can damage the rod with forced it into the hard ground. So, the alternative method is by using soil treatment with additive material which is water absorbent polymer that can hold the water around the grounding system. Therefore, the soil resistivity can be reduced which lead to the reduction of ground resistance.

CHAPTER 3

METHODOLOGY

3.1 Experiment Procedure

In order to finish this project, a necessary project planning should be arranged carefully to ensure the experiment will run smoothly and will be done successfully. In figure 3.1 was shown the flowchart of experiment procedure for this project. The first step is survey and testing soil resistivity at site. After the soil resistivity testing was done, the value of soil resistivity with various depths will decide the length of ground rod electrode for this project. The type of installation for this project is vertical ground electrode and the types of rod that was used in this project are copper steel ground rod as an experiment reference and galvanized steel ground rod. Besides that, the material that was used for soil treatment in this project is coconut husk as an additive material. The installation for ground electrode at site was done with 6 different type of installation which is vertical copper steel rod electrode, vertical galvanized steel rod electrode without added with coconut husk and vertical galvanized steel rod electrode added with coconut husk in different type of installation. The different type of installation with coconut husk is by added coconut husk with different weight which is 1kg, 1.5kg, 2kg and added coconut husk layer-by-layer with local soil. Besides that, the test instrument that was used in this project for measurement of soil resistivity and resistance of ground electrode system is Megger digital earth tester (DET4TD2). This project was conducted in 3 months by collected data of soil resistivity at for testing site, installation of ground electrode at testing site and collected data for resistance of ground electrode system.

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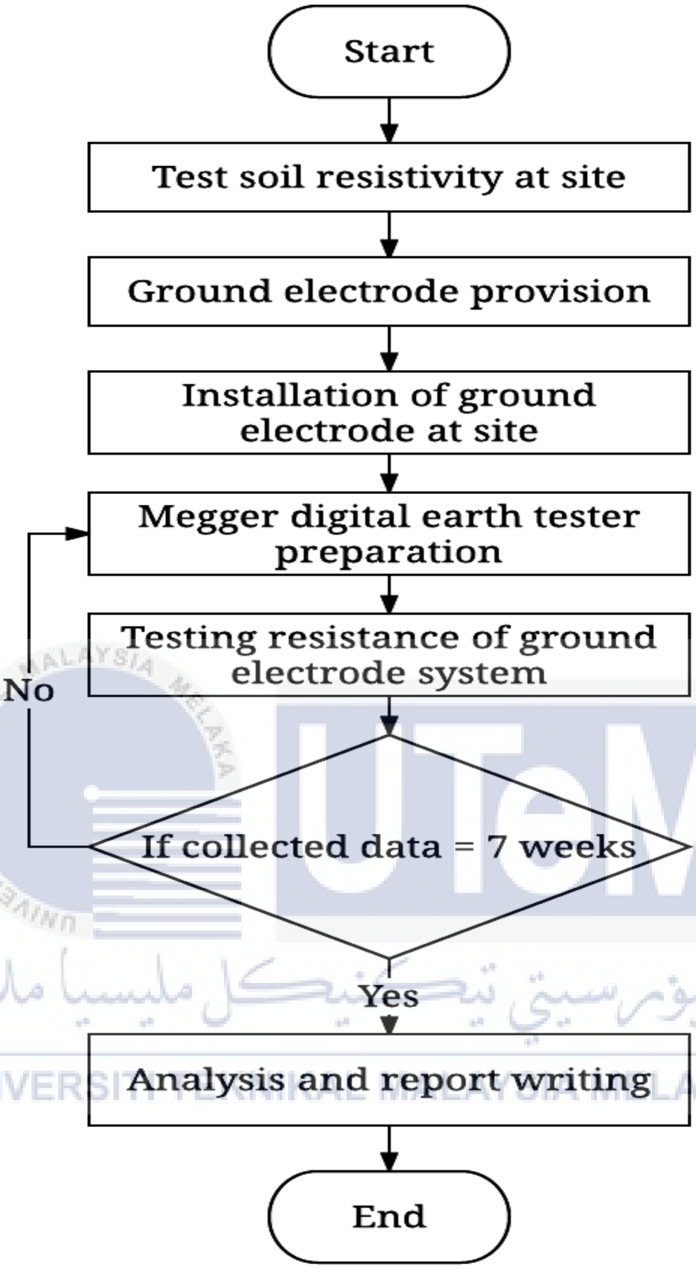

Figure 3.1: The flowchart of experiment procedure for this project.

Figure 3.2 shows the parts of Megger DET4TD2 instrument that was used in measured soil resistivity and ground resistance.

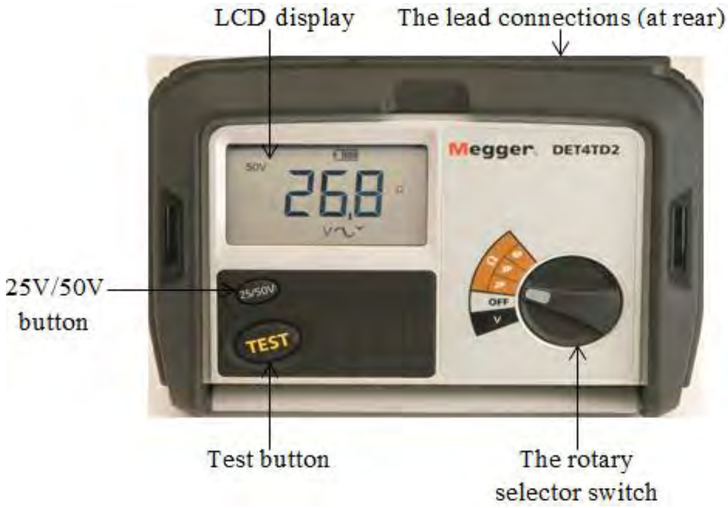

Figure 3.2: The parts of Megger DET4TD2 [20].

3.2 Type of installation for rod electrode

Figure 3.3 shows the single vertical copper steel ground rod electrode installation as reference for this project. Copper rod is one of the better and commonly used materials for earth electrodes and underground conductor because it has a better performance compared to other conductor. This installation of copper steel rod is to compare the performance of grounding systems which is in context of ground resistance with galvanized steel rod. The length of copper steel electrode is 1.5m and the diameter is 1.5cm. Besides that, the copper steel electrode was driven into ground in 1m depth.

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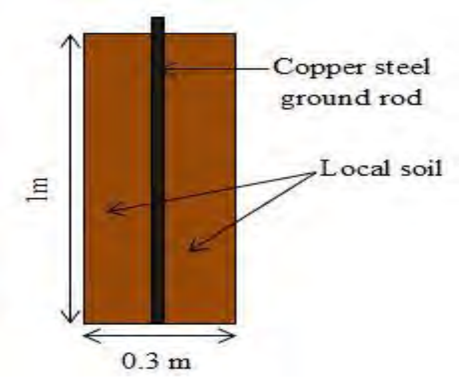

Figure 3.3 : Copper steel ground rod electrode model

Figure 3.4 shows the galvanized steel ground rod electrode with coconut husk as an additive material. This installation was done with three different quantity of coconut husk by weight which is 1kg, 1.5kg, and 2kg in different hole. The coconut husk was added almost at the upper of hole to reduce the soil resistivity where the coconut husk will act as water absorbent. Since the soil resistivity at the upper hole is lower, thus the ground resistance also becomes lower and it can easily channel the fault current to the ground. The different quantity of coconut husk is to compare between amount of moisture content and soil resistivity value.

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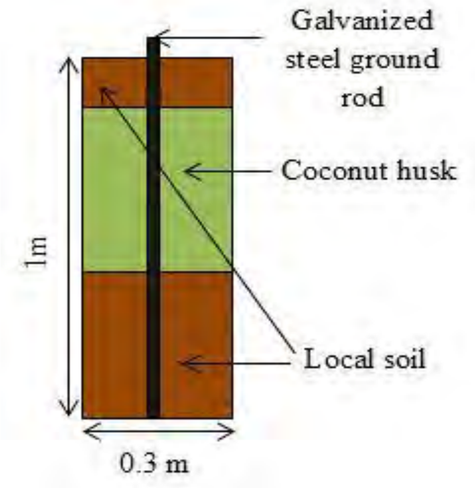

Figure 3.4: Galvanized steel ground rod electrode with coconut husk model.

Figure 3.5 shows the galvanized steel electrode (hollow rod) that was used for this project by added with coconut husk as an additive material. The length of galvanized steel electrode is 1.5m and the diameter is 2.3cm. Besides that, the galvanized steel electrode was driven into ground in 1m depth.

Figure 3.5: Galvanized steel ground electrode (hollow rod) at testing site.

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Figure 3.6 shows the galvanized steel ground rod electrode was driven into ground in 1m with layer-by-layer of coconut husk and local soil. There are 4 layer of coconut husk for this electrode system and each layer was added by 500g of coconut husk in order to increase the moisture content within the soil. The moisture content will effect on soil resistivity. The higher of moisture content, the lower of soil resistivity.

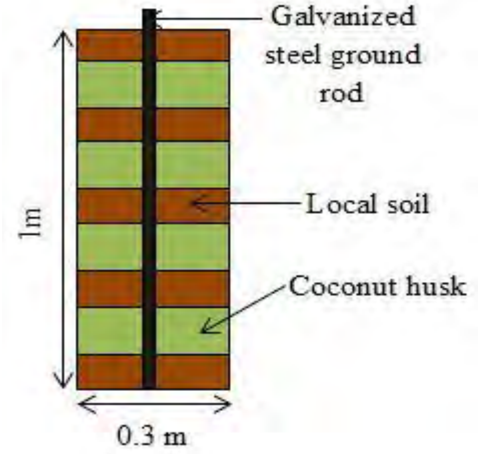

Figure 3.6: Galvanized steel ground rod electrode with layer-by-layer of coconut husk model.

