International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

STUDY ON EARTH PIT AND ANALYSIS OF EARTH RESISTANCE IN DIFFERENT SOIL FOR EARTH PIT DESIGN

N Prithiviraj[1], N R Charlin[2]
[1]Assistant professor, Dept. of Safety and Fire Engineering Excel Engineering College, Namakkal, Tamilnadu, India
[2]PG-Student, M.E-Industrial Safety Engineering, Dept. of Safety and Fire Engineering Excel Engineering College, Namakkal, Tamilnadu, India

Abstract
This study explores the design of earth pits and the analysis of earth resistance in different soil types. By examining soil properties like resistivity and moisture content, the study highlights how soil composition impacts earth resistance, with clay providing lower resistance and sand offering higher resistance. The results inform optimal earth pit design recommendations, ensuring effective grounding and compliance with electrical safety standards.

Introduction
All industrial and commercial applications require power continuity and electrical safety. Loss of power, equipment damage, and injury to operating employees are just a few of the disastrous results caused by system failures, all of which may be greatly avoided by appropriate electrical system earthing. The earth resistance value must be within a specific range for efficient earthing protection of a system. As a result, earthing system installation must be carried out systematically. To get a low resistance path for the dissipation of electricity into the earth, every electrical equipment, appliance, and the system must be Earthed or grounded. Earthing is essential for the safe and proper operation of any electrical installation in the generation, transmission, and distribution sectors. Leakage current flows through the human body, resulting in death. Every exposed overhead wire, substation, or generator station is at risk of being struck by lightning.
The current affects cardiac muscles, and when they contract too strongly, the muscles get disturbed and flutter, resulting in respiratory arrest, in which the heart stops working. It will be necessary to understand whether the current and potential
system is functioning properly.
(1)Indian Standard Code of Practice for earthling is the code of practice that guides the methods that may be used to earth an electrical system to limit the potential (respect to the general mass of the earth) of current-carrying conductors forming part of the system, such as system earthling and non-current carrying metal work association with equipment, apparatus, and appliances connected to the system (that is, equipment earthling).
(1)Indian Standard Code of Practice for earthling is the code of practice that guides the methods that may be used to earth an electrical system to limit the potential (respect to the general mass of the earth) of current-carrying conductors forming part of the system, such as system earthling and non-current carrying metal work association with equipment, apparatus, and appliances connected to the system (that is, equipment earthling).
(2) IEEE Guide for Safety in AC Substation Grounding provides guidance and information on safe grounding methods in ac substation design. The specific objectives of this guide are to establish the safe limits of potential differences that can exist in a substation under fault conditions between points that can be contacted by the human body as a basis for design, grounding design practices

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

with special reference safety, and develop criteria for a safe design and procedure for the design of effective grounding systems based on these criteria

Importance of Earthing:

- The main objective of grounding is to prevent or reduce the risk of electric shock and fire caused by current flowing through an unwanted path from the earth, as well as to ensure that the potential of a current-carrying conductor does not rise higher than its designed insulation when compared to the globe. When the metallic component of an electrical appliance (parts that conduct or permit the passage of electrical current) comes into contact with a live wire, the metal becomes charged, and static charge develops on it, perhaps as a result of installation or connection insulation failure. When someone comes into contact with such a charged metal, they will receive a powerful shock. To avoid such occurrences, the facility's equipment and appliances must be earthed to transmit the charge to the outside world.
- The earthling is necessary for the following reasons:
- The earthling shields the person from the short out current.
- The earthling gives the simplest way to the progression of short out current even get-togethers disappointment of the protection.
- The earthling shields the mechanical assembly and workforce from the high voltage floods and lightning release
- Earthling can be performed by electrically connecting the installation's various components to a system of electrical conductors or electrodes located at or below ground level. Under the ground level, the earthling mat or electrode has a flat iron riser through which all of the equipment's non-current-carrying metallic elements are connected.
- It concludes that soil resistivity value varying with increasing the depth. the prediction of soil resistivity and ground rod resistance for deep ground electrodes has been developed by comparison of actual values and projected values for four different types of soil conditions for different depths
- The soil resistivity measurement was conducted in 20 different places (dry area) and various depths, the result shows values change accordingly. These values probably reflect differences in lithology and water content in the upper soil layer due to local topography and drainage situation. The purpose of the PVC pipe is to allow water to be poured into the earth mat and electrodes during the dry season to ensure repair
- In electrical installations electrode resistance is the most important aspect used after following the comparison, information on the resistivity of the soil as well as the size and layout of electrodes on their resistance is provided. The electrode resistance depends on the type of soil in which it is buried
- To measure accurate theoretical estimations of earth resistance measurements electrodes are installed at various soil conditions and different environments. The results show that the impacts of soil compactness, which may alter the electrode's and surrounding soil's contact resistance. Vegetation soil has a high moisture content which reduces the resistivity of soil, So moisture contents of soil tend to affect the soil resistivity.
- For locations with high resistive soil, distributed earthing systems treated with backfill materials are ideal. Clay-based backfill materials, such as bentonite-mix, shield electrodes from corrosion and erosion in strongly acidic, alkaline, saline, and sulfur-rich environments while also reducing earth resistance. When soil is very acidic, it contains a lot of hydrogen (H +) ions, which can accelerate the corrosion of steel electrodes

