ASSESSMENT OF PROSPECTS AND CHALLENGES OF LOCALLY MANUFACTURED BURNT BRICKS FOR HOUSING CONSTRUCTION IN BENUE STATE

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN CONSTRUCTION MANAGEMENT

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JUNE, 2016

DECLARATION

I declare that the work in this dissertation entitled 'Assessment of Prospects and Challenges of Locally Manufactured Burnt Bricks for Housing Construction in Benue State, Nigeria has been carried out by me in the Department of Building. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another Degree or Diploma at this or any other Institution.

Kundushima Tarhemba KOKO Signature Date

CERTIFICATION

This dissertation "ASSESSMENT OF PROSPECTS AND CHALLENGES OF LOCALLY MANUFACTURED BURNT BRICKS FOR HOUSING CONSTRUCTION IN BENUE STATE by Kundushima Tarhemba KOKO meets the regulations governing the award of the Degree of Master of Science of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my late father Mr. Stephen Tarhemba Koko and my lovely mum Mrs. Esther Koko.

ABSTRACT

The study was carried out to assess the prospects and challenges of locally manufactured burnt bricks for housing construction in selected local government areas in Benue state. The study focused on public's acceptance of locally manufactured burnt bricks for housing construction, users perception of the performance of the material in use, barriers to the use of the material and ways to create awareness and motivate stakeholders towards the use of the material. To achieve the objectives of the study, four local government areas in Benue state were selected based on their geologic setting for the study. Cluster sampling technique was employed to collect data from respondents. Data collected were analyzed using percentage and mean score. The study discovered that, most people (84%) are familiar with locally manufactured burnt bricks and are willing to utilize it based on its durability and availability with mean values of 3.96 and 3.68 respectively. The locally manufactured burnt bricks were perceived to perform very well with respect to durability, strength, fire resistance and resistance to water ingress with mean values of 4.21, 4.11, 3.98 and 3.81 respectively. The study identified problem of mass production, social acceptability and lack of standards as the major barriers to the use of the material with mean values of 4.37, 4.23 and 4.07 respectively. The study concludes that, with burnt bricks quality is assured and the problem of durable, decent and affordable housing can be solved. The study recommends that public awareness be created through the media to enlighten the public on the numerous benefits and suitability of locally manufactured burnt bricks for housing construction.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

The building materials sector contribution to the construction industry of every nation cannot be over emphasized; this is because materials constitute the single largest input in construction accounting for about half of the entire cost of most or any construction project (Baiden, Agyegum and Ofori-kuragu, 2014). According to Abiola (2000), building materials is one of the key factors that affect the effective performance of the Nigerian construction industry. Kabiraj and Mandal (2012) Posited that the impediments to solving the housing crisis encountered in developing countries are scarcity and high cost of building materials. This means that access to decent housing in Nigeria will continue to be elusive until the scarcity and exorbitant cost of conventional building materials and components are checked (Njoku, 2012).

According to Maton, Danjuma, Didel and Edom (2014), a critical strategy to proffer solution to the housing deficit experienced in Nigeria is to develop and promote cheaper but durable alternative building materials from local sources. The approach of developing and promoting more sophisticated building materials has benefited mainly the conventional building sector, e.g. government construction and the more affluent sections of urban and rural population (Food and Agricultural Organisation, 1993). It is worthy to say that, the more affluent section of the population builds houses which last and appreciate in value while the poorer population build semi-permanent or temporary shelter that require frequent repairs and maintenance and appreciate much less, if at all in value (Spence and Cook, 2007).

A large number of housing experts believe that the use of local building materials will go a long way in alleviating the shortage of housing in developing countries thereby reducing importation and reducing the overall cost of construction (Omole and Bako, 2013). Another argument is that the so-called local materials compare favorably well with the imported building materials (Olusanya, 1991).

One of the materials that readily come to mind when talking of local materials is burnt bricks which experts posit, could be cost effective especially in building houses for the lower income and vulnerable groups (Njoku, 2012). According to Tse (2012) a significant decline in the operation of cement manufacturing plants in Nigeria since the 1990,s has raised the already exorbitant cost of cement above the reach of the average Nigerian thereby prompting the emergence of a strong local burnt bricks industry in many parts of Nigeria and Benue state in particular.

Burnt clay bricks are used in a wide range of buildings from housing to the building of incinerators, perimeter walls and water ways (Olawuyi, Olusola, Ogunbode and Kyenge, 2010; Duggal, 2012). Its raw material (clay) is a natural material with plastic properties. Clays vary considerably in physical properties, colour and mineralogical content. They however have certain properties in common. It becomes cohesive when kneaded, expands when wet, shrinks when dry and gains strength when fired (Brick Institute of America, 2006).

Burnt bricks production can be done in any locality where enough suitable clay occurs. In Benue state, it is mainly done around the river banks with its raw materials comprising solely of soil deposits found around the flood plains of major rivers and seasonal streams (Tse, 2012). The banks of these rivers are often flooded during the raining season,

producing flood plain deposits made up of fine to medium grained sand, silt and clay in varying proportions. However the waters dry up in the dry season making available 15 to 30m wide stretch of the river banks which yield the raw materials and provide the sites for the industry (Tse, 2012).

According to Ushie and Anike (2010), if the production of burnt bricks is carried out under reasonable and cost-effective conditions, burnt bricks should be much cheaper than sandcrete blocks. Houses built with bricks are reported to be cooler than those built with cement blocks since burnt bricks are poorer conductors of heat than cement blocks, giving rise to superior insulation properties that contribute to greater thermal comfort (Ushie and Anike, 2010). In addition to being fire resistant because of the high temperature of firing, they also have superior aesthetics than unpainted cement blocks (Sa'ad, 2006).

The widespread sites for local brick production and the bricks increased popularity within Benue state gives rise to a study on its prospects and challenges for housing construction.

1.2 Statement of the Research Problem

The future of any local material depends on the extent to which it is acceptable to the people. The notion that buildings of local materials are substandard is the main obstacle to solving the housing deficit experienced in Nigeria. Even with the superior benefits of burnt bricks as compared to most other building materials and the numerous benefits derived from the use of the material, housing programs taken up in Nigeria either in the public or private sector has not really favored burnt bricks (Odunjo, Oladimeji and Okanlawon, 2015). The general observation in Nigeria is that the use of the material is yet to be fully accepted and adopted especially in the urban areas due to uncertainties in its performance.

It is worthy to note also that not much development efforts has been geared towards the local building materials sector which in general is small scale, locally/privately owned and uses local raw materials and equipment (Food and Agricultural Organisation, 1993).

1.3 Justification of the Study

According to the Benue Advance Plan of 2008, about 10% of the population within the rural and semi urban areas of the Tiv speaking population are directly or indirectly involved in the local brick production industry especially during the off farming seasons when other employment opportunities are almost non-existent. This research will help boost their economic base and create more employment opportunity for the rural populace.

In addition, cost savings when locally manufactured burnt bricks are used in a standard family bungalow (3-4 bedrooms) may be as much as 30% (Tse, 2012). The research will also assist the low income earners as well as medium income earners access affordable housing. Furthermore, burnt bricks are very durable and they have superior aesthetic over other materials (Sa'ad, 2006). The research will assist the general public in accessing permanent housing which will appreciate much more in value and thus not requiring frequent repairs or replacement of elements.

For those that would be involved in the promotion and improvement of this local material, the research will provide the platform to solve the problems that constitutes a stumbling block to the effective utilization of the material for housing construction.

Based on the economic impact of using locally manufactured burnt bricks in Benue state and the great need for cheap and permanent housing for the teaming population of the

country, an assessment of the problems and prospects of locally manufactured burnt bricks for housing construction is necessary.

1.4 Aim and Objectives

1.4.1 Aim

The aim of the study is to assess the prospects and challenges of locally manufactured burnt bricks for building construction in Benue state with a view to encouraging its use.

1.4.2 Objectives

i. To assess the level of public acceptance of burnt bricks for housing construction in Benue state.
ii. To assess users perception of the performance of locally manufactured burnt bricks in Benue state.
iii. To assess the barriers to the use of burnt bricks for housing construction in Benue state.
iv. To assess the perception of professionals on ways to increase awareness and motivate stakeholders towards the use of locally manufactured burnt bricks for housing construction.

1.5 Scope of the study

This research work focused on assessing the prospects and challenges of locally manufactured burnt bricks for housing construction in selected local governments in Benue state. The study was limited to only the headquarters of Makurdi, Gwer-West, Katsina-Ala and Vandeikya local government areas in Benue state.

1.6 Limitation

Accessing construction professionals in some of the selected local government areas was a challenge.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition

Brick is defined in the Encarta English Dictionary (2009) as a rectangular block of clay or similar material (i.e.laterite) that is fired until it is hard and is used for construction of houses, walls or other permanent structures. The soil used for brick making is often called different names such as earth, clay or laterite.

