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EXPERIMENTAL STUDY ON THE GROUND RESISTANCE REDUCTION BASED ON EARTH ELECTRODE

NAMA:	AHMAD TARMIZI B AZILY
MATRIX NO:	B011110243
SUPERVISOR'S NAME:	MS ARFAH BT AHMAD

EXPERIMENTAL STUDY ON THE GROUND RESISTANCE REDUCTION BASED ON EARTH ELECTRODE

AHMAD TARMIZI BIN AZILY

A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle "Experimental Study on The Ground Resistance Reduction Based on Earth Electrode" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : AHMAD TARMIZI B. AZILY

Date : 18 / 06 / 14

" I hereby declare that I have read through this report entitle "Experimental Study on The Ground Resistance Reduction Based on Earth Electrode" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature :

Supervisor"sName : MISS ARFAH AHMAD

Date : 18/06/2014

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ABSTRACT

Grounding of electrical installation is primarily concern with ensuring safety. The main purpose of grounding is to channel the fault current straightly to earth. To produce a good grounding system, the value of earth resistance must be reduce as low as possible. In this project, a 3 meter length of copper, GI and pure steel rod will be installed in formatting 12 of grounding system. Six system for single installation and six for parallel installation. The aim of this study is to determine the effect on the resistance value when the soil condition is change and different type of rod is use. Furthermore, the Kyoritsu Digital Earth Tester will be used to measure the value of earth resistance. The diameters of rod are constant for each type of rod. Fall of Potential method will be used for this project to find the value of resistance. Single rod testing and parallel rod testing is performing in this project. From the result, it is expected that, the soil condition surrounding the rods are greatly influenced the value of earth resistance. The grounding system that use galvanized iron (GI) rod has the lower earth resistance compared to copper and steel.

ABSTRAK

Tujuan pembumian untuk setiap pemasangan sistem elektrik adalah untuk keselamatan. Kegunaan utama pembumian adalah untuk menyalurkan arus yang tidak dikehendaki terus ke dalam tanah, untuk menghasilkan sistem pembumian yang baik, nilai rintangan mestilah serendah yang mugkin. Dalam projek ini, panjang setiap rod adalah 3 meter antara rod tembaga,besi bergalvani (GI), dan besi tulen digunakan untuk menghasilkan dua belas sistem pembumian. Enam sistem untuk pemasangan tunggal dan enam untuk pemasangan secara selari. Tujuan kajian ini adalah untuk menentukan kesan ke atas nilai rintangan apabila keadaan tanah di sekeliling rod berubah dan jenis rod yang berbeza digunakan. *Kyoritsu Digital Earth Tester* akan digunakan untuk mengukur nilai rintangan bumi. Setiap jenis rod mempunyai diameter yang tetap. *Fall of potential method* akan digunakan dalam projek ini untuk menentukan nilai rintangan. Pengujian secara tunggal dan selari dlaksanakan dalm projek ini. Daripada keputusan yang diperolehi, dijangka bahawa keadaan tanah banyak mempengaruhi nilai rintangan bumi. Sistem pembumian yang menggunakan besi bergalvani (GI) rod mempunyai rintangan bumi yang lebih rendah berbanding dengan rod tembaga dan rod besi.

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TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVATION

UTeM - Universiti Teknikal Malaysia Melaka

EPR - Earth Potential Rise

EAF – Earth Additive Filler

GI – Galvanized Iron

CDEGS – Current Distribution, Electromagnetic Field Grounding and Soil Structure

DET – Digital Earth Tester

GPR- Ground Potential Rise

GPD - Ground Potential Difference

CHAPTER 1

INTRODUCTION

1.1 Project Background

Electric power system grounding is very important, particularly since large majority of faults are caused by poor grounding system or due to lightning strikes. The terms earthing and grounding have the same meaning. The purpose of grounding is to minimize potential transient overvoltage, in compliance with standard for personnel safety requirements also to assist within the rapid detection and isolation in the fault areas. Grounding connection is accomplished by driving ground electrode in several places in the earth. Earth electrode is often a metal plate, metal pipe or steel conductors electrically connected to the earth. The materials generally used for earth electrodes are made of copper, aluminum, mild steel and galvanized iron in order of preference. The factors that influence the earthing resistance of an electrode or group of electrodes includes are the composition of the soil, the temperature of the soil, the moisture content of the soil and the depth of the electrode [1].

Based on previous study by Megger researchers there is not much information has been collected on the effect on temperature, two facts lead to the logical conclusion that an increase temperature will decrease resistivity and decrease the moisture content in the soil [2]. Moreover, the depth of electrode also influence the ground resistance due to soil layer in which the upper layer of the soil have higher resistivity than lower layer. The soil types are mostly different in every part of the world and the resistivity also differ compare to other. The resistivity of soil is all depend on the type of soil. Thus, to install an electrical system and complete its circuit, a grounding system performance must be taken into account, but in certain cases, due to geological condition, the soil resistivity is not good enough which is the resistance must be below 5Ω (depending on the type of electrical system). Single rod installation may not enough to decrease the resistivity. To overcome this problem, solutions that require by installed another rod that connected in parallel. But, these solution need extra area which is minimum space between each rod are 6 foot away.

The provision of good and effective electrical grounding system is necessary to protect personnel and equipment from the hazards of high potential rise due to the flow of high current to earth. Besides that, this system also becomes a major importance in the efforts to increase the reliability of the supply service, as it helps to provide stability of voltage conditions, preventing excessive voltage peaks during disturbances and also means to discharge lightning surges.

1.2 Motivation

The motivation for this project is to propose a new type of grounding electrode to replace the typical grounding electrode which is copper rod. The copper rod is very expensive in the market. This cause a lot of stealing case over the year that had been reported by the newspaper and television that cause the entire electrical system are unsafe. Electric shocks can paralyze the respiratory system or disrupt heart action, causing instant death. Based on the Department of Occupational Safety and Health (DOSH), three fatal cases were recorded to due to electrical shock taken from 2011 until 2013. The new type of grounding system is propose in this research by using the galvanized iron rod (GI) and steel rod.

1.3 Problem Statement

There are several important reason why a grounding system should be installed. But the most important reason is to protect people, another reason include protection of structures and equipment from unintentional contact with energized electrical lines the grounding must ensure maximum safety from electrical system faults and lightning.

In recent years, many report published in newspaper on the stealing of cable activities from substation telecommunication towers and power system network and the number of theft has increase over the year. From this activity, it affects the continuity of the system supply, disrupting service and the utilities company suffers great losses. Most of the grounding electrode is made of copper. Since the rise of copper price in the market, it attracted thieves to steal the grounding rod in the residential or commercial building. Moreover, it also bring huge problem to the utilities company such as Tenaga Nasional Berhad (TNB), Telekom and other.

To overcome this problem, the use of copper as a grounding is proposed to be replace by using galvanized iron or steel as an electrode. The performance and popularity of cooper are very well comparing to galvanized iron and steel. The prices of galvanized iron rod are much lower than cooper rod and provide an advantage in terms of installation cost for the ground system. Galvanized iron is chosen because of the electrical characteristic and reasonably low price. Since today, only a few testing had been conducted to test the effect on the value of resistance between type of electrode in use. Most of the testing was done by simulation only and that have a lot of limitations. This project will conduct by using single and parallel installation method with 3.0 meter length for each type of rod (copper, GI, steel).

1.4 Project objective

The aim of this study is to achieve the objective listed below:

1. To analyze the best type of rod between copper, galvanized iron (GI) and steel.
2. To investigate the effect of grounding resistance based on soil condition.
3. To analyze the best installation type for grounding system between single and parallel installation.

1.5 Project Scope

To pursuit the objective of this project, there are several scope that have been specified. The scope of the projects are.

1. Location of the experiment will be conducted at an area around FKE, UTeM which have the same type of soil.
2. Apparatus that will be used is digital earth tester (DET).
3. Three types of rod will be analyzed, copper rod, galvanized iron and steel rod.
4. The ground electrode that will be used are vertical type single and parallel installation
5. The length of the ground electrode is 3m for single and parallel installation with the same diameter for each type of electrode.
6. Fall of potential method will be used to measure the resistance of the electrode.
7. The data will be recorded and compared to ensure which type of installation give a lower value of resistance.

1.6 Thesis Outline

Chapter 1 briefly review the summarize about project background and project scope. Project background basically describe about the purpose of grounding system followed by the problem statement which stated the problem that initiate in this project. The project objective and project scope also describe in this chapter to clarify the limitation of this project.

In chapter 2, describe about the basic theory on grounding rod, and type of rod will be used in this project. This chapter also discussed and summarize the related previous study that will be use as a reference in completed this project. Furthermore, the purpose of this chapter also to make sure that this project are not the same with other.

In chapter 3 of this report, consist of all methodology and procedure that need to be taken in completing this experiment. All the procedures are described in a flowchart. It is important to follow all the methodology and procedure that had been stated to make sure all the objective achieved and not exceed the scope of the project. Other than that, the installation process also included in this chapter.

Chapter 4 consists of the preliminary result in 15 day of measurement based on previous study. All the result was shown in the graph that had been plotted and discussed. It is expected that the length of the rod greatly influenced the value of grounding resistance.

In chapter 5, the final chapter will describe the analysis of the data for the 15 days. All type and efficiency of the rod were discussed and elaborate. This consist of recommendation that need to be taken for further study.

CHAPTER2

LITERATURE REVIEW

2.1 Introduction

The term “ground” is defined as a conducting connection where a circuit or equipment is connected to the earth. The connection is used to establish and maintain as closely as possible the potential of the earth on the circuit or equipment connected to it. A “ground” consists of a grounding conductor, a bonding connector, its grounding electrodes and the soil in contact with the electrode. Grounds have several protection applications. For natural phenomena such as lightning, grounds are used to discharge the system of current before personnel can be injured or system components damaged. For foreign potentials due to faults in electric power systems with ground returns, grounds help to ensure rapid operation of the protection relays by providing low resistance fault current paths. This provides for the removal of the foreign potential as quickly as possible. The ground should drain the foreign potential before personnel are injured and the power or communications system is damaged. Ideally, to maintain a reference potential for instrument safety, protect against static electricity, and limit the system to frame voltage for operator safety, a ground resistance should be zero ohms. In reality, this value cannot be obtained. Last but not least, low ground resistance is essential to meet National Electrical Code (NEC), Occupational Safety and Health Administration (OSHA) and other electrical safety standards [7]. To have a lower ground resistance, there are a few factor that need to be consider are type of soil, depth, spacing, size of the electrode and soil treatment before installation [2].

2.1.1 Copper Rod

Typically, grounding copper rod is made up from solid copper. For this specific experiment, the rod will be used are copper bonded type, which mean only the surface of the rod covered using copper. The inside material was made up from iron. It comes in many forms such as plates, strip, tubes, and wire. For example of bonded copper rod as shown in Figure 2.1.

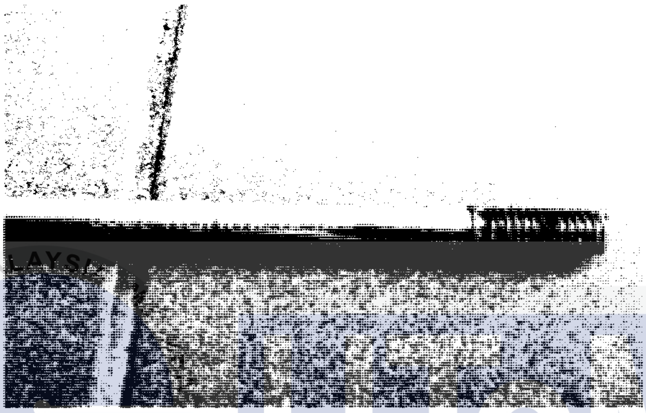

Figure 2.1: Copper rod

In this experiment, the length and also the diameter of the rod is the main characteristic that needs to be considered. The diameter has to be same for every type of rod.

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2.1.2 Galvanized iron

Nowadays, many companies have changed their mind in when designed a grounding system. They began to use the GI conduit for grounding due to cheaper price than copper rod. GI pipe is usually used as a conduit pipe for wiring system. So, the balanced from the wiring will be used as a grounding rod. Figure 2.2 show the example of GI rods.

