Cost-Benefit Analysis of Using Stabilized-Earth Block to Conventional Block Use in Housing Construction

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Abstract- ***The housing deficit in Nigeria of 17million units is at alarming point with her continuous growing population of 2.64% annual average increase without adequate housing provision to meet the demands. The result of this is increase in congestion and slums rate i.e. Meanwhile, affordable housing provision through earth blocks would have reduce the limitation set by high cost of conventional sandcrete blocks. This paper presents the data on availability of the earth materials across the country, the significant cost reduction that can be achieved through the use of earth materials and its inflationary stability. Descriptive survey was employed for this study while comparative cost analysis was carried out to ascertain cost difference between earth block and convectional blocks. Results were presented in tables and charts. Findings revealed that earth materials are available in all the part of the country with largest deposit in south east and least in the south-south states. The cost analysis carried out on the convectional blocks and stabilized earth block affirmed that earth blocks are cheaper alternatives to convectional blocks with ₦98.03 cost difference, giving a 46% reduction in the total production cost. Finding revealed further that earth block has 60% economic stability. That is, has lesser fluctuation effect. Earth blocks is thus recommended for achieving sustainable and cost affordable housing delivery in Nigeria thereby solving deficiency in the system***

Indexed Terms- ***Availability, Convectional blocks, Cost, Earth blocks, Housing and sustainable***

I. INTRODUCTION

Stabilized Earth block being referred to adobe is one of the oldest building material, made from earth and some organic materials. The availability, simplicity of manufacture, and minimal effort for long-term maintenance of Adobe bricks made this material popular throughout the world. With its high thermal capacity, adobe construction is perfectly adaptable for use in the cold as well as in hot and dry areas. However, nowadays, this oldest building material started to attract more attention because of its minimal ecological impact to the environment Gubasheva (2017)

Nigeria is the most populous black nation with a population of 213,677,178 world meter (2021). Nigeria 2020 population is estimated at 206,139,589 people at mid-year according to UN data. Nigeria population is equivalent to 2.64% annual average increase. Furthermore, the population density in Nigeria on average is at 223 persons per kilometre square has resulted in high demand for infrastructural facilities (Saidu & Yeom, 2020). The major reason for this high density (ratio of person/coverage area) is due to the high cost of conventional building materials which resulted to low housing provision and high tenement rates. It is therefore necessary to examine the cost of convectional and stabilized earth block materials to give room for the masses to access low-cost and available alternatives. In addition, due to the high cost of conventional building materials, it will be of great importance to adopt sustainable materials (Danso, 2016). The material cost efficiency and sustainability would reduce housing deficit and enhance the growth of local content.

The earth blocks doubtlessness has thermal comfort and durability; but also essential is the cost effectiveness of its usage. The economy of the world hangs on unstable balance while the demands for housing increases daily due to population growth around the world. Income earners and moderate

income earners alike need cost savings in realizing their housing dream without losing the building functionality. Meanwhile there is huge need for more housing in Nigeria as confirmed by a World Bank report which estimated that 75 per cent of the housing deficit in Nigeria affected families who earned less than three times the minimum wage. It noted that some of these people have to spend as much as 60 per cent of their average disposable income on rented apartments. This figure is higher than the 20 to 30 per cent recommended by the United Nations. In a similar vein, a report by the Central Bank of Nigeria showed that in 1991, the country's housing deficit was about seven million units but by 2007, the figure rose to 12 million units and currently sits at about 17 million units. To bridge this housing deficit, the World Bank estimated that it would cost about N59.5tn. In 2018, the World Bank further noted that to solve Nigeria's housing deficit problem, about 700,000 housing units were required to be built annually over 20 years to accommodate the increasing population.