2.2 History of Bricks

Bricks has been part of man's history for several thousands of years, since the ancient man began experimenting with dry mud trying to solve the problems inherent in the material. Burnt bricks usage dates back to the Stone Age (i.e. 2500 BC) as recorded in the Bible story of The Tower of Babel where the people were said to make bricks and burn them thoroughly (Olawuyi *et al.*, 2010). They had brick for stone, and they had asphalt for mortar. Another evidence of burnt bricks was the Tower of Ur, built by Ur-Nammu, the self-styled "king of the four quarters of the world", around 2300 BC. The remains of the Tower reveal that both sun-dried and fired bricks were used in its construction, the sun-dried variety providing the core of the building and fired bricks the outer facing (Plumridge and Meulenkamp, 1993). Zami and Lee (2011) were of the view that, the use of bricks as a standard building material began in the early 1900s in most of the African countries.

Innovations in the use of bricks during the past 50 years have rarely had the glamour of the modern building projects. However, the introductions of recent techniques such as steel reinforcement have greatly enhanced brick's structural potentials, enabling it to be used in

even larger and more complex structures (Brick Institute of America, 2006). Most importantly, brick remains one of the most versatile, reliable and widely used building material.

2.3 Raw Material for Burnt Bricks Production

In brick making terms, clay covers a range of naturally occurring raw materials which are used to make a product (Clay Brick Association, 2002). Clays varies considerably in physical properties, colour and hardness. The key, in geological terms, is the mineral content of the raw material. The major raw material used for brick production is laterite. Laterite has been used in construction of shelter from time immemorial and roughly 30% of world's present population still lives in laterite structures (Zakari and Akani, 2013).

Numerous definitions have been given to laterite depending on the professional preference of the authors. Some are solely physical while others are purely chemical (Olawuyi *et al.*, 2010). The term "laterite", according to Hamilton (1995), is a ferruginous (high iron content), vesicular (contain small cavities), unstratified and porous material with yellow archers caused by its high iron content. It was used for weathering materials from which blocks are cut, that after drying are used as building bricks. The word "laterite" was derived from the Latin word "later" which means brick or tile. The degree of weathering to which the parent material is subjected to influences greatly the physical and chemical composition of Laterite soils (Olusola, 2005). Gidagasu (1976) opined that the laterite should be used to describe "all the reddish residual and non-residual tropically weathered soils, which genetically form a chain of materials ranging from decomposed rock through clays to sesquioxides (Al_2O_3 + Fe_2O_3) rich crust, generally known as cuirass or carapace". Cuirass stands for the upper layer of laterite accumulation zone and is particularly enriched

in iron oxide minerals. Carapace on the other hand stands for the lower part of laterite accumulation zone. Miller (1999) asserted that laterite is heavily leached tropical subsoil which is not fertile and comprises mainly iron and aluminum oxides and kaolinite-clays.

Rajput (2006) further stated that brick earth must have proper proportions of sand, silt and clay; be homogeneous; have sufficient plasticity and be free from lumps of lime and nodules of kankar. This conforms to the postulations that the material used for brick production falls under other previous authors and researchers' classification of the soil called laterite.

2.4 Burnt Bricks Production Process

Although the basic principles of manufacture are reasonably uniform, manufacturers tailor their production to fit their particular raw materials and operation (BIA, 2006). Essentially, brick are produced by mixing clay with water, forming the clay into the desired shape, and drying and firing. (Fernandes, Lourenco and Castro, 2009).

2.4.1 Soil Winning

The choice of method of clay winning depends mainly on the depth, thickness, hardness and physical geology of the clay beds. The usual method for extracting clay from the quarry is by using hoes, shovels and diggers (Tse, 2012).

2.4.2 Soil Preparation

Clay as a raw material must be prepared to guarantee a high quality end product. Water is poured on the stacked soil to wash out the soluble salts which might later cause white scum on the product. The soil is then mixed thoroughly to form a paste (Olawuyi *et al.*, 2010).

2.4.3 Forming the Brick Shape

The thoroughly mixed soil is placed into a mould prior to which a mould release medium (sand, oil or water) is applied to the mould to prevent the clay from sticking to the box. The excess clay is struck off from the top of the mould and the bricks are turned out (Food and Agricultural Organisation, 1993). This method usually involves a craftsman who would produce one brick by hand at a time.

2.4.4 Drying

The freshly produced bricks are stored in the open air in rows. They are covered temporarily with dried grass to ensure protection against adverse weather condition (Clay Brick Association 2002). The essence of drying is to remove as much moisture as possible for the bricks will explode in the kilns during firing if they still contain moisture (Duggal, 2012). The drying period depends completely on the weather conditions and can take as from 1 – 5 weeks of proper or desired drying before burning (Olawuyi *et al.,* 2010).

2.4.5 Firing

Clay is fired when it is heated above a point where an irreversible change occurs. The chemically combined water is driven off altering the clays composition, so that it will not disintegrate in water or return to its plastic state (Hamer, Frank and Janet, 2004). Clay changes colour, becomes harder, shrinks and if the temperature is taken high enough, it vitrifies and finally melt. Clay bodies undergo several changes during drying and firing stages as a result of physical, chemical and mineralogical modifications (Aramide, 2012). The properly dried bricks are carefully arranged in tabular or pyramid shape forming a kiln with a provision for firing or heating to develop hardness at the bottom (Olawuyi *et al*., 2010). The staked bricks are covered with a thick layer of soil paste to

reduce the loss of heat during firing. The fire is started, heat develops and then after few days of firing, the fuel is cut off entirely and the burnt bricks are allowed to cool down naturally. The fuel mostly used in firing is wood. Sufficient fuel must be available when the burning starts as the entire batch of bricks might be lost if the fire is allowed to die down during the operation (Kumar, 2013). The bricks are adjudged to have been thoroughly burnt when a part of the heap starts falling without the bricks breaking. As the bricks are taken out of the staked batch after firing, they are sorted to different grades with the main criteria being strength, irregular dimensions and sometimes cracks.

2.5 Properties of Burnt Bricks

Technically, the most important properties of bricks are their strength, their absorption properties, and their insulation against sound and fire (Fernandes and Lourenco, 2007). Clay bricks exhibit a set of properties that are important in the evaluation of strength and durability. The properties are closely related to the quality of the raw clay and directly associated with the conditions of manufacture (Fernandes *et al.*, 2009).

2.5.1 Strength

Strength is simply the quality or state of being physically strong. The strength of every building is important because it determines the durability and security of the building. Burnt bricks as a building material have an appreciable strength in compression and the compressive strength of burnt bricks is related to its density (Danquah, Abrokwah, Twumasi and Ankrah, 2015).

The compressive strength of building bricks varies according to its applications (Brick Institute of America, 2006). NIS 87:2004 stipulates a standard compressive strength value

of 2.8 N/mm^2 for bricks to be used for load bearing walls and 2.0 N/mm^2 for non-load bearing walls (Apebo, Iorwua and Agunwamba, 2013).

2.5.2 Durability

The durability of a material is its ability to undergo permanent deformation without cracking or fracturing. Durability is an important factor in analyzing a building's life-cycle costs. Materials that last longer will, over a building's useful life, be more cost-effective than materials that need to be replaced more often (MCwhirr, 1979). The durable nature of burnt bricks for building construction is obvious in Benue state. The surviving structures of the colonial era exhibit the durability qualities of burnt bricks. However, burnt bricks' longevity depends on the quality of ingredients, skill of artisans and efficiency of the burning kilns. This finding is consistent with the view of Riza, Rahman and Zaidi (2011) that most soil in their natural condition lack the strength, dimensional stability and durability required for building construction. The above indicates that soils used for burnt bricks, if not properly tested to ascertain its suitability and properly prepared, may lack the desired strength and hence its flimsiness. Brick is permanent. Once it's built it remains weather proof and age proof. Brick doesn't get tired like man-made materials, so it requires virtually no upkeep or repairs. Bricks don't rust or erode, rot or decay, bend, twist or warp (Danquah *et al.,* 2015).

2.5.3 Absorption Property

The power of the brick to soak up water is one of its most useful characteristics. The water absorbed during wet spells is harmlessly evaporated again when the weather clears. In freezing conditions up to 7 % absorption is considered to be safe for brickwork (Fernandes and Lourenco, 2007). According to Fernandes *et al.* (2009), pores constitute a large part of

the brick's volume, and when the bricks are exposed to rainfall or rising damp, water generally penetrates into the pores. Water absorption then determines the capacity of the fluid to be stored and to circulate within the brick, favouring deterioration and reduction of mechanical strength. Additionally, when soluble salts are present in the bricks, water tends to react with them to cause efflorescence. Though this is mostly an aesthetic deterioration of the surface of the brick, the volume increase caused by the crystallization of the salts can cause severe damage (Clay Brick Association, 2002). Rajput (2006) specifies that, immersion of bricks in cold water for twenty four hours, water absorption shall not be more than 20% by weight.

2.5.4 Sound Insulation

Insulation against air-borne sound depends more on the mass or weight of the wall than on anything else. A solid brick wall sets the standard for sound-proofing in both residential and commercial construction, (Clay Brick Association, 2002).

