THE EFFECTS OF FAULTY DESIGN AND CONSTRUCTION ON BUILDING MAINTENANCE IN LAGOS STATE, NIGERIA

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Abstract
Building defects arising from design and construction are recognized to have ample effects on the level of maintenance of buildings which often lead to increased costs causing dissatisfaction. Minimizing these defects will reduce building maintenance problems and increase the lifespan of structures. This study examined the effects of faulty design and construction on building maintenance in Nigeria. The objectives are to identify and investigate building defects due to design and construction errors and to determine the effects of faulty design and construction on building maintenance. Conclusively, recommendations were made on ways of improving design and construction work on building maintenance. A field survey involving a sample size of 55 respondents, mainly the professionals in the built environment managing housing projects awarded to different contractors using structured questionnaires was carried out. The research concludes that there is a great potential for improvement in the production of quality designs and construction processes in the construction industry. Designs should be drafted with consideration for changes in soil condition and properly reviewed before approval for construction. There should be a standard practice of working with complete detailed drawing so that defects due to specification will be eliminated. Construction workers should provide adequate soil compaction, curing procedures, concrete vibration; even mixture of aggregates and use suitable materials appropriate to climatic conditions. Also, they should avoid differential settlement, overloading, cracking in plastering, holes in plaster walls, plaster falling off from ceiling, loss of bond between coats and importantly, necessary maintenance should be carried out.

Keywords
Faulty Design and Construction, Building Maintenance, Lagos

Introduction

Maintenance, according to Smith (2003) means to keep in its existing state, preserve, continue in good operating condition and protect. Building maintenance is a major activity in most countries and defects arising from design and construction are recognized to have substantial consequences on the level of maintenance during occupancy of buildings. These often translate to high costs, causing dissatisfaction to users.

Building maintenance is an important programme for the sustainability of infrastructural development. It plays an important role among other activities in the building operations (Zulkarnain 2011). Maintenance according to British Standard 3811 (1984) is the combination of all technical and associated actions intended to retain an item or restore it to a state in which it can perform its required function. Work carried out in anticipation of failure is referred to as preventive maintenance and those carried out for restoring after failure is referred to as

corrective maintenance. It is a known fact that the primary objective of building maintenance is to preserve buildings in their initial functional, structural and aesthetic states (Adejimi, 2005). This is to ensure that such facility continue to remain in such state and retain their investment value over a long period of existence. Buildings are generally required to provide safe and conducive environment for the performance of various human activities. Odediran *et al.* (2012) stated that the ability of a building to provide the required environment for a particular activity is a measure of its functionality. Therefore, as the components of a building begin to deteriorate, it becomes necessary to take measures to ensure that the desired characteristics of that facility which provides safety and convenience are retained.

Maintenance programme in Nigeria according to Ahmed (2000) and Odediran *et al.* (2012) has not received much attention in the past as the emphasis is on the development of new properties. This is also in line with the statement of Kunya *et al.* (2007) who observed that there is apparent lack of maintenance culture in Nigeria, and that emphasis is placed on the construction of new buildings for public sector and neglecting the aspect of maintenance which commences immediately the builder leaves the site.

Nigeria is a developing country that has a very fast development process in almost every sector especially building construction. Public and private sectors have initiated the need for large and complex construction projects. In order to meet the high demand of both parties in a short time, it is expected that many errors and defects have occurred during the design and construction stages which will result later in high maintenance costs. A popular quote attributed to Vonnegut (1922 – 2007) states that "Another flaw in the human character is that everybody wants to build but nobody wants to do maintenance." In the context of building construction industry, it could be literally taken from this quotation that maintenance aspect is rarely considered from planning and design to the construction of a new building. Maintenance experts are rarely included in these pre-occupational stages to provide their expertise in order to instill maintenance efficient criteria into the new building.

