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Design Inadequacies and the Maintenance of University Buildings in Ile-Ife, Nigeria

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Abstract

It is imperative that the maintenance possibilities of a building be considered at the design stage, this will enhance ease of maintenance of such buildings and prevent building failures resulting from design inadequacies. This study analyzed the design configurations of selected buildings in Obafemi Awolowo University, Ile-Ife; the maintenance problems traceable to design; and also determined the impact of design related problems in the maintenance of the buildings. This was with a view to providing information that could enhance the maintenance of future buildings in the study area. The study used primary data obtained from physical observations of the selected buildings and secondary data from existing maintenance records. There were thirteen (13) faculties with forty-four (44) buildings and eighteen (18) lecture theatres within the study area. Using stratification based on design configuration, twenty-seven (61%) faculty buildings and ten (56%) lecture theaters were selected as sample size for the study. Forty five questionnaires were administered on the staff of Maintenance Unit, building occupiers and the staff of Physical Planning and Development Unit (PPDU) of the university. Data collected were analyzed using frequency counts and percentages. The results of the study revealed that in-built access for maintenance operations was provided for only 31% of the total building facades. The problems encountered in the management of maintenance operations on the defective elements were traceable to factors such as environmental impacts (13%), structural stability (11.1%), functional failures (10.5%), and inaccessible defective portions (9.3%). Others were aesthetic considerations (9.3%), users' impacts (9.3%), choice of inappropriate construction materials (8%), and building shapes (6.8%). The identified physical impacts traceable to design inputs were moisture stain (2.92%), weeds on building elements (2.63%) cobweb stains (2.34%), broken concrete fins at stairwells (0.15%), plumbing defects (0.44%), blocked drains (0.15%), and undersized roof gutter (0.15%) among others. The study concluded that problems encountered in the management of the maintenance operations such as provision of as-built drawings; working space and safe access to defective portions; choice of correct construction materials and methods by certified personnel were not taken care of during the design stage. The study recommended that all building items, elements or components be designed and constructed for ease-of-maintenance to ensure better future performances.

Keywords: Building, Building Design, Building Reliability, Building Availability, Building Maintainability, Maintenance Problems

1. Introduction

Zulkarnain, Zawawi, Rahman, & Mustafa, (2011) described university buildings as edifices with walls, roofs and other structural elements which offered facilities for habitation, learning and research activities. Melvin (2006) opined that the design of these buildings included the summation of the professional contributions of Architects, Builders, Engineers and Maintenance Experts among others. These iconic structures are expected to be available, functional, reliable and maintainable throughout their service years (with minimum service cost) thereby providing conducive environment for habitation, learning and other research activities in the university. These unique buildings need to be designed within the bounds of code of professional practice (Egboramy, 1981). Deviation from strict adherence to the code of professional practice might lead to failure in the performance of such buildings during post-occupation stage if the design parameters are improperly set and/or neglected (Rozita, 2006). The link between building design and its maintenance during post occupation stage as noted by Ahmad, Chew, & Arditi (2006), is vital in order to ensure the delivery of building products with good shape/form and aesthetic appeal which will economically perform its designed functions throughout its useful life. The ability of buildings to economically perform these functions throughout their useful life may be hampered by a number of factors some of which can be traced to design flaws. Alabi, Okunola, Dabara and Odewande (2012) asserted that the life span and functionality of a building can be prolonged through property maintenance. The authors posited that maintenance provides a continuous protective care of the fabric, contents and settings of a building. However, according to Omotehinshe (2014) maintenance aspects are rarely considered in most design processes and maintenance experts are seldom invited into the design teams, this usually breeds maintenance problems which adversely affect the performance of such buildings. This assertion is in agreement with what was earlier pointed out by Ahmad et al. (2006). The authors observed that the non-consideration of maintenance experts in building production processes facilitated the development and growths of inbuilt defects and increased the difficulties in carrying out maintenance tasks especially on public buildings leading eventually to none or under performance of such facility utility.

Zulkarnain et al. (2011), while researching on factors that enhances building availability and reliability in Malaysia university sector, identified: service excellence, technology, teamwork, management, finance, staff development and asset utilization as critical success factors in building maintenance management practice in the university sector. Melvin (2006) opined that 85% of the causes of maintenance problems in high rise public buildings in South Africa were traceable to building design flaws. Mbamali's (1998) study on hand operated water pumps for rural areas in northern Nigeria identified design fault as major cause of failure of the programme while Ikpo (1990) identified design flaws as a factor responsible for deterioration phenomena of selected housing estates in South Western Nigeria.

The need for designs to conform to appropriate maintenance standard for particularly university buildings cannot be overemphasized. Preliminary survey carried out on the Obafemi Awolowo University (OAU) campus buildings showed that 80% of the first generation buildings are of flat concrete roofs. In the same vein information from the maintenance personnel of the university revealed that most of the design related maintenance problems in the campus centered around the building shape; roof type and slope; choice of construction materials and method among others. These design parameters, according to Ahmad et al., (2006) are what most building clients actually valued, rather than the proper functions and performances as needed by the users or occupiers.

Obafemi Awolowo University buildings and other facilities are maintained by the institution's authorized personnel (Omotehinshe, 2014). These facilities, according to Zulkarnain et al. (2011), are designed and constructed for students (who are the consumers) and staff (who are the operators) to ensure conducive and uninterrupted academic and research activities. Wordsworth (2001) observed that continuous functioning of these facilities is required to optimize service outputs from the facility users at an economic price. Proactive measures (with minimum down time and cost) should be directed to ensuring continuous functioning of these buildings throughout their service years.

