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Earthen Construction, as a Solution to Building Industries in Ghana

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Abstract
Adequate shelter is a basic human need. The use of sandcrete blocks as walling units have greatly influenced the construction industry in Ghana as compared to other building materials.Laterite but the latter forms about 70% of the land surface of the country and can be used for moulding blocks when combined with cement.(Adam, 2004, Gooding and Thomas, 1995). The purpose of the study was to determine the factor that has impact on the use of sustainable innovative building technologies for low-income residential buildings in the urban areas. The study also sought to compare the durability properties of walling units produced from the mixture of laterite and cement to that of sand and cement. A structured interview approach was adopted for the data collection. Architects, property developers – Ghana Real Estate Developers Association (GREDA), Social Security and National Insurance Trust (SSNIT) and the State Housing Company Ltd (SHC) were among the institutions that were interviewed. Text were carried out on twelve blocks each moulded from different mix ratios of 1:6, 1:8, 1:10 for landcrete blocks, and 1:10 for landcrete blocks to determine the compressive strength, density, water absorption and total volume porosity after seven days and twenty eight days respectively.It was found out that residential building industries have stopped using earth material for construction but have high expectation on the success of the new building technology if introduced into the market. The test results showed that sandcrete blocks were more durable than landcrete blocks but the latter can equally be used as a walling unit to assist in the solving of the housing problems in the country.
Keywords: durability, landcrete blocks, low-income housing, Ghana, sandcrete blocks,

1. Introduction

Ghanaians have been facing serious housing problems, particularly for the poor who make up the majority of the total population of twenty- three million eight hundred and thirty seven thousand (23,837,000). Affordability is one of the problems faced by housing finance institutions in Africa. It was estimated that an accumulated housing deficit of Ghana was 1,000,000 and about 130,000 housing units should be built annually in addition to the 25,000 to 40,000 units the citizens are providing currently (Statesman (2007). The National Housing Policy by the Ministry of Works and Housing, Ghana, in 1986 emphasized the development and use of local building materials to contribute to the solution of the housing crisis and to reduce the importation of foreign building materials to a minimum as indicated by the National Housing Policy (Gidigasu, 2005). This research considered the construction industry and building technologies in use for residential buildings in Ghana, and on the potential to put this industry into contact with innovative building technologies and changes which have taken place in the construction industry elsewhere in the country. The significant proportions of population increases in the developing countries have been absorbed by urban areas i.e. 83% in 2000-10. Urban settlements in developing countries are at present growing five times as fast as those in the developed countries and Ghana also becomes more and more urbanized (Karl, 2000). Shelter conditions in many developing countries have deteriorated steadily over the last 50 years while the privileged few have access to better housing.

The construction industry has succeeded in improving its performance and in the alleviation of at least a part of the housing problems in urban areas by developing and applying innovative building technologies based on locally available resources, that can be sustained economically and ecologically. Laterite has been used in construction of shelter from time immemorial and approximately 30% of world's present population still lives in laterite structures. Due to its wide application, the cost of sandcrete block has been gradually increased which has affected the overall cost of the housing delivery in the country.Their wide spread use can be attributed to their relative cost advantage, easiness to obtain and satisfactory durability characteristics (Andam, 2004: Gooding and Thomas, 1995).Walling materials constitute an essential element in housing delivery and its choice depends on material, cost, and availability of material, durability, aesthetics and climatic condition. According to Barry (1996) a wall is a continuous, vertical structure of brick, stone, concrete, timber or metal, thin in proportion to its length and height, which encloses and protects a building or serves to divide buildings into compartments or rooms. In a recent research conducted by Raheem et al (2012) on comparative analysis of sandcrete hollow and laterite interlocking blocks as walling, material concluded that laterite interlocking blocks are denser and stronger than sandcrete hollow blocks However, laterite interlocking block is

