

Research Article

Perceptions on Barriers to the Use of Burnt Clay Bricks for Housing Construction

Bernard K. Baiden, Kofi Agyekum, and Joseph K. Ofori-Kuragu

Department of Building Technology, Kwame Nkrumah University of Science and Technology, Private Mail Bag, Kumasi, Ghana

Correspondence should be addressed to Kofi Agyekum; agyekum.kofil@gmail.com

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Burnt clay bricks can be readily manufactured in Ghana as all ten regions have significant clay deposits with the Ashanti region having the highest estimated deposit of 37.1 million metric tonnes. In recent times, burnt clay bricks have been regarded as old fashioned and replaced by other perceived modern walling units within Kumasi, the metropolitan capital of Ashanti Region, despite its availability, unique advantages (aesthetics, low maintenance cost, etc.), and structural and nonstructural properties. This study involved a questionnaire survey of 85 respondents made up of architects, brick manufacturing firms, and brick house owners or occupants in the Kumasi Metropolis of Ghana and sought to examine their perceptions on barriers to the use of burnt clay bricks for housing construction. The findings revealed that the key factors inhibiting the use of burnt clay bricks for housing construction are low material demand, excessive cost implications, inappropriate use in construction, noncompatibility of burnt clay bricks with other materials, unreliable production, and transportation problems. The findings however provide a platform for stakeholders to address the barriers to enable the extensive use of clay bricks in housing constructions.

1. Introduction

The construction industry is very vital to the socioeconomic development and, in many countries, the yardstick for the measurement of national progress is hinged on the degree of contributions of the construction industry. The building materials sector is also a major contributor to the construction industry of every nation because materials constitute the single largest input in construction often accounting for about half of the total cost of most or any construction products [1–5]. Furthermore, Adedeji [6] noted that about 60% of the total house construction cost goes towards the purchase of construction materials. According to Abanda et al. [7] the share of materials often used in construction is huge and most other factors depend on them.

A report by the United Nations revealed that the building materials sector was split into three production groups [8]: modern or conventional building materials which are based on modern conventional production methods like concrete, steel, and glass; traditional materials which include those materials that have been in local production from ancient

times using small-scale rudimentary technologies, for example, laterite, gravel, thatch, straw, stabilised mud, Azara, and raphia palm; and innovative materials which are materials developed through research efforts aimed at providing alternatives to import-based materials, for example, fibre-based concrete and ferrocement products [9, 10].

The population of Ghana was estimated to be over 20 million in the year 2000 and projected to be 35 million by the year 2025. Results from the 2010 population census indicated that Ghana's population stood at 24, 233, and 431. Available data also shows that the housing deficit in Ghana is in excess of 800,000 housing units. Housing supply growth varies between 25,000 and 40,000 units per year as against the annual requirements of 100,000 units [11].

This requires that more housing units would have to be constructed to satisfy the growth rate of about 1.822%.

The most popularly used walling unit for housing construction in the two most densely populated regions of Ghana, Greater Accra, and Ashanti is the sandcrete block, whilst some remote areas have most of their housing units constructed with mud or earth [11]. The rate of urbanization

varies from one administrative region to another in Ghana [11]. The Ashanti region shows an average of 32% urban residency second to Greater Accra region with 58% [11]. In order to meet the increasing population and urbanization in Ghana, the housing units or stock will have to increase. To achieve this, it is very important to look into the possibilities of using available local materials which would be cost-effective.

Studies have shown that despite the modern and innovative materials in the market, there is still the need to return to traditional materials [8]. In Nigeria, for instance, Abiola [12] identified building materials as one of the principal factors affecting the effective performance of the Nigerian construction industry. In Ghana, the Building and Road Research Institute, BRRI [13], reported that despite the commendable performance and properties of burnt clay bricks, the usage of sandcrete blocks containing cement, produced from clinker which is imported, is widespread [13]. According to BRRI [13], if part of the expenditure currently incurred in the importation of clinker is invested in the production and usage of burnt clay bricks, some substantial gains could be made in solving the nation's housing deficit. Though several researchers worldwide have called for the need to revert to indigenous building materials [8, 13–18], little is being said about the factors inhibiting the use of such materials in Ghana [19]. For many years, the government of Ghana has tried to find suitable ways to solve the housing problem of the country through various means. One of such means is trying to encourage the use of indigenous local materials such as burnt clay bricks and tiles [20]. The efforts to construct more houses have become a priority because the country is said to have a housing deficit of 1.5 million [20]. The critical factor in making the extraction of clay an available proposition is the proximity of a market to absorb the bricks. This study presents the findings of the perceptions of architects, burnt clay brick manufacturers, and owners or occupants of burnt clay brick houses and the reasons behind the apparent low usage of burnt clay bricks for building construction in the Kumasi Metropolis.

