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Research Article

Selection of Green Materials toward Construction of Affordable and Low Cost Building in Nigeria

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A b s t r a c t

Selection of materials for building construction is one of the greatest tasks, because the successful completion and sustainability of the building highly depends on the types and qualities of the materials used during construction activities. There are lots of green materials that can be obtained locally for building construction in Nigeria at affordable price. The study was conducted by reviewed relevant literature and survey questionnaires for collections of data from the North Central Nigeria on the key factors and criteria that would assist the building professionals in the selection of green materials and components for sustainable low-cost building constructions. Four hundred questionnaires were distributed, out of which three hundred and five were retrieved. Structural equation model (SEM) statistical tools were used to analysed the data. The results revealed that eco-friendly, ozone friendly, availability of technical skill labour, reusability and recyclability, energy efficiency, low cost of materials, materials embodied, and compatibility with cultural tradition are main factors that are extremely required in order to select sustainable green materials for low cost building constructions.

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1. Introduction

The housing construction industry is one of the most significant industries that support the economic growth of any country. However, one of the problems of housing shortage arises from the types and cost of selected materials for its constructions. According to Mehta and Sharma, (2014) 'building materials are all the physical substances that are assembled to create the interior and exterior of a building'. In the current time, the cost of building construction has been escalated due to the fact that the players of the building industry mostly used conventional materials with little or no consideration for natural materials (green materials) in carrying out its activities. Materials that have at least one positive environmental characteristic are simply refer to as green materials, Green building materials or components are further known as materials or components with lower cost and energy requirements across their life cycle, when compared to conventional materials that serve the same purpose. Hence, the study was on different criteria/factors that need to be considered prior to selection of suitable green materials for low building constructions.

Consequently, this paper concluded that there are many green materials which can be used for construction of low-cost buildings, but there is a need to select the appropriate ones among the materials which meet up with the indentified criteria.

2. Materials and Methods

2.1 Affordable Housing

The role of housing in human life cannot be overemphasized. It has incredible social and economic influence on the total living environment of the creation. Housing is widely recognized as a human right, yet Nigeria's low-income households in particular struggle when it comes to finding an adequate housing that does not leave them in financial trouble. According to Mao & Yang, (2011) the term "affordable housing sometimes also called social housing or mass housing commonly features in discussions on housing issues, which are also social and economic issues. Because the perception of what is affordable varies significantly across cities, states and income groups", mostly, inexpensive housing deals with housing solutions that are priced and financed in a way that ensures low-income occupants satisfy their other basic needs.

According to Olanrewaju, et al (2016), housing is a degree of the quality of life. They however stated that in most of the developing countries, housing is insufficient. Housing is said to be

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affordable only when the rental value per annual of repayment of mortgage does not exceed 30%-40% of the employees (U.S. Department of Housing 2006).

The Nation's number-one housing problem is the lack of affordable housing for extremely low-income households (Wolfe, 2012). Vicent et al (2001) citing (Ogu and Ogbuozobe, 2001) summarized in Table1, the federal housing program of Nigeria indicating different cost and prices of various types of houses as at 1996.

Table 1: Federal housing program in Nigeria: production costs, advertised and selling prices by house types as at 1996 (in Naira)

Type	Construction cost	Infrastructure cost	Land, admin. and developer profit	Economic selling price	Advertising price	Recommended price
1 BB in BLK of 4	261,558	78,467	102,007	442,033	70,000	261,558
2 BB in BLK of 4/5	241,157	102,346	133,050	567,554	100,000	341,156
1 BB in BLK of 5/6	395,817	118,745	154,368	668,931	90,000	395,817
2BB in BLK of 5/6	437,704	131,311	170,705	739,720	110,000	437,706
3 BB with courtyard	750,537	225,161	292,709	1,268,407	200,000	750,537
2 BR Det. Bungalow	589,877	176,963	230,052	996,893	210,000	589,877
3 BR Det. Bungalow	811,998	324,799	341,093	1,477,837	600,000	1,477,837
2 BR Flat in BLK of 6	1,114,348	445,739	468,026	2,082,114	780,000	2,082,114
3 BR Flat in BLK of 6	1,325,103	530,041	556,543	2,411,688	920,000	2,411,684
5 BR Semi-Flat Duplex	3,802,453	1,520,981	1,597,030	6,920,645	2,200,000	6,920,465
Kubwa 5 BR S/D. Duplex	3,155,121	1,262,048	1,325,151	5,742,321	3,000,000	5,742,321
Dolphin 94 BR S/Det.	3,309,690	1,323,848	1,390,040	6,023,508	3,000,000	6,023,508

