TOWARDS THE ACHIEVEMENT OF AFFORDABLE HOUSING IN GHANA; THE USE OF EXPANDED POLYSTYRENE (EPS)

By

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MASTER OF SCIENCE

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The aim of this study was to investigate the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana. Data were gathered from a total of 44 architects and quantity surveyors through a questionnaire survey. The data was analysed with descriptive statistics using frequencies and percentages and a Relative Agreement Index (RAI) model. Analysis of the data revealed significant economic impacts of using EPS. The highly rated impacts were that "EPS enhances speed of construction", "EPS reduces construction period", "EPS provides durability of project" and "EPS enhances waste reduction", with respective RAI values of 0.909, 0.905, 0.859 and 0.850. The relatively high RAI values implied a positive economic impact of the use of EPS as being a cost effective technology. Building cost estimations revealed a significant difference in cost of a building using block work and the one using EPS panels resulting from the relatively high cost of the block work component and the concrete component. The total estimated cost of the structural system was 37.6% higher than that of the EPS building. The results further showed knowledge of EPS among the general public was low as indicated by about 66% of the respondents. Surprisingly, about 45% and 43% of the respondents further indicated that design professionals' knowledge of EPS was average and low respectively. This had translated into a low adoption rate of EPS for housing within the Ghanaian construction industry. The study concludes that the prospects of EPS in providing affordable housing lies in its marked economic benefits given the widespread need of housing requirement in the country. However, limited knowledge of EPS and its widespread unavailability are notable challenges to its adoption and as such the study recommends that professional and public education of EPS should be enhanced to increase the knowledge, awareness and confidence in EPS for providing affordable housing in Ghana.

Keywords: Achievement, Affordable, Housing, Ghana, Expanded Polystyren

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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DEDICATION

I dedicate this work to all my family members for their support and prayers throughout the programme

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Globally, the benefits of housing in both developed and developing countries cannot be overemphasized. Housing plays a critical role in the improvement of the quality of people's lives. According to Lee et al. (2006), safe and affordable housing provides personal, social, and economic benefits and most directly contributes to the health and safety of individual inhabitants.

The United Nations Commission on Human Settlements (UNCHS), has long observed the need for adequate shelter to make human settlement safer, healthier, livable, equitable and productive (UNCHS, 1996).

As noted by the UN-Habitat report on Africa’s affordable housing (UN-Habitat, 2011), housing is unaffordable for the urban poor majority in Africa because of the high costs of both land and building materials. Typically, high costs of building materials forms the single largest input into the construction of housing, and can account for up to 80 per cent of the total value of a simple domestic house.

Affordable housing becomes a key issue especially in developing nations where a majority of the population is not able to buy houses at the market price. Affordable housing refers to housing units that are affordable by that section of society whose income is below the median household income. This inherently implies the use of affordable but quality building materials. In this regard, one such affordable but quality building material is the expanded polystyrene (EPS).

EPS is a rigid and tough, closed-cell foam with a normal density range of 11 to 32 kg/m^3. It is usually white and made of pre-expanded polystyrene beads. This is an excellent material for home construction because of its low thermal conductivity, moderate compressive strength, its affordability in terms of building and excellent shock absorption.

This research is carried out to determine the prospects of EPS in providing affordable housing solutions within the Ghanaian housing sector.

1.2 PROBLEM STATEMENT

Housing, being a basic human need has been one of the major challenges faced by many countries worldwide. This is particularly due to the high cost of building materials for the housing industry. Ghana is an example of the countries that has for long struggled with the provision of decent and affordable housing for its growing population. This is despite having various strategic plans to curb the situation.

In Ghana, the shortage of housing continues to be one of the most critical socio-economic challenges facing the country (Ghana National Development Plan, 2008). The high property prices particularly in the urban centers such as Accra, Tema, Kumasi and Takoradi fueled by a rapidly growing middle-class, as well as rapid and uncontrollable urbanization have turned the housing industry into one of the critical developmental issues facing policy makers.

The housing shortage in Ghana manifests itself through overcrowding, proliferation of slums and informal settlements in urban areas with poor quality of housing fabric and lack of basic services.

1.3 RESEARCH QUESTIONS

The research was guided by the following research questions:

1. What are the economic impacts of EPS in the provision of affordable housing?
2. How does the cost of EPS compare with conventional construction materials?
3. How well is EPS known in the Ghanaian market?
4. How can the use of EPS as a solution to affordable housing problem in Ghana be promoted?

1.4 RESEARCH AIM

The aim of this research was to determine the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana.

1.5 RESEARCH OBJECTIVES

In order to achieve the aim of the research, the following specific objectives were set:

1. To determine the economic impacts of EPS.
2. To compare cost of EPS over conventional construction materials.
3. To find out how well EPS is known in Ghanaian market.
4. To identify ways of promoting EPS as a solution to affordable housing problem in Ghana.

1.6 RESEARCH SCOPE

The study was carried out within Greater Accra Region of Ghana. The region was selected for the study because of its significant need of affordable housing. The region is very populous and serves as a destination for most migrants across Ghana. The information sought related mainly to prospects of EPS in affordable housing considering economic impacts and costs. The study also sought information related to acceptability and availability of EPS as a means of providing affordable housing. The region was appropriate for the study since it had adequate number of construction professionals and consultants registered with the Association of Building and Civil Engineering Contractors of Ghana (ABCECG) from whom data were sought.

1.7 METHODOLOGY

This study was an exploratory study which involved the use of data obtained from primary sources. Primary data were obtained through a questionnaire survey with the respondents. This was necessary in order to obtain first-hand information on the issues of the topic under study. Secondary information from the review of literature was necessary to give an insight into the study and enable the thorough examinations of the various views and works related to the study.

The respondents comprised quantity surveyors and architects in the Ghanaian construction industry who have used EPS in any of their projects. A detailed questionnaire was developed based on the study objectives and distributed to the various respondents to solicit their views.

The data were analysed using descriptive statistical analysis and a relative index. The data analysis was in the form of comprehensive statements and analytical discussions based on the primary data as well as the secondary information.

1.8 JUSTIFICATION

The UN Agenda 21; on environment and development, advocates and promotes sustainable settlement developments. However, Ghana is saddled with problems of adequate supply of affordable housing to its citizens. The output of this research will contribute to knowledge and serve as basis for policy makers to make informed decisions relating to Affordable Housing Investments.

The high population growth and urbanization processes witnessed in Ghana in recent times call for the need to expedite the facilitation of housing provision to be more proactive in the realization of affordable housing.

Attempts in meeting housing demand by citizens both in the urban and rural areas have witnessed enormous use of conventional building materials. This mode of construction not only takes long periods but also adds enormously to the costs housing delivery. Alternative construction materials and new technologies have over the recent years been introduced in the Ghanaian market including EPS to try to mitigate this phenomenon. This study therefore attempts to investigate the prospects of EPS in the provision of affordable housing.

1.9 SIGNIFICANCE OF THE RESEARCH

The findings of the research will be relevant to all stakeholders of affordable housing in Ghana including the inhabitants and policy makers. Also, the outcome of this research will be injected into future projects and offer ways to promote and propagate the use of the EPS for affordable housing provision.

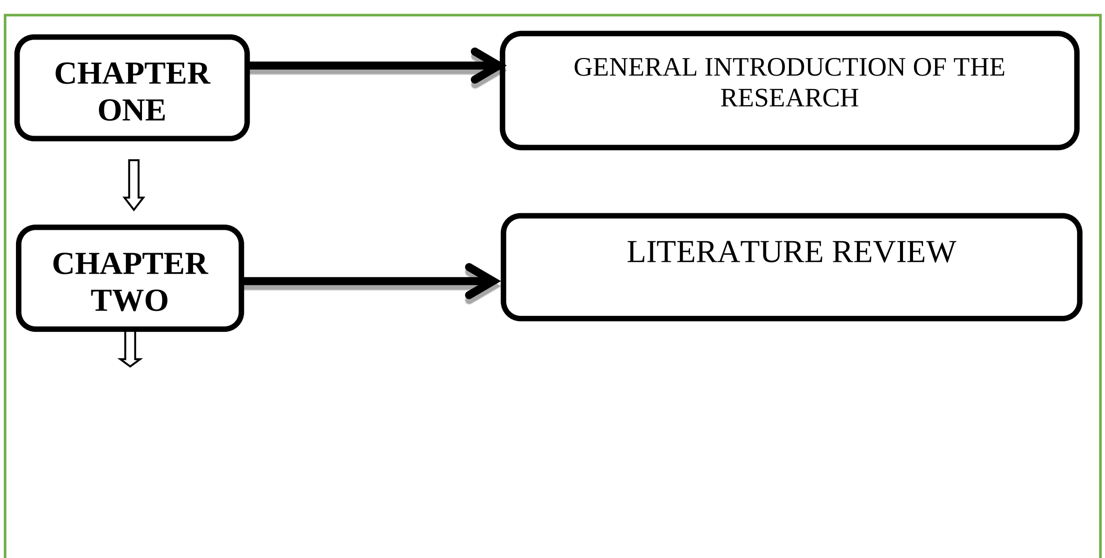
In addition, the obtained data on economic benefits will be used to lower housing construction costs hence making housing provision affordable. Finally the research will add to the body of knowledge on the provision of housing using affordable construction materials.

1.10 LIMITATIONS

The major limitation for this research was the difficulty in getting the required people to answer the items of the questionnaires mainly because of their busy schedules. Also, most of the required people were reluctant to partake in the study because of their quest to keep trade secrets from competitors in the industry. Also, the duration for the thesis and budgetary constraints did not allow the researcher to conduct a comprehensive study on a larger sample size.

1.11 ORGANIZATION OF THE STUDY

The research report is organized into five chapters. Chapter one encompasses the introduction of the research consisting of the research background, problem statement, aim and objectives, research questions, research justification and significance. Chapter two contains the review of related literature on the topic under study. Chapter three provides details of the research methodology. Chapter four contains the results and discussions of the data obtained. The summary of findings, conclusions and recommendations are contained in chapter five. Figure 1.1 shows the diagrammatic representation of the structural workflow for this research.



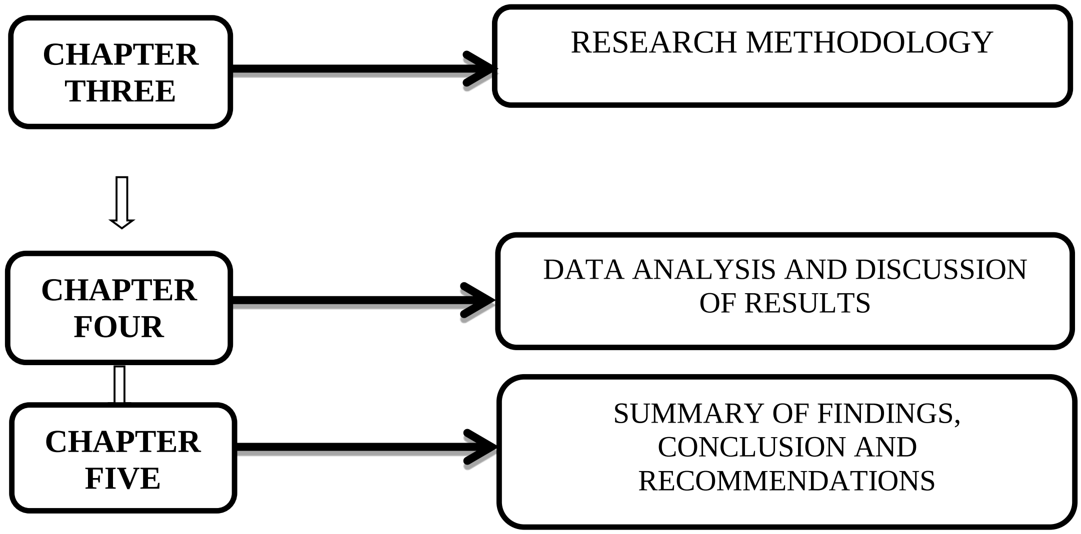


Figure 1.1: Research Organisation

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In chapter one the general introduction of the research was discussed, including the research background, problem statement, research aim and objectives, methodology, justification and the significance of the research. In this chapter, pertinent literature relating to affordable housing and construction technology are reviewed. It covers secondary materials from research articles and other relevant publications related to the conceptual issues relevant to this study. This chapter provides the conceptual and theoretical basis for this research. The chapter starts with an overview of housing and affordable housing. This is then followed with a discussion of the factors that affect affordability of housing; adoption of new construction technology and materials; and ends with an overview of EPS technology and discussions of its use in housing.

2.2 THE CONCEPT OF HOUSING

In general, terms, housing can be considered as the physical structure within which man lives or works. The United Nations Commission on Human Settlement (UNCHS) provides a more concise definition of housing as the physical structure that man uses for shelter and the environs of that structure (UNCHS, 1996).

In the same vein, Linn (1983), earlier simply defined housing to include not only the structure of the shelter but also the plot on which the shelter stands. Linn (1983) further adds that housing is the single most important land use in towns and represents a very significant proportion of all planning applications for development.

From these definitions and viewpoints of housing, the concept of housing therefore is not limited to the physical structure but an embodiment of comfort and convenience. In this regard, housing must be considered in relation to its surroundings and basic infrastructure necessary for its functionality.

2.3 THE CONCEPT OF AFFORDABLE HOUSING

Affordable housing refers to housing units that are affordable by the section of society whose income is below the median household income as rated by the national government or a local government by a recognized *housing* affordability index. Milligan et al. (2004) argues that the idea of affordable housing recognises the needs of households whose incomes are not sufficient to allow them to access appropriate housing in the market without assistance. In this regard, the concept of affordable housing describes housing that assists lower income households in obtaining and paying for appropriate and decent housing without experiencing undue financial hardship.

According to Gabriel et al. (2005), the term affordable housing has recently been used as an alternative to terms such as ‘public’, ‘social’ or ‘low cost’ housing. Notwithstanding, Milligan et al. (2004) explicitly argue that there is no single accepted definition of what constitutes affordable housing because conceptualising and measuring affordability is as complex as understanding the causal factors of the housing affordability problem itself. This implies that housing affordability is a relative term and tends to have different meaning to different stakeholders in the housing industry. According to Stone (2005), the relativity in housing affordability is an expression of the subjective social and material experiences of people, constituted as households, in relation to their individual housing situations.

The need for affordable housing in Ghana cannot be overemphasized considering the significant growth in population over the years. However, there has been a noticeable shortage in housing in Ghana which according to the Ghana National Development Plan (2008) continues to be one of the most critical socio-economic challenges in Ghana.

2.3.1 The Need for Affordable Housing

It is generally observed that over the past decades, many countries in the developing world particularly in Africa, Asia and Latin America have had substantial increases in their populations, resulting in housing shortages. Such housing deficits have both quantitative and qualitative components and they are most notable in the cities (Bredenoord, 2016).