This study seeks to find answers to the following questions: What are the design configurations for OAU buildings? What are the maintenance problems traceable to design in OAU buildings? What are the physical impacts of design inadequacies on the physique of OAU buildings? The aim of this study is therefore to examine the designs of faculty buildings and lecture theaters of Obafemi Awolowo University (OAU) Ile Ife, Nigeria with a view to providing information that would enhance the quality of future building design and performance of university buildings.

2. Literature Review

OAU Building Design Configurations

Egboramy (1981), the designer of most Faculty Buildings in OAU, reported that OAU buildings were designed and constructed on the concept of group architecture; a thought of creating architectural ensembles related to each other in shape, function and character; an idea originating from the physical site features such as topography, soil, vegetation and customs and character of the host community. These resulted in buildings that have been shaped and sited with the intention of creating an idyllic, stimulating and fulfilling working environment, (research and learning) for staff and students. However, Melvin (2006) observed that consideration for design related impact on the buildings was almost neglected and that difficulties in maintaining these buildings after completion also had never been taken into account, especially at the design stage. As a result, the cost of maintaining the buildings increases as its life-cycle performance declines and more parts of the buildings easily deteriorate. In line with the foregoing, Ikpo (2006) noted that flaw in design influences the performance and physical characteristics of the building and its ability to stand against environmental elements, noise and social interferences such as graffiti and vandalism. Some of these architectural interests are the Natural History Museum, Faculty Buildings and Civil Engineering Structures.

Maintenance Problems Traceable to Design

Lack of integration of construction processes by the professionals involved as noted by Adejimi (2005) is one major hindrance in making maintenance–free buildings achievable. Construction processes are still sequential in nature and are only linked at the terminal tail-end of each other rather than overlapping and benefitting from one another. Maintenance problems may be initiated during design, construction or occupation stage. The author identified some maintenance problems which could be mitigated during design stage to include: workable design resolutions, good structural strength, unambiguous materials specifications, availability of maintenance manual, adequate safety measures, involvement of skilled maintenance personnel, availability of plants & equipment, consideration for environmental factors, space for maintenance operations and good workmanship. Similarly, accessibility to defective portions, funding, client's requirements and user's attitudes to maintenance issues may be enhanced through design inputs. The following factors inhibiting maintenance operation in building are further considered.

Poor and Irregular Building Shapes:The common slogan in architecture is 'function follows form'. However, Wai-Kiong' (2006) study seems to have contradicted this view as most building designers preferred aesthetic rather than function in their choice of building shapes and appearances. Findings of Paul (1997), Chew (2002) and Sermin (2008), corroborated this view especially in the design of Public Buildings. Ikpo (2006) also observed that building shapes and profiles are part of maintainability factors which inhibit maintenance operations. Models developed by these authors in determining the ease of maintaining buildings consisted of complex mathematical expressions whose application during design stage as noted by Omotehinshe (2014) could be cumbersome or unattractive to the building designers. Barringer (2009) reported that projection of walls beyond the roof system (parapet), steep pitched roof, slanting structural members, and concrete flat roofs were constant sources of maintenance problems. According to the author, maintenance operations on square and rectangular shapes seem to be easier and more economical than those of circular and hexagonal shapes.

Roof Type and Slope: Roof stands on the tallest part of a building and serves as the cap protecting the structures below it. Defective roof could therefore be a source of maintenance problem to itself and the structures below it. Brian et al. (2014) noted that a truly sustainable roof would be designed to permit material separation or refurbishment and re-use or recycling at the end of its life. The authors, while working on 'Sustainable Roofs via Design for Heightened Maintainability and Future Disassembly in Canada', considered Economic Performance as a major factor sustaining roof structures. Factors such as: the ease of installing the roof structures, future maintenance and availability of materials/personnel/technology at local level during the service years of the roof were relegated to the background. Flat, gable, hipped and parapet roofs are common sites in Nigerian cityscape. Ikpo (1990) identified insufficiently sloped concrete flat roofs as sources of fluid leakages, ponding, cracks and biological growths. Hipped and parapet roofs have been generally identified to inhibit maintenance operations.

Choice of Materials or Finishes: Problems of poor material/finishes selection and usage which are mostly manifested in roof system may be traceable to their design complexity. Previous studies (e.g Ikpo, 2008) have shown that construction materials and finishes used in pitched, flat, mansard or parapet roofs are always prone to leaks. This was a reassertion of what Seeley (1987) noted earlier, the author posited that these leaks are basically the result of insufficient data and information that can support design inputs, inexperienced designer or a failure to obtain a good design team who can advise on the building features. furthermore, Ikpo (2008) also identified the use of inferior or poor materials as causative factors of significant problems such as malfunctioning openings, rapid degradation of materials over time due to climatic changes, short life spans, using rare materials that are difficult to substitute when the existing one damaged or lost due to wear and tear (replacement of quarters' asbestos roofing sheets) etc. However, the study did not specify whether the inadequacy in design configuration and workmanships were the consequential effect of the client's decisions. Experience has also shown that most contractors or operatives deviated from the properly specified materials through ignorance, but more often as an expedient to save time or money without realizing that the end product may not satisfy the required standard.