Maintenance costs of a building during their functional lifetime could easily surpass the initial outlay of a new building. Therefore, it is important to consider maintenance aspects at the very onset of the life cycle of a building because decisions made at planning, design and construction stages have a large effect on the maintenance costs and works incurred later in the life cycle of a building. Aged building does not necessarily have to be associated with high maintenance cost as a new building with numerous defects from faulty design and construction could easily equal or surpass the maintenance cost of an aged building.

Although it is hardly feasible to produce maintenance-free buildings, much can be done at the design stage to reduce the amount of subsequent maintenance works (Ramamarthy, 1990). This is why Seeley (1987) takes this notion further. He stated that for developing countries (including Nigeria) where there is deep-rooted ignorance of the importance of maintenance and where the construction industry may not be capable of meeting the increased demand arising from maintenance, the most effective maintenance strategy should be one that minimizes the incidence of maintenance works through appropriate design. The reality, however, is that traditionally construction projects are planned, designed, built and delivered to the owner or user with very little attention given to maintenance over the lifespan of the facility (El-Haram & Horner, 2002). Maintainability is a measure of the ease of maintaining a building or its elements and components, which depends not only on the design and the technical aspects but also on the availability of the building or components/element when required for maintenance. The nature of

some building designs hinders their maintainability. This may result from inaccessibility of some elements and components for maintenance works, inadequacy of available technological know-how to remedy defects, or non-availability of replacement parts and components as in the case of many imported lifts and air-conditioning systems used in Nigeria today (Oladapo, 2004).

Design and maintenance are two core activities in the building cycle which directly contribute to the quality and performance of construction works. Unfortunately, however, there is deep-rooted separation of design and maintenance which (Amairilla et al, 2002) puts bluntly this way: "In the field of architecture, we are primarily … to create new objects, relegating maintenance and preventive actions to a secondary and almost shameful place." The fact that design and maintenance are undertaken by professionals, operated through conflicting criteria and objectives, are often counter-productive leading to unacceptable quality of building performance (Briffett, 1990). In reality, buildings usually differ from what the designers intend. The extent of variations depends on the technical and managerial competence of the contractor. Some construction site problems that accelerate building decay have been identified as defective materials and over-emphasis on first costs, inadequate soil compaction and incorrect setting out resulting in excessive soil settlement and building movement. Poor site practices and supervision, lack of training and skill on part of site operatives, lack of motivation and care by site operatives and defective documentation.

In general, there have been several building defects that are commonly found such as erosion of mortar joints, peeling paint, defective plaster renderings, cracking of walls, defective rainwater, roof defects, unstable foundations and tiles settlements Fathi (2015). In like manner, there are a number of challenges towards achieving sustainable management like inadequate finance, shortage of fund and bad management. Anyway, most design and construction defects that affect maintenance cost are avoidable if sufficient care is being exercised during design and construction phase (Bassam, 2015). These defects have large implication on maintenance costs and works which are incurred later in the life of a building. Maintenance personnel should be engaged to inspect the works of designers during design phase while contractors should be engaged in construction phase to ensure that avoidable defects affecting maintenance are not built into the proposed building. According to Bassam (2015), a building with few or no defects arising from design and construction will not burden the building maintenance's staff, budgets and works. In order to achieve that, a study needs to be done to identify severe design and construction defects/errors affecting regarding to the effects of faulty design and construction on maintenance of building. These therefore, maintenance cost of buildings, so that future projects will be given sufficient care on matters present the need for studying the various factors affecting building maintenance with the view to proffering relevant solutions.

Logically, the defects arising from design and construction are recognized to have substantial consequences on the level of maintenance during occupancy of buildings which often translate to more expenditure on building maintenance process causing dissatisfaction to users. Therefore, minimizing these defects will reduce maintenance cost and increase the lifespan of structures. Very significant number of buildings in Nigeria suffer from numerous defects that reduce their lifespan. These defects are clear and common, and they come about as a result of poor design and construction. This study attempts to investigate through a field survey the significance of design and construction defects on maintenance of buildings in Lagos State, Nigeria.