2. Brief History of Clay Bricks in Ghana

Clay bricks are man-made materials that are widely used in building, civil engineering work, and landscape design [20]. The history of clay bricks in Ghana dates back to the precolonial era [21] as can be observed from the existence of some old brick buildings in Accra, Kumasi, Cape Coast, and Takoradi. One of the legacies of the colonial government was the scattered pieces of colonial and government flats built with clay bricks dotted within the countries especially along the coastal areas [21].

According to Hammond [21], the practice of burnt clay brick manufacturing for housing died down until after the Second World War. Before and during the war, the missionaries, notably, Basel, and Scottish missionaries continued to produce bricks and tiles on a small scale and all the skills were taught at their teacher training colleges and schools [21]. Hammond [21] further reported that in 1954, the Ghana

Industrial Holding Corporation (GIHOC) set up a brick and tile factory in Ghana and the demand for the products were very high. Heading towards the later part of the 1960s, new bricks and tiles factories were set up in Ghana following the success of GIHOC. Through a mass importation of Brazilian brickmaking machines, more factories were established in the late 1970s and early 1980s [21]. However, their products exerted little impact on the building construction industry following the closure of many large-scale factories [19]. Research was initiated to support the industry and focused on clay evaluation and kiln design. The research later focused on identifying the poor performance of the brick and tile industry to find means of overcoming the problems [21].

3. Properties of Bricks

Generally, a good brick must be hard, well burnt, uniform throughout, sound in texture and colour, and sharp in shape and dimension and should not break easily when stuck against another brick or dropped from a height of about one meter [22]. In using burnt clay bricks for construction, certain desirable properties should be achieved. Among these desirable properties are compressive strength, density, thermal stability, porosity, sound insulation, fire resistance, durability, and so forth.

Compressive strength is a mechanical property used in clay specifications which has assumed great importance for several reasons [23, 24]. Compressive strength is easy to determine whereas other properties are difficult to evaluate [23, 24]. A higher compressive strength increases other properties like flexure, resistance to abrasion, and so forth [23]. Compressive strength is the only property of brick which can be determined accurately [25]. Compressive strength depends on the raw materials used, the manufacturing process, and the shape and size of the brick. The crushing resistance varies from about 3.5 N/mm^2 for soft facing bricks to 140 N/mm^2 for engineering bricks when tested in the dry state [23]. Generally, compressive strength decreases with increasing porosity, but strength is also influenced by clay composition and firing [24].

Density is described as the ratio between the dry brick weight and the volume of the clay brick, measuring the proportion of matter (clay) found in the volume. It is evident from this description that the higher this value is, the denser the brick is, and obviously, the better its mechanical and durability properties are. Typical values for the apparent density range from $1,200 \text{ kg/m}^3$ to $1,900 \text{ kg/m}^3$ [26].

Bricks generally exhibit better thermal insulation property than other building materials such as concrete. Perforation can improve the thermal insulation property of bricks to some extent. The mass and moisture of bricks help to keep the temperature inside a brick house relatively constant. The thermal conductivity of bricks measured at various water content and densities have shown that the thermal conductivity of denser bricks are higher than less dense bricks [27]. The increase in thermal conductivity due to wetting varies from brick to brick and may be as low as five percent (5%) or as high as thirteen percent (13%) for

one percent (1%) increase in moisture content. Generally, the thermal conductivity is doubled when it is saturated with water. The thermal conductivity of bricks varies between 0.7 and 1.3 w/mk [27].

