# ASSESSMENT OF THE NEED FOR ENVIRONMENTAL, FRIENDLY BUILDING MATERIALS FOR CONSTRUCTION IN KADUNA STATE.

**BY**

**MICAH, Zam, Zam**

**2016/1/60417TI**

**DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOLOGY**
**MINNA**

**APRIL, 2023**

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**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION FEDERAL UNIVERSITY OF TECHNOOGY, MINNA IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF TECHNOLOGY DEGREE (B. TECH) IN INDUSTRIAL AND TECHNOLOGY EDUCATION**

**APRIL, 2023**

## DECLARATION

I MICAH, Zam Zam, Matric No: 2016/1/60417TI, an undergraduate student of the Department of Industrial and Technology Education certify that the work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other university.

_____ _____

**MICAH, Zam Zam** **Signature & Date**
**2016/1/60417TI**

## CERTIFICATION

This project has been read and approved as meeting the requirements for the award of B. Tech degree in Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology, Minna.

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| _____ | _____ |
| DR. A.B. Kagara<br>Project Supervisor | Sign & Date |
| _____ | _____ |
| Dr. T. M. Saba<br>Head of Department | Sign & Date |
| _____ | _____ |
| External Examiner | Sign & Date |

## DEDICATION

With profound joy and gratitude in my heart, I dedicate this project to God Almighty for His Unshakable and Unbreakable Faithfulness. His Divine and constant guidance in my life has made this project a reality today. Thank God

## ACKNOWLEDGEMENTS

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## ABSTRACT

The study was designed to assess the need for environmentally friendly materials for building construction in Kaduna State. Four research questions were raised. The study adopted the descriptive survey research design. The sample for the study comprised of thirty-seven (37) respondents that consisted of builders, engineers, surveyors, architects, project and facility managers. The instrument for data collection titled "Assessment of Environmentally Friendly Materials for Building Construction Questionnaire" (AEFMBCQ)". The instrument was validated by ITE experts and a reliability test was carried out using the Pearson's Product Moment Correlation Coefficient (PPMC) which gave reliability index of r=0.67. the data collected was analyzed using mean and standard deviation. The findings of the study revealed that environmentally friendly materials are available. The findings of this study also revealed that environmentally friendly materials are being utilized. The findings of this study also revealed that environmentally friendly materials has an a positive effect on the environment, the findings of this study also revealed that environmentally friendly materials are cost intensive. The study made recommendations which included that the government should consider the implementation and revision of already existing policies as regarding the utilization of environmentally friendly materials, there should be subsidies and laws to promote environmentally friendly materials.

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# CHAPTER ONE

# 1.0 INTRODUCTION

## 1.1 Background of the study

A building can be generally considered as a structure consisting of floors, walls and roofs erected to provide covered space for different uses such as residence, business, entertainment, workshop etc (National Academic Digital Library of Ethiopia, 2021). The majority of such construction is the outcome of the design for better living conditions. A construction is something made by man for one purpose or another. It may be a road or a path, a bridge, a dam, a dwelling place, airport or building etc. The construction industry has a significant impact on the environment, economy, and society. Buildings are one of the biggest contributors to greenhouse gas emissions; for which they are responsible for 38% of all carbon dioxide **emission(**United Nations Environment Programme, 2019**).** Industrial sectors, including the building sector, started to recognize the impact of their activities on the environment in the 1990s. Significant changes were needed to mitigate the environmental impact of building sector (Mesaros *et al.,* 2023). There is concern about how to improve construction practices in order to minimise their detrimental affects on the natural environment (Mackova *et al.,* 2016).

Construction materials use resources of a country, and a proper selection of materials is thus important for sustainable development. Thus, there is a clear need to design and construct buildings to support the concept of sustainable development. Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs

can be met not only in the present, but in the indefinite future (Emas, 2015). The quality of the built environment also affects its inhabitants in many ways and is dependent not only on the architectural form and specification, but also on the quality and nature of materials used, the care taken in construction, the quality of building services design and components, and the timely and effective maintenance of the building fabric and support systems. A major factor in the development of building materials is that new structures are being asked to perform increasingly multifaceted tasks. In addition to their traditional load-bearing capacities and use as room partitions, building materials also need to fulfil a multitude of additional functions today. Along with technical criteria, economic and environmental criteria have become increasingly important factors when choosing and developing building materials. Materials with the smallest possible environmental impact (such as low levels of toxic emissions or required primary energy) are considered sustainable and suitable for use in the future (Kumar, 2020). Environmentally friendly building materials and constructions are intended to reduce energy and material flows during the entire building life cycle. The evaluation is focused on the assessment of consumption and depletion of material resources, especially non-renewable resources, to minimize the life-cycle impact of materials on the environment and enhance the indoor environmental quality by concentrating on the evaluation of energy flows through the building construction.

For few decades climate change has become increasingly important in the global context (Apanavičienė *et al.,* 2020). By acknowledging destructive changes in the environment, governments, scientists, entrepreneurs, and society consider the new ways of living and doing business with the least impact on nature and the environment. Buildings construction and operations accounted for 36% of global energy use and 39% of energy related carbon dioxide emissions in 2017 (Intergovernmental Panel on Climate Change, 2018). The construction industry

is the single largest global consumer of resources and raw materials. It consumes about 50% of global steel production and, each year, 3 billion tonnes of raw materials are used to manufacture building products worldwide. It produces an enormous amount of waste (World Economic Forum, 2016). These are significant issues to think over and change the standards for building design, construction and operation that have been established during the past decades. In many advanced countries norms, laws and standards have been adopted that define the life cycle of a country's buildings from design to demolition. Unfortunately, not all countries are concerned about the sustainability of buildings, which requires a responsible approach to the environment, awareness of the problem from the public and private sector and a common understanding of society. Only in the last decade significant research has been carried out on this subject, which made it possible to realize the results to be achieved in the area of building sustainability and emphasize the direction to be followed in order to reduce the environmental impact caused by buildings.

Environmentally friendly building materials are those that provide appropriate service and life span, with minimum maintenance, while minimizing the extraction of raw materials, the pollution from, and energy consumed by manufacturing and use, and that have the maximum potential for reuse or resource recovery (Rousseau, 2008). Building materials, from their resource extraction through manufacturing, use and disposal have become a major component of the total human effects on global ecosystems and the earth’s climate, particularly in the two centuries since the advent of the industrial revolution. In the past half-century, with the rapidly advancing pace of urbanization worldwide, finding the raw materials and energy to produce building materials, and absorbing the waste from their production, use and disposal have become pressing global problems. For example, the production of Portland cement alone represents 8% of total global greenhouse gas releases deriving from human sources (WRI) (Mikulčić, 2016). Another highly

visible example is the unprecedented degree of deforestation occurring worldwide to produce wood for building construction. The resulting loss of forest diversity, soil stability, water quality and other long-term ecological and economic values are well known. Because all manufactured building materials industries are raw material and energy consumers, and produce some degree of waste, they are important targets worldwide for efficiency improvements and environmental pollution reductions. The search for environmentally friendly building materials represents a response from the building sector intended to reduce the environmental cost of making and using buildings. Environmentally friendly building materials may come from traditional sources, such as earth and stone materials, they may come from existing industrial processes, found by life-cycle-analysis to be the most environmentally benign, or they may come from new processes or raw material inputs such as industrial waste (Rousseau, 2008). Whatever their source, environmentally friendly materials are just one part of the necessary range of responses required to make buildings and cities that are more environmentally responsible. Many other factors such as operating energy efficiency, integrated design, reduction of water consumption and waste, reduction of private automobile use etc. are at least as important as environmentally-friendly materials alone. Furthermore, the way materials are selected and applied in a building is also a very significant component of resource efficiency. For example a floor system may be as complex as a framing layer, a structural sub floor layer, a flooring underlayment, an adhesive or fastening layer and a finish layer. Alternatively, a single material such as a reinforced concrete suspended slab may be finished with a colorant and sealer and serve all these functions.

The increasing environmental impact from the construction becomes a serious problem. Therefore, it is necessary to approach and continuous effort within the industry in order to achieve the objectives sustainable construction and reducing of the environmental impacts of construction.

The majority of constructions are still constructed using traditional technology (masonry, concreting). On the other hand, the last few years it has been increased use of modern methods of construction mainly for housing, driven by a range of factors including demands for faster construction, skills shortages and sustainability of construction. Modern methods of construction involve a wide range of techniques and materials, but the overarching aim is minimise the amount of time required to construct a building on site.

### 1.2 Statement of the problem

The use of the prevalent building materials for construction have been deemed as pollutant as this has not only affected the human health but has constituted a threat to the environment, studies by experts (Pacheco-Torgal *et al.*, 2022; Malik & Marathe, 2022; Pacheco-Torgal & Jalali, 2011) have revealed the dangers to environment by the use of toxic building materials, these materials have contaminated water bodies, toxic building materials causing emission of volatile organic compounds from paints and varnishes, the toxicity of impregnating agents, materials that release toxic fumes during a fire, asbestos-based materials, radioactive materials and lead plumbing. research findings have proferred alternative to this environmental crisis such as sustainable housing (**Švajlenka** & **Kozlovská**, 2018; Ezennia & Hoskara, 2019). The general goal of sustainable development is to meet the essential needs of the world's poor while ensuring that future generations have adequate resources base to meet theirs. It is thus geared towards meeting the needs of the present generation without compromising the ability of future ones to meet their own needs. Notably, the rapid increase in the population of urban centres has resulted in an increase in the cost of living because of higher demand on urban commodities. There is a dearth and high cost of urban land, and high cost of housing, which is often in short supply and out of the economic reach of the majority of the urban households (Oladapo & Olotuah, 2010). The issue of ecological

and environmental pollution due to toxic building materials is a significant problem worldwide, and Nigeria is not exempted. The high and increasing population in urban centers has also created severe housing problems, resulting in overcrowding in inadequate dwellings. This situation has led to mass production of building materials for construction, some of which are toxic to the environment. Eco-friendly building materi-als (EBMs) available in Nigeria include earth-based bricks, bamboo, quarry dust, natural fibres, agro-waste ash and industrial wastes [11]. Earth-based bricks (EBBs) have the potentials of reducingthe cost of building units in Nigeria which will ultimately make housing affordable to the populace. The advantages ofusing earth-based bricks in place of cement blocks include reduction in the release of greenhouse gases to the atmos-phere, energy efficiency, and low cost of production.

### 1.3 Aim and Objectives of the Study

The aim of this study is to assess the need for environmentally friendly materials for building construction in Kaduna State Specifically, the study will achieve the following objectives: To;

1. Investigate the level of availability of environmentally friendly materials for building construction in Kaduna State.
2. Determine the level of utilization of environmentally friendly materials for building construction in Kaduna State.
3. Find out the effect of of environmentally friendly materials on the environment
4. Examine the financial cost of environmentally friendly materials for building construction in Kaduna State.

