EFFECTS OF ELECTRICAL MATERIALS AND INSTALLATION COST ON THE TOTAL CONTRACT SUM OF RESIDENTIAL BUILDINGS IN ABUJA

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MTech/SEMT/2017/7334

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN PROJECT MANAGEMENT

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ABSTRACT

The non-availability of working drawing for electrical services for most residential buildings have led to variations and false claims by the contractors. In addition, this has led to inaccuracy in cost estimates due to the technicality and complexity involved in the interpretation of electrical working drawings and specifications. Hence, the aim of this study was to assess the implication of electrical materials and installation cost on total contract sum in selected building types in Abuja. The methodology involved a structured questionnaire administered to 384 industry professionals (electrical engineers, project managers, quantity surveyors, electrical technicians, and procurement managers). Using a random sampling technique, 197 responses was recorded which represents 51.3% return rate. The study thus used multiple regression for cost modelling of total contact sum using piping, cable, fitting and installation costs for two, three, and four bedroom apartments respectively. Findings revealed that there exists a positive and moderate relationship between the independent variables (piping, cable, fitting and installation costs) and the dependent variable (total contract sum). Additionally, the cost estimation models developed for the selected building types (two, three, and four bedroom apartments) are $C_S = 0.584 + 0.215 P_C + 0.344C_C + 0.275 F_C + 0.166I_C$, $C_S = 0.597 + 0.206 P_C + 0.389C_C + 0.237F_C + 0.165I_C$, *and* $C_S = 0.588 + 0.202P_C + 0.402C_C + 0.229F_C + 0.165I_C$ respectively. The study concluded that the contract technique mostly adopted in electrical project is the lump Sum (or fixed price) contract technique. The major factors affecting the total contract sum as a result of electrical material and installation costs in order of importance according to findings are design error, supplier manipulation, change order, government policies and cost of labour with mean values 4.57, 4.40, 4.38, 4.23 and 4.20 respectively. Hence, the study recommends that electrical contract sum must be determined and calculated accurately and correctly using the required components from correct electrical/architectural working drawings, and the appropriate contract technique must be selected.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Electricity is a necessity for every house, regardless of the building type. Access to power supply generally promotes every sector of the economy (Mandelli *et al*., 2014), and a critical tool for national development (Sambo, 2009). Hence, an electrical service just like any other generic project is constrained by time, cost, and quality. Mores so, cost management as a critical success factor involves developing strategic plans, estimation, budget, and control mechanisms to complete the project (Kasem and Alhaffar, 2011).

According to Adepitan and Oladiran (2012), electrical services estimates for most projects are inaccurate due to differences between initial and final contract sums of electrical services in Nigerian construction projects. Furthermore, (Alumbugu *et al*., 2014) opined that experience of consultants, detailed drawings and specifications, and accuracy of cost source are crucial factors affecting the reliability of pre-tender cost estimate. Consequently, Kwon and Kang (2019), attributed inaccuracy in project cost estimate to unidentified project risks. Hence, the study recommended the adoption of 3-pointscost estimation method and R-value determination for estimating risk costs to improve budget accuracy.

Material cost most times constitutes a significant part of the total project cost. These building materials according to (Alabi and Fapohunda 2021), is any materials used for construction activities which are available in different forms. In the Nigerian construction industry, the installation cost of an electrical system in a building is a crucial element, just like the material cost. According to Simon and Andy (2012), installations for building services usually amount to about 25% of the total contract sum. Consequently, the high demand for building services installations in recent times has brought about complexity for smart operations to drive innovation to improve satisfaction. Additionally, Yusuf *et al*. (2013) supported that that this complexity in modern buildings has increased service installation development.

Electrical installation in basically subdivided into Electrical Supply/Power/Light systems and Communication/Security/Controls. The classification was based on functions of the installations which could be likened to elements in the case of building. Thus to measure installation that performs a particular function, requires a combination of trades. The trades covered in BESMM3 are in Work Group Y and includes among others; Conduit and Cable trunking (Y60), HV/LV Cables and Wiring (Y61), Earthing and Bonding components (Y80), switchgear and Distribution boards (Y71), Luminaries and Lamps (Y73)

Lawrence listed five main categories of electrical accessories (as cited in Keraminiyage *et al.,* 2009) which are accessories in power circuits, accessories in lighting circuits, protective devices, accessories in other circuits, cables and other sundry items. Each of these categories comprise of several key accessories.

However, the priority of the list of these features varies with the situation and the characteristics of the person with the need. Due to the diversification of availability of different types of accessories, a systematic approach should be adopted in the process of building the model. Several procedures can be adapted to this effect and the following three steps will be followed in building this particular cost model:

1. Identification of the Cost Variables
2. Collection and analysis of cost data

3. Representation of analyzed data in the model in a way that it reflects the cost variables of the system, while catering to the need of ease of use of the model and ability of simulating various combinations

1.2 Statement of the Research Problem

The non-availability of working drawing for electrical services for most residential buildings in Abuja have led to variations and false claims by the contractors. In addition, inaccuracy in cost estimates could arise due to the technicality and complexity involved in the interpretation of electrical working drawings and specifications (Adepitan and Oladiran, 2012). In such situations, underestimation for such electrical installations is found to found to be prevalent. Hence, accurate cost estimation in such electrical works in residential buildings becomes impossible.

According to Yusuf *et al.* (2013), the quantity surveyors in the traditional practice only allow prime cost and provisional sums for building services, while the services consultants conduct the detailed breakdown of costs. In view of this, Kadiri (2015) argued that the existing cost estimation models are either low in accuracy or slow in application. Hence, several predictive models have been developed over the years (Chan, 1999; Temitope, 2001; Adeniyi, 2004). An effective cost model aims to provide an acceptable solution within this scenario. Thus, this research adopts critical variables such as materials cost (piping cost, cable cost, fitting cost) and installation cost to model the contract sum for electrical services in residential buildings.

1.3 Aim and Objectives of the Study

This study is aimed at assessing the effects and implication of electrical materials and installation cost on total contract sum in selected building types in Abuja. The specific objectives are to:

i. identify the contract management techniques adopted in electrical projects for residential building in Abuja

ii. assess the effects of electrical materials and installation cost on total contract sum in selected building types

iii. identity critical items considered for electrical contract sum

iv. identify the factors affecting the total contract sum

1.4 Research Questions

The following are the research questions.

i. What are the contract techniques adopted in electrical projects for residential building in Abuja?

ii. How does electrical materials and installation cost affect total contract sum in selected building types?

iii. What are the critical item considered for electrical contract sum?

iv. What are the factors affecting the total contract sum?

1.5 Research Hypotheses

$H0_1$: There is no significant relationship between piping cost and total contract sum

$H0_2$: There is no significant relationship between cable cost and total contract sum

$H0_3$: There is no significant relationship between fitting cost and total contract sum

$H0_4$: There is no significant relationship between installation cost and total contract sum

1.5 Justification for the Study

Poor cost estimation is regarded as the beginning of project failure. This could lead to over or under-estimation as reported by Robert (2012).

The findings of this study will therefore contribute to the existing body of literature to provide useful guide to both contractors and clients alike in the determination of preliminary cost estimate for electrical installation works. More so, the established cost model for total contract sum for electrical services installation for residential buildings will provide appropriate guide to quantity surveyors or cost estimators for accurate cost estimation.

1.6 Scope and Limitation of the Study

This scope of this research will generally be limited to the specified research objectives. In addition, the study is limited to electrical services in residential buildings. Residential building types considered were 2 bedroom apartment, 3 bedroom apartment, and 4bedroom apartment. Electrical services in this context covers only wiring of the entire apartment, including all necessary fittings such as luminaries, sockets, and switches. Geographically, the research is limited to FCT, Abuja, as working drawings of completed buildings were randomly selected in this location. Summarily, the content scope of this research centered on services in residential buildings, service delivery in facility management, and costing services in residential buildings. Additionally, the finding of this study was restricted to data acquired from the questionnaire administered to respondents between April and August, 2021.

