



Effect of Design Deficiencies on Building Maintenance of Residential Buildings: A Post Occupational Evaluation of Residential Buildings in Enugu Urban, Enugu State, Nigeria

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Provision of housing and its quality are two issues, which remained the subject of research and interest to researchers' and designers'. Whenever a designer completes a project, they are not fully aware of the consequences of their design. Only through post occupational survey, the designer usually realizes the shortfall they have made during the design process. Unfortunately, such unforeseen conditions are the part of daily life for the end user of residential buildings in developing cities. The main purpose of this research is to understand and identify the causes of design tribulations and their effects on residential buildings at post occupational stage. This research circumscribes the issues and problems faced by the users of private housing at post occupational stage, which results in because of poor design. These problems affect the users through unplanned maintenance to major repairs leading to danger of collapse. In order to evaluate these effects on buildings, case studies were conducted in housing of metropolitan areas of Enugu State. The finding reveals that the housing is experiencing common building defects for housing such as dampness, facade deterioration and sanitation problem.

ABSTRACT



Keywords: Design Deficiencies; Building Maintenance; Residential Buildings; Post Occupational Evaluation; Enugu Urban

Introduction

The concentrations of planning and design solution are cradled for maintenance issues related to design faults in built forms. Maintenance which emerges from design faults indicates that design has not been practiced in the perception of building maintenance, or that the construction phase has remained unchecked by the field experts. Reviewing the maintenance problems in various built forms reveals that the housing sector is the most effective of these activities.

House is an enclosure which presents the perception of peaceful and protecting environment. A house is supposed to be a place/enclosure which is capable enough to accommodate ideas of living and work. In prehistoric days, caves were used to fulfil that requirement of living space as well as protecting its user from extremes climatic conditions. With the passage of time and advent of technology, the perception of shelter has changed its form in modern day housing. Under developing countries which normally have an unplanned growth, development and law, transient in almost all spheres of life, particularly in urban centers. Alarming rate of population growth is another problem faced by these countries which ultimately creates the demand for increased number of housing facilities. In modern days, house is a basic icon of shelter where people can plan to live and work under a protected environment. House or its multiple form of housing has remained subject of research and discussion on number of reputable platforms. Around the globe the importance of housing has increased many folds and it is still growing with every day past. Its importance gains more momentum when the state of housing in developing nations is taken into account, (Chohan, Che-Ani, Tahir, Abdullah, Tawil and Kamaruzzaman 2011).

The importance of housing design is pronounced by Chowdhury, (1985), as design of the house is one of the most difficult tasks in the field of architecture. A proper understanding of the nature of human needs is of crucial importance in the formulation of houses and space standards. Chowdhury further stressed that, a shelter provides people with functional, social and spiritual needs. The life of an individual and family unfolds in the space within shelter. Conceivably it can be declared that any attempt at formulating housing and space standards should start by recognizing the quality of space and social aspects of society or individual to avoid the design deficiency at post occupational stage.

Towards the need to improve the housing quality and its design in under developed world is highlighted by renowned architect, Correa, (1980) that the wonderful thing about third world is that there is no shortage of housing. What is in short supply, of course is the urban context. The real task and responsibility of the third world architect is to help generate this urban context. The study of Correa reveals that urban amenities are missing in the housing sector of underdeveloped regions. These amenities should be considered and properly planned at design stage to facilitate the user and to avoid nuisance of reworks or redesign at later stage.

Chohan et al (2011) states that the lack of maintenance often results in deterioration that leads the building to the point of collapse or to it having to be demolished. The question arises as to whether there is any way to avoid this waste of the built environment in developing countries.

The answer lies in better design as the lack of it would appear to be a major cause of the problem. Hence, it could be suggested that unplanned maintenance can be avoided if building design takes account of the need for careful and methodical planning, budgeting, monitoring and execution.