## 1.4 Research Questions

The following research question were formulated to guide this study:

1. What is the level of availability of environmentally friendly materials for building construction in Kaduna State.
2. What is the level of utilization of environmentally friendly materials for building construction in Kaduna State.
3. What is the effect of of environmentally friendly materials on the environment
4. What are the financial cost of environmentally friendly materials for building construction in Kaduna State

## 1.5 Significance of The Study

The result of this research will be of immense importance or benefit to residents of kaduna state, environmental organizations, builders, and construction companies, building material suppliers, government agencies and the society at large in the following ways:

Residents of Kaduna State: The residents of Kaduna State can benefit from the study findings by living in buildings that are constructed using environmentally friendly materials. These buildings can offer a healthier and more sustainable living environment, which can have a positive impact on their quality of life. Environmental organizations in Kaduna State can benefit from the study too by using them to advocate for policies and regulations that promote sustainable building practices

Builders and construction companies: Builders and construction companies in Kaduna State can benefit from the study findings by using them to improve their building practices and materials. The findings can help them to make informed decisions about the types of materials they use, and

to develop strategies to reduce their environmental impact. Building material suppliers in Kaduna State can also benefit from the study by using them to develop marketing strategies and to improve their product offerings.

Government agencies: The state government agencies responsible for housing, construction, and environmental regulation can benefit from the study findings. They can use the results to develop policies and regulations that promote the use of environmentally friendly building materials in the state.

### 1.7 Scope of The Study

This study covers the assessment of the need for environmentally friendly materials for building construction in Kaduna State. It involves gathering reliable data from Professionals involved directly and indirectly with construction activities- builders, engineers, surveyors, architects, project and facility Managers in Construction companies that either has a branch or its headquarter in Kaduna State. This study will cover all the construction companies and will last for a period of four (4) weeks.

### 1.8 Operational Definition of Terms

**Building**: A building can be generally considered as a structure consisting of floors, walls and roofs erected to provide covered space for different uses such as residence, business, entertainment, workshop etc

**Sustainable development**: Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but in the indefinite future

**Environmentally friendly materials**: Materials with the smallest possible environmental impact (such as low levels of toxic emissions or required primary energy) are considered sustainable and suitable for use in the future.

# CHAPTER TWO

# LITERATURE REVIEW

In this chapter, applicable literature related to the present study had been reviewed, they have been under the following heading: Conceptual Framework, Theoretical Framework, Empirical Studies and Summary of Literature Reviewed.

## 2.1 Conceptual Framwork

### 2.1.1 Building construction

In project architecture and civil engineering, construction is the building or assembly of any infrastructure on a site or sites (WikiUniversity, 2020). Building construction means generally the construction of sheltered enclosures with walk-in access for the purpose of housing persons, machinery, equipment, or supplies. It includes all construction of such structures, the installation of utilities and the installation of equipment, both above and below grade level as well as incidental grading, utilities and paving, unless there is an established area practice to the contrary. Additionally, such structures need not be "habitable" to be building construction. The installation of heavy machinery and/or equipment may not change the project's character as a building. Building construction is the process of creating or constructing buildings or other structures, such as bridges or dams, from a design or blueprint (Reitherman, 2008). It involves a series of activities that include planning, design, excavation, foundation work, framing, plumbing, electrical work, roofing, and finishing work. Building construction is a complex process that requires the coordination and integration of various disciplines, including engineering, architecture, and construction management.

Planning is an essential component of building construction (Goud and Kumar, 2021). It involves the development of a project plan, which outlines the goals, objectives, and requirements of the project. The project plan typically includes a detailed schedule, budget, and resource allocation

plan. The project plan serves as a guide for the entire construction process, and it is used to monitor progress and make adjustments as needed. The design phase of building construction involves the development of the building's design and the preparation of construction documents (Ogasawara & Yashiro, 2018). The design process is typically led by an architect, who works closely with the owner and other stakeholders to develop a design that meets their needs and requirements.

The design phase involves the selection of materials, finishes, and fixtures, as well as the development of detailed construction drawings and specifications. Excavation and foundation work are critical components of building construction. Excavation involves the removal of soil and other materials from the construction site to create the foundation for the building (Ethelbert, 2022). Foundation work involves the creation of a solid base on which the building will be constructed. The type of foundation used depends on the type of soil and other factors such as the height of the building. Framing is the process of creating the structure of the building. This involves the installation of support beams and columns, as well as the installation of walls, floors, and ceilings. Plumbing and electrical work are also installed during this phase of the construction process (Korman & Lu, 2011).

Roofing and finishing work are the final stages of building construction. The roofing process involves the installation of the roof, which can be made of various materials, such as asphalt shingles, metal, or tile. Finishing work involves the installation of flooring, wall finishes, and other details such as trim, paint, and fixtures. Throughout the building construction process, it is essential to ensure that the construction meets all safety and building code requirements. Building codes are regulations that are enforced by local governments to ensure that buildings are safe, structurally sound, and meet minimum standards for health and safety. Building codes vary depending on the location of the building and the type of building being constructed.

In conclusion, building construction is a complex process that requires careful planning, design, and execution. It involves the coordination of various disciplines and requires a deep understanding of materials, techniques, and safety regulations. Building construction is essential for creating the physical infrastructure that is necessary for modern society to function, and it is an industry that will continue to be important for many years to come. Although this may be thought of as a single activity, in fact, construction is a feat of multitasking. Normally the job is managed by the construction manager, supervised by the project manager, design engineer or project architect. While these people work in offices, every construction project requires a large number of laborers, carpenters, and other skilled tradesmen to complete the physical task of construction.

For the successful execution of a project effective planning is essential. Those involved with the design and execution of the infrastructure in question must consider the environmental impact of the job, the successful scheduling, budgeting, site safety, availability of materials, logistics, inconvenience to the public caused by construction delays, preparing tender documents, etc. Building construction is the process of adding structure to real property. The vast majority of building construction projects are small renovations, such as the addition of a room, or renovation of a bathroom. Often, the owner of the property acts as a laborer, paymaster, and design team for the entire project. However, all building construction projects include some elements in common - design, financial, and legal considerations. Many projects of varying sizes reach undesirable end results, such as structural collapse, cost overruns, and/or litigations reason, those with experience in the field make detailed plans and maintain careful oversight during the project to ensure a positive outcome.

### 2.1.2 **Toxic building materials**

Toxic building materials are materials used in construction that can release harmful substances into the air or water, putting the health of both humans and the environment at risk. These materials can be found in everything from insulation to flooring, paint, and roofing materials. Our planet faces a major challenge that if not solved, or if it is just postponed, may lead to the end of our civilisation, as we know it. Humans use many kind of resources, including non-renewable ones, leaving traces of pollution in the consumption process, and only a few people consume the majority of resources to make things worse (Freedman, 2018). The immediate effects of civilisations' consumption patterns, with the consequences for nations and for future generations, have never been revealed in inter-generational and inter-geographic dimensions (Stern 2006).

A recent report of the Intergovernmental Panel on Climate Change (IPCC 2007) mentioned that rising sea levels would have, therefore, approximately 200 million refugees. Environmental worries in the modern society have increased since 1972 when the United Nations Conference about the Environment took place in Stockholm. But it was only in 1987 that they gained a wider impact after the publication of the report 'Our Common Future', also known as the Bruntland Report (Bruntland 1987), in which the concept of sustainable development first appears as the one 'that allows the fulfilment of current needs without preventing the needs of future generations'. The construction industry is responsible for the depletion of large amounts of non-renewable resources and for the carbon dioxide gas emissions. To achieve a more sustainable construction, the European Union recently established that in a medium term, raw material consumption must be reduced by 30% and that waste production in this sector must be cut by 40%. Although sustainable resource consumption is of paramount importance for sustainable construction, building material's toxicity is no less important. While our ancestors lived in buildings made of raw materials, nowadays residential buildings contain thousands of chemicals and heavy metals,

polluting indoor air or contaminating tap water. Thus, causing several health related problems such as asthma; itchiness; burning eyes, skin irritations or rashes, nose and throat irritation; nausea; headache; dizziness; fatigue; reproductive impairment; disruption of the endocrine system; impairing child development and birth defects; immune system suppression and cancer. Beyond the toxicity of indoor building materials, one must not forget also the toxicity potential during the production of such chemicals. Remember for instance the Bhopal disaster that occurred in India, in 1984, when a cloud of methyl isocyanine caused almost 15,000 deaths and health problems in almost 200,000 human beings (Varma and Mulay 2006, Satyanand 2008). During the production of chemical materials, hazardous wastes are generated, and that impact must be associated to building materials containing these chemicals. The most common toxic chemicals are the following: Dioxins and furans Dioxins and furans are the chemical waste generated in the industrial process evolving chlorine as it occurs in PVC production.

1. Dioxins and furans are extremely toxic and bio-cumulative (Central Pollution Control Board, 2004). This has hazardous effects in biodiversity by all of the food chain (Meer *et al.,* 2020). Thornton (2000) revealed in the last four centuries the concentration of dioxin and furans in sediment cores from the Baltic region and in two German lakes increased from zero to almost 100%. Furthermore, chemical analysis carried out on dolphins in the northern Pacific Ocean revealed dioxin and furan concentrations between 13 and 37 million times higher than water concentrations (Thorton 2000). Several scientist groups already suggest that chlorine industrial-based production should be prohibited (Flores et al. 2004).
2. Phthalates: These are the chemical compounds formed due to phthalic acid. Phthalates are used to soften plastic materials. Several studies show that phthalates are very toxic to

human health (Lovekamp-Swan and Davis 2003, Hauser and Calafat 2005, Heudorf et al. 2007, Swan 2008, Wolff et al. 2008, Meeker et al. 2009).

3. Volatile organic compounds These are the atmospheric pollutants released from the building materials which contain organic solvents like paints and varnishes. The reduction of indoor ventilation to minimise energy consumption (as it often happens in Portugal) contributes to increasing the effects of volatile organic compounds (VOCs) in human health (Sterling 1985, Samfield 1992, Hansen and Burroughs 1999). The importance of this subject will require awareness for everyone; mainly those who will have a major role in climate change issues as in the case of professionals working in construction-related activities (industry or academia). The present paper covers emissions of VOCs from paints and varnishes, the toxicity of wood impregnating agents, the materials that release toxic fumes during a fire, asbestosbased materials, radioactive materials and lead plumbing.
4. Emission of VOCs from paints and varnishes: Several authors confirm the release of VOCs from paints and varnishes (Kwok et al. 2003). More recently, Salasar (2007) studied VOCs emissions in solvent- and water-based paints stating that their form is responsible for VOCs emissions, which is 520 times higher than the latter. Paint can also be a source of several cancer agents. In Portugal, the legal Decree No. 181/2006 of 6 September corresponds to the EU Directive No. 204/42/CE (21 April 2004). This legislation intended to put a threshold on the VOCs emissions from paints and varnishes. One can see that beyond 1 January 2007, the VOCs emissions must be reduced, and beyond 1 January 2010 they must be reduced even more. This means that until the new low VOC paints and varnishes are introduced into the construction market, we all have been breathing very high levels of VOCs.