Source: Vicent et al (2001). Note: BR"bedroom; Det."detached; BLK"block; BB"bedroom bungalow.

Table 1 illustrates the cost of constructing housing and the recommended cost price by federal government of Nigeria as at 1996.

Sard (2001), found out that severe housing problems are concentrated among extremely low-income households and that three-fourths of low-income renter households with severe housing problems have incomes below 30 percent of area median. This scenario made it difficult for low income group to acquire a building of their own.

2.2 Affordable Green Materials

There are different types of building materials ranges from the locally available to the internationally imported conventional building materials for the purpose of housing constructions

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in Nigeria, it is curtains that the conventional building materials lead to the escalating cost of constructing building in the present dispensations, because most of these materials were imported into the country, while naturally available local materials will be more economical to build low-cost housing projects.

Most low-income households have limited access to affordable housing, and therefore it is apparent that housing shortages cannot be solved without focusing on sustainable low-cost building materials. The potential savings from using natural building materials as alternative construction materials cannot be overemphasized. In the study carried out by Zami (2008), it revealed that the use of earth on site as a building material saves manufacturing cost, time, energy, environmental pollution and transportation cost.

Oshike, (2015) also observed that earth has been in use as a wall building material for centuries, in many ways, around the world and particularly in all parts of Nigeria for residential house construction. As observed above other naturally available materials otherwise known as green materials had similar characteristics and advantages as earth materials. In the study carried out by Kumar (2015), the following were highlighted as the characteristics of green building materials:

- Easy to make,
- Easy affordability
- Easy assembly
- Faster & cheaper construction
- Effective excess utilization
- Energy efficient and environment-friendly

Hence, green materials for construction of low cost (LC) housing will increases the access to buildings by low income group peoples. Generally, LC housing can be achieved by use of efficient planning and project management, LC materials, economical construction technologies and use of alternate construction methods available.

2.3 Types of Green Materials (GM)

Green materials are natural materials that are available within our environment and considered suitable for the construction of building. According to Hsieh, et al (2012), green building material is one of the basic elements of a sustainable building, and stated further that the serious energy and natural resources shortage that our living environment is currently facing shows an imperious

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demand on developing a better building material certification and management mechanism. Kayode and Ayodele (2013), described the following; clay, laterite, stone, lime, agro-industrial waste, timber, bitumen, glass sand etc., as potential natural building materials deposits in their natural state in Nigeria thus complements the call for the use of these local materials for building construction purposes. Bredenoord (2017), also suggested that attention should be given to the following five groups of building materials: Bamboo and timber; Compressed earth bricks/blocks; Adobe blocks; Interlocking blocks of recycled materials and Improved concrete panels; as promising green building materials for low cost housing constructions. Fradinho & Nedelcu (2017) highlights stone, straw and earth as the most prominent materials used in building traditions of Africa.

2.4 Factors that Determine the Green Materials Selection

Many studies have been carried out on the factors that determine the selection of relevant green materials for the construction of low-cost building. Table 2 below shows some scholars work factors that determine the selection of the materials for the construction of low-cost building

Table 2: Previous studies on the factors that determine selection of green materials