According to UN estimates, the urban population of the developing world alone will increase from 2.7 billion in the year 2011 to 5.1 billion by 2050 (UN, 2012). Consequently, millions of new and upgraded houses will have to be provided in order to accommodate a rapidly growing urban population. However, most low-income households have limited access to affordable housing, and therefore it is apparent that housing shortages cannot be solved without focusing on sustainable low-cost housing.

Housing is big investment and few people can afford. Those who cannot afford housing investment automatically become Renters or Squatters of houses in which they perceive to have their housing and other personal satisfaction. As noted by O’Sullivan (2003), households ultimately choose homes that maximize their utility subject to budget constraints. In this regard, it is noticeable that budget constraints have a significant bearing on demand and supply interactions in the housing market. Household normally spends between two (2) and three (3) times its annual income when purchasing a home and are also required to make large down payment (O’Sullivan, 2003).

The need for houses that are affordable by typical households is very crucial. As noted by Arnot (1987), as mortgage rates decrease, households may have greater incentive to invest in purchasing homes that are considerably affordable and will therefore demand less rental housing units. In the same vein, if housing units are available and suitable, housing rents become relatively affordable. In this regard, if housing is produced and supplied at lower unit cost, new dwellings could be built in large numbers (Abrams, 1971).

2.4 FACTORS THAT AFFECT THE AFFORDABILITY OF HOUSING

Typically, high costs of building materials forms the single largest input into the construction of housing, and can account for a large percentage of the total value of a simple domestic house (Seeley, 1996). In this regard, the price of building construction materials determines whether housing unit could be demanded and supplied at highly expensive or reasonably affordable rates to households. Investors in the housing industry are saddled with ever increasing prices of building construction materials for housing projects. This has been explicitly noted by Agus and Abdullah (2000), that price increase of building materials such as cement, steel bars, bricks and timber affect housing affordability.

As outlined in the Project Management Body of Knowledge (PMI, 2008), project cost management is an essential knowledge area which focuses on the cost of resources needed to complete the project and this includes all processes involved in estimating, budgeting, planning and controlling costs. The cost management processes include the following; Cost estimation; Cost budget; and Cost control. Considering that building materials account for the greater part of the total construction costs, alternative construction materials and technologies with their many varieties thus become important in lowering construction costs owing to the fact that these new technologies can reduce materials cost by up to 50 per cent (Ngigi, 2016).

The affordability of housing can also be influenced by the location of the housing unit as well as the availability of financing options. The availability of financing options is very crucial to the affordability of housing. It is noticeable that funding affordable housing projects is not an easy task. According to the UN-HABITAT (2010), financing affordable housing is frustrating and when funds are available, unreasonably high interest rates and unfriendly or stringent terms of loan repayments are disincentive to affordable housing investment.

2.5 ADOPTION OF NEW CONSTRUCTION TECHNOLOGY AND MATERIALS IN MAKING HOUSING AFFORDABLE

According to the UN-Habitat (2004), new and alternative construction methods have been widely acknowledged and accepted in the developed world as a means of providing housing. This is in line with the idea to curtail materials that create pollutants and the need for buildings to adhere to new requirements to save energy.

Quite recently, the UN-Habitat (2011) has acknowledged that the world is now ready to adopt and utilize alternative building systems and methods to reduce the deficit of housing demanded by the rising population. The urge is more critical in Africa where the demand for shelter is extremely high. As noted by Ngigi (2016), the longstanding criticism about the construction industry's poor performance is a contributory factor to the worldwide increased attention to the use of modern construction methods with regard to costs, adoption and effectiveness.

Considering that building materials account for about 60 per cent of the total construction costs, alternative construction materials and technologies with their many varieties could be instrumental in lowering construction costs owing to the fact that these new technologies can reduce materials cost by up to 50 per cent (Ngigi, 2016).

A variety of new construction technology and building materials can be emphasized recently. In the first place, there are the prefabricated components that are simple building blocks that usually involve a single building trade. Hartley and Blagden (2007) outline key examples of these prefabricated components to include timber frame panels; precast panels; steel frame panels; Structurally Insulated Panels; building envelope/façade systems; composite panels; precast cladding; Light Steel Frame Building Systems; pre-cast structural elements; Insulating Concrete Formwork; and tunnel form construction.

Also, there are the steel prefabricated structures that are viewed as being modern. It is used in flooring, walling and roofing materials which are easily prefabricated in workshops and off sites then transported to construction sites. These materials are easily assembled and installed on site. It is worth noting that the concrete industry also embraces innovation and modern methods of construction by offering concrete solutions which can be used to reduce construction time and promote sustainable development, as well as offering cost savings. Precast concrete industry has adopted and used various products in promoting and providing housing. These alternative products include concrete roofing tiles, waffle slabs, pre-stressed floor slabs, precast concrete wall panels and many more.

Of more importance to this current study are the manufactured materials particularly with Expanded Polystyrene panels (EPS) that offer another avenue of alternative construction methods. Such materials include Three Dimension EPS integrated with galvanized steel trusses; steel mesh clipped or welded to the protruding points of the trusses and then finished with coat of cement plaster. This technology implements the 3D- Panel Systems and is a relatively new innovative approach used in many parts of Africa (Ngigi, 2016). This has been favoured as the most suitable approach for mass housing construction worldwide because of its versatility. This is ideal for unsuitable soil conditions; physically, the joined panels create structures which are monolithic in nature providing superior strength to the walls, which prevents cracking.

The use of alternative construction technology has been demonstrated in Lagos, Nigeria and Johannesburg, South Africa where expanded polystyrene is widely used to provide housing in settlement schemes in a World Bank-supported Lagos Slum Upgrading Programme dubbed “provision of one million housing units for low income households in Lagos“ which was instituted in 1999 and South Africa’s new national housing policy dubbed "Breaking New Ground" (BNG) used to accelerate the delivery of quality housing (UN-Habitat, 2010).

2.6 EXPANDED POLYSTYRENE (EPS) TECHNOLOGY

EPS begins as a polystyrene bead or pellet. The pentane-loaded bead is then exposed to pressurized steam, which causes the polystyrene to expand and mold into the desired shape and density needed (Lee et al., 2006).

EPS is a thermoplastic material manufactured from styrene monomer, using a polymerization process which produces translucent spherical beads of polystyrene. EPS is a rigid cellular plastic found in a multitude of shapes and made available for a multiplicity of applications. According to Ede et al. (2014), EPS was initially mainly used for insulation foam for closed cavity walls, roofs and floor insulation. Quite recently, EPS usage has extended in the building and construction industry in road construction, bridges, floatation, railway lines, public buildings, drainage facilities and family residences.

A variety of EPS types and sizes are used for building construction with the most common ones being for wall panels and for slab that are erected with steel meshes. EPS technology is used in making manufactured low cost building materials such as 3D panel system. According to the Lee et al. (2006), 3D panel system is an alternative building system using prefabricated polystyrene panels with wire mesh. Unlike other building systems, 3D Panel is an environmentally friendly product, withstands extreme temperatures and earthquakes and is a recycled green product. The 3D panel system comprises of Expanded Polystyrene (EPS) foam sandwiched between a galvanized steel wire mesh that is plastered on both sides by pneumatically spraying it onto the surface a process known as shoot concreting. The steel mesh serves as reinforcement (Lee et al., 2006).

2.7 FACTORS THAT FAVOUR EXPANDED POLYSTYRENE (EPS) USE IN HOUSING

Expanded polystyrene (EPS) is an innovative building material that lends to the design and structural integrity of many building projects. EPS is a powerful design element and an ideal choice for green building design, offering tangible environmental advantages that can maximize energy efficiency, providing improved indoor environmental quality and enhancing durability. Given the proven strengths of plastic materials used in commercial and residential construction in the past three decades, Ede et al. (2014) asserts that the adoption of plastic in civil constructions is dramatically on the increase due to improved material performance and the need for lightweight, durable materials and insulation purposes.

Expanded Polystyrene (EPS) is widely available and is currently being used in many countries worldwide to provide housing. In many parts of Africa, the EPS technology has recently been adopted in construction although EPS technology had already been used in other countries including Mexico, Britain, Qatar and USA (Ngugi et al, 2017).

EPS as a construction material provides environmental, technical, commercial and social benefits. Use of EPS material for construction yields numerous benefits to the users, investors and to the environment. EPS yields construction time saving and reduce construction periods. It is very quick to erect because of its lightness and the availability in any length. The light weight panels which is easy to lift and erect at any height inside the plant or any other place. Despite the low weight, buildings constructed using the EPS panels are strong enough to withstand natural calamities better than houses build using the conventional stone and mortar.

EPS provides flexibility in design and enables choosing various options on fascia of panels and colours. EPS material is resistant to fire and earthquakes. Also EPS panels can be used to construct up to twenty storey building structures. According to Okumu (2014), mass production of factory houses using the EPS panels is expected to drastically reduce the cost and time taken to put up a house.

2.7 SUMMARY OF LITERATURE REVIEW

Throughout this chapter, pertinent literature relating to affordable housing and construction technology have been reviewed. The review has shown that housing is big investment and few people can afford with those who cannot afford housing investment becoming renters or squatters of houses in which they perceive to have their housing and other personal satisfaction.

The affordability of housing has been found to be important giving the rising population and the needs of a range of very low to moderate income households. Consequently, millions of new and upgraded houses will have to be provided in order to accommodate a rapidly growing population. Ghana’s housing deficit has been found to be increasing over the years despite the many housing policies and interventions of various governments since the colonial times. This becomes a great opportunity for the construction companies in Ghana to adopt and use new construction technology and materials such as Expanded

Polystyrene (EPS) that cuts housing costs with demonstrated success stories in many African countries including Nigeria, Kenya and South Africa.

As outlined in the Project Management Body of Knowledge, project cost management is an essential knowledge area which focuses on the cost of resources needed to complete the project. Considering that building materials account for the greater part of the total construction costs, alternative construction materials and technologies with their many varieties thus become important in lowering construction costs owing to the fact that these new technologies can reduce materials cost by a significant amount.

Expandable Polystyrene has become an essential part on the development of affordable housing in developing countries. The EPS raw material has demonstrated all the benefits it brings to help the housing deficit with some of the notable benefits being: cost effective as compared to traditional methods in construction time, energy savings and final cost; safer than conventional construction methods including withstanding earthquakes and fires better; easy transportation; easy installation; providing thermal insulation that helps in saving energy and environmental protection. Based on the literature review, this current study aims to investigate the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the research methodology adopted for this study to achieve the research aim and objectives. The chapter discusses the research design, types and sources of data, sampling methods, techniques of data collection and data management and analysis. It provides detailed explanations to the methods used and how they were suitable in carrying out this research.

3.2 RESEARCH DESIGN

This study was an exploratory study which involved the collection of reliable data using questionnaires to make the study as objective as possible. This research obtained data from primary sources in order to find more meaning, comprehensiveness and value to the study. The research follows a quantitative strategy through the use of questionnaires for data collection. The quantitative strategy provided an insight on the relationships among the various variables as they were analysed statistically. The research further adopted a cross-sectional approach in data collection in the sense that data collection occurred at a single point in time for each primary respondent.

3.3 DATA SOURCES AND TYPES

The researcher employed the use of data obtained from primary sources and information from secondary sources to meet the research objectives. Primary data was sourced from construction professionals and consultants of selected construction and consultancy firms. The data included background information as well as information on the economic impacts of EPS; cost of EPS over conventional construction materials; how well the EPS is known in Ghana; and ways of promoting EPS as a solution to affordable housing. The primary data assisted the researcher to get original information from the respondents on key issues pertaining to this research.

Secondary information was used to supplement the primary data. Secondary information was obtained through a review of existing literature from published books and journals as well as policy documents and existing reports about the topic under study. The secondary information thus provided the conceptual and theoretical foundation for this current study.

3.4 RESEARCH POPULATION

In research, a population refers to the universe of units from which a sample is selected (Kothari, 2004). The population for this study comprised all stakeholders within the building construction industry in Ghana. However, for the purpose of this research, the study population was limited to include only the construction professionals and consultants within construction companies that were registered with the Association of Building and Civil Engineering Contractors of Ghana (ABCECG).

3.5 SAMPLING PROCEDURE AND SAMPLE SIZE

Sampling is concerned with the selection of a subset of individual elements within a population and intended to yield some knowledge about the population of concern. In order to take care of all the issues under consideration in the research objectives, this study employed varied sampling methods. In the first place, the researcher identified construction companies in the Greater Accra Region that had active construction sites within the region. From this, purposive sampling was used to select twenty (20) construction companies that have used EPS in any form for their projects. Within each selected company, a total of three (3) respondents consisting of quantity surveyors and architects were selected in consideration of their different experience and functions in building design and cost management. These respondents were selected because they have over-site responsibilities for construction projects and are therefore expected to contribute to cost management efforts. The respondents were selected based on their availability and willingness to participate in the study. This gave a total sample size of sixty (60) respondents. The choice of the varied respondents was to enable the researcher to identify the varying responses and dimensions to the issue of construction project costs and materials affordability.

3.6 RESEARCH INSTRUMENTATION

This research used a questionnaire as the instrument for data collection. Kothari (2004) defines a questionnaire as a formal set of questions or statements designed to gather information from respondents that accomplish research objectives. According to Naoum (1998), the questionnaire is probably the most widely used data collection technique for conducting surveys to find out facts, opinions and views. For this research, a questionnaire was selected because it enhances the reliability of observations and improves replications because of the inherent standardized measurement and sampling procedures.

A structured questionnaire was designed and administered to each selected respondent to obtain the required data pertaining to all issues of the topic outlined in the objectives of the study. The questionnaire was brief and simple. The questionnaire was structured into separate sections based on the objectives of the study. The questionnaire consisted of closed-ended and open-ended questions. The closed-ended questions were used for their advantages of being quick to answer and requiring no writing by the respondent (Naoum, 1998). The various questions were obtained with the help of a detailed literature review and were simple, easy, unambiguous and void of technical terms to minimize potential errors from respondents.

