OPTIMISING DESIGN STRATEGIES TO MINIMISE MAINTENANCE COST IN PROPOSED POST GRADUATE SCHOOL UMAR MUSA YARADUA UNIVERSITY KATSINA.

Khalid Lawal SAULAWA B.Sc (Arch) 2010

MSC/ENV-DES/06125/2010-2011

DEPARTMENT OF ARCHITECTURE,

AHMADU BELLO UNIVERSITY, ZARIA,

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NIGERIA.

MARCH, 2015

DECLARATION

I declare that this thesis entitled ‘‘OPTIMISING DESIGN STRATEGIES TO MINIMISE MAINTENANCE COST IN PROPOSED POST GRADUATE SCHOOL UMAR MUSA YARADUA UNIVERSITY KATSINA.’’ is the outcome of my research work and has been written by me in the department of Architecture under the supervision of Dr. R. B. Tukur and Dr. Y.Y.Badiru. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this project thesis was previously presented for another degree or diploma at this or any other university.

Khalid Lawal SAULAWA,		MARCH, 2015
Name of student	Signature	Date

CERTIFICATION

This thesis entitled ‘‘OPTIMISING DESIGN STRATEGIES TO MINIMISE MAINTENANCE COST IN PROPOSED POST GRADUATE SCHOOL UMAR MUSA YARADUA UNIVERSITY KATSINA” by Khalid Lawal SAULAWA meets the regulations governing the award of the Master of Science degree of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research is dedicated to all those that helped me on this important journey to reach where I am today especially my parents and lecturers. I will forever be grateful. Thanks for everything.

ACKNOWLEDGEMENT

All praise is due to Almighty Allah Lord of the worlds, the most gracious and most merciful for His nonstop Guidance.

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ABSTRACT

Due to the growth of the construction industry with the lack of building Standards, more maintenance, rehabilitation, and renovation work have become necessary to ensure the serviceability after completion and of public buildings. Therefore, ways must be found to reduce the maintenance cost works due to ageing of the buildings while keeping the same quality. Building maintenance is seriously neglected area of research and study. Designers lay more emphasis on how a building would look like and ignored how to maintain the building and therefore raising the cost of maintenance. This research therefore is aimed at minimizing maintenance cost in public buildings from the design stage. It shall also make designers and Architects to make minimizing the cost of maintenance a priority during the design stage of any public building.

Thus the research concluded by identifying the key areas that the designer needs to pay attention to during the design stage. These key areas were found during the case study, personal observation and oral interviews. The outcome of these studies leads to the proposal of a School of Post Graduate for Umar Musa Yaradua University Katsina that if fully implement require a very minimum amount of maintenance cost throutout the life time of the proposed building.

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CHAPTER ONE

INTRODUCTION

1.1BACKGROUND.

The role of Public Institutions in National development cannot be over-emphasized. However, in spite of the heavy investment in public buildings, public institutions allow their structures to care for themselves without any sustainable maintenance plan to preserve the quality of the buildings. The problem occur because of low quality of maintenance work, lack of ethics in maintenance effectiveness, ignorance to understand maintenance work, inexperienced and unskilled workers and manpower, lack of supervision from building team, delays in repairing and replacing, failure of the management to provide clear policies and standards to guide the maintenance staffs, insufficient information of maintenance, and lack of commitment to maintenance plan (Onohaebi, 2010). In Nigeria, according to Adenuga and Iyagba (2005), public buildings are in very poor and deplorable conditions of structural and decorative disrepairs. Despite huge finances spent to erect imposing and monumental buildings, they are left, as soon as commissioned, to face premature but steady and rapid deterioration, decay and dilapidation. Anele (2010) perceives that Nigeria will continue to waste scarce financial resources on building new infrastructure which cannot be sustained if urgent steps are not taken to solve these problems.

Maintenance is necessary not only to maintain function of the building, but also to minimize future maintenance costs and to ensure a safe environment to building occupant. Olusanya (1998) observed that building maintenance cost is one of the crucial areas draining our national economy. Folorunso (2001) explains the need for designing our future buildings, with every little attention being given to the enormous cost of their up keep. Arayela (2002) observed that it is necessary to seek ways of lowering the escalating construction costs, minimizing repairs and maintenance cost. Moreover, the reduction of building maintenance cost can be done through deep understanding of the building maintenance cost concepts. An increase in cost of maintenance can be attributed to faults in the operation of systems and components as a result of deficiency in design (Al-Hammad A.,Assaf.S. & Al-Shihah, M 1997). The issue of building maintenance is a universal issue and is highly considered in the early process of the construction (design) to assure the quality of the building (David1999). The effects of the decisions made during the design stage would have far reaching effects on future building maintainability (Chew, 2004). The approach to reducing deterioration and consequently the cost of maintenance is for the Architect to try as much as possible to try to minimize the impact of the causative agents or factors right from the design stage. The building's spatial organization should be informed by, and integrated with, its site features and climatic considerations. Collectively, the design of the various interdependent building systems and the envelope should pursue optimal performance at the lowest life cycle cost. An integrated design approach is required to ensure that the architectural elements and the engineering systems work effectively together (Intergovernmental Panel on Climate Change, 2007). The traditional way of designing buildings does not include an energy conscious design strategy, and the design process often focuses on extreme situations rather than on the running costs of the building. Research into building energy efficiency over the last decade has focused on efficiency improvements of specific building elements like the building envelope, including its walls, roofs and fenestration components, and building equipment such as heating, ventilation, air handling, cooling equipment and lighting. Significant improvement have been achieved, and whilst most building elements still offer opportunities for efficiency and improvements. This research therefore aims to identify a better approach to the design process to produce high-performing buildings that are more resource efficient, require less maintenance and provide healthier working environments for users.

1.2 PROBLEM STATEMENT

Most designers of institutional building lay their emphasis on how a building will look like rather than how it can be maintained. This often leads to the erection of structures that are very difficult to maintain and consequently leads to the rise in the cost of maintenance. Therefore there is the need to design public structures where maintenance budgets are expected to be low. This research therefore aims to identify a better approach to the design process to produce buildings that are more resource efficient, require less maintenance and provide healthier working environments for users.

1.3 RESEARCH AIMND OBJECTIVES

This study is aimed at developing a building concept, where appropriate responsive building elements are integrated into the building design to achieve an optimum environmental performance and a minimized maintenance cost in institutional buildings. The following objectives shall be focused on during the course of this research:

i. To study the concept of building maintenance and the factors affecting the building maintenance cost.

ii. To make architects conscious of economical maintenance cost considerations by identifying key areas that should be focused on during the design stage.

iii. To develop and optimize new building design strategies using both natural and renewable energy sources so as to minimize maintenance cost in institutional buildings

v. To demonstrate the outcome of the study through a proposed school of postgraduate studies for Katsina State University.

1.4 RESEARCH QUESTIONS

This research intends to answer the following basic questions:

a. What are the basic challenges that are responsible in raising the cost of maintenance in institutional buildings?

b. How can these problems be solved by a different design approach that is cost effective?

1.5 SIGNIFICANCE OF STUDY

This study is essential in the sense that it would not only contribute to knowledge and theory, but will also contribute to good maintenance practice in the public institutions in Nigeria. Unlike much of the academic literature in this topic area, this study is aimed at practical application of the findings rather than expounding upon theoretical concepts. Furthermore the study will assist managers of public institutions to become aware of the current state of their buildings and its effect on the safety and health and also to put in place adequate innovative measures to prevent deterioration which ultimately lead to increased cost in restoring these buildings to their original state.

1.6 JUSTIFICATION

Umar Musa Yaradua University Katsina (UMYUK) is proposing to build a school of post graduate studies in accordance with the complete realization of the schools master plan. This was as a result of the growing number of post graduate students being enrolled into the university since the inception of the post graduate program in 2014. As part of my contribution to my own state of origin to which I shall remain very grateful to by its financial support in the course of my studies, I will like to propose a school of post graduate studies for Katsina state university and with the aim of proposing some design solutions and strategies on how to minimize the cost of maintaining this proposed structure. The problem of maintenance if properly tackled shall be of important benefit to the following:

a. **University.**

The research will help the university in improving the well being and livelihood of its students, by the improvement of unsatisfied buildings. This will help in reducing cost and providing buildings that will last for a very long period of time. It will also help the university economically through the reduction of huge sums of money that are been spent every year as maintenance budget.

b. **Students**.

The problems if properly tackled will provide a comfortable learning atmosphere and a safer environment to students. This will help them feel lively, spirited and reduce their physical stress.

c. **The Researcher**.

As Architects and designers of the physical environment, this research will help the researcher a lot by improving his knowledge on design problems for his future Architectural practice.

1.7 SCOPE AND LIMITATIONS

This research shall focus on proposing an appropriate design for the school of post graduate studies that will minimize maintenance cost to the lowest possible level. The proposal shall include the main administrative building consisting of offices, conference rooms and a multipurpose theater, the student’s center and their accommodation.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The word maintenance is a noun derived from the verb “to maintain” which means the process of keeping something in good condition (Telang and Telang, 2010). The process of maintenance involved task or activities to restore the equipments in its normal operating condition, at minimum cost throughout their life cycle. According to Smith (2003) means to keep in its existing state, preserve, continue in good operating condition, and protect. According to British Standard 3811:1984, maintenance is defined as a combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or to restore it to a state in which it can perform the required function (Wordsworth, 2001; Chang 2010). Maintenance is defined as “any activity carried out on an asset or system in order to ensure that it will continue to perform its intended functions” (Dunn, 2007). Maintenance activities can be technical or administrative in nature, and they include any effort to protect, preserve, or prevent a system from decline (Smith, 2000; Dekker, 1996). Regardless of construction and durability, all buildings, equipment, and infrastructure require responsible operation and some amount of periodic maintenance; failure to perform intended maintenance will shorten the operating life of these assets (Whole Building Design Group Sustainable Committee, 2007; Sullivan et al., 2004). The primary conflict facing Maintenance management programs can vary greatly depending on the context of the maintenance operation (Ahire et al., 2000). Building deterioration is generally unhealthy and constitute a menace in any given society Maintenance assists retaining economic life of buildings. Moreover, it is a productive activity both at the private and the national levels. At the private level, proper maintenance leads to lower depreciation costs (due to longer economic life) and consequently leads to higher profitability. While at the national level, proper maintenance leads to lower expenditures on replacement. Thus, allowing more expenditure on expansion into new productive investment (Rajamani, 2002). Additionally, maintenance operations are often constrained by external factors and increasing maintenance resources is rarely an option (Turner, 2002). Maintenance activity covers the whole building envelope which includes the building structures, roofing, building exterior and interior, wall, columns and fixed furniture. Due to the growth of construction industry with the lack of building Standards, more maintenance, rehabilitation, and renovation work have become necessary to ensure the serviceability and safety of the constructed buildings. In addition, the existing buildings need to be sustained as long as possible. These will include the original specification of the component, its appropriate installation within the building, interaction with adjacent materials, use and abuse, frequency and standards of maintenance, local conditions and the acceptable level of actual performance by the user. All facilities have useful and economic life expectancy yet the process of gradual deterioration or depreciation is inevitable. The speed can be reduced through routine maintenance to avoid decay and eventual collapse. Low performance qualities of most building materials available in the building market reveal a decline in quality and this demands early maintenance. Traditionally, in the villages, people take pride in the proper care and maintenance of their houses and surroundings. With the mass rural-urban migration that came in the wake of urbanization and post-independence, this culture seems to have been lost in transit. There was a building boom and very little attention was given to the maintenance of existing stock of buildings by the government.

It is an important factor in the delivery of teaching and learning education system as a whole University buildings are procured to create a suitable, conducive and adequate environment that can support, stimulate and encourage learning, teaching, innovation and research activities. A failure in the supply of these essential services is a loss in value of the building to the university institution, the community, the students, staff and other stakeholders. Proper maintenance management has effect on the reliability, safety, availability and quality of the building. However, efficient and effective maintenance depends on the availability of information on the criteria that influences university building maintenance, criteria that influences users' satisfaction in university building, nature of defects in university buildings and maintenance performance metrics for the university buildings.

2.2 TYPES OF MAINTAENANCE

. According to the US Department of Education, There are two types of maintenance process which are preventive maintenance and corrective maintenance. Preventive maintenance is the routine, regularly scheduled maintenance of a piece of equipment to ensure its continued use and maximize its life expectancy. While, corrective maintenance is an emergency work orders which the maintenance activity done after damage occur. However, preventive maintenance is recommended to minimize equipment failure due the time schedule. The cost associated with routine servicing of equipment is small compared to the cost of coping with unexpected and catastrophic breakdown which require not only major repairs but even the replacement of affected components and systems. BS 3811 categorizes building maintenance by means of the following terms and definitions.

i. Planned maintenance: 'The maintenance organized and carried out with forethought, control and the use of records to a predetermined plan."

ii. Unplanned maintenance: "The plan carried out to no predetermined plan." It refers to work necessitated by unforeseen breakdown or damages. For example, the ripping-off of a building, through the action of a storm, and its remedial action constitute unforeseen damages. It can also be termed unexpected and unavoidable maintenance.

iii. Preventive maintenance: “The maintenance carried out at predetermined intervals or corresponding to prescribed criteria and intended to reduce the probability of failure or the performance degradation of an item.”

iv. Corrective maintenance: “The maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function.”

v. Emergency maintenance: “The maintenance which it is necessary to put in hand immediately to avoid serious consequences.” This is referred to as day-to-day maintenance, resulting from such incidents as gas leaks and gale damage.

vi. Condition-based maintenance: “The preventive maintenance initiated as a result of knowledge of the condition of an item from routine or continuous monitoring.”

vii. Scheduled maintenance: “The preventive maintenance carried out to a predetermined interval of time, number of operations, mileage, etc.”

viii. Running maintenance: “Maintenance which can be carried out whilst an item is in service.”

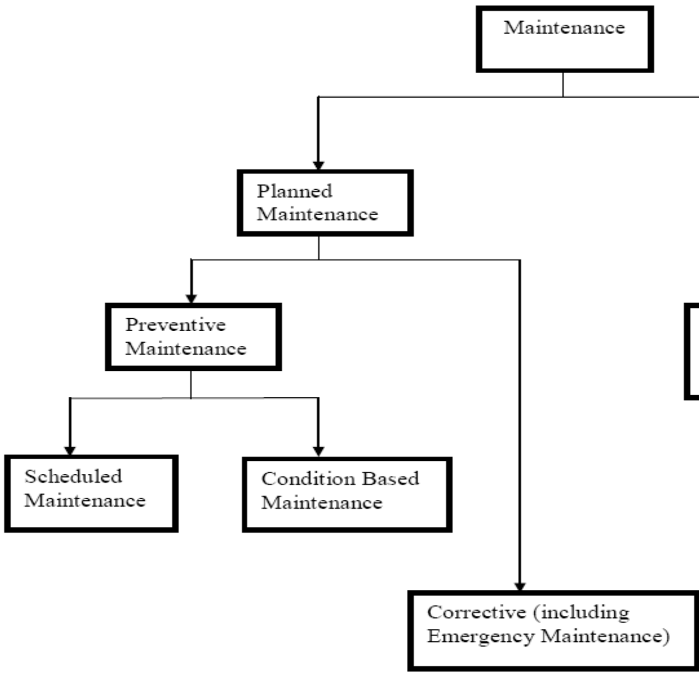

Figure 2.1 Maintenance Classification (source BS 3811, 1984)

Maintenance work has also been categorized as 'predictable' and 'avoidable'.

a. **Predictable maintenance** is regular periodic work that may be necessary to retain the performance characteristics of a product, as well as that required to replace or repair the product after it has achieved a useful lifespan.

b. **Avoidable maintenance** is the work required to rectify failures caused by poor design, incorrect installation or the use of faulty materials.

Another approach to maintenance classification has been adopted by Speight (1982) as cited in Seeley (1987), subdivided maintenance into three broad categories:

1. Major repair or restoration: such as re-roofing or rebuilding defective walls and often incorporating an element of improvement.

2. Periodic maintenance a typical example being annual contracts for decorations and the like.
3. Routine or day-to-day maintenance: This is largely of the preventive type, such as checking rainwater gutters and servicing mechanical and clerical installations.

A research by Adenuga, O.A and Iyaba, R.O.A, (2010) on the need for effective maintenance practices in public buildings, investigated the causes of neglect of maintenance responsibilities and concluded that the lack of maintenance culture in the country, lack of maintenance knowledge, lack of emphasis on training, retraining and continuing education on effective management by the establishment, indiscipline and ignorance on the part of users, absence of planned maintenance programme and reactive maintenance, complexity of design, non-involvement of maintenance team at design stage and inadequate funds for maintenance are the factors affecting maintenance management of public building in Nigeria. The authors of this paper agree with the findings of the research on the causes of neglect of maintenance responsibilities especially in the area of lack of maintenance knowledge. In Nigeria, the management of land, buildings and facilities, plant and machinery is perceived as the responsibility of the Estate Surveyor and Valuer. Given the skills and training, the Estate Surveyor and Valuer do not have the competence to appropriately manage facilities as they have limited knowledge in this field (Adewunmi and Ogunba, 2008). However, the authors of this paper, fairly disagree with the issue of lack of adequate provision of funds as reasons for the condition of public buildings in Nigeria but will rather state that corruption by highly placed individuals in the public sector is responsible for this problem.

Ahmad Ramly (2002) stated that the aims of maintenance from building perspective

are:-

1. Increase the maximum benefit, especially to owners of buildings shaped the industry, private Or business oriented

2. Get maximum performance at a lower cost, especially public-owned buildings, safety-oriented and nonprofits.

3. Provide comfort and peace building, especially to building occupant

In the three decades after World War II, research in the field was mainly directed at properties of materials and few of the results were actually implemented. Therefore, the relationship between design, maintenance, execution of maintenance, economic significance of maintenance, and the actual performance of the materials and components under varying condition should be considered (Al-Shiha, 1993). In the early nineties, researcher notes the heavy need to conduct such types of studies. Moreover, many researchers did specific studies related to their countries. In 1993, Al-Shiha conducted a research discussing the effect of faulty design and construction factors on building maintenance. As a result, the most severe factors which affect the maintenance works and causes the high maintenance cost are determined as: inadequate structural design such as foundation, hiring unqualified designers, not complying with specification, not relating exterior materials selection to climate conditions, inadequate waterproofing and drainage, unqualified workplace, inability to read the dawning's. The criteria affecting the priority rating of public building maintenance works were studied by Al-Majed in the late nineties. Twenty three criteria were identified (i.e. Function of the building, location, initial cost etc.). These criteria were classified into two major groups as follows:

1. Building performance group: Twelve criteria which emphasis on the building.
2 Managerial group: Eleven criteria which deal with decision-making process and behavior of decision maker.

