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EVALUATION OF BUILDING CONSTRUCTION AND ELECTRICAL WIRING INTEGRITY IN DELTA STATE, NIGERIA

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ABSTRACT

This study was carried out to ascertain if the building construction industry in Delta State was operating in compliance with national andinternational approved guidelines. Two sets of questionnaires (500 questionnaires per set) were used to acquire primary data. One set was administered specifically to the people working directly in the building industry, while the remaining set was administered generally to the public. The results obtained revealed that most of the private and corporate buildings' electrical wiring and other related civil construction works, were done without compliance with Nigeria Industrial Standard (NIS), Nigeria National Building Code (NNBC)or any other standards regulatory agency. Soil geotechnical properties were only determined for 5%, 24% and 93% of the private, corporate and government buildings respectively, before their foundation and wiring plans were designed. It was also noted that only 2% of the private buildings, 31% of the corporate buildings and 68% of government buildings underwent soil electrical properties tests before installation of the earthing systems. Additionally, the results showed that 58% and 65% of the buildings were wired, without appropriate building electrical plans and electrical load calculations. It was seen that most (64%) of the electrical and other building materials used for buildings' electrical and structural works, fell into the substandard range. The questionnaires further revealed that high cost of electrical materials is one of the major factors leading to the utilization of substandard materials for building wiring. Also, the questionnaires depicted that deceitful actions of some electrical and civil engineering personnel, is responsible for the construction of buildings with compromised materials.It was noted from the findings that governmental buildings (11%) had the highest integrity, when compared to findings relating to private and corporate buildings. Findings generally depicted the need for relevant agencies, to monitor the materials and procedures used, particularly for the construction of private and corporate organization's buildings, to avert frequent occurrence of building failures, electrocutions and electrical fire outbreaks.

Keywords: Electrical wiring system, soil electrical properties, foundation design, soil geotechnical properties, substandard materials

INTRODUCTION

Nigeria presently suffers from sustainable accommodation problems, mainly due to its rapidly rising population. As a result of this, numerous building constructions are on-going in several parts of the country. Building construction can be categorized into three major parts, which are: the civil engineering aspect which involved the blocks, concrete and wood works; mechanical and electrical engineering aspects, with the electrical aspect incorporating electrical wiring and installations. The mechanical aspect involves heating and cooling of the building (ASHRAE, 1993; Uguru and Obukoeroro, 2020a). According to the Nigeria National Building Code (NNBC), proper foundation design is an essential requirement for building construction, and it is influenced by soil's geotechnical properties, the anticipated use of the building, and the building'scumulative dead and live loads. Soil tests reveal the soil's weaknesses and its maximum permissible bearing capacity, and thisdeterminesthe foundation type – shallow/deep - suitable for the structure. A good foundation should be able to distribute the total building loads uniformly across the adjourning soils (Youdeowei and Nwankwoala, 2013; Jiménez and Dias, 2022).

Building construction and its electrical wiring are ideally done by certified engineers technicians and technologist, trained masons and trained electricians (craftsmen) (Uguru *et* al., 2022). Electrical wiring system can be surface wiring or hidden wiring (conduit). Conduit wiring is considered safer, compared to surface wiring, but it has serious limitations in faults detection and with correction applications. The wiring system adopted for a structure is influenced by the intended use of the structure and the nature of the building materials used in the structure's construction (Olatomiwa and Alabi, 2012; Uguru and Obukoeroro, 2020a). Inadequate skilled workforce has resulted in self-claimed engineers "quacks", infiltrating into the building industry, utilizing substandard materials and procedures for building construction and wiring. This has led to serious consequences, in terms of human and materials losses (Akpokodje *et al*., 2020; Obukoeroro and Uguru, 2021_a; Eboibi *et al*., 2022). According to Gbonegun (2022), poor attitude of Nigerian construction professionals towards soils tests has led to incessant structural and electrical collapses across the country.

Numerous incidences of building failures and electrical fires in Nigeria, are linked to the non-adherence of the materials and procedures, employed for the building construction,to the standard engineering guidelines. These engineering standards are set for general building constructions, to minimize the occurrence of structural and electrical failures (Uguru and Obukoeroro, 2020_b; Uguru *et al*., 2021; Gbonegun, 2022). The Nigeria Industrial Standard (NIS) guidelines stated that the minimum acceptable compressive strength of sandrete block, meant for the construction of non-load bearing walls should be 2.5 N/mm^2, while the sandcrete block used for the construction of load bearing walls should be 3.45 N/mm^2 (Agbi et al., 2020; Akpokodje *et al*., 2021). The Nigeria Rural Electrification Agency (REA) approved the recommendation by NIS, thatinformation about the soilgeotechnical properties are required for the engineering design of power generation and substation structures. Also materials used for the civil works of power stations and other related utilities (roads and drainage) should be in conformity with existing NNBC and NIS codes (REA, 2021).