No	Author (s)	Objectives	Results
1	Nambatya (2015)	The research was set out to investigate the current barriers to more widespread adoption of Interlocking Stabilized Soil Blocks (ISSB) technology in relation to the rationale for building material selection.	The study found out that cost, durability, availability and acceptability by clients were the common reasons for material choice. However, acceptability by clients was governed by their perceptions towards stabilized soil.
2	Umar et al (2012)	Selection of construction materials that have minimum environmental burdens is useful in the sustainable development of a nation	Sustainability as an alternative criterion for building materials are generally chose through functional, technical and economical specifications.
3	Ogunkah, and Yang, 2012)	Investigating Factors Affecting Material Selection: The Impacts on Green Vernacular Building Materials in the Design-Decision Making Process	The argument is advanced that the explicit incorporation of sustainability in the material selection process requires the assessment of the social, economic, technical, sensorial and environmental consequences of potential material options

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4	Ogunkah and Yang 2012	To determine how the understanding of the principles of best practices associated with the impacts of low-cost green building materials could be improved to fulfill the objective of their greater use in mainstream housing.	Most important decision factors having significant impacts on the process of material selection for low- cost green residential housing development was established.

Umar, et al (2012), revealed that substantial initiatives have been carried out by the research community globally, in order to discover alternative sustainable building materials and low technology techniques, which would result in a more sustainable and affordable construction complying with the comfort standards required today thus embracing green building materials is a good alternative to meet this objective. They concluded that material selection is very important to achieve the above goal. According to Ogunkah & Yang (2012), material selection is a complex and delicate task determined by the immense number of building material options. Likewise, multiple factors are often considered by the architect when evaluating the various categories of building materials.

Nambatya, (2015), in a study which is on investigating the rational for material selection in tropical housing projects in Uganda found out that, cost, durability, acceptability and availability are the most common factors considered by promoter/non promoter of building providers. Ogunkah & Yang (2012), also concluded that cost, location, durability and aesthetics are the major criteria's to be considered in the selection of green building materials for LC building construction. Finally, in their study they formulate a framework of factors or variable to be considered in assessing materials as summarized in figure 1.