1.7 Study Area

Abuja in the center of Nigeria and within the Federal Capital Territory (FCT) Abuja was built mainly in the 1980s. It officially became the Nigeria capital on 12th December 1991, replacing Lagos which is till the country's most populous city. It has Kaduna State by the north, Nasarawa State to the east, Kogi State to the south-west and Niger State to the west. It lies between 7°20′ and 9°15′ North of the Equator and longitudes 6°45′ and 7°39′East Greenwich Meridian, Abuja is geographically located in the center of the country (Figure 1.1).

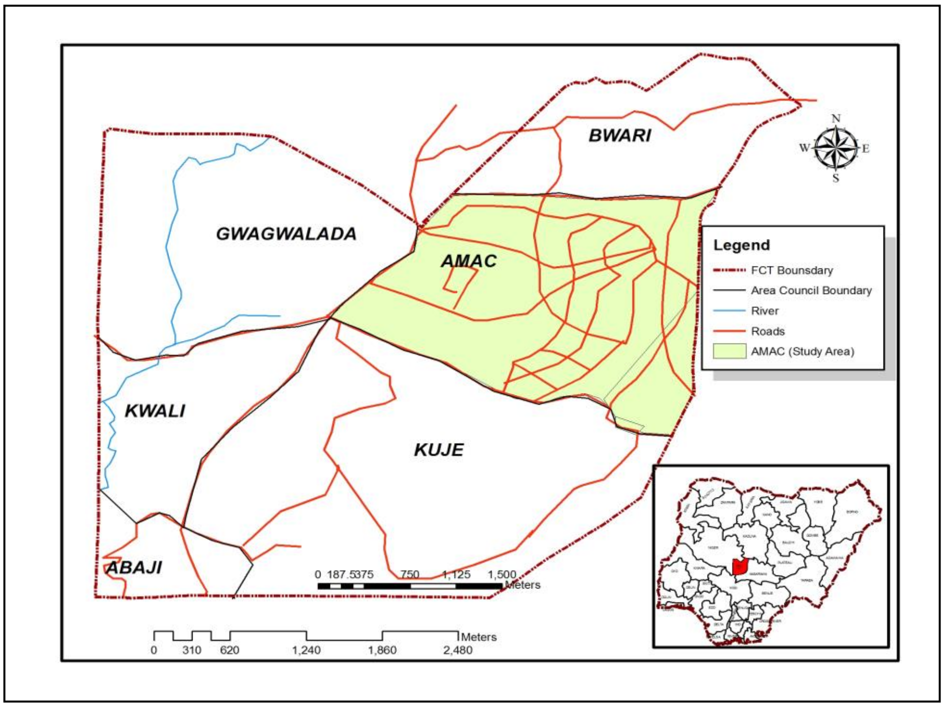

Figure 1.1: Location of Abuja
Source: FCDA, Abuja (2011)

Abuja is one of the fastest growing cities in West Africa. The territory has experienced rapid changes, urban spatial expansion and transportation infrastructure expansion over the last 30 years. Over time, urban growth significantly changed in Abuja which gave way to complex urban dynamics such as conversion of agricultural land to settlement, road and infrastructure (FCDA, 2011). The rate of population growth is high with an estimated annual growth rate of 9.4% (WHO, 2015). Because of its status in the country as the FCT, it has undergone and is still undergoing a vast amount of development in terms of commercial, residential, industrial, social and political growth, with the Federal Capital Development Authority (FCDA) charge with the responsibility of its spatial planning and development. The level of development in the city and the amount of offices and headquarters offices located in the FCT makes it a city where urbanization is at a high pace.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Services in Residential Buildings

The concept of building construction is a complex one, important, and a satisfying process, which starts with an idea and finishes in a structure that may serve its occupants for several years. According to Ogunbajo *et al*. (2016)residential buildings occupy a sizeable proportionate urban space, as they provide residency for human occupancy. Residential building development according to Ansah (2012) is regarded as a significant subsector of the real estate industry, and an essential element of national development. The subsector is capital intensive and attracts investors due to increased demand (Olujimi and Bello, 2009)

Mohammad (2006) states that the preliminaries in building constructions are required services necessary to complement services provided on the primary work. Such services account for about 10% of the total contract sum. These preliminaries may include storage facilities, site office, and power, among several others Mohammad (2006).
However, Udoka (2013) and Borvorn and Kunishima (2017) observed that urban infrastructure in Nigeria is generally constrained by corruption, political instability, inadequate budgeting among others.

Hence, measuring service delivery/performance to establish users' satisfaction is imperative. This is accomplished by contrasting the actual perception of the delivery with the users' anticipation. Consumers' expectations are predictions about what a good/service might deliver, whereas perception is consumers' real sentiments about the product/service; the degree of disparity between consumers' perceptions and expectations determines the service quality and level of satisfaction.

2.2 Service Delivery in Facilities Management

Chang and Wang (2007) described a service as “an activity or set of actions of a more or less intangible type that generally occur in interactions between customers and service staff, as well as the services provider’s physical assets. Consequently, facilities management as a growing discipline across the world was regarded as a cost cutting initiatives in the 1970s when outsourcing of services was trending (Noor and Pitt, 2009) this practice involves numerous activities under various professions, and combines resources which make facilities management vital to organizational success. Facilities management as defined by Becker (1990); Barrett (1995); Alexander (1996); Nutt (1999); Tay and Ooi (2001); Goyal and Pitt (2007); and Noor and Pitt (2009) means the creation of a cohesive environment using an integrated approach to conduct primary operations of an organization, and to improve user satisfaction.

Hence, the study supports Goyal’s opinion that facilities management is referred to as “the practice of managing and maintaining building fabrics and all associated equipment and services including the occupants of buildings, and financial resources to ensure the efficient performance of the property to give value for money”. Value for money is one of the most important aspects of high-rise residential facilities management because it determines the building’s economic performance and also contributes to the effectiveness of such a housing plan. (Hamzah *et al*., 2011).

Quality service is related to the customers’ need and expectations (Johnston and Clark, 2005; Kotler, 2003). According to Tang *et al*. (2010), service quality has five dimensions that, if met, can help reduce the cost of monitoring service contractors’ performance. Assurance, reliability, empathy, tangibles, and responsiveness are among the five dimensions.

According to Tansey *et al*. (2001), a study of the classical Roman bath would be incomplete without consideration of the pipes, water, and distant aqueducts that enabled it to function. Nowadays, the most important infrastructure is not water, but electricity in all of its vastness. This has become the built environment's new architectural order. Being without power for a period of time reminds us how reliant we have become on it and how impossible it is to picture life without it. Data networks and electricity lines are two separate types of installations. Because their origins (voice and data closets, electrical panels), paths (trays, tubes), and end pieces of the network, such as computers or television sets, are comparable or even physically fit into the same element. Hence, it is natural to arrange them in a unified manner.

Furthermore, these commonalities in line laying do not imply that they must always be adjacent. In fact, the requirements of services sensitive to electromagnetic interferences, such as scenic lighting lines in an auditorium or operating room supply lines, sometimes necessitate those networks to run parallel but separated by a short distance, minimizing the consequences. Nowadays, if the location of the power points and switches does not suit the users, the system used in these installations does not always satisfy them; changing the position of just one means calling in different tradesmen or spending hours of do-it-yourself work to attain a not-always satisfactory result.

Considering the disparities between the use and maintenance of electrical installations in a kitchen, possibly the most technologically demanding section of the house, and a car. A partial answer to the dilemma would be to accept installations in full view, with no design interpretation, from a practical and economic standpoint.

