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DEVELOPING A MAINTENANCE MANAGEMENT SYSTEM FOR PUBLIC BUILDINGS IN DISTRICT LOCAL GOVERNMENTS OF UGANDA:

A CASE OF AMURIA DISTRICT LOCAL GOVERNMENT

BY

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CERTIFICATION

The undersigned, certify that they have read and hereby recommend for acceptance by Kyambogo University a dissertation titled: "**Developing a Maintenance Management System for public buildings in District Local Governments of Uganda: A Case of Amuria District Local Government**" in fulfilment of the requirements for the award of a degree of Master of Science in Construction Technology and Management of Kyambogo University.

Supervisor: Signature: ______________________ **Date:** 28/11/2020

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Supervisor: Signature ______________________ **Date** 02/12/2020

Dr. Muhwezi Lawrence

DECLARATION

I, **Eonya Julius Elolu,** hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree of the University or any institute of higher learning, except where due acknowledgement has been made in the text and reference list.

Student: Signature ____________________ Date 28/11/2020

Eonya Julius Elolu

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May the Almighty God continue blessing all of you as you help others in the academic endavours.

DEDICATION

I dedicate this book to my dear wife Imede Esther and our children Abeda Felice Eonya, Eonya Aldo, Eonya Anthelm and Eonya Arthur for their endurance, tolerance and sacrifice during the time of study and writing this report.

May the Almighty God bless you all abundantly.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASOCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ATWS	Average Total Weighted Score
BCA	Building Condition Assessment
BS	British Standard
CAO	Chief Administrative Officer
CCIS	Component Condition Index System
CSP	Condition Survey Protocol
CSR	Condition Standard Rating
CVR	Content Validity Ratio
DLG	District Local Government
DTPC	District Technical Planning Committee
FAHP	Fuzzy Analytical Hierarchy Process
GoK	Government of Kenya
GoU	Government of Uganda
HoD	Head of Department
ICA	Infrastructure Condition Assessment
LC	Local Council
MCDM	Multi Criteria Decision Model
MMS	Maintenance Management System
MS	Microsoft
MVA	Multivariate Analysis
NDP	National Development Programme
RICS	Royal Institute of Chartered Surveyors

SDG	Sustainable Development Goals
TCI	Theoretical Condition Index
UNDP	United Nations Development Programme
UN	United Nations

ABSTRACT

The practice of building maintenance is globally accepted as the most sustainable way to conserve buildings from deterioration. In most developing countries, costs incurred for assessment, repair and maintenance of buildings are principally met by the local governments other than insurance companies and yet the former have insufficient funds to cater for the challenges of maintenance of buildings. This study sought to develop a maintenance management system for public buildings in District Local Governments of Uganda. Published literature on building maintenance management systems, condition survey index, defects severity and their priorities on the need to rectify was reviewed. The methodology used in this study had mechanisms of collecting both primary and secondary data sources that included key informant interviews, observations, inspections and desk studies. The maintenance management system was used determine the components to be maintained by ranking. This was premised on the severity of defects using a Multi-Criteria Decision Model (MCDM) that was based on the principals of Fuzzy Analytical Hierarchy Process (FAHP). During the study, condition assessment of buildings was conducted using an assessment tool and the staff that were involved in the management of buildings were interviewed. The findings showed that visual observation was the common mechanism used for condition assessment of building components due to the limited allocation maintenance activities in the development budgets. The common defects that affected components of the buildings were mostly cracks, surface deterioration, moisture ingress and debonding which was attributed to the social behavior of users and environmental factors. Most components were in good condition that required regular routine maintenance and a few were dilapidated and required immediate attention. This study recommended that District Local Governments need to establish the Maintenance Management System and regularly conduct condition assessments to inform the planning and budgeting of the built asset portfolio.

Key Words: Maintenance, Defects, Components, Assessment, Management System

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Building maintenance is the process involving a set of activities aimed at slowing down the rate of deterioration, bring back to a usable state and extend service life of a building. The practice of building maintenance is globally accepted as the most sustainable way to conserve buildings from deterioration. In most of the developed countries, maintenance is considered a key aspect in the life of an asset and is given great attention. Management of maintenance activities is rather a complex but necessary measure for the planning of maintenance activities.

According to Lai (2010), most developed cities in Africa have buildings constructed with quality fabrics and sophisticated facilities that require adequate and proper maintenance to ensure their effective operation. The requirement for maintenance has resulted into the demand for the development of maintenance management systems to enhance the effective running of the maintenance of buildings.

The countries in East Africa, like most of the African countries, have emulated the modern construction methods using a blend of materials including the sophisticated fabrics and these require adequate maintenance. It is, however, noted that there has been rather a slow adoption of maintenance management systems for buildings both public and privately owned attributed to a number of factors as noted in the reports by Government of Kenya (2015) and Government of Uganda (2016).

Maintenance of public buildings in Uganda is mostly done as a reactive measure to emergency situations (GoU, 2016). This practice is attributed to the limited priority given by authorities to the management of buildings. The District Local Governments according to the Local Government Act (2003), are the authorities charged with the responsibility for planning and management of the public built environment portfolio where the local population gets public services in their jurisdiction. Tsang (2002), says that maintenance works is an important function in any organization with significant investment in physical assets.

Alani and Khosrowshahi (2007) confirm that in most developing countries, costs incurred for assessment, repair and maintenance of buildings are principally met by the local governments other than insurance companies. In most cases, these local governments have insufficient funds to cater for the challenges of maintenance of buildings (Alani and Khosrowshahi, 2007).

In a report by the Government of Kenya (2015), the challenges of limited funding coupled with poor maintenance culture in organizations, most local governments tend to prioritize construction of new buildings rather than maintenance of the existing stock. This assertion is confirmed in the report by the Government of Uganda (2016), where it is stated that the Ugandan society is characterized by a poor repair and maintenance culture of their houses leading to a high rate of deterioration requiring upgrading or replacement. This poor culture, together with the inadequate regulatory framework to enforce maintenance of public buildings has often resuited to poor maintenance management. Most personnel involved in the condition assessment of buildings depend mostly on manual methods of assessing and recording the findings which results to a bulk of clerical work that is in most cases not well managed hence making planning and budgeting for maintenance works not done according to the available data by management.

The report by Government of Uganda (2016) suggests that there is need to have a coordinating mechanism for building development at all management levels and this call for a systematic mechanism for the management of maintenance activities. Marilyn (2006) emphasizes the need for having a regularly updated maintenance management system of buildings that requires the maintenance supervisor or manager to monitor the buildings frequently. The monitoring is to establish the extent of deterioration and for the time inspection is done, an update of the database is to be conducted and reports generated are shared among different levels of management.

Planning, organizing, directing and controlling budgets for maintenance of buildings, which is a basic framework for management, requires adequate information about the building stock. This will enable informative decisions regarding the maintenance management of buildings to be made as part of the maintenance process. A building maintenance management system is, therefore, very relevant to inform decisions made so that wasteful maintenance expenditures are avoided and the facilities can attain the required service life.

The Global Sustainable Development Goal (SDG) number 9 states that "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" requires more investment in innovation and infrastructure (UN, 2015). Bridging the digital divide, promoting sustainable industries, and investing in scientific research and innovation are all important ways to facilitate sustainable development.