Figure 2.2: Galvanized iron rod (GI)

2.1.3 Steel

Steel rod also had been as a grounding rod in certain country, like China due to the higher price of copper rod. Steel rod actually have a higher permeability but lower conductivity compared to copper and GI rod. Figure 2.3 shows an example of steel rod.

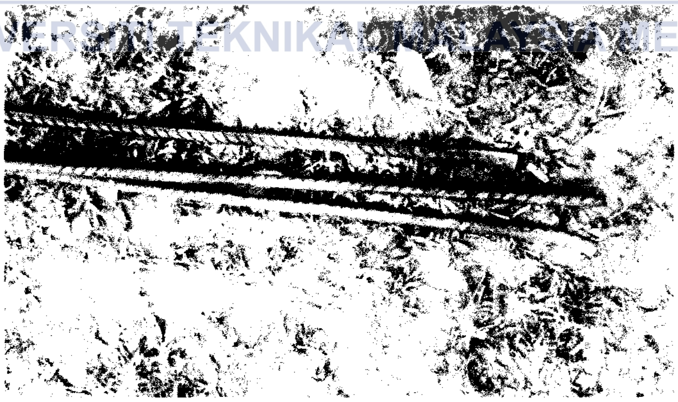

Figure 2.3: Steel rod

2.2 Related previous study

2.2.1 Analysis on the Factors Affecting Resistance of the Earth Electrode

Researches by Ms. Kalyani and Dr.A.K Sharma from International Journal of Engineering Research and Technology, Jabalpur in 2013 investigate the factor affecting resistance of the earth electrode by comparative analysis for a variety of grounding electrode types. The experiment was done in the limited source of soil type and soil resistivity within Las Vegas valley and included areas within local municipalities. In this paper there is no detail on experiment setup, the researchers only explain there are few major factor that affect the performance of the earth electrode such as resistivity of the soil, effect of shape, spacing, number and size of electrode and artificial soil treatment [2].

Soil resistivity is the most important factor that affect the resistance of the earth electrode. Soil resistance may be varied from a few hundred ohms to 106 ohm per cm cube within the range 500-50000 ohms per cm cube [2]. The conductivity depends on type of soil, chemical composition of salt dissolved in the contained water, concentration of salts dissolved in contained water, moisture content, temperature, grain size of the mineral and distribution of grain size and closeness of packing and pressure. The moisture content and the temperature of the soil vary with the seasons and give a periodic change in the resistance of the earth electrode.

The effect of form, spacing, range, and dimension of electrode furthermore influence the particular resistivity from the earth electrode. The shape of an electrode is actually influenced the earth resistance itself. The resistance from the electrode can be reduce by spacing the particular electrode very much further. Furthermore, the author also discussed on the mixing of coke breeze into the soil that the electrode was buried or by replacement of the soil around the electrode, but the method is expensive and accelerate the corrosion. Alternative methods that can be used to reduce the resistivity of the electrode are by treating the soil around the electrode with common salt.

In conclusion, engineer's dilemma in planning an earth connection. To determine what value from the resistance is usually require and to decide how this value from the resistance may be obtained. The value from the resistance is usually controlled by several factors.

- The prevention of a dangerous contact voltage occurring between the earthed metal work.
- The operation of protective gear in the event of earth fault
- When the maximum fault current is flowing, the maximum fault current being the current which just fail to operate the protective gear.
- The prevention of drying out of the soil due to the flow of current.

2.2.2 Power grounding safety: copper grounding vs steel grounding system

Yexu li, Jinxi Ma, and Farid Paul Dawalibi, a group of researchers from Safe Engineering & Technology Ltd has conducted an experiment about copper grounding versus steel grounding. This paper focus on the performance of grounding system made of steel or copper conductors. A series of computer model are used to stimulate the grounding systems of different sizes in various soil structures. Numerical result such as ground potential rise (GPR), touch voltage and step voltage and potential differences between the conductors inside the copper grounding grids. This paper documents the performance advantages of grounding grids made of copper over those made of steel conductors. Furthermore, the grounding performance, like ground potential rises and ground potential differences (GPRs and GPDs), touch voltages and step voltages, are evaluated accurately during a phase- to ground fault.

The reference computer model used in this study consists of a square grounding grid. Different grids with various dimensions in different soil model are examined. The burial depth of the grid is 0.5m. For steel grids, resistivity of steel is 12 times that of copper and permeability of steel is about 250 times that of air (during fault). The steel conductors have a cross section of 480mm and an equivalent radius of 1.236 cm. The copper conductors have a cross section of 160mm and an equivalent radius of 0.7137cm.

There are several effects involving soil and also grid sizing, for consistent soil the grounding performance is drastically influence by means of soil resistivity. With the grid imbedded in a very uniform soil within the above portion, the soil impedance, GPR, GPD, touch and also step voltage are usually computed for any 200m by 200m by 200m grid. The result for the uniform soil are that ground conductor characteristic do effect the grounding performance of a grounding grid, especially when the soil resistivity is low. Grid with copper conductor have a better performance compared to steel ones.

As a conclusion, the analysis of grounding systems made of steel and copper has been carried out, the advantage are likely to copper grounding grid compared to steel grounding conductor. There are a few results, for uniform soil with high resistivity the performance of steel conductor is similar to the copper conductor, but for the low resistivity steel conductor are ineffective compared to copper conductor. For the two layer soil, a grounding grid made of copper conductors will have much better performance than a steel conductor grid. When the size of grounding grid is small, the performance of a copper grounding is not significantly increase compared to the steel grid. Lastly, due to the complexity of real soil structures, the performance of individual grounding system must be evaluate correctly using adequate software tools to avoid costly over design or dangerous under design [3].

2.2.3 Comparison Study of Usage as Grounding Electrode Between Galvanized Iron and Copper With and Without Earth Additive Filler.

A group of researchers through Telekom Malaysia (research and development) have been carried out an analysis on the performance of grounding system made of galvanized iron and copper, at same site which has a resemblance of soil resistivity model and value, plus the effect of earth additive filler (EAF) which has been utilized about the mock in place system [4].

The study were done on the same site that have 2 layer soil model dependant on soil resistivity measurement that conducted and stimulated by Current Distribution Electromagnetic Fields Grounding Structure Analysis. (CDEGS). The applied of (CDEGS) is to make sure that the soil resistivity data collected are purely soil resistivity without the influence by buried steel structure by using 4 pole measurement method base on Wenner Array method. Figure 2.4 demonstrate the Trench having stranded galvanized metal and copper tape.

The grounding system consists of 4 trenches with 4 different scenario which are:-

1. Stranded galvanized iron
2. Stranded galvanized iron with addition of earth additive filler (EAF)
3. Copper tape
4. Copper tape with addition earth additive filler (EAF)

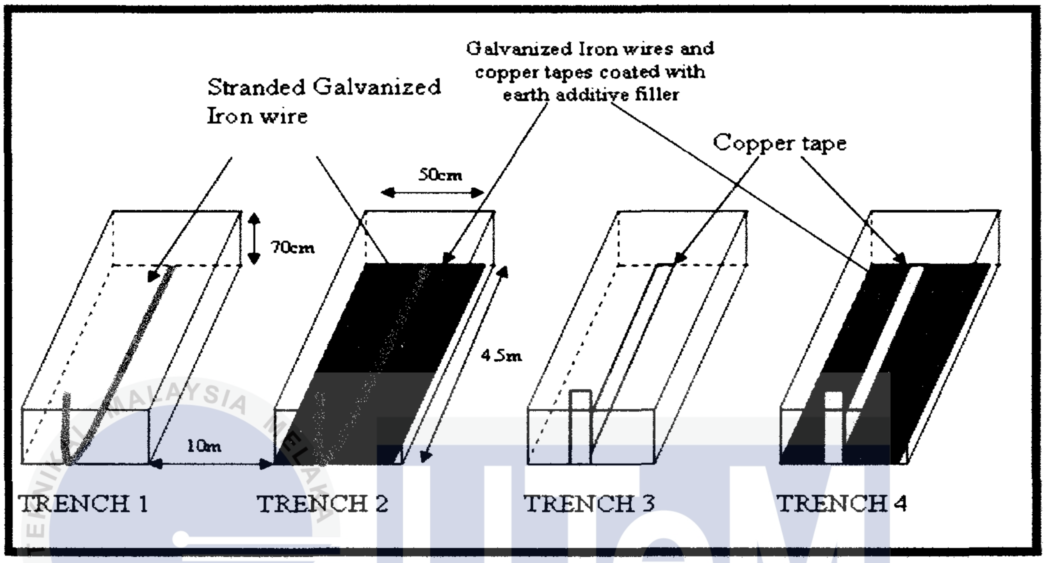

Figure 2.4: Trench with stranded galvanized iron and copper tape [4]

The diameter regarding copper tape is 35mm and galvanized metal is 75mm with the same length of 5m. The mock up system are monitored about 6 month in order to measure the grounding impedance. From the measured data, there are decreasing values at all trenches in term of grounding resistance in 25 weeks. For trenches with EAF, the value keeps constant starting from the week 20 and beyond. The reduction of ground impedance values between the same conductor trenches with EAF and without EAF are 41.9% for galvanized iron and 42.9% for copper tapes. Table 2.1 shows the percentages of reduction for trenches with EAF taken by weekly basis.

Table 2.1: Percentages of reduction for trenches with EAF taken by weekly basis [4]

Duration in weeks after first installed	**Percentages of reduction for GI wire with EAF (%)**	**Percentages of reduction for copper tape with EAF (%)**
2	68	66
4	50.6	48
8	51.5	50
12	45.6	45
16	44.8	43
20	43.6	42.9
24	42.4	42.5

For the system EAF, the difference of grounding impedances value for copper tape and galvanized iron is 10.45%. Meanwhile for the system without EAF, the difference is much higher which is 11.13%. This may cause by the surface contact between the grounding electrode and the soil which so inferior, compare to those trenches with addition of EAF where the surface contact between the horizontal part and the soil is much bigger with the addition of low resistivity material, EAF. So, the current will easily dispersed to earth and copper is better than galvanized iron in term of current conductivity [4].

In conclusion, the result shows that there exists a difference for the performance of copper tape and galvanized iron in the multilayer soil for 25 weeks of measurements. Since the radius of copper tape and galvanized iron is slightly different, it plays important role in getting the value of grounding impedances.

2.2.4 Study on Influence of Buried Metallic Structures on Soil Resistivity Measurement

Studies have been carried out by J. Ma and F.P. Dawalibi, researcher from Safe Engineer & Technologies, on the influence of buried metallic structures on soil resistivity measurement at Montreal, Canada. Different measurement methods, various soil structures and different location of measurements profiles with respect to metallic structures have been analyzed.

Soil resistivity measurement are stimulate by low frequency grounding analysis computer algorithm in which the analysis technique of the algorithm is based on method of images following the technique that develop by Oslon and Stankeeva. Soil measurements made with the Wenner and Schlumberger methods are simulated with and without a nearby grounding grid, in uniform, two layer and multilayer soils. A comparison was made between the result, with and without the grounding grid.

For the Wenner method, a plan view of 100mx50m 16 mesh grounding was buried at a depth of 0.5 meters in a 100 Ω-m, and the soil resistivity measurement electrode arrangement of the wenner method. The first measurement profiles are parallel to the top perimeter conductor of the grid and 10 meters away from it. The second also parallel to the top perimeter but 50 meters away. The setup model for this method as illustrated in Figure 2.5. The internal components of the meter will be able to calculate the resistance through ohm' s law using equation 2.1 :

$$R = \Delta V / I \qquad (2.1)$$

where,

R= earth grounding resistance

ΔV= between the two potential

I= amplitude of test current injected by the instrument

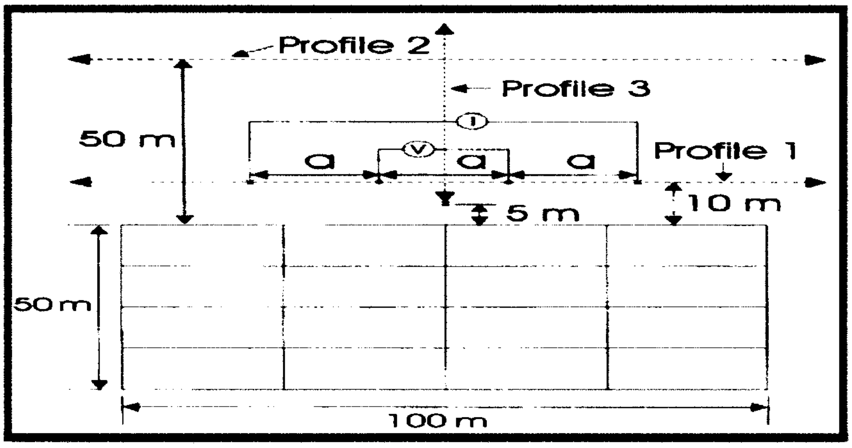

Figure 2.5: Soil resistivity measurement set-up modeled for Wenner method [5].