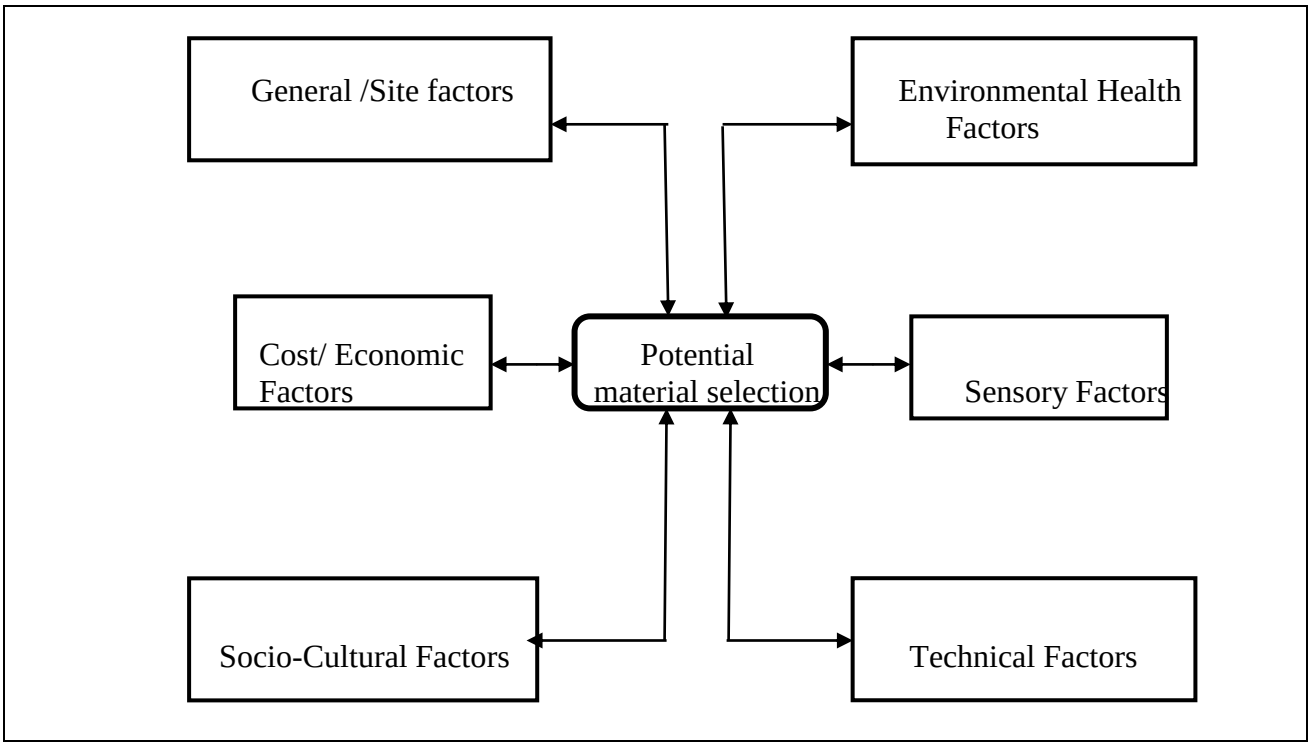

Figure 1: A framework of factors or variables for assessing building material sustainability adapted from Ogunkah and yang (2012)

In their frame work the potential material selection factors include; general site factors, environmental health, cost/economic, sensorial, socio-cultural and technical factors as layout in the diagram in figure 1.

2.5 Methodology and Analysis

During the conduct of this study, questionnaire survey was carried out among the Nigerian Building Construction professionals, who were duly registered members of different organisations in the building industry. Out of the 400 questionnaires distributed in six different states in Nigeria (that is, in Plateau, Niger, Benue, Nassarawa, Kogi and Kwara States); 305 questionnaires were able to be retrieved for data analyses. The data were entered in to special package for social science (SPSS 22) for analysis and structural equation model (SEM) statistical tool was further used to carry out a confirmatory factor analysis and regression analysis through a comprehensive fitness index.

2.6 Fitness Index

Fitness Indices reflect how fit the model is to the data (Zainudin, 2012). Wan Afthanorhan, (2014) noted that there is several Fitness Indices in SEM that reflect how fit is the model to the data. It was recommended that the use of at least one fitness index from each category of model fit

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Fitness Indices in SEM models are assessed through three model fit categories namely Absolute Fit, Incremental Fit and Parsimonious Fit. Wan Afthanorhan, (2014)described the three categories as follows:

Table 3: Fitness Indices

Name of category	Name of index	Index name	Level of acceptance
Absolute Fit	Chisq	Discrepancy chi square	P > 0.05
	RMSEA	Root Mean Square of Error Approximation	< 0.08
	GFI	Goodness of Fit Index	> 0.90
Increment Fit	AGFI	Adjusted Goodness of Fit	> 0.90
	CFI	Comparative Fit Index	> 0.90
	TLI	Tucker-Lewis Index	> 0.90
	NFI	Normed Fit Index	> 0.90
Parsimonious Fit	Chisq/df	Chi-Square/Degree of freedom	< 5.0

3. Results

3.1 Factors that Determined Selection of GMs (Measurement Model Fit)

The construct on factors that determine selection of GMs contains 22 indicators to be assessed in CFA analysis. These 22 indicators are derived from 12 items in Section C of the questionnaire. Figure 2 illustrates the initial measurement model for the construct on factors that determine selection of GMs. Table 4 lists the indicators for the initial measurement model for construct on factors that determine selection of GMs.

