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ENHANCING EFFECTIVE EARTHING IN ELECTRICAL DOMESTIC INSTALLATION AMONG GRADUATES OF TECHNICAL COLLEGE IN IMO STATE, NIGERIA

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Abstract

The study investigated the techniques required for enh0ancing effective earthing in electrical domestic installation among graduates of Technical College in Imo state, Nigeria. Three research questions coupled with one hypothesis were answered by the study. Descriptive survey design was used to carry out the research in Owerri Education zone of Imo State. The population of the study was comprised of 29 Polytechnic Electrical Technology lecturers from the zone and 61 electrical workers (Technologist Technicians and Craftsmen) with Owerri Zone Enugu Electricity Distribution Company(EEDC) formerly PHCN. There was no sampling, intact population was used. The questionnaire was designed by researchers tagged „Effective Earthing Techniques in Domestic Electrical Installation(EETDEI) was used for data collection with 22 items questionnaire, validated by three experts and also pilot tested outside the research zone. Cronbach alpha was used to establish the internal consistency of the instruments which yields 0.87. The questionnaire was administered and 87 copies of the questionnaire were returned. Mean and Standard deviation were used in analyzing the research questions while null hypothesis was tested at 0.05 level of significance using Z-test. Results of the study revealed that 7 items earthing points/parts and materials, 8 items method/process of earthing and 7 items test modalities were identified as the needed earthing techniques for effective electrical domestic installation and there was also no significant difference between EEDC electrical workers and Electrical Technology lecturers on the required effective techniques for enhancing earthing in domestic installation. Consequently, it was recommended that using real building is required for teaching student earthing practically and not board practice, enough time should be given to students for practice and a set of earthing tests must be carried out on a new installation with test instrument.

Keywords: *TVET, Earthing, Electrical Installation, Testing.*

Introduction

Presently, Technical College in Nigeria is known as Government Science and Technical College (GSTC) or Government Technical College (GTC).They are specialized Post Basic Institution of learning offering trades and modular courses in addition to general education and science subjects. In the National Policy on Education, Technical colleges are presented under the umbrella of TVET (Technical Vocational Education and Training); which is used as —a comprehensive process involving, in addition to general education, the study of technologies and related science and the acquisition of practical skills attitudes, understanding and

knowledge relating to occupations in various sectors of economic social life.‖ (Federal Republic of Nigeria (FRN), 2013:16). Therefore, it is believed that the graduate of GSTC should be equipped with technical knowledge, practical skills necessary for self-reliance or be employed in industries at the end of the programme

Electrical Installation and Maintenance Works (EIMW) in technical colleges is an aspect of

Electrical installation works with their associated skills is a vocational area that enables individual to gain self employment. Electrical installation means assembling and fixing electrical equipments at site and the pre-requisites of successful installation and functioning are designing, selection and preparation of site, provision of recommended physical and technical environment coupled with earthing and testing (Law-Obi, 2014). Therefore, in the electrical domestic installation process error exists in the omission of earthing.

electrical/electronic technology and it is among the trade subjects offered in technical colleges and are made of three areas of subject grouping - domestic and industrial installation, cable jointing and correct battery charging; and winding of electrical machine (National Business and Technical Examination Board (NABTEB), 2017). The objectives of studying electrical installation and maintenance works as stated by the National Board for Technical Education (NABTEB, 2007) is that the graduates of this course should be able to carry out with expertise, domestic and industrial electrical installation works, detects and repairs fault in domestic/industrial appliances; carryout the various test on new and existing electrical installation and rewind electrical machine and other portable electrical devices and interprets electrical working drawing and manuals. Therefore on the completion of electrical installation and maintenance works (EIMW) course in technical colleges, students graduate to become crafts men while their academic performance was determined by their ability to install and maintain electrical and equipment and appliances, in addition to carry out minor and major domestic and industrial wiring.

