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Biological Earthing for Domestic Installations

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Abstract – Electrification of domestic buildings are well planned considering the consumers requirements and the budget. Any electrical installation either small or multistoried, will be provided with earthing installation to protect men and machines. Earthing installations need routine inspections, maintenance of the earth points; however it is not truly done in a proper channel. Normally, earthing of installation involves the process of digging, installing earth electrode, pouring of alternate layers of salt and charcoal, finally connecting the installations with earth continuity conductor, for regular watering brick chambers with funnel shaped plumbing accessories are built. In this paper we wish to present an idea which directly forces us to maintain the earth pit, as it is yielding a byproduct along with the safety of the electrical installation. This also motivates to green the environment, soil multiplication, works even in hard soil, and circulates the water in the soil mass to reduce the earth resistance.

Index Terms — Biological, Domestic, Byproduct, Earthing, Earthworm, Environment, Waste, Organic, Bentonite, Earth Resistance.

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I. INTRODUCTION

Effective Grounding system is very important as it deals with personnel safety and protection of household electrical equipment's. Earth Fault gives rise to a potential gradient within the end-user installation. This voltage gradient should not exceed the tolerable human body limit. This is the reason why every electrical installation is provided with an efficient earthing system. Traditional domestic earthing system involving pipe or plate earthing is very common, but reconditioning of the earthing system is of less careful step. In this paper we focus our attention towards the careful earthing system that yields a byproduct, i.e. a compost, which is rich with nutritional values to green the environment at or around the house, at the expense of organic waste from the household.

Most of the municipal and industrial waste is disposed in lands. Due to the increasing volume of waste, land disposal becomes increasingly expensive, and therefore, efforts at minimizing the waste stream are essential. Organic waste can be recycled by composting. Studies at waste management sites have indicated that about 50 to 75% (by weight) of wastes generated by urban communities operations are of organic and potentially biodegradable in nature. House hold organic waste can be converted into compost. The composted end-products are applied to soil to improve its nutritional characteristic of household garden, while compost has beneficial aspects, such as providing nutrients to plants, increasing soil organic carbon content, and contaminant retention in the garden. Green environment is a green environment, which keeps physical and mental health fit.

II. METHODOLOGY

Earth resistance may be defined as the resistance between actual earth and the earthed body of the installation or equipment body. In other words it is the resistance of the path connecting the body of the installation to the actual earth. This resistance should be low enough to carry sufficient current to the earth to ensure proper operation of protective relays, miniature circuit breakers or blowing of fuses associated to the installation. The earth path consists of the earth continuity conductor, soil in between the end of the earth continuity conductor inside the ground and actual general mass of the earth. As the resistivity of soil depends upon its moisture content, it varies time to time throughout the year. As a result earth resistance of an installation is not constant throughout the year, it varies with weather conditions. Earth resistance of an installation is minimum in rainy season whereas it is maximum in dry season. There

are some standards of maximum permissible earth resistance.

Table 1. Max. Permissible earth resistance

S. No.	Type of Installation	Maximum permissible earth resistance
1.	Large Power station	0.5 Ω
2.	Major Power station	1.0 Ω
3.	Small Substations	2.0 Ω
4.	All other cases	5.0 Ω

It should be noted that, the resistance between any point on the earthed body and the earth pit should be less than 1 Ω. Based on these criteria many methods of earthing are in practice. some of them are as below.

A. Strip or wire earthing

B. Rod earthing

C. Pipe earthing

D. Plate earthing

E. Bentonite/ Kaeolite/ Marconite earthing

F. Biological earthing (Proposed method)

Let us glance these methods one by one.

A. Strip or wire earthing: In this method of earthing, a copper strip of minimum cross-section 25mm × 1.6mm is buried horizontally inside the ground at minimum depth 0.5m. Considering the cost of the copper for economy GI strip may be used with minimum of cross-section 25mm × 4mm which is also buried horizontally at a same depth inside the ground. For this purpose a round conductor (wire) may be also be used and in this case the minimum permissible cross-sectional area for copper conductor would be 3 mm^2 and for galvanised iron conductor it would be 6 mm^2. The buried portion of the electrode that is either strip or wire should be long enough to provide required minimum resistance to the earth path. Generally, the length of the conductor inside the ground is maintained more than 10 to15 m. The buried conductor should be widely distributed considering the land availability, either in a straight trenches or loop. This type of earthing is mainly used in rocky area where excavation work is quite cost consuming.

