International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Impact Factor (2018): 5.426

Earthing System Design for Electrical Installations of Building Construction and Laboratory Equipments

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Abstract: ***This paper presents the design of earthing system for electrical installations for domestic, commercial and laboratories, etc. and calculation of its technical parameters. Successful operation of entire building power system depends on efficient and satisfactory performance of well-designed earthing system. Lack of safe and effective earthing system can result in non-operation of control and protective devices. (Earthing/ Proper grounding) of system design deserves considerable attention for all the building power system. Earthing system has to be safe as it is directly concerned with safety of persons living in building and working within the building power system. Main concern of this work is designing safe and cost effective earthing system for building power system situated at such locations where soil of the site is non-uniform. Initially significance of earthing is explained & methodology for design of building power system earthing system. Earthing is very important to achieve instruments and personnel protection. Operation of any electrical and electronics instrument or appliances directly affected by value of earthing. Standard formulas are used in design of earthing system to get required values such as touch and step voltage criteria for safety, earth resistance, minimum conductor size and electrode size and resistivity of soil.***

Keywords: Earthing, Earth Electrodes, Ground Mess, Building Power System Earthing, Safety

1.Introduction

The earth is the most omnipresent conductive surface, and so it was adopted in the very beginnings of electrical distribution systems as a nearly universal standard for all electric systems. The main reason for doing earthing in electrical network is for the safety. When all metallic parts in electrical equipment are grounded then if the insulation inside the equipment fails there are no dangerous voltages present in the equipment case. If the live wire touches the grounded case then the circuit is effectively shorted and fuse will immediately blow. When the fuse is blown then the dangerous voltages are away. Earthing and Grounding are actually different terms for expressing the same concept. Ground or earth in a mains electrical wiring system is a conductor that provides a low impedance path to the earth to prevent hazardous voltages from appearing on equipment. Earthing is more commonly used in Britain, European and most of the commonwealth countries standards (IEC, IS), while Grounding is the word used in North American standards (NEC, IEEE, ANSI, UL) [1, 10, 11].

We can also describe as “Earthing means connecting the dead part (it means the part which does not carries current under normal condition) to the earth for example electrical equipment’s frames, enclosures, supports, etc. The purpose of earthing is to minimize the risk of receiving an electric shock if touching metal parts when a fault is present. Generally green wire is used for this as a nomenclature. Under fault conditions the non-current carrying metal parts of an electrical installation such as frames, enclosures, supports, fencing, etc. may attain high potential with respect to ground so that any person or stray animal touching these or approaching these/ comes in contact will be subjected to potential difference which may result in the flow of a current through the body of the person or the animal of such a value as may prove fatal. To avoid this non-current carrying metal parts of the electrical system are connected to the general mass of earth by means of an earthing system comprising of earth conductors to conduct the fault currents safely to the ground. Earthing is to ensure safety or Protection of electrical equipment and Human by discharging the electrical energy to the earth [1, 9, 10, 11].

2.Purpose

2.1 Safety for Human life / Building /Equipment

- To save human life from danger of electrical shock or death by blowing a fuse i.e. to provide an alternative path for the fault current to flow so that it will not endanger the user.
- To protect buildings, machinery & appliances under fault conditions.
- To ensure that all exposed conductive parts do not reach a dangerous potential.
- To provide safe path to dissipate lightning and short circuit currents.
- To provide stable platform for operation of sensitive electronic equipment i.e. To maintain the voltage at any part of an electrical system at a known value so as to prevent over current or excessive voltage on the appliances or equipment[1, 6, 7].

2.2 Over voltage protection

Lightning, line surges or unintentional contact with higher voltage lines can cause dangerously high voltages to the electrical distribution system. Earthing provides an alternative path around the electrical system to minimize damages in the system [1, 6, 7].

2.3 Voltage stabilization

There are many sources of electricity. Every transformer can be considered a separate source. If there were not a common reference point for all these voltage sources it would be extremely difficult to calculate their relationships to each other [1, 6, 7].

3.Types of Earthing System

3.1 TN-S

In this type of earthing, after building distribution point, protective earth (PE) and Neutral (N) conductors from transformers to consuming device not connected together at any place [4, 5, 9, 10].