Earthing or grounding in an electrical installation is the connection of specific parts of that installation with the Earth‘s conductive surface for safety and functional purposes, having the points of references as the Earth‘s conductive purpose (Bookslley, 1996). It is the connection of the equipment and facilities ground to mother earth. According to Erico (1999), design and installation of electrical grounding system is one of the most important aspect of any electrical distribution system but it‘s often misunderstood leading to improperly installation. There are many reasons of earthing in an electrical installation; firstly, is to protect people by providing a low impedance route, secondly is to protect structure and equipment from intentional contact with energized electrical lines and provide maximum safety from electrical faults and lightning (Erico, 1999, Jain & Rao, 2009). In addition, is to provide stable tensions between active phases and ground, when a single phase faults takes place in an electric power system coupled with an effect of atmospheric discharge, so that the great energy will be driven to ground (Nagar, Velazques, Mukhedar & Gevais 1985). But the standard of earthing practice is often neglected

by many craftsmen and a lot of problems attributed to improper or non-application of earthing system in our houses during domestic electrical installation are created, resulting to earth fault, manifesting to electric shock, burns or death. The experience is felt on touching unearthered energized: appliances, exposed metallic conductors in the building and conductor lying in the electric field of the leakage current to earth. Earth fault can result to other hazards and the hazards associated with electrical installation are: electric flash over lightning faults, leakage current and fires (Christopoulous & Wright 1999, Neitzel. 2006). Hence confirming Erico (1999) who maintained that electrical earthing is an aspect of electrical distribution system that is often misunderstood and subsequently installed improperly. Thus it has become necessary to determine the techniques of earthing in electrical domestic installation, for the finding of the study will be of immense benefit to Technical Vocational Institutions- technical colleges, polytechnics and universities because it will enable them secure the right technique and skills in earthing, therefore safe guarding: their lives, general public and their properties in addition to enriching the curricula in electrical technology.

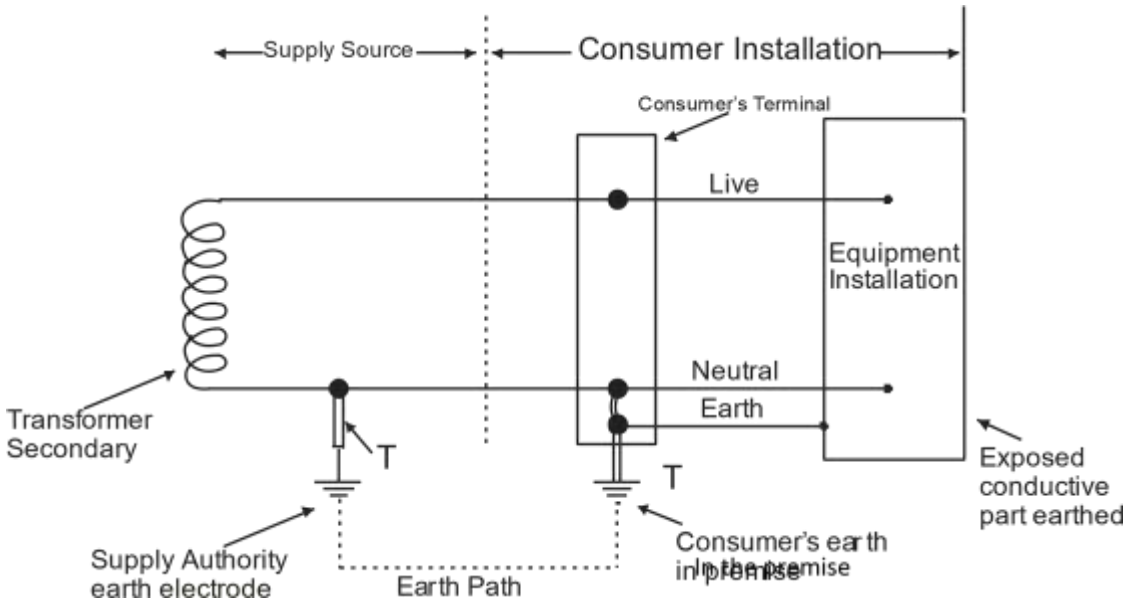
In a domestic installation - the installation of electricity in private houses like bungalows and multi-storey buildings; which are not used for commercial purposes. The wiring system is made up of three wires (live, neutral and Earth) that run through the domestic electrical circuit (Donelley, 1980). Electricity always flow back to its source when an appliance is switch on, the circuit complete its parts from live wire to return wire (neutral). In case of any short circuit, as live wire comes in contact with metal part of an appliance, the user is in a position to get shocked when the metal part of appliances is touched because the current is completed by the use as a return conductor to the ground (Erico,1999).