3.7 DATA ANALYTICAL METHODS

The data collected was checked and edited to eliminate potential errors that would limit the reliability of the research results. This involved checking the completeness and accuracy as well as consistency of the responses provided in the questionnaire. Afterwards, the responses were entered into Microsoft Excel 2010 for analysis. The data were analyzed with descriptive statistics using frequencies and percentages. Also, the quantitative analyses involved the use of a Relative Agreement Index (RAI) to rank the responses on the Likert-type questions that were provided by the respondents. The respondents were asked to rate their responses using a five-point Likert. The RAI was calculated by multiplying the individual frequencies by their corresponding values of responses under each rating of 1-5 and dividing the sum by the product of total number of respondents and 5 which is the highest figure on the five-point Likert scale.

$$RAI = \frac{1y1 + 2y2 + 3y3 + 4y4 + 5y5}{5n}$$

Where: y1 = number of respondent who answered 1 on the Likert scale

y2 = number of respondent who answered 2 on the Likert scale

y3 = number of respondent who answered 3 on the Likert scale

y4 = number of respondent who answered 4 on the Likert scale

y5 = number of respondent who answered 5 on the Likert scale

n= the total number of respondents

In addition, charts and tables were created to visually present and describe the results of the analysis. The results of the data analysis were interpreted and discussed to arrive at the findings. Furthermore, the discussion of the findings was in the form of comprehensive statements and analytical descriptions based on the primary data to address the research objectives.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 INTRODUCTION

This chapter presents the results of the analysis of the survey data collected. For the purpose of this study, a total of 60 questionnaires were distributed to construction professionals particularly architects and quantity surveyors from construction and consultancy firms in the Greater Accra Region. This was to solicit for their views on the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana. In all, 44 of these construction professionals completely filled their questionnaires which were retrieved and used in the analysis accordingly. This represented a questionnaire response rate of 73.3% which was very high and appropriate for the study. The analysis begins with a discussion of the background information of the respondents. This is then followed by thematic sub-sections based on the research objectives. The themes were: economic impacts of EPS; cost of EPS over conventional construction materials; how well EPS is known in the Ghanaian market; and ways of promoting EPS as a solution to affordable housing in Ghana.

4.2 BACKGROUND INFORMATION RESPONDENTS

This section of the analysis provides the background information of the respondents that were involved in the questionnaire survey. The respondents' background covered various characteristics including their profession educational qualification, years of being in professional practice, their clients and their experiences with EPS as discussed below:

4.2.1 Distribution of Respondents by Profession

With regard to profession, the respondents were made up of quantity surveyors and architects. Table 4.1 illustrates a summary of the professions of the various respondents.

Table 4.1: Professions of Respondents

Profession	**Frequency**	**Percent (%)**
Quantity Surveyor	23	52.27
Architect	21	47.73
Total	**44**	**100.00**

Source: Field survey, 2018

It is noticeable from Table 4.1 that 52.3% of the respondents were Quantity Surveyors with the remaining 47.7% being Architects. For the purpose of building construction, quantity surveyors and architects are seen to be involved from the inception of housing projects to completion and thus have reliable information on costing and design of housing project. For instance, quantity surveyors are responsible for calculating the quantities and costs of building materials whereas the architects are involved in the design and review of buildings.

4.2.2 Distribution of Respondents by Educational Qualification

The educational qualifications of the respondents show that the respondents have obtained different educational statuses. The educational level of the respondents is shown in Figure 4.1.

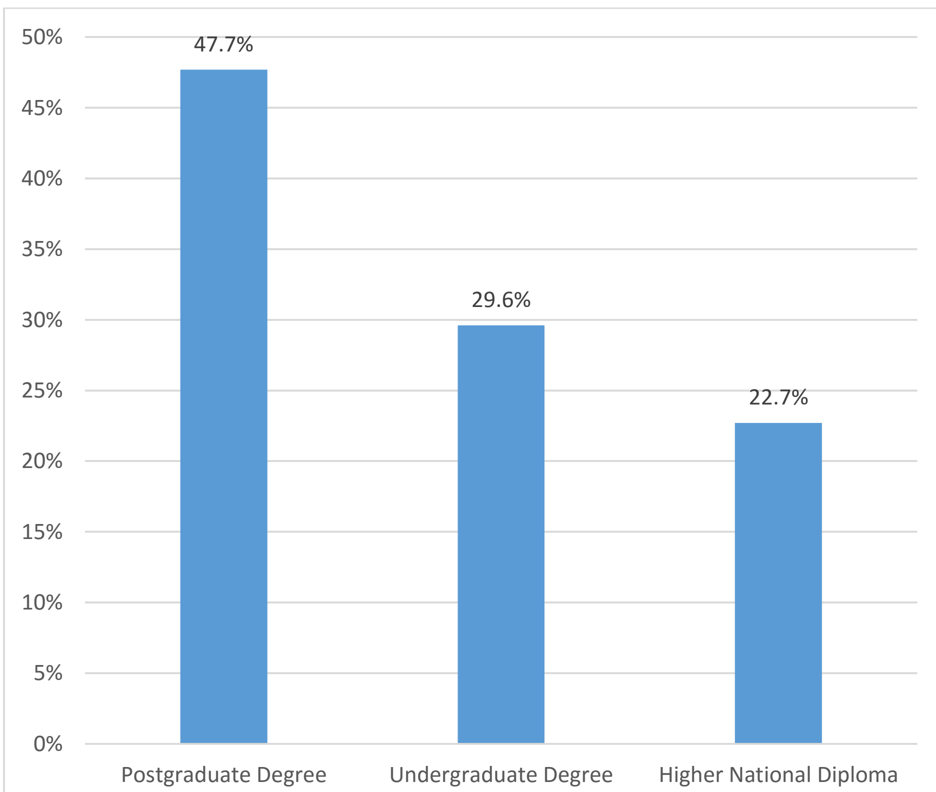


Figure 4.1: Highest Educational Level of Respondents

Source: Field survey, 2018

As shown in Figure 4.1, the majority of the respondents (47.7%) have obtained a Postgraduate Degree. Also, 29.6% have obtained an Undergraduate Degree with the remaining 22.7% of the respondents having obtained a Higher National Diploma (HND). This finding signifies that the respondents have attained an appreciable level of tertiary academic qualifications. This indicates that quantity surveying and architecture are highly specialized professions within the construction industry.

4.2.3 Distribution of Respondents by Period of Professional Practice

Another vital detail of the respondents profile was the number of years they have been in professional practice. This detail helped in getting information from respondents with varying work experiences who have different functions in housing construction. The responses ranged from less than 5 years to more than 20 years as displayed in Figure 4.2.

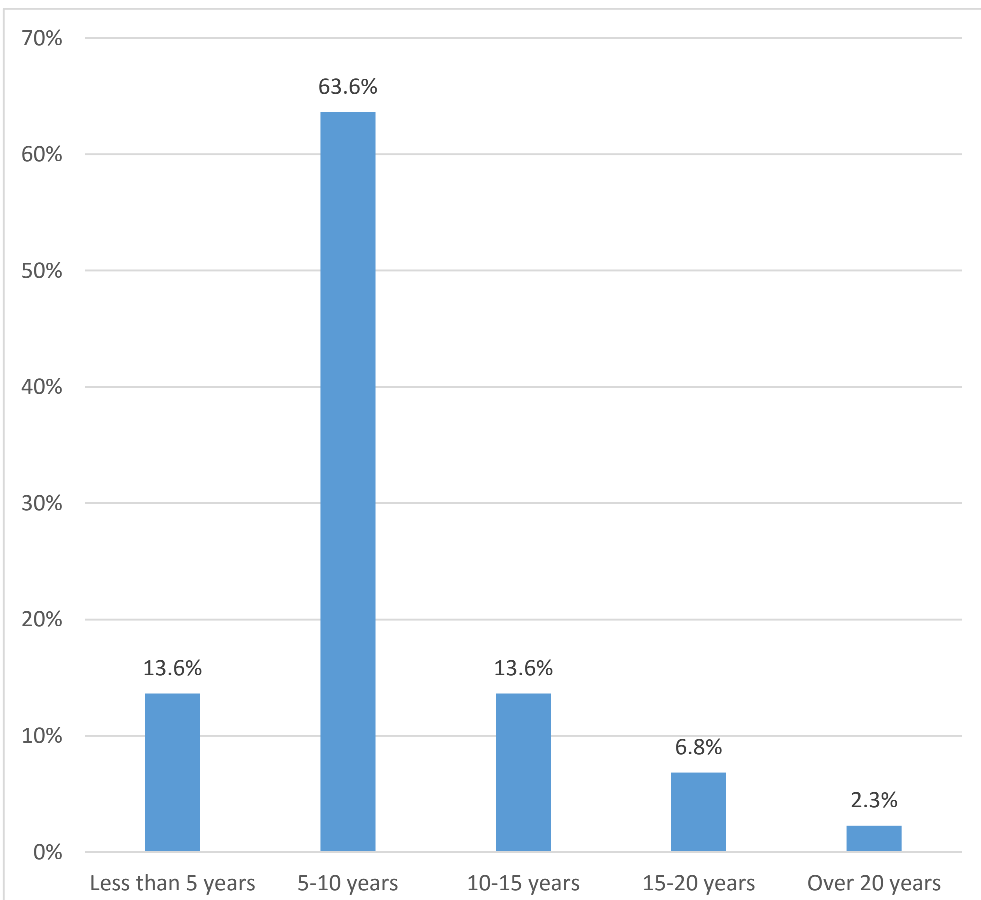


Figure 4.2: Respondents Period of Professional Practice

Source: Field Study, 2018

With regard to the respondents' period of practicing their professions, the majority of the respondents (63.3%) have been in professional practice for 5-10 years. Also, 13.6% of the respondents have been in professional practice for between less than 5 years with another 13.6% having been in professional practice for 10-15 years. Another 6.8% of the respondents have practiced for 15-20 with another 2.3% of them practicing for over 20 years.

4.2.4 Distribution of Respondents by Major Clients

Clients are very important stakeholders in the construction industry. In Ghana, clients of the construction industry are made up of both public and private sector entities. These clients employ most of these respondents in their respective firms and hence necessary to identify the type of clients the respondents work with. It was found that most of the respondents have multiple clients from both the public and private sectors. This is illustrated in Table 4.2.

Table 4.2: Major Clients of Respondents

Client type	Frequency (n=44)	Percentage (100%)
Public Organisations	13	29.5
Private Corporate Organisations	37	84.1
Private Individuals	40	90.9

Respondents selected multiple responses. This is because most of the respondents have multiple clients from both the public and private sectors

Source: Field survey, 2018

With regard to the client type the respondents worked for, all the respondents indicated at least one client type. The majority of them (90.9%) indicated private individuals as their major clients. Also, 84.1% of the respondents indicated private corporate organisations as their major clients. In addition, 29.5% of the respondents indicated Public organisations as their major clients. An interesting finding was that all the respondents indicated working with clients from the private sector. However, not all the respondents worked with the public sector.

4.2.5 Respondents Experiences with EPS

The respondents were asked to indicate the types of projects in which they have successfully used EPS in any form. Their responses included residential buildings, commercial buildings and warehouses as shown in Figure 4.3.

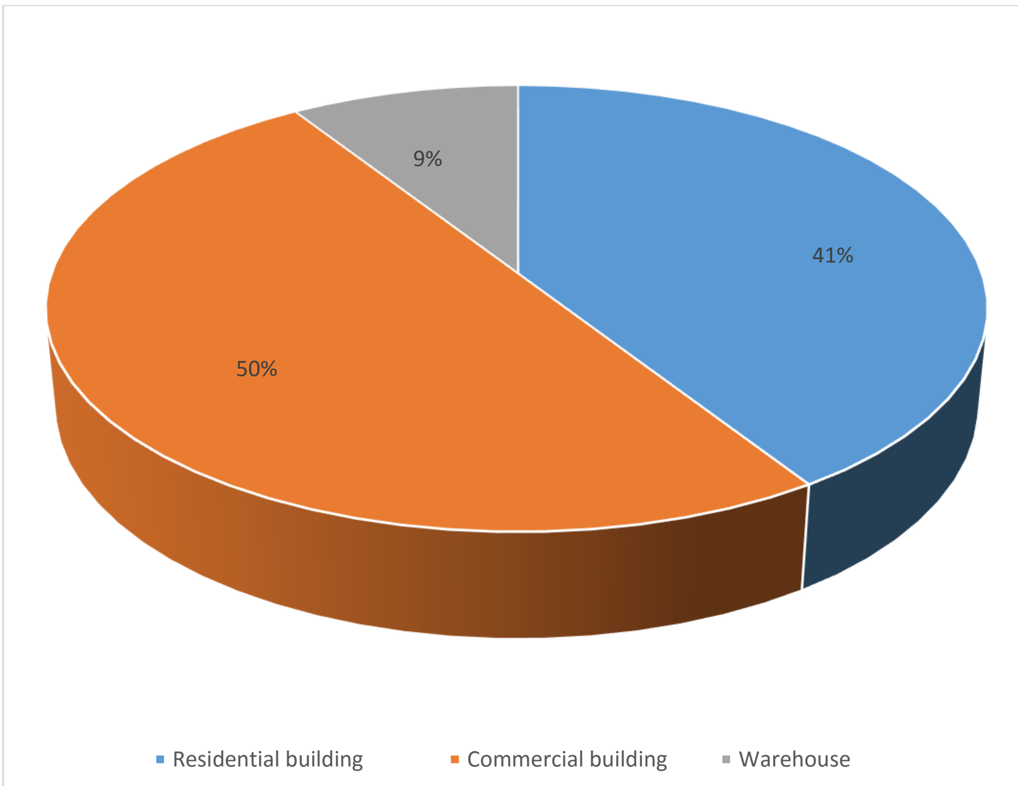


Figure 4.3: Respondents Period of Professional Practice

Source: Field Study, 2018

From Figure 4.3, it is noticeable that half of the respondents (50%) claimed to have used EPS successfully in commercial buildings. Also, 41% claimed to have used EPS successfully in residential buildings. Finally, the remaining 9% indicated the successful use of EPS in building warehouses. As a follow-up, the respondents were further asked to indicate the part of the projects in which they used the EPS. Their responses are shown in Figure 4.4.