Schlumberger method are set-up by 100mx50m 16 mesh grounding grid buried at a depth of 50 meters in a 100Ω-m and the soil resistivity measurement profiles are the same as in case Wenner method. Figure 2.6 shows the soil resistivity measurement set-up modeled for Schlumberger method.

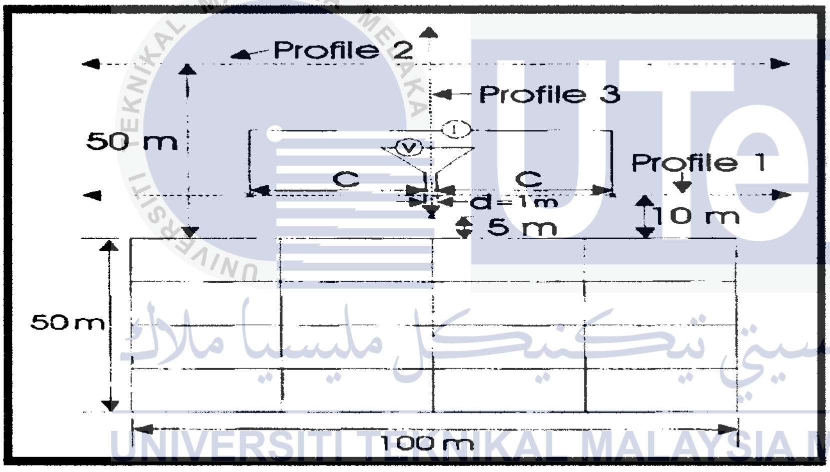

Figure 2.6: Soil resistivity measurement set-up modeled for schlumberger method [5].

In conclusion, different measurement methods, soil structures, and position of measurement profiles with respect to metallic structures have been analyzed. It is found that the influence of buried metallic structures on soil resistivity measurements can be significant, and the effect varies in a wide range, depending on measurement method, location of measurement profile, and soil structures.

2.2.5 Calculating Grounding Electrode Impedance Using Fall of Potential and Impedance Method.

Researchers from department electrical and computer engineering, University of Utah has carried out on how to calculate grounding electrode impedance using fall of potential and impedance method. The impedance method is very similar to the classical finite difference method, this paper used to model single and double grounding electrode system for residential construction in various type of soil.

This paper demonstrates on how to predict the grounding effectiveness of a single or dual electrode grounding system using fall of potential technique or impedance solution to calculate the resistance to ground and it is resulting electrode potential. The ratio of the distance between current electrode (CE) and potential electrode (PE) should be 61.8% and by fulfill this requirement the ground impedances value of the system can be accepted.

For Fall of Potential Method, a current electrode (CE) is actually driven far from the actual grounding electrode (GE), current had been inject to the current electrode and sunk to the grounding electrode as shown in Figure 2.7. As the current is actually circulating, a third electrode called potential electrode (PE) is actually driven at many, a minimum of ten locations involving the grounding electrode and current electrode. At each one of the potential electrode area, the voltage difference is measured involving the potential electrode and the grounding electrode. The earth impedance at that potential electrode area then gets to be the ratio of the voltage difference and the injected current [6].

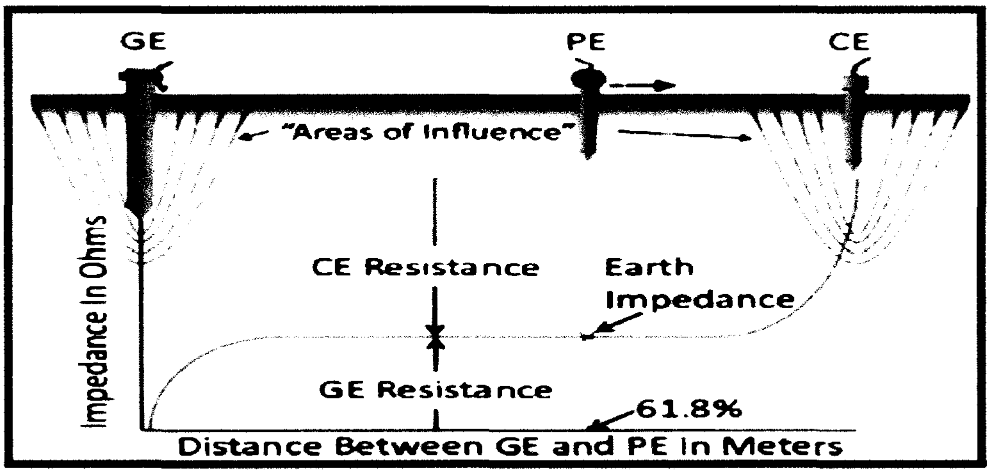

Figure 2.7: The fall of potential method test set-up [6].

Typically, the impedance method models a test environment as a matrix of complex impedances. A version of the matrix was used in the program, three separates array are required in order to fully realize the network, one for the impedance values in the *x* direction, one for the impedance values in the *y* direction, and one for the resulting values of the current as shown in Figure 2.8.

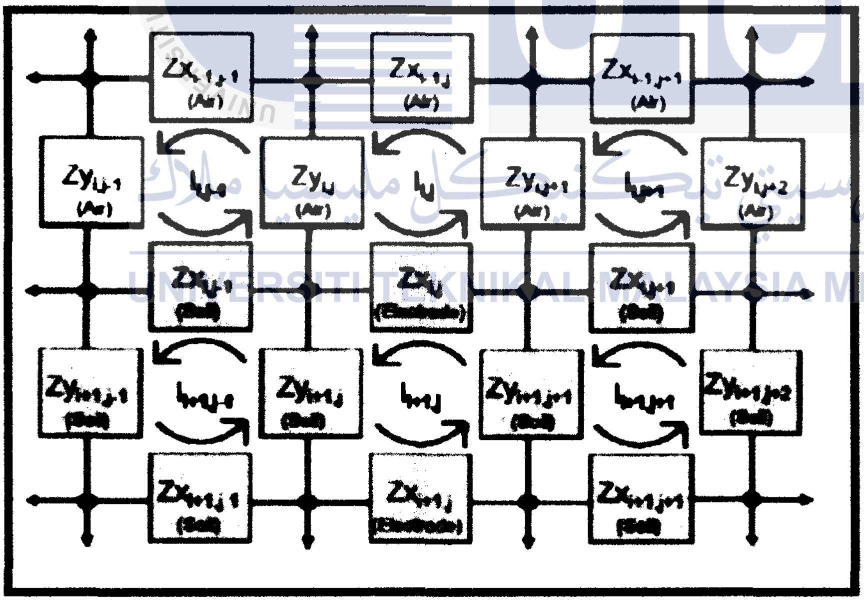

Figure 2.8: The resistivity network used in the Impedance Method [6].

For the conclusion, the journal has demonstrated how to use the impedance method to calculate the electrode-to-ground resistance and potential for grounding electrodes typically used in residential and commercial construction. The effect of grounding electrodes on reducing the earth impedance of an electrical system depends mostly on soil resistivity. These simulations showed that the earth impedance of single-electrode systems varies widely, depending on the type of soil surrounding them.

2.3 Conclusion

From the experiment and study that was done, it can be conclude that the engineer have a problem in designing an earth connection and the way that the earth resistance might be obtained [2]. Other than that, due to the complexity involving real soil structures, the efficiency of specific grounding system need to be evaluate the right way using sufficient software tools to stop wasting throughout cost and reduce risk to safety under design [3]. In addition, there is difference with the performance involving copper tape and galvanized iron from the multilayer soil with the 25 weeks of measurement. Since the radius of copper tape and galvanized are different, it play important in getting the value of grounding impedances, it might be much lower than copper [4].

Four methods were discovered to measure the earth resistivity which are Fall of potential method, Wenner method, impedance method and Schlumberger method. The different measurement procedures, soil, and situation of dimension profiles with respect to metallic structures were analyzed. The influence of buried material structures about soil resistivity measurements is usually significant, and the effect varies a lot, depending on measurement method, location of measurement profile, and earth structures [5]. The resistance of the grounding electrode mostly influence by the earth resistivity [6]. Fall of potential method will be used in this experiment due to easy and practical based on recommendation from IEEE Standard.

Table 2.2: Comparison table on the previous study

Author	Project title	Method Used	Method Description	Result
Ms.Kolyani Pole, Dr A.k Sharma (2013)	Analysis on the factors affecting resistance of the earth electrode	Analysis on the variety grounding electrode type	Grounding electrode are install in test beds of varying soil mediation and multiple site location	The resistance of electrode depend on the type of soil in which it is buried.
Yexu li, Jinxi Ma, Farid Paul Dawalibi (2006)	Power grounding safety : copper grounding vs steel grounding system	A series of computer model are used to stimulate grounding system of different size in various soil structures	Experiment consist of a square grounding grids, different grid with various dimension in different soil model	Copper grid provide much better performance than a steel grid depend on soil layer .
F. Mahtar , A. ramli , etc (2007)	Comparison study of usage as grounding electrode between galvanized iron and copper with and without earth additive filler	Setting up 4 process, only two galvanized iron in addition to only two copper, all of the process is included with chemical filler.	The actual grounding program is build in the same place along with the value regarding resistance can be measure using fall of potential technique.	Cooper along with earth additive filler present good efficiency in grounding system than galvanized iron along with other system devoid of earth additive filler.

J. Ma, F.P. Dawablibi (1998)	Study of influence buried metallic structures on soil resistivity measurements.	Soil resistivity is stimulated by the low frequency grounding analysis.	The soil measurement is made by using Wenner method and Schlumberger method on uniform soil, two layer soil and multilayer soil.	The influence of buried metallic structures on soil resistivity measurement can be significant, and that the effect varies in wide range depending on the measurement method.
Glenn Barton, Cyntia Furse (2010)	Calculating grounding electrode impedance using fall of potential method and impedance method	Measured the grounding effectiveness of a single or dual electrode grounding system using fall of potential and impedance method.	A single grounding electrode is measure, if the impedance is greater than 25 ohms, second electrode is driven 6 feet away and connected in parallel to reduce the impedance.	Earth impedance of an electrical depends on soil resistivity, impedance of single electrode varies widely depend on type of soil, larger separation in parallel electrode would give greater reduction in impedance.
Experimental Study of Ground Resistance Reduction Based on The Earth Electrode	A study on grounding rod resistance	3 unit of copper, GI, and steel which have a different length are driven into the soil using vertical installation. Fall of Potential use to obtain the earth resistance value.	6 systems are set up, each type of electrode have a length of 3.0m and the radius between each type are same.	It is expected that the resistance value of the single installation that have twice length of parallel installation are same.

CHAPTER 3

METHODOLOGY

3.1 Project Methodology

This section contains of the methodological issue that used in this research. The main purpose of this project methodology is to collect information that related to the methods and techniques that used in this project development, such as process of research, process identifying, measuring activities and result. By using the appropriate methodology for the research, it is necessary to ensure that all the data and information required can be implemented accordance the time setting. Furthermore, a good project methodology also makes this research run smoothly as desired. Other than that, it is also considered as a process to analyze the data using the right way. Figure 3.1 shows the flowchart of the project methodology.

