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The use of local building materials and its challenges in Ghana: a case study of Denkyembour district–Akwatia

FRANCIS KWAKU AZUNU

DECEMBER, 2017

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THE USE OF LOCAL BUILDING MATERIALS AND ITS CHALLENGES IN GHANA: A CASE STUDY OF DENKYEMBOUR DISTRICT–AKWATIA

FRANCIS KWAKU AZUNU

7151190001

A Dissertation in the Department of CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for the award of Master of Technology (Construction) degree.

DECEMBER, 2017

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DECLARATION

STUDENT'S DECLARATION

I, Francis Kwaku Azunu, declare that, this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……..

DATE:……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: PROF. ING. NICHOLAS KYEI-BAFFOUR

SIGNATURE ……

DATE: ……..

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ACKNOWLEDGEMENT

I must first and foremost acknowledge the divine guidance by the Almighty God for taking me through the programme. Honestly, I want to acknowledge my supervisor, Prof. Nicholas Kyei-Baffour. Not forgetting the following personalities for their Tremendous contribution; The entire staff of the Denkyembour District Assembly Akwatia, especially Mr. Solomon Dodoo, ((Human Resource Manager), Mr. Aziz Amed (Assist. Director), Mr. Wonder Davor (Works Department Engineer), Mr. Mensah Kwateng: (General Managing Hodidi Real Estate Company Development Limited, Ghana -Akwatia Branch), Mr. Narh Amartey (The Principal, Akwatia Technical Institute) and finally those who helped either directly or indirectly to make this work a success.

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DEDICATION

This work is dedicated to my mother, Agnes Tey, and late father Albert Agbovi, my wife Gladys Ohene Akuffo Azunu, my three children, Agnes Azunu Esiman, Albert Azunu Gameli, Lawrence Selorm Tenkorang Azunu and my three siblings, Joyce Dompey, Comfort Fosua Okor and Phillis Naana Okor for their prayers, love and encouragement that have seen me through this programme.

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ABSTRACT

Over the years, the construction industry of Ghana has witnessed tremendous increase in the cost of building. Despite the clarion call by successive governments and civil society organisations to use indigenous materials, the patronage still remains a challenge. This study sought to investigate into the use of indigenous materials for buildings construction and its inherent challenges using Denkyembour District-Akwatia as the case study. The target population involves contractors, employees of construction firms and clients. Convenience sampling technique was employed in selecting sample size of 207, out of which 186 responded. Questionnaire served as the main data collection instrument and results were analysed using descriptive statistics and inferential statistics. The study found that most respondents alluded they patronise indigenous materials for construction activities. The three most dominant challenges to the use of indigenous materials were apathy, low technical know-how and misconception based on social class. This has been fueled by the misconception that indigenous materials are of low standard and quality. It was established that the quality of buildings are highly determined by the nature and type of materials used. The use of indigenous materials were found to promote cultural heritage, keeps money in the local economy, provide cool room temperature and most of them were affordable and cheap. Despites these challenges, the use of indigenous materials help to promote culture of the local communities and retain income in the local economy. There should be a comprehensive policy that would motivate the communities to adopt the use of local materials for buildings and it is appropriate for producers of local materials to adopt enhanced technology to improve their products.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry is one of the most robust and growing sectors of our economy. As an emerging lower middle income country this sector provides the vital engine for economic growth. Indeed, the construction subsector contributed 9.7 percent to the 2012 GDP (Ghana Statistical Service, 2013). Opoku et al. (2015) stressed that the increase in population and human activities in Ghana has rapidly pulled up a high demand of buildings to house individuals and activities (i.e. the provision of residential, commercial, industrial or the combination of any of the building categories). However, the demand for building has beckoned the activeness of the building construction industry (BCI) to support in whinging the wheels of development, especially in developing countries (Ofori, 2012; Lopes, 2012).

The provision of adequate housing in decent human settlement is essential to satisfy the physical and biological as well as social requirements of man, in order to improve his quality of life (Kronenburg, 2001). However, despite upward trends in housing production over the years, generally, the increases are not enough to offset the accumulated deficits, and also to meet the needs of the increase in population in urban Ghana (Andersen et al., 2006). With the failure of the nation taking decisive and sustainable action on housing materials to enable production of housing (Badu & Owusu-Manu, 2011), it comes as no surprise that housing shortage has hit government officials, leading to political upheaval. Sustainable construction requires a critical review of prevailing practices, techniques and sources for raw materials

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(Danso, 2013). Currently, there is over reliance on foreign and imported materials especially for building as the nation import about 80 per cent of construction materials at the expense of local content (Tamakloe, 2012). Danso alludes to this assertion by stating that there is an acute lack of affordable houses which is largely due to the high cost of the conventionally processed construction materials such as steel and Portland cement. The desire generated for these materials has a negative impact, leading to reduced value and perceived inappropriateness of locally available materials. This phenomenon drains the economy of dire needed foreign exchange which is needed for other developments.

Ghana is endowed with local raw materials for the manufacture of indigenous building materials. Since 1953, some national efforts have been made into promoting the development of indigenous building materials (Atiemo, 2005). Attempts by the governments to augment the informal sector in housing delivery have not been encouraging. Findings by the Building and Road Research Institute (BRRI) of the Council for Scientific and Industrial Research (CSIR), the Geological Survey Department of Ghana and others indicate that there are enough indigenous materials in all the ten regions of the country which are suitable for construction. This has resulted in the production of materials such as burnt clay bricks and tiles, pozzolana cement, compressed and stabilized earth blocks for low cost housing in Ghana (Atiemo, 2005). Surprisingly however, the proposal for houses to be constructed with indigenous materials has not been embraced as expected by key professionals of the industry (Architects, Structural Engineers and Quantity Surveyors). There is overdependence on conventional building materials for which local substitutes can be developed and for which there is comparative advantage for local production. It has therefore become necessary to investigate

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factors that inhibit the use of these indigenous building materials in the Ghanaian Construction Industry (Acheampong et al., 2014).

The use of local materials in the construction is one of the ways to support durable development on the entire planet, because it is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The world heritage is very rich in all countries in construction. However, the construction using local materials, in the developed countries, became marginal. These techniques were abandoned because it is not possible to standardize the composition of materials because it varies locally. To resolve the economic and environmental problems, concerning the concrete or cinder block construction in Africa, this material can be again a local resource to traditional housing (Lawane et al., 2012).

1.2 Statement of the Problem

Housing is a structurally separate and independent place of abode within which a person or group of persons can isolate themselves from the hazards of the climate. It is a basic need that provides security and privacy all of which one considers as a human right. In 2006 the World Bank described Ghana as a third World country having only 1 out of 3 persons sheltered (UN-Habitat, 2006). The Short fall in housing stock was blamed on the inclusion of expensive imported material components in the total costs of procurement. The suggestion was therefore made that more locally available materials instead of imported materials be used in building so as to cut down on costs and subsequently increase supply of housing units (Lilly et al., 2001). In Ghana, the Government in its effort to promote the use of local building materials adopted a policy initiative in November, 2010 on the use of 60% local building materials in

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the construction of public buildings by 2015. The focus is, among others, to bring to the fore, the quality and best practices in the use of locally developed building materials (Danquah et al., 2015). By the researcher's observation there is lack of patronage of local building materials in Ghana although it is readily available and abundant in many parts of the country. Players in the real estate sector have called for consistent and regular use of cheaper local resources in Ghana's building and construction industry. Such, they believe, would add value to the country's natural resources and create jobs for the unemployed. At a roundtable discussion on "Sustainable Real Estate in Ghana" in Accra, it was reportedly suggested that the prevailing building system was not environmentally sustainable and needed to be modified, as foreign materials did not suit our environment.

"There is a stigma attached to people who have decided to blend the use of local resources with the imported resources for building. The perception is that when you use local materials, it means you are poor, which should not be so," a design/build consultant deplored (The Chronicle, 2014).

There is therefore the need to conduct a study into the need for constructing houses with locally available materials in order to appreciate peoples' experience about the benefits and challenges of using local materials for building houses and again, to make recommendation for future studies to improve and make them preferable materials for building houses using Denkyembour District – Akwatia as the study area.

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1.3 Aim of the Study

The main aim of this study seeks to identify the challenges associated with using locally made materials for building construction, the extent of the usage and its effects.

1.4 Objectives of the study

The study seeks to achieve the following objectives:

1. To identify the extent to which locally made building materials are patronised.
2. To identify challenges associated with using locally manufactured building materials.
3. To examine effects of using locally manufactured materials for construction activities.

1.5 Research Questions

In achieving the objectives of the study, the following research questions are set to be answered:

1) To what extent are locally made building materials patronised for construction activities?
2) What are the challenges associated with using locally manufactured building materials?
3) What are the effects of using locally manufactured materials for construction activities?

1.6 Scope of the Study

The study was focused on Denkyembour District-Akwatia in the Eastern Region. The focus was geared towards construction firms in the catchment areas selected for the study. This limits the survey to only Akwatia and therefore it would be difficult to generalise its findings to cover other parts of the region and Ghana as a whole. Issues dealt in this study include challenges inherent in using indigenous materials, the extent to which firms use indigenous materials and their effects on buildings and the economy as a whole.

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1.7 Significance of the study

The study is expected to provide adequate education on local materials used for building activities by recognising the significance attached to their use. It is expected that the findings of this study promote empathy towards the use of indigenous materials for construction activities. The study will add knowledge to existing literature on indigenous materials and their effects on buildings and the local economy as a whole. The work is expected to serve as a major source of reference material for people in academia and other interested groups or individuals.

1.8 Limitations of the Study

The researcher encountered certain difficulties in the process of the survey especially during the data collection stage. Some management of the selected construction firms were simply not interested in the survey and were reluctant in giving out information for fear of victimisation eventhough the academic purpose of the study was fully communicated. This affected the response rate of the study.

1.9 Organization of the Chapters

The study is organised into five sections. The first chapter deals with the background of the study, statement of the problem, objective of the study, research questions, scope of the study, significance and limitations of the study. The chapter two of the study presents the review of related literature which consists of conceptual, theoretical and empirical studies of other authors on the subject matter. The chapter three presents methodology of the study which includes the research design, population, sample size and sampling technique, data collection techniques and procedure and data analysis. The chapter four deals with analysis and

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discussion of the findings and the fifth chapter presents the summary of findings, conclusions and recommendations and suggestions for future studies.

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CHAPTER TWO

LITERATURE REVIEW

2.1 The Construction industry of Ghana

Ofori (2012) posits that the construction industry is important because of the outputs and outcomes of its activities. It contributes to national socio-economic development by providing buildings which are used in the production of all goods in the economy. There is no doubt that the Ghanaian Construction industry as in many other construction economies holds the key to the development of the nation. Construction contributes to the national socio-economic development by providing significant employment opportunities at non-skilled and skilled levels (Ahadzie, 2009).

Ahadzie (2009) further stated that, the industry provides the infrastructure and facilities required for other sectors of the economy to flourish such as; schools for education and training, factories and shops for commercial and business activities, housing for basic human needs, hospitals for health care, buildings for the national communications network and so on. Ofori (2012) argued that the physical infrastructure built through construction activity is the nation's economic backbone as it forms arteries for the facilitation of productivity by enabling goods and services to be distributed within and outside the country. The items built also offers social welfare benefits, for instance he argues that housing for instance fulfills one of the basic needs of humanity by providing shelter from physical elements (Ofori. 2012).

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For many years, the government of Ghana has tried to find suitable ways to solve the housing problem of the country through various means. One of such means is trying to encourage the use of indigenous local materials such as burnt clay bricks and tiles (Ahiabor, 2014). The efforts to construct more houses have become a priority because the country is said to have a housing deficit of 1.5 million (Ahiabor, 2014). Building construction in Ghana in recent times is faced with high costs of building materials due to high percentages of imported materials. This has resulted in high deficiencies in housing supply. Cardoso et al. (2007) reiterated that to alleviate this problem of deficiency in housing supply there is the need to embrace the use of local materials like timber and bamboo which are paramount in the Ghanaian building construction industry. Ghana's forest timber production area is declining in an increasing manner in both size and productivity due to unecological logging practices and over utilization of traditional timber species. The extreme exploitation of the forest has beckoned on authorities to put in place strict regulations which have eventually reduced the quantity of timber supplied to the furniture and construction industries (Ayarkwa, 1998).