- Statement Of the Problem

These are not the best of times for potential homeowners and developers as a sharp increase in prices of building materials across the country may further compound the existing housing deficit in the low/medium income segments of the real estate market. Access to affordable homes is fast becoming an unfulfilled dream to the majority with the gaps growing from bad to worse while efforts of governments haven't yielded the much-desired result (Gbonegun, 2021). The cost of raw materials such as reinforcement, cement, finishing, paint and other components rose by over 300 per cent in recent times. With higher project prices, which include material and rising labour costs, the construction industry struggles as activities are postponed, reviewed or projects are cancelled. For every construction project, over 45 percent of the total cost goes to material; this value is dependent on the taste and design of the projects. Bamgbola (2021), asserts that" as the prices of the materials increase, the cost of rent and value placed on buildings would increase and there might be a tendency for intending homeowners to use substandard building materials. Ani (2021) further opined those potential homeowners may abandon projects over rising cost of building materials. There is need to assess materials that is cheaper, available affordable with effective methods to meet housing requirement which is the purpose of this work.

- Aim And Objectives

The work is aim at determine the cost-benefit analysis of using stabilized-earth block to conventional block use in housing construction. The aim was achieved through creating the awareness of the affordability of earth block in housing production; appraising the availability and workability of the earth blocks in housing production and determining the cost efficiency and its fluctuation resistant.

- Significance of the study

This study presented stabilized earth block as alternative to conventional blocks due to its durability, availability and cost efficiency. The work provide other cost effective options for developers, contractors and consultants. It would help the government in effective planning of housing production. It would guide the budget office especially on housing and economic growth. Research institutes and academics would also be provided with relevant information towards more research works and utilization.

II. LITERATURE REVIEW

Utilization of clay and laterite as sustainable building materials has become source of concern to construction industry due to its positive effect on the social, economic and environmental aspects to humanity and society. Rising, rural and urban population in developing nations such as Nigeria has led to the more demand and effective utilization of these gifted materials in development of housing, roads, dams, air fields, and others infrastructures. There are many locally available resources such as laterite and clay which can be exploited and readily be applied to the local production of low-cost construction materials product. Stabilized compressed earth is the enhancement of soil as an alternative building material which is comparatively cheaper than conventional building material in the construction of urban low-cost housing (Zami, 2011). In addition, stabilization of earth building materials has been suggested as a way out in obtaining affordable building materials (Alagbe, 2010). It was noted that compressed stabilized earth blocks are more workable

than other building materials such as brick and sandcrete blocks (Riza, 2011). It is also an environmentally friendly building material and contributes to sustainable development (Riza, 2011).

- Earth blocks in Housing production

Fasola (2018) observed that since independence in 1960, many administrations had embarked on many housing policies. Some of these housing policies included the National Development Plan 1, 2, 3, and 4, the National Housing Policy and the National Housing Programme. Unfortunately, the policies were unable to effectively tackle the housing deficit. Individuals handling housing projects including estate developers had witnessed an undue rise in the price of building materials. It must be understood that no housing policy would be effective without effective control of materials cost. The prices of basic materials such as cement, steel rods, granite, sharp sand, tiles, etc, have almost doubled in a short time. For instance, the cost of a bag of cement before the end of 2019 was between N2,050 and 2,100 but has now risen by about 100 per cent this year to about N3,800 –N4,200 for every 50kg bag. The current price also varies based on locations.

Meanwhile, local materials is cheaper and affordable. The usage of these materials would reduce the cost of sourcing, haulage and other government levies that increase cost of materials in Nigeria. The experiment carried out by the Nigerian Building and Road Research Institute (NBRRI) with the Federal Housing Authority (FHA) as stated by Madedor (1994) shows that there is at least a 40% cost saving in the use of local building materials over conventional modern ones of identical construction. Nigeria depends on the importation of these materials (i.e. cement, steel etc) thereby putting pressure on the suppliers of the materials (Oruwari, Jev, and Owei (2002)). Nigeria imports not only finished products but also raw materials, machinery, and energy, this has led to issues of cost in not only purchase but maintenance as well. Apart from the importation, the modern-concept of using convectional blocks with higher components of cement to sand ratio increase the building cost. These factors have made the construction of structures in Nigeria a capital-intensive activity. Meanwhile, the earth material is relatively available at every doorstep of Nigerians without paying much attention to it as a dominant factor in solving housing challenges in the country.