cheaper than sandcrete hollow block, both in terms of unit cost and cost per square metre. Barry (1996) asserts that, building blocks can be produced from laterite or earth. The type of block produced depends on the material used. Thus, it is important to find alternative local materials for block production which could be comparable in performance but less expensive than sand to reduce the cost of walling in housing construction in Ghana. The search for these alternative materials may require methods of combining various existing ones, including sand to come out with new composite materials (Dorcas, 2006). A mixture of laterite and cement for block production may be the efficient way of achieving the cost reduction. Laterite is an extra-ordinary material and it can be found in all parts of Ghana. About 70 percent of the land surface of Ghana is covered by laterite, as stated by (Gidigasu, 2005).Laterite is cheap, environmentally friendly and abundantly available building material in the tropical region (Fales, 1991).The research was limited to low-income households in the urban areas because the demand for housing is currently high at the major cities of Ghana namely, Accra, Tema and Kumasi. It has been established that durability of a cement- based material is influenced by physio- chemical agents. This research however focused mainly on the physical aspects of durability such as the bulk properties. These properties of the two materials under consideration (sandcrete and Landcrete blocks) were compared and conclusions drawn.

1. 1 Statement of the problem

There is rapid population growth in the urban areas. This situation has led to high demand on residential buildings. The problematic housing situation in Ghana- alike in many developing countries- has been attributed to the rapid urban growth and the non-performance of the construction industry in the housing sector to meet the demand for housing (Government of Ghana, 2000). A major contributing factor to the housing problems is the inadequate application of technologies and use of natural resources (UNCHS, 1991).Only very wealthy Ghanaians and the international community in Ghana can afford to buy a house in the urban core (www.Ghanaweb.com). The urge to find alternative materials to existing conventional ones and the need to bring down the cost of construction has compelled the researchers to intensify work on laterite with a view to investigating its usefulness wholly as a construction material or partly as a substitute for fine aggregate component of sandcrete. It is therefore important to fully explore and utilize all available local building materials as well as possible production of materials for construction from our industrial and agricultural wastes. Doing this, it is necessary to examine possibilities of introducing the use of our local material such as laterite which will assist in construction of low-cost housing, yet more durable buildings to that of sandcrete blocks.

1. 2 Purpose of the study

The study compared the durability properties of the walling units produced from the mixture of laterite and cement to that of sand and cement building blocks and its possible application for low-income housing in the urban areas.

The specific objectives for the study are as follows:

i. To find out the compressive strengths (CS) of the various blocks.

ii. To find out their bulk dry densities (BDD) and total water absorption (TWA).

iii. To establish the total volume porosities (TVP).

iv To find out the circumstances under which innovative building products/technologies are transferred in the building industry

3. Methodology

3.1 The researcher examined how and under what circumstances residential housing innovations become standard industry practices. Architects, property developers – Ghana Real Estate Developers Association (GREDA), Social Security and National Insurance Trust (SSNIT) and the State Housing Company Ltd (SHC) were among the institutions that were interviewed. Representatives of Building and Road Research Institute (BRRI) at the Centre for Scientific Research Institute (CSRI) were also interviewed.

3.2 Grading test for sand and laterite samples were conducted to know the size ranges of aggregates for block production. Samples were obtained from a pit and weighed to get the required mass necessary to produce the blocks. The sample was air

dried and quartered. The sample was weighed and poured into an arranged BS sieves and covered. After which the sieves containing the material were subjected to five minutes shaking using an automatic sieve shaker. The retained sample in each sieve was weighed and recorded.

3.3. Silt test for sand and laterite samples was conducted to determine the silt content in the sand and laterite and its effect on the block production.50ml of sodium chloride solution ($Nacl^2$) was poured into a 500ml BS measuring cylinder. Fine aggregate was poured into the cylinder gradually until the height of the sand and laterite reached 100ml.Additional sodium chloride solution was added until the solution reached 150ml mark. The mixture was shaken vigorously for three minutes and placed on a level bench for 3 hours to settle. Measurement was taken after the silt content appeared visible above the sand. The same procedure was used to determine the silt content in the lateritic soil. The test was performed once and the results were recorded. Three silt tests were conducted on both sand and laterites and an average result was recorded.

