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Uncertainties Surrounding the Economic Potential of Locally Available Laterite Deposits in Promoting Environmentally Sustainable Housing in Nigeria

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Abstract: The wide-scale availability of clays in Southern Nigeria should be an avenue for the successful promotion of alternative natural cladding materials such as bricks for the construction of low cost housing. However, local clays and lateritic soils for use in engineering application, mostly lie wasted and unextracted. A major issue of contention being their structural viability as a building material for modern structures, with the bulk of its usage limited to rural areas. As such a fundamental gap remains, wherein the economic potential of locally available clay reserves is not translated into commercial production of bricks and patronage. The study appraises the factors determining the acceptability level of bricks as cladding materials for low-cost housing construction in Nigeria. The opinions of key construction industry professionals as well as marketers and developers in Port Harcourt were sought through the administration of structured questionnaires. The study revealed that aside from the perceived structural shortcomings of bricks, several issues abound as being responsible for the unpopularity of bricks. Typically, such views centered around difficulties in securing skilled labor for brick laying, lack of exact standards of material and workmanship, perceptions of adaptability to the environment, accessibility, supply shortfalls/poor marketing by brick manufacturers and the attitudinal propensity of Nigerians to view local materials as inferior. The study espouses the need for public enlightenment; skills development in bricklaying, creation of a viable platform for improved productivity, more aggressive marketing and quality control via standardization.

Keywords: Acceptability, Bricks, Housin

1. Introduction

Soil as a construction material is long-established in different forms around the world. The most popular soil types used for housing construction are sands and clays. Soils consisting mostly of particle sizes between 0.1mm to 2mm are referred to as sands, while clays (< 0.01 mm), are fined grained soils [1]. Mud bricks and rammed earth made up of clays, for cheap housing construction continue to be used in many parts of the world. “Pise de terre” in France, Cob in England and Adobe in South America, are well known examples of the use of soil as a major building element [2]. In sub-Saharan Africa, the Djenne’s Mosque in Mali, is one of the largest structures constructed with mud brick [3]. However, unlike other parts of the world where bricks are used in the construction of housing, in Nigeria, the use of sandcrete blocks is the norm [4]. Sandcrete blocks are walling units produced from cement and sand mixed with water and laid in cement mortar. Cement is a material with adhesive and cohesive properties, which makes it capable of bonding mineral fragments into a compact whole. Due to the naturally coarse and non-adhesive nature of sands, large quantities of cement as a hydraulic binder is required. Cement is thus a basic input in the manufacture of sandcrete blocks, whose demand and production in Nigeria is very high, due to the heavy reliance on the use of sandcrete walling units in housing.

The high cement content in sand-based cladding, however constitutes a health concern, due to the attendant pollution associated with its extraction, as well as energy demand required for processing its raw materials. Generally, cement raw materials consist of combinations of limestone, shells or chalk, shale, clay, sand or iron ore, mined from quarries in large quantities, and fed into massive cement plants which have very high energy consumption (Figure 1).

Figure 1. *Cement Plant in Nigeria.*

Further to this environmental implication, the price of cement in Nigeria is always on an incremental scale, due to supply demand inequalities. The demand-supply gap has further widened considering the increasing demand for home ownership, as government's efforts towards controlling the inequality have so far proved abortive. As local production of cement remains at 50% of installed plant capacity, the problem of supply insufficiency continues to exist. With a population of over 140 million people and a growth rate of approximately 3% per annum, the demand for and consumption of cement in Nigeria is expected to increase [5]. The price of cement has increased by over 300% since 1999. Considering the prevailing pricing structure of cement, seeking alternative cladding material to reduce its demand is of vital and strategic significance to the availability of housing in Nigeria.

Port Harcourt is a metropolitan town of considerable co-operational and commercial activities, located in southern Nigeria. It is the centre of the Nigerian hydro-carbon industry, with a high population density of 31,000/m^2, which continues to rise due to the rapid influx of population into the city. The prevailing high cost of construction, due to the drift to cement-based construction in the city, has made affordable housing a mirage. Considering the rising price of conventional construction materials, high cost of land, funds and labour in the city, there is a need to utilise alternative locally sourced materials and technologies, to meet the housing needs of low- and mid-income earners. One of the materials that readily avails itself in the local surrounds of Port Harcourt is clay. As the literature evidences, the use of bricks is a cost effective and aesthetically pleasing alternative to conventional sandcrete cladding materials, and can be utilised in providing housing particularly for low income groups [6]. Bricks are also very effective in building healthy and environmentally friendly housing [4].