2.3 Measurement of Service Quality

User satisfaction or discontent is determined by meeting or failing to meet three types of expectations: implicit, explicit, and talent (Chang and Wang, 2007). The premise for answering two fundamental questions is the measurement of service quality and/or service delivery:

a. Is what is being done worth doing?
b. Has it been done well?

Performance measurement is critical for assessing past accomplishments and forming the basis for planning and control decisions (Cole, 2014). The goal of measuring service delivery/performance is to determine client or user satisfaction with a product or service. This is accomplished by contrasting the actual perception of the service/product with the users' expectations. The quality of service and level of satisfaction of consumers/users of products/services is determined by the degree of misalignment between consumer perceptions and expectations. The service quality (SERVQUAL) model can be used to assess the level of service provided by facilities management services. Customer satisfaction is the most important deliverable in facilities management when it comes to meeting contract agreements. (Siu *et al*., 2001; Chang and Wang, 2007).

Under the Strata Title Act (STA) of 1985, management corporations were established and charged with the job of facilities management in high-rise residential buildings in Malaysia. Facilities management in the Western world is farmed out to service providers with a clearly defined Service Level Agreement (SLA).

In Nigeria, the quality of services is primarily measured using benchmarking, which helps to establish a set of benchmarks against which the performance of facilities and the quality of services may be measured. In this instance, the standard defined by a provider or in an estate may be used as a yardstick by which any similar estate could be measured or surpassed. In-house or outsourced FM services are also options. The Service Quality Indicator has long been the go-to tool for gauging customer satisfaction with services. It has the following five generic dimensions:

a. *Tangibility* – Physical facilities, equipment and appearance of personnel
b. *Reliability* – Ability to perform the promised service dependably and accurately
c. *Responsiveness* – Willingness to help customers and provide prompt service
d. *Assurance* – (including competence, courtesy, credibility and security). Knowledge and courtesy of employees and their ability to inspire trust and confidence
e. *Empathy* – (including access, communication, understanding the customer) Caring and individualized attention that the firm provides to its customers.

The term "installation design" alludes to the ease with which it may be put up and maintained, rather than (obviously) the aesthetic effect. The true open floor in many architectural projects is not only the possibility of access to all services requested by users in any location, but also the more or less sophisticated changing of partitions. As a result, the true flexibility limit is the ability to employ the entire installation services in any part of the building.

The design of various installations has traditionally provided an excellent opportunity for architects to participate in the design of objects of various scales, ranging from lamps to air conditioning ducts integrated into the façade, with examples as notable as Kahn's concept of served and server spaces at the Salk Institute, a concept that in and of itself generates magnificent buildings, fundamental. Similarly, the stairwells, which also function as emergency exits, are divided into four sections in the plan, each positioned in one of the building's four outside corners, allowing the entire interior surface to be used for jobs. (Brooks, 2004).

Consequently, parking garages and decks are contemporary architectural elements that demonstrate the interdisciplinary character of the various themes that make up the structure, as well as its interior order, which is a mirror of what happens inside the building. Thus, TV aerials, satellite dishes, mobile phone aerials, collective chimneys, individual chimneys, cooling towers, cooling units, air conditioners, car parking ventilation extractors, and bathroom and toilet extractors all shape and are a part of the city's urban environment and image (Martín-Gómez and Zuazua-Ros 2012).

The layout of installations, the way the primary centralizations are raised, and the fire evacuation system used are all significant shapers of structures in certain typologies, such as high-rise or large-volume buildings. Different typologies emerge when these issues are considered. Researchers must also consider that each architectural typology necessitates a certain way of thinking. How is a high-rise structure cooled? Why aren't skyscrapers topped with a massive chimney? Why aren't these design principles employed in other structures? Once again, a parallel with the automobile industry may be drawn: just as developments in Formula 1 cars eventually filter down to simpler vehicles, concepts and advances in energy control and management previously reserved for the most "advanced" structures will eventually find their way into homes (Mahayuddin *et al*., 2017).

Numerous architects have studied various naval and aeronautical references in order to apply them to architecture, albeit in some cases just official activities rather than mental rigidity were transferred to their project. It's surprising that, on a high-tonnage ship with limited space, machines have everything they need in their technical rooms to make maintenance simple (without it, the ship's machine won't work), but in some architectural projects, installations must be reduced to minimum areas, in plan and section, without knowing the reason. The virtues of these advanced equipment (ships, aircraft), the coordination between the occupancy of areas and the laying of networks of the various installations, and the rest of the aesthetic, functional, and economic parameters that make up architecture should all be considered in the accurate installation design in architecture (Dickerson and Mavris, 2016; Cole, 2014).

2.4 Categories of Services/Installations in Buildings

Building services engineering is the engineering of a building's internal environment and its associated impact. It simply breathes life into buildings and structures. The mechanical, electrical, and public health systems essential for the safe, comfortable, and environmentally friendly functioning of modern buildings are designed, installed, operated, and monitored by building services engineers (Hall and Greeno 2017).

Building services engineering comprises mechanical engineering, electrical engineering and plumbing or public health engineering. Building services engineers work closely with other construction professionals such as architects, structural engineers and quantity surveyors. They influence the architecture of a building and play a significant role on the sustainability and energy demand of a building (Hensen and Lambert, 2012)
As such, a typical building services engineer has a wide-ranging duties and responsibilities:

i. Design: layouts and requirements for building services for residential and commercial developments are designed.

ii. Construction: managing the building services construction, commissioning systems, and continuous service maintenance and operation.

iii. Environmental: creating innovative energy-saving construction methods and constructing new and enhanced energy-saving building systems.

iv. Heating, ventilation, and air conditioning (HVAC): HVAC systems are designed, developed, built, and operated by HVAC specialists.

v. Electrical technology is concerned with the design and development of electrical systems that are necessary for the safe and efficient operation of structures.

2.5 Electricity Supply in Nigeria

Nigeria, with a population of 170 million people and a combined electrical producing capacity of 10,396.0 MW and available capacity of 6,056 MW, is still suffering from frequent power outages, as presented by Awosope (2014). The main reason for this is a lack of energy consumption planning. Despite the fact that the current administration is doing everything it can to increase daily generating capacity, little is known about residential power demand among customers in the industrial, commercial, and residential sectors of the economy. As may be seen in the majority of other emerging countries. Nigerian power consumption has increased with an upward trend of over 23% increment between 2000 and 2008.Although energy saving and efficiency is not a resource per se, it is acknowledged that its adoption in the country can significantly mitigate the supply challenge (Sambo, 2008)

According to data from (Langheim *et al.*, 2014), comparative analysis of electricity consumption in residential, commercial and industrial sectors accounted respectively for 51.3, 26.7 and 22 percent of total electricity consumption. It is highly important for government to take into account proper utility planning at the residential sector of the consumption. The Supply of electricity is a major challenge for both the urban and rural dwellers (Ohajianya *et al*., 2014; Awosope, 2014; Oyedepo *et al*., 2019)

Electricity has progressed from a curiosity of ancient scientists and engineers like Michael Faraday and James Prescott Joule to a daily requirement for people all around the world in the last century. Modern society requires sophisticated, safe, and dependable electric power infrastructure for social, political, and economic activity. Furthermore, regardless of the type of structure, the government and its regulatory agencies have a responsibility to ensure that electrical facilities are well-planned, consistent with building codes, efficient, simple to maintain, and operated in a safe manner.

There is currently a partial demand for electrical design plans by statutory bodies in Nigeria, as a result of which there is no comprehensive record of load demand and consumption for some types of buildings (bungalows and one-story buildings), which make up the majority of structures in our environments. All work on permanent electrical installations in residential and associated structures must conform to relevant building rules and standards in Europe and several African nations. Design, installation, inspection, testing, verification, and certification are all covered by these standards. Increase in energy demand was observed in case buildings at the University of Ibadan (Odunfa, 2015).

