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Factors Inhibiting the Use of Indigenous Building Materials (IBM) in the Ghanaian Construction Industry.

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Abstract

The cost of construction in Ghana, as in many developing countries is increasing at an exponential rate. In spite of the numerous calls by stakeholders to incorporate the use of indigenous building materials (IBM) which seek to reduce cost of construction, the use of conventional building materials continue to dominate the construction industry. This paper seeks to investigate factors that inhibit the use of IBM in the Ghanaian construction industry, from the professional's perspective. The study adopted a self-administered questionnaire survey of 120 Architects, Quantity Surveyors, and Structural Engineers. The data was analysed using a relative importance index and Kendall's coefficient of concordance to establish the degree of agreement among the respondents. The results show that factors such as non-availability, inadequate strength, apathy towards the use of such materials, high initial cost of construction, low level of technical expertise, high maintenance costs, and a low level of education inhibit the use of IBM. It is recommended that government takes the initiative to use IBMs in its mass housing projects in order to attract the participation of private developers. This study is of value to the construction industry to reduce housing deficit and provide affordable houses.

Keywords*:* indigenous building materials, professionals, construction industry, Ghana

INTRODUCTION

Adequate shelter is considered as one of the most important basic human needs, yet about 25% of the world's population lacks decent homes and in African cities the housing shortage ranges from 33% to 90% (Zami and Lea, 2008; Boison, 2002). In view of this, no developing country without practical strategies for the utilization of low cost construction materials is likely to meet the growing demands of the industry (Kerali, 2001). While shelter conditions in the last few decades have been worsening, resources have remained scarce and costs of building materials have escalated due to increase in population, and the urgency to provide immediate practical solutions has become more acute (Kerali, 2001). Recent studies have reported that high cost of construction materials remains the most important cause of inadequate infrastructure (Olutoge, 2010; Sarfo-Ansah, 2010; Ayeh *et al.,* 2009; Oruwari *et al*., 2002; Lilly and Wai, 2001). Principally, the predominant use of conventional materials (cement, granite and sand) continues to hinder the provision of shelter and other infrastructural facilities in Ghana and other developing countries.

The use of IBM for construction and its associated benefits have been well documented in literature. For example, IBM requires simple tools and less labour, it is economically beneficial, it saves energy, promotes local culture and heritage through its construction, good fire resistant properties, good thermal comfort, a good sound absorbent which is a desirable quality in house design, and constructing with IBM requires thick walls which provide a sense of security (Zami and Lee, 2008; Hadjri *et al*., 2007; Minke, 2007; Morton, 2007; Hadjri *et al*., 2007; Adam and Agib, 2001; Lal, 1995; Cassell, 1993; Frescura, 1981).

Ghana is endowed with local raw materials for the manufacture of IBM. Since 1953, some national efforts have been made into promoting the development of indigenous building materials (Atiemo, 2005). Attempts by the governments to augment the informal sector in housing delivery have not been encouraging. Findings by the Building and Road Research Institute (BRRI) of the Council for Scientific and Industrial Research (CSIR), the Geological Survey Department of Ghana and others indicate that there are enough indigenous materials in all the ten regions of the country which are suitable for construction. This has resulted in the production of IBM such as burnt clay bricks and tiles, pozzolana cement, compressed and stabilized earth blocks for low cost housing in Ghana (Atiemo, 2005).

Surprisingly however, the proposal for houses to be constructed with indigenous materials has not been embraced as expected by key professionals of the industry (Architects, Structural Engineers and Quantity Surveyors). There is overdependence on conventional building materials for which local substitutes can be developed and for which there is comparative advantage for local production. It has therefore become necessary to investigate into factors that inhibit the use of these indigenous building materials in the Ghanaian Construction Industry.

LITERATURE REVIEW

The building materials sector of the construction industry is a major contributor to the success of the industry. This is because materials constitute the largest input in construction, usually accounting for about half of the total cost of construction projects (Fellows *et al* 1983; Mogbo, 1999). Cunningham and Cunningham (2002) defined indigenous building material as any material that is locally produced and manufactured, naturally occurring, and abundant in a country. Loken et al. (1994) also defined indigenous materials as materials which are produced in the same bioregion or regional ecosystem where they will be used. Some practitioners consider materials to be indigenous only if they are available on the same site where they will be used (Pearce, 2001). Indigenous materials also suffer from widespread but generally erroneous belief that a material is indigenous only if it is "primitive" and as such requires little or no processing between harvest and use (Owusu, 2001).