- Availability of Earth Materials in Nigeria

Olotuah (2002) expound more on the type of building earth found in various locality. For example, in South-Western Nigeria argillaceous clay, which is very grainy, is most common. The clay deposits in these parts are residual and secondary and were formed through the hydrolysis of the alumino-silicate mineral contents of the crystalline precursor rocks [Ojo and Oyinloye, 1998]. The best earth material for building here is usually a mixture of greasy clay and sandy laterite soil. The earth material belongs to the group of ferruginous tropical soils [Areola, 1982]. Its clay fraction is made up mostly of Kaolin. In the South-Eastern States of Nigeria, the building earth commonly used is loam which is prepared by mixing common earth containing gravel with high-quality clay to give it strength. Red clay-like loam, viscous in nature, is the best earth material found in these areas. The worst is the greyish loamy soil which is not strong enough to be used without an inner reinforcement of wattle. These are ferralitic soils (ferrasols) with the clay content of the kaolin type with low water-holding capacity. In Northern Nigeria, the building earth commonly found is kaolinitic clay with a mixture of quartz. Soils from termites' mounds which contain a sticky slime from the insects are also used as additives with building earth. In the northern parts of Kano, Kaduna and Sokoto states clay abounds, in regosols type of soil. The clay is of the montmorillonite type which has high water-holding capacity. Kaolinitic clay deposits are also found in the Guinea Savanna Zone in Northern Nigeria in ferrisols. Along the courses of the Niger River, the Benue River, the Niger-Delta area and the Chad Benin clay deposits are found in small pockets within the valleys and alluvial soils.

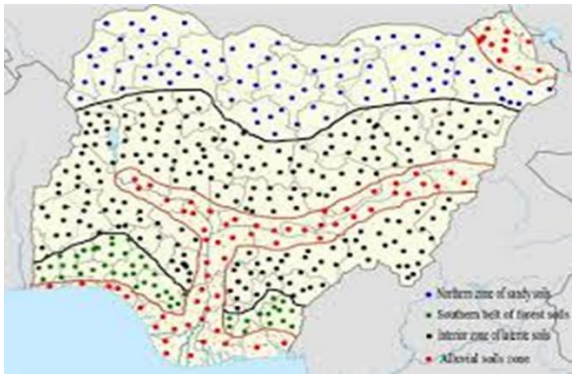

Fig 1: Distribution of laterite earth in Nigeria
Source: tunza.ecogeneration.org

There are many locally available resources which can be exploited including small-scale raw material deposits, agricultural products and residues, industrial wastes, low-cost and renewable sources of energy, unskilled and semi-skilled labour, and established technologies which can readily be applied to the local production of low-cost materials, Adogbo and Kolo (2006). The research also conclude that laterite earth is relatively available in all the states and localities in Nigeria as shown in fig 1. Traditional building materials such as clay, loam, and sand can be used in new ways, such as with uniform, rectangular compressed earth blocks (CEB) and (interlocking) stabilized soil (earth) blocks (SSB or ISSB). In both systems, the use of cement is absent or minimized. In SSB, earth can be mixed with a low percentage of cement or lime. As a professional-grade mix preparation is necessary, a field lab and training of the labor force are required. CEB and SSB blocks are used for the construction of houses, latrines, schools, community facilities, etc. These earth technologies are being used in a series of countries in Africa, Asia and Latin America, Bredenoord (2017).