According to the Uganda Vision 2040, access to decent shelter by the population in both rural and urban settings is a way of social transformation. Housing is essential for the well-being of mankind and the conditions of the house are important in improving the sanitation status of a household. In addition, the condition of a structure could be a proxy indicator of the welfare status of a household.

In Uganda, preliminary inquiries from the District Engineers of some of the District Local Governments of Soroti, Kumi, Serere, Amuria, Kaberamaido, Bukedea, Ngora, Katawki, Kole, Zombo, Tororo, Amolatar, Kotido, Amudat and Oyam indicate that, all had no systematic maintenance management system of buildings. For most of the districts mentioned, maintenance works were done on buildings after the defects had accumulated to a deplorable situation that nearly become dilapidated and unfit for occupancy mostly posing a health and safety risk. Amuria District, was taken as a case of study for the development of the maintenance management system for district public buildings because preliminary studies indicated that it had the worst scenarios of building maintenance deficiencies and had no proper maintenance mechanism as compared to the other districts. This was attributed to the fact that there was no designated officer to handle buildings in the engineering department.

1.2 Statement of the Problem

Buildings are required to be maintained so as to meet certain standards of safety and health requirements. District Local Governments have to manage the maintenance of public buildings adequately with regular assessment to monitor the condition of the building so as to ensure the users or the occupants enjoy the comfort of the built facilities. The housing policy by the Government of Uganda (2016) provides that the government has to increase access to institutional or employer housing in many parts of the country especially in newly created districts.

However, maintenance management of buildings in Amuria district local government is an area that is given low priority and less attention having no budget provisions for preventive maintenance. Government of Kenya (2015) and Government of Uganda (2016), agree that maintenance management of public buildings in local governments is poor as evidenced by the number of fast deteriorating buildings under their management. In Amuria District, funding for maintenance of buildings is less prioritized. This was attributed to the poor culture of the responsibility of planning and budgeting for buildings and their management by the user departments. These user departments not only have budget limitations to fulfill their primary mandate, but also lack basic data and the technical engineering expertise to identify, plan and budget for the necessary interventions of building maintenance. The engineering department, on whose dockets the execution of repair and maintenance works falls, is not directly involved in the planning and budgeting process of these user departments. This has often led to unrealistic allocation of funds for maintenance activities since the decisions made are not founded based on the engineering technicality and limited availability of the condition status of the buildings. In addition, the department is understaffed and thus not much attention is given to maintenance of the built environment or facilities.

District local governments with no proper maintenance management system of public buildings will always suffer heavy financial burdens in the long run due to corrective interventions that are done as a reactive measure of maintenance. In addition to the financial burden, the building users and occupants are exposed to both health and safety threats, (Gidudi, 2012).

To ensure good maintenance of buildings, it is important for Amuria district local government to have maintenance management system that the engineering department can use to generate information about the building conditions and these will enable the user departments to identify and prioritize during the planning cycle the buildings to be maintained. This study sought to develop a maintenance management system for public buildings in district local governments of Uganda.

1.3 Objectives of the Study

1.3.1 Main Objective

The main objective of the study was to develop a maintenance management system of public buildings in local governments of Uganda.

1.3.2 Specific Objectives

The specific objectives of this study were;

i. To establish the current mechanisms used for condition assessment of public buildings in Amuria district;

ii. To establish the common defects causing the deterioration of the building components in Amuria district;

iii. To establish the maintenance requirements of the building components in Amuria district;

iv. To develop a maintenance management system for building components in Amuria district.

1.4 Research Questions

i. What are the current mechanisms used for condition assessment of buildings Amuria district?

ii. What are the common defects that cause deterioration of building components in Amuria district?

iii. What are the maintenance requirements of the building components Amuria district?

iv. What can be done to reduce deterioration of building components in Amuria District?

1.5 Justification

The growing demand for public housing facilities in Amuria district local government has resulted to the need for the construction of new buildings and the renovation of the already existing ones. The district has no specific budget allocation for the maintenance of the built facilities. To cater for maintenance interventions, other budget items have to be affected which interferes with the whole budget execution and leads to poor performance in sections of the budget. The resources are inadequate to meet all the growing demand for the built facilities and thus a need to maintain the existing old stock of the building portfolio effectively. The Maintenance Management System (MMS) was important for real time assessment to be conducted, information about the building conditions would easily enable the user departments to identify and prioritize during the planning and budgeting cycle the buildings to be maintained. This would minimize or eliminate the current practices.

1.6 Significance of the Study

The maintenance management system once instituted and regularly updated will facilitate the local governments to plan, organize, direct and control budgets for maintenance of buildings. This will lead to cost effective and efficient measures for maintenance management of buildings and thus saving resources that can be utilized to fund other development priorities in the local government. The district local governments will, therefore, have a safe and well maintained portfolio of public buildings at reduced life cycle costs. This study will have a significant contribution to similar studies elsewhere that are made towards development of maintenance management systems for the built environment.

1.7. Scope of the Study

1.7.1 Geographical Scope

The public building portfolio with in Amuria Town Council was considered for the study basically because it is where the largest number of public buildings managed by most departments of Amuria District Local Government is concentrated. Additionally, Amuria town had good proximity to both the researcher and the key personnel involved in the maintenance management of buildings.

1.7.2 Content Scope

This study focused on the analysis of the evaluation of the condition of components in building constructed between 2006 and 2016 a period in which Amuria district has been in existence as a local government. Assessment of defects was conducted, rating of defects and establishing the maintenance requirements. The results from these activities were then analyzed, ranked and according to their severity used to develop the required maintenance management system.

1.7.3 Financial Scope

The financial resources used during the study for mobility, allowances, communication and associated clerical work were mobilized from personal savings by the researcher. Traversing of the entire district was limited by the available resources and as a result most of the study was conducted in the area of Amurai Town Council. A total of three million shillings (3,000,000/=) was used during the study for allowances and transport of data collectors, hire of equipment for conducting tests.

1.7.4 Time Scope

The study was conducted between December 2017 and May 2018. Report writing was conducted during the same time and stretched over to August 2019. During the study, emphasis was made towards the evaluation of the condition of buildings constructed between 2006 and 2016, a period in which Amuria district has been in existence as a local government.

1.8 Conceptual Framework

A conceptual framework represents the researcher's synthesis of the literature on how to explain a phenomenon. Sekaran (2003) defines the conceptual framework as how one makes logical sense of the relationships among the several factors that have been identified as important to the problem.

This study was conceptualized from the Kimberley and Zumpano (2009) report in which the recommendation for the need of a quick and practical approach to performing building inspections was emphasized. It includes a concise approach that applied by the Royal Institute of Chartered Surveyors (RICS) reporting procedure for building inspection that is considered shorter and less detailed in a standardized format and a condition rating with a special feature which standardizes the report and provides a quick overview of the entire property's condition (Che-Ani et.al., 2011). Amuria District Local Government like many other local governments incurs a large proportion in the development budget to carryout maintenance of buildings which could be reduced by introducing a maintenance management system. These expenditures can be greatly avoided by carrying out regular inspections to assess the condition of building components and appreciating this data to establish when, how and which building component are to be maintained thus informing timely response to defects. The Conceptual framework provides an illustration of the study process that was employed to achieve the design of the maintenance management system.