Equations

$$Earth\ Resistance = \frac{Potential\ earth\ electrode}{\text{Current}}$$

$$Earth\ Resistance = \frac{V}{\text{I}}$$

Large Power Station – 0.5 ohms

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

Major Power Station – 1.0 ohms
Small Substation – 2.0 ohms
In all other situations – 8.0 ohms Some Common Mistakes

- Earthling only performs its purpose if its resistance is within a limited range of values, and this value is typically maintained constant as possible to make the current flow easier during abnormalities
- Consider earthling, which is meant to safeguard those who work with electrical equipment
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).

2 Electrical System With Earthing

Earthling is the term for the contacting assembly. Electrical connections are the metallic wires that connect the components of the installation to the earthling. The earthling system is made up of the earthling and the earthling connection.

Authors and Affiliations

1)Basic requirements of Earthing

a)To protect a person's life as well as electrical devices and appliances from stray currents.

b)To maintain a constant voltage inside the healthy section (If the fault happens in any phase).

C)To keep the electrical system and structures safe from the effects of lighting.

Identify the Headings

The earth resistance, also known as resistance to earth, is the resistance provided by the earth electrode to the transfer of electricity into the ground. The resistance between the electrode and the point of zero potential is referred to as earth resistance. It is equal to the ratio of the earth electrode's potential to the current dissipated by it in terms of numbers. The potential fall technique is used to determine the resistance between the earthling plate and the ground. The resistance of the earthling electrode is distributed throughout the soil around it, rather than being concentrated at one spot.

The earth resistance is calculated as the ratio of the voltage to the current, as illustrated below.

Figures and Tables

The earth pit resistivity was measured at 2 m to 10 m at the location. Area resistivity value shows that a variation in each rod, but values are not having more deviations. Locations it is composed of is very dry rocky soil and also the irregular surface of the soil may be the reason for variations of the earth resistivity.

Day	**Resistivity of Earth pits in ohm**					**Average**
	R1	R2	R3	R4	R5	
1	3.8	3.8	3.5	3.4	3.4	3.5
2	3.7	3.6	3.3	3.5	3.5	.352
3	3.8	3.7	3.4	3.6	3.7	3.64
4	3.3	3.2	3.4	3.4	3.5	3.36
5	3.4	3.3	3.2	3.5	3.6	3.4
6	3.7	3.7	3.5	3.5	3.6	3.6

7	3.8	3.6	3.6	3.6	3.5	3.62

Table 6- 1 Area 1 Earth Resistance value

In Area 2 Earth pits are designed in the vegetation or crops' area weekly twice the water poured by using the water sprinkler, so moisture content value is high in this area. So earth resistance value is less in this area compared with area. The crops hold the water content and increase the moisture of the soil.

Research Methodology

The most essential element impacting an electrode's resistivity is the soil's resistivity. It can range from a few hundred ohms per cm cube to 106 ohms per cm cube, excluding mineral deposits, also most soil falls between 500 and 50 000 ohms per cm cube.

The validity of the results was confirmed after that calculations by measuring the earth resistance of earth electrodes at various places[6]. The chosen places are,

a) Small buildings with un irregular soil surface

b) Near buildings areas with vegetation

c) Land plots in the agriculture area

d) The earth pit resistivity was measured at 2 m to 10 m at the location. Area resistivity value shows that a variation in each rod, but values are not having more deviations. Locations it is composed of is very dry rocky soil and also the irregular surface of the soil may be the reason for variations of the earth resistivity.

e) The Waco Digital Earth Tester, it used three terminal type. For E1 and P1 are to be shorted and connected to the earth connection to check the resistance.

f) In Area 2 Earth pits are designed in the vegetation or crops' area weekly twice the water poured by using the water sprinkler, so moisture content value is high in this area. So earth resistance value is less in this area compared with area. The crops hold the water content and increase the moisture of the soil.

Soil is analysed to know its composition, to classify the properties of soil. A complete soil, of course, cannot be moved into a laboratory. The value of the laboratory work depends upon precision in sampling. Each soil sample needs to be a fair representative of the specific area or horizon. For soil survey work, samples are collected from a profile typical of the soil in the surrounding area.

