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Assessment of Maintainability Consideration during Design and Construction Stages of Public Buildings in Abuja Metropolis

Abubakar, M, Chukwu, J. N., Zailani, M. B. & Ibrahim, A. G.
Department of Building, Ahmadu Bello University, Zaria

Most buildings suffer from defects resulting from poor maintainability considerations at the design and construction stages. The apparent lack of maintainability considerations has often given rise to high cost of building maintenance during its operation. This study is therefore an attempt to assess the maintainability considerations in the design and construction stages of public buildings in Abuja metropolis. A quantitative research approach was adopted, and a structured questionnaire was used to elicit the perception of professionals working with the Federal Capital Development Authority (FCDA) Abuja. The population was purposively targeted because of their direct involvement in the design and construction activities in the Metropolis. Both descriptive and inferential statistics were used for data analysis. The study found that functionality of buildings, detailing of structural components and safety of building users are the most significant considerations to be made at all times in the design and construction of buildings. High life cycle cost of buildings, high rate of defects development, frequent maintenance work and high maintenance budget were found to be most prevalent consequences of ignoring maintainability issues in the design and construction of buildings in Abuja metropolis. The study recommends production of functional buildings by considering maintainability issues at the early stage of building development through synergy among the design team. Standard procedures and practices for the procurement of qualitative structures must also be upheld by all stakeholders in the built environment.

Keywords: Building maintenance, Maintainability, maintainability considerations, Design and construction

Introduction

Buildings provide infrastructural base for a wide range of human activities and functions. The efficiency in the delivery of such activities and functions depends largely on the state of repair and general maintenance of the buildings (Mosaku, 2002). For this reason, design and construction of buildings should be made to support their future maintenance throughout their lifecycle. This will go a long way in preserving the quality and functions of all constructed facilities in the built environment (Ismail & Mohamad, 2015). In order to ensure that buildings are preserved for higher productivity, Olajide and Afolarin (2012) observed that maintainability should be considered right from the early stage of development. The need for higher maintenance productivity is related to the choice of maintenance strategies adopted at both the design and construction stages of buildings.

The procurement processes of most buildings, according to Gatlin (2013) are characterized by mistakes, errors, omissions and discrepancies. This is as a result of the failure of the design professionals to produce complete, accurate and well-coordinated design. All these lapses have culminated to poor performance resulting in high cost of maintenance over the building lifecycle. Further observation was that the generators of maintenance problems could be looked at from three different angles thus: cause initiated during design stage, construction stage and operation stage of the building. Mills (1980), Dekker (2000) and Rozita (2006) stated that the thinking of

maintenance should commence at the design phase of building development, while Speight (2000) found that it is at the design phase that the maintenance burden can positively influence the state of the final product. Similarly, De Silva and Ranasinghe (2010) observed that the cost effective decisions of maintainability of a facility should be initiated from the early development phase of the building.

However, Ishak, Chohan and Ramly (2007) observed that communication gaps that exist during the development process of buildings are among the major factors that affect maintainability during the lifecycle of the buildings. More so, poor communication in the building development phase often leads to faults in the finished product (Gibson, 1979; Wordsworth, 2001; Chi-Ani *et al.*, 2009). This has resulted to the inadequate functionality and poor performance of most buildings, coupled with lack of users' satisfaction with the finished products. Consequently, the need to examine the extent to which maintainability is considered at both the design and construction stages of building development becomes imperative in order to highlight areas that require improvement.

This study therefore assesses the perception of construction professionals on maintainability consideration at both the design and construction stages of buildings in Abuja metropolis, with a view to ensuring procurement of maintainable buildings in the Nigeria's capital city. Subsequent sections of the paper present the review of literature, research methodology, results and discussion, conclusions and recommendations.

Literature Review

The advancement in science and technology has contributed immensely to the improved methods of building production. In spite of these advancements, Zulkarnain *et al.* (2011), Olajide and Afolarin (2012) maintained that it has not really been possible to produce buildings that are maintenance-free. Usman *et al.* (2012) posit that all the materials, components and systems that make up a building do deteriorate or suffer loss of aesthetics, strength or functional values with the passage of time, due to the inherent lapses in the design and construction process coupled with the environmental conditions and the actions of users. All constructed facilities are prone to aging, wear and tear in the course of performing their functions. They also deteriorate as a result of exposure to the disparate elements in the environment.