Figure 3.7 shows the galvanized steel ground rod without coconut husk. This installation of galvanized steel rod is to compare the performance of grounding systems which is in context of ground resistance with galvanized steel rod with coconut husk.

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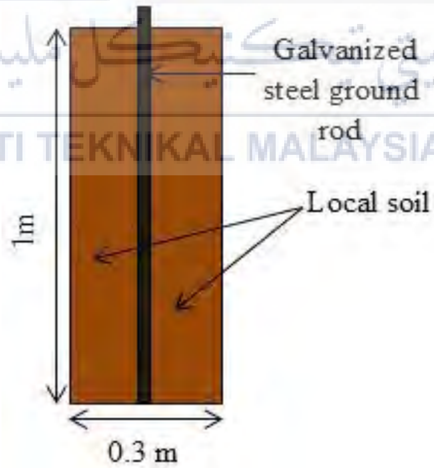

Figure 3.7 : Galvanized steel ground rod electrode without coconut husk model.

Figure 3.8 shows the arrangement of 6 rod electrode installation. The spacing between rod electrode installations is 3m. The depth of holes is 1m and the width of holes is 0.3m. Hole A is for single copper steel rod electrode. Hole B is for single galvanized steel rod electrode without coconut husk. Hole C is for galvanized steel rod electrode with

1kg coconut husk. Hole D is for galvanized steel rod electrode with 1.5kg coconut husk. Hole E is for galvanized steel rod electrode with 2kg coconut husk. Hole F is for galvanized steel rod electrode with layer-by-layer of coconut husk with local soil.

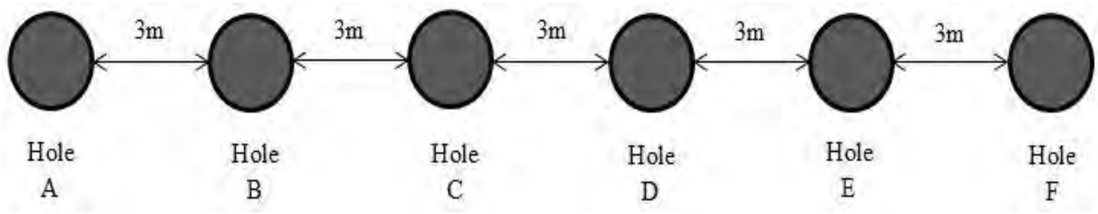

Figure 3.8: Installation of ground rod electrode scale model design.

3.3 The sample of additive material

The total weight of additive material that was used for soil treatment in this project is 6.5kg. Figure 3.9 shows the coconut husk that was used in this project as an addictive material in order to increase the moisture content in ground electrode system.

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Figure 3.9: Tested sample of additive material (coconut husk).

3.4 Four-Terminal Resistivity Measurement

Resistance to earth of a ground electrode is influenced by the resistivity of surrounding soil. The resistivity of surrounding soil is depending to the type of the soil and its moisture content. Before the installation of ground electrode into earth, it is regularly helpful to make a primary survey of the soil resistivity of surrounding site. This primary survey will enable decisions to be prepared on the best position for the ground electrode and to choose whether any advantage can be increased by driving rod to greater depth. Since the test was repeated with different value of spacing between four test spikes, thus the depth of test also different. In this project, the different spacing between four test spikes that was done is 1m, 2m, 3m and 4m. In figure 3.10 was explains the step on how to measure soil resistivity by using digital earth tester 4TD2 (DET4TD2). The suitable spacing between four test spikes for this project is 4 meters and the depth of the test spikes is 0.2 meters. The rotary selector switch of DET4TD2 was ensured in the OFF position before connect all the test spikes at C1, P1, P2 and C2 terminal. After all test spikes was connected with all terminal, the rotary selector switch was changed to 4P position and the desired test voltage using 25V/50V button was selected. Next, the test button must was pressed and released. After that, the four-terminal resistance reading was displayed at DET4TD2 screen. Then, the soil resistivity was calculated by using equation 2.4.

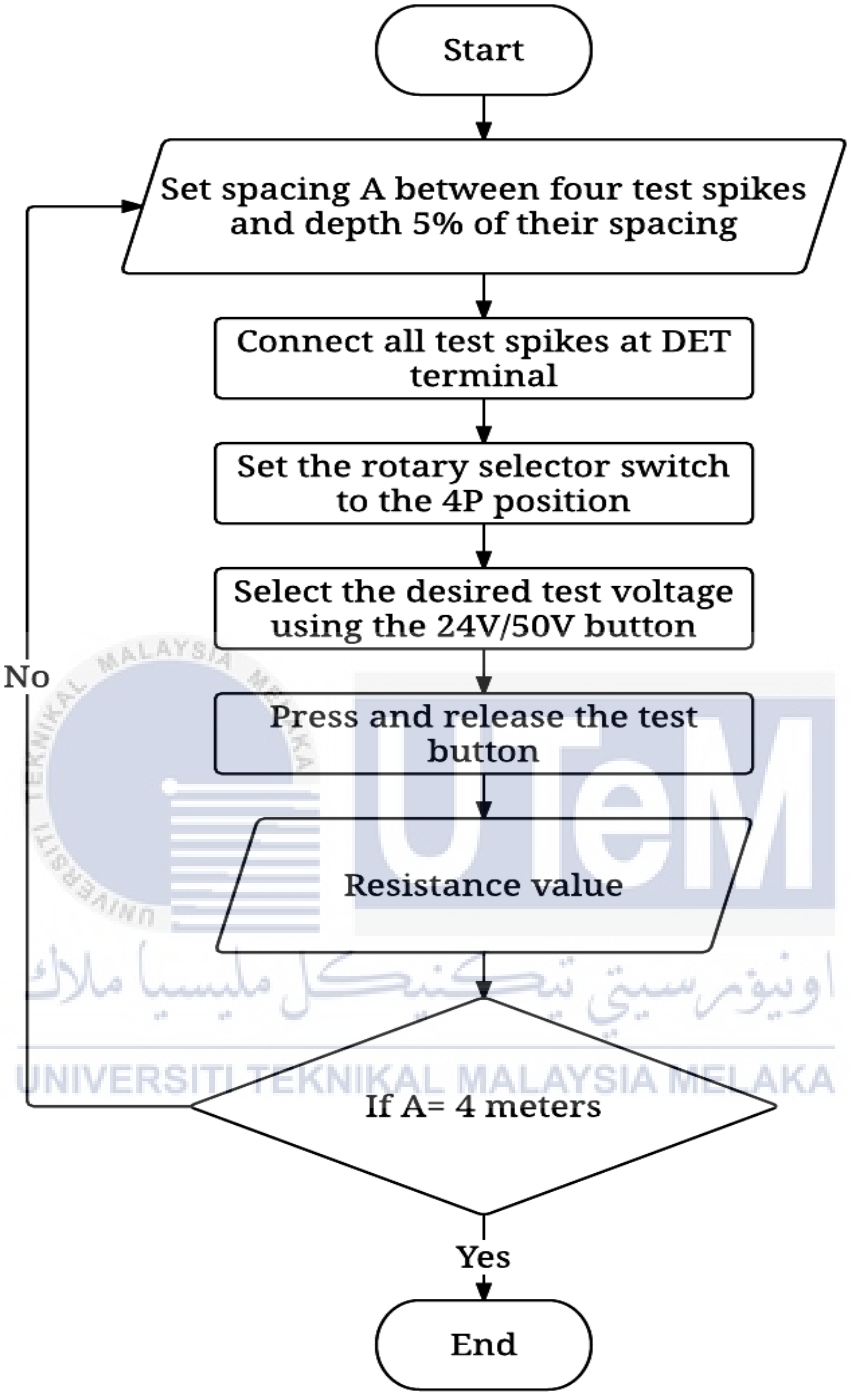

Figure 3.10: Flowchart for four-terminal measurement.

Figure 3.11 shows the connection for all test spikes at Megger DET4TD2 terminal in measuring soil resistivity. The connection of C1 and C2 is for current spikes while the connection of P1 and P2 is for potential spike.