The construction industry (the "industry") in Ghana is aware of the many challenges facing the country and the industry in particular. The industry, in collaboration with government, academia and the public sector, is working towards a process that will both meet their own business interests while simultaneously protecting the environment. The issue is less one of awareness of the challenges than of formulating a strategy to move towards sustainability in the industry. The challenges are complex, involving a multitude of causes, impacts and diverse stakeholders, all with their own vision of what 'successful' development can and

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should look like. In short, the industry is searching for a vision of a sustainable future, and a process to arrive there (Ahmed et al., 2014).

2.2 Concept of Building

Building is as old as humanity whose product it is; and has evolved through centuries of activities, from dwelling in caves to skyscrapers and recently to intelligent structures that can smartly respond to stimuli in its environment. Mosaku et al. (2006) observed that building practice has also undergone a great deal of metamorphosis in response to the dynamic nature of human needs and development. Essentially however, building design and construction are processes which traditionally involve several professionals collaborating for relatively short periods to develop a facility (Anumba, 2006). The building process may also be grouped into three major phases: the conception/design phase, construction phase and operation or use phase (Horsely et al., 2003).

The conception and design phase is when most of the decisions that influence the performance of the building are made; the construction phase represents the actualization stage when much of the capital cost is incurred; and the operation or use phase account for the greatest proportion of time period of the building life – usually in the range of 60 – 100 years, as against the few weeks, months or years usually used for the first two phases. Building practice entails the entire system that defines procedure and standards for all three phases of the building process; as well as spells out the responsibilities and interaction among the building industry professionals – town planners, architects, builders, engineers, quantity surveyors and estate managers. Two phenomena – free market economy and advancement in information and communication technology (ICT) are simultaneously working for the fast

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transformation of the whole world into a global village where goods and services can be made available with minimum restrictions and delays. The project team for a building may therefore involve partners from widely distributed geographical areas, sometimes on different continents (Madigan 1993). For example a project in Ghana, with a Ghanaian client, could have a French architect, a British engineer, an Italian constructor, Japanese subcontractors and Korean material supplier. Such a global construction environment requires uniform (global) standard and quality of the built environment. This makes improvement an imperative for local players' survival.

Buildings in the tropical area of the world are constantly exposed to solar radiation almost everyday. As a result, building design should aim at minimising heat gain indoors and maximising evaporative cooling so that users of these spaces can have adequate thermal comfort. To achieve this objective, buildings in this part of the world should have shapes and forms which should (1) be responsive to this objective, (2) be properly oriented, and (3) the fabric of the buildings should be specified to prevent or minimise heat gain. Also buildings in this area should respond to passive energy and have minimal use of active energy for economic viability. In order to meet the above requirements, it implies that buildings should be bioclimatic adaptable (Ajibola, 2000).

2.3 Building materials

A report by the United Nations revealed that the building materials sector was split into three production groups (Adogbo & Kolo, 2009). modern or conventional building materials which are based on modern conventional production methods like concrete, steel, and glass; traditional materials which include those materials that have been in local production from

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ancient times using small-scale rudimentary technologies, for example, laterite, gravel, thatch, straw, stabilised mud, Azara, and raphia palm; and innovative materials which are materials developed through research efforts aimed at providing alternatives to import-based materials, for example, fibre-based concrete and ferrocement products (Baiden et al., 2014). Building materials constitute the largest single input in housing construction. While Adedeji (2010) observed that about sixty (60) per cent of the total housing expenditure goes for the purchase of building materials, Arayela (2005) averred that the cost of building materials constitute about 65 percent of the construction cost. Ogunsemi (2010) opined that building materials form the main factors that restricts the supply of housing and ascertained that they account for between 50-60 percent of the cost of buildings.

Building materials have been playing an important role in the construction industry. They are those materials put together in erecting or constructing structures, no field of engineering is conceivable without their use (Akanni, 2006; Udosen & Akanni, 2010). Building materials contribute immensely to the quality and cost of housing, from what is used in the foundation to the materials for roofing and finishes, while the building materials industry is an important contributor to the national economy of any nation as its output governs both the rate and the quality of construction work.

2.3.1 Indigenous building materials in the construction sector

The building materials sector of the construction industry is a major contributor to the success of the industry. This is because materials constitute the largest input in construction, usually accounting for about half of the total cost of construction projects (Mogbo, 1999). Cunningham and Cunningham (2002) defined indigenous building material as any material

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that is locally produced and manufactured, naturally occurring, and abundant in a country. Loken et al. (1994) also defined indigenous materials as materials which are produced in the same bioregion or regional ecosystem where they will be used. Some practitioners consider materials to be indigenous only if they are available on the same site where they will be used (Pearce, 2001). Indigenous materials also suffer from widespread but generally erroneous belief that a material is indigenous only if it is "primitive" and as such requires little or no processing between harvest and use (Owusu, 2001).

Three distinct construction materials can be identified based on the method of production: 1) the traditional materials which have been in local production from ancient times using rudimentary technologies. For example stabilized mud, straw, laterite, gravel, thatch, raphia palm, etc. 2) the conventional building materials which are materials based on modern production methods like concrete, steel and glass. The third (3rd) groups of materials are innovative materials which are developed through research efforts aimed at providing alternatives to import-based materials such as fibre-based concrete, ferro-cement products, pozzolana, etc (Fadairo and Olotuah, 2013; Adedeji, 2011).

Undoubtedly, the use of local building materials in construction presents some challenges that undermine its use. Mahgoub (1997) objects to the return of indigenous building materials in modern buildings for two reasons. First, he posited that these materials cannot satisfy the new needs of building forms and functions and, secondly, it is impossible to provide enough materials to satisfy demand. According to Cassell (1993), earthen construction is labour intensive which makes it expensive to construct with. Cather (2001), however, observed that better understanding of the failings of these materials and their innate characteristics,

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overcoming their shortcomings and ways to use them with confidence, can be gained, by applying new knowledge and techniques.

Okereke (2003) categorized locally available materials into naturally occurring raw material deposits such as soil and stones, agricultural products or residue such as mulch and products of manufacturing processes such as landcrete blocks or mud bricks. The nature of the building materials, especially sandcrete or sand-cement blocks and housing construction, has been sufficiently treated elsewhere by Yeboah (2003), Ofori (1985) and others but their conclusions are largely characterised by users' poor attitudes towards earth building materials on one hand, and lack of technical knowledge as well as building codes and regulations on the other. The apparent lack of attempts to address those problems has been compounded by taste of modernization for sand-cement or concrete housing construction technology (Afrane & Asamoah, 2011).

Cement based building materials are preferred more readily to earth based building materials. It is important to identify and use locally manufactured and available materials (sand, stones, grass, thatches, clay, timber, clay bricks and clay blocks) in providing houses especially in the developing countries in order to meet the housing demand of their people (Danso, 2013). In general, the use of local materials needs to be supported and reinforced to produce sufficient quantities of materials of adequate quality to withstand the effects of climatic conditions which range from humid rainy seasons to extremely hot dry seasons. Mud structures, mud and wattle buildings, and locally produced bricks and blocks do not endure for many of these seasons, and must be constantly patched and repaired (Danso, 2013).

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2.3.2 Building materials used in the Construction Industry

Bamboo

The uses of bamboo for building construction have metamorphosed from simple pole construction to more sophisticated construction (Tekpertey, 2006). Bamboo can serve as a material for the whole or part of a construction of a building (Tekpertey, 2006). It has greatly been given consideration by several countries in Asia and Latin America as an important building material not only for the construction of rural houses but also for urban private houses and public buildings (Shyamasundar and Vengala, 2008). According to Malin and Boehland (2006), the use of bamboo in building construction can be classified into temporary (Props, Scaffolding, Workers shed, Ladder, Formwork and Hoarding) and permanent uses (Bamboo Reinforcement, Trusses, Ceiling, Doors and windows, Roofing, Bamboo floor, Partition walls and Landscape).

Addo Attuah (2017) emphasised testament to its siting in West Africa's forest belt, fast-growing and renewable bamboo is widely grown and available in Ghana, supporting 25 identified species including native and introduced kinds. Bambusa multiplex holds court as the true indigenous variety. The clumping (sympodial) type proves useful for agricultural and environmental purposes, while the running or open (monopodial) type is handy for construction purposes. Environmentally, bamboo assists with such issues as soil stabilization, coastal edge maintenance and microclimatic conditions, while for construction, bamboo aids in scaffolding, furniture, laminated boards and floor-and-roof paneling. Solomon-Ayeh (2005) expressed that bamboo comes on its own in such a situation. However, constraints to the development of bamboo as a modern structural/construction material is the lack of locally-

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derived mechanical/engineering data, availability of safe, effective and cheap preservation methods and the non-availability of plantation grown bamboo (which tend to have more uniform dimensions).

Bricks

Brick is permanent. Once it's built it remains weather proof and age proof. Brick doesn't get tired like man-made materials, so it requires virtually no upkeep or repairs. Bricks don't rust or erode, rot or decay, bend, twist or warp (Think Brick, 2013). Bricks are non-combustible and don't support the spread of fire, making them ideal for building in bushfire-prone areas. Clay bricks generally do not suffer any structural damage after a fire and can be re-used even as load bearing walls (Danquah et al., 2015). Generally, a good brick must be hard, well burnt, uniform throughout, sound in texture and colour, and sharp in shape and dimension and should not break easily when stuck against another brick or dropped from a height of about one meter (Gopi, 2009). In using burnt clay bricks for construction, certain desirable properties should be achieved. Among these desirable properties are compressive strength, density, thermal stability, porosity, sound insulation, fire resistance, durability, and so forth. Density is described as the ratio between the dry brick weight and the volume of the clay brick, measuring the proportion of matter (clay) found in the volume. It is evident from this description that the higher this value is, the denser the brick is, and obviously, the better its mechanical and durability properties are. Typical values for the apparent density range from 1,200 kg/m3 to 1,900 kg/m3 (Fernandes et al., 2009).

Bricks generally exhibit better thermal insulation property than other building materials such as concrete. Perforation can improve the thermal insulation property of bricks to some extent.

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The mass and moisture of bricks help to keep the temperature inside a brick house relatively constant. The thermal conductivity of bricks measured at various water content and densities have shown that the thermal conductivity of denser bricks are higher than less dense bricks. The increase in thermal conductivity due to wetting varies from brick to brick and may be as low as five percent (5%) or as high as thirteen percent (13%) for one percent (1%) increase in moisture content. Generally, the thermal conductivity is doubled when it is saturated with water. The thermal conductivity of bricks varies between 0.7 and 1.3 w/mk (Baiden et al., 2014).

Danquah (2011) emphasised that Ghana stands to derive a lot of benefits from the production and use of burnt clay bricks if this alternative local building material is critically promoted. Whilst recognising the challenges facing the brick industry such as energy requirements, environmental issues and cost of production, a collaboration with the stakeholders of the housing sector can fashion out practical solutions to these. To date clay brick usage as a construction material is showing signs of slow, but improved patronage. Despite various fora and workshops being undertaken to promote the use of clay bricks as a major construction material in Ghana, usage is still not up to expectation.

Laterite

Present in hot and wet tropical conditions, laterite is a reddish-brown surface formation derived from weathered rock containing rich iron and aluminum deposits. In its weathered form, laterite has a clay-like consistency granting it greater water-holding capacity than sandy soils and thus making it valuable for flooring and blockwork (wall units). When compacted, laterite serves as flooring systems for vernacular homes, bases for roadways and fill for

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foundations and embankments. When moistened, builders can mold laterite into dense bricks that require little mortar, cured according to strength needs, and because of its thermal nature, it can act as building coolants (Addo-Atuah, 2017).

Timber

A prized international export product and domestic resource, timber offers the Ghanaian architectural industry, vernacular and hybridized, a myriad of benefits. Timber use in Ghana often manifests in the form of sawn wood, veneer sheets, particleboards and plywood for both domestic use and export. Within Ghana's indigenous architecture, timber acts as structural frames or walls (2 to 6 inches in diameter) or as suspended horizontal floors in lagoon-based settlements for food and tools storage (Addo-Atuah, 2017).

Stone

Stone's primary use in Ghana's indigenous architecture is as a critical component in foundation prepping. To alleviate the need for foundations, builders typically select sites of firm ground, which will serve as substructures and ground floors for homes. Where firm ground is lacking, builders excavate the earth until hitting firmer ground and carve out holes that will act as footings for vertical wooden posts. From there, masons will add to each individual footing, small pieces of stone held together with lime mortar (Addo-Atuah, 2017).

