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Post-Occupancy Evaluation of Modification of Residential Buildings for Effective and Efficient Mass Housing Delivery: Case Study of Owerri Urban, South-Eastern Nigeria

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ABSTRACT
This study evaluates Aladinma and Prefab Housing Estates in Owerri Urban South-Eastern Nigeria which is experiencing population increase emanating from rapid urbanization. The aim is to improve future mass housing delivery in the area through feed-back information from the building consumers. The specific objectives were: to establish the nature and extent of post-occupancy modifications carried out in the estates; to determine the reasons for the modification and factors of satisfaction that are necessarily required to be considered in the programming and design of residential buildings in the study area for optimal performance; and to develop a mathematical method of conducting post-occupancy evaluation of modification of residential buildings.. The evaluation was based on a theoretical frame work of tripartite quality of architecture emphasized by Vitruvius; Utilitas (functionality or utility value: the social dimension), Firmitas (strength and rigidity: the technological dimension) and Venustas (beauty: the aesthetic dimension). The methodology involved field survey or case study. The field study involves six research approaches: archival retrieval; comparative mapping; physical trace identification; observations; questionnaires and interviews. The sample population of 405 building consumers and 409 housing units from the population of 1261 were used. The quantitative data were analyzed using SPSS software and the results were exported to Microsoft Excel to generate the graphs used. The research revealed that Overall Modification Index for model predicted data was 0.9126 and overall experimental data was 0.9126 with Overall Deviation of 0.00%. Average Modification Index for Housing Estates in Owerri South-Eastern Nigeria was 0.9126. Design factors that necessitated post-occupancy modifications in the study area were: functionality- 92.6 percent; Aesthetic- 92.7 percent; and Constructional issue- 97.3 percent. This implied that for a sustainable housing estate to be achieved, the concept of Equilibrium of Appropriate Balance (Construct-Functional Aesthetic Balance) has to be adopted. The consumers of building products should be involved in the programming, design and construction of their buildings to capture their needs and aspirations. Overall Modification Index for Owerri was 91.26%. The Authors successfully developed a mathematical model for Post-occupancy evaluation of modification of residential buildings in Owerri, South-Eastern Nigeria $MI_{MOD}^{Overall} = C_I MI_{IAV}$ which can be used in evaluating modification of public residential buildings in other states in Nigeria.
Keywords: Post-occupancy evaluation, modification, Mass Housing, Building Consumers, Index.

I. INTRODUCTION

Housing is one of the three basic needs of mankind and it is the most important for the physical survival of man after the provision of food. Many researchers Kadir (2005), Aribigbola (2008), Adedeji (2005), Ademiluyi and Raji (2008) have viewed housing shortage as a result of urbanization which resulted in increase in population in urban centers. In Nigeria, government has actively sought to alleviate the problem of housing by addressing basic needs of the urban poor through ambitious initiatives such as public housing schemes (Wahab, 1983). These public housing initiatives have been implemented for over five decades with the completion and occupation of thousands of houses in different housing estates spread all over the six geo-political zones of Nigeria. Imo State Housing Corporation Owerri in South-Eastern Nigeria has thirteen housing estates to her credit while Federal Housing Authority Owerri has four. The housing estates include Aladinma Housing Estate, Prefab Housing Estate, Uratta Road Housing Estate, Federal Housing Estate Egbeada, Trans-Egbu Housing Estate, Uratta Road Housing Estate, Federal Housing Estate Egbeada and etcetera.

Reconnaissance or pilot survey done by the researchers on some of the public housing estates in the study area reveals that most of the building units have been modified while the remaining ones are currently undergoing modification. Since 1995 till date, the researchers have modified so many buildings for clients in Federal Housing Estate Egbeada, Aladinma and Prefab Housing Estates. This modification could rightly be viewed as acknowledgement of failure of the estates and at the same time deflates the exalted regard for the architectural profession and social role of architecture on society. The architectural designs of the residential buildings in the housing estates which are being modified were in their days succeeded to be registered and approved for construction thus became a contract of the architect with the society's spirit of the time (Zeitgeist) for generation of a material culture of a people (Nwankwo, 2013). And so, the post-occupancy modification constitutes a breach, as it were, of an essential aspect of that contract and it distorts and manipulates the harmony of a people's built environment and historical development, especially in their material culture. The built environment is at the very heart of the identity of the Owerri urban centre. This modification has become frequent that it needs to be investigated. Owerri urban which was known for its colorful architectural character has gradually been losing the architectural identity as the urban-scape continually changes. No concerted effort has been made or researches conducted to find out these user preferences that have resulted in this post-occupancy modification. The modification is an attempt by the building consumers to presumably personalize the houses to meet their unattended needs and aspirations during programming, design and construction. There is a challenge therefore to carry out a study on post-occupancy evaluation of modification of public residential building in the study area, directed on the occupants in order to obtain feed-back information that is needed for future policy formulation, program and design development of public residential buildings in the zone. The problem this research is to tackle is therefore this lack of adequate feed-back information from public housing consumers on the performance of buildings in-use that necessitates the frequent modification of residential building. According to the World Health Organization, health is not merely the absence of disease and infirmity but a state of optimal physical, mental and social well-being. Building characteristics may affect health and well-being of the consumers in a positive or negative way by such things as light, noise, indoor air quality, colors and materials. The well-known studies of Ulrich (1984, 1991, and 2000 quoted in Nwankwo, 2013) show that views from a window may influence recovery of patients. Later studies have been carried out into the positive effects of nice environments, leading to the so-called "healing environment" (Malkin, 1992; Haskin and Haggard 2001 quoted in Nwankwo, 2013). A stream of studies has considered the negative effects of poorly designed residential buildings and environments and the 'Sick building syndrome' (SBS) (Hedge, 1986; Burge, 1987; Molhave, 1987; Valjborn, 1989; Norback, 1990; DeBoo, 1990 quoted in Nwankwo, 2013). In 1982, the World Health Organization officially reorganized SBS as a medical condition where people in a building suffer from symptoms or illness or feel unwell for no apparent reason. Public buildings in the study area were not built to address the health implications of the consumers. Unfortunately, no attempt has been made by any past researcher to conduct post-occupancy evaluation on the existing public housing estates in the study area. Therefore, the contribution of this study is a welcome development in the housing sector for optimal performance.

The outcome of this research is expected to improve the design of future public residential buildings and minimize the incidence of modification and defacing of housing estates in the study area. By designing new buildings with an understanding of how similar buildings perform in-use, mistakes will be avoided and successful design features would be sustained (Nwankwo, 2013). The result of this research will establish the design factors that require adequate consideration at the programming and design stages. Information and data from the research will equally be a reference for teaching architects and future operators in the area of public residential building development. The continuous feed-back from post-occupancy evaluation on performance of buildings in-use can be used to document deficiencies as part of the justification of new construction or remodeling projects. The result of this study will also serve as a platform for empirical studies on public residential buildings performance in any other Urban Center in Nigeria. Post-occupancy evaluation aims at discovering how the completed building performs; determining possible misfits, mistakes or omission; and accumulating information for future programming and design (Duffy, 2008). According to Watson (2003) post-occupancy evaluation is a systematic evaluation of opinions about buildings in use, from the perspective of users. Post-occupancy evaluation by the actual users of buildings is therefore important in order to discover the root course of post-occupancy modification of these buildings and for improving future design quality.

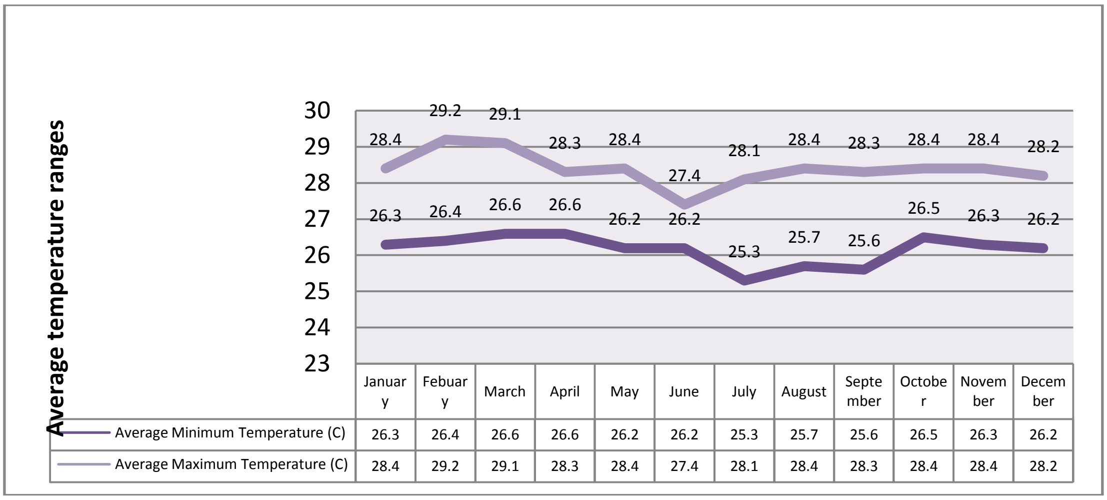
Aim and Objectives

The aim of the study is to come up with parameters for post-occupancy evaluation using consumer feed-back information that will improve the performance of public housing delivery in the study area. The objectives are: to establish the nature and extent of post-occupancy modification carried out in the residential buildings; to determine the reasons for the modification and establish consumer group-factors that are necessarily required to be considered in the programming and design of mass residential buildings for optimal performance; and to develop an assessment model for conducting post-occupancy modification.

Study Area

Owerri is in South-Eastern Nigeria which is located between latitude 04^{o} 15^{1} and 07^{o}N and longitude 05^{o} 50^{1} and 09^{o} 30^{1}E. Its lowland rain forest lies between the rain forest savanna acetone and the salt and fresh water swamp forest along the coast (Igbozurike, 1975 quoted in Nwankwo, 2013). South-East is bounded on the north by Kogi and Benue States of North-Central geo-political zone and on the east, west and south by Cross River, Akwa Ibom, Rivers, Bayelsa, Delta and Edo States of South-South geo-political zone. The Tropical rainforest climate is found in the South-Eastern part of Nigeria. This climate is influenced by the monsoons originating by the South Atlantic Ocean, which is brought into the area by the maritime tropical air mass, a warm moist sea to land seasonal wind. Its warmth and high humidity gives it a strong tendency to ascend and produce copious rainfall, which is a result of the condensation of water vapor in the rapidly rising air.

