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# **Effective Implementation of Maintenance Models in Building Maintenance Process**

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### **Authors' contributions**

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

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## **ABSTRACT**

Buildings are essential facilities which represent a substantial percentage of most tertiary institutions assets, user needs and operating costs. The maintenance levels of these buildings are very crucial to educational effectiveness. However, in spite of the crucial role of these buildings in the education and construction sector of the economy, most educational buildings in Nigeria are in deplorable conditions as a result of lack of maintenance. The efficient and effective maintenance management of both new and old buildings constitutes a challenge to the management. Presently, studies on maintenance of buildings have not been conducted in sufficient details for educational buildings in Nigeria. This research was therefore, aimed at effective implementation of maintenance models in building maintenance process. Maintenance is reactive rather than proactive and no evidence of maintenance plan and manual were in use.

*Keywords: Model; maintenance; planning; institution; building; construction and design.*

## 1. BACKGROUND TO THE STUDY

A building is regarded as an enclosure or “envelope” designed and constructed to provide minimum level of comfort, and conveniences for man. Building provides safety, protects human inhabitants, animals, materials and equipment from effects of weather, and gives internal comfort [1]. According to Obiegbo [2], a building is an essential modifier of micro-climate, a space isolated from climate temperature and humidity, fluctuations, sheltered from prevailing winds and precipitation, and with artificial means. Generally, buildings are designed and constructed to provide comfortable environment, create a conducive atmosphere for working, living and learning [3]. In addition, a healthy building is one that adversely affects neither the health of its occupants nor the large environment [4]. According to Okoye and Ogunoh [5], buildings are expected to function effectively throughout their expected life span. In a nutshell, a building must function to accommodate the activities for which it is built, and provides comfortable indoor and outdoor climates to its occupants. It also investigates how regular the buildings are inspected and maintained by the unit’s in-charge of maintenance of buildings in the university. It further looked into budgetary provisions and administrative bottleneck if any in the maintenance of buildings. Details of this have been discussed in subsequent section of this research.

## 2. RESEARCH AIM

The aim of this research is an effective implementation of maintenance models in building maintenance process in Universities.

## 3. INTRODUCTION TO BUILDING MAINTENANCE MODELS

A model is defined as a physical or symbolic representation of the relevant aspects of the reality with which we are concerned [6]. It can also be defined as a simplified method of representing an object or situation. Building maintenance model is, therefore, a process of showing, representing or depicting how maintenance activities or tasks are to be carried out. Building maintenance model means a decision making framework, for the maintenance of buildings. This indicates that maintenance model defines those tasks, uncertainties, that need to be indenting show how, when and what

information needs to be communicated, for successful execution of maintenance works.

According to Ojedokun, Odewumi and Fasola [7], an essential part of modeling maintenance, is taking account of the uncertainties in the deterioration and time of failure, for the purpose of maintenance optimization. However, several factors affect the maintenance of tertiary institutional buildings, and based on previous studies, various models have been developed and thus:

## 4. BUILDING CONDITION AND STUDENTS’ ACHIEVEMENT MODEL

According to Mutlag (2002), Cash developed this model in 1993, to show some possible factors that affect the building condition and in turn affect student’s achievement and behaviour. Cash [8] states that leadership and finance influence maintenance and custodial staff (Faculty Staff) which in turn have a corresponding effect on school building condition and performance. Again building conditions influence attitudes of students, teachers and parents. These attitudes of teachers particularly influence the students’ perception of the building which affects both academic achievement and behaviour of students. This shows that lack of maintenance of tertiary institutional buildings affects both academic achievement and behaviour of students. Mutlag (2002), illustrates Cash [8], model as shown in Fig. 1.

The variables identified in Cash [8]’s model provides the evidence that support this model importance to the maintenance of educational buildings. However, the range of variables identified in the model is narrow. It did not consider factors such as budget, management decisions, and maintenance staff. Though, the model is relevant to this study.