Floor Tiles

Ugochukwu et al. (2014) stressed that a tile is a manufactured, thin square or rectangular piece of material such as ceramic stone, metal, baked clay, concrete, cork or even glass. Tiles are generally used for covering roofs, floors, walls, showers or other objects such as tabletops.

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Tiles are sometimes referred to as similar units made from lightweight materials such as wood and mineral wool typically used for wall and ceiling applications. The word tile is derived from the French word '*tuile',* which is gotten from the Latin word '*tegula'* meaning a roof tile composed of fine clay. Tiles are often used to form wall and floor coverings and can range from simple square tiles to complex mosaics. Tiles are most often made from porcelain, fired clay or ceramic with a hard glaze or other materials such as glass, metal, cork and stone. Tiles or fire clay are basically inorganic, non-metallic solid materials produced by techniques of heating and subsequent cooling. In 2010, world tile production amounted to 9.515 billion square meters, although much of that growth was concentrated in Asia and Europe with China in the world top manufacturing country with 4,200 million square meters i.e. 44.1% of world production and also world leading consumer with about 3,500 million square meters about 37.4% world consumption and also world leading exporting country with about 705 million square meters is about 36.8% (David, 2011).

Cement

The demand for cement is the function of construction activity spurred by the growth and development of an economy and the continuous inflow of investment into the development of both residential and commercial estates construction by government, corporate and private developers. The cement industry thrives in growing economies where new construction projects are continuously springing up (Ugochukwu et al., 2014).

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2.4 Building materials and regulations in Ghana

Ghana is geographically divided into three main climatic zones: the warm-humid (e.g. Kumasi), the hot-dry (e.g. Tamale) and the coastal-hot savannah climatic zones (e.g. Accra). The Greater Accra region constitute the Coastal-hot savannah climatic zone . Building materials and construction technology generally differ from one climatic zone to another in Ghana. Regulation 32 (1) of the Legislative Instrument (L.I.) 1630 stipulates that mud or swish used in plastic state to erect an earthen wall or for swish walling (locally known as *atakpame)*; wattle and daub; pise or earth rammed between wooden or other formwork to make a wall in situ; unburnt earth bricks or blocks (adobe); stabilised earth products, bricks and blocks (or landcrete); burnt clay products; sandcrete, concrete, or reinforced concrete; thatched or leaves in roofing or otherwise; timber or bamboo products; asbestos-cement products; metal products; glass and synthetic materials; stone products; lime-based materials; and other approved building materials may be used in the construction of buildings so long as they conform to the provisions of the L.I. 1630 (The Republic of Ghana, 1996).

Notwithstanding the provisions regarding building materials under Regulation 32, designated planning authorities, having regard to the architectural values and general standard of development of any particular area, may reject any application for approval of a building, if it is viewed the building would detract from the general trend of development in a particular area (The Republic of Ghana, 1996). However, Ghana, like many other countries in sub-Saharan Africa has practical difficulties of enforcing the wide range of restrictive building regulations (Boamah *et al*., 2012).

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Ikejiofor (1999) argued that little modification to existing rigid building regulations and housing codes constituting serious barriers to shelter provision in sub-Saharan Africa, particularly regarding acceptable local building materials, can provide an alternative that is perhaps more appropriate to enhance urban housing. Accordingly, Ikejiofor (1999) assertion will be in line with United Nations Commission on Human Settlements (UNCHS)'s Enablement Strategy to housing where governments are to assume the role of providing housing through the concentration on reforming and managing the legal, regulatory and financial policy framework (Ogu & Ogbuozobe, 2001). Currently in Ghana, the Local Government Act, (Act 462), 1993 and the National Building Code, (L.I. 1630), 1996 are the main instruments used for the guidance of physical development throughout Ghana. From a distance, one may be tempted to believe that there are no rules and regulations that guide physical development activities in Ghanaian cities and towns (Boamah *et al*., 2012).

Building construction and the use of building materials appeared to be at odds with climatic considerations. This paper does not argue that building rules and regulations should be applied to limit peoples' taste and preferences of building materials because when regulations are made on building materials, it limits peoples' accessibility to explore for innovation but some degree of sustainable building should be adhered to as pertains in Singapore where the Building Control (Buildable Design) Regulations, introduced in 2001, require buildings to attain minimum buildability scores under the Buildable Design Appraisal System (BDAS) (Pheng & Chen, 2011).

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2.5 Construction and the Environment

Site design and response of construction to the natural environment remains a common problem in Africa. By not allowing a proper investigation of the site, the natural environment ceases to be an integral part of design and construction implementation and is thereby compromised. As argued by Schaefer (1994), the architects, developers, builders and owners often overlook the site as one of the significant elements of sustainable development and construction. He further argues that development proceeds in a heroic mode - that nature is to be conquered, the rugged individual mastering and subduing the land for economic gain. In many urban areas of Africa and especially in the cities, construction of buildings generally, but especially residential buildings has been carried out to occupy the entire site. The natural green system has been destroyed and compaction has taken place to a level that prevents air movement even after construction is completed. The existing natural environment has in many cases been destroyed beyond repair. In South Africa for example, new housing, especially in the state low-cost projects, has turned areas of natural vegetation to desert, with construction activity causing removal of all the trees on site rather than integrating them into the built environment. A comparison of this scenario with informal settlements in Durban and other South African cities reveals that trees are well -preserved in areas where there is no intervention of new construction.

In addressing the complex problem of construction and the environment, efforts towards sustainable design are fundamentally an attempt to put into place practice that restores the balance between the natural and built environment. It is a search for an ecological model that views both realms as fundamentally interconnected. It should be recognised that mankind is

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locked into a highly dynamic relationship with the natural world and that the two are acutely interdependent. If this relationship is forgotten, certainly mankind and his integration into the environment has failed to effectively utilize it to build and shape the land in a manner that is harmonious, symbiotic and sustainable (Schaefer, 1994).

Site planning as an approach is well understood by the professional as a way in which to achieve balance between the built and natural environment. The work of Lynch (1975) gives a comprehensive approach to site planning, to identify the critical and important aspects of the site to be integrated in the project. Norberg-Schultz (1984) also argues that the point of departure of design on site and construction should understand the existing characteristics of the site as Genius loci which also includes climatic conditions, orientation, hydrology, geology, ecology, etc. It is not uncommon in today's construction to see sinking, cracking of walls and unbearable indoor temperatures coupled with faulty foundations, construction material choice yielding unhealthy environments and high maintenance costs and compromising the notion of sustainable construction (Schaefer, 1994).

Waste on construction sites is equally important in most African countries, with dumping taking place in landfills and sometimes with other hazardous material, and in other instances left on the site, often in the case of smaller construction sites. Dams or unseen river courses and hollows also usually attract dumping. Dumping sites, if left unchecked, become a breeding ground for mosquitoes and vermin. The building materials manufacturing industries in some urban areas are also not exempt from problems of waste disposal, with disposal taking place in water or rivers, pits, landfills, etc. These are all contributory factors to

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environmental degradation. The recycling of construction and waste management in the construction industry are areas that require strengthening. Perhaps the failure in this area lies in the synthesis of theory and practice. The other environmental malady of African cities is to be found in residential areas. Land is a costly commodity and a basis of many an economic activity on which survival rests. The use of land, especially where there is lack of stringent application of environmental standards and regulations, tends to disregard the quality of the built and natural environment in pursuit of maximum economic gain. Sustainability in such instances is questionable (Adebola, 2001).

Further, massive deforestation in Africa can be attributed to the building material industry. Timber for construction and related industries is often harvested, sometimes from indigenous forests and not necessarily replaced. While forestry and timber harvesting is an important economic activity, it can only continue to be so if deliberate steps to replace the harvested trees are taken. The other dimension related to the timber industry is the tendency of sawmills to be located in towns as part of urban industry, with noise, and air pollution from dust and smell, and the unsightly appearance of industrial waste contributing to environmental problems. Griffith (1994) also draws attention to the environmental effects of construction activities resulting in a number of comfort disturbances to individuals living and working in the areas surrounding construction projects. This is manifested through noise of construction operations and equipment, dust from construction process and traffic, hazardous contamination, for example toxic waste and other visual disturbances from signs and advertising boards, as environmental problems associated with construction sites.

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2.6 Building materials and Cost of Housing

Thus, Adedeji (2002) rightly observed that one main barrier to the realization of effective housing revealed in successive government efforts has been the cost of housing in countries such as Ghana and Nigeria. He argued that in the early periods, shelter in Nigeria was easily affordable as building materials were sourced from the immediate environment at affordable costs. Technology also was readily available with commensurate simple techniques. But contact with the outside world through interregional and international training of professionals in foreign countries as occasioned by colonization, brought changes to tastes and hence outlook to house forms. These changes rendered the undeveloped local building materials inadequate while there was an increased demand for exotic ones.

Accordingly, Arayela (2002) posited that the modern building industry lays much emphasis on sophisticated building materials and techniques that are expensive and energy consuming. Though, housing delivery efforts have evidently been inhibited by prohibitive costs of building materials, this problem cannot be reasonably and reliably overcome by merely resorting to the use of locally available materials without due considerations to the applicable initiative, the cost of processing and sustainability of the local materials. One of the most important components of a sustainable building is the material efficiency. Correct selection of building materials can be performed by taking into account their complete life span and by choosing products with the minimal environmental impacts. For instance, González and Navarro (2006) estimated that the selection of building materials with low environmental impacts can reduce carbon dioxide emissions by up to 30%. The use of renewable and recycled sources is widely encouraged as the life-cycle of a building and its elements can be

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closed (Chwieduk, 2003). The major factor that greatly affect the selection of building materials are their costs and social requirements such as thermal comfort, good mechanical properties (strength and durability), aesthetic characteristics and an ability to construct quickly. Ideally, the combination of all environmental, economic and social factors can give a clear description of a material, and thus helps in a decision making process regarding the cost of the materials suitable for buildings (Abeysundara et al., 2009).

The cost of building materials poses a significant threat to both the construction industry and people aspiring to own houses (Anosike, 2009; Mekson, 2008). Supporting this view, Jagboro and Owoeye (2004) earlier established that increase in the prices of building materials has multiplier effects on housing development while Idoro and Jolaiya (2010) affirmed that many projects were not completed on time due to the cost of materials, which have been on the increase. Besides timely completion, high prices of building materials form a crucial constraint to improving housing conditions.

2.7 Material Selection and Management Issues

The choice of materials has been identified as an important design variable that can significantly affect the overall life-cycle energy cost in housing projects, and influence the building's life cycle impact on the environment (Nassar et al., 2003). The consequences of a decision according to Gluch and Baumann (2004) are often observable long after decisions are made at the onset of the design. Thus, making informed decisions at the early stages of the design offer a greater chance of reducing life-cycle cost, and enhancing the eventual technical, socio-cultural, environmental and economic success of a product, than when

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considered at the construction or occupancy stage (Ding, 2008). Hence, it is important that designers are better enabled to incorporate sustainability principles and understand which material decisions most significantly determine a building's life cycle impact at the earliest stage of the design, when the design problem is typically not well defined, and the potential to reduce environmental impacts is greatest. As such, conventional material assessment methodology employs life cycle cost analysis (LCCA) technique to aid this process (Van Pelt, 1994).

With the growing interest to reduce the overall environmental, and socioeconomic impact of a building using the multi-criteria approach, information systems are increasingly recognised as a key-supporting tool in the material selection decision-making process (Trusty, 2003). While there is evidence of the usefulness of Information and Communications Technology (ICT) in the assessment of conventional building materials, questions and doubts of their appropriateness in the assessment of locally made remain. Little attention is paid to material assessment systems that embrace significant sustainability criteria where local made materials are assessed using an appropriate assessment method that best suits their nature (Kibert, 2008; Seyfang, 2010). Therefore, there is a need for a multi-criteria approach that incorporates the principal determinants of sustainable development principles into the decision-making process when selecting local building materials.