Iqhwan in the early nineties proposed some concrete measures that can lead to the improvement of maintenance status in Saudi Arabia along the following dimension:

3. Developing and enforcing sound of maintenance practices.

4. Supporting researches in maintenance management systems appropriate to Saudi Arabia.

These measures are

According to Smith (2003) there should be a law dictating the minimum maintenance requirements necessary to ensure safe and healthy buildings, services and surroundings. There should also be agents to ensure that the law is duly enforced. Best maintenance practices are actually defined in two distinct categories. There are the standards, which are the measurable performance level of maintenance execution, and then there are the methods and strategies that must be practiced in order to meet the standards. Arics (1991) identified various ways of defining property maintenance with the following principal objectives: Prevention of the capital investment, Maintaining a pleasant and functional environment, Compliance with statutory regulations, Minimizing and spreading maintenance cost, Allowing the building to fulfill its best use, Presenting a good appearance, Prolonging the building useful and economic life. To achieve these objectives he stated that a plan must be formulated and developed with the emphasis on the owner or occupier's need and the physical condition of the buildings. Most buildings were not on inception, designed to minimized maintenance and required therefore constant planned maintenance to run economically. Long-term neglect often results in serious structural failure requiring major expenditure. Prevention is better than cure. Every building has inherent weakness and many undetected defeats, which if left unattended to, will result in costly repair and possibly structural failure. Early detection of faults and weakness may prevent high cost of maintenance. Carlton, (2004) described the existing arrangement for building maintenance especially in public buildings as the type that could no longer stand the test of time. Historically, in both public and the private sectors, maintenance is seen as an avoidable task which is perceived as adding little to the quality of the working environment, and expending scarce resources which could be better utilized (Higher Education Backlog Maintenance Review, 1998). Sufficiency of the design, constructional details and the methods of building construction determines the usefulness of buildings. It is also dependent upon the way that the building is used and the maintenance policies and practice undertaken during its life (Iyagba, 2005).

2.3 OBJECTIVES OF BUILDING MAINTENANCE

Oyefeko (1999) enumerated the following as the major objectives of building maintenance:

a) To ensure that the functional requirements of the facility are attained at all times.

b) To create a conducive and tenantable accommodation for owners and occupants users.

c) To enhance the quality of building structure to meet modern day requirements.

d) To prolong the life span of the building.

e) To preserve the physical characteristic of the building and associated services so as to reflect fewer breakdown and thereby reduce the probability of early failure.

f) To ensure that assets are kept at reasonable standard and at least cost.

g) To maximize the economic and financial returns from the use of the building.

h) To ensure the safety of the users/occupants.

2.4 LIFE CYCLES OF BUILDING COMPONENTS

The life span of the individual materials and components has a contributory effect upon the life span of the building. The particular circumstances of each case will have a significant influence upon component longevity. These will include the original specification of the component, its appropriate installation within the building, interaction with adjacent materials, use and abuse, frequency and standards of maintenance, local conditions and the acceptable level of actual performance by the user. The management policies used by the owners or occupiers are perhaps the most

Crucial factors in determining the length of the components live. The study of (Adenuga, 1999) concluded that the rapid deterioration of buildings and their components can be attributed to many different causes:

a) An emphasis upon initial building costs without considering the consequences of cost in use.

b) Inappropriate design and detailing of buildings and components.

c) Use of materials and components that have sufficient data on their longevity.

d) A lack of understanding of the various mechanisms of deterioration.

e) Insufficient attention given to the maintenance of the building stock.

f) Inappropriate use by owners and occupier

Previous research (Zubair, 1999; Oyefeko, 1999, Iyagba, 2005) identifies three main components of building and their average life spans:

a) Building shells: which include major physical elements such as structural frames, floors, the building exterior envelope and vertical transportation/services core. These have a life span of 40 to 50 years.

b) Fitting-out elements: these include ceilings, partitions and floor finishes. They have an average life as short as 5 years.

c) Building services: these include mechanical and electrical services, Telecommunication and data, lighting and interior transportation systems. Their life span ranges from 5 to 25 years.

2.5 MATERIALS AND ELEMENTS

Resources, pollution and performance are the most general criteria of building materials (Berge, 2000: 3). Resources used by any construction material include all the raw materials and energy used from its extraction to its disposal. Performance is the criterion for how well the material does the job for which it was produced (Milani, 2005). Natural materials and processed materials perform differently. Natural materials tend to be more complex and have different positive qualities and, if correctly utilized, can bring a plus to the building industry by enhancing the performance of buildings. When compared to traditional materials, methods and technologies, natural materials can provide energy efficiency in buildings. However, May (2006) maintains that not any kind of natural material will suit any situation. Suddell (2008) proclaims that the construction industry is the second largest sector that uses natural material. Natural materials are generally lower in embodied energy and toxicity than manmade materials (Godfaurd, 2005). They require less processing and are less damaging to the environment. Many, like wood, are theoretically renewable. When natural materials are incorporated into building products, the products become 117 more sustainable (Godfaudr, 2005). The use of building material sourced locally can help lessen the environmental burdens, shortens transport distances, thus reducing air pollution produced by vehicles (Joseph and Tretsiakova-McNally, 2010). Often, local materials are better suited to climatic conditions, and these purchases support area economies. It is a simple known fact that people will continue to construct buildings for as long as they are on this earth.

Kelly & Hunter (2009) propose the application of the three R’s (reduce, re-use and recycle) as being helpful in selecting building materials. Traditionally, the focus in construction is on minimizing the initial building cost. It has, however, since the 1930s become obvious that it is unfavorable to base the choice between material alternatives solely on the initial cost alone (Kishk, 2003). An inefficient building imposes a cost penalty on the client throughout its lifetime. While the client has an incentive to minimize whole life costs, the contractors and consultants do not, as they have no long-term interest in the building and are not accountable for performance in use (Sorrell, 2003). The sustainability of a building can be enhanced by increasing the durability of its materials (Malholtra, 2002), and a material, component or system may be considered durable when its useful service life (performance) is fairly comparable to the time required for related impacts on the environment to be absorbed by the ecosystem. Materials with a longer life relative to other materials designed for the same purpose need to be replaced less often. This reduces the natural resources required for manufacturing and the amount of money spent on installation and the associated labor. The greater the material durability, the lower the time and resources required to maintain it (Cafi and Rejna, 2000; Silva, 2004). Durable materials that require less frequent replacement will require fewer raw materials and will produce less landfill waste over the building's lifetime. It is however; more expensive to renovate a building if the frequency of maintenance is rapid. Most of these maintenance needs are direct consequences of the effects of climate on the materials. One of the major causes of "Building Sickness" is poor use of materials in relation to prevailing climate Folorunso, (2001). In general, there are several building defects which usually happen to building parts such as roofs, walls, floors, ceilings, toilets, doors and windows (Cheun, 2008). Roofs are the most vulnerable part of a building. Roof are two types, the flat roof and pitched roof. But Douglas and Ransom [2006] in their research on understanding building failure find out that pitched roof have given few problems and flat roofs have given many. The roof's equipment is to protect the building from rain, sun, and wind and also the roof is used to keep water from getting into the building, but there are roof problems arise such as roof leakage and ridge leakage (Cheun, 2008). Floors have not been a high risk area in recent years but failures have occurred, particularly in concrete screeds, by chemical attack, usually by sulphates, on the concrete base slab and through insufficient support to the slab by inadequately compacted hardcore. Cheun (2008) identified the types of floor defect as concrete floor cracking, floor moisturizing and floor finishes defect. The function of ceilings is to cover the electrical, water pipe and fire resistance system which located between ceiling and roof structure. The types of ceilings defect are ceilings moisturizing, asbestos ceiling damage and peeling of ceiling paint. The functions of windows and doors are to protect the building from rain and wind and to provide good ventilation for school building. Such defects are wet rot in the frames, attack by termites and peeling of doors and windows frame. While, for the toilets, he identified the common types of defect as leaking in pipe and clog.

"What are green materials?" Simply put, materials of green building are those materials that implement the resources of earth in an environmentally friendly approach, esteem the restrictions of non-renewable resources, work within the approach of nature's cycles, are nontoxic, prepared from recycled materials, energy efficient and water-efficient, and green in the style that they are made, applied, and reclaimed after use. The materials implemented in green construction are important, like the buildings, and work to make constructive affects on the environment, all as making a building that meets all the demands of a building made from common materials. The simple variation is that they perform so without depleting the natural resources of surroundings, and also secure money in the long run (Retzlaff, 2009).

2.5.1 PROPERTIES OF MATERIALS

Quality evaluation as applied to building materials and products has been limited to a differential assessment of individual properties of a given object until recently. This to a great deal has impeded the determination of the overall level of quality and hampered the choice of all optimum material from a variety of competitive alternative. The characteristic properties of materials will determine its performance in the reality of climate. Some of the properties are;

a. Physical Properties

These are structural and mass characteristics such as density, porosity, void ratio etc, these describe the response of a material to water, vapor, gases (examples are hygroscopicity, water absorption, water permeability, moisture resistance, water resistance and permeability to water vapor and gases, heat, fire, cold, electric current, acoustics waves, radiation (thermal conductivity, heat resistance, fire resistance, refractoriness, cold resistance, electrical conductivity, sound-proofing and sound capacity, resistance to radiation, etc).

b. Chemical Properties

These characterize the ability of materials to withstand attack by corrosive environments, which can give rise to exchange reactions and eventually destroy the materials. Examples are acid resistance, alkali resistance and resistance to the simultaneous action of several corrosive agents.

c. Mechanical Properties

These have to do with the ability of a material to resist deformation and breakdown under the action of external forces. They include various kinds of strength hardness, elasticity, brittleness, ductility, yield, creep, abrasion resistance etc.

d. Biological and Sanitary Properties

These have to do with response to fungi, microorganisms, insects etc. Sanitary properties deal with dirt retention, which is usually determined, by the amount of open pores on the materials' surface. Building materials are exposed to physical, mechanical, chemical, biological, physico-chemical, biochemical and other factors acting in combination or even all at the same time (Airapetov, 2002).

2.6 RELATIONSHIP BETWEEN DESIGN AND BUILDIN G MAINTENANCE

Building efficiency can be affected by decision taken and actions performed at any time in the history of a building from its initial stage to its final stage. The designer should be involved in all these decisions because the design influence on the maintenance of all building is greater than ever before. Today, buildings are designed to meet more complicated needs than those of previous times do. Designer should know the building owner's requirements such as amount of space that he needs, the amount of money he can afforded to spend and the length of life he requires for his building. At this time in the preparation of the design, brief decisions can be taken which will have a vital effect on the amount of maintenance the completed building will need. The lowest initial cost in not necessary the most economical at the end, for cheaper materials often require more frequent maintenance and may have a shorter working life than the more expensive. Physical decay and deterioration of buildings due to weathering and even normal use, which are resulting in the need for an abnormal amount of repair and renewal, can be avoided by the exercise of greater care in detailed design at critical points of the structure and a better understanding of the nature and behavior of materials. The important factors, which contribute to the deterioration of a building, are:

A. Moisture.
B. Natural weathering.
C. Corrosion and chemical action.
D. Structural and thermal movement.
E. User wear and tear.

Therefore, at the design stage of a project, the building must be visualized in use, and materials and finishes chosen, capable of withstanding everyday wear and tear. The designer must choose materials and building that meets his client's functional needs and meets the budget constraints laid down and can be maintained in good working order for a reasonable time at a reasonable cost. Maintenance planning should be started at the design stage and continue throughout the life of that building (Mills, 1980).

2.7 RELATIONSHIP BETWEEN CONSTRUCTION AND BUILDING MAINTENANCE

The efficiency, appearance, life span and economic viability of any building can be affected by decision taken and action performed during construction stage. A construction defect as a consequence of wrong decision is one of the most common causes of early deterioration. Construction contractors should be aware about materials selection, construction techniques used and skilled labor hiring. The carelessness is one of those factors that affect the efficiency and durability of any building. The defects on any building during construction stage that causes more maintenance expenditure can be predicted to inaccuracies during construction. The fixings and bearing cannot tolerate the differential movements leading to structural defects.

2.8 BUILDING MAINTENANCE COST'S FACTORS

Building maintenance costs increase and decrease according to the designers and construction contractor's education, experience and comply with the specifications and standard. In this research, effort will be done to identify factors affecting building maintenance cost.

2.8.1 ENGINEERING SERVICES

A.DESIGN COMPLEXITY

Building should be designed in such a way to be simple in maintenance. Design complexity will prevent maintenance work to be carried out easily, quickly and economically. Major replacement can often be avoided if regular cleaning and minor repair can be carried out without difficulty. For example, maintenance requires some tools to be performed. If the designer does not allow enough clearance to get the tools in and out, this minor problem will get bigger and become major problem. In addition, designer should always avoid permanent fixing of elements, which need continuous maintenance, e.g. such as lamp, carpets (Mills, 1980).

B.FAULTY DESIGN

It includes all defects that were caused during the early stage of design and particularly in the structural design such as: when designer ignores the spacing for contraction and expansion movement. Such movement causes cracking of the structure, which will result in fractures in pipes or joint failure (Al-Shiha, 1993).

C.POOR QUALITY CONTROL

Quality Control is the process used to control, inspect, test and record procurement, fabrication and installation in conformance with contract document. During the construction and maintenance stages, quality control program should be set out. It is used to control, inspect and test record of activities in accordance with the contract requirement and construction procedures. A facility with the presence of an effective QC program has fewer defects and therefore requires less maintenance than a facility where no QC program has been considered. Also, during the maintenance stage the presence of QC is vital to assure that the components are required or maintained as per the contract documents (Mohamoud, 1994).

D.UNFAMILIARITY WITH LOCAL CONDITIONS

The designer should have an idea about the building location and type of plants and insects existing in the area. He should specify the treatment method if existing in the design drawings. It is because such these biological factors can harm the building and lead to continuous maintenance (Liska, 1988).

E.UNFAMILIARITY WITH SITE CONDITIONS

Designer should be familiar with buildings site condition such as soil condition. Ignoring variation in soil condition will cause setting, which will cause cracking of structural elements (Al-Khudair, 1988).

2.8.2 LABORS

A.UNAVAILABILITY OF SKILLED LABORS

Skilled labors are important for maintenance work and they should be available to perform job and utilize equipment. It is because they perform work according to their past experience and their skills. Employing labor with the requisite skills will assist to improve the quality of work, minimizing cost and reduce work time span. Therefore, just having the right tools does not mean the job will be performed properly (Al-Khudair, 1988).

B.DEFECTS AND FAULTY WORKMANSHIP IN THE INITIAL CONSTRUCTION

Some building defects have their origin in the building process itself. Due to inaccuracies during construction, the fixing and bearings cannot tolerate the differential movements leading to structural defects (Mills, 1980).

2.8.3 BUILDING MATERIALS

C. MATERIALS SELECTION DOES NOT COMPLY WITH CLIENT'S ACTIVITIES

Materials selection should meet the performance requirements expected. Using bad quality of materials will cause failure of the materials, which will require replacement, correction or more maintenance works in the future. Selection of inferior materials during the construction stage will cause more problems during the maintenance stage (Merritt, 1975). Therefore, selection of materials should be in compliance with the performance specification requirements in order to minimize future expenses during maintenance stage.

D.IGNORANCE ABOUT THE BASIC PHYSICAL AND CHEMICAL PROPERTIES OF MATERIALS

One of the major causes of building deterioration and other unsatisfactory features of many buildings is the bad understanding of the nature and behavior of materials. The failing to make allowance for the differing thermal and moisture movements of materials in combination will adversely affects building functional performance or appearance (Lee, 1987).

E.USAGE OF CHEAPER/ SUB- STANDARD MATERIALS

The lowest initial is not necessarily the most economical in the end. For cheaper and sub-standard materials often require maintenance that is more frequent and may have a short working life than the more expensive alternative.

2.8.4 ENVIRONMENTS

A.HARD CLIMATE CONDITION

Weather condition is often responsible for chemical action on building materials. Atmospheric pollution associated with rain, causes rapid deterioration of some materials (Patton, 1982).

B.UNQUALIFIED MAINTENANCE CONTRACTORS

The specialized and well-experienced maintenance contractors are important to perform maintenance work effectively. A good maintenance contractor is a solid performer who knows the costs and knows what he can or cannot do, and realizes that his regulations are built upon his past performance (Al-Hazmi, 1995).

C.AGING OF THE BUILDING

Building components have expected life, at the end of which, demolition or replacement would be imperative.

2.8.5 BUILDING USERS BEHAVIORS

A.USER DOES NOT UNDERSTAND IMPORTANCE OF MAINTENANCE WORK

Building users often pay little attention to keeping their building in good working order and are surprised when they fail to give the service they expected. It has already been emphasized that buildings start to deteriorate from the day they are completed. The length of time this process of decay takes depends on the care taken in: firstly, the design, secondly the construction, and thirdly the upkeep or maintenance.

B.MISUSE OF BUILDING AFTER COMPLETION OF THE CONSTRUCTION

When building construction is completed, owners must be using their buildings and its components in proper way. The misuse of components will result in their damage and need for repair, which would be costly (Mahmud, 1994).

C.NOT USING PREVENTIVE MAINTENANCE

Neglect of preventive maintenance such as checking the efficacy of rainwater gutters and servicing mechanical and electrical installation causes more extensive periodical maintenance and, in the long run, major repair or restoration which could have been avoided or postponed (Fattani, 1998).

D.WRONG BEHAVIORS OF OCCUPANTS

Building occupants often pay little attention to keeping building in good working order and are surprised when they fail to give the service they expected. The misuse of building services will result in their damage and the need for repair, which will be costly. Also, the abnormal occupier activities can cause the rapid deterioration.

2.3 CONCLUSION

2.3.1. Summary of Key Literature Findings

According to Faremi (2007) the longevity of any building can be prolonged by the designers at the design stage. Therefore every decision made during the building design stage of a design has its own impact on a building. Architects at the design stage of a project must visualize the building in use, and materials and finishes chosen, its capability of withstanding everyday wear and tear. According to Iyagba (2005) all buildings are prone to deterioration (i.e., wear and tear) and no structure can reasonably be expected to last forever. The designer according to Chong (2006) the maintenance condition of any building is determined by accessing the building components including the roof, walls, floors plumbing and electrical fittings and also doors and windows.

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CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION.

When undertaking research it is important to choose the correct methodology, to ensure that the research objectives can be met and that the findings can be validated (Steele 2000; Fellows and Liu, 2003). This chapter discusses the research design and methodology and highlights the general approach to the research. It describes and justifies the methods and processes that will be used in order to collect data that will be used in answering the research questions.