5. Toxicity of wood impregnating agents Although wood is an excellent example for sustainable building,it has low resistanceto biologic degradation (fungal and insect attack) (Morrell 2002). Until very recently, wood preservation would mean the use of impregnating agents (insecticides or fungicides) like creosote or others based on salt impregnation like copper, chrome, and arsenic (CCA). However, these salts are highly toxic also biocumulative. When they are in contact with rainwater, most part of these salts are leached away, contaminating the environment. Since 1 January 2004, the US EPA forbade the use of CCA for wood preservation (Edlich et al. 2005). As to creosote, it contains cancer potential agents (ASTDR 2002, Smith 2008); therefore, since 2001 Directive 2001/90/EC, a process was initiated to ban the use of creosote in wood treatment purposes. Some studies mentioned that wood used in railway cross ties has a high content of creosote (Thierfelder and Sandstrom 2008) so they must be seen as hazardous wastes, meaning that they must be properly immobilised and they can no longer be reused. The same should happen to all the creosote-treated wood, which in the near future would become construction and demolition waste.
6. Materials that release toxic fumes during fire Another case of building materials toxicity is related to materials that release toxic fumes during a fire. Some studies show that the majority of deaths during fires are due to inhalation of toxic fumes, and that the deaths are increasing since the 1980s, which may be due to the fact that the amount of combustible materials inside households have increased in the last three decades (Levin and Kuligowski 2005). Liang and Ho (2007) studied the toxicity during a fire of several insulation materials concluding that polyethylene foam and polyurethane foam have a toxicity index (TI) above 10, thus meaning a very high toxicity. The IT is obtained from

the emissions of 14 different combustible gases to form a deadly concentration after 30 min exposure. These authors recommend that polyethylene foam and polyurethane foam should not be used unless covered by non-combustible materials. Others (Doroudiani & Omidian, 2010) say that polystyrene decorative mouldings should be avoided because polystyrene is a very combustible material, which releases toxic fumes during a fire. They also say that new polystyrene with flame-retardant properties is now being produced, but it also releases other toxic substances.

7. Asbestos-based materials: One of the most common toxic building materials is asbestos. Asbestos was commonly used as insulation in homes and buildings until the 1980s when its dangers were discovered. Asbestos fibers are known to cause cancer and lung diseases, and if disturbed during renovations or demolition, can release toxic dust into the air.Asbestos covers several mineral fibres with 5-mm length and 3mm in diameter such as chrysolite, crocidolite, amosite, anthrophyllite, tremolite and actinolite. It was not until the 1960s that a relation between asbestos exposure and several specific diseases was established by the scientific evidence. By that time, only some mineral fibres (crocidolite – blue asbestos and amosite – brown asbestos) were judged as toxic and responsible for pleural mesothelioma from which most patients died, 12 months after being diagnosed (Azuma et al. 2009). Chrysolite (white asbestos) was left aside because it was thought that it had a low toxic risk and that is why asbestos continued to be produced. Only in the 1980s with the Directive 83/477/CEE, the asbestos problem started to be taken more seriously. In Portugal only after 6 years, the Decree No. 284/89 of 24 August came into practice the content of Directive 83/477/CEE.After some years the Directive 91/382/EEC, which has enforced even more strict caution about asbestos, and finally Directive 2003/18/EC

prohibited the production of asbestos-based products. In the meantime, scientific evidence proved that all mineral fibres present a cancer risk as asbestosis (lung damage due to acid formation in an attempt of the body to dissolve the asbestos fibres) (Akira 2010) or even lung cancer or other types of cancer (Silverstein et al. 2009, Antonescu-Turcu and Schapira 2010).

Four years later, Portugal adopted the Directive 2003/18/EC by issuing the Decree No. 266/2007 of 24 July which defines a threshold risk (value of limit exposition) when asbestos fibre concentration is higher than 0.1 fibre/cm3. Although some may think asbestos is no longer a problem let, we cannot forget the vast number of fibre cement materials, which are asbestos, based which are still in place. Portugal, for instance, has almost 600,000 ha of fibre cement asbestos roofing sheets. One may argue that Toxicity of wood impregnating agents Although wood is an excellent example for sustainable building,it has low resistanceto biologic degradation (fungal and insect attack) (Morrell 2002).

Until very recently, wood preservation would mean the use of impregnating agents (insecticides or fungicides) like creosote or others based on salt impregnation like copper, chrome, and arsenic (CCA). However, these salts are highly toxic also biocumulative. When they are in contact with rainwater, most part of these salts are leached away, contaminating the environment. Since 1 January 2004, the US EPA forbade the use of CCA for wood preservation (Edlich *et al.,* 2005). As to creosote, it contains cancer potential agents (Smith 2008); therefore, since 2001 Directive 2001/90/EC, a process was initiated to ban the use of creosote in wood treatment purposes. Some studies mentioned that wood used in railway cross ties has a high content of creosote (Thierfelder and

Sandstrom 2008) so they must be seen as hazardous wastes, meaning that they must be properly immobilised and they can no longer be reused. The same should happen to all the creosote-treated wood, which soon would become construction and demolition waste.

8. Radioactive materials: The use of waste materials with some form of radiological contamination is known to be a matter of concern to public health because exposure over a long term even of low doses can develop cancer formations (Ojovan & Lee, 2014). In general, building materials do not show radioactivity levels that deserve concern (Papaefthmiou and Gouseti 2008), but the same cannot be said about some industrial by-products used for concrete production such as phosphogypsum, some blast furnace slags and some fly ashes. Some phosphogypsum possesses heavy metals and radioactive elements such as radium (226Ra), lead (210Pb) and uranium (238U, 234U) that come from phosphate rocks (Rihanek 1971). The use of phosphogypsum with a concentration level of 370 Bq/kg (in which 1 Bq corresponds to 1 nuclear disintegration per second) has been prohibited since 1992 (EPA 1992). The Euratom (1996) threshold is 500 Bq/kg. Since different phosphate rocks possess different radioactivity levels, not all the phosphogypsum can be considered to be radioactive (Canut 2006). Another important case of radioactive contamination is related to radon, a radioactive gas that can be found in some types of phosphogypsum and can be toxic in indoor air with low ventilation rates (Kovler 2009). In most cases, radon comes from the ground in granite areas, but the source can be from granite floor materials thus polluting indoor air. Chen *et al.,* (2010) analysed 33 different types of granites and mentioned that only two of them had exhalation rates above 200 Bq/m2 d. These authors studied the joint influence of the indoor air ventilation rate and the granites exhalation rates serving as floor materials, concluding that the highest

exhalation rate of granite serving as floor material in a place with a low ventilation rate (air changes per hour, ACH ¼ 0.3) contributed only to 18 Bq/m3 of the total concentration (Table 4). To ACH levels near zero of high exhalation rate, granite can effectively be responsible for toxic radioactive concentrations. Other cases of radioactive building materials can be found in the literature, in Sweden 300,000 residential buildings were made with concrete based on aggregates from a uranium mine (alum shale). Recent studies revealed that infants and children were more prone to develop leukaemia-related diseases (Axelson *et al.,* 2002).

9. Lead plumbing: another toxic building material is lead. Lead was commonly used in paint until it was banned in the late 1970s. However, many older buildings still contain lead-based paint, which can flake or peel and release lead dust into the air. Lead exposure is particularly dangerous for children, as it can cause developmental delays and other health problems.Formaldehyde is another common toxic building material. It is a colorless gas that is used in many building products such as adhesives, insulation, and pressed-wood products. Exposure to formaldehyde can cause respiratory problems, headaches, and even cancer. Due to its low corrosion characteristics, lead has been used as water pipe material since the Roman Empire (Hodge 1981, Dutrizac et al. 1982, Nriagu 1983). Several authors mentioned that lead plumbing is responsible for health problems, because a film of corrosion products is formed on the pipe's surface that eventually will be leached away, thus contaminating water (Zietz *et al.,* 2009). This contamination is particularly toxic to infants and children, causing behavioural problems and intellectual impairment (Pocock et al. 1994, Canfield et al. 2003, Wilhelm and Dieter 2003). Troesken (2006) refers to several cases of lead poisoning due to lead plumbing during the last two centuries, a

problem as big as the Chernobyl or Bhopal disasters. This author states that not only in the USA thousands of children have died due to lead poisoning but also many suffered from intellectual impairment.

A blood lead content higher than 10 mg/dl is considered to be the threshold for lead poisoning (Labat et al. 2006, Tararbit et al. 2009), being associated with cardiovascular death and cancer development. Khalil et al. (2009) mentioned that a blood lead level higher than 8mg/dl is responsible for increased mortality of coronary heart disease. Others (Menke et al. 2006) found out that a blood lead level higher than 2mg/dl was associated with myocardial infarction and stroke mortality. Eventhough health-related risks due to lead pipe poisoning were known from quite some time, in fact many cities in the USA tried to prohibit lead-based plumbing in the 1920s which was not enough to stop the counter actions of the lead pipe industry (Rabin 2008).

In the 1970s, the World Health Organization (WHO) still admitted 300 mg/l as the threshold for lead in drinking water. Since then, this value has fallen significantly (Table 5) as suddenly the toxic risks of lead plumbing were made clear. Some how this threshold evolution is quite similar to the asbestos problem, in which increased patterns of restrictions were adopted until finally the final prohibition came. It is then no surprise to see that the related Directive (98/83/CE) established a 15-year delay period before the 10 mg/l lead content threshold is enforced. This delay period is related to the cost of pipe substitution if the 10 mg/l lead content threshold was to be enforced immediately. For Portugal, the survey carried out in 1995 under the Directive (98/83/CE) revealed 1,177,300 m of lead pipes, as for Europe this amount reached almost 50 million metres. The

replacement costs applied back then were almost 34,000 million euros (Papadopoulos 1999). Estimates that are more recent refer to 200,000 million euros (Hayes 2009).

Other toxic building materials include PVC, which releases dioxins during manufacturing and incineration, and VOCs (volatile organic compounds) found in many paints and adhesives. These substances can cause respiratory problems, headaches, and other health issues. To avoid toxic building materials, it is important to choose materials that are low or free of harmful substances. This can include natural materials like wood, stone, and cork, as well as synthetic materials that have been certified as low-VOC or free of toxic substances. It is also important to properly ventilate buildings during construction and renovation to avoid the buildup of harmful substances in the air. In conclusion, toxic building materials can have serious health and environmental consequences. It is important to be aware of the risks associated with these materials and to take steps to avoid them whenever possible. By choosing low or non-toxic materials and properly ventilating buildings, we can create safer, healthier living and working environments for everyone.