Porosity can be defined as the ratio between the volume of void spaces (pores and cracks) and the total volume of the specimen. 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 [26]. The amount of water a brick or a brick structure absorbs varies depending on the properties of the brick. The dimension and distribution of the pores are influenced by the quality of the raw clay, the presence of additives or impurities, the amount of water, and the firing temperature. Cultrone et al. [28] observed that if the firing temperature increases, the proportion of large pores (3–15 μm) 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, several studies by Cultrone et al. [28] and Elert et al. [29] reported that the formation of small pores, with a diameter below 1 μm , 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. A similar conclusion was given by Winslow et al. [30] for bricks with a pore size smaller to 1.5 μm .

Brick walls also have good insulation properties due to their dense structure. The sound insulation of brickwork is generally 45 decibels for 4.5 inch thickness and 50 decibels for a 9 inch thickness for the frequency range of 200 to 20000 Hz which is specified for buildings [31].

Brick has excellent fire resistance. 100 mm brickwork with 12.5 mm normal plastering would provide a fire-resistance of 2 hours and 200 mm nonplastered brickwork would give a maximum rating of 6 hours for nonload bearing purposes. Bricks can support considerable load even when heated to 1000°C in contrast to a concrete wall which can sustain the same load only up to 450°C due to loss of water of hydration [31].

The durability of a material is its ability to withstand a particular recurrent weathering effect without failure [23]. Burnt clay bricks are extremely durable and perhaps are the most man-made structural building material so far. There have been numerous ancient brick buildings standing for centuries as a testimony of the endurance of burnt-clay bricks [24].

4. Sizes of Clay Bricks Used in Ghana

The extensive use of bigger 18'' \times 9'' \times 6'' sandcrete blocks makes it very difficult for small-size standard bricks to compete with it [32]. On the other hand, clay bricks cannot be made in bigger sizes due to danger of cracking on drying and burning which is an inherent property of clay, unless brick is made hollow or perforated. For this reason, solid clay bricks

TABLE 1: Sizes of clay bricks proposed by BRRI for use in Ghana.

Type	Nominal	Actual	Mould size
Metric (modular) cm	20 \times 10 \times 10	19 \times 9 \times 9	20 \times 9.5 \times 9.5

Source: BRRI [13].

are generally made in standard size which is 20 cm \times 10 cm \times 10 cm nominal units. Actual size of brick is slightly less than this as it includes thickness of mortar joint [32]. Actual size of finished bricks and required sizes of green bricks for two nominal sizes are given in Table 1.

5. Sustainability Importance of Clay as an Indigenous Material

Sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs [33, 34]. Brick masonry has been a primary technique of the built environment for at least seven millennia and this makes it one of the oldest construction technologies still in use [35]. Recently clay bricks have come under different kinds of fire due to their environmental impact [35]. Fired clay bricks have certain inherent, sustainable properties such as durability and high thermal mass, whereas the kilning process has raised some sustainable concerns because of energy consumption and greenhouse gas emissions [35]. New ways have been sought by the brick industry to address sustainability, altering certain time-honoured practices [35].

Sustainability is an umbrella concept that has come to encompass efforts to address a multitude of “environmental sins” [35]. Sustainability issues surrounding brick manufacture (and construction processes in general) include raw materials consumption, recycled content, embodied energy, and greenhouse gas emissions [35]. According to the Brick Industry Association, BIA, [33], every sustainable building is unique and designed specifically for its site and the programming requirements of the user. However, all high-performance, sustainable buildings should consider certain components of design such as environmentally responsive site planning, thermal comfort, renewable energy, water efficiency, safety and security, and acoustic comfort among others [33]. The versatility and durability of brick facilitate its use as part of many elements of sustainable design [33].

6. Materials and Methods

A multiple research approach was adopted to carry out the current study. The study involved a questionnaire survey of senior architects of architectural firms, brick manufacturing firms, and inhabitants of brick housings in the Kumasi Metropolis of Ghana and aimed at examining the key barriers to the use of burnt clay bricks in housing construction. Face-to-face interviews and physical observations were also carried out to aid in the data gathering.

Data from the Architects Registration Council of Ghana [36] and The Building and Roads Research Institute (BRRI) indicated that there are 16 fully registered architectural firms

TABLE 2: Perceptions of architects on barriers to the use of burnt clay bricks.