- Benefits of the Earth Blocks

The earth materials comprises more of clayish constituents are locally and abundantly available; the technology is local and readily available; Usage of cement is lesser, thus reduction in cost; Ease of use with little or no supervision; It is environmental friendly and sustainable; It is stronger and fire resistant and has ability for on-site production, curing and fixing. Dabaieh (2014) affirms that earth production is more economical in developing countries in so also its maintenance. Productivity of rammed earth construction depends on several factors like site circumstances, weather conditions, workers proficiency and formwork system. The earth - ramming requires little water, which can be an important consideration in dry climates with scarcity of fresh water. They require few other resources like aggregates or additives to improve their properties. Earth can be recycled, is easy and agreeable to work. It has good insulating properties if built with high thermal mass especially for hot climate. Known fact is that earth gives off no harmful emissions. It is good for noise reduction and insulation. Earth doesn't burn, so rammed earth walls are fire proof. It is load bearing, which reduces the need for structural supports, therefore reducing building costs. Standard 400mm thick rammed earth walls can be used as load bearing in constructions up to four stories high. - Termites and other pests are of little concern to rammed earth walls. In summary, the usage of earth materials for housing production is cost and environmental friendly.

III. METHODOLOGY

The research design employed for this work was the descriptive survey in which professionals in the construction industry in Nigeria were randomly selected. The area covered in this research is Nigeria with a consistent growing population of 213,677,178 and total land area of 910,770 Km2 (351,650 sq. miles) is the area of the study. The country is divided into six geopolitical regions. The data for this research work was gotten from two sources; the primary and the secondary sources. Major town in each geopolitical region of Nigeria was reached through well-structured questionnaire containing closed ended questions with suggested answers measured in a Likert Scale to relevant stakeholders to get primary data. The state are Lagos (South West), Enugu (South East), Portharcout (South South), Kogi (North Central), Adamawa (North East) and Kaduna (North West) and Abuja (FCT). The secondary data was gotten through published data such as population distribution and so on from United Nation. A total of 360 copies of questionnaires were distributed, out of which 342 returned were used for analysis. In order to ascertain the cost benefits of using stabilized earth block over conventional blocks; samples of each block type were produced. This was carried out in order to enable comparison of both

materials for their production in terms of cost. The costs of production using both materials were evaluated and a comparative cost analysis was carried out to ascertain cost differentials.

IV. RESULTS AND DISCUSSION

- Comparison between the quantity of conventional block and Earth block

Raw materials for the production of blocks (conventional and earth) were collected and shown.

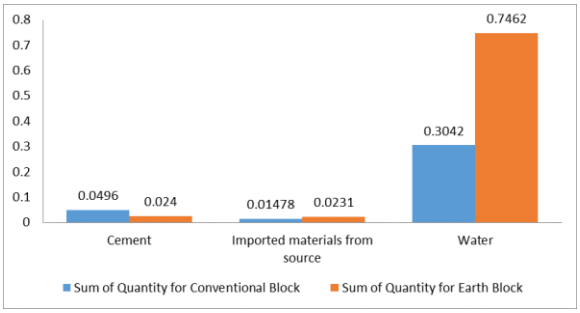

Fig. 2: Showing a unit cost comparison in quantity between conventional block and earth block
Source: Researcher, 2021

The quantity of cement in conventional block is higher than earth block as depicts in Fig. 2. It implies that the concentration of cement is more in conventional block than it is in the earth block. More so, the study reveals that the quantity of imported materials from source is slightly bigger in earth block than conventional block at ratio 1: 1.34 respectively. Finally, the study reveals that the quantity of water needed in earth block is higher than the conventional block.

- Comparison between the Rate of conventional block and Earth Block

The cost comparison was evaluated using three indicators which are quantity, rate and amount**.**

Table 1: Comparison of cost of a unit convectional block to earth block

MATERIALS USED	Convectional Blocks				Earth Blocks			
	Quantity	Unit	Rate	Amount	Quantity	Unit	Rate	Amount
Imported materials from source	0.01478	Ton	1600	23.65	0.0231	Ton	800	18.48
Cement	0.0496	Bag	3800	188.48	0.024	Bag	3800	91.20
Water	0.3042	Litre	10	3.04	0.7462	Litre	10	7.46
Total				215.17				117.14