Statement of Problems

Most buildings in Nigeria are in abandon conditions of structural and aesthetic disrepair and if corrective measures are not properly carried out, it could result in a total breakdown of structural components. Despite the various strategies being adopted by the government for the maintenance of those facilities, the buildings remain a home for defects that should have been avoided if proper feasibility planning on maintenance has been given cognizance right from the design and construction stage of the project. This has led to unnecessary expenditure from the various authorities in carrying out remedial work to curb the effects. Brennan (2000: cited in Okuntade, 2014) that the main purpose of maintenance of property is essentially to retain it values for investment, aesthetics, safety and durability with a view to ensuring that the property is continually used for habitation and to satisfaction of the owner. It was

even observed that majority of the new construction were being built up with defects which later transpire into substantial expenses on maintenance.

These problems were identified as:

1. Lack of proper planning on maintenance right from design stages.
2. Imitation of building design without considering the condition that lead to such design.
3. Designs not being finished within the required standards and thus resulted in faults.
4. Unawareness amongst Nigerians about the significance of maintenance in both private and public buildings.

Aim and Objectives

The aim of this study is to understand and identify the design tribulations and their effects on maintenance of residential buildings at post occupational stage.

Objectives are:

1. To identify the issues and problems faced by users of private housing at post occupational stage.
2. To identify whether or not the problems are caused by design faults.
3. To identify the cause of deterioration in private buildings at post occupational stage.
4. To ascertain the level of awareness of building maintenance manual.

Significance of the Study

Results of this study will be beneficial to the stakeholders in building industry, planners, designers and architects. They will realize the urgency to practice design in the perception of building maintenance. It will also help to signal the need and awareness for building maintenance amongst the public.

Scope of the Study

The focus is to investigate the level of dilapidation caused by design defects on residential buildings in Enugu metropolis. The scope is limited to the various housing densities within Enugu North, Enugu East and Enugu South LGAs that made up Enugu state urban.

Research Question

1. Do the owners and occupiers of buildings know the benefit of building maintenance manual?
2. Do the architect and other professionals in building industry carry out their jobs properly at the early stage?
3. Are the public building owners and occupiers aware of building maintenance?

Literature Review

Repercussions of Poor Design

Faults in building design place a heavy burden on the building for the rest of its life and there is no compensation for it. In such situations, the responsibility falls on the shoulders of the designer in that they must think carefully with full concentration and consideration towards completion of their design project.

Explaining the link between maintenance and building design, Ramly (2006) suggests that four sectors of building design should be considered and regarded as important if one is to avoid the need for unplanned maintenance at the post-occupation stage. These sectors are:

1. the *main fabric* which includes walls, floors, roofs, doors and windows;
2. *internal finishes* which includes ceiling and wall finishes as well as floors;
3. *special design features* such as decorative elements for the doors, windows, glass, air vents and special brick and stone work;
4. the fourth and the last sector is *cleaning and housekeeping* of all building components.

The study identified deterioration in these sectors that resulted from design faults, which subsequently imposed a heavy financial burden on the occupier or owner.

Based on the outline of causes derived from the work of Gibson (1979), the implication of design fault on maintenance in buildings has resulted from the following:

1. the consequence of *thermal movement*;
2. the consequence of *inefficient detailing*;
3. the consequence of *improper material selection*; and
4. the consequence of poor design for *access for maintenance* measures.

The designer must understand what consequences the use of materials in combination can impose on their designs. *Thermal movement* in materials can affect a building in a number of ways. It can cause cracking in walls or plaster and fractures in structural elements if consideration has not been given to thermal expansion. Thermal movement can also result

in distortion of otherwise impervious joints with the result that penetration of water takes place or there is a loss of adhesion. *Inadequate detailing* can cause deterioration of the building façade. In the absence of proper architectural detailing of rainwater discharge from the building face, water may penetrate into the building or stagnate within or on the construction. Ponding water is a potential source of disease, as it can harbour insects that transmit malaria or dengue fever, for example. Incorrect *material selection* can add to the financial burden of maintenance, as well as be the cause of thermal movement, distortion, ponding, or early failure. Whereas *poor access* for maintenance will cause delay in the repair process that escalates the cost and increases the probability of substandard remedial actions.