Statement of Problem

The satisfaction derived from buildings in fulfilling the function and aesthetics properties is somehow missing in most buildings in Nigeria. This could be attributed to the fact that most of these buildings have developed various forms of defects through design deficiency, faulty construction or lack of adequate maintenance. The design problems have occurred through wrong specifications or difficulty in understanding by constructors or designers forgetting about maintenance of such facilities in the future date. Also, different types of building materials used mainly for maintenance works are not fitting with existing materials (Baiden and Tuuli, 2004). Most public buildings in Nigeria are in dilapidated conditions of structural and aesthetic disrepair and if corrective measures are not embraced carefully, it could lead to failure of structural component. Although, it is expected that many faults/errors will happen, especially during design and construction phase; most of the defects are avoidable if maintenance aspects are being considered during design and construction stage of the buildings. As a result of thorough observation, it was discovered that majority of the new construction were being built up with defects which later result into huge expenses on maintenance.

Aim and Objectives of Study

The aim of this research is to investigate the effects of faulty design and construction on building maintenance. To achieve the aim, the specific objectives are to:

- Identify building defects due to design errors that are affecting building maintenance
- Investigate building defects due to construction errors that are affecting building maintenance
- Determine the effects of faulty design on building maintenance
- Determine the effects of faulty construction on building maintenance
- Recommend ways of improving design and construction work on building maintenance

Research Questions

The study answered the following research questions:

- What are the design phase defects in building affecting maintenance?
- What are the construction phase defects in building affecting maintenance?
- How would faulty design affect maintenance?
- How would faulty construction affect maintenance?
- What are the possible suggestions that can solve future maintenance problems?

Scope of Study

This research included the following limitations:

(a) This study is limited to building design and construction defects affecting maintenance. Electrical and Mechanical defects are excluded from the study. This study focused on the buildings that mainly suffer from deficiencies due to poor design and construction practices.

(b) There is a lack of similar previous studies implemented in Nigeria

(c) The study is restricted to Nigeria.

(d) Building maintenance will be considered in the field survey. However, the investigation would be conducted on buildings in Nigeria, but other buildings of similar design and construction elsewhere can benefit from the findings of this research.

Significance of the Study

Most design and construction defects that affect maintenance are avoidable if sufficient care is exercised during the project life cycle. In order to identify and assess the effect of faulty design and construction on building maintenance, the various factors which directly influence the maintenance of building with respect to the stakeholders (Architect, planners, engineers, contractors, facility managers and all other actors in the construction industry) and how it benefits them have been critically considered. Their responsibilities are closely related such that each one relies on the other to achieve results and these responsibilities should not only be confined on the architects, builders and civil engineers but also from the client to the contractors, consultant and the manufacturers of building materials. All must work together to avoid the issue of faulty design and construction causing unnecessary expenditure on building maintenance.

Methodology

The study was executed using two methods such as literature review and questionnaire. One Hundred buildings were surveyed to detail various defects. Questionnaire was developed to sample professional opinions on the probable causes of identified defects and to profer remedies to same. Eighty (80) questionnaires were distributed, fifty five (55) were collected back for analysis. The Statistical Package for Social Sciences (SPSS) was used for the analysis. Percentage, mean, and relative significance index (RSI) were determined. The relative significance index ranking (RSI) was used for ranking the factors studied. These methods had been used in construction research by authors like Elhag and Boussabaine (1999), Faniran (1999), Idrus and Newman (2002), Kangwa and Olubodun (2003), Oladapo (2006), among others.