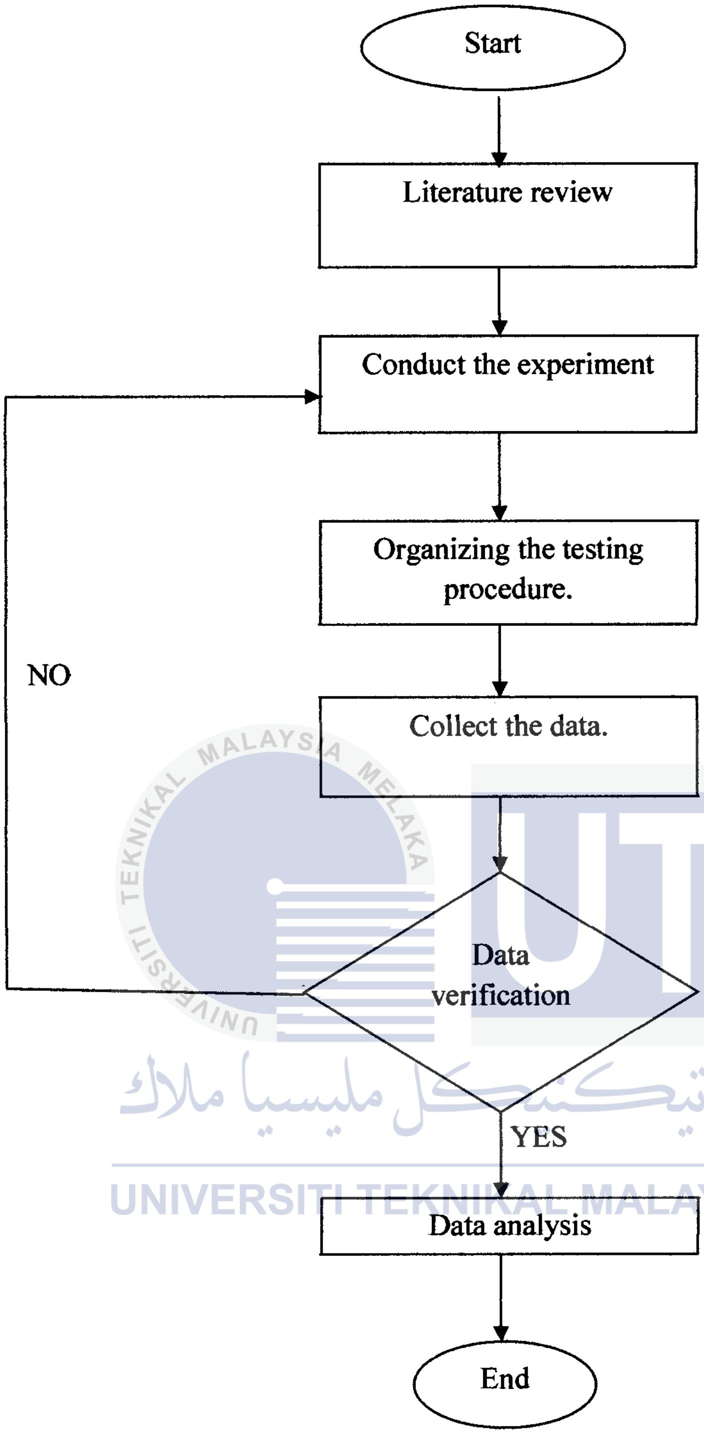

Figure 3.1: Flowchart for methodology

3.2 Experiment Procedure

In completed this research the experiment procedure are compulsory to eliminate experimental error and to ensure that the results are due to the factors being tested. Throughout this experiment procedure, the entire steps that need to be done are clearly stated to ensure that the experiments are run smoothly. All of the procedure needs to be follow as required to avoid the error in data collection which can affect the final result. Figure 3.2 show the experiment procedure.

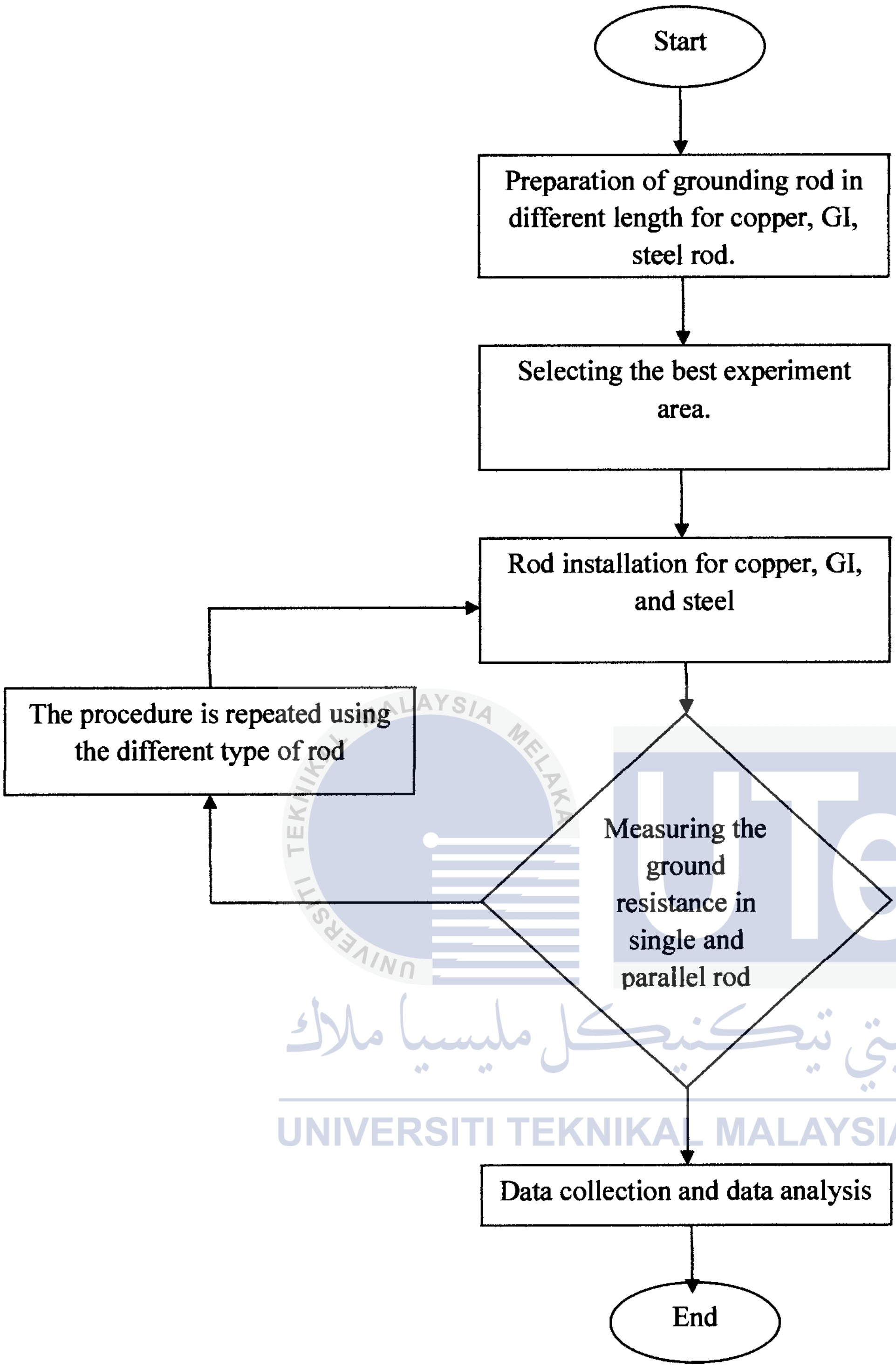

Figure 3.2: Experiment procedure

3.3 Material Provision

In this particular experiment, 3 different types of rod was used which are, copper rod, GI rod and steel rod.

Table 3.1: Specification of earth electrode

Type of grounding rod	Length (m)	Diameter (cm)	Quantity
Copper rod	1.5	1.00	6
Galvanized iron	1.5	2.00	6
steel	1.5	1.20	6

To complete the measurement of the grounding resistance, there are a few equipment that used such as digital earth tester (DET), ear canal clamp, copper wire, sledgehammer, hand glove and measurement tape. Method that will be used in this experiment is following the recommendation from IEEE Standard 81-1983. According to this standard, the fall of potential are the best method that can be apply because it is applicable to all type of ground impedance. The fall of potential method is more reliable compare to Wenner, impedance and Schlumberger method. Ear canal clamp are used to clamp the copper wire at the top of the rod that driven in the soil early. It is also to make sure that the copper wire that connected in parallel are tightly clamped. To installed the rod, a sledgehammer was use manually because it have much punching power compare to normal hammer and the rod are punched vertically. As a safety precaution, the hand glove was use to protect hand from any unwanted injury during the rod was punched. Measurement tapes are required to measure the distance between each rod as desired and to prevent any unwanted bias when taken the earth resistance. Figure 3.3 and Figure 3.4 shows the digital earth tester (DET) and the arrangement for measuring the grounding resistance.

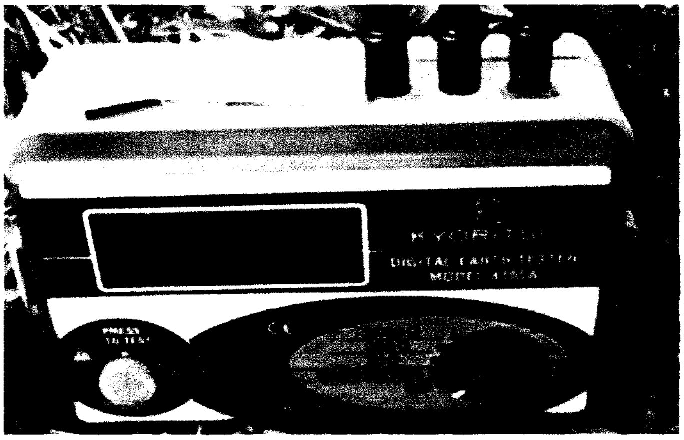

Figure 3.3: Digital earth tester

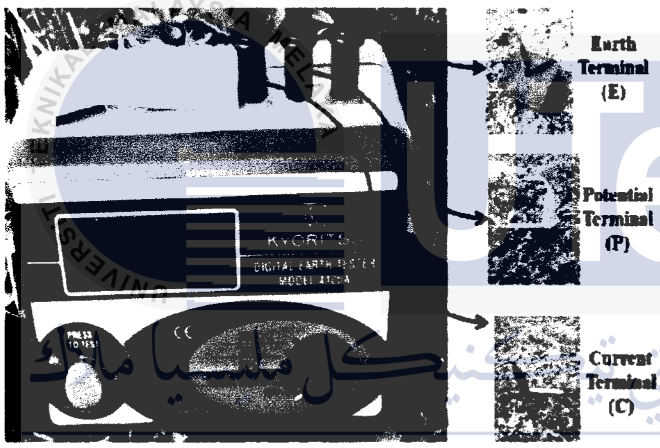

Figure 3.4 Connection Arrangement for measuring grounding resistance

3.4 Installation Process

When installed ground rod, the right technique must implemented to make sure that the resistance readings are accurate without any error. Always ensure that at least 8' of the rod are directly contact with the soil and that the rods are embedded a good distance below the permanent moisture level of the soil. Ground rods should be placed no less than 6' away from each other [6]. Also to be sure that national electric code is adhered when installed the ground rods. The location or site of the experiment should have wide areas that have same type soil. For this experiment the type of soil are peated- type which have less rock contained in the soil to ensure that the rod can be driven without encounter the rock. The resistance value of the ground resistance are obtained by using fall of potential method where the potential spikes and current spikes are installed 15 meter and 20 meter away from the testing rod. Furthermore, the potential spikes and current spikes are aligned in straight line. Figure 3.5 and 3.6 show the real installation of the experiment.

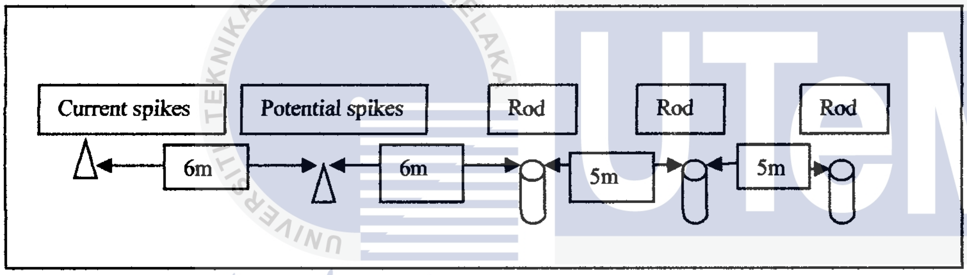

Figure 3.5: Installation for parallel electrode. (Copper, GI, steel)

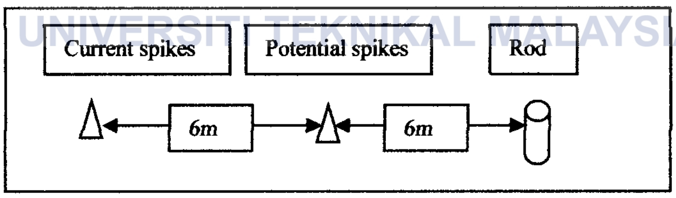

Figure 3.6: Installation for single electrode. (Copper, GI, steel)

3.5 Testing and data collection

To get valid and accurate value of resistance, the right ways of testing need to be done. In this experiment, there are procedures that need to follow correctly to obtain the resistance value of earth impedances. By using DET, the resistance value can be obtained for the single and parallel rod testing. Figure 3.7 shows all the procedure that need to be followed.