2.6 Electrical Building Design Diagram

Electrical building design diagrams, according to (Garba, 2019), are technical drawings that illustrate information concerning power, lighting, and communication for an engineering or architectural project. Lines, symbols, dimensions, and notations are typically used to accurately communicate an electrical engineering design to the employees (technicians) who install the electrical system on the job. The electrical design diagram is included in the documents intended for owners and can be used as evidence in court instances involving contractor unethical behavior or failure to follow the drawings and specifications' goals. Three important functions are served by an electrical design diagram.

a. Describes in details the electrical services of the building project; which enables electrical contractors to use the drawings in estimating the cost of materials, labour, and services when preparing contract bids.
b. Provides guidance to electricians in performing the required wiring of lighting and power installations while also warning them of potential hazards such as existing wiring, HVAC pipes, or plumbing systems.
c. Provides the owner with an "as-built" record of the installed electrical services for the purposes of maintenance or planning future expansion.

Components of an Electrical Diagram

i. General electrical requirements; which includes receptacles (sockets)
ii. Specialized electrical requirements such as specialized office equipment, microwave ovens, washing machines etc.
iii. Lighting systems
iv. Electrical distribution systems.

Electrical installation activities include:

i. installing electrical equipment and systems into new sites or locations;
ii. installing electrical equipment and systems into buildings that are being refurbished because of change of use;

iii. installing electrical equipment and systems into buildings that are being extended or updated;

iv. replacement, repairs and maintenance of existing electrical equipment and systems

2.6.1 The electrical team

A group of employees who have distinct tasks and duties make up an electrical contracting company. There is often no clear line between certain responsibilities, and an employee’s responsibilities vary from one employer to the next. If a firm is to prosper, its employees must work together to meet the needs of its customers. Customer contacts are crucial to a company’s performance and an employee’s job security.

2.7 Importance of electrical design drawings for all categories of buildings

Just as the architectural design of a proposed building is a necessary requisite for the erection of all cadre of buildings so is the electrical plans also imperative. The primary reason is not farfetched, electrical design drawing presents a potential direct additional load demands on the national grid, as such there is need for authority to be aware of this new requirements and adequately plan for growth. Also electrical building diagrams contain specific designs information for both installation works and load schedule estimates in conformity with all required building codes. Therefore, its importance towards adequate electric power supply are enumerated below:

i. Electrical design drawing eliminates tendencies of over loading of existing distribution facility. Appropriate expansion plans for additional feeders as the case may be would have been factored into the utility design plan for the particular area.

ii. Realistic projection or forecast of future load demand are easily made.

iii. Adequate record of buildings that are connected to the national electricity grid are captured by the regulatory bodies.
iv. Electrical design diagram makes maintenance work easier from an informed point of view. Thus, preventive and proactive maintenance is enhanced rather than repair and replacement.
v. It enables professionals and regulatory bodies to advice the public appropriately on energy efficiency and conservation.
vi. It ensures compliance with relevant electrical building and installation codes.
vii. Electrical design diagram offers improved safety against electrical shocks and fire out breaks.

Hence, The Institute and Regulatory Board should restrict the use of prime cost and provisional amount unless there are no drawings, and QS should be taught and retrained in electrical works, to name a few of the useful proposals offered (Ebekozien *et al.*, 2015)

2.8 Costing Services in Residential Buildings

Financing a residential building or any kind of project has always been a challenge for construction industry stakeholders. (Odunjo and Okanlawoa 2016), noted that the two major sources of finance strategies are formal and informal finance.

Odediran *et al.* (2013), the satisfaction of a building is a function of its facilities and quality of construction materials. However, Yusuf *et al*. (2013) identified five critical obstacles to pricing mechanisms for building services. These are; difficulty in design interpretation, late participation of consultants, lack of expertise, late production of working drawings, and the absence of a homogeneous method of measurement.

Kadiri (2015) noted that Contemporary valuation models provide frameworks for estimating the likely costs of an intended construction projects. However, many have been condemned for being either inaccurate or delayed to implement.

Owners demand that their design and construction teams respect the owner's financial and economic objectives and that they control costs during project delivery. This expectation is found in both the public and the private sectors in all client industries, locations, and financial situations. Owners also have in expectation that a budget prepared early in a project will be accurate and that the project will be completed to the required scope, quality, and performance within that budget (in terms of cost and time factors).

Owners invariably place a high priority on cost issues, regardless of the quality or other attributes of the project. They may even judge success or failure exclusively in terms of cost. During the past decade, professional organizations, educational institutions, government and private entities have supported the development of building cost models and provided seminars and other educational programs on this subject. The success of these efforts has varied, but one issue has become clear: Achieving high-quality design and implementing effective cost analysis and management are not contradictory objectives.

2.8.1 Requirements for electrical installations

Electricity design as described by Learn (n.d) 'is the process involving creating, planning, testing, and installation of electrical equipment in agreement with the approved regulations. The design may include power layout, electricity distribution layout and lighting plan among several others. According to Adelakun and Asogba (2020) electric power exists in forms that is easy to exploit. Hence, to minimize power losses, the design of electricity distribution in a residence must be accurate, as well as efficient installation. Olatomiwa and Alabi (2012) in their study posits that for any electrical installation involving any building type, a good plan or design involving calculations based on several considerations is the first step. These electricity service designs and specifications are normally regulated by several professional and government regulatory bodies Adelakun and Asogba (2020). Some of which include; 'NESIS (Nigerian Electricity Supply and Installation Standards), NERC (Nigerian Electricity Regulatory Commission), BSS (British Standard Specification), IEE (Institute of Electrical Engineers), and IES (Illuminating Engineering Society)' among others.

2.8.2 Notifiable electrical work

Before work begins, any work to be done by a firm or individual who is not registered under a "authorized competent person scheme" must be informed to the Local Authority Building Control Body (Linsley, 2008). That is, work that involves:

i. the provision of at least one new circuit,
ii. work carried out in kitchens,
iii. work carried out in bathrooms,
iv. Work carried out in special locations such as swimming pools and hot air saunas.

Upon completion of the work, the Local Authority Building Control Body will test and inspect the electrical work for compliance with Part P of the Building Regulations.

2.8.3 Non-Notifiable electrical work

This is electrical work performed by an individual or firm that is registered under a competent persons, self-certification scheme, or electrical installation work that does not entail the construction of a new circuit (Kitcher, 2009). This includes work such as;

i. replacing electrical fittings such as socket outlets, control switches, and ceiling roses;
ii. replacing a like-for-like cable for a single circuit that has been damaged by, for example, impact, fire, or rodent;
iii. re-fixing the enclosure of an existing installation component if the circuit's protective measures are unaffected;
iv. installing or upgrading the main or supplemental equi-potential bonding provided that the work is not in a kitchen, bathroom, or special location;
v. installing or upgrading the main or supplementary equi-potential bonding provided that the work is not in a kitchen, bathroom, or special location

CHAPTER THREE

3.0 MATERIALS & METHODS

The scope of this study is such that there might not be available data for this class of building; surrogate cost data will be made use of as opposed historical cost data for the development of the model. This involves the generation of piping cost, cable cost, fitting cost, and installation cost using current electrical market costs, on-site productivity constants, and relevant interviews with technicians and electrical engineering constants. The processes for analyzing the cost data received from the drawings are described in this chapter, as well as the process for acquiring data for the study. The research population, sampling frame and size, data collection device, data collection technique, and data analysis method are all covered in this chapter.

3.1 Research Design

The structure of a study aiming at finding variables and their relationships is characterized as research design. This is used to collect data in order for the researcher to test hypotheses or answer research questions. The goal of this study is to create a cost model for calculating the total contact sum for electrical installations in residential building floors. Hence, a structured questionnaire was adopted to gather primary data from Electrical engineers, Project managers, Quantity surveyors, Electrical technicians, and Procurement managers.

3.2 Study Population

The population for this research involves electrical engineers, project managers, quantity surveyors, electrical technicians, and procurement managers in Abuja, Nigeria who supplied the required information from architectural and electrical drawings of residential buildings.