The likert scale has a rating interval of 5 to 1 which is a range of digits developed for application in social sciences and management researches for qualitative variables and was used for this study. “Extremely Important” (EI) were scored 5, “Very Important” (VI) were scored 4, “Somewhat Important” (SI) were scored 3, “Not Very Important (NVI) were scored 2 and “Not Important (NI) were scored 1. Bakhary (2005) gave an equation that could be useful for determining Relative Significance Index (RSI) in prevalence data as

$$RSI=\sum \mu/AN \qquad \ldots(\text{eqn.1})$$

Where μ is the weighting given to each factor by correspondence;

A is the highest weight (which is 5 in this case)

N is the total number of respondents

Hence, RSI for this type of study that where 5-point scale was used can be calculated using the equation:

$$RSI = (5a + 4b + 3c + 2d + 1e)/įN \quad (0\leq index\leq 1) \quad \ldots (\text{eqn. } 2)$$

Where: a = number of respondents “extremely important and perfectly known”

b = number of respondents “very important and partially known”

c = number of respondents “somewhat important and known”

d = number of respondents “not very important and partially unknown”

e = number of respondents “not important and perfectly unknown”

N = Sample size = 55

Į = number of response categories = 5

Data Presentation and Analysis

The data were presented with tables showing survey results and the discussion of the questionnaire's sections by analysing the data collected from the various categories of respondents. The analysis tools included both descriptive and inferential statistics.

Table 1. Nature of Projects Executed

Project Executed	Frequency	Percentage
Client	14	25.5
Contractor	19	34.5
Consultant	22	40.0
Total	**55**	**100**

Table 1 shows the result of the analysis from the questionnaire; it is observed that among the 55 responses obtained from the respondents for the study, 25.5 % of them are grouped as clients organization, 34.5% are contractors organization, while 40.0% of them are consultants.

Table 2 Respondents' Position in the Organization/Company

Position in Organization	Frequency	Percentage
Director	6	10.9
Contract Manager	15	27.3
Site Manager	19	34.5
Engineer/Designer	5	9.1
Supervisor	10	18.2
Others	0	0
Total	**55**	**100**

Table 2 showed 55 respondents that filled this section in the questionnaire and the result indicated that 10.9% of the respondents were Directors, 27.3% were Contract Managers, 34.5% were Site Managers, Engineers/ Designers were 9.1% and Supervisors were 18.2%.

Table 3. Gender of Respondents

Gender	Frequency	Percentage
Male	35	63.6
Female	11	20.0
Gender Sum	46	83.6
Missing	9	16.4
Total	**55**	**100**

From Table 3, there were 55 respondents that filled this section in the questionnaire and the result showed that 35 were males with a total percentage of 63.6%, 11 were females with a total percentage of 20%. There were 9 respondents with a total percentage of 16.4% who did not tick or identify their gender with any reason.

Table 4. Age Category of Respondents

Age Category	Frequency	Percentage
20 – 30	2	3.6
31 – 40	21	38.2
41 – 50	28	50.9
51 and above	4	7.3
Total	**55**	**100**

From Table 4, there were 55 respondents that filled this section and the result showed that more than half of the respondents were between the ages of 41 - 50 years with 50.9%, followed by 31 – 40 with 38.2%. The age category of 51years and above has 7.3% and then lastly 20 – 30 has 3.6% of the total respondents.

Table 5. Marital Status of Respondents

Marital Status	Frequency	Percentage
Single	13	23.6
Married	42	76.4
Total	**55**	**100**

From Table 5, there were 55 respondents that filled this section and the result showed that more than half of the respondents were married with 76.4% and respondents who were single are 23.6%.

Table 6. Professional Background of Respondents

Professional Background	Frequency	Percentage
Architecture	16	29.1
Building	11	20.0
Civil Engineering	14	25.5
Quantity Surveying	5	9.1
Engineering Services	8	14.5
Others	1	1.8
Total	**55**	**100**

Table 6 shows that 29.1% of the respondents are from the Architectural field, 20% are from Building, 25.5% are from Civil Engineering, 9.1% of the respondents are Quantity Surveyors, 14.5% are from the Engineering Services whilst 1.8% was from others (Environmental Services).

Table 7. Respondents' Professional Bodies

Professional Bodies	Frequency	Percentage
NIA	17	30.9
NIOB	4	7.3
NIQS	5	9.1
NSE	19	34.5
Unregistered	10	18.2
Total	**55**	**100**

Table 7 shows that only 17 out of the 55 respondents are registered with the Nigerian Institute of Architects (NIA), 4 respondents are registered with the Nigerian Institute of Builders (NIOB), 5 respondents are registered with the Nigerian Institute of Quantity Surveyors (NIQS), 19 respondents are registered with the Nigerian Society of Engineers (NSE) and there were 10 respondents who did not indicate their registration with the respective professional bodies.