Laboratory tests were carried out on sand and laterite with four different mix ratios of 1:6, 1:8 and 1:10 of landcrete (cement: laterite) blocks of sizes of 450mm× 225mm× 150mm were moulded, making twelve (12) in number for each ratio and was compared with twelve (12) number cement: aggregate ratio of 1:10 as specified by the Ghana Standard Contract Document. Hence the total sample was forty-Eight (48). Census was used in this research in order to ensure the validity of the study, since all the ratios in the population of interest were considered. Data were analyzed by categorizing them in an orderly manner in terms of their ratios. Quantitative and ordinal data were employed, this include tables and figures.

3. Results and discussions

3.1 Interview

It was found out that Building and Road Research Institute (BRRI) has conducted research on burnt brick, adobe, wood, stabilised earth brick and rammed earth and all the research products been implemented across the country with the exception of bamboo and cast earth.The institute has future plans to further develop on earth/stabilised earth bricks and it is considered to be marketable in terms of flexibility, adaptability and durability. BRRI has developed pozzollana as a new material/product in the last fifteen years which has successfully been introduced. It also considered cost of imported components and inflation as some of the factors that contribute to high cost of building materials. High cost of timber and taste for new products/prestige are the factors that force home developers to change to alternatives? Delays in acquiring for funds/payments form part of the difficulties in execution of construction projects. Insufficient on-site-supervision and construction management as well as land litigation contribute to construction constraint (personal communication, Mar, 2008).Estate developers were of the view that the government tenders for low-cost housing projects, specify expensive conventional building materials and technologies, instead of proven low-cost technologies developed by the government research institution. Training was identified as one of the key factors for the success of self-help building and cost of building materials was the main factor which prevents people to have access to domestic dwellings. Local research and development institutions have been able to disseminate information on new technology but no information about their supply to the local producers is disseminated. This is solely the responsibility of government bodies. The government has not been able to provide essential industrial extension services to feasibility studies, access to credit, import of equipment, or give training to domestic building materials industries. Lack of acquisition and documentation, clear procedures for building permits and certification, clear procedures for physical development and on the other hand, inflation on capital do not permit savings and thus, enhance haphazard physical development were found to be the impediment to the development of new building g materials /products(personal communication,Mar,2008).

3.2. Test Results

3.2.1 Silt Content of Sand

The result of the silt test conducted on the sand sample from the cylinder test showed that the sand contained an amount of 17.97% of silt, whilst the laterite contained an amount of 6.77% of silt.

Table 1 Grading Tests on Sand Sample of weight = 2789g.

Time lapsed = 5minutes

Amplitude = 8 (Intensity of vibration)

B.S. Sieve	Wt.Retained	% Retained	% Passing	Riffled Wt.
6.30mm		0	100	100
5.00mm	137	4.92	95.08	95
4.75mm	8	0.29	94.79	95
2.36mm	146	5.25	89.54	90
1.18mm	599	21.52	68.02	68
600µm	1142	41.03	26.99	27
300µm	537	19.30	7.69	8
150µm	168	6.04	1.65	2
63µm(200mesh)	38	1.37	0.28	0.3
Receiving pan	8	0.28	0	0
Total	2783			

The grading test performed on the sand sample (Table 1) indicates that 95.08% passed through the 5.00mm sieve and hence the sand sample could be classified as fine sand since the percentage passing through the sieve size 5.00mm was more than 50% (Neville,1995). Furthermore, the percentage retained on the receiving pan was 0.28, which indicates that the amount of silt/clay in the sand was 0.28% (Table 1).Thus the sample contained a low amount of silt/clay particles, which conforms to a value of 16% maximum, required in sand for block or concrete production (Neville, 1995).Again that silt content (receiving pan) of 0.28% shows that the result obtained from the grading test (Table 2) was far lower than that obtained from the cylinder test which recorded a value of 18% as the later is an approximate method.