### 4.1 Maintenance Feedback Model

One of the best maintenance practices is feedback information. It is a system of keeping things in track; through analysis of past maintenance information records. It enables for adjustments, so that, improved performance of maintenance productivity will, therefore, be finally achieved. The model was developed by Seeley [10] in 1987. According to Seeley’s model, maintenance feedback should be an essential part of any maintenance feedback administration

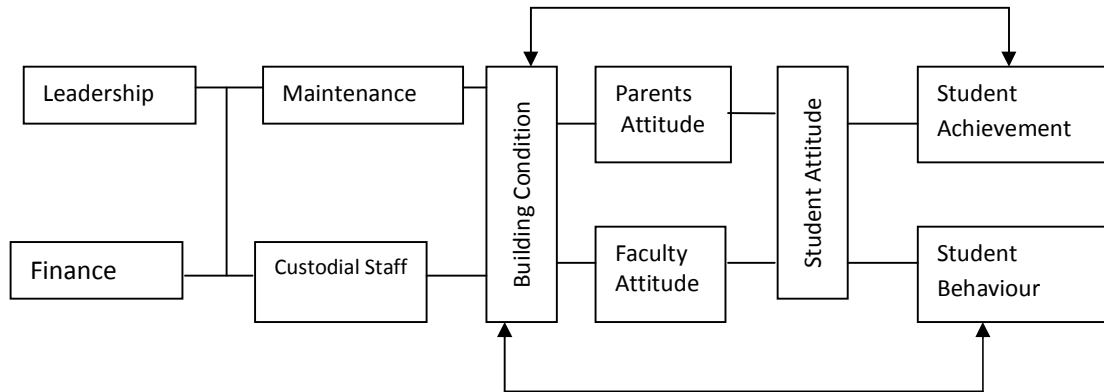
and may be mainly injected into the system in two ways.

- (1) **Directly to design team:** particularly information on design faults, faulty workmanship and material failures,
- (2) **By general discussion** with the maintenance team, when solutions to problems should be documented and passed on to all appropriate personnel.

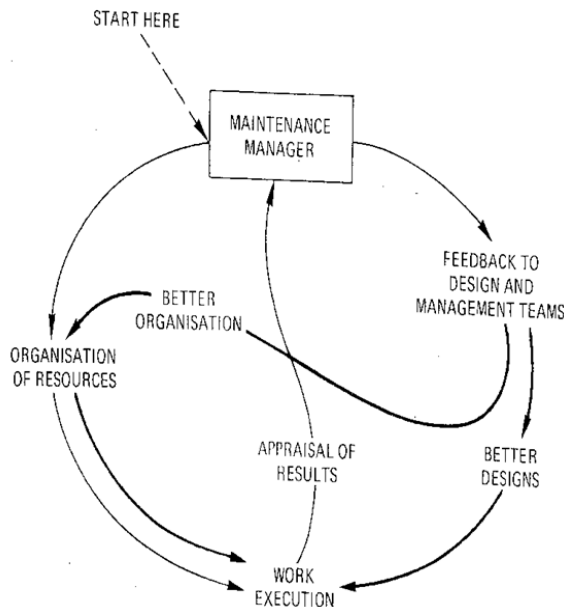
- (a) Management organization of resource;
- (b) Work execution
- (c) Appraisal of result; and
- (d) Corrective action through feedback to design and management team.

According to Seeley [10], to assist in the feedback of information, site defects are suitably recorded showing the symptoms, diagnosis, prognosis (projection of defect performance in time), and the agreed remedy. However, through analysis of past maintenance information, sequence of activities in each task need to be identified, with the type of work done and location in the building, and the cause of failure.