However, although the use of brick is well established in sustainable housing, much about its commercial potential remain largely untapped in Port Harcourt, with its usage limited to rural areas where sun dried or fired clay bricks are laid with mixed soft soil joints (Figure 2).

Figure 2. *Construction of a Typical Rural Dwelling with sun dried mud bricks laid with mixed soft soil joints.*

Statics show that 90% of physical infrastructure in Nigeria are built from concrete block [7]. With Enenmo [6] resounding:

"*Despite the thousands of modern new homes in urban areas, something is amiss. There is hardly a brick house in sight. Nearly all the houses in Port Harcourt, and in most of Nigeria, are built from concrete blocks".*

The research question thus posed in this study is – why? This is considering that bricks usage is evident in older Nigerian architecture, before the emergence of concrete block [8]. The study investigates factors determining the acceptability level of bricks as cladding materials in Port Harcourt. As the unpopularity of bricks in urban areas of the state has been linked to the public perception of its structural suitability for modern housing [4]. The study addresses this perception, prior to evaluating the distinct economic advantages of brick usage, such as its cost effectiveness and low maintenance requirement.

2. Literature Review

Structural Suitability of Bricks as Cladding Material

Brick is a viable and structurally sound alternative cladding material to conventionally used sandcrete blocks. However, it is common reasoning in Nigeria that bricks are defective in their functional requirements as building materials, due to the perception that natural soils have poor resistance to water, a feature of heavy rains characteristic of Nigeria's tropical climate [7]. Soil science however has advanced considerably during the past decades, and it is now possible, by laboratory analysis of the soil to predict with reasonable accuracy its behaviour under load and weather [9, 10]. It has thus further become possible to greatly improve the load bearing and weather resistance properties of lateritic soils used for making bricks, by mixing small quantities of insoluble binders like cements, bitumen, lime or resinous compounds to produce stabilised bricks. The combination of soil with chemical binders under controlled conditions of moisture and density produces material of distinct physical and engineering characteristics

Table 1 shows the results of a practical laboratory analysis of the use of Nigerian lateritic soils for brick manufacturing, carried out in an earlier study by [9] under the auspices of the Federal Ministry of Works in Nigeria. Three locally obtainable laterites were selected for testing and designated types 'X' 'Y' and 'Z'. Bricks were made with each type of laterite adding 5%, 7%, and 10% concentrations of cement respectively. Each mix was tested for unconfined compressive strength after seven and twenty-eight days curing. This was carried out to deduce the most suitable type of laterite that can deliver optimum strength characteristics in excess of the required minimum strength, while achieving the most cost savings in terms of cement concentration.

Table 1. *Compressive strength results of stabilized laterite bricks.*

	Laterite Type 'X'- Brownish grey, silty sand with concretionary granules and angular rock pieces and laterite	**Laterite Type 'Y' Dark grey, silty sand with angular gravel of igneous material**	**Laterite Type Z Soil No. z. Reddish brown sandy silt with angular gravel and laterite.**
Mix -5% cement, 95 Laterite Curing time – 7 days' compressive strength kg/cm^2	58.0	71..8	52.7
Mix -5% cement, 95 laterite. Curing time 28 days compressive strength kg/cm^2	71.5	99.7	69.0
Mix- 7% cement, 33 sand, 60% laterite. Curing time -7 days comp. strength kg/cm^2	38.5	51.2	43.2
Mix- 7% cement, 33% sand 60% laterite. Curing time 28 days comp. strength kg/cm^2	113.6	51.2	123.0
Mix -10% cement, 90% laterite Curing time – 7 days comp. strength kg/cm^2	97.5	95.3	75.9
Mix -10% cement, 90% laterite. Curing time-28 days comp. strength kg/cm^2	114.0	110.1	80.2

Source: Aggarwal and Holmes [9]

From results shown in Table 1, which range from 3.43 to over 12.47N/mm^2 (38.5 to over 123 kg/cm^2), all three laterites give results well in excess of the minimum of 2.75 N/mm^2 required. Comparatively, it is also evident that using type "Y' a lower concentration of cement is necessary to obtain an acceptable strength. Laterite type 'Y' therefore will give the greatest cost savings by requiring the addition of the least amount of cement for stabilization.