2.5.5 Fire Resistance

Fire resistance rating is a measure of the length of time a walling element will resist a fully developed fire. The fire resistance of brickwork is high, because the materials are inherently resistant to fire. Its low thermal conductivity ensures that heat is not quickly transferred through brick walls. Fire rarely damages brickwork in a building, although thermal expansion of unprotected steel columns, girders or roof trusses may cause displacement or even collapse of brick walls (Olawuyi *et al*., 2010).

2.5.6 Porosity

Firing of clay bricks produces a series of mineralogical, textural and physical changes that depend on many factors that influence porosity. Porosity can be defined as the ratio

between the volume of void spaces (pores and cracks) and the total volume of the specimen (Cultrone *et al*., 2004). Porosity is an important parameter concerning clay bricks due to its influence on properties such as chemical reactivity, mechanical strength, durability and the general quality of the brick. The dimension and distribution of the pores is influenced by the quality of the raw clay, the presence of additives or impurities, the amount of water and the firing temperature. (Mesida, 1978) observed that if the firing temperature increases, the proportion of large pores (3–15 μ m) increases and the connectivity between pores is reduced, whereas the amount of small pores diminishes. This has a strong impact on the durability of the bricks as it has been shown that large pores are less influenced by soluble salts and freeze/thaw cycles. Furthermore, studies by (Elert, Coultrone, Navarro and Pardo, 2003; Cultrone *et al.*, 2004) reported that the formation of small pores, with a diameter below 1 μ m, is promoted by carbonates in the raw clay (low quality material) and by a firing temperature between 800 and 1,000°C. Such pore sizes negatively influence the quality of the bricks, as their capacity to absorb and retain water increases.

2.5.7 Apparent Density

Apparent density is described as the ratio between the dry brick weight and the volume of the clay brick, measuring the proportion of matter (clay) found in the volume. It is evident from this description that the higher this value is, the denser the brick is, and obviously, the better it's mechanical and durability properties (Cultrone *et al.*, 2004).

2.6 Types of Bricks

The various available types of bricks may be classified by mode of production, colour, mechanical strength and the purpose for which they are intended (Hamilton, 1995). The

types of brick found in developing countries fall into two main categories: they are either handmade or machine-made.

2.6.1 Handmade Bricks

As the name suggests, these are bricks which are molded in individual boxes by hand, dried, and then fired either in temporary clamp kilns or permanent kiln structures (Brick Institute of America, 2006). All traditionally made bricks are graded according to their suitability for use, into three main types. The best bricks were selected for facing work. These are generally described as stock or facing bricks. General brick suitable for building work but not for facing brickwork is called place brick or common brick. The rest of the bricks from the kiln are either over-burnt or misshapen (clinkers) or under-burnt and are generally unusable for anything other than rough or non-structural work (Olawuyi *et al*., 2010).

2.6.2 Common Bricks

These bricks are used in buildings where their appearance is of little or no consequence. They sometimes vary in colour from red to pale yellow. They are not vitrified and normally not fired higher than 1830^0F (1000^0C). They are not expected to have a great compressive strength.

2.6.3 Engineering Bricks

These are strong type of bricks which are fired to the point of vitrification or a temperature approaching this state under reduction condition which achieves maximum strength without deformation. Such bricks have very great compressive strength and the production is carefully controlled (Brick Dictionary 2010-2014).

2.6.4 Machine Made Bricks

Machine-made bricks are those made by a mechanised process, such as an extruded 'wirecut', pressed and 'simulated' handmade. Machine-made bricks can be solid, perforated, or paneled and are often stamped with the maker's name.

2.6.5 Special Brick

As the name implies, the bricks are made and named accordingly dependent on their final use (Brick Dictionary 2010-2014). Radial bricks either have one edge shorter than the other or vary in thickness. This type of brick is used for walls with curved edges. Arch bricks are used for arches as they have one end thicker than the other. Facing bricks on the other hand are more carefully made and the quality of the raw materials is vigorously controlled. They are sometimes fired beyond 1000^0C to produce a more acceptable surface and this is accompanied by greater mechanical strength. They are mostly used on approach elevations, entrance porches and specific areas to captivate the attention of the observer. Fire bricks are generally yellow in colour and used in places where they would be subject to high temperatures. Paving bricks are of uniform size and colour and have been made by burning hard clay or shale (Brick Dictionary 2010-2014).

2.7 Sourcing Locally Manufactured Burnt Bricks for Housing Construction

Burnt brick for house construction can be accessed through the self-help initiative or commercial arrangement.

2.7.1 Self help initiative

According to Svare (1974) the self help initiative is a process where prospective house owners' embarks on the production of the bricks to be used themselves thereby investing their own labour. With this arrangement labour is free and the production is carried out

with very small expenditure. This method is common within the rural communities as majority of their houses are delivered through this means.

2.7.2 Commercial arrangement

Here prospective house owners or contractors purchase the material from the producers or marketers. With this arrangement the cost of construction becomes a concern since the amount of work involved in the production greatly influence the price (Svare, 1974). Bricks produced for sale has to meet certain quality requirements called standards and have to compete economically with other wall materials.

2.8 Advantages of Burnt Bricks as a Housing Material

There are many advantages when bricks are used as part of the construction. According to Rodriguez (2015), the following list presents some of the most common advantages when using bricks instead of other construction materials.

i. Burnt bricks offer natural and a variety of colours, including various textures.
ii. Burnt bricks offer excellent high compressive strength.
iii. The porosity of burnt bricks in attributed to its fine capillaries. The ability to release and absorb moisture is one of the most important and useful properties of bricks, regulating temperatures and humidity inside structures.
iv. When prepared properly a burnt brick structure can give a fire protection maximum rating of 6 hours.
v. The burnt brick sound insulation is normally 45 decibels for a 4.5 inches brick thickness and 50 decibels for a nine inch thick brick.
vi. Burnt bricks can exhibit above normal thermal insulation when compared to other building materials.
vii. Burnt bricks can help regulate and maintain constant interior temperatures of a structure due to their ability to absorb and slowly release heat. This way bricks can produce significant energy savings, more than 30% of energy saving, when compared to wood.
viii. Burnt bricks are so strong, that their molecular composition provides excellent wear resistance.

In summary advantages of burnt bricks can be seen in its durability, strength, fire resistance, thermal comfort, aesthetics and porosity. These contextually, are the

performance indicators or properties which are used for measuring and evaluating the operation or functioning of burnt bricks as a building material (Danquah *et al*, 2015).

2.9 General Benefits of Locally Manufactured Burnt Bricks

Regarding locally manufactured burnt bricks as an indigenous material the following benefits can be derived (Adogbo and Kolo 1998).

i. Providing affordable housing
ii. Reduction in the cost of construction.
iii. Provision of employment opportunity
iv. Meeting increasing demand for housing stock
v. Use of environment friendly resource
vi. The development and propagation of indigenous technological ingenuity and skills of the local people.
vii. Enlarging and promoting the economic strengths of people and the country at large.
viii. Utilisation of local materials.
ix. Provides a source of study and research for both present and future generations.

2.10 Constraints to the Use of Burnt Bricks for Housing Construction

The main constraint to the use of locally manufactured burnt bricks for housing construction according to Odunjo *et al.* (2015) is the acceptability of the material in view of the bias and stigma attached to it. Odunjo *et al.* (2015) further stated other constraints to include: lack of institutional arrangement for market availability of the material as is normally available for sandcrete blocks through block industries and suppliers, lack of support through codal provisions either in the National Building Codes or through the public works department, lack of references of material in most of the schedule of rates in the country as an alternative to sandcrete blocks and over-emphasizing the use of materials like sandcrete blocks.

Baiden *et al.* (2014) on the other hand stated that, problem of mass production, quality of output, low demand, inappropriate use in construction, limitation in design forms, inadequate supply of clay, excessive cost implications, non compatibility with other materials, transportation problems, constructability problems, social acceptability, and unavailability are the major constraints to the use of burnt bricks for housing construction.

2.10.1 Affordability

According to Danso (2013), local building materials are gotten free of charge, the cost incurred in obtaining them are for those who will fetch the materials. This makes it cheap and affordable for obtaining local materials for building houses. On the other hand, extensive labour work is required in constructing houses with burnt bricks due to the fact that the actions involved in preparing the bricks are considered part of the entire labour works (Danquah *et al*., 2015). However, the labour works from the acquisition of the raw materials and their production for houses built with conventional materials are not considered as part of the labour works required for the construction of such houses.

2.10.2 Acceptability

The general observation in Nigeria is that the use of the material is yet to be wholly accepted and adopted especially in the urban areas (Odunjo *et al*., 2015). Acceptability measures the ease at which Nigerians accept houses constructed with burnt bricks regardless of the status. There is the general feeling that a building made with the material is a “poor man’s building” whereas, in Brazil, cities wear a red look because of the predominance of burnt brick used in construction. In a survey conducted in Accra Ghana

(as cited in Danquah *et al.,* 2015), a resident said "he would have liked to use burnt clay bricks but he would be the odd one out because everyone in the area had used cement blocks instead so he would rather prefer to use these building materials in the rural home. Baiden *et al.* (2014), posited in his study that stigmatization against burnt bricks is due to lack of motivation and awareness about the benefits of using the material. He further suggested that, increasing awareness and motivation of stakeholders towards the use of burnt bricks can be achieved through the following:

i. Showcase on construction using burnt bricks projects through the media.
ii. Organization of seminars and trainings for masons.
iii. Development of suitable technologies for mass production of the material.
iv. Formulation of standards for the use of the material by various local and international agencies on housing matters.
v. Agreement on specification and construction methods.

