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Factors for the Preference for the Use of Interlocking Masonry in Housing Delivery in Nigeria

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Abstract: This study examines the preference level for the use of interlocking masonry over the conventional types in housing delivery in Nigeria. The study summarizes and interprets findings from a comparative survey carried out empirically among some practising professionals in the building industry on some residential projects selected from 4 out the 6 geo-political zones in Nigeria through the use of questionnaire, direct observations, photo prints and interview schedules. Research variables investigated include: cost of masonry works, time of setting of blocks and willingness to use the materials. In addition, two-way Analysis of Variance (ANOVA) was used to test for the presence of significant difference in the level of willingness of respondents to use the selected materials for future projects and material price ratings. Findings signify shorter time of construction and reduced cost of construction expended when interlocking blocks are used. The preference for the use of interlocking masonry in housing delivery as compared with the use of conventional blocks was also investigated. The study concludes that interlocking masonry is a good replacement to the conventional types in construction of housing in Nigeria.

Key words: Preference, masonry, conventional blocks, interlocking blocks, housing

INTRODUCTION

Building materials constitute the largest single input in housing construction. While, Onibokun and Agbola (1990) observed that about 60% of the total housing expenditure goes for the purchase of building materials, Mogbo (1999) claimed that the cost of building materials constitute about 65% of the construction cost. Ademiluyi and Solanke (1977) opined that building materials form the main factors that restricts the supply of housing and ascertained that they account for between 60-70% of the cost of buildings. Thus, Adedeji (2000) rightly observed that one main barrier to the realization of effective housing in Nigeria as revealed in successive government efforts has been the cost of housing in the country. He argued that in the early periods, shelter in Nigeria was easily affordable as building materials were sourced from man's immediate environment at affordable costs. Technology also was readily available with commensurate simple techniques. But contact with the outside world through interregional and international training of professionals in foreign countries as occasioned by colonization, brought changes to tastes and hence, outlook to house forms. These changes rendered the undeveloped local building materials inadequate, while there was an increased demand for exotic ones. Accordingly, Arayela (2002) posited that the modern building industry lays much emphasis on sophisticated building materials and techniques that are expensive and energy consuming.

Though, housing delivery efforts have evidently been inhibited by prohibitive costs of building materials, this problem cannot be reasonably and reliably overcome by merely resorting to the use of locally available materials without due considerations to the applicable initiative and the cost of processing the local materials. Bello (2000) observed that the mere presence of a raw material in an area will not give it a comparative advantage if the cost of making it useful is more than that of bringing in a substitute. He reported that sharp sand for example, responds in direct variation to those of sanitary wares even though sand is wholly 100% locally sourced, while sanitary wares are imported. Gonzalez-Gandalf (1977) also identified the problems in developing countries to include among others the:

- Use of capital-intensive technologies.
- Large import of building materials, components and equipment.
- Lack of incentives to use abundant labour and to increase the production of building materials, components and equipment.

Table 1: Types and description of common interlocking blocks

Name of system/country	Block type and material	Interlocking mechanism
Meccano system, Peru	Hollow (sand-time)	No interlocking geometry-stability only through grouting
Modified H-block, U.S.A	Hollow (concrete)	Tongue and groove in head joint
Sparfil system, Canada	Hollow (Light weight concrete)	No geometric interlocking used as surface bonded masonry.
Haener system, U.S.A and Canada	Hollow (concrete)	Projecting nibs in bed joint. Tongue and groove head joint
WHD Block, U.S.A	Hollow (concrete)	Dovetail arrangement in head joint
Sparklock System, Canada	Hollow (concrete)	Through geometry and stacking pattern
Solid Interlocking	Solid (laetrile stabilised with cement)	Projecting nibs in bed joint. Tongue and groove head joint

Source: Culled from Anand and Ramamurthy (2003)

Accordingly, Akingbohungbe (2002) exploring the works of Alexander King posited that an aptitude for technology or technological innovations has been the characteristic of man since, his earliest time. He further stressed the need for an appropriate Nigerian technology with an over riding objective of adequate mass production and standardisation of building materials and components at modest cost. Thus, the achievements of countries of South-East Asia (Japan, India, Taiwan, Korea), Latin America (Brazil, Argentina, Mexico) and others in the field of industrialization and economic development were not supernatural but facilitated through natural development and effective utilization of appropriate initiative produced by mastery, adaptation and replication of foreign technology. In China, for example, technical innovations and scientific experiments have taken over the place of traditional methods of brick making resulting in mass building productions. Standard designs, productions of components and new techniques in fabrications resulting into mass production of housing units with special emphasis on innovation of walling materials and technology (Adedeji, 2002). It is along this line that the building industry in Nigeria is evolving varied kinds of building system adapted to the local materials, environmental conditions, city developments and levels of techniques of building construction that are in use. One of such system is the adaptation/introduction of interlocking masonry into the building industry which forms the focus of this research.