Similarly, experimental studies such Adebisi *et al*. [10] investigated the fundamental characteristics of the clay content of Nigerian lateritic soils, and established their suitability for use in construction and civil engineering projects. Others such as by the ASTM [11] carried out analysis of cost reduction obtainable from the adoption of stabilised laterite cement in various elements of a building. Table 2 outlines the savings in cement for stabilized laterite relative to conventional building mixes.

Table 2. *Cost Reduction Factors for Stabilised Laterite Cement/Conventional Concrete Mixes.*

(b)	Stabilized laterite cement content	Conventional normal mix	Building cement Content	Reduction factors, (F)
Foundations Floor Slab Floor Screed Blocks	7%	1:3:6	10%	1.5
	5%	1:2:4	14%	2.8
	10%	1:3	25%	2.5
	5%	1:6	14%	2.8
	Average			
Mortar Render	5%	1:6	14%	2.8
Render	5%	1:4	20%	4

*Note: Cement now required = conventional quantity /F.
Source: ASTM [11]

The durability of lateritic mixes with finishes has also being established. In the UK, an experimental building of soil compressed bricks, stabilized with 5 percent cement, was constructed by the Building Research Establishment. Various finishes were applied in sections on the external walls and their condition after over 20 years of exposure to the British climate is tabulated in Table 3.

Table 3. *Results of Long Term Exposure Tests of Finishes on Stabilized Soil Bricks.*

Wall	Area	Treatment	Present conditions
	A	Aerated cement	Excellent
	B	Aerated cement	Excellent
South	C1	PVA emulsion; followed by 2 coats of cement based paint mixed with PVA emulsion.	Has not provided any effective protection
	D	Rendered 1:2:9 cement: lime: sand wood float finish	Excellent
	E	Rendered 1: 3:12 cement: lime sand wood float finish.	
West	F	Untreated flush pointed brickwork.	
	G1	Thick coating, white, having appearance of silicate coating.	Slightly hair-cracked but maintained brickwork beneath in excellent condition.
	Hi	Lime /tallow	Good as F
	H2	Colorless, wax-based water-repellant liquid treatment.	Very poor, more eroded
	I	Untreated weather-pointed brickwork, Untreated brick set in a minimum of cement	
North	J	1:2 cement: sand aerated; followed by 1:2 white cement sand.	Excellent.
	K	1:2 cement: sand aerated; followed by 2 coats of 1:2 cement: sand,	Excellent.

(Source: BRE [12])

Although the experimental work is contextual to the British climate, the results show that by using stabilized laterite, buildings of good quality and finish can be achieved. A more contextual study relevant to the tropics was carried out by Chew and De Silva [13], and showed that out a total of 450 buildings inspected in Singapore, 16% of the brick houses showed signs of cracks, while 5% had evidence of efflorescence and staining. This is relative to defects in sandcrete block houses, 50% of which evidenced cracks, and 20% showing efflorescence.

Economics of Bricks/Sandcrete Block Usage as Cladding Material in Port Harcourt

The choice of cladding materials has significant impact on cost. This is considering that cladding accounts for a significant proportion of total costs of buildings. A cost breakdown by Mac-Barango [14] for a typical bungalow in Nigeria built with hollow sandcrete blocks (1:7 cement to sand ratio), revealed the following as a percentage of super structure costs: Roof - 11.38%; Windows – 4.78; Electrical – 11.34%; Plumbing – 4.57; Finishing – 11.05%; Painting – 4.50%; Fitting & Fixtures – 8.63%; Doors – 3.29; Walls – 37.49% and Drainage – 1.51%. Figure 3 further captures the upward price trend of the sands used for sandcrete block production in Port Harcourt.