2.11 Sustainability of Locally Manufactured Burnt Bricks

Sustainability is a concept that has come to cover efforts to address a multitude of environmental sins (Baiden *et al.,* 2014). According to Danquah (2009), sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own requirements. Bricks have thrived over thousands of years because of their durability and a number of factors that contribute to their natural sustainability (Danquah *et al.,* 2015). Many concerns have been raised on the sustainability of the use of bricks on a large scale due to its energy demand on the environment, some of these concerns are: deforestation, land degradation and pollution (FAO, 1993). Energy consumption and pollution are the two important environmental and cost concerns related to the brick industry. Over the past thirty years the manufacture of bricks has improved significantly, contributing to the inherent sustainability of the product. According to Deboucha and Hashim (2011), consumption of fuels, combined with inefficient combustion

process produces large quantity of harmful gases that threaten the environment as well as those working in brick kilns. However, Danquah (2009) asserts that modern methods in the production of burnt bricks have really reduced the energy demands as well as proper land management methods which preserve the land after the land mining. For example the use of woodlots for firing is being replaced with more environmentally friendly ones like cow dung (organic manure), palm kernel shells, saw dust and liquefied petroleum. Danquah (2009) further stated that, land wining which resulted in land degradation is being managed by either cautiously removing the top soil and later replacing or making it a landfill site for repossession. Also, manufacturing plants have been re-engineered to make use of highly efficient tunnel kilns, fired using natural gas, and all waste clay and heat is recycled within the plant (Rodriguez, 2015).

Bricks can be reused or recycled in three ways. Firstly because of their longevity and durability, brick buildings can often be renovated for different purposes, removing the need to erect a whole new building with all its associated environmental impacts. Secondly bricks can be salvaged, cleaned and reused to build new buildings. Thirdly old bricks can be recycled into new bricks or into other building materials such as aggregate for concrete, for landscaping or as sub-base for pavements or roads" (Think Brick, 2013).

2.12 Benue Brick Industry

Within Benue state, the brick industry is diverse, ranging from very small manually operated seasonal units, to a very large mechanized unit with a year round operation (Tse, 2012). The brick size differs not only among different manufactures but between batches produced by the same factory. The actual size may range between

150x125x100mm and 150x125x125mm in length, width and thickness (Olawuyi *et al.*, 2010).

Most of the manufacturers generally claim that, clay excavation from the quarries is only affected for one year and that by the second year, everything is back to normal (Tse, 2012). This is probably due to regular flooding of the land which results in silt deposits. Most of the bricks are hand molded and almost all the operations are manual, ranging from bringing the clay to the pug mill, to the molding and drying ground, to the kiln and from the kiln to supplies (Olawuyi *et al.*, 2010). All the brick manufacturers operate only during the dry season because bricks are dried in the open air and if sudden rains occur, a large part of the production will be spoiled. The bricks are fired using wood, as sources of energy which can be a cheap fuel depending on its source (Tse, 2012).

Bricks are normally sold at the production sites to contractors and individuals. The average sales price is approximately 7-8 naira during normal period and 8-10 naira during peak period for 150x125x100mm and 9-10 naira during normal periods and 10-12 naira during peak periods for 150x125x125mm bricks (Olawuyi *et al.*, 2010).

Much still has to be done because brick making is still not considered an "industry" and as a result it is subject to all kinds of restrictions. In general it can be said that the industry is very tradition bound and very few changes have been introduced into the industry.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

To evaluate the prospects and challenges of locally manufactured burnt bricks for housing construction in selected local government areas in Benue state, the research design was divided into four broad steps as shown in Figure 3.1 below. Step 1 was the review of relevant literature. Step 2 explains how the data for this research work was collected and analysed. Step 3 showed the interpretation of the results that were collected. And step 4 covers summary of findings, conclusion and recommendation.

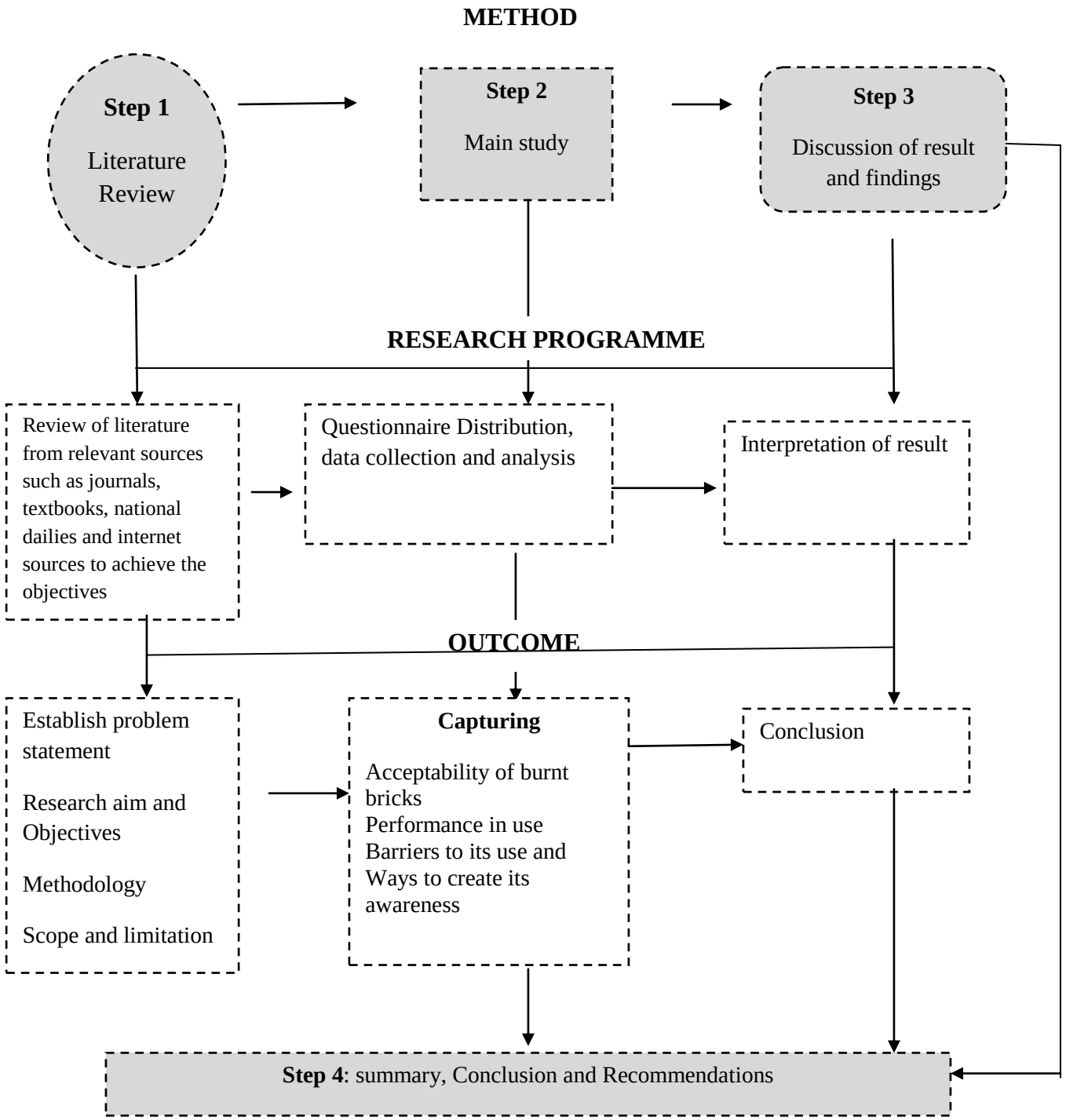

Figure 3.1 Research Design

3.2 Study Area

The study is conducted in Benue state north central Nigeria which lies between latitudes 6° and 8° N and longitudes 7° and 10° E, covering an area of about 50460 km2. The study covers the headquarters of selected local governments namely: Makurdi in Makurdi local government area, Naka in Gwer-West local government area, Katsina-Ala in Katsina-Ala local government area and Vandeikya in Vandeikya local government area. The four local government areas were selected based on their geologic setting.