3.2 METHOD OF STUDY

Kothari (2003) defines research as the pursuit of truth with help of study, observation, comparison and experiment that is a systematic method of finding solutions to a research problem identified. Kothari (2003) further argues that the process of research is a systematic method that includes the following in logical sequence:

a) Enunciating or defining the research problem.

b) Formulating the hypothesis/research questions from the research problem.

c) Designing the appropriate research process.

d) Collecting facts or data to help answer the research questions

e) Analyzing the data

f) Reaching certain conclusions from the analyzed data hence answering research questions.

The nature of a research topic, its aims and objectives and the resources available largely determine its design (Creswell, 2003).This research therefore integrates a literature review and a case study. While the literature review provides an overview of building maintenance practices, the case study provides qualitative and contextual data on the building maintenance procedures of a typical institutional building in Nigeria.

3.3 POPULATION OF STUDY

A population can be defined as the complete set of subjects that can be studied: people, objects, animals, plants, organizations from which a sample may be obtained (Shao, 1999). Frankfort-Nachmias and Nachmias, (1996), describe population as the entire group or set of cases that a researcher is interested in generalizing. For the purpose of this research, the population consists of the buildings of some selected public institution in Nigeria. This include the faculty of applied sciences Umar Musa Yaradua university Katsina, the college of science and technology Hassan Usman Katsina Polytechnic Katsina, the department of Architecture Ahmadu Bello University Zaria an also the Center of Excellence Ahmadu Bello university Zaria.

3.4 SAMPLING

Kumar (1999) explains that a sample is a sub-group of the population which is an ideal representative of the entire population. Researchers usually cannot make direct observations of every individual in the population they are studying. Instead, they collect data from a subset of individuals (a sample) and use those observations to make inferences about the entire population (Zickmund 1991). For the purpose of this research, a non-probability sampling was used and the selection was purposive where three institutional buildings were selected after careful consideration and due to the fact that they will provide the answers to the reserch questions in chapter one. The sampling has being limited to four buildigs, two from the same region of this research (Katsina) and also two from the nearest area (Kaduna) having the closest climatic characteristics.

3.5 INSTRUTMENT OF DATA COLLECTION

Case study for theoretical research in architecture may require the use of general methods for data collection (Oluigbo, 2010). For purpose of this research, Data was collected from the population using the following data collecting techniques or instruments; Field survey and physical observation of the buildings under study, and a structured interview. Furthermore, Photographs of buildings defects relevant to the study were also taken.

3.6 PROCEDURE FOR DATA COLLECTION

Data was collected from the population using the following data collecting procedures:

3.6.1 FIELD SURVEY AND PHYSICAL OBSERVATION

The researcher undertook field observation of buildings in the selected institutions to see physically and to determine the nature of the coated surface, check for cracks and fungi infestation, the floor screed, broken windows and doors, non functional electrical fittings, faulty sewerage and broken down drains, damaged ceiling and ripped off/ rusty/ leaking roofs.

3.6.2 STRUCTURED INTERVIEW

. According to Moser and Kalton (1971) an interview is a conversation between interviewer and the respondent with the purpose of eliciting certain information from the respondent. The personal interview is a face-to-face, interpersonal role situation in which an interviewer asks respondents questions designed to elicit answers. With this form of interview the number of questions and the content are identical for all of the respondents. Respondent were largely occupants and or users of the buildings under study and were selected randomly.

3.6.3 PHOTOGRAPHS

Photographs of the building defects were taken of the cases possibly any floor screed, broken windows and doors, non functional electrical fittings, faulty sewage and broken down drains, damaged ceiling and ripped off/rusty/leaking roofs.

3.6.4 CASE STUDY.

According to Frankfort and Nachmias (1996 p. 146), a case study involves an observation of a single group or event at a single point in time, usually subsequent to some phenomenon that allegedly produced change. To Kumekpor (2002), a case study method can be conceived as a method of investigation which aims at studying the facts of a particular case from all aspects and from all angles. The results generated through case studies are considered more compelling and more robust (Yin, 2003). It gives an opportunity to delve into one aspect of a problem in more detail within a limited timeframe (Bell, 2005). Therefore, considering the nature of the information required, it will not be difficult to conclude that the case study approach is appropriate for this study. In reference to the research at hand, the researcher would study the public institutions extensively in order to have an in depth understanding of their maintenance policies and practices and how it impacts on the maintenance cost and the lifespan of these buildings.

3.7 VARIABLES OF THE STUDY

According to Kumar (1999), a variable is a property that takes on different values. However in this study, the main variables to be measured include specific building elements such as roofs, walls, and foundation that decay as a result of non maintenance, the age of the buildings, and the design (facilities) of the building. A set of indicators have been developed by the author to measure and asses the maintenance condition of public and institutional buildings.

Elements and Facilities	Indicators of Measuring Maintenance of Buildings
Roofs	Leakage, rusty, partly ripped off, completely ripped off.
Windows and Doors	Partly broken down, completely broken down, no problem
Painting	No Painting, faded painting, dirty, well painted
Floor	Develop cracks, peel-off, partly broken down, no problem
Walls	partly broken down, develop cracks, peel – off, tilted
Age of the building	Old (above 50 years) medium aged (20-50 years) and younger buildings (less than 20)

Source: Authors contribution to knowledge

3.8. DIFFICULTIES EXPERIENCED DURING FIELD SURVEY.

Access to every facility was very easy as a result of the letter of introduction I received from my department. Therefore there were no major difficulties experienced during the field survey except for the fact that I did not get the chance to interview the dean of the p.g school in Ahmadu Bello University Zaria

CHAPTER FOUR

CASE STUDY

4.1 INTRODUCTION

Case study research in Architecture goes beyond the documentation and description of the physical characteristics of the built environment (Oluigbo, 2010). Hence, the findings and results gotten have to be assessed based on specific approaches addressing the research question or issue directly and out listing how the findings have been able to be of help to answer the research question. This can be in the form of variables that seek to point out certain features as identified in the visual survey.

The basis for selection of these case studies is their potential to supply the necessary information and details with regard to maintenance. All the relevant information were collected through personal observation, notes and checklist as well as photographs.. Generally, four case studies were documented which include:

1. College of science and Technology in Hassan Usman Katsina Polytechnic (CST), Katsina
2. Department of Architecture, Ahmadu Bello University Zaria.
3. Faculty of Natural and Applied Science, Umar Musa Yaradua University
4. Center of Excellence Ahmadu Bello University Zaria

This case study examines the general maintenance situation of the three public institutional buildings in relation to the building elements. A building is made of several elements with each performing specific functions. The effective functioning of these elements determines the condition of a building. The maintenance condition of the buildings will be done by assessing the following elements: the foundation/substructure, the roof, the floor, the wall, painting, and wooden members (window and door) sanitary facilities, plumbing and electricity. The case studies shall be discussed under the following checklist.

A. General background
B. structure
C. management
D. present state/condition of building elements

4.2 CASE STUDY ONE: COLLEGE OF SCIENCE AND TECHNOLOGY, HASSAN USMAN KATSINA POLYTECHNIC

4.2.1 BACKGROUND

Hassan Usman Katsina polytechnic is located along the Katsina to Dutsinma expressway in Batagarawa local government area in Katsina State. The college of Science and Technology is located in the center of the main campus.

4.2.2 STRUCTURE

Built in the 1970s, the rectangular shaped structure consisting of offices and lecture rooms is made of reinforced concrete frame with parapet and roofs gutters. Roof is flat with a slope of less than 10 degrees. External and internal walls are made of sandcrete block work. The floor has a fine and durable terrazzo finishing while the windows are glass with aluminum metal frame as shown in plate i.

Plate I: building structure of College of science and technology Katsina polytechnic.(Source: fieldwork April, 2013.)

4.2.3 MANAGEMENT

The building is maintained and managed by staffs from the maintenance unit of the institution. It therefore depends completely on the schools maintenance policies. However, they faced many problems in maintenance policy and procedures which results to a lot of defects to the building as shown in figure ii.

Plate III: concrete feel off on the administrative block polytechnic.(Source: fieldwork April, 2013.)

4.2.4 PRESENT STATE/ CONDITION OF BUILDING ELEMENTS

1. ROOF

The predominant roofing material identified in the study area was the iron sheet. It was identified that the roof was a flat roof with the presence of parapets. Most of the buildings have leaking roof due to the fact that the roof is flat as shown in plate iii. Therefore to solve the problem of a leaking roof, pitched roof with the appropriate slope is highly recommended.

Plate III: flat roof the student's library
(Source: fieldwork April, 2013.)

II.WALL

The walls in the study area were found to be very durable as no visible cracks were noticed. The walls are of sand Crete blocks in plate iv. Hence concrete walls are the most recommended wall type because it hardly has maintenance problems.

Plate IV: wall (Source: fieldwork April, 2013.)

III.FLOORS

The floor of any public building is an area that experiences a lot of activity due to the movement of occupants and as such undergoes both imposed and natural stress; hence the rate of wear is enhanced and more pronounced. But fortunately, the floor under survey was in a fair condition as only the floor finishing in some offices needs repair. The floor is of concrete and finished with a fine and durable terrazzo finishing in classes and tiles in the offices as shown in plate v . This floor type is highly recommended.

Plate V: floor in offices (Source:fieldwork April, 2013.)

IV.PAINTING

The painting has faded over long period of time as shown in plate vi. This problem can be taken care of by tiling some parts or the entire walls with ceramic, marble, granite tiles or alluco bond especially the exterior walls. Apart from its maintenance free nature, it also has the advantage of been aesthetically pleasing.

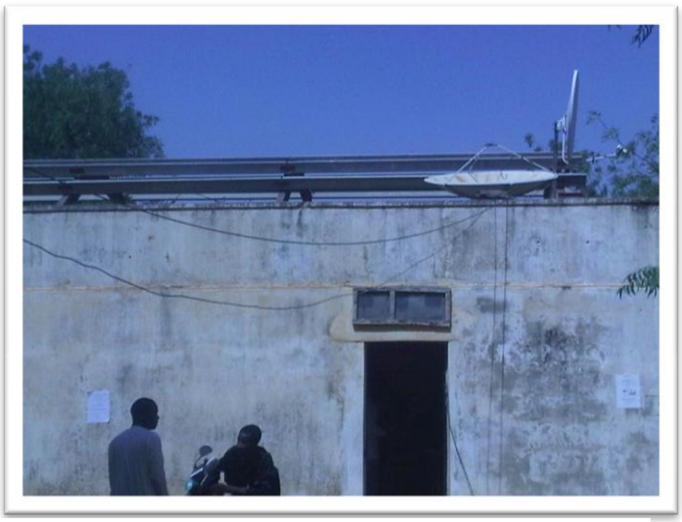

Plate VI: faded painting at the rest room Source: fieldwork April, 2013.)

V. DOOR AND WINDOWS

The building was designed in such a way that it is very difficult to access the windows on the second and third floors as shown in plate vii. It is necessary to design buildings by providing a kind of platform for maintenance of windows and to provide them with the necessary protection from several weather elements.

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Plate VII: difficult to clean windows of classes(Source: fieldwork April, 2013.)

VI. PLUMBING FITTINGS

The building has a lot of plumbing problems. This is because the pvc made pipes are exposed and they tend to suffer a lot of accidental breakage as shown in plate viii. This can be solved by using preferably metal pipes and also by encasing them in concrete or walls or hiding the exposed ones from activity areas.

Plate VIII: plumbing services in a very bad condition:(Source: fieldwork April, 2013.)

VIII. ELECTRICAL FITTINGS

Fitting here are in a very bad condition mostly affected by rain. Design should provide adequate protection to from rain and other elements by the use of long eves or parapet as shown in plate ix

Plate IX : electrical services in bad condition
(Source: fieldwork April, 2013.)

SCALE FACTOR:4=very bad, 3=bad, 2=fairly good, 1=good

VARIABLES/BUILDING ELEMENTS/FACILITIES	CONDITION	SCALE FACTOR	REMARK
Wall	peel – off	2	Fairly good
Floor	Develop crack	3	bad
Roof	Leakage, rusty, partly ripped off,	4	Very bad
Painting	faded painting	3	bad
Windows and doors	Partly broken down	2	Fairly good
Plumbing fittings	Leakage, exposed, partly broken down	4	Very bad
Electrical fittings	Damaged, exposed to weather elements	4	Very bad

Table 1 SUMMARY OF THE MAINTENANCE CONDITION OF COLLEGE SCIENCE AND TECHNOLOGY HASSAN USSMAN KATSINA POLYTECHNIC KATSINA.

(Source: fieldwork April, 2013.)

4.2.5 CONCLUSION

From the above analyses, the roof, plumbing and electrical fittings are in a very bad condition. Walls here are in a good condition as no visible cracks were noticed. The floor is in a good condition except for cracks been experienced due to poor finishing design. The building walls have faded over time therefore in need of urgent repairs. Doors and windows are in a fair condition because most of them are shaded against weather elements but also difficult to access when maintenance operation is needed.

4.3 CASE STUDY TWO: DEPARTMENT OF ARCHITECTURE, AHMADU BELLO UNIVERSITY ZARIA

4.3.1 BACKGROUND

Ahmadu Bello University is located along the Zaria to Sokoto highway in samara, Zaria. The department of Architecture is located in the center of the main campus.

4.3.2 STRUCTURE

The Architecture department is a cantilevered structure built in 1950S. The rectangular planed shape building was designed as an administrative as well as an academic building consisting of both staff offices and lecture rooms. The departmental studio was designed as a separate building but connected to the main building by the means of a staircase. The main structure has a vertical shading device that protects the building from the various elements of whether. Horizontal glass louvered windows provide the means by which the building is ventilated and lightened as shown in plate x.

Plate X: building structure Department of Architecture A.B.U Zaria (Source: fieldwork April, 2013.

4.3.3 MANAGEMENT

The building is maintained and managed by the staff from the maintenance department of the school. Therefore maintenance is purely based on the schools maintenance policies. No major maintenance work has been carried out on the building.

4.2.4 PRESENT STATE/ CONDITION OF BUILDING ELEMENTS

I.ROOF

Similar to the previous study, roofing material identified in the study area was the galvanized iron sheet. There is leakage on the roof and the roof is blown off in some parts. This can be due to the high amount of rainfall being experienced in the area. Most problems of cracked walls and floor leakage is associated with leaking roof. Leaking problems here can be avoided by the use of a pitched roof It was identified that the roof was a flat roof with the presence of roof gutters. This can be seen in plate xi.

Plate XI: roof leakage at the roof top studio (Source: fieldwork April, 2013.)

II.WALL

Very few problems exist to the walls as visible cracks and peel-off was noticed. The walls were made of sandcrete block and problems may arise as a result of the leakage, poor workmanship or the blocks do not have adequate strength. Therefore concrete walls are the most desired wall type because it hardly has maintenance problems and will be suitable for areas with high rainfall as erosion and weathering can equally be avoided.

Plate XII: faded painting on walls (Source: fieldwork April, 2013.)

III.FLOORS

The ground floors here are in a good condition which are of concrete and finished with a fine and durable terrazzo finishing. Except in the case of floor slabs in which a lot of leakage is been experienced.

Plate XIII: floor leakage (Source: fieldwork April, 2013.)

IV.PAINTING

The painting has really faded over time. This is even more pronounced in areas exposed to different weather conditions. This problem can be taken care of by using double coating or by tiling some parts or the entire walls with ceramic, marble, granite tiles or alluco bond.

Plate XIV: faded painting on walls (Source: fieldwork April, 2013.)

V. DOORS AND WINDOWS

Mainly glass louvered windows with metallic frame and. The door and windows here are relatively in a fair condition due to the presence of vertical fins that protects them, but also making it very difficult for proper maintenance operation. Therefore it is necessary to design buildings by providing a kind of platform for maintenance of windows and to provide them with the necessary protection from several weather elements.

vi. PLUMBING FITTINGS

The building has a lot of plumbing problems. This is because the pipes are p.v.c made and are exposed and therefore suffers a lot of accidental breakage as show in plate xv. This can be solved by using preferably metal pipes also by encasing them in concrete or walls or hiding the exposed ones from activity areas.

Plate XV: plumbing services
(Source: fieldwork April, 2013.)

VII. ELECTRICAL FITTINGS

Fittings here are in a fair state because they are mostly protected from different weather elements .Design should provide adequate protection to from rain and other elements by the use of long eves or parapet**.**

SCALE FACTOR:4=very bad, 3=bad, 2=fairly good, 1=good

VARIABLES/BUILDING ELEMENTS/FACILITIES	CONDITION	SCALE FACTOR	REMARK
wall	peel – off	2	Fairly good
Floor	peel-off of finishes	3	bad
Roof	Leakage, rusty, partly ripped off	4	Very bad
Painting	faded painting, dirty	3	bad
Windows and doors	Partly broken down	2	Fairly good
Plumbing fittings	Leakage, Partly broken down, exposed	3	bad
Electrical fittings	Mostly shaded from weather elements	2	Fairly good

Table 2: SUMMARY OF MAINTEANCECONDITION OF DEPARTMENT OF ARCHITECTURE AHMADU BELLO UNIVERSITY ZARIA

(Source: fieldwork April, 2013.)

4.3.5 CONCLUSION

The roof here has the most intense problem followed by plumbing, painting and floors respectively.

The electrical fittings are in a good condition while some windows need urgent repair

4.4 CASE STUDY THREE: FACULTY OF NATURAL AND APPLIED SCIENCE, UMAR MUSA YARADUA UNIVERSITY KATSINA.

4.4.1 BACKGROUND

Umar Musa Yaradua University is located along the Katsina to Dutsinma road almost 11km away in Batagarawa local government area in Katsina State. The faculty of science is located in the center of the campus and very close to the faculty of education as shown in plate xvi.

Plate XVI: building structure of the faculty (Source: fieldwork April, 2013.)

4.4.2 STRUCTURE

Built in the 2005, the structure consists of offices and lecture rooms made of reinforced concrete frame with concrete parapet roof as shown in plate xvii. External and the internal walls are of sandcrete block work. The doors are of metallic and therefore very durable while windows are of glass with steel frame. The floor is of terrazzo floor finishing.

Plate XVII: structure showing shading devices
(Source: fieldwork April, 2013.)

4.4.3 MANAGEMENT

The building is been managed and maintained by a private maintenance company which is also responsible for maintaining and managing all the buildings in the university. Therefore maintenance is purely based on the company's maintenance policies.

4.4.4 PRESENT STATE/ CONDITION OF BUILDING ELEMENTS

i. ROOF

This new building has already started to experience roof leakage as shown in figure xviii because the roof is flat with slope less than 10. Therefore a pitched roof with the appropriate slope is highly recommended

Plate XVIII: roof leakage (Source: fieldwork April, 2013.)

II.WALL

There are some few cracks on walls and on some parts of floor as shown in plate xix. This is a sign of a weak foundation, leaking roof and or poor workmanship or the bricks do not have adequate strength. Hence concrete walls are the most recommended wall type because it hardly has maintenance problems.