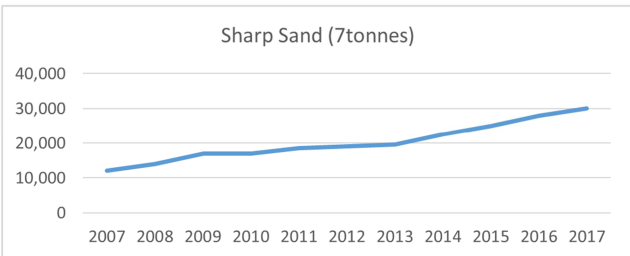

Figure 3. *Increment (in Naira) in Pricing of Sand.*

Yet against this, developers have continued to utilize sandcrete block to the neglect of bricks. As cladding element carries a reasonable bulk of the total cost of housing, it therefore follows that significant cost differences could potentially arise with use of brick as an alternative to conventional sandcrete blocks. The cost implications, would however vary with respect of location, as the availability of clay, in terms of proximity to proposed the site, is an important factor. Clays available for construction in Nigeria often as exists as fine grained lateritic soils to various extents at different locations. Some major clay deposits locations in south-southern Nigeria are shown in Table 4.

Table 4. *Location of Major Clay Deposits in Rivers State.*

L. G. A	Location of Major Clay Deposits
Ahoada	Ahoada West, Ikodu, Olokuwma,
Omoku	Obiri-Kom
Cinohua	Rumuche, Rumwa Kunko
Ecthe	Ormuma, Okomoko
Obi-Akpo	Roumorluminine, Choba, Elenwo
Port Harcourt	Rebisi, Oruworukwo, Oghum-um-abali

Typically, clay reserves in Abua area of south-southern Nigeria is estimated at over 15 million tonnes. Most parts of south-eastern and south-western Nigeria are also underlain by vast quantities of lateritic deposits [10]. However, the Northern parts of Nigeria, mostly have rocky outcrops with deficient clay reserves.

As cement is the most common binder in sandcrete blocks, it becomes necessary to investigate the cost contribution of this stabilising agent. Blocks are commonly used in Port Harcourt and other urban areas of Rivers state, mostly in the form of hollow sandcrete blocks. However, the total cement required for the blocks and mortar is far greater than that required for the mortar in a brick wall. For concrete blocks made of 1:7 concrete, a 15% cement content will logically be required, compared to the 5% cement in stabilized laterite bricks. This cost difference is further amplified considering the hikes in the pricing of cement Figure 4.

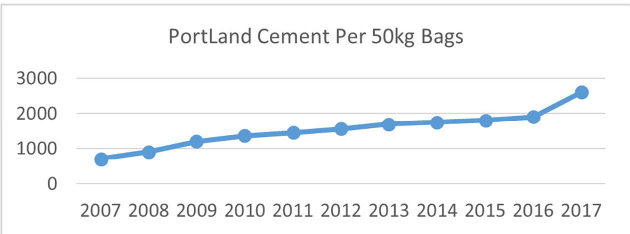

Figure 4. *Hikes in the Pricing of Cement.*

Furthermore, due to the high porosity of commercially available blocks, external rendering of high cement content (sand: cement 4:1) is needed, particularly considering the heavy convectional rains associated with the climate of southern Nigeria. This is before additional decorative finishing, using either less durable paint (2 undercoats, one finishing coat), or relatively more durable and expensive ceramic tiles.

Labour cost however is a factor arguably higher in the laying of bricks. This is as the overall volume covered by one 456 x 228 x 228mm block is equal to that covered by twelve standard sized bricks of 225mm x 112.5 x 75mm. The additional labour for laying twelve bricks as opposed to one block is evident. Furthermore, there is little difficulty in finding tradesmen for sandcrete block laying, whereas bricklayers in Nigeria are relatively scarce and more expensive to employ. Due to the low cost of brick making materials, labour costs will thus have a proportionally greater effect on the overall price of brick housing.

Allasseh [15] however argued, the cost saving in material cost, more than offsets the increase in labour cost. This is because cost is greatly reduced as the need for plastering, painting and other external and internal finishes associated with the use of sandcrete blocks is eliminated. As Allasseh [15] reveals, a considerable cost reduction in walling cost by approximately 40% is tenable. This figure was based on a cost analysis of a block of standard two- bed roomed flat bungalows built using bricks stabilised with 5% cement content as opposed to sandcrete walls which require much higher cement input. This cost profile was computed based on the assumption that the bricks are moulded on site, thus eliminating the cost of transporting blocks to site. This conclusion drawn however remains approximate as pricing will depend on the availability of locally obtainable material and current rates at the time of estimate.