There are different types of earthing system accepted internationally such as: TN, TT, IT, TN-S, TNC-S, TNC and TTNS (T means Terra or earthing, N – Neutral, S – Separate, C - Combined and i – isolated), Fig 1, displays an application in domestic installation- TT earthing type. This is carried out by connecting neutral point of the source of energy at that source earth point only coupled with earthing neutral equipment, and exposed metallic conductive part at the consumer‘s earth point. All water pipe, gas pipe are also earthed and earthing pits is also installed in the consumer‘s premises (Goyal& Aggarwal, 2016; Erico, 1999).

Thunder arrester must also be earthed at consumer‘s premise and terminate at source earth terminals through the general mass of earth.

The earthing method/process entails that the earthing terminal of every socket outlet, earthing terminal provided at lighting and switch position; exposed metal work of all apparatus and support structure in addition to earthing terminal of lighthning protection system should be connected to earth continuity/conductor (ECC While the ECC is connected to consumer‘s earth terminals. The neutral point is connected to the same earth point of the consumers earth ternimal and thereby connected to the earth/ground point via earthing lead to earth electrode. While the consumers earthing terminals is typically connected to the metallic sheath or armmour of the distributors services cable in the premise (Francis, 1985; Boosksell, 1996).

driven depth to obtain maximum advantage



EARTHING SYSTEM

Cronshaw (2005) *Fig ..i* TT Earthing type

The 16mm^2 copper earth continuity conductors and 10mm^2 earth continuity conductor connected to metals supports structure terminates at consumers' earth terminal and the main earthing lead is connected to earth electrode and labeled safety electrical connection do not touch. The resistance of the earth must be measured with Megger and the allowable earth resistance is 5 ohms in domestic installation but if it is higher, the buried length should increase (Jain& Rao, 2009). According to Donelly (1980), if it is higher, the number of electrode to be buried will increase. The type of electrode to be used and the effectiveness of the electrode depend on the earth contact made with the surrounding (Douglas, 2007). Since TN-S is utilized, one electrode is driven into virgin earth and not into backfilled in a situation where two or more rods are needed in order to achieve a desired result, the separation between rods should be at least equal to their combined from each rod (British Standard (BS), 27430). If the soil resistivity is found on top soil on conducting resistivity test, while below it may be filled with rock or other impervious start. The top soil may be considered. According to Bradoland Guruwodeyar (2018), earthing in installation involves the process of digging, installing earth electrode, pouring of alternate layers of salt and charcoal and connecting the installation with earth continuity conductors. The connection of earth electrode to general mass of earth via earth continuity conductor, earthing lead and earth electrode is shown in Fig 2