### 2.1.3 Environmentally friendly materials

In recent years, there has been a growing concern about the environmental impact of the construction industry. As a result, there has been a shift towards using more environmentally friendly building materials. Environmentally friendly building materials are those that are sustainable, renewable, and have minimal negative impact on the environment (Patel & Patel, 2021). Environmentally friendly building materials are those that provide appropriate service and life span, with minimum maintenance, while minimizing the extraction of raw materials, the pollution from, and energy consumed by manufacturing and use, and that have the maximum potential for reuse or resource recovery. Building materials, from their resource extraction through manufacturing, use and disposal have become a major component of the total human effects on

global ecosystems and the earth's climate, particularly in the two centuries since the advent of the industrial revolution (Rousseau, 2008).

In the past half-century, with the rapidly advancing pace of urbanization worldwide, finding the raw materials and energy to produce building materials, and absorbing the waste from their production, use and disposal have become pressing global problems. For example, the production of Portland cement alone represents 8% of total global greenhouse gas releases deriving from human sources (WRI). Another highly visible example is the unprecedented degree of deforestation occurring worldwide to produce wood for building construction. The resulting loss of forest diversity, soil stability, water quality and other long-term ecological and economic values are well known. Because all manufactured building materials industries are raw material and energy consumers, and produce some degree of waste, they are important targets worldwide for efficiency improvements and environmental pollution reductions.

The search for environmentally friendly building materials represents a response from the building sector intended to reduce the environmental cost of making and using buildings (Akadiri *et al.*, 2012). Environmentally friendly building materials may come from traditional sources, such as earth and stone materials, they may come from existing industrial processes, found by life-cycle-analysis to be the most environmentally benign, or they may come from new processes or raw material inputs such as industrial waste. Whatever their source, environmentally friendly materials are just one part of the necessary range of responses required to make buildings and cities that are more environmentally responsible. Many other factors such as operating energy efficiency, integrated design, reduction of water consumption and waste, reduction of private automobile use etc. are at least as important as environmentally friendly materials alone. Furthermore, the way materials are selected and applied in a building is also a very significant component of resource

efficiency (Kedir & Hall, 2021). For example a floor system may be as complex as a framing layer, a structural sub floor layer, a flooring underlayment, an adhesive or fastening layer and a finish layer. Alternatively, a single material such as a reinforced concrete suspended slab may be finished with a colorant and sealer and serve all these functions.

These are some of the examples of environmentally friendly building materials.

1. **Bamboo**: Bamboo is one of the most sustainable building materials available. It is a fast-growing plant that can be harvested within 5 years, making it an excellent alternative to traditional wood (Borowski *et al.*, 2022). Bamboo is also strong, durable, and flexible, making it an ideal material for construction. It is often used for flooring, walls, and furniture.
2. **Hempcrete**: Hempcrete is a relatively new building material that is made from the woody core of the hemp plant mixed with lime and water (Bas *et al.*, 2022). It is an excellent alternative to concrete as it is lightweight, breathable, and has excellent insulation properties. Hempcrete is also fire-resistant, pest-resistant, and mold-resistant.
3. **Recycled plastic**: Recycled plastic is another environmentally friendly building material. It is made from recycled plastic bottles and other waste plastics that are melted down and molded into various shapes and sizes. Recycled plastic is durable, lightweight, and resistant to rot and decay. It is often used for outdoor furniture, decking, and fences.
4. **Cork**: Cork is a sustainable building material that is harvested from the bark of cork oak trees. The harvesting process does not harm the trees, and the bark grows back within a few years. Cork is a lightweight material that is often used for flooring, walls, and ceilings. It is also an excellent insulator and is fire-resistant.

5. **Straw bale**: Straw bale is a natural building material that is made from the stalks of harvested grains, such as wheat or rice. It is an excellent insulator and is often used for walls, roofs, and foundations. Straw bale is also fire-resistant and has excellent soundproofing properties.
6. **Rammed earth**: Rammed earth is a sustainable building material that has been used for thousands of years. It is made from a mixture of soil, sand, and gravel that is compacted into forms. Rammed earth is an excellent thermal mass, which means it can store and release heat. It is often used for walls and floors.
7. **Reclaimed wood**: Reclaimed wood is another environmentally friendly building material. It is wood that has been salvaged from old buildings, barns, and other structures that are no longer in use. Reclaimed wood is often used for flooring, walls, and furniture. It is durable, has a unique character, and reduces the need for cutting down new trees.
8. **Glass**: Glass is an excellent environmentally friendly building material. It is recyclable, energy-efficient, and provides natural light. Glass is often used for windows, skylights, and walls. It also has excellent insulation properties.

In conclusion, there are many environmentally friendly building materials available, and using them is an excellent way to reduce the negative impact of construction on the environment. By using sustainable, renewable, and recyclable building materials, we can create buildings that are not only beautiful and functional but also environmentally friendly.

### 2.1.4 Sustainable building materials

Sustainable building materials are those that are environmentally friendly, energy-efficient, and minimize the negative impact on the natural environment. These materials are becoming increasingly important as the world becomes more aware of the need to reduce carbon emissions

and minimize waste. In this article, we will discuss some of the most popular sustainable building materials and their benefits. The current state of the earth is quite alarming nowadays. Especially with the issue of global warming caused by human activities such as industry and the use of materials that are not environmentally friendly. All of that has an impact on global warming which is dangerous to the earth. One of the solutions is to reduce the impact of global warming and to apply the concept of Sustainable Design (Ahmed *et al.,* 2021). A building has an impact on its environment and resulted in contributing to global warming. A lot of waste impact, ranging from garbage, dirty water, and household waste pollutes the environment. It is also contributing to the effects of greenhouse gases, mainly heating from the AC machine. It also has a bad impact for users, such as health that is beginning to be disrupted and reduces the efficiency of activities.

Besides, when construction begins, it also contributes to many adverse impacts on the environment, starting from waste materials, noise, smoke and dust, and so on [6]. Several architectural experts and other experts proposed and made solutions to these impacts, starting with how to make some recycled materials, design a house to grow, and structure that is light and fast construction. Adopting the concept of green architecture becomes the main solutions so that the environment becomes balanced (Liu, 2022). The activist sustainable design movement was started in 1970 and many buildings have applied the concept. At that time, there are many energy-efficient buildings. Ecobrick is one of the applications of Sustainable material, where the material used consists of used bottle waste and plastic waste which are combined, then form several modules (Suhamad & Martana, 2020). At first glance, it turns out that making sustainable materials is easy to make and can reduce the impact of global warming.

Sustainable building materials are becoming increasingly important as the world becomes more aware of the need to reduce carbon emissions and minimize waste. By using environmentally

friendly building materials, we can create structures that are both energy-efficient and minimize their negative impact on the natural environment. Some of the most popular sustainable building materials include bamboo, timber, recycled materials, rammed earth, hempcrete, green roofs, clay bricks, and cork.

### 2.1.5 Availability of Environmentally friendly materials

It was revealed that environmentally friendly materials such as bamboo are readily available as material for building construction by Koko and Dakur (2019) due to its rapid growth and adaptability to most climatic conditions as well as its properties and superiority to most rapidly growing plant in Nigeria, bamboo emerges as a sustainable material for building construction in Nigeria. Koko and Dakur (2019) noted that bamboo has numerous unique advantages like the ability to grow fast with a high yield, environmental friendliness, lightness in weight, and matures quickly for harvesting.

Bamboo is a building material that is readily available in Nigeria but has not been properly utilized as establishedby various researches (American Bamboo Society, 2002). The report of RawMaterials Research and Development Council (RMRDC), (2004) described bamboo as a widely available anddistributed material for building construction in the Southern and Middle belt regions of Nigeria. According to thereport, the distribution of bamboo in Nigeria is associated with the ecological conditions of the rainforest areashaving the most abundant rainfall. The distribution pattern indicates that bamboo is particularly adapted to therainforest belt of Nigeria where it is found in abundance due to the high mean annual rainfall and length of therainy season. Aribisala (1993) revealed that the Southern parts of Nigeria has the highest mean annual rainfall,which is more than 1000mm as compared to the North-Central zone which has a mean annual rainfall of between600-1000mm. The North-Western and the North-Eastern zone of the

country has a mean annual rainfall of between400-600mm. Taraba State in the North-Western region of Nigeria has a sub-temperate climate which makesavailable in the state because of this climate (RMRDC, 2004). Bamboo is commonly available in almost all thestates of Southern region of Nigeria except for Bayelsa State and Lagos State where the distribution is considered to be relatively low.

The states with the abundance of bamboo occurrence are identified to be Abia, Anambra,Akwa Ibom, Cross River, Delta, Edo, Ebonyi, Enugu, Imo, Ogun, Oyo, Osun, Ondo, and Rivers States (Ladapo *et al.*, 2017). Also, thereport of RMRDC (2004) indicates that at least ten (10) per cent of the natural vegetation in these states isdominated by bamboo, with the existing bamboo clumps showing substantial gregarious growth that is continuousover large areas. In states like Bayelsa, Benue, Ekiti, Kogi, Kwara, Lagos and Nassarawa States, the distributionof bamboo was observed to be frequent, indicating that between six (6) to nine (9) per cent of the natural vegetationis occupied by bamboo. Several bamboo clumps were also reported in Niger, Plateau and Taraba States as well as within the Federal Capital Territory (FCT). However, there are 12 North-Western and North-Eastern states wherethe bamboo occurrence is rare. These states include Adamawa, Bauchi, Borno, Gombe, Kano, Kaduna, Katsina,Kebbi, Sokoto, Jigawa, Yobe, and Zamfara State.

Cement-bonded particleboard is a value-added wood product made from the combination of two or more raw materials such as particles from wood and agricultural byproducts, cement and a catalyst (Melichar *et al.,* 2021). Cement-bonded board is produced from strands, particles and wood fibers mixed together with cement and manufactured into panels, brick tiles and other products used in the construction industry. Cement-bonded product can be classified into cementbonded board, wood-wool excelsior boards and gypsum-bonded board. The excellent properties of cement-bonding make it useful for ceiling, walling, roofing, flooring, claddings,

partitioning and shuttering. Cement-bonded boards can be applied for internal and external works as it is resistant to termites, insects, fungi, moisture movement, fire, and good insulating properties, durable and excellent nailing ability. Ajayi (2005) asserted that cement-bonded composite has been accepted as panel products for construction works for interior and exterior purposes. The main interest in boards manufacture in Nigeria is associated with the availability in large quantities of the two major production variables (Portland cement and wood wastes) and the low cost of cement compared with that of the resin binder usually used in the production of resin-bonded particleboards.

Wood wastes of various grades (sawdust, off cuts, slabs, defective logs, thinning, pruning's and shavings) form the main raw materials base and such wastes are derived from wood processing and forest industries. Different agricultural residues are being used as raw materials for boards manufacture, for example Banana stem with saw dust (Ajayi 2003), Maize stalk (Ajayi, 2006a), bagasse (Sandermann, 1970, Simatupang et al, 1993), and coffee chaff (Ajayi, 2006b). The inherent excellent characteristics of cement-bonded boards, particularly its high resistance to moisture, fire, termites, fungi and other forms of degrading agents have made it versatile construction material for roofing, ceiling, flooring, partitioning, cladding and shuttering (Babatunde & Com, 2006).