3.2.2 Silt Content of laterite

The percentage retained on the receiving pan was 1.18%, which indicates that the amount of silt/clay in the laterite was 1.18%.Thus the sample contained a low amount of silt/clay particles which conforms to a value of 16% maximum required in laterite for block or concrete production (Neville, 1995). Again, this silt content value of 1.18% shows that the result obtained from the grading test was far lower than that obtained from the cylinder test which records a value of 7% as the later was an

approximate method. The result of grading test performs on both laterite and sand samples were summarized in tables 1 and 2 and presented in figures 1 and 2 respectively.

3.2.3 Grading test on laterite

The grading curve of a soil sample indicates whether particle distribution of a given sample is too fine or deficient in a particular size. The grading test performed on the laterite sample indicates that the dry laterite sample constituted 41.36% gravels (i.e. those that were retained on the BS 20mm sieve- to the 4.75mm sieve), 57.46% of sand (those that were retained on the BS 2.36mm sieve to the 63 micron sieve) and the fine particles in the laterite constitute 1.18% of Silt/clay (that was those retained on the receiving pan). This was further portrayed in figure 1, which shows the trend in which the particle size distribution occurred for the laterite sample. The figure shows that the laterite was uniformly graded material. Its silt/clay content of values 1.18%(dry laterite) and 6.77% (wet laterite) proves that the silt was very low compared to the allowable value of 16% and may impact positively on the strength of the blocks that may be produced using the laterite sample alone as stated by (Neville,1995).

Table 2 Grading Tests on Laterite Sample of weight = 1367g

Time lapsed = 5minutes Amplitude = 8 (Intensity of vibration)

B.S. Sieve	Wt.Retained	% Retained	% Passing	Riffled Wt.
20.00mm		0	100	100
14.00mm	16	1.18	98.82	99
9.50mm	109	8.05	90.77	91
6.30mm	241	17.80	72.97	73
5.00mm	146	10.78	62.19	62
4.75mm	48	3.55	58.64	59
2.36mm	387	28.58	30.06	30
1.18mm	193	14.25	15.81	16
600um	76	5.61	10.20	10
300um	51	3.77	6.43	6
150um	41	3.03	3.40	3
63um(200mesh)	30	2.22	1.18	1
Receiving pan	16	1.18	0	0
Total	1354			

The graph shows that the Laterite was uniformly graded material. The 57.46% of the material that passed through the

4.75mm sieve and was retained on the 63 micron sieve indicates that the Laterite sample could be classified as sandy since more than 50% of it passed through the 4.75mm sieve (Table 2). According to (Neville, 1995), the uniformity of a soil (sand) was expressed qualitatively by a term known as uniformity co-efficient, Cu. From the particle size distribution curve in the figure 1 for laterite, Cu = 8.08. This means, the Laterite was well-graded. Cu was found to be 3.21 for sand, in figure 2. This means the sand was not well-graded.