His model as shown in Fig. 2, shows some of the major stages in the operation of maintenance schemes as:



**Fig. 1. Cash’s model of relationships between building condition and student achievement**  
Source: [9]



**Fig. 2. Maintenance feedback model**  
Source: [9]

This model advocates the need for integration of building professionals in the design of buildings especially builders so that they can advice on the importance of integrated buildability and maintainability analysis during design stage. The model can be used as a management tool for effective maintenance of buildings in tertiary institutions. Consequently, the development of building maintenance model for this study will be guided by maintenance feedback model in this study. It should be noted that other models on maintenance feedback will be reviewed in this study [9].

## 5. RESEARCH METHODS

To obtain or gather data for any research work, certain procedures must be used. Research methods are merely tools used in gathering and analyzing data for the research [3]. Research method is described as the subset of the methodology, different research methodology. Thus, within a research methodology, different research methods or tools may be used to achieve the aim and objectives of the research [11].

### 5.1 Research Design

By virtue of the nature of the research, survey research method was adopted for this research. Survey research method according to Nworgu, (1991) is one in which group of people or items are studied by collecting and analyzing data from only a few people or items considered being representative of the entire group. The use of survey research method makes the data generated directly from respondents to be more distinct and finite.

#### 5.1.1 Primary data

Primary data is the information gathered directly by the researcher. For this research primary data was collected through questionnaire, oral interviews, direct observations and walkthrough evaluations and photographs. The data collection took about six (6) months.

### 5.2 Determination of Sample Size

The sample size for this study was determined using Bouely's formula as cited in Ogunoh [1]:

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

When, n = sample size, N = population, e<sup>2</sup> = Margin of error (assumed 5%)

1 = unity or constant

$$\text{Therefore} = \frac{1300}{1+1300(0.05)^2}$$

$$\frac{1300}{1+(1300 \times 0.0025)} = \frac{1300}{1+3.25}$$

$$\frac{1300}{4.25} = 306$$

The sample size of 306 was adopted for this study.

**Table 2. Distribution of questionnaire**

Group	Campuses	
	Total	%
Students	180	64
Works and service department	30	11
Physical planning unit	19	7
Bursary department	15	6
Academic staff	36	12
Sub Total	280	100%

Source: Researcher's field study (2018)

## 6. ANALYSIS AND INTERPRETATION

### 6.1 Building Maintenance Model

Buildings are essential physical facilities, expected to function effectively to accommodate the activities for which they are constructed. For buildings to meet these basic requirements, they need constant and regular maintenance. The concept of building maintenance is, therefore, one of the major theoretical backgrounds of this study. It is the act of embracing all actions which injects a new or better life into a building system, and helps to bring a building back to its original standard or well above such standard [12]. One of the objectives of this study was to recommend/develop a building maintenance model that would incorporate best practice criteria for maintenance of tertiary educational buildings. The model that will be recommended is based on the best practice criteria identified in the literature and case study investigations. Building maintenance model is a decision making framework for successful execution of building maintenance work.