Plate XIX: cracked walls (Source: fieldwork April, 2013.)

III.FLOORS

The floor under survey was in a fair condition as some few cracks were noticed. The floor is of concrete and finished with ceramic tiles in the offices and a fine and durable terrazzo finishing in the lecture rooms and lobbies as show in plate xx.

Plate XX: floor finishing along staircase
(Source: fieldwork April, 2013.)

IV.PAINTING

The painting has really faded over long period of time. This problem can be taken care of by tiling some parts or the entire walls with ceramic, marble, granite tiles or alluco bond especially on the exterior walls.

V.DOORS AND WINDOWS

The building was designed with horizontal fins that protects the windows and also in such a way that it is very easy to access the windows on the second and third floors. It is necessary to design buildings by providing a kind of platform for maintenance of windows and to provide them with the necessary protection from several weather elements.

VII. PLUMBING FITTINGS

The building has a no plumbing problems because metal pipes were used and were encased them in concrete or walls

VIII. ELECTRICAL FITTINGS

The building was designed to provide protection for almost all electrical fittings.

SCALE FACTOR:4=very bad, 3=bad, 2=fairly good, 1=good

VARIABLES/BUILDING ELEMENTS/FACILITIES	CONDITION	WEIGHT FACTOR	REMARK
wall	develop cracks,	2	Fairly good
Floor	Develop cracks	2	Fairly good
Roof	Leakage	3	Bad
Painting	dirty	2	Fairly good
Windows and doors	Mostly protected	1	Good
Plumbing fittings	Not exposed, no problem	1	Good

Table 3 SUMMARY OF THE MAINTENANCE CONDITION OF THE FACULTY OF NATURAL AND APPLIED SCIENCES UMAR MUSR YARADUA KATSINA

(Source: fieldwork April, 2013.)

4.4.5 CONCLUSION

From the above table, the roof has the most severe problem followed by walls and floors. This can be due to the fact that the roof is a flat roof. The windows and electrical, plumbing fittings were found to be in a good condition. Windows here are fully shaded and easily accessed in case of periodic maintenance operation.

4.5 CASE STUDY FOUR: CENTER OF EXCELLENCE AHMADU BELLO UNIVERSITY ZARIA.

4.5.1 BACKGROUND

The center of excellence is located in Ahmadu Bello University Zaria in the Samaru main campus very close to the school dam. The construction of this institutional structure started in 2010 and its been financed by the central bank of Nigeria. The aim of choosing this building as a case study is to have an idea and insight of the current facilities that are to be expected in any modern postgraduate school as shown in plate xxi.

Plate XXI: building structure
(Source: fieldwork October, 2014.)

4.5.1 STRUCTURE

Thou not fully constructed, the building is up 90% completion. It was designed as a postgraduate school housing many facilities including the administrative building and students hostels. The structure consists of offices, seminar room, lecture rooms library, students screening rooms and many other facilities necessary in any post graduate school. It also has a social center as an adjoining building housing few restaurants, shops and a open courtyard. External and some internal walls are finished with a good looking mosaic tiles while the floors are finished with a durable terrazzo floor finish.

4.5.2 MANAGEMENT

The building is to be managed by the central bank of Nigeria for a period of six months after which the school management will take over. Therefore maintenance is purely based on the school's maintenance policies.

4.5.3 FACILITIES AND FUNCTIONS

The building was designed to house several facilities which can be found in any world class postgraduate school. This facilities and spaces are very important in any academic environment. The include

a. Staffs offices
b. Lecture rooms
c. Seminar rooms
d. Computer room
e. Auditorium
f. Library
g. Restaurant or eatery
h. Students lounge

i. Staffs lounge

j. Bookshop and so many other facilities.

4.5.4 MERIT AND DEMERITS AS IT RELATES TO BUILDING MAINTENANCE

Merits

a. External walls and some internal walls are entirely finished with mosaic tiles which require low maintenance at the same time is aesthetically pleasing as shown in plate xxii.

Plate XXII: external walls finished with mosaic tiles which are maintenance free (Source: fieldwork October, 2014.)

B Internal floors are finished with terrazzo floor finishing which is highly recommended in public building because of its durability as shown in plate xxiii .

Plate XXIII: floor finishing with terrazzo which is durable for maintenance (Source: fieldwork October, 2014.)

b. Presence of a courtyard system which makes proper ventilation possible therefore lowering the cost of cooling the interior spaces.

c. Presence of a sanitary system that will allow easy maintenance operation to be carried out if the need arises as shown in plate xxiv

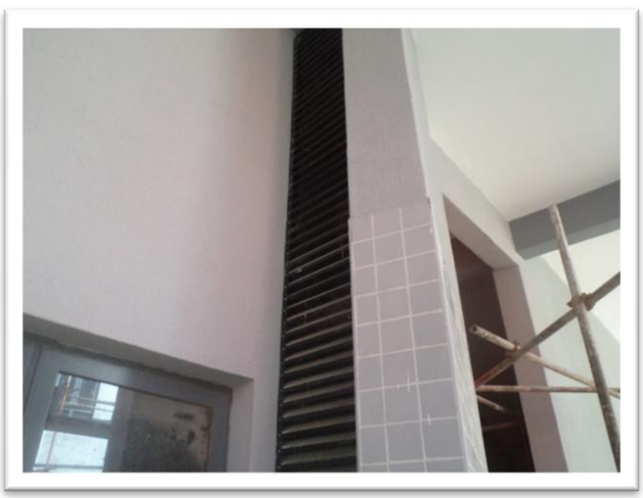


Plate XXIV: service duct for easy maintenance and servicing (Source: fieldwork October, 2014.)

Demerits

1. Access to windows on the first and second floors for maintenance operations will be very difficult. This is due to the absence of a ledge or anything that can serve as a flat form for maintenance operations to be carried out with ease as shown in plate xxv.

Plate XXV: difficult to access windows for maintenance (Source: fieldwork October, 2014.)

2 Absence of shading devices on the second floor. The windows are too much exposed and direct solar radiation will have easy access into the building.

3 Electrical fittings are exposed due to absence of roof overhang.

iii. Absent of screening rooms for students.

4.5.5 CONCLUSION

This case study has concluded by providing the researcher with information on the facilities needed in any postgraduate school and at the same time the merits and demerits in relation to the buildings maintenance. These findings of this case study therefore shall be applied in the design of the proposed school of postgraduate studies for Umar Musa Yaradua university Katsina.

SCALE FACTOR: 4=very bad, 3=bad, 2=fairly good, 1=good

VARIABLES	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	REMARK
wall	2	2	2	Fair
Floor	2	2	2	Fair
Roof	3	3	2	Very bad
Painting	3	3	3	Very bad
Windows and doors	3	1	1	Fairly good
Plumbing fittings	4	4	2	Very bad
Electrical fittings	3	1	1	Fairly good

Table 4 SUMMARY AND ANALYSES OF CASE STUDIES
(Source: Authors fieldwork April, 2013.)

The analyses of the table above shows that among all the building elements surveyed, the roof and plumbing fitting has the most maintenance problems. The reason for this was identified to be presence of flat roofs and exposed plumbing system respectively. Wall, floors, windows and doors are in a fair condition while faded painting problems needs urgent attention.

Among the causative factors studied, poor design is the main contributing factor responsible for the maintenance problems. Inappropriate use of materials was found to be the second most influential factor followed by poor workmanship. Lack of proper and functional maintenance operations is also a leading factor in institutional buildings.

4.6 SUMMARY OF KEY RESEARCH FINDINGS

Among all the building elements surveyed, roof and plumbing and painting were found to have most maintenance problems respectively while the walls, floors doors and windows as well as electrical fittings had the least of problems. The following are findings also drawn from this research

- A flat roof contributes a lot to maintenance problems in institutional buildings especially where the amount of rainfall is relatively high. Therefore pitched roofs are highly recommended to cater for this problem
- Most building designs do not provide a platform or any means by which windows especially of high rise buildings can be easily cleaned and maintained.
- Building designs should consider the possibility of tilling some wall parts especially external walls with ceramic, marble, alluco bond etc to solve periodic painting problems
- Designs should encourage the use of parapets, long eaves and other elements that will protect electrical fittings
- All designs should be in such a way that all plumbing fittings are either encased in walls/concrete or are hidden away from activity areas to avoid vandalism

4.7 CONCLUSION

The research concludes by enumerating a number of findings aimed at addressing the maintenance problems and rising cost of maintaining public buildings in Nigeria. It is hoped that these recommendations if properly implemented will contribute in no small way in reducing the problems and consequently the high cost of maintenance plaguing the public sector in the country at the moment

CHAPTER FIVE

SITE LOCTION AND ANALYSES.

5.1 SITE LOCATION

The site for the proposed school of postgraduate studies Katsina national museum is located in the Umar Musa Yaradua University along Dutsen-ma road, Katsina. Katsina is one of the hot dry parts of the savannah to the north. Katsina is located about 1126 kilometers away from the sea (12°58 'N-7°45 'E). The total area of Katsina is 8000 square kilometres and bordered by Niger Republic to the north, Kano and Jigawa states to the East, Kaduna state to the south and Zamfara state to the west.

Figure 1: Map of Nigeria showing Katsina state (Source: Ministry of Works, Housing and Transport Katsina)

5.2 CLIMATIC CONDITION

Katsina possesses a tropical continental climate with distinct wet and dry season. This is generally classified as semi-arid. Generally the weather is cool in the morning, hot in the afternoon, cool again in the evening. Between November and January the dry season lowers the temperature. The wind is dry in January to April.

5.2.1 TEMPERATURE

Temperature is generally high throughout the year. The average maximum daily temperature reached is 29.4°C. The average minimum daily temperature reached is 12.5' C. The temperature varies from season to season, but the total average hours receiving sunshine in a day is 8.3 hours.

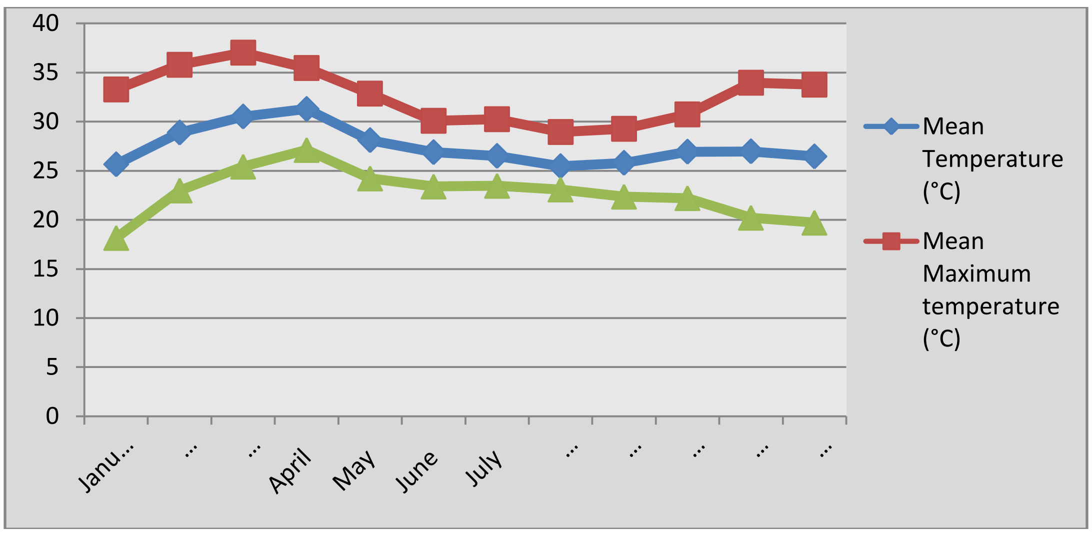


Figure 2: Temperature

(Source: http//www.gaisma.com, may20th, 2013)

5.2.2 RAINFALL

The rains usually start in June or July during these rainy months the south-westerly winds are dominant winds and are heavy with moisture. They produce zones of intense convectional rainfall. The month of August has the highest amount of rainfall each year.

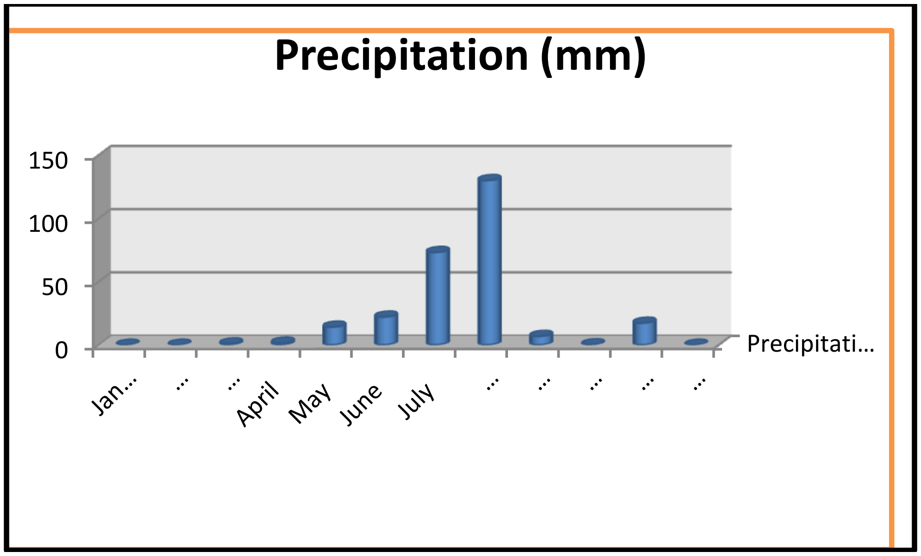


Figure 3:: Precipitation

(Source: http//www.gaisma.com, .may20th, 2013)

5.2.3 EVAPORATION

The rate of evaporation usually increases during the dry season. During the rainy, season the rate of evaporation decreases due to increase in the atmospheric pressure. The daily vapor evaporation is 13.4mL

5.2.4 WIND DIRECTION

In Katsina the wind direction follows the two reasons; the wet and dry seasons. The type of air masses prevailing in Katsina are the dust laden harmattan from the north east winds (November to March) and the moisture laden south-west trade winds from the Atlantic Ocean. The wind run in Katsina is 197.81 km/s.

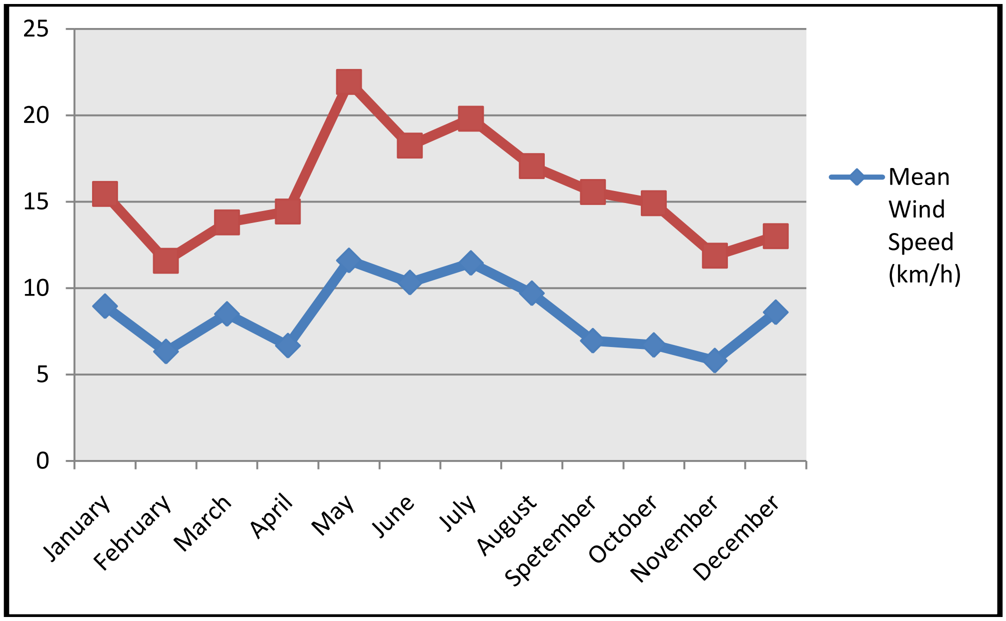


Figure 4: Wind speed

(Source: http//www.gaisma.com, may20th, 2013)

5.2.5 RELATIVE HUMIDITY

The relative humidity is always very low. The average humidity is 22 %.

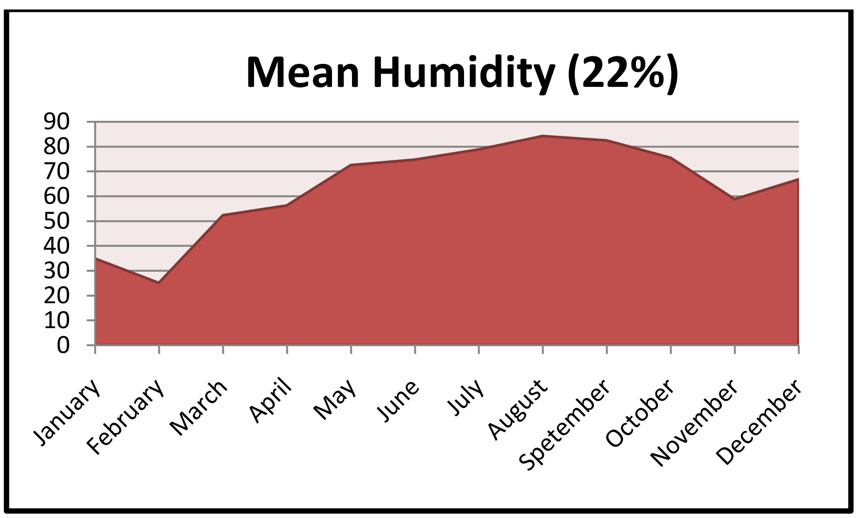


Figure 5: Mean Humidity

(Source: http//www.gaisma.com, May 20th, 2010)

5.3 SITE SELECTION

The site has a total area of about 110,000msq. The whole site can be utilized and developed considering the good features it possesses. Site selection is considered to be one of the most important steps to be considered during a design. It entails the selection of a site based on certain key factors such as proximity, compatibility, suitability with the purpose of the proposed structure, views, surrounding features and so on. However, for the purpose of this research, the already proposed site by the university was found to be suitable due to the factors listed below:

5.3.1 CRITERIA FOR SITE SELECTION

- The site is located in the core administrative area of the school very close to the senate building.
- Availability of services including road network, drainage system, as well as electricity poles.
- Presence of existing trees that can be utilised as shading devices thus minimising the cost of cooling.
- Relatively flat site with no interrupting features whatsoever.
- Visual aesthetic potentials
- Size of the site is suitable in case of future expansion.

