Department of Physics

WMO Arts and Science College Muttil

SOIL RESISTIVITY

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Submitted by

AFSAL N

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UNDER THE GUIDANCE OF :

Dr BIJU KG (Head of the department of physics)

TEAM MEMBERS

- LINI ALBERT

  WMARSPH008

- MISRIYA SHURBIN K

  WMARSPH043

- AFSAL N

  WMARSPH015

- MUHAMMED ASNAD VC

  WMARSPH032

- HRUSHI SHYAM

  WMARSPH026

CERTIFICATE

This is to certify that the project entitled **'SOIL RESISTIVITY'** done by **LINI ALBERT, MISRIYA SHURBIN K, AFSAL N, MUHAMMED ASNAD VC & HRUSHI SHYAM** Sixth semester B.Sc Physics students of WMO Arts and Science College, under my guidance for the partial fulfilment of B.Sc programme in physics during the year 2017-2020.

EXAMINER SUPERVISOR

Dr Biju KG

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In the name of God.

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LINI ALBERT
MISRIYA SHURBIN K
AFSAL N
MUHAMMED ASNAD VC
HRUSHI SHYAM

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CHAPTER 1

INTRODUCTION

It is a well known that the resistance of an earth electrode is heavily influenced by the resistivity of the soil in which it is driven and as much soil resistivity measurements are an important parameter when designing earthing installations. A properly installed grounding system helps to protect buildings and equipments from damage caused by un intentional fault currents and lightening surges.

The soil resistivity value is subject to great variation, due to moisture, chemical content and temperature. Three important methods to find the soil resistivity are wenner method, Schlumberger array and three pin method. Here we are choosing wenner method to measure the soil resistivity.

GROUNDING

Proper grounding proves to be an important issue when designing and installing power and lightening protection systems. The goal of any grounding system is to provide a low impedance path for fault and lightening-induced currents to enter the earth, ensuring maximum safety from electrical system faults and lightening.

A properly installed grounding system not only helps protect buildings and equipments from damage caused by unintentional fault currents or lightening surges but more importantly, it also protect people.

Grounding is a very complex subject. The proper installation of grounding systems requires knowledge of national and international standards, grounding conductor materials and compositions, and grounding connections and terminations.

Soil resistance is a major aspect in the design and calculation of an earthing system/grounding installation. On its resistance depends on the efficiency of the removal of unwanted currents to zero potential.

SOIL RESISTIVITY

Soil resistivity is a measure of how much the soil resists or conducts electric current. Unit of resistivity is Ωm (ohm meter). Wenner method, Schlumberger array and three pin method are commonly used to measure soil resistivity.

Wenner four pin method is the most commonly used to technique for soil resistivity measurements. It was intended in 1915 by American physicist Frank Wenner.

Schlumberger array is named for conrad Schlumberger, founder the modern day Schlumberger oilfield services. In this method four electrodes are placed in line around a common mid point. The outer electrodes are current electrodes and inner electrodes are potential electrodes.

Three pin method is normally suitable for use in circumstances such as areas of difficult terrain where the usage of previous two methods difficult.