Additionally, NIS-IEC 62068 stated that all structures should be adequately earthed using suitable materials, after appropriate soil tests; while bolts, nuts and washers used for electrical installation should be in compliance with British Standard (BS) 4190 - grade 4.6, BS 4190 - grade 4 and BS 4320, respectively (REA, 2021; Obukoeroro and Uguru, 2021_b). National Electrical Code (NEC) guidelines NEC- 400.8, banned the use of flexible wire and cables in conduit wiring, and as replacements for permanent wiring of a building; NEC- 400.10 guideline stated that flexible cables must not be subjected to high tension or tensile forces at the connection terminals (Holt, 2010). BS 8007, BS-8110 and BS 6651 which are adopted by NIS, stated that concrete structures electrical installations and applications, should have high capabilities for fire and lightning resistance. Earthing is a vital component of buildings and power generating plants, as it protects such structures from temporary voltage surgescaused by lightning, electrical errors or other anthropogenic actions (Win and Soe, 2016).

Although, the status of civil engineering works, and electrical wiring and installations in buildingshave been discussed by several researchers, recorded literature on the adherence to standard guidelines during building construction in Nigeria is still scanty. Therefore this work is aimed at evaluating the current status of building and electrical wiringstandards in Delta State, to establish their compliance to international/national standards. This study's findings will be useful to buildings regulatory agencies, in finding solutions to the ambiguities in the building industry, in order to avert occurrences of human, materials and capital losses.

MATERIALS AND METHODS

Study area

This study was carried outwithin the confinesof Delta state, Nigeria (Figure 1). Delta state is blessed with a lot of rapidly growing towns and villages, due to the presences of several oil exploring companies, several educational centres and other medium and small scales industries. Delta State is situated in the South-South geopolitical zone, having a population of about 5.5 million people and land mass of about 17,698 km^2 (DSG, 2015). Delta State geographically falls into the tropical forest zone of the region, with two climatic seasons categorized into -rainy and dry season; and an annual rainfall of approximately 1800 mm, with soilsof mostly alluvial deposits in the lowlands (wetland) and laterite deposits in the uplands (Eboibi *et al.*, 2018; Uguru *et al*., 2021). Resulting from its fast growing population and industrialization, there are lots of building construction works in the state.

Figure 1: Delta State map (Source: Delta, 2022).

Data collection

To acquire robust data for this study, 1,000 questionnaires were produced, 500 of the questionnaires were administered specifically to people involved in building construction (civil and electrical engineering sectors), while the remaining 500 questionnaires were generally administered without special attention to any group of people. All the questionnaires were evenly administered to cover the entire Delta State, between the period of January 2021 and September 2021.

Research questions

1. What are the effects of distrust between the client and the contractor on building standards?
2. What are the impacts of high cost of building materials and laboratory test on building standards?
3. What are the effects of fraudulent activities of some contractors on building integrity?

These research questions will be determined through these null hypotheses;

Null hypothesis 1

Ho_1**:** Clients non-cooperation with building professionals has no significant effect on the building qualities in Nigeria

Null hypothesis 2

Ho_2: High cost of building materials and tests do not have a significant effect on the number of soils tests carried out

Null hypothesis 3

Ho_3: fraudulent actions of some professionals and the activities of quacks do not have significant effect on the integrity of buildings.

Data analysis

Out of the 500 questionnaires administered to professionals in the building sector, 460 were retrieved (92% success rate). The raw data were statistically analyzed using chi-square, pie chart, bar chart and tables, with the aid of the MS-Word excel for Windows.The Chi-square equation is given in Equation 1 (Obukoeroro and Uguru, 2021_a).

$$X^2 = \frac{\sum(O-E)^2}{E} \quad (1)$$

Where:

X^2 = Chi-square
O = Observed Frequency
E = Expected frequency

Interpretation of X^2 = When $X^2_{cal} > X^2_{table}$; then the null hypothesis is rejected.

RESULTS AND DISCUSSION

Site managers' qualification

The results of the site managers' academic qualifications, and the population of buildings based on their various categories are presented in Figure 2 and Figure 3respectively. As provided by Figure 2, only 43% of the respondents had formal tertiary education and were registered with professional engineering bodies; while the remaining 57%neither acquiredtertiary education, nor belonged to any professional engineering body. Figure 3 depicted that 71%, 18% and 11% of the buildings in the region, fell under the private, corporate and government building groups respectively. The respondents' response shows that private buildings dominated the state's building population.

The registered respondents are generally referred to as "engineers", while the unregistered respondents are loosely/simply referred to as "electricians" or "builders". The "electricians" are specialized in structures electrical wiring, while the "builders" are specialized in civil engineering construction works. Both the electrician and builder groups are usually infiltrated by quacks, involved with carrying out building constructions, electrical wiring and faults rectification, mainly through trial and error methods (Uguru and Obukoeroro, 2020a). Quacks generally lack basic knowledge of electrical wiring systems and other building construction and management procedures, and eventually compromise standards to maximize monetary gains (Babrauskas, 2009; Arubayi, 2017; Ekruyota and Uguru, 2021). Quackery is a major problem in the electrical power sector, because the activities of quacks contribute greatly to the epileptic electric power supplies experienced in Nigeria (Nigeria Engineers, 2020). According to Nigeria Engineers (2020), wrong connections can lead to collapse of power distribution lines, shutting down of power transformers, and short-circuiting, which can result to electrical fires or electrocution.