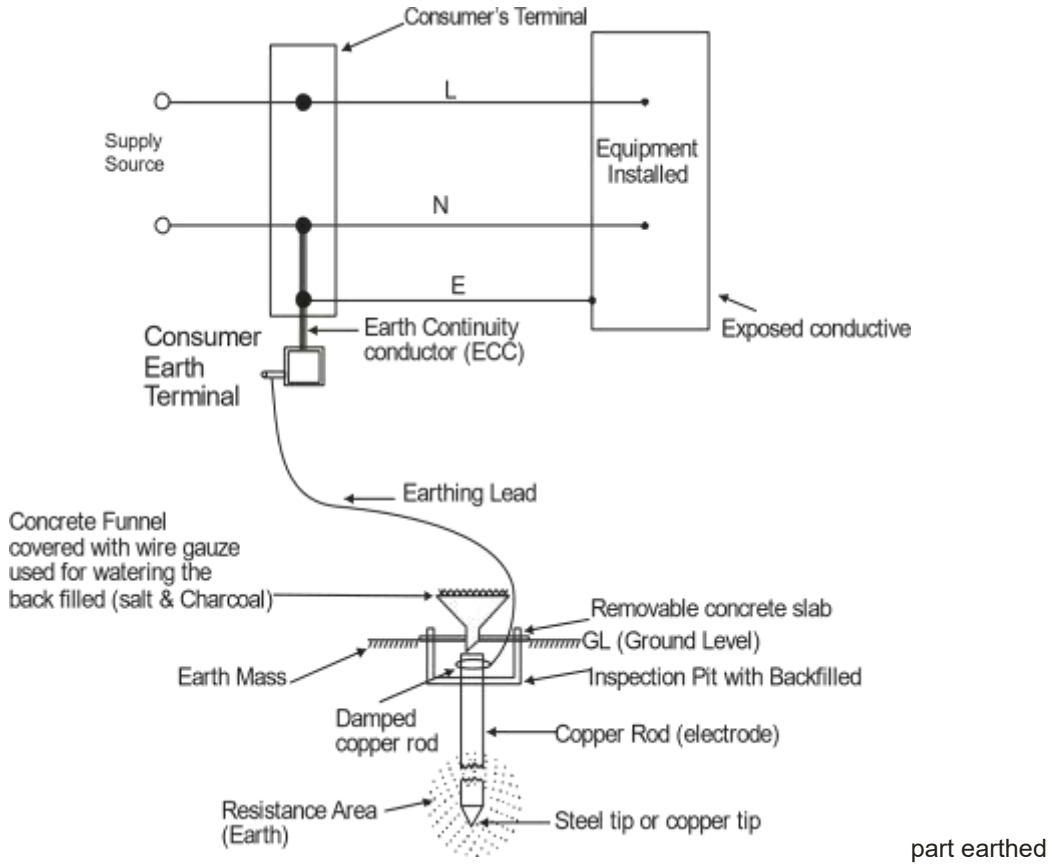


Fig.2: Connection of earth electrode to earth (ground) mass; Cronshaw, 2005; Bamiro etal, 1983.

The earthing material are salt which can be table salts (NacL), copper sulphate ($CuSo_4$) Calcuim chloride ($Cacl_2$), Sodium carbonated ($Na_2\ Co_3$), coke ((Charcoal) are used as backfilled over the years in reducing soil resistivity. A resent research conducted to determine the best soil resistance reducing agent for electrical earthing application among charcoal and salt, pig dung, and Bentonite clay. Though pig dung is the highest in dropping the soil resistivity value but Bentonite clay was chosen as the best artificial compound for electrical earthing application due to relative limited demerits of Bentonite (Opara, Nduka, Ilokah Amaizu & Onyebuchi, 2014). Earth electrode also can be in form of earth rod, earth pipe, earth strip, earth plate and earth underground structural metal work (Erico, 1999, Goyal Aggarwal, 2016).The earthing conductor wire of $16mm^2$ and $10mm^2$ copper cables can be used.

Testing an installation is the act of detecting faults using electrical measuring instruments before dangerous situation arises. Installation must be protected against earth leakage and danger of electric shock, excess current, moisture and corrosion. Test for effectiveness of earthing is carried out on a new installation, addition to existing installation and periodically on existing installation. According to Donelley (1980) Earthing test are carried out in order to: (i) Ascertain that there is no break in the continuity of the conductors which connect the earthing lead to those parts of an installation

supposed to be earthed. (ii) Ensure that earth continuity conductor is capable of carrying leakage current. (iii) To make sure that earth electrode (e.g. Copper rod) is connected to the general mass of the earth.

To ascertain that there is no break in the continuity of the conductors which connect the earthing lead to those parts of an installation supposed to be earthed;usinga double wound transformer of 240V primary and 40V secondary (10–30A),Voltmeter (10– 50V) and variable resistor; It is then, checked by disconnecting the main supply, connecting the current injection tester between one cable of installation of known resistance and the earth continuity conductors and then injecting current (1 ½ times final sub-current or maximum of 25A at a maximum voltage of 40V (Donelley, 1980, IEE-2001) using ohms's law, the resistance is then calculated using the values of voltmeter and ammeter which will not be more than 1Ω,so that, a low resistance safe return will be provided to earth.

To ensure that earth continuity conductors is capable of carrying leakage current, firstly the good condition of earth-leakage circuit breaker must be ensured by applying a maximum voltage of 45V across the neutral and earth terminal and injecting a current through the fault detector coil. If the circuit breaker trips instantaneously, it indicates a good state of the circuit breaker. According to Donnelly (1980), the test should be carried out at least once every three months. Secondly, the earth fault loop impedance test is done to determine whether earth fault is able to carry heavy leakage current thereby energizing protective gear (circuit breaker) to operate as leakages occur between the line conductor and the earthed metal work of the installation. The instrument (Megger) is used to measure the value of the earth fault loop impedance (resistance in ohms which is determined as circuit operate on full mains voltage (240V) and passes a short duration current of approximately 20A from line conductor through the consumer earth continuity conductor and earth return path to the neutral of the supply transformer.