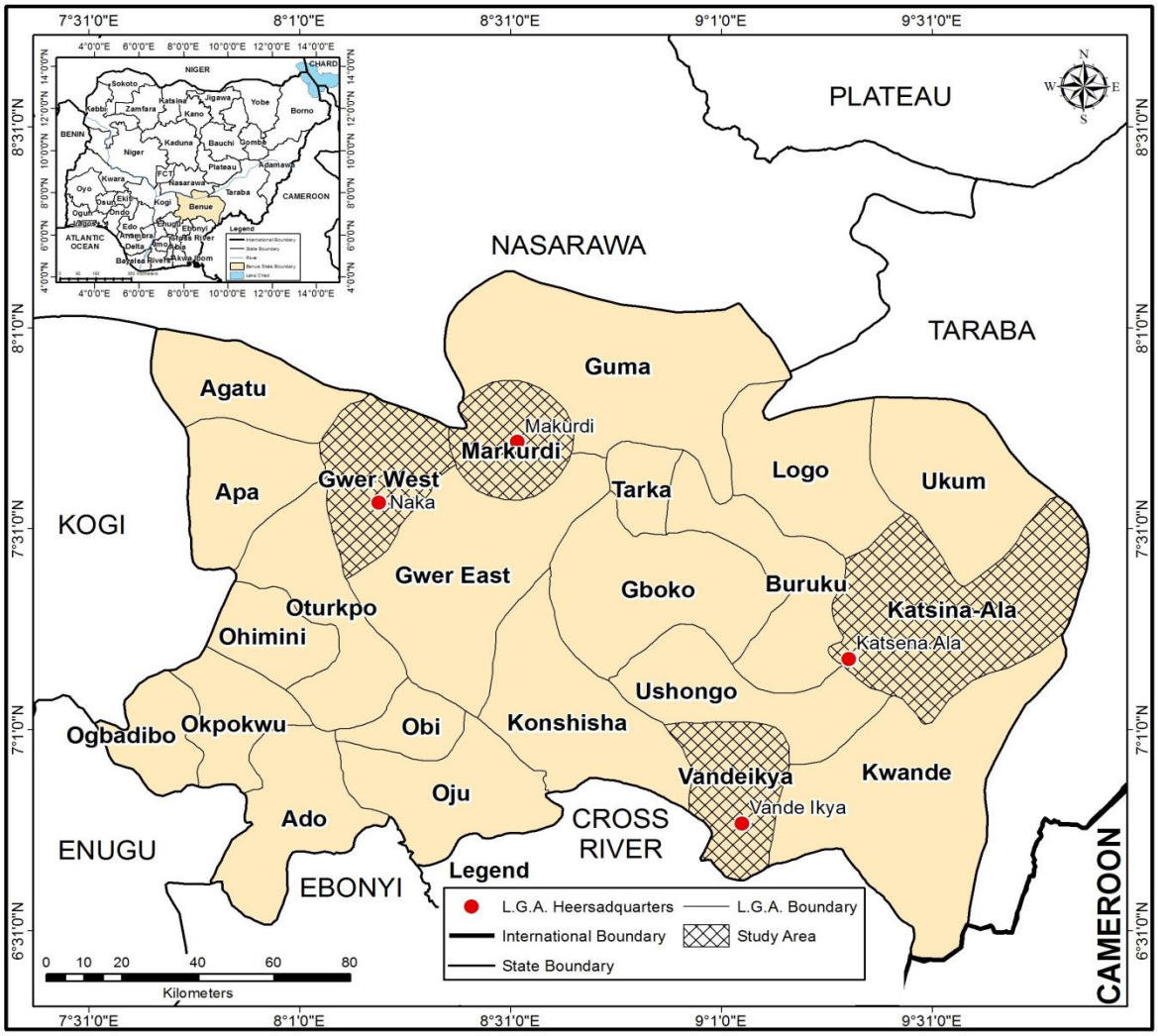

Figure 3.2: Benue State showing Study Area

Source: Modified from the Administrative Map of Benue State

3.3 Data Collection

Primary data for the study was obtained through field survey. In order to collect data and meet set objectives of the research, two separate questionnaires based on the aim of the study were designed for the two types of respondents who were construction practitioners on one side and house owners other side. For construction practitioners, section A was used to generate data on respondents' profile which included: profession, educational qualification, professional qualification attained and the sector of construction industry engaged. Section B sought data on the level of use of locally manufactured burnt bricks, section C targeted the barriers to the use of the bricks, section D was concerned with the benefits derived from the use of burnt brick while section E dwelled on the ways of increasing awareness and motivating stakeholders towards the use of locally manufactured burnt bricks.

Questionnaire for house owners was divided into section A and B. section A sought information on familiarity and willingness of the respondents to utilize locally manufactured burnt bricks as well as criteria's that determine the utilization of locally manufactured burnt bricks. While section B focused on their perception of the performance of locally manufactured burnt bricks.

3.4 Population of the Study

The population of the study consists of practitioners in the construction industry (which includes Architects, Builders, Engineers and Quantity surveyors), housing owners and prospective house owners in Benue state. The specific population size of the study could not be ascertained.

3.5 Sample size and sampling Techniques

Since the number of practitioners in the construction industry, housing owners and prospective house owners is infinite, the sample size is determined using the formula by Glenn (2003) which shows that a sample size can be determined considering the targeted population is not known.

$n = (z^2pq)/d^2$) ----------**3.1**

Where;

n = the desired sample size

z = the ordinate on the normal curve corresponding to α or the standard normal deviate. For the purpose of this study a confidence level of 90% will be adopted.

Usually a 90% level of confidence has α = 0.10 and critical value of $z_{\alpha/2} = 1.64$

p = the proportion in the target population estimated to have a particular characteristics (normal between the range of 0.1 – 0.5)

q = 1.0 – p

d = degree of accuracy corresponding to the confidence level and Z selected.

The sample size is determined using the following parameters,

z = 1.64, d = 0.1, p = 0.3 q = 0.7

Sample size n = $(1.64^2 \times 0.3 \times 0.7)/ (0.1)^2$ = 56 Respondents.

Because of the difficulty in testing every single element of a population, sampling is employed. Cluster sampling technique and subsequently the random sampling technique were adopted for data collection from respondents.

3.6 Methods of Data Analysis

The data collected was analysed using percentages and mean score, it was then presented in tables.

$$\text{Mean score} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{n_5+n_4+n_3+n_2+n_1} \quad \text{---------- 3.1}$$

Where,

n1 = number of respondents who answered strongly disagree

n2 = number of respondents who answered agree

n3 = number of respondents who answered neutral

n4 = number of respondents who answered disagree

n5 = number of respondents who answered strongly disagree

CHAPTER FOUR

4.0 RESULTS PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Response to Questionnaire Administered

In order to achieve the objectives of this study, two sets of questionnaires were distributed to two categories of respondents which comprise of house owners and construction practitioners. All the fifty six (56) questionnaires directed to house owners were returned making a hundred percent (100%) response rate. While out of the fifty six (56) questionnaires given to construction practitioners only forty three were returned making a response rate of seventy seven percent (77%). This is presented in Table 4.1.

Table 4.1 Descriptive result of Response to Questionnaire Administered

	No. distributed	No. properly filled and returned	Percentage response
House owners and Gen. Public	56	56	100%
Construction practitioners	56	43	77%

Source: Field survey (2015)

4.2 Respondents Profile

This section deals with the presentation of results on the profile of respondents as shown in Table 4.2. From the table, it can be seen that, the respondents comprised of more Civil Engineers (47%) followed by Builders and Architects (23%) and then Quantity surveyors (7%). Majority of the respondents (55.8%) have first degree and above qualification. It was also observed that, most of the respondents (60.5%) are not registered with their professional bodies. While the sector of the construction industry the respondents were

engaged comprised of public (7%), organized private sector (9.3%) and individual practice (83.7%).

Table 4.2 Respondents Profile

S/N	Variable	Option	Frequency (No)	Percentage (%)
1	Profession:	a. Architects	10	23
		b. Builders	10	23
		c. Civil Engineers	20	47
		d. Quantity Surveyors	3	7
		Total	**43**	**100**
2	Educational qualification:	a. OND	4	9.3
		b. HND	9	20.9
		c. PGD	6	14.0
		d. BSc	20	46.5
		e. MSc	3	7.0
		f. PHD	1	2.3
		Total	**43**	**100**
3	Professional Qualification:	a) Corporate	6	14.0
		b) Graduate	11	25.6
		c) Not Registered	26	60.5
		Total	**43**	**100**
4	Sector of Construction Industry	a. Public	3	7.0
		b. Organised Private Sector	4	9.3
		c. Individuals	36	83.7
		Total	**43**	**100**

Source: Field Survey, (2015**)**

4.3 Public Acceptance of Locally Manufactured Burnt Bricks

This section deals with an evaluation of public awareness of burnt bricks, willingness to use the material for construction, an assessment of the factors that determine utilization of

burnt bricks, section of the population that patronizes the material most and the part of building that is preferred for the use of the material.

4.3.1 Familiarity with locally manufactured burnt brick

It can be seen from Table 4.3 that, majority of the respondents are familiar with the material. This implies that, burnt bricks are generally known by most of the people within the study area. Those who do not know it may probably be leaving in locations where the use of burnt bricks is not popular.

Table 4.3 Familiarity with Burnt Bricks

Familiarity	Frequency	Percentage
Familiar	47	84%
Not Familiar	6	11%
Undecided	3	5%
Total	56	100%

Source: Field Survey, (2015**)**

4.3.2 Willingness to Utilize Locally Manufactured Burnt Bricks for Housing Construction

Table 4.4 shows that, out of the respondents that are familiar with locally manufactured burnt bricks, majority are willing to utilise the material for housing construction. The decision of the group who are undecided as well as those unwilling to utilize burnt bricks might be affected positively if they are exposed to the numerous benefits and advantages of using the material.