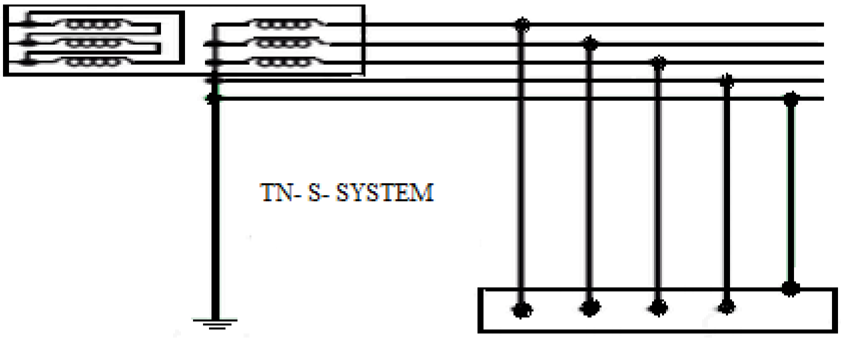

Fig. 1: TN-S earthing system [4, 5]

3.2 TN-C: Protective earth (PE) and Neutral (N) conductor combined in all the way from the transformer to the consuming device. [4][5][9][10]

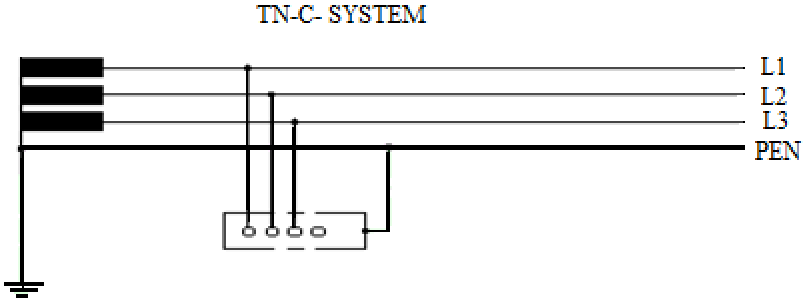

Fig. 2: TN-Cearthing system [4, 5]

3.3 TNC-S: Combined PEN conductor from transformer to building distribution point, but separate PE and N conductors in fixed indoor wiring and flexible power cords. [4][5][9][10]

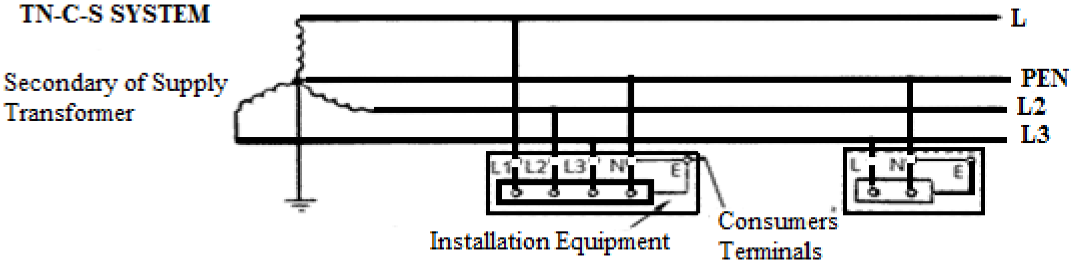

Fig. 3: TN-C-Searthing system [6]

4.Methods of Earthing

Earthing can be done in three ways for the house wiring or laboratory and other connected electrical equipment and machineries. Details of them are described below:

4.1 Plate Earthing

In the system of plate earthing, a plate made up of either GI with dimension 60mmX60mmX6mm thick or copper earth plate with dimension 60mmX60mmX3mm thick is buried in the earth pit including accessories, and providing masonry enclosure with cover plate having locking arrangement and watering pipe of 2.7 meter long etc. with charcoal/ coke and salt as required.[12]