By using the core sampler equipment soils were collected from the different locations. Fig 6.9 shows the collection of soil samples procedure.

g) After collecting the soil sample, the physical and chemical properties of soil are measured in the laboratory by using equipment and apparatus with some chemicals. Soil contents are different in each location.

h) Weight of emptymoisturebottle = 36.18g

Weightof the moisturebottle +moist soil sample = 150 g

Weightof the moisturebottle +soilsampleafterdryingin theoven = 148.51g

Weightof moistureinthesoil = (b– c)g

Percentageof moisturein the soil sampleon oven drybasis = (b-c) / (b-a) * 100

= 150 – 148.51/ (194.7-29.78)
= 0.01326
= 1.326 %

i) For soil, the temperature coefficient of resistivity is negative, but it is negligible above the freezing point. The resistivity changes by around 9% per degree Celsius at around 20°C. When the temperature drops below 0°C, the water in the soil freezes, causing a massive increase in the temperature coefficient, such that as the temperature drops, the resistivity increases dramatically.

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

j) end amounts, are the most often used compounds.

k) The pH is defined as the negative logarithm of hydrogen ion concentration or simply the log of the reciprocal of the hydrogen ion concentration (Sorensen, 1906).

l) The principle of this method is A glass electrode in contact with H ions of the solution acquires an electric potential which depends on the concentration of H ions. This is measured potentiometrically against some reference electrode which is usually a calomel electrode. The potential difference between glass electrode and calomel electrode is expressed in pH units.

Determination of pH

Procedure:

- Weigh 20 g of air dry soil passed through 2 mm sieve and transfer to a clean 100 ml beaker
- Add 50 ml of distilled water (1: 2.5 ratio)
- Using glass rod, stir the content and allow it to stand for half an hour.
- Wash the electrodes carefully with a jet of distilled water and wipe it dry with a piece of filter paper.
- Calibrate the pH meter using buffer solution.
- Stir the soil suspension again just before taking the reading.
- Immerse the electrodes into the beaker containing soil water suspension and change the function switch to the particular pH range.

m) Multiple rods, even in large numbers, may sometimes fail to achieve a sufficiently low earth resistance. This problem occurs in installations with high-resistivity soils. Reduce the resistivity of the soil directly surrounding the earth electrode as an alternative. To lower soil resistivity, a chemical that is highly conductive in its water solution must be dissolved in the moisture normally present in the soil.

n) Sodium chloride (NaCl), also known as common salt, calcium chloride (CaCl2), sodium carbonate (Na2CO3), copper sulphate (CuSO4), salt, and soft coke, as well as salt and charcoal in suffici

o) The electrical conductivity (EC) measurement gives the total amount of soluble salts present in the soil and is expressed as milliohms cm-1 or dSm-1.

p) Soil composition, moisture content, pore-water chemistry, the presence of organic components, and, most important, soil pH all affect electrical resistivity. [7]

q) In earthing system design, a knowledge of the soil's pH, as well as a measure of the soil's acidity or alkalinity, is required in addition to the soil's resistivity.

r) pH of a soil indicates whether it is acidic or alkaline. Experiments demonstrate that excessively high alkalinity reduces soil resistivity and increases soil corrosivity, whereas mild alkalinity resists corrosion for a longer period of time

s) The study conclude that in sub soil above 6.5 pH value is slightly acidic in nature and top soil pH value above 6.8 is neutral. Knowledge of the values of resistivity, acidity, and alkalinity will not only aid in the design of the test site's grounding system, but will also ensure that the earthing rods buried in the appropriate area/location revealed by this paper will perform their protective functions on the various buildings for a very long time without corroding.

Soil moisture is estimated both by direct and indirect methods. In direct methods soil moisture is estimated thermo-gravimetrically either through oven drying or volumetric method and it is estimated through the properties of water in the soil. These methods of measuring soil moisture are divided in to many branches:

Gravity method:

Place a clean and empty moisture bottle with lid separately in an electric oven at 1050C for 15 minutes. Replace the stopper or lid, remove the moisture bottle, cool in a desiccator, weigh accurately and record the weight. Fill the moisture bottle to about two third of its capacity with soil sample. Close with stopper / lid and weigh quickly. Remove the stopper / lid and keep it in the oven at 1050C for about 8 hours. After the expiry of time, remove the moisture bottle, cool it in a

DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

desiccator and weigh quickly. Calculate the loss in weight and express the moisture content on oven dry basis.

The most essential element impacting an electrode's resistivity is the soil's resistivity. It can range from a few hundred ohms per cm cube to 106 ohms per cm cube, excluding mineral deposits, also most soil falls between 500 and 50 000 ohms per cm cube.

The conductivity of any soil depends on the following factors:

- Soil Type
- Chemical composition of salts dissolved in the contained water.
- Concentration of salts dissolved in the contained water.
- Moisture content.
- Temperature.
- Grain size of the material and distribution of grain size.
- Closeness of packing, and pressure.