Construction Techniques to Suit Design: The choice of method and technique of building construction can be linked to its design through the needs to achieve the designer's intended form or characteristics (Ikpo, 2006). Some of the deficiencies associated with construction techniques can be seen in prefabricated structures manifesting in leakages at joints between the panels especially at the roof parts. The sealant used for excluding adverse weather conditions on windows, doors and service ducts becomes source of maintenance problems with passage of time. The sealant and the technology needed for its application are not readily available (Rozita, 2006). This system is not a good construction technique for the tropical regions such as Ile-Ife, Nigeria.

Inaccessible Defective Portions:Experience in maintenance operation shows that safe access to defective portion or item is critical to its restoration. Safe access is needed for both equipment and personnel for correct diagnosis and eventual rectification. Assaf et al. (1996) and Atkinson (2003) opined that difficulty in accessing high altitude ceilings was majorly responsible for the continuous presence of faulty bulbs and cobwebs in high rise buildings. Preliminary building survey carried out in the Campus highlighted problems of safe and adequate access in restoring leaking sewers and drains. Inaccessibility may also be responsible for the non-removal of weeds and shrubs on most of the buildings in the campus; irregular cleaning of water reservoirs, and painting of building facades and their finishes. Could proactive measures be taken to ensure safe and reliable access to all portions in a building? The answer could be positive at the design stage.

Non-Availability of Maintenance Manual: Usually building Designers provide the necessary working drawings needed for the physical production of building on site. In practice however, some of the constructed structures differed significantly from the ones described in the designers' working drawings. Omotehinshe (2011) noted that a number of reasons such as; challenges of site conditions, client request, non-availability of specified materials, shift in the positions of buried utilities such as drain pipes, electrical cables (conduit), sewers and water mains were responsible for the variations resulting in details of the building produced being different from the one described in the working drawings. New and current drawings representing the building in its built form with all inclusive details specifying all materials, means of repair and replacement of parts, items and components are expected to be produced by the designer. This is hardly the case as information from Physical Planning Unit of the University confirmed that no building in the campus has As-Built Drawings. This type of drawing forms a manual for building users and occupiers in maintaining their properties. As-built drawings are important to building occupiers/users just as car manufacturer's manual is important to its owner.

Non-Availability of Appropriate Technology: During construction processes, the constructing firm is equipped with appropriate personnel, technology and other resources in carrying out its construction work (Rozita, 2006). Tall, irregular shaped and complex structures are fitted with special equipments for their construction. However, upon completion and handing over, these facilities are withdrawn and gone with the construction firm leaving the building owner with virtually nothing for its maintenance. Availability and deployment of these resources in restoring defective portions during service years becomes problematic hence the continuous downtime of any defective facility.

Building Design and Construction Flaws: Ikpo (2009) rightly pointed out that building design and its production process commence from statement of intent from the building owner and terminates at commissioning date. Faulty architectural, structural, mechanical and electrical designs on one hand and bad construction practice by the constructor on the other hand may result in maintenance problems. Chew (2002) noted that bad incompatible material selection and usage, insufficient or inaccurate detailing of working drawings, leaving out users, occupiers and maintenance personnel at the design stage, builder not notified of the original concept or intent of the designer may all constitute maintenance problems. Existing literature indicated that most building designers were not sufficiently equipped with information on soil conditions, building environment and weather issues at the design stage leading to products which, invariably, became faulty (Omotehinshe, 2014). The effects of driving rains on facades may be considerably reduced if proper and sufficient study was carried out during the design stage.

Finance: Most maintenance problems revolve around availability of funds (Dabara, Adegoke, Ankeli, & Akinjogbin, 2014). Budgetary allocation for maintenance work is rarely considered by most organizations and where it exists it is as low as 5% of the organization annual budget (Chew, 2003). Despite the fact that budgetary allocation to O.A.U. has been on the increase during the past 10 years (₦2,421,824,173 in 2000/2001 to ₦7,105,833,819 in 2008/2009) allocation for maintenance operations has been progressively reduced from 4.5% to 2.2% during the same period (Budget Planning & Development Unit, see Table 1). Money is needed for the procurement of maintenance actions in buildings. Wordsworth (2001) and Dabara et al. (2014) observed that majority of the budget allocated to the construction industry in developing countries is used for the procurement of new facilities rather than completing on-going projects or updating the existing ones.

Table 1: O.A.U. Budgetary Allocation for Works and Maintenance Unit

S/N	YEAR	WORKS & MAINTENANCE	TOTAL ALLOCATION	PERCENTAGE %
1	2000/2001	108,651,377	2,421,824,173	4.5
2	2001/2002	118,668,044	2,928,554,860	4.1
3	2002/2003	100,566,251	2,662,158,417	3.8
4	2003/2004	122,483,086	3,267,776,745	3.7
5	2004/2005	129,138,495	3,534,391,505	3.7
6	2005/2006	152,216,204	5,076,574,539	3.0
7	2006/2007	179,804,716	5,840,841,119	3.1
8	2007/2008	146,371,983	6,120,474,270	2.4
9	2008/2009	155,622,959	7,105,833,819	2.2
10	2009/2010	258,686,323	9,783,065,741	2.6
	Mean	**147,220,943.8**	**4,874,149,518.8**	**3.31**

Source: Budgetary, Planning and Development Unit (2013)

Mean Time to Repair (MTTR):

One of the problems encountered in the maintenance of public buildings is the inability of managers of facilities to easily decide when such facilities should be shut down for maintenance works (Sermin 2008). In the case of O.A.U., general maintenance work on buildings is only possible when such a building is not in use. Hostels, lecture halls or workshops can only be temporally shut down for maintenance activities during long students' vacations – which are rare because of problems in Nigerian educational system. General maintenance work on defective staff quarters requires relocation of the occupiers during the period of maintenance. This becomes problematic to the management. From the foregoing it can be seen that most of the maintenance problems encountered in university buildings are traceable to building designs.