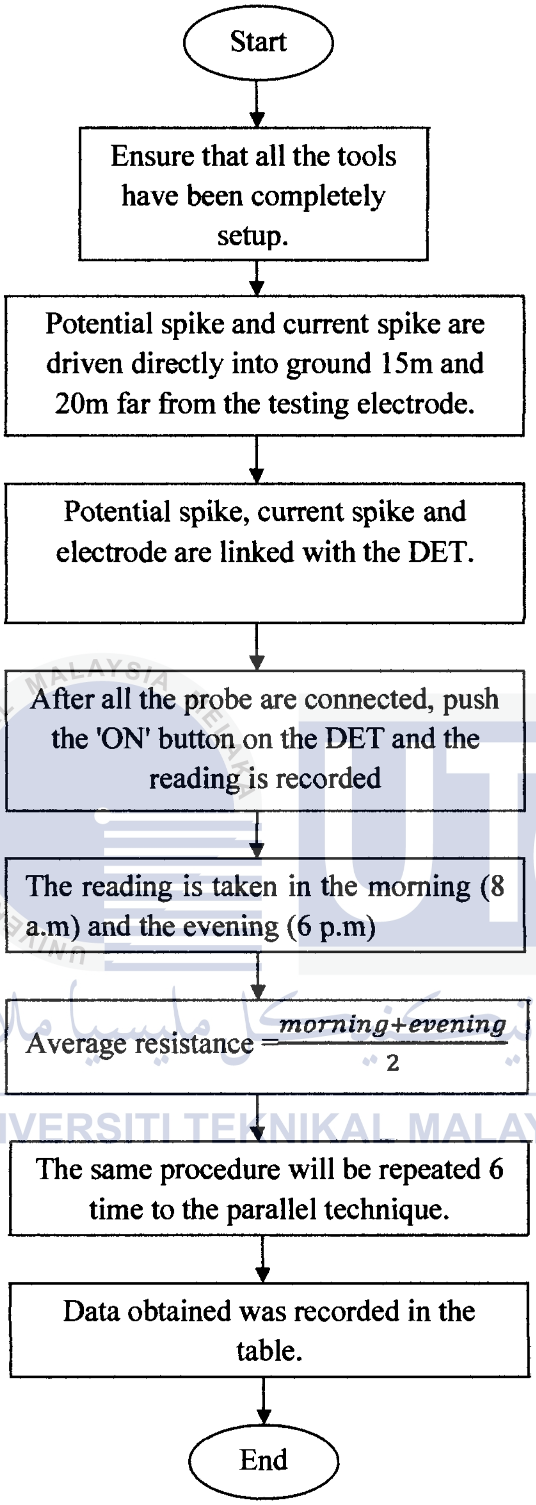

Figure 3.7: Flowchart for data collection

3.6 Data and Rods Performance Analysis

All the electrodes and system give the different value of earth resistance. The value of resistance can be said depend mostly on whether condition such as rainy day or sunny day. The reading recorded for this experiment was tabulated in a table. Besides, these projects were used to determine which material has the lowest resistance value. For each rod and system, the expected percentage of reduction for everyday was calculated to find if any reduction or increment in the value of resistance from day to day during the period of the experiment conducted. The formula for percentage of reduction is shown in equation 3.1.

$$\text{Percentage of reduction} = \frac{R_{next\ day} - R_{present\ day}}{R_{next\ day}} \text{x } 100\% \tag{3.1}$$

The value of the resistance for the parallel installation can be obtained by using equation 3.2.

The formula is,

$$\frac{1}{R} = \frac{1}{R1\ (first)} + \frac{1}{R2\ (middle)} + \frac{1}{R3\ (last)} \tag{3.2}$$

Each of the data on the experiment was recorded inside table and the graph was plotted for 2 weeks of experiment. Many aspects that need to be considered while taken the reading on the DET, the data that collected were use for analysis purpose. The graph was plotted for each type of rods and installations, and the purposes are to find the difference in the performance regarding resistance value.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Overview

The grounding resistances were recorded in this chapter for all types of grounding system installation. All the data was recorded for 2 weeks of experiment that had been done in the UTeM grass field that consist of peat soil. Two type of installation was analyzed which are single and parallel installation. For the single and parallel installation, each type of rods has a same diameter and same length. Each rod used in this study has a same length of 3.0 meters. The difference on were in the type of installation technique, which is single and parallel installation. The analysis was done by using Microsoft Office Excel 2010.

4.2 Result

4.2.1 Parallel rod testing

From Figure 4.1, the lowest resistance value is steel rod for 15 day of experiment. The resistance value of the GI rod are almost same with the steel rod. The resistance value for this two type of rod are stable from day 1 until day 15. The higher resistance value for the parallel system was copper rod. The higher resistance value for copper is 195Ω at day 2 and the lower is 144.5Ω at day 7. This is because the materials that use to make the copper rod are not purely copper, and the copper is actually only use to coated the surface of the rod only. The resistance value for the three type of rod start to stable started at day 2 until day 15.

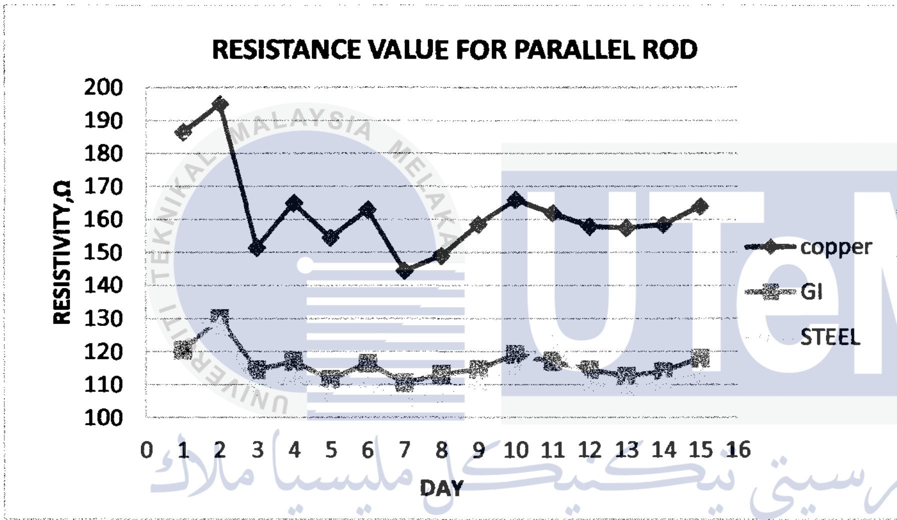

Figure 4.1: Resistance value for parallel rod

The plot of percentage of reduction is as shown in Figure 4.2. The pattern of the plot indicates that there is unstable reduction from day 1 until day 15. Overall graph pattern shows a dramatically increase from day 1 to day 2. The difference between copper to GI and steel are almost about up to 70 Ω. The pattern is rapidly decreased at day 2 until day 3 for each type of rod. The resistance value for GI and copper shows almost same reading in term of the resistivity. This is due to the weather condition such rain and sunny day. The soil condition really affected the percentage of reduction for every type of rod.

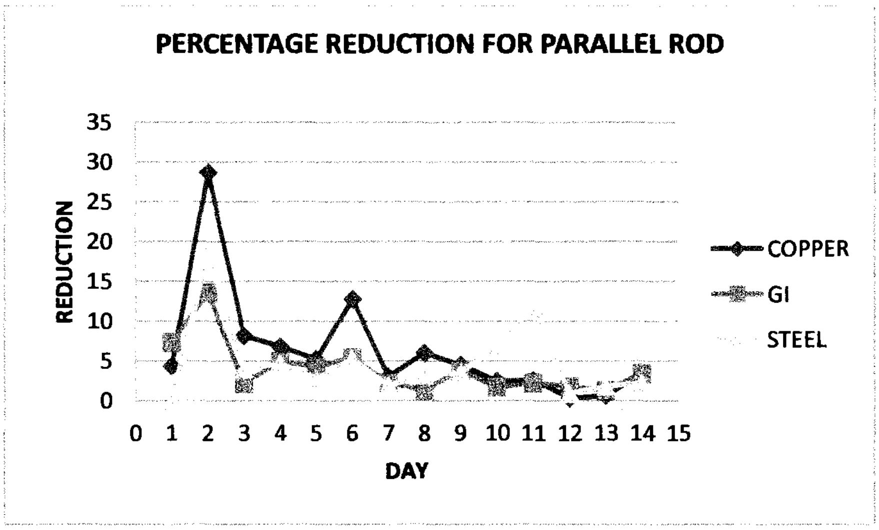

Figure 4.2: Reduction for copper, GI, and steel rod

4.2.1.1 Resistance value between morning and evening

The line diagram in Figure 4.3 depicts the resistance value between a.m and p.m for copper rod over the 15 day of experiment. The graph shows an unstable pattern for a.m and p.m graph. The resistance values vastly decrease from day 2 to day 3. The higher difference in term of resistivity between a.m and p.m is at day 5 and day 7 which the difference is 47Ω and 37Ω. The root cause of this is because of the present water inside the soil due to rainy condition at evening.

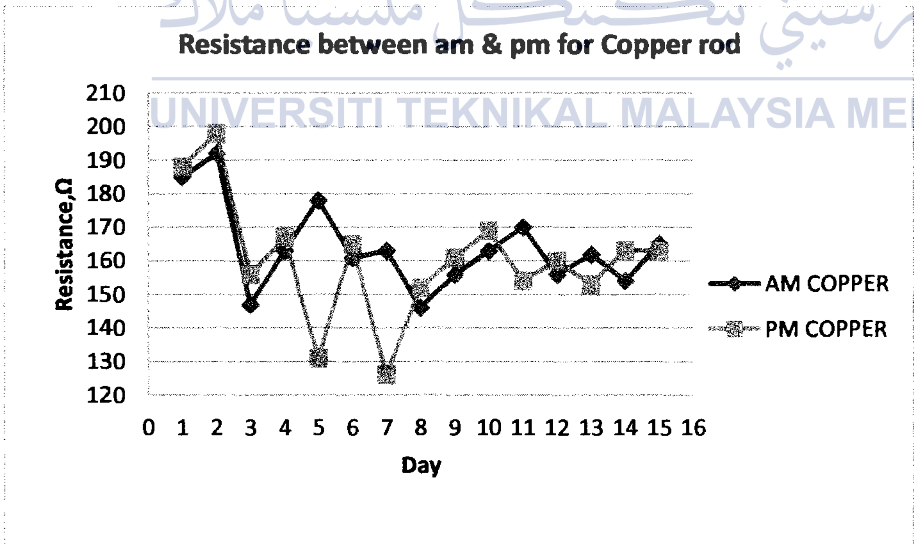

Figure 4.3: Resistance value between a.m and p.m for copper rod

Form the graph in Figure 4.4, the overall graph shows that the higher difference is at day 5 and 7. The graph for a.m and p.m shows that dramatically increase from day 1 to day 2. This is because of the weather condition during second day which is sunny day. At day 3, the resistance for GI rod is decrease to 117Ω due to present of water inside to soil. At day 5 and day 7, the present of water cause by the rainy condition at the evening really affected the resistivity of the grounding electrode. The resistance value for this two day fall to 104Ω and 103Ω. The remaining day of the experiment shows a fluctuate pattern and only a little different between a.m and p.m regarding the earth resistivity.