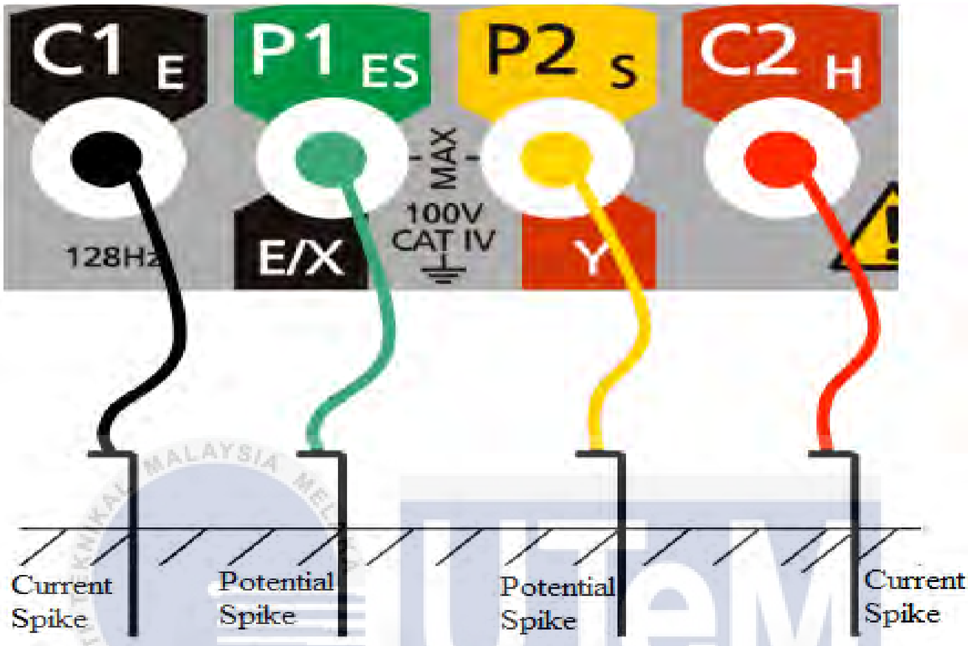

Figure 3.11: The connection for all test spikes at DET terminal [20].

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3.5 Three-Terminal Resistance Measurement

The method that was used in three-terminal resistance measurement is fall of potential 61.8% method. In figure 3.12 was explains the step on how to measure resistance of ground electrode system by using digital earth tester 4TD2 (DET4TD2). The distance A of current test spike from ground electrode under test was set with 12 meters and the distance B of potential test spike from the ground electrode under test was set with 7.4 meters. The rotary selector switch of DET4TD2 was ensured in the OFF position before connect ground electrode under test at P1 terminal, potential test spike at P2 terminal and current test spike at C2 terminal. After all test spikes and ground electrode under test was connected with all terminals, the rotary selector switch was changed to 3P position and the desired test voltage using 25V/50V button was selected. Next, the test button was pressed and released and the first three-terminal resistance reading was displayed at DET4TD2 screen. After that to make sure the accuracy of the first resistance value reading of ground electrode system, the positions of potential test spikes (distance B) was changed into 6 meters and 8.4 meters from the ground electrode under test. If the reading within 5% of the value from 7.4 meters tests then the first reading was considered as correct value. If the reading not within 5% of the value from 7.4 meters test, the current test spike (distance A) need to move further away.

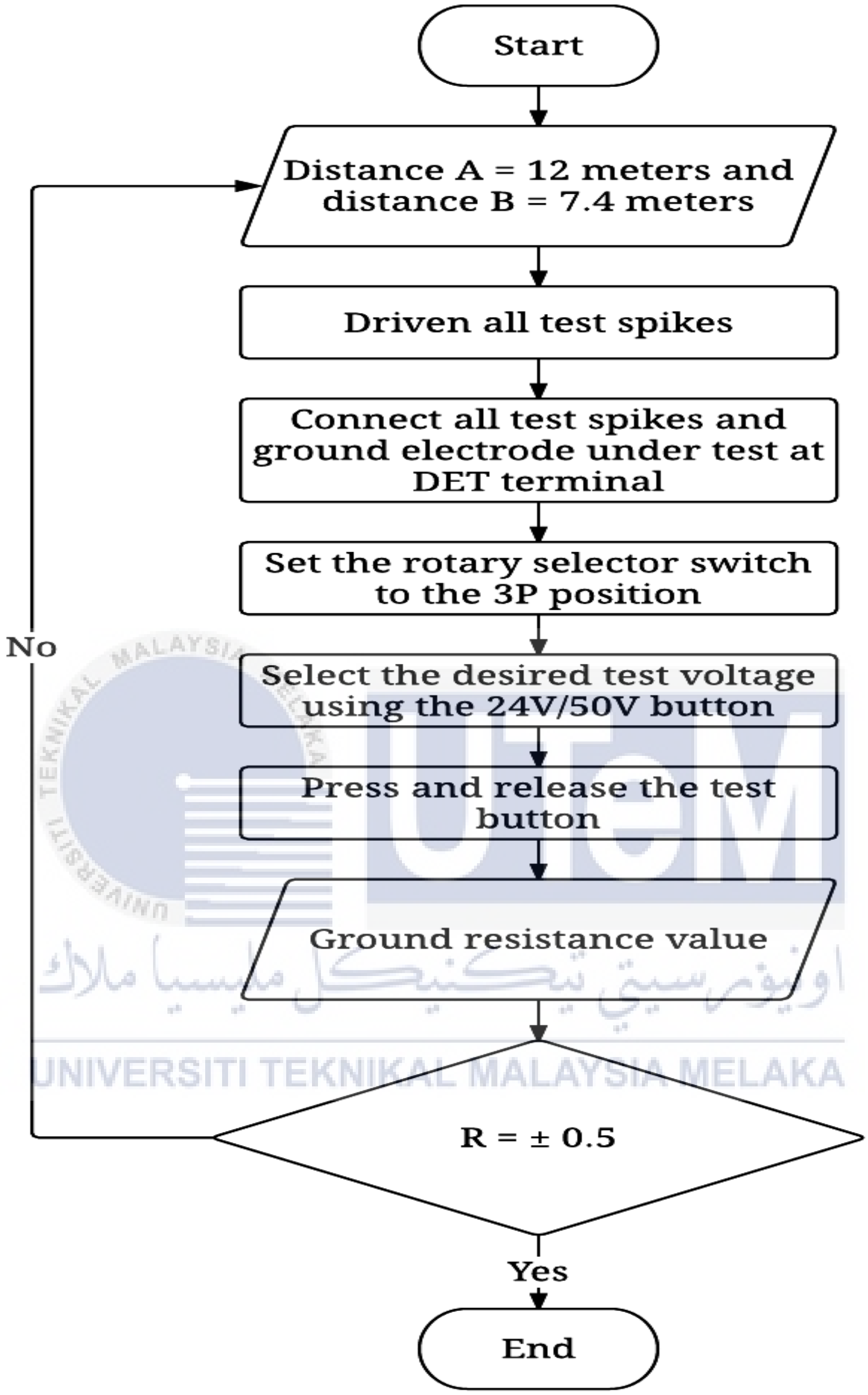

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Figure 3.12: The flowchart of three-terminal measurement.

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Figure 3.13 shows the connections for ground electrode under test and all test spikes at Megger DET4TD2 terminal in measuring the ground resistance. The connection of P1 is for rod electrode under test. Besides that, the connection of P2 is for potential spike while the connection of C2 is for current spike.

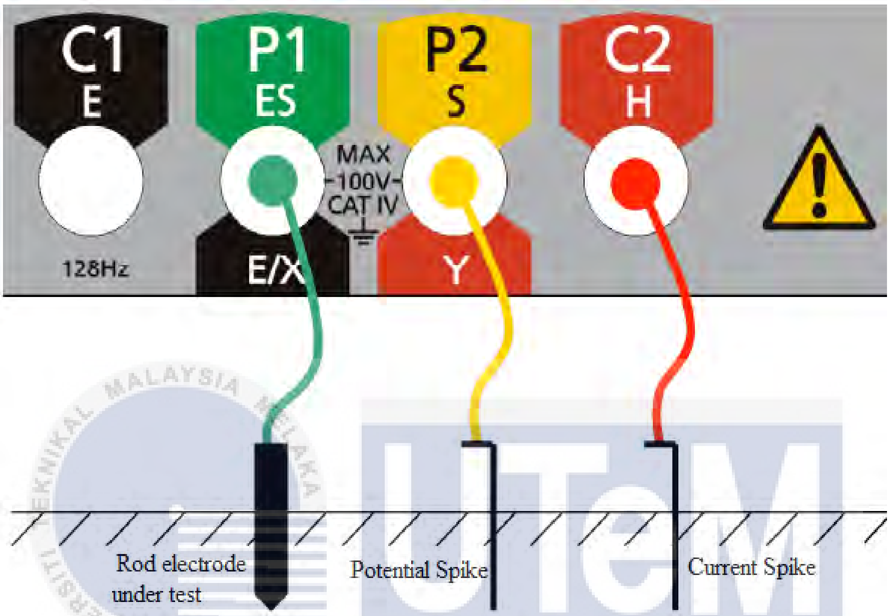

Figure 3.13: The connections for ground electrode under test and all test spikes at DET terminal[20].

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3.6 Calculation of soil resistivity for ground electrode

The value of soil resistivity for ground electrode is determined by equation 3.2. The length and diameter of rod is constant value. Besides that, the ground resistance was determined by measured with using Fall of Potential method.

$$R = \frac{\rho}{2\pi L}\left[\ln\left(\frac{8L}{d}\right) - 1\right] \tag{3.1}$$

Where:

R is the resistance to earth of a vertical rod;

L is the length of the electrode, in meters (m);

d is the diameters, in meters (m);

ρ is the resistivity of the soil in ohm meters (Ωm);

Hence:

$$\rho = \frac{2\pi RL}{\left[\ln\left(\frac{8L}{d}\right) - 1\right]} \tag{3.2}$$

Where:

L = 1.5 meters.

d = 0.023 meters for vertical galvanized steel rod electrode.

d = 0.015 meters for vertical copper steel rod electrode.

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CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter discusses the results for soil resistivity for testing site, galvanized electrode with different weight of coconut husk, galvanized electrode with different configuration of layer and the different type of ground electrode. This project was conducted in 3 months and the result for soil resistivity and ground resistance was obtained through Wenner method and Fall of potential method by using digital earth tester (DET4TD2). In addition, the weather condition is taking as a consideration in this project to determine the increasing and decreasing of ground resistance and soil resistivity.