Table 8. Respondents' Educational Qualifications

Educational Qualification	Frequency	Percentage
OND	1	1.8
HND	18	32.7
Bachelors	16	29.1
Masters	20	36.4
Total	**55**	**100**

Table 8 shows that 36.4% of the respondents are Masters' degree holders, 29.1% of the respondents are Bachelors' degree holders, 32.7% of the responders are HND degree holders and only 1.8% of the respondents acquired OND.

Table 9. Years of Experience of Respondents

Years of Experience	Frequency	Percentage
1 – 5	6	10.9
6 – 10	14	25.5
11 – 15	14	25.5
16 – 20	15	27.3
Above 20 years	6	10.9
Total	**55**	**100**

Table 9 shows that 10.9% of the respondents have 1-5 years of experience, 225.5% of the respondents have 6 -10 years of experience, 25.5% of the responders also have 11 - 15 years of experience, 27.3% of the respondents have 16 – 20 years of experience and again, above 20 years of experience were 10.9%.

Factors leading to Building Defects affecting Building Maintenance

This part shows the results of the respondents regarding 5 groups of factors (total 87 factors) used as follows:

(f) Factors related to building defects in design and construction affecting building maintenance (Section B)
(g) Factors related to causes of building defects in design affecting building maintenance (Section C)
(h) Factors related to causes of building defects in construction affecting building maintenance (Section D)
(i) Factors related to effects of faulty design and construction on building maintenance (Section E)
(j) Factors related to how design and construction work on building maintenance can be improved (Section F)

Table 10 Defects in Design and Construction Phase affecting Building Maintenance

Defects in Design &Construction Phase	Mean	Rank
Sagging Roof	4.44	1
Rising Dampness	4.02	2
Timber decay	4.00	3
Unstable Foundation	4.00	4
Erosion of mortar joints	3.85	5
Services leaks	3.85	6
Peeling Paints	3.84	7
Insect or Termite Attacks	3.83	8
Water penetration due to damages	3.82	9
Fungi and small Plants attacks	3.64	10
Leaky Roof	3.58	11
Surface Cracking	3.58	12
Cracking due to reinforcement corrosion	3.38	13
Support cracking.	3.29	14
Line crack at the center of panel	3.26	15
Cement Oozing	3.25	16
Tile spots and stains	3.13	17
Vertical crack away from corners	3.09	18
Popping Tiles	2.93	19
Crack between bay window corners	2.93	20

Table 10 shows the defects in design and construction affecting building maintenance.

Majority of the respondents agreed that sagging roof, rising dampness, timber decay and unstable foundation, with mean values of 4.44, 4.02, 4.00 and 4.00 respectively have very high defective effect on buildings which in turn affects building maintenance. The importance of studying building defects due to design and construction faults and it impact on building maintenance is generally recognized by the building maintenance conferences and seminars. These factors as affecting operative's productivity, they did not feel convinced enough to agree or strongly agree to these factors as affecting construction operative's productivity.

Table 11 Causes of Building Defects in Design affecting Building Maintenance

Causes of Building Defects in Design	Mean	Rank
Poor structural design and defects in construction drawing	4.20	1
Overlooking the changes in soil condition	4.07	2
Defects due to specification	4.05	3
Incomplete detail drawing	3.94	4
Inadequate concrete cover for reinforcement	3.91	5
Inadequate provision for movement due to thermal effects	3.91	6
Inaccurate dimensions on drawing	3.84	7
Wrong detailing of production material i.e Schedule	3.71	8
Improper design of construction joints between finishes	3.69	9
Ignoring buildability and maintainability in design	3.65	10
Architectural design inadequacies	3.58	11
Ignoring changing environmental weather conditions	3.44	12
Suitability of design for the existing technology	3.40	13
Inadequate assessment of exposure	3.24	14
Problems of consulting firms	3.13	15