Counter arguments in the literature, however highlight the slow pace of traditional methods of brick production in Nigeria, and the lack of skilled labor to lay the conventional brick size. Typically, it is argued that the production of traditional fired clay bricks is labor intensive, being fundamentally associated with rural dwellings whereby tremendous quantities of firewood obtained from deforestation are required for the firing process, with further heat loss and pollution of the environment [16] However, as Figure 5, shows block-making machines to produce various patterns of cement stabilized bricks the size of blocks have now being developed, cutting down the environmental impacts and labor costs associated with traditional methods of brick production [17, 18]

Figure 5. *Block Sized Cement Stabilized Bricks.*

The curing process requires the simple process of exclusion of moisture by covering with water proof material, which makes it more environmentally friendly. The brick making machines are now commercially available and are adequate for small to medium sized construction. These machines can impact a compressive force of more than $3N/mm^2$ to produce fire resistant cement stabilized blocks on sites, which is suitable and adequate for cost effective structures (Figure 6).

Figure 6. *NIBRR Brick Machine and Construction Using Block Sized Bricks.*

The block-making machine developed by the Nigerian Building and Road Research Institute (NBRRI) produces three blocks in one operation. Normal production of blocks is achieved by a three-person team. One person mixes and loads the soil into the press, another compacts and extracts blocks while the third person transports the block to the drying area, 800 blocks can be produced daily, based on the construction of a model house. This enhances the potential of the machine for urban housing, evidencing a reduction of 50% on cladding material cost [18].

3. Study Methodology

Preliminary pilot interviews were carried out, targeted at soliciting information on perceived uncertainties surrounding the use of local clays in housing. Further to this, a questionnaire survey was conducted among building owners, construction professionals and stakeholders in the building industry, including contractors, brick manufacturers, marketers. One hundred (100) questionnaires were administered randomly to the target population of study. Table 5 shows the distribution of the questionnaires amongst the target population.

Table 5. *Distribution of Questionnaires Amongst the Study Population.*

S/No	Description	No. of Questionnaires	No of respondents	Response rate (%)
1	Professionals	40	37	93
2	Contractors	25	21	84
3	Developers	23	19	75
4	Suppliers	12	9	82
	Total	100	86	86

The sample sizes depended on variability of population sampled, hence all elements of the population are well represented and had adequate response rate. Nevertheless, the table reveals that more responses were received from professionals. This could be due to the level awareness and interest of professionals. The sampled groups expressed their opinion on factors they perceive as responsible for the lack of acceptability and willingness to use this material as a replacement for conventional sandcrete blocks.

The severity ranking of factors responsible for deduced acceptability level are also computed using Likert's 5-point weighting scale. Acceptability and Severity Index analysis were then conducted on the data to rank the factors listed on the questionnaire per their relative importance. The Acceptability and Severity Indices are computed using the formula

$$Ai\ /\ s.i = \sum_{t=1}^{t=n} wifi \text{ x } 100/\text{n} \qquad (1)$$

Where Ai / S.I = Acceptability / Severity index
wi = Weighting for each rating on the scale
fi = Frequency of response
n = Total number of respondents
n = Valid number of respondents

The following 5 levels of weighting scores were adopted for respective indices (Table 5).

Table 6. *Analytical Weighting scores.*

S/No	Acceptability Index	Severity Index	Weighting score
1	Highly Acceptable	Extremely severe	5 points
2	Moderately Acceptable	Very severe	4 points
3	Acceptable	Severe	3 points
4	Neutral	Least severe	2 points
5	Unacceptable	Not severe	1 points

As a final step, a Multiple Classification Analysis (MCA) is deployed to explain variation in level of acceptability by target groups in the population based on the explanatory variables of the study. MCA is a type of regression technique for predicting values of the dependent variable using independent or predictor variables [19]. Mathematically, MCA is given by:

$$Y_{ij.........n} = Y + ai + b_j + ...e_{ij.....n.} \quad (2)$$

Where $Y_{ij.........n}$ = The score (on the dependent variable) of individual n who falls in the category of j of predictor B

Y = Grand mean of the dependent variable

a_i = The "effect" of membership in the i^{th} category of predictor A

b_j = The "effect" of membership in the j^{th} category of predictor B

$e_{ij.....n}$ = Error term for this individual

The MCA technique yields three coefficients: eta, beta and multiple r squared (r^2).