New data management technologies have been widely employed in various developed economies to handle data and information integration from multiple sources, in order to provide material knowledge to users. While many integration frameworks have been effective

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in improving the performance of multi-unit residential developments in many developed countries (Ellis, 2009), there is little in the current literature to demonstrate such efforts in developing countries (Malanca, 2010). Sebake (2009) noted that sustainable and green building material selection practices suggest a way to portray the housing construction industry's responsibility towards protecting the environment, which he claims urges the industry to pursue a balance among economic, social, and environmental performance when undertaking housing projects. Low-cost green building materials and components have been described as having considerable environmental, economic and socio-cultural advantage over their conventional counterparts (Fairlie 2009; Adegboye 2009; Zami, 2010), given their relatively lower cost and energy requirements in their extraction, production, and transportation processes.

Oluwakiyesi (2011) further explains that the basic problem associated with the material selection process owes much to whether or not designers are very knowledgeable about such products. He observed that the knowledge of most professionals who are responsible for making key decisions in the housing industry are sometimes negligible, as their decisions are based on the information of other colleagues or what they recommend. He stated that material choices for some designers often means them sifting through catalogues of competing suppliers and manufacturers. Nwokoro and Onukwube (2011) also see the lack of information as a potential cause, giving examples of resources such as handbooks, and advisory services from material suppliers as the readily available sources. They found, through interviews with designers, that material selection tends to originate primarily from experience. They suggest that the industry set up a system for information so product information is readily available, to

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ensure that design and building professionals develop a clearer understanding of the nature and characteristics of the materials and products they specify.

2.8 Traditional Architecture

The concept of sustainable development within the environmental movement is understood by the early tradition in human civilization. This is recognized in the importance of utilizing the resources provided by nature on a sustainable basis, and indigenous people who have practical experience of the fact that humans are dependent on the earth's life support system and traditional cultures, have practiced sustainable resource use for millennia (Hill et al., 1994). With regard to construction, traditional communities have always used the natural materials in their immediate environments for construction, and the resultant buildings have been well integrated in the natural environment. Rudofsky (1994) states that nature is being tamed by modern design implementation but that traditional architecture welcomes, embraces and integrates as a continuum aspect of nature. Norberg-Schultz (1984) supports the same argument that traditional buildings relate to the existing characteristics of the site. This characteristic of architectural elements is supported by the choice of materials of construction that respond to the environment.

Traditional building materials have the added advantage of being cheap and easily accessible. There has been wide use of such materials across Africa. Mud wall construction for houses is one such example. There is also still evidence of stonewall construction in greater Zimbabwe. Wood is not only used for roof trusses and doors but also to erect buildings. In swampy areas of the delta region of Nigeria, the Cameroon riverbanks and Senegal among others, timber has been used for piling to suspend buildings above water, as well as for frames, walling and

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ceiling. Such materials have proved to be climatically friendly as demonstrated in studies by Schwelferger (1982) and Prussin (1986). Environmental response to construction sustainability has been enacted for decades in the frequent adaptation of buildings and invariable re-use of earlier material or materials close at hand, or drawn from abandoned or collapsing buildings. Such buildings were simple and in today's interpretation may not have exhibited high building quality, but were often robust and basic if not necessarily well-suited to their purpose (Wyatt, 1994).

In terms of dealing with building waste in the more recent past, thatched timber frame and stone buildings with timber roofs would have resulted in a local natural solution whereby when they collapsed, nature would decay and return such material to the earth. Where sound to reasonably sound timber and stone survived, it would have been re-used, or even adapted to suit a new 'design'. Even when fired materials were first introduced, many of the early bricks when left, would also be returned to the earth through the natural agency of weathering (Wyatt, 1994). While this form of natural degradation may still be possible in rural areas across Africa where use of rudimentary building materials and technologies is still rampant, one has to question its workability in the urban setting where the sheer might of construction volume and construction waste, and use of materials that do not lend themselves to natural degradation, is the norm. Nature's re-use and degradation technology needs to be incorporated where possible into modern-day construction processes. Where this is impossible, sustainable construction requires new and innovative methods of waste disposal and re-use.

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2.8.1 Fusion of Traditional African architecture with technology

To gain knowledge on how traditional building materials have been re-devised in the today's architectural customs, two different scopes need to be considered. First, there are those ethnic communities that continue to employ these age-old traditional building practices together with modern techniques that have reached the rural settlement. This practice has been reinvented majorly because of its economic benefits. Secondly, there are contemporary architects and clients that individually or collectively promote and use these materials in innovative ways motivated either by ideology or by individual interest (Ejiga, Paul & Cordelia, 2012).

Societal perspective

The introduction of modern technologies such as the concrete blocks and slabs during the industrial periods had relegated traditional components and methods to the background and it became the goal of those in the *wattle and-daub* houses to remake them with the new trend material; concrete blocks, in spite of the obvious truth that they did not present the same kind of thermal comfort. The native dwellers thus replaced their comfortable, low cost and sustainable houses with the modern opposite which were the current fashion and expressed advancement, modernity and a show of affluence and status in the social hierarchy. Recently, amidst these unsustainable practices earth construction has received greater attention as a building material that can be very affordable and still deliver the same modern needs (Dayaratne, 2011). This solution does not seek to drastically alter the community building practices in its use of adobe/earth except for the introduction of compressed earth blocks (CEBs) and the retraining of artisans. Although with slow acceptability the material is gaining acceptance by the community. Currently, many researches are underway as to maximizing all the benefits offered by indigenous traditional architecture nevertheless, urban earth buildings

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are becoming a common place where recreational park structures, shops and eating houses are being built in earth (Ejiga et al., 2012).

Sustainable urban cities

The gradual return to traditional technologies within the conventional architectural practices in Africa has emerged as a result of the world call for proactive steps in managing the earth's resources. It still behooves on architects of the continent to explore all the options available to be creative. Consequently, many need to return to local materials and technologies like the late Hassan Fathy who being innovative re-invented a number of traditional technologies to cater to the modern housing requirements (Ejiga et al., 2012). In many instances, the re-invention is not so much in the material itself, but the methods in which the material and its products are utilized for creating architectural splendor in structures. Really, these innovations are important in that collectively, they have evolved a methodology to architecture that is supported on the vernacular and traditions of the African building custom. It is necessary for African architects to stick to this approach and adopt the attitude and expertise on how to use materials and technologies of the past and re-create them for the contemporary world in a sustainable manner (Ejiga et al., 2012).

2.9 Challenges inherent in using locally manufactured raw materials for construction activities

A survey (Danquah, 2009) amongst stakeholders in the building industry indicated amongst others in order of ranking the following defects and reasons for their preference of Sandcrete blocks to burnt bricks:

- lack of design data on its use

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- non-availability of design and construction experts
- initial cost of construction high
- non availability of the bricks on the market
- irregularity in shape and colour
- smaller and appears weaker than the Sandcrete block
- flaky and algae formation
- Performance Indicators

Adzraku et al. (2016) stated that challenges associated with the unburnt earth brick wall were, lack of recognition by Statutory Authorities, lack of strength and durability, challenges in satisfying new needs in building forms and functions, invasion by termites and rodents as well as its weakness in withstanding vagaries of the weather. Notwithstanding the benefits already mentioned, locally available materials pose various challenges when used for building. Laterite again is said to be lacking strength, stability and durability. It is also noted to be deficient in satisfying new needs of building forms and functions. As a result of all these deficiencies, no matter the type of wall it has been used for laterite tend to require high labour intensive maintenance (Riza et al., 2011; Haper, 2011). Danso (2013) noted that there are many problems plaguing the construction industries in Africa and in other developing regions, in view of growing populations and demand for housing. The high cost of importing materials, and of producing high quality building materials domestically, are perhaps the major constraints to progress. In addition, local production of building materials in many areas cannot keep pace with demand, particularly in rural areas where there is limited access to urban factories and where transportation facilities are limited.

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Another critical factor that hinders the use of local buiding materials are the lack of skilled manpower, low level of technical know-how, unavailability of standards and the fact that local buiding materials cannot satisfy the needs of modern building forms and functions among the three groups of respondents. These factors can be classified as technical barriers to the extensive use of local buiding materials in the construction industry. This is in agreement with the assertion of Hammond (1984) that the overall effect of the technical deficiencies of locally produced building materials creates acceptability barriers. The training of manpower calls for increased investment. While standards are identified as the basic framework for promoting quality production, there are hardly any available standard for indigenous building materials (Adogbo *et al.*, 2002).

The lack of skilled personnel and technical know-how, especially in the indigenous building industry, is partly because the IBM has hitherto not been a principal building material. Unfortunately, it is the same factor which makes indigenous materials unattractive as building materials to the prospective house builder. Lack of access to sources of appropriate technical assistance and the perception of additional costs involved have also contributed to the low level of appreciation and application of these materials and technologies in the construction industry. Another important reason for the lack of skilled personnel has been the low patronage and investment in local building materials (Acheampong, 2014).

Reddy and Mani (2007) identified lack of standardised local-based materials, rapid urbanisation, changing lifestyles and increased adoption of energy intensive modern construction materials as some of the issues that have lead to a steep decline in adoption of

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local building materials. They argue that most developing nations, under pressure for modernisation, have so far neglected the promotion of local construction methods and materials. A similar study by Zami (2010) identified several barriers to the adoption of local building materials, including the need for new legislation, technical training, public awareness of sustainability, and knowledge sharing. His study emphasised the lack of knowledge amongst the majority of construction professionals of their relative impacts on design-decisions as a key factor despite their enormous potentials. He added that local building materials are perceived as 'second class', while modern construction methods and materials are seen as 'civilised' or 'symbols of affluence'. His findings were that the inhibitors influencing the adoption of local building materials depended on the context and situation of particular countries.

Studies also identified clients' resistance (Aye, 2003), knowledge of materials, limited materials and authenticity of suppliers, along with understanding of the impact of the materials (Kang & Guerin, 2009), accurate and accessible information and appropriate tools (Aye, 2003). Other barriers identified include client demands, designer and client poor knowledge, inaccurate and inaccessible information (Hes, 2005; Davis, 2001) and inappropriate tools, peoples mistaken perceptions and cultural problems, lack of knowledge, skills, and understanding amongst professionals, government, donors, and users, lack of technologies and resources, lack of building codes, policies to adopt local building materials, and difficulties in obtaining insurance (Morton, 2007). Some key factors have however been identified as constraints to the realization of the full potential of local materials in Nigeria, these include, poor quality of product which is as a result of non compliance with standards

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(Oladapo and Oni, 2012), low demand for local materials in construction, and inappropriate used of local building materials in construction (Sanusi, 1993). A number of possible reasons have also been identified for the low patronage of local building materials and these include; doubtful durability and life span, low aesthetic value, poor finishing, lack of standard and poor commercial status.

2.10 Factors affecting Housing Prices in Ghana

The importance of housing cannot be overemphasized. With socio-economic benefits attributed to individuals and a country as a whole, housing has become an integral component for many developed economies:

- ***Demand***

Demand is one of the leading price determinants of a home. Demand adds or subtracts from the value of a property. A fall in demand as was characterized in the United States' (US) housing market during the housing crisis of 2006 leads to a fall in prices. Conversely a rise in demand increases the likelihood of a price hike. In Ghana, there is a huge disparity between the rate of housing construction and population growth. This puts pressure on the existing resources, inevitably leading to a home price increase (Lamudi, 2015).

- ***Land availability***

This is one of the most pressing issues in Ghana. Land availability has the propensity to affect the price of a home. With Ghana's cumbersome land tenure system, access to lands has been made all the more difficult. Actors in the real estate industry have been calling on the government to grant them land banks in order to make homes more affordable. A land bank is the aggregate parcels of land for future sale or redevelopment. One of the key benefits derived

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is the clearance of land titles, making it easier for real estate developers to gain access (Lamudi, 2015).

- ***Cost of building materials***

Building materials also affect the price of a home. In Ghana, the most widely used material is cement. The positive aspect is that Ghana has a cement manufacturer, Ghacem. The drawback is that most of the components used in the making of cement are imported. The high cost of construction becomes even more apparent in the face of importing an estimated 70 percent of building materials. These imported materials are linked to foreign currencies and a depreciation of the national currency means higher cost of materials. A reliance on local materials however will lead to a positive effect on prices (Lamudi, 2015).

- ***Foreign exchange volatility***

For developing countries like Ghana, foreign exchange is a crucial factor that affects the price of commodities. This is because the country's imports outstrip its exports, thereby leading to an over reliance of foreign currencies such as the US Dollar. The instability of the Ghana Cedi has led many property owners to fall on the US Dollar as a way of hedging against value depreciation. This means home prices move up when the Cedi depreciates and conversely drops when the local currency outperforms the US Dollar (Lamudi, 2015).