The Tropical rainforest climate has a very small temperature range. The temperature ranges in Owerri, South-East Nigeria are almost constant throughout the year. According to Nwankwo, (2010) Owerri records a mean maximum temperature of 28^{o}C for its hottest month's ranging from February to march before the rain storms in June to October while its lowest mean temperature is 26^{o}C in its coldest months ranging from July to September (Fig.1& Fig.2). In the study area, there is a need to reduce environmental heat in or on buildings to increase human comfort. The following measures are taken to address the issues of tropical heat intensity in the study area: at critical places thermal insulators are introduced to reduce heat transmission; natural cross ventilation is achieved through wide openings to create steady normal air flow and to ensure that temperature values remain at considerable limit; tree planting is used to achieve both shading and cooling effects; and since thermal expansion is likely to occur in long buildings, expansion joints are employed.



	Januar y	Febuar y	March	April	May	June	July	August	Septe mber	Octobe r	Novem ber	Decem ber
Average Minimum Temperature (C)	26.3	26.4	26.6	26.6	26.2	26.2	25.3	25.7	25.6	26.5	26.3	26.2
Average Maximum Temperature (C)	28.4	29.2	29.1	28.3	28.4	27.4	28.1	28.4	28.3	28.4	28.4	28.2

Fig. 1: Line charts showing mean daily Maximum & Minimum temperatures in Owerri (2004-2005).

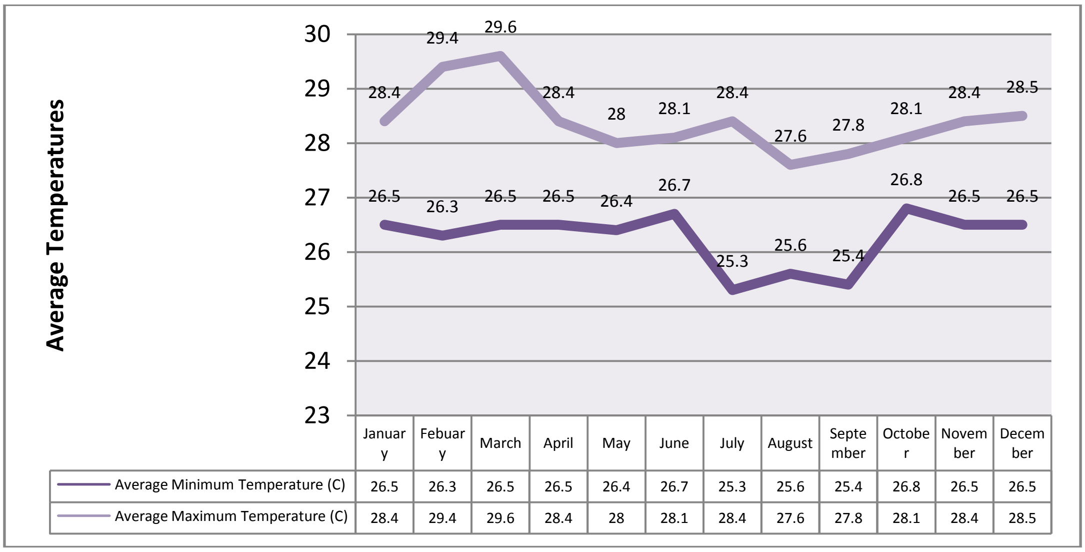


Fig. 2: Line charts showing mean daily Maximum & Minimum temperatures in Owerri (2006-2008).

The annual rainfall received in the study area is very high, usually above the 2000mm rainfall totals giving for tropical rainforest climates worldwide. The area receives between 2000mm to 3000mm of rain per year. The study area experiences double *rainfall maxima* characterized by two rainfalls *speaks* with a short dry season and a longer dry season falling before and after each peak. According to Nwankwo, (2013),the first rainy season begins around March and lasts to the end of July with a peak in June, this rainy season is followed by a short dry break in August known as *August break* which is a short dry season lasting for two or three weeks in August. This break is broken by Short rainy season starting around early September and lasting to Mid October with a peak period at the end of September. The ending of the short rainy season in October is followed by *Long Dry Season*. This period starts from late October and lasts till early March with peak dry conditions between early December and late February. When buildings are not well protected, dampness can occur. Dampness in building is a possible result of several factors which include: penetration of rain water through the walls and roof; penetration of rain water window cracks; condensation on internal surfaces of water vapors generated in the building; and penetration of water at ground level through the floor and up the walls. The following design solutions are employed to address the problem of dampness: buildings are designed to have enough roof overhangs to protect the building walls from diving rain; and the roof pitch of the buildings is designed to be high enough to ensure rapid rain water run-off.

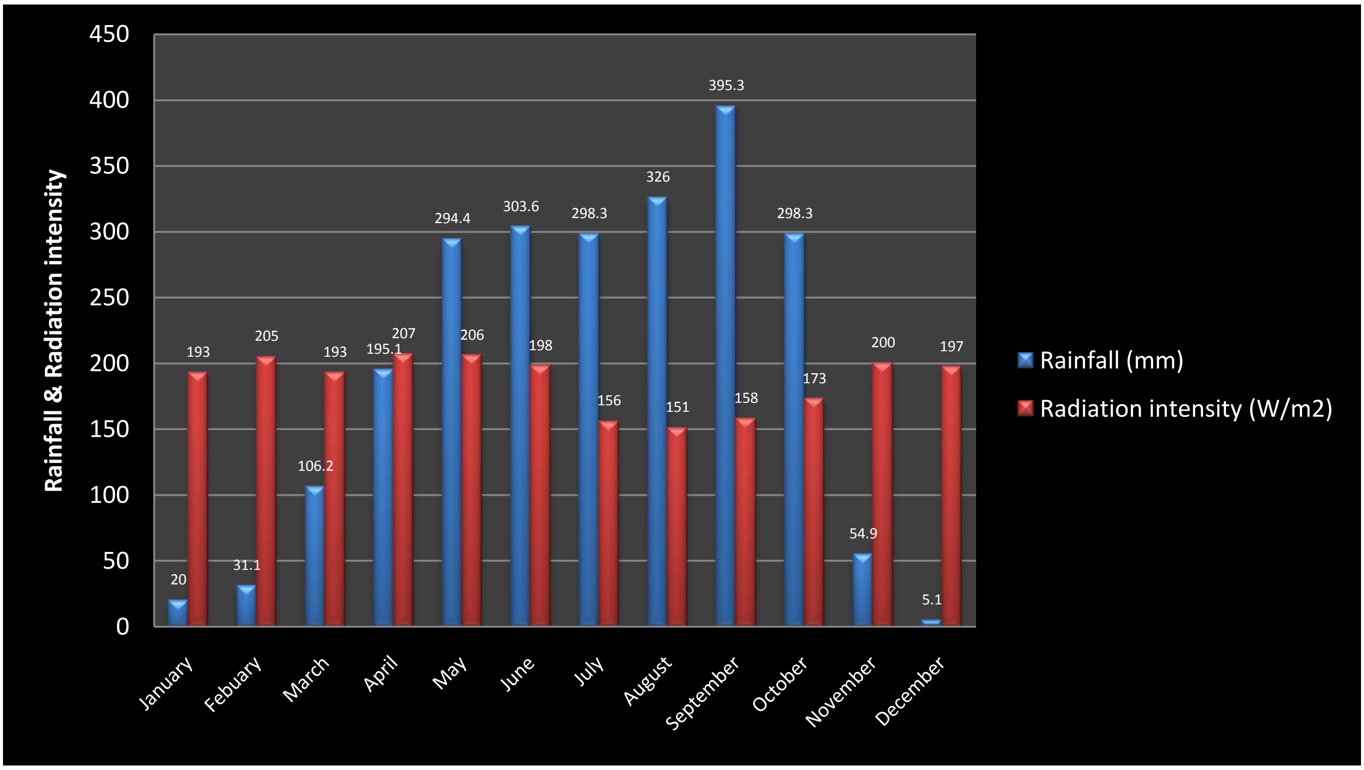


Fig. 3: Bar chart showing record of rainfall and radiation intensity in Owerri (2004-2009)

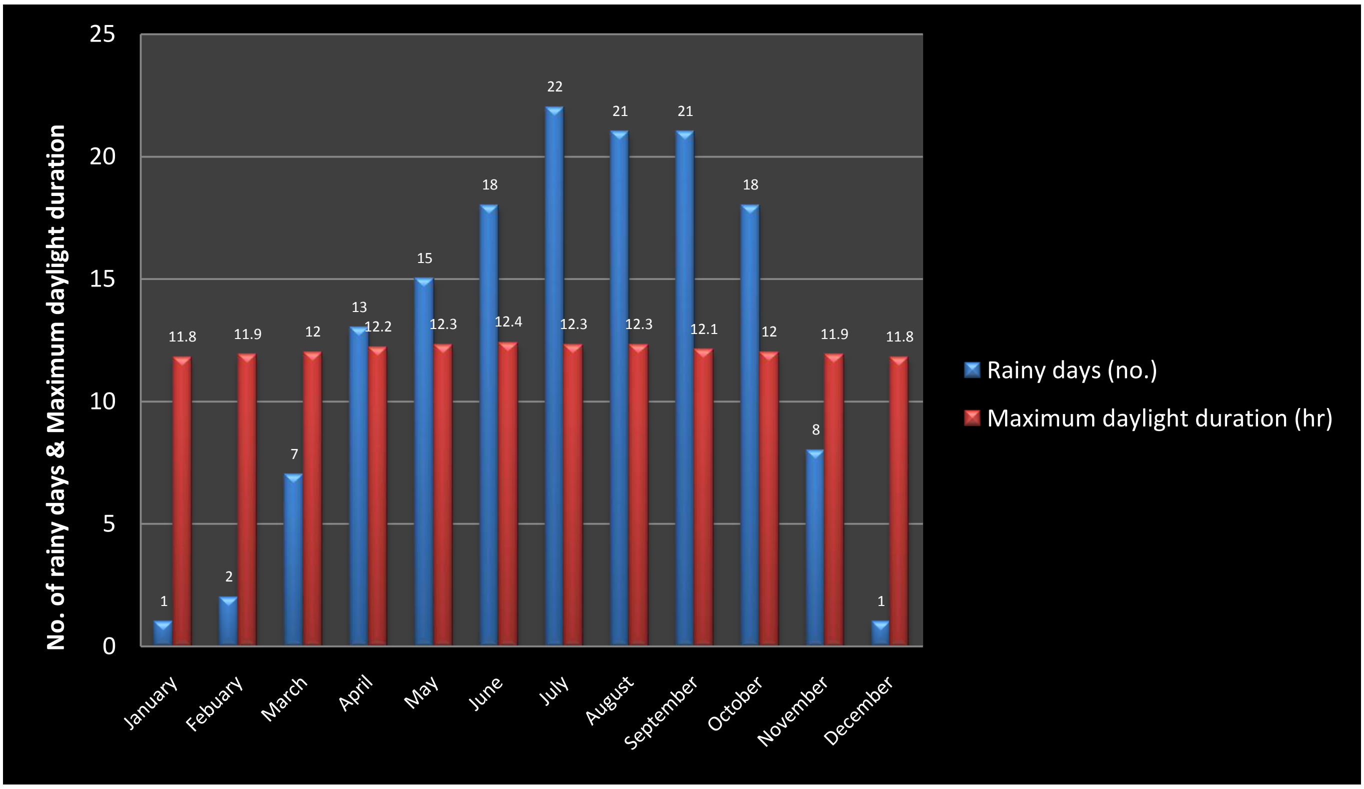


Fig.4: Bar chart showing record of number of rainy days and maximum daylight duration in Owerri (2004-2009).