The concept of maintainability attempts to survey the necessary considerations, recommendations and provisions at both the design and construction stages of buildings to ensure ease of maintenance (Ismail & Mohamad, 2015). Sivanathan *et al.* (2012) stated that maintainability concept can be applied to minimize the overall maintenance problems and the defects that can occur in buildings and ultimately optimize maintainable buildings. In the position of De Silva (2012), maintainability of buildings should focus on achieving efficient maintenance by eliminating waste in maintenance cost in the course of rectifying maintenance deficiencies. Bagadia (2009) opined that the maintainability concept should be considered as a systematic approach aimed at identifying, analyzing and eliminating waste through proper management and continuous improvement.

While many scholars including Mbamali (2003), Iyagba (2005), Adedokun (2011) and Usman *et al.* (2012) agreed that Nigeria lacks maintenance culture. However, Jambol (2013) shared a different view and maintained that Nigeria has maintenance culture. The argument was based on the fact that every organization whether private or public has maintenance department of some sort and that such departments have structures that are manned by personnel who are employed and given some roles and responsibilities of maintenance, and are paid. Such departments have annual maintenance budgets, plans and programmes. Failure to practice and operate the culture and keep it dynamic and

sustainable was adjudged to be the missing link.

Research Methodology

Research Design

This study adopted a cross sectional quantitative research approach. This is due to the nature of the research question which aims at assessing what the perception of the targeted population is regarding maintainability considerations. A structured questionnaire was designed and distributed to achieve the aim. The questionnaire was classified into two sections. Section A inquired about the demography of the respondents, while section B enquired about the perceptions of respondents on maintainability considerations at design and construction stages.

Study Population and Sample Population

The population for this research comprised of professionals working with the Federal Capital Development Authority (FCDA) Abuja. This is the agency overseeing and controlling the construction activities in the capital city. The population was targeted because of their direct involvement in the design and construction activities in the Metropolis. They are the professionals that scrutinize every design before granting approvals for construction. They also visit construction sites periodically to ensure adherence to good practice in the construction process. It was therefore envisaged that they should be able to provide information on issues relating to maintainability considerations usually taken in the process.

Information obtained from the office of Finance and Administration, FCDA, Abuja, revealed that a total number of one hundred and thirty-three (133) technical staff comprising of 46 Architects, 43 Builders, 21 Quantity Surveyors and 23 Civil Engineers are currently in the service of the Federal Capital Development Authority (FCDA), Abuja.

Sample size

The sample size was determined with the formula formulated by Yamane (1967)

$= N / \{1 + N(e)2\}$

Where n= Sample size

N=Total population size

e= Standard error of sampling distribution or margin of error (95% confidence interval).

Therefore,

n= 133/1+ {133 x (0.05)2},

n= 133/ {1+0.3325}, n= 133/1.3325, n= 100

Add 10% of 100 to cover non-response and/or invalid responses

The required sample size is 110.

Data collection instrument

One hundred and ten (110) structured questionnaires were distributed purposively to collect data from the respondents. The questionnaires consist of two parts and were developed using the close-ended questions using the variables identified in the literature as parameters. The first part was designed to capture the profiles of the respondents, while the second part comprised of design and construction maintainability considerations of buildings which were scored on a five-point Likert scale based on the extent to which they are considered in the study area.

Results and Discussion

A total number of one hundred and ten (110) questionnaires were distributed to the respondents, out of which one hundred (100) were successfully completed and returned.

Questionnaire responses

Table 1 indicates that 90.9% response rate was achieved in the survey. This signifies the result of the study is a good representation of the opinion of the professionals considered in the research.

Table 1: Returned Questionnaires

No. of questionnaires distributed	No. of returned questionnaires	Percentage response
110	100	90.9%

Table 2 shows the demographics of the respondents. On educational attainment, 37% were HND holders, 48% were B.Sc. degree holders, while 15% were holders of Master's Degree. Considering their professions, 52% of the respondents were Builders, 14% were Civil Engineers, 9% were Quantity Surveyors and 25% were Architects. This shows that the majority of the respondents by their academic qualifications and professional background are technically qualified to provide appropriate responses to the issues raised in the questionnaire.

In terms of years of professional experience of the respondents, it was observed that 14% had 1 to 5 years' experience, 31% had 6 to 10 years' experience, 38% had 11 to 15 years' experience and 17% had above 16 years' experience in their respective organisations. This translates to the fact that many of the respondents have stayed long enough in their respective organisations and therefore have reasonable understanding of issues concerning the subject matter.

Importance of Maintainability Considerations with respect to Stages of Development

Figure 1 presents the perception of the respondents on the stage of design development that maintainability considerations are most valuable. 52.0% of the respondents indicated conceptual stage, 11.0% indicated schematic stage, and 14.0% was for preliminary stage, 12.0% chose the final stage while 11.0% indicated detailed design. Majority of the respondents which constitute 52% are in agreement that maintainability should start at the early stage of building design development. The findings of this study is in line with Olajide and Afolarin (2012) that maintainability of a building should be considered right from the early design stage. Similarly, De Silva and Ranasinghe (2010) posit that the cost-effective decisions of maintainability of a facility should be initiated from the early development phase of the building.