- ***Interest rates***

Most estate developers and individuals resort to bank loans to construct properties. These loans carry interests and invariably affect the price of a property. The high interest rates in Ghana raise the cost of construction and this ultimately passed down to a prospective home owner. Conversely, lower interest rates would mean a stability in housing price. A more stable

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Cedi culminated with low interest rates is likely to lead to lower housing prices (Lamudi, 2015).

- ***Location***

Location is another key factor that affects the price of a home. The nation's capital, Accra has been demarcated into zones, indicating their respective valuations. In reference to location, the proximity to major landmarks such as the Kotoka International Airport is an important valuation component. Social amenities like roads, electricity and water access are also important valuation tools. Prices indicated on Lamudi support this view, with a three-bedroom house at Kutunse valued at GH¢240,000 while a similar one at East Legon is on sale for over GH¢1 million. This is because Kutunse is regarded as a peri-urban area while East Legon is noted as a prime location in the city (Lamudi, 2015).

2.11 Theories on building materials in the Construction Industry

Game theory

Game theory is appropriate approach for decision making in construction engineering and management processes to solving different problem from real life. Game theory assumes that the players information about the strategies of the other players. Review showed that many researchers in different research fields' work applied the game theory in: construction engineering, management area. Applications of game theory are varied. Many authors have applied game theory to solve problems in construction engineering and management: Zavadskas *et al.* (2004) solved construction technology and management problems; Peldschus and Zavadskas (2005) investigated fuzzy matrix game in construction; Su *et al.* (2007) proposed a model of urban public traffic networks; Sun and Gao (2007) applied an

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equilibrium model for urban transit assignment; Homburg and Scherpereel (2008) analysed the cost of joint risk capital to be allocated for performance measurement.

Motchenkova (2008) applied a differential game to describing interactions between a firm that might be violating competition law and the antitrust authority; Peldschus (2008) presented a review of the game theory application experience in construction management; Podvezko (2008) applied game theory in technology and management of construction solutions; Schotanus *et al.* (2008) analysed unfair allocation of gains under the equal price allocation method in purchasing groups; Meszek (2008) analysed investment projects; Tamošaitienė *et al.* (2008) – modelling of contractor selection taking into account different risk levels; Gu *et al.* (2009) analysed Chinese strategies for energy-efficient housing development from an architect's perspective; Zhao and Jiang (2009) presented optimisation model between project risk set and measure set; Peldschus *et al.* (2010) demonstrate construction site selections.

Lean principle

The understanding of what is construction extrapolates its technical characteristics. In this research, construction is not restricted to civil engineering and architecture, but comprehends a broader understanding of building, putting up, setting up, establishing and assembling. Construction is the materialization of a concept through design, taking into account functional requirements and technical specifications for a project product utilizing specialized labour. In other words, it is the creation of a product that will fulfil a strategic goal. This study excludes prototyping as the final product; however, a project scope may include prototyping as a deliverable or stage, as, for example, in the design phase. Prototype objectives test a process or concept in real situations and then provide information about what works and what needs

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improvement before the final product. In contrast to prototypes, the project product is final and definitive. Project products, according to the design specifications, have usability in a first and unique building. Project products of building construction are, for instance, software, pipelines, roads, bridges, tunnels, house building and oil well construction (Antunes & Gonzalez, 2015).

The building construction industry has also demonstrated interest in lean principles; later named lean construction. The transformation, flow and value generation views associated with a set of principles constitute the transformation-flow-value (TFV) theory of production. However, the implementation of lean principles has been sporadic, rather than an industry standard. Several contradictions to the lean values, such as excessive consumption of raw material, disconnection of activities, preventing the establishment of a flow, a focus on costs over value, an inefficient measurement system, high levels of rework due to production errors or changes in technical specifications and worker safety, still populate the list of the most common problems in construction endeavours (Antunes & Gonzalez, 2015).

The trade-off theory and the agency cost theory

The trade-off theory and the agency cost theory state that tangibility is positively related to debt. Because if a company's tangible assets are high, then these assets can be used as real guarantees to the firm's creditors; therefore, when the value of tangible assets that are used as a guarantee rises, the firm can get more debt easily (Padron *et al*., 2005). Moreover, in firms with more intangible assets, the controlling capital expenditures costs are higher; hence, a relatively higher part of the tangible assets is expected to be associated with high leverage (Qian & Wirjanto, 2007; Sangeetha & Sivathaasan, 2013). Consistent with the trade off theory and agency theory, many studies indicated a positive relationship between the

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tangibility and debt ratio such as Zoo and Xiao (2006) and Qian and Wirjanto (2007). In addition to the findings of a number of more recent studies which examined the emerging markets and found a positive relationship between debt ratio and tangibility. The pecking order theory suggests that firms that own more fixed assets have less asymmetrical information. Therefore, they tend to rely on equity financing and when considering maturity, the pecking order theory suggests that share of fixed assets is positively related to long-term debt financing and negatively related to the short-term debt financing (Sayılgan *et al*., 2006; Qian and Wirjanto, 2007). In addition, many studies support the finding of the pecking order theory for example Sayılgan *et al*. (2006) who researched the relationship between the debt ratio and the assets tangibility on 123 Turkish manufacturing firms listed on Istanbul stock exchange for the period between 1993-2002 and found that assets tangibility is negatively related to the long term debt ratio.

Free trade versus infant industry theory

In addition to forging national identity through the use of building materials available in the immediate environment, the socio economic benefit of improving on materials and technology that belong to the immediate environment includes high employment rate, and conservation of foreign exchange earnings. The argument against a return to local Ghanaian environment and its resources may be hinged on the freedom of individual citizens to choose from all available options in materials, forms, technology and styles in accordance with international free trade and human rights chatter. But the 'Free Trade' theory has been faulted by economic theorist as being detrimental to industrial and economic advancement of the less developed countries of the world. This argument is well articulated in the theory called 'Free Trade' versus 'State Protection' (Toyo, 2001). The theory, sometimes called 'Free Trade

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versus Infant Industry' examines and prescribes appropriate trade options for the more developed and less developed industries/nations of the World. Mercantilism or the state use of the market was popular in Europe throughout the late middle –ages (1100-1500AD). State directed all economic production and commerce towards expanding exports and limiting imports; as export surplus meant good foreign exchange.

Theory of people and environmental relations (PER)

In the theory of 'People-Environment Relations' three distinctive views are adequately reflected in contemporary literature. These are the 'Minimalist' 'Instrumental' and 'Spiritual' perspectives (International Association for the Study of People and their Physical Surroundings-IAPS, 1988). The Minimalist view, which was popular among designers and behavioral scientists, prior to mid 1960s, argued that physical environments had minimal or negligible influence on the behavior, health and well being of their users. A relevant, but advanced extension of this theory is the one by Maslow, (1962), referred to as the theory of Psychological Health and 'Self Actualization'. This theory, also reflecting the Minimalist stance towards the environment recognizes that the physical and social environment serves basic human needs for shelter and security (emphasis mine). The aspect of the 'Minimalist' view that professes negligible environmental influence on users' health and behavior has since been discarded. This is in the face of evidences that environmental pollution leads to health hazards; over population leads to epidemics and incidents of plagues and spread of contagion through pollution - of water, air and other components of the environment. This led to another theory called the 'Instrument' or 'Mean-to end' view. This theory views the physical environment as a means for achieving important behavioral and economic goals (emphasis mine). The 'Means-end' view pervades much of the recent research on strategic

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facilities planning, which is clearly reflected in the Functionalist and modern movements in Architecture. The analyses of people environment relation through instrumental view measure the capacity of environments to promote behavioral and economic efficiency as well as enhance levels of occupants' comfort, safety and well-being.

2.12 Effects of adopting locally manufactured raw materials for construction activities

The use of natural, locally-available materials makes good housing available to more people, and keeps money in the local economy rather than spending it on imported materials (Deboucha & Hashim, 2011; Danquah et al., 2015). There abound many locally made building materials which are not being promoted let alone used in construction. One of these materials is the burnt bricks. Burnt bricks are found to be stronger due to the intensity of heat (a temperature ranging from 900 - 1200°C1) that is used to dry them.

This is in line with Kim and Rigdon (1998) assertion that the firing process exposes the formed clay to high, prolonged heat, producing a hard, water-proof, permanent brick or tile. A study by the FAO (1986) contends that burnt bricks have good resistance to moisture, insects and erosion and create a good room environment. Although tenable, their longevity depends on the quality of ingredients, climate and skill of artisans. Besides cost savings, the use of locally available materials comes with many benefits. Laterite for instance is described as environmentally friendly and a renewable natural resource which can be found free and in abundance everywhere in Ghana (Gidigasu, 2005)

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CHAPTER THREE

METHODOLOGY

3. 1 Introduction

Chapter three of this study provides essential methods or strategies for collecting and analyzing the data. Basically issues dealt with in this section involve research design, population, sample size, sampling techniques, sources of data, instruments for data collection and procedure, pilot study as well as data analysis.

3.2 Research Design

A research design can basically be defined as strategy adopted by researchers to conduct a study in coherent and logical manner which addresses the problem under study. With reference to this study, a descriptive research is adopted. Descriptive research entails providing adequate description of various characteristics of a given population under study. A cross sectional survey which involves collection, comparison and analyzing data at a particular point in time was adopted. The brain behind the use of descriptive research in this study involves opportunities that come with it to merge or fuse qualitative and quantitative data to ascertain underlying issues the study seeks to achieve. The study adopts triangulation which involves both quantitative and qualitative techniques to deal with issues under study. The quantitative aspect will help in measuring data in figures or numerical terms whilst the qualitative aspect gives detail explanation on several issues which emerges out of the survey through words.

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3.3 Population

The target population for this study involves employees of Denkyembour District Assembly, contractors, clients and employees of construction firms.

3.4 Sample Size and Sampling Techniques

A sample is basically a subset of people, animals, objects or materials used to represent a broader or entire population under study. A sample size of 207 was selected for the study. This was made possible through adoption of the idea of Nwana (1992) who indicated that with a population of few hundreds, 40-50% can be selected as sample size. This study adopted non-probability sampling techniques. The choice of purposive and convenience sampling for individuals for the sample was to ensure that people of interest to the study were focused to attain objectives of the study. Details of the sample size are presented in Table 3.1. Convenience sampling technique was adopted to select employees of various stakeholders for the sample size. This was done to ensure that only people willing and available at the time of the survey will be part of sample. Even though this may lead to a bias situation towards some groups but it is cost effective.

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Table 3.1: Sample size determination

Departments	Population	Sample Size (50%)
Contractors	54	27
Employess of construction firms	258	129
Clients	14	7
Employees of Denkyembour District Assembly	88	44
Total	**414**	**207**

Source: Field survey, 2017

3.5 Sources of Data

This study depended on data from two main sources namely; primary and secondary. The primary source involves first hand data which included responses from questionnaire. The questionnaire provides the basis for the quantitative analysis. Secondary data in this study consists of reports on indigenous materials and other reliable materials already known to the public which the researcher deemed appropriate to use in dealing with issues under study.

3.6 Instruments for Data Collection and Procedure

The researcher resorted to the use of questionnaire as a means of gathering data for the study. The questionnaire was designed to include both open and closed ended-questions. Dichotomous questions with Yes or No answers were also provided in the questionnaire. The questions were grouped into five sections with section A dealing with demographic characteristics of respondents. Section B presents the extent to construction firms use indigenous materials for building activities. Section C on the other hand presents the

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challenges associated with indigenous materials. The last section (D deals with examining the impact of indigenous materials. The respondents were given opportunity to give out their opinions on the various questions mostly through rankings on a 5- point likert scale where 1- strongly disagree, 2- disagree, 3- not sure, 4- agree, 5- strongly agree. However opportunity was given to people willing to complete and submit on the same day.

3.7 Pilot Testing

The questionnaire were pilot tested and all identified ambiguous and vague questions were corrected and rephrased. These were done to ensure that validity and reliability were achieved. The validity aspects were achieved through accurate information contained in the data whilst the reliability was ensured through consistency in the findings.