Table 4.4 Willingness to Utilize Burnt Bricks

Willingness	Frequency	Percentage
Willing	32	68%
Not Willing	12	26%
Undecided	3	6%
Total	47	100%

Source: Field Survey, (2015**)**

4.3.3 Reasons for Utilisation of Locally Manufactured Burnt Bricks

Table 4.5 shows the ranking of responses in relation to the criteria for utilization of locally manufactured burnt bricks for housing construction. From the results, it can be inferred that durability, availability and cost effectiveness are the major reasons people use burnt bricks. This implies that more people will be willing to utilize locally manufactured burnt bricks if construction professionals begun to recommend it for housing construction.

Table 4.5 Reasons for Utilisation of Burnt Bricks

Reasons	Frequency					N	TS	Mean Score	Rank
	1	2	3	4	5				
Durability	0	7	4	20	16	47	186	3.96	1
Availability	0	12	4	18	13	47	173	3.68	2
Cost effectiveness	0	5	16	20	6	47	168	3.57	3
Compatibility with other materials	1	7	22	15	2	47	151	3.21	4
Recommendation from professionals	5	21	5	13	3	47	129	2.74	5

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

4.3.4. Patronage of Burnt Bricks

Table 4.6 shows that medium income earners of the population patronizes burnt bricks most followed by low income earners. In summary, more than half of the population that patronizes burnt bricks are medium income earners.

Table 4.6 Descriptive Result of Patronage of Burnt Bricks

Section of Population	Frequency	Percentage
High income earners	6	14%
Medium income earners	24	55.8%
Low income earners	13	30.2%
Total	43	100%

Source: Field Survey, (2015)

4.3.5 Part of Buildings for which Burnt Bricks are Preferred

Table 4.7 presents responses relating to part of building preferred for the use of burnt bricks in percentages. More respondents preferred it for substructure (37.2%) followed by whole building (34.9) and lastly fence wall (27.9%). The preference of the respondents to use burnt bricks in foundations can be attributed to its strength and durable characteristics.

Table 4.7 Part of Buildings for which Burnt Bricks are Preferred

Part of Building	Frequency	Percentage
Whole building	15	34.9%
Fence wall	12	27.9%
Sub-structure	16	37.2%
Total	43	100%

Source: Field Survey, (2015)

4.4 Perception on the Performance of Burnt Bricks

The result in Table 4.8 indicates that, respondents agreed with the performance of burnt bricks in relation to durability, strength, fire resistance, resistance to water ingress,

aesthetics and bullet proof. This implies that, quality is assured when burnt bricks are used and the users have value for their money. Again maintenance needs are minimized due to the high strength of the material. Furthermore with the aesthetic appeal of the bricks need for plastering can be eliminated thereby making housing construction cheap and affordable.

Table 4.8 Perception on the Performance of Burnt Bricks

Factors	Frequency					N	TS	Mean Score	Rank
	1	2	3	4	5				
Durability	0	4	3	19	21	47	198	4.21	1
Strength	0	2	8	20	17	47	193	4.11	2
Fire resistance	0	1	13	19	14	47	187	3.98	3
Resistance to water ingress	1	5	5	27	9	47	179	3.81	4
Aesthetics	0	5	13	20	9	47	174	3.70	5
Bullet proof	0	2	19	19	7	47	172	3.66	6
Thermal comfort	2	5	15	19	6	47	163	3.47	7
Cost saving	5	6	12	16	8	47	157	3.34	8
Resistance to env. conditions	1	5	25	9	7	47	157	3.34	9
Serviceability and Maintainabilty	7	12	20	3	5	47	128	2.72	10
Health benefits	14	15	13	3	2	47	105	2.23	11

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

4.5 Benefits Derived from the Use of Locally Manufactured Burnt Bricks

Table 4.9 presents the results of the responses to the benefits derived from the use of burnt bricks which shows that; meeting increased demand for housing stock, provision of

employment opportunities and enlargement and promotion of the economic strength of the people are the most significant benefits derived from the use of burnt bricks based on their mean scores. This implies that, the problem of durable and affordable housing can be solved through the use of burnt bricks. Furthermore the use of burnt bricks will provide employment opportunities for the growing unemployed population thereby bringing the economic situation of the people and country to a better position.

Table 4.9 Benefits Derived from the Use of Locally Manufactured Burnt Bricks

Benefits	Frequency					N	TS	Mean Score	Rnk
	1	2	3	4	5				
Meeting increased demand for housing stock	1	0	1	20	21	43	189	4.40	1
Provision of employment opportunities	1	1	2	14	23	43	180	4.19	2
Enlargement and promotion of the economic strength of the people and country at large	2	6	7	12	16	43	163	3.80	3
A good measure of conserving foreign exchange	5	5	6	8	19	43	160	3.72	4
Provision of affordable housing	7	7	7	8	15	43	149	3.47	5
Development and propagation of indigenous technological ingenuity and skills of the local people	7	10	6	8	13	43	142	3.30	6
Reduction in the cost of construction	7	8	7	7	14	43	142	3.30	6
Use of environmental friendly resources	10	9	5	6	13	43	132	3.07	8

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

4.6 Barriers to the use of Burnt Bricks for Housing Construction

This section presents the analysis and discussion of results of the respondents' perceptions on both the market and technological barriers to the use of burnt bricks**.**

4.6.1 Market Barriers

Table 4.10 presents the mean score of respondents' perception of the market barriers to the use of locally manufactured burnt bricks. The results indicate that, social acceptability and transportation problem are the major market barriers to the use of burnt bricks.

Table 4.10 Market Barriers to the Use of Locally Manufactured Burnt Bricks

Barriers	Frequency					N	TS	Mean Score	Rank
	1	2	3	4	5				
Social acceptability	0	2	6	15	20	43	182	4.23	1
Transportation problem	3	7	7	10	16	43	158	3.67	2
Excessive cost implication	5	8	13	7	10	43	138	3.21	3
Inadequate supply of clay	9	9	9	8	8	43	126	2.93	4
Unavailability	8	11	8	9	7	43	125	2.91	5
Low demand	7	11	12	8	5	43	122	2.84	6

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

4.6.2 Technological Barriers

Table 4.11 indicates that problem of mass production, lack of standards and constructability problem are the major factors that constitute technological barriers to the

use of burnt bricks for housing construction. This explains the reluctance by professionals to adopt the use of the material for mass housing since the conventional materials are easier to use and more convenient.

Table 4.11 Technological Barriers to the Use of Locally Manufactured Burnt Bricks

Barriers	Frequency					N	TS	Mean Score	Rank
	1	2	3	4	5				
Problem of mass production	0	2	5	11	25	43	188	4.37	1
Lack of standards	2	4	5	10	22	43	175	4.07	2
Constructability problem	5	5	6	8	19	43	160	3.72	3
Non compatibility with other materials	9	10	5	6	13	43	133	3.09	4
Structural problem	9	10	6	6	12	43	131	3.05	5
Low aesthetics	19	11	4	4	5	43	94	2.19	6
Doubtful durability and life span	21	10	6	2	4	43	87	2.02	7

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

4.7 Increasing Awareness and Motivation towards the Use of Burnt Bricks

Table 4.12 shows ways to increase awareness and motivate stakeholders in the construction industry towards the use of locally manufactured burnt bricks for housing construction. Showcase on construction using burnt bricks projects through the media, organization of seminars and trainings for masons in respect to the construction methodologies of burnt bricks, formulation of standards for the use of the material by the various local and international agencies on housing matters, development of suitable technology for mass

production of the material and agreement on specification and construction methods are all considered very suitable ways to increase awareness and motivate stakeholders towards the use of locally manufactured burnt bricks for housing construction based on their mean scores. This result correlates with Baiden *et al.* (2014) assertion that the above mentioned ways are suitable for motivation and creating awareness.

Table 4.12 Awareness and Motivation towards the Use of Burnt Bricks.