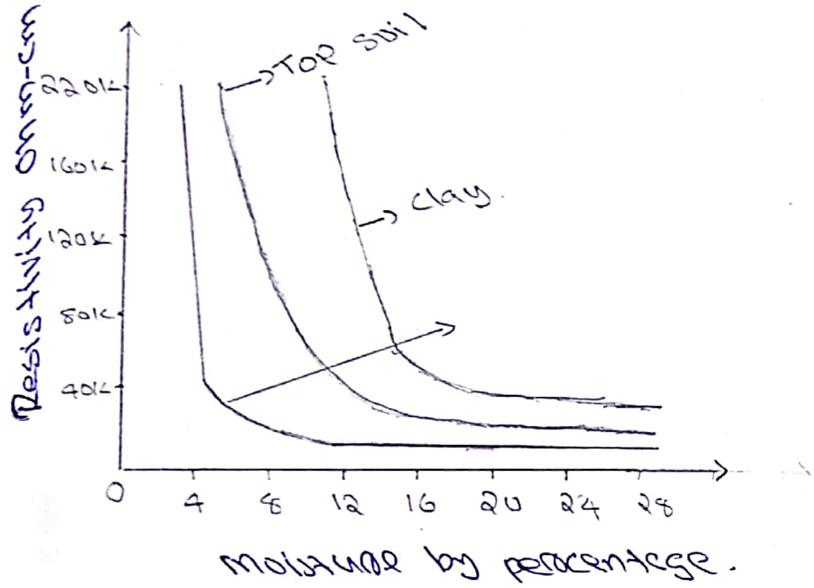
FACTORS AFFECTING SOIL RESISTIVITY

Factors that affect resistivity may be summarised as:-

- Type of earth (eg: clay, loam, sandstone, granite)
- Stratification: layers of different types of soil (eg: loam backfill on a clay base)
- Moisture content: resistivity may fall rapidly as the moisture content is increased.
- Temperature: above freezing point, the effect on earth resistivity is practically negligible.
- Chemical composition and concentration of dissolved salt.
- Presence of metal and concrete, pipes, tanks, large slabs, cable ducts, rail tracks and metal pipes.
- Topography: rugged topography has a similar effect on resistivity measurement as local surface resistivity variation caused by weathering and moisture.

EFFECT OF MOISTURE CONTENT

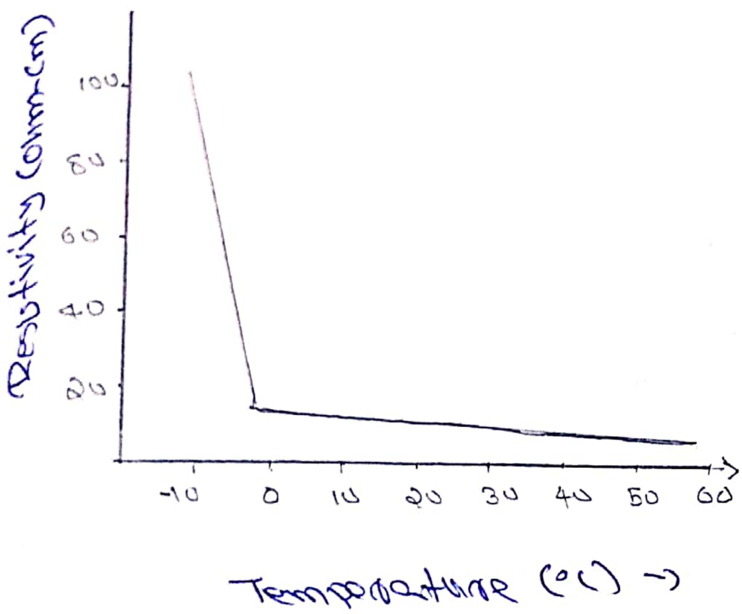
Moisture content is one of the controlling factors in soil resistivity.



According to the figure that above about 20 percent moisture, the resistivity is very little affected while below 20 percent the resistivity increases very abruptly with the decrease in moisture content. A difference of a few percent moisture will therefore make a very marked difference in the effectiveness of earth connection. if the moisture content falls below 20 percent. The value of high moisture content in soil is advantageous in increasing the solubility of existing natural elements in the soil.