3.8 Data Analysis

Data gathered were checked and sorted out for effective categorization. Descriptive statistics such as mean scores, standard deviations, percentages were employed in handling data analysis. Results from the analyzed data were captured and presented in the form of tables, charts and graphs.

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

Chapter four of this study presents results and discussion of data gathered during the survey. It includes demographic characteristics of respondents, the extent to which people patronise locally produced materials for building activities, challenges associated with the use of locally produced building materials, and their effects. Out of the 207 participants selected for the sample size, 186 responded and this gives a response rate of 90%.

4.2 Demographic Characteristics of Respondents

The demographic characteristics of respondents in this study include their gender, age, number of years worked and their educational background. These formed the basis for analysing their demographics.

4.2.1 Gender of Respondents

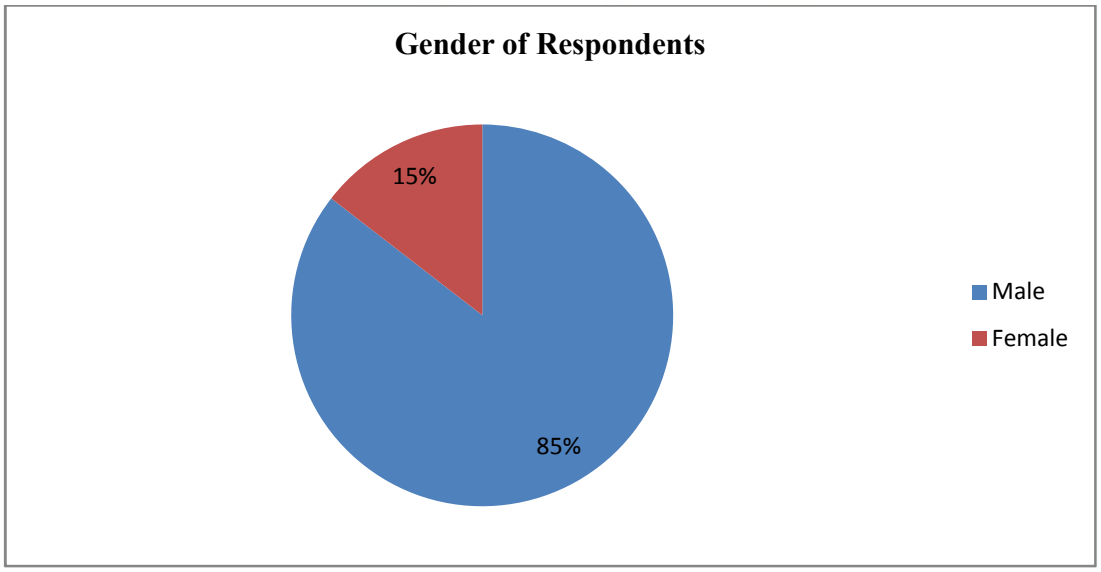

Figure 4.1: Gender of Respondents

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Figure 4.1 presents gender characteristics of respondents. It was realized that most of respondents were males and constituted 85% whilst females obtained 15%. The results imply that there were more male respondents than females during the survey. The construction industry in Ghana has been over the years been dominated by mostly males with females showing less interest in the sector despite the existence of some institutions offering courses related to construction.

4.2.2 Age distribution of Respondents

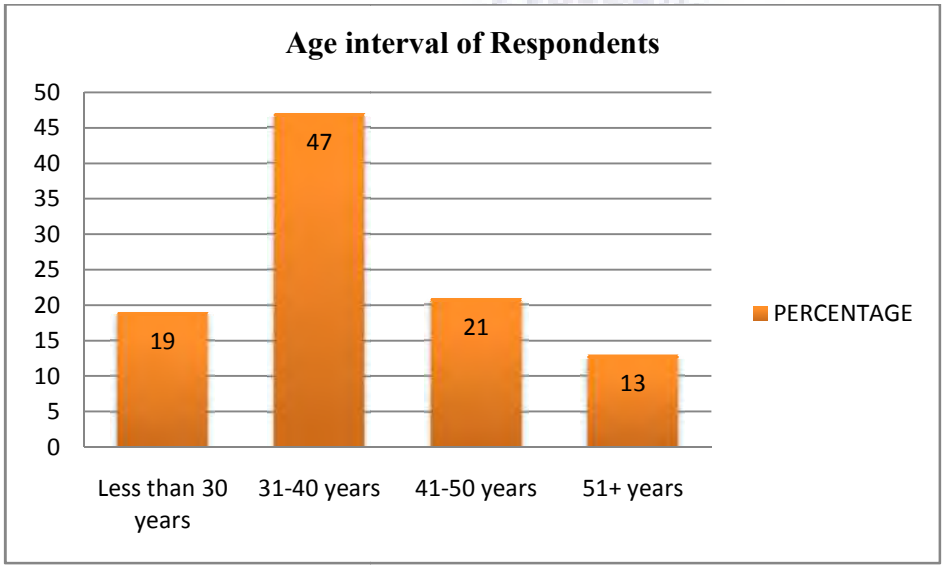

Figure 4.2: Age distribution of Respondents

Source: Field survey, 2017

Figure 4.2 presents the age distribution characteristic of respondents. It is shown in Figure 4.2 that majority of respondents were 31-40 years constituting 47%. Next to this were respondents with 41-50 years obtaining 21%. Some of the respondents happen to be less than 30 years and constituted 19% and the least been 51+ years who obtained 13%. Per this outcome, the results indicate majority of respondents are in their youthful ages.

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4.2.3 Educational background of Respondents

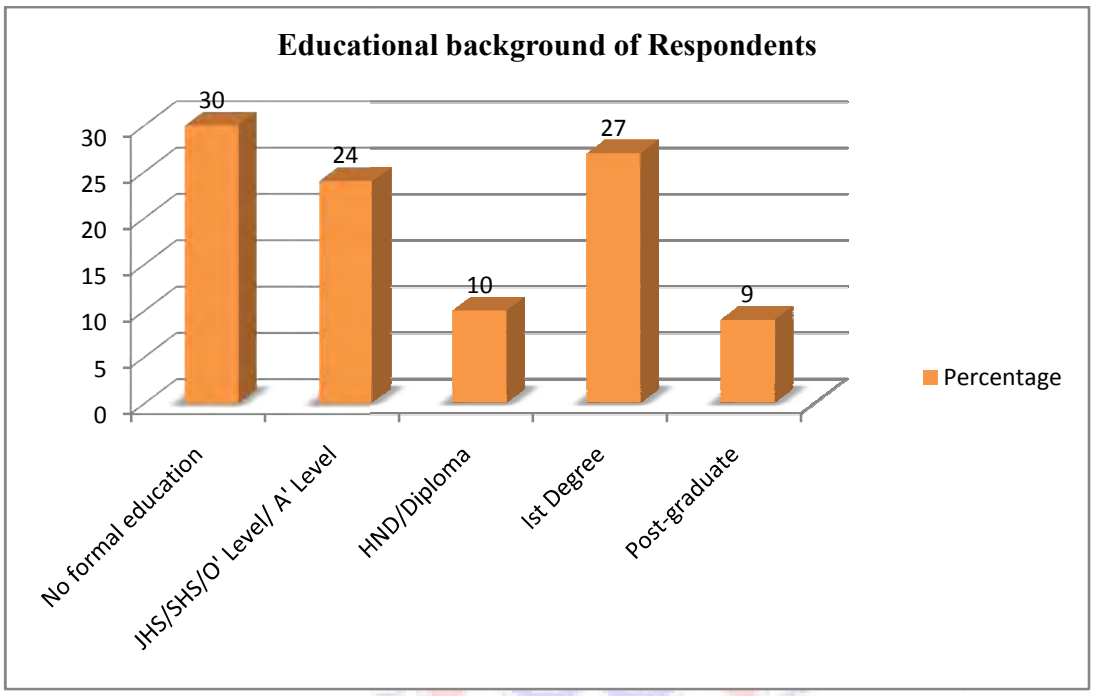

Figure 4.3 Educational background of Respondents

Source: Field survey, 2017

Figure 4.4 presents educational background of respondents. It was realized that majority of respondents were employees of construction firms with no formal education who obtained 30%. Next to this were those with 1st degree holders and respondents from this category constituted 27%. Some respondents were found to have attained SHS/A'Level/O'Level (24%) and 10% had attained HND/Diploma and postgraduate degree holders obtained 9%. The results indicate majority of respondents were literates. The higher one acquires knowledge, the more he/she is able to evaluate the significance using a particular material for building activities.

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4.2.4 Number of years Respondents have worked

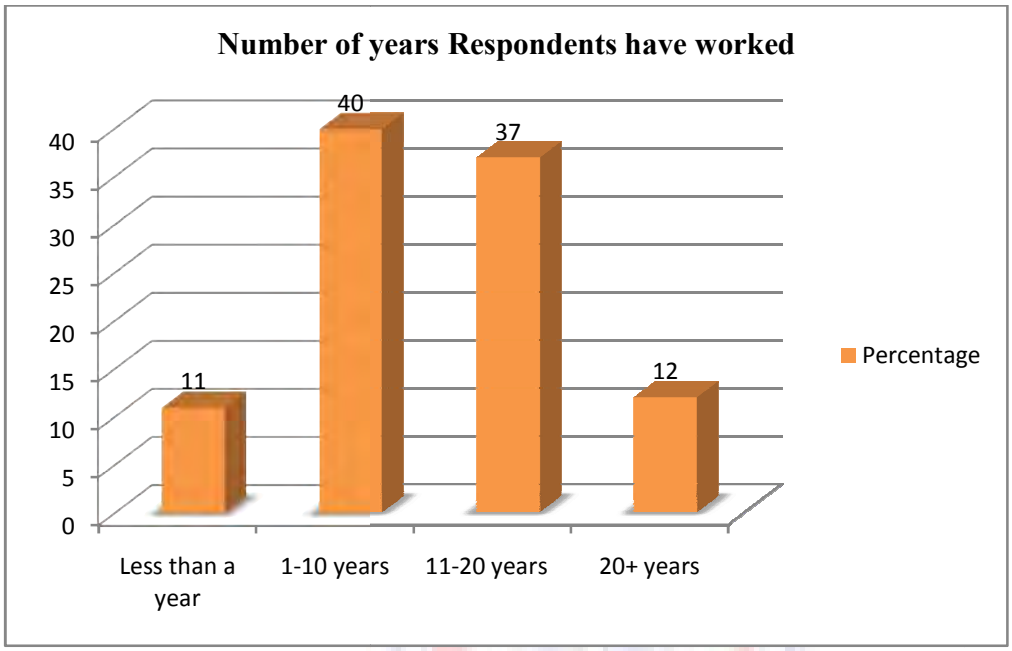

Figure 4.4: Number of years Respondents have worked

Ascertaining the number of years respondents have worked was crucial to the study in the quest to know their level of experience on their job. It was evidenced in Figure 4.4 that majority of respondents had served for 1-10 years and constituted 40%. It was found that 37% of respondents had worked for 11-20 years. This was followed by some respondents, 12% who emphasised that they have worked for 20+ years. The result implies that majority of respondents have some considerable adequate level of experience on the job and were conversant with the purpose of the study.