Ways	Frequency					N	TS	Mean Score	Rank
	1	2	3	4	5				
Showcase on construction using burnt bricks projects through the media	0	0	1	14	28	43	199	4.63	1
Seminars and trainings for masons	0	1	4	12	26	43	192	4.45	2
Formulation of standards for the use of the material	1	5	4	9	24	43	179	4.16	3
Development of technologies for mass production of the material	1	3	8	12	19	43	174	4.05	4
Agreement on specification and construction methods	1	5	7	12	18	43	170	3.95	5

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)
Source: Field Survey, (2015)

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings

The major findings in this study are summarized as follows:

a) Most of the respondents (84%) are familiar with locally manufactured burnt bricks out of which 68% are willing to utilize it for the construction of their houses.

b) The willingness of the public to utilize burnt bricks is based majorly on its durability with mean score of 3.96, availability (3.68) and cost effectiveness (3.57).

c) The section of the population that patronizes burnt bricks most is the medium income earners (55.8%).

d) Burnt bricks were preferred for use at substructure (37.2%) followed by whole building (34.9%) and lastly fence wall (27.9%).

e) The major areas of performance of locally manufactured burnt bricks were found to be in its durability (mean score = 4.21), strength (mean score = 4.11), fire resistance (mean score = 3.98) resistance to water ingress (mean score = 3.81), aesthetics (mean score = 3.70) and bullet proof (mean score = 3.66).

f) The benefits derived from the use of locally manufactured burnt bricks were found to be; meeting increased demand for housing stock (mean score = 4.40), provision of employment opportunities (mean score = 4.13) and enlargement and promotion of the economic strength of the people and country at large (mean score = 3.80).

g) The research also found out that, problem of mass production (mean score = 4.37), social acceptability (mean score = 4.23), lack of standards (mean score = 4.07), constructability problem (mean score = 3.72) and transportation problem (mean

score = 3.67) are the major factors that constitute barriers to the use of locally manufactured burnt bricks for housing construction.

h) showcase on construction using burnt bricks projects through the media (mean score = 4.63), organization of seminars and trainings for masons in respect to the construction methodologies of burnt bricks (mean score = 4.45), formulation of standards for the use of the material by the various local and international agencies on housing matters (mean score = 4.16), development of suitable technology for mass production of the material (mean score = 4.05) and agreement on specification and construction methods (mean score = 3.95) are all considered to be suitable ways of increasing awareness and motivating stakeholders towards the use of locally manufactured burnt bricks for housing construction based on their mean scores.

5.2 Conclusion

From the findings of the study, the following conclusions were made:

Burnt bricks are generally known by most of the people within the study location and those that have no knowledge about the material may be leaving in areas where stigmatization of the material still exists. Furthermore willingness to utilize the material is very high and those who are not willing to utilize the material might be positively affected if the numerous benefits and advantages of using the material are exposed to them.

The high level patronage of burnt bricks within the study area can be attributed to the availability of the material within the study area and its superior properties.

With burnt bricks quality is assured and the users have value for their money. Again maintenance needs are minimized due to high strength of bricks and the aesthetic appeal of

the bricks eliminates plastering. Thus with burnt bricks the problem of durable and affordable housing can be solved.

Burnt bricks usage is still facing discrimination and the reluctance of professionals in adopting burnt bricks for housing construction is justified by its problem of mass production, lack of standards and constructability problems.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made:

a) Showcase on construction using burnt bricks projects through the media should be adopted by relevant stakeholders to boost the confidence of users and bring to fore the numerous benefits derived from the use of the material.
b) Suitable and improved technologies should be adopted for the production of the material to ease mass production.
c) Standards should be formulated for the use of the material by the various local and international agencies on housing matters.
d) Trainings and seminars should be organized for masons and professionals in the construction industry for better application of the material.

5.4 Areas of Further Studies

a) Further studies should be carried out on more cost effective ways of producing the material.
b) Further studies should also be carried out with a larger scope.

5.5 Contribution to Knowledge

1. The research has established the suitability of locally manufactured burnt bricks for the construction of permanent and affordable housing in Benue state.
2. The research has also established the major challenges (such as; problem of mass production, social acceptability, lack of standards, constructability problem and transportation problem) associated with the use of locally manufactured burnt bricks that if taken care of would enhance better patronage of the material.
3. The study established suitable ways (such as; demonstration on the material through the media, organization of seminars and trainings for masons on the construction methodologies of the material, formulation of standards for the use of the material, development of suitable technologies for mass production of the material and agreement on specification and construction methods) to motivate and encourage stakeholders towards the use of locally manufactured burnt bricks
4. The study serves as a basis for further research work to those that would be interested in locally manufactured burnt bricks as a building material.

REFERENCE

Abiola, R. O. (2000). Management Implications of Trends in the Construction Cost in Nigeria from 1989-1999: *The Quantity Surveyor, 30 (2): 35-40*.

Adogbo, K. T. and Kolo, B. A. (1998). The Perceptions on the use of Indigenous Building Materials by Professional in the Nigerian Building Industry: Construction Focus, *Journal of Construction Management and Engineering*, 4(2):4-8.

Apebo, N. S., Iorwua, M.B., and Agunwamba, J. C. (2013). Comparative Analysis of the Compressive Strength of Concrete with Gravel and Crushed over Burnt Bricks as Coarse Aggregates. *Nigerian Journal of Technology (NIJOTECH), 3(1):7-12*.

Aramide, F. O. (2012). Effects of Firing Temperature on Mechanical Properties of Fired Masonry Bricks Produced from Ipetumodu Clay. *Leonard Journal of Sciences*, 21(4):70-82.

Baiden, B. Agyegum, K. and Ofori-kuragu, J. (2014). Perception on Barriers to the Use of Burnt Clay Bricks for Housing Construction: *Journal of Construction Engineering*. Retrieved at http://dx.doi.org/10.1155/2014.

Brick Institute of America (2006). *Manufacturing of Brick*. Technical Notes on Brick Construction: Brick Institute of America Reston Virginia, retrieved at www.gobrick.com.

Clay brick Association. (2002). *Technical Guide to Clay Brick and Brickwork*. First Edition.

Cultrone, G., Sebastián, E., Elert, K., De La Torre, M. J., Cazalla, O. and Rodriguez, N. C. (2004). Influence of mineralogy and firing temperature on the porosity of bricks. *Journal of the European Ceramic Society*, 24(3):547–564.

Danso, H. (2013). Building houses with locally available materials in Ghana: Benefits and Problems. *International Journal of Science and Technology*, 2(2) 225-231.

Danquah, J. A. (2009). *Production of Affordable but Quality Housing for the Low Income Urban Dwellers: "Promoting the use of Local Building Materials*". Retrieved at www.hdm.ith.se/alumni/papers/SDD. retieved 07/05/2015

Danquah, J. A., Abrokwah P. O., Twumasi A. and Ankrah J. S. (2015): Appraisal of Burnt Bricks as a Building Material in Ghana. *International Journal of Scientific Research and Education*, 3(1): 2814-2826.

Deboucha, S. and Hashim, R. (2011). A review on Bricks and Stabilized Compressed Earth Blocks. *Journal of Science Research and Essay*, 6(3): 433-506.

Duggal, S. K. (2012). *Building Materials*. New Age International Publishers, New Delhi. pp 8-33.

Elert, K., Cultrone, G., Navarro, C.R. Pardo, S.E. (2003). Durability of bricks used in the conservation of historic buildings—influence of composition and microstructure. *Journal of Cultural Heritage*, 2(1):91–99.

Encarta English dictionary (2009): retrieved at www.microsoft Encarta.com.

Fernandes, F. and Lourenco, P.B. (2007). Evaluation of the compressive strength of ancient clay bricks using microdrilling. *Journal of Materials in Civil Engineering*, 19(9):91-800.

Fernandes, F.M., Lourenco, P.B. and Castro, F. (2009). Ancient Clay Bricks: Manufacture and Properties in Bostenary et al (Eds) *Materials, Technologies and Practice in Historic Heritage Structures.* Springer Science + Business Media B.V

Food and Agricultural Organisation of the United Nations. (1993). *Status and Development Issues of the Brick Industry in Asia.* Printed by: FAO Regional Wood Energy Development Programme, Asia, Bangkok, Thailand.

Gidagasu, M.D. (1976). *Laterite Soil Engineering*, Elsever Scientific Publishing Company, New York, 238.

Hamer, Frank, and Janet (2004). *The Pothers dictionary of materials and techniques*. Fifth Edition. A&C Black Publishers Ltd (London) and University of Pennsylvania Press Philadelphia.

Hamilton, E. (1995). "*Laterite- The whole Story" Everything You Want to Know about Laterite.* Retrieved at www.thekrib.com/plants/fertilizer/laterama.html.

Kabiraj and Mandal (2012). Experimental Investigation and Feasibility Study on Stabilized Compacted Earth Block Using Local Resources. *International Journal of Civil and Structural Engineering*, 2(3):12-28.

Kumar, S. (2013). *Manufacturing of Bricks part 3: Drying*. Retrieved at Blogspot.com/2013/08. Accessed 31/01/2015.

Maton, D. J., Danjuma, G. A., Didel, J. M., and Edom, A. (2014). *Quality Application and Cost Benefits of NBRRI Interlocking Blocks as Solution to Nigerian Affordable Housing Aspirations.* Proceedings of International Conference on Achieving Affordable Housing in Nigeria: Housing Summit by the Nigerian Building and Road Research Institute.

MCwhirr, A. (1979). *Roman Brick and Tiles: Studies in Manufacture, Distribution and Use in the Western Empire*. British Archeological Reports, no. 68 Oxford

Mesida, E.A. (1978). Utilization of Some Lateritic Clays for Burnt Bricks. *Journal of Mining and Geology*, 15(2):114.

Miller, R.S. (1999); "*Laterite and Clay": Everything You Want to Know about Laterite*, retrieved at www.thekrib.com/plants/fertilizer/laterama.html.