Eta and eta^2: Eta indicates the ability of the predictor (factors), using the categories given, to explain variation in the dependent variable (acceptability level). Eta is the correlation ratio and is an indication of the proportion of the total sum of squares explainable by the predictor.

Beta and beta^2: This are directly analogous to the eta statistics, but are based on the adjusted means rather than the raw means. Beta provides a measure of the ability of the predictor to explain variation in the dependent variable after adjusting for the effects of all other predictors.

Multiple Correlation Coefficient squared (adjusted for degrees of freedom): This coefficient explains the proportion of variance in the dependent variable explained by all predictors together.

4. Results

The analysis in Table 7 shows that a very low percentage of respondents (8%) displayed a very high acceptance of brick as walling materials. 14% and 20% respectively showed moderate to simple acceptance of bricks. The responses indicated that these were mainly professionals mostly comprising of Architects and Engineers. There is an apparent indication that their preference is likely based on their level of awareness of the structural and economic advantage of bricks. The highest proportion of sampled population (30%) of respondents expressed neutrality in their views, showing that they lacked informed opinion about the use of bricks. It is however worthy of note that a significant proportion of respondent found the use of bricks unacceptable. From the result of the field survey there is an apparent indication that majority of the respondents about a total of 52% did not express acceptability for the bricks. The study thus further goes on to investigate the likely factors responsible for this outcome.

Table 7. *Acceptability of Burnt Bricks as an Alternative Cladding Material in Port Harcourt.*

S/No	Acceptability Index	Frequency	% of respondents	Weighted score
1	Highly Acceptable	7	8	35 points
2	Moderately Acceptable	12	14	48 points
3	Acceptable	17	20	51 points
4	Neutral	26	30	52 points
5	Unacceptable	24	28	24 points
		86	100	210 points

AI (Acceptability Index) = 210/86 =2.44

Table 8. *Severity Ranking of Variables Affecting Brick Acceptability in Port Harcourt.*

S/No	Explanatory Variables	Es	Vs	S	Ls	Ns	Weighted score	Severity Index	Ranking
1	Low Aesthetic Appeal	18	12	21	3	32	239	2.80	12
2	Poor Performance rating	59	12	9	1	5	377	4.38	1
3	High Material pricing	20	30	24	4	8	308	4.28	3
4	Price stability	14	25	23	10	12	271	3.15	8
5	Maintenance factor	17	33	2	11	23	268	3.11	10
6	Non-Availability of skilled workmanship	58	11	8	5	4	372	4.32	2
7	Product availability/accessibility	32	17	16	18	3	315	3.66	7
8	Quality/ standardization	42	21	7	4	11	334	3.88	6
9	Quantity of labor requirement	12	25	15	12	14	243	2.82	11
10	Foreign material preference	55	10	8	7	6	359	4.17	4
11	Environmental non-suitability	12	8	6	41	19	311	3.45	8
12	Structural suitability	38	25	13	4	6	359	4.17	4

Key E - Extremely severe
V - Very severe
S - severe
L - Least severe
N - Not severe

Table 9. *Reliability of the Questionnaire Output.*

Cronbach's Alpha	N of items
0.947	12

The outcome of the survey (Table 8) shows the factors affecting the present level of brick patronage in Port Harcourt, along with their severity ranking. However, to infer statistically valid cause-effect relationships, the responses were analysed using MCA to account for the explanatory power of the identified factors in determining the level of acceptability of bricks usage in Port Harcourt. Prior to further inferential statistical analysis however, the reliability of the questionnaire output is established (Table 9).

The Cronbach alpha value of approximately 0.95 shows a good internal consistency of the data. As Pallant [20] recommends, the closer the value of the Cronbach alpha towards one, the greater the internal consistency, establishing the reliability of factors deduced from the preliminary pilot interviews. Table 10 shows the results of the Multiple Classification Analysis in explaining acceptability level of indigenous patronage of local bricks for building construction in Port Harcourt as determined by the listed variables.