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

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

Generally, failure in IBM construction and the general unpopularity of the materials are due to lack of knowledge of properties of soils prior to their use in construction (Madedor and Dirisu, 1991). Recent investigations have revealed encouraging strength properties of traditional building materials for low cost construction. The properties of soils, for example, vary considerably depending on the dominant soil particle fraction forming the soil and the complex nature of its formation (Minke, 2007; Rigassi, 1985). Rigassi (1985) thus, posited that a thorough understanding of these properties ensure quality and proper performance of soil for building purposes. Laterite, for instance, has been used for wall construction around the world; it is cheap, environmentally friendly and abundantly available in the tropical region (Ukpata *et al*., 2012; Olugbenga *et al*., 2007). Osadebe and Nwakonobi (2007) reports that the compressive and flexural strength of laterite concrete were 27 MPa and 4.12 MPa respectively. The modulus of Elasticity, modulus of rigidity and poisson's ratios were also found to be 18888.9 MPa, 7495.6 MPa and 0.26 respectively for a mix proportion of 1:1:2:0.65 (OPC: laterite: granite: water). Based on the experimental results, it was concluded that laterite could be used in the construction of silos, reservoirs, etc. The results further revealed that strength properties of laterite are high and comparable to the strength properties of other conventional materials. Lanre and Mnse (2007) studied the influence of weather on the performance of laterized concrete. It was reported that specimens conditioned to a temperature range of 75 ^{o}C – 125^{o}C attained compressive strength as high as 22.52 N/mm^2. However, the study could not ascertain the critical failure temperatures. Soil stabilization involving the use of stabilizing agents in weak soils has been reported to improve the geotechnical properties of soils (Makusa, 2012). Though stabilized earth blocks may not generally be as strong in compression as sandcrete blocks, they are stronger than mud construction (Okyere et al, 2000).

METHODOLOGY

This study employed the quantitative research approach for the collection of primary data. The primary data collection instrument involved the use of structured questionnaire administered to three key professionals of the Ghanaian construction industry (i.e. Architects, Structural Engineers and Quantity Surveyors) to obtain precise information needed for hypothesis testing (Danesh *et al*., 2012). The questionnaire comprised of demographic information, barriers to the full utilization of indigenous building materials and measures for promoting the use of indigenous materials. To this end, twenty barriers and nine measures were identified from literature (Okereke, 2003; Adogbo *et al*., 2002; Sanusi, 1993; Hammond, 1984). The respondents were asked to indicate, based on their experience, the level of influence of each of the identified barriers and measures on a five-point Likert scale (1= Not very influential 2= Not influential 3= Neutral 4= Influential 5= Very influential).

The respondents were professionals in both private and public practice in Ghana, registered with the relevant professional associations. A total number of one hundred and twenty (120) questionnaires were distributed to construction professionals in Kumasi, Accra, Takoradi, and Sunyani. These geographical locations were selected because most of the target respondents are found in these cities and that residents in these areas continue to face acute housing shortage. Questionnaires were distributed through purposive sampling to Architects, structural engineers and quantity surveyors. To this end, respondents with at least 10 years practice in the Ghanaian Construction Industry were selected. Out of the 91 questionnaires retrieved, 82 were considered responsive resulting in a 68%.

From the professionals' viewpoint, the relative importance index (RII) (Iyer and Jha, 2005; Ugwu and Haupt; 2007; Danso and Antwi, 2012) was used to determine the relative importance of the identified factors inhibiting the use of the IBM and the measures to promote the use of IBM.

To determine whether there exists a significant degree of agreement among the three key professionals -Architects, Structural Engineers and Quantity Surveyors - with respect to their rankings, Kendall's coefficient of concordance was used (Enshassi *et al*., 2009; Moore *et al*., 2003; Frimpong *et al*., 2003). Kendall's coefficient of concordance, determined from equation 1, indicates the degree of agreement on a 0 to 1 scale (Enshassi et al., 2009), where coefficients (closer to 1) indicates a strong agreement and vice versa. This was determined as thus:

$$W = \frac{12U - 3m^2 n(n-1)^2}{m^2 n(n-1)} ------- (1),$$

Where: $U = \sum_{i=1}^{n} (\sum R)^2$, *n = number of factors, m = number of groups, j = the variables 1, 2, ……. N.*
Null hypothesis: H_0: There is no statistically significant degree of agreement among Architects, Structural Engineers and Quantity Surveyors.
Alternative hypothesis: H_1: There is a statistically significant degree of agreement among Architects, Structural Engineers and Quantity Surveyors.
This means that if $p < 0.05$ (the p-value indicates the level of significance) the null hypothesis, H_0, is rejected and the alternative hypothesis, H_1, is accepted.