5.3.1 ACCESSIBILITY

The site can be accessed from two major roads that are to the west and northern part of the site. But the best and easier access to the site is from the northern part which is easy to locate and less busy as shown in plate xxvi.

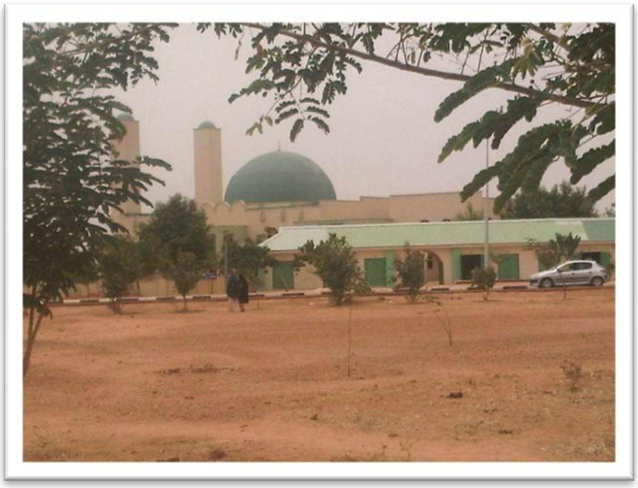


Plate XXVI: access to the site is along the road linking to the central mosque
(Source: fieldwork April, 2013.)

5.3.2 GEOLOGY

The sub-soil comprise of clay and lateritic bed of granite type. While the top soil is made of fine lateritic silt sand with very few gravel stones as shown in plate xxvii

Plate XXVII: site geology which is relatively flat: (Source: fieldwork April, 2013.)

5.3.3 VEGETATION

The site is covered by tall grasses and trees which are distributed covering up to 45% of the ground as shown in plate xxviii. The trees are to be appropriately utilised for landscaping and to reduce solar radiation thus minimising the cost of cooling.

Plate XXVIII: site vegetation to be utilized for shading devices and wind breakers
(Source: fieldwork April, 2013.)

5.3.4 TOPOGRAPHY

The site can be referred to as relatively flat as it has a very low lying strip of land with 0.5% gradient sloping towards the north-western end of the site as shown in plate xxix.

Plate XXIX: site topography (Source: fieldwork April, 2013.)

5.3.5 SERVICES

The site is located in the central part of the school where services such as electricity and sewage networks are adequately provided and installed to enable easy future expansion of the school.

5.4 SITE ANALYSIS

A. AIR MOVEMENT:

i) North East Trade Winds: Bringing dry humid desert winds sweeping south west across the site Trees and shrubs to be used as shield and air filter.

ii) South West Trade Winds: Blowing north east across the site with rain and humid air from the Atlantic Ocean. Wind pressure to be created through small external openings and large internal openings.

B. ORIENTATION OF BUILDINGS:

Longer side of the building should face north-east direction to reduce heat discomfort

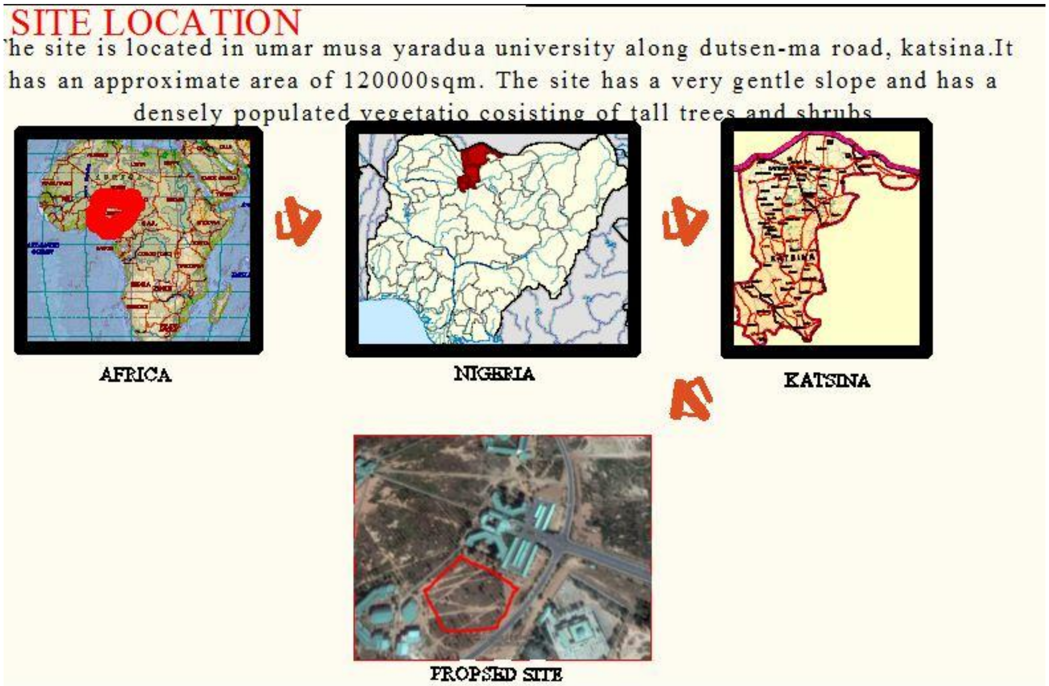
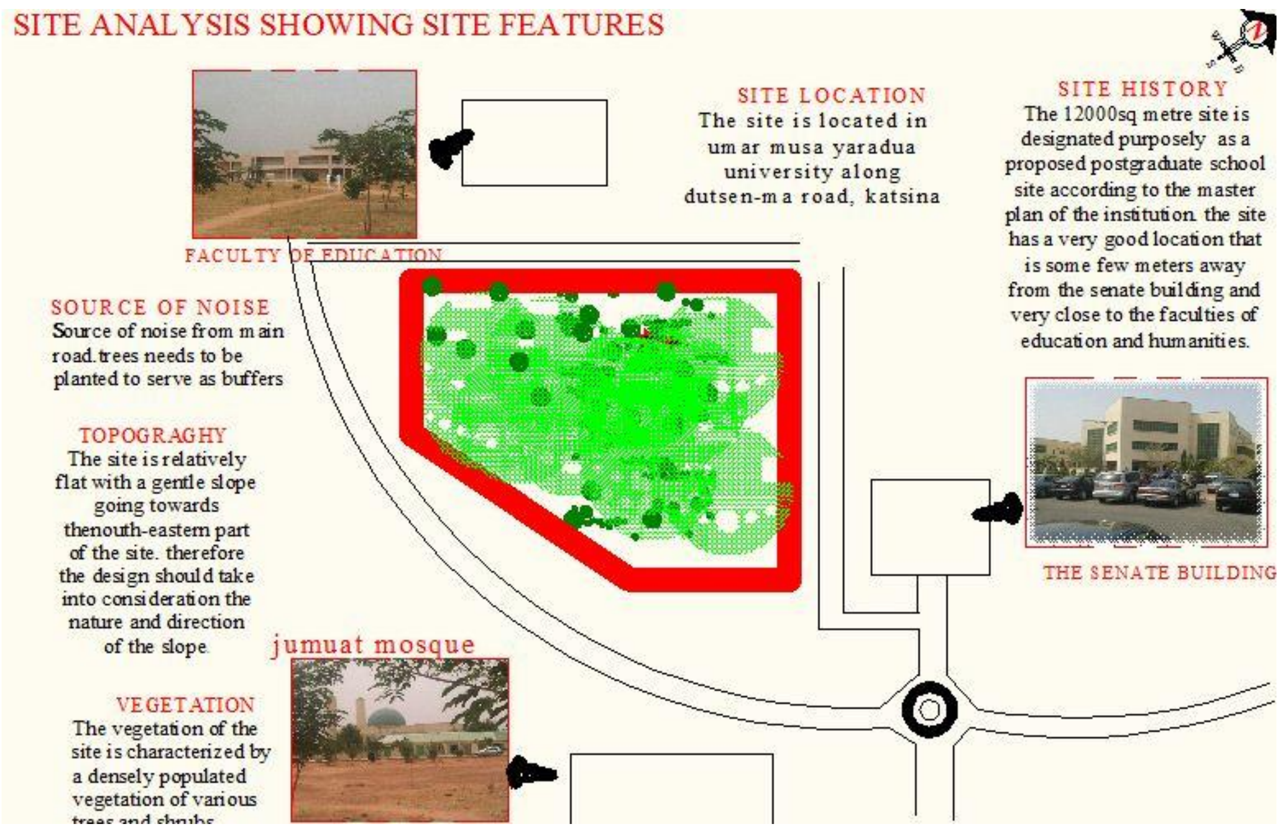
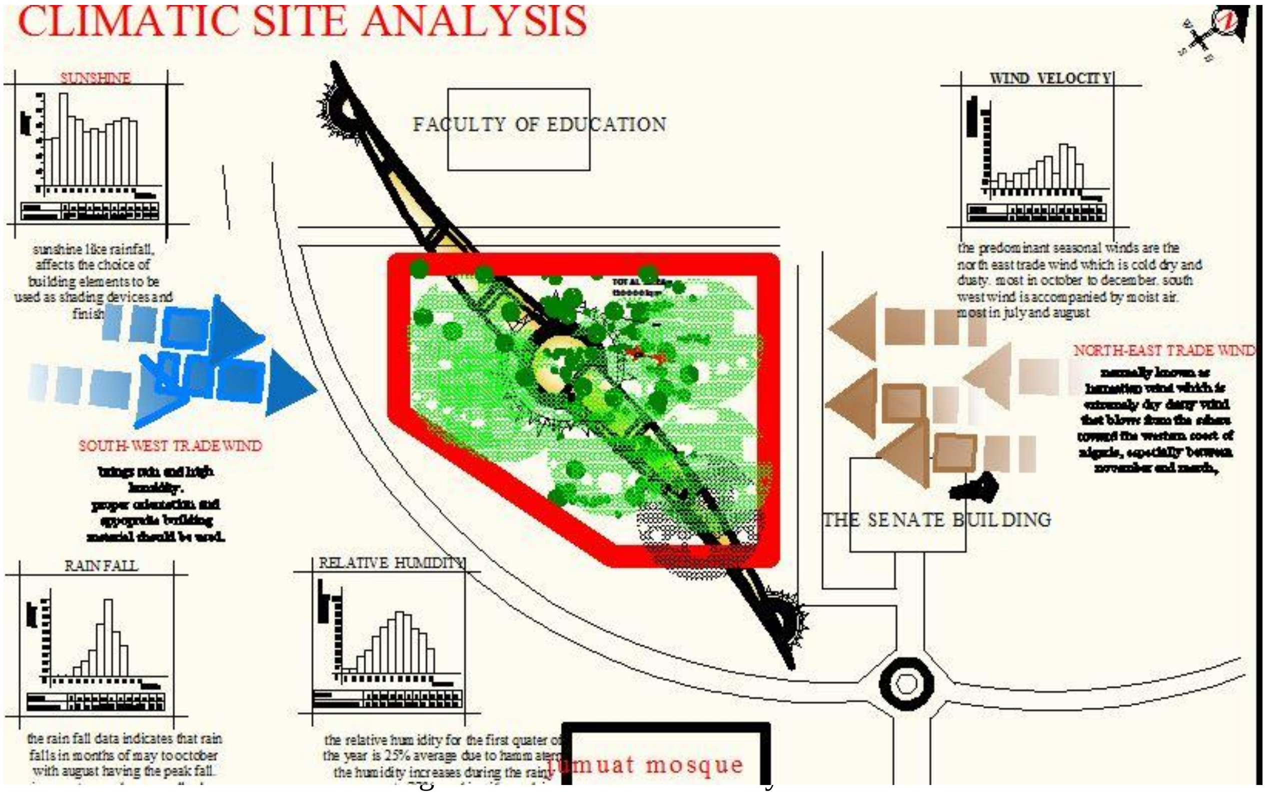


Figure 6: Site Location (Source: Author's Design)



(**Source:** Author's Design)



(**Source:** Author's Design)

5.5 CONCLUSION

In consideration to above advantages possessed by the proposed site, it will be very suitable to accommodate the proposed school of postgraduate studies of Umar Musa Yaradua University Katsin

CHAPTER SIX

DESIGN REPORT

6.1 DESIGHN BRIEF

The Katsina state government intends to build a post graduate school for Umar Musa Yaradua University, to be located in the main campus along Katsina Dutsinma road. This is in inline with achieving the schools master plan and to provide an administrative office for the post graduate school after almost five years since the program started. The main building shall be the administrative center of the post graduate school while the mini social center attached to the main building can serve both the post graduate school and the senate building. The admin building shall extend up to two floors with an open courtyard while the mini center has a single floor. The brief for postgraduate school evolved from a number of factors including the master plan for the Campus, the site, and other factors to be considered minimizing maintenance cost.

6.2 DESIGN CONSIDERATIONS

6.2.1 SITE PLANNING AND LANDSCAPING

Special considerations were given to the planning and landscaping of this site to enhance a good circulation around the building. Vehicular and pedestrian routes were clearly demarcated. Landscaping was utilized and existing trees were utilized to serve as shading devices therefore reducing the cost of cooling.

Plate XXX: site existing trees to be used as shading devices or wind breakers (Source: fieldwork April, 2013)

6.2.2 SPATIAL ORGANIZATION

The building was designed with the concept of simplicity with no complicated spots whatsoever that could make maintenance operations difficult. The design allowed for uninterrupted connection of spaces to every part of the structure so that there is a continuous flow of people, activities and services. An open courtyard provides lightening as well as ventilation to interior spaces thus minimizing the cost of lightening and cooling. Provision was made for a fountain inside the courtyard to help in evaporative cooling and for aesthetics.

Table 5: schedule of accommodation

MAIN BUILDING			
S/No	**Space**	**units**	**Total Floor area(mm) For each**
	Ground floor		
1	Screening rooms	2	225
2	Records or data room	2	120
3	Students lounge	1	48

4	Male and female toilets	20	80
5	Computer room	1	225
6	Exams office	1	36
7	Seminar rooms	3	96
8	Video conference room	1	96
9	Reception desk	1	25
10	Security office	1	25
11	Library	1	96
12	Bookshop	1	80
13	Maintenance unit	1	30
14	External defense room	2	96
15	General store	1	30
16	Junior staff office	3	30
17	Career guidance unit	1	30
18	Staff lounge	1	45
	Social center.		
1	shops	2	36
2	Restaurant	2	96
3	kitchen	2	60
4	Server	2	36
5	Store	2	25
4			
5	Internet cafe	2	45
	First floor		
1	Faculty officers office	6	30
2	Male and female toilets	20	80
3	Staff lounge	1	36
4	Publications unit	1	30
5	Board room	1	80

6	Seminar rooms	2	80
7	Senior staffs Offices	4	36
8	Digital library	2	30
9	Maintenance unit	1	25
10	Chief securities office	1	36
	Second floor		
1	Deans office	1	80
2	Deans waiting room	1	36
3	Deputy deans office	1	60
4	Secretary to deputy dean	1	30
5	P.G Secretary's office	1	60
6	Secretary to P.G secretary	1	30
7	Board room	1	96
8	Accountants office	1	60
9	Accountants secretary	1	30
10	Cashiers office	1	36
11	Admin officers office	1	36
12	Expenditure control unit	1	36
13	Senior staff lounge	1	60
14.	Seminar room	1	96
15	Senior staffs offices	3	30
16	Waiting rooms	3	25

6.3 CONCEPT DEVELOPMENT

The design concept in this study is purely functional, the concept was derived from how the main functions of the building interrelate with each other resulting in the formation of a simple plan concept **Figure 9:** concept development

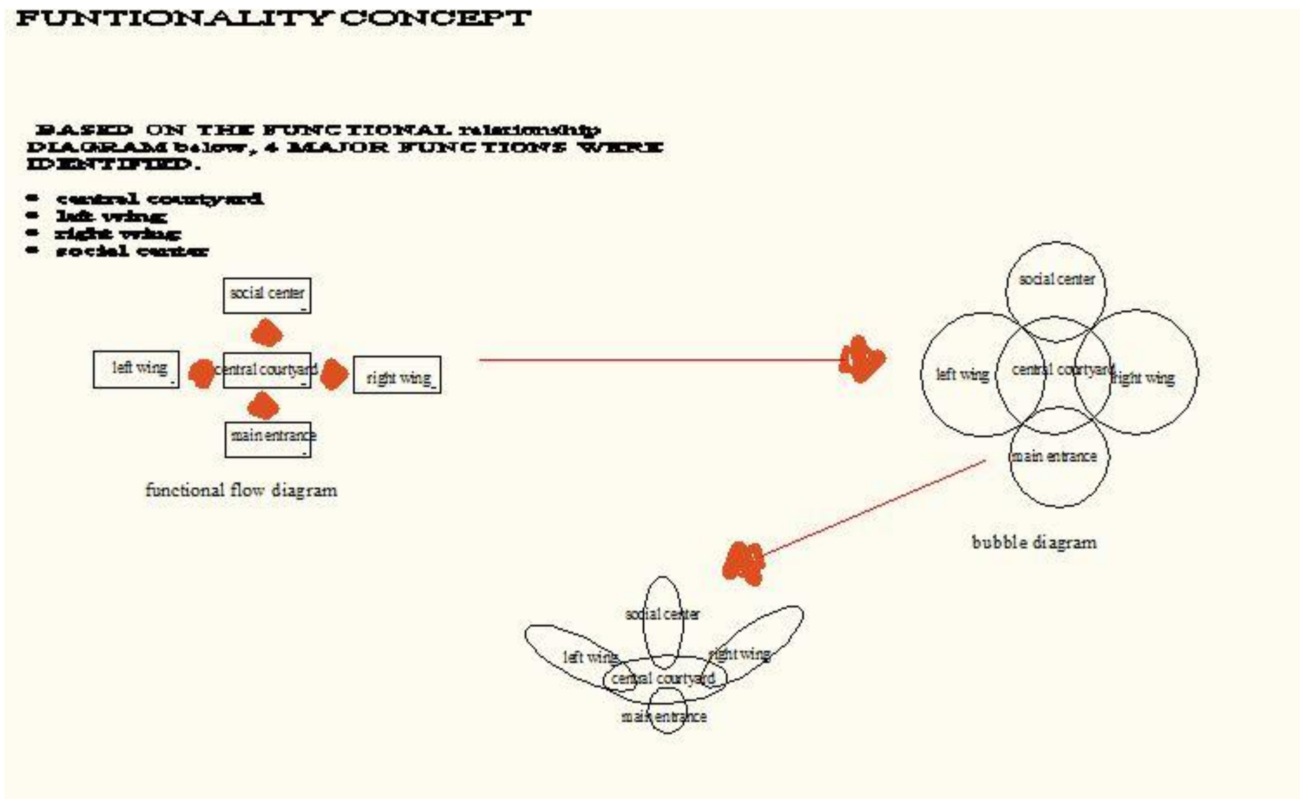


Figure 11: concept development
(Source: Authors design)