### 6.1.1 Building conditions and students achievement model

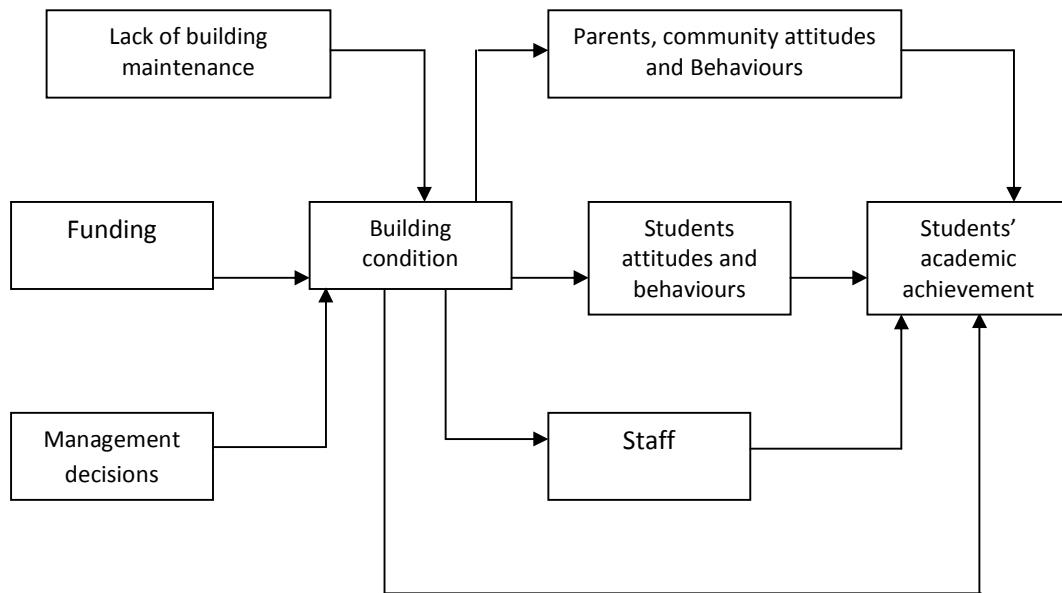
The success of educational building is assessed by the extent the building is functioning, and how the teachers, students and staff are utilizing the buildings and the impact on academic activities [3]. This shows that lack of maintenance of educational buildings has an adverse impact on students' academic achievements, their behaviours and workers' productivity. The maintenance of educational buildings in an organization involved the management, funding, and stakeholders. The building condition and students' achievement model provides a good alternative for the management for implementation of maintenance of educational buildings in an organization. Educational institutions could, therefore, use this model for effective maintenance of buildings. Fig. 3, describes the implementation strategies of building conditions and students' achievement model.

The model in Fig. 3 shows that several factors affect the school building condition. This indicates that management decisions, poor funding and lack of building maintenance will have a corresponding effect on building condition. There is no doubt; building condition affects student's attitudes and behaviours as well as their academic achievement. On the other hand, building condition affects parents,

community attitudes and behaviours which in turn affect students' academic achievement. Consequently, building condition affects the staff productivity for teaching, maintenance staff and other operatives, which also influence the students' academic achievements. The key issues in the building condition and students achievement model are that it establishes that management decisions, funding and priorities for maintenance determine the building condition of a school. The development and recommendation of a building maintenance model for this dissertation are therefore guided by the building condition and students' achievement model.

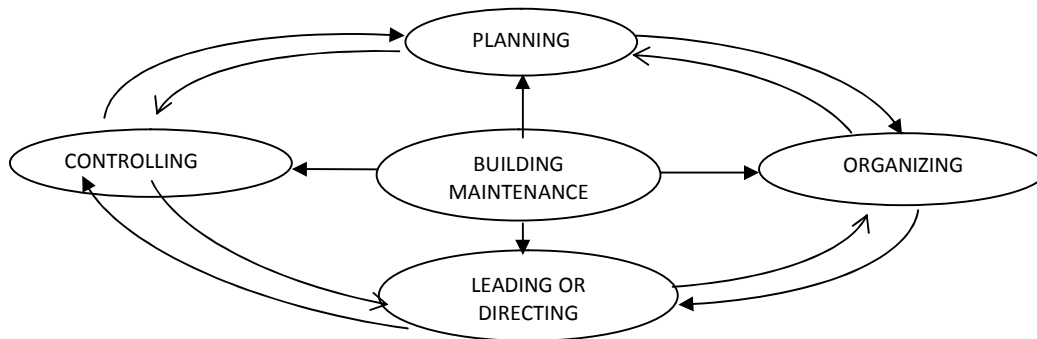
### 6.1.2 The model

Knowledge about the constant use of information to manage maintenance of building in an organization must be considered important. This study has shown that there is a need to provide a model for management and maintenance of buildings in the case organization. Thus, the proposed model focuses on how maintenance managers and other building service providers in institutions should consciously and continually adopt management model, in order to solve buildings maintenance activities. It also provides the institutions with bases to evaluate maintenance activities [9]. An outline and description of this model is illustrated in Fig. 4.



