



## Factors Affecting Maintenance of Buildings in Petroleum Training Institute, Uvwie and Delta State University Abraka, Delta State, Nigeria

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### *Authors' contributions*

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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Case Study

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### ABSTRACT

**Aim:** The aim of this study is to assess the factors hindering effective maintenance of public buildings in Delta state with a view to establishing common defects in public buildings and significant factors affecting effective maintenance in the study area.

**Study Design:** It was a survey research; the study was affected via literature review and a well-structured questionnaire. Likewise, physical observations were carried out to substantiate the findings of the questionnaire survey.

**Place and Duration of the Study:** The study was conducted in Petroleum Training Institute (P.T.I), Uvwie LGA and Delta State University (DELSU), Ethiope West LGA, in Delta state, Nigeria for a period of 2 years.

**Methodology:** Being survey research, the study employed the use of review of related literature, structured questionnaire, personal survey, and photographs for data collections. The study respondents were selected using purposive sampling technique. Relative Importance Index (RII), mean scores, frequency tables and descriptive statistics were employed for the data analysis.

**Results:** The study found out that the four most significant deficiencies identified include; rising dampness problem (0.8656), cracks on walls (0.8469), unstable foundation (0.8094) and defective

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plastering and rendering (0.7875) while the three least defects are fungi and small plant attack (0.6313), insects (termite) attack (0.6656) and timber decay (0.7031). The most four significant factors affecting building maintenance is Poor supervision (0.8875) followed by defective construction material, incompetent workforce and non-conformance with the specification with RIIIs of 0.8719, 0.8531 and 0.8375 respectively.

**Conclusion:** The study concludes that professionals should focus on teamwork rather than personal competitiveness in ensuring defects free design and construction. Professionals should pay more attention to the possibility of defects occurrence when planning construction projects, critical consideration of factors affecting design and construction defects when planning construction activities, engaging required professionals at every stage of the construction process, and strict monitory and supervision of construction works among others are recommended.

*Keywords: Design; construction; defect; maintenance; Delta State.*

## 1. INTRODUCTION

Building maintenance plays an important role among other activities in the building operations [1]. Various attempts have been made to give a comprehensive definition of maintenance and to explain vividly what it entails. Adamu et al. [2] defined maintenance as the combination of any action carried out to retain an item in or restore it to an acceptable condition. Maintenance can also be referred to all necessary work done to preserve a building with its finishes and fittings so that it continues to provide the same or almost the same facilities and amenities and service as it did when it was built [3]. The primary objective of building maintenance is to preserve buildings in their initial functional, structural and aesthetic states [4].

Despite the development in technology, buildings still suffer from defects resulting from inadequate design and construction making them vulnerable to unplanned maintenance during their life cycle [5]. The greater part of these defects may be attributed to professionals ignoring maintainability during design and construction, leading to buildings requiring constant repair and maintenance which often translate to high cost causing dissatisfaction of users [6].

Ramly [7] reports that design plays a major role in determining the conditions of a building after completion, mainly in terms of managing defects and maintenance. Also, [8] explained the vital role of design in the early stage of project management. Further [8] stated that functional design can promote skill, economy, conveniences, and comforts while a non-functional design can impede activities of all types of detracting from quality of care, and raise the cost to intolerable levels. This is further reiterated by [9] who observed that most

professionals ignore the aspect of maintenance during design, and when such design is accompanied by poor construction, we obtain poor buildings requiring constant maintenance during their life cycle.

The effect of faulty building design and construction has become one of the major issues in maintaining public buildings in Delta state. Because, most of the professionals involve in the design and construct the facilities most times don't bother whether the facilities they design and construct will function optimally, they just want to complete the job and move to next job while the consequences is left for the client to address [10]. If a building was not properly designed and constructed the client/building owner most time spend large amount of money in the course of maintaining the property. Consideration of maintenance issues during design, construction and post-occupancy stage ensures that maintenance requirements are minimised in the future. This means that the building component can be easily maintained at less expense, in less time and fewer efforts. Unfortunately, many times building designers often neglect considering a very important aspect which is the possibility to perform future maintenance needs. It is therefore imperative that the building design and its subsequent construction method be guided right from the inception. By getting it right the first-time during design and construction, this will prevent errors that might occur and subsequently ease maintenance work and of course, reduce the maintenance cost of the building in the long run. With regards to the above, this research is being conducted to establish the factors hindering effective maintenance of public buildings in Delta state to establish common defects in public buildings and significant factors affecting effective maintenance in the study area.