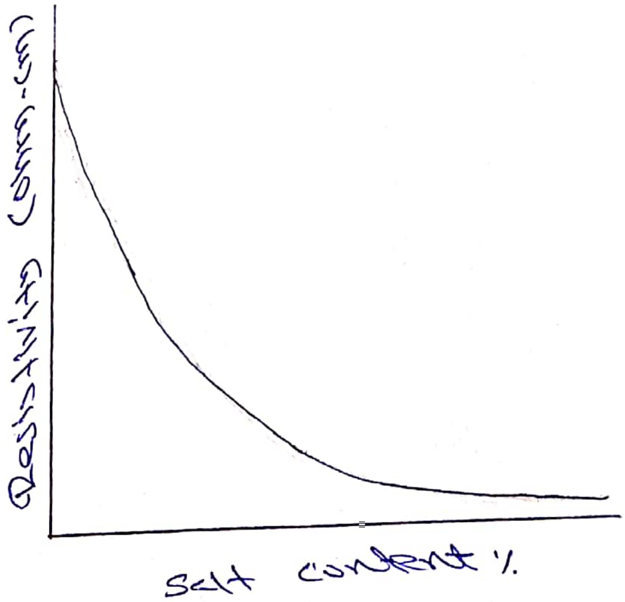
EFFECT OF TEMPERATURE

The temperature coefficient of resistivity for soil is negative. But is negligible for temperature above freezing point. At about 20°c, the resistivity change is about 9 percent per degree celsius. Below 0°c the water in the soil begins to freeze and introduce, a tremendous increase in the temperature coefficient, so that the temperature becomes lower the resistivity rises enormously.



EFFECT OF SALT CONTENT

The mineral content has the most dramatic influence in the soil resistivity. The higher mineral content also reduces soil sensitivity to moisture content. It is therefore, obvious that increasing the mineral content is the first step to considered in soil conditionings. For example, igneous rocks are more resistive than ore minerals. Dissolved salts from compounds like sodium chloride, copper sulfate and sodium carbonate provide the necessary charge to carry current.



CHAPTER 2

STRUCTURE OF EARTH

Core, mantle, and crust are divisions based on composition. the crust makes up less than 1 percent of earth by mass, consisting of oceanic crust and continental crust is often more felsic rock. The mantle is hot and represents about 68 percent of earth's mass. Finally, the core is mostly iron metal. The core makes up about 31 percent of the earth. Lithosphere and asthenosphere are divisions based on mechanical properties. The lithosphere is composed of both the crust and the portion of the upper mantle that behaves as a brittle, rigid solid. The asthenosphere is partially molten upper mantle material that behaves plastically and can flow.

CRUST

Earth's outer surface is its crust, a cold, thin brittle outer shell made of rock. The crust is very thin, relative to the radius of the planel. There are two very different types of crust, each with its own distinctive physical and chemical properties.

Oceanic crust is composed of magma that erupts on the seafloor to create basalt lava flows or cools deeper down to create the intrusive igneous rock gabbro. Sediments, primarily muds and the shell of tiny sea creatures, coat the sea floor. Sediments is thickest near the shore where it comes off the continents in rivers and on wind currents.

Continental crust is made up of many different types of igneous, metamorphic and sedimentary rocks. The average composition is granite, which is much less dense than the mafic igneous rocks of the oceanic crust. Because it is thick and has relative is low density, continental crust rises high on the mantle than oceanic crust, which sinks in to the mantle to form basins. When filled with water these basins form the planet's oceans.

MANTLE

The two most important things about the mantle are:

i) It is made of solid rock

ii) It is hot.

Scientists know that the mantle is made of solid rock based on evidence from seismic waves, heat flow and meteorites. Mantle is extremely hot because of the heat flowing outward from it and because of its physical properties. Heat flows in two different ways within the earth:

- Conduction
- Convection

Conduction is defined as the heat transfer that occurs through rapid collisions of atoms, which can only happen if the material is solid. Heat flows from warmer to cooler places until all are the same temperature. The mantle is hot mostly because of heat conducted from the core.

Convection is the process of a material that can move and flow may develop convection currents. Convection current within earth's mantle form as material near the core heats up. As the core heats the bottom layer of mantle material, particles move more rapidly, decreasing its density and causing it to rise. The rising material begins the convection current. When the warm material reaches the surface, it spreads horizontally. The material cools because it is no longer near the core. It eventually becomes cool and dense enough to sink back down into the mantle. At the bottom of the mantle, the material travels horizontally and is heated by the core. It reaches the location where warm mantle material rises, and the mantle convection cell is complete.