4.2 Soil Resistivity for Testing Site

The resistivity of surrounding soil is depending to the type of the soil and its moisture content. The result was taken at 20 January 2017 and the measurement of soil resistivity at site was conducted by using Wenner method which is the distance between four probes is 4 meters and the depth of four probes is 0.2 meters. The primary survey of the soil resistivity of surrounding site have found that the soil at site have a difference of geological structure which is vertically layered soil.

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Figure 4.1 shows the plan of soil resistivity from the top view. The test of soil resistivity was conducted in 6 different points and the distance between the points is 3 meters. The distance during the test of soil resistivity is 12 meters to the right from the each point. From the measured value obtained it shows that the type of soil at surrounding site is vertical profile due to the different range of soil resistivity. At the first and second point the measurement value of soil resistivity is around 500Ωm. Besides, at the third and fourth point the value of soil resistivity is around 300Ωm while at the fifth and sixth pint the value of soil resistivity is around 200Ωm. Therefore, it can be shown that the type of soil at testing site is non-uniform soil with the value of soil resistivity is different in vertical.

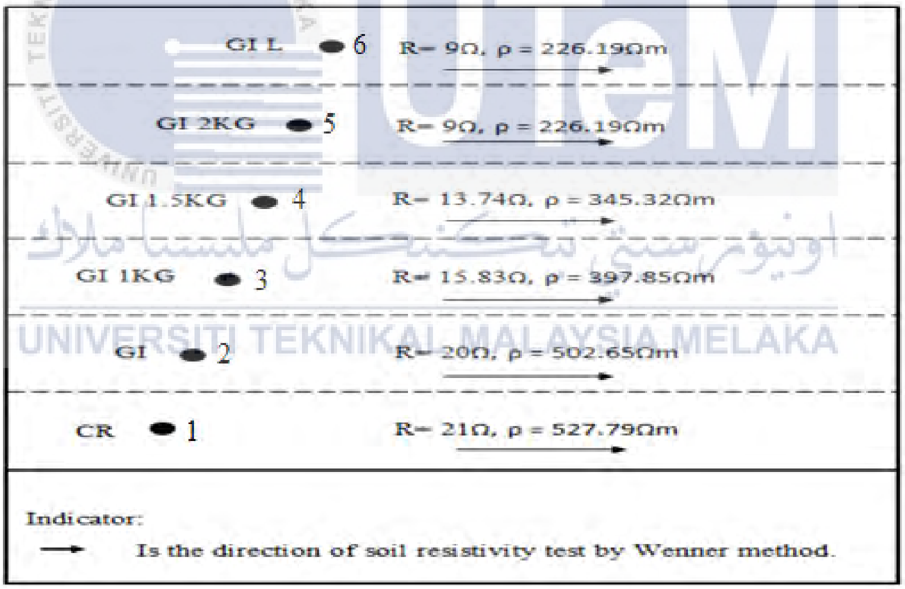

Figure 4.1: Soil resistivity of surrounding site.

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Figure 4.2 shows the different position of soil resistivity test at point A, B and C. The distance between three point is 6 meters. In order to get the same range of soil resistivity at each point, the test of soil resistivity has been performed in incline direction so that the value in incline direction at point A is around 400Ωm, point B is around 200Ωm and point C is around 300Ωm. However, when the test had been made on straight line direction, the value of soil resistivity did not show the same range.

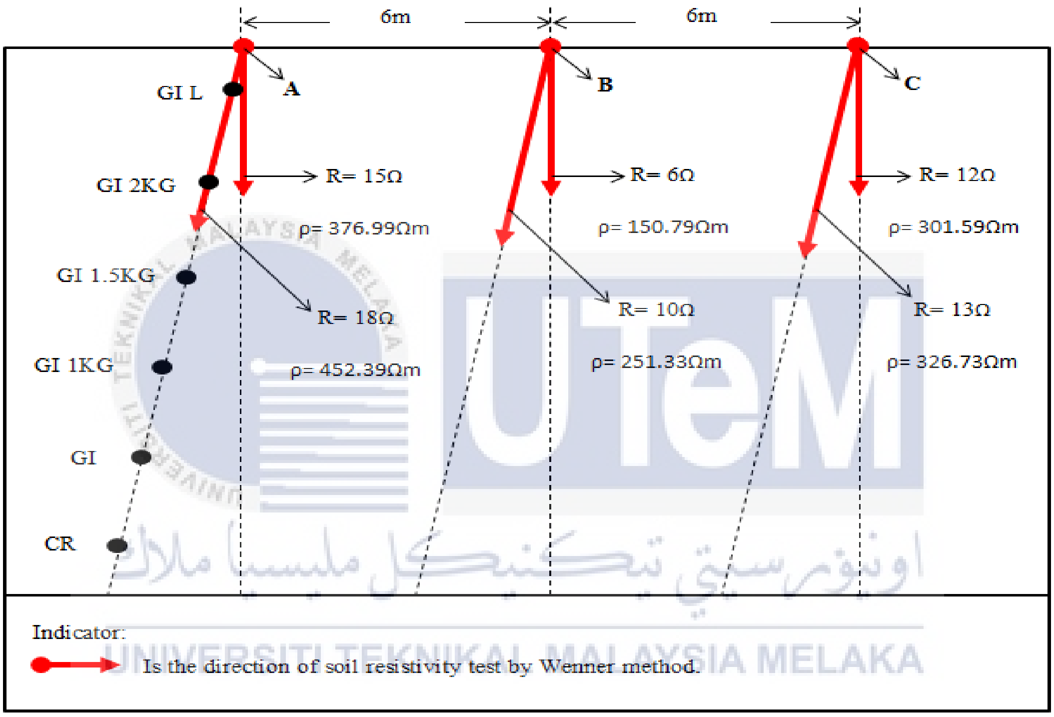

Figure 4.2: The soil resistivity at different position.

Besides that, figure 4.3 shows the soil resistivity at straight line with the line of installations for ground electrode. The test of soil resistivity has been performed in a two different direction which is forward direction and backward direction. This is because to investigate the overall value of soil resitivity at straight line with ground electrode. From the measured value obtained it shows the value of soil resistivity within the range of 400Ωm. Therefore, this position is appropriate to conduct the fall of potential 61.8%

method for measured resistance of ground electrode system. Thus, comparison of coconut husk behaviour in terms of soil resistivity for each ground electrode can be made.

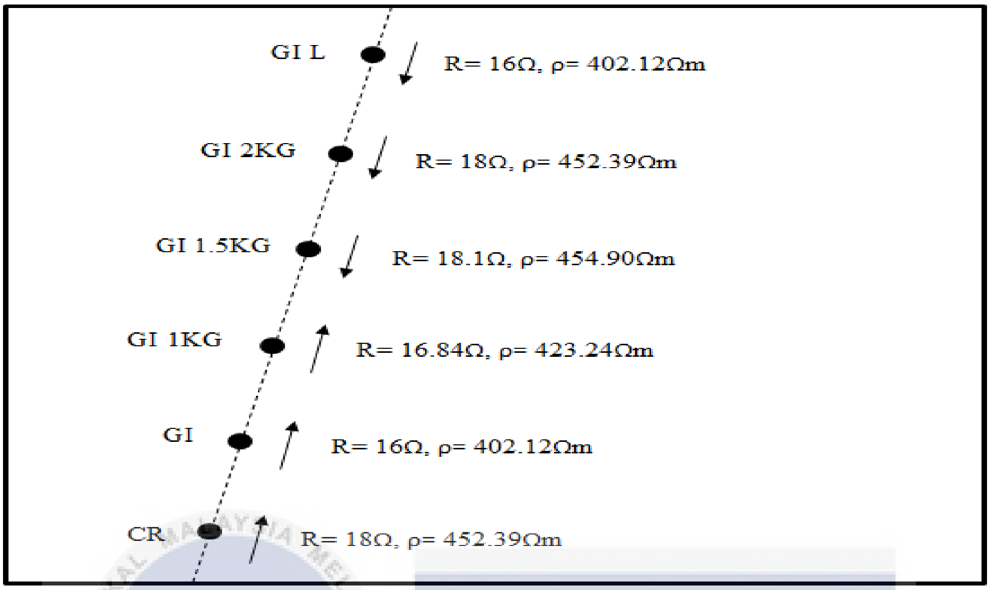

Figure 4.3: The overall value of soil resistivity in incline direction.

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Once all the measurement data of soil resistivity of local soil at site have already been collected, the installations for ground electrode at site have been done with 6 different types of installation during the day on 26 January 2017. After that, the fall of potential 61.8% method for measured resistance of ground resistance of ground electrode system was conducted from 14 February 2017 until 31 March 2017.

4.3 The Weather Condition along the Testing Day.

Weather is one of the factor that determine the increasing and decreasing of soil resistivity and ground resistance value. During the rainy day, the data of ground resistance was collected after the rain was occurred on that day. Table 4.1 shows the weather condition during measurement of ground resistance at the site. In this experiment, the ground enhancement material have been exposed to rainy and sunny condition.

Table 4.1: The weather condition before and during the data was collected.