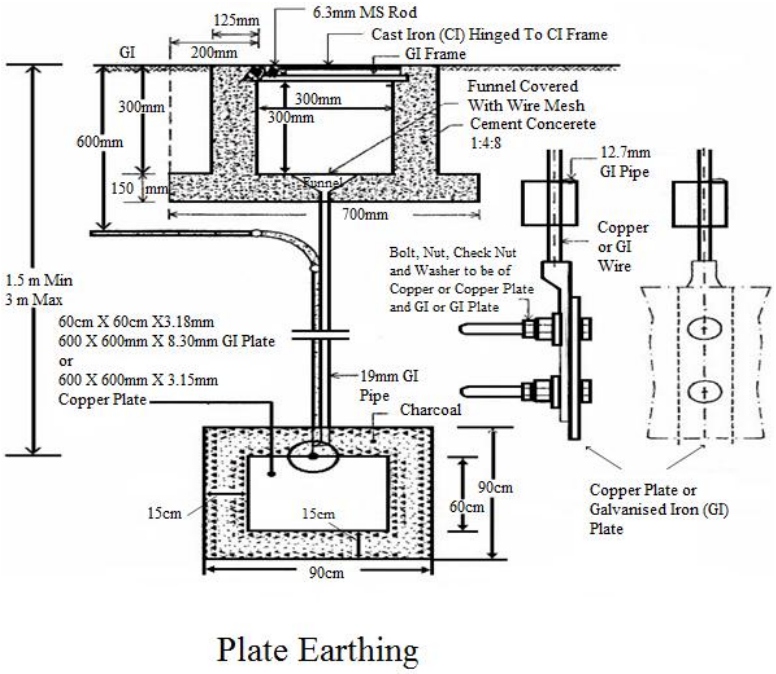

Fig. 4: Plate earthing

4.2 Pipe Earthing

In the system of pipe earthing, G.I. pipe of length 4.5 metre, 40 mm dia should be used including accessories, and providing masonry enclosure with cover plate having locking arrangement and watering pipe etc. with charcoal/coke and salt as required. [12]

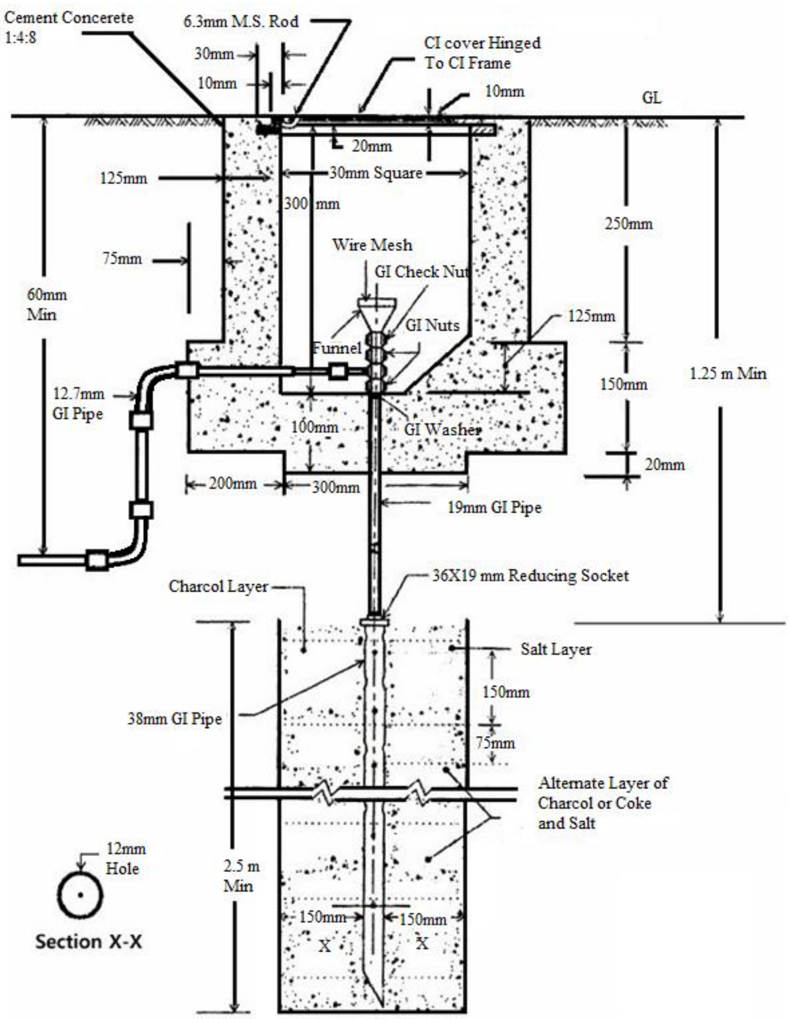

Fig. 5: Pipe earthing

4.3 Rod Earthing

It is more similar as pipe earthing, in this type of earthing a copper rod of 12.5 mm diameter or GI rod of 16 mm dia. of length 2.5 m are buried upright in the earth manually or with the help of pneumatic hammer. [3][10]