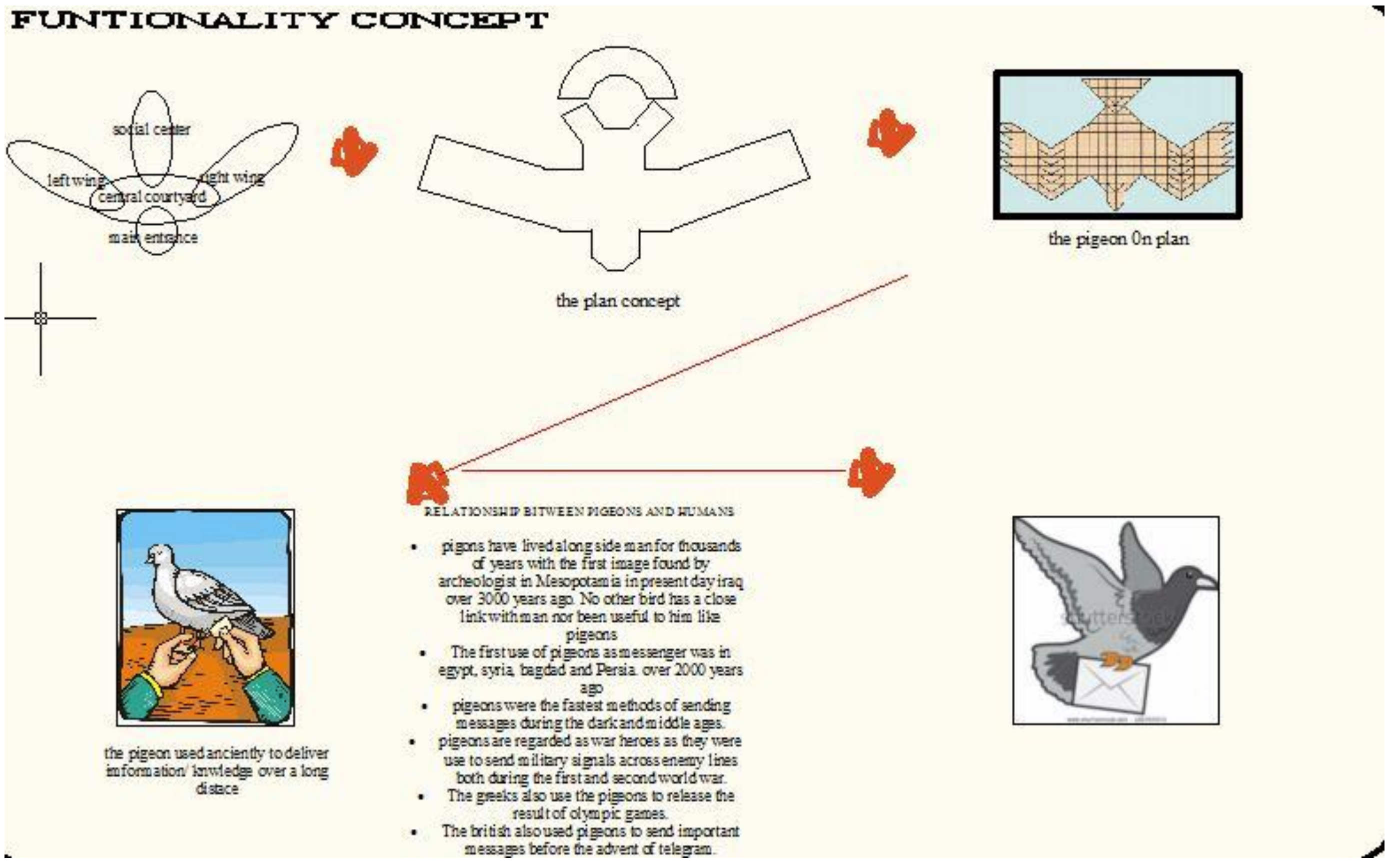


Figure 10: concept development

(Source: Authors design)

6.4 Relationship between pigeons and humans.

- Pigeons have lived alongside man for thousands of years with the first evidence of its existence found in Mesopotamia in the present day Iraq over 3000 years ago. No other bird has a close link with man nor been useful to him than pigeon.
- Pigeons were first used as messengers over 2000 years ago in Egypt, Bagdad, Syria and Persia.

- They were the fastest means of sending messages or information during the dark and the middle ages.
- Pigeons were regarded as war heroes as they were used to send military signals across enemy lines during both the first and second world wars.
- Pigeons were used to release Olympic results by the Greeks
- The British also used pigeons to send important messages before the advent of telegram

6.5 DESIGN STRTEGIES AIMED AT MINIMIZING MAINTENANCE COST.

6.5.1 Building form

The form adopted here is a simple form which allows for easy planning and flexibility in the use of materials. Complex forms tend to make maintenance operations difficult therefore raising the cost of maintenance. The building form chosen allows for easy roofing and draining of water.

6.5.2 SPARTIAL ORGANIZATION.

Placing of facilities having similar functions like toilets make it easier for maintenance and replacement of service pipes and other installations when the need arises.

6.5.3 `SITE PLANNING AND LANDSCAPING

Existing tree were utilized to serve as shading devices responsible to reduce the amount of heat gain into the building thereby reducing the cost of cooling. New trees to be planted were selected based on Self sustenance, low maintenance, durability, low water requirement, resistance to heat and drought. The walkways were design using concrete pavers which are durable and resistant to abrasion from pedestrians. This materials are known for exceptional resistance to moisture (low water absorption), Resistant to chemicals attack by acid and alkalis, High resistance to erosion and impact and possesses tremendous strength, Ease of maintenance offering outstanding durability and long life.

6.5.4 Construction System and building components

To enable easy maintenance in a minimized cost, the following two factors were considered;

i. **Fountain and open courtyard system**: the building was designed to employ natural ventilation with the aid of a central courtyard system which is open and shaded against high and intense solar radiation. This is very essential in cases where the mechanical systems of air conditioning and humidifiers malfunction. Thus presence of a courtyard saves a lot in terms of cooling cost. The courtyard system also provides lightening to indoor spaces therefore saving the cost of lightening. A fountain was provisioned for to provide cooling using evaporative cooling to indoor spaces. Also the courtyard was shaded using steel members so as to provide flexible construction methods for easy assembling and dismantling

ii. Walls

External walls were designed with a maintenance free material and they are tiled using alluco bond very durable and low heat absorbing tiles. Also internal walls across lobbies, passages and other high traffic areas were finished using a combination of ceramic and mosaic tiles.

Toilet wall were completely tiled using mosaic tiles to so as to avoid dampness on walls and to minimize maintenance cost

iii. ROOF

The roof garden is incorporated in the design to serve as an absorbent of the radiant heat from the solar on the roof of the building. The use of roofing sheet is minimized to reduce solar heat gain in the building and the environment. The roofing sheets refract some amount of heat to the interior of the building and reflect some to the surrounding environment thereby increasing the temperature of the environment. While partly roofed areas were covered using a highly reflective and low heat absorbing alluminium roofing sheet. This type of roof with roofing sheet has steel trusses to support the roofing sheet with a void serving as vacuum to contain the radiant heat

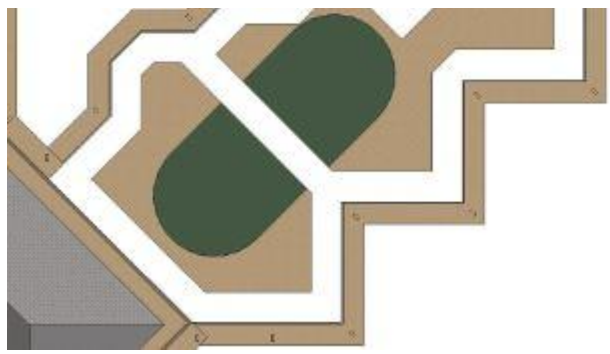


Figure 11: Part of the roof plan showing green roof

iv. Floor

They use of **marble floorings and ceramic tiles** along the entrance facades which have good resistance to rainfall and solar radiations. For areas with high traffic flow which included areas like lobbies, restaurant, library, exhibition hall, and computer rooms, materials which have good abrasion and are resistant to vandalism were specified such as terrazzo, marbles

v. WINDOWS

The type of windows to be used in this proposed project is purpose made decorative swinging casement windows. The reason for swinging casement window is that, it is the type of window that gives almost 100% of ventilation. A ledge was purposely provided to serve as a platform on which maintenance for windows can be carried out on high level floors with ease. These platforms also serve as shading devices for the building against intense sunlight and radiation.

Similarly, low emissivity glass along the exterior of the building was used in this structure. This blocked UV lights and helps to reduce the damages caused on the building materials such as on wood, fabrics, leather. Such damages however include discoloration of materials, ulterior condensation that inhabits mold growth. Thus this helps in minimizing the maintenance cost.

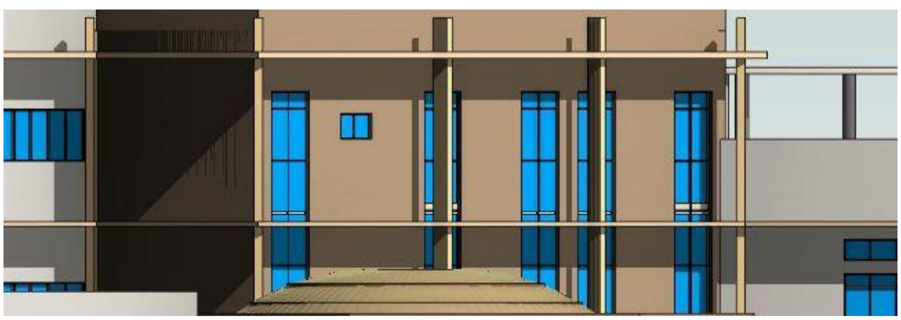


Figure 12: Elevation showing the application of ledges for easy access to upper levels

Vi. DOORS

The door type recommended for this proposed design is purpose made doors with high thermal resistance to prevent heat gain through the doors. The surface is coated with a glossy type finishing to allow for easy cleaning.

Vii. ELECTRICAL SERVICES

This building is designed to have an extended roof overhang and a ledge that will shade all external electrical fittings and to provide protection against the elements of weather. Also internal electrical fittings were located in such a way that they can be easily accessed whenever maintenance operations are to be carried out.

viii. PLUMBING FITTINGS.

A service duct was provided for in this design so as provide an easy access to service pipes in cases of repairs and or blockages. This ducts also exists to add an aesthetical quality to the building besides its main function.

Figure 13: service duct

(Source: Authors design)

ix. PAINTING

This structure was designed to eliminate and or minimized maintenance cost to the lowest possible level. This was why internal walls especially in high traffic areas has to be tiled because it requires low maintenance while painting faded over time. External alls on the other hand were finished with a maintenance free alloco bond and a stone like cracked tile finishing’s.

CHAPTER SEVEN

CONCLUSION

7.1 SUMMARY

This research is mainly on the subject of minimizing maintenance cost in institutional buildings in Nigeria. The problem definition is that optimizing architectural design strategies can offer a better methodology towards minimizing maintenance challenges in buildings. Review of relevant literature on the maintenance issues aided in establishing a conceptual framework on which architectural designs can be ordered. Case studies were analyzed using the variables directly related to the subject of building maintenance. Findings from the case studies and literature review were used in generating design and concepts that minimizes maintenance cost for the propose facility.

7.2 CONCLUSION

This research revealed that high cost of maintenance could be a serious problem if proper care is not taken during the design stage. A designer who knows the risk is more likely to design buildings that will require very low cost of maintenance, since it is impossible to provide maintenance-free structures. However, considering the various design factors studied during the research will definitely reduce the amount and need for maintenance. Based on these several important factors at the design stages where listed out during the course of the research to guide architects alongside the formulation of design ideas to achieve a structure with minimum maintenance cost.

7.3 RECOMMENDATION

From the research conducted, the major findings suggest that the architects are expected to design buildings that require less maintenance cost to the society or maintenance free buildings if not totally but to an extent. The design stage is very important to address the issues of defects, particularly with respect to how these defects can be managed and how such problems can be avoided by professionals in future. These can be achieved by enlightening architectural professionals that design goes beyond just lines and forms but also involves futuristic projections and adopting a more open-minded approach toward maintenance during the design stages of building. Special care therefore should be taken since the design stage has a vital effect on the amount of maintenance cost that will be needed after the building is commissioned. Minimizing the cost of maintenance from the design stage produces energy efficient buildings improves the comfort levels of the occupants and Sreduces the cost of energy for heating, cooling and lighting.

The public, along with designers and clients, now realize the tremendous impact our buildings have on the natural and built environment. However, architects must work towards providing friendly environment for the occupants of these buildings, by encouraging the use of architectural solutions based on the observation of this research that can reliably minimize the cost of maintaining the buildings.

7.4 CONTRIBUTION TO KNOWLEDGE

i. This research has identified key maintenance challenges facing institutional buildings in Nigeria such as poor drainage system of roofs resulting in leakages and deterioration of both roofing and walling materials, specification of materials which were in contradiction with its usage or climate.

ii. The study established a relationship between architectural features of buildings in relation to maintenance challenges.

iii. The study provided a framework for the selection of architectural design features that will minimize maintenance cost in institutional building design.

iv. The research was able to point out specific areas that need to be addressed by the architect during the design stage to avoid high cost of maintenance.

v. The study was able to specify the various types of materials to be used in institutional building so as to reduce the cost of maintenance.

vi. The findings of this research if properly applied will help in avoiding deterioration and subsequently the collapse of institutional buildings in Nigeria. Thus saving both human lives and properties.

vii. The author was able to establish a design framework which can be used to acess the maintenance condition of public and institutional buildings

REFRENCE

Oluigbo, S.N. (2010). *Context and Applications of Case Studies in Architectural Research.* Department Of Architecture, Ahmadu Bello University, Zaria.

lyagba, A. R. (2005, June 1). *The Menace of Sick Buildings: A Challenge to All For Its Prevention and Treatment.* An inaugural lecture delivered at university of Lagos. Akoka, Yaba-Lagos, Nigeria.

Folorunso, C.O. (2006). Maintenance Reduction through Climate Compliant Building Materials Utilization. *Journal of Land Use and Development Studies,* 2(1).

Afolarin, A. D & Olajide, F. J. (2012). Evaluation of Maintenance Management Practice in Banking Industry in Lagos State, Nigeria. *International Journal of Sustainable Construction Engineering & Technology,* 3(1): 45-53.

Chang, W., M.ASCE & Low, S. (2006). Latent Building Defects: Causes and Design Strategies to Prevent Them. *Journal of performance of constructed facilities, 20(3):213-221,* doi: 10.106/(ASCE)0887-3828(2006)20:3(213).

Al-Hammad, A., Assaf, S. & Al-Shihah, M . (2007). The effect of faulty design on building maintenance. *Journal of Quality in Maintenance Engineering,* 3(1): 29-39.

Zainal Abidin Bin Akasah. (2007). *Effective Maintenance Practice In Public Buildings*.University of Technology, Malaysia: PhD.Thesis.

Tan Wei Cheun (2008). *Minimizing Maintenance cost in Hospital*. University of Technology Malaysia : Under graduate, Degree Thesis.

Ajibola, J. K. (2009). *Maintenance Culture in Nigeria; Problems and Challenges.* Paper presented at the Sensitization Campaign on Maintenance Culture, Ibadan.

Adenuga, O.A, Odusami, K.T, Faremi, J.O. (2007). *Assessment of Factors Affecting Maintenance Management of Public Hospital Buildings in Lagos State, Nigeria*.

Adejimi A. (2005. June 29-May 3). *Poor Building Maintenance in Nigeria: Are Architects Free From Blames?* Paper presented at the International conference on Housing: New Challenges and Innovations in Tomorrow's Cities, Ogun State.

Agabi, C. (2013, February 24). We need three billion naira for national theatre main bowl-kabiru Yusuf. *Sunday Trust, pp 30-31.*

Bell, J. B(2005), *A Guide for First Time Researchers in Education, Health and Social Science,* 4th Edition, Open University Press, London

Chan, K. T., Lee, R. H. K., & Burnett, J. (2001). *Maintenance performance:* a case study of hospitality engineering systems, *Facilities*, 19(13): 494-504.

Fellows, R and Liu, A. (2008) *Research Methods for Construction,* 3rd Ed. Blackwell publishing, Oxford.

Sani, A. S., AH, H. M. & Shahidan, S. E. (2012). *A Review of the Effect of Building Design on Maintenance Management.* Proceedings of ICBER'12: International conference on business and economic research, Indonesia. Pp 648-662

Olanrewaju, A. A. (2009). *Maintenance management of university buildings*. accepted for publication in *Journal of Building Appraisal.*

Akadiri, P.O. and Olomolaiye, P.O. (2009). *Sustainability Criteria for Decision Support in the UK Construction Industry, in Global Innovation in Construction.* Conference , Loughborough University, UK.

Creswell, J. W. (2003). *Research design: qualitative, quantitative, and mixed method approaches*, Thousand Oaks, Calif., Sage Publications.

Adenuga, O. A and lyagba, R.O.A (2005) Strategic Approach to Maintenance Practices for Public Buildings in Lagos State, *Journal of Environmental Studies*, Faculty of Environmental Sciences, University of Lagos 5(1).

Amusan , J.(2003). *Evaluation Factors Influencing Hostel Maintenance In University Of Lagos*. B.sc Building Dissertation, University Of Lagos, Nigeria.

Oladapo O, (2004). *Assessment Of Factors Influencing Housing Maintenance Priorities in*

Tertiary Institutions In South Western Nigeria. Ph.D Construction Management, Obafemi Awolowo University.

Kothari, C.R, (2003), Research Methodology-Quantitative Techniques for Managerial Decisions. Wiley Eastern Limited, U.K.

Wenger Corporation. (2nd Ed.) (2008). *Planning Guide for Performance Spaces.*

Syce, M. (2006). *Designing for maintenance.* Published thesis, nelson Mandela Metropolitan University.

Faremi, J .O., Odusami, K.T., & Adenuga, O.A. (2007). *Assessment of Factors Affecting Maintenance Management of Public Hospitals in Lagos State, Nigeria.* Proceedings of RICS'07: The construction and building research Conference of the royal institution of chartered surveyors, Atlanta, United States of America.

Corner, B. & Paarlberg, K. (2007). Spotlight on Theatre Accessibility. *Journal on Building Safety.* Pp 44-46.

Khan, A. (2012, February). *Constructability and Maintainability: Exploring a Relationship.* Retrieved from http:/M[r]ww.tibmcw.com/articles/miscellaneous/others/'28078-constructability-d-maintainabilitv-exploring-a-relationship.html

Stanford, W. H. (2010). *Effective Building Maintenance: Protection of Capital Assets.* Fairmont press, United States of America

Leong, K. C. (2004). The Essence of Good Facility Management - A Guide for Maximization of Facility Assets' Economic Life and Asset Optimisation for Reliable Services and User Satisfaction. *Buletin Ingenieur* 24:7-19.