Suppose that the circuit fuse will operate at 50A while the supply voltage is 240V, then the resistance of the earth fault loop will be determined using ohms law - R

$$= \frac{V240}{I50} = 4.8\Omega$$

Therefore, if the resistance (impedance) of the earth is greater than 4.8Ω, the fuse (circuit breaker) will not open under serious condition.

To ensure that earth electrode (copper) is connected to the general mass of the earth. Using voltmeter, ammeter, transformer 40V secondary, 4 electrode and variable resistor, an alternating current of 240V primary and at a maximum voltage of 40V is connected between the main earth, electrode A and auxiliary electrode B, placed about 30m from A, an ammeter is placed in series with the supply to measure the current through the circuit. With the voltmeter, the potential difference (v) is measured between A and C and the resistance Area are found by talking various readings from point A towards B. Therefore, R = Voltage between A and C (Average V)

Current

Outside the resistance area, the resistance is constant but within the resistance area, the

resistance decrease with increase in the number of electrode. This shows that the electrode is connected to earth.

The grounding system must receive periodic inspection and maintenance in order to retain its effectiveness. Though adequate design, choice of materials and proper installation techniques can help to reduce deterioration of grounding system and minimizing repair throughout the life of the structure (Erico, 1999). All earthing terminals points shall be visible for inspection and testing to ensure that equipment in the house do not become dangerous by attaining high touch potential during any fault and therefore should carry earth fault current till clearance without creating any fire hazard. In the word of Bradol and Guruwodeyar (2018), regular watering through brick champers plumbing accessories, arebuilt to aid in the watering of earthing pit.

Enugu Electrical Development Company of Nigerian Electrical workers are technologists, technicians and craftsmen with regards to this paper, technologists are holders of HND certificate, who have high technical and interpretational knowledge in scientific and engineering outfit trained in the application of existing technologies and care about creation of new technologies. They can undertake domestic and industrial electrical installation and earthing, testing existing, new and temporal installation. They repair and maintain equipments and electrical wiring and distribution of power from transformer or generating plant (Somolu, 2008). Technician is a holder of National Diploma with minimum knowledge in all area where the technologist claim expertise, a member of engineering team in construction, installation and maintenance while graduate of Science and Technical College and Government Technical College (GTC) possess NTC (National Technical Certificate) or ANTC (Advanced National Technical Certificate), a skilled tradesmen that work in team with technologist and technicians in different cadre of generation, transmission, distribution and installation of electricity.

Electrical technology lecturers are engineers who perform the Job of impartation of knowledge of electrical technology into the learners studying Electrical Technology.

Therefore, technicians technologists are their product while craftsmen are the product of technical education lecturers.

Purpose of the Study

The major purpose of this study is to investigate the techniques required for enhancing effective earthing in domestic installation among graduates of Technical Colleges in Owerri Education Zone of Imo State. Specifically, the study will seek to determine the needed techniques for enhancing earthing in domestic installation as indicated by the:

1. Earthing points/parts and materials to be used
2. Earthing methods/ process to be used.
3. Earthing test modalities to be carried out.

Research Questions

1. What are the parts/parts of electrical installation needed to be earthed and the required materials to be used for enhancing earthing in domestic installation?
2. What are the earthing methods/process needed to be used in enhancing earthing in domestic installation?

3. What are the test modalities needed to be carried out for enhancing earthing in domestic installation?

Research Hypothesis

A null hypothesis was tested at 0.05 significant levels as follows

1. There is no significant different on the mean rating of electrical technology lecturers from polytechnic and Electrical workers(Craftsmen, Technicians and technologists) from Enugu Electrical Distribution Company (EEDC) on the test modalities required to be carried out upon earthed domestic installation