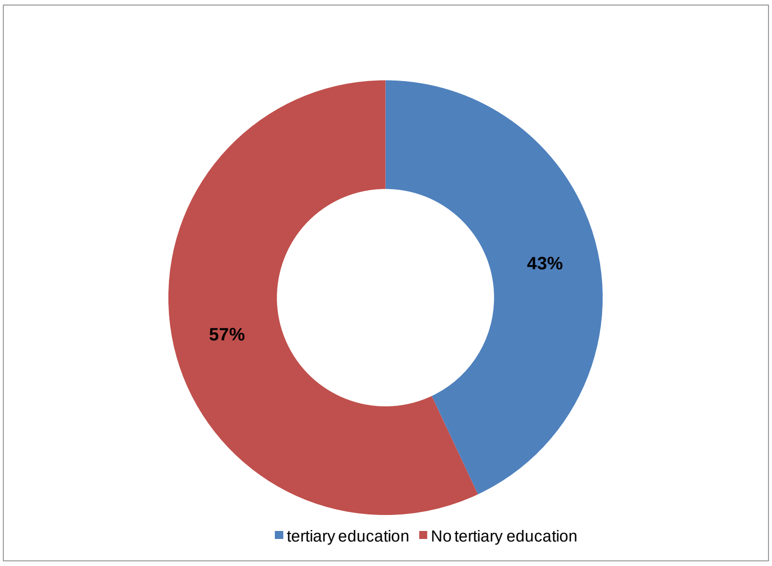

Figure 2: Qualifications of the site's managers

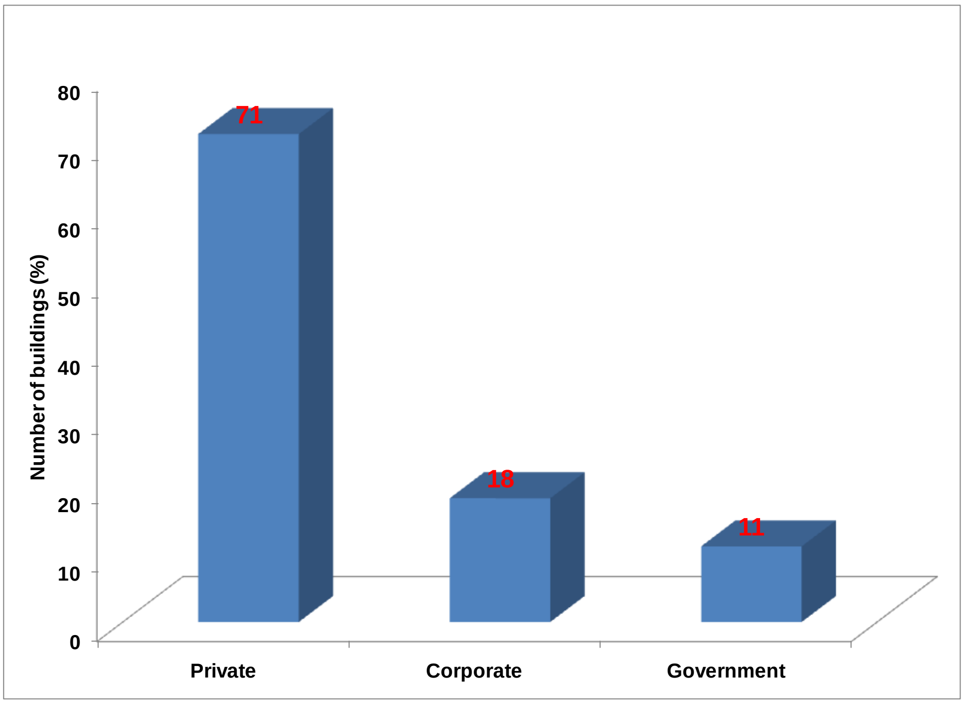

Figure 3: The building population

Soil geotechnical properties tests

The results of responses related to soil geotechnical properties tests, as provided by the professional respondents are presented in Figure 4. As presented in Figure 3, majority of the private and corporate organizations buildings (95% and 76% respectively) were constructed and wired without appropriate soil related tests; and in contrast, soils tests were done for majority (93%) of the government buildings. These findings that conform with Gbonegun's (2022) report which stated that approximately 95% of Lagos State buildings are constructed without adequate soil and electrical materials tests. These results revealed that though most of the buildings in the region were constructed by qualified professionals, they failed to adhere to the NIS codes of practice for building construction. NNBC and NIS-IEC guidelines stated that sites managers should endeavor to determine the relevant geotechnical properties of the soil, before commencement of any structure on the land. Faulty foundation can be attributed to poor foundation design calculations, which result from poor knowledge of the soils' geotechnical properties (Rahman *et al*., 2019).