Lind, H. & Muyingo, H. (2012). Building Maintenance Strategies: Planning under uncertainty. *Property Management*, 30(1): 14-28.

Ikpo, J. I. (2009). Maintainability indices for public building design. *Journal of Building Appraisal*, 4, 321 - 327. Doi: 10.1057/jba.2009.2

Harris, C. M. (Ed). (2006). *Dictionary of Architecture and Construction.* Newyork: McGraw-Hill.

Haruna, G. (2009, April 27). Nigeria: Bringing back the culture of maintenance. *This Day.*

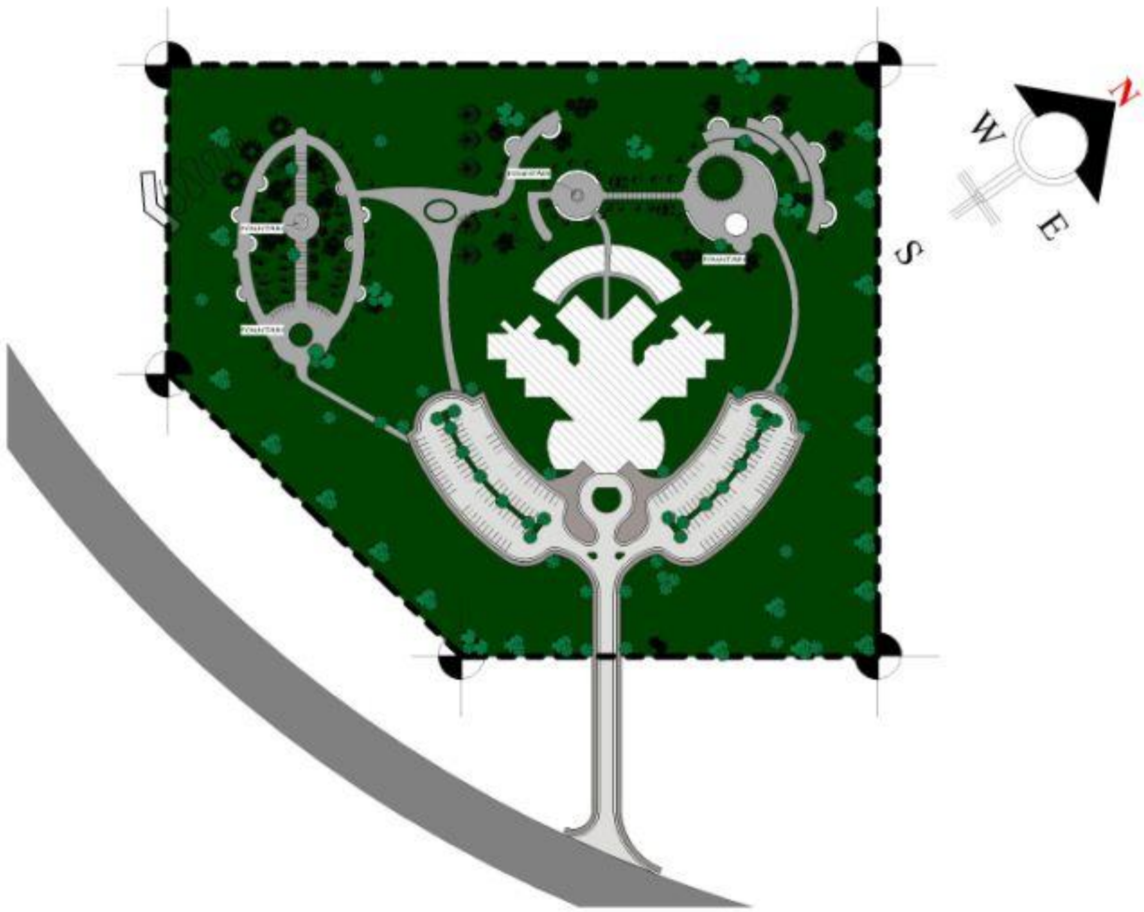
Guyer, J. P. (2009). *Introduction to roofing systems.* Retrieved from http://www.cedengineering.com/upload/An%20Intro%20to%20Roofing%20Syste ms.pdf.

Al-Khatam, A. J. (2003). *Building Maintenance Cost.* A Published Master Thesis, Department of Construction Engineering and Management, King Fahd University Of Petroleum And Minerals, Dahahran Saudi- Arabia.

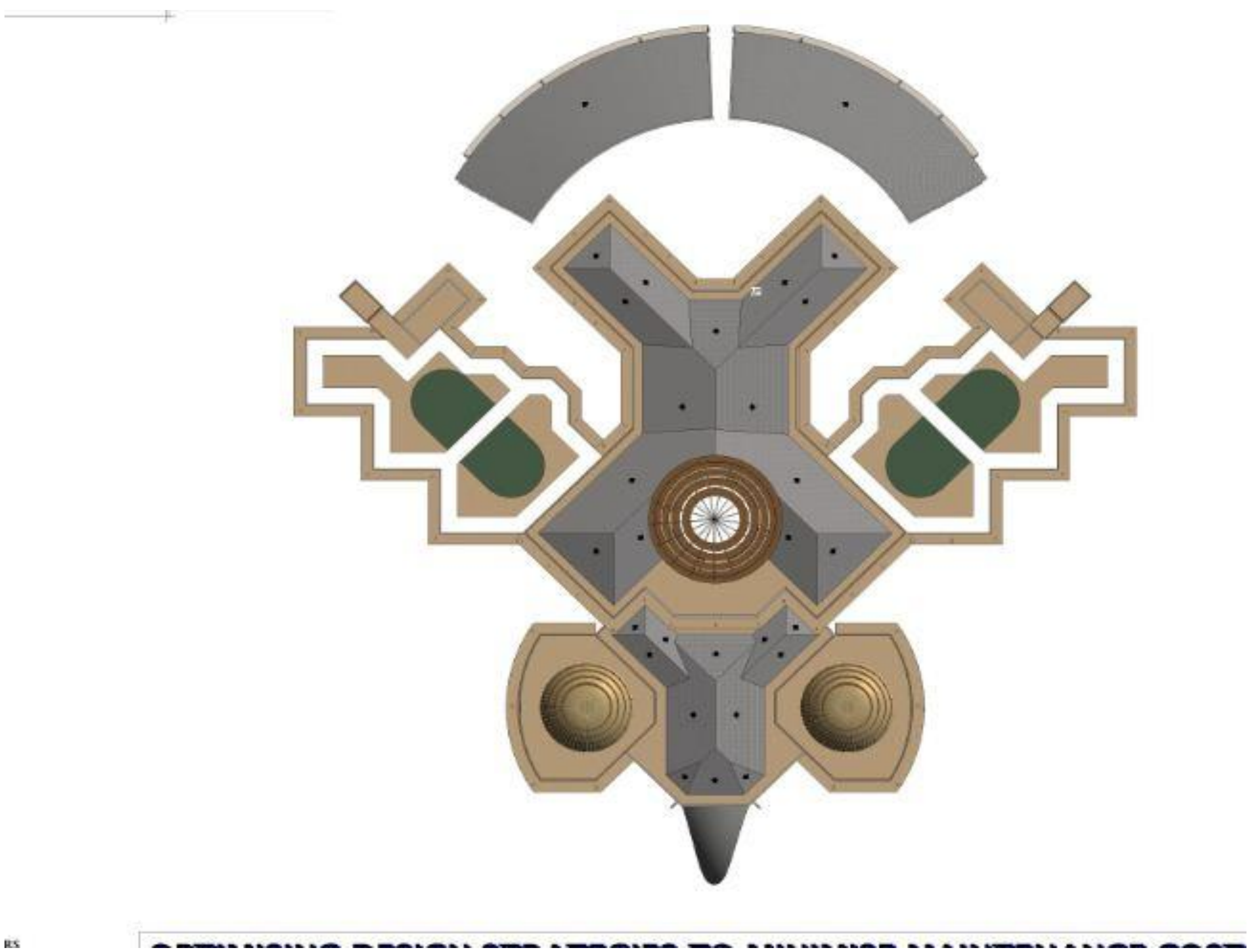
Cobbinah, J. (2010). *Maintenance of Buildings of Public Institutions in Ghana: A Case Study of Selected Institutions in the Ashanti Region of Ghana.* A Published Master Thesis, Department of Planning, Kwame Nkrumah University of Science and Technology, Kumasi.