Table 10. *MCA Factor Summary.*

		Eta	Beta
			Adjusted for Factors
Acceptability of bricks	Non-Availability of skilled workmanship	0.274	0.222
	High Material pricing	0.112	0.106
	Poor Performance rating	0.211	0.162
	Structural suitability	0.215	0.190
	Foreign material preference	0.191	0.135
	Product availability/accessibility	0.193	0.173
	Quality/ standardization	0.235	0.193
	labor requirement	0.072	0.071
	Price stability	0.042	0.023
	Maintenance factor	0.180	0.107
	Low Aesthetic Appeal	0.287	0.032
	Environmental non-suitability	0.187	0.143

Table 10 shows the bi-variate as well as multivariate effect of the individual factors in explaining the variance in the level of acceptability of brick. The MCA output shows that the non-availability of skilled workmanship is the most important factor impacting the usage of bricks. It also shows that low aesthetic appeal has had maximum effect bivariately. However, much of this may be attributed to spuriousness, when considered in composite effect, relative to other factors. Non-availability of skilled workmanship therefore has the highest impact, considering all other factors. Table 11 further shows that taken together, the independent variables explain 67% of the variation in the dependent variable (Acceptability of bricks).

Table 11. *R-squared.*

	R	R-Squared
Acceptability of bricks, Non-Availability of skilled workmanship, High Material pricing, Poor Performance rating, Structural suitability, Foreign material preference, Product availability/accessibility, Quality / standardization, Labor requirement, Price stability, Maintenance factor, Low Aesthetic Appeal, Environmental non-suitability	0.82	0.67

5. Conclusion

The results reveal a low level of enlightenment by the various elements of the study population in Port Harcourt. This is deducible from the severity ranking of the key factors causing low level of acceptability, which stands in direct contradiction with the reality of the distinct techno-economic benefits derivable from the use of bricks. Typically, it is perceived that bricks have a "poor performance rating and is not structurally suitable.

Further accounting for the unpopularity of bricks are skills/market-driven factors, such as the "non-availability of skilled workmanship", "product availability/accessibility" and "quality/standardisation", upheld by both the severity ranking results as well as the MCA output. This is logically an indication of the need for attention to be given to skills development in bricklaying, higher production, more aggressive marketing and quality control via standardisation. The issue of quality control is however a concern, considering the lack of enforcement of standards on indigenous materials. As Bamisile [21] notes, many local standards are to be yet instituted in Nigeria, while the few existing, are mostly unknown. Typically, the 2007 National Building Code approved by the Nigerian Federal Government, is largely unpublicised and un-enforced.

The severity rankings and explanatory powers of "environmental suitability" and "maintenance factor", are relatively lower, and shows that these are not the major decisive factors determining the level of brick acceptability. The results also reveal that even though the aesthetic rating, as implied from the least severity ranking, which was further corroborated by the outcome of the composite MCA result (Beta), bricks are still minimally used. This may not be unconnected to the attitudinal leaning of Nigerians towards foreign products which ranked 4th, while relegating locally available products to the background as being inferior. As Adogbo and Kolo [7] as well as Anigbogu. and Dalyop, [22] opined, this has had significant wide-scale impact, in making the Nigerian brick market non-competitive, relative to foreign materials which feature in building regulations, and have thus become the default choice in tender documentation and design specification.

The study has shown that it is quite feasible to use stabilized laterite, as substitute for sand/cement blocks in cladding Cost saving can be substantial by using stabilized laterite and with the building techniques currently developed, major cost saving can be made. It is the submission of the study that there is need to revisit the use of locally available bricks.

The following recommendations are thus put forward:

1. The need for rigorous enlightenment campaigns is very significant, as indicated by the lack of public awareness about the performance ability of bricks.
2. Government agencies and stakeholders in the building industry should accept the use of bricks to give it wider publicity. Bricks should be used in public housing projects to demonstrate government's focus on promoting the use of locally available alternative materials.
3. Skills acquisition programs and workshops for bricklayers should be organized by relevant stakeholders.
4. Manufacturers of bricks should on embark on more aggressive marketing of their range of products via the electronic and paper media and other sales promotion avenues. They should also identify and provide skilled workmanship and relevant labor requirements for their clients to give sales a boost and evoke more active interest in the use of bricks.
5. More commitment should be made by relevant enforcement bodies to highlight gaps in the quality-control procedures in the specification of commercially produced bricks. Such regulatory framework is necessary to enhance commercial patronage.

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