Solar radiation intensity in Owerri varied from 151W/m2 in august to 207W/m2 in April with annual average of 186W/m2. The dry season average value is 199W/m2 while rainy season average is 156W/m2. Day-length or length of light period (hours) in Owerri varies from 11.8 hours in January to 12.4 hours in

June with an annual average of 12.08 hours. The average day lengths during the rainy season and dry season are 12.2 hours and 11.9 hours respectively. The region has a prevalence of short-day condition with a difference of only 36 minutes between the longest and shortest day in the year. Actual mean daily sunshine vary from 2.4 hours in August to 5.8 hours in December with an annual mean value of 4.6 hours. The mean daily value for sunshine duration is 27 percent greater in the dry season than in rainy season.

Knowing exactly how the sun will strike a building means that it is possible to precisely calculate the length of the overhang of a sun shade, depth of a fin, the angle of a solar collector, the placement of a courtyard, the length of the shadows cast by nearby buildings, or even the way sunset will be affected by distant hills or other objects that rise above the local horizon.

Relative humidity is the actual water vapor pressure to the saturated vapor pressure expressed in percentage. This could be termed the ratio of amount of water vapor actually present in the air to the amount the air could hold. In the study area, the following deductions were made: Vapor pressure increases with increase in relative humidity and Vapor pressure and relative humidity rise sharply between January and April; and vapor pressure and relative humidity are fairly constant between July and September and Low relative humidity results in low pressure. Design solutions usually employed in the study area to counter problems associated with relative humidity include provision of proper ventilation in the buildings to enhance air flow. This will help to maintain the comfort zone in heavy humid periods.

Soil inventory of the high rainfall region of Owerri, Southeastern Nigeria shows that the major soil unit consists of deep, course textured, well-drained acidic loam, largely derived from coastal plain sand sediments, sandstones, and shale. The study area has a mixture of flat, undulating and rugged topography. The study area supports a mixture of savanna and a luxuriant type of dense vegetation – the tropical rain forest because of the very heavy rainfall and uniformly high temperature. The vegetation is set on flat plains, hills and valleys. The vegetation comprises a multitude of evergreen trees that yield tropical hardwood, e.g. mahogany, ebony, greenheart, cabinet woods, palm trees, and dyewood. These trees supply most of the wooden building materials required in the area.

II. LITERATURE REVIEW

The term post-occupancy evaluation describes studies that focus on completed building projects. Preiser and Schramn, (1998) attempted to widen the scope in the direction of building performance evaluation, to integrate user and aesthetic factors with technical and economic factors. Watt, (2007) uses the term ‘Building pathology’ to describe that aspect of building appraisal that is concerned principally with defects and associated remedial action. Although Duffy, (2008) suggests the existence of a terminological dilemma, all of these concepts aim at discovering how the completed building performs; determining possible misfits, mistakes or omissions; and accumulating information for future programming and design efforts. Preiser and Vischer (2004), however, consider post-occupancy evaluation to be the most commonly used term for the activity of evaluating buildings in- use.

Post-occupancy evaluation is about procedures for determining whether or not design decisions made by the architect are delivering the performance needed by those who use the building. By using occupants as a benchmark in evaluation, post-occupancy evaluation provides enormous potential for improving the performance of a building. Post-occupancy evaluation evolved to fill the gap in the conventional building process, which consists of planning, programming, design, construction and occupancy of a building. It represents the vital diagnostic step needed to feed the prescriptive tools of planning and programming (voordt and Wegen, 2005).

Post-occupancy evaluation is a systematic manner of evaluating buildings after they have been built and occupied for duration of time (Preiser, 1995, 2002). The gap between the actual performance of buildings and explicitly stated performance criteria constitute the evaluation (Preiser et al, 1988). One of the applications of the post-occupancy evaluation is the comparison between the use that the designer intended for an environment and that to which its users put it. Watson (2003) defined post-occupancy evaluation as a systematic evaluation of opinions about buildings in use, from the perspective of users. It is important to elicit the perceptions of the residents and correlate these with the performance level of housing as determined by post-occupancy evaluation.

The merits of post-occupancy evaluation are diverse. First, it ensures the sustenance of building performance, particularly of public residential buildings and facilities. Vischer (2002) suggests that post-occupancy evaluation is used in determining building defects, formulating design and construction criteria, supporting performance measures for asset and facility management, lowering facility life cycle costs by identifying design errors that could lead to increased maintenance and operating costs, and clarifying design objectives. Second, post-occupancy evaluation provides a mechanism for understanding the mutual interaction between buildings and users' aspirations and for proposing ways of improving the environment necessary to accommodate these aspirations. In addition, post–occupancy evaluation serves as multifaceted tool to account for building quality through the identification of successful design features, redundant or unnecessary building features, problems to mitigate, and defects to rectify (Watson, 2003). Several other authors including Bordas and Leaman, (2000); Vischer, (2002); add that post-occupancy evaluation helps to empower users to negotiate building issues and reduce maintenance works and cost.

In history, building performance was evaluation in an informal manner, and the lessons learned were applied in subsequent building cycles of similar building types (Preiser, 2002). Although informal, subjective evaluations of the environment have been conducted throughout history, systematic evaluations, employing explicitly stated performance criteria with which performance measures of buildings are compared, is of more recent origin.

Post-occupancy evaluation evolved from the architectural programming techniques of the late 1950s and early 1960s. Early significant evaluative efforts were in response to severe problems faced in institutions such as mental hospitals and prisons, some of which were attributable to the built environment. The 1960s saw the growth of research that focused on the relationship between human behavior and building design, leading to the creation of the new field of environmental design research and the formation of interdisciplinary professional associations, such as the Environmental Design Research Association in 1968.The 1970s witnessed significant increase in the scope, number, complexity and magnitude of evaluation studies and publications, with developments such as: the use of multiple buildings for data collection and comparative analysis; the use of multi-method approaches to building evaluation; the investigation of a comprehensive set of environmental factors, not as isolated variables, but to access their relative importance to the users of the facilities; and the addition of technical and functional factors to the scope of evaluation studies, compared with the earlier emphasis on strictly behavioral research. The final decades of the century was the era of applied evaluation in which Post–Occupancy Evaluations become routinely used (Preiser, 2002)

From the early 1970s, the tools of Post-Occupancy Evaluation became more relevant to public housing in the developed countries of the world. Some evaluation projects relating to housing for the elderly and public housing were conducted. The work done by Newman (1973 quoted in Nwankwo, 2013) which examined data from 100 housing projects, and linked the incidence of crime to housing form and disposition, site design and circulation stands out in terms of scope and influence. Though provocative, Newman's work was well published and effectively influential on housing policy on the national level, stimulating the renovation of existing public housing projects. Researchers at the University of Illinois also conducted an important evaluation study that significantly influenced policy of the United States Department of Housing and Urban Development (Francescato et al, 1979 quoted in Nwankwo, 2013). This effort included project management as part of the study and demonstrated its importance to the residents' satisfaction. It tested the nature and relative importance of various factors that contribute to residents' satisfaction.

Evaluation research in architecture and housing fall into three environmental dimensions: the physical, the social and the socio- physical environments. In all cases, the assumption is that residents judge the adequacy or habitability of their environments based on predefined standards of quality. Some studies evaluate cognitive responses to the physical environment, focusing on issues such as the perceived quality of buildings and environmental quality (Kane et al, 2000; Fornara et al, 2006; Cold, 1993 quoted in Nwankwo, 2013). They concluded by viewing the experience of 'quality' not as a static, objective, rational concept, but as originating in the interaction between the individual and the object, building or place. Voordt and Wegen (2005) described quality as the extent to which a product fulfils the requirements set for it; and architectonic quality as an umbrella term covering various aspects of quality such as aesthetic, functional (building efficiency) symbolic and cultural value. Other studies attend to the evaluation of the quality of the built environment in terms of effective responses, using user assessment of the environments (AL-Momani, 2003). Satisfaction, attitudes and preferences are three types of criterion normally used. Though these affective responses are not mutually exclusive, satisfaction as an affective criterion has been more widely investigated (Lawrence, 1987; Varady, 2004 quoted in Nwankwo, 2013).

Three levels of effort in typical Post-Occupancy Evaluation work have been identified namely: (1) indicative (2) investigative and (3) diagnostic (Preiser and Vischer, 2004). 'Effort' refers to the amount of time, resources and personnel, the depth and breadth of investigation, and the implicit cost involved in conducting a Post–Occupancy Evaluation. Indicative Post-Occupancy Evaluations give an indication of major strengths and weaknesses of a particular building's performance. Investigative Post–Occupancy Evaluations go into more depth whereby objective evaluation criteria are explicitly stated. Diagnostic Post–Occupancy Evaluations require considerable effort and expense and utilize sophisticated measurement techniques. This review of literature confirms the relevance of Post-Occupancy Evaluation in public housing evaluation. However, despite the preponderance of research in the context of building performance, Post-Occupancy Evaluation as a systematic method of collecting data on buildings in use has not found wide usage for public housing in Owerri, South-Eastern Nigeria hence the need for this study.

