GROUNDING ROD DESIGN EVALUATION FOR RESIDENTIAL USAGE

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"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)"

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

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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	:

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.

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

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 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 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.

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.

CHAPTER 2

LITERATURE REVIEW

2.1 Grounding system

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.

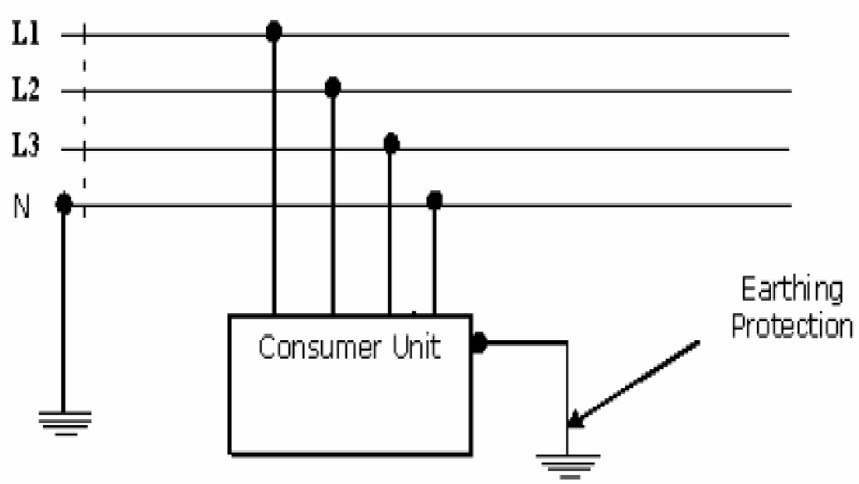

Figure 2.1 : The arrangement of the connection earthing installation in TT network system [9].

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].

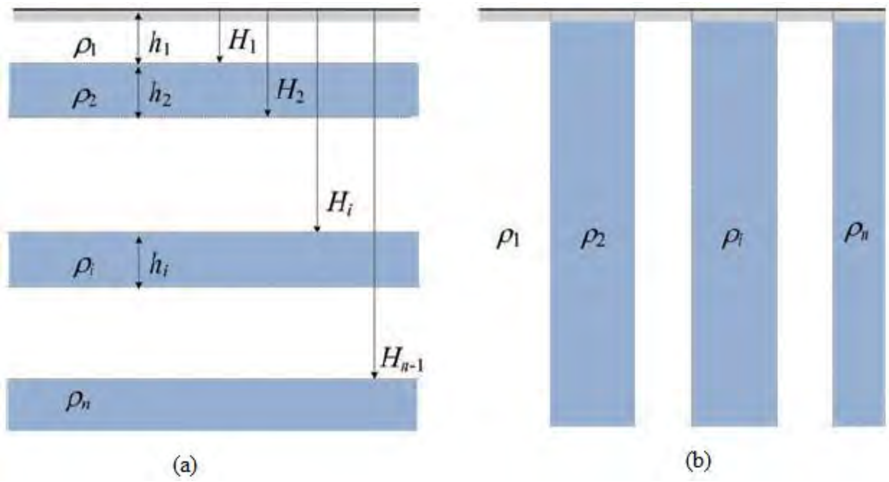

Figure 2.2: Type of non-uniform soil which is horizontally layered soil (a) and vertically layered soil (b)[12].

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:

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