B. Rod earthing: In this type, a metallic rod of sufficient length is driven vertically into the ground normally by hammering on the top. A Galvanized iron rod of 16mm diameter or hollow GI (Galvanized Iron) pipe of 25mm diameter of minimum length 1.5- 2.5m are used for this purpose. The electrical installation which to be earthed, is connected to the top of the earth rod or pipe by means of copper or aluminium earth continuity conductor of suitable cross-section. The rod earthing system is preferred where the soil is of sandy in nature or for temporary earthing purposes. This is the cheapest, easiest and fastest method of earthing as excavation work is eliminated.

C. PIPE EARTHING: Pipe earthing system is most commonly used and reliable system. In this method, a galvanized steel pipe of suitable length and diameter is buried vertically in the permanent wet soil under the ground. The length and diameter of the pipe are pre determined by the conditions of soil and the current to be carried. Normally a minimum diameter and length of the pipe that is maintained is 40 mm and 2.5m - 3.0m respectively for ordinary condition of soil and greater length is used for rocky and dry soil conditions. The depth under ground level at which the pipe is buried, depends upon the moisture condition of soil but it should not be less than 3.0 m under the ground. The earthing pipe is surrounded by alternative layers of charcoal and salt to keep moisture which reduces the earth resistance. Another galvanised iron pipe of lesser diameter (19mm) is fitted vertically on the top of the earthing pipe by means of reducing socket. The top of this pipe is projected in a cement concrete chamber on the ground. One or more GI plates are welded on this pipe by keeping the pipe openings clear to facilitate the connections of earth continuity conductors from different electrical installations. The cement concrete work is done to keep the water arrangement accessible and in dry season to keep the earth resistance minimum, 3 to 4 buckets of water are put in the concrete chamber or through the funnel if it is fitted to the top of the 19mm diameter pipe.

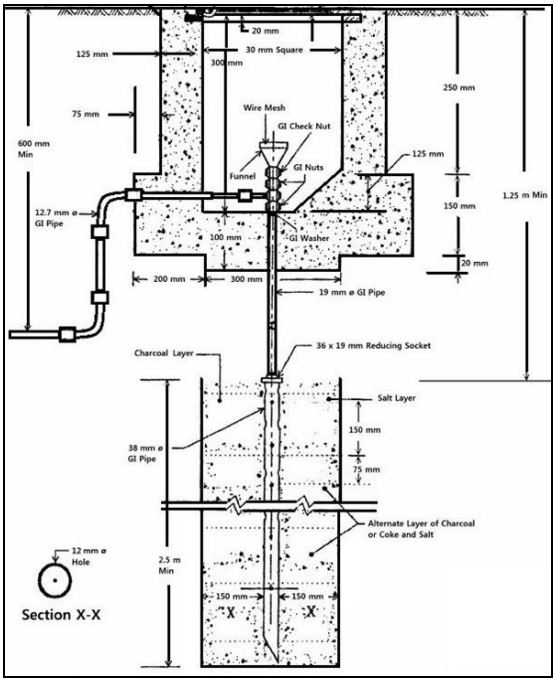

Fig.1. Pipe Earthing System

D. Plate earthing: In this method a metallic plate of sufficient size is buried in wet soil vertically under the ground. If copper plate is used for this purpose the minimum dimensions of the plates should be 600mm × 600mm × 3.14 mm and if it is GI plate, then minimum dimension should be 60 cm × 60 cm × 6.27 mm. In case of copper plate, a copper earth continuity conductor is connected to the plate with the help of copper nuts bolts and washers whereas in the case of GI plate, GI earth continuity conductor is connected to the plate with the help of GI nut bolts and washers. This earthing plate is connected along with earth continuity conductor and is buried vertically at minimum 1.5m and maximum of 3.0 m depth under the ground. The surroundings of the plate are filled with alternative layers of charcoal and salt of minimum 15 cm thickness of each layer. Rest of the things are as shown in the fig.