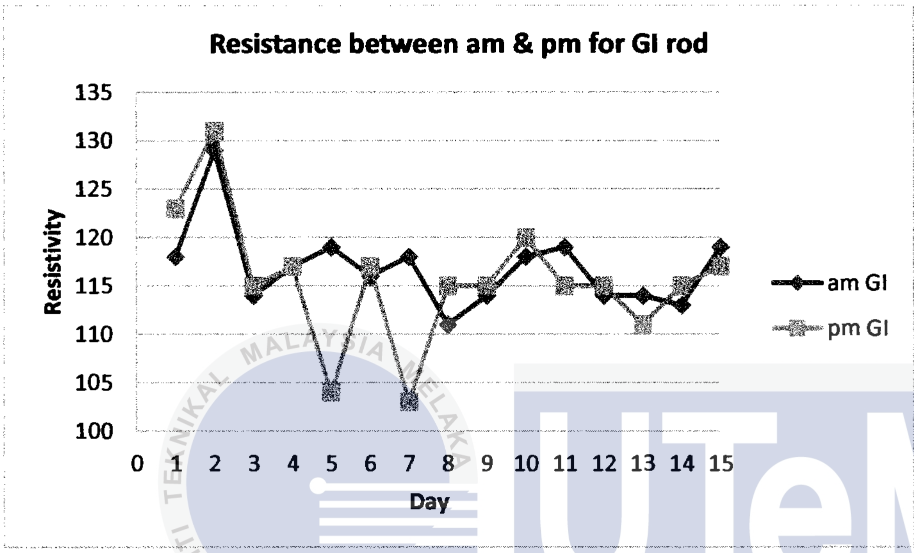

Figure 4.4: Resistance between a.m and p.m for GI rod

Figure 4.5 show graph of resistance value for steel rod over the 15 day of experiment. From the figure, it can be seen that the pattern between a.m and p.m are almost the same except at day 5 and day 7. There is a huge resistance value between a.m and p.m for this two day. The resistance value for day 5 is 101Ω and at day 7 is 100Ω. The soil condition is wet during this two day due to rain that decreases the soil resistivity. The soil resistivity is rapidly increase started at day 8 until day 11 because of the soil is slowly started to dry and increase the soil resistivity surrounding the rod. But then, dramatic falls occur at day 12 and the graph patterns are level off for the remaining days.

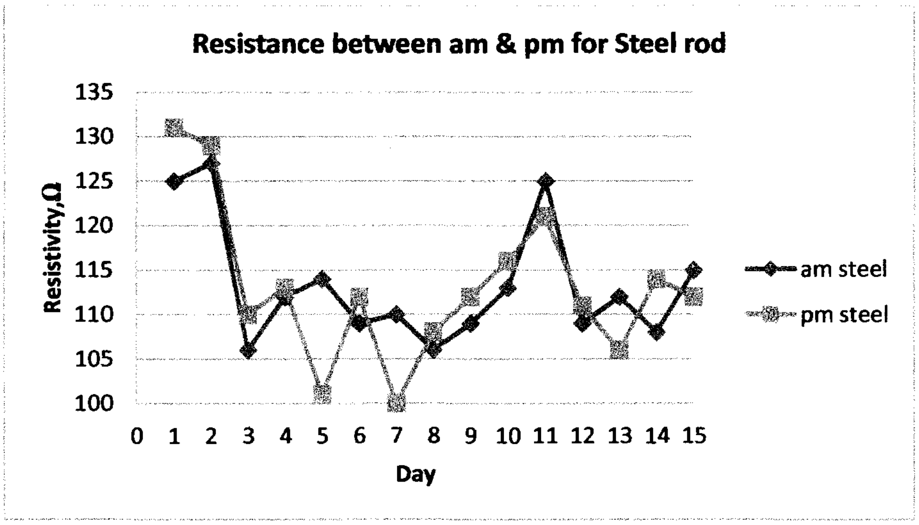

Figure 4.5: Resistance value between a.m and p.m for steel rod

The line diagram in Figure 4.6 depicts the resistance value at a.m for the three types of rod over the 15 days of experiment. The lowest pattern is steel and the higher is copper rod. The different between copper and steel is almost 60Ω for the 15 day of the experiment. a gradually decrease is from day 2 to day 3 for all type of rod because of rainy condition during that day.

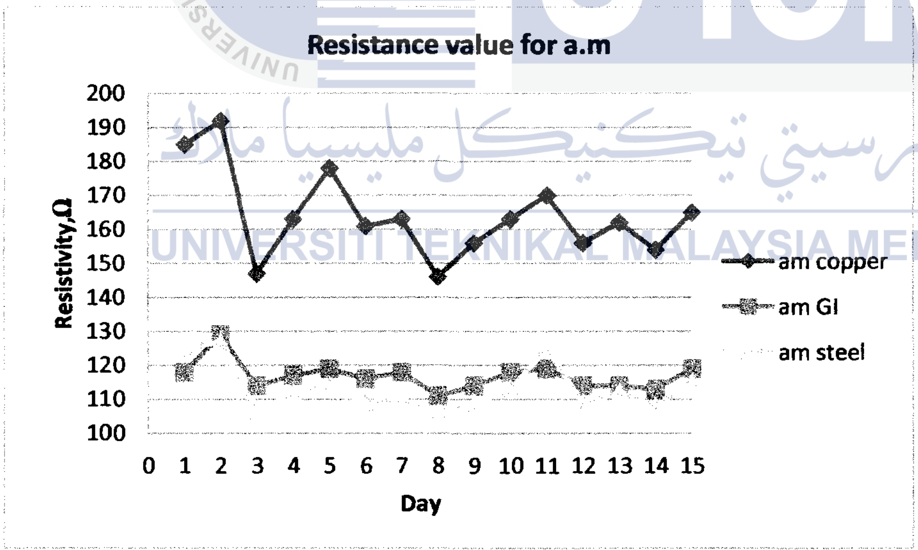

Figure 4.6: Resistance value for a.m

The graph in Figure 4.7 illustrates the resistance value at p.m for three type of rod over the 15 days of experiment. Overall graph shows almost the same pattern where the lowest resistance occurred at day 7. The lowest resistivity between three types of rod is steel rod. This maybe because by the material of the rod itself that have much better performance compare to GI and copper.

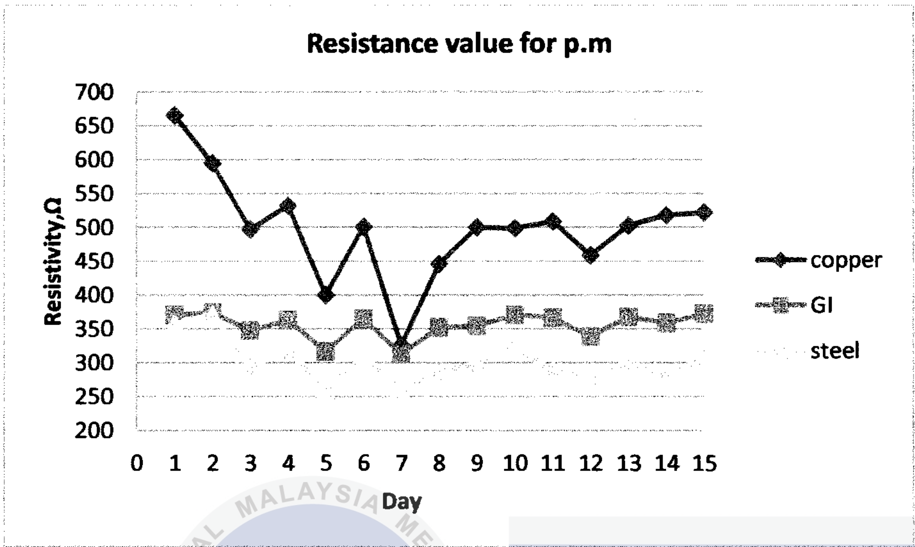

Figure 4.7: Resistance value for p.m

4.2.2 Single rod testing

Figure 4.8 shows the average resistance value for three type of rod which are copper, GI, and steel rod. It clearly shows that the higher resistance between three type of rod are copper rod. This is may cause from the diameter of the copper rod which is much smaller compare to the GI and steel rod. The higher resistance value for the copper rod is 544Ω at day 2 and the lower resistance is at day 7 where the resistance value is 393Ω. The resistance value for the GI and steel rod are almost same starting from day 1 until day 15. The ranges of the resistance value between this two rod are from 283Ω to 358Ω.

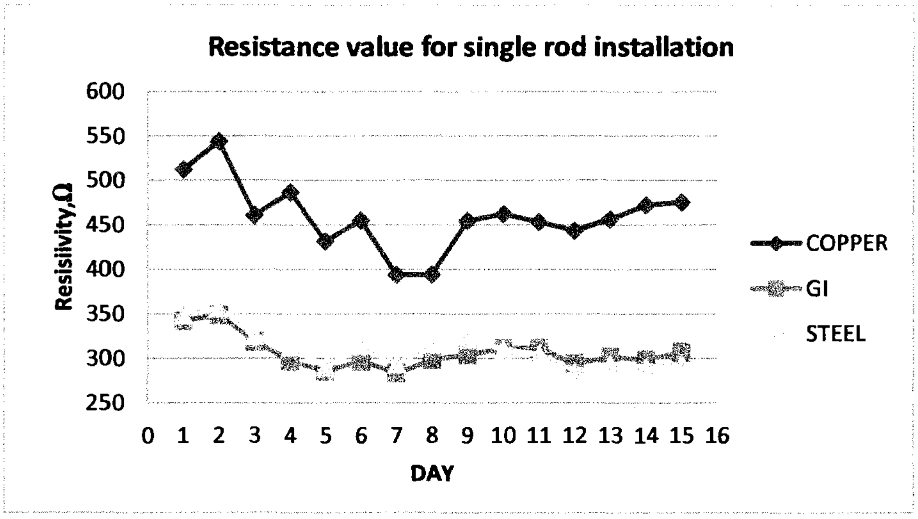

Figure 4.8:Resistance value for single rod

From the graph in Figure 4.9, the percentages of reduction for copper rod are fluctuate from day 1 until day 9. From day 9, the percentage of reduction is started to stable. The graph for copper shows a difference pattern compare to the GI and steel. This may cause by the soil resistivity where the rod was driven. Moreover, the rod number 1 and rod number 2 are not really fit to the ground compare to rod number 3. The resistivity of the copper are higher compare to other rod because of the total surface of the rod that contact with the soil are less.

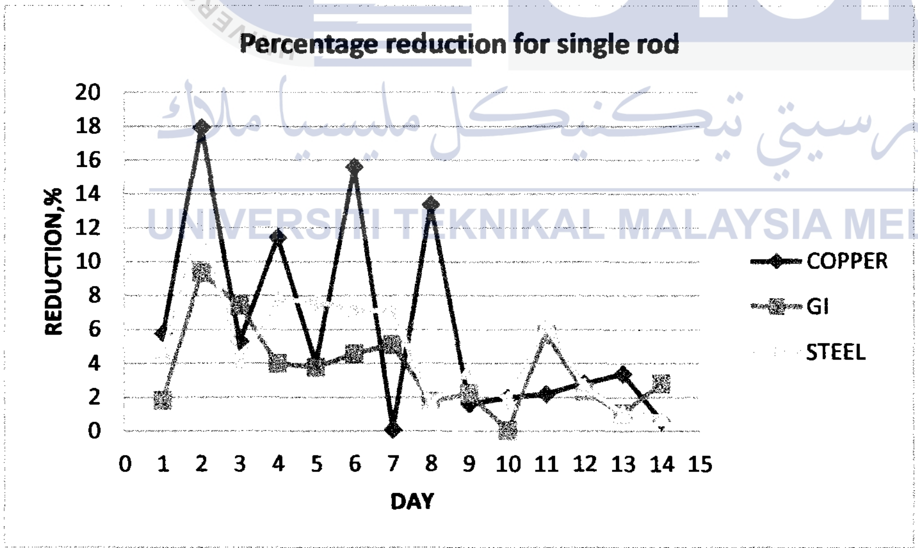

Figure 4.9: Percentage reduction for single rod

4.2.2.1 Resistance value between morning and evening

The graph in Figure 4.10 shows the resistance value for copper rod over the 15 days of experiment. The pattern of the graph between a.m and p.m are dramatically decreased from day 1 until day 3. But then, had a slightly rise at day 4. Started day 4, the resistivity of the rod at a.m merely stabilizes. For the p.m pattern, it shows a huge decrease at day 5 and day 7 and start to level off until the last day of the experiment. a lot of different for the resistance value for a.m and p.m for this two days are cause by the humidity of the soil which reduce the resistance in the area where the was driven.