III. METHODOLOGY

Six research approaches have been employed to obtain the data used in this research and they have been derived from the text 'Architectural Research Methods' (Groat & Wang, 2002, Voordt & Wegen, 2005). These approaches were: comparative mapping through systematic sampling process; Physical Trace Documentation which enabled the researcher to understand the nature and extent of post-occupancy modification in the study area; Environmental Observation was a technique used to investigate the relationship between human activities and physical settings in the housing estates; Questionnaires and interviews were used to explore the impulse of consumers and their expectations about their buildings; 'Archival Retrieval approach which helped retrieve documents such as original site plans, plot designs and building construction techniques from the authorities concerned. The final step employed was the evaluation which was based on a theoretical frame work of tripartite quality of architecture; Utilitas(functionality or utility value: the social dimension), Firmitas(strength and rigidity: the technological dimension) and Venustas(beauty: the aesthetic dimension). Thirteen performance criteria developed and used in this post-occupancy evaluation were as follows: Functional efficiency; Functional flexibility, Functional accessibility, Functional Spatial orientation, Functional physical well-being, Aesthetic visual quality, Aesthetic representational quality, Aesthetic symbolic quality, Visual and cultural history, Order and complexity, Constructional safety, Environmental friendliness, and Sustainability. Fifty two questions were developed and used in this evaluation based on the thirteen performance criteria: Twenty five for Functionality Factor; Nineteen for Aesthetic Factor; and Eight for Constructional Issues. These came in form of structured questionnaires administered to sample population of 405 building owners from the population of study of 1261. In this research, probability sample technique was adopted which according to De Vaus cited by Uji (2009), is one in which each person/ object in the population has an equal, or, at least, a known, chance (probability) of being selected. The researcher deemed it fit that the most commonly acceptable way of providing an equal probability of selection of samples from populations is to use principle of systematic sampling. In this systematic sampling, the researcher worked out a sampling fraction by dividing the required sample size by the size of the population (n/N), then selecting one case out of every (n/N) case in the population. This would enable the collection of information from a representative group good enough to permit conclusion to be drawn about the large study group. Through this method, a template of one out of every three buildings was developed for the sample population. The most common ways in which data collected in this research were organized, summarized and presented included the use of illustrations such as Tables and Graphs. After sorting out, organizing and summarizing the data in a presentable manner, the returned questionnaire was collated and analyzed using SPSS software and Microsoft Excel to generate the graphs used for presentation.

IV. RESULTS AND DISCUSSION

Nature and Extent of Post-Occupancy Modification

Eight major indices of modification were identified (Table 1).

Table 1: Eight Major Indices of Modification Identified

S/No	Index	Description/Index of Modification
	Index 1	Addition of fence
	Index 2	Paving around the perimeter of the house
	Index 3	Extended eaves/addition of porch
	Index 4	Addition of security house, shop, plant house and boys quarters
	Index 5	Change affecting materials and finishes
	Index 6	Alteration of form/ change of roof composition
	Index 7	Increase in size of spaces e.g. living room, bedrooms and kitchen
	Index 8	Increase in number of bedrooms

Some houses have had minimal modification while others have had limited and multiple modification. For clarity purposes, the houses have been classified into three categories as shown in Table 2: Minimal Modification (Index 1 & Index2); Limited Modification (Index 3 & Index 4); and Multiple Modifications (Index 5, 6, 7 & 8).

Table 2: Eight Major Indices of Modification

S/No	Index	Description	Category
	Index 1	Addition of fence	Minimal Modification
	Index 2	Paving around the perimeter of the house	
	Index 3	Extended eaves/addition of porch	Limited Modification
	Index 4	Addition of security house, shop, plant house and boys quarters	
	Index 5	Change affecting materials and finishes	Multiple Modification
	Index 6	Alteration of form/ change of roof composition	
	Index 7	Increase in size of spaces e.g. living room, bedrooms and kitchen	
	Index 8	Increase in number of bedrooms	

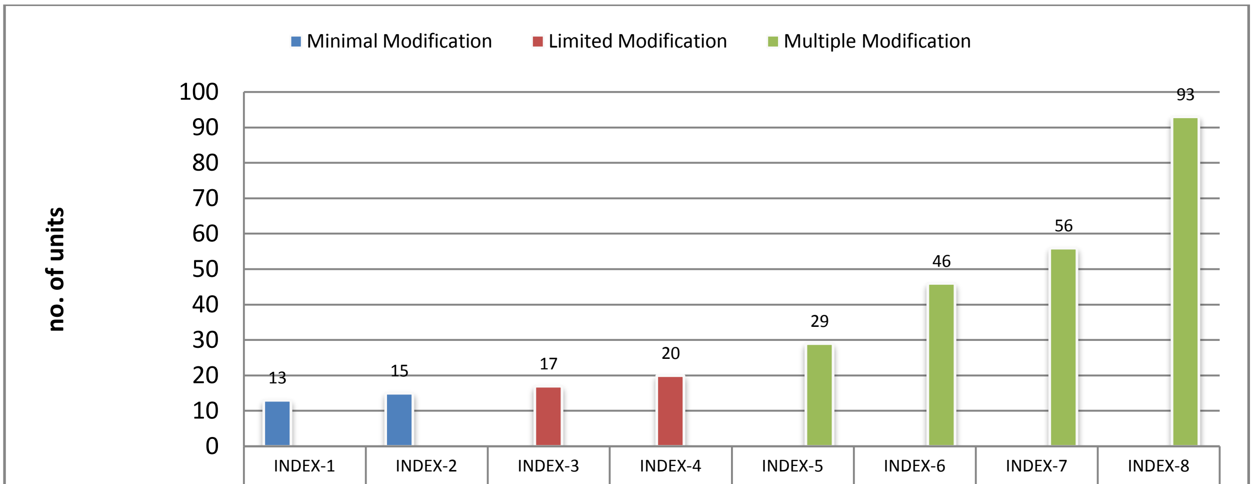
Developed by the Author

Case Study One: Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

The researchers studied 33.5 percent or 289 housing units out of 876 and 8 housing typologies were identified as follows: 66 one-bedroom detached bungalows; 152 one-bedroom semi-detached bungalows; 13 one-bedroom row bungalows; 193 two-bedroom detached bungalow; 203 two-bedroom semi-detached bungalow; 210 three-bedroom detached bungalow; 35 four-bedroom bungalow and 4 unclassified houses. Eight Indices of modification were identified with percentage distribution as shown in Table 3, Fig.5&6 as follows: Minimal modification 9.69 percent-Index 1(4.5 percent) and Paving Index 2 (5.2 percent); Limited Modification 12.8 percent-Index 3 (5.9 percent) and Index 4 (6.9 percent); Multiple Modification 77.5 percent-Index 5(10.0 percent), Index 6 (15.9 percent), Index 7 (19.4 percent) and Index 8 (32.2 percent). Most of the building owners especially those involved in limited and multiple modifications did not engage professional architects and engineers in doing their works.

Table 3: Categories of Modification Identified in Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

Week	**Name of Housing Estate**	**No of Housing units Studied.**	**Major Indices of modification Identified**							
			Minimal Modification.		**Limited Modification.**		**Multiple Modification.**			
	AHEOWIMS		Index 1	Index 2	3 Index	Index 4	Index 5	Index 6	Index 7	Index 8
1		57	03	05	01	02	10	10	06	20
2		59	05	04	03	01	13	01	14	18
3		59	01	05	03	02	02	18	06	22
4		56	02	01	07	05	01	15	12	13
5		58	02	00	03	10	03	02	18	20
	Total.	289	13	15	17	20	29	46	56	93
% Distribution		**100**	**4.50**	**5.19**	**5.88**	**6.92**	**10.03**	**15.92**	**19.38**	**32.18**
			9.69		**12.80**		**77.51**			



	INDEX-1	INDEX-2	INDEX-3	INDEX-4	INDEX-5	INDEX-6	INDEX-7	INDEX-8
Minimal Modification	13	15						
Limited Modification			17	20				
Multiple Modification					29	46	56	93

Fig. 5: Bar Charts Showing Distribution of Modification Indices in Aladinma Housing Estate Owerri South-Eastern Nigeria (AHEOWSEN)

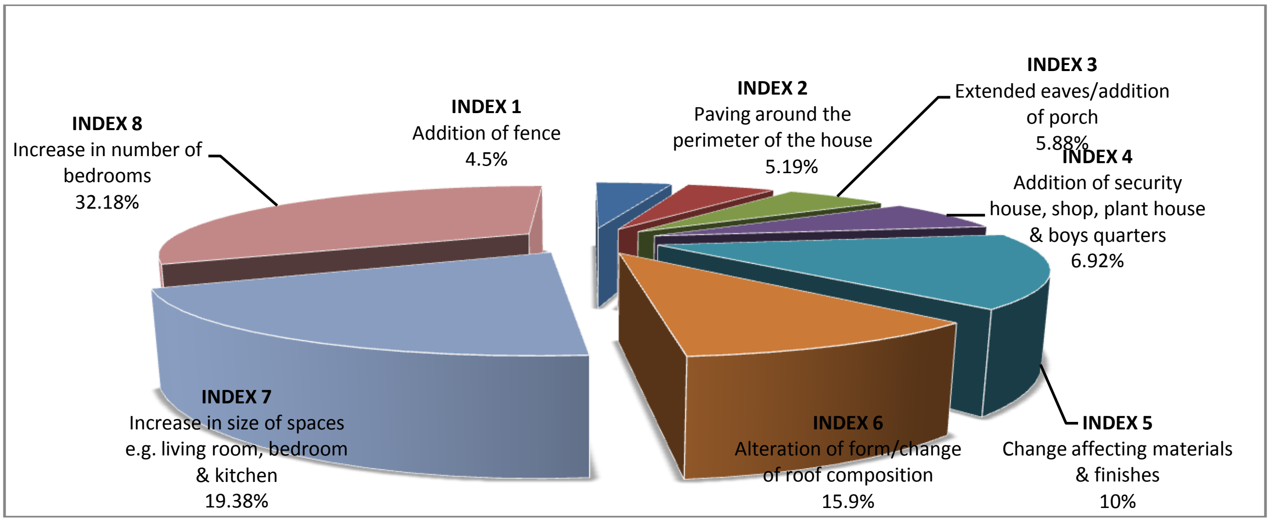


Fig. 6:3D Pie Charts Showing Percentage Distribution of Eight Major Indices of Modification in Aladinma Housing Estate. Owerri , South-Eastern Nigeria (AHEOWSEN)