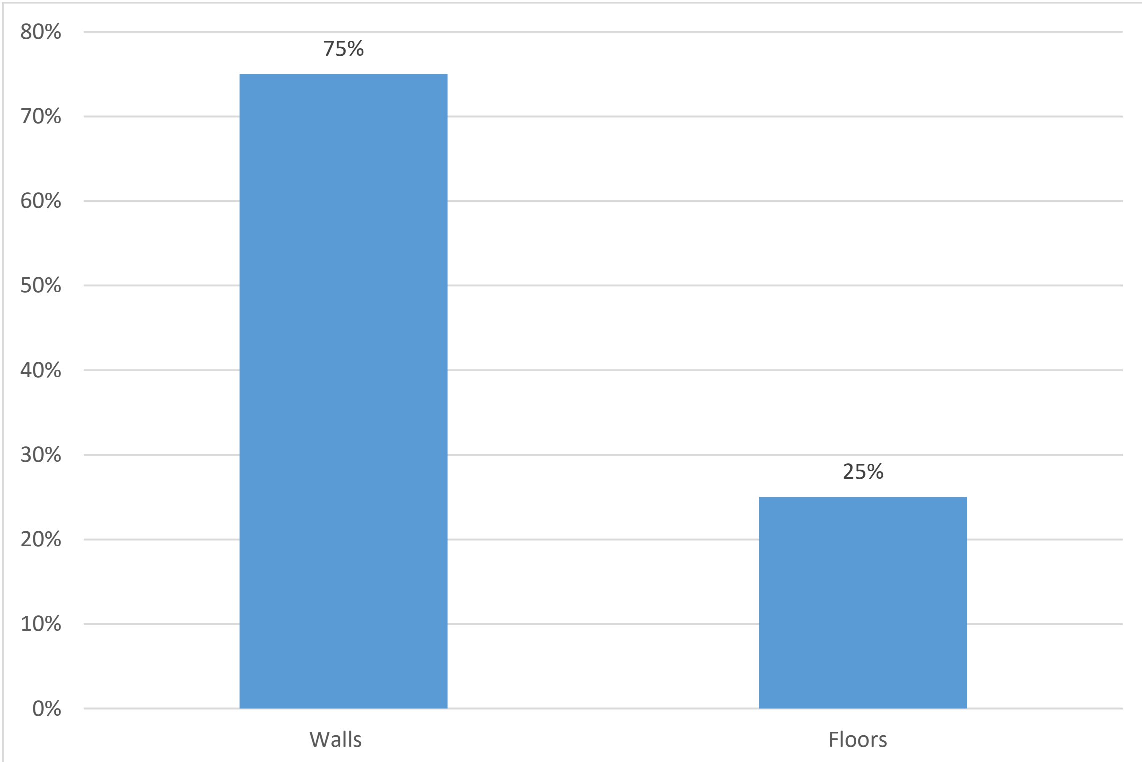


Figure 4.4: Respondents Use of EPS

Source: Field Study, 2018

Majority of the respondents (75%) indicated the use of the EPS for the walls of their respective projects. The remaining 25% indicated using the EPS for the floors of their respective projects. These findings are indicative of the varied usage of EPS in building construction.

4.3 ECONOMIC IMPACTS OF EPS

In this section of the analysis, the economic impacts of using EPS are assessed based on the responses by the respondents. In this regard, the respondents were asked to empirically rate their extent of agreement to some statements on the economic impacts of EPS using a five-point Likert scale with 1 representing strongly disagree, through to 5 representing strongly agree. The data was analysed using a Relative Agreement Index (RAI) developed for each statement. The RAI values range from 0-1. This means that the higher the RAI value; closer to 1, the stronger the agreement on that statement. The result of the analysis is presented in Table 4.3.

Table 4.3: Respondents Rating of Economic Impacts of EPS

Statements	**1**	**2**	**3**	**4**	**5**	**Total**	**Weighting**	**RAI**	**Rank**
EPS enhances speed of construction	0	0	0	20	24	44	200	0.909	1st
EPS reduces construction period	0	0	0	21	23	44	199	0.905	2nd
EPS enhances output of labour crew	0	0	4	14	26	44	198	0.900	3rd
EPS provides durability of project	0	0	7	17	20	44	189	0.859	4th
EPS enhances waste reduction	0	0	0	33	11	44	187	0.850	5th
EPS reduces cost of construction	0	0	6	28	11	45	185	0.841	6th
EPS enhances design flexibility	0	0	6	30	8	44	178	0.809	7th
EPS eases variations in the construction	0	0	2	39	3	44	177	0.805	8th
EPS increases financial returns	0	0	12	23	9	44	173	0.786	9th
EPS reduces maintenance costs	0	0	7	33	4	44	173	0.786	9th
EPS is compatible with other technology	0	0	8	34	2	44	170	0.773	11th

1=Strongly Disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree

Source: Field survey, 2018

From Table 4.3, the general impression of the results is that all the respondents expressed some form of agreement with the statements on the economic impacts of using EPS. Evidently, with all the statements, majority of the respondents expressed either agreement or strong agreement. Likewise, it is noticeable that all statements had high RAI values (above 0.700). In terms of ranking, the statements that "EPS enhances speed of construction", "EPS reduces construction period" and "EPS enhances output of labour crew" were ranked first, second and third respectively by the respondents with respective RAI values of 0.909, 0.905 and 0.900. These were followed by the statements that "EPS provides durability of project", "EPS enhances waste reduction", "EPS reduces cost of construction", "EPS enhances design flexibility" and "EPS eases variations in the construction" occupying the fourth, fifth, sixth, seventh and eighth positions with respective RAI values of 0.859, 0.850, 0.841, 0.809 and 0.805. The statements that "EPS increases financial returns" and "EPS reduces maintenance costs" were both ranked ninth with an RAI value of 0.7866 while the statement that "EPS is compatible with other technology" had an RAI value of 0.773.

The relatively high RAI values for the statements indicate a positive economic impact to the use of EPS. For instance, high speed of construction result in reduced construction period and consequently on early delivery of housing. Furthermore, reduced construction period means reduced overhead costs and other charges related to time. In addition, the reduction of material waste through the use of EPS also cuts down on construction costs and enhances financial returns for the developers and users. Reduction in maintenance costs is also good for the developers and users. These combined aspects contribute positively towards economic impacts of EPS.

4.4 COST OF EPS OVER CONVENTIONAL CONSTRUCTION MATERIALS

In this section of the analysis, cost estimation was performed in order to evaluate and compare the affordability of EPS over conventional building materials. In this regard, two bills of quantities were developed for the construction of a three-bedroom semi-detach building. One of the bills of quantities was developed using conventional block walls and concrete and the other developed using EPS panel system. The rates were divided into basic components to determine the approximate proportion of expenditure in each segment.

Tables 4.4 and 4.5 provide the bill of quantities for the building. As this study was focused on the main structural system, items such as the roofing, carpentry, joinery and other finishing components of the building were not considered. The detailed bills of quantities are provided in appendix 2.

Table 4.4: Bill of Quantity Using EPS

Item	Description	Amount (GH¢)
a	Substructure	42,366.80
b	Panel Work	72,080.00
	Total	**114,446.80**

Source: Author's Construct, 2018

Table 4.5: Bill of Quantity Using Block Work

Item	Description	Amount (GH¢)
A	Substructure	47,487.30
B	Concrete Work	28,976.40
C	Block Work	106,848.00
	Total	**183,311.70**

Source: Author's Construct, 2018

It is noticeable that the rates were divided into separate components. However, it is also noticeable that there was a significant difference of GH¢68,864.90 between the total estimated cost of the building using block work and the one using EPS panels. While the structural system of the block work building had an estimated total cost of GH¢ 183,311.70, the EPS panel building had an estimated total cost of GH¢ 114,446.80. It is noticeable that the difference in estimated cost result from the relatively high cost of the block work and the concrete components. The EPS building however, accounts for only the cost of the panel work and does not require any concrete work.

Table 4.6 provides the percentage cost difference for the components between the EPS building and the block work building.

Table 4.6: Percentage Cost Difference

EPS building	Estimated cost (GH¢)	Block work building	Estimated cost (GH¢)	Cost difference (GH¢)	% cost difference
Substructure	42,366.80	Substructure	47,487.30	5,120.50	10.8
Panel Work	72,080.00	Concrete Work	28,976.40	63,744.40	46.9
		Block Work	106,848.00		
Total	**114,446.80**	**Total**	**183,311.70**	**68,864.90**	**37.6**

Source: Author's Construct, 2018

In terms of percentages, the total estimated cost of the whole structural system was 37.6% higher than that of the EPS building. Breaking down the results revealed that the estimated cost associated with the substructure of the block work building was 10.8% higher than that of the EPS building. Similarly, the estimated cost associated with the block work and concrete of the block work building was 46.9% higher than that of the EPS building. This finding implies that the use of EPS is very cost effective particularly relating to material costs in construction. This finding supports the many studies (eg Ngugi et al., 2017; Okumu, 2014) that conclude that EPS provides relatively affordable buildings.

4.5 HOW WELL EPS IS KNOWN IN THE GHANAIAN MARKET

In this section of the analysis, the respondents' views on how well EPS is known and its availability in the Ghanaian market is examined. The respondents responded to the statements as being very low, low, average, high or very high. The data was analysed using frequencies and percentage shares of the responses for each statement. Their responses are summarized in Table 4.7

Table 4.7: Respondents Rating of Knowledge and Availability of EPS

Statements	Responses	Frequency	Percent
Public knowledge of EPS used in housing construction	Low	29	65.91
	Average	15	34.09
	Total	**44**	**100.00**
Clients knowledge of EPS used in housing construction	Low	15	34.09
	Average	28	63.64
	High	1	2.27
	Total	**44**	**100.00**
Design professionals knowledge of EPS used in housing construction	Low	19	43.18
	Average	20	45.45
	High	5	11.36
	Total	**44**	**100.00**
Adoption rate of EPS in the Ghanaian construction industry	Low	19	43.18
	Average	25	56.82
	Total	**44**	**100.00**
Availability of EPS in the Ghanaian market	Low	31	70.45
	Average	13	29.55
	Total	**44**	**100.00**

Source: Field survey, 2018

It is noticeable in Table 4.7 that the responses on the knowledge and availability of EPS in Ghana was generally low. For instance, as many as 65.9% of the respondents held the view that public knowledge of EPS used in housing construction is low. The remaining 34.1% of the respondents also held the view that there is an average public knowledge of EPS used in housing construction. In terms of clients' knowledge of EPS used in housing construction, 63.6% of the respondents indicated average knowledge with another 34.1% of them indicating low clients knowledge. These findings imply that the public does not have enough knowledge of EPS and its potential benefits to housing construction. Access to information about EPS in Ghana could thus be inadequate.

With regard to design professionals' knowledge of EPS used in housing construction, the responses from the respondents revealed a relatively average to low knowledge. About 45% and 43% of the respondents indicated that design professionals' knowledge of EPS used in housing construction was average and low respectively with only 11% of the respondents indicating that it was high. This is very surprising as design professionals are expected to be knowledgeable of modern construction technologies and materials.

Overall, the responses on the adoption rate of EPS in the Ghanaian construction industry was not encouraging. About 57% of the respondents held the view that the adoption rate of EPS in the Ghanaian construction industry was average. The remaining 43% held the view that it was low. The relatively low adoption rate of EPS used in housing construction could be attributed to the limited knowledge of EPS among clients and the public. As clients and the general public tend to be the end users of housing facilities, their limited knowledge of EPS could impact negatively on their acceptance of it in their projects. Clients with limited to no knowledge of EPS tend to stick to already known conventional materials and develop strong biases for them.

Further analysis of the data revealed that the relatively low adoption rate of EPS used in housing construction could be attributed to its unavailability on the market. A little over 70% of the respondents believe that the availability of EPS in the Ghanaian market is low. The remainder of respondents also believed that there is an average availability of EPS in the Ghanaian market. This finding implies widespread availability of EPS in the Ghanaian market could enhance people's particularly clients' knowledge of its benefits and consequently their acceptability of it in their projects.

4.6 WAYS OF PROMOTING EPS AS A SOLUTION TO AFFORDABLE HOUSING IN GHANA

The respondents empirically rated their extent of agreement on some statements as promoting EPS for affordable housing provision in Ghana using a five-point Likert scale with 1 representing strongly disagree, through to 5 representing strongly agree. The data was analysed using a Relative Agreement Index (RAI) developed for each statement. The RAI values range from 0-1. This means that the higher the RAI value; closer to 1, the stronger the agreement on that statement. The result of the analysis is presented in Table 4.8.

Table 4.8: Respondents Rating of Ways of Promoting EPS for Affordable Housing in Ghana

Statements	1	2	3	4	5	Total	Weighting	RAI	Rank
Raising awareness about EPS	0	0	0	16	28	44	204	0.927	1st
Provision of necessary training in EPS technology	0	0	0	41	3	44	179	0.817	2nd
Enhancing capacity of existing EPS manufacturers	0	0	0	41	3	44	179	0.817	2nd
Support and incentives from construction policy makers: standards and codes must be set	0	0	0	44	0	44	176	0.800	4th

1=Strongly Disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree

Source: Field survey, 2018

It is noticeable from Table 4.8 that all respondents either agreed or strongly agreed to the statements on promoting EPS for affordable housing provision in Ghana. In this regard, all the statements had relatively very high RAI values of 0.800 and above. In terms of ranking the statements, "Raising awareness about EPS" had the highest RAI value 0f 0.927. This is not surprising as raising of awareness of EPS could possibly enhance peoples' knowledge of it and its potential benefits. This implies that the raising of public and clients' awareness of EPS could enhance its adoption and acceptability for use by them in their projects.

"Provision of necessary training in EPS technology" and "Enhancing capacity of existing EPS manufacturers" both had an RAI value of 0.817. "Support and incentives from construction policy makers: standards and codes must be set" had an RAI value of 0.800. These relatively high RAI values imply that the promotion of EPS by providing necessary training in EPS technology, enhancing capacity of existing EPS manufacturers, setting standards could enhance public confidence in the product.

As a follow-up, the respondents were asked to indicate whether they envisage widespread use of EPS in providing affordable housing in Ghana. Their responses are presented in Figure 4.5.