Material Cost difference	98.03
Percentage difference	46%

Source: Researcher. 2021

The prices of cement and water for the production of both block types are the same at #3800 and #10 for cement and water respectively as shown in table 1. Meanwhile there is a huge difference in the price of sharp sand and earth materials. Noticed too is the quantity of materials used which brought a final cost difference. From table 1, the total cost of producing one (1) Number of conventional block in Nigeria is N215 while that of earth block is ₦117.14. There is a cost difference of ₦98.03, at 46% difference. Meanwhile, the labour cost of laying blocks is the same (for both) ranging from #35 per block to #45 per block depending on location and weather situations.

- Comparison Between amount in conventional block and Earth block

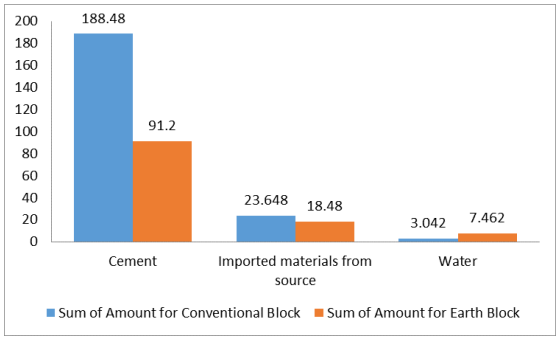

Fig. 3: Showing a unit cost comparison in amount between conventional block and earth block
Source: Researcher, 2021

The result of the chart in fig 3 shows that the amount of cement needed in a unit conventional block is more than the amount of cement needed in a unit earth block. The study further reveals that the amount of imported materials from source needed in a unit conventional block is higher than the amount of imported materials from source needed in a unit earth block. Finally, the amount of water needed in a unit earth block is higher than the amount of water needed in a unit conventional block on the average.

Yearly Cost Difference between the Conventional Block and the Earth Block (Inflation effect)

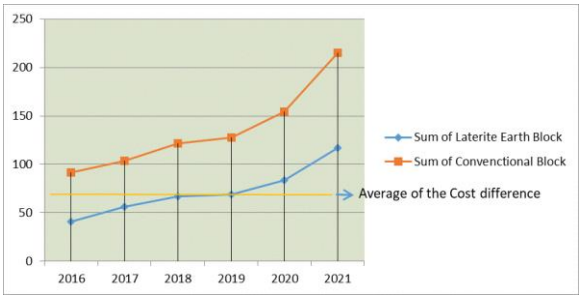

Fig. 4: Showing a unit cost comparison in amount between conventional block and earth block
Source: Researcher, 2021

Giving the average of the cost difference and the trend of the earth block and the conventional block within the timeframe of 2016-2021 in fig 4, we can understand that the cost difference is very minimal in earth block. The cost difference is very low in earth block and slightly higher in conventional block production. This is because the source of convectional blocks' two major materials; sand and cement are dictated by the market forces. The level of inflation is thus less and sometimes insignificant in earth block, especially in 2017-2020.

Table 2: Factors Comparing Impact of the Conventional Block and Earth Block on users

	Factors	Convectional Blocks			Earth Blocks		
		High	Moderate	Low	High	Moderate	Low
1	Labour Involvement	12	34	4	30	15	3
2	Knowledge transfer within	10	30	8	35	12	2
3	Improve Internal Income	11	35	4	40	8	2
4	Design and Planning are localized	15	22	10	42	7	1
5	Rate of execution is convenient	35	10	4	22	20	4

Source: Researcher, 2021

Table 2 considers impact of some factors the usage of convectional and earth blocks has on the users. It shown that the design and planning of the earth blocks production and usage are localized. The nature of the environment will determine its design. Knowledge of its production and usage is also transferred within the people. This is not the same with the convectional blocks.