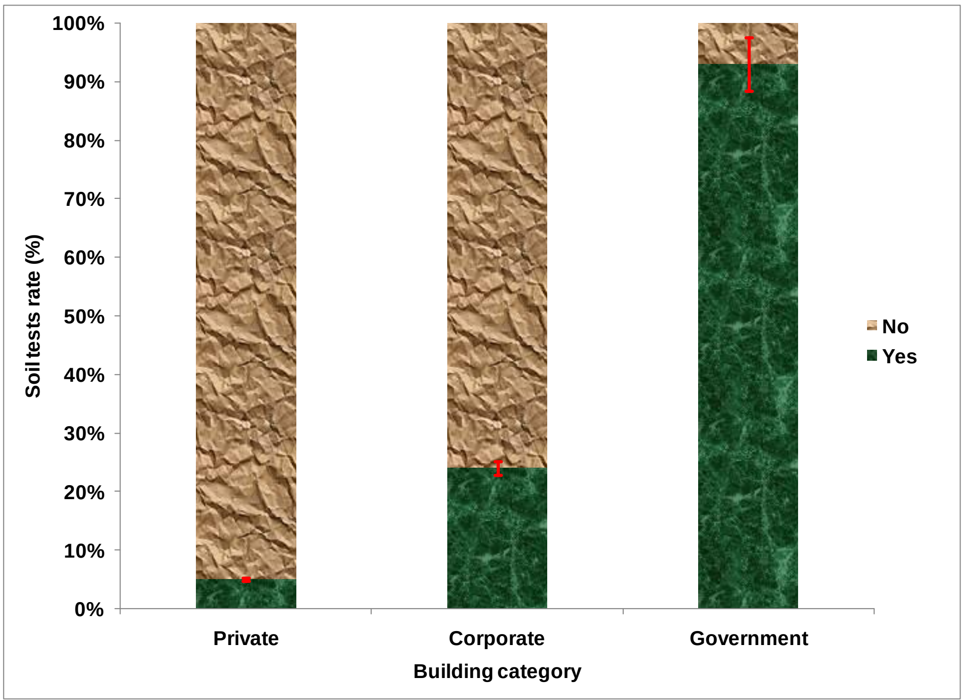

Figure 4: Soil geotechnical properties

Soil electrical properties determination and electrical earthing

The results presented in Figure 5 shows the number of respondent that carried soils electrical properties test, before wiring and earthing of their structures. The results depicted that only 2% of the private buildings, 31% of the corporatebuildings and 68% of the government buildings had soils' electrical properties tests conducted before electrical earthing. The remaining buildings were earthed based on assumption of the soil electrical properties. Nigerian Electricity Management Services Agency (NEMSA) recommended that the resistance of soils suitable for earthing should not be greater than 2.0 Ω; while National Electric Code (NEC) recommends soil resistance not exceeding 5.0 Ω (Omorogiuwa and Fayose, 2018). Similarly, NIS-IEC stated that the earth rod used must be buried at satisfactory depth into the earth's crust (Omorogiuwa & Oboh, 2018).

The non-adherence of some the electricians/technicians to the NIS-IEC earthing guidelines, posed a serious threats tobuildings, human beings, electrical appliances and other occupants of the building. Earthing decreases the potential of temporary overvoltage. It provides an alternative path for excess current to flow to the earth reservoir; thus safeguarding the electrical materials/equipment and the safety of human being in the building (Win and Soe, 2016). According to Cronshaw (2005), building earthling is affected by the immediate neighboring soil's electrical properties, and the total electrical load on the building. The soil's resistivity is a critical parameter which determines the efficiency of an earthing system for a structure or an electrical power plant. Soils are heterogeneous materials, hence its resistivity varies across the landmass; a factor that directly affects the electrical plan design and the earthing systems' functionality (Win and Soe, 2016). Ye *et al*. (1994) and Samouëlian *et al*. (2005) strongly recommend soils test before installing an earthing system for any building.