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4.3 Patronising of Locally produced building materials

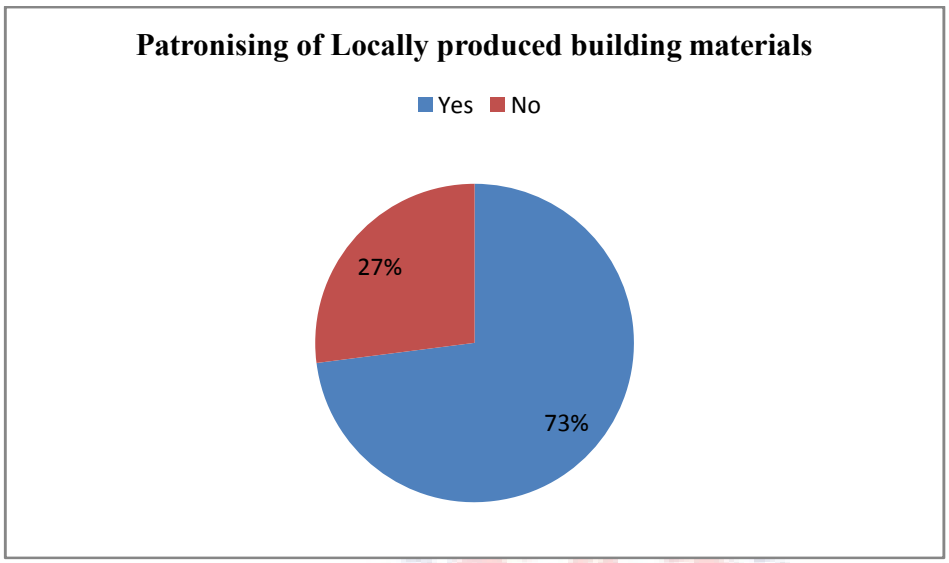

Figure 4.5: Patronising of Locally produced building materials

Source: Field survey, 2017

The researcher found it appropriate to identify whether respondents patronise locally manufactured materials for building construction activities. Responses shown in Figure 4.5 indicate majority of respondents (73%) asserted they use locally manufactured building materials for their activities on construction sites. However, 27% were of the view that their organisations do not normally patronise locally made materials for construction activities. The overall implication to this effect indicate that there have been considerable move by some construction firms to use local materials. Lawane et al. (2012) alluded that the use of local materials in the construction industry is one of the ways to support durable development without compromising the ability of future generations to meet their own needs. Some of the reasons attributed to the patronage of locally manufactured materials were the motive to promote local made materials on the market and reduce over-dependence of foreign materials

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which have implications on the foreign exchange of Ghana. This supports the position of Atiemo (2005) that efforts have been made by successive government in promoting the development of indigenous building materials in Ghana.

4.4 Respondents income levels affecting their preference for locally made building materials

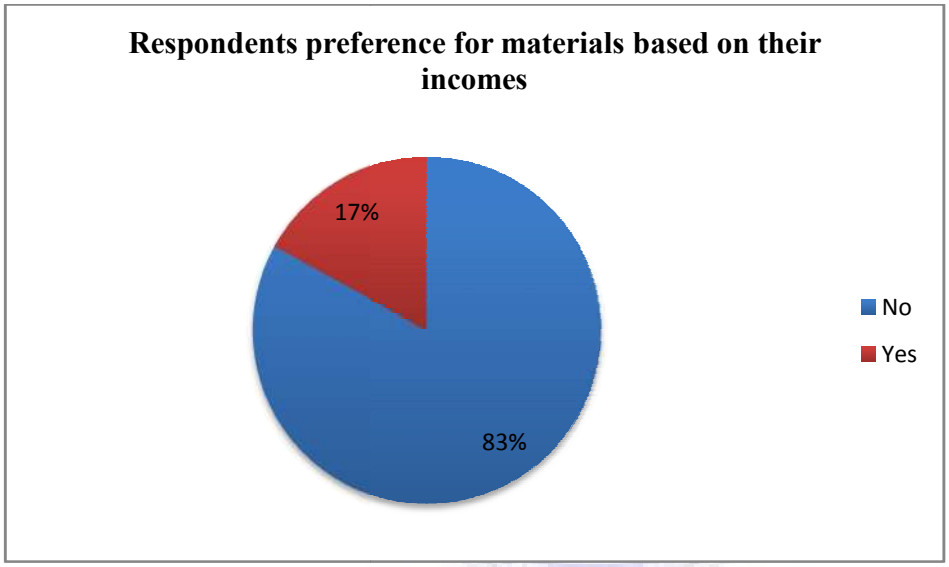

Figure 4.6: Respondents preference for locally made building materials based on their level of income

Source: Field Survey, 2017

The researcher after ascertaining as to whether respondents patronised locally made materials for building construction went on to identify whether their preference was based on income levels. It was established that majority of respondents held the position that their preference for locally manufactured products were informed based on their purchasing power. This assertion was buttressed with 83% while 17% indicated otherwise. The ability to patronise certain locally made materials were founded on the grounds of capacity of the person

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involved to pay. There is wide perception that most locally made materials such as bricks are expensive and this creates apathy towards their use for building activities. This perception has gained serious prominence on the minds of people to chose foreign materials over the indigenous types. Some construction firms find it cheaper to use cement blocks than bricks. Danquah (2009) emphasised that the cost of some indigenous materials like the burnt bricks are expensive as compared to the cement blocks.

4.5 Challenges associated with using locally manufactured materials

Table 4.1: Challenges associated with using locally manufactured materials

Challenges	Mean	SD
Houses built with local materials have low strength	3.75	*.19*
Low level of importance attached to social status and its symbolism	4.02	.20
Lack of recognition for by Authorities	3.20	*.22*
Houses built with local materials require frequent maintenance	3.45	*.20*
Apathy towards the indigenous building materials	4.29	*.22*
Low level of technical know-how	4.21	*.19*
Houses built with local materials require a lot of labour work	3.86	*.23*
Lack of skilled personnel	4.15	*.19*
Poor Quality	3.94	*.23*
They are not durable	3.62	*.21*
Low value of buildings constructed with indigenous materials	3.55	*.24*

Source: Field survey, 2017

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Form Table 4.1 it was found that apathy towards the use of indigenous building materials was rated as the biggest challenge by most respondents (Mean=4.29, SD=.22). The apathy in this regard is in connection with poor attitudes and behaviours of people towards the use of locally made materials for construction activities. There have been misconception that locally produced materials are of low standard and are not durable. The continuous existence of such mindset has led to negative perceptions on local materials for building projects. This negativity has fuelled the occurrence of low patronage for locally made materials for construction. Some authors like Reddy and Mani (2007), Sanusi (1993) and Adogbo et al. (2002) shared similar view that public perception on fall in standard as well as durability were highly attached to indigenous materials.

The second most dominated factor enumerated by respondents was the issue low technical know-how to produce local materials for building activities (Mean=4.21, SD=.19). Lack of technological expertise was rated as the second most dominating factor which impedes production of building materials locally. The absence of needed skills and knowledge to produce local building materials using acceptable standards, quality and medium affect their level of patronage. Where there is lack of expertise to handle production, systems put in place to ensure efficiency and effectiveness of work output suffers. The inability to bring more expertise in the area of technology hinders activities of locally manufactured materials for building. In most cases, vendors fail to add appreciable value to locally available materials. This situation does not promote high patronage of materials manufactured locally for construction projects. Qualified and competent personnel with knowledgeable expertise are mostly lacking in producing local materials. It was found that in some cases, personnel to handle these mentioned factors are lacking. The poor skills and competence to modify locally

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available materials to meet required standards on competitive market has slowed the rate at which people use local materials for building projects. This supports earlier assertions by Acheampong (2014) and Morton (2007) that critical factor that hinders the use of local building materials for construction projects can be attributed to low level of technical know-how.

Another obstacle to the use of locally made materials for construction was low level of importance attached to social status and its symbolism (Mean=4.02, SD=.20). There is poor perception that materials produced locally are of inferior value and quality compared to foreign materials. Some people have the wrong impression that the use of local materials for building is an indication of 'lower class' in society. Some people have the impression that local materials such as clay, red sand, laterite etc are not durable and require a lot of maintenance after their specific use. This supports the position of Zami (2010) that local building materials are perceived as 'second class', while modern construction methods and materials are seen as 'civilised' or 'symbols of affluence'.

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4.6 Building materials affect cost of housing projects

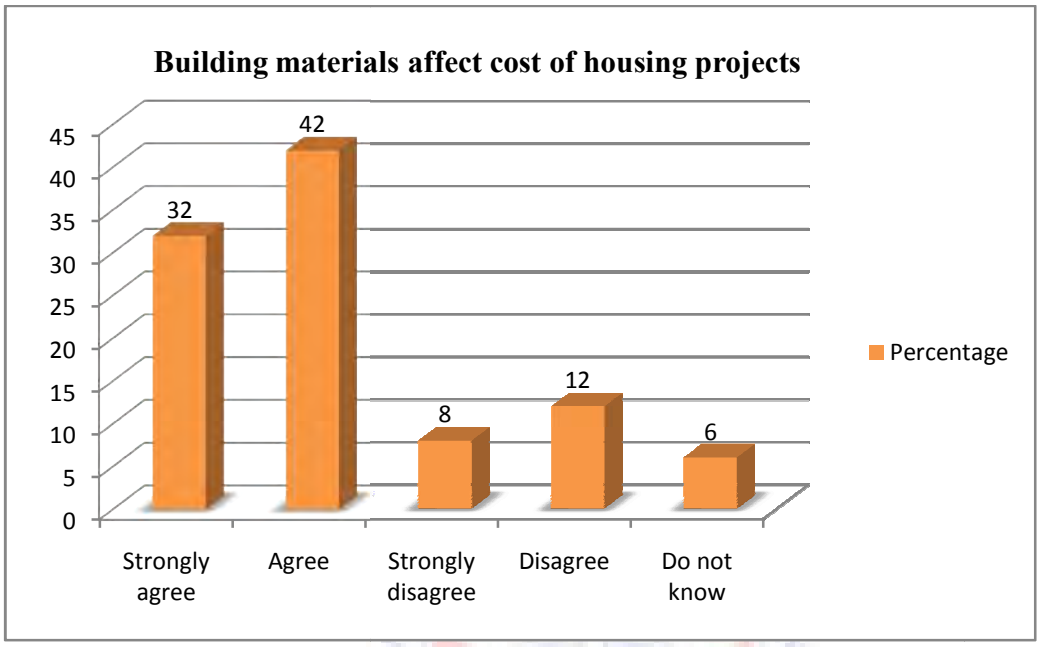

Figure 4.7: Building materials affect cost of housing projects

Source: Field survey, 2017

From the responses, majority of respondents agreed convincingly that cost incurred on materials for construction projects influence the overall cost of housing projects at Denkyembour District. This position was overwhelmly supported by 74% of the entire respondents. It was established that high prices of materials used for building projects eventually lead to high costs placed on the buildings after their completion. This certainly raise the amount of money spent on house rental since owners consider their inputs before arriving at concrete prices. Increase in materials cost on building materials will have subsequent increase in the amount charge on rent. This situation has the potential of increasing the cost of living to the ordinary Ghanaian. Akanni (2006) emphasised that building materials contribute immensely to the quality and cost of housing, from what is used

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in the foundation to the materials for roofing and finishes. However, some respondents (20%) held contrary view that building materials do not have influence on the cost of buildings.

4.7 Relationship between building materials and cost of housing projects

Table 4.2: Relationship between building materials and cost of housing projects

			Building materials	Cost on housing
Pearson	Building materials	Correlation coefficient	1.000	**0.742**
		Sig. (2-tailed)		0.005
		N	186	186
	Cost of housing	Correlation coefficient	**0.742**	1.000
		Sig. (2-tailed)	.005	
		N	186	186

Source: Field survey, 2017

Correlation is significant at the .05 level (2-tailed)

The results presented in Table 4.2 show a strong positive relationship between building materials and cost of housing projects. This assertion was backed by a correlation co-efficient of 0.742 which was set at significant level of 0.5. This result indicates that an increase in prices of building materials will have a significant effect on overall cost of housing. When prices of building materials such as iron rods, cement, laterite, nails, roofing sheets, tiles, sand, gravel etc increase, it affects total expenditure on building projects. Lamudi (2015) and Udosen and Akanni (2010) noted that building materials have major stake in determining the cost on projects. Arayela (2005), Adedeji (2010) and Ogunsemi (2010) stressed that cost incurred on materials during building construction form close to more than 60%. This means that building materials, be it local or foreign have influence on overall cost of a project.