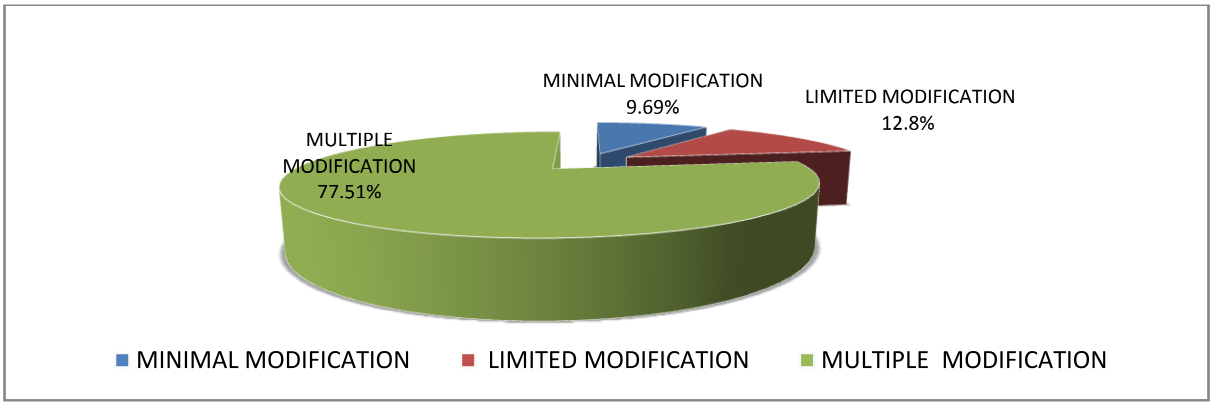


Fig. 7:3D Pie Charts Showing Percentage Distribution of Categories of Modification in Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

Case Study Two: Prefab Housing Estate Owerri, South-Eastern Nigeria (PHEOWSEN)

A total of 385 housing units were built in the estate as follows: 66 Two-Bedroom Detached Bungalow; 46 Two-Bedroom Semi-detached Bungalow; 136 Three-Bedroom Detached Bungalow; 138 Four-Bedroom Detached Bungalow and 45 Five-Bedroom Bungalow. The Researchers sampled 128 housing units. Eight Indices of modification were identified as follows: Minimal Modification 15.0 percent-Index 1(6.7 percent) and Index 2 (8.3percent); Limited Modification 15.8 percent-Index 3(5.0 percent) and Index 4 (10.8 percent); Multiple Modification 69.2 percent- Index 5 (13.3 percent), Index 6 (17.5 percent), Index 7 (21.7 percent) and Index 8 (16.7 percent) as shown in Table 4, Fig.7& Fig.8).

Table 4: Categories of Modification Identified in Prefab Housing Estate Owerri, South-Eastern Nigeria (PHEOWSEN)

Week	Name of Housing Estate	No of Building units Studied.	Major Indices of modification Identified							
			Minimal Modification.		**Limited Modification.**		**Multiple Modifications.**			
	PHEOWIMS		Index 1	Index 2	Index 3	Index 4	Index 5	Index 6	Index 7	Index 8
1		24	03	01	00	00	08	01	02	09
2		22	02	00	01	00	05	03	06	05
3		25	01	04	00	05	03	07	02	03
4		24	01	03	02	03	00	03	11	01
5		25	01	02	03	05	00	07	05	02
	Total.	120	08	10	06	13	16	21	26	20
% Distribution		**100**	**6.67**	**8.33**	**5.00**	**10.83**	**13.33**	**17.50**	**21.66**	**16.66**
Grand Total			**15%**		**15.83%**		**69.17%**			

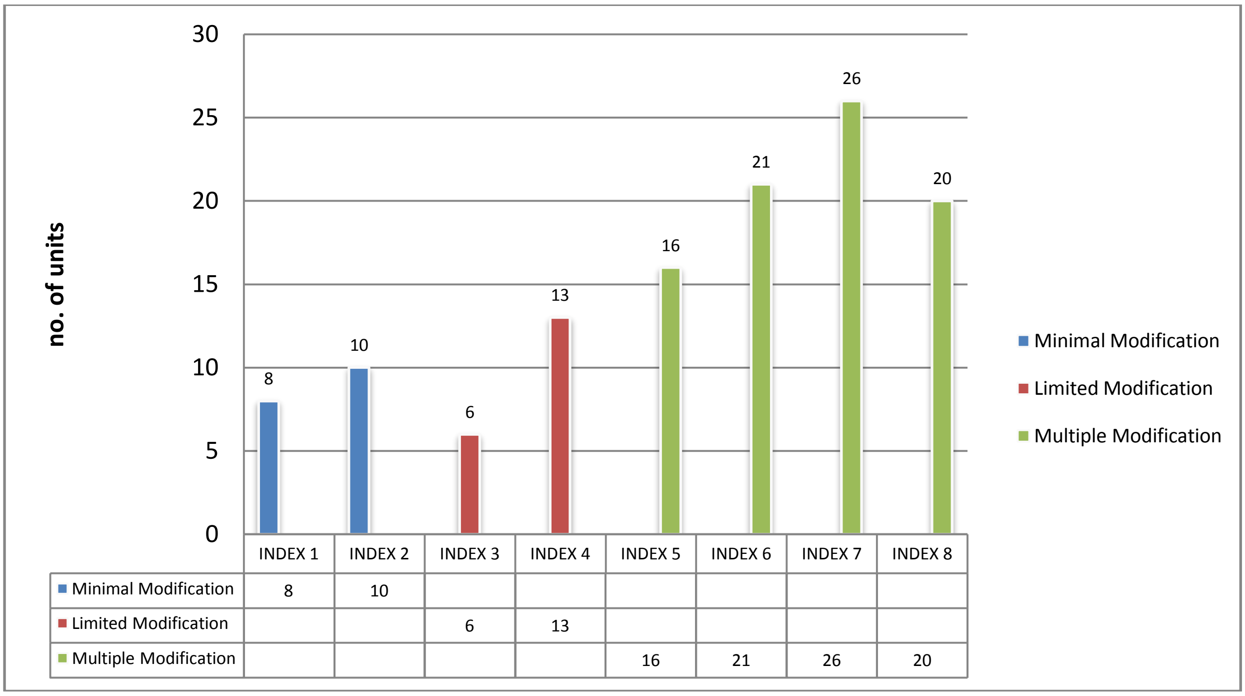


Figure 8: Bar Charts Showing Distribution of Modification Indices in Prefab Housing Estate. Owerri South-Eastern Nigeria (PHEOWSEN)
Developed by the Author

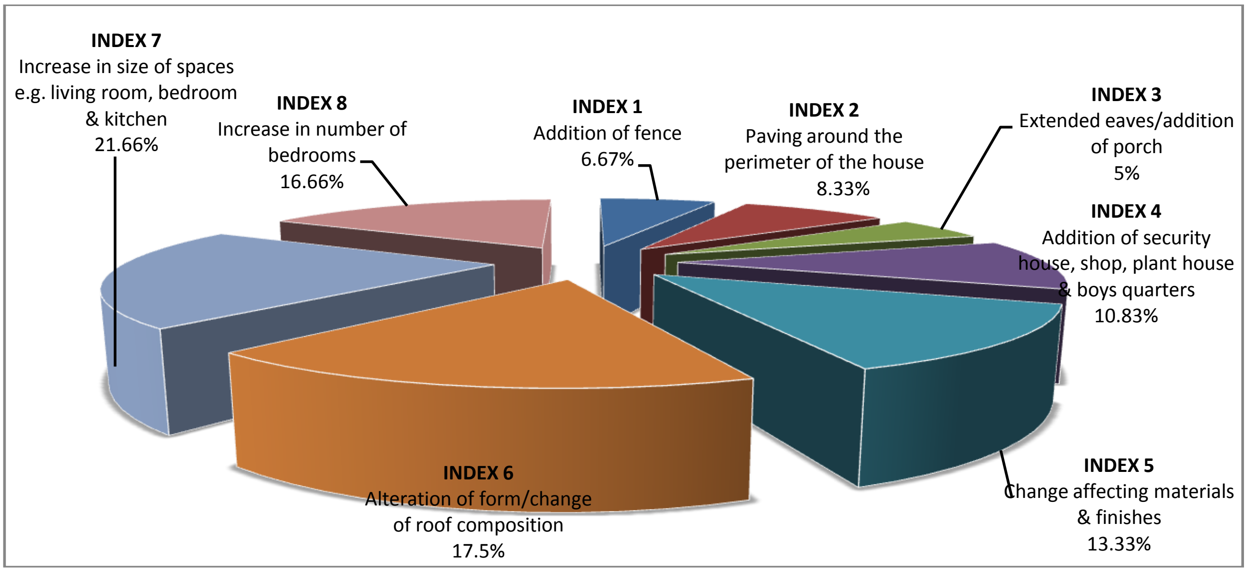


Fig. 8: Exploded 3D Pie Charts Showing Percentage Distribution of Eight Major Indices of Modification in Prefab Housing Estate. Owerri (PHEOWIMS)
Developed by the Authors

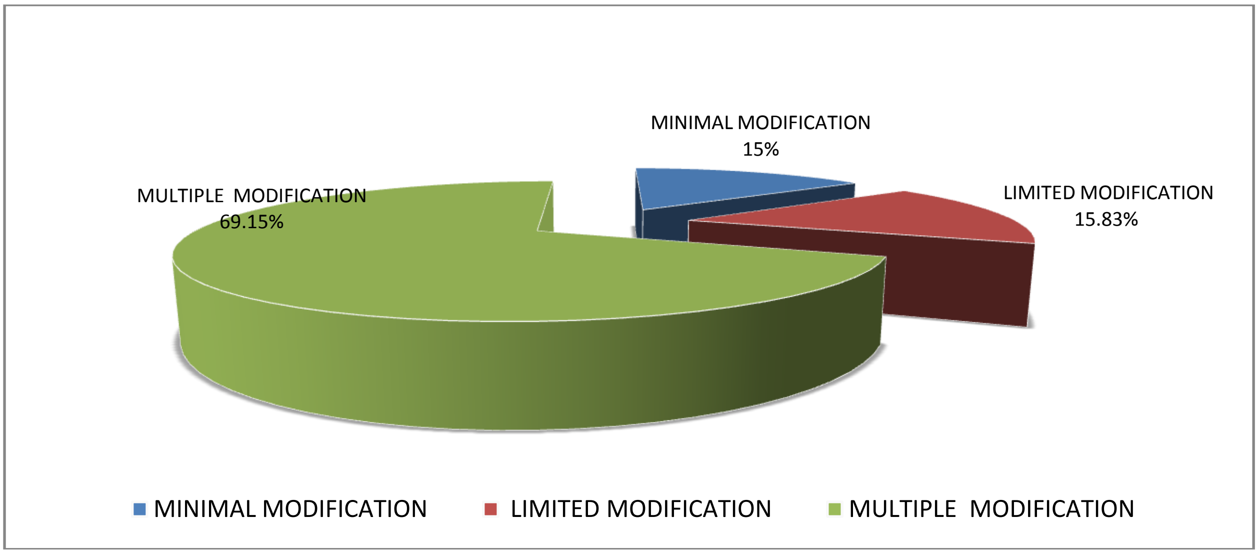


Fig. 8: Exploded 3D Pie Charts Showing Percentage Distribution of Categories of Modification in Prefab Housing Estate, Owerri (PHEOWIMS)
Developed by the Authors

Reasons behind the Modification

The questionnaires for the study were administered on the respondent building consumers in the housing estates as shown in Table 5. The questionnaires were structured in line with the design factors – functionality (25 questions), aesthetic (19 questions) and structural issues (08 questions).