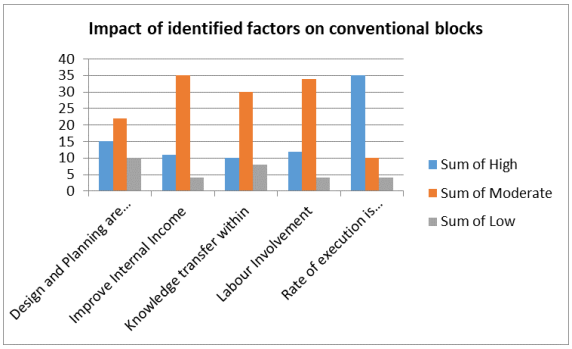

Fig. 5: Showing the level of impact the identified factors have on conventional block

Source: Researcher, 2021

From fig 5 above, the impact of design and planning in conventional block is moderate, the impact of improve internal income in conventional block is moderate, the impact of knowledge transfer within in conventional block is moderate, the impact of labour involvement in conventional block is moderate and the impact of rate of execution in conventional block is high.

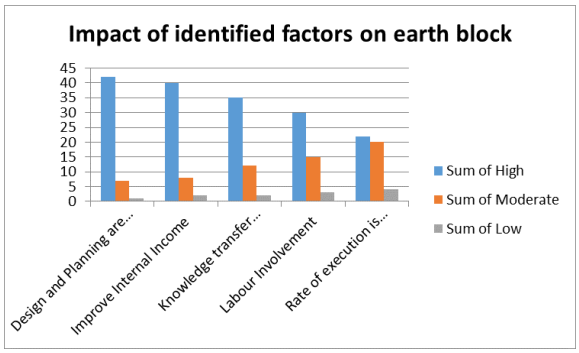

Fig. 6: Showing the level of impact the identified factors have on earth block

Source: Researcher, 2021

From fig. 6, the impact of design and planning in earth block is high, the impact of improve internal income in earth block is high, the impact of knowledge transfer within in earth block is high, the impact of labour involvement in earth block is high and the impact of rate of execution in earth block is high.

- Availability of Earth Block Materials in Nigeria

Due to the advantages of earth blocks over convectional blocks, availability of the materials were sampled over the country and shown below

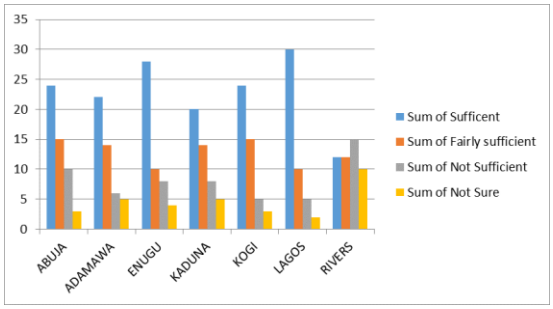

Fig. 7: showing the availability of earth materials in Nigeria

Source: Researchers, 2021

The result from the fig 7 above shows that there is sufficient availability of earth block materials in Abuja, Adamawa, Enugu, Kaduna, Kogi and Lagos; but not sufficient in river state.

CONCLUSION AND RECOMMENDATION

The reduction in quantity of cement usage in earth blocks makes its cost cheaper to that of convectional blocks which is at a higher cost. The materials are readily available in all the states and localities of the country. The technology is traditional, thus easily acquired and utilized. Earth blocks production can be achieved both in the urban and rural areas. The cost analysis carried out on the convectional blocks and stabilized earth block affirmed that earth blocks are cheaper alternatives to convectional blocks, giving a 46% reduction in the total production cost. Finding revealed that it has 60% economic stability. That is, has lesser fluctuation effect. Previous authors have shown that the blocks from earth or adobe are cost effective, viable and more sustainable alternatives to the widely used conventional Sandcrete blocks. this study further provide quantitative cost data to further confirm that earth blocks are more cost efficient with a 46% reduction per unit cost of production.

Earth blocks is thus recommended for achieving sustainable and cost affordable housing delivery in Nigeria thereby solving deficiency in the system.

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