CORE

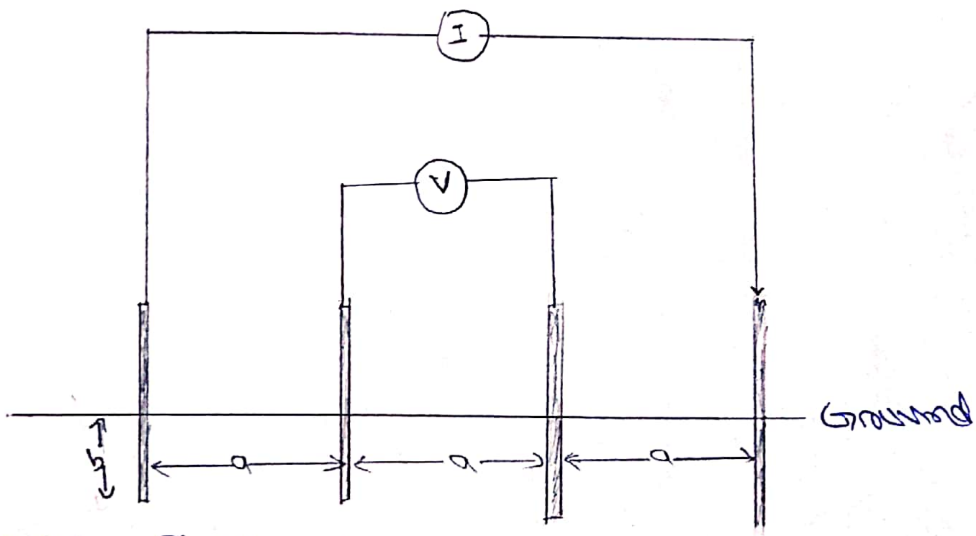
At the planet's center lies a dense metallic core. Scientists know that the core is metal for a few reasons. The density of earth's surface layers is much less than the overall density of the planet, as calculated from the planet's rotation. If the surface layers are less dense than average, then the interior must be denser than the average.

The core is about 85 percent iron metal with nickel ~~metmetel~~ making up much of the remaining 15 percent. Also metallic meteorites are thought to be representative of the core. If earth's core were not metal, the planet would not have the magnetic field. Metals such as iron are magnetic, but rock which makes up the mantle and crust, is not. The strong magnetic field is is caused by convection in the liquid outer core. Convection current in the outer core are due to heat from the even hotter inner core. The heat that keeps the outer core from solidifying is produced by the breakdown of radioactive elements in the inner core.

CHAPTER 3

WENNER METHOD

Wenner four pin method is developed by Dr Frank Wenner in 1915. On this method used four electrodes, two for current injection and two for voltage measurement. The four electrodes embedded to the ground in straight line, the two outer electrodes are current electrode and two inner electrodes to measure voltage drop due to resistence of soil path when current passed between the outer electrodes.



Wenner four pin arrangement as shown in figure above is the most commonly used technique for soil resistivity measurements.

Using the wenner method, the apparent soil resistivity value is:

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2+b^2}} - \frac{a}{\sqrt{a^2+b^2}}}$$

Where

a → electrode spacing (in m)

b → depth of the electrodes (in m)

Resistance measured $R = \frac{V}{I}$

V → Voltage measured and I → injected current

If b is small compared to a, as is the case of probes penetrating the ground only for a short distance (as normally happens) the previous can be reduced to:

$$\boxed{\rho = 2\pi a R.}$$

The depth of electrode shall not exceed the value of $a/20$.

The apparent resistivity is a function of the array geometry, measured voltage (V) and the injected current (I). It should be noted that measurement made in this manner indicate average resistivity over a depth of soil correspond to the spacing b/w the adjacent pin or electrode.