Method

The study adopted descriptive survey research design to determine the techniques required for enhancing effective earthing in domestic installation among graduates of technical colleges in Owerri Education zone. The population of the study was 90 comprised of 29 polytechnics Electrical technology lecturers from the zone and 61 electrical workers from EEDC, formerly (PHCN). There was no sampling due to smallness of the population; an intact population was used. There were three research questions and one hypothesis answered by the study. The questionnaire tagged —Effective Earthing Techniques in Domestic installation (EETDI) was used for data collection. The reliability of the instruments was 0.87, established using Cronbach Alpha. The questionnaire items were generated from the review of the related literature which consisted of four sections A to D. Section A solicited for information on the personal data of the respondents. Section B, sourced for data on the required earthing parts of the installation and the material to be used for enhancing earthing in domestic electrical installation. Section C, was based on the required method or processes of carrying out effective earthing in domestic electrical installation and Section D, is centered on electrical test modulation needed to be carried out on the earthed in domestic installation.

The 22-item questionnaire made use of five point Likert scale-highly required (HR), required (R), undecided (U), not required (NR) and highly not required (HNR). The response categories values were assigned 5,4,3,2 and 1 respectively the instrument was validated by 3 experts from Technical Education Department Ignatius Ajuru University of Education Portharcourt outside the area of the study, mean and standard deviation were used to answer each of the three research questions while Z- test was used to answer the hypothesis and any item with a mean of 3.50 or above was considered required. The hypothesis was tested at 0.05 level interpreted to significance. Out of 90 questionnaires administered, only 87 were completed and returned.

Table 1: respondents mean rating of the earthing points/ parts and materials to be used enhancing earthing in domestic installation.

S/N	ITEMS: Ability to connect/use:	$\bar{X}$	SD	REMARKS
1.	Neutral point to earth	4.36	0.79	R
2.	Earth thunder arrester earth point to earth continuity conductor	3.97	0.81	R
3.	All metal structures, sheaths insulator	4.03	0.85	R
4.	All earth terminals in socket outlets, lighting switch position	4.25	0.79	R

5.	Alternate layers of salt and charcoal	3.97	0.86	R
6.	Pig dung or bentonite clay	3.61	0.98	R
7.	Earth rods and earth wire	4.71	0.88	R

The data presented in table 1 revealed that the 7 required earthing point and materials for the items had mean range of 3.61 to 4.71 above the enhancement of effective earthing in domestic minimum cut off points of 3.50. These items are the installation.

Table 2: Respondents mean rating of method/process of earthing for enhancing effective/earthing in domestic installation.

S/N	ITEMS: Ability to connect/use	$\overline{X}$	SD	REMARKS
1.	Terminate Neutral point at consumer's earthing terminal	4.21	0.82	R
2.	Terminate Earth point at consumer's earthing terminal	4.50	0.67	R
3.	Drive the copper electrode or rod in the virgin land at least 1.5m deep	3.95	0.77	R
4.	Connect 16mm earth wire to tip of the rod and terminate at consumer's earthing terminal	4.42	0.71	R
5.	Surround the area with brick wall squarely.	3.85	0.82	R
6.	Fill the space with the chosen artificial backfill.	3.97	0.88	R
7.	Cover the square wall with a small hollow slab to enable maintenance and water application	3.78	0.83	R
8.	Label safety electrical, do not remove.	3.67	0.79	R

The data presented in table 2 showed that the 8 required process of earthing for the enhancement of items had mean ranges from 3.67 to 4.56 above the effective earthing in domestic installation.

minimum cut off point of 3.50. These items are the

Table 3: Resondents mean rating of test modalities required to be conducted on earthed domestic installation for its effectiveness.

S/N		$\overline{X}$	SD	REMARK
	ITEMS: Ability to carry out test to:			
1.	Ascertain that resistance of the earth continuity conductor exist and continued from the earthing lead (wire) to those part of installation supposed to be earthed.	4.55	0.67	R
2.	Ensure that the circuit breaker will trip instantly on emergence of leakage current.	4.25	0.71	R
3.	Ascertain if the earth loop is able to carry heavy current thereby			

	energizing protective gear	4.50	0.78	R
4.	Find out whether the earth electrode is connected to the general mass of earth	4.36	0.73	R
5.	Find out the resistance of the earth continuity conductor, which will not be more than 1 ohm on disconnecting the supply 3.81 0.82 R			
6.	Determine the resistance of the earth mass around the buried electrode, which will not be above 5ohms using megger. 3.92 0.87 R			
7.	Ascertain that increase in the number of electrodes lowers the resistivity of the earth	3.88	0.91	R

The data presented in table 1 revealed that the 7 required test modalities to be conducted on earthed items had mean ranging from 3.81 to 4.55 above the domestic installation for its effectiveness.

minimum cut off point of 3.50. These items are the

Table 4: Z-test of difference between the mean responses of EEDC electrical workers and electrical polytechnic lecturers on the required test modalities to be conducted on earthed domestic installation for its effectiveness.