3.3 Sampling Size

The Cochran's sample size formula was adopted to calculate the sample size of the study. This was used because the population size of could not be ascertained. Taking p as 0.5, e as 0.05 and a 95 % confidence level gives us Z values of 1.96, from the Z table.

$$n_0 = \frac{Z^2 pq}{e^2} \tag{3.1}$$

Where e = the desired level of precision (i.e. the margin of error),

p = the (estimated) proportion of the population which has the attribute in question,

q = 1 – p.

Thus

$$n_0 = \frac{1.96^2(0.5 * 0.5)}{0.05^2}$$

n_0= 384

3.4 Sampling Techniques

Because there is no list of electrical residential floor designs by electrical specialists, this research was conducted using a random sample technique. As a result of the sample technique used, caution should be applied when generalizing the findings of this study.

3.5 Data Collection Instrument

This study made use of information supplied by the identified practitioners which included piping cost, cable cost, fitting cost, and installation cost based on current market prices and site-observed productivity constants for the development of the cost model for electrical installation cost for selected residential building types.

3.6 Method for Data Analysis

According to Mason *et al*. (1983) statistics is a collection of tools for collecting, organizing, presenting, analyzing, and interpreting data in order to make better decisions. The analysis was conducted using Statistical Package for Social Science (SPSS). Results will be presented using descriptive and inferential statistics

3.6.1 Multiple regression analysis

Mason *et al*. (1983) define regression analysis as "the general technique of predicting one variable based on another variable". More so, it can be described as a method for determining a formula or mathematical model that best describes the facts collected. The dependent variable is designated by Y and is the factor whose value we want to estimate (e.g. aggregate scores). The independent variable, denoted by X, is the factor from which these estimations are derived. Following the same idea, multiple regression analysis extends this equation to incorporate several dependent variables. As a result, the dependent and independent variables' relationship might be characterized as

$$C_S = \beta_0 + \beta_1 P_C + \beta_2 C_C + \beta_3 F_3 + \beta_4 I_4 \qquad (3.2)$$

Where C_S = Total contract sum;

β_0 = Constant

$\beta_1 - \beta_6$ = coefficients of regression

P_C = Piping cost

C_C = Cable cost

F_c = Fitting cost

I_c =Installation cost

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

In this chapter, collected data has been analysed, arranged and summarized in tables in such a way as to transform them into usable information. Both descriptive and inferential statistical analyses are presented herein and the results discussed within the context of the research questions and objectives.

4.1 Response Rate

The outcome of the response was presented in Table 4.1

Table 4.1: Response Rate

Response Rate	Frequency	Percentage (%)
Response	197	51.3
Not returned	187	48.7
Total	384	100

Out of 384 questionnaires distributed, 197 were filled out correctly and collected, yielding a response rate of 51.3%. A response rate of 50% and above is adequate for research work (Idrus and Newman, 2002).The other 187 questionnaires were either incorrectly filled or not returned to the researcher and therefore were disqualified.

4.2 Demographic Characteristics

The following demographic characteristics were considered: Gender, Educational Qualifications, Professional Qualifications, Organization Type and Professional Practice Experience. These demographic data are further discussed below.

4.2.1 Gender of respondents

The gender distribution of the respondents is presented in Table 4.2

Table 4.2: Gender of Respondents

Gender	Frequency	Percentage (%)
Male	162	82
Female	35	18
Total	197	100

The study result shows that a total number of 162 representing 82% were male, while the remaining 18% represents the female gender. This implies that there are more male practitioners than females

4.2.2 Educational qualifications of respondents

The educational qualification of the respondents is presented in Table 4.3

Table 4.3: Educational Qualifications of Respondents

Qualifications	Frequency	Percentage (%)
ND	10	5
B.Sc/HND	107	54.3
M.Sc	61	31
PhD	19	9.7
Total	**197**	**100**

The result showed that 10 (5%) of the respondents have National Diploma qualification, 107 (54.3%) have Bachelor's Degree and Higher National Diploma, 61 (31%) have Master's Degree and 19 (9.7%) had PhD. This implies that a high number of respondents had above average education that goes beyond secondary education.

4.2.3 Profession of respondents

The professional qualification of respondents is represented in Table 4.4

Table 4.4: Profession of Respondents

Profession	Frequency	Percentage (%)
Electrical Engineer	79	40.1
Project Manager	39	19.8
Quantity Surveyor	10	5
Procurement Manager	20	10.2
Technicians	49	24.9
Total	**197**	**100**

This result shows 79 (40.1) of the respondents were Electrical Engineer, 39 (19.8%) were Project Manager, 10 (5%) were Quantity Surveyor, 20 (10.2%) were Procurement Manager and 49 (24.9) were Technicians. Respondents' professional qualifications were deemed suitable and adequate, as they are considered to have a basic understanding of the research questions.

4.2.4 Organization Type

The distribution based on the respondents' organization type is presented in Table 4.5

Table 4.5: Type of Organization

Profession	Frequency	Percentage (%)
Client Organization	79	40.1
Contracting Firm	97	49.2
Consulting Firm	21	10.7
Total	**197**	**100**

For the objective of this research, three (3) major organizations were chosen.40.1% (79) practice in Client Organization, 49.2% (97) in Contracting Firm and 10.7% (21) in Consulting Firm.

4.2.5 Profession practice experience

The years of respondent's professional practice is presented in Table 4.6

Table 4.6: Profession Practice Experience

Years	Frequency	Percentage (%)
1 – 5	12	6.1
6 – 10	87	44.2
11 – 15	39	19.8
16 – Above	59	29.9
Total	**197**	**100**

The result shows that 6.1% (12) have been practicing professionally between 1 – 5 years, 44.2% (87) between 6 – 10 years, 19.8% (39) between 11 – 15 years and 29.9% (59) between 16 – above. This implies that respondents have enough profession practice experience to partake in this research.

4.3 Contract Techniques Adopted In Electrical Projects

The study sought to identify the contract techniques adopted in electrical projects. The respondents were given a list of variables on different contract techniques and asked to tick the contract techniques adopted by them. The results are presented in Table 4.7.

Table 4.7: Contract Techniques

Contract Techniques	Frequency**	Percentage
Lump Sum or Fixed Price Contract	152	77%
Cost Plus Contracts	142	72%
Unit Pricing Contract	148	75%
Unilateral Contract	59	30%

***Multiple Responses Allowed*

The results show that the contract technique mostly adopted in electrical project is the Lump Sum (or Fixed Price) Contract accounting for 77% responses. This is because the Lump Sum (or Fixed Price) Contract is the simplest of all the other contract techniques.

It allows Engineers freedom and flexibility and provides the sponsors with a bit of certainty. The Engineer or Project Manager predetermines how much the project will cost, builds in their profit and contingency and works within the contract's scope and this gives the project sponsor the assurance that the project won't exceed a certain amount. This is closely followed by the Unit Price Contract accounting for 75% response. This is because under a Unit Price Contract, the Engineer provides the owner with a specific price for one or more tasks or a partial segment or a block of the overall work that's required on the project. The sponsor then agrees to pay for the units that the Engineer expends to complete the project which gives more flexibility to them. Result further showed that the Cost Plus contract was also adopted accounting for 72% of the responses. This is because the Engineer or contractor is paid for all of the project's expenses plus an additional fee to allow for a profit. It is also flexible allowing for changes in specification. Furthermore, Unilateral Contract with a response score of 30% was less adopted. This is because it is a contract created by an offer that can only be accepted by performance. In other words, the offer can only be accepted when the project is fully completed. So there is a possibility for the sponsor to fail or refuse to keep their promise even when the other party completes the project.