Pipe and plate earthing systems are used as permanent type earthing systems for bulk consumers having heavy loads. Generally two or more earthing installations are connected in parallel to reduce the earth resistance. System earthing and equipment earthing are usually done separately.

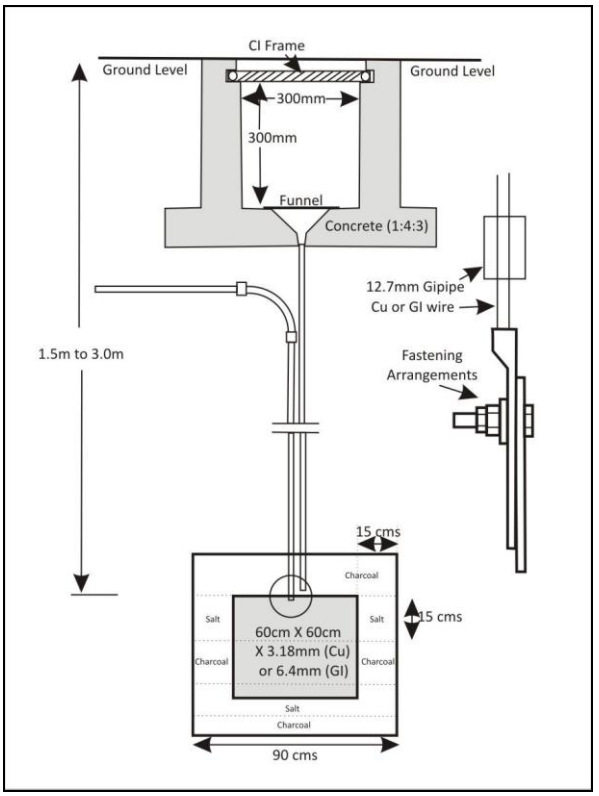

Fig.2. Plate earthing system

E. Bentonite/ Kaeolite/Marconite earthing: Bentonite and Kaeolite are the moisture retaining clays used as a back-fill purpose to an earth electrode to lower soil resistivity. The Bentonite clay is of sodium activated compound, which shows much increase in its volume, when mixed with water. It is available in granular or powder form, while the granular form is preferred as it is easier to handle. Marconite is a granulated electrically conductive aggregate which is used to replace the sand in the process of concreting, thereby producing an electrically conductive concrete. Electrodes (GI or copper earth rods) can be encased in Marconite mixture to greatly increase their surface area, lowering the resistance to earth.

Marconite benefits include low resistivity, conduction of current is electronic (not ionic), permanent and stable, which results in increased contact surface area. Marconite has been approved and used by the various departments such as electrical utilities, rail systems and water supply companies.

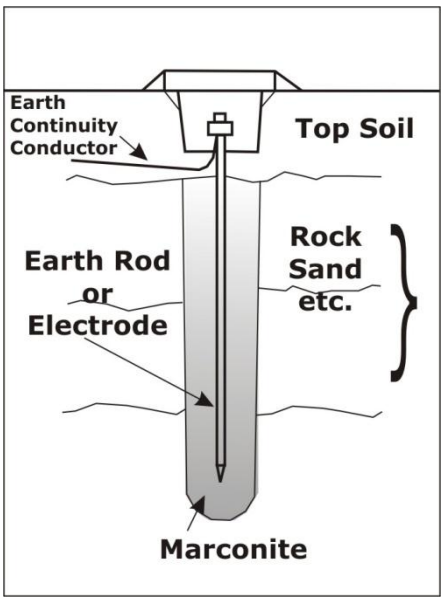

Fig.3. Marconite back filled earthing system

F. Biological Earthing : This is the proposed earthing system for domestic installations. As the earth resistance depends on the moisture content of the soil, we are proposing a parallel earthing system to the existing one. Moisture content of the earth varies from season to season, thus reducing the earth conductivity. External watering systems of earthing are of not much careful methods, because of following reasons.