Barriers	Frequency	Percentage	Rank
Quality of output (poor workmanship)	12	75%	5th
Low demand for burnt clay bricks	14	88%	2nd
Inappropriate use of burnt clay bricks in construction	14	88%	2nd
Limitation in design forms	10	63%	7th
Inadequate supply of clay	1	6%	11th
Structural problems	1	6%	11th
Excessive cost implications	15	94%	1st
Noncompatibility with other materials	13	81%	4th
Transportation problems	9	56%	9th
Constructability problems	10	63%	7th
Psychological problems	9	56%	9th
Unavailability of burnt clay bricks when needed	12	75%	5th

in good standing and 9 active burnt clay bricks manufacturing companies in the Kumasi Metropolis. Using a census sampling approach the respondents (senior personnel) from the architectural and burnt clay brick manufacturing firms were selected and interviewed. This sampling approach was used because a census is attractive for small populations of 200 or less as it eliminates sampling error and provides data on all individuals in the population [37]. Information on the total number of inhabitants living in burnt clay bricks in Kumasi was difficult to obtain. As a result, convenience purposive sampling approach was adopted to select 60 inhabitants living in burnt clay bricks in Kumasi for the study. All 85 questionnaires were sent out to the various respondents. The questionnaire was administered through a face-to-face session which ensured the participation of all the 85 respondents, bringing the response rate to 100%. The questionnaire was divided into two main sections. The first part sought information on their experiences with the use of burnt clay bricks and the second part sought information on their perceptions on barriers to the use of burnt clay bricks in the metropolis. Data obtained from the questionnaire surveys were analysed with SPSS, Version 20 based on their frequencies.

7. Results and Discussions

7.1. Experiences with the Use of Burnt Clay Bricks. All the respondents demonstrated in-depth knowledge on the use of burnt clay bricks in housing. Twelve (12) out of 16 senior architects interviewed indicated that they had been actively involved in the use of burnt clay bricks for housing before. According to these respondents, they had frequently been involved in the design of burnt clay bricks for clients for about 8 years of their practices. These architects further stated that though they had been involved in the design of these housings, clients normally shied away when they recommended burnt clay bricks to them as alternative building materials.

The opinions on the experiences of the 60 inhabitants living in burnt clay brick housings were sought. For the interviewed inhabitants, about 50 of them opted to build with burnt clay bricks because of its aesthetic appeal. All the

interviewed inhabitants indicated several reasons for their choice of burnt clay bricks. All the interviewed inhabitants indicated several reasons for their choices of burnt clay bricks. Among the reasons are that burnt clay bricks are aesthetically appealing, could be used without painting and are unique in nature.

The experiences of the senior members interviewed from the nine burnt clay bricks manufacturing firms were further sought. According to the respondents, their respective firms produced burnt clay bricks and these bricks were mainly purchased for government housing projects. The respondents further indicated some of their major challenges to include the outskirts locations of the factories and unavailability of burnt clay bricks when needed.

7.2. Barriers to the Use of Burnt Clay Bricks in the Kumasi Metropolis. The perceptions of the various respondents on barriers to the use of burnt clay bricks are presented in Tables 2 to 4. The results in the tables also show the frequencies, percentage of responses, and ranking of the barriers by the respondents.

Table 2 shows that the architects interviewed identified “excessive cost implications,” “low demand for burnt clay bricks,” “inappropriate use of burnt clay bricks in construction,” “noncompatibility with other materials,” and “quality of output (poor workmanship)” as the five most important factors that inhibit the use of burnt clay bricks in construction in the Kumasi Metropolis. However from Table 3, the perceptions of the burnt clay bricks manufacturers, “unavailability of burnt clay bricks when needed,” “transportation problems,” “excessive cost implications,” “low demand for burnt clay bricks,” and “inappropriate use of burnt clay bricks in construction” are the five main barriers hindering the use of burnt brick clays in construction in the metropolis. The results, as shown in Table 4, further indicate that the inhabitants of burnt clay brick houses consider “quality of output (poor workmanship),” “low demand for burnt clay bricks,” “excessive cost implications,” “noncompatibility with other materials,” and “unavailability of burnt clay bricks when needed” to be the major factors that inhibit the use of burnt clay bricks in construction in the Kumasi metropolis.

TABLE 3: Perceptions of manufacturers on barriers to the use of burnt clay bricks.