WEEK	TESTING DAY	WEATHER CONDITION
Week 1	1	Rainy day (the night before testing day 1)
	2	Sunny day
	3	Sunny day
Week 2	4	Sunny day
	5	Rainy day (the night before testing day 5)
	6	Rainy day
Week 3	7	Rainy day (one day before testing day 7)
Week 4	8	Sunny day
	9	Sunny day
Week 5	10	Sunny day
Week 6	11	Rainy day (one day before testing day 11)
	12	Rainy day (two day before testing day 12)
Week 7	13	Rainy day
	14	Rainy day (one day before testing day 14)

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4.4 Galvanized Steel Electrode with Different Weight of Coconut Husk

The coconut husk can improve soil resistivity and reducing the ground resistance. This is because from characteristic of coconut husk which is it can retain moisture content or in other words, it is able to hold or store water. Figure 4.4 shows the line graph for the ground resistance of vertical galvanized (GI) steel rod electrodes depends on quantity of coconut husk. This graph shows the ground resistance of galvanized steel electrode without coconut husk is higher than galvanized steel electrode with coconut husk. The average ground resistance of GI steel electrode without coconut husk is 485.86Ω and more reduced when the coconut husk added with GI steel electrode. The ground resistance is decreasing to 37.27% when 1kg coconut husk added with GI steel electrode while 26.4% and 65.82%, respectively when 1.5kg and 2kg coconut husk added with GI steel electrode.

By increasing the quantity of coconut husk will decrease the ground resistance as shown in figure 4.4. Besides, the quantity of water that coconut husk can store is different due to different quantity of coconut husk. The higher of moisture content around the grounding systems, the lower of soil resistivity value and it will lead to the reduction of ground resistance. Since the value of ground resistance and soil resistivity depends on the quantity of water that can be store by coconut husk, the ground resistance and soil resistivity are decreases on the rainy day due to wet soil condition. It can be shown at testing day 1 where the rain occurred at night before measurement was taken. Therefore, at testing day 1 the ground resistance of GI steel electrode without coconut husk is 442Ω and more reduced when the coconut husk added with GI steel electrode. The ground resistance is decreasing to 35.52% when 1kg coconut husk added with GI steel electrode while 25.11% and 65.88%, respectively when 1.5kg and 2kg coconut husk added with GI steel electrode. Besides that, at testing day 5 the ground resistances for GI steel electrode without coconut husk is 490Ω and was decrease slightly to 439Ω at testing day 6. For the

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GI steel electrode with coconut husk, the ground resistances also decrease slightly at testing day 6 and the lowest value is 141.2Ω which is from the GI steel electrode added with 2kg coconut husk.

Meanwhile, the increments of ground resistance are due to hot and dry weather before the data was collected. The highest value of ground resistance this graph is 530Ω at testing day 10 which is from GI steel electrode and further reduced when the coconut husk added with GI steel electrode. The ground resistance is decreasing to 41.69% when 1kg coconut husk added with GI steel electrode while 30.57% and 68.15%, respectively when 1.5kg and 2kg coconut husk added with GI steel electrode.

Besides that, figure 4.5 shows the soil resistivity of vertical galvanized (GI) steel rod electrodes depends on quantity of coconut husk. The graph pattern for soil resistivity is same with graph of ground resistance. This graph shows the soil resistivity of galvanized steel electrode without coconut husk is higher than galvanized steel electrode with coconut husk. The average soil resistivity of GI steel electrode without coconut husk is 822.62Ωm and more reduced when the coconut husk added with GI steel electrode. The soil resistivity is decreasing to 37.27% when 1kg coconut husk added with GI steel electrode while 26.4% and 65.82%, respectively when 1.5kg and 2kg coconut husk added with GI steel electrode. Furthermore, the lowest value for soil resistivity is 253.14Ωm which is from GI steel electrode added with 2kg of coconut husk and the highest value is 950.16Ωm which is from GI steel electrode without coconut husk. Since the moisture content of the soil increase due to coconut husk which is water absorbent material, thus the soil resistivity will decrease. Therefore, the ground resistance and soil resistivity for rainy day is lower than sunny day due to effect of soil moisture content.

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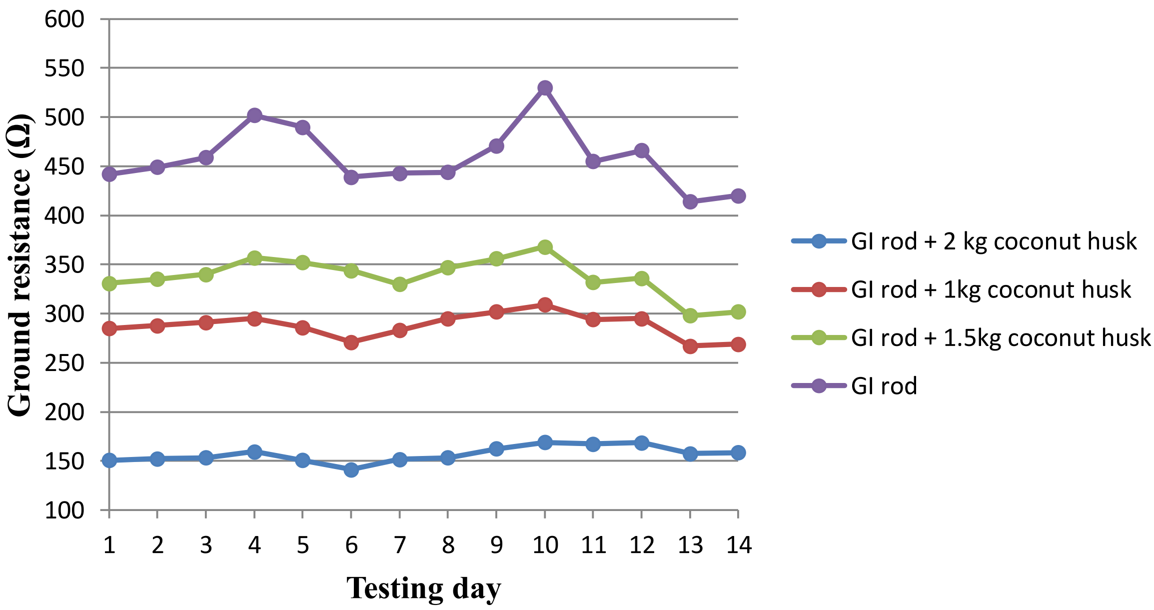

Figure 4.4: Graph of ground resistance depends on different weight of coconut husk.

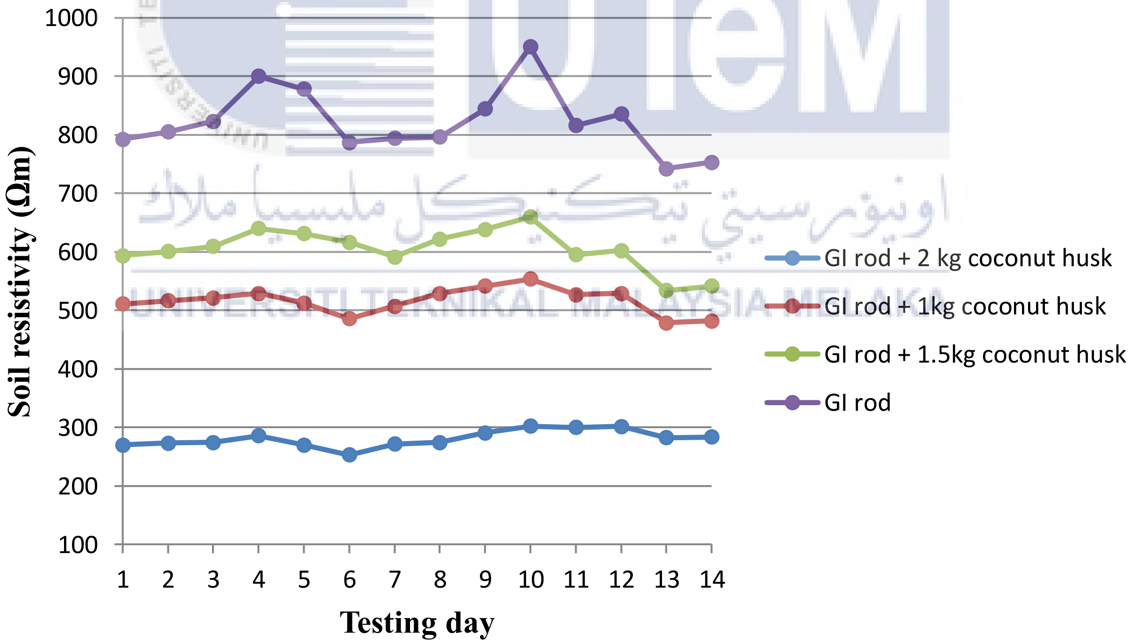

Figure 4.5: Graph of soil resistivity depends on different weight of coconut husk.

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4.5 Galvanized Steel Electrode with Different Configuration of the Layer

There are two type of configuration of the layer for this project which is 2kg coconut husk that had been added almost at the upper hole of ground electrode as shown in figure 3.4 and layer-by-layer of coconut husk with the local soil as shown in figure 3.6. Figure 4.6 shows the line graph for ground resistance of galvanized steel electrode with different configuration of the layer. From the data that was collected, the ground resistance for GI steel electrode added layer-by-layer of coconut husk with local soil is higher than GI steel electrode added with 2kg of coconut husk. The average ground resistance for GI steel electrode added layer-by-layer of coconut husk is 257.93Ω while the average ground resistance for GI steel electrode added with 2kg of coconut husk is 156.84Ω. This is because there are different quantities of coconut husk at the upper hole for these two configurations which is 2kg of coconut husk and 500g of coconut husk. Therefore, 2kg of coconut husk was affected more than 500g of coconut husk to the soil resistivity. So, the soil resistivity at the upper hole is lower for the GI steel electrode with 2kg of coconut husk compared to GI steel electrode added layer-by-layer of coconut husk. Since the soil resistivity is lower, thus the ground resistances also become lower and it can easily channel the fault current to the ground.