Table 11 shows the causes of building defects in design affecting building maintenance. The importance of considering maintenance at the design stage of a building project is now generally recognized by the building maintenance conference and seminars. It is the design stage that the maintenance burden can be positively influenced for better or worse. A total of 15 design defects were selected to guage its level of impact on building maintenance. The factor of Poor structural design and defects in construction drawing was deemed the most severe design defect by respondents with a mean value of 4.20. it should be realized by building designers that items of design should be properly and adequately produced and renewed or have extensive works executed to them to maintain their efficiency during the life of the building. Therefore, facilities for access should be provided to permit the components to be exchanged or serviced without wasteful consequential works. Buildings are designed so that the maintenance workers with their equipment can reach any place in the building to perform maintenance works. Ignoring such a factor will increase the maintenance cost, effects and obstruct preventive maintenance.

The respondents also strongly agreed that the factors of overlooking the changes in soil condition with mean value of 4.07 and defects due to specification with mean value of 4.05 will severely affect building maintenance. The designer should always consider the soil condition in the design buildings.

The other factors with average mean values of 3.50 and above are incomplete detail drawing (3.94), inadequate concrete cover for reinforcement (3.91), inadequate provision for movement due to thermal effects (3.91), inaccurate dimensions on drawing (3.84), wrong detailing of production material i.e Schedule (3.71), improper design of construction joints between finishes (3.69), ignoring buildability and maintainability in design (3.65) and architectural design inadequacies (3.58). Respondents have shown through their response that these factors strongly affect maintenance and hence designers should always design the building with complete drawing details. Corrosion reaches the concrete reinforcement (steel bars) faster if the concrete cover on the steel bars is insufficient, which will result in corrosion of the steel bars and cracking of the concrete element.

Interestingly, the respondents feel that ignoring changing environmental weather conditions, suitability of design for the existing technology, inadequate assessment of exposure and problems of consulting firms are not strong factors affecting building maintenance.

Table 12 Causes of Building Defects in Construction affecting Building Maintenance

Causes of Building Defects in Construction	Mean	Rank
Differential settlement, Overloading	4.40	1
Cracking in plastering holes in plaster walls, plaster falling off from ceiling, loss of bond between coats	4.35	2
Failure to carry out necessary maintenance	4.15	3
Poor soil compaction, inadequate curing procedures, uneven mixture of aggregates, inadequate concrete vibration	4.15	4
Performance and potential deterioration of the materials, defective materials	4.11	5
Insufficient reinforcement bar concrete cover, improper construction of joints	4.05	6
Damaged formwork, insufficient mortar for block work, using block work as formwork, movement of formwork, premature formwork removal	4.05	7
Leakage of roof system, Inadequate provision for under proofing and drainage	4.04	8
Bad plumbing, water penetration through walls, rising damp and flooding	3.98	9
Poor workmanship in installation, improper installation	3.96	10
Action of load underestimated at the design and construction stage	3.91	11
Incorrect identification of the cause of defect	3.80	12
Movement due to moisture expansion	3.75	13
Environmental changes resulting in excessive defects	3.69	14
Designer lacks the knowledge of the physical properties, construction/fixing of building elements/components	3.65	15
Failure due to poor joint design, noncompliance with specification	3.58	16
Poor surface preparation, painting on unsuitable surface	3.51	17
Inappropriate choice and use of joint material	3.49	18
Movement due to thermal expansion	3.49	19
Inappropriate choice and use of joint material, inaccurate measurement	3.49	20

Table 12 shows the causes of building defects in construction affecting building maintenance. Another source of maintenance expenditure is construction defects which happen during the construction phase and because of construction performance or use of materials. Faulty construction is one of the most common causes of early deterioration. A total of 20 construction defects were selected to gauge its effects and impact on building maintenance. The factors of differential settlement, overloading and "cracking in plastering holes in plaster walls, plaster falling off from ceiling, loss of bond between coats" were deemed the most severe construction defects by respondents with average mean values of 4.40 and 3.35. According to the response from the respondents, factors such as "Failure to carry out necessary maintenance" and "poor soil compaction, inadequate curing procedures, uneven mixture of aggregates, inadequate concrete

vibration" with average mean of 4.15 were also chosen as one of the most common causes of defects due to construction in building maintenance.