Physical Impacts of Maintenance Problems

Basically, in virtually all the towns and city centers, as noted by Ani (2011), the Nigerian buildings and infrastructural facilities are gradually and systematically decaying, dilapidating and deteriorating. In the same vein, Ikpo (2006), Ahmad et. al., (2006) and Omotehinshe (2014), while working on maintenance of public buildings identified local environment, users' impacts, and design flaws among others as factors responsible for major cracks, fluids leakages, biological growths, rusting, staining and prolonged down time in facility usage. Ahmad et al. (2006) reported that the understanding of a good building design always relates to the shape of the building and its aesthetic value. This perception on many occasions has neglected the actual function of why the building was built in the first place. In other words, the incapability of the building to serve its purpose has been automatically ignored by the public because of the attractive design of the building, that is, without even considering whether it has been designed for economic reasons, or for safety, usability and maintainability. The more unique a building is designed to be, the more, it seems, gains artistic value, becoming appealing and much appreciated. Actually, what most Clients value about buildings as noted by Ahmad et al. (2006)**,** are their forms and shapes, rather than the proper function and performance as needed by the occupants or users. The consideration of design impacts on the building after completion is almost neglected. The difficulties in maintaining the building after completion seems also to have never been taken into account, especially at the time the building is proposed to be built. As a result, the cost to maintain the building increases, its life-cycle declines and more parts of the building easily deteriorate. Studies in this research area have shown (see Melvin, 2006) that design plays a major role in determining the condition of a building after completion, especially in the aspect of defects and maintenance. Therefore, the effects of building design on maintenance should not only be seen from the point of an increasing number of repair works or cost involved, but there is need to consider also the impact of design on structure and materials installed as well as the life-cycle for each component or element of the building.

3. The Study Area

The study area for this research work is the Obafemi Awolowo University (O.A.U), Ile-Ife, Osun State, Nigeria. Founded in 1962 as the University of Ife but rechristened by the Federal Military Government as the Obafemi Awolowo University on May 12, 1987 (oau website, 2013). This University is one of the first generation universities in Nigeria, and situated on a vast expanse of land totaling 11,861 hectares in the tropical forest of

Ile-Ife, Osun State, South-West Nigeria with annual humidity of 68% and rainfall averaging 125cm (Egboramy, 1981). Information on the university website (2013) revealed that the population of the University in 2012 was 31,117, made up of staff (2,544) and students (28,573) in the following Faculties: Administration (4,163), Agriculture (1,635), Arts (3,035), Education (2,292), Environmental Design & Management (2,153), Basic Medical Sciences, Clinical Sciences and Dentistry (1,838). Others are Faculties of Law (2,084), Pharmacy (771), Sciences (3,986), Social Sciences (3,359), and Technology (4,484).

University buildings are expected to be reliable, available and maintainable for learning and research activities (Wordsworth, 2001). Defects associated with the prevailing adverse weather elements on building components are critical to the fulfillment of the objectives for which the university was established. OAU was considered a good choice for this study because it is one of the first generation universities in Nigeria. Similarly, among the Nigerian universities, OAU has a lot of buildings consisting of both old and modern designs, it is actually considered as the 'most beautiful campus in Africa'. This makes available to the researchers sufficient number of buildings that suit the purpose of the study.

4. Methodology

The research design adopted for this study involved the use of questionnaire survey technique and physical observation of the subject buildings used in the study. The study focused on OAU faculty buildings and lecture theaters. The study concentrated on the following elements of the buildings: floors, walls, roofs, ceiling, doors, windows, services, brick works, stone works, and wooden construction. This facilitated identification of design configurations, maintenance problems and design impacts with design data that could facilitate ease of maintenance within each group. Two variable factors were considered, namely design and maintenance factors (maintainability).

The study used primary data obtained from physical observations of the selected buildings and secondary data from existing maintenance records in the university. The population of the study consisted of forty-four (44) faculty buildings and eighteen (18) lecture theatres making a total of sixty two (62) buildings covering all the thirteen (13) faculties within the study area. Using stratification based on design configuration, twenty-seven (61%) faculty buildings and ten (56%) lecture theaters were randomly selected as sample size. A total of Forty five questionnaires were administered on the respondents who were randomly selected from staff of Maintenance Unit, building occupiers and the staff of Physical Planning and Development Unit (PPDU). Three sets of questionnaire were prepared; a set each for maintenance staff, occupiers or users and PPDU staff of the selected O.A.U. buildings. A total of thirteen questionnaires (13) were administered on the maintenance staff of the university, however, only 10 copies were returned (76.92%), eighteen questionnaires (18) were administered on the occupiers of the selected university buildings, a total of 11 copies returned for analysis (61.11%) and finally, ten questionnaires (10) were administered on the PPDU staff, however, only 8 copies were returned (80.0%). Information elicited from the respondents included problems encountered during maintenance operations, building design flaws and choice of appropriate materials. Data collected were analyzed using descriptive statistics; this involved the use of frequency counts and percentages.

5. Results And Discussion

The data used in this study consisted of both primary and secondary data from the building elements earlier enumerated. These data were analyzed and discussed below.