Besides that, there are slightly difference values of ground resistance between testing day 6 and testing 7 due to the different time of collecting data which is at testing day 6, the data was collected right after rain was occurred while at testing day 7, the data was collected one day after the rain was occurred. The ground resistance at testing day 6 for GI steel electrode added layer-by-layer of coconut with local soil is 247Ω. Besides, the ground resistance of GI steel electrode with 2kg coconut husk is decreasing to 42.83% compared to GI layer-by-layer of coconut husk. However, the ground resistance at testing day 7 for GI steel electrode added layer-by-layer of coconut with local soil is 250Ω while

GI steel electrode with 2kg coconut husk is decreasing to 39.36% compared to GI layer-by-layer of coconut husk.

However, figure 4.7 shows the line graph for soil resistivity of galvanized steel rod electrode with different configuration of the layer of coconut husk. This graph shows the soil resistivity for GI steel electrode with 2kg of coconut husk is lower than GI steel electrode added layer-by-layer of coconut husk with local soil. It can be shown that the average ground resistance for GI steel electrode added with 2kg of coconut husk is 281.17Ωm while the average soil resistivity for GI steel electrode added layer-by-layer of coconut husk is 462.40Ωm. The lowest value for soil resistivity is 253.14 Ωm from the GI steel electrode with 2kg of coconut husk system and the highest value for soil resistivity is 501.97 Ωm from the GI rod added layer-by-layer of coconut husk with local soil system. Therefore, the value of soil resistivity is depends on the quantity of coconut at the upper hole of the grounding system.

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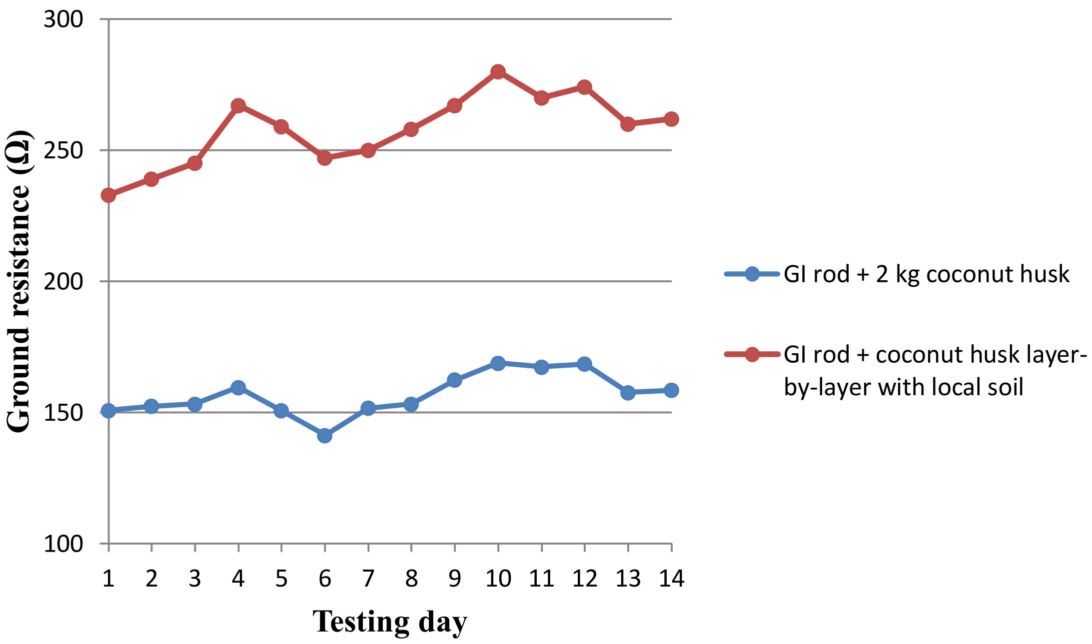

Figure 4.6: Graph of ground resistance depends on different configuration of the layer.

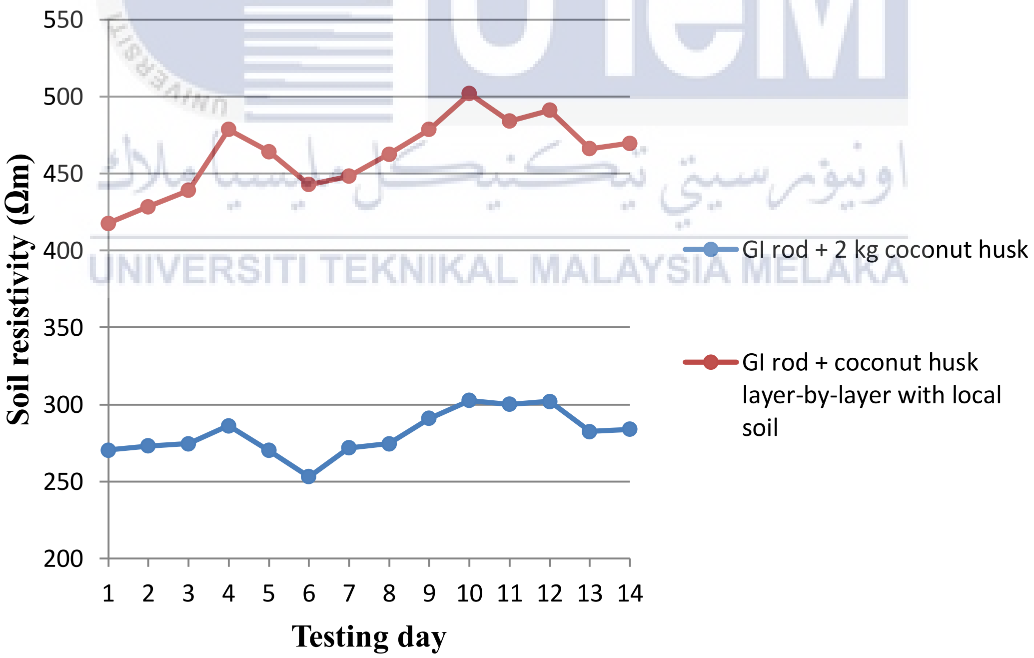

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Figure 4.7: Graph of soil resistivity depends on different configuration of the layer.

4.6 The Different Type of Ground Electrode and Ground Electrode with Enhancement Material

From the value of soil resistivity for testing site as shown in figure 4.3, it shows the value of soil resistivity within the range of 400Ωm. Based on BS 7430, the soil resistivity within the range 400Ωm is in category rocky ground. Since the testing site in category rocky ground which mean in high soil resistivity, thus the ground resistance also will become high. So, one of the methods to reduce soil resistivity is using soil treatment, where the addictive material was added which is water absorbent polymer that can reduce the soil resistivity. With the reduced value of soil resistivity, the ground resistance of earth electrode system will be reduced as well. As shown in figure 4.8, the grounding system with soil treatment which is galvanized steel rod electrode added with 2kg coconut husk have the lower value of ground resistance compare to copper steel rod electrode and galvanized steel rod electrode. The average ground resistance for is galvanized steel rod electrode added with 2kg coconut husk is 156.84Ω while for copper steel rod electrode is 771.86 and for galvanized steel rod electrode is 458.86Ω.

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Besides that, copper steel electrode is one of the better and commonly used materials for earth electrodes and underground conductor because it has high conductivity level compared to other conductor. For this project, the ground resistance and soil resistivity of copper steel electrode is higher than GI steel electrode. This is because GI steel electrode is hollow rod as shown in figure 3.5 and diameter of GI steel electrode is higher than copper rod. So, the total surfaces that contact the soil for GI steel electrode is more than copper steel electrode. Then, the GI steel electrode is easier to flow the fault current to the earth compared to copper steel electrode. However, the highest value of ground resistance for this graph is 1003Ω which is from copper steel electrode. Besides, the ground resistance for GI steel electrode with 2kg coconut husk is decreasing to 84.09%

compared to copper rod while for GI steel electrode without coconut husk is decreasing to 49.95%. Furthermore, the value of ground resistance for GI steel electrode with and without coconut husk was slight different. The highest value of ground resistance for GI steel electrode without coconut husk is 530Ω due to weather condition before and during data was collected is sunny day while the value of ground resistance for GI steel electrode with coconut husk at the same testing day was decreasing to 68.15% due to the effectiveness of coconut husk in reducing the soil resistivity thus the ground resistance also will be reduced as well.

Besides that, from the graph in figure 4.9 it can be observed that the soil resistivity of GI steel electrode with 2kg coconut husk is lower compared to copper steel electrode and GI steel electrode without coconut husk. Therefore, it can be observed that the average value of soil resistivity for GI steel electrode with 2kg coconut husk is 281.17Ωm but the value increase drastically when copper steel electrode and GI steel electrode was not added with an addictive material. The average soil resistivity for copper steel electrode is 1279.70Ωm while the average soil resistivity for GI steel electrode is 822.62Ωm. Thus, the existence of high moisture content in GI steel electrode added with 2kg coconut husk contributes largely to the lower value of soil resistivity.