4.4 Effects of Electrical Materials and Installation Costs on Total Contract Sum

The study sought to assess the effects of electrical materials and installation cost on total contract sum in selected building types. The factors investigated were Materials Cost (Piping Cost, Cable Cost, and Fitting Cost) and Installation Cost. The inferential analysis is further discussed in the following sections.

4.4.1 Correlation results

Because the obtained samples are not normally distributed, the non-parametric statistic approach was applied. The relationship between the predictor variable(s) and the criterion was investigated using Spearman's Rank Correlation in this section. A range of 0.50 to 1.00 is considered strong, 0.30 to 0.49 is moderate, and less than 0.30 is weak while evaluating and interpreting the strength of the relationship between these variables. The results of the correlations between the variables for each of the selected type of apartment are presented in Tables 4.8, 4.9 and 4.10.

Table 4.8: Correlation Between the variables for Two Bedroom Apartment

		Piping Cost	Cable Cost	Fitting Cost	Installation Cost	Contract Sum
Piping Cost	rho	1				
	Sig.					
Cable Cost	rho	-.049	1			
	Sig.	.490				
Fitting Cost	rho	.038	.001	1		
	Sig.	.592	.985			
Installation Cost	rho	.090	-.019	-.031	1	
	Sig.	.209	.795	.669		
Contract Sum	rho	.332**	.793**	.313**	.325**	1
	Sig.	.000	.000	.000	.000	

***. Correlation is significant at the 0.01 level (2-tailed).*

The result of the correlation between the variables as presented in Table 4.8 reveals that there is a positive and moderate relationship (*r=.332)* between Piping Cost and Contract Sum significant at $p<.01$which indicate that an increase in Piping Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. There exist a very strong and positive relationship (*r=.793)* between Cable Cost and Contract Sum also significant at $p<.01$ which indicate that an increase in the Cable Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. Furthermore, there exist a positive and moderate relationship (*r = .313)* between Fitting Cost and Contract Sum significant at *p<0.01* which indicate that an increase in the Fitting Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between them. Additionally, there is positive and moderate relationship (*r = .325)* between Installation Cost and Contract Sum also significant at *p <.01* which indicate that an increase in the Installation Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between these variables.

Table 4.9: Correlation Between the variables for Three Bedroom Apartment

		Piping Cost	Cable Cost	Fitting Cost	Installation Cost	Contract Sum
Piping Cost	rho	1				
	Sig.					
Cable Cost	rho	.061	1			
	Sig.	.395				
Fitting Cost	rho	.034	.029	1		
	Sig.	.633	.691			
Installation Cost	rho	-.037	-.022	-.041	1	
	Sig.	.603	.755	.566		
Contract Sum	rho	.437**	.840**	.263**	.222**	1
	Sig.	.000	.000	.000	.000	

***. Correlation is significant at the 0.01 level (2-tailed).*

For the three bedroom apartment, the result of the correlation between the variables as presented in Table 4.9 reveals that there is a positive and moderate relationship (*r = .437)* between Piping Cost and Contract Sum significant at *p < .01* which indicate that an increase in Piping Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. There exist a very strong and positive relationship (*r = .840)* between Cable Cost and Contract Sum also significant at

$p < .01$ which indicate that an increase in the Cable Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. Furthermore, there exist a positive and weak relationship ($r = .263$) between Fitting Cost and Contract Sum significant at $p < 0.01$ which indicate that an increase in the Fitting Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between them. Additionally, there is positive and weak relationship ($r = .222$) between Installation Cost and Contract Sum also significant at $p < .01$ which indicate that an increase in the Installation Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between these variables.

Table 4.10: Correlation Between the variables for Four Bedroom Apartment

		Piping Cost	Cable Cost	Fitting Cost	Installation Cost	Contract Sum
Piping Cost	rho	1				
	Sig.					
Cable Cost	rho	.131	1			
	Sig.	.066				
Fitting Cost	rho	.008	-.024	1		
	Sig.	.909	.737			
Installation Cost	rho	.048	.061	-.117	1	
	Sig.	.502	.392	.101		
Contract Sum	rho	.299**	.714**	.570**	.247**	1
	Sig.	.000	.000	.000	.000	

**. *Correlation is significant at the 0.01 level (2-tailed).*

Also for the four bedroom apartment, the result of the correlation between the variables as presented in Table 4.10 reveals that there is a positive and weak relationship ($r = .299$) between Piping Cost and Contract Sum significant at $p < .01$ which indicate that an increase in Piping Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. There exist a very strong and positive relationship ($r = .714$) between Cable Cost and Contract Sum also significant at $p < .01$ which indicate that an increase in the Cable Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between the variables. Furthermore, there exist a positive and strong relationship ($r = .570$) between Fitting Cost and Contract Sum significant at $p < 0.01$ which indicate that an increase in the Fitting Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between them. Additionally, there is positive and weak relationship ($r = .247$) between Installation Cost and Contract Sum also significant at $p < .01$ which indicate that an increase in the Installation Cost would correspond to an increase in the Total Contract Sum, thus implying a direct relationship between these variables.

4.4.2 Hypothesis Testing

Because the dataset was not normally distributed, this study used Spearman Rank Correlation. The following hypotheses were investigated in this study.

$H0_1$: There is no significant relationship between Piping Costs and Contract Sum

$H0_2$: There is no significant relationship between Cable Costs and Contract Sum

$H0_3$: There is no significant relationship between Fitting Costs and Contract Sum

$H0_4$: There is no significant relationship between Installation Costs and Contract Sum

The summaries of the Spearman rank Correlation test for hypotheses one, two, three and four are shown in Table 4.11.

Table 4.11: Hypotheses 1 – 4 testing summaries (using spearman rank correlation)

Null Hypothesis	Sig.	Decision
$H0_1$ There is no significant relationship between Piping Costs and Contract Sum	.000	Reject the null hypothesis.
$H0_2$ There is no significant relationship between Cable Cost and Contract Sum	.000	Reject the null hypothesis.
$H0_3$ There is no significant relationship between Fitting Cost and Contract Sum	.000	Reject the null hypothesis
$H0_4$ There is no significant relationship between Installation Cost and Contract Sum	.000	Reject the null hypothesis.

For the first hypothesis, $H_o1$was rejected while $H_11$was accepted since it has a significant value of $p < .01;$ this implies that "there is a significant relationship between Piping Cost and Contract Sum". Also H_o2 was rejected while H_12 was accepted since it has a significant value of $p < .01;$ this implies that "there is a significant relationship between Cable Cost and Contract Sum". Also, H_o3 was rejected while H_13 was accepted since it has a significant value of $p < .01;$ this implies that "there is a significant relationship between Fitting Cost and Contract Sum". Furthermore, H_o4 was also rejected while H_14 was accepted since it has a significant value of $p < .01;$ this therefore implies that "there is a significant relationship between Installation Cost and Contract Sum". In conclusion, these hypotheses result is true for all the selected type of apartment used in this study.

4.4.3 Multiple regression analysis

A multiple regression was run to predict the total contract sum from piping cost, cable cost, fitting cost and installation cost for two bedroom apartment, three bedroom apartment and four bedroom apartment respectively. The results for each building type are further discussed.

4.4.3.1 Two bedroom apartment

The results of the multiple regression are presented in Table 4.12 to Table 4.14

Table 4.12: Model Summary

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
	.737	.643	.641	.374

The four significant predictors have a multiple correlation of R = .737 with the criterion. This indicates that the independent and dependent variables have a 73.7% relationship, implying that the model has a very high level of correlation. The *R* Square of the model is .643, this show that 64.3% of the dependent variable (Contract Sum)is explained by the independent variables (Piping, Cable, Fitting and Installation Cost); this further indicate that the regression plane is highly fit to the sample observation, with just 35.7% of the variable explained by other factors not included in the model. Additionally, the adjusted *R* Square shows that in the population, the four factors account for 64.1% of the variance contributing to contract sum.