Only four out of the thirteen faculty buildings (31%) had concrete floor slabs projected beyond the surfaces of external walls. The few floor projections were only found on the corridors and could only offer platforms and accesses to maintenance operations on the facades along such corridors. Lecture desks and other items of furniture were poorly jointed resulting in easy detachment from the concrete base. Provision for accessing most high altitude building components, elements or items were not incorporated in the design. Building designer's non-consideration for the continuous availability of the chosen materials, the required technology and personnel in maintaining them was found to be majorly responsible for the delayed maintenance actions on defective portions within the selected buildings.

Inadequate roof fall, insufficient moisture treatments and inaccessibility to defective portions were major maintenance problems in concrete roof structures. Opened eaves, poor construction techniques and absence of wind breakers were some of the identified factors responsible for the destructive wind actions on most lecture theater roofs. Similarly, strong, durable and impact resistance doors with self-operating mechanism which are ideal for public buildings were absent in the selected buildings. The use of flush and batten doors in faculty buildings and glass doors in most lecture theaters, could not functionally withstand the pressure from the users hence the frequent breakdown.

Window glazing materials (especially at lower portion) in lecture theaters and offices were not impact resistance, opaque and durable. This encouraged incident of breakages, visual diversions and not maintenance friendly. Aluminium sliding window along faculty corridors would reduce accidents common to half opened casements on corridors.

Design consideration for finishing materials with ease of replacement or repairs or cleaning, in addition to condition of services for floor and wall surfaces were observed to be significantly absent. Also, lack of as-built drawings for all the buildings under review was a source of maintenance problems especially for buried services. Manual regulation of electrical and mechanical appliances or fittings was responsible for most of the maintenance problems identified.

As stated earlier, the selected buildings were divided into 10 elements with 12 design factors used as weighing factors in determining their maintainability. Average maintainability of the mean building segments (components) was considered, (Table 2).

Table 2: Maintenance Problems of the Selected O.A.U. Building Components Using Maintainability Ratio

	BUILDING ELEMENTS Percentage Maintainability										AVG
	Wall	**Floor**	**Roof**	**Ceili**	**Door**	**Wdo**	**Fnis**	**Dec El**	**Stone**	**Clng**	
FUNCTION	94.4	88.9	97.2	100.0	100.0	100.0	100.0	44.4	50.0	55.6	83.05
FORM	61.1	63.9	91.7	100.0	80.6	100.0	100.0	97.2	97.2	97.2	88.89
FINANCE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	72.2	75.0	95.05
HEIGHT	97.2	91.7	94.4	97.2	97.2	100.0	100.0	47.2	30.6	91.7	84.72
AESTHETICS	100	83.3	94.4	94.4	75.0	100.0	100.0	58.3	52.8	88.9	84.71
STRUCTURAL STABILITY	97.2	88.9	91.7	97.2	80.6	100.0	100.0	44.4	52.8	69.4	82.22
SPACE UTILITY	86.1	80.6	94.4	97.2	91.4	100.0	100.0	83.3	86.1	88.9	89.41
CHOICE OF APPROPRIATE MATERIALS	97.2	94.4	94.4	97.2	94.4	100.0	100.0	55.6	55.6	86.1	87.49
CULTURE OF USERS	91.7	88.9	94.4	97.2	88.6	100.0	100.0	58.3	52.8	83.3	85.52
BUILDING'S ENVIRONMENT	91.7	88.9	94.4	97.2	88.9	100.0	100.0	41.7	34.3	55.6	79.27
CLIENT'S INSTRUCTION	58.3	66.7	88.9	97.2	75.0	100.0	100.0	100.0	100.0	100.0	88.61
MAINTENANCE CONSIDERATION	97.2	100.0	100.0	97.2	97.2	100.0	100.0	72.2	69.4	63.9	90.71
AVERAGE	**89.34**	**86.35**	**94.66**	**97.67**	**89.07**	**100.0**	**100.0**	**66.32**	**64.48**	**79.63**	**86.64**

Source: Analysis of Field Survey Data, 2013.

Design of Windows and finishes was the only problem (100%) in the management of maintenance operations within the selected O.A.U. Buildings. Between 64.48% and 97.67% of the maintenance problems in other components of the selected buildings were traceable to design factors. Insufficient and untimely flow of fund was responsible for 95.05% of the delay in executing maintenance operation on the selected O.A.U. Buildings. Non-consideration for future maintenance of elements (90.71%); Access to and Non-availability of Working

Space (89.41%); Building Form (88.89%); Client's Brief (88.61%); Height of Installation (84.72%) and Aesthetic Consideration (84.71%) were design induced problems in the management of maintenance operations on the selected buildings. Outright replacement of item was the only option in restoring defective finishes and decorative elements. Majority (64.48% - 97.67%) of the problems encountered in the management of maintenance operations on the defective elements within the study area were foreseeable and therefore could have been taken care of during the design stage.

Cash Flow, Considerations for Future Maintenance, Access & Safe Working Space, Building Form, Client's Brief, Height of Installation and Aesthetic Considerations were found to be the major (84.71 – 95.05%) problems inhibiting design for ease of maintaining selected O.A.U. Buildings (Table 2). Occupants and users' ignorance on how building and its components perform constituted most of the maintenance problems identified in services.