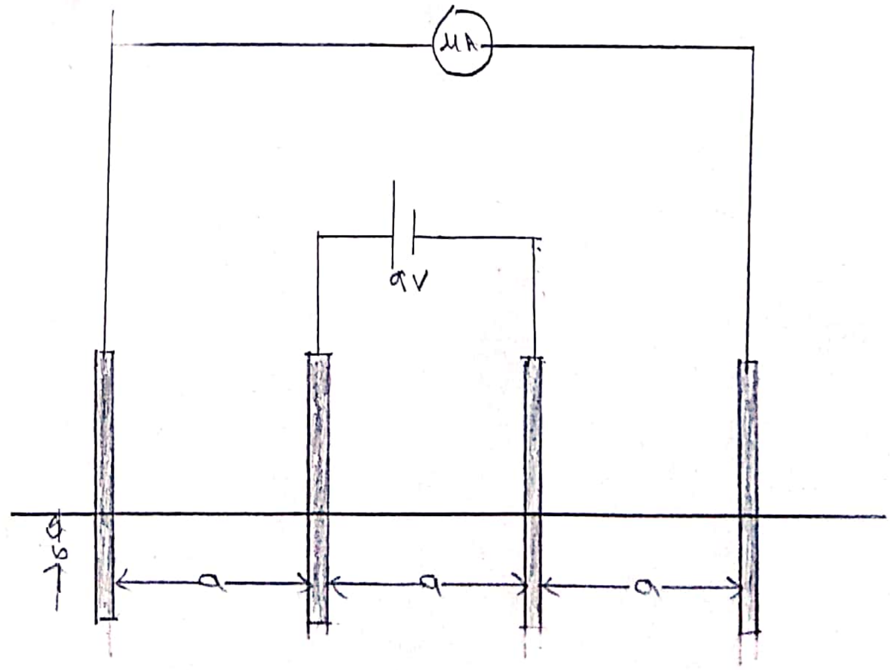
CHAPTER 4

EXPERIMETAL SET UP

Apparatus Required:

- Four electrodes
- Micro ammeter.
- 9V battery.
- Connector
- Connection wires.

Diagram:



PROCEDURE

The following steps can be used to test the soil resistivity in Wenner method.

1) Placed the soil resistivity measure equipment on the center of the assessment location.

2) Put two potential electrodes on the left and right side point of view based on the distance test required. This electrode embedded to the ground, which depends on the electrode spacing.

3) Put two current electrode on the left and right side point of view based on the distance test required. These also embedded to the ground depending on the electrode spacing.

4) Connect all the electrodes with the cables. It is important that all the electrodes are equally spaced and are in a straight line.

5) A 9V battery is connected to the potential electrodes and an ammeter is connected to current electrodes to measure the current.

6) Resistance is found by using the formula $R = \frac{V}{I}$ and the soil resistivity is calculated using the formula $\rho = 2\pi a R$, where 'a' is the electrode spacing.

OBSERVATIONS

To measure the soil resistivity we choose two different places. One is ground which is most dry and the other place is near to a river. Ground has higher resistivity But we observed a smaller resistivity near to river with the same electrode spacing. It means the resistivity of soil decreases with an increasing water content.

If the electrode spacing increases then the depth to which the electrode driven also increases. The resistity measured for a given current probe spacing represents, the apperent resistivity of the soil to a depth correspond to that spacin-g.

Type of soil, moisture content, temperature, chemical composition, presence of metal and concreate pipes, tanks are also influnce the soil resistivity.

There are some difficulties during this experiment. It mainly includes we have to move all four electrodes for each new measurement and requires a lot of walking when the electrode spacing become large. Another problem is the we need a lot of connection wires when the electrode spacing become large. The resistivity of soil varies from one place to another place.

Place	Electrode spacing (a) m	Depth (h) cm	Voltage (V) in Volt	Current (I) A	$R = \frac{V}{I}$ Ω	$\rho = 2\pi a R$ Ωm
Ground	2	10	9	1.5×10^{-6}	6000000	75398223
	1	5	9	10×10^{-6}	900000	5654866
Near to river	2	10	9	2×10^{-6}	4500000	56520000

CHAPTER 5

CONCLUSION

Soil resistivity is how resistive the soil is to the flow of electricity. A measurement of the soil resistivity is conducted before the grounding system is designed. Understanding how the soil resistivity varies with depth is important for the designer, as it can determine if a deep or shallow ground electrode design is desired.

In addition to the type of soil, other factors that can influence soil resistivity are temperature and moisture level. Because of this, change season or weather patterns can have an soil resistivity, and therefore grounding system performance.

The apparent resistivity of dry ground is 1000Ω-m and dry-sand mixture have resistivity 100Ω-m. The observed values at ground is 75398223 and near to river is 56520000 Ω-m with electrode spacing 2m. That means soil resistivity decreases with an increase in water content.

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