Njoku, J. (2012). Dearth of Affordable Building Materials: Experts Proffer Solutions. *Vanguard Newspaper Publication*.

Odunjo, O.O., Oladimeji, S. B. and Okanlawon, S. A. (2015). Public Acceptability of Burnt Bricks for Mass Housing Projects in Illorin, Nigeria. *Journal of Civil and Environmental Research*, 7(3). www.iiste.org .

Olawuyi, B.J., Olusola, K.O., Ogunbode, E.B. and Kyenge, S.S. (2010). Performance Assessment of Makurdi Burnt Bricks: Construction Focus, *Journal of Construction Management and Engineering*, 3(1):11-23

Olunsanya, O. (1991). Towards an Intermediate Building Technology, Materias and Construction Methods. *Journal of the Federation of Building and Civil Engineering Constructors in Nigeria*, 8(1):3-12.

Olusola, K.O. (2005). *Factors Affecting Compressive Strength and Elastic Properties of Laterized Concrete"*, An Unpublished Ph.D. Thesis Department of Building Obafemi Awolowo University Ile-Ife.

Omole, F.K. and Bako, A.I. (2013). Analysis of the Problems and Prospects in the use of Local Building Materials: Review of Literature. *Civil and Environmental Research Journal*, 3(11): www.iiste.org.

Plumridge, A. and Meulenkamp, W. (1993). *Brickwork*, Breslich and Foss Publishers, London. ISBN 0987-4987.

Rajput, R.K (2006). *Engineering Materials* S. Chand and Company Limited, New Delhi India.

Riza, F. V., Rahman, I. A. and Zaidi, A. M. (2011). Preliminary Study of Compressed Stabilized Earth Brick (CSEB). *Australian Journal of Basic and Applied Sciences*, 5(9): 6-12.

Rodriguez, R. (2015). Bricks and Bricks Advantages. Retrieved from About.com.html on 8/4/201

Sa'ad, M. M. (2006). *Comparative Study of Pozzolanic Activities of Selected Nigerian Burnt Bricks.* An Unpublished Msc Thesis Submitted to the Department of Industrial Design Ahmadu Bello University Zaria.

Spence, J. S. and Cook, D. J. (2007). *Building Materials in Developing Countries*. University of Michigan, John Wiley and Sons Inc. New York.

Svare T. I. (1974). *Better Burnt Bricks*; A Technical Pamphlet: by National Housing and Building Research Unit Ministry of Lands, Housing and Urban Development Dar es Salaam, University of Nairobi Publishers ISSN 02392272.

The Brick Dictionary (2010-2014). *The History of Bricks and Brickmaking*. English Heritage retrieved at www.expressbrick.com http://www.brick

Tse, A. C. (2012). Suitability of Flood Plain Deposits for the Production of Burnt Bricks in Parts of Benue State, Central Nigeria. *Journal of Mining and Geology, Nigerian Mining and Geosciences Society,* 2 (2):1-6 DOI:10.5923/j.geo201202.01

Ushie, F. A. and Anike, O. L. (2010). Utilization of laterite Clays for Burnt Bricks and other Earthen Wares in Obudu Area S.E Nigeria. *Scientia Africa*. 9(2): 59-67.

Zakari, M. and Akani, M. (2013). Earthen Construction, as a Solution to Building Industries in Ghana. *Journal of Economics and Sustainable Development*, 4(3):3-8.

Zami, M. S. and Lee. A. (2011). Widespread Adaption of Contemporary Earth Construction in Africa to address Urban Housing Crisis. *The Built and Human Environment Review*, 4(2)

APPENDIX

DEPARTMENT OF BUILDING

FACULTY OF ENVIRONMENTAL DESIGN

SCHOOL OF POST GRADUATE STUDIES,

AHMADU BELLO UNIVERSITY, ZARIA.

QUESTIONNAIRE SURVEY

Dear respondent

AN EVALUATION OF PROBLEMS AND PROSPECTS OF LOCALLY MANUFACTURED BURNT BRICKS FOR HOUSING CONSTRUCTION IN BENUE STATE.

This questionnaire is part of an M.Sc Dissertation research of Ahmadu Bello University Zaria, Nigeria as part of the requirement for the award of M.Sc Construction Management. It is designed to obtain relevant information on the above mentioned research work. The topic is being studied as an academic work and also as a contribution to the construction industry. Respondents are assured that all information shall be treated as confidential.

Thank you.

Koko Kundushima T

QUESTIONNAIRE FOR PRACTITIONERS IN THE CONSTRUCTION INDUSTRY

Section A: Respondents Profile

Please tick (√) one as appropriate.

1. Your Profession? (a) Builder [ ] (b) Engineer [ ] (c) Architect [ ]
   (d) Quantity surveyor [ ] Others specify……
2. Highest level of educational qualification obtained (a) OND [ ] (b) HND [ ]
   (c) PGD [ ] (d) BSC [ ] (e) MSC [ ] (f) PHD [ ] (g) others (please specify)…
   ……
3. Highest level of professional qualification attained (a) Fellow [ ]
   (b) Corporate [ ] (c) Graduate [ ] (d) Associate [ ] (e) Non member (f) others (please specify)……
4. Which sector of the construction industry are you engaged? (a) Govt [ ]
   (b) Private sector company [ ] (c) Private practice [ ]
   (d) Others (please specify) ……

Section B (Assessment of the level of use of locally manufactured burnt bricks for housing construction)

1. What is your assessment on the level of use of burnt bricks in your area? (a) Very High [ ] (b) High [ ] (c) Average [ ] (d) Low (e) Very Low
2. In your locality what section of the population patronizes burnt bricks most?
   (a) High income earners [ ] (b) Medium income earners [ ] (c) Low income earners [ ]
3. Which part of the building will you prefer burnt bricks to be used? (a) whole [ ]
   (b) Only front [ ] (c) Fence wall [ ] (d) Columns and arches [ ]
   (e) Foundation [ ] (f) others (please specify)…….

Section C (Barriers to the use of burnt bricks for housing construction)

1. Please kindly rank the following barriers to the use of locally manufactured burnt bricks for housing construction.

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

S/NO	Market barriers to the use of burnt bricks	1	2	3	4	5
1.	Low demand					
2.	Excessive cost implication					
3.	Transportation problem					
4.	Social acceptability					
5.	Unavailability of burnt bricks when needed					
6.	Inadequate supply of clay					

S/NO	Technological barriers to the use of burnt bricks for housing construction.	1	2	3	4	5
1.	Doubtful durability and life span					
2.	Constructability problem					
3.	Problem of mass production					
4.	Non compatibility with other materials					
5.	Structural problem					
6.	Lack of standard					
7.	Low aesthetic value					

Section D (Benefits derived from the use of burnt bricks)

1. The following are some of the benefits that can be derived from the use of burnt bricks, please rank them accordingly.

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

S/NO	Benefits derived from the use of burnt bricks	1	2	3	4	5
1	Provision of affordable housing					
2	Reduction in the cost of construction					
3	Provision of employment opportunities					
4	Meeting increased demand for housing stock					
5	Use of environmental friendly resources					
6	Development and propagation of indigenous					

	technological ingenuity and skill of the local people.					
7	A good measure of conserving foreign exchange					
8	Enlargement and promotion of the economic strength of people and the country at large					

Section E (Ways to increase awareness and motivate stakeholders towards the use of locally manufactured burnt bricks).

1. The following are ways to increase awareness and motivate stakeholders in the construction industry to participate in the use of burnt bricks for housing construction. Please rank them accordingly.

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

S/NO	**Possible ways**	**1**	**2**	**3**	**4**	**5**
1	Showcase on construction using burnt bricks projects through the media					
2	Organization of seminars and trainings for masons					
3	Development of suitable technology for mass production of the material					
4	Formulation of standards for the use of the material by the various local and international agencies on housing matters					
5	Agreement on specifications and construction methods					

QUESTIONNAIRE FOR HOUSE OWNERS

Section A (Assessment of public acceptance of burnt bricks for housing construction)

1. Are you familiar with locally manufactured burnt bricks? (a) Yes [ ] (b) No [ ] (c) undecided [ ]

   If yes, answer the following questions if no please ignore.

2. Will you use locally manufactured burnt bricks to construct your house? (a) Yes [ ]

(b) No [ ] (c) undecided [ ]

3. Please kindly rank the following criteria that determine the utilization of burnt bricks accordingly.

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

S/NO	**Criteria that determine utilization of burnt bricks**	**1**	**2**	**3**	**4**	**5**
1	Durability					
2	Cost effectiveness					
3	Availability					
4	Compatibility with other materials					
5	Recommendation from professionals					

Section B (Performance in use of locally manufactured burnt bricks)

1. Please kindly rank the performance in use of locally manufactured burnt bricks.

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

S/NO	**Factors of performance**	**1**	**2**	**3**	**4**	**5**
1	Durability					
2	Aesthetics					
3	Cost saving					
4	Thermal comfort					
5	Strength					
6	Resistance to environmental conditions					
7	Health benefits					
8	Resistance to water ingress					
9	Serviceability and maintainability					
10	Fire resistance					
11	Bullet proof					