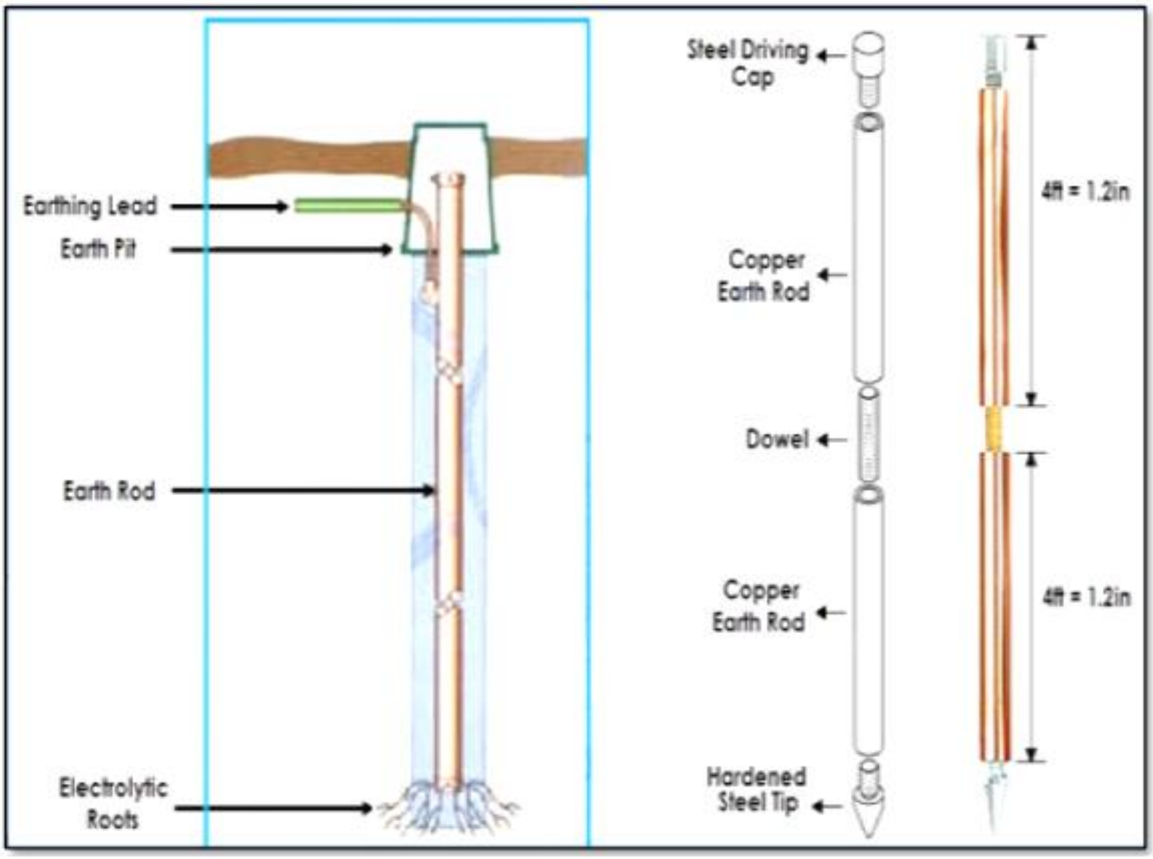

Fig. 6: Copper rod electrode earthing system

5.Factors Affecting the Resistance of Earthing System

Quality of soil varies according to change of location. The wet soil has low resistance in comparison of dry soil. The main factor that affects the resistivity listed here:

1) Type of Earth (i.e. clay, cinder, ashes, shale, sand, stone, loam)
2) Layers of different types of soil
3) Content of moisture in soil
4) Temperature of soil
5) Presence of metal and other materials in soil [11]

6.Method for Measuring Earth Resistance

Soil resistivity is the resistance between the two opposite faces of cube of soil having soides of length one meter and it expressed in Ohm-meters. If the resistivity of the soil is less then numbers of electrodes are required less. Resistance to the earth of any earth electrode is directly affected by resistivity of surrounding soil.