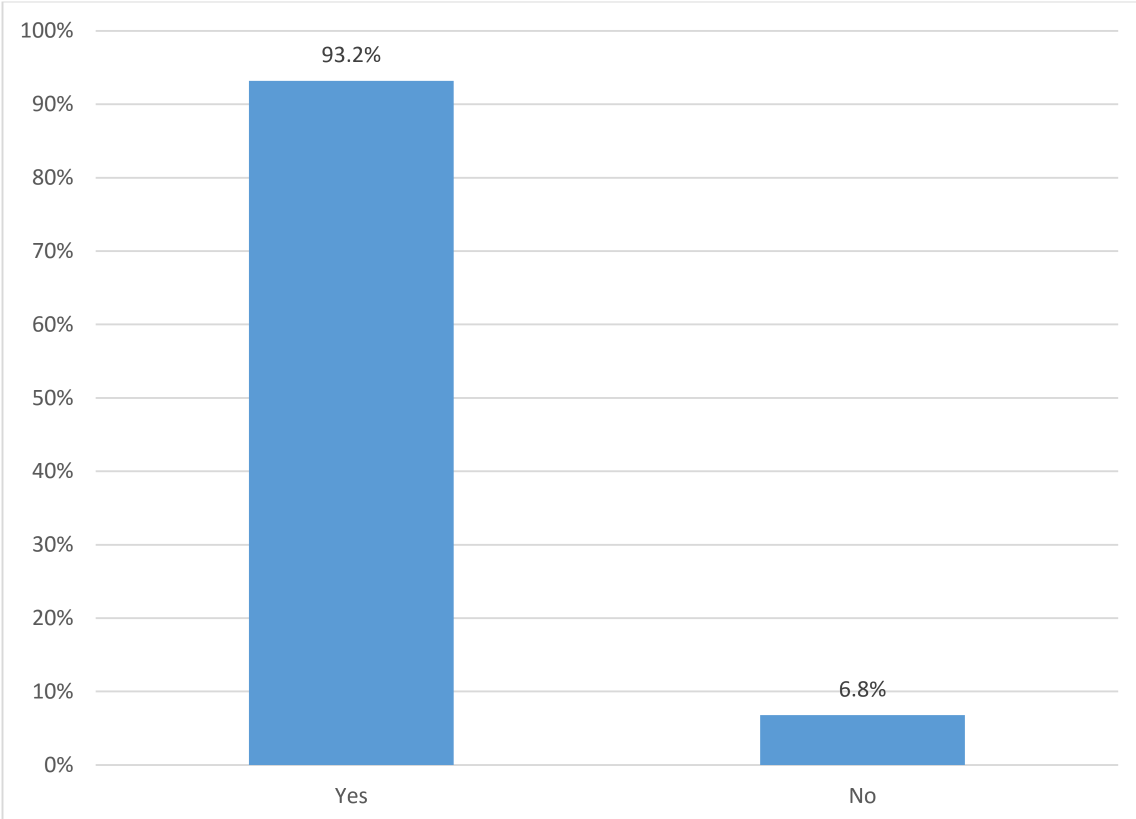


Figure 4.5: Respondents Envisaging Widespread Use of EPS in Ghana

Source: Field Study, 2018

Interestingly, from Figure 4.5, a large majority of the respondents (93.2%) indicated that they envisage widespread use of EPS in providing affordable housing in Ghana. The remaining 6.8% of the respondents however indicated otherwise. Varied reasons were given by those who envisage widespread use of EPS in providing affordable housing in Ghana. Some typical comments provided by the respondents included the following:

"Everyone wants to own a house in Ghana, and if they can get one at a low cost they will go for it"

"It is likely to solve our high cost of putting up a building"

"Makes building affordable"

"Everyone wants to build at a cheaper cost"

"Fast in construction"

"It reduces transportation cost of materials to site"

A summary of the varied reasons the respondents provided as to why they envisage widespread use of EPS in providing affordable housing in Ghana is provided in Table 4.9.

Table 4.9: Reasons for Envisaging Widespread Use of EPS in Ghana

Reason	**Frequency**	**Percentage**
Reduces cost of construction	12	30.00
Reduces construction time	9	22.50
Durability of the product	8	20.00
Easy to use	7	17.50
Easy to solve housing deficit	4	10.00
Total	**41**	**100.00**

Source: Field survey, 2018

From the summary of their responses, it becomes apparent that the respondents envisage widespread use of EPS in Ghana because EPS reduces construction costs; reduces construction time; is durable; is easy to use; and is easy to solve housing deficit. Notwithstanding, the few respondents who do not envisage widespread use of EPS in providing affordable housing in Ghana cited reasons relating to the negative attitude towards change in the Ghanaian construction industry as the EPS is a relatively new technology.

Although the majority of the respondents envisage the widespread use of EPS in providing affordable housing in Ghana, all the respondents were able to identify at least one challenge in the adoption of EPS in housing in Ghana. Table 4.10 provides a summary of the challenges identified by the respondents in the current rate of adopting EPS in the Ghanaian housing industry.

Table 4.10: Challenges to Adopting EPS in Ghana

Challenges	Frequency	Percentage
Inadequate knowledge of the product	13	29.55
Lack of public confidence in the material	8	18.18
Inadequate trained personnel to install the product	7	15.91
Unavailability of the material	6	13.64
Adoption of new technology takes time	6	13.64
Competition from manufacturers of conventional building materials	4	9.09
Total	**44**	**100**

Source: Field survey, 2018

From the summary of the responses on challenges of EPS adoption in Ghana, inadequate knowledge of the product, was the most cited. This was cited by 29.55% of the respondents. This was followed by the challenge of lack of public confidence in the material, cited by 18.18% of the respondents. Another challenge outlined by the respondents was the inadequate trained personnel to install the product. This was cited by 15.91% of the respondents. Unavailability of the material was also cited as a significant challenge. In addition, the challenge of adoption of new technology was raised. Both of these challenges were cited by 13.64% of the respondents. Some 9.09% of the respondents also cited competition from manufacturers of conventional building materials as a challenge to the adoption of EPS in Ghana. These findings imply that despite the marked benefits of using EPS in housing, notable challenges to its adoption in the provision of affordable housing in Ghana remain apparent.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter provides a summary of the findings of the research based on the previous chapters. The chapter also contains the conclusion to the research and suggests some recommendations based on the research findings.

5.2 SUMMARY OF FINDINGS

This research was carried out to determine the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana. A total of 60 questionnaires were distributed to the architects and quantity surveyors working in the Ghanaian construction industry. However, out of the retrieved questionnaires, 44 of them were completely filled and appropriately used for the analysis accordingly. This represented a response rate of 73.3%. The following subsections provide a summary of the findings based on thematic sub-sections in line with research objectives.

5.2.1 Economic Impacts of EPS

The respondents empirically rated their extent of agreement to some statements on the economic impacts of EPS on a five-point Likert scale with 1 representing strongly disagree, through to 5 representing strongly agree. The data was analysed using a Relative Agreement Index (RAI) developed for each statement. From the analysis, it was found out that majority of the respondents either agreed or strongly agreed to the statements as all the statements had RAI values above 0.700. In terms of ranking, the statements that "EPS enhances speed of construction", "EPS reduces construction period" and "EPS enhances output of labour crew" were ranked first, second and third respectively with respective RAI values of 0.909, 0.905 and 0.900. These were followed by the statements that "EPS provides durability of project", "EPS enhances waste reduction", "EPS reduces cost of construction", "EPS enhances design flexibility" and "EPS eases variations in the construction" occupying the fourth, fifth, sixth, seventh and eighth positions with respective RAI values of 0.859, 0.850, 0.841, 0.809 and 0.805. The relatively high RAI values for the statements implied a positive economic impact to the use of EPS as being a cost effective technology. For instance, high speed of construction result in reduced construction period and consequently reducing overhead costs and other charges related to time. In addition, the reduction of material waste through the use of EPS also cuts down on construction costs and enhances financial returns for the developers and users.

5.2.2 Cost of EPS over Conventional Construction Materials

In addressing this objective, cost estimation was performed in order to evaluate and compare the affordability of EPS over conventional building materials. In this regard, two bills of quantities were developed for the construction of a three-bedroom semi-detach building. The analysis focused on the main structural system. It was observed that there is a significant difference in cost of the building using block work and the one using EPS panels. It was observed that the difference in estimated cost resulted from the relatively high cost of the block work component and the concrete component. On the whole, estimated cost of the whole structural system was 37.6% higher than that of the EPS building. Breaking down the whole revealed that the estimated cost associated with the substructure of the block work building was 10.8% higher than that of the EPS building. Similarly, the estimated cost associated with the block work and concrete of the block work building was 46.9% higher than that of the EPS building. This finding showed that the use of EPS is very cost effective particularly relating to material costs in construction.

5.2.3 How Well EPS is Known in the Ghanaian Market

The respondents responded to statements on the knowledge and availability of EPS in the Ghanaian market as being very low, low, average, high or very high. It was found out that knowledge and availability of EPS in Ghana was generally low. For instance, as many as 65.9% of the respondents held the view that public knowledge of EPS used in housing construction is low. In terms of clients’ knowledge of EPS used in housing construction, 63.6% of the respondents indicated average knowledge with another 34.1% of them indicating low clients knowledge. These findings implied that the public does not have enough knowledge of EPS and its potential benefits to housing construction. Surprisingly, about 45% and 43% of the respondents indicated that design professionals' knowledge of EPS used in housing construction was average and low respectively with only 11% of the respondents indicating that it was high. Bearing on this, the responses on the adoption rate of EPS in the Ghanaian construction industry was not encouraging as 57% of the respondents claimed that the adoption rate was average with the remaining 43% claiming that it was low. The relatively low adoption rate of EPS used in housing construction could be attributed to the limited knowledge of EPS among clients and the public and also its unavailability on the market as about 70% of the respondents believe that the availability of EPS in the Ghanaian market was low. These findings implied that the widespread availability of EPS in the Ghanaian market could enhance people's knowledge of its benefits and consequently their acceptability of it in their projects.

5.2.4 Ways of Promoting EPS as a Solution to Affordable Housing in Ghana

The respondents empirically rated their extent of agreement on some statements as promoting EPS for affordable housing provision in Ghana using a five-point Likert scale with 1 representing strongly disagree, through to 5 representing strongly agree. The data was analyzed using a Relative Agreement Index (RAI) developed for each statement. From the analysis, the statement of "Raising awareness about EPS" had the highest RAI value 0f 0.927 which was not surprising as raising awareness of EPS could possibly enhance peoples' knowledge of it and possibly enhance its adoption and acceptability in their projects. Other significant statements were "Provision of necessary training in EPS technology" and "Enhancing capacity of existing EPS manufacturers" both with an RAI value of 0.817. Further analysis of the data revealed that 93.2% of the respondents envisage widespread use of EPS in providing affordable housing in Ghana. This was due to reasons relating to reduction of construction costs and time, durability and ease of use. Notwithstanding, the respondents were able to identify at least one challenge in the adoption of EPS in housing in Ghana. These challenges included inadequate knowledge of the product, as cited by 29.55% of the respondents; lack of public confidence in the material, cited by 18.18% of the respondents; inadequate trained personnel to install the product, cited by 15.91% of the respondents. In addition, the challenge of unavailability of the material and slow adoption of new technology were both cited by 13.64% of the respondents. This implied that despite the marked benefits of using EPS in housing, notable challenges to its adoption in the provision of affordable housing in Ghana remain apparent and as such activities to promote EPS should be enhanced.

5.3 CONCLUSION

The aim of this study was to investigate the prospects of Expanded Polystyrene (EPS) in the provision of affordable housing in Ghana. This has stemmed from governments' need of providing decent and affordable housing for the growing population as well as the highly urbanizing areas. The study was set on addressing the specific objectives of determining the economic impacts of EPS; assessing cost of EPS over conventional construction materials; finding out how well EPS is known in Ghanaian market; and identifying ways of promoting EPS as a solution to affordable housing problem in Ghana.

The study established that there were significant economic impacts of using EPS to which the respondents predominantly expressed agreement. The highly rated economic impacts were found to be enhancing construction speed, reducing construction period, enhancing labour output, durability of project, waste reduction. All these impacts consequently lead to the reduction of construction costs. In this regard, the study concludes that there is a positive economic impact to the use of EPS as being a cost effective technology for the provision of affordable housing in Ghana.

The study established that there is a significant difference in cost of the building using block work and the one using EPS panels. It was observed that the difference in estimated cost resulted from the relatively high cost of the block work component and the concrete component.

The findings of the research further established that the knowledge of EPS among the general public and clients was generally low. Likewise, the knowledge of EPS among design professionals was not very encouraging as it was relatively average. This had translated into a low adoption rate of EPS for housing within the Ghanaian construction industry which could further be due to its relatively low availability on the Ghanaian market. The study therefore concludes that the widespread availability of EPS in the Ghanaian market could enhance people's knowledge of its benefits and consequently on its adoption.

In promoting EPS, raising awareness about EPS, provision of necessary training in EPS technology and enhancing capacity of existing EPS manufacturers were found to be very significant measures. Given, the economic benefits of EPS, the study concludes that the promotion of EPS among clients and the general public would lead to the widespread use of EPS in providing affordable housing in Ghana.

The outcome of this study is that the prospects of EPS in providing affordable housing lies in its marked economic benefits given the widespread need of housing infrastructure in the country. However, notable challenges to its adoption in Ghana remain apparent and as such activities to promote EPS should be enhanced to increase public knowledge, awareness and confidence in EPS for providing affordable housing in Ghana.

5.4 RECOMMENDATIONS

Based on the findings of the study, the following recommendations are suggested to enhance the prospects of EPS in affordable housing provision in Ghana:

- In the first place, the study recommends that professional bodies such as the Ghana Institute of Architects (GIA), the Ghana Institution of Surveyors (GhIS) and the Ghana Institution of Engineers (GhIE) should expose their members to new construction technologies such as EPS through some form of continuing professional development programmes. This would increase their awareness and build on their capacities to utilise EPS technology in their projects.
- Furthermore, the study recommends that government should strengthen research institutions such as the Building and Road Research Institute to research into new technologies such as EPS for housing construction and come up with best practices and codes for use. This would help increase public confidence in the material.

- The study recommends the sensitizing and education of the general public through open forums, printed pamphlets, show houses, physical demonstrations of construction speeds, active public participation and other promotion methods. Through, this education and exposure, an increasing number of people particularly clients will get to know EPS and accept it in their projects.
- Also, manufacturers of EPS should be given the necessary government support and capital to expand on their produce for its widespread availability throughout the country.
- In order to reduce housing shortage, the Government of Ghana through partnership with private house developers should continually carry out research on the best building technologies which can help solve the increasing housing problems. Innovative developers in the housing sector who use such alternative technologies like EPS should also be given some incentives and recognition by Government and thier parent organisations to motivate them.

5.5 DIRECTION FOR FUTURE RESEARCH

This research has investigated the prospects of EPS in the provision of affordable housing in Ghana from the viewpoint of architects and quantity surveyors. Further investigations can be conducted through case studies to assess the durability of EPS constructed buildings to further augment public confidence and enhance adoption rates.

REFERENCES

Abrams, C. (1971). *The language of cities, New* York Viking press p.243.

Agus, A. and Abdullah, M. (2000). Total quality management practices in manufacturing companies in Malaysia: an exploratory analysis. *Total Quality Management Magazine*, 11(8), 1041-1051.

Arnott, R. (1987). Economic theory and housing. Handbook of Regional and Urban Economics 2, 959-985.

Bredenoord, J. (2016). Sustainable Housing and Building Materials for Low-income Households. *Journal of Architectural Engineering Technology*, Vol. 5, No. 1, pp. 17-21.

Ede, A. N. and Ogundiran, A. (2014). "Thermal Behaviour and Admissible Compressive Strength of Expanded Polystyrene Wall Panels of Varying Thickness," Current Trends in Technology and Science, Vol. 3, No. 2, pp. 110 -117.

Ede, A. N., Alegiuno, V., and Oluwa, P. (2014). "Use of Advanced Plastic Materials in Nigeria: Performance Assessment of Expanded Polystyrene Building Technology System." American Journal of Engineering Research (AJER), Vol. 03, No. 04, pp. 301-308.

Gabriel, M., Jacobs, K., Arthurson, K., Burke, T. and Yates, J. (2005). Conceptualising and measuring the housing affordability problem, National Research Venture 3: Housing affordability for lower income Australians Research Paper No. 1, Australian Housing and Urban Research Institute.

Hartley A. and Blagden A. (2007). Current Practices and Future Potential in Modern Methods of Construction, Banbury, UK, Wrap.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques (Second Edition)*, New Age International Publishers.