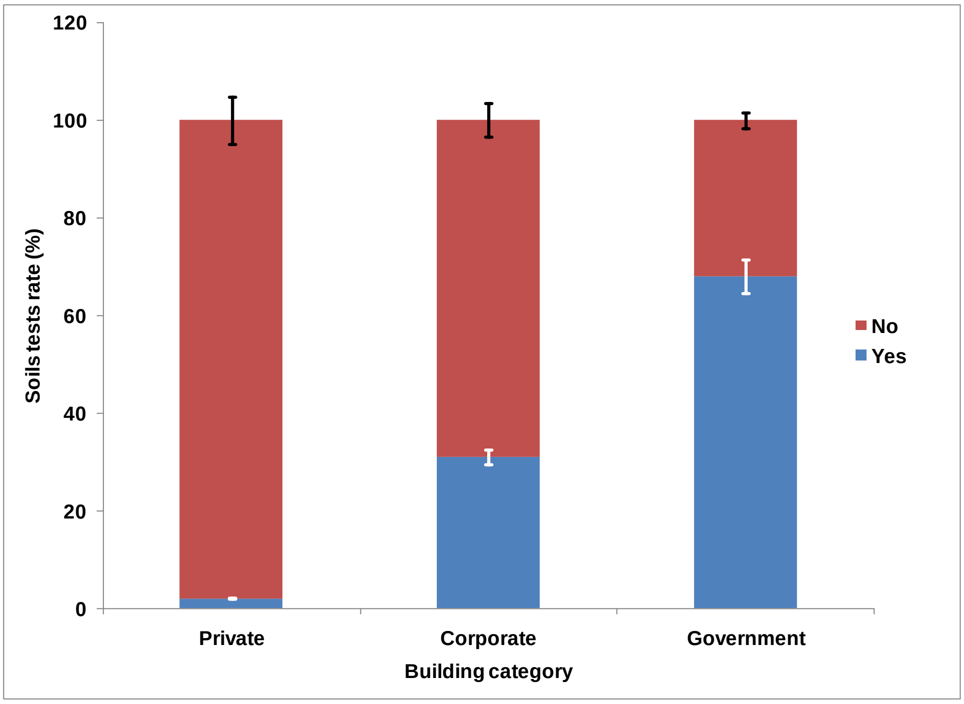

Figure 5: Soil Electrical properties

Electrical plan and load determination

The results of the number of the professional respondent that provided electrical design plans and load distribution calculations before the commencement of wiring is presented in Table 1. Table 1 revealed that 42% of the respondents carried out electrical wiring with suitable electrical plans, while only 35% of the respondents bothered about electrical load calculations. The high percentage of soil related tests, building designs and other ethical standards observed in government buildings, when compared to private residential and corporate buildings, can be linked to the quality of the terms of contract, between the client and the builder.Findings portrayed that most buildings in Delta state may be at risk of electrical and structural overloads, and that some of the trained electricians refused to adhere to their profession code of conduct. Olatomiwa and Alabi (2012) stated that it is inevitable to obey national and international guidelines during electrical wiringbecause; a structure with poorly designed load carrying capacity tends to have problems of power outages.

Electrical plans help to distribute power evenly to all the outlets and appliances in a structure, and aids future corrective maintenance of faulty electrical installation (Obukoeroro and Uguru, 2021_a). Earthing resistance calculations are necessary during electrical earthing applications (i.e. design, installation and operation) to prevent situations of “over-earthing” or “under-earthing”. “Rough-and-ready” jobs carried out by some of the respondents make buildings prone to electrical fire, due to poor connections and terminal. Also failure using substandard wires and cables can cause heating up of the circuit (above 1000^0C at times), which can result in ignition under favorable environmental conditionsleading to electrical fires (Babrauskas, 2003; Obukoeroro and Uguru, 2021_c). According to Ringelectric (2013), the electric arc produced in an electrical circuit through loose connections, can produce a temperature, high enough to ignite an electrical fire.

Table 1: Appropriate electrical load and connections during electrical wiring

Parameter	**Percentage of respondents**	
	Yes	**No**
Electrical plans	42	58
Electrical load determination	35	65

Materials integrity

The results of the qualities of materials used by the respondents for their buildings civil and electrical works are presented in Figure 6. Figure 6revealed that 64% of the material used for building constructions did not pass any integrity test. A situation the respondents blamed on their inability to access high quality materials, and their clients' unwillingness to buy high quality electricaland other related construction materials.This contravenes NIS and NBC guidelines that all building materials must be mechanically and electrically fit for their intended application. All wires and cables used for building wiring must meet the NIS 430:2000, NIS 356: 1997 and NIS 170: 1983 recommendations for their metallic components' resistance, and their insulators' flame retarding characteristics, while NIS 87:2000 recommended that compressive strength of concrete and non-load bearing sandcrete block walls, should be a minimum of 17 N/mm^2 and 2.5 N/mm^2 respectively. Akpokodje *et al*. (2021) stated that most Nigerians construction materials manufacturers tend to produce substandard materials, due to high cost of raw materials and the perceived inability of their customers to pay for the required standard materials. Standard materials meeting NIS recommendations are sometimes produced with different additives (Akpokodje and Uguru, 2019; Agbi and Uguru, 2021); thus adding to the overall cost of the building materials.

Madueme (1997) reported that most people living in low/medium income countries tend to use poor quality electrical materials, during building construction and maintenance due to the non-availability, and the high cost of the original materials. Utilization of substandard earthing materials in electrical installations should be discouraged. Fake earth rods and conductors corrode easily due to favorable environmental conditions, such as warmth, adequate moisture and acidic/basic levels in the soil (Samouëlian *et al*., 2005; Win and Soe, 2016). The use of sub-standard material in building construction is quite cheaper, but has severe long term effects. It can either lead to structural/electrical failures or threaten the safety of the building and its occupants (Madueme, 1997).

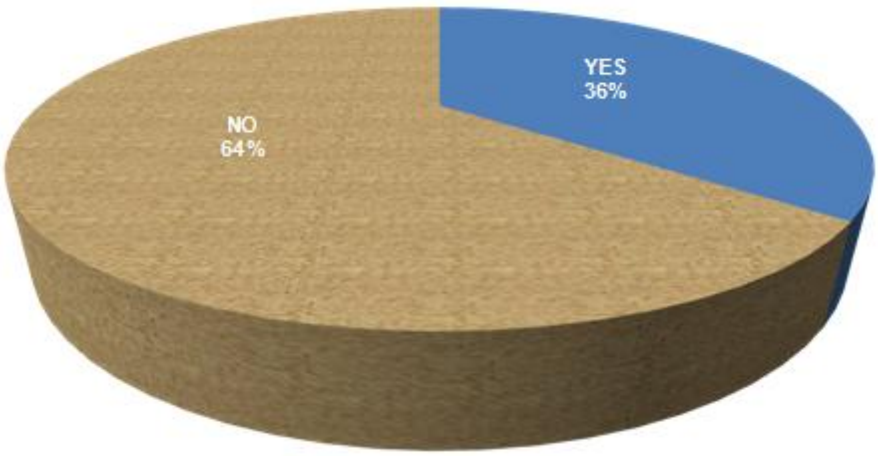

Figure 6: The materials' integrity

Testing of the hypotheses

The academic profile of the respondents to the questionnaires' generally administered to the public, is presented in Table 2. Table 2 shows that 40.29% of the respondents obtained tertiary institution certificate; while 56.85% and 2.86% of the respondents had secondary school and primary school certificates respectively.