Table 4.13: ANOVA (Model Validity)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.035	4	.009	68678.508	.000
Residual	.000	192	.000		
Total	.035	196			

This shows that this regression is significant at P < 0.01. This implies that all four predictor variables are effective at explaining the criterion.

Table 4.14: Regression Coefficients and Significance of the Independent Variables

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.584	.012		48.175	.000
Piping Cost	.215	.001	.358	186.687	.000
Cable Cost	.344	.001	.808	423.550	.000
Fitting Cost	.275	.002	.334	174.914	.000
Installation Cost	.166	.001	.345	180.154	.000

The model shows that all independent variables (Piping Cost, Cable Cost, Fitting Cost and Installation Cost) are statistically significant at $p < .001$. Unstandardized coefficient value for Piping Cost (0.215), Cable Cost (0.344), Fitting Cost (0.275) and Installation Cost (0.166) implies that a unit increase in these independent variables (when all other independent variables are held constant) will cause an increase of 0.215, 0.344, 0.275 and 0.166 respectively for the Total Contract Sum.

Therefore, the predicted equation is:

$C_S = 0.584 + 0.215P_C + 0.344C_C + 0.275F_C + 0.166I_C$................................Model 4a

Where, C_S = Contract Sum (₦)

P_C = Piping Cost (₦)

C_C = Cable Cost (₦)

F_C = Fitting Cost (₦)

I_C = Installation Cost (₦)

4.5.3.2 Three bedroom apartment

The results of the multiple regression are presented in Table 4.15 to Table 4.17

Table 4.15: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.763	.654	.650	.363

The four significant predictors have a multiple correlation of R = .763 with the criterion. This indicates that the independent and dependent variables have a 76.3% relationship, implying that the model has a very high level of correlation. The *R* Square of the model is .654, this show that 65.4% of the dependent variable (Contract Sum) is explained by the independent variables (Piping, Cable, Fitting and Installation Cost); this further indicate that the regression plane is highly fit to the sample observation, with just 34.6% of the variable explained by other factors not included in the model. Additionally, the adjusted *R* Square shows that in the population, the four factors account for 65% of the variance contributing to contract sum.

Table 4.16: ANOVA (Model Validity)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.020	4	.005	182536.430	.000
Residual	.000	192	.000		
Total	.020	196			

This shows that this regression is significant at $P < 0.01$. This implies that all four predictor variables are effective at explaining the criterion.

Table 4.17: Regression Coefficients and Significance of the Independent Variables

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.597	.008		74.641	.000
Piping Cost	.206	.001	.383	325.931	.000
Cable Cost	.389	.001	.815	695.198	.000
Fitting Cost	.237	.001	.271	230.988	.000
Installation Cost	.165	.001	.282	240.826	.000

The model shows that all independent variables (Piping Cost, Cable Cost, Fitting Cost and Installation Cost) are statistically significant at $p < .001$. Unstandardized coefficient value for Piping Cost (0.206), Cable Cost (0.389), Fitting Cost (0.237) and Installation Cost (0.165) implies that a unit increase in these independent variables (when all other independent variables are held constant) will cause an increase of 0.206, 0.389, 0.237 and 0.165 respectively for the Total Contract Sum.

Therefore, the predicted equation is:

$C_S = 0.597 + 0.206P_C + 0.389C_C + 0.237F_C + 0.165I_C$................................Model 4b

Where, C_S = Contract Sum (₦)

P_C = Piping Cost (₦)

C_C = Cable Cost (₦)

F_C = Fitting Cost (₦)

I_C = Installation Cost (₦)

4.5.3.3 Four bedroom apartment

The results of the multiple regression are presented in Table 4.18 to Table 4.20

Table 4.18: Model Summary

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.787	.715	.698	.282

The four significant predictors have a multiple correlation of R = .787 with the criterion. This indicates that the independent and dependent variables have a 78.7% relationship, implying that the model has a very high level of correlation. The *R* Square of the model is .715, this show that 71.5% of the dependent variable (Contract Sum) is explained by the independent variables (Piping, Cable, Fitting and Installation Cost); this further indicate that the regression plane is highly fit to the sample observation, with just 28.5% of the variable explained by other factors not included in the model. Additionally, the adjusted *R* Square shows that in the population, the four factors account for 69.8% of the variance contributing to contract sum.

Table 4.19: ANOVA (Model Validity)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.020	4	.005	182536.430	.000
Residual	.000	192	.000		
Total	.020	196			

This shows that this regression is significant at $P < 0.01$. This implies that all four predictor variables are effective at explaining the criterion.

Table 4.20: Regression Coefficients and Significance of the Independent Variables

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.588	.012		50.748	.000
Piping Cost	.202	.002	.192	117.915	.000
Cable Cost	.402	.001	.696	426.874	.000
Fitting Cost	.229	.001	.627	385.019	.000
Installation Cost	.165	.001	.290	177.908	.000

The model shows that all independent variables (Piping Cost, Cable Cost, Fitting Cost and Installation Cost) are statistically significant at $p < .001$. Unstandardized coefficient value for Piping Cost (0.202), Cable Cost (0.402), Fitting Cost (0.229) and Installation Cost (0.165) implies that a unit increase in these independent variables (when all other independent variables are held constant) will cause an increase of 0.206, 0.389, 0.237 and 0.165 respectively for the Total Contract Sum.

Therefore, the predicted equation is:

$C_S = 0.588 + 0.202P_C + 0.402C_C + 0.229F_C + 0.165I_C$................................Model 4c

Where, C_S = Contract Sum (₦)

P_C = Piping Cost (₦)

C_C = Cable Cost (₦)

F_C = Fitting Cost (₦)

I_C = Installation Cost (₦)

4.6 Items Considered for Total Contract Sum

The study sought to identify the items considered for total contract sum. The respondents were given a list of variables on different items and asked to tick their choices. The results are presented in Table 4.20

Table 4.20: Items Considered for Total Contract Sum

Contract Techniques	Frequency**	Percentage
Piping Cost	190	96.4%
Cable Cost	190	96.4%
Fitting Cost	189	95.9%
Installation Cost	191	96.9%
Building Type	190	96.4%
Gross Floor Area	170	86.3%

***Multiple Responses Allowed*

Findings showed that respondents considered all the items identified. Installation Cost ranked 1st with a percentage score of 96.9%, this indicate how important the cost of installation is to the total contract sum. Piping Cost, Cable Cost and Building type with a joint score of 96.4% all ranked 2nd. Furthermore, Fitting Cost and Gross Floor Area ranked lowest with a percentage score of 95.9% and 86.3% respectively.

4.7 Factors Affecting the Total Contract Sum

This study sought to identify the factors affecting the total contract sum. The respondents were given a list of variables on the following factors and asked to rate them using a five-point measurement scale. The results are presented in Table 4.22

Key: Strongly Disagree (1) Disagree (2) Undecided (3) Agree (4) Strongly Agree (5)

Table 4.22: Factors Affecting the Total Contract Sum

Factors	SD	D	UN	A	SA	Mean	ST.D	Rank
	Freq	Freq	Freq	Freq	Freq			
Design Error	0	0	10	64	123	4.57	0.712	1
Supplier Manipulation	0	0	10	98	89	4.40	0.643	2
Change Order	0	2	3	111	81	4.38	1.271	3
Government policies	0	1	25	101	70	4.23	0.745	4
Cost of Labour	0	5	23	96	73	4.20	0.575	5
Cost of Electrical Materials	6	10	15	79	87	4.17	0.659	6
Cost of Transportation	2	10	20	87	78	4.16	0.635	7
Method of Estimation	0	6	21	119	51	4.09	0.731	8
Duration of Contract Period	11	19	27	79	61	3.81	0.652	9
Gold Plating	12	25	62	65	33	3.42	0.866	10

Author's Field Survey (2021)