Interlocking blocks: Introduction of interlocking or dry stack mortarless masonry systems in masonry construction requires the development of efficient, easy to handle and yet versatile blocks. Varied interlocking blocks developed for use include Sparlock system, Meccano system, Sparfil system, Haener system and the Solid Interlocking blocks which are an improvement over the traditional adobe bricks that were prevalent in the 20th century in some African countries. In Nigeria, the Nigerian Building and Road Research Institute (NBRRI) developed an interlocking block making machine meant to produce solid interlocking block types. The blocks have geometric size of 225×225×112 mm. This machine produces solid blocks of laterite composition mainly and stabilised with cement material of ratio 1:19 (Adedeji, 2005, 2007). Interlocking block can also be of cement and sand content only.

An interlocking building block system comprises a plurality of rectangular building blocks, each with longitudinal side faces and walls normal side surfaces and longitudinal faces. The upper longitudinal face of the blocks has a longitudinal accurate rib and a pair of transverse spaced accurate ribs thereon. The transverse ribs extend laterally from the longitudinal rib to one of the surfaces. Corresponding longitudinal and lateral transverse concave and accurate recesses in the lower longitudinal face mate with the ribs of an adjacent block when assembled. A pair of spaced vertical slot extends through the block inwardly of each end wall opposite to the transverse ribs and terminates tangentially to the longitudinal rib. One rib may be placed on the intersection between the two abutting blocks with one transverse rib from lower block in vertical alignment with the slots of the upper block. Corner blocks have a single vertical slot and a third transverse rib and recess opposite and coextensive with one of the pair of transverse ribs and recesses formed on the longitudinal faces.

Tracing the development of interlocking blocks reveals that: Many have complex shapes, which appear to have been deliberate and such intricacies in block geometry (tongue and groove or undercut and dovetail arrangement) necessitate mechanized production methods and the presence of continuity of horizontal and vertical joints from inner to outer face. On the basis of this assessment, a need for development of interlocking blocks with simple geometry and for a study of their structural behaviour and functional performance is found to be essential. Such requirements are found in Solid Interlocking blocks. These requirements includes: Simplicity of shape, limited number of basic block shapes, interlocking without thin tongue and groove or undercuts, interlocking in horizontal and vertical directions, discontinuity of bed joint and cross joint from inner to outer faces and economic production by conventional methods. The system is comprised of units of three basic shapes, i.e., stretcher, jamb and corner blocks, with full-course (200 mm) and half-course (100 mm) high units (Anand and Ramamurthy, 2003) (Table 1).

MATERIALS AND METHODS

This research was carried out in 4 randomly selected geo-political zones out of the 6 existing in Nigeria. A multi-stage sampling technique was adopted in selecting the zones and the cities. The stages of the multi-stage sampling technique employed were, adoption of the original 6 geo-political zones and random selection of 4 zones out of the 6 zones; random selection of one state per zone and specific selection of State capitals in the surveyed zones as they were adjudged to be the most urban. A town was randomly selected from each of the geopolitical zones as follows Abuja (North-central zone); Port-Harcourt (South-south zone), Lagos (Southwest zone) and Enugu (Southeast zone).Two sets of data were collected for this study. The first sets of data were collected by means of well structured multiple-choice questionnaires which were administered to professionals (Architects, Engineers, Quantity Surveyors and Builders) distributed within the study area. The second sets of data were collected with the use of interview schedules, observations through visits to construction sites and completed projects, research institutes and institutions involved in the use of Interlocking blocks materials within the study area. The major materials investigated were interlocking blocks and conventional sandcrete blocks. Descriptive statistics such as means and frequency distributions were utilised for the analysis of socio-economic data, while Chi-square (χ^2) was used to test bi-variate relationships and determine the superiority of the selected materials in terms of cost-efficiency over the conventional type. In addition, One-way Analysis of Variance (ANOVA) was used to test the significant differences in the level of willingness of respondents to use the selected materials for future projects and material price ratings. The chi-square model used is given as:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

where:

O_1 = Observed frequency.
E_1 = Expected frequency.
n = Number of category.