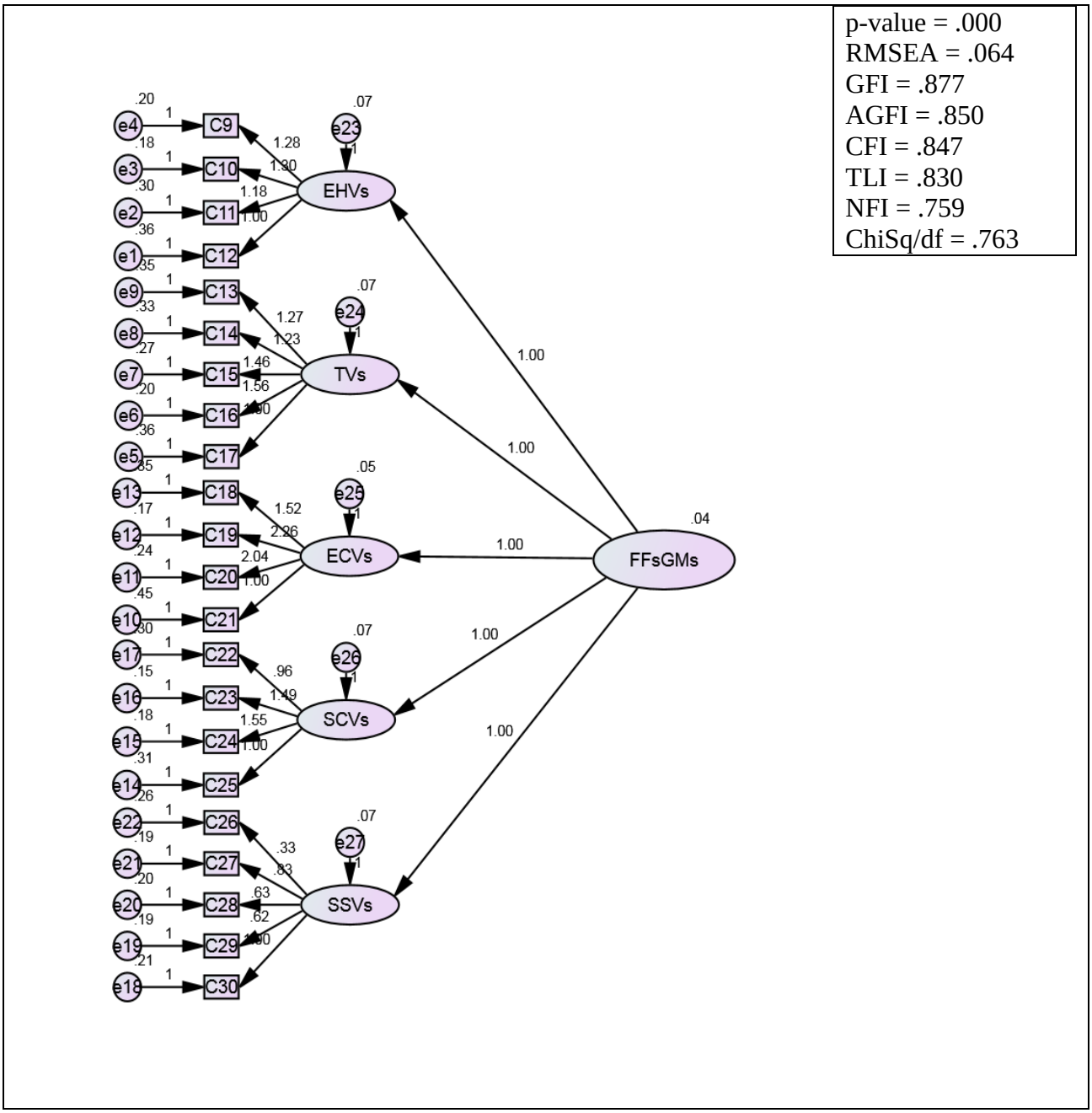

Figure 2: Initial measurement model for construct on Factors that Determined Selection of GMs

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Table 4: Indicators for the initial measurement model for construct on main Factors that Determined Selection of GMs

Constructs	Code	Indicators
	C9	Eco-friendly
	C10	CO2 emission
	C11	Ozone friendly
	C12	Biodegradability
	C13	Availability of technical skill labour
	C14	Level of maintenance
	C15	Reusability and recyclability
	C16	Waste reduction
	C17	Weather resistance
Factors that	C18	Energy efficiency
determine	C19	Low cost of materials
selection of	C20	Low cost of transportation
Green	C21	Materials embodied
Materials	C22	Material compatibility with regional setting
	C23	Compatibility with cultural tradition
	C24	Local knowledge of the custom & life style
	C25	Types and size of family unit
	C26	Temperature regulation
	C27	Acoustic
	C28	Colour of the structure
	C29	Odour of the materials
	C30	Thickness/thinning of the element