The figure 1.1 illustrates the concept in relation to influencing factors.

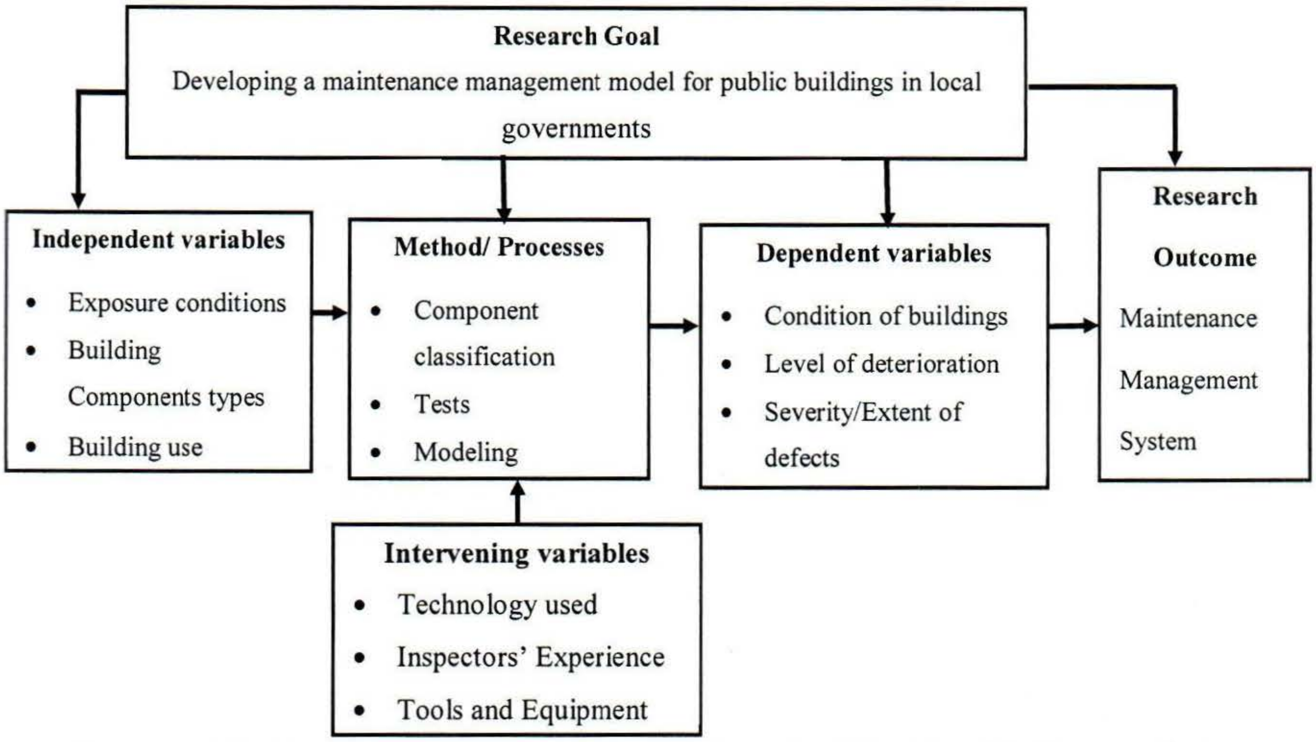


Figure 1.1: Conceptual Framework (Adopted from Murthy et.al., 2002 and modified by researcher)

1.9 Chapter Summary

Most local governments have the responsibility of managing the public built environment. Due to the vast building portfolio, often, inadequate funds are allocated to carry out sufficient maintenance of their built asset portfolio. This study was premised on the background that most local Governments in Uganda face considerable financial constraints in the maintenance of the built asset portfolio that has resulted to poor and untimely response and often neglect maintenance interventions. The next Chapter provides an in depth of the relevant literature. This helped in the achievement of the objectives of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature pertinent to the study as presented by various researchers, scholars and authors that relates to the management of maintenance systems of buildings in local governments. It summarizes literature that has been reviewed for purposes of the study. Empirical and theoretical review studies of previous studies are also covered in here. The chapter concludes with the findings and recommendation from previous studies upon which the research gap that the study sought to address.

2.2 Building Maintenance

Maintenance is the combination of all technical and administrative actions including supervision, intended to retain an item or restore it to a state in which it can perform a required task (GoK., 2015). Maintenance of buildings is the process or a set of activities which are aimed at slowing down the rate of deterioration, bring back to a usable state and extend service life of a structure. Maintenance of buildings is defined as work undertaken in order to keep, restore or improve every part of the building, its services and surrounds to a currently acceptable standard and to sustain the utility and value of the facility (Chanter and Swallow, 2008). Maintenance Management refers to an orderly and systematic approach to planning, organizing, monitoring and evaluating maintenance activities and their costs (Nurul and Othuman, 2014). The Queensland Department of Housing and Public Works (2017), describes a maintenance management system (MMS) as a systematic process to manage a maintenance program.

A number of scholars have defined several of maintenance interventions and classified them according to intent, timing or frequency of maintenance. The BS 3811 (1984) classifies maintenance in two categories of planned and unplanned. As regarding the classification by timing or frequency, maintenance is categorized as periodic or routine.

Building maintenance requires a strategy that will identify factors causing poor maintenance of various types of buildings that may include inappropriate setting up, policies and quality standards, inadequate understanding of occupant satisfaction, insufficient number of staff members and the inefficient strategies used in maintenance delivery (Chan, 2014). The most sensible approach to take at the outset is to see maintenance work as that which enables the building to continue to efficiently perform the functions for which it was designed (Chanter and Swallow, 2008).

2.2.1 Routine maintenance

These are activities (preventive or corrective) are carried out more often than once a year. These include mopping, sweeping and lubrication of movable parts. Such activities include operations that may be planned and organized with forethought, control and the use of predetermined plan or operations necessary to put in hand immediately to avoid serious consequences and these include activities like inspection, lubrication and servicing, cleaning, adjusting and component replacement (Ofori et. al., 2015).

2.2.2 Periodic maintenance

According to Ofori et. al., (2015), periodic maintenance involves activities carried out less often than once a year such as once every two or five years. The maintenance tasks are often programmed in predetermined plans or schedules. These activities are scheduled to be carried out at predetermined interval of time, number of operations and mileage. This is a strategy that requires maintenance tasks to be performed at set time intervals while the facility is operational. Similar to scheduled maintenance, periodic maintenance activities are planned ahead of time and are performed with or without signs of deterioration (Forster and Kayan, 2009).

2.2.3 Corrective maintenance

This is the maintenance carried out after a failure has occurred and is intended to restore an item to a state in which it can perform its required function (Forster and Kayan, 2009). This maintenance is conducted as a result of breakdown or noticeable infrastructure deterioration. Ofori et al., (2015) refer to corrective maintenance as failure-based or unplanned maintenance that is meant to rectify failures caused by incorrect design, incorrect installation or use of faulty materials.