RESULTS AND DISCUSSIONS

The average number of years of experience of the respondents was in the range of 10 to 15 years, indicating significant level of experience in the construction industry. It is seen from Fig. 1 that respondent Architects and Quantity Surveyors have average level of knowledge on IBM of 55%. Respondent Structural Engineers (64%) however, showed a higher level of knowledge on IBM. It is also seen from Fig. 1 that the professionals have very little knowledge of compressed soil blocks, followed by pozzolana and stabilized earth blocks in that order. Low levels of familiarity with these materials imply that, these professionals would least recommend them to prospective clients.

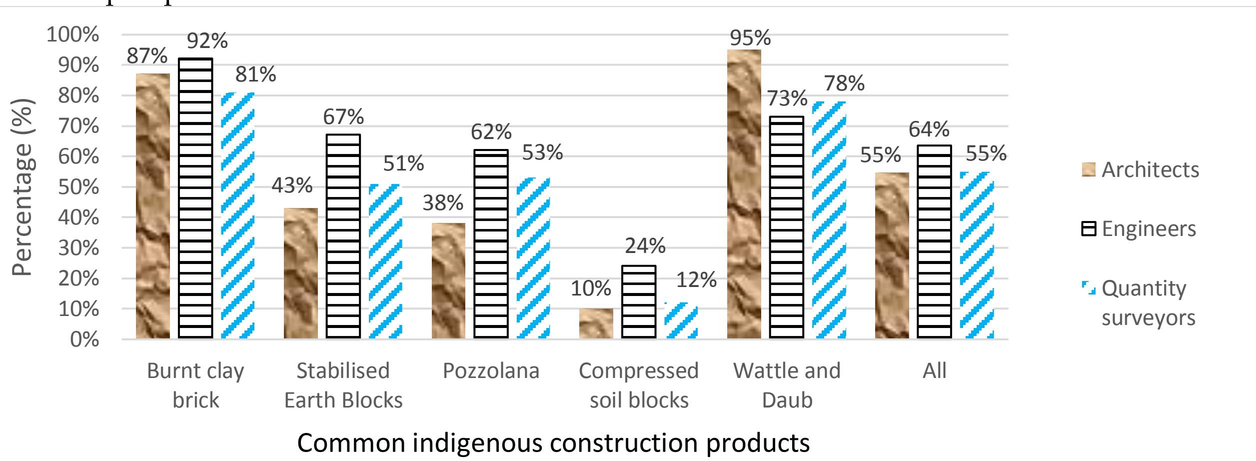

Fig. 1 Percentage distribution of Level of knowledge of some IBM by respondents

Factors that inhibits the use of IBM in construction

It can be inferred from Table 1 that the four most important factors that inhibits the use of IBM according to the perceptions of Architects, Structural engineers and Quantity Surveyors studied are: Inadequate strength requirements, lack of skilled manpower, unavailability of standards and inability of IBM to satisfy the needs of modern building forms and functions. It appears that, in the opinion of the professionals studied, the low strength of IBM which limits the extent to which the material can be used in construction is the most important factor. It was ranked first among structural engineers and Quantity surveyors with relative index (RII) = 0.911 and 0.908 respectively. However, it was ranked third by the Architects with a relative index (RII) = 0.805. This perception could be attributed to the weakness of traditionally made blocks which had very low compressive strength and durability when exposed to rain (Fadairo and Olutuah, 2013). However, this also shows that adequate information on the strength properties of these materials are still lacking. It is not surprising therefore that Architects and Quantity Surveyors ranked the problem of non-durability as 6th and 9th with RII of 0.789 and 0.768 respectively. This shows that the perception of non-durability of IBM is not recognized by Architects and Quantity Surveyors of the Ghanaian Construction industry. Fadairo and Olutuah (2013) confirmed that properties of laterite blocks can be improved upon controlling the moulding water content and increasing the compacting pressure during production. In a separate study, Adam and Agib (2001) pointed out that the use and adoption of the right stabilization method can improve the compressive strength of a soil by as much as 400% to 500% with other supplementary characteristics.