The Fitness Index, as revealed in Figure 2, indicates the poor fit of the measurement model, with values of specified indices of (ChiSq/df= 0.763 <3.00), (GFI, AGFI, CFI, TLI and NFI <0.90), and (RMSEA=0.064>0.08). Therefore, the model needs some modification to achieve the acceptable index. To attain uni-dimensionality for the model, items with low factor loading less than 0.5 were deleted. Since the Fitness Index was still not meeting the required value after items deletion, the MI values for the model are checked for possible redundant items. Some high MI values are detected (more than 15); hence paired items with lower factor loadings are deleted to obtain the discriminant validity of the model. The final measurement model for the construct on factors that determine selection of GMs, after items removal, was portrayed in Figure 3. The model achieves the construct validity with the acceptable Fitness Index of: P-value=0.003, RMSEA=0.045, GFI=0.957, AGFI=0.934, CFI=0.949, TLI=0.933, NFI=0.980 and ChiSq/df=

0.719. Table 5 shows the indicators for the final measurement model for construct on factors that determine the selection of GMs for low-cost building in Nigeria.

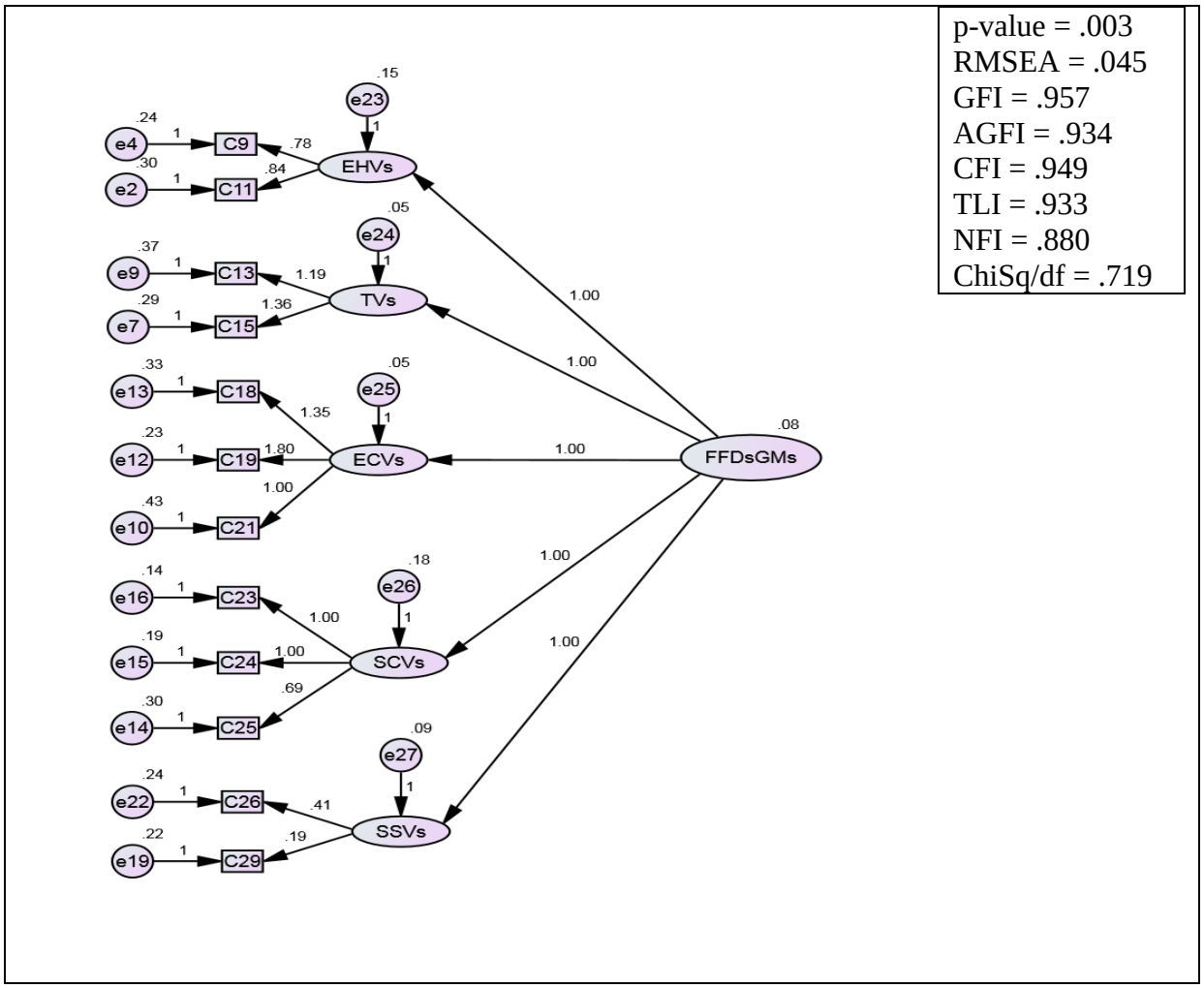

Figure 3: Final measurement model for construct on Factors that Determine Selection of GMs

Table 5: Indicators for the final measurement model for construct on Factors that Determine Selection of GMs

Construct	Code	Indicators
	C9	Eco-friendly
	C11	Ozone friendly
	C13	Availability of technical skill labour
	C15	Reusability and recyclability
	C18	Energy efficiency
Factors	C19	Low cost of materials
that	C21	Materials embodied

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determine selection of GMs	C23	Compatibility with cultural tradition
	C24	Local knowledge of the custom & life style
	C25	Types and size of family unit
	C26	Temperature regulation
	C29	Odour of the materials

The convergent validity and composite reliability for the model are also achieved with the AVE values of 0.66, 1.64, 2.02, 0.92 and 0.21 (≥0.5), and CR values of 0.79, 1.27, 1.22, 0.96 and 0.17 (≥0.6). Table 6 shows the details of the validity and reliability assessment for the model. From the overall satisfied values of Fitness Index, uni-dimensionality, validity and reliability for the measurement model, the model was then accepted for inclusion in the next assessment of the whole structural model.