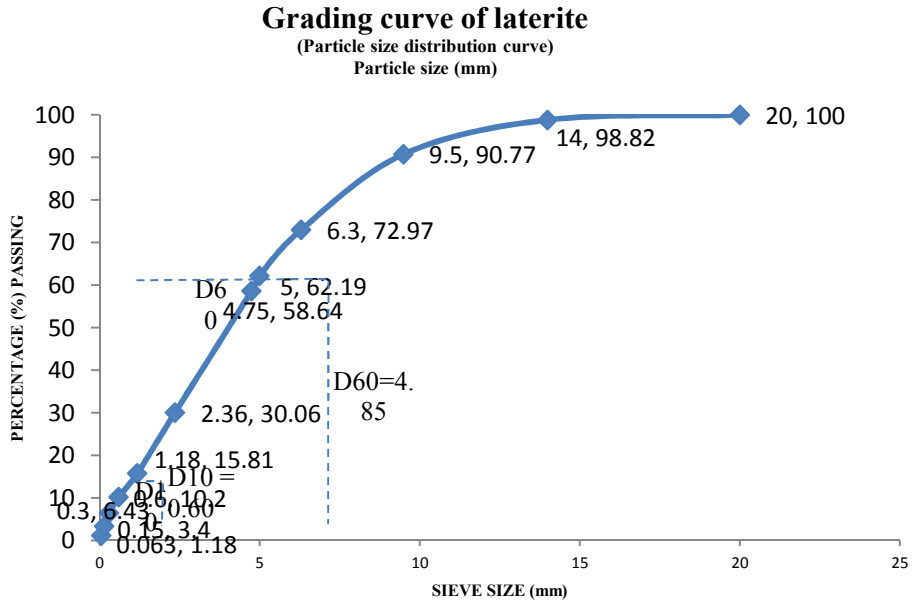

Figure 1 Grading Curve of Laterite

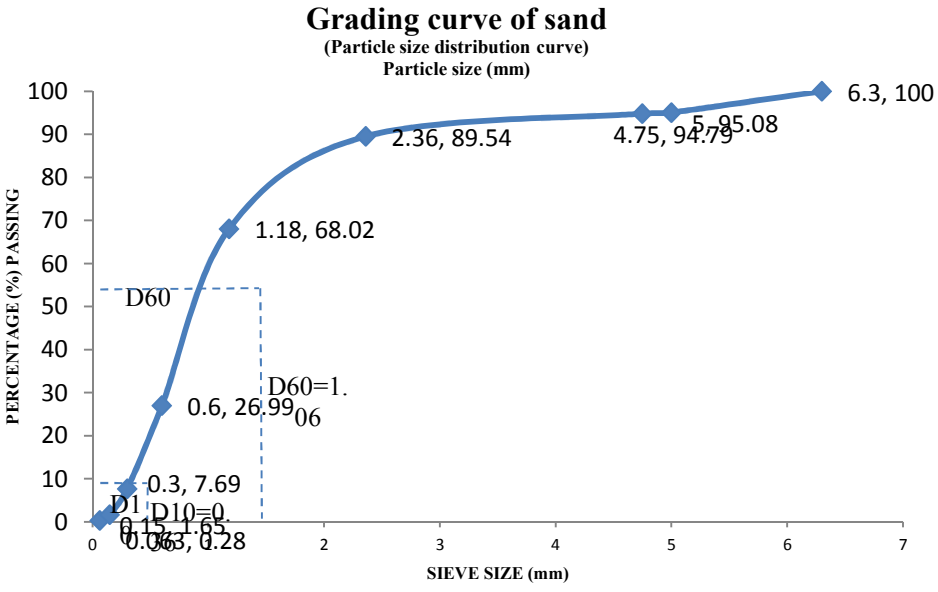

Figure 2 Grading Curve of Sand

3.2.4 Compressive Strength of Laterite & Cement Blocks

The results of the seven-day and twenty-eight-day compressive strength tests performed on the various laterite and cement samples (landcrete Blocks) showed that, for the seven- day compressive strength test, the laterite and cement blocks recorded

a compressive strength of 0.20 N/mm^2 for the ratio 1:6, 0.22 N/mm^2 for the ratio 1:8, 0.27 N/mm^2 for the ratio 1:10 and 0.76 N/mm^2 for the sandcrete block. Futhermore,the 28-day compressive strength test results showed that, the laterite and cement blocks recorded the values of 0.27N/mm^2 for the ratio 1:6,0.39 N/mm^2 for the ratio 1:8, 0.49N/mm^2 for the ratio 1:10 and 1.14 N/mm^2 for the sandcrete blocks. This further implies that the sandcrete blocks are more durable than their landcrete blocks counterparts since a higher compressive strength indicates a higher durability property (Kerali, 2001).