1) The soil collapse inside the earth pit or solidification of the clay at the exit of the water (hole is provided for watering) or both the situation. there is no body to stir up the soil for loosening.

2) In many buildings a rule of electrode center distance from the domestic building of 1.5m is not maintained.

3) During the construction most of black cotton or soft soil is separated away from the site location or back filled with hard or concrete waste.

4) Most of the area around the building are covered with paver or concrete for neatness or cleanliness, which maintains dryness around the earth pit.

5) It is the human tendency; if earthing pit yields any by product then they could have done it carefully.

Considering the above situations, we would like to propose biological earthing system, which retains moisture in the soil throughout the year, indirectly supporting in the reduction in earth resistance. In this process red worms called earthworms are grown, which convert the kitchen waste in to wormi compost. Later, compost may be used for gardening or roof top gardening to harvest healthy organic vegetables.

Arrangements: GI cube, PVC pipes with circumferential holes of 25mm diameter, Earth continuity conductor, Pit, black cotton soil, red worms (earthworms) and kitchen organic waste is essential.

Vermi composting:

Red worms in pits consume food scraps, vegetable trimmings, fruit peels, yard trimmings, grass, husk and other organic matter to create compost. The worms break down this material into high quality compost called castings. The pit can be sized to match the volume of food scraps that will be turned into castings.

It typically takes three to four months to produce functional castings. The castings can be used as potting soil. It is good for the environment. Keeping our garbage out of the landfills reduces methane gas released into our environment. Worms recycle our wastes and put it to a good purpose. Using worm compost restores natural soil condition and soil biotic condition.

A typical biological earthing system is shown in fig.4

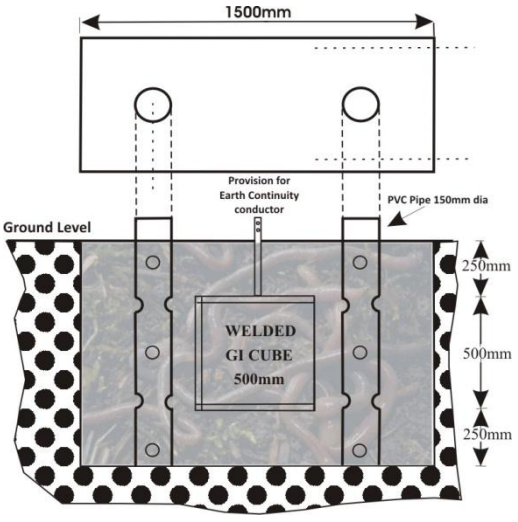

Fig.4. A typical biological Earthing system

In this system a pit of minimum 1500mm X 1000mm X 1000mm depth is excavated. As a bed soil a layer of black cotton (BC) soil of 250mm is essential. Two PVC pipes of about 150mm diameter are used as shown in fig to feed water and food to feed the red worms. A central portion is used for the electrode, which is a welded Galvanized Iron cube of 500mm X 500mm X500mm, with provision for fastening at the ground level i.e. a separate pvc insulated GI flat 300mm may be used. Initially 250mm from the bottom surface is backfilled with BC soil over

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which a GI cube is placed. Then locally available young earthworms of about 50 numbers are sufficient for the pit of this dimension. A layer of 100mm organic materials such as vegetable trimmings, garden wastes flowers, old news papers, fruit wastes etc are spread around and inside the pipes and a GI cube. sufficient water is poured into the pit for successful operation.

Waste to Soil : As we know soil is the gift of the nature. It takes more than 500 years to form 1" (25mm) of soil. It is the earthworm which converts waste organic matter into energetic fertilizer and thus serving the earth. It is very popularly known as farmer's friend.