One of such materials is unfired solid interlocking laterite / clay (Hydraform blocks) (Oti *et al.*, 2009) otherwise known as stabilized earth blocks. The usage of stabilized blocks, in place of conventional fired bricks, can significantly reduce the energy use and also cut down carbon dioxide emissions and minimize generated wastes (Joseph, 2010). Made largely from soil excavated on site, stabilized earth houses require substantially less fossil fuel–derived energy to build, than the conventional concrete buildings commonly found in many urban centers in Nigeria.

Stabilized earth buildings help to ease pressure on the world's over-harvested forests. Laterite which constitutes more than 80 percent of the materials needed for the production of stabilized blocks is abundantly available in Nigeria. Materials used for its construction are collected locally: no huge mines are required to supply building materials, and the blemish produced when extracting laterite can generally be repaired quickly and easily with little environmental impact (Arayela, 1996). The ability of the Nigerian economy has not being buoyant enough to sustain importation and use of expensive building materials for construction works. Furthermore, some existing locally produced building materials are capital intensive to manufacture locally, as production of such materials are based on sophisticated technologies. Construction of stabilized building techniques requires very little skill and is ideally suited to owner–building projects. You can learn what you need to know in a week–long workshop. Stabilized earth buildings can be quite economical, thereby further adding to their appeal. Usually, solid laterite blocks are produced on the site where the materials are available. Laterite soil with good grain size distribution and good cohesive performance is a good material for production of interlocking block, but the proportion of clay and aggregates has to be checked (Adedeji, 2011). Interlocking blocks are manufactured by hydraulically compressing a soil and cement mixture in a blockmaking machine. Where the material is unused, excess can be recycled on site and reused. The development of interlocking blocks (solid interlocking laterite blocks) shows some merits over the conventional types. First, substantial cost savings can be achieved due to elimination of binding mortar in the superstructure, thereby reducing workmanship. In this system freely available subsoil is the main raw material and the blocks do not require costly burning; transport costs are minimized since production of Hydraform blocks takes place on site in hydraulic block machines, available from Hydraform International (Pty) Ltd., headquartered in Johannesburg,

South Africa. In addition, speed of construction is a valuable feature of the system, which is much faster than other building methods (Adedeji, 2011).

Abimaje and Baba (2014) reported that timber is locally available in Nigeria. It can be purchased from local suppliers and transported to site using even small vehicles. Timber is accepted as an attractive building material in most cultures. Timber is a fibrous rigid material of plant origin. The word, timber, which is wood that is prepared for use in building construction, is sometimes used interchangeably with wood in our construction parlance. It is broadly classified as hardwood and softwood. Hardwood is derived from angiosperm or broad-leaved trees such as Iroko, Mahogany and Danta. Softwood is obtained from coniferous trees, which have needle-like leaves. Examples of softwood trees include Scots Pine, Norway spruce and Douglas fir. Timber has been used as a primary source of building material for ages in construction of building. The Raw Materials Research and Development Council of Nigeria, RMRDC, (1998) opined that the roof structure and ceiling noggins of most buildings are constructed with timber because of its workability and durability.

Opepe (Nauclea diderrichii), a yellowish, very hard timber is used for door and window frames because of its natural resistance to insect attack. Timber is natural and renewable. It has a high strength to weight ratio and is easy to work with, making it especially useful even where only basic technology and procedures are available (Apu, 2003). According to Douglas (1995) timber remained the most predominant building material until the last half of 19th century. Today, proponents of timber as a building material perceive it as an attractive building material while its opponents opine that it is unreliable for construction. However, Andreas (2005) asserted that architects are only limited not by the material but their knowledge of how the material works.

### 2.1.6 Utilization of Environmentally friendly materials

Sustainable and eco-friendly building materials (SEBMs) available in Nigeria include earth-based bricks, bamboo, quarry dust, natural fibres, agro-waste ash, and industrial wastes. Earth-based bricks (EBBs) as SEBMs have the potentials of reducingthe cost of building units in Nigeria which will ultimatelymake housing affordable to the populace. The advantages ofusing earth-based bricks in place of cement blocks includea reduction in the release of greenhouse gases to the atmos-phere, energy efficiency, and low cost of production. Obianyo *et al.*, (2021) revealed that the demand for EBBs for housing construction is still low when compared to that of cement blocks. Ajayi (2005) asserted that cement-bonded composite has been accepted as panel products for construction works for interior and exterior purposes. The main interest in boards manufacture in Nigeria is associated with the availability in large quantities of the two major production variables (Portland cement and wood wastes) and the low cost of cement compared with that of the resin binder usually used in the production of resin-bonded particleboards. Wood wastes of various grades (sawdust, off cuts, slabs, defective logs, thinning, pruning's and shavings) form the main raw materials base and such wastes are derived from wood processing and forest industries. Different agricultural residues are being used as raw materials for boards manufacture, for example Banana stem with saw dust (Ajayi 2003), Maize stalk (Ajayi, 2006a), bagasse (Sandermann, 1970, Simatupang et al, 1993), and coffee chaff (Ajayi, 2006b). The inherent excellent characteristics of cement-bonded boards, particularly its high resistance to moisture, fire, termites, fungi and other forms of degrading agents have made it versatile construction material for roofing, ceiling, flooring, partitioning, cladding and shuttering.

Achieving sustainability in housing provision requires major societal changes, restructuring of institutions and management approaches. It requires the appropriate political will based on the conviction of the responsibility of government to its citizens, and the need to create humane and

decent environment for dignified living. In order to realize sustainable housing provision the housing needs of the Nigerian population have to be put into proper focus, and a coordinated program to achieve this should be thoroughly worked out. With due consideration given to the input of the local communities, government may initiate aided self-help programs and low-cost core housing units. It can also facilitate the acquisition of building materials, the cost of which constitutes about 60% of the entire cost of a building. Production of building materials of indigenous origin by private investors should be given logistic and material support by government. Taiwo and Adeboye (2013) noted that laterite which constitutes more than 80 percent of the materials needed for the production of stabilized blocks is abundantly present in Nigeria. The technology required for its production is also very low, thereby reducing the overall cost for wall construction. The combination of the use of stabilized earth blocks as an indigenous material for construction and composite building materials when fully used in housing delivery will drastically ameliorate the shortage of housing in Nigeria.

### 2.1.7 Effect of Environmentally friendly materials

Environmentally friendly materials have a positive impact on the environment as they are designed to minimize harm to the planet and its inhabitants. Justenergy (2021) outlined some ways in which environmentally friendly materials can make a difference:

1. Reduced Carbon Footprint: Environmentally friendly materials are produced using fewer resources, resulting in a lower carbon footprint. This means that they contribute less to global warming and climate change, making them a better choice for the environment.
2. Sustainable Production: Many environmentally friendly materials are made from renewable resources, such as bamboo or hemp. This means that they can be produced sustainably, without depleting natural resources.

3. Healthier Living: Many conventional building materials contain toxic chemicals that can be harmful to human health. Environmentally friendly materials, on the other hand, are often made without these chemicals, making them safer for the people who use them.
4. Resource Efficiency: Environmentally friendly materials are often designed to be more resource-efficient, meaning that they use less energy, water, and other resources during production and use. This helps to conserve natural resources and reduce waste.
5. Improved Indoor Air Quality: Many conventional building materials emit volatile organic compounds (VOCs), which can reduce indoor air quality and negatively impact human health. Environmentally friendly materials, however, are often low or zero VOC, which helps to improve indoor air quality.

Overall, using environmentally friendly materials can help to reduce the negative impact that construction and production have on the environment, while also providing health benefits to the people who use them.

### 2.1.8 Financial implication of Environmentally friendly materials

Abimaje and Baba (2014) reported that the local availability of high-quality wood and the abundance of local millers make timber production less dependent on imports. Prices are relatively stable, since they are less influenced by the volatile foreign currency exchange market. This gives timber a costcomparative advantage over other materials that have high import content. Key financial benefits of new green construction generally relate to lower operational costs, lower energy, waste and water costs, lower maintenance costs, and increased productivity and health (Sumateja, 2016). The latter, while difficult to measure/ prove, have come to be regarded as the holy grail of green building given that labor costs for most businesses comprise the overwhelming majority of costs. Building green also presents opportunities for incentives to offset any higher

initial (capital) costs and may result in increased occupancy rates and rental rates, insurance discounts and higher property value. “Green” or “sustainable” buildings use key resources like energy, water, materials, and land much more efficiently than buildings that are simply built to code. They also create healthier work, learning, and living environments, with more natural light and cleaner air, and contribute to improved employee and health, comfort, and productivity. Sustainable buildings are cost-effective, saving taxpayer dollars by reducing operations and maintenance costs, as well as by lowering utility bills.

Tafese (2012) reported that Agrostone panel is an alternative low-cost eco-friendly building material which mainly uses agricultural/industrial wastes and/or natural minerals as raw materials. It reduces the cost of wall construction significantly while attaining the desired physical and mechanical properties. The building materials are one of the significant components in the construction industry that determines the overall total cost of constructing the building as it constitutes the most significant single input in executing a project (Windapo *et al.*, 2018). Due to the escalated price of the conventional materials, stakeholders in the building industry now suggest alternative materials known as green materials to reduce the overall cost of construction (Alabi & Fapohunda, 2021). Accordingly, potential green materials are materials that are locally oriented and renewable that are environmentally friendly; they composed of renewable rather than non-renewable resources. It was further revealed that mixing of the natural materials into the construction of housing could mitigate the effect of the environment problem links with the production, conveyor, processing assembly, construction, recycle, reuse, and discarding of these materials.

Kaanchan and Mahendraa (2017) argued that there are no economic disadvantages of environmentally friendly materials and some; such a reducing embodied energies are clearly

economic. Underlying all is technological change,particularly in relation to materials.Materials are the key to sustainability in the built environment and innovative new materials will allow architects and engineers to build structures that have greater value as they are more pleasing to use, live in or look at, healthier and much more sustainable.

## 2.2 Theoretical framework

### 2.2.1 Conservation Theory

Conservation theory is a scientific concept that describes the preservation, protection, and management of natural resources and ecosystems (Minteer & Corley, 2007). It is based on the idea that the Earth's natural resources are limited and that it is necessary to manage these resources carefully to ensure their sustainable use for current and future generations. The conservation theory has its roots in the late 19th and early 20th centuries when concerns about the depletion of natural resources and the destruction of natural habitats began to emerge. Conservationists argue that the natural world has value in and of itself and that humans have a responsibility to protect it. There are several different approaches to conservation theory, including preservation, sustainable use, and restoration. Preservation focuses on protecting natural areas from human development and maintaining them in their natural state. Sustainable use emphasizes the careful use of natural resources to ensure their long-term availability while minimizing environmental impact. Restoration aims to restore degraded ecosystems to their original state. Conservation theory has become increasingly important in the face of growing concerns about climate change, habitat destruction, and loss of biodiversity. Governments, non-governmental organizations, and individuals are working to develop and implement conservation strategies to protect the natural world for future generations.