Another critical factor that hinders the use of IBM are the lack of skilled manpower, low level of technical know-how, unavailability of standards and the fact that IBM cannot satisfy the needs of modern building forms and functions among the three groups of respondents. These factors can be classified as technical barriers to the extensive use of IBM in the construction industry. This is in agreement with the assertion of Hammond (1984) that the overall effect of the technical deficiencies of locally produced building materials creates acceptability barriers. The training of manpower calls for increased investment. While standards are identified as the basic framework for promoting quality production, there are hardly any available standard for indigenous building materials (Adogbo *et al.*, 2002). As indicated in Table 1, structural engineers believe that the lack or unavailability of standards means that the output of the productive process will not have a basis for standardization and acceptance, hence its rejection. This finding is in agreement with the finding of Dunlap (1993) that a significant problem associated with the construction of earthen building materials is the lack of standard criteria for evaluating the finished product. It is expected that the provision of standards will not only provide a means of evaluation but will also boost investor and the users' confidence.

The lack of skilled personnel and technical know-how, especially in the indigenous building industry, is partly because the IBM has hitherto not been a principal building material. Unfortunately, it is the same factor which makes indigenous materials unattractive as building materials to the prospective house builder. Lack of access to sources of appropriate technical assistance and the perception of additional costs involved have also contributed to the low level

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of appreciation and application of these materials and technologies in the construction industry. Another important reason for the lack of skilled personnel has been the low patronage and investment in IBM.

Table 1 Summary of RII and rank for factors inhibiting the use of IBM

Barriers	Architects		Structural engineers		Quantity Surveyor	
	RII	Rank	RII	Rank	RII	Rank
IBM cannot satisfy the needs of modern building forms and functions	0.838	1	0.811	5	0.876	4
Lack of skilled personnel	0.812	2	0.800	6	0.888	3
Inadequate strength requirements	0.805	3	0.911	1	0.908	1
Unavailability of standards	0.801	4	0.889	2	0.858	5
Low level of technical know-how	0.791	5	0.824	4	0.900	2
They are not durable	0.789	6	0.863	3	0.786	9
Low demand for IBM by prospective clients	0.786	7	0.733	13	0.745	11
Apathy towards the indigenous building materials	0.781	8	0.797	7	0.841	6
High maintenance cost in the long-term	0.780	9	0.785	8	0.811	8
Non-availability due to low production capacity to meet increasing demands	0.775	10	0.765	11	0.713	14
Deep seated psychological resentment of the Public	0.755	11	0.781	9	0.772	10
Inappropriate use of the material	0.751	12	0.727	14	0.601	20
Poor Quality	0.738	13	0.777	10	0.706	15
Lack of awareness - low level of education	0.725	14	0.716	15	0.721	13
High initial cost of construction	0.701	15	0.708	16	0.822	7
Low value of buildings constructed with indigenous materials	0.692	16	0.681	18	0.700	16
Low level of investment in the indigenous materials industry by investors	0.681	17	0.681	18	0.612	19
Institutional barriers	0.673	18	0.748	12	0.661	18
Low level of importance attached to social status and its symbolism	0.632	19	0.609	20	0.679	17
Lack of basis for cost comparison between IBM and the conventional materials	0.611	20	0.701	17	0.738	12

According to the BRRI/CSIR (2009), the greatest problem with the use of indigenous building materials has been the negative perceptions attached to them over the years as being materials for the poor. On the issue of cost, Quantity Surveyors ranked 'high initial cost of construction' in the 7^{th} position but it is ranked 15^{th} and 16^{th} by Architects and Engineers respectively, indicating that the QS who are cost experts find the factor a more important barrier to promotion and use of IBM.

According to the UNCHS (2001), the deteriorating housing conditions in developing countries are mainly as a result of low levels of investment in the construction sector and in Africa, generally, an average of five percent of central government expenditure goes into housing. However, the issue of low level of investment was ranked 17^{th}, 18^{th} and 19^{th} by architects (RII=0.681), engineers (RII=0.681) and quantity surveyors (RII=0.612). This shows that investment in the housing sector should be directed towards developing the human resources to use IBM for construction.

The relative importance indices and rankings of the measures to promote the use of IBM in the Ghanaian construction industry are summarized in Table 2. The results indicate that all measures provided in the studied are critical in promoting the use of indigenous building materials. According to the Architects, Structural Engineers and Quantity Surveyors studied, a vigorous advertisement of the materials is very critical. This factor was ranked first among all respondents (Table 2). 'Production of construction manuals on IBM and 'training of manpower' were ranked either 2^{nd} or 3^{rd} by all respondents. Such measures would spread the technical know-how and ensure that skilled personnel would be available for the manufacture and use of indigenous building materials (Okyere *et al*., 2006).