3.2.5 Density of blocks

The average densities of all the mix ratios were found to be different even though, they had different strength values (Tables 3 and 4). These different in densities and strengths may be explained by the different in the particles size distribution of the different mixers.

3.2.6 Permeability of blocks

The results of the seven-day and twenty-eight-day absorption tests performed on the various laterite and cement samples (landcrete Blocks) and sandcrete blocks were carried out to determine the level of water absorption of landcrete and sandcrete blocks. The results showed that, on the seventh day test for the landcrete blocks, the sample with ratio 1:6 recorded permeability of 21.07%, ratio 1:8 recorded 26.00% and ratio 1:10 recorded 13.81%. Ratio 1:10, which recorded the highest strength among the landcrete blocks also recorded the minimum water absorption. Also, the sandcrete blocks recorded water absorption level of 11.87%. This is just below the value recorded for the 1:10 landcrete block. This means that the sandcrete blocks were more durable than the 1:6, 1:8 and 1:10 landcrete blocks which recorded higher permeability. Futhermore,the 28-day water absorption test results showed that, the laterite & cement blocks recorded permeability of 10.30% for the ratio 1:6,10.25% for the ratio 1:8, 11.39% for the ratio 1:10. Ratio 1:10, which recorded the highest strength among the landcrete blocks also recorded the highest water absorption. Also, the sandcrete blocks recorded water absorption level of 9.35%. This is just below the value recorded for the 1:8 landcrete block. This further implies that the sandcrete blocks are more durable than the 1:6, 1:8 and 1:10 landcrete blocks which recorded higher permeability.

3.2.7 Porosity of blocks

This test was conducted to determine the amount of pores in the landcrete and sandcrete blocks. The results of the seven-day and twenty-eight-day porosity tests performed on the various laterite and cement samples (landcrete Blocks) and sandcrete blocks were tabulated in tables 3 and 4. The results showed that, on the seventh day test for the landcrete blocks, the sample with ratio 1:6 recorded porosity of 32%, ratio 1:8 recorded 41% and ratio 1:10 recorded 22%. Ratio 1:10, which recorded the highest strength among the landcrete blocks also recorded the minimum porosity. Also, the sandcrete blocks recorded a porosity of 22%. The same value recorded for the 1:10 landcrete block. This means that the sandcrete blocks were only more durable than the 1:6 and 1:8 landcrete blocks which recorded higher porosity.The 28-day results showed that, the laterite and cement blocks recorded the values of 14% for the ratio 1:6, 16% for the ratio 1:8, 18% for the ratio 1:10 and 17% for the sandcrete blocks. This further implies that the sandcrete blocks were only more durable than the 1:10 landcrete blocks which recorded higher porosity.

4. Recommendations

The following recommendations were given on the bases of the results of the study:

1. In forming landcrete blocks, special attention should be paid to the selection of the laterite and sand materials, as well as the sizes of the block.

2. More investigations should be carried out with a larger scope than was used in the study to confirm some of the finding as reported.

3. Other factors which are known to influence durability such as chemical attacks should be carried out in the future to find out their level of influence against durability of the blocks.

4. Government should: specify and tender for proven low-cost technologies developed by the government research institutions for its projects to help disseminate information on the new technology, establish training centers for individuals in the area of proven low-cost technologies to be self sufficient in the self-help building and be able to provide essential industrial extension services to feasibility studies, access to credit, import of equipment, or give training to domestic building materials industries.

5. There should be proper acquisition and documentation, clear procedures for building permits and certification, clear procedures for physical development.

5. Conclusions

The following conclusions were drawn based on the results of the various tests conducted:

i.Sandcrete block was found to be more durable than landcrete blocks in compressive strength, density, permeability as well as porosity.

ii.Landcrete block is cheaper than sandcrrete block and environmentally friendly, hence can be used for low-income housing in the urban areas.

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