Conservation theory has a direct relationship with environmentally friendly materials for building construction. The theory emphasizes the sustainable use of natural resources and the protection of the environment, which are both key considerations in choosing building materials. Using environmentally friendly materials for building construction is an important way to conserve natural resources and reduce environmental impact. These materials are typically made from renewable or recycled materials, or they have a lower environmental impact during their production, use, and disposal.

### 2.2.2 Sustainable Development Theory

The concept of sustainable development emerged in the 1980s as a response to the increasing awareness of the negative impact of economic development on the environment, society, and economy. Sustainable development theory proposes a framework for balancing economic growth, environmental protection, and social development to meet the needs of present and future generations (Mensah, 2019). Sustainable development is often defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition emphasizes the intergenerational equity and highlights the importance of conserving natural resources, reducing pollution and waste, and promoting social and economic justice.

The three pillars of sustainable development are economic, social, and environmental. These pillars are interconnected, and achieving sustainable development requires balancing the needs and aspirations of all three. The economic pillar emphasizes the importance of economic growth, productivity, and efficiency in achieving sustainable development. However, economic growth alone cannot be sustainable without considering the social and environmental aspects of development. The social pillar of sustainable development emphasizes the importance of meeting

the basic needs of people, such as access to food, water, shelter, and healthcare. It also emphasizes the importance of social justice, equity, and participation in decision-making processes. Social development is critical to achieving sustainable development because it enables people to participate in economic activities and promotes the well-being of communities.

The environmental pillar of sustainable development emphasizes the importance of protecting natural resources, reducing pollution and waste, and promoting biodiversity. Environmental protection is critical to achieving sustainable development because it ensures the continued availability of resources for future generations. The sustainable development theory proposes a number of principles to guide sustainable development practices. These principles include intergenerational equity, social and environmental justice, economic efficiency, precautionary principle, and stakeholder participation. Intergenerational equity requires that current generations consider the needs and aspirations of future generations. Social and environmental justice requires that development benefits all people and that environmental risks and impacts are distributed equitably. Economic efficiency requires that resources are used in the most productive and sustainable manner. The precautionary principle requires that risks are assessed and managed to avoid irreversible damage to the environment or human health. Stakeholder participation requires that all stakeholders, including communities, businesses, and governments, participate in decision-making processes. Sustainable development theory proposes a framework for balancing economic growth, environmental protection, and social development to meet the needs of present and future generations. It emphasizes the interdependence of the economic, social, and environmental pillars of development and proposes a set of principles to guide sustainable development practices. Achieving sustainable development requires a long-term perspective, a

commitment to equity and social justice, and a willingness to balance competing interests and trade-offs.

The use of environmentally friendly materials in building construction is an important aspect of sustainable development. The construction sector is one of the largest consumers of natural resources and energy, and it is responsible for a significant portion of greenhouse gas emissions and other environmental impacts. Therefore, the use of sustainable building materials is critical to achieving sustainable development goals. The sustainable development theory emphasizes the importance of balancing economic growth, environmental protection, and social development. In the context of building construction, this means using materials that are environmentally friendly, socially responsible, and economically viable. Environmentally friendly materials are those that have a lower impact on the environment throughout their lifecycle, from production to disposal. The use of environmentally friendly materials in building construction promotes sustainable development by reducing environmental impacts, conserving natural resources, and improving the health and well-being of occupants. It also promotes social development by creating jobs in the sustainable building materials industry and supporting local economies. Additionally, it can lead to economic benefits in the long-term, as sustainable buildings have lower operating costs and can be more valuable in the real estate market.

### 2.3 Empirical Studies

Burdova and Vilcekova (2012) introduce the one of most significant filed in building environmental assessment system (BEAS), which was developed at the Technical University of Košice. The Slovak system was developed on the basis of existing systems used in many countries. BEAS as a multi-criteria system which is incorporated in proposed main fields: site selection&project planning; building construction; indoor environment; energy performance;

water management and waste management. Selection of building materials and structures is very important in term of embodied energy and emissions of pollutants. The field of building construction will be introduced in the paper. The aim is also weighting and analysis of significance of building construction indicators in system BEAS with is applicable in Slovak conditions.

Adegbile (2013) presents a comparative analysis of seven well-known sustainable rating systems – BREEAM, CASBEE, GREEN GLOBES, GREEN STAR, HK-BEAM, IGBC Green Homes and LEED by the perceptions and opinions of stakeholders in Nigeria certified in green building rating systems in an attempt to select and adapt a green building rating system for Nigeria. Various aspects of these systems were scrutinized and analyzed in order to find out the best option for the Nigerian built environment. Based on the findings of this study the green building rating systems LEED which is the dominant system in the United States and Canada is appropriate for Nigeria because it helps costumers determine environmental performance, with strong base, large investments and proven advantages scored the highest with 80 points out of 100 points.

Taiwo and Adeboye (2013) highlights the combination of the use of stabilized earth blocks as an indigenous material for construction and composite building materials in Nigeria, and further stressed that the sustainability of these materials will drastically ameliorate the shortage of housing in Nigeria. Recommendations were made as to how these indigenous and composite building materials can be used to meet the housing needs of majority of the both rural and urban dwellers in Nigeria

Abimaje and Baba (2014) assessed timber for its sustainability using data from secondary sources. It established that a sustainable building material must be environmentally friendly, affordable, flexible in usage and durable. Timber possesses these characteristics. The paper thus compared fuel energy required to produce timber as well as carbon dioxide released and stored during

production with other common building materials such as steel, concrete and aluminium. It observed that 750 MJ/m3 , 26600MJ/m3 , 4800MJ/m 3 and 1100000 MJ/m3 of fossil fuel energy is required to produce Rough Sawn Timber, Steel, Concrete and Aluminium respectively. The work revealed that timber stores as much as 250 Kg/m3 of carbon dioxide (CO2) and releases only 15Kg/m 3 into the atmosphere. In contrast, Steel, Concrete and Aluminium store no carbon dioxide while they release 5320 Kg/m3 , 120Kg/m3 and 22000 Kg/m3 respectively into the atmosphere. Additionally, plants, the primary source of timber, absorb carbon dioxide and release oxygen into the atmosphere during photosynthesis with a comparatively low thermal conductivity advantage. The paper consequently concluded that since timber is readily available in the country, it is a highly sustainable building material in the nation. It posited that the problems associated with the usage of wood, such as attack by insects, fungi, fire, depletion of natural resources etc can be ameliorated with the aid of preservative treatments, fire retardant and afforestation.

Ayodeji *et al.,* (2018) evaluated the application of eco-friendly systems in some selected buildings in Nigeria with a aim of taking advantage of natural resources for building efficiency. Qualitative and Quantitative research methods were employed in this study. Data was obtained by the administration of questionnaires to occupants of residential buildings and the designs of their building were also assessed against sustainable standards. Findings showed that the buildings of sampled respondents were not sustainable and the natural resources available in the environment were not properly utilized. In addition, the residents pay more for energy consumption because the natural resources in the environment were not adequately integrated in the building. The study therefore recommended that a green building rating system like the Leadership in Energy and Environmental Design (LEED) suitable for Nigeria should be designed to guide new projects and renovations.

Iwuagwu (2019) critically appraises some major local building material available in Nigeria such as adobe, bamboo, thatch, stones, timber, coconut tree, grasses etcetera. These materials are cheap relative to the imported materials from outside the country. The purpose of this paper was to examine the major advantages, challenges and the way forward for traditional building materials in increasing low cost housing supply and affordability in Nigeria. The study found promotion of cultural heritage, availability and affordability of the materials, energy efficiency, reusability, biodegradability among others as the major advantages of traditional building materials. However, acceptability, durability, deforestation, low strength, frequent maintenance, among other issues were found to be the major challenges associated with houses built with traditional building materials. Recommendation for adoption and improvement of the locally available materials for building houses are made. This paper contributes to the body of knowledge in the area of traditional building materials in Nigeria and Africa at large.

Obianyo *et al.*, (2021) assesses the current status of the production and utilization of earth-based bricks (EBBs) in Nigeria through a questionnaire survey to identify the challenges and proffer solutions. The majority of the surveyed participants indicated a lack of awareness of the existence of the earth-based bricks industry in Nigeria. Identified obstacles to the production and utilization of the EBBs include low patronage and lackof demand. Strategies identified to be adopted for increasing the demand and utilization of EBBs include the enactment of government policies/laws to encourage the use of EBBs as well as improving the durability and aesthetics of EBBs. The findings of this study provide a deeper understanding of the dynamics of production and utilization of EBBs in Nigeria within sights on how stakeholders can help to foster increased production and effective utilization resulting in the achievement of Goal 11 of the Sustainable Development-Sustainable cities and communities.

Shittu (2021) appraised green building materials within the Nigerian construction industry, with a view to suggesting a veritable strategy for their adoption. To achieve this, a Mixed Method Design was adopted. A total of 372 questionnaires were distributed for the purpose of the study, 156 valid questionnaires were administered. Descriptive method of data analysis was adopted using simple random sampling technique and through the use of interview. Percentages, Frequency, Mean Item Score (MIS), and Relative Importance Index (RII) were used to analyse the collected data through the administration of questionnaire. The study found that construction stakeholders are aware of the existence and adoption of some green materials like empty plastic bottles, clay and mud, grasses, bricks, stone and timber, with the correlation showing an insignificant level of $p>0.05$. The major drivers of green building materials adoption in construction are; resource efficiency, reduction in the lifecycle costs of buildings, legislation / legal requirement, financial incentives, and cost reduction, the Resource efficiency is ranked 1 st with RH of 0.972 while Developing regulatory mechanisms is the least with RH of 0.473 of Driver of GBM Adoption in NCI. Also, higher costs of green building construction, lack of professional knowledge and expertise in green building, lack of importance attached to green building technology by senior management, lack of financing schemes such as bank loans, and lack of government incentive are the major barriers to the adoption of green building materials in construction, the Barrier to Green Building Materials Adoption in Construction is highest in Higher expenses of Green buildings construction and lowest in Lengthy repayment timeframes from implementing GBT with 0.99 and 0.50 respectively. Provision of incentives to encourage innovation in sustainable construction, rigorous green building promotion by government, use of technologies that permit the deconstruction and recycling of the building components, and adequate training centres with adequate funding of research and development; were the strategies for improving the adoption of green building

materials, strategies to improve GBM uptake has 0.99 RH value, ranked 1st Establishment of enticements to inspire invention in sustainable construction and 0.70 RH value for Provision of Sustainable Materials Selection Criteria which is ranked the least. It was concluded that there is a very strong and positive relationship between level of awareness and adoption of GBM and was recommended that appropriate legislations should be put in place by the Nigerian government to encourage the adoption of green building practices in the construction industry with support from top stakeholders and the provision of financial and other incentive to encourage the adoption of GBM.