Physical Impacts on the Physique of Selected OAU Buildings

The following maintenance impacts were identified on the selected O.A.U building elements during the field work: Continuous presence of stains on the stone plinths at performing arts and E.D.M. buildings; presence of expired and irreplaceable defective decorative elements; missing tiles, discolored surfaces, heaves, cracks and moisture on floors; stains, biological growths, failure of finishes, cracks, collapsing fins at stairwells, and moisture presence on walls; pounding water, weeds and leakages on roofs; dusts, broken or missing panels on the windows, doors and other surfaces; and busted, blocked, open drains, pipes, gutters or sewers.

Maintenance staff responses for ease of building maintenance

Information concerning problems encountered during maintenance operations and contributions to design process among others were collected (see Table 3).

Table 3: Ease of Maintenance for Maintenance Staff

AREAS OF CONCERN	**Maintenance Staff (%)**
Quality of Staff	80
Permanent Staff	100
Above 20yrs Working Experience	70
Involved in Selected Buildings	70
Ease of Maintenance	20
Problems in Building Maintenance	
1. Lack of Staff	100
2. Accessibility	100
3. Lack of Fund	100
4. Poor building Shape	100
5. Building Design Flaws	100
6. Poor Construction Quality	100
7. Inadequate Design Information	70
8. Occupier Ignorant of Building	70
Performance	60
9. Choice of inappropriate materials	60
10. Supply logistics	
Ever Taken Part in Building Design	0
Areas of Contribution if Invited	
1. Choice of Building Shapes	67
2. Choice of Construction Materials	67
3. Structural Stability of Building Elements	80
4. Functional Design Alternative	60
5. Construction Logistics	60
6. Cost alternative in Maintenance	60

Source: Analysis of Field Survey Data, 2013.

Table 3 clearly showed that most (80%) senior staff of maintenance unit of O.A.U were professionally qualified to practice, permanently engaged (100%) having more than 20 years working experience (70% and were being involved (70%) in the day-to-day maintenance of the selected buildings. Most respondents (80%) agreed that the selected buildings were not easily maintained. Majority of the staff (60-100%) identified a number of problems in the maintenance of selected buildings. Although none of them (0%) had ever been invited, but majority (60-80%) would have love contributing to building design for ease of maintenance.

The following maintenance management problems were identified: inadequate junior staff (100), access to defective portions (100%), insufficient maintenance budget (100%), poor building shapes (100%), building design flaws (100%), poor construction quality (100%), inadequate design information (70%), occupiers' ignorance on how building elements performed (60%), choice of inappropriate construction materials (60%), and maintenance logistics (60%). Maintenance experts believed that their contributions to the following building design factors would ensure products with ease of future maintenance and better service condition; choice of building shape (67%), choice of construction materials (67%), structural stability of building elements (80%), functional design alternative (60%), construction logistics (60%), and cost alternative in maintenance (60%).

Information concerning problems encountered during maintenance operations and their contributions to design process among others were collected (see table 4).

Table 4: Ease of Maintenance for Occupiers and Users

AREAS OF CONCERN	Users or Occupiers (%)
Quality of Staff	100
50 and above occupiers or users	63.6
Maintenance Problems Encountered	
1. Cleaning	45.5
2. Repairing	36.4
3. Inspecting	9.1
4. Conversion	9.1
Factors Responsible for Prolonged Down Time	
1. Lack of Staff	100
2. Accessibility	100
3. Lack of Fund	60
4. Poor building Shape	100
5. Building Design Flaws	100
6. Poor Construction Quality	100
7. Inadequate Design Information	30
8. Occupier Ignorant of Building Performance	70
9. Choice of inappropriate materials	60
Authority in Charge of the Maintenance	
1. O.A.U Maintenance Unit	70
2. Department	30
Time-lag between Maintenance Report and Rectification	
1. 6 weeks and above	70
2. Below 6 weeks	30
Designers Coming Back to Assess their Buildings	0
Users' Areas of Design Contribution if Invited	
1. Choice of Construction Materials	36.4
2. Choice of Building Shapes	36.4

Source: Analysis of Field Survey Data, 2013.

Majority (63.6%) of the selected buildings had more than 50 occupiers or users (Table 4). Designated maintenance officers identified cleaning (45.5%) and repairing (36.4%) as major maintenance problems in the selected buildings. All (100%) maintenance reporting officers in the selected buildings agreed that inadequate maintenance staff, accessibility, poor building shapes, building design flaws, and poor construction quality, among others, were responsible for delay in restoring defective items to their service conditions. Majority (70%) of maintenance complains were directed to the maintenance unit of the University while minor ones (30%) were handled by the Departments. Most respondents (70%) agreed that it could take 6 weeks or more for any defective portion to be restored to service condition. All respondents (100%) agreed that building designers had never come to assess the performance of their designs during post occupation stage. Users identified choice of construction materials (36.4%) and building shapes (36.4%) as the areas they would like to contribute when designing buildings. Data on inbuilt maintenance problems envisaged during design stage were sourced from the staff of Physical Planning and Development Unit (PPDU). These included criteria for choosing building materials, knowledge of maintenance operations, and contributions of other professionals in the built industry among others (see Table 5).