With modern pressure for speed and economy in construction; there is a high tendency of such occurrences as performance and potential deterioration of the materials (4.11), defective materials, insufficient reinforcement bar concrete cover, improper construction of joints, damaged formwork, insufficient mortar for block work, using block work as formwork, movement of formwork, premature formwork removal, leakage of roof system, inadequate provision for under proofing and drainage with an average mean value of 4.05. Removal of formwork before the concrete attains sufficient strength often causes severe concrete cracks. Most contractors if not all would like to remove the formwork as soon as possible and some of them before the allowable time. Water leakage problems are resultant effects of shoddy water proofing works. Experience is key in this area of work because performed wrongly or inadequately especially at the joints would result in in water seepage through the roof, ceiling or block wall.

It is worth noting that the respondents feel that inaccurate measurement is not an important factor that affects building maintenance. Situations where the contractor under measures or over measures; inappropriate choice and use of joint material, movement due to thermal expansion are not considered to have sever effects on building maintenance.

Table 4.13 Effects of Faulty Design and Construction on Building Maintenance

Effects of Faulty Design and Construction	Mean	Rank
Increase in maintenance budget	4.24	1
Increase workforce	4.07	2
Increase in maintenance work	4.00	3
Increase in maintenance quality	3.93	4
Reduction in material strength due to attack on Portland cement by sulphate	3.85	5
Permanent compaction of materials	3.75	6
Overloading of the ground on which the building stands	3.73	7
Corrosion of Steel	3.67	8
Instability of the structure	3.60	9
Increase maintenance frequency	3.51	10
Displacement of building parts	3.44	11
Reduced durability of building element	3.42	12
Changes in size	3.29	13
Lower maintenance quality	3.24	14
Dirty wall ties	3.11	15
Redistribution of dirt on the surface of a building	2.96	16
Difficulties in maintenance planning	2.95	17
Maintenance works become obsolete	2.91	18
Transfer of water across the cavity to the inner leaf	2.82	19

Table 13 shows the effects of faulty design and construction on building maintenance. A total of 19 effects were identified for the respondents to gauge their degree of effects on building maintenance. The respondents indicated that increase in maintenance budget is the most important effect with an average mean value of 4.24. A building with numerous defects due to design and construction would inevitably necessitate a high maintenance budget. The respondents also strongly indicated that increase in maintenance workforce and works are the consequences of faulty design and construction of buildings. This can be attributed to severe and complex defects that require longer duration in the repair process and the financial implications that are required to perform building maintenance would increase in tandem with building defects as part of the cost for performing maintenance operation, buying materials and equipment.

Table 14 Suggested Remedies for Improving Design and Construction Work on Building Maintenance

Suggested Remedies	Mean	Rank
Qualified workforce	4.55	1
Good communication between design firm and Client	4.47	2
Undertaking work with adequately skilled Personnel	4.42	3
Adequate supervision	4.38	4
Not compromising quality in order to increase profit	4.35	5
Adequate drawing interpretation skills	4.33	6
Conformity with specification	4.18	7
Training of staff on new technology	4.11	8
Employment of legitimate workers	4.02	9
Improved worker's welfare, Health and Safety during project execution	4.00	10
Adherence to building regulations	3.95	11
Ability to create and work with maintenance manual	3.85	12
Timely completion of quality work	3.75	13