Table 5: Summary of Distribution of Questionnaire in the Housing Estates.

S/No	housing estate	Actual population as at time of study	Sample size with finite population correction	Number of responses	Response rate %	Number of non-responses	Non-response rate %
01	**AHEOWSEN**	876	295	289	98	06	02
03	**PHEOWSEN**	385	125	120	96	05	04

Developed by the Author

Case Study One: Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

Questionnaires were administered to 295 respondents out of 876 to determine the design factors that contributed to post-occupancy modification. The response rate was 98.0 percent. The same number of questionnaire was evenly administered in five weeks. The percentage of the respondents that accepted functionality as a design factor that necessitated post-occupancy modification of housing units in the estate was 92.7 percent (Table 6). The percentage of the respondents that supported aesthetic as a design factor that contributed to post-occupancy modification in the estate was 93.1 percent (Table 7). Also 97.9 percent of the respondents accepted constructional issue as a design factor that caused the building consumers to modify their buildings (Table 8). The summary is shown in Fig.9.

Table 6: Assessment of Functionality as a Factor of Modification in AHEOWSEN

week	**Total No of Respondent**	**No of Non-** Responses	**No of Responses**	**No in Support of Functionality as a Factor**	**No Against Functionality as a Factor**	**No of Respondent Acceptability of Functionality Factor**	**No of Non-Acceptability of Structural Factor.**
1	59	02	57	22	03	54	03
2	59	00	59	20	05	55	04
3	59	00	59	21	04	56	03
4	59	03	56	19	06	50	06
5	59	01	58	23	02	53	05
TL	295	06	289	……….	…………	268	21
Percentage Distribution						**92.73%**	**7.27%**

Table 7: Assessment of Aesthetic as a Factor of Modification in AHEOWSEN

week	**Total No of Respondent**	**No of Non-Responses**	**No of Responses**	**No in Support of Aesthetic as a Factor**	**No Against Aesthetic as a Design Factor**	**No of Respondent Acceptability of Aesthetic Factor**	**No of Non-Acceptability of Aesthetic Factor.**
1	59	02	57	16	03	55	02
2	59	00	59	17	02	56	03
3	59	00	59	14	05	52	07
4	59	03	56	18	01	55	01
5	59	01	58	13	06	51	07
TL	295	06	289	……..	………..	269	20
Percentage Distribution						**93.08%**	**6.92%**

Table 8: Assessment of Structural as a Factor of Modification in AHEOWSEN

week	**Total No of Respondent**	**No of Non-Responses**	**No of Responses**	**No in Support of Constructional Issue as a Design Factor (Agree)**	**No Against structural Issue as a Design Factor(Disagree)**	**No of Respondent Acceptability of structural Factor**	**No of Non-Acceptability of structural Factor.**
1	59	02	57	08	00	57	00
2	59	00	59	07	01	58	01
3	59	00	59	08	00	59	00
4	59	03	56	06	02	53	03
5	59	01	58	07	01	56	02
TL	295	06	289	………..	…………	283	06
Percentage Distribution						**97.92%**	**2.08%**

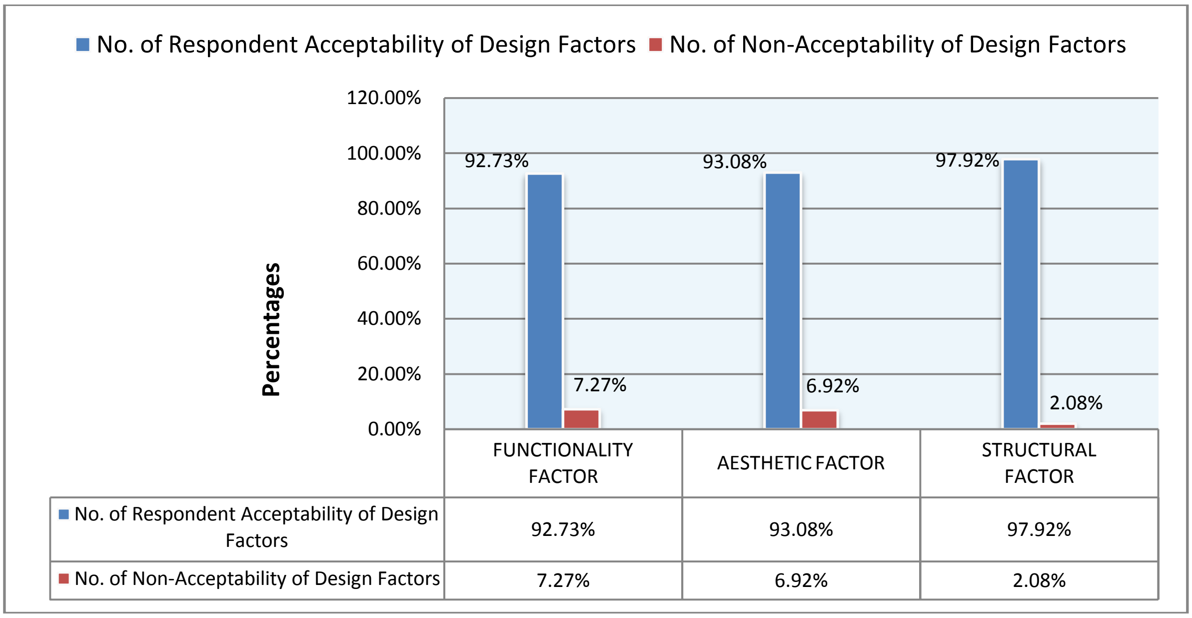


Figure 9: Bar Charts Showing Distribution of Respondents to Factors of Modification in AHEOWSEN

Case Study Two: Prefab Housing Estate Owerri, South-Eastern Nigeria (PHEOWSEN)

The population of study in Prefab Housing Estate was 385 respondents and 125 were sampled. The percentage response was 96.0 percent (Table 9). 92.5 percent accepted functionality as a strong design factor that caused them to modify their buildings (Table 10). The percentage of respondents in support of aesthetic as a design factor that contributed in no small measure to the modification in the estate was 91.7 percent. In the same vein, 96.7 percent was in support of construction issue as a design factor that contributed to the frequent modification in the estate (Table 11&Fig.10).

Table 9: Assessment of Functionality as a Factor of Modification in PHEOWSEN.

week	Total No of Respondent	No of Non-Responses	No of Responses	No in Support of Functionality as a Factor	No Against Functionality as a Factor	No of Respondent Acceptability of Functionality Factor	No of Non-Acceptability of Functionality Factor.
1	25	01	24	20	05	22	02
2	25	03	22	23	02	21	01
3	25	00	25	24	01	23	02
4	25	01	24	23	02	21	03
5	25	00	25	20	05	24	01
TL	125	05	120	……….	…………	111	09
Percentage Distribution						**92.50%**	**7.50%**

Table 10: Assessment of Aesthetic as a Factor of Modification in PHEOWSEN

week	Total No of Respondent	No of Non-Responses	No of Responses	No in Support of Aesthetic as a Factor	No Against Aesthetic as a Factor	No of Respondent Acceptability of Aesthetic Factor	No of Non-Acceptability of Aesthetic Factor.
1	25	01	24	15	04	21	03
2	25	03	22	16	03	20	02
3	25	00	25	17	02	23	02
4	25	01	24	18	01	23	01
5	25	00	25	17	03	23	02
TL	125	05	120	……..	…………	110	10
Percentage Distribution						**91.67%**	**8.33%**

Table11: Assessment of Structural as a Factor of Modification in PHEOWSEN

week	Total No of Respondent	No of Non-Responses	No of Responses	No in Support of Structural as a Factor	No Against Structural as a Factor	No of Respondent Acceptability of Structural Factor	No of Non-Acceptability of Structural Factor.
1	25	01	24	07	01	23	01
2	25	03	22	06	02	20	02
3	25	00	25	08	00	25	00
4	25	01	24	08	00	24	00
5	25	00	25	07	01	24	01
TL	125	05	120	……….	………….	116	04
Percentage Distribution						**96.70%**	**3.33%**

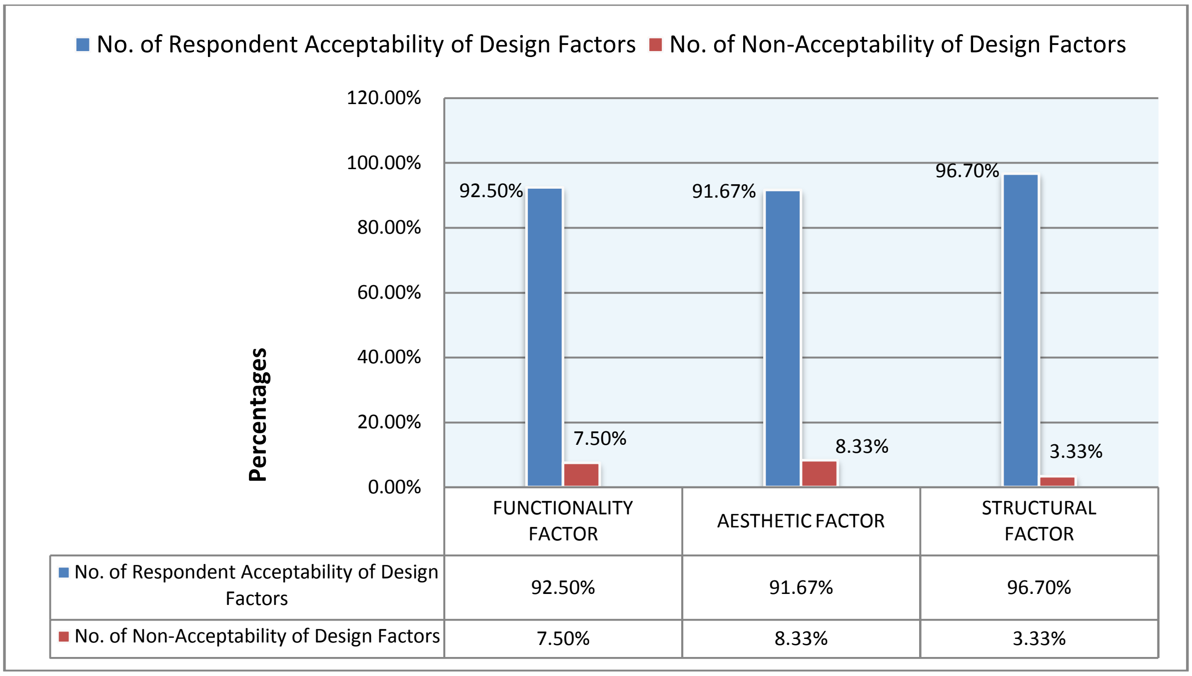


Figure 10: Bar Charts Showing Distribution of Respondents to Factors of Post Occupancy Modification in PHEOWIMS

Models for Evaluation of Post-Occupancy Modification of Residential Buildings in Public Housing Estates in Owerri, South-Eastern Nigeria

The models were products derived from the identified design factors that necessitated the post-occupancy modifications in the selected housing estates in the South-Eastern Nigeria (see field data: Table 5- Table 12 below).