2.2.4 Preventive maintenance

This refers to maintenance carried out at predetermined intervals or corresponding to a prescribed criterion and is intended to reduce the probability of failure or the performance degradation of an item (Ofori et. al., 2015). Smith (2003) says that this maintenance is as a result of a systematic pre-scheduled activities or programmes of inspections and maintenance activities aimed at early detection of defects and implementation of actions to avoid breakdown or infrastructure deterioration. These operations may include condition-based maintenance activities often initiated as a result of knowledge of the condition of an item from routine or continuous monitoring (Lee, 1987).

2.2.5 Rehabilitation

This refers to activities carried out to correct major defects in order to restore a facility to its intended operational status and capacity without significantly expanding it beyond its originally planned or designed function or extent (Ofori et.al., 2015). Rehabilitation activities are generally more expensive than corrective maintenance activities.

2.3 Theoretical Review

Georgiou (2010) maintain that maintenance is still accepted as the most sustainable and suitable way to conserve buildings. Brereton (1995), suggests that the best means of ensuring the continued preservation of a building is to carry out regular maintenance.

The study by Syagga and Aligula (1995), recommends an appropriate maintenance policy with an appropriate legal backup, establishment of information systems to collect and store information, creation of efficient financing mechanisms for building maintenance of public buildings, supervision of contractors to maintain and improve standards of workmanship and sensitization of occupants on their roles in maintenance of built assets.

Preventive maintenance can prevent minor problems from escalating into major system and equipment failures that result in costly repairs. In avoiding costs of major repairs, preventive maintenance creates efficiencies. Increasing preventive maintenance can reduce time spent reacting to crises, which is a more cost-effective way to operate buildings. Deferring preventive maintenance can generate higher costs over the long term.

2.4 Review of Specific Literature

2.4.1 Condition Assessment

Queensland department of housing and public works (2017), defines condition assessment of buildings as the process by which the physical state of building elements and services and the maintenance needs of the facility are evaluated technically by competent assessors. The ultimate aim of condition assessment is to have a reliable knowledge of the physical state of the buildings and the impacts so as to enable the development of appropriate strategies and actions for maintenance, major replacements, refurbishments and investment (Department of housing and Public Works, 2017). Marilyn (2006) opined that collecting information about the condition of a building is necessary to help building managers identify maintenance needs and qualify works that can be attended to immediately or deferred.

According to the Department of Housing and Public Works (2017), survey and audit are the two methods of carrying out condition assessment of buildings. Survey method is a broad appraisal which produces a relatively fast-scan of the asset condition and is generally used where a quick result is required, funding is limited and or where assets are less complex. The inspection involved is basic and can be carried out by technical or non-technical personnel. The Audit method involves a more structured inspection approach that requires consistent, quantitative and qualitative information relating to the asset in terms of condition and associated risks using a detailed appraisal of the asset's individual services elements.

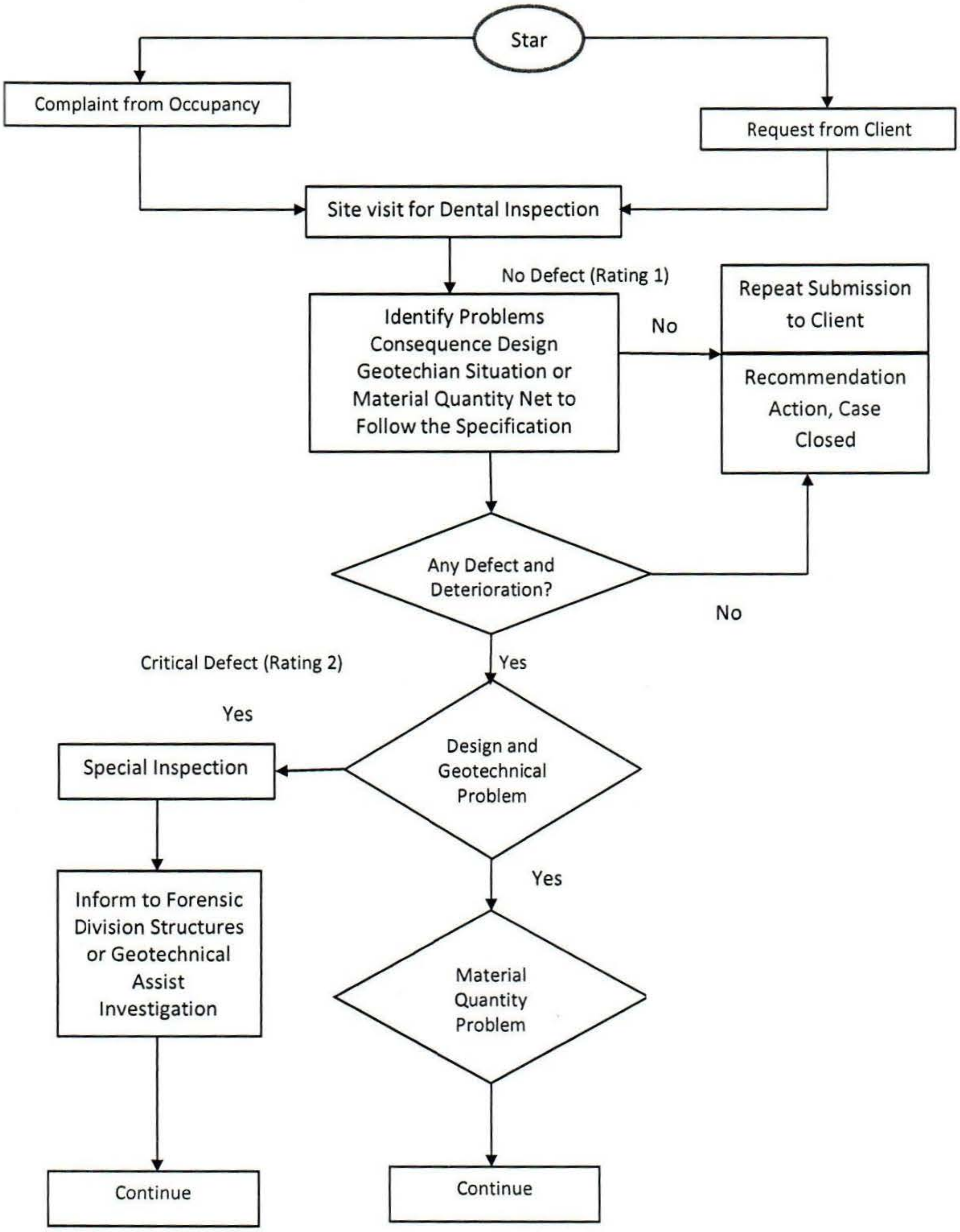
The Building Research Institute of Japan (2002), recommends three ways that information from the assessment of buildings can be collected: -

i. Data collected through quick visual inspection;
ii. Data collected in (i) plus additional information on the characteristics of the structural elements of buildings; and
iii. Data required for all full engineering evaluation.

Thus, inventory and condition data are considered vital as that provide managers with the information needed to plan maintenance projects, set priorities among them, and estimate their costs (Marilyn, 2006). The information necessary in the condition assessment involves the parameters that include the importance of defects, intensity and the extent of defects. The extent and the intensity of a defect combined with the importance of the defect lead to a condition rating, and with a defect score as an intermediary product (Dabo et.al., 2014).