Nicastro (1997), reported the case of a high rise luxury condominium in Austin, Texas, USA and built in 1980 in which the fine network of the cracks hinted at widespread cladding cracks. The identified defect was described by the author as like 'skin cancer' due to the uncontrollable situation of maintenance. The solution under such condition is usually total replacement of the building's cladding. This study also shows that even in the wealthy parts of the world, poor material selection and design control can still result in expensive defects in their buildings.

The Factors of Deficient Design and Maintenance: A Review of Developing Regions

Study by Okpala (1992), regarding housing in developing country is précised; as the larger faction of population living in third world has a little access of quality housing. In the housing sector of developing world, it is worth mentioning that unlike other parts of the world, private sector is much more efficient than public sector in providing housing to residents (Okpala, 1992).

According to report on housing conditions in Pakistan published by Human Right Commission of Pakistan (HRCP, 2005) it is mentioned that the estimation suggest that more than half a million housing units are required in Pakistan. In other words, a small city is required annually to meet the severe housing shortage in the country and the increasingly dilapidated state of existing housing presented new threats.

Reviewing the history of housing and its related issues in Pakistan, Syed (1996), describe it as; Pakistan has faced formidable housing problems from its very birth in August 1947, as an independent nation; in the wake of the mass influx of millions who migrated to the country from India.

The situation has not changed much almost 50 years and problems, for example, issue mentioned in paragraph 3 of the report. Since every problem of housing is coupled with some degree of defects or compromising design quality, therefore there are high chances for end user to experience the end results of these issues.

By developing an understanding for issues mentioned by researchers, organizations and expertise of field in above paragraphs, it is revealed that lack of housing is not only mounting pressure on available housing but ever growing housing demand in these regions have paved the track for improper and faulty design and construction.

Design deficiency and its implications on the house maintenance has remained a neglected part in field of research and modern society, especially in developed and developing nations. The theme of this study can be understood in terms of Architectural Eco System.

The proportion of the maintenance is highly controlled and governed by the quality of design. In fact, these two characters of building are inversely proportional to each other, that is, the higher the quality of the design, the lower the maintenance and the lower the quality of the design, the higher the maintenance. It is well phrased by CIOB (1982) as; it is at the design stage that the maintenance burden can be positively influenced for better or for worse. Hence it could be concluded that skillful design can reduce the amount of maintenance work.

In this perspective, Seeley (1987) added that design team frequently neglects the consideration of maintenance aspects and there is great need to reduce the gap between design and maintenance. Seeley identified the problem of design and maintenance as the gap between design and maintenance. Conceivably Seeley stress that maintenance is important issue to be considered right from the design stage to prevent its unplanned reappearance at post occupational stage of building. This could be more implicating and it has effect on the building. But how would this gap be reduced, the answer may be found in developing understanding for design and maintenance in the light of definition given by RICS (2000), according to which the building design should consider a design of the auto. The auto is usually provided with schedule of planned and emergency manual, thus it could be recommended that one way to reduce the gap between the maintenance and design is to provide the residents with manual of house/building design and product used in that design.

The caption of this research has gained certain momentum and attracts good number of researchers to address the similar problem in other parts of globe and they have highlighted the vitality of topic through their publications and also developed a reliable link between the design and maintenance issues. Research by Ramly (2006) showed that, the design plays a major role in determining the condition of the building after completion, mainly in aspects of defects and maintenance.

Ramly (2006) further stresses that indirectly, design influences the performance and physical characteristic of building and its durability to withstand environmental condition, social interfaces such as graffiti and vandalism. Therefore, the link between design and maintenance should not only be seen from the point of increasing the repair work or cost involve, but it need to consider also the impact of design on structure and material installed as well as the life cycle of each component of building.