ELECTRICAL STAFF	MEAN	STANDARD DEVIATION	N	Df	STANDARD ERROR	LEVEL	ZCAL	ZCRIT	REMARK
EEDC electrical workers	4.04	0.935	58	128	0.76	0.05	0.526	196	Accept
Electrical technology lecturers	4.21	0.894	29						

The Z-test analysis summarized in table 4 reveals that, there is no significant difference between the mean rating of EEDC electrical workers and Electrical Technology Lecturers on the required effective techniques for enhancing earthing in domestic installation. Tested at 0.05 α – level and degree of freedom, 128. The calculated Z-value (0.526) is less than the critical Z value (196). This led to the decision

that the null hypothesis should not be rejected

Discussion

It was found out from the first research question that 7 items were needed effective techniques, the findings affirmed that neutral point of the source energy must be connected at consumer's earthing point coupled with earthing all exposed conductive parts; and installing earthing pit at consumer's premise (Goyal and Aggarwal 2016; Erico, 1999) as well as thunder arrester. The accepted earthing materials are also confirmed (Opara, Nduka, Ilokah, Amaizu and Onyebuchi, 2014). Erico, 1999, Goyal & Aggarwal, 2016) maintained that alternate layer of salt and charcoal are acceptable. The lowest mean of 3.61 indicated on the table for the use of pig dung or Bentonite clays has shown that it is not generally used as earthing materials in Nigeria.

The finding of research question, 2 indicated 8 methods/processes of enhancing effective earthing in domestic installation. Among the 8 items, 3 items have the mean range of 4.21 to 4.42 indicating that they are accepted by all, they are: joining neutral points, earth points to terminate at the consumers earthing terminals and connecting the 16mm^2 earth wire (lead) into the same place which agree with Donelley (1980); Bookslley (1996), and (IEE, 2001). Driving the copper electrode in the virgin land up to 1.5m is not up to the mean of 4.00 and above, one may infer that, it is because the number of earth electrode to be used and the depth is not fixed, for it depends on the resistivity of the soil in agreement with Douglas (2008), and Jain and Rao (2009). The mean values for other items indicate that the standard practice of earthing has not been achieved.

The findings of research question 3 indicate that the respondents are aware of the test and modalities confirming Donelly (1980) and Bookslley (1999) as they maintained that continuity (resistance) of the earth continuity conductor, capability of earth continuity conductor carrying heavy current and ensuring that earth electrode is connected to the general mass of earth, Also Tests must be carried out with standard instruments the derive results must be upheld. The issue is whether it is practiced, judging from the statement of problem of the research.

There is no significant difference established indicates that EEDC electrical workers and Electrical Technology Lecturers possess effective earthing techniques utilized in domestic installation. Confirming the view of (Somolu, 2008), who declared that technologists and technicians undertake domestic and industrial electrical installation and earthing, testing existing, new and temporal installation.

Conclusion

Earthing is an important aspect of electricity distribution system, that is often neglected by many craftsmen. Sometimes instead of using 1.5mm^2 cable with live, neutral, and earth used in wiring socket outlet (power circuit) they choose to use 1.0mm^2 twin cable for lighting point, leaving earth pin open without connecting any earth cable. Even if they use 1.5mm^2, there will be no continuity. The standard practice identified, which are the required techniques for effective earthing must be adhered to, and practiced for complete prevention of electrical havoc in our residential houses.

Recommendation

1. Real building should be used for teaching students earthing practically and not board practice.
2. Enough time should be given to student for practice.
3. Electrical measuring/test instrument such as Megger, Voltmeter, Ammeter should be utilized to obtain reading by the student without any aid from the teacher.
4. Student should be taught how to measure resistance of earth with megger and be given opportunity to practice by comparing two earthing pits; one is regularly watered while the other will be completely dry.
5. All test instruments should be made available in the workshop.

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