The most commonly used method of measuring the earth resistance of an earth electrode is the Fall-of-Potential measuring technique. Earth resistance (Rg) of a single spike, of diameter (d) and driven length (L) driven vertically in to the soil of resistivity (ρ), can be calculated by this formula:

$$Rg=\rho/2\pi L\ [\ln(8L/d-1)]$$

ρ is the soil resistivity in the Ohm-Metre
L is the buried length of electrode in Metre
d is the diameter of the electrode in Metre [13]

6.1 Fall of Potential Technique

Fall-of-Potential Measurement Technique is easiest technique of earth resistance. This test method is used to measure an earth ground system or an individual electrode to dissipate energy from a site.

In this method three points of ground contact are used in which first is earth electrode under test (COM), second is current probe (C) which is placed at some distance from the ground system under test and last third is voltage probe (P) that is inserted at various distance between the system under test and the current probe. The Megger metre is used to create current in tower footing earth electrode under test. Then current flows by the earth to the remote current probe (C) and return back to the metre. When current flows through resistance (earth) a voltage drop created. This voltage drop is directly proportional to the amount of the current flow and the resistance of the earth electrode to the earth. The voltage probe (P) is used to measure this voltage drop and the metre display the amount of current flow and the resulting voltage drop. During the measurement, the position of the current probe (C) is moved far enough away from the earth electrode under test so that the voltage probe (P) can lie outside the effective resistance areas of both the earth electrode.

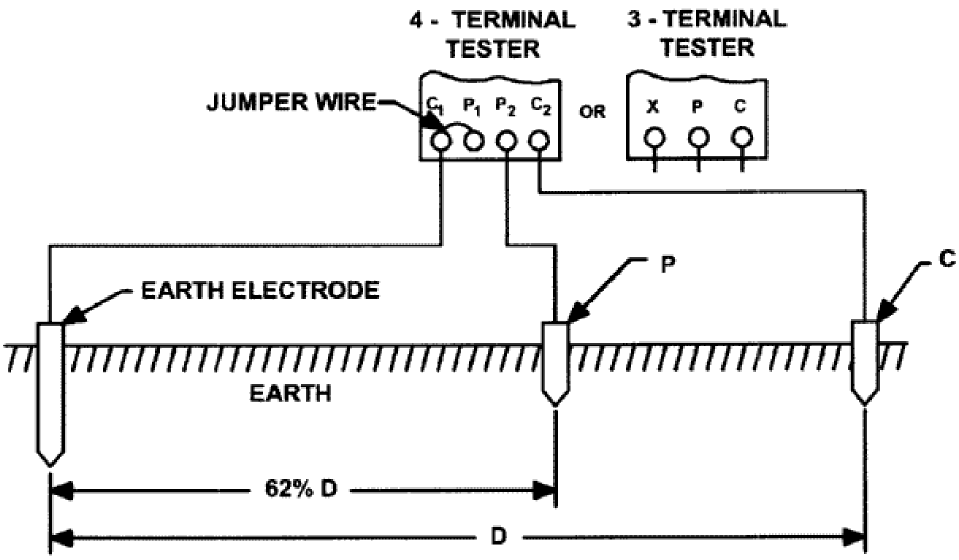

Fig. 7: Fall potential techniques

7.Conclusion

A well-designed earthing system is a necessity to protect a person, reduction of electromagnetic disturbance and overall network of supply system. So, for enforcement of safety measures, the faults in any supply system are unavoidable. So, each electrical equipment's, system must be earthed to obtain a lower resistance path for dissipation of fault current in to the earth. It is also clear that value of earth resistance is directly related to soil property and eathing electrode.

By using good conducting property earthing electrode and good soil preparation can reduce the value of earth resistance.

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