The discussion above reveals that mostly the researchers have agreed on the importance of emerging issue of faulty design and building maintenance. Through their work they highlighted the various issues and aspects of design tribulations and their effects on building maintenance. Identification of issues and their causes had remained major task for researches.

Materials and Methods

Study Area

Enugu Urban is the most developed urban area in Enugu state. It is one of the states in south eastern Nigeria, its capital is Enugu. The state was created in 1991 from the old Anambra State. Enugu state is located within latitude $06^{\circ} 00'N$ and $07^{\circ} 00'N$ and longitude $07^{\circ} 00'E$ and $07^{\circ} 45'E$.

The State shares borders with Abia State and Imo State to the South, Ebonyi state to the east, Benue state to the Northeast, Kogi State to the northwest and Anambra State to the west. Enugu state is made up of 17 local government areas. There are 18 prominent residential areas in the urban. These are Abakpa, TransEkulu, Nike, GRA, Ogui, Asata, New Layout, Achara Layout, Ugwuaji, Maryland, Awkanaw, Uwani, Agbani, and Caol Camp.

Methodology

Survey research method was adopted for this study. Questionnaire was used which represent the survey research method.

Research Population and Sampling Frame

The population of the study is 722, 664 respondents which is estimated population of the study. They are made up of population from the three local government area in the Enugu urban. (Enugu East, Enugu North, and Enugu South). It comprises the occupants and architects and house owners in the study area.

Population and Sample Size

The Cochran sample size formula for the 722,664 population was used to determine sample size for the study.

$$N = z^2pq/d^2$$

Where:

N = the desired sample size

Z = standard normal size at 95% confidence interval (1.96)

P = proportion attributes of a population (50%)

q=1-p (50%)

d= desired precision (0.05) $n = (1.96)^2 * (0.50) * (0.50) / (0.5)^2 = 384.16$

Rounding off to the nearest hundredth, n= 400. The 400 respondents were breakdown into three groups which represent the occupants (262), architects (128) and house owners (10)

Results and Findings

To estimate the nature of building defects as a result of poor design in Enugu urban area, the following observation were obtained from the respondent and analyzed as follows.

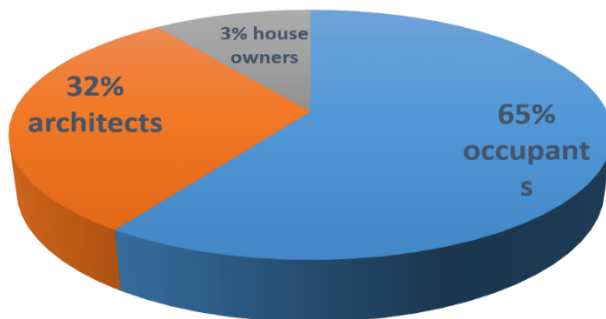


Figure 1: Population of the Respondents

Source: Field Survey (2022)

From the above figure, it is observed that 100% of distributed questionnaires were completed and returned with 65% as occupants, 32% as architects and 3% as house owners. The level of respondents was highly satisfactory.

Table 1: Demographic Characteristics of the Respondents

<i>Variable</i>	<i>Category</i>	<i>Frequency</i>	<i>Percentage</i>
<i>Age group</i>	20–29	217	53.3
<i>Age group</i>	30–39	124	31.0
<i>Age group</i>	40–49	34	8.5
<i>Age group</i>	50 and above	25	6.3
<i>Age group</i>	Total	400	100
<i>Sex</i>	Male	275	68.8
<i>Sex</i>	Female	125	31.3
<i>Sex</i>	Total	400	100
<i>Level of education</i>	No formal education	4	1.0
<i>Level of education</i>	Primary	8	2.0
<i>Level of education</i>	Secondary	102	25.5
<i>Level of education</i>	Tertiary	286	71.5
<i>Level of education</i>	Total	400	100
<i>Marital status</i>	Married	258	64.5
<i>Marital status</i>	Single	133	33.3
<i>Marital status</i>	Separated	6	1.5
<i>Marital status</i>	Widow/Widower	3	0.8
<i>Marital status</i>	Total	400	100
<i>Occupation</i>	Civil servant	175	43.8
<i>Occupation</i>	Farmer	14	3.5
<i>Occupation</i>	Trader	75	18.8
<i>Occupation</i>	Artisan	136	34.0
<i>Occupation</i>	Total	400	100