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4.8 Building materials affect quality of housing projects

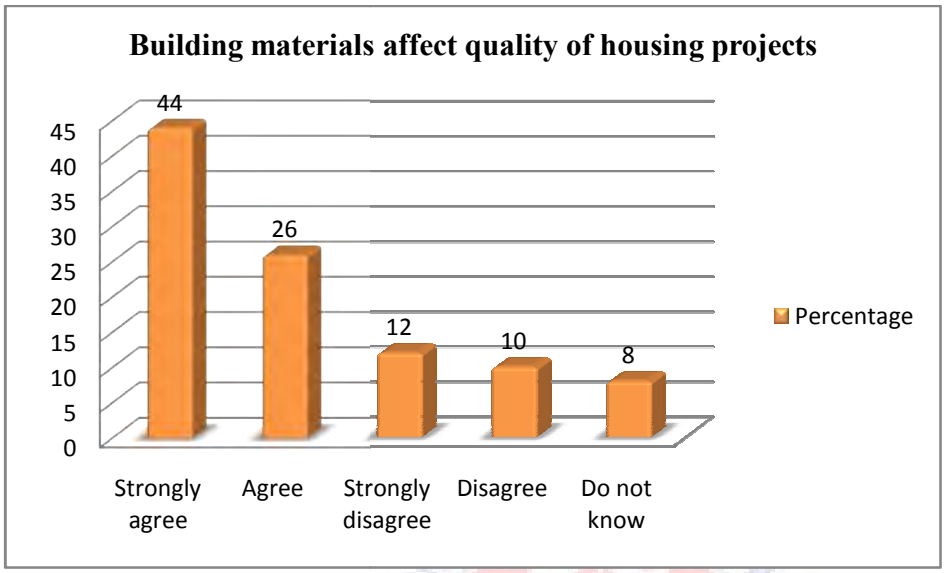

Figure 4.8: Building materials affect quality of housing projects

Source: Field survey, 2017

It was established in Figure 4.8 that building materials affect the quality of housing projects. The use of materials based on right proportions and type suitable for specific purposes ensure that quality is achieved on projects. Majority of respondents agreed the choice of materials for building projects affect their quality (70%). The use of low standard materials negatively affect project quality. Local building materials are perceived to be of poor quality. It can be emphasised that indeed, some of them like laterite, clay are subjected to frequent wear and tear. Adzraku et al. (2016) noted that laterite in its raw form lacks maximum strength and durability. These factors pose serious challenges to the quality of buildings upon using such materials without adequate value addition through enhanced technology. This does not enhance the lifespan of buildings. However, 22% of respondents were of the view that materials do not affect the quality of buildings.

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4.9 Relationship between building materials and quality of housing projects

Table 4.3: Relationship between building materials and quality of housing projects

			Building materials	Quality of housing
Pearson	Building materials	Correlation coefficient	1.000	**0.706**
		Sig. (2-tailed)		0.005
		N	186	186
	Quality of housing	Correlation coefficient	**0.706**	1.000
		Sig. (2-tailed)	.005	
		N	186	186

Source: Field survey, 2017

Correlation is significant at the .05 level (2-tailed)

From Table 4.3, a Pearson's correlation coefficient of 0.706 indicates a strong positive relationship between building materials and quality of construction project. This means that, as appropriate materials are used for construction activities on buildings, there is a corresponding influence on quality. The relationship is significant at the .05 alpha level (.005< .05). Using the right quantity of materials for its specific purpose ensures efficiency and this leads to quality of workdone.

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4.10 Effects of using locally manufactured materials for buildings

Table 4.4: Effects of using locally manufactured materials for buildings

Item	Mean	SD
Provision of cool room temperature	4.25	*.22*
Promotion of cultural heritage	4.39	*.20*
Local building materials provide less environmental effect	4.08	*.18*
Local building materials are affordable and cheap	4.12	*.22*
Local building materials have fire resistance characteristics	3.88	*.20*
Provide thermal comfort	4.01	*.18*
It keeps money in the local economy	4.28	*.19*

Source: Field survey, 2017

Table 4.4 presents opinion of respondents on effects of using indigenous materials for building. It is evidenced that the use of indigenous materials help in promoting the cultural heritage of the people (Mean=4.39, SD=.20). The use of traditional buildings with some form of drawings and inscriptions help in preserving the culture of the people. It serves to promote the cultural identity of the people. This allows traditional people in the area to portray their cultural beliefs and values through such building designs. For instance, some traditional buildings have certain designs such as ‘Adinkra’ symbols like ‘Gye Nyame’ and ‘Sankofa’ embodied on the walls which promotes the culture of the people. This finding is in line with position held by Danso (2013) that the use of indigenous materials for buildings promote culture of the people.

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Moreover, the patronage of locally manufactured building materials help to keep money in the local economy (Mean= 4.28, SD= .19). Since local materials are sold by mostly indigenes of the country, it does not put pressure on foreign exchange of the local economy since income generated out of the sales are usually spent within the country. This has the possibility of creating other job opportunities and incomes for other people within the local economy. The patronage of conventional materials indirectly mounts pressure on the local currency and this usually leads to high inflation. Authors like Danquah et al. (2015) and Deboucha and Hashim (2011) share similar view that the use of local materials keep money in the local economy rather than spending it on imported materials.

The third dominated effect of using indigenous material for building activities was provision of cool temperature in the rooms (Mean= 4.25, SD= .22). It was established that the use of local materials such as earth, laterite and thatches. The warm climatic condition in most part of Ghana makes it conducive to use local materials to provide cool temperature in the room. Earth as a material is able to control heat since it does not allow easy penetration. This makes it suitable in warm climatic areas. Mud houses are usually good in providing cool temperature in warm seasons and warm in rainy seasons. Some of the respondents maintained that local materials like laterite, clay, sand and thatches are cheaper than most imported materials like concrete, steel, and glass etc.

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CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter five of this study presents summary of key findings, conclusions drawn from the findings and recommendations made based on the findings as well as suggestions for future studies.

5.2 Summary of Findings

It was evidenced in the study that majority of respondents alluded that they patronise indigenous materials for construction. Laterite for instance has been major material for filling after foundation. Construction firms use materials such as bamboo, sand, wood and locally made nails to execute building activities on site. It was further established that income levels of respondents affect the rate at which they patronise locally made building materials. The ability to patronise a product is based on the purchasing power of an individual or construction firm. People and construction firms are likely to purchase indigenous materials when they are affordable. Burnt bricks were found to be quite expensive and this usually influences people to use conventional materials over indigenous types.

The three most dominant challenges to the use of indigenous materials were apathy, low technical know-how and misconception based on social class. This has been fueled by the misconception that indigenous materials are of low standard and quality. There is negative impression that materials produced locally are not durable and this perception has promoted apathy on indigenous materials. The issue of low technical know-how to produce local materials for building activities was key in the results. Producers of local materials usually

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lack the needed expertise with modern technology to modify and add value to their end products. This does not encourage the patronage of locally made materials for construction activities as expected. The failure to adopt modern technology to produce materials locally with acceptable standards does not encourage high patronage on the local market. The situation does not improve effective utilization of endowed local materials to satisfy our housing needs. The third factor was low level of importance attached to social status and its symbolism in using indigenous materials. Most people in society have the perception that locally made materials are meant for lower class and does not reflect prestigious and wealthy living. This perception does not encourage its patronage on the market.

It was further found that expenditure incurred on building materials affect overall cost of housing projects. When prices of materials are high, it automatically affects the cost on overall project since materials constitute the large expenses on buildings. Moreover, it was established that the quality of buildings are highly determined by the nature and type of materials used. The use of indigenous materials was found to promote cultural heritage, keeps money in the local economy, provide cool room temperature and most of them were affordable and cheap.

5.3 Conclusions

The use of locally available materials for buildings is a crucial venture that ought to be supported by government and all. The use of materials such as bamboo, clay, thatch, mud, stones are relatively cheaper than those of cement, tiles, glasses, shingles etc. Locally made materials were patronised by construction firms and individuals even though the rate is not high as expected. The patronage of building materials were based on the purchasing power of

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builders or clients. The expenses incurred on materials determine to a large extent the overall cost of the project at the end. The quality of work is also measured and influenced by the standard of materials used for projects. The use of indigenous materials for building have not been impressive due to apathy, low technical know-how and low level of importance attached to its social status and symbolism. Despites these challenges, the use of indigenous materials help to promote culture of the local communities and retain income in the local economy.

5.4 Recommendations

- There should be awareness creation on the need to adopt the use of locally available materials by the government through the district to ensure that the natives are well informed on the need to patronise.
- There should be a comprehensive policy that would motivate the natives to adopt the use of local materials for buildings to reflect modernise look without scrapping the existing system. In view of this, the district should be well equipped to enforce policies and should ensure that their activities do not deter the people from patronising.
- It is appropriate for producers of local materials for construction activities to adopt enhanced technology to improve their products. This will make it attractive to prospective builders and clients.
- Training programmes should be organised for producers of local materials for construction activities. This will equip them with the needed skills and expertise to produce high quality standard materials which are durable.

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5.5 Suggestions for further studies

This study focused on Denkyembour District only without the entire Eastern Region. It is expected that future studies concentrate on assessing the effects of using indigenous materials on sustainability of buildings in Eastern Region and beyond.

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APPENDIX

QUESTIONNAIRE

THE USE OF LOCAL BUILDING MATERIALS AND ITS CHALLENGES IN GHANA: A CASE STUDY OF DENKYEMBOUR DISTRICT – AKWATIA

This study is being conducted to examine the use of local building materials and its challenges in Ghana using Denkyembour District – Akwatia as the study area. The researcher is a Master of Technology (Construction) student who would appreciate very much if you could take some time off your tight schedule to complete the questionnaire. The questionnaire is for academic purposes only and the responses will be treated with the utmost confidentiality.

SECTION ONE: DEMOGRAPHICS OF RESPONDENTS

All responses will be confidential and will not be connected in any way to yourself or your institution

SECTION A: Background Information of Respondents.

1. Please indicate your gender. *Please tick* [√]
   Male ☐ Female ☐
2. What age category do you belong? *Please tick* [√]
   a. Less than 30 years ☐
   b. 31 – 40 ☐
   c. 41-50 ☐

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d. 51+ ☐

3. What is your highest educational qualification? *Please tick* [√]

a. J. H.S ☐ c. HND ☐

b. S. H. S ☐ d. First degree ☐

e. Post-graduate ☐

f. No formal education ☐

Others (Please state)_____

4. How long have been working at your organisation? *(Please tick)*

a. Less than a year ☐

b. 1-10 years ☐

c. 11-20 years ☐

d. 20+ years ☐

Other (Please state)_____

SECTION B: PERCEPTIONS ON THE USE OF LOCALLY MADE BUILDING MATERIALS

5. Do you patronize locally manufactured building materials in your hotel?

a. Yes [ ] b. No [ ]

Give reasons to your answer in Question 5

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6. Does your income level affect your preference for locally made building materials? a. Yes [ ] b. No. [ ]

Give reasons to your answer in Question 7

……

……

7. In your view, do you think the cost of locally manufactured building materials affect their patronage? a. Yes [ ] b. No. [ ]

Give reasons for your answer in Question 7

……

……

……

8. Rank the following components of **challenges associated with using locally manufactured materials** in a range of one (1) to five (5) with one (1) being the most important factor and (5) being the least important factor. Just tick (√) the blank space for the answer which is right to you.

No.	**CHALLENGES**	**RESPONSES**				
		1	2	3	4	5
1	Houses built with local materials have low strength					
2	Houses built with local materials require frequent maintenance					
3	Houses built with local materials require a lot of labour work					
4	Houses built with local materials ware or erode so easily					

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5	Houses built with local materials are easily attacked by rodents/pests					
6	Lack of skilled personnel					
7	Low level of technical know-how					
8	They are not durable					
9	Apathy towards the indigenous building materials					
10	High maintenance cost in the long-term					
11	Poor Quality					
12	Low value of buildings constructed with indigenous materials					
13	Low level of importance attached to social status and its symbolism					
14	Cannot withstand vagaries of the Weather					
15	Lack of recognition for by Authorities					

SECTION C

9. Rank the following components of **Effects of Using Locally manufactured materials for building** in a range of one (1) to five (5) with one (1) being the most important factor and (5) being the least important factor. Just tick (√) the blank space for the answer which is right to you.

No.	**Effects of Using Locally manufactured materials for building**	**RESPONSES**				
		1	2	3	4	5
1	Promotion of cultural heritage					
2	Provision of cool room temperature					
3	Local building materials provide less environmental					

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4	Local building materials are affordable and cheap					
5	Local building materials provide less environmental effect					
6	Local building materials have fire resistance characteristics					
7	Provide thermal comfort					

10. In your view, do you think building materials affect cost of housing in Denkyembour District – Akwatia?

a. Strongly agree [ ]

b. Agree [ ]

c. Strongly disagree [ ]

d. Disagree [ ]

e. Do not know [ ]

11. In your view, do you think locally made building materials affect quality of housing projects at Denkyembour District - Akwatia?

a. Strongly agree [ ]

b. Agree [ ]

c. Strongly disagree [ ]

d. Disagree [ ]

e. Do not know [ ]

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12. In what way(s) can the use of locally manufactured building materials be improved at Akwatia?

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