Lee, A. J., Kelly, H., Jagoda, R., and Rosenfeld, A. (2006). Affordable, safe housing based on expanded polystyrene (EPS) foam and a cementitious coating. *Journal of Material Science*, 41: 6908. https://doi.org/10.1007/s10853-006-0223-4

Linn, J. F. (1983). Cities in the Developing world. Policies for their equitable and efficient growth. Oxford University press.

Milligan, V., Phibbs, P., Fagan, K. and Gurran, N. (2004). A Practical Framework for Expanding Affordable Housing Services in Australia: Learning from Experience, Final Report No. 65, Australian Housing and Urban Research Institute.

Naoum, S.G., (1998), Dissertation Research and Writing for Construction Students. Oxford: Bultermouth-Heinemom.

Ngigi P. N. (2016). Evaluation of Alternative Construction Technologies in the Delivery of Affordable Housing-A Case Study of Nairobi County. Master's Thesis, Jomo Kenyatta University Of Agriculture And Technology, Kenya.

Ngugi, H. N., Kaluli, J. W., Abiero-Gariy, Z. (2017). Use of Expanded Polystyrene Technology and Materials Recycling for Building Construction in Kenya. *American Journal of Engineering and Technology Management.* Vol. 2, No. 5, pp. 64-71.

O'Sullivan, A. (2003). Urban Economics. London: McGraw-Hill UK.

Okumu, E. A. (2014). Strategy, technology and innovation in low cost housing by Elsek and Elsek (Kenya) limited. Doctoral dissertation, School Of Business, University of Nairobi, Nairobi, Kenya.

PMI (2008) *PMBOK Guide:* A Guide to the Project Management Body of Knowledge, Project *Management Institute.*

Raj, R., Nayak, M. K., Akbari, M. A., and Saha, P. (2014) "Prospects of Expanded Polystyrene Sheet as Green Building Material." *International Journal of Civil Engineering Research.* Vol. 5, No. 2, pp. 145-150.

Seeley, H. I. (1996). *Building Economics: Appraisal and control of building design cost and efficiency.* Macmillan International Higher Education.

Sneha, K., and Tezeswi, T. P. (2016). "A Comparative Study of Construction Using Schnell Concrewall Pre-Cast Sandwich Composite Panel and RC Moment Frame with Brick Infill." *International Journal of Civil Engineering and Technology (IJCIET)*, Vol. 7, No. 5, pp. 110-110.

Somerville, C. T., and Holmes, C. (2001). Dynamics of the Affordable Housing Stock: Micro-Data Analysis of Filtering. *Journal of Housing Research, Vol.* 12, No. 1, pp 115-40.

Stone M.E. (2005). A Housing Affordability Standard for the UK. *Housing Studies*, Vol. 21, No. 4

Takahashi, K. (2009). Evolution of the Housing Development Paradigms for the Urban Poor: The Post-war Southeast Asian Context. *Journal of Asia-Pacific Studies,* Vol. 3: pp. 67-82.

Tipple, G. (1987). Housing Policy and Culture in Kumasi, Ghana: A Study of Constraints and Resources. *Environment and Behaviour,* Vol. 19, No. 3, pp. 331–352.

UN (2012). World Urbanization Prospects. The 2011 Revision. Highlight, New York. UN Department of Economics and Social Affairs, Population Division.

UNCHS (1996). An Urbanizing World: Global Report on Human Settlements. Oxford University Press.

UN-Habitat (2004). The State of the Worlds Cities 2004/2005: Globalization and Urban Culture, London, Earthscan, UN Habitat.

UN-Habitat (2010). The State of African Cities 2010: Governance, Inequality and Urban Land Markets, Nairobi, UN-Habitat.

UN-Habitat (2011), Africa affordable housing (report), volume 3; Slum Dwellers to double by 2030, UN HABITAT report, 2007

APPENDIX 1

RESEARCH QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST), KUMASI

INSTITUTE OF DISTANCE LEARNING

RESEARCH TOPIC

"TOWARDS THE ACHIEVEMENT OF AFFORDABLE HOUSING IN GHANA; THE USE OF EXPANDED POLYSTYRENE (EPS)"

This research is being conducted as part of a graduate study in the Kwame Nkrumah University of Science and Technology. The information obtained from this survey shall be kept anonymous and completely confidential and used for research purposes only. Your participation in this survey is much needed and I will be grateful if you could answer the following questions. Please respond to the questions by either writing in the blank space provided or ticking in the appropriate space provided.

PART A: BACKGROUND INFORMATION

1) What is your role, relative to the construction industry?

a. Quantity Surveyor [ ]

b. Architect [ ]

2) What is your highest educational qualification?

a) Basic/Primary Education [ ]

b) JHS [ ]

c) SHS/Tech [ ]

d) Diploma [ ]

e) Undergraduate Degree [ ]

f) Postgraduate Degree [ ]

g) Other (please specify) [ ]……………………………………..

3) How long have you been in professional practice?

a. Less than 5 years

b. 5-10 years

c. 10-15 years

d. 15-20 years

e. More than 20 years

4) Who are your major clients? (Please select all that apply)

a) Public Organisations [ ]

b) Private Corporate Organizations [ ]

c) Private Individuals [ ]

d) Other (please specify) [ ]……………………

5) In which of your projects have EPS technology been successfully used in any form?

Please tick all that apply

a) Residential building [ ]

b) Commercial building [ ]

c) Industrial building [ ]

e) Warehouse [ ]

f) Others (please specify) ……………………………………….

6) Which part of your projects have EPS technology been successfully used?

Please tick all that apply

a) Walls [ ]

b) Ceiling [ ]

c) Roofs [ ]

e) Floors [ ]

f) Others (please specify) ……………………………………….

PART B: ECONOMIC IMPACTS OF EPS

7) Based on your experience, what is your impression of the impacts of the EPS used in your project as a relatively economic performing technology based on the following parameters? Please tick in the appropriate space provided. The range of weighting is from 1 to 5 as shown in the table below:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

	Statements	**1**	**2**	**3**	**4**	**5**
a	EPS reduces cost of construction					
b	EPS enhances speed of construction					
c	EPS reduces construction period					
d	EPS enhances waste reduction					
e	EPS increases financial returns					

f	EPS reduces maintenance costs					
g	EPS eases variations in the construction					
h	EPS provides durability of project					
i	EPS is compatible with other technology					
J	EPS enhances output of labour crew					
k	EPS enhances design flexibility					

8) In your opinion, to what extent would you rate EPS as a technology used in delivering relatively cheaper and affordable houses?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

PART C: KNOWLEDGE AND AVAILABILITY OF EPS ON GHANAIAN MARKET

9) How would you rate public knowledge of the EPS technology used in housing construction?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

10) How would you rate clients knowledge of the EPS technology used in housing construction?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

11) How would you rate design professionals knowledge of the EPS technology used in housing construction?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

12) How would you rate the adoption rate of the EPS technology in the Ghanaian construction industry?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

13) How would you rate the availability of the EPS technology in the Ghanaian market?

a) Very low [ ]

b) Low [ ]

c) Average [ ]

d) High [ ]

e) Very high [ ]

PART D: WAYS OF PROMOTING EPS FOR AFFORDABLE HOUSING

14) What is the extent of your agreement on the following statements as promoting EPS technology for affordable housing provision in Ghana? Please tick in the appropriate space provided. The range of weighting is from 1 to 5 as shown in the table below:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

	Statements	**1**	**2**	**3**	**4**	**5**
a	Support and incentives from construction policy makers: standards and codes must be set					
b	Raising awareness about EPS					
c	Provision of necessary training in EPS technology					
d	Enhancing capacity of existing EPS manufacturers					

15) In your opinion, do you envisage widespread use of EPS in providing affordable housing in Ghana?

a) Yes [ ]   b) No [ ]

Please explain why?

____

____

____

____

____

16) What are the main challenges you see in the adoption of EPS in housing in Ghana?

____

____

____

____

APPENDIX 2

BILL OF QUANTITY WITH THE USE OF EPS

(All Provisional)

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Excavation and earthwork				
A	Excavate trench not exceeding 1.50 metres deep commencing 150mm below existing ground level.	52	m3	40.00	2,080.00
B	Excavate pit not exceeding 1.50 metres deep commencing 150mm below existing ground level.	6	m3	45.00	270.00
C	Load excavated material, wheel and spread and level around foundation	18	m3	8.00	144.00
D	Load surplus excavated material into trucks(provided by client) for disposal offsite	40	m3	20.00	800.00

E	Load hardcore/laterite filling deposited on site, wheel, spread and ram in making up levels	96	m3	60.00	5,760.00
	Concrete work				
F	50mm Plain insitu concrete (1:4:8-40mm aggregate) as described blinding	10	m2	24.50	245.00
G	Plain insitu concrete (1:3:6-20mm aggregate) as described foundation in trenches	13	m3	450.00	5,850.00
	Reinforced insitu vibrated concrete (1:2:4-20mm aggregate) as described filled into formwork and around reinforcement (both measured separately):				
H	Column base.	3	m3	480.00	1,440.00
K	Column.	1	m3	480.00	480.00
M	100mm Bed.	214	m2	48.00	10,272.00
	Mild steel bar reinforcement and fixing as described:				
N	12mm Diameter bar in column base	250	kg	5.20	1,300.00

O	12mm Diameter bar in column	182	kg	5.20	946.40
P	10mm Diameter bar as stirrups and links	802	kg	5.20	4,170.40
	C/F				**33,757.80**

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
				B/F	**33,757.80**
	Sawn formwork as described to:				
	Edge of bed 150mm wide	70	m	6.75	472.00
	Pannel work				
	supply and install eps pannel as sleeper walls in fdn				
F	PN 80 panels	125	m2	53.00	6,625.00
	Plasterwork				
G	20mm Cement and sand render (1:6) as described on wall	42	m2	18.00	756.00

	Painting				
H	Brush down rendered surfaces and paint with three coats of vinyl emulsion paint on rendered wall	42	m2	18.00	756.00
	SUBSTRUCTURE TO SUMMARY				**42,366.80**

CONCRETE WORK

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**

PANEL WORK

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
A	supply and install PN 80 panels wall	848	m2	53.00	44,944.00
	-				
B	plastering PN60 panels wall	1,696	m2	16.00	27,136.00
	PANELS WORK TO SUMMARY				**72,080.00**

ROOFING

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Aluminium Sheet Roofing				
	0.60mm Thick " IDT 6" industrial deep trough long span aluminium corrugated sheet with two corrugation side laps and 150mm end laps to hardwood purlins (measured separately) approximately 1200mm centres with aluminium drive screws and "sela" washers as de				
A	Sloping roofing sheets.	340	m2	89.00	30,260.00
	ROOFING TO SUMMARY				**30,260.00**

CARPENTRY

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Structural timbers				

	Sawn treated hardwood as described				
A	50 x 150mm wall plate	76	m	16.00	1,216.00
B	50 x 150mm Rafter	188	m	16.00	3,008.00
C	50 x 100mm Rafter	158	m	15.50	2,449.00
D	50 x 100mm Purlin.	363	m	15.50	5,626.50
E	50 x 75mm Joist.	583	m	15.00	8,745.00
F	50 x 50mm Nogging.	562	m	12.00	6,744.00
G	50 x 50mm Hanger	513	m	12.00	6,156.00
	Metal work				
H	Include a provisional sum of GH¢ 500.00 for metal works in connection with carpentry				500.00
	CARPENTRY TO SUMMARY				**33,228.50**

JOINERY

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Eaves and Verge Boarding				
A	20 x 300mm Wrought hardwood as described fascia in one width	82	m	25.00	2,050.00
	Doors				
	Wrought hardwood as described:				
	44mm (Finished) 2 Panelled door (Prime Cost GH 750.00 per unit)comprising 150mm stiles, top, middle rails and 225mm bottom rails, both panels filled in solid 20mm bevelled, raised and fielded hardwood boarding.				
B	812 x 2056 x 44mm (Finished)	12	No.	550.00	6,600.00
C	712 x 2056 x 44mm (Finished)	10	No.	550.00	5,500.00
	Frames				
	Wrought hardwood as described				
	Unload, cut and fix wrought hardwood frames				
D	44 x 144mm Frame	112	m	26.00	2,912.00

	Skirting etc.				
	Wrought hardwood as described				
E	12 x 44mm stop	120	m	5.50	660.00
F	19 x 100mm Charmfered skirting	155	m	15.00	2,325.00
G	12 x 75mm Moulded architraves fixed to hardwood	224	m	5.50	1,232.00
	Ironmongery				
	Supply and fix the following stainless steel ironmongery to hardwood including matching screws				
H	Pair 100mm brass butt hinge	22	No.	18.00	396.00
J	75mm Brass barrel bolt	4	No.	25.00	100.00
K	Mortice lock with set of lever handle furniture	22	No.	200.00	4,400.00
	JOINERY TO SUMMARY				**24,125.00**

METALWORK

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Mild steel burglar proofing				
	Supply and install galvanised mild steel burglar proofing complete with accessories design to fit the following windows				
A	2 Bay sliding window size 1800 x 1200mm high	8	No.	756.00	6,048.00
					-
B	1 Bay sliding window 900 x 1200mm	10	No.	378.00	3,780.00
					-
C	1 Bay sliding window 900 x 600mm	8	No.	189.00	1,512.00
	Glazed aluminium windows				
	Supply and install bronze anodized glazed aluminium sliding windows including 6mm tinted glass mosquito netting and associated ironmongery				

D	2 Bay sliding window size 1800 x 1200mm high	8	No.	1,188.00	9,504.00
					-
E	1 Bay sliding window 900 x 1200mm	10	No.	594.00	5,940.00
					-
F	1 Bay sliding window 900 x 600mm	8	No.	297.00	2,376.00
	METALWORK TO SUMMARY				**29,160.00**

PLUMBING AND ENGINEERING INSTALLATIONS

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Rainwater, Sanitary, cold and hot water installations				
A	Provisional Sum of GH¢1000.00 for rainwater, sanitary, cold and hot water		Item		10,000.00
	Sanitary Appliances				
	Supply and fix the following sanitary fittings				

B	"Twyfords" wash basin	8	No.	400.00	3,200.00
C	"Twyfords" low level wc	8	No.	600.00	4,800.00
D	Single bowl single drainer stainless steel sink unit	2	No.	400.00	800.00
E	Shower tray	6	No.	400.00	2,400.00
F	Towel rail	8	No.	180.00	1,440.00
G	Toilet roll holder	8	No.	80.00	640.00
	PLUMBING AND ENGINEERING INSTALLATIONS CARRIED TO SUMMARY				**23,280.00**

ELECTRICAL INSTALLATIONS

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Main Switchgear, Power Distribution and Lighting Installations				