RESULTS AND DISCUSSON

Respondents opinions on comparative cost of Interlocking blocks with conventional types were obtained from the 4 selected locations. Prices of interlocking blocks and conventional blocks were also obtained from the market. While, conventional sandccrete blocks (225×225×450) sells at ₦120.00, interlocking block (225×112×225) mm sells at ₦25.00 as at January 2007. Taking into consideration that conventional blocks requires the use of mortar for the laying of the blocks and associated non-contributory activities that affects its cost and the net output, these activities together with the use of mortar are eliminated in the operation of interlocking blocks (Anand and Ramamurthy, 2003). Though 4 units of interlocking blocks will combine to make a unit of the conventional block, the cost of 4 units of interlocking blocks is still lesser than that of a corresponding conventional masonry. Interlocking blocks are designed and produced in varied sizes in such a way that it does not require cutting into sizes during setting operations. This further reduces the time for setting operation and eliminates associated wastages. Besides, the cost of using interlocking blocks in construction is lower than that of conventional blocks as its operation does not require special skilled labour as it is in the case of conventional blocks. It was generally observed that where a labour gang of 1 mason and labour achieved It was also observed that while, a gang of 1 mason + 1 labour could achieve a Productive hours 6.5 m^2 h^{-1} with interlocking masonry, a gang of 1 mason + 1 labour could only achieve a Productive hours 1.55 m^2 h^{-1} with conventional masonry. These results were not significantly different from each other from one location to the other. The results obtained from the various zones are not significantly different from each other, implying that the locations of the selected projects did not significantly affect the willingness of respondents to use these materials. Consequently, respondents favoured the use of interlocking masonry in housing construction based on its shorter time of construction, reduced cost and high acceptability index as against the use of the conventional types.

Findings from the field are discussed under two broad sub-headings showing the factors for the inclination of respondents for the use of interlocking masonry. These include F-test Anova of respondents opinion on Interlocking blocks and Chi-Square test for significance of differences between materials price rating and acceptability of Interlocking masonry.

The result of two way analysis of variance revealed that there are no significant differences ($p>0.05$) in the locations but there are significant differences ($p<0.05$)in the willingness of the respondents to use interlocking block masonry. Majority of the respondents (61%) observes that interlocking blocks are cheaper. Only 19% indicated that the cost of interlocking blocks is higher than that of conventional types while, 18% of the respondents opined that the cost of interlocking block is moderately cheap (Table 2).

Table 2: ANOVA results on respondents' opinion on comparative Cost of Interlocking blocks with conventional types

Anova: Cost sample 2

Summary	Count	Sum	Average	Variance
Lagos	4	100	33.33333	902.3333
Abuja	4	100	33.33333	1922.333
Port-Harcourt	3	100	33.33333	217.3333
Enugu	3			
Expensive	3	56	18.66667	8.333333
Cheaper	4	201	67	273
Moderate	3	43	14.33333	196.3333

ANOVA

Source of variation	SS	d.f.	MS	F	p-value	F crit
Location	0.38	3	0.083333	0	1	4.757055
Cost	5128.667	2	2564.333	10.73692	0.024657	6.944276*
Error	955.3333	4	238.8333			
Total	6084	8				

Table 3: ANOVA results of respondents' opinion on comparative time of setting of interlocking and conventional blocks

Summary	Count	Sum	Average	Variance
Lagos	3	100	33.33333	1304.333
Abuja	3	100	33.33333	1130.333
Port-Harcourt	3	100	33.33333	30.33333
Enugu	3	100	33.33333	126.3333
Longer	4	91	22.75	185.5833
Moderate	4	102	25.5	172.3333
Shorter	4	207	51.75	686.25

ANOVA

Source of variation	SS	Df	MS	F	p-value	F crit
Location	0	3	0	0	1	4.757055
Time	2050.167	2	1025.083	1.963448	0.220807	5.143249
Error	3132.5	6	522.0833			
Total	5182.667	11				

Table 4: ANOVA results of respondents opinion on willingness to use interlocking-blocks masonry from 4 locations

Summary	Count	Sum	Average	Variance
Lagos	3	100	33.33333	2581.333
Abuja	3	100	33.33333	1617.333
Port-Harcourt	3	101	33.66667	1504.333
Enugu	3	100	33.33333	2129.333
Unwilling	4	10	2.5	9
Undecided	4	57	14.25	57.58333
Willing	4	334	83.5	46.33333

ANOVA

Source of variation	SS	d.f.	MS	F	p-value	F crit
Location	0.25	3	0.083333	0.001477	0.999912	4.757055
Willingness	15326.17	2	7663.083	135.8301	1.01E-05	5.143249
Error	338.5	6	56.41667			
Total	15664.92	11				

The result of two way analysis of variance (Table 3) reveals that there are no significant differences ($p>0.05$) in the locations but there are significant differences ($p<0.05$) in the willingness of the respondents to use interlocking block masonry. Highest percentage of the respondents (62%) indicated that the setting time for interlocking blocks is shorter than that of conventional masonry, while 18% opined that it is longer. The other 18% of the respondents rated the setting time of interlocking blocks to be moderately short.