According to Li et al., (2009), the aim of carrying out a condition survey is to have close and more intensive examination of all elements of the structures. According to the study by Nima et.al., (2012) on Infrastructure Condition Assessment (ICA), they observed after conducting an extensive literature review on related studies of Component Condition Index Systems (CCIS), that component assessment is a basis for the management of the infrastructure life cycle. The information obtained from the condition survey is required for planning for the routine maintenance, rehabilitation, modification, of the service condition, investigation of the structural stability, and study of the performance of material under a specific exposure condition (Straub, 2009).

Therefore, in formulating any maintenance planning or activity, the condition survey has to be carried out first and this condition survey often seeks to identify three condition matrixes which includes importance of defects, intensity of defects and extents of defects (Dabo et.al., 2014). Syed and Wan (2010) provided a systematic flow chart highlighting the procedures for conducting a condition assessment. In this study, Figure 2.1 illustrates the flow chart of the procedures adopted during the condition assessment of the components.


Star
Complaint from Occupancy
Request from Client
Site visit for Dental Inspection
No Defect (Rating 1)
Identify Problems Consequence Design Geotechian Situation or Material Quantity Net to Follow the Specification
No
Repeat Submission to Client
Recommendation Action, Case Closed
Any Defect and Deterioration?
No
Critical Defect (Rating 2)
Yes
Yes
Special Inspection
Design and Geotechnical Problem
Yes
Inform to Forensic Division Structures or Geotechnical Assist Investigation
Material Quantity Problem
Continue
Continue

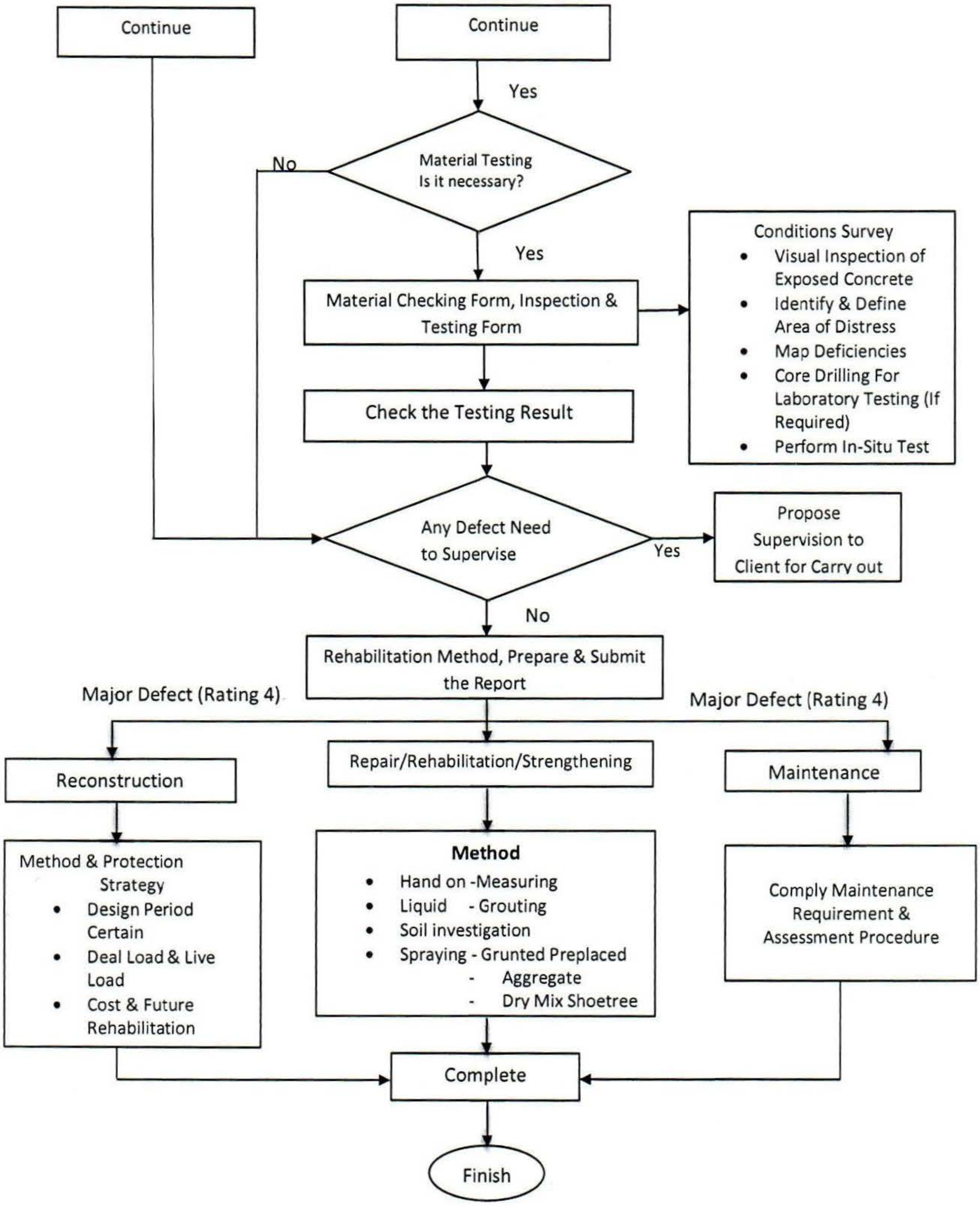


Figure 2.1: Assessment Procedure for Defect and Deterioration of Building Structures

Source: Adopted from Syed and Wan (2010)

2.4.2 Maintenance Requirements and Standards

The assessment of buildings will involve visual inspection, detailed assessment of structural and non-structural elements and full engineering evaluation. For an organization that has a large portfolio of buildings, a cursory condition assessment is generally suitable for screening multiple buildings to establish relative priorities for unit assessment and to develop a facility assessment plan (Alani and Khosrowshahi, 2007). A checklist with a numerical rating system may be provided so that assessors have a common overview of the assessment from which subsequent ranking of the buildings is done. Marilyn (2006) emphasizes the need for using a building condition rating as this provides the scale that describes the extent to which the building element has deteriorated from which decisions if the maintenance action is warranted or not are deduced. Stonewell (2013) suggests rating good, fair and poor as conditions of an element in relation to the level of maintenance requirement, however, Marilyn (2006) prefers the rating scale to be a simple to a more sophisticated one using a numerical index depending on the local needs. Stonewell (2013) described the rating criteria as: -

i. Good Condition being a reasonable condition, not expected to require capital expenditure within the near future;
ii. Fair Condition to mean a deteriorating condition, likely to become "poor" within a few years if not addressed; and
iii. Poor Condition is where an observable deterioration requiring immediate capital repair.

In the event where multiple assessors are involved, it is important to use well-designed inspection forms to collect uniform data for assessment. Checklists, however, are insufficient unless used by personnel with knowledge to identify the root causes of building deficiencies and this helps improve accuracy and diminish the subjectivity of individuals' judgments.