A	Allow for electrical installation comprising providing and fixing cabling, switchboard, general lighting, power, extractor, lighting fittings and accessories, lighting protector and earthing systems.				30,000.00
	ELECTRICAL INSTALLATIONS TO SUMMARY				**30,000.00**

PLASTERWORK FLOOR WALL AND CEILING FINISHINGS

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Insitu finishings				
	16mm Cement and sand render (1;4) as described on blockwork and concrete				
A	Wall	1159	m2	18.00	20,862.00
	Wall tile				
	200 x 150 x 10mm Polished Porcelain wall tiles to BS 1287 fixed with tile adhesive to cement and sand backing (measured separately) and grouted in coloured cement.				
B	Wall tiling	225	m2	85.00	19,125.00

	400 x 400 x 12mm Unpolished porcelain floor tiles as described bedded and jointed with tile adhesive on cement and sand bed (measured separately) and grouted in coloured cement.				
C	300 x 300 x 12mm polished porcelain floor tiles	122	m2	120.00	14,640.00
D	300 x 300 x 12mm unpolished porcelain floor tiles	69	m2	110.00	7,590.00
E	12mm Finish to riser 150mm wide	8	m	16.50	132.00
F	12mm Finish to tread 300mm wide	8	m	33.00	264.00
	Cement and sand (1:4) as described beds and backings				
G	20mm Backing to wall	69	m2	22.00	1,518.00
H	38mm screeded bed laid level on concrete	191	m2	40.00	7,640.00
	Sundries				
J	Aluminium edge strip fixed at junction of wall tiling	24	m	5.50	132.00
	Plain sheet finishing				

K	Unload, cut to lengths,hoist and fix plastic t &g ceiling to hardwood	269	m2	45.00	12,105.00
	PLASTERWORK, FLOOR WALL AND CEILING FINISHINGS TO SUMMARY				**84,008.00**

GLAZING

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
A	600 x 450mm Polished plate glass mirror four times countersunk drilled and chromium plated dome headed screws	8	No.	80.00	640.00
	GLAZING CARRIED TO SUMMARY				**640.00**

PAINTING AND DECORATING

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
A	Rub down to a smooth surface, dust off, prime surfaces and apply one of aluminium primer on hardwood	84	m2	8.50	714.00
	Brush down rendered surfaces and paint with three coats of 'Acrylic' emulsion paint:				
B	Rendered wall	1159	m2	16.50	19,123.50

	Rub down to a smooth surface, dust off, prime surfaces and apply three coats of oil paint on:				
C	General surfaces	123	m2	16.50	2,029.50
D	Surfaces not exceeding 300mm girth	34	m2	16.50	561.00
E	Prepare and apply one undercoat and two finishing coats of oil paint on metal work	50	m2	16.50	825.00
	PAINTING AND DECORATING TO SUMMARY				**23,253.00**

SUMMARY

Item	**Description**	**Page No.**		**Amount (GH¢)**

A	SUBSTRUCTURE				42,366.80
C	PANEL WORK				72,080.00
D	ROOFING				30,260.00
E	CARPENTRY				33,228.50
F	JOINERY				24,125.00
G	METAL WORK				29,160.00
H	PLUMBING INSTALLATIONS				23,280.00
J	ELECTRICAL INSTALLATION				30,000.00
K	PLASTER AND OTHER FLOOR WALLS AND CEILING FINISHING				84,008.00

L	GLAZING				640.00
M	PAINTING AND DECORATING				23,253.00
	SUB TOTAL(1)				392,401.30
	ADD PRELIMINARIES				19,620.07
	SUB TOTAL(2)				412,021.37
	ADD CONTINGENCIES				41,202.14
	TOTAL ESTIMATED COST				**453,223.50**

APPENDIX 3

BILL OF QUANTITY (BLOCK WORK BUILDING)

(All Provisional)

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Excavation and earthwork				
A	Excavate trench not exceeding 1.50 metres deep commencing 150mm below existing ground level.	52	m3	40.00	2,080.00
B	Excavate pit not exceeding 1.50 metres deep commencing 150mm below existing ground level.	6	m3	45.00	270.00

C	Load excavated material, wheel and spread and level around foundation	18	m3	8.00	144.00
D	Load surplus excavated material into trucks(provided by client) for disposal offsite	40	m3	20.00	800.00
E	Load hardcore/laterite filling deposited on site, wheel, spread and ram in making up levels	96	m3	60.00	5,760.00
	Concrete work				
F	50mm Plain insitu concrete (1:4:8-40mm aggregate) as described blinding	10	m2	24.50	245.00
G	Plain insitu concrete (1:3:6-20mm aggregate) as described foundation in trenches	13	m3	450.00	5,850.00
	Reinforced insitu vibrated concrete (1:2:4-20mm aggregate) as described filled into formwork and around reinforcement (both measured separately):				
H	Column base.	3	m3	480.00	1,440.00
K	Column.	1	m3	480.00	480.00
M	100mm Bed.	214	m2	48.00	10,272.00

	Mild steel bar reinforcement and fixing as described:				
N	12mm Diameter bar in column base	250	kg	5.20	1,300.00
O	12mm Diameter bar in column	182	kg	5.20	946.40
P	10mm Diameter bar as stirrups and links	802	kg	5.20	4,170.40
	C/F				**33,757.80**

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
				B/F	**33,757.80**
	Sawn formwork as described to:				
C	Vertical side of column.	11	m2	45.00	495.00
E	Edge of bed 150mm wide	70	m	6.75	472.50
	Blockwork				

	Solid sandcrete block work in cement and sand mortar (1:4):				
F	150mm Solid sandcrete blockwall in cement mortar (1:4) as described	125	m2	90.00	11,250.00
	Plasterwork				
G	20mm Cement and sand render (1:6) as described on wall	42	m2	18.00	756.00
	Painting				
H	Brush down rendered surfaces and paint with three coats of vinyl emulsion paint on rendered wall	42	m2	18.00	756.00
	SUBSTRUCTURE TO SUMMARY				**47,487.30**

CONCRETE WORK

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**

	Reinforced insitu vibrated concrete (of strength 25N/mm2) as described filled into formwork and around reinforcement (both measured separately):				
A	Beam	9	m3	540.00	4,860.00
B	Column.	3	m3	540.00	1,620.00
	Mild steel bar reinforcement and fixing as described:				
C	12mm Diameter bar in Beams.	556	kg	5.20	2,891.20
D	12mm Diameter bar in Column.	1006	kg	5.20	5,231.20
E	10mm Diameter bar in links	595	kg	5.20	3,094.00
	Saw formwork to				
F	Vertical side of column.	81	m2	48.00	3,888.00
G	Sides and soffit of beam.	154	m2	48.00	7,392.00

	CONCRETE WORK TO SUMMARY				**28,976.40**

BLOCKWORK

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
	Solid sandcrete block work in cement and sand mortar (1:4):				
A	150mm Solid sandcrete block wall in cement and sand mortar (1:4):	848	m2	90.00	76,320.00
	-				
B	20mm cement and sand rendering (1:6) as describe on wall	1696		18.00	30,528.00
	BLOCK WORK TO SUMMARY				**106,848.00**

ROOFING

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
	Aluminium Sheet Roofing				

	0.60mm Thick " IDT 6" industrial deep trough long span aluminium corrugated sheet with two corrugation side laps and 150mm end laps to hardwood purlins (measured separately) approximately 1200mm centres with aluminium drive screws and "sela" washers as de				
A	Sloping roofing sheets.	340	m2	89.00	30,260.00
	ROOFING TO SUMMARY				**30,260.00**

CARPENTRY

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Structural timbers				
	Sawn treated hardwood as described				
A	50 x 150mm wall plate	76	m	16.00	1,216.00
B	50 x 150mm Rafter	188	m	16.00	3,008.00
C	50 x 100mm Rafter	158	m	15.50	2,449.00

D	50 x 100mm Purlin.	363	m	15.50	5,626.50
E	50 x 75mm Joist.	583	m	15.00	8,745.00
F	50 x 50mm Nogging.	562	m	12.00	6,744.00
G	50 x 50mm Hanger	513	m	12.00	6,156.00
	Metal work				
H	Include a provisional sum of GH¢ 500.00 for metal works in connection with carpentry				500.00
	CARPENTRY TO SUMMARY				**33,228.50**

JOINERY

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
	Eaves and Verge Boarding				

a	20 x 300mm Wrought hardwood as described fascia in one width	82	m	25.00	2,050.00
	Doors				
	Wrought hardwood as described:				
	44mm (Finished) 2 Panelled door (Prime Cost GH 750.00 per unit)comprising 150mm stiles, top, middle rails and 225mm bottom rails, both panels filled in solid 20mm bevelled, raised and fielded hardwood boarding.				
b	812 x 2056 x 44mm (Finished)	12	No.	550.00	6,600.00
c	712 x 2056 x 44mm (Finished)	10	No.	550.00	5,500.00
	Frames				
	Wrought hardwood as described				
	Unload, cut and fix wrought hardwood frames				
d	44 x 144mm Frame	112	m	26.00	2,912.00
	Skirting etc.				
	Wrought hardwood as described				
e	12 x 44mm stop	120	m	5.50	660.00

f	19 x 100mm Charmfered skirting	155	m	15.00	2,325.00
g	12 x 75mm Moulded architraves fixed to hardwood	224	m	5.50	1,232.00
	Ironmongery				
	Supply and fix the following stainless steel ironmongery to hardwood including matching screws				
h	Pair 100mm brass butt hinge	22	No.	18.00	396.00
j	75mm Brass barrel bolt	4	No.	25.00	100.00
k	Mortice lock with set of lever handle furniture	22	No.	200.00	4,400.00
	JOINERY TO SUMMARY				**24,125.00**

METALWORK

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Mild steel burglar proofing				

	Supply and install galvanised mild steel burglar proofing complete with accessories design to fit the following windows				
a	2 Bay sliding window size 1800 x 1200mm high	8	No.	756.00	6,048.00
					-
b	1 Bay sliding window 900 x 1200mm	10	No.	378.00	3,780.00
					-
c	1 Bay sliding window 900 x 600mm	8	No.	189.00	1,512.00
	Glazed aluminium windows				
	Supply and install bronze anodized glazed aluminium sliding windows including 6mm tinted glass mosquito netting and associated ironmongery				
d	2 Bay sliding window size 1800 x 1200mm high	8	No.	1,188.00	9,504.00
					-
e	1 Bay sliding window 900 x 1200mm	10	No.	594.00	5,940.00
					-

f	1 Bay sliding window 900 x 600mm	8	No.	297.00	2,376.00
	METALWORK TO SUMMARY				**29,160.00**

PLUMBING AND ENGINEERING INSTALLATIONS

Item	**Description**	**Qty**	**Unit**	**Rate (GH¢)**	**Amount (GH¢)**
	Rainwater, Sanitary, cold and hot water installations				
a	Provisional Sum of GH¢1000.00 for rainwater, sanitary, cold and hot water		Item		10,000.00
	Sanitary Appliances				
	Supply and fix the following sanitary fittings				
b	"Twyfords" wash basin	8	No.	400.00	3,200.00
c	"Twyfords" low level wc	8	No.	600.00	4,800.00
d	Single bowl single drainer stainless steel sink unit	2	No.	400.00	800.00

e	Shower tray	6	No.	400.00	2,400.00
f	Towel rail	8	No.	180.00	1,440.00
g	Toilet roll holder	8	No.	80.00	640.00
	PLUMBING AND ENGINEERING INSTALLATIONS CARRIED TO SUMMARY				**23,280.00**

ELECTRICAL INSTALLATIONS

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Main Switchgear, Power Distribution and Lighting Installations				
a	Allow for electrical installation comprising providing and fixing cabling, switchboard, general lighting, power, extractor, lighting fittings and accessories, lighting protector and earthing systems.				30,000.00
	ELECTRICAL INSTALLATIONS TO SUMMARY				**30,000.00**

PLASTERWORK FLOOR WALL AND CEILING FINISHINGS

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
	Insitu finishings				
	16mm Cement and sand render (1;4) as described on blockwork and concrete				
a	Wall	1159	m2	18.00	20,862.00
	Wall tile				
	200 x 150 x 10mm Polished Porcelain wall tiles to BS 1287 fixed with tile adhesive to cement and sand backing (measured separately) and grouted in coloured cement.				
b	Wall tiling	225	m2	85.00	19,125.00
	400 x 400 x 12mm Unpolished porcelain floor tiles as described bedded and jointed with tile adhesive on cement and sand bed (measured separately) and grouted in coloured cement.				
c	300 x 300 x 12mm polished porcelain floor tiles	122	m2	120.00	14,640.00
d	300 x 300 x 12mm unpolished porcelain floor tiles	69	m2	110.00	7,590.00

e	12mm Finish to riser 150mm wide	8	m	16.50	132.00
f	12mm Finish to tread 300mm wide	8	m	33.00	264.00
	Cement and sand (1:4) as described beds and backings				
g	20mm Backing to wall	69	m2	22.00	1,518.00
h	38mm screeded bed laid level on concrete	191	m2	40.00	7,640.00
	Sundries				
j	Aluminium edge strip fixed at junction of wall tiling	24	m	5.50	132.00
	Plain sheet finishing				
k	Unload, cut to lengths,hoist and fix plastic t &g ceiling to hardwood	269	m2	45.00	12,105.00
	PLASTERWORK, FLOOR WALL AND CEILING FINISHINGS TO SUMMARY				**84,008.00**

GLAZING

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
a	600 x 450mm Polished plate glass mirror four times countersunk drilled and chromium plated dome headed screws	8	No.	80.00	640.00
	GLAZING CARRIED TO SUMMARY				**640.00**

PAINTING AND DECORATING

Item	Description	Qty	Unit	Rate (GH¢)	Amount (GH¢)
a	Rub down to a smooth surface, dust off, prime surfaces and apply one of aluminium primer on hardwood	84	m2	8.50	714.00
	Brush down rendered surfaces and paint with three coats of 'Acrylic' emulsion paint:				

b	Rendered wall	1159	m2	16.50	19,123.50
	Rub down to a smooth surface, dust off, prime surfaces and apply three coats of oil paint on:				
c	General surfaces	123	m2	16.50	2,029.50
d	Surfaces not exceeding 300mm girth	34	m2	16.50	561.00
e	Prepare and apply one undercoat and two finishing coats of oil paint on metal work	50	m2	16.50	825.00
	PAINTING AND DECORATING TO SUMMARY				**23,253.00**