Barriers	Frequency	Percentage	Rank
Quality of output (poor workmanship)	4	44%	6th
Low demand for burnt clay bricks	7	78%	3rd
Inappropriate use of burnt clay bricks in construction	6	67	5th
Limitation in design forms	3	33%	8th
Inadequate supply of clay	1	1%	11th
Structural problems	3	33%	8th
Excessive cost implications	7	78%	3rd
Noncompatibility with other materials	2	22%	10th
Transportation problems	8	89%	2nd
Constructability problems	4	44%	6th
Psychological problems	3	33%	8th
Unavailability of burnt clay bricks when needed	9	100%	1st

TABLE 4: Perceptions of house owners/occupants on barriers to the use of burnt clay bricks.

Barriers	Frequency	Percentage	Rank
Quality of output (poor workmanship)	55	92%	1st
Low demand for burnt clay bricks	50	83%	2nd
Inappropriate use of burnt clay bricks in construction	25	42%	6th
Limitation in design forms	15	25%	8th
Inadequate supply of clay	5	8%	11th
Structural problems	4	7%	12th
Excessive cost implications	48	80%	3rd
Noncompatibility with other materials	35	58%	4th
Transportation problems	20	33%	7th
Constructability problems	15	25%	8th
Psychological problems	10	17%	10th
Unavailability of burnt clay bricks when needed	29	48%	5th

It could be seen from the results of this study that all the three respondent groups had different perceptions on why the materials are not being used in housing construction. For the architects, their main challenge was the cost aspect of the material. To the manufacturers, unavailability of burnt clay bricks due to seasonal changes together with transportation problems were issues of major concern. The occupants on the other hand in most cases were concerned about the poor quality of outputs arising from poor workmanship.

Several possible reasons have been identified from the literature for the persistent discrimination in the use of indigenous building materials of which burnt clay bricks are part. These reasons include doubtful durability and life span of the materials, low aesthetic value, poor social acceptability by the general public, noncommercial status, and lack of standards [2, 4, 8]. From the results of the current study, it could be deduced that “low demand for burnt clay bricks,” “excessive cost implications,” “inappropriate use of burnt clay bricks in construction,” and “noncompatibility with other materials” among others are barriers to the use of burnt clay bricks in construction in the Kumasi Metropolis.

From these findings, it can be deduced that these barriers do exist and the variableness of projects and locations could have largely influenced the respondents’ choices. However,

the existence of these barriers should not be viewed as a reason to abandon burnt clay bricks but could be a worthy challenge to enhance its acceptance and uptake by the construction industry.

8. Conclusions

Even though burnt clay bricks have the potential for adoption as alternatives to conventional building materials, this study has found them to suffer persistent discrimination. In Ghana, several studies have been conducted by the BRRI into the use of burnt clay bricks, but the implementation of the results of the studies has been limited by inadequate patronage of the product. Furthermore, the use of burnt clay bricks in the construction of buildings has been inhibited by several barriers. From the perceptions of the respondents interviewed, “low demand for burnt clay bricks,” “excessive cost implications,” “inappropriate use of burnt clay bricks in construction,” “noncompatibility with other materials,” “unavailability of burnt clay bricks when needed,” and “transportation difficulties” are the main barriers to the use of burnt clay bricks in construction. Though the use of burnt clay bricks presents significant potential benefits, these are yet to be fully explored by professionals in the Ghanaian construction industry.

Retraining of professionals in the construction industry is recommended for better appreciation of the use of these materials. The cost of the materials should also be subsidized to encourage high levels and sustained production of burnt clay bricks. Clients should be educated on the benefits of using burnt clay bricks in housing constructions.

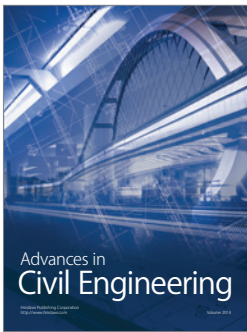
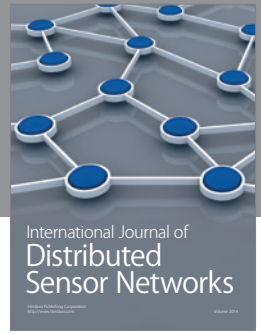
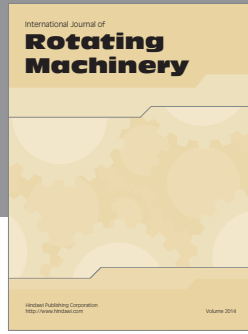
Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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