Table 2: Respondents' profile

Certificate obtained	Number	Percentage
Tertiary	197	40.29
Secondary	278	56.85
Primary	14	2.86
Total	**489**	**100**

Hypothesis one

Ho_1**:** Clients non-cooperation with building professionals has no significant effect on the building qualities in Nigeria

The respondents value (outcome) categorization table and Chi-square summary table for the Ho_1 are presented in Table 3 and 4 respectively.

Table 3: Question 1 respondents' value

	YES	NO
Tertiary	159	38
Secondary	201	77
Primary	10	4

Table 4: Chi-square summary table for Ho_1

O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
159	149.1	25.9	670.81	4.49
38	47.9	-9.9	98.01	2.04
201	210.35	-9.35	87.42	0.41
77	67.65	9.35	87.42	1.29
10	10.59	-0.59	0.348	0.03
4	3.41	0.59	0.348	0.102
Σ				**8.362**

$X^2_{cal}= 8.362$
df = 2
Testing the hypothesis at $\alpha \leq 0.05$
$X^2_{critical}$ at df of 2 = 5.991

Discussion: Since $X^2_{cal}>X^2_{critical}$; the Ho_1 will be rejected.
Therefore, poor cooperation relationship between building professionals and their clients has significant effect on building qualities in Nigeria ($\alpha \leq 0.05$)

Hypothesis two

Ho_2**:** High cost of building materials and tests does not has a significant effect on the number of soils tests carried out

Table 5 gives the respondents results, while Table 6 presents the Chi-square summary table for Ho_2.

Table 5: Question 5 respondents' value

	YES	NO
Tertiary	163	34
Secondary	211	67
Primary	8	6

Table 6: Ho_2 Chi-square summary table

O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
163	153.9	9.1	82.81	0.538
34	43.1	-9.1	82.81	1.921
211	217.2	-6.2	38.44	0.177
67	60.8	6.2	38.44	0.632
8	10.9	-2.9	8.41	0.772
6	3.1	2.9	8.41	2.713
Σ				**6.753**

$X^2_{cal}= 6.753$
df = 2
Testing the hypothesis at $\alpha \leq 0.05$
$X^2_{critical}$ at df of 2 = 5.991

Discussion: Since $X^2_{cal}>X^2_{critical}$; the Ho_2 will be rejected.
Therefore, the high cost of laboratory tests and building materials have a significant effect on the number of soils tests and qualities of materials used during buildings constructions ($\alpha \leq 0.05$)

Hypothesis three

Ho_3**:** fraudulent actions of some professionals and quacks activities have no significant effect on the integrity of buildings.

Table 7 and Table 8 present the respondents values and the Chi-square summary table for H_{o3} respectively.

Table 7: Question 5 respondents' value

	YES	NO
Tertiary	184	13
Secondary	192	86
Primary	9	5

Table 8: Chi-square summary table for Ho_3

O	**E**	**O-E**	**$(O-E)^2$**	**$(O-E)^2/E$**
184	155.1	28.9	835.2	1
13	41.9	-28.9	835.2	0.999
192	218.9	-26.9	723.6	0.999
86	59.1	26.9	723.6	1
9	11	-2	4	1.002
5	3	2	4	0.993
Σ				**5.993**

$X^2_{cal}= 5.993$
df = 2
Testing the hypothesis at $\alpha \leq 0.05$
$X^2_{critical}$ at df of 2 = 5.991

Discussion: Since $X^2_{cal}>X^2_{critical}$; the Ho_2 will be rejected.
Therefore, fraudulent activities of some engineers, electricians and activities of quacks have significant effect on the integrity of buildings constructed in Nigeria ($\alpha \leq 0.05$).

The discussions from the Chi square analysis revealed that fraudulent activities, high cost of building materials and lack of trust between the professionals and their clients, have negative impacts on building qualities in Nigeria. Similar observations were made by Otunola *et al*. (2021) and Agbi *et al*. (2020), where they stated that high materials cost is significantly affecting the progress of the building industry in Nigeria. According to Owolabi and Olayinka (2018), fraud and corruption have eaten deep into the fabric of the Nigeria building industry, and it is now seriously affecting the standard of buildings erected in the country. Manipulation of the building design, utilization inferior materials, and manipulation of production recipes and receipts are some of the fraudulent activities identified by Bertoli (2016) and Saim *et al*. (2018) that are bore by property developers.