Table 2: Respondents' Backgrounds

Qualification	Frequency	Percentage
HND	37	37
B.Sc.	48	48
M.Sc.	15	15
Total	100	100
Profession	**Frequency**	**Percentage**
Architects	25	25
Builders	42	42
Civil Engineers	14	14
Quantity Surveyors	19	19
Total	100	100
Working experience	**Frequency**	**Percentage**
1 - 5	14	14
6 - 10	31	31
11 - 15	38	38
16 and above	17	17
Total	100	100

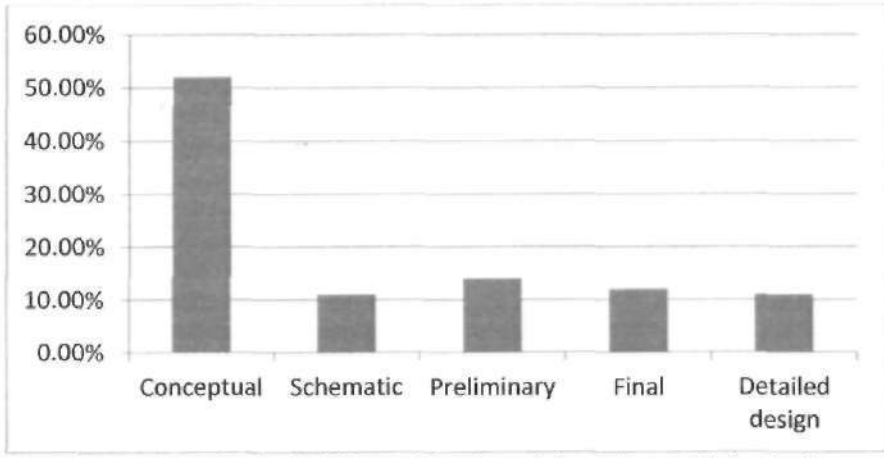


Figure 1: Importance of maintainability considerations relative to Stages of design development.

On the extent to which maintainability considerations are upheld in building design and construction, Table 3 shows that respondents considered the importance attached to functionality of building as the first significant factor with RII of 0.73. Functional design and detailing of structural components was ranked 2nd with RII of 0.70, while safety considerations was ranked 3rd with RII of 0.66. Selection of quality materials, effectiveness of building operations and fulfillment of statutory requirements all ranked 4th with RII of 0.64. Adherence to material specifications ranked 5th with RII of 0.63, while ease of maintenance and repair occupied the 6th position. Creation of maintenance assesses and adaptability to future use of buildings ranked the 7th position with RII of 0.61. Information from geophysical survey and frequency of maintenance operations all ranked 8th position with RII of 0.60, while regular routine maintenance occupied the 9th position with RII of 0.58.

It can be seen that the respondents indicated the importance attached to building functionality and detailing of structural components as the most significant. In a similar study, Odediran *et al.* (2012) found that the ability of a building to provide the required environment for a particular activity is a measure of its functionality. Adejimi (2005) stated that the control of quality and workmanship are significant factors which affect maintenance and therefore should be considered during the design stage, while Zulkarnain *et al.* (2011) opined that maintainability is an important programme for the sustainability of infrastructural development and more so plays an important role among other activities in the overall building operations

In assessing the consequences of not considering maintainability issues in building design and construction, Table 4 revealed that the first significant consequence considered by the respondents was the high life cycle cost during the usage of the building with RII of 0.73. High rate of defects development on the building occupied the 2nd ranking with RII value of 0.71. Frequency of maintenance work and high maintenance budget for building all occupied the 3rd position with RII of 0.69. Likelihood of encountering early deterioration of building finishes, effects on the quality of finished product, and chances of wall dampness during wet season, all occupied the 4th ranking with RII value of 0.68, while possibility of building components corroding under wet condition occupied 5th position with RII of 0.67. Functionality of building components, lack of safety of facility users and possibility of water seeping into building ranked the 6th position with RII of 0.66. Operational efficiency of building, likelihood of crack development, chances of encountering fungi growth on building components and high financial investment for maintenance operations during the usage of the building all ranked the 7th position with RII of 0.65.