Ekhaese and Ndimako (2023) addressed three key objectives—Ascertaining the physical architectural features of health resorts, assessing the eco-friendly building material contribution to SDG attainment, and identifying the health benefits of eco-friendly building materials in the health resort. The researchers engaged the qualitative research method for the study, using a case study technique as a qualitative research design/strategy. The authors used three health resorts across three countries in the global south; China, India, and Brazil. The data collection instruments include; an in-depth interview guide In-depth Interviews (IDI), a direct observation guide, a checklist of green construction materials for health facilities and a qualitative photo-production study based on the essential features of a health resort checklist. The authors use content and narrative analyses to analyze data. Findings show that eco-friendly materials may be best suited for both exterior and interior works of health resort facilities. Wood, stone and concrete are the most preferred materials as they occur across all three case studies. The results align with current global trends towards eco-beneficial facilities. Adopting natural materials such as wood and stone for the Port Harcourt health resort would be expedient, given the health benefits inherent in using

such eco-friendly materials and their alignment with the Sustainable Development Goals (SGD 11 and 13).

### 2.4 Summary of Literature Reviewed

This study reviewed literature under three frameworks: conceptual framework, theoretical framework and empirical studies. The conceptual framework encompassed concepts such as building construction, toxic building materials, environmentally friendly materials, sustainable building materials, availability of environmentally friendly materials, utilization of environmentally friendly materials, effect of environmentally friendly materials and financial implication of Environmentally friendly materials. The theoretical framework reviewed two key theories that were relevant to the study, these theories are the conservation theory and sustainable development theory. The empirical studies reviewed several related previous studies that helped guide the study.

## CHAPTER THREE

## RESEARCH METHODOLOGY

### 3.1 Introduction

This chapter presents the research methodology employed by the researchers and therefore, provides information on the research design, population and sample size, sampling technique, data collection instrument, procedure for data collection, procedure for data analysis.

### 3.2 Research Design

The study adopted the descriptive survey research design which involves involves collecting data from a sample of individuals through a survey or questionnaire. The main purpose of this design is to describe the characteristics, attitudes, beliefs, opinions, or behaviors of a particular group or population. This research design involves the collection of qualitative data from the respondents.

### 3.3 Population of the study

The populace of the find out about consists of of large development firms, building substances manufacturers, environment managers in Kaduna state. The target population for the study consists of ten construction companies in Kaduna State.

**TABLE 3.1.1: Population Distribution**

| S/N | NAME OF THE FIRM |
|---|---|
| **1** | De Brightz Engineering & Constructions Company |
| 2 | Binkam Nigeria LTD |
| 3 | Gyetmah constructions |
| 4 | CCECC kaduna |
| 5 | Steelagon engineering limited |
| 6 | Enviro construction pty.ltd |
| 7 | Dream measures nig.ltd |
| 8 | Obtainit nig.ltd |
| 9 | UBBI concrete industry nig.ltd |
| 10 | Hepthadel group of companies |

***Source Research field survey (2022)***

### 3.4 Sample and sampling technique

The study adopted a multi-stage sampling in order to determine the sample size for the study, the researcher first randomly selected five construction companies from the target population of the study. The second stage involved sampling experts from the five randomly selected construction companies. The sample consists of thirty-seven respondents that consisted of builders, engineers, surveyors, architects, project and facility managers. The simple random sampling technique was used in selecting the respondents for the study, this technique was appropriate as it allowed for adequate representation of the population and prevented bias from influencing the sample.

**TABLE 3.2.1 Sample Distribution**

| S/N | NAME OF THE FIRM | Sample |
|---|---|---|
| 1 | Binkam Nigeria LTD | 8 |
| 2 | Gyetmah constructions | 5 |
| 3 | CCECC kaduna | 8 |
| 4 | Dream measures nig.ltd | 9 |
| 5 | UBBI concrete industry nig.ltd | 7 |
| | Total | 37 |

***Source Research field survey (2022)***

### 3.5 Instrument of data collection

The instrument used for gathering data for the study is a questionnaire titled "Assessment of Environmentally Friendly Materials for Building Construction Questionnaire" (AEFMBCQ), The instrument was made up of four sections A, B, C and D. Section A was made up of five items that elicited responses on the level of availability of environmentally friendly materials for building construction in Kaduna State, section B was made up of five (5) items aimed at finding out the level of utilization of environmentally friendly materials for building construction in Kaduna State,

section C had five (5) items aimed at finding out the effect of of environmentally friendly materials on the environment and section D was made up of five (5) items aimed at finding out the financial implication of environmentally friendly materials for building construction in Kaduna State. All the section requires the respondents to respond to the item on a four-point scale; For section A: Fully Available, Available, Partially Available and Not available, Section B: Fully Utilized, Utilized, Partially Utilized and Not Utilized. Section C and D: Strongly Agree, Agree, Disagree and Strongly Disagree.

### 3.6 Validity of instrument

In order to ensure the validity of the instrument the questionnaires were subjected to face and content validity which required the instrument to be validated by Industrial and Technology Education (ITE) experts from the School of Science and Technology Education (SSTE), Federal University of Technology Minna, Niger State. Their expert judgement led to corrections that were made to the instrument that ascertained its validity.

### 3.7 Reliability of the instrument

The reliability of the research instrument was determined through pilot test by administering the instrument to a total of ten (10) builders and architects from "De Brightz Engineering & Constructions Company" which is not among the sampled departments for the study, a reliability co-efficient of 0.67 was established for the instrument using Pearson product moment coefficient.

### 3.8 Method of data collection

The researcher obtained permission from the administrative heads of the various construction firms in Kaduna State with the aid of a letter obtained from the head of department (ITE), School of Science and Technology Education (SSTE), Federal University of Technology Minna, Niger State. Before the researcher administered the questionnaire, the respondents were adequately briefed on

the aim and objective of the study. The data was collected using the research instrument. The questionnaires were administered to the thirty-seven respondents and retrieved immediately after to prevent loss.

### 3.9 Method of Data Analysis

The statistical method to be used for the analysis of the data to be gathered from the administration of the instrument is the mean and standard deviation. A decision/ criterion mean of 2.50 was used to ascertain available, utilized and agree. Also, a z-test was used to test the hypotheses at 0.05 level of significant to compare whether the differences between the mean responses of the two groups were significant to accept or reject the null hypotheses. The data collected was computed using the statistical package for social sciences (SPSS) ver. 23.00. Where the z-probability value set by the computer was greater than 0.05 then the null hypothesis was accepted, but where the z-probability value was less than 0.05 then the null hypothesis was rejected and its alternative form accepted Refer to appendix H for SPSS breakdown and details of statistical calculations.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION OF DATA

The purpose of the study is to assess the need for environmentally friendly materials for building construction in Kaduna State. This chapter discusses the data analysis, presentation of the results of data analyzed and discussion of the results. The data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 25. A satisfactory scale was set to infer, not available/not utilized/disagree and available/utilized/agree for the availability, utilization, effect of environmentally friendly building material and its financial implications; 1.0 – 2.4 not available/not utilized/disagree, 2.5 – 4.0 available/utilized/agree.

### 4.2 Response to Research Questions

**Research Question One:** What is the level of availability of environmentally friendly materials for building construction in Kaduna State? The response is shown below on table 4.2

**Table 4.1.1** availability of environmentally friendly materials

| S/N | Items | N | Mean | Std. Deviation | Decision |
|---|---|---|---|---|---|
| 1 | Bamboo | 37 | 3.43 | 0.647 | Available |
| 2 | Strawbales | 37 | 3.49 | 0.559 | Available |
| 3 | Hempcrete | 37 | 3.19 | 0.908 | Available |
| 4 | Cork | 37 | 3.38 | 0.758 | Available |
| 5 | Rammed earth | 37 | 3.54 | 0.767 | Available |
| | **Grand Mean** | **50** | **3.40** | | **Available** |

**Decision mean: 2.50**

Table 4.1 shows the Mean and Standard Deviation of availability of environmentally friendly materials for building construction in Kaduna State. The table reveals the computed mean score of 3.43 with Standard Deviation of 0.64 for item one, 3.49 with Standard Deviation of 0.55 for item two, 3.19 with Standard Deviation of 0.90 for item three, 3.38 with Standard Deviation of 0.75 for item four, 3.54 with Standard Deviation of 0.76 for item five. The table revealed further that, the grand mean score of responses to the ten items was 3.40 which was greater than the decision mean score of 2.50. This implies the availability of environmentally friendly materials for building construction in Kaduna State.

**Research Question 2:** What is the level of utilization of environmentally friendly materials for building construction in Kaduna State? The responses is revealed in Table 4.3

**Table 4.2.1** utilization of environmentally friendly materials

| S/N | Items | N | Mean | Std. Deviation | Decision |
|---|---|---|---|---|---|
| 1 | Bamboo | 37 | 3.68 | 0.747 | Utilized |
| 2 | Strawbales | 37 | 2.62 | 1.963 | Utilized |
| 3 | Hempcrete | 37 | 2.27 | 1.146 | Utilized |
| 4 | Cork | 37 | 2.65 | 1.798 | Utilized |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Rammed earth | 37 | 2.30 | 1.266 | Not Utilized |
| | **Grand Mean** | | **2.70** | | Utilized |

**Decision Mean: 2.50**

From Table 4.2, The table reveals the computed mean score of 3.68 with Standard Deviation of 0.74 for item one, 2.62 with Standard Deviation of 1.96 for item two, 2.27 with Standard Deviation of 1.14 for item three, 2.65 with Standard Deviation of 1.79 for item four, 2.30 with Standard Deviation of 1.79 for item five. Item 5 reveals that rammed earth despite been available is not utilized as determined by the mean (2.30) responses analyzed. The table revealed further that, the grand mean score of responses to the ten items was 2.70 which was greater than the decision mean score of 2.50. This implies a level of utilization of environmentally friendly materials for building construction in Kaduna State.

**Research Question 3:** What is the effect of environmentally friendly materials on the environment? The responses is revealed in Table 4.3

**Table 4.3.1** effect of environmentally friendly materials on the environment

| S/N | Items | N | Mean | Std. Deviation | Decision |
|---|---|---|---|---|---|
| 1 | The use of eco-friendly building materials positively affect the environment | 37 | 3.54 | 0.505 | Agree |
| 2 | The use of materials such as bamboo for building | 37 | 3.65 | 0.484 | Agree |

| | | | | | |
|---|---|---|---|---|---|
| | construction can help tackle climate change | | | | |
| 3 | The use of environmentally friendly materials can address the issue of land, water and air pollution. | 37 | 3.51 | 0.651 | Agree |
| 4 | Emphasis placed on eco-friendly building materials will promote recycling and further lead to a healthy, non-toxic environment | 37 | 3.65 | 0.484 | Agree |
| 5 | Eco-friendly building materials will lead to the reduction in the consumption of natural and non-sustainable resources. | 37 | 3.57 | 0.765 | Agree |
| | **Grand Mean** | | **3.58** | | Agree |

**Decision Mean: 2.50**

From Table 4.3, The table reveals the computed mean score of 3.54 with Standard Deviation of 0.50 for item one, 3.65 with Standard Deviation of 0.48 for item two, 3.51 with Standard Deviation of 0.65 for item three, 3.65 with Standard Deviation of 0.48 for item four, 3.57 with Standard Deviation of 0.76 for item five. The table revealed further that, the grand mean score of responses to the ten items was 3.58 which was greater than the decision mean score of 2.50. This implies that environmentally friendly materials has an effect on the environment.