Source: Field Survey (2021)

Table 1 shows that majority of respondents are between the ages of 20-39 (85.3%), a number of male 68.8%, tertiary as the highest level of education 71.5%, single respondents 33.3%, and civil servants 43.8%.

Table 2: Problems faced by users of private housing at post occupational stage.

<i>Problems Faced by Users</i>	<i>Frequency</i>	<i>Percent</i>
<i>Soaked ceiling and roof leakage</i>	125	31.3%
<i>Peeling paints</i>	77	19.3%
<i>Soaked walls / damp</i>	153	38.3%
<i>Water drains restrictions</i>	118	29.5%
<i>Wall cracks</i>	47	11.8%
Total	520	130.2%

Source: Field Survey (2022)

From table 2 above, it can be seen that the data is above the respondent's population and 100%. The reason is that the opinion gives the respondents room to answer as many opinions as possible. It shows that 31.3% of private housing are battled with soaked ceilings as a result of roof leakage, 19.3% are facing paint pelage, 38.3% have problem of

soaked walls or damp usually caused by service pipe leakages, 29.5% are water drainage restrictions which does not allow the free flow of water, while 11.8% complained of sudden wall cracks.

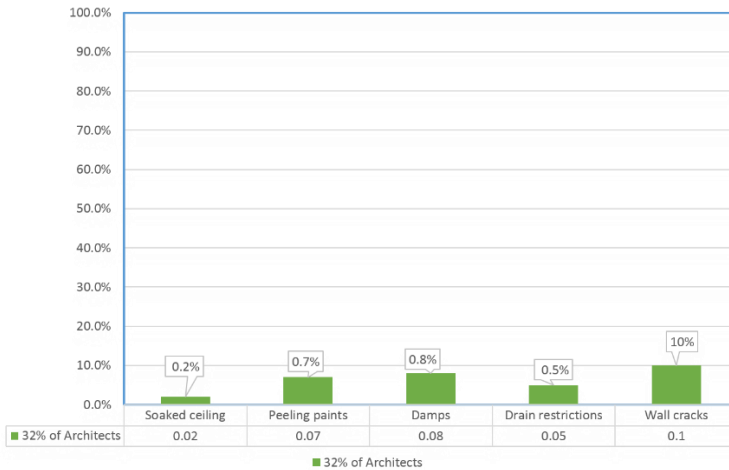


Figure 2: Building Defects Caused by Design Faults by 32% of the Architects

Source: Field Survey (2022)

From figure 2 above, 0.2% of the architects agreed that soaked ceilings are caused by design faults, 0.7% agreed with peeling paints, 0.8% agreed with soaking of walls and damp, 0.5% believes drain restrictions are as a result of design faults, while 10% agreed with wall cracks.