Durability of building components, reliability of building performance, services to be rendered to building users, building users' satisfaction, chances of creating maintenance access, design quality of building and harmonization of building with the environment all occupied the 8th, 9th, 10th, 11th, 12th, 13th and 14th positions with RII of 0.64, 0.63, 0.62, 0.60, 0.59, 0.57 and 0.56 respectively.

The respondents identified that high life cycle cost during the usage of the building, high rate of defects development, high frequency of maintenance work, low safety of facility users and high maintenance budget of the building will be significant. These findings are in agreement with the studies of Wong and Hiu (2005), Flores-Colen *et al.* (2008) and De Silva and Ranasinghe (2010) that deficiencies in maintenance considerations in building development constitute maintainability risks which originate from poor design and construction practices. Adejimi (2005) asserted that a poorly resolved building design will eventually result in severe maintenance problem, while Ikpo (2009) and Wood (2012) maintained that lack of attention to maintainability considerations at the design stage may lead to difficult and costly operation to facilities users, hence user's expectation may not be achieved.

Table 3: *The extent to which maintainability considerations are upheld in building design and construction in* Abuja metropolis

S/N	Maintainability factors	Mean	RII	Rank
1	Importance attached to functionality of buildings	3.64	0.73	1st
2	Detailing of structural components	3.51	0.70	2nd
3	Level of safety considerations	3.30	0.66	3rd
4	*Effectiveness of building operations*	3.19	0.64	4th
5	Fulfillment of statutory requirements	3.20	0.64	4th
6	Selection of quality materials	3.22	0.64	4th
7	Adherence to material specifications	3.16	0.63	5th
8	Importance of ease of maintenance and repair	3.12	0.62	6th
9	Adaptability to future use of buildings	3.07	0.61	7th
10	Creation of maintenance assess	3.03	0.61	7th
11	*Information from geophysical survey*	2.99	0.60	8th
12	Frequency of maintenance operations	2.99	0.60	8th
13	Regular routine maintenance	2.92	0.58	9th
14	Assessment of defect development	2.91	0.58	9th

Key: 1= Very low, 2= Low, 3= Moderate, 4= High, 5= Very high

Table 4: Consequences of not considering maintainability issues in building design and construction in Abuja metropolis

S/N	Maintainability factors	Mean	RII	Rank
1	Increase in life cycle cost	3.66	0.73	1st
2	Increase in rate of defects development	3.54	0.71	2nd
3	Frequency of maintenance work	3.43	0.69	3rd
4	High maintenance budget of building	3.45	0.69	3rd
5	Likelihood of encountering deterioration of building finishes	3.40	0.68	4th
6	Reduction on the quality of finished product	3.39	0.68	4th
7	Increase in chances of wall dampness during wet season	3.42	0.68	4th
8	Building components corroding under wet condition	3.35	0.67	5th
9	Poor Functionality of building components	3.32	0.66	6th
10	safety of facility users at risk	3.34	0.66	6th
11	Possibility water seeping into building	3.28	0.66	6th
12	Operational inefficiency of building	3.23	0.65	7th
13	Poor durability of building components	3.12	0.64	7th
14	Crack development	3.27	0.65	7th
15	Fungi growth on building components	3.23	0.65	7th
16	Increase in financial investment for maintenance operations	3.30	0.65	7th
17	Reduction in reliability of building performance	3.13	0.63	8th
18	Accumulation of services to be rendered to building users	3.11	0.62	9th
19	Low building users satisfaction	3.00	0.60	10th
20	Difficulty of building maintenance	2.95	0.59	11th
21	Low design quality of building	2.83	0.57	12th
22	Poor harmonization of building with the environment	2.82	0.56	13th

Key: 1= Very low, 2= Low, 3= Moderate, 4= High, 5= Very high

Conclusion and Recommendations

This study has evaluated the perceptions of professionals working with the Federal Capital Development Authority (FCDA) Abuja, regarding maintainability considerations upheld in design and construction of buildings and the consequences of neglecting them in Abuja, the Capital City of Nigeria. The study revealed that functionality of buildings, functional design and detailing of structural components and safety of building users are the key issues considered to ensure maintainability of buildings in the capital city. Moreover, the study revealed that professionals perceive ignoring maintainability considerations at the design and construction stages leads to high life cycle cost during the usage of the building, high rate of defects development, which yields high frequency of maintenance work and exorbitant maintenance budget for such buildings in Abuja metropolis.

It is recommended that considering the capital investments on buildings in the federal capital, maintainability considerations should commence at the early stages of building procurement in order to ensure the delivery of sustainable and maintainable structures in Abuja. Standard procedure and practices that promote maintainability of constructed facilities must be ensured by all construction stakeholders in order to ensure quality and sustainability of the entire built environment.

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