## 2. LITERATURE REVIEW

### 2.1 Building Defects

Building problems can be classified as defects or failure. The term 'defect' has been defined differently by researchers. It means the shortcomings in the design and construction practices for some of them, while to others; it implies the inadequacies that arise from normal wear and tear. Some of these definitions are thus: [11], opined that; a defect can be defined as a shortcoming in the performance of a building element. A defect will occur after the building has been occupied. Watt [12] view building defects as "failing or shortcoming in the function, performance, statutory or user requirement of a building, and might manifest itself within structure, fabric, services or other facilities of the affected building". A defect is a shortfall in performance occurring at any time in the life of the product, element or building in which it occurs [13]. Further [14] indicates that design and construction defects are those that are caused due to wrong of methods construction, poor materials and bad labour practices.

According to the Insurance and Risk Management Institute, a building defect is a deficiency in the design or construction of a building or structure resulting from a failure to design or construct in a reasonably workmanlike manner and/or in accordance with a buyer's reasonable expectation.

Table 1 show that there has been a recent increase in research on defects in the house building sector and presented building defect definitions from various authors as compiled by [15].

Generally, building defect is defined as a defect or deficiency in the design, the construction, and/or in the materials or systems used on a project that may not be readily observable and results in a building, structure or component that is not suitable for the purpose intended [16]. It includes both design and construction defects that result in financial harm (either property damage or personal injury) to the owner or to a third party [17].

### 2.2 Common Defects in Building

In general, there are several building defects which usually occur to building parts such as roofs, walls, floors, ceiling, toilets, doors and windows [18]. Building defects that are commonly found include; wall crack, peeling

paint, dampness, timber decay, fungi and small plant attack, sagging or deformation, erosion of mortar joint, defective plaster rendering, insect or termite attack, roof defect, and also unstable foundation and services [19].

### 2.3 Factors Responsible for Design and Construction Defects Affecting Building Maintenance

The performance of buildings depends to a great extent on the quality of its design and construction decisions. Okuntade [10] stated that inadequacies in the performance of buildings emanate from deficiencies in design and construction which reflect on the level of maintenance during operation. Adejimi [9] noted that the extent to which the various factors contribute to maintenance problems in governmental office buildings in Nigeria are; inadequate architectural design 6%, inadequate structural design 7%, inadequate electrical design 9%, inadequate mechanical design 11%, poor construction 12%, use of poor quality components and materials 14%, natural deterioration due to age and environment 18%, misuse by occupants 18% and other factors 5%. Assaf [20] categorized design and construction faults contributing to maintenance into (11) groups viz; defects in civil design, defects in architectural design, defects due to consulting firm's administration, defects due to construction drawings, defects due to construction inspection and supervision, defects due to civil construction, defects due to contractual administration, defects due to construction materials, defects due to construction equipment, defects due to specifications and design defects in maintenance practicability and adequacy.

Generally, the performance and physical characteristics of building as well as its durability of withstanding environmental conditions and social interfaces are influenced by various factors which are responsible for design and construction deficiency.

#### 2.3.1 Factors responsible for design defects

According to [21] the design related problems are "Problems that are occurring during the post-occupancy stage but originated during the design process. There are various types of design-related problems that can be found during the post-occupancy stage. They include Poor material selection, Access, Lack of detail, Poor communication, Poor Ventilation design, Poor structural design, Poor Geotechnical design, Ignoring environmental issue, Lack of standardization etc.

**Table 1. Definition of defects in various context**

Context of definition	Definition	Literature sources
Wider Construction environment	Wider construction at any time in the life of the environment	BRE (1990)
Wider Construction	Non-fulfilment of intended usage environment requirements	Josephson and Hammarlund (1999)
House building Environment	Failing or shortcoming in function, performance, statutory or user requirements of a building that manifests itself within the structure, fabric services and other facilities of the building.	Ilozor, (2004)
House building Environment	A component has a shortcoming and no longer fulfils its intended function	Georgiou (2010)
House building Environment	A final product that does not meet the required quality	Kim,(2007)
House building Environment	Breach of any mandatory requirement by builder or anyone employed by or acting for the Builder.	NHBC (2011)
House building Environment	Something that is unfinished, or an imperfection that is inadequate or causes failure.	Beattie (2011)

Source: [15]

**2.3.2 Factors responsible for construction defects**

Construction defect are another source of the high cost of maintenance which happens during the construction stage and because of construction performance or material used. Faulty construction is one of the most common causes of early deterioration. A construction defect may include any problem that reduces the value of a home, condominium, or building, it can be the result of design error by the architect, the contractor’s flaw, defective materials, improper use or installation of materials, lack of adherence to the blueprint by the contractor [10]. Okuntade [10], streamlined the identified defects to; inaccurate measurement, Movement or changes in the position of formwork, the use of damaged formwork, Painting on unsuitable surface, Insufficient reinforcement bars concrete cover, Improper construction of joints, Early or premature formwork removal, Poor soil compaction, Inadequate provision for waterproofing and drainage, Inadequate curing procedures, Not complying with specification, Using block work as formwork, Uneven mixture of aggregates, Using unwashed aggregate for construction, Insufficient mortar for block work, Improper soil analysis, Defective material.