Two of these parameters, particularly soil moisture content and temperature, change with the seasons, resulting in a periodic shift in electrode resistance. Changes in temperature above the freezing point are low, but moisture changes potentially change a good earth connection into a useless during a lengthy dry period. Regular resistance measurements and, if necessary, water supply of adding salt must be considered to prevent such an occurrence.

The soil resistivity profile of the selected site has been measured by Waco Digital Earth Resistance Tester. To get accurate value measurement were repetitively checked. To determine the effect of electrode-soil contact resistance, for selected 5 number of electrodes the measurements were repeated on daily basis for a period of one week.
Soil moisture is estimated both by direct and indirect methods. In direct methods soil moisture is estimated thermo-gravimetrically either through oven drying or volumetric method and it is estimated through the properties of water in the soil. These methods of measuring soil moisture are divided in to many branches:

Gravity method:
Place a clean and empty moisture bottle with lid separately in an electric oven at 1050C for 15 minutes. Replace the stopper or lid, remove the moisture bottle, cool in a desiccator, weigh accurately and record the weight. Fill the moisture bottle to about two third of its capacity with soil sample. Close with stopper / lid and weigh quickly. Remove the stopper / lid and keep it in the oven at 1050C for about 8 hours. After the expiry of time, remove the moisture bottle, cool it in a desiccator and weigh quickly. Calculate the loss in weight and express the moisture content on oven dry basis.
water is relatively pure, it will have a high resistance, and unless the soil includes enough natural elements to produce a conducting electrolyte, the abundance of water will not supply sufficient conductivity to the soil.
High moisture content in soils is beneficial for increasing the solubility of natural materials already present in the soil and for ensuring the solubility of ingredients that may be artificially introduced to improve soil conductivity

CONCLUSION
This analyses states that earth pit resistivity is affected by conductivity or contents like type of the soil, chemical and physical properties of the soil, moisture content, temperature and grain size and also the soil resistivity various with the depth as well as area. It is show that the soil resistivity at a location has some vulnerability to the environmental factors. Soil resistivity short tress with

DOI:10.46647/ijetms.2025.v09i02.037 ISSN: 2581-4621

vegetation area and agriculture site may have low soil resistivity with compared to the dry area and irregular surface area effects the resistance value.

The following points are maybe helpful for engineers to obtain good earth configurations for efficient grounding of the power system in sites.

- Before installing the earth pit, analysing the soil resistivity and environment are the crucial part.
- Measuring the chemical and physical properties may help to obtain the soil resistivity of the soil. It will help to select the earth pit configurations and design of grounding system.
- Periodical maintenance should be done maintaining the earth resistance.

This analysis shows that grounding system performance may be predicted. Predictability reduce the guessing ground system performance.

References

1. IEEE Guide for Industrial and Commercial Power Systems. IEEE Std 142 – 2007 (Revision of IEEE Std 142-1991)
2. IEEE Guide for Safety in AC Substation Grounding. IEEE Stand. 80-2013.
3. Chandima Gomes., Mohd Zainal Abidin Ab Kadir., Lee Weng Choun., Siow Chun Lim. " Environmental Effects on the Performance of Electrical Grounding Systems", 2013 IEEE 7th International Power Engineering and Optimization Conference, pp.330 - 333.
4. Ms.Kalyani Pole., Dr.A.K.Sharma. "Analysis On the Factors Affecting Resistance of the Earth Electrode", Vol. 2 Issue 5, May – 2013, 1304 – 1307.
5. Lee Weng Choun., Chandima Gomes., Zainal Kadir., Wan Fatinhamamah Wan Ahmad. "Analysis of earth resistance of electrodes and soil resistivity at different environments", 2012 International Conference on Lightning Protection (ICLP), Vienna, Austria.
6. Yexu Li., Jinxi Ma., Farid Paul Dawalibi. "Power Grounding Safety: Copper Grounding Systems vs. Steel Grounding Systems", 2006 International Conference on Power System Technology.
7. Omar Faruk Murad. "Obtaining Chemical Properties through Soil Electrical Resistivity", Journal of Civil Engineering Research 2012, 2(6): pp.120-128.
8. Oyubu A.O. "Soil Resistivity and Soil PH Profile Investigation: A Case Study of Delta State University Faculty of Engineering Complex", International Journal of Scientific & Engineering Research, Volume 6, Issue 10, October-2015: pp.583 – 588.
9. Md. Abdus Salam., QuaziMehbubar Rahman., Swee Peng Ang., Fushuan Wen. "Soil resistivity and ground resistance for dry and wet soil", October-2015.
10. Abdulrehman Ali Al-Arainy., Nazar Hussain Malik., Muhammad Iqbal Qureshi., Yasink Khan. "Grounding Pit Optimization Using Low Resistivity Materials for Applications in High Resistivity Soils", Volume 12, pp.1 - 18, Issue