**Fig. 3. Building condition and students achievement model**

Source: [9]



**Fig. 4. Building maintenance management model**

Source: [9]

The building maintenance model describes the relationship among the various variables. This approach recognizes the best practices identified in the study and can transform the current situation in the institution into a systematic method of managing building maintenance. The model is built around the following four perspectives:

1. **Planning** implies deciding what type of maintenance work to be done, how it is to be done, who is to do it and at what cost, time and materials required. Planning assists maintenance managers to develop maintenance objectives for organizations and determining how to achieve them. It guides managers on how to obtain and commit the resources required for maintenance activities, carry on these activities consistent with the laid down procedures. Furthermore, it enables managers to monitor and measure progress of maintenance so that corrective action can be taken if progress is unsatisfactory. This means that the building maintenance objectives/criteria developed in this perspective support the fulfillment of the institutional maintenance strategic objectives.
2. **Organizing** is the process of organizing human and material resources, which includes staffing, purchasing materials, securing funds and other logistics for maintenance activities. Organizing perspective defines how authorities are structured, how communication flows and how tasks are accomplished in an organization. Simply put, organize in relation to the efficiency and effectiveness of managing building maintenance activities within an organization especially in educational institutions.
3. **Leading or Directing:** This is a system in which maintenance managers in organizations direct, influence, and motivates workers to achieve organizational objectives. This shows that, leading concerns with the building of a learning culture by management, in order to ensure that staff, especially those in charge of maintenance activities are trained. Thus, involving skills, competency development, frequency of training and adequate support for change.
4. **Controlling** is the process in which managers keep things on track by ensuring that standards are attained, measuring current performance and taking corrective action to ensure that there is improved quality of work. In fact, controlling function comes in the form of feedback/feed forward mechanism which ensures that organization performs better and learns from the outcome of their decisions.

The building maintenance management model is an effective, graphical, cognitive and description tool that would guide managers, institutions and other stakeholders in the industry on how to carryout effective and efficient management of maintenance activities. The implication of this model would ensure that activities are focused on the educational buildings and users (Staff and students) making sure that they get the satisfaction they desired from such buildings. Also, that workers are better trained, so that more efficient educational institutions are available in the academic institutions.

All the variables are integrated into the model. Furthermore, a mathematical model in the form of regression was also developed as supplementary to the graphical models already described in Figs. 4 and 5.

## 6.2 Approach or Framework for Effective Implementation of Building Maintenance Process

The literature from this research work shows that maintenance of building is an effective and efficient process for the improvement of teaching and learning in tertiary institutions. The maintenance of building problems identified in the case organization by this research should be addressed by maintenance managers and other stakeholders in the institution. This forms part of the information and process needed to identify and assist management and maintenance managers to improve the performance of existing and future buildings in the institution. In this regard, the following areas should be considered for an effective and efficient implementation of maintenance of building process.