2.4.3 Defects and deterioration of building components

Defects or defective work occur when the standard and quality of workmanship and materials, as specified in the contract are deficient (Georgiou, 2010). Defects may occur in any part of a construction project and at any stage of construction. Douglas & Ransom (2007) define a 'defect' as a shortfall in performance occurring at any time in the life of the product, element or building in which it occurs. In Atkinson (1987) cited by Buys and Le Roux (2013), they sighted, to have referred a failure as a departure from good practice, which may or may not be corrected before the building is handed over and a defect being a shortfall in performance which manifests itself once the building is operational. Defect is the nonconformity of a component with a standard or specified characteristic. Defect is used sometimes as a synonym for "failure", but the preferred meaning is to indicate only a deviation from some (perceived) standard that may, but will not necessarily result in failure (Wood, 1997).

Nurul and Othuman (2014), categorized building defects as structural and non-structural. The Northern Territory Consolidated Regulation (2013) defines a structural defect as any defect in a structural element of a building that is attributable to defective design, defective or faulty workmanship or defective material and sometimes any combination of these while a non-structural defect is described as a defect in a non-structural element of the building as a result of defective residential building work.

In the study by Seth (2014), causes of defects in building elements range from many underlining reasons right from physical agents, biological, chemical and mechanical agents and these (defects) can also occur when buildings age or not used in accordance to design requirements as well as lack of adequate maintenance. When a building structure experiences an improper condition that leads to failures or low performance and utilization of the building, its result does not only affect the building aesthetically but the safety users may sometimes be threatened (Che-Ani et.al., 2011).

Therefore, to rectify a defect, one needs to fully understand the causes before embarking on any remedial works.

In planning for remedial works, the rate of defects and their severity are required so as to prioritize the components of the building that are grossly affected. A defect rate as defined by Seth (2014), is the measure of defects identified and recorded from the field divided by the population count of interest while the severity index is the assessment of the true extent of the defect occurrence on the various building components in terms of both function and usability. The principle behind the defect severity index is to have more serious defects carry a higher weight than less serious defects (Seth, 2014). According to Nurul and Othuman (2014), the most common defects in the building are cracks and they adopted a weighted score classification of common defects in walls as illustrated in Table 2.1. It is worth noting that the functionality of the building components is influenced by the extent of the defects' intensity and severity (Dabo et.al., 2014).

2.4.4 Maintenance Management System

A Maintenance Management System is a reporting system designed to track daily maintenance activities and used to plan, organize, schedule, control and evaluate maintenance activities using standardized procedures while tracking labour, material, equipment and contract costs (Gidudi, 2012). This system links science, engineering and technology in assessing the condition of equipment and predicting degradation under different maintenance and operating loads (Pitt et.al., 2006). Murthy et.al., (2002), further opine that a maintenance management system should have an integral component to include the importance of decisions of resourcing strategy either work to be done in-house or outsourcing. Nkado and Buys (2006), enumerates several elements of an effective maintenance management system that include having maintenance budgets based on maintenance plans, computerized maintenance information management, setting maintenance standards, regular maintenance inspections and life cycle costing at design stage among others.

Table 2.1: Classification of visible damage

Category of Damage	Degree of Damage	Description of Typical Damage	Approximate Crack Width (mm)
0	Negligible	Hairline crack of less than about 0.1 mm widths are classed as negligible. No actions required.	Up to 0.1
1	Very Slight	Fine cracks which can be easily treated during normal decoration. Damage generally restricted to internal wall finishes and cracks that are rarely visible in external brickwork.	Up to 1
2	Slight	Crack easily filled. Recurrent crack can be masked by suitable linings. Cracks on not necessarily visible externally, some external reappointing may be required to ensure weather tightness. Doors and Windows may slight and require easing and adjusting.	Up to 5
3	Moderate	Crack which required some opening up and can be patched by a mason. Repointing of external brickwork and possibly small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 to 15 (or several of 3mm)
4	Severe	Extensive damage which required breaking-out and replacing sections of walls, especially over doors and windows. Windows and doors frame distorted, floor sloping noticeably. Wall leaning or bulging noticeable, some loss of bearing in beams. Service pipes disrupted.	15 to 25 But also depends on number of cracks
5	Very Severe	Structural damage which requires a major repair job involving partial or complete rebuilding. Beams lose bearing, wall lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually greater than 25 but depends on number of cracks

Source: Adopted from Nurul and Othuman (2014)

Straub (2009), maintained that maintenance management systems should enable users to calculate maintenance performance levels and priority setting of maintenance work dealing with the risks of failure of components. In a study by Straub (2009), until 2000, most maintenance management systems were lacking possibilities to calculate alternative maintenance strategies and maintenance performance levels in planned maintenance and thus, most systems just supported the tuning of the "maintenance stock" for the available budget by setting priorities.

Most existing maintenance and management systems are developed majorly focusing on the life-cycle cost minimization only while forecasting and calculation of reliability and durability remain a challenge (Dabo et.al., 2014). This was because the performance of a structure is usually described by the visual inspection-based on structural condition only.

According to Raposo et.al., (2012), the internationally recognized guidelines defined in the British Standard BS 8210 (BSI, 2012) and Italian UNI 10604 (EIN 1997) provide rules for the development of building maintenance management systems. In the study by Natario (2016), a maintenance management system can have various stages of implementation and development as well as different levels of complexity. Raposo et.al., (2012) grouped these systems according to the degree of maturity development as basic, intermediate and advanced.

Teicholz and Gary (2012) developed a Theoretical Condition Index (TCI) as one of the building management system whereby the building components that make up every type of a constructed asset have average life expectations. This system is used to derive age-based theoretical condition indices for the buildings using existing published average life expectancy information and a calibrated deterioration curve.

2.4.5 Developing a Maintenance Management System

According to Straub (2009), maintenance management systems should enable users to calculate maintenance performance levels and priority setting of maintenance work dealing with the risks of failure of components. Mathematical models have to be developed to enable the estimation of the time and cost of the interventions so as to arrive at an ultimate decision.

In the study by Ali (2017), any decision making that involves cost, time, and human participation or involvement of many parties becomes a complex one with some model factors weighing more than others. This is all defined as a Multiple-Criteria Decision Making (MCDM) model. The Weighted Sum Model (WSM) is known to be the simplest method in Multiple-Criteria Decision Analysis (MCDA) in evaluating a number of alternatives in terms of a number of criteria (Ali, 2017). There are many other models that can be derived for decision making basing on earlier scholars. Some of these include Fuzzy logic developed by Lotfi (1965) and Analytical Hierarchical Process (AHP) designed by Thomas (1970).

The development of the maintenance management system will comprise of elements that include rating of the severity of defects (Che-Ani et al., 2011 and Danyaro et al., 2010), muliti-criteria decision model using Analytical Hierarchical Process (Saaty, 1970) through a deffuzification process (Zadeh, 1965). The other elements include calculating the condition indices assuming a linear deterioration of building systems Teicholz and Gary (2012) for decision making.

2.5 Summary of Literature Review and Research gaps

From the literature reviewed, it was evident that the condition assessment of buildings is a costly activity that needs prior planning so as to determine the intervention to be prioritized. There may be a perceived lack of maintenance work, because of unfavourable economic or business conditions, or because a building owner unwillingness. The building condition assessments are to be prioritized according to the intensity and severity effect on a building component using a defect rating system.