CONCLUSION

This study was done to ascertain the structural and electrical integrities of buildings constructed in Delta State of Nigeria. 460 of the 500 questionnaires distributed to people professionally entrusted with buildings; electrical and civil works were retrieved. The raw data from the questionnaireswere statistically analyzed to establish the engineering status of buildings in the state. Results obtained revealed that most of the buildings in the region are constructed without appropriate soil geotechnical and electrical properties tests. Also the findings depicted that most of the building materials (for both civil and electrical works) were below the standards recommended by NNBC and NIS. The response of the respondents portrayed that most of the buildings (58%) in region are at risk of electrical fire, and their occupants, under the threat of electrocution, because the buildings were not properly earthen with standard materials or after appropriate soil/material tests and electrical load distribution calculations. It was noted from the findings thatgovernment buildings had the highest integrity, when compared to private and corporate buildings. These findings depicted the need forrelevantagencies, to monitorthe standard of private and corporate buildings constructed across the state. Also government and professional regulatory bodies should intensify efforts to weed quacks from the construction/wiring system to enhance building integrity, and to minimize the occurrences of electrical fires and electrocutions.

REFERENCES

Agbi, G.G., Akpokodje, O.I. & Uguru, H. (2020). Compressive strength of commercially produced sandcrete blocks within Isoko Metropolis of Delta State, Nigeria. *Turkish Journal of Agricultural Engineering Research (TURKAGER)*, 1(1), 91-103.

Agbi, G.G. & Uguru, H. (2021). Assessing the impact of cassava starch on the structural properties of sandcete blocks produced from recycled paper. *Saudi J Eng Technol*, 6(5), 99-103.

Akpokodje, O.I. & Uguru, H. (2019). Effect of fermented cassava waste water as admixture on some physic-mechanical properties of solid sandcrete blocks. *International Journal of Engineering Trends and Technology (IJETT)*, 67(10), 216 – 222

Akpokodje, O.I., Agbi, G.G. & Uguru, H. (2020). Evaluation of cassava effluent as organic admixture in concrete production for farm structures.*Turkish Journal of Agricultural Engineering Research (TURKAGER)*, 1(2),271-282. https://doi.org/10.46592/turkager.2020.v01i02.005

Akpokodje, O.I. Agbi, G.G., Uguru, H. & Nyorere, O. (2021). Evaluation of the compressive strength of commercial sandcrete blocks produced in two metropolises of Delta State, Nigeria. *Applied Journal of Physical Science.* 3(2), 61-71

Arubayi, M.K. (2017). Problems of electrical installation in Nigeria. Available online at: https://www.linkedin.com/pulse/problems-electrical-installation-nigeria-pmp-mnse/. Retrieved on June, 2021.

ASHRAE. (1993). ASHRAE Handbook: Fundamentals. American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329.

Babrauskas, V. (2003). *Ignition Handbook*, Fire Science Publishers/Society of Fire Protection Engineers, Issaquah WA.

Babrauskas, V. (2009). Research on Electrical Fires: The State of the Art. *Article in Fire Safety Science*.1-14

Bertoli, J. (2016) Preventing Corruption in Public Procurement. OECD Biennial Publication. Paris. 1-30

Eboibi, O., Akpokodje, O.I. & Uguru, H. (2018). Growth performance of five bean (*Phaseolus spp*) varieties as influenced by organic amendment. *Journal of Applied Sciences & Environmental Management*. 22, 759 - 763.

Eboibi, O., Akpokodje, O.I. & Uguru, H. (2022). Evaluation of organic enhancer on the mechanical properties of periwinkle shells concrete. *Journal of Engineering Innovations and Applications*. 1(1), 13-22,

Cronshaw, G. (2005). Earthing: IEE Wiring Matters. Available online at: https://www.ee.iitb.ac.in/course/~emlab/assets/earthing.pdf. Retrieved on June, 2022.

Ekruyota, O.G. & Uguru, H. (2021).Development of an autonomous multifunctional fruits harvester.*Journal of Agricultural Research*, 6(2), 1-7.

Delta (2022). Delta State Map. Available online at: https://maps-nigeria.com/img/0/delta-state-nigeria-map.jpg. Retrieved on December, 2022

Delta State Government - DSG (2015). Isoko Population. Available online at: https://www.deltastate.gov.ng/downloads2/Population%20by%20sex%20and%20LGA.pdf (January, 2022).

Gbonegun, V. (2022). 95% of building construction without soil test in Lagos, say experts. Available online at: https://guardian.ng/property/95-of-building-construction-without-soil-test-in-lagos-say-experts/ Retrieved on December, 2022

Holt, M. (2010). Flexible Cords, Cables and Fixture Wire. Available online at: https://www.ecmweb.com/national-electrical-code/code-basics/article/20888058/flexiblecordscablesandfixturewire#:~:text=Banned%20uses&text=Unless%20specifically%20allowed%20in%20400.7,%2C%20windows%2C%20or%20similar%20openings Retrieved on December, 2022

Jiménez, G.A.L. & Dias, D. (2022). Dynamic soil–structure interaction effects in buildings founded on vertical reinforcement elements. *Civil Eng*, 3, 573–593. https://doi.org/10.3390/civileng3030034

Madueme, T.C. (1997) Minimizing electric fire outbreaks in residential houses in Nigeria: A case study of eastern states. *Conference: Electric Power Engineering Conference (EPEC)*At: Nsukka, Nigeria, I-8

Nigeria Engineers (2020).Power Sector Suffering Due To Quack Electricity Installers?Stakeholder. Available online at: http://www.nigerianengineer.com/2020/06/power-sector-suffering-due-to-quack-electricity-installers-stakeholder/. Retrieved June, 2022

Obukoeroro, J. & Uguru H. (2021$_a$). A survey of electrical materials counterfeiting in Bayelsa State: A Case Study of Yenagoa Local Government Area. *Journal of Physical Science and Environmental Studies*. 7(1), 9-14.