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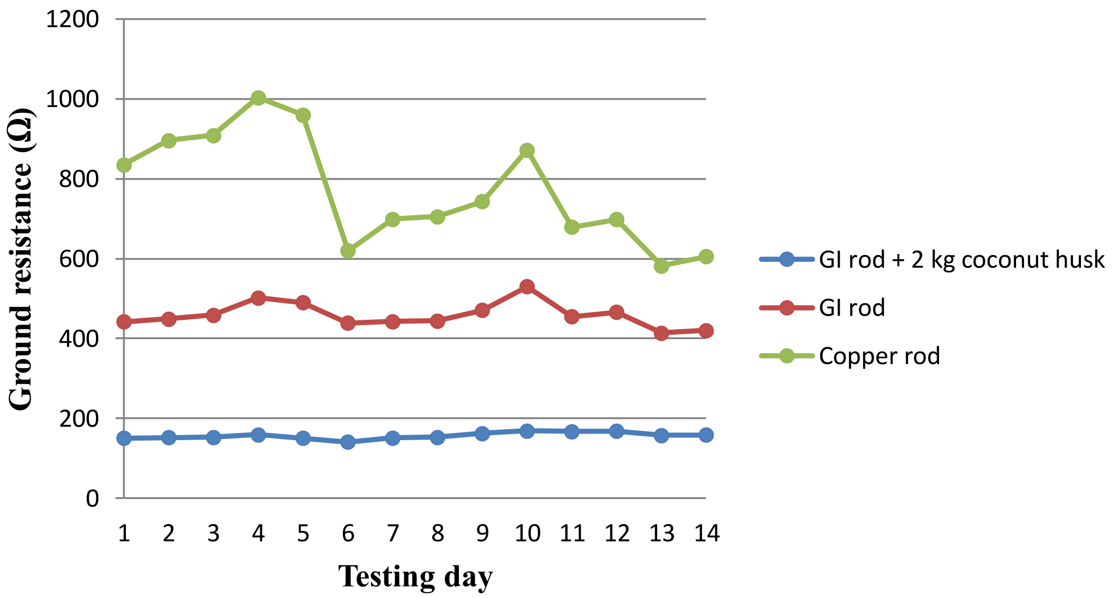

Figure 4.8: Graph for ground resistance depends on different type of rod electrode and rod electrode with enhancement material.

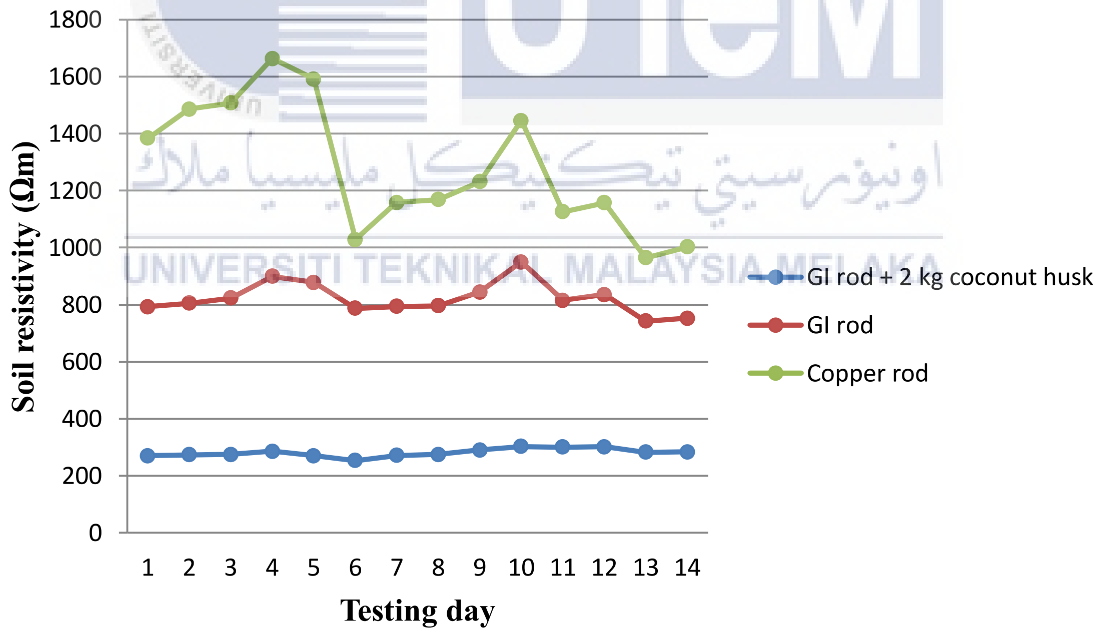

Figure 4.9: Graph for soil resistivity depends on different type of rod electrode and rod electrode with enhancement material.

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4.7 The Cost of the Material for This Project

Table 4.2 shows the price for the material that had been used in this project. The total price for vertical galvanized steel rod electrode and coconut husk is RM 15.42 and the total price for vertical copper steel rod electrode is RM 18.00. From the analysis of ground resistance above the average ground resistance for vertical copper steel rod electrode is 771.86Ω and the average ground resistance for vertical galvanized steel rod electrode with 2kg coconut husk is 156.84Ω. Therefore, the price for galvanized steel electrode with 2kg coconut husk is cheaper than copper steel electrode and the ground resistance of earth rod electrode system can be reduced to 79.68%.

Table 4.2: The quantity and price of material for this project.

Type of material	Quantity	Price
Vertical copper steel rod electrode	1 rod	RM 18.00
Vertical galvanized steel rod electrode	1 rod	RM 7.92
Coconut husk	2kg	RM 7.50

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CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The lowest value of ground resistance is good for grounding system. So, to get the lowest value of ground resistance, the soil resistivity of soil needs to improve by using soil treatment with additive material. By using the additive material which is coconut husk in grounding system, it can improve the soil resistivity due to characteristics of coconut husk. The characteristics of coconut husk is water absorbent polymer which is it can retain the moisture content or in other words, it can able to hold or store water. Besides that, galvanized steel rod electrode is investigated as alternative to copper steel rod to reduce the theft activity. In this project, the galvanized steel rod electrode as conductor was added with coconut husk as additive material to soil. The ground resistance for galvanized steel rod electrode added with 2kg of coconut husk gives the lowest value compare to 1kg and 1.5kg of coconut husk. Moreover, the ground resistance for galvanized steel rod electrode added with 2kg of coconut husk on the top of the hole is lower than galvanized steel rod electrode added layer-by-layer of coconut husk with the local soil. Furthermore, the ground resistance of copper steel electrode is higher than galvanized steel rod electrode added with 2kg of coconut husk. As conclusion, based on the experiment galvanized steel rod electrode with additive material is potential to be an alternative for copper grounding.

5.2 Recommendation

As a recommendation, an extended studies need to be perform to have deep understanding in the performance of galvanized steel electrode as conductor in grounding system. Since this project was conducted for 7 weeks in collected data of ground resistance and soil resistivity, it will be better to expand the duration for the further studies about the corrosion effect on the performance of galvanized steel electrode. Besides that, the long term effect of the effectiveness of coconut husk as additive material. This is because migration and leaching of additive material over period of time will reduce the efficiency of soil treatment.

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APPENDIX

A. Result of Ground Resistance and Soil resistivity for Ground Electrode System

Table 1: The value of ground resistance for vertical copper steel rod electrode

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	829	835	839
15-02-17	23 °C	10.00am	889	896	898
16-02-17	29 °C	12.30pm	903	909	914
22-02-17	32 °C	2.15pm	999	1003	1009
23-02-17	33 °C	2.15pm	953	960	963
24-02-17	25 °C	9.00am	616	620	625
02-03-17	28 °C	12.30pm	693	699	703
08-03-17	31 °C	2.30pm	696	705	710
10-03-17	26 °C	8.50am	737	743	748
17-03-17	25 °C	8.50am	864	872	876
23-03-17	28 °C	9.00am	673	679	683
24-03-17	27 °C	9.30am	692	698	702
30-03-17	28 °C	12.30pm	576	582	586
31-03-17	26 °C	9.15am	599	605	609

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Table 2: The value of soil resistivity for vertical copper steel rod electrode

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	1374.44	1384.38	1391.02
15-02-17	23 °C	10.00am	1473.91	1485.52	1488.84
16-02-17	29 °C	12.30pm	1497.13	1507.07	1515.36
22-02-17	32 °C	2.15pm	1656.29	1662.92	1672.87
23-02-17	33 °C	2.15pm	1580.02	1591.63	1596.60
24-02-17	25 °C	9.00am	1021.29	1027.93	1036.22
02-03-17	28 °C	12.30pm	1148.96	1158.90	1165.54
08-03-17	31 °C	2.30pm	1153.93	1168.85	1177.14
10-03-17	26 °C	8.50am	1221.91	1231.85	1240.14
17-03-17	25 °C	8.50am	1432.47	1445.73	1452.36
23-03-17	28 °C	9.00am	1115.80	1125.75	1132.38
24-03-17	27 °C	9.30am	1147.30	1157.25	1163.88
30-03-17	28 °C	12.30pm	954.98	964.92	971.56
31-03-17	26 °C	9.15am	993.11	1003.06	1009.69

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Table 3: The value of ground resistance for vertical galvanized steel rod electrode without added with coconut husk

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	438	442	445
15-02-17	23 °C	10.00am	445	449	452
16-02-17	29 °C	12.30pm	454	459	461
22-02-17	32 °C	2.15pm	497	502	505
23-02-17	33 °C	2.15pm	485	490	493
24-02-17	25 °C	9.00am	435	439	443
02-03-17	28 °C	12.30pm	430	443	446
08-03-17	31 °C	2.30pm	440	444	447
10-03-17	26 °C	8.50am	465	471	473
17-03-17	25 °C	8.50am	524	530	533
23-03-17	28 °C	9.00am	451	455	458
24-03-17	27 °C	9.30am	461	466	469
30-03-17	28 °C	12.30pm	409	414	417
31-03-17	26 °C	9.15am	415	420	422