Table 2 Measures to promote the use of IBM

Measures	Architects		Structural Engineers		Quantity Surveyor	
	RII	Rank	RII	Rank	RII	Rank
A vigorous advertisement of the materials	0.940	1	0.914	1	0.904	1
Production of construction manuals on IBM	0.902	2	0.900	2	0.872	3
Training of manpower	0.871	3	0.889	3	0.897	2
Advertise through public lectures/ seminars	0.847	4	0.875	4	0.822	6
Promulgate an enforceable National Housing Policy to promote the production and utilization of indigenous building materials at the national level	0.824	5	0.813	5	0.839	4
Increase research on the properties of IBM	0.800	6	0.744	7	0.765	5
Increase use of the materials by the professionals of the Industry	0.766	7	0.723	8	0.732	9
Government should promote the use of IBM in the construction of public buildings.	0.734	8	0.794	6	0.716	8
Provision of incentives for contractors who utilize local materials for their projects	0.636	9	0.714	9	0.774	7

Architects and Structural Engineers ranked the issue of promulgating an enforceable National Housing Policy which promotes the production and utilization of IBM at the national level 5th with RII of 0.824 and 0.813 respectively. However, this factor was ranked 4th with RII of 0.839 by quantity surveyors. The results show that there is a lack in awareness of these materials and the technologies due to inadequate promotion. Increasing research in this area is also found to be one of the critical factors in promoting the use of IBM as it was ranked by 6th (0.800), 7th (0.744) and 5th (0.765) by the architects, engineers and quantity surveyors respectively. Government should support research and encourage the use of local materials in construction of houses

Provision of incentives for contractors who utilize local materials for their projects was ranked 9th (RII=0.636 and 0.714) by the respondent Architects and Structural Engineers. This issue was ranked 7th by the Quantity Surveyors (RII=0.774). This is probably due to the fact that professionals and clients ultimately specify the building materials for the construction.

To determine whether there is a significant degree of agreement among the 3 groups of respondents i.e. Architects, Structural Engineers, and Quantity Surveyors, Kendall's coefficient of concordance was used. At 5% significance level, the p-values (Table 3) are less than $\alpha = 0.05$, thus, the null hypothesis, H_0 is rejected and the alternative hypothesis, H_1 is accepted (Table 3). Thus, it is said that there is a significant degree of agreement among the architects, structural engineers and quantity surveyors regarding factors inhibiting the use of IBM in Ghana. It is also seen that the Kendall's coefficient, W, between the three professionals was 0.890, indicating that the rankings of the three groups of respondents are strongly related.

Similarly, for the measures to promote the use of IBM, the p-values (Significance) are less than α = 0.05. Therefore, the null hypothesis, H_0 is rejected and the alternative hypothesis, H_1 is accepted (Table 3). This shows a significant degree of agreement among the architects, structural engineers and quantity surveyors on the measures to promote the use of IBM in Ghana. Additionally, the Kendall's coefficient (W) between the three professionals is 0.890 which shows a strong correlation among the three groups of respondents.

Table 3 Results of Kendall's coefficient of concordance

Survey items	Professionals	Mean rank	Kendall's W	Chi-Square	p-value	Significant difference (α = 0.05)
Barriers	Architects	1.82	0.890	89.006	0.000	No
	Structural engineers	2.02				
	Quantity surveyors	2.15				
Measures	Architects	2.22	0.89	40.048	0.000	No
	Structural engineers	1.89				
	Quantity surveyors	1.89				

CONCLUSIONS AND RECOMMENDATIONS

This paper considered factors that inhibit the use of indigenous building materials in the Ghanaian construction industry from the perspective of Architects, Structural Engineers and Quantity Surveyors. Some of the reasons found to have contributed to the lack of use of IBM include lack of skilled manpower, inadequate strength requirements, non-availability of standards for these materials, lack of technical know-how as well as the inability of the material to satisfy modern design forms. Additionally, the perceptions of low quality of IBM, apathy towards the indigenous building materials, coupled with the deep seated psychological resentment of the public are issues that hinder the use of the materials in the Ghanaian Construction Industry.

Respondents, however, believe that a vigorous advertisement of the materials, production of construction manuals on IBM, training of manpower and the promulgation of enforceable National Housing Policy to promote the production and utilization of IBM at the national level would go a long way promote the use the material in the construction industry. It was also found that there is a significant degree of agreement among the architects, structural engineers and quantity surveyors.

With the recent advances in research in these areas, it is recommended that authorities initiate the development of appropriate standards and codes of practice to promote and encourage the use of the IBM. Additionally, conscious efforts should be made to train skilled man-power to undertake earthen construction. This has a dual advantage of creating employment and ensuring affordable construction in Ghana.

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