Table 5: Ease of Building Maintenance for P.P.D.U. Staff

AREAS OF CONCERN	PPDU Staff (%)
Quality of Staff	
1. NIA ARCON Registered	71.4
2. NSE, COREN Registered	28.6
Areas of Specialization	
1. Architecture and Project Management	42.9
2. Design and Project Management	28.6
3. Design Monitoring and Project Supervision	28.6
Factors Influencing Choice of Construction Materials	
1. Material Aesthetics	71.4
2. Cost of Material	71.4
3.Functional Requirement of the Material	100
4. Availability of the Material	71.4
5.Material Durability	100
6.Client Choice	100
7.Maintenance Requirement for the Material	0
8. Material Transportation and Storage	28.6
9. Material Familiarity to Handlers	28.6
10. Cultural Indifference to the Use of the Material	28.6
11. Technological Requirement for Installation and Maintenance	28.6
Training of Designers on Building Operation & Maintenance	0
Level of Knowledge of Designers on Building Operation & Maintenance	42.9
Inputs from Maintenance Experts	28.6
Designer Assessing Building during Post Occupation Stage	28.6
Areas of Consideration for ease of Maintenance when Designing Building	
1. Ease of Cleaning Surfaces	71.4
2. Ease of Repair	57.1
3. Ease of Replacement	57.1
4.Access for Maintenance Operation	100
5. Availability of Required Technology	71.4
6. Availability of Required Expert	71.4
7. Availability of Replaceable Material	71.4
8.Functional layout of Space (Rooms)	100
9. Building Shape and Profile	28.6
10. Choice and Positioning of Material	71.4
11. Choice of Construction Equipment	28.6
12.Aesthetics Appearance	100
13. Relationship with User's Culture	71.4
14. Vertical Transportation	100
15. Construction Method	100
16. Structural Constrain	71.4
17. Clean water supply	28.6
18. Waste Water Disposal	71.4
19. Telecommunication Facilities	28.6
20. Garbage Disposal	28.6

Source: Analysis of Field Survey Data, 2013.

Table 5 showed that most respondents (staff) both Architects (71.4%) and Engineers (28.6%) of PPDU unit of

O.A.U were professionally qualified to practice specializing in architecture and project management (42.9%), design and project management (28.6%) and design monitoring with project supervision (28.6%). All respondents (100%) agreed that the following factors influenced their choice of construction materials: functional requirement of the material, material durability and client choice. Majority (74.1%) considered material aesthetics, cost and availability as the factors influencing their choice of materials. Only few (28.6%) considered material transportation and storage; material familiarity to handlers; cultural indifference to the use of the material; and technological requirement for installation and maintenance, as factors influencing their choice of building materials. None (0%) of these designers considered maintenance aspect when considering materials for construction purposes.

Table 5 equally indicated that some of the respondents had never undergone formal training in building operation and maintenance leading to their limited knowledge (42.9%) in this area. Respondents considered the following factors to be useful if buildings were to be designed for ease of maintenance: access for maintenance operation, functional room layout, aesthetics appearance, vertical transportation, and construction method (100%). Others are: ease of cleaning surfaces, availability of required technology, availability of required expert, availability of replaceable material, choice and positioning of material, relationship with user's culture, structural constrain, and waste water disposal (71.4%). Others are: ease of repair (57.1%), ease of replacement (57.1%), building shape and profile, choice of construction equipment, clean water supply, telecommunication facilities, and garbage disposal (28.6% each).

6. Conclusion/Recommendation

The study examined the implications of design inadequacies on the maintenance of Obafemi Awolowo University buildings in Ile-Ife, Nigeria. This was borne out of the fact that continuous availability and reliability of University buildings at economic prices are essential in providing uninterrupted academic and research activities for which the institution was established. This uninterrupted service condition of the buildings can be enhanced through proactive actions taken at the design stage. The study therefore examined the design configurations, maintenance problems and the physical impacts of maintenance issues on the physique of selected Obafemi Awolowo University buildings with a view to providing information that would enhance the quality of future building design and performance. Focus was centered on the elements of the Faculty buildings.

The study revealed that buildings under review were not consciously designed for future maintenance. Inbuilt accesses were provided for 31% of existing building components. Building shapes, environmental factors, choice of appropriate materials, fund, and users' ignorance on how building operates among others were identified as major maintenance issues. No building had as-built drawings which would have served as maintenance guide for both the building users and maintenance personnel. Inadequate roof fall, insufficient moisture treatments and inaccessibility to defective portions were major maintenance problems in concrete roof structures. Opened eaves, poor construction techniques and absence of wind breakers were some of the identified factors responsible for the destructive wind actions on most lecture theater roofs.

Furthermore the study identified continuous presence of stains; expired and irreplaceable decorative elements; missing tiles; discoloring surfaces; biological growths; failure of finishes; cracks; ponding water; weeds; fluid leakages; broken or missing panel and busted, blocked, open drains, pipes, gutters or sewers as physical evidences of poor maintenance issues which could have been inhibited through design inputs. Collaborative efforts of building designers, including maintenance experts, during the design stage would ensure future products with ease of maintenance and economic life-cycle performance.

It seems not practically possible to have a concerted synergy between building designers that would ensure a near maintenance-free structure. The study therefore recommends a thorough knowledge of maintenance requirements, design data and spirit of team work to all public building designers. Inclusion of as-built-drawings should be part of contract documents and building clients should, as much as possible, allow designers exercise their professionalism in their design decisions. In line with the foregoing, future research work in this field is needed. Researchers in this area of study could look at the effect of faulty designs on building construction as well as building maintenance cost concepts as it relates to building designs.

References:

Adejimi, A. (2005). Poor Building Maintenance in Nigeria: Are Architects Free From Blames? A Papaper Presented at the ENHR International Conference on 'Housing: New Challenges and Innovations in Tomorrow's Cities'. Iceland. Email akinadejimi@yahoo.com

Ahmad, R. Chew, M. Y. I. & Arditi, D. (2006). The Effect of Design on the Maintenance of Buildings in Malaysia. Abe International Publications, Building Engineering Digest, Vol.4, Pp 40.