**Research Question 4:** What are the financial cost of environmentally friendly materials for building construction in Kaduna State? The responses is revealed in Table 4.3

**Table 4.3** financial cost of environmentally friendly materials

| S/N | Items | N | Mean | Std. Deviation | Decision |
|---|---|---|---|---|---|
| 1 | Materials such as bamboo and straws are readily available and cheaper alternatives to concrete and cement | 37 | 3.49 | 0.507 | Agree |
| 2 | Eco-friendly building materials are expensive to design and construct | 37 | 3.54 | 0.505 | Agree |
| 3 | There are no government subsidies for eco-friendly building materials | 37 | 3.57 | 0.502 | Agree |
| 4 | Eco-friendly construction are labor intensive, therefore hiking the cost. | 37 | 3.41 | 0.498 | Agree |
| 5 | Eco-friendly building materials have high maintenance compare to conventional building materials | 37 | 1.95 | 1.201 | Disagree |
| | **Grand Mean** | **50** | **3.19** | | Agree |

**Decision Mean: 2.50**

From Table 4.3, The table reveals the computed mean score of 3.49 with Standard Deviation of 0.50 for item one, 3.54 with Standard Deviation of 0.50 for item two, 3.57 with Standard Deviation of 0.50 for item three, 3.41 with Standard Deviation of 0.49 for item four, 1.95 with Standard Deviation of 1.20 for item five. The table revealed further that, the grand mean score of responses to the ten items was 3.19 which was less than the decision mean score of 2.50. This implies that environmentally friendly materials are cost intensive, although the findings reveal that materials such as bamboo and straws are readily available and cheaper alternatives to concrete and cement

and eco-friendly building materials have low maintenance compare to conventional building materials

### 4.5 Discussion of Findings

Findings revealed that environmentally friendly materials are readily available in Kaduna State as the responses gave a grand mean score of 3.40 indicating the availability of environmentally friendly materials. This is in line with the findings of Abimaje and Baba (2014) who revealed that environmentally friendly materials are available for building construction.

The findings also revealed that environmentally friendly materials are utilized in Kaduna state, with the grand mean score of 2.70 indicating non-utilization. This is contrary to the findings of Obianyo *et al.,* (2021 who revealed that environmentally friendly materials are not being utilized and credited it to the lack of awareness by most people.

The findings also revealed that environmentally friendly materials has an effect on the environment with a grand mean score of 3.58. this revealed the effect of environmentally friendly materials on the environment. This finding is in line with the findings of Abimaje and Baba (2014) who revealed that environmentally friendly materials absorbs carbon dioxide and overall produces less pollution as compared to conventional building materials.

Findings further revealed that environmentally friendly materials are cost intensive and consume more financial resources as compared to conventional building materials, although the findings revealed that environmentally friendly materials are comparatively easier to maintain. The findings were contrary to the findings of Ayodeji *et al.,* (2018), who revealed that environmentally friendly materials are sustainable and cheaper than traditional building materials.

# CHAPTER FIVE

## 5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

### 5.1 Summary of the Study

The research assessed the need for environmentally friendly materials for building construction in Kaduna State. However, the study is divided into five chapters in which each chapter is discussed extensively.

Chapter one of the research contains the background of the study, statement of the problem, research questions, significance of the study, scope of the study, methodology, limitations of the study and definition of the terms. Similarly, in Chapter two, many relevant literature from several authors were used to expose what various researchers have done in the area of environmental friendly building materials. In Chapter three of the study that based on research methodology, the descriptive survey research design was adopted in which questionnaires were administered. Simple random sampling technique was also adopted to select respondents. Chapter four of the project revolved on the data analysis and interpretations of findings. The mean and standard deviation statistics were used for the data analysis. This chapter contains the summary, conclusion, and recommendation of the study.

### 5.2 Major Findings of the Study

The following findings have been made from the research work

1. The findings of the study revealed that environmentally friendly materials are available.
2. The findings of this study also revealed that environmentally friendly materials are being utilized.
3. The findings of this study also revealed that environmentally friendly materials has an a positive effect on the environment,
4. The findings of this study also revealed that environmentally friendly materials are cost intensive.

**5.3 Implications of the Major Findings**

The following are the implications of the major findings.

1. Reduced environmental impact: The use of environmentally friendly materials can reduce the environmental impact of construction activities in Kaduna State. Such materials are typically made from renewable resources, are biodegradable or recyclable, and have lower levels of toxicity than conventional materials. This can help to reduce waste, conserve resources, and minimize the release of harmful chemicals into the environment.
2. Health benefits: The use of environmentally friendly materials can also have health benefits for construction workers and residents of Kaduna State. Conventional building materials can contain harmful chemicals such as volatile organic compounds (VOCs), which can be released into the air and cause respiratory problems. Using environmentally friendly materials can reduce exposure to these chemicals and improve indoor air quality.
3. Economic benefits: The availability of environmentally friendly materials can create new economic opportunities in Kaduna State. The production and use of such materials can create jobs and support local industries, while also attracting investment from environmentally conscious businesses and consumers.

4. Sustainability: The use of environmentally friendly materials can promote sustainability in Kaduna State by reducing the reliance on non-renewable resources and minimizing waste. This can help to create a more sustainable and resilient built environment for future generations.

### 5.4 Contribution to Knowledge

1. Identify the current building materials in Kaduna State: To access the need for environmentally friendly building materials in Kaduna State, it is important to first identify the building materials currently used in construction. This will determine the extent of the environmental impact of this material and highlight areas where improvement can be made.

2. Evaluate the environmental impact of current building materials: once the current building materials have being it edified, and evaluation of their environmental impact should be conducted. This can include assessment of the energy and the resources required to manufacture and transport the materials as well as the amount of waste generated. During construction.

### 5.5 Recommendations

The following can be recommended after critical examination of the responses and review of the previous literature.

1. Change in Government policies: the government should consider the implementation and revision of already existing policies as regarding the utilization of environmentally friendly materials, there should be subsidies and laws to promote environmentally friendly materials.

2. Enlightenment campaigns and behavior change communication should be used in order to educate consumers and manufacturers on the environmental benefits of environmentally friendly materials.
3. The Kaduna State Government should ensure strict adherence to public safety measures that will lead to environmental safety, houses should be build with sustainable and environmentally friendly materials to address issues of pollution.

**5.6 Suggestions for Further Research**

1. Further research should not be limited to a specific area, it should cover a wider geographic area

2. Further research should investigate the impact of building materials on water pollution.

3. A comprehensive study should be carried out using experimental or mixed-research methods to investigate the effect of environmentally friendly materials on the environment in Kaduna State, Nigeria.

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## APPENDIX A

### List of construction companies in Kaduna State.

| S/N | NAME OF THE FIRM |
|---|---|
| **1** | De Brightz Engineering & Constructions Company |
| 2 | Binkam Nigeria LTD |
| 3 | Gyetmah constructions |
| 4 | CCECC kaduna |
| 5 | Steelagon engineering limited |
| 6 | Enviro construction pty.ltd |
| 7 | Dream measures nig.ltd |
| 8 | Obtainit nig.ltd |
| 9 | UBBI concrete industry nig.ltd |
| 10 | Hepthadel group of companies |

***Source Research field survey (2022)***

## APPENDIX B
## Letter of Request for Instrument Validation

Department of Industrial and Technology Education,

School of Science and Technology Education,

Federal University of Technology Minna, Niger State.

Date…….

Dear Sir,

**REQUEST FOR VALIDATION OF RESEARCH INSTRUMENT**

I am an undergraduate student of the Department of Industrial and Technology Education (Building Technology), School of Science and Technology Education, Federal University of Technology Minna, currently undertaking a research project titled**: Assessment of the Need for Environmental, Friendly Building Materials for Construction in Kaduna State .**

Kindly read the attached questionnaire and assess its validity, your comments and suggestions that could enhance the validity of the instrument and also improve the quality of the instrument will be highly appreciated. I count on your co-operation while thanking you in anticipation.

Yours Faithfully,

**Micah Zam Zam**
**2016/1/60417TI**
**BTech Research Student.**

**APPENDIX C**

**FEDERAL UNIVERSITY OF TECHNOLOGY MINNA**
**SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION**
**DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION**

**ASSESSMENT OF ENVIRONMENTALLY FRIENDLY MATERIALS FOR BUILDING**

**CONSTRUCTION QUESTIONNAIRE" (AEFMBCQ)**

**Key: FA (Fully Available), A (Available), PA (Partially Available), NA (Not available)**

**SECTION A:** What is the level of availability of environmentally friendly materials for building construction in Kaduna State

| S/N | ITEMS | FA | A | PA | NA |
|---|---|---|---|---|---|
| 1 | Bamboo | | | | |
| 2 | Strawbales | | | | |
| 3 | Hempcrete | | | | |
| 4 | Cork | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Rammed earth | | | | |

**SECTION B:** What is the level of utilization of environmentally friendly materials for building construction in Kaduna State

**Key: FU (Fully Utilized), U (Utilized), PU (Partially Utilized), NU (Not Utilized)**

| S/N | ITEMS | FU | U | PU | NU |
|---|---|---|---|---|---|
| 1 | Bamboo | | | | |
| 2 | Strawbales | | | | |
| 3 | Hempcrete | | | | |
| 4 | Cork | | | | |
| 5 | Rammed earth | | | | |

SECTION C: What is the effect of environmentally friendly materials on the environment?

| S/N | ITEMS | SA | A | D | SD |
|---|---|---|---|---|---|
| 1 | The use of eco-friendly building materials positively affect the environment | | | | |
| 2 | The use of materials such as bamboo for building construction can help tackle climate change | | | | |
| 3 | The use of environmentally friendly materials can address the issue of land, water and air pollution. | | | | |
| 4 | Emphasis placed on eco-friendly building materials will promote recycling and further lead to a healthy, non-toxic | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | environment | | | | |
| 5 | Eco-friendly building materials will lead to the reduction in the consumption of natural and non-sustainable resources. | | | | |

SECTION D: What are the financial cost of environmentally friendly materials for building construction in Kaduna State?

| S/N | ITEMS | SA | A | D | SD |
|---|---|---|---|---|---|
| 1 | Materials such as bamboo and straws are readily available and cheaper alternatives to concrete and cement | | | | |
| 2 | Eco-friendly building materials are expensive to design and construct | | | | |
| 3 | There are no government subsidies for eco-friendly building materials | | | | |
| 4 | Eco-friendly construction are labor intensive, therefore hiking the cost. | | | | |
| 5 | Eco-friendly building materials have high maintenance compare to conventional building materials | | | | |