SUMMARY

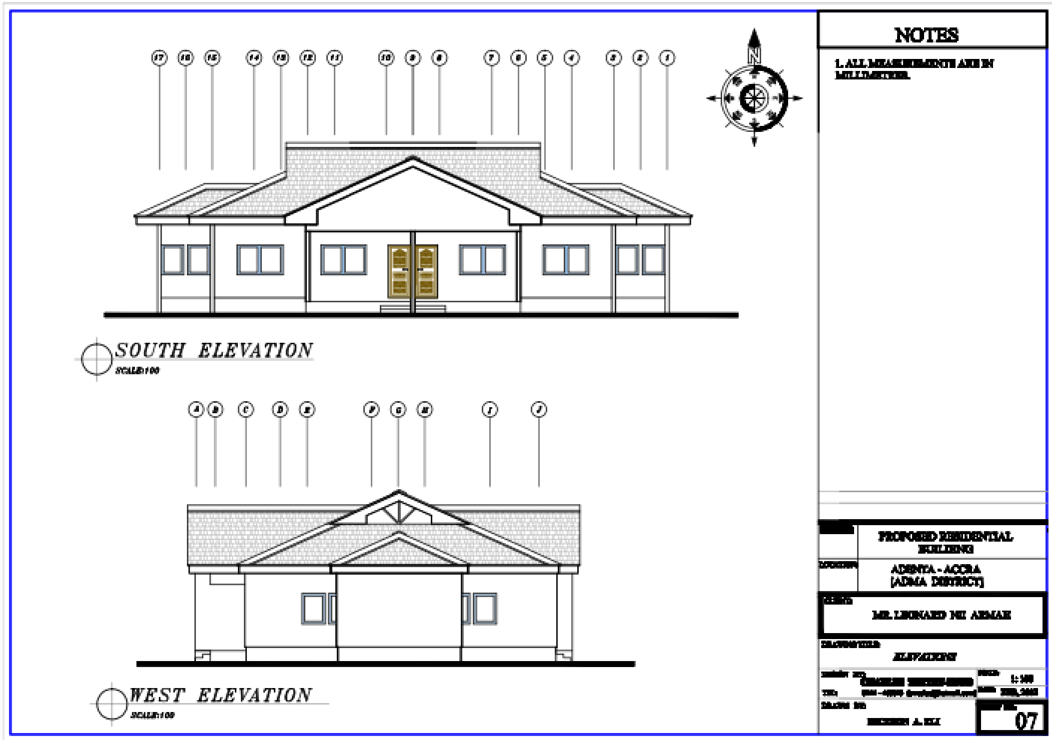
Item	**Description**	**Page No.**			**Amount (GH¢)**
a	SUBSTRUCTURE				47,487.30

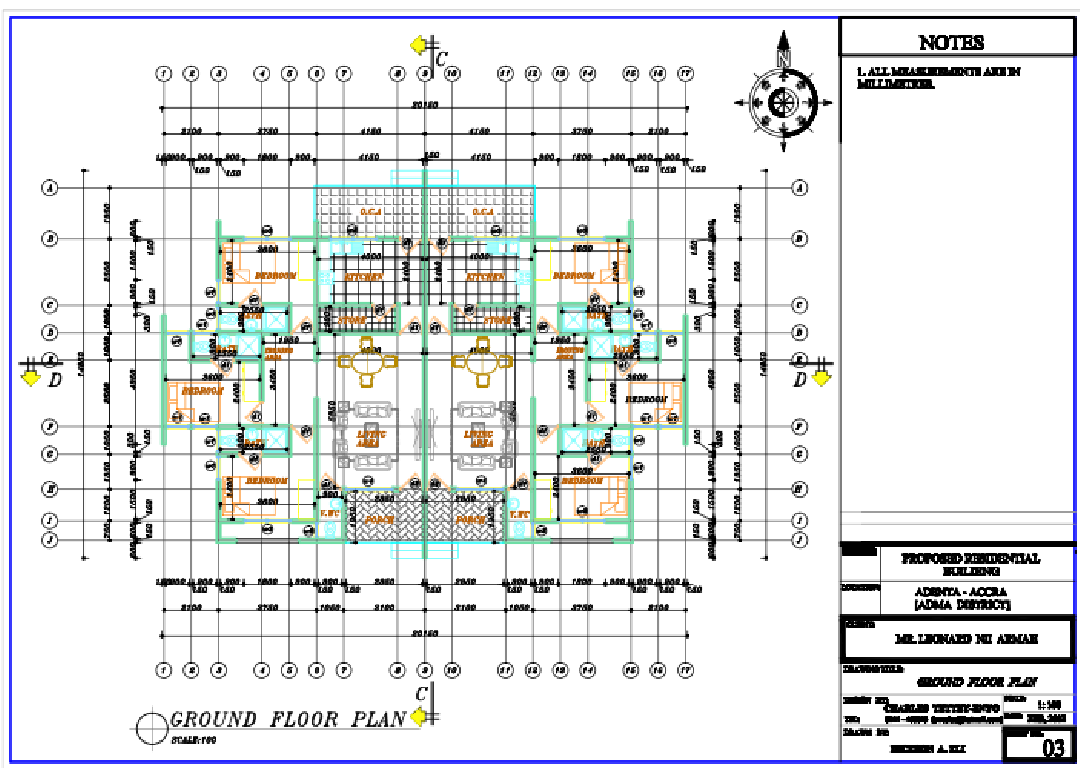
b	CONCRETE WORK				28,976.40
c	BLOCK WORK				106,848.00
d	ROOFING				30,260.00
e	CARPENTRY				33,228.50
f	JOINERY				24,125.00
g	METAL WORK				29,160.00
h	PLUMBING INSTALLATIONS				23,280.00
j	ELECTRICAL INSTALLATION				30,000.00
k	PLASTER AND OTHER FLOOR WALLS AND CEILING FINISHINGS				84,008.00
l	GLAZING				640.00

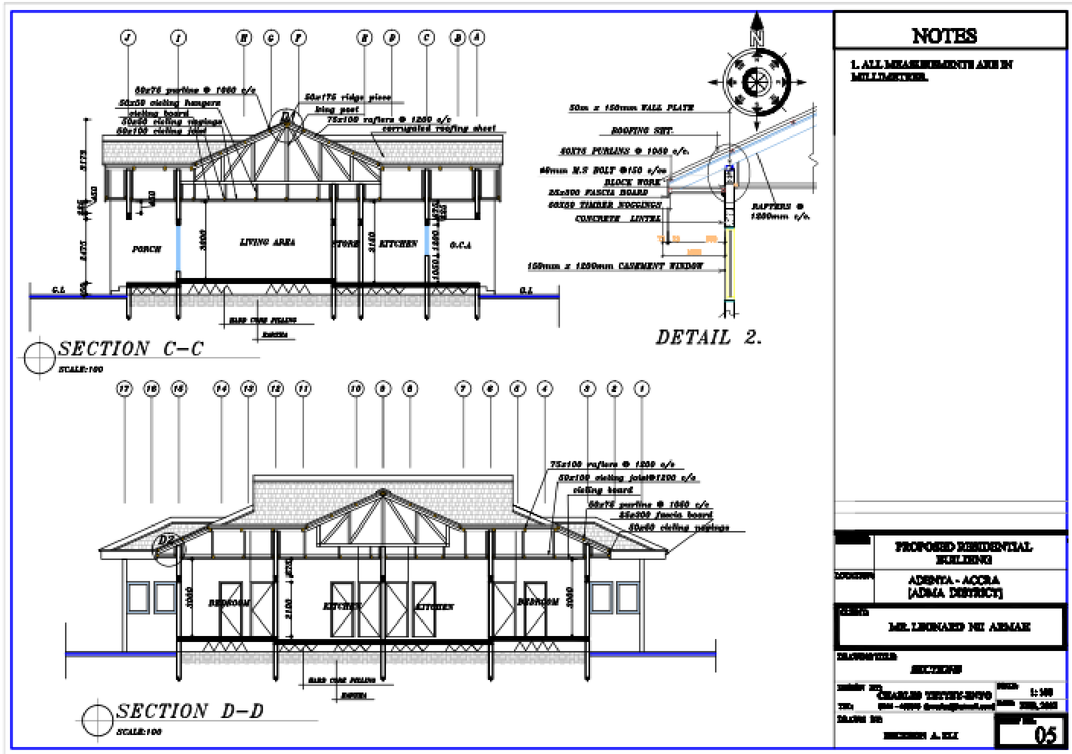
m	PAINTING AND DECORATING				23,253.00
	SUB TOTOTAL(1)				461,266.20
	ADD PRELIMINARIES				23,063.31
	SUB TOTAL(2)				484,329.51
	ADD CONTINGENCIES				48,432.95
	TOTAL ESTIMATED COST				**532,762.46**

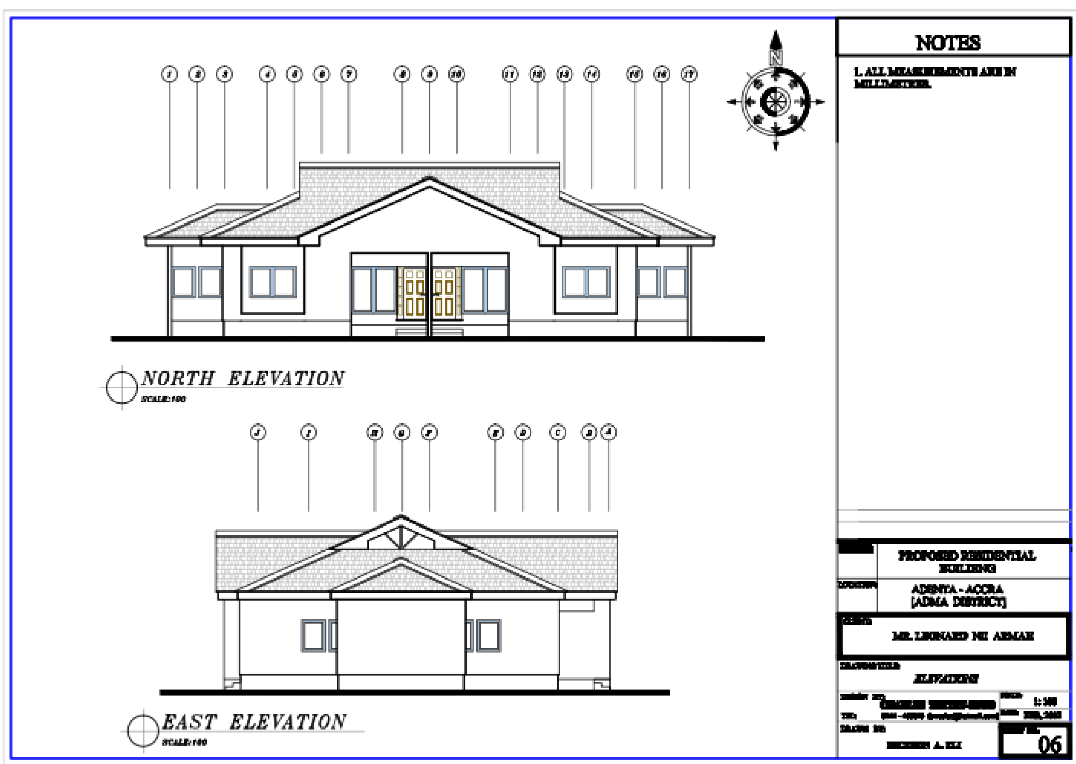
APPENDIX 4

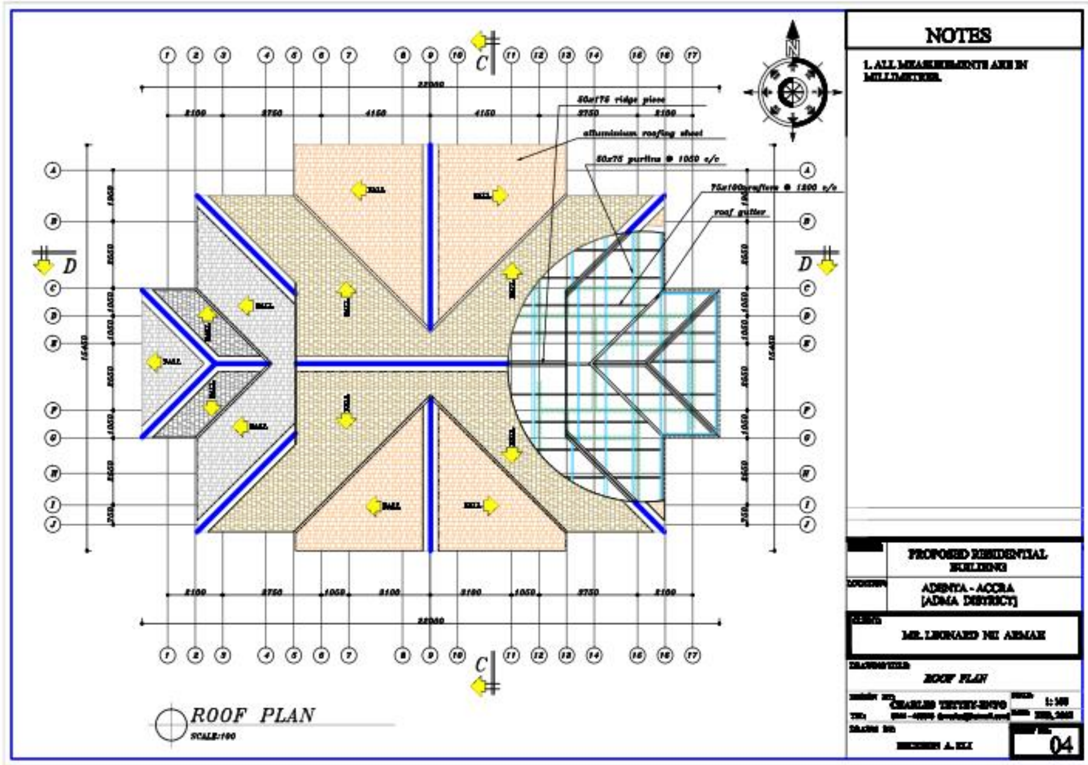
BUILDING DRAWINGS






SECTION C–C
SCALE:100
DETAIL 2.
SECTION D–D
SCALE:100
PORCH
LIVING AREA
STORE
KITCHEN
BEDROOM
NOTES
1. ALL MEASUREMENTS ARE IN MILLIMETRES.
PROPOSED RESIDENTIAL BUILDING
ADENTA - ACCRA (ADMA DISTRICT)
MR. LEONARD NII ARMAH
SECTIONS
1:100
05


NORTH ELEVATION
SCALE:100
EAST ELEVATION
SCALE:100
NOTES
1. ALL MEASUREMENTS ARE IN MILLIMETRES.
PROPOSED RESIDENTIAL BUILDING
ADENTA - ACCRA (ADMA DISTRICT)
MR. LEONARD NII ARMAH
ELEVATIONS
1:100
06


NOTES
1. ALL MEASUREMENTS ARE IN MILLIMETERS.
aluminium roofing sheet
roof gutter
PROPOSED RESIDENTIAL BUILDING
ADENTA - ACCRA (ADMA DISTRICT)
MR. LEONARD NII ARMAH
ROOF PLAN
1:100
04
ROOF PLAN
SCALE:100