**3. METHODOLOGY**

The research used survey design (a questionnaire survey) to access the design and construction deficiencies on the maintenance of

public buildings in the study area. Questionnaire was administered to the professionals in the construction industry that shared common characteristics and know building design, building construction and maintenance management.

The research population include; Architects, Builders, and structural engineers of the facilities/maintenance department of Petroleum Training Institute (P.T.I), Uwvie LGA and Delta State University (DELSU), Ethiope West LGA, in Delta state, and Professionals who engage in design and construction of buildings in the two institutions. The population of these professionals were obtained from the records available at the town planning office and the procurement and maintenance department of the two selected institution. The preliminary survey of the study as shown in Table 2 revealed a total of about 120 population which includes vast number of Builders, Architects and Civil Engineers.

**Table 2. Population of the study**

	PTI	DELSU	Total
Architects	16	23	<b>39</b>
Builders	19	30	<b>49</b>
Civil engineers	14	18	<b>32</b>
<b>Total</b>	<b>49</b>	<b>71</b>	<b>120</b>

Source: Field Survey, 2018

To determine the sample size of the distribution, Taro Yamane’s formula was employed, which is given as:

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

where;

n is the sample size,  
 N is the population size = 120  
 E is the confidence level, the research would assume a 95% confidence level, thus, e =0.05

$$n = 120/1 + 120(0.05)^2 \tag{2}$$

$$n = 92.$$

The sample size of 92 was adopted for the study.

A total of 92 questionnaires were administered, 80 were correctly filled, returned and analysed. This represents 87% of the number distributed. The rest of the 12 questionnaires which represent 13% were either not properly completed, returned uncompleted or not returned. The returned questionnaires formed the basis for the analysis.

The perception of the professionals about design and construction deficiencies on the maintenance of public building in Delta State was collected. The respondents were asked to respond to each question based on four points Likert scale where 4- Very Significant, 3-Significant, 2-Somewhat significant and 1-Less significant. The data collected was presented in form of tables and descriptive statistics were employed to run the analysis of the demographic profile of the respondent. Relative Importance Index (RII) was used to rank the identified variables with the aid of Excel package.

The RII is obtained for each variable using the formula below;

$$RII = \sum \frac{W}{A+N} \tag{3}$$

where

W= Weight giving to each constant by the respondents relating to (1 to 4)  
 A= Highest response integral i.e 4  
 N= Total number of respondents.

#### 4. RESULTS AND DISCUSSION

The results of the data analysis listed in Table 2 shows the ranking of the defects affecting building maintenance. The results indicate. that the four topmost defects affecting the maintenance in the study area are; rising dampness problem, cracks on walls, unstable foundation and defective plastering and rendering with RIIs of 0.8656, 0.8469, 0.8094 and 0.7875 respectively. The result also shows fungi and small plant attack, insects (termite) attack and timber decay with RIIs of 0.6313, 0.6656 and 0.7031 respectively as the least significant defects affecting building maintenance in the study.

Based on the findings in Table, the researchers carried a physical survey of the public buildings in the study area. The result of the survey is presented in the attached plate.

The finding Plates 1,2,3 further show that out of the nine design and construction defects identified, the significant defects affecting building maintenance in the study area rising dampness problem, cracks on walls, unstable foundation, defective plastering and rendering which supports the findings in Table 4.

Table 3 shows the ranking of factors affecting building maintenance with their respective RII. The most significant factor affecting building maintenance is Poor supervision with RII of 0.8875 followed by defective construction

**Table 3. Building defects affecting building maintenance**

S/No	Design's factors	Total respondents=80							Rank
		1	2	3	4	N	W	RII	
1	Cracks on walls	5	7	20	48	80	271	0.8469	2 <sup>nd</sup>
2	Peeling of paint	7	12	24	37	80	251	0.7844	5 <sup>th</sup>
3	Rising dampness problem	3	8	18	51	80	277	0.8656	1 <sup>st</sup>
4	Defective plastering and rendering	9	9	23	39	80	252	0.7875	4 <sup>th</sup>
5	Roof defects	14	15	21	30	80	227	0.7094	6 <sup>th</sup>
6	Unstable foundation	5	12	22	41	80	259	0.8094	3 <sup>rd</sup>
7	Timber decay	16	12	23	29	80	225	0.7031	7 <sup>th</sup>
8	Insects (termite) attack	18	19	15	28	80	213	0.6656	8 <sup>th</sup>
9	Fungi and small plant attack	22	15	22	21	80	202	0.6313	9 <sup>th</sup>

Source: Field Survey, 2018



**Plate 1. Cracks as a result of the settlement of the foundation**



**Plate 2. Dampness of walls**



**Plate 3. Defective plastering and rendering**

material, incompetent workforce and non-conformance with specification with RIIs of 0.8719, 0.8531 and 0.8375 respectively. The findings in Table 3 further revealed a total of twenty-seven (27) factors that are responsible for defects in building and of course affecting building maintenance in the study area. Among the twenty-seven factors the findings identified the following factors base on the ranking are the top most significant factors affecting building

maintenance: Poor supervision, defective construction materials, incompetent workforce, non-conformance with specifications, Ignoring buildability and maintainability during design and incomplete detail drawing. The least significant factors include: Improperness or lack of required equipment for construction, not considering the effects of climate on materials, poor soil condition and lack of design standards.