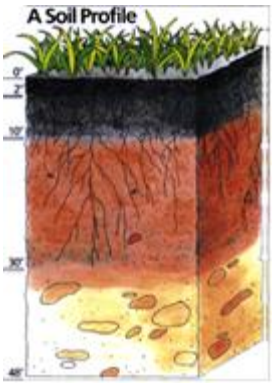

Fig.5 Earth's crust/ soil profile

Behaviour of Earth worms :

Earth worms are available in verities of species, such as Eisenia fetida, Dendrobaena veneta, Eudrilus eugeniae and Perionyx excavatus may be used. It is better practice to add organic materials in thin layers (25mm-50mm). Earthworms require aerobic conditions and remain in the top 10-15 cm of a system moving up as new organic matter is added to the surface layer. Temperature should be maintained ideally at 20°-25°C . Moisture content should be 75%-90% . we should not cover beds with impermeable materials, such as plastic, which prevent oxygenation. As we are using earthworms for an earthing purpose they continuously agitate the soil. Earthworms on the way form tunnels behind, make it easier for roots and plants to grow. As roots grow and reach the worm tunnel they can get into the ground easier. In the process of watering water gets easily circulated through the tunnels and sufficient moisture gets stored in to the soil mass.

Biology of Earthworms:

Earthworms breathe through their skin, So they must be in an environment that has at least 40% moisture. If their skin dries out, they cannot breathe and will die. Earthworms prefer a near-neutral soil pH. Instead of teeth, earthworms have a gizzard like a chicken that grinds the soil and organic matter that they consume. Their main intention is to eat the soil microorganisms that live in and on the soil and organic matter. Worm excrement is commonly called worm casts or castings. These soil clusters are glued together when excreted by the earthworm and are quite resistant to erosive forces. Their castings contain many more microorganisms than food sources because their intestines immunize the casts with microorganisms. Earthworms become sexually mature when the familiar band (the clitellum) appears around their body, nearer to their mouth. Each worm with a clitellum is capable of mating with other worms and producing cocoons that contain baby worms. Cocoons are lemon shaped and of about 25mm in length. Anecic worms are capable of burrowing to depths of 6 feet.

Electrical behavior of Earthworms :

Earthworms are sensitive. they drive back against fire and electric shock. It has been observed in the previous studies for the effectiveness of the electric field at repelling earthworms, earthworm diameter and resistance are two of the controlling variables. Earthworm diameter and resistance were determined in two species of earthworms. Electrical resistance was measured by connecting an Ohm meter to two copper leads. Each earthworm was placed so as to have the two leads touching the opposing sides of its diameter and its resistance recorded.

Fig.6 Earthworms (mature)

Experiment (above) was helpful in repelling earthworms in the process of separation of compost without collecting worms. But in the domestic earthing installation, fault current is very less and earthworms are wide spread over the area and feeding pipes (PVC) function as a separator.

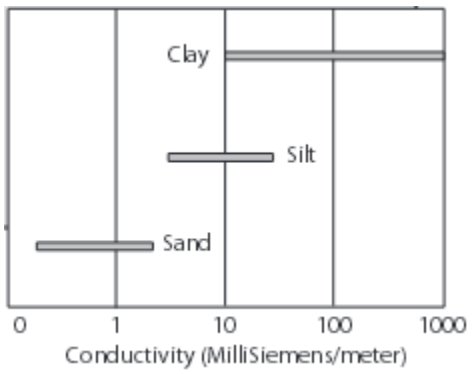

Fig.6 Comparison of conductivity: Sand, Silt & Clay

Worm casting is a rich clay without sand and silt, so conductivity of the worm pit is too high and resistance is less. As the moisture is maintained and the current flows through the easiest path, a bottom BC soil acts as low resistance area. So, earthworms are safe enough to serve for domestic installations.

Comparison of earthing systems with proposed:

Table 2. Comparison

Parameter	Traditional Earthing	Biological Earthing
Need of Regular Inspection, Watering	Yes	Yes
Soil Resistivity	Climate reliant	Constant
Contribution in Waste management	No	Yes
Any by product	No	Yes
Ecological friendly	No	Yes
Cost of Earthing	High	Low
High Voltage/ current	Yes	No

Conclusion: The low resistance, low variability in soil resistance across the earth pit, low cost and a byproduct release encourages to use biological earthing system for the domestic installations. Biological earthing can be used in parallel to the existing earthing system for reliability, which absolutely improves the earth conductivity. This is the unique earthing system to support the environment, awareness towards the electrical safety and ecology.

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