Table 6: Validity and reliability assessment for Factors that Determine GMs Selection measurement model

Constructs	**Sub-construct**	**Items**	**Factor Loading**	**AVE (≥ 0.5)**	**CR (≥ 0.6)**
Factors that determine selection of Green Materials	Environmental and health variable	C9	0.78	0.66	0.79
		C10	deleted		
		C11	0.84		
		C12	deleted		
	Technical variable	C13	1.19	1.64	1.27
		C14	deleted		
		C15	1.36		
		C16	deleted		
	Economic variable	C17	deleted	2.02	1.22
		C18	1.35		
		C19	1.80		
		C20	deleted		
	Social cultural variable	C21	1.00	0.92	0.96
		C22	deleted		
		C23	1.00		
		C24	1.00		
		C25	0.69		
	Sensorial variable	C26	0.41	0.21	0.17
		C27	Deleted		
		C28	Deleted		
		C29	0.19		
		C30	deleted		

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4. Conclusion

The study focused on the factors that determine the selection of green materials for the construction of low-cost building in developing countries such as Nigeria. Since building project involves the use of various materials which are very important part of the construction process; it was perceived that much of the current research and information on material selection of low-cost green materials present generalized guidance, which are neither supported by quantitative nor qualitative data. Thus, this study was carried out in the north central Nigeria using questionnaires to obtained data from building professionals. SPSS 22 and structural equation model (SEM) were used to encode and analysis the data respectively. The finding reveals that eco-friendly, ozone friendly, availability of technical skill labour, reusability and recyclability, energy efficiency, low cost of materials, materials embodied, and compatibility with cultural tradition as major factors that determined the selection of green materials for building projects. The finding of this study agreed partially with that of Ogunkah and Yang (2013). These works have established the major and useful criteria for selection of green materials which if put into consideration will address the problems and challenges of housing for the low-income earners in Nigeria and the developing countries at large.

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