APPENDIX

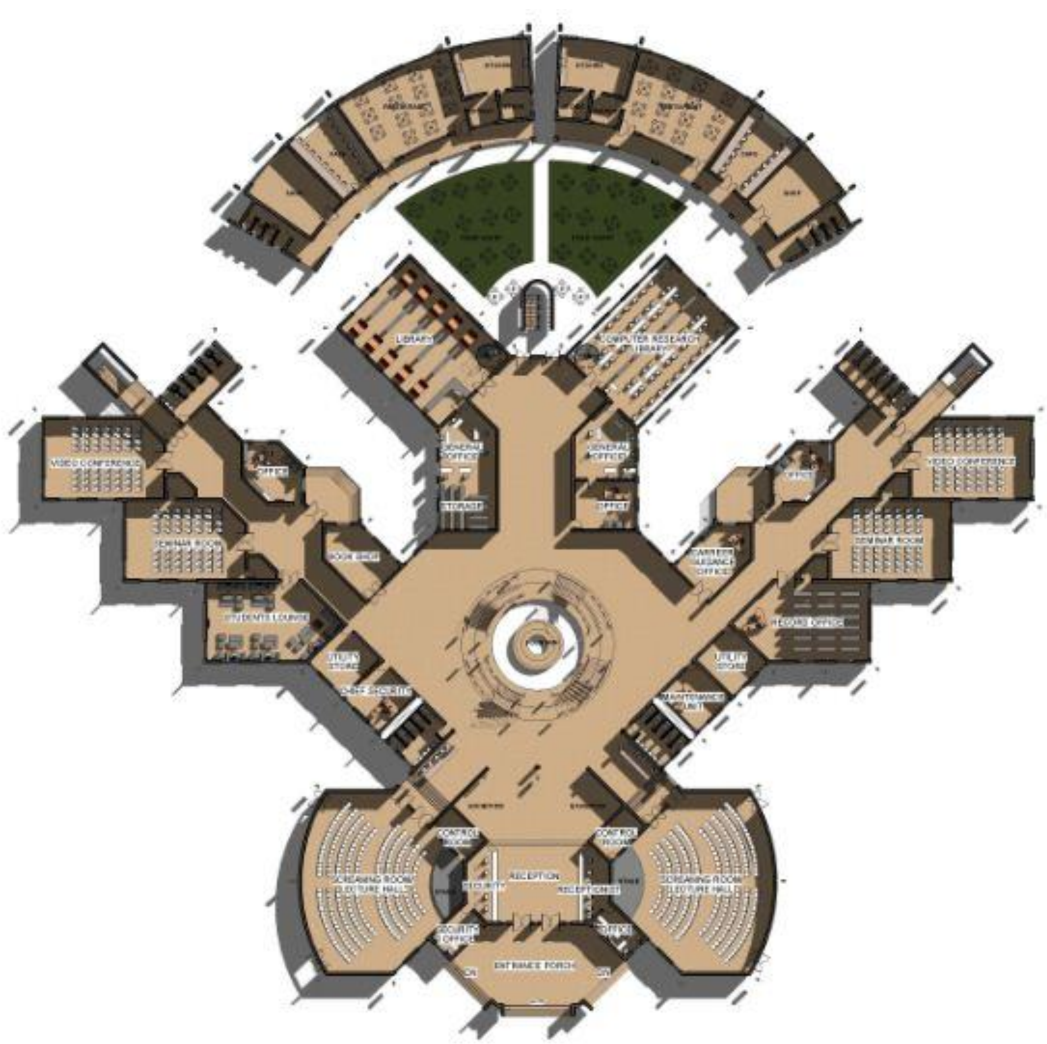
Drawing no.1: site plan



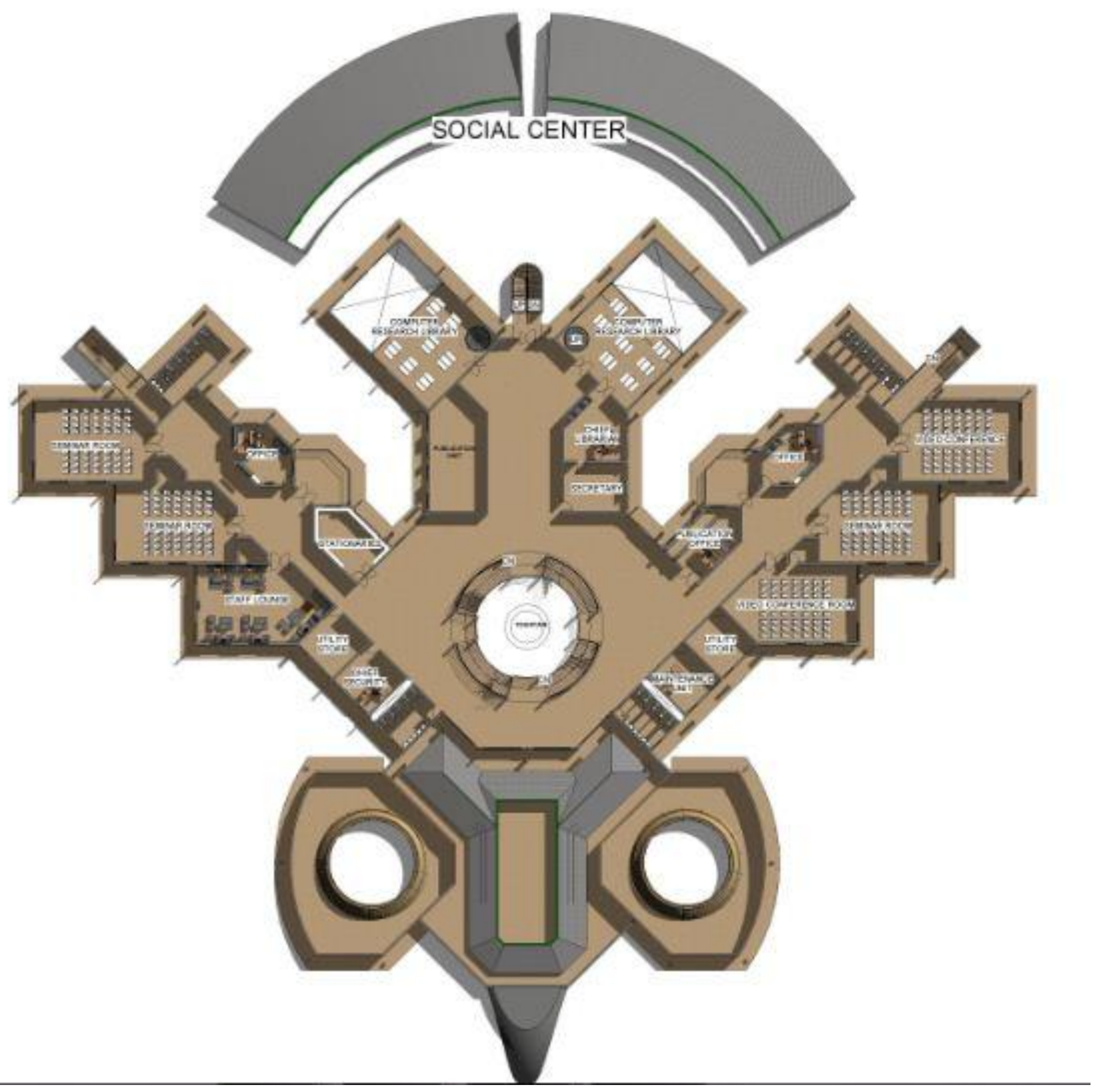
Drawing no.2: roof plan



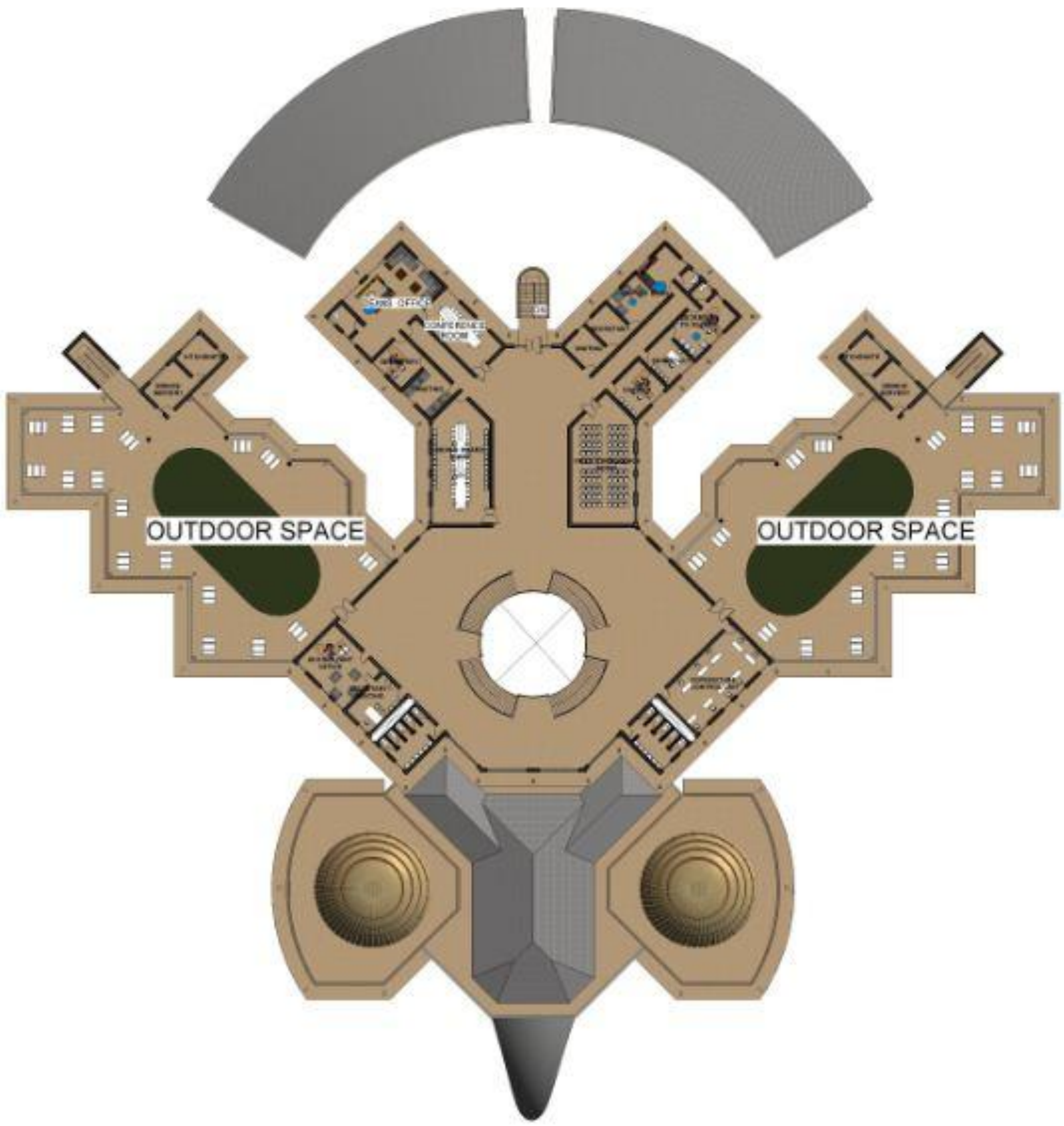
Drawing no.3: Ground floor plan



Drawing No.4: First Floor Plan



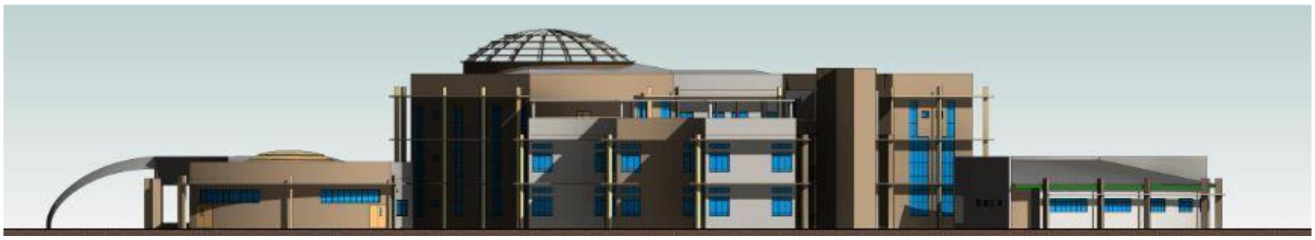
Drawing No.5: Second Floor Plan



Drawing No 6: South Elevation

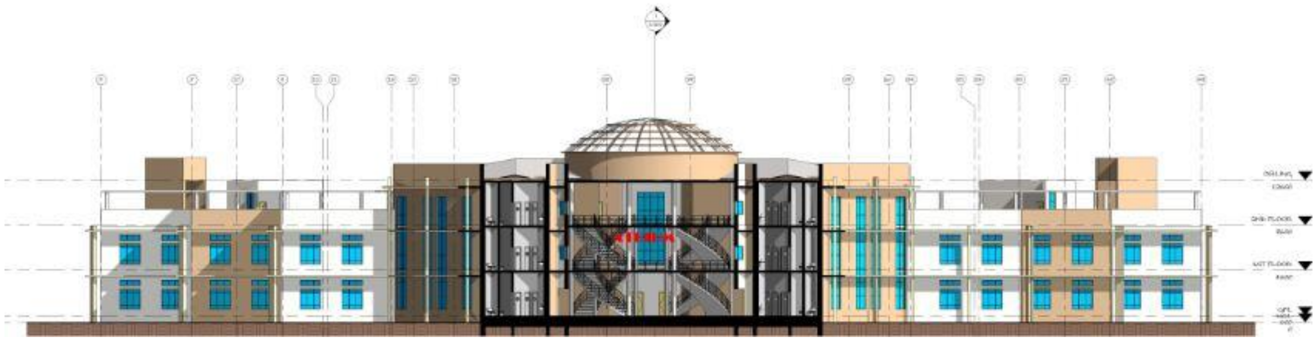
Drawing No.7: North view

Drawing No.8: West View

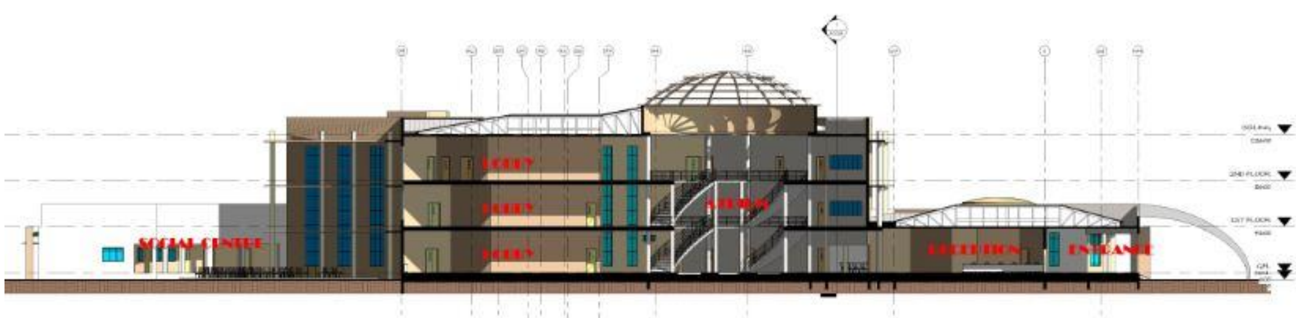


Drawing No.9: East View

Drawing No.10: Section showing the spiral staircases and open courtyard



Drawing No.11: Section showing interior lobbies



Drawing No.12: 3d image

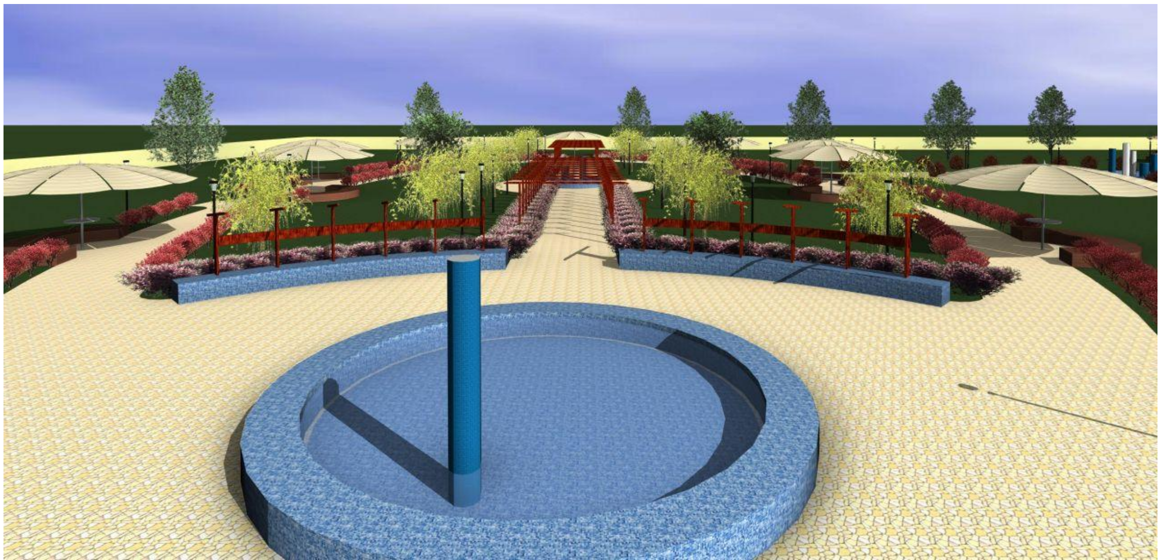
Drawing No.13: Areal view

Drawing No.14: 3d image

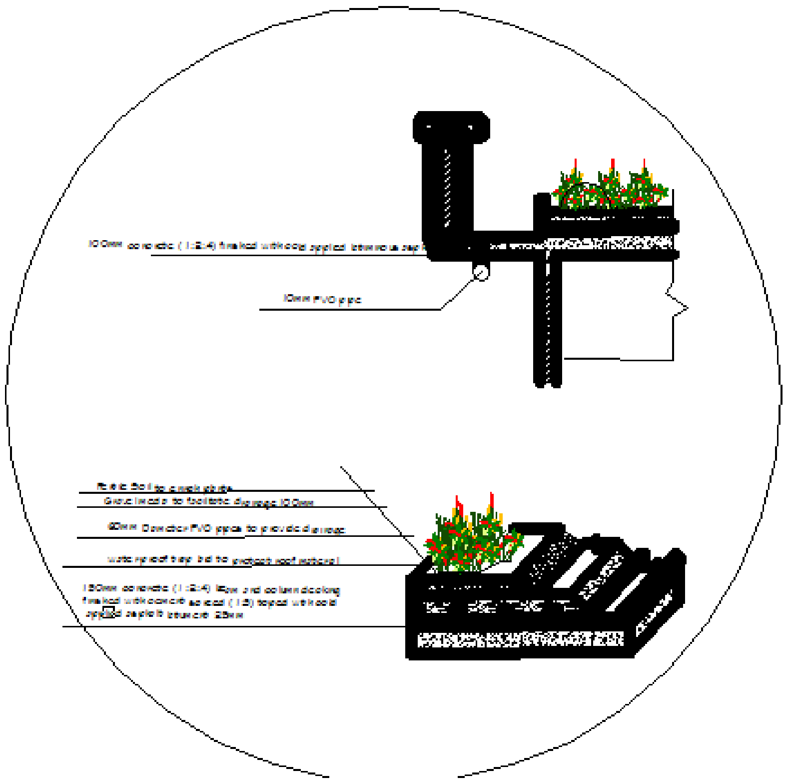
Drawing No.15: 3d image

Drawing No.16: 3d image

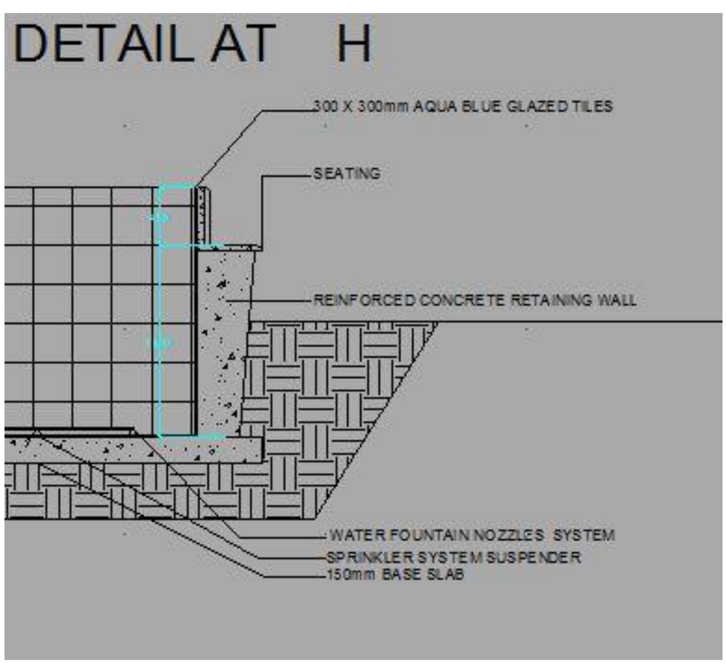
Drawing No.17: 3d image



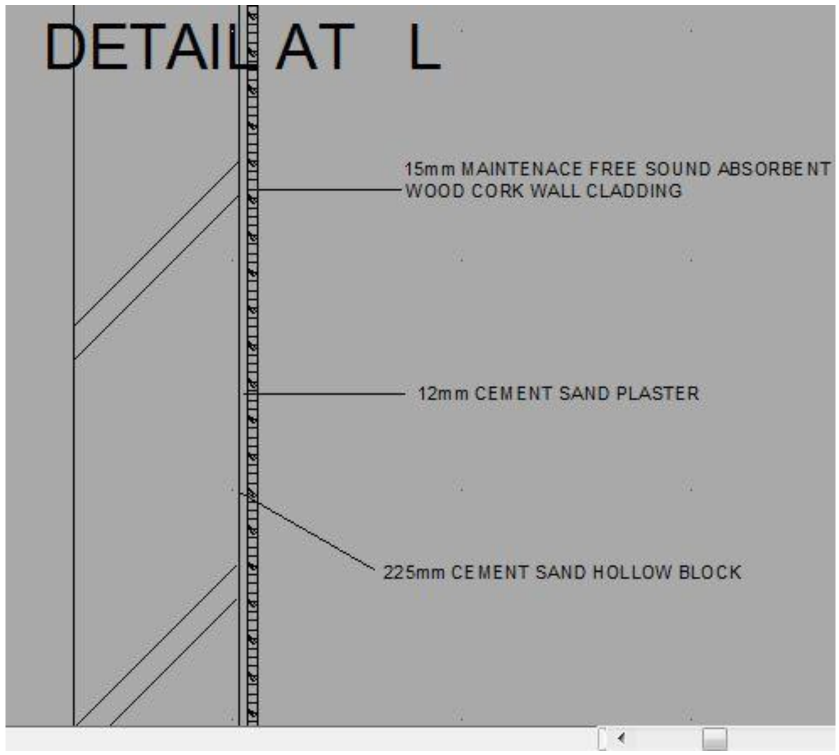
Drawing No.18: green roof details



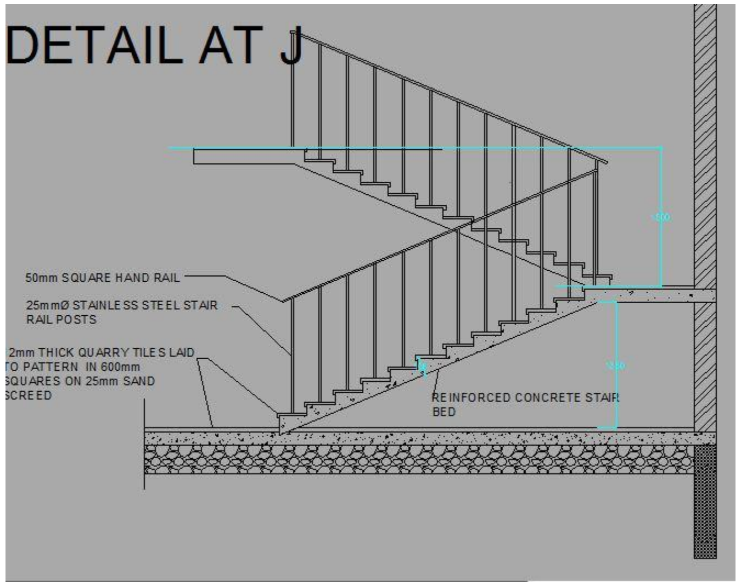
Drawing No.19: Retaining wall details



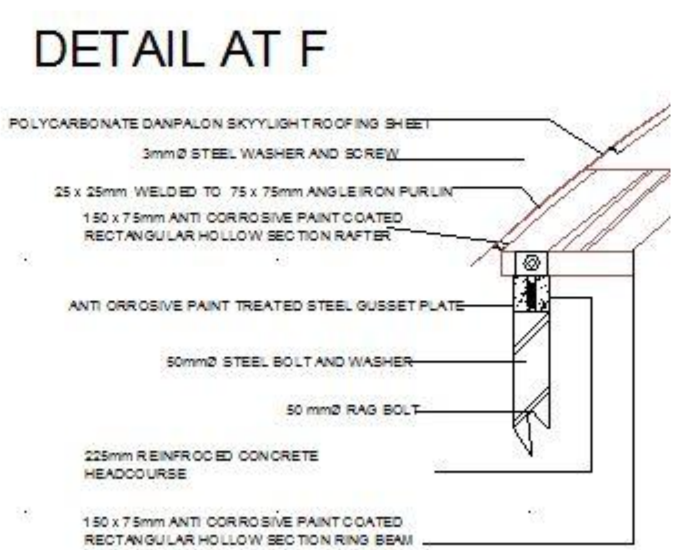
Drawing No.20: Detail of service duct



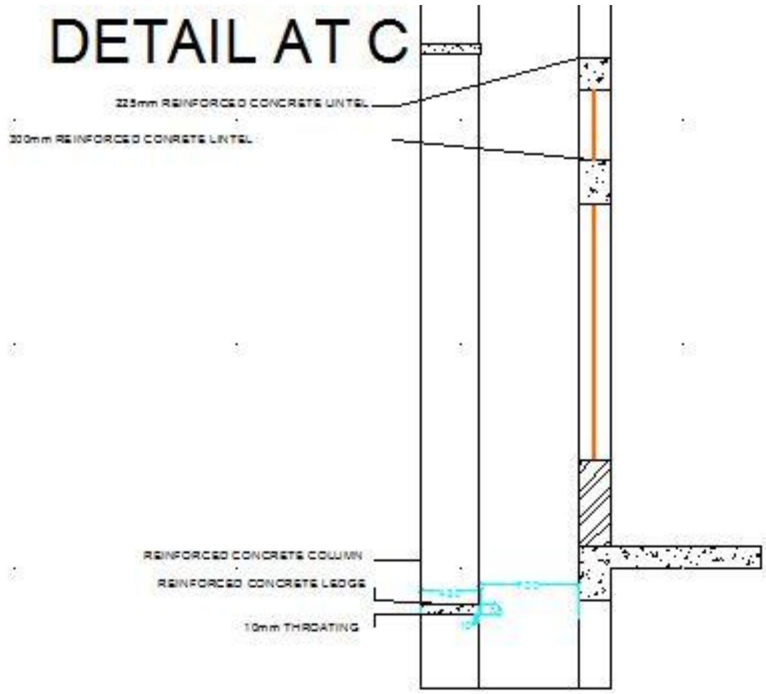
Drawing No.21: Staircase details

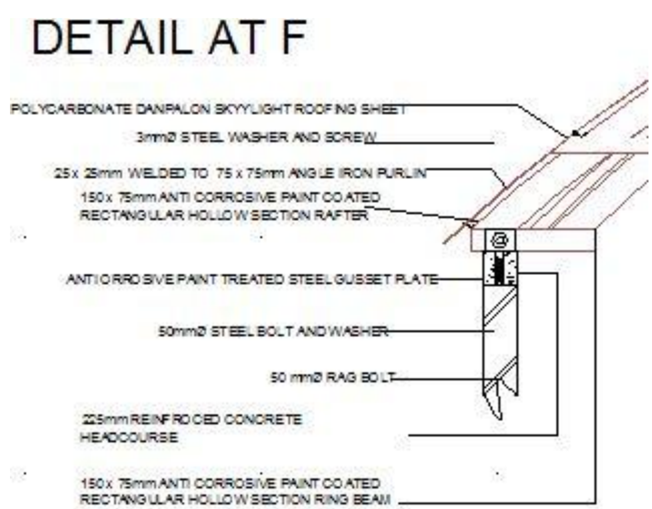


Drawing No.22: Detail at steel connections



Drawing No.23: Detail of screen windows





Drawing No.24: Detail of theater seats