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Table 4: The value of soil resistivity for vertical galvanized steel rod electrode without added with coconut husk

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	785.22	792.39	797.77
15-02-17	23 °C	10.00am	797.77	804.94	810.32
16-02-17	29 °C	12.30pm	813.91	822.87	826.46
22-02-17	32 °C	2.15pm	891.00	899.96	905.34
23-02-17	33 °C	2.15pm	869.48	878.45	883.82
24-02-17	25 °C	9.00am	779.85	787.02	794.19
02-03-17	28 °C	12.30pm	770.88	794.19	799.57
08-03-17	31 °C	2.30pm	788.81	795.98	801.36
10-03-17	26 °C	8.50am	833.63	844.38	847.97
17-03-17	25 °C	8.50am	939.40	950.16	955.53
23-03-17	28 °C	9.00am	808.53	815.70	821.08
24-03-17	27 °C	9.30am	826.46	835.42	840.80
30-03-17	28 °C	12.30pm	733.23	742.20	747.58
31-03-17	26 °C	9.15am	743.99	752.95	756.54

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Table 5: The value of ground resistance for vertical galvanized steel rod electrode added with coconut husk 1kg coconut husk

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	282	285	288
15-02-17	23 °C	10.00am	284	288	291
16-02-17	29 °C	12.30pm	287	291	294
22-02-17	32 °C	2.15pm	292	295	299
23-02-17	33 °C	2.15pm	280	286	289
24-02-17	25 °C	9.00am	267	271	285
02-03-17	28 °C	12.30pm	279	283	286
08-03-17	31 °C	2.30pm	291	295	298
10-03-17	26 °C	8.50am	299	302	305
17-03-17	25 °C	8.50am	306	309	294
23-03-17	28 °C	9.00am	291	294	297
24-03-17	27 °C	9.30am	292	295	299
30-03-17	28 °C	12.30pm	263	267	270
31-03-17	26 °C	9.15am	265	269	273

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Table 6: The value of soil resistivity for vertical galvanized steel rod electrode added with coconut husk 1kg coconut husk

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	505.55	510.93	516.31
15-02-17	23 °C	10.00am	509.14	516.31	521.69
16-02-17	29 °C	12.30pm	514.52	521.69	527.07
22-02-17	32 °C	2.15pm	523.48	528.86	536.03
23-02-17	33 °C	2.15pm	501.97	512.73	518.10
24-02-17	25 °C	9.00am	478.66	485.83	510.93
02-03-17	28 °C	12.30pm	500.18	507.35	512.73
08-03-17	31 °C	2.30pm	521.69	528.86	534.24
10-03-17	26 °C	8.50am	536.03	541.41	546.79
17-03-17	25 °C	8.50am	548.58	553.96	527.07
23-03-17	28 °C	9.00am	521.69	527.07	532.45
24-03-17	27 °C	9.30am	523.48	528.86	536.03
30-03-17	28 °C	12.30pm	471.49	478.66	484.04
31-03-17	26 °C	9.15am	475.08	482.25	489.42

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Table 7: The value of ground resistance for vertical galvanized steel rod electrode added with coconut husk 1.5kg coconut husk

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	326	331	334
15-02-17	23 °C	10.00am	320	335	341
16-02-17	29 °C	12.30pm	333	340	347
22-02-17	32 °C	2.15pm	350	357	363
23-02-17	33 °C	2.15pm	345	352	359
24-02-17	25 °C	9.00am	333	344	350
02-03-17	28 °C	12.30pm	315	330	336
08-03-17	31 °C	2.30pm	340	347	354
10-03-17	26 °C	8.50am	349	356	363
17-03-17	25 °C	8.50am	361	368	374
23-03-17	28 °C	9.00am	325	332	339
24-03-17	27 °C	9.30am	329	336	343
30-03-17	28 °C	12.30pm	291	298	304
31-03-17	26 °C	9.15am	295	302	309

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Table 8: The value of soil resistivity for vertical galvanized steel rod electrode added with coconut husk 1.5kg coconut husk

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	584.44	593.40	598.78
15-02-17	23 °C	10.00am	573.68	600.57	611.33
16-02-17	29 °C	12.30pm	596.99	609.53	622.08
22-02-17	32 °C	2.15pm	627.46	640.01	650.77
23-02-17	33 °C	2.15pm	618.50	631.05	643.60
24-02-17	25 °C	9.00am	596.99	616.71	627.46
02-03-17	28 °C	12.30pm	564.72	591.61	602.36
08-03-17	31 °C	2.30pm	609.53	622.08	634.63
10-03-17	26 °C	8.50am	625.67	638.22	650.77
17-03-17	25 °C	8.50am	647.18	659.73	670.49
23-03-17	28 °C	9.00am	582.64	595.19	607.74
24-03-17	27 °C	9.30am	589.81	602.36	614.91
30-03-17	28 °C	12.30pm	521.69	534.24	545.00
31-03-17	26 °C	9.15am	528.86	541.41	553.96

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Table 9: The value of ground resistance for vertical galvanized steel rod electrode added with coconut husk 2kg coconut husk

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	146.7	150.8	155.7
15-02-17	23 °C	10.00am	145.4	152.4	158.1
16-02-17	29 °C	12.30pm	146.7	153.2	159
22-02-17	32 °C	2.15pm	153.3	159.6	165.6
23-02-17	33 °C	2.15pm	143.6	150.7	156.7
24-02-17	25 °C	9.00am	136.3	141.2	144.6
02-03-17	28 °C	12.30pm	150.1	151.6	152.8
08-03-17	31 °C	2.30pm	147.2	153.2	159.3
10-03-17	26 °C	8.50am	155.8	162.3	168.5
17-03-17	25 °C	8.50am	162.3	168.8	174.6
23-03-17	28 °C	9.00am	160.2	167.4	172.2
24-03-17	27 °C	9.30am	162.1	168.5	175
30-03-17	28 °C	12.30pm	151.2	157.6	163.9
31-03-17	26 °C	9.15am	152.9	158.4	164.6

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Table 10: The value of soil resistivity for vertical galvanized steel rod electrode added with coconut husk 2kg coconut husk

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	263.00	270.35	279.13
15-02-17	23 °C	10.00am	260.67	273.21	283.43
16-02-17	29 °C	12.30pm	263.00	274.65	285.05
22-02-17	32 °C	2.15pm	274.83	286.12	296.88
23-02-17	33 °C	2.15pm	257.44	270.17	280.92
24-02-17	25 °C	9.00am	244.35	253.14	259.23
02-03-17	28 °C	12.30pm	269.09	271.78	273.93
08-03-17	31 °C	2.30pm	263.89	274.65	285.58
10-03-17	26 °C	8.50am	279.31	290.96	302.08
17-03-17	25 °C	8.50am	290.96	302.62	313.01
23-03-17	28 °C	9.00am	287.20	300.11	308.71
24-03-17	27 °C	9.30am	290.60	302.08	313.73
30-03-17	28 °C	12.30pm	271.06	282.54	293.83
31-03-17	26 °C	9.15am	274.11	283.97	295.09

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Table 11: The value of ground resistance for vertical galvanized steel rod electrode added coconut husk layer-by-layer with local soil

DATE	TEMPERATURE	TIME	Resistance value (Ω)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	228	233	237
15-02-17	23 °C	10.00am	233	239	246
16-02-17	29 °C	12.30pm	239	245	253
22-02-17	32 °C	2.15pm	261	267	276
23-02-17	33 °C	2.15pm	253	259	266
24-02-17	25 °C	9.00am	241	247	254
02-03-17	28 °C	12.30pm	246	250	256
08-03-17	31 °C	2.30pm	252	258	265
10-03-17	26 °C	8.50am	261	267	274
17-03-17	25 °C	8.50am	273	280	288
23-03-17	28 °C	9.00am	265	270	277
24-03-17	27 °C	9.30am	268	274	280
30-03-17	28 °C	12.30pm	254	260	267
31-03-17	26 °C	9.15am	255	262	268

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Table 12: The value of soil resistivity for vertical galvanized steel rod electrode added coconut husk layer-by-layer with local soil

DATE	TEMPERATURE	TIME	Soil resistivity value (Ωm)		
			PP 50%	PP 61.8%	PP 70%
14-02-17	30 °C	10.00am	408.75	417.71	424.88
15-02-17	23 °C	10.00am	417.71	428.47	441.02
16-02-17	29 °C	12.30pm	428.47	439.22	453.57
22-02-17	32 °C	2.15pm	467.91	478.66	494.80
23-02-17	33 °C	2.15pm	453.57	464.32	476.87
24-02-17	25 °C	9.00am	432.05	442.81	455.36
02-03-17	28 °C	12.30pm	441.02	448.19	458.94
08-03-17	31 °C	2.30pm	451.77	462.53	475.08
10-03-17	26 °C	8.50am	467.91	478.66	491.21
17-03-17	25 °C	8.50am	489.42	501.97	516.31
23-03-17	28 °C	9.00am	475.08	484.04	496.59
24-03-17	27 °C	9.30am	480.46	491.21	501.97
30-03-17	28 °C	12.30pm	455.36	466.11	478.66
31-03-17	26 °C	9.15am	457.15	469.70	480.46

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