Alabi, J.K., Okunola, A.S., Dabara, I.D and Odewande, A.G. (2012). Principles of property development and management. Ibadan, ASEDA Publishing.

Ani, A. C., (2011). The Impact of Maintenance of Buildings and Infractural Facilities to the National Economy (A Case Study of Shell Camp Housing Estate, Owerri, Imo State, Nigeria). Department of Bulding Technology, School of Environmental Design and Technology, Federal Polytechnic Nekede,

Assaf. S. Al-Hammad, A. M. and Al-Shihah, M. (1996). Effects of Faulty Design and Construction on Building Maintenance. Journal of Performance of Constructed Facilities. Vol.23 No.3 Pp 175-181.

Atkinson, A. R. (2003). The Pathology of Building Defects; A Human Error Approach. Journal of Engineering Construction and Architectural Management. Vol.9. No.1. Pp53-61.

Barringer & Associate, Inc. (2009). Designing and Developing Maintainability Products and Systems. www.barringer1.com/jul01prb.htm.

Brian K., Peter K., Craig, B., and Vince C. (2014). Toward Sustainable Roofs via Design for Heightened Maintainability and Future Disassembly. Canada. docserver.nrca.net/technical/7309.pdf

Buys and Nkado (2006): Bench-Ranking Model for Maintenance Management Systems in South Africa Tertiary Education Institutions. The Construction and Building Research Conference of the Royal Institution of Chartered Surveyors, University College London. 7 – 8 September, 2006.

Chew, D. (2002). Maintainability of Facades in the Tropics. www.linkingghub.elsevier.com

Chew, D. (2003). Maintainability Problems of Wet Areas in High-Rise Residential Buildings. Building Research and Information. Vol.31. No.1. Pp 60-69.

Dabara, I. D., Adegoke, O. J., Ankeli, I. A., & Akinjogbin, I. O. (2014). Government policies and household mobility behavior in Nigeria: The case of Osun State Property Development Corporation (OSPDC). Proceedings of the14th African Real Estate Society (AFRES) Annual Conference, 2nd – 5th September 2014. Pg 146-164, Kramer Building, University of Cape Town, Cape Town South Africa.

Egboramy, (1981). University of Ife Ile-Ife Nigeria Master Plan. Arieh Sharon.eldar Sharon – architects and town planners.

Ikpo, I. J. (1990). Deterioration Phenomena of Selected Housing Estates in South Western Nigeria. An Unpublished PhD Thesis Submitted to The Department of Building, OAU Ile-Ife.

Ikpo, I.J. (2006). Building Maintenance Management. Manson Publishing Company, 43 Secretariat Road, Box 219, Oron, Uyo, Akwa-Ibom State, Nigeria.

Ikpo, I.J. (2008): Building Maintenance Culture: The Nigerian Experience. The Professional Builder Journal of Nigerian Institute of Building. June, 2008. Pp.12-18.

Ikpo, I. J. (2009). Building Maintainability Index. Journal of Building Appraisal – A Professional Journal, Vol.4, No.4 spring 2009.

Mbamali, I. (1998). Nigerian Journal of Construction Technology and Management. Department of Building University of Jos. Vol.1, No1. Pp34-37.

Melvin, S. (2006). Quality Designing for Maintenance. Unpublished thesis in the Faculty of Economic and Building Sciences of Nelson Mandela Metropolitan University January 2006.

Oladapo, D. A. (2004): An Evaluation of the Maintenance Management of the Staff Housing Estates of Selected First Generation Universities in South Western Nigeria. Unpublished Ph.D Thesis, Department of Building, O. A. U, Ile-Ife.

Omotehinshe, O. J. and Akinjogbin I. O. (2011): Building Construction in Practice. Furhrer Publishers Ltd. Oja-Timi Ede.

Omotehinshe, O. J., (2014). Design Related Problems in the Maintenance Management of Selected Buildings in Obafemi Awolowo University, Ile Ife Nigeria. An Unpublished MSc. Thesis Submitted to the Department of Building, Obafemi Awolowo University, Ile Ife, Nigeria.

Paul, Barringer (1997). Availability, Reliability, Maintainability, and Capability. www.barringer1.com

Rozita B. A. (2006). Maintenance issues in High-Rise Buildings. A research publication submitted to Faculty of Engineering, Universiti Teknologi Malaysia.

Seeley, I. H. (1987) Building Maintenance, 2nd Edition, MacMillan Education Ltd, London.

Sermin, E. (2008). Maintainability Analysis of Mechanical System of Electric Cable Shovels. Journal of Scientific & Industrial Research, Vol. 67, April 2008, Pp. 267-271.

Wai-Kiong, C. (2006): Latent Building Defects: Causes and Design Strategies to Prevent Them. Journal of Performance of Constructed Facilities http://www.fep.up.pt/disciplinas/PGI914/Ref_topico1/LatentBuilding%20Defects.pdf

Wireman, T. (2004). Benchmarking Best Practices in Maintenance Management. Industrial press, New York. NY.

Wordsworth, P. (2001). Lee's Building Maintenance Management. 4th Edition, Blackwell Science.

Zulkarnain, S.H. Zawawi, E.M.A, Rahman, M.Y.A Mustafa, N.K.F. (2011). A Review of Critical Success Factor in Building Maintenance Management Practice for University Sector. World Academy of Science and Engineering and Technology. Vol 77. Pp 195 – 199.