Table 14 shows the factors that can improve design and construction works on building maintenance. The results indicated by respondents show qualified workforce, good communication between design firms and client and undertaking work with adequately skilled personnel as the three most important factors that would improve design and construction works with average mean values of 4.55, 4.47 and 4.42 respectively. Respondents strongly believe that unqualified workforce in construction site will often produce defects that affect maintenance. With the influx of foreign workers in the construction industries, some contractors might be tempted to bring in or hire cheap unqualified workers to minimize cost. Quality of work is affected by the quality of supervision and workforce. Both parties should possess considerable or appropriate experience. For example, if the supervision is good but the implementation is poor because of poor workmanship, the maintenance defects will increase during the construction operation. Poor communication with the design firm and client is considered a strong factor by respondents with an average mean value of 4.47. The respondents feel that if communication is not effective during meetings and consultations the level of understanding will be inadequate. Hence site staff would result to using their experience in

performing the job. When this happens, it could cause a lot of maintenance defects if the experience is limited or not confirmed to be standard.

The respondents also strongly believe that adequate supervision with a mean value of 4.38 in construction site will often produce high quality job with less maintenance defects. In the same vein, not compromising quality for profit is a major factor to design and construction works that can improve maintainability of buildings. Respondents also believed strongly with their indications on the questionnaire that adequate interpretation skill, conformity with specification, training of staff on new technology, employment of legitimate staff, improved worker's welfare, and health and safety during project execution with average mean values of 4.33, 4.18, 4.11, 4.02, 4.00 will produce defects that affect building maintenance. Among the listed factors are the above mentioned which are viewed to strongly affect building maintenance. Efficiency and cost effectiveness of building designs and construction to a great degree translates to an output that requires less maintenance on buildings.

Other areas of concern that affect maintenance are adherence to building regulation, ability to create and work with maintenance manual and timely completion of quality work with average mean values of 3.95, 3.85, and 3.75 respectively. It is worth noting that the respondents feel that these factors are of lesser degree to the ones mentioned in the above paragraph. Situations where these factors are disregarded or approached with lesser concern would result in defects in buildings but to a lesser degree

Summary of Findings

Buildings exhibit defects due to design and construction faults and these have major effects on building maintenance. This is evidenced by the nature of responses received from the respondents. For all responses received the opinion of the respondents was that faulty design and construction impact building maintenance. It is therefore appropriate to note that design and construction should be carefully carried out in order to reduce defects that occur in building. Remedies were, thus, proposed in order to mitigate the challenges of building maintenance. Though there are factors indicated as causative factors for the occurrence of the observed defects, the research showed that most of the defects were preventable at the design and construction stages if qualified and competent workforce had been engaged early enough to handle the design and management of the building production processes. Adequate structural design and improved construction drawing at the design stage and even settlement and proper loading at the production stage will result in building a structure with very low frequency of future maintenance.

Conclusion and Recommendations

The maintenance of buildings requires attention at the highest level. This attention is of basic importance of which the objective must be to keep buildings to acceptable standard in order to make them functional and reliable. Execution of projects with qualified workforce, good communication between staff at different levels, undertaking work with adequately skilled personnel and adequate supervision as against the set-back of executing projects with few maintenance resources for work requirement, will optimize the quality of work achieved. Building maintenance can be effective and efficient if building processes that are involved in design and construction are executed with these qualities and factors properly considered as indicated by the respondents in the course of this study.

The knowledge of challenges posed from building maintenance in Nigeria over the years offered some guiding lessons for future policies. Based on the faults identified in the first objective, there are several measures that can be taken in order to overcome them. The following recommendations are made in view of the results of the study:

- The practice of design review should be encouraged before approval for construction
- Designs should be drafted with consideration for changes in soil condition
- A strict practice which eliminates defects due to specification should be embraced
- There should be a standard practice of working with complete detailed drawing

a) Avoid differential settlement, overloading, cracking in plastering, holes in plaster walls and plaster falling off from ceiling, and loss of bond between coats

b) Necessary maintenance should be carried out
Provide adequate soil compaction, curing procedures, concrete vibration; even mixture of aggregates and use suitable materials appropriate to climatic conditions.

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