The parametric estimating method is a maintenance management system that is designed to be performed annually by field assessors. It relies on photographic evidence, interviews and questionnaires. While this system reduces costs, many organizations do not have the resources to even perform this level of assessment. Therefore, a much simpler system is needed. Also, these methods do not identify individual projects at the tactical level, which is often seen as an essential requirement by facility managers. Most of the available maintenance management systems are limited to only managing the inventory of building stock but offer less in the planning for the interventions in a prioritized manner based on the assessments conducted. This study thus sought to bridge the gaps in maintenance management system of public buildings under the management of local governments. The next chapter presents a detailed description of the methods that were employed to obtain the data used for the findings during the study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methods and approaches that were employed in the process of accomplishing the research study. The methods that were used in condition assessment data collection, sampling, data presentation and analysis are all elaborated herein. The study population was both from the staff involved in the building management and the buildings that were assessed. Analysis was done using suitable computer software like SPSS and MS EXCEL. The chapter also explains the ethical considerations that were observed during data collection and concludes with the limitations to the study and the proposed counteracting measures.

3.2 Study design

A study design is the overall strategy chosen to integrate the different components of the study in a coherent and logical manner so as to ensure that the research problem was effectively addressed. The study designs used in research studies include exploratory, explanatory, correlational and review among others. The design for this study was an explanatory case study where a number of building components were considered in the condition assessment, the defects evaluated and a component finally compared with the others in a model. Zaidah (2007) describes an explanatory case as a method used for causal studies where pattern-matching can be used to investigate certain phenomena in very complex and multivariate cases. Yin and Moore (1987), indicate that these complex and multivariate cases eventually end up with commercial products that are the results of ideas and discoveries from basic research. These products are derived from external sources rather than from research basing on the frequent communication between the overlapping professional networks. The researcher's aim was to enhance the decision making for the maintenance of the building components based on the condition assessments.

3.3 Research Approach

The research approach employed was largely quantitative. The data collected were used to determine the condition of building elements in relation to the deterioration as caused by defects. Description of the defects and the associated priority according to its severity and effect on the building component enabled the analysis by employing appropriate modelling used for rating of defects and grading the buildings' components.

3.4 Study Population

The study population included technical staff from Amuria District Local Government involved in the use and regular maintenance management of public buildings in the district. The targeted population was drawn from three categories of officers in the top management, middle level management and the operational level staff who actually execute operations of maintenance activities. The staffs that were considered in the study were purposively selected in a stratified non probabilistic cluster sampling method taking departments that they belonged to as strata.

The study also focused on the condition assessment of the public buildings from which the business of delivery of services is conducted. These included health, education and public service management services. The buildings condition assessment was conducted in the said buildings.
A quick count of the building stock conducted by the researcher and the respective Heads of Departments (H.o.Ds) indicated that some of the departments did not have any buildings under their jurisdiction. Table 3.1, shows a sample population of the building stock in Amuria Town Council distributed per department.

Table 3.1: Summary of the Total building stock in Amuria Town Council

S/N	Department	No. of Buildings
1	Finance	1
2	Education	8
3	Health	14
4	Planning	1
5	Production	3
6	Works	1
7	Administration	2
8	Community Based Services	1
9	Natural Resources	0
10	Council and Statutory Bodies	1
11	Procurement Unit	0
12	Trade and Industry	0
13	Internal Audit	0
TOTAL		32

Source: Amuria District Local Government Asset Register (2018)

According to the records at the Human Resource Office, Amuria District Local Government had an estimated staffing population of about 1530 civil servants, 30 politically elected councilors and a District chairperson. The total numbers of staff at the district headquarters in all the departments were 125 civil servants including the support staff. Table 3.2 indicates the total population of staff that was considered in the study.

Table 3.2: Staff at Amuria District Headquarters

S/N	Department	No. of Staff
1	Finance	11
2	Education	26
3	Health	44
4	Planning	3
5	Production	9
6	Works	4
7	Administration	11
8	Community Based Services	5
9	Natural Resources	4
10	Council and Statutory Bodies	3
11	Procurement Unit	2
12	Trade and Industry	1
13	Internal Audit	2
	TOTAL	**125**

Source: Amuria District Human Resource Department.

3.5 Sampling Strategies

The strategies of sampling that were employed included stratified cluster non probabilistic approach. Samples were drawn from different strata at the District Headquarters and the Lower Local Government units like Sub-Counties and Town Council. The clusters were drawn from the various departments in the District Local Government such as Health and Education. The non-probabilistic or purposive approach was basically to eliminate the chance of obtaining a sample that would not have the interest of the study.

3.5.1 Determination of the Sample size

According to Mugenda and Mugenda (2003), a sample population of at least 30% of the target population is recommended as appropriate so as to arrive at results that are accurate and reliable.

The sample sizes were determined from the population using Yamane's formula expressed in the equation 3.1; whose results conform to the findings of Mugenda and Mugenda (2003).

Yamane' formula

$$n = \frac{N}{1 + Ne^2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (Equation\ 3.1)$$

$Where;$

$n -\ is\ the\ Sample\ size\ to\ be\ determined$

$N - is\ the\ total\ population\ from\ which\ the\ sample\ is\ drwan$

$e - is\ the\ degree\ of\ freedom\ adopted\ for\ the\ study\ (0.05).$

a) Number of Staff Sampled

The number of respondents that were considered from the total population of staff at the District Headquarters and those from the facilities where the buildings were located like primary schools, and Health Centres were also sampled.

Using Yamane's formula, the total sample size of the staff was determined as below;

$From\ Table\ 3.2; N = 125\ and\ considering\ 95\%\ confidence\ interval, e = 0.05$

$$n = \frac{N}{1 + Ne^2}$$

$$= \frac{125}{1 + 125(0.05)^2}$$

$$= 95.23 \approx 95$$

The sample size considered during the study was the interview of 95 staff.

b) Number of Buildings Sampled

The number of buildings that were considered for condition assessment the total population of building stock at the District headquarters and those from the facilities in the lower local governments like primary schools, and Health Centres.

Using Yamane's formula, the total sample size of the buildings was determined as below;

$From\ Table\ 3.1; N = 32\ and\ considering\ 95\%\ confidence\ interval, e = 0.05$

$$n = \frac{N}{1 + Ne^2}$$

$$= \frac{32}{1 + 32(0.05)^2}$$

$$= 29.6 \approx 30$$

The sample size that was considered for condition assessment during the study was 29 buildings.

3.6 Description of study area

The study was conducted in Amuria district local government. Amuria district is approximately 400km road distance North East of Kampala Capital City. The District headquarters was located at coordinates 2.0302° N, 33.6428° E as seen in figure 3.1. According to the 2014 census Amuria district has a population of approximately 183, 348,000 people. The district had three counties of Amuria, Kapelebyong and Orungo and one town (urban) council before the creation of Kapelebyong district in July 2018. The district was politically headed by the District Chairperson who was the chairman of the District Council and the Chief Administrative Officer (CAO) was the head of civil service and directly answerable to the District Council.