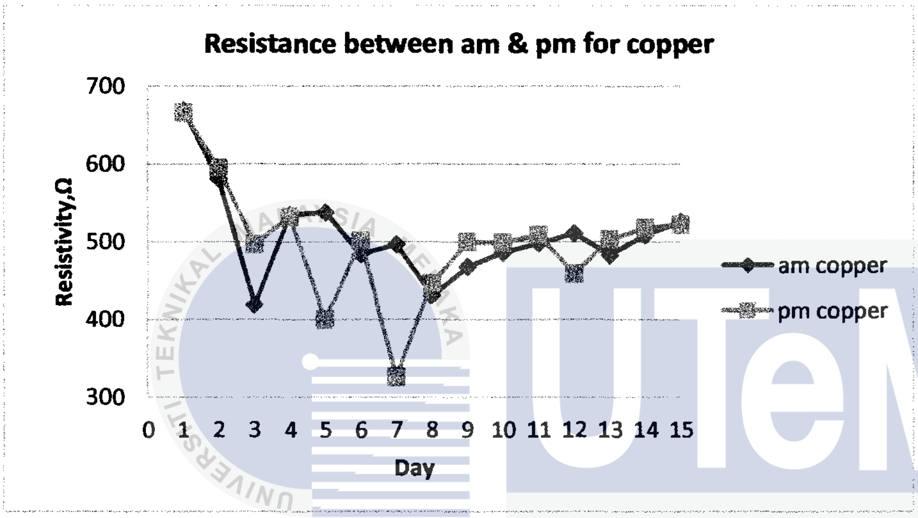

Figure 4.10: Resistance value between a.m and p.m for copper rod

The line diagram in Figure 4.11 illustrates the resistance value for GI rod between a.m and p.m over the 15 days. Overall pattern exhibit an unstable reduction of the resistance value. The graph for p.m reveals a weird decrement at day 5 and 7. The factors that can be related to this graph movement such as the water content within the rod area. At day 5 and 7, the rain starts to pour into the soil.

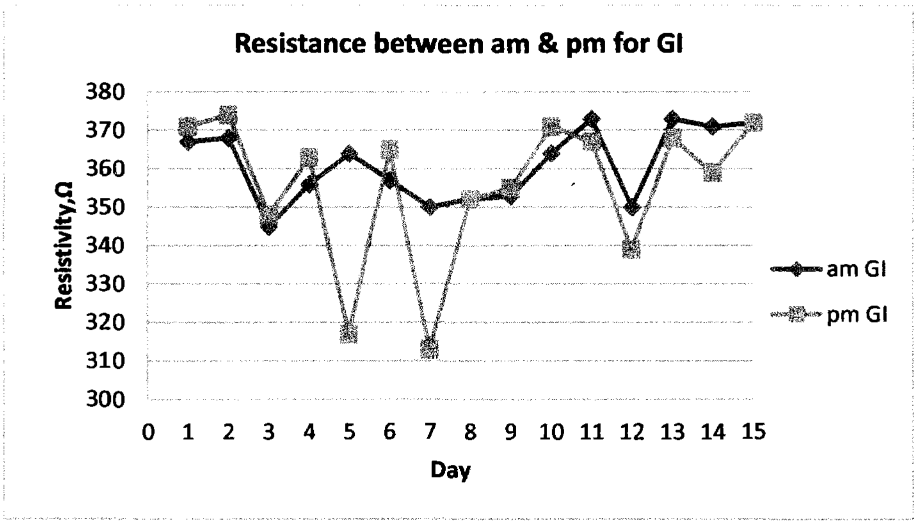

Figure 4.11: Resistance value between a.m and p.m for GI rod

The graph in Figure 4.12 represents the resistance value between a.m and p.m for the steel rod over the 15 days of experiment. A slightly increase from day 1 to day 2 and gradually decrease at day 3 for both pattern. The pattern for a.m was fluctuated until the end of the experiment. The lowest resistivity for the steel grounding is at day 5 and day 7 which the resistance value is 259Ω and 260Ω. This phenomenon is because by the weather condition which the present of rain during that day and unintentionally reduce the resistivity surrounding the rod.

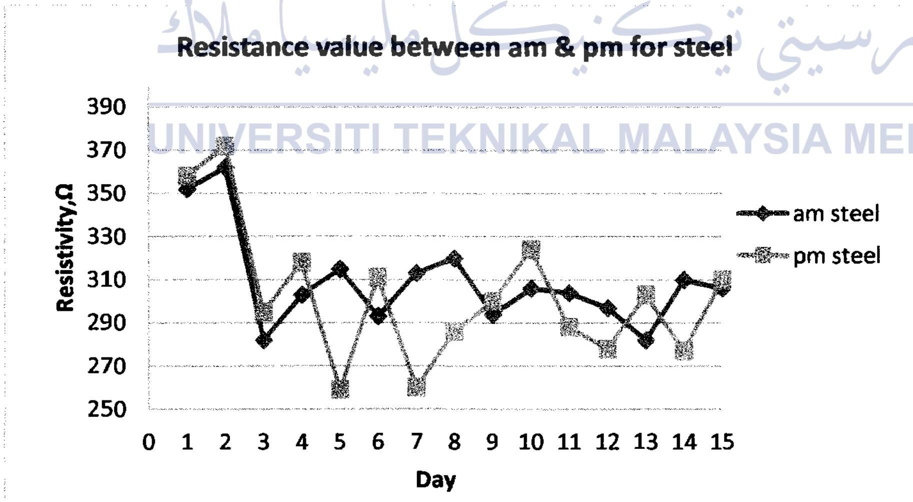

Figure 4.12: Resistance value between a.m and p.m for steel rod

The graph in figure 4.13 shows the resistance value a.m for three type of rod over the 15 day of experiment. The higher resistance value between three types of rod is copper. The resistivity of the rod is at 666Ω at first day of measurement. A dramatically decrease from day 1 until day 3 which the resistance value is 419Ω. The pattern for steel shows a constant movement from day 3 until day 15.

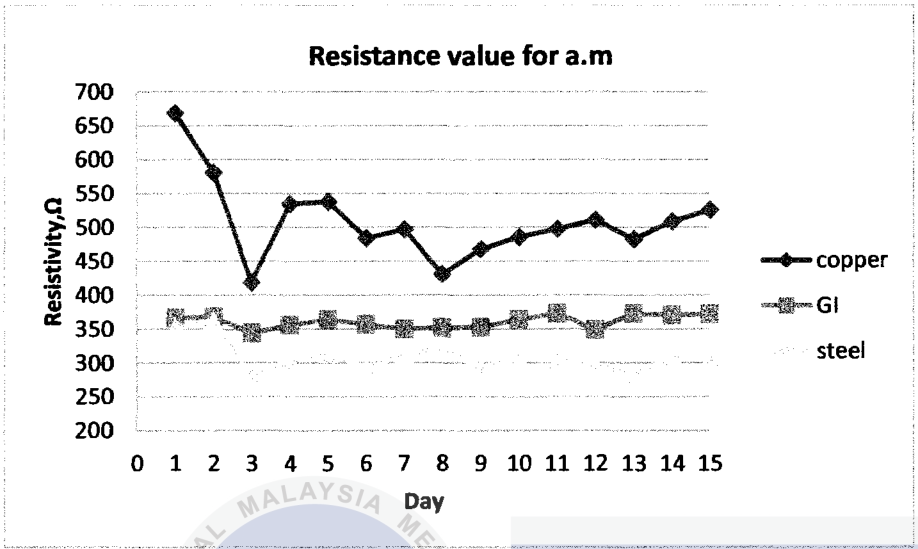

Figure 4.13: Resistance value for a.m

The graph in Figure 4.1 depicts the resistance value for three types of rod which are copper, GI and steel for a period of 15 days. The lowest resistance between three types of rod is steel rod. The graph for the GI and steel had almost the same pattern for the 15 days of experiment. However, the graph for copper rod shows a steadily decrease from day 1 until day 7. The reason behind this pattern is cause by the soil condition at the location of the experiment.

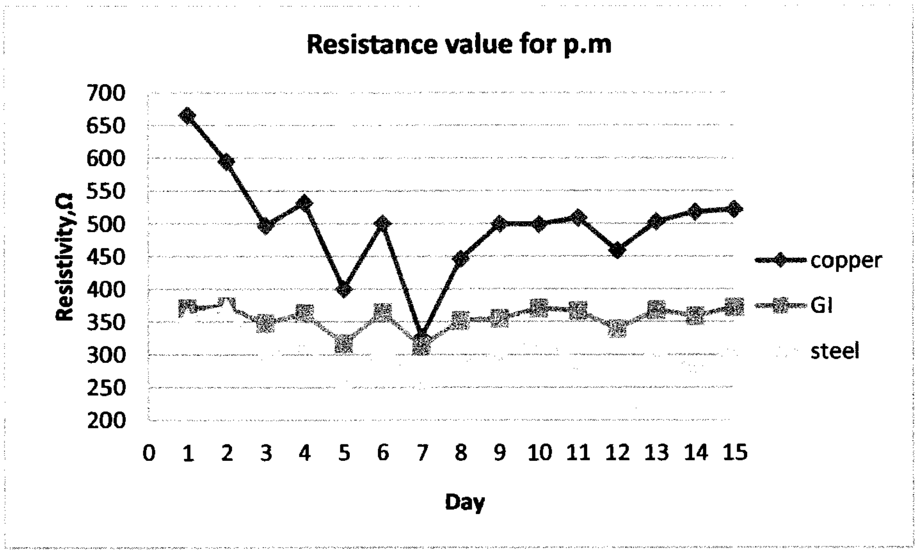

Figure 4.14: Resistance value for p.m

4.3 Maintenance

Before the reading was taken, there are a few things that need to be considered such as the distance between potential probe and current probe, the crocodile clipped of the cable and the C-clamped. The distance between potential probe and current probe must be at range between 5 meter to 10 meter from the grounding electrode under the test [6]. This distance is suggested by the manual of the DET to make sure that the resistance value that comes out from the meter are purely resistive and followed the standard. The resistance value of the rod also affected by the crocodile clipped at the rod under the test. These happen when the clipped is not really tight and will increase the resistivity of the rod. For the parallel rod testing, 1.5mm cable was use to connect between each rod to make it parallel. The cable was clamped using C-clamped that located on the top of the rod. To make sure that the reading that comes from the DET meter is purely resistive and accurate. The C-clamped must really tight to prevent any factor that can increase the resistance during the experiment. Figure 4.15, 4.16, 4.17 shows the single installation system using copper, GI and steel. Furthermore, Figure 4.18, 4.19, 4.20 shows the parallel installation system for copper, GI and steel.