### 6.2.1 Building maintenance manual

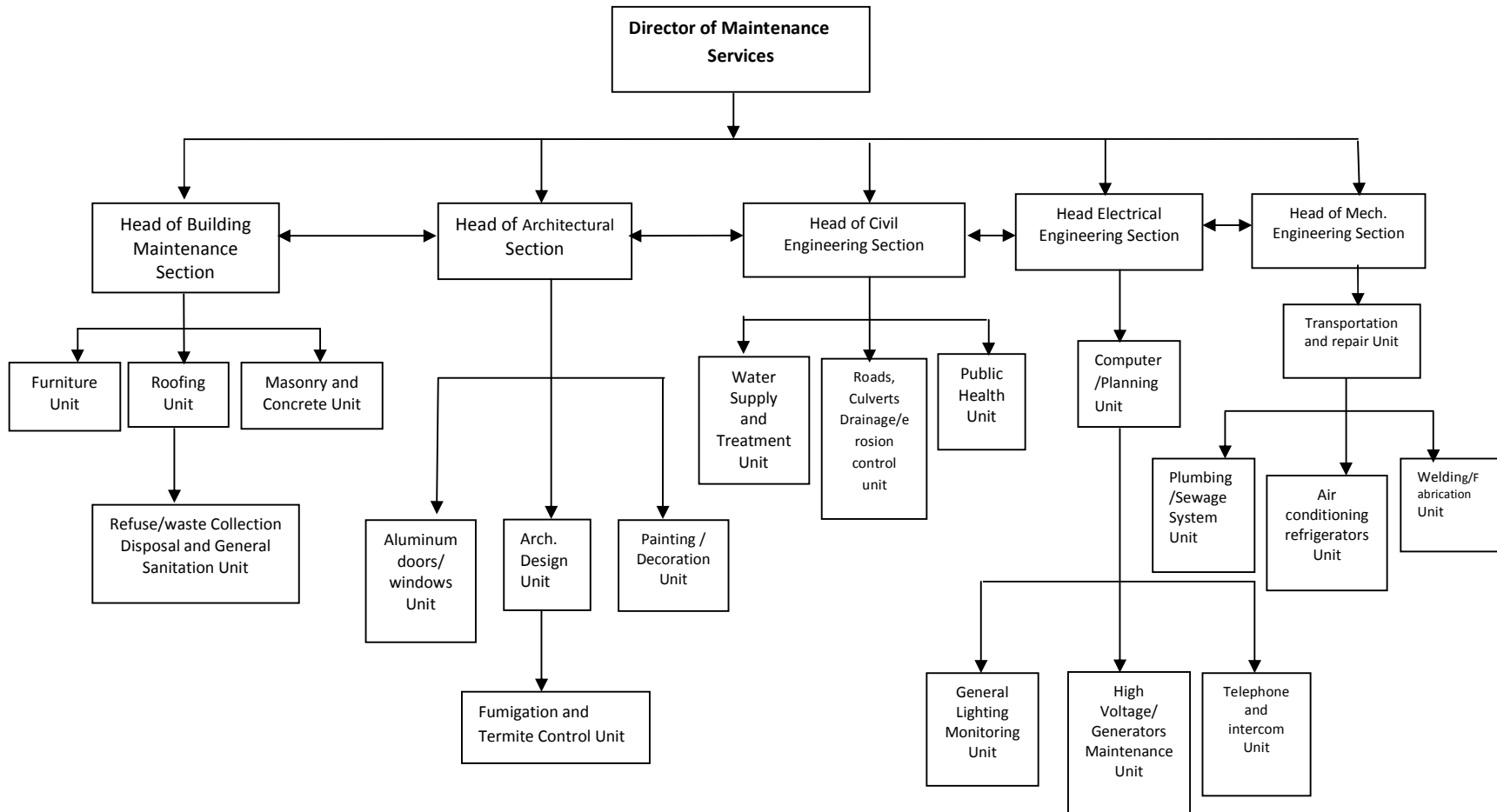
One of the problems identified in the case institution by this research is lack of building maintenance manual. Building maintenance manual forms part of the information and tools needed to assist management and maintenance managers. Building maintenance manual is a comprehensive guide, which will include appropriate forms and log books for the maintenance of buildings, prepared by a consortium of registered architects, registered builders and registered engineers NBC, 2006.

This shows that building maintenance manual will no doubt ensure the following goals.

- (a) Help educational buildings function as they were designed and operate at peak efficiency.
- (b) Prevents breakdown of building elements/components and services that would hinder teaching, learning, and working activities.
- (c) Provides and sustain a safe and healthful environment for users
- (d) Provides maintenance activities in such ways that are cost-effective and time frame.
- (e) Building maintenance manual provides accurate data for management decision making for planned and preventive maintenance programme.