Obukoeroro, J. & Uguru, H. (2021$_b$). Appraisal of electrical wiring and installations status in Isoko area of Delta State, Nigeria.*Journal of Physical Science and Environmental Studies*. 7 (1),1-8.

Obukoeroro, J. & Uguru H. (2021$_c$). Analysis of electrical and mechanical properties ofelectrical cables sold in Anambra State. *International Journal of Innovative Scientific &Engineering Technologies Research*. 9(1),30-38.

Olatomiwa, L.J. & Alabi, A.C. (2012) Design and development of calculator software for residential electrical services design. *International Journal of Engineering and Technology*. 2(3), 1-9.

Omorogiuwa, O.S., & Fayose, O. (2018).Performance evaluation of the earthing system in Ambrose Alli University, Ekpoma, Nigeria. *Advances in Electrical and Telecommunication Engineering*, 1(2), 93-98.

Omorogiuwa, O. & Oboh, E. (2018). Evaluation of Earthing System of Distribution Substations in Ekpoma, *Advances in Electrical and Telecommunication Engineering*, 1(1), 31-37

Otunola, A.O., Musa, H.A. & Lukman, Y.G. (2021).Effect of rising cost of building materials on property development in Bariga Lagos State, Nigeria. *International Journal of Environmental Design & Construction Management*, 20(4), 287 - 305

Owolabi, O.S.B. and Olayinka, A.O. (2018). Effect of fraud and corruption in the Nigerian construction industry (A Case Study of Oyo and Osun State).*International Journal of Engineering and Innovative Technology (IJEIT)*, 8(2):23-27

Rahman, M.U., Ullah, G., Tayyib, M., Kaleem, N., Shah, S.S.A. & Zaman, F. (2019). Geotechnical investigation of soil for building construction.*GSJ*, 7(9),1241-1253.

Ringelectric (2013). Electric cables. Ottawa electricians explain the dangerous effects of a loose neutral wire. Available online at: https://ringelectric.ca/the-dangerous-effects-of-a-loose-neutral-wire/ Retrieved on June, 2022

Rural Electrification Agency -REA (2021). Harmonised technical standards: designs and minimum specifications. Available online at: https://rea.gov.ng/May272021REA-Harmonised-Technical-Standard.pdf Retrieved on December, 2022.

Saim, N.A.I.M., Rahman, I.A. & Ismail, M.F. (2018). Factors contributing to fraudulent practices in construction project life cycle. *International Journal of Engineering & Technology*, 7 (3.20), 647-651

Samouëlian, A., Cousin, I., Tabbagh, A., Bruand, A. & Richard, G.(2005).Electrical resistivity survey in soil science.*A review. Soil Till Res*, 83(2),173–93.

Uguru, H. & Obukoeroro J. (2020a). A Survey of Residential and Mini-industrial Wiring Systems in Nigeria: A Case Study of Bayelsa State, Southern Nigeria. *Journal of Engineering and Information Technology*, 7(7), 148-154

Uguru, H. & Obukoeroro, J. (2020_b). Physical characteristics and electrical resistivity of electric cables sold in Delta State. A case Study of Isoko Metropolis. Journal of Engineering and Information Technology. 7(7), 155-162.

Uguru, H., Akpokodje, O.I. & Agbi, G.G. (2021). Assessment of spatial variability of heavy metals (Pb and Al) in alluvial soil around Delta State University of Science and Technology, Ozoro, Southern Nigeria. T*urkish Journal of Agricultural Engineering Research (TURKAGER),* 2(2), 450-459. https://doi.org/10.46592/turkager.2021.v02i02.017

Uguru, H, Akpokodje, O.I. & Agbi, G.G. (2022).Assessment of compressive strength variations of concrete poured in-site of residential buildings in Isoko District, Delta State, Nigeria. *Turkish Journal of Agricultural Engineering Research (TURKAGER),* 3(2), 311-327. https://doi.org/10.46592/turkager.1128061

Win, L.L. & Soe, K.T. (2016). Design consideration of electrical earthing system for high-rise building. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, 26(2), 270-282.

Ye, M., Scuka, V. & Lövstrand, K.G. (1994). Earthing mechanism for an electrical system in sea water. In: Proceedings, 22nd international conference on lightning protection (ICLP), Budapest, Hungary, Paper R3a-04.

Youdeowei, P.O. & Nwankwoala, H.O. (2013). Suitability of soils as bearing media at a freshwater swamp terrain in the Niger Delta. *Journal of Geology and Mining Research*, 5(3): 58 - 64