**Table 4. Factors affecting building maintenance**

S/N	Factors	Specification value							Rank
		1	2	3	4	N	W	RII	
1	Incomplete detail drawing	6	7	24	43	80	264	0.8250	6 <sup>th</sup>
2	Ignoring changing environmental weather condition	8	15	25	32	80	241	0.7531	15 <sup>th</sup>
3	Ignoring buildability and maintainability in design	6	8	20	46	80	266	0.8313	5 <sup>th</sup>
4	Deviation from standard specifications	8	12	18	42	80	254	0.7938	10 <sup>th</sup>
5	Lack of design standards	14	15	24	27	80	224	0.7000	20 <sup>th</sup>
6	Suitability of design for the existing technology	10	18	25	27	80	229	0.7156	18 <sup>th</sup>
7	Poor structural design	8	8	21	43	80	259	0.8094	8 <sup>th</sup>
8	Ignoring the impact of load on the building stability	13	8	26	33	80	239	0.7469	17 <sup>th</sup>
9	Wrong detailing in production information	8	8	24	40	80	256	0.8000	9 <sup>th</sup>
10	Overlooking the changes in soil condition	10	11	25	34	80	243	0.7594	14 <sup>th</sup>
11	Not considering the effects of climate on materials	14	21	21	24	80	215	0.6719	22 <sup>nd</sup>
12	Poor supervision	2	4	22	52	80	284	0.8875	1 <sup>st</sup>
13	Communication gap between contractors and design professionals	6	17	22	35	80	246	0.7688	12 <sup>th</sup>
14	Defective construction materials	2	7	21	50	80	279	0.8719	2 <sup>nd</sup>
15	Poor quality control on site	7	7	25	41	80	260	0.8125	7 <sup>th</sup>
16	Using improper construction method	3	18	26	33	80	249	0.7781	11 <sup>th</sup>
17	Poor soil conditions	11	19	26	24	80	223	0.6969	21 <sup>st</sup>
18	Use of new and untested materials	7	14	30	29	80	241	0.7531	15 <sup>th</sup>
19	Inadequate curing procedures	10	19	24	27	80	228	0.7125	18 <sup>th</sup>
20	Incompetent workforce	2	9	23	46	80	273	0.8531	3 <sup>rd</sup>
21	Non-conformance with specifications	4	7	26	43	80	268	0.8375	4 <sup>th</sup>
22	Poor construction procedures	6	17	25	32	80	243	0.7594	13 <sup>th</sup>
23	Damaged or improper formwork	5	17	17	41	80	254	0.7938	10 <sup>th</sup>
24	Poor soil compaction	6	26	23	25	80	227	0.7094	19 <sup>th</sup>
25	Inaccurate measurement	5	21	25	29	80	238	0.7438	16 <sup>th</sup>
26	Inadequate concrete vibration	8	21	23	28	80	231	0.7219	17 <sup>th</sup>
27	Improperness or lack of required equipment for construction	12	25	23	20	80	211	0.6594	23 <sup>rd</sup>

Source: Field Survey, 2018

## 5. CONCLUSION AND RECOMMENDATIONS

From the above findings, the study concludes that to ensure defects free design and construction processes and in producing a standard quality public building the professionals involve should focus on teamwork rather than personal competitiveness. The search for key factors that influence the maintenance of public buildings is fundamental in ensuring maintainability and sustainability. It was observed that numerous building maintenance problems are partly or entirely as a result of readily identifiable faults in design and construction which could have been foreseen and hence prevented.

From the study the following recommendations were made:

- I. Professionals should pay more attention to the possibility of defects occurrences such as rising dampness, cracks on walls and unstable foundation when planning construction projects for public buildings in Delta state.
- II. Factors affecting design and construction defects should be critical consideration when planning construction activities to reduce the occurrence of defects which may subsequently create excessive maintenance works.
- III. The required professionals should be brought in at each stage of the construction process as this will have great impacts on the building performance and thus reduce the possible effects of building defects.
- IV. The client should engaged the service of qualified designers and strict monitory and supervision during construction should be ensured when carrying out a building projects.
- V. Materials used for construction works should be according to specifications, duly certified and rightly procured. Contractors should be made to strictly comply with the materials and construction specifications.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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