The result of two way analysis of variance shows that there are no significant differences ($p>0.05$) in the locations but there are significant differences ($p<0.05$) in the willingness of the respondents to use interlocking block masonry. Majority of the respondents (83.4%) are willing to use the products. Only 6.6% claimed that they are not willing to use this material for construction. About 10% of the respondents are undecided on the choice of masonry they could use for house construction. The decision of this group may be affected positively toward the use of interlocking blocks as the material becomes more popular in the building market (Table 4).

Table 5: Measures of association between materials price rating and acceptability of inter-locking

Cross tab		Acceptability of interlocking blocks: Not acceptable at all	Rarely acceptable	Moderately acceptable	Acceptable	Very Acceptable	Total
Materials price rating							
Very expensive	Observed	1	3	5	14	15	38
	Expected	1.0	7.9	6.3	14.6	8.2	38.0
Expensive	Observed	1	12	7	25	5	50
	Expected	1.3	10.4	8.3	19.2	10.8	50.0
Moderately cheap	Observed	1	10	7	7	4	29
	Expected	0.7	6.0	4.8	11.1	6.3	29.0
Cheap	Observed	0	0	0	0	1	1
	Expected	0	0.2	0.2	0.4	0.2	1.0
Very cheap	Observed	0	0	1	0	0	2
	Expected	0.1	0.4	0.3	0.8	0.4	2.0
Total	Observed	3	25	20	46	26	120
	Expected	3.0	25.0	20.0	46.0	26.0	120.0

Source: Researcher's Field Survey (2005), obtained from the four selected cities

Chi-square test for significance of differences between materials price rating and acceptability of interlocking masonry: Chi-square model was used to test for association between the materials price rating and acceptability of inter-locking masonry by the respondents. The respondents' opinions on materials price rating were found to depend on their acceptability of interlocking masonry.

Based on the result in Table 5, there is association between acceptability of interlocking masonry and price of materials. The χ^2 results shown in the table indicated a significant level ($p \leq 0.05$) for the variables used to assess acceptability and material price rating.

Since, the χ^2 result showed a significant level of association between material price rating and acceptability of interlocking blocks irrespective of the cost of the material in the locality, the material is therefore, recommended for use as a better alternative to conventional blocks in housing delivery.

RECOMMENDATIONS

Based on the major findings in this research, it has become imperative to put up some recommendations that are necessary to for the preference of interlocking masonry over the conventional types in housing delivery in Nigeria. These include:

- Accelerated dry masonry system is advocated for in housing projects as an alternative method cheaper than the conventional wet type. It is also faster in operation with a potential of saving over 65% of time and cost of the masonry work. It reduces wastage of materials and number of labour required for operation. Interlocking blocks can be produced with the same materials as used in the production of conventional blocks.
- The policy makers should encourage standardisation of building components in Nigeria in line with the global trend as canvassed by the International Standard Organisation (ISO). This implies that building materials particularly masonry materials should be available in the market in this form for users to purchase in finished form to be assembled on site. Factories that produce standard components should be established. Besides, quality of materials should be controlled manufacturer's association.
- The use of dry construction methods with appropriate standardised components to reflect the designer's specification would reduce or completely eliminate wastages, reduce labour to be engaged, reduce cost as well as the time for construction if the building operation is professionally handled. In view of this, dry construction method is therefore, more cost-effective and preferred above the conventional method as confirmed by this research.
- Specialisation on building materials at entrepreneurship scale should be facilitated to generate employment opportunities for teeming unemployed youths. Small scale entrepreneurship production workshop should be set up on-site for production and easy replication of building components thus facilitating employment generation. In the alternative, standard building components can be purchased off-site to be assembled with few workers and within a short period of time.

CONCLUSION

This study examines factors for the preference of interlocking masonry over the conventional type in construction of housing in Nigeria. Though the survey covered 4 out of 6 geo-political zones in Nigeria, the respondents opinion on the variables investigated did not show significant differences from one location to the other but in the willingness of respondents to use

interlocking masonry as a better alternative to conventional masonry. This is predicated on the cost-efficiency and shorter period of setting of the material. The field data obtained from 4 different locations were analysed for the mean separation result using Fishers LSD F-test significance, which showed 83% respondents preference for the use of interlocking masonry as against the use of the conventional type. The analysis of measure of association and their significance of interlocking-blocks masonry based on variables such as material price rating and suitability, material price rating and strength/ willingness indicated results of significance level at ($p \leq 0.05$) of the association of variables measured. Besides, interlocking blocks offer several advantages such as design flexibility, cost effectiveness, reduced construction time, environmental friendly and solution to space shortage. Thus, the result of the research has provided information that could help to reduce cost of housing projects in order to make housing affordable and sustainable.

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