Symbols

$TR = Total\ Respondent,$
$NR = No\ Response, R = Response$
$PSF = Points\ Supporting\ Functionality$,
$PAF = \ Points\ Against\ Functionality$
$FIF = \ Functionality\ Input\ Factor\ , RAM = No\ Of\ Respondent\ Accepting\ Modification$
$MAR = Modification\ Acceptability\ Ratio$
$, PSA = \ Points\ Supporting\ Aesthetics$
$PSC = Points\ Supporting\ Constructional\ Issue, PAA = Points\ Against\ Aesthetic$
$PAC = Points\ Against\ Constructional\ Issue, AIF = Aesthetic\ Input\ Factor\ (y)$
$CIF = Constructional\ Input\ Factor\ (\gamma)$,
$M_I = Modification\ Index$

$$\boldsymbol{FIF = \frac{PSF}{PSF+PAF}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

$$\boldsymbol{AIF = \frac{PSA}{PSA+PAA}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

$$\boldsymbol{CIF = \frac{PSC}{PSC+PAC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(3)}$$

$$\boldsymbol{MAR = \frac{RAM}{TR}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(4)}$$

$$MI_{EXP} = \frac{1}{3}[MAR_{FIF_i} + MAR_{AIF_i} + MAR_{CIF_i}] \quad .... (5)$$

$$MI_{MOD}^{Overall} = MI_{IAV} \quad .... (6)$$

$$Deviation\ DV = \frac{Predicted\ Value - Experimental\ Value}{Experimental\ Value} \times 100\% \quad .... (7)$$

$$Correction\ Factor\ Cf = -DV \quad .... (8)$$

$$Cf = \frac{-100[Predicted\ Value - Experimental\ Value]}{[Experimental\ Value]} \quad ...... (9)$$

C_I = $Coefficient\ of\ modification\ for\ Imo\ State$

Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

$$MI_1 = -A_1X^2 + A_2X - B_1Y^2 + B_2Y - C_1\gamma^2 + C_2\gamma - D$$

$Introducing\ the\ constant\ values\ of A_1, A_2, B_1, B_2, C_1, C_2, D$ W

$Where\ A_1 = 3.7842, A_2 = 6.428, B_1 = 0.5173, B_2 = 0.9451, C_1 = 0.5435, C_2 = 1.0641, D = 2.7257$

$$MI_I = -3.7842X^2 + 6.428X - 0.5173Y^2 + 0.9451Y - 0.5435\gamma^2 + 1.0641\gamma - 2.7257$$

Prefab Housing Estate Owerri, South-Eastern Nigeria (PHEOWSEN)

$$MI_I = A(X^2 + Y^2 + \gamma^2) + B(X + Y + \gamma) + D$$

$Introducing\ the\ Constant\ values\ of\ A, B\ and\ D$

$Where\ A = 9.6667\ x\ 10^{-4}, B = 1.8333\ x\ 10^{-3}, D = 0.8881$

$$MI_I = 0.9667x10^{-4}(X^2 + Y^2 + \gamma^2) + 1.8333\ x\ 10^{-3}(X + Y + \gamma) + 0.8881$$

Evaluation of Modification Index of the Housing Estates

Table 12: Evaluations for Modification Index of Housing Estates

ESTATE	MOD	EXP	SYMBOL	WKS
AHEOWIMS	4.6501	4.6329	I_1	5
PHEOWIMS	4.4762	4.4934	I_2	5
Total	**9.1263**	**9.1263**		**Total = 10**

Overall Modification Index for model predicted data and experimental data is obtained by:

$$MI_{MOD}^{Overall} = \frac{9.1263}{10Weeks} = 0.9126$$

$$MI_{Exp}^{Overall} = \frac{9.1263}{10Weeks} = 0.9126$$

$$Deviation = \frac{[0.9126 - 0.9126}{0.9126} \times 100 = 0.00\%$$

This is the overall deviation of model predicted data from the experimental.

$$MI_{MOD}^{Overall} = C_I MI_{IAV} \quad .... (10)$$

$$C_I = \frac{MI_{MOD}^{Overall}}{MI_{IAV}} \quad ....(11)$$

$$Where MI_{IAV} = \frac{[I_1 + I_2]}{[10Weeks]} = \frac{[4.6501 + 4.4762]}{10Weeks} = \frac{9.1263}{10Weeks} = 0.9126.$$

$Substituting\ the\ value\ of\ MI_{IAV}\ into\ equation$ (11)

$$C_I = \frac{0.9126}{0.9126}$$

$$C_I = 1.0000$$

$$MI_{MOD}^{Overall} = C_I MI_{IAV} \quad .... (12)$$

$Substituting\ the\ values\ of\ C_I, into\ equation$ (12)

$$MI_{MOD}^{Overall} = [1.000 MI_{IAV}] \quad .... (13)$$

$$\varepsilon = 1.000\alpha \quad .... (14)$$

$$Where\ MI_{MOD}^{Overall} = \varepsilon = MI_{MOD}^{Overall} = C_I MI_{IAV} = C_I\alpha$$

$$Where\ \ MI_{IAV} = \alpha$$

$CHECKING$

Substituting the values of α, into equation (14) and equating to the value Modification Index (0.9126)

$$\mathbf{0.9126 \ = \ (1.0000 \, x \, 0.9126 \quad = 0.9126}$$

0.9126 = 0.9126

Therefore, Post-occupancy Modification Evaluation for Housing Estates in Owerri, South-Eastern Nigeria can be conducted using the model:

$$[\boldsymbol{\varepsilon} = \ \mathbf{1.0000}\boldsymbol{\alpha}\,]$$

$\boldsymbol{Where\ MI_{IAV} = Average\ Modification\ index\ for\ housing\ estates\ in\ Owerri.}$

$\boldsymbol{\varepsilon = Overall\ Modification\ index\ for\ Owerri.}$
$\boldsymbol{C_I = Coefficient\ of\ Modification\ for\ Owerri.}$
$\boldsymbol{Based\ on\ the\ foregoing, in\ Owerri\ state\ Overall\ Modification\ index\ \varepsilon = 0.9126\ or\ 91.26\%}$

GRAPHICAL REPRESENTATION OF VARIATION OF MODIFICATION INDEX WITH DESIGN FACTORS

Aladinma Housing Estate Owerri, South-Eastern Nigeria (AHEOWSEN)

Table 13: Functionality Factor.

WK	TR	NR	R	PSF	PAF	FIF	RAM	MAR
1	59	02	57	22	03	0.88	54	0.9153
2	59	00	59	20	05	0.80	55	0.9322
3	59	00	59	21	04	0.84	56	0.9492
4	59	03	56	19	06	0.76	50	0.8475
5	59	01	58	23	02	0.92	53	0.8983

Table 14: Aesthetic Factor.

WK	TR	NR	R	PSA	PAA	AIF	RAM	MAR
1	59	02	57	16	03	0.8421	55	0.9322
2	59	00	59	17	02	0.8947	56	0.9492
3	59	00	59	14	05	0.7368	52	0.8814
4	59	03	56	18	01	0.9474	55	0.9322
5	59	01	58	13	06	0.6842	51	0.8644

Table 15: Construction Factor.

WK	TR	NR	R	PSC	PAC	CIF	RAM	MAR
1	59	02	57	08	00	1.000	57	0.9661
2	59	00	59	07	01	0.875	58	0.9831
3	59	00	59	08	00	1.000	59	1.0000
4	59	03	56	06	02	0.750	53	0.8983
5	59	01	58	07	01	0.875	56	0.9492

$$\boldsymbol{MI_{MOD} = \ -3.7843X^2 + 6.428X - 0.5173Y^2 + 0.9451Y - 0.5435\gamma^2 + 1.0641\gamma - 2.7257.}$$

Table 16: Variation of Modification Index

MI_{EXP}	MI_{MOD}	$DV(\%)$	$Cf(\%)$
0.9379	0.9500	+1.29	−1.29
0.9548	0.9467	−0.85	+0.85
0.9435	0.9516	+0.86	−0.86
0.8927	0.8973	+0.52	−0.52
0.9040	0.9045	+0.06	−0.06
$Av = 0.9266$	$Av = 0.9300$		

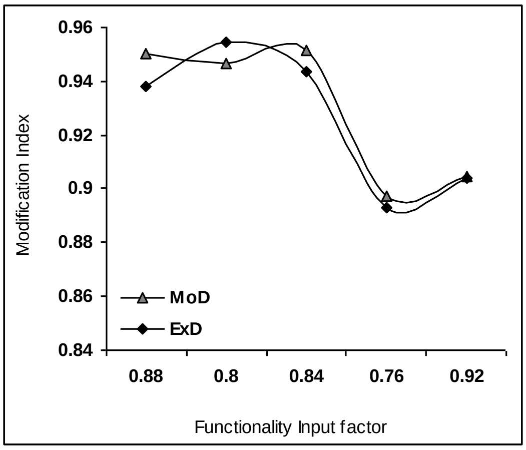


Figure 11: Variation of Modification Index with Functionality Input Factor.

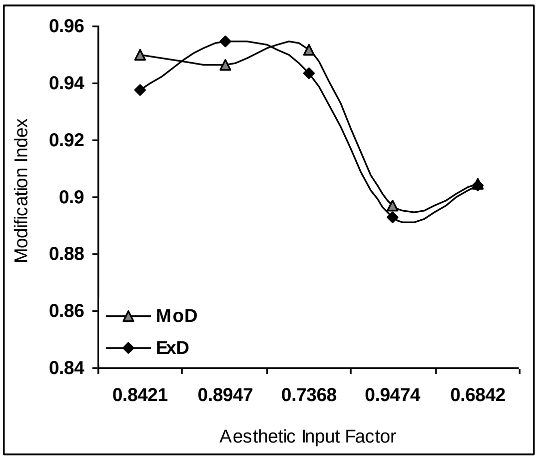


Figure 12: Variation of Modification Index with Aesthetic Input Factor.