From the descriptive analysis, it is evident that most of the respondents with a mean of 4.57 strongly agree that design error is a major factor affecting the total contract sum. Design Errors are deviations from plans and specifications thereby resulting in modifications to the project design and specifications, in turn affecting the entire contract sum. Supplier Manipulation ranked second with a mean value of 4.40 is also another major factor affecting contract sum. Suppliers can substitute products or materials of lesser quality than specified in the contract, or use counterfeit, defective or used parts, in order to increase profits or comply with contract time schedules. The dishonest suppliers might give gifts or favours to inspectors or pay kickbacks to contracting officials to facilitate the scheme and will submit false documentation to conceal it. Furthermore, Change Order was ranked third with a mean of 4.23; this indicate that a contractor, in collusion with procurement official, can submit a low bid to insure winning a contract and then increase its price and profits by submitting change order requests after the contract is awarded. A dishonest contractor, acting alone or in collusion with contract personnel can submit unjustified or inflated change order requests to increase profits or as the result of corruption, use the change order process to extend a contract that should be re-bid. Government policies, cost of labour, cost of electrical materials, cost of transportation with mean values 4.23, 4.20, 4.17 and 4.16 are ranked 4^{th}, 5^{th}, 6^{th} and 7^{th} respectively. Method of estimation, duration of contract period and gold plating ranked lowest with mean values of 4.09, 3.81 and 3.42 respectively.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main aim of this research was to assess the effect of electrical material cost and installation cost on the total contract sum of selected building types (two-bedroom, three-bedroom and four-bedroom apartment). This was accomplished through the formulation of four research questions and objectives, and four hypotheses were also formulated. The following sections therefore makes conclusion according to the results in chapter four.

5.1.1 Objective One: to identify contract techniques adopted in electrical projects

This was accomplished through a detailed literature review on different contract techniques adopted. In addition to this, respondents were further asked to tick different contract techniques they have adopted over the years. Hence the study concluded that the contract technique mostly adopted in electrical project is the Lump Sum (or Fixed Price) Contract. It allows Engineers and Project Managers freedom and flexibility and provides the sponsors with a bit of certainty.

5.1.2 Objective Two: to assess the effects of electrical materials and installation cost on total contract sum on selected building types

To achieve this objective, three regression models were developed for this study for the selected building types (two-bedroom, three-bedroom and four-bedroom apartments). The variables investigated were Materials Cost (Piping Cost, Cable Cost, and Fitting Cost) and Installation Cost. For each of the models, all independent variables were found to be statistically significant at $p < .001$. Hence, the final models for each apartment are presented below:

$C_S = 0.584 + 0.215P_C + 0.344C_C + 0.275F_C + 0.166I_C$................................Model 4a

$C_S = 0.597 + 0.206P_C + 0.389C_C + 0.237F_C + 0.165I_C$................................Model 4b

$C_S = 0.588 + 0.202P_C + 0.402C_C + 0.229F_C + 0.165I_C$.................................Model 4c

Model 4a, Model 4b and Model 4c represents the final model for Two-Bedroom Apartment, Three-Bedroom Apartment and Four-Bedroom Apartment respectively.

5.1.3 Objective Three: to identify critical items considered for electrical contract sum

This objective was achieved by identifying critical items considered for total contract sum from literature. Respondents were further asked to tick the identified variables as related to their experience and considerations. From the findings, the study concluded that Installation Cost, Piping Cost, Cable Cost, Building Type, Fitting Cost and Gross Floor Area are the most important factors and items considered for the total contract sum.

5.1.4 Objective Four: to identify the factors affecting the total contract sum

Different factors affecting the total contract sum from were identified from literature and respondents were further asked to rate them (using a five-point measurement scale) according to their level of agreement and disagreement. Hence, the study concluded that the major factors affecting the total contract sum in order of importance according to findings are Design Error, Supplier Manipulation, Change Order, Government Policies and Cost of Labour while Contract Duration and Gold Plating were ranked lowest.

5.1.5 Hypotheses

The Spearman Rank Correlation was used in this study to test the hypotheses. From the correlation results, the null hypotheses (H_o1, H_o2, H_o3 andH_o4) were all rejected and the alternative hypotheses (H_11, H_12, H_13 andH_14) were accepted. Hence, the study concluded that “there is a significant relationship between Piping Costs and Contract Sum,” “there is a significant relationship between Cable Costs and Contract Sum,” “there is a significant relationship between Fitting Costs and Contract Sum,” and “there is a significant relationship between Installation Costs and Contract Sum.”

5.2 Recommendation

Based on the research findings and the models generated for this research, the following recommendations are made;

- The Piping Cost, Cable Cost, Fitting Cost and Installation Cost are good predictors of the Total Electrical Contract Sum and therefore should be determined and calculated accurately and correctly.
- Accurate electrical/architectural working drawings must be used for cost estimation.
- The study further recommended the Lump Sum (or Fixed Price) Contract, Unit Price Contract and Cost Plus Contract as the best contract technique for electrical projects (most especially for the selected building types).

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Appendix

THIS QUESTIONNAIRE SEEKS TO STUDY THE EFFECT OF ELECTRICAL MATERIALS AND INSTALLATION ON THE TOTAL CONTRACT SUM OF SELECTED BUILDING TYPES

SECTION A: DEMOGRAPHY OF RESPONDENTS

Instruction: Please specify and mark (√) in the appropriate column/box as it applies to you

1	Gender	Male	
		Female	
2	Academic Qualification	National Diploma (ND)	
		Bachelor's Degree/HND	
		Master's Degree	
		PhD	
3	Profession	Electrical Engineer	
		Technicians	
		Project Manager	
		Procurement Manager	
		Quantity Surveyor	
4	Type of Organization	Client Organization	
		Contracting Firm	
		Consulting Firm	
5	Years of Experience in Building Construction	1 – 5	
		6 – 10	
		11 – 15	
		16 – Above	

SECTION B: CONTRACT TECHNIQUES ADOPTED IN ELECTRICAL PROJECTS

Instruction: Please mark **(√)** in the appropriate column/box as it applies to you

Which of the following contract techniques do you adopt in your projects (multiple answers can be ticked)

	Contract Technique	
i	Lump Sum or Fixed Price Contract	
ii	Cost Plus Contracts	
iii	Unit Pricing Contract	
iv	Unilateral Contract	
v	Other (s)	

SECTION C: EFFECTS OF ELECTRICAL MATERIALS AND INSTALLATION COSTS ON TOTAL CONTRACT SUM

Instruction: Please give the right answers as related to your current experience in each of the following building types

1. Two Bedroom Apartment

Piping Cost (₦)	**Cable Cost (₦)**	**Fitting Cost (₦)**	**Installation Cost (₦)**	**Total Contract Sum (₦)**

2. Three Bedroom Apartment

Piping Cost (₦)	**Cable Cost (₦)**	**Fitting Cost (₦)**	**Installation Cost (₦)**	**Total Contract Sum (₦)**

3. Four Bedroom Apartment

Piping Cost (₦)	**Cable Cost (₦)**	**Fitting Cost (₦)**	**Installation Cost (₦)**	**Total Contract Sum (₦)**

SECTION D: Items Considered for Total Contract Sum

Instruction: Please mark (√) in the appropriate column/box as it applies to you

Which of the following do you consider for your Total Contract Sum.

	Items	
i	Piping Cost	
ii	Cable Cost	
iii	**Fitting Cost**	
iv	Installation Cost	
v	Building Type	
vi	Gross Floor Area	
vii	Other (s)	

SECTION E: Factors Affecting Total Contract Sum

Instruction: Please mark (√) in the appropriate column/box as it applies to you

	Factors Affecting Total Contract Sum	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
i	Cost of Labour					
ii	Cost of Transportation					
iii	Government policies					
iv	Cost of Electrical Materials					
v	Design Error					
vi	Change Order					
vii	Gold Plating					
viii	Method of Estimation					
ix	Supplier Manipulation					
x	Duration of Contract Period					