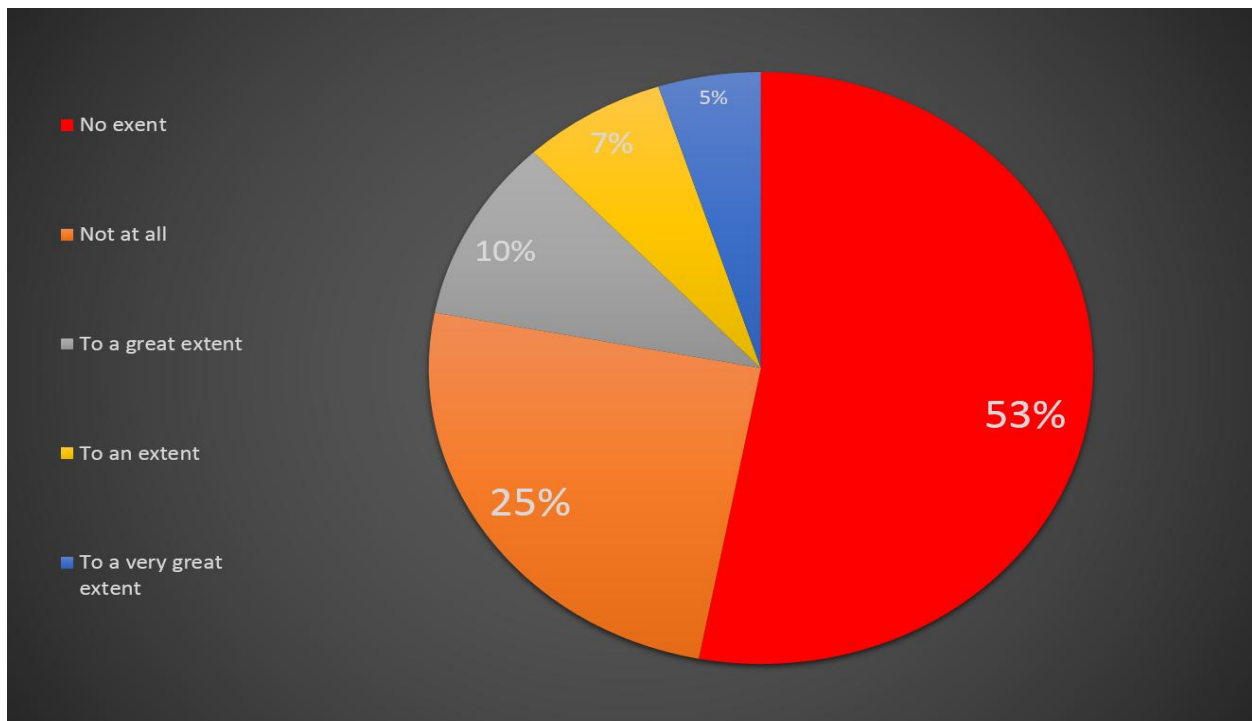


Figure 3: Awareness of Building Maintenance Manual

Source: Field Survey (2022)

Figure 3 above seeks to find out the extent which people are aware of building maintenance manual. 5% of the respondents responded 'no extent' on the awareness of building maintenance manual, 10% responded 'to a great extent', 7% responded 'to an extent', 25% responded 'not at all' heard of any maintenance manual, while 53% responded 'no extent' meaning that people are not aware of building maintenance manual.

Conclusion

While a journey of thousand miles begins with a single step, the most complex design of a building starts from the single stroke of designer. Errors in design can, however, result in unplanned maintenance where the designer fails to understand the buildability of that initial concept. The designer who is aware of the risk is more likely to create buildings that will require only planned maintenance. One way of evaluating the work of the designer is to go through the occupier's experience of maintenance requirements, even if the building may be regarded as a landmark of urban design.

Thus, it can be suggested that there must be a strong relationship between design and maintenance and only those design should be considered good which were proved as less demanding in terms of maintenance. This research has revealed several important factors at various design stages. The work has aided understanding of avoidable building / housing maintenance issues caused by design faults. The consequence of poor design has been considered from the minimum level of maintenance such as surface decay to the ultimate level of collapse. Design faults not only result in unplanned maintenance they also are expensive in terms of the lives of occupants and the cost of repairs. Faulty design and its consequences are a global problem that can be seen in both developed and underdeveloped countries. There is a need for more research to be conducted in this field to resolve the design deficiencies that result in a high maintenance and monetary burdens.

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