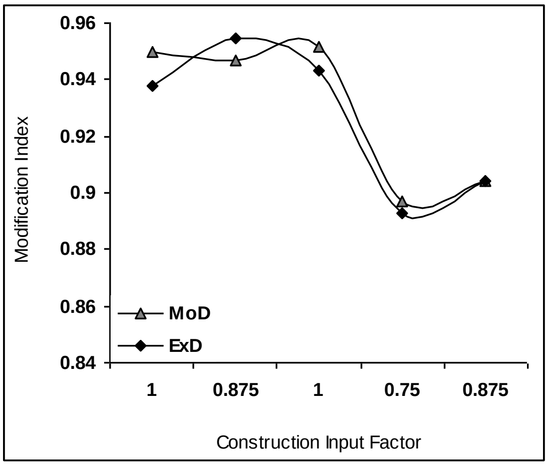


Figure 13: Variation of Modification Index with Construction Input Factor.

Prefab Housing Estate Owerri (PHEOWSEN)

Table 17: Functionality Factor.

WK	TR	NR	R	PSF	PAF	FIF	RAM	MAR
1	25	01	24	20	05	0.80	22	0.88
2	25	03	22	23	02	0.92	21	0.84
3	25	00	25	24	01	0.96	23	0.92
4	25	01	24	23	02	0.92	21	0.84
5	25	00	25	20	05	0.80	24	0.96

Table 18: Aesthetic Factor.

WK	TR	NR	R	PSA	PAA	AIF	RAM	MAR
1	25	01	24	15	04	0.7895	21	0.84
2	25	03	22	16	03	0.8421	20	0.80
3	25	00	25	17	02	0.8947	23	0.92
4	25	01	24	18	01	0.9474	23	0.92
5	25	00	25	17	02	0.8947	23	0.92

Table 19: Construction Factor.

WK	TR	NR	R	PSC	PAC	CIF	RAM	MAR
1	25	01	24	07	01	0.875	23	0.92
2	25	03	22	06	02	0.75	20	0.80
3	25	00	25	08	00	1.00	25	1.00
4	25	01	24	08	00	1.00	24	0.96
5	25	00	25	07	01	0.875	24	0.96

$$\boldsymbol{MI_{MOD} = 0.9667x10^{-4}(X^2 + Y^2 + \gamma^2) + 1.8333x10^{-3}(X + Y + \gamma) + 0.8881}$$

Table 20: Variation of Modification Index

MI_{EXP}	MI_{MOD}	$DV(\%)$	$Cf(\%)$
0.880	0.8946	+1.66	−1.66
0.8133	0.8947	+10.01	−10.01
0.9467	0.8959	−5.37	+5.37
0.9067	0.8961	−1.17	+1.17
0.9467	0.8949	−5.47	+5.47
$Av = 0.8987$	$Av = 0.8952$	− − −	− − −

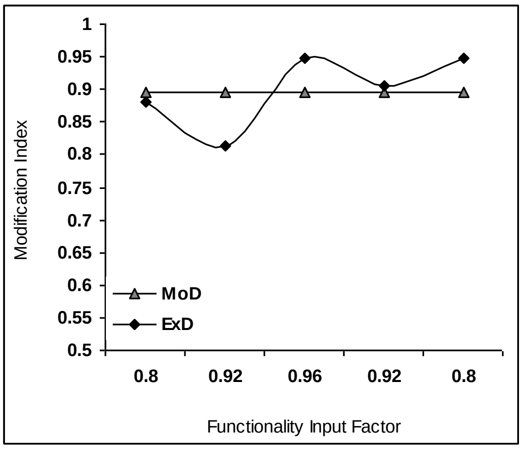


Figure 14: Variation of Modification Index with Functionality Input Factor.

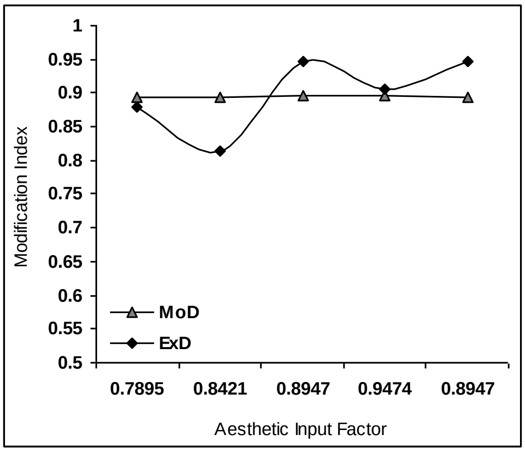


Figure 15: Variation of Modification Index with Aesthetic Input Factor.

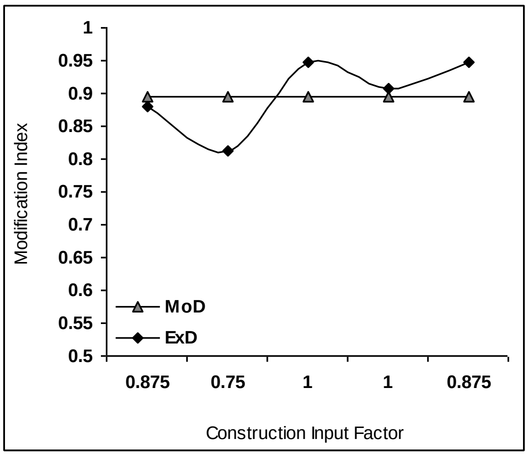


Figure 16: Variation of Modification Index with Construction Input Factor

Findings

The following findings were made:

Minimal Modification in all the housing estates studied was 12.4 percent. Limited Modification in the housing estates studied was 14.3 percent. Multiple Modification in the housing estates studied was 73.3 percent. Overall Modification Index for model predicted data was 0.9126 and overall experimental data was 0.9126. Overall Deviation of model predicted data from the experimental data was 0.00%. Average Modification Index for Housing Estates in the study area was 0.9126. Coefficient of modification was 1.0000. Average Modification as a result of functionality, aesthetic and structural issues were 92.6 percent, 92.7 percent and 97.3 percent respectively. The reason for the modification was negligence of due consideration of balancing operational variables which include issues pertaining to functionality, Aesthetic and structures. The housing provision was based on only economic factors thereby relegating to the background necessary design variables necessary to be considered in the programming, design and construction of mass housing development.

Discussion

Minimal Modification implied that these buildings before undergoing post-occupancy modifications lacked protective and territorial functions. According to Zeeman (1980), a building is functional if it meets its protective function e.g. protection of people and property against harmful influences and dangers such as inquisitive onlookers and interference. Zeeman added that a functional building should also satisfy its territorial function e.g. consumers have to enjoy privacy, safety and security. In the same vein, Hillier and Leaman (1976) cited in Nwankwo, 2013, suggested that a building should satisfy social and climatic functions where a building creates spaces in which people can carry on their activities optimally. This informed the reason why 14.4 percent of the buildings studied had undergone Limited modification. That 73.33% of the buildings studied had undergone Multiple Modification implied that the buildings lacked symbolic or aesthetic function before undergoing modifications. Leaman (1976) suggested that a building should be seen as the material embodiment of the specific ideas and expectations and as such should be seen as a cultural object with social and cultural significance and meaning. This implied that some consumers modified their buildings in search of identity and image. According to Van Dijk and De Graaf (1990), consumers of building products believe that a building only becomes architecture when it plays a part in aesthetic and cultural discussion and there should be expression of experiential value, conveyance of meaning, visual quality, aesthetic and symbolism. It implied that this category of buildings originally failed to satisfy functional or utility quality and as such could not be suitable for the activities that were meant to take place inside. According to Van der Voordt and Vrielink (1987) cited in Nwankwo, 2013, a building should fulfill its required functional quality or utility value without which it becomes a failure.

From the above discussions, aesthetic, functionality and constructional issues were established as necessary design factors that could not be ignored at the formulation/programming, design and construction stages of public residential buildings in mass housing provision. According to Van der Voordt and Van Wegen (2005), this was in line with the three components of architecture distinguished by Vitruvius as: *utilitas*(functionality or utility value: the social dimension), *firmitas*(strength and rigidity: the technological dimension) and *venustas* (beauty: the aesthetic dimension). The factor variables should be in Equilibrium. The researchers entitled this approach Equilibrium of Appropriate Balance which is an attempt to reconcile and bring design factors into equilibrium (Martins, 2010). The 'Equilibrium of Appropriate Balance' describes the state of intellectual balance between opposing design forces and actions that is deliberately designed to be in harmonious balance.

The authors observed that the programming and design of public residential buildings in the study area were based only on one portion of a total theoretical design-economic design factor and this has led to frequent modification of residential buildings at post-occupancy stage.

From the analysis result, it was discovered that the overall modification Index for model predicted data was 0.9126 and overall experimental data was 0.9126. Overall deviation of model predicted data from the experimental data was calculated to be 0.00 percent. Average modification index ($\boldsymbol{MI_{IAV}}$) for Owerri necessitated by functionality, aesthetic and constructional input factors based on field data was 0.8914 with coefficient of modification ($\boldsymbol{C_I}$) of 1.0000. This implied that 91.3 percent of the buildings in housing estates studied in Owerri had undergone post-occupancy modifications since inception. Mathematical model for post-occupancy evaluation for Owerri was developed to be $\boldsymbol{MI_{MOD}^{Overall} = C_I MI_{IAV}}$.

V. Conclusion and Recommendation

For efficient and effective mass housing delivery to be achieved in the study area, the following recommendations are made:

- Mass housing providers in Owerri, South-Eastern Nigeria should develop the culture of conducting post-occupancy evaluation of residential buildings in the housing estates they provide with a view to determining the success of their building products through feed-back information from the consumers.
- The post-occupancy evaluation is made possible using the model $\boldsymbol{MI_{MOD}^{Overall} = C_I MI_{IAV}}$ developed in this study. This approach would bring the necessary improvement required in the housing sector.
- The consumers of the building products should be involved in the design and construction of their buildings and their opinions respected since this research revealed that post-occupancy modification was a reaction in response to needs and aspirations not met.
- The building products should be made consumer-specific.
- The concept of Equilibrium of Appropriate Balance which the researcher entitled Construct-Functional Aesthetic Balance should be used in the design and construction of mass housing.
- Tertiary Institutions in the study area should restructure their academic curriculum on mass housing delivery to capture the contributions of this study.

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