From the foregoing, building maintenance manual should, therefore, comprised of the following

- (1) **Health and Safety:** According to section 12 (Post Construction Requirements) of the Nigeria, National Building Code provides for the maintenance, health and safety requirements to be observed on a new and existing building in Nigeria. For example, maintenance of existing building that involves underpinning method will require health and safety plan.
- (2) **Organizational Structure:** The organizational structure is the arrangement of job positions, relationship and hierarchy of operations for the purpose of accomplishing organizations task and responsibilities. Therefore, the organizational structure of the maintenance department should clearly define duties and responsibilities. It should not be rigid, but flexible which will involve appropriate personnel in decision making and communicating building needs. The structure should include architects, builders, engineers and craftsmen. The maintenance department will be headed by any of the professionals mentioned as the Director of Maintenance Services. For the effective and efficient flow of maintenance information and hierarchy of operations, all requisition for maintenance work orders comes to the Director of maintenance and the director channels the work to the appropriate section for necessary action. In this regard, line and staff pattern of organizational structure is suitable for maintenance department of this institution, because it provides a means of utilizing these special skills while still maintaining a hierarchy of line authority. In line and staff organizations functions are differentiated downward and outward. However, there is current organizational structure in the studied institution, but the one proposed by the researcher is flexible and covered the entire sections of the works and services department for effective maintenance as shown in Fig. 5.
- (3) **Inspection:** Adequate planning of the inspection of buildings is the best practice to control its costs. Inspection of educational buildings should be conducted methodically. This is because, it improves data consistency from building to building and over time. Inspection should be a continuous process in order to update the maintenance program. It is advisable to start the inspection with direct observations and walkthrough evaluations of the inside and outside of the building.



**Fig. 5. Proposed maintenance organizational structure**

Source: Researcher Field Study 2018



**(4) Maintenance Plan:** Involves, deciding what type of maintenance work to be done, when it is to be done, how it is to be done, who is to do it and at what cost and time. Maintenance plan will ensure effective execution of maintenance work in an organization. Use the following checklist listed below, to determine which items require attention and then match the recommendations in the corresponding section to determine what section to be taken. The checklist has been divided into the following areas of educational buildings and thus.

**(a) Structure:** The structure of a building is its elements/components which carries loads and transfers the loads safely to the foundations and hence to the ground. The structure of an educational building is, therefore, the group of columns, beams walls, floors and roof structure. There is a need to pay special attention to these aspects.

- (i). Warping in columns, beams, structural walls, floors and roof structure
- (ii). Rotting of metal structural components
- (iii). Rusting of metal structural components

Carryout routine checks on the structural members of the building at least every three months

## 7. DISCUSSION

The research is based on building maintenance practices in Universities and their implications on the achievement of educational goal and objectives. The research explored qualitative instruments such as direct observations, walkthrough evaluations, photographs were taken and interview were used to generate important constructs from the targeted population. This was followed by a quantitative method of data production, which comprised of the design, pre-test and administration of structured questionnaires in the studied institution. Data and information obtained from the quantitative research instruments were used to test the hypotheses postulated by the researcher.

Furthermore, the result from this study demonstrated that many designers do not integrate buildability and maintainability analysis during the design stage of buildings. A survey carried out by Adekoya (2006), reveals that one

of the factors that contribute to the deterioration of buildings is a failure to carry out maintainability analysis during the design stage. Ikpo [12], shares the same view that designers do not highlight the importance of maintainability analysis at the design stage, which in turn affect the performance of the finished product. In view of this, the researcher, therefore, recommends that buildability and maintainability analysis be integrated during the stage of buildings. Builders who are responsible for the production of such document should be part of the design team, because of their expertise, to ensure maximization of project goals.

## 8. CONCLUSIONS

The research is based on building maintenance practices in universities and their implications on the achievement of educational goal and objectives. The institution and construction professionals/maintenance managers have been urged to adopt the building maintenance plan, manual, building maintenance management model and organizational structure as a tool to address the functionalities in buildings in the university system in Nigeria. From the results of investigations and analysis carried out, it could be concluded that the aim and objectives of this research have been achieved.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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