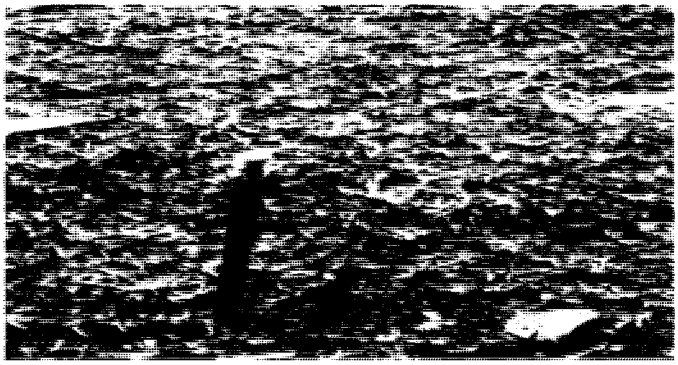

Figure 4.15: Copper rod single test

Figure 4.16: GI pipe single rod test

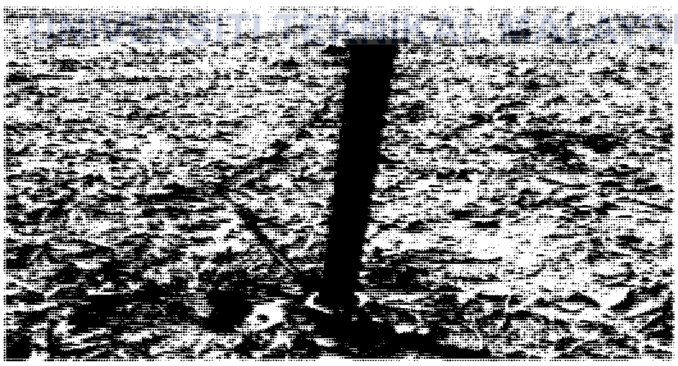

Figure 4.17: Steel single rod test

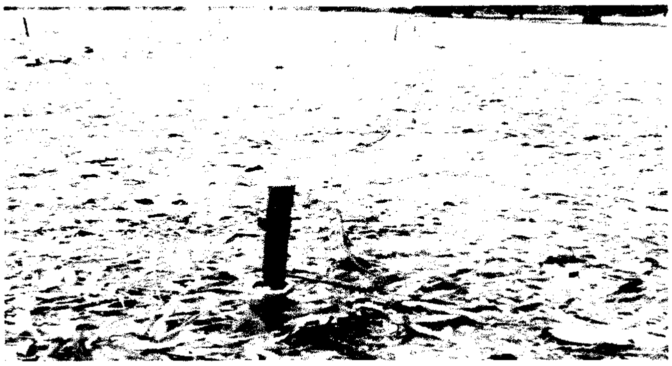

Figure 4.18: Copper rod for parallel installation test

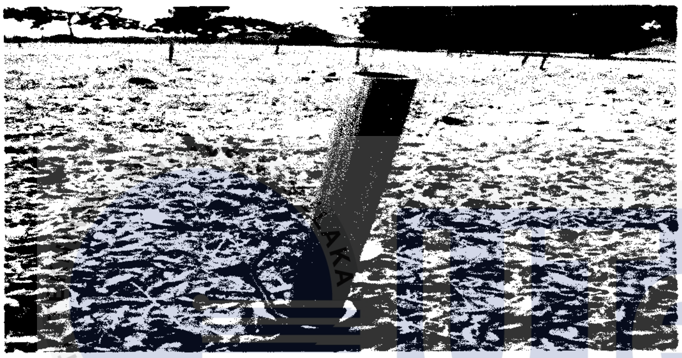

Figure 4.19: GI rod for parallel installation test

Figure 4.20: Steel rod for parallel installation

4.4 Conclusion

The resistance value is different with different type of electrode. The steel rod shows the lowest resistivity among copper and GI rod for both types of installation which is single and parallel installation. This is based on the analysis that had been done in chapter 4. It is believed that the weather affected the resistance value of the grounding system. The higher the humidity of the soil, the lower the resistance of the electrode.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Comparison between copper rod, GI rod, and steel rod for parallel testing

Based on the data that collected for 15 days for the parallel testing between copper, GI, and steel it shows that the copper rod have the higher resistance value compared with other two type of rod. Because of this, the resistance values for the copper rod are not followed the theory of grounding rod from the references journal which state that the copper grounding rod had high current conductivity compare to galvanized iron and steel [4].

Referring to the IEEE regulation, there are many factors which affect the resistance of the earth electrode such as type of rod, spacing, and dimension of the rod. In this experiment, the copper rod that had been use are not purely copper, only the surface of the rod that laminated with copper, beside that, the diameter of the copper rod also much smaller compared to the GI and steel. Moreover, based on observation, the copper rod also not really fit to the ground where the rod can easily shake even after the rod had been drive. These three causes can lead to the higher resistivity of the copper.

For the GI rod and steel rod, the graph showed that the patterns for the 15 day are nearly the same to each other. The radius of the GI rod and steel are not same, where the radius of the GI rod is 20mm and steel is 12mm. from this From the analysis that have been done can conclude that the earth resistivity not only depend on the radius of the electrode but also depends on the material or type of rod. For the parallel installation, the lowest resistivity likely to be steel where the lowest resistance is 105Ω at day 7 due to rainy condition which make the soil resistivity become lower. The higher resistivity for GI and steel rod is at day 2 where the reading for GI rod is 130Ω and 128Ω for steel rod. This is because of the temperature during that day which reduce the moisture of the soil.

The percentage of reduction for the parallel installation system between three types of rod clearly shows that the peak of reduction is at day 2, which the reduction for copper is 29%, GI 14% and steel 18%. The reason behind this pattern is because of the present of rain that make the soil wet and reduces the soil resistivity itself. The effect of the water content inside the soil is shows for the next few day depends mostly on weather condition. From day 3 until day 5 the reduction are not change too much, but at day 6 the reduction for all type of rod are increase to 13% for copper, 6% for GI and 5% for steel rod. This is also due to the rainy condition. The pattern slowly shows some constant reduction for the copper rod and GI rod for the 15 day of experiment. Unfortunately, the pattern for the steel rod shows some abnormal increase starting at day 10 to day 11. This is maybe the water content inside the area which the steel rod are driven are still trapped. Other thing that can affect the pattern reduction of steel is due to human error while taking the reading, the crocodile clip of the DET meter should be tight to make sure the reading is purely resistive.

Based on the finding in this experiment, it shows that the result are not similar to the journal that written by Yexu li where stated that copper grounding system are much better compare to steel system [3]. The analysis was done by using copper grounding system and steel grounding system. There is no detail explanations about the rod that use in this experiment are purely copper or not. The resistivity of the pure copper and laminated copper are extremely different in term of resistivity for the electrode itself. Another finding that found in this experiment is similar to that found by Ms. Kalyani in his study on the analysis on the factor affecting resistance of the earth electrode stated that the soil resistivity most important factors that affect the resistance of the earth electrode. The conductivity depends on type of soil, moisture content, and temperature. The moisture content and temperature of the soil vary depend on weather condition [2]. During rainy condition, the earth resistivity is extremely decreased due to present of water inside the soil.

5.2 Comparison between copper rod, GI rod, and steel rod for single rod testing

From the data analysis in chapter 4, the graph of the single testing for the copper, GI, and steel was analyzed. It shows that higher resistivity likely to be copper rod. The GI rod and steel rod shows nearly same resistivity between each other. The resistivities for all type of rod are increase at day 2 because of the sunny condition during that day. The resistivity started to decrease from day 2 until day 7 for each type of rod. From day 9 until day 15, the earth resistivity started to stable.

The higher resistivity for the copper rod is 544Ω at day 2 and the lowest is at day 7 which give the reading of 393Ω. The resistivity of the electrode starting to decrease from day 2 until day 8 because of the water content that pour into the soil due to rainy condition regarding that day. The effect of rainy condition will reduce the earth resistivity for the few days after the rain coming. The earth resistivity for the GI rod and steel rod had nearly the same pattern for the 15 days of experiment. Even though, the radius of the GI rod are much bigger than steel rod the earth resistivity of the rod are almost same with each other. The higher earth resistivity for GI is 348Ω and steel is 356Ω at day 2 of the experiment. From this two graph, it can be concluded that the earth resistivity not only depends on the diameter of the rod, but also depend on the type or material of the rod. The permeability of the steel rod is much better compare to GI rod and steel rod.

The theory of the grounding system in the journal that written by researcher from Telekom Malaysia stated that the conductivity of the current through the electrode depends on the type of electrode [4]. Pure copper and laminated copper rod are slightly difference thing, pure copper mean by the material of the rod are 100% copper. But, for the laminated copper only the outside surface of rod laminated with copper. The laminated copper rod is made up from steel also but the rod is much stronger than normal steel. In terms of resistivity, the cooper laminated rod had higher resistivity compare to the steel rod and GI rod.

The percentage of reduction for the single rod installation between three type of rod was plotted and shows that the reduction of copper rod are fluctuate starting from day 1 until day 9, and start to stable until the end of experiment. The graph of the copper rod should follow the graph pattern for the GI and steel pattern. This may cause by the rod number 1 and rod number 2 of the copper rod where the rod are not fit to the soil which reduce the total surface that contact the soil. The reduction for GI rod and steel rod shows almost same pattern. The reductions for steel rod are much better compare with the GI rod for the 15 day of experiment. The reduction for all type of rod shows slowly decrease until the reduction is lower than 5% for each type of rod. This is due to the surface contact between rod and soils are already fit starting day 9 until day 15.

5.2.1 Comparison between morning and evening for single rod installation

From the result in chapter 4, the resistance value for single rod installation for the 15 days of experiment between morning and evening in the same type of soil was analyzed. From the graph pattern it shows that the lower resistance value mostly happens at evening compare to morning. The higher resistance value for evening likely to be copper rod which have about 666Ω followed by GI rod which have about 371Ω and lastly steel rod about 358Ω.

The resistance value of copper rod is the higher between GI and steel. The resistivity in the morning pattern shows a gradually decrease until day 3 and increase back at 535Ω at day 4. For the evening resistivity, the pattern shows that steadily decrease from day 1 until day 7. This decrement are cause by the rainy condition at the evening before the reading was taken at 6 .00 p.m. The graph for the GI rod clearly shows that the resistance value is much lower in the evening. The higher different between morning and evening are at day 5 where the different are about 47Ω. The patterns for the steel rod are almost the same with the GI rod, but have a little bit abnormal increment for the evening at day 10. This may cause by the soil resistivity itself which mostly depend on moisture content inside the soil.

The weather condition really effect the soil resistivity based on 15 day of experiment. The higher the moisture contents inside the soil, the lower the earth resistivity. This finding shows that similar to that found by the Ms. Kalyani in her journal stated that moisture content can reduce the earth resistivity of the electrode [2].

5.3 Conclusion

Every grounding system need to have as lowest resistance value as possible, the lower the resistance value, the better the performance of the grounding system and easily channel the fault current to the ground without cause any damage in electrical system. The material of the copper, GI and steel are the important role in order to reduce the resistance value. The higher the conductivity of the rod, the lower the resistance value. Parallel installation is much better compare to single rod installation. It can reduce the resistivity of the grounding electrode up to 65% depends on the rod that connected. Through both parallel as well as single rod testing, it can be conclude that the weather condition play essential role in reducing or increasing the resistance value of the grounding rod. During the rainy day or wet condition the performance of the grounding system reaches the peak as a result of present of water. This will affect the value of resistance for the next few days before the soil dry in hot day condition. Throughout this project, steel rod is chosen as a best grounding material than copper rod and GI rod because it gives lower resistance value in term of resistivity. The steel rod also much cheaper compare to copper and GI rod in the market. Furthermore, by using the steel rod also can reduce the stealing case over the transmission tower and substation that usually use pure copper as a grounding electrode. In other words, it is better to use a cheaper material with a good performance than the expensive material that has bad performance. GI pipe is predicted to become the finest grounding rod compare to copper rod because it gives the less resistance value than copper and steel. The entire objective in this experiment was successfully achieved.

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APPENDIX A

PARALLEL DATA TESTING

DAY/TYPE	COPPER		GI		STEEL		SOIL COND
	AM	PM	AM	PM	AM	PM	
1	185	188	118	123	125	131	DRY
2	192	198	129	131	127	129	DRY
3	147	156	114	115	106	110	WET
4	163	167	117	117	112	113	WET
5	178	131	119	104	114	101	WET
6	161	165	116	117	109	112	DRY
7	163	126	118	103	110	100	WET
8	146	152	111	115	106	108	DRY
9	156	161	114	115	109	112	DRY
10	163	169	118	120	113	116	DRY
11	170	154	119	115	125	121	WET
12	156	160	114	115	109	111	WET
13	162	153	114	111	112	106	DRY
14	154	163	113	115	108	114	WET
15	165	163	119	117	115	112	DRY

APPENDIX C

Project Gantt Chart

Gant Chart	FINAL YEAR PROJECT 1 (BEKU 4792) 2013				FINAL YEAR PROJECT 2(BEKU 4894) 2014					
Activities / Month	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Project Briefing	■									
Find Supervisor & project title	■									
Discussion with supervisor		■	■	■	■	■	■	■	■	■
Study and research about project		■	■	■	■	■	■	■		
Preparing material and equipment					■	■	■			
Conducting experiment						■	■			
Proposal writing for FYP 1		■	■	■						
Presentation for FYP 1			■							
Seminar Report Refinement & Submission							■	■	■	■
Prepare For Presentation FYP2							■	■	■	■