According to GoU (2018), The Ministry of Public service approved a structure for District Local Governments in Uganda to have eleven departments (Appendix F). Amuria District Local Government has thirteen departments that include Administration, Planning, Finance, Health, Education, Works, Production, Community Based Services, Natural Resources, Procurement Unit, Trade and Industry, Internal Audit and Council and Statutory bodies. Most of the departments named have a building stock under their jurisdiction spread throughout the District including the Lower Local Councils. Some of these buildings were sampled and considered for condition assessment during the study.

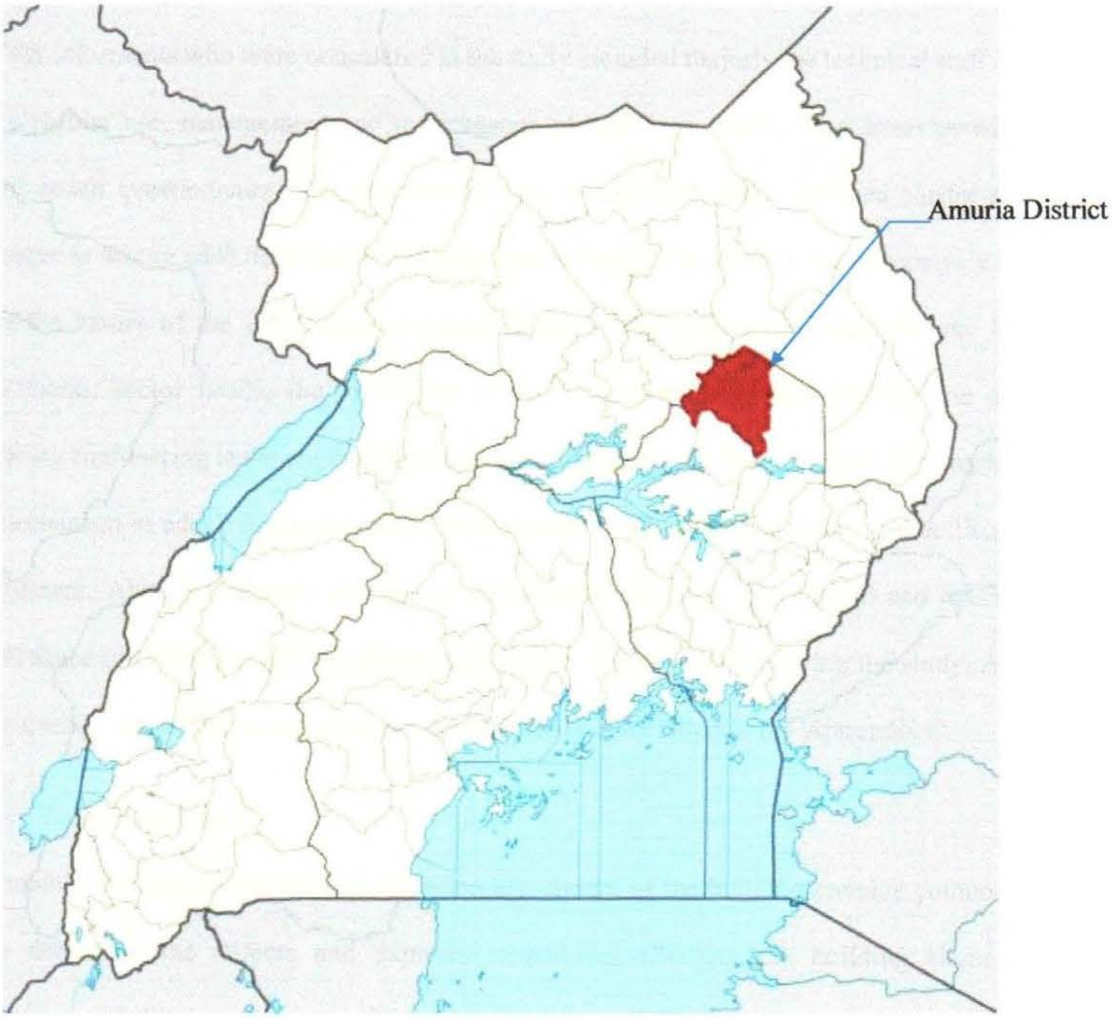


Figure 3.1: Location of Amuria District in Uganda

3.7 Sources of data

These involved the areas from which the data were obtained and they included both the primary and secondary sources.

3.7.1 Primary data sources

These sources included all the information that was obtained from the field through checklists and field test reports. The methods used included the following;

i) Key informant interviews

The key informants who were considered in the study included majorly the technical staff involved in the regular use, management and maintenance of buildings. These were interviewed using a closed ended questionnaire. The respondents were determined using stratified cluster sampling technique to ensure each department had been represented in the sample that purposively sampled given the nature of the information required of them. The respondents included the heads of departments, sector heads, the in-charges of the respective sampled buildings and all those practicing engineering in the engineering department. The purpose was to collect information about the mechanism in which the maintenance interventions had been executed in Amuria district local government. Also, information about how the departments planed, budgeted and executed the maintenance interventions and rectification of defects was considered during the study. A sample of the questionnaire that was used to conduct the study is included in the Appendix C.

ii) Visual inspection

This mainly focused on the cursory condition assessment of the building envelop components so as to determine the defects and exposure conditions affecting the building elements. An observation condition assessment form was used to collect these data. The purpose was to determine the maintenance requirements of the building components. A surveying technique suggested by Hollis and Gibson (2000) and Hoxley (2002) was adopted during the study. This technique proposes the process for inspection of a building to be conducted following a top-down and clockwise procedure for building inspections. This was to prevent omission of some elements to be assessed. The inspections were conducted starting with the exterior and concluding with the interior of the building. The general use, comfort and condition of the buildings and any deterioration and defects in the building components were noted. The researcher predetermined elements of the building envelop that were assessed so that the aspects of maintenance condition matrix formed the basis of the observation schedule that was used. Tables 3.3, 3.4, 3.5 3.5 and 3.7 were adopted from Che-Ani et.al., (2011) and used as reference in guiding the judgment during the assessment of the building components.

Table 3.3: Condition Assessment Index

Condition	**Extent of Defects (%)**	**Scale Value**	**Description**	**Action**
Good	<2	1	• No defects • As new condition and appearance	Minor servicing
Fair	2-10	2	• Minor defects • Superficial wear and tear • Some deterioration to finishes • Major maintenance not required	Minor repair
Poor	10-30	3	• Average condition • Significant defects are evident • Worn finishes require maintenance • Services are functional but need attention	Major repair/replacement
Very Poor	30-70	4	Badly deteriorated, Potential structural problems, Inferior appearance, Major defects, Components fail frequently.	Malfunction
Dilapidated	≥70	5	• Building component has failed • Not operational • Not viable • Unfit for occupancy or normal use	Replacement of damaged/ missing part

Source: Adopted from; Che-Ani et.al., (2011)

Table 3.4: Priority Assessment/Ranking

Priority	Timing	Scale Value	Description
Normal	Work can be safely and economically deferred beyond 3 years (24 - 36 Months)	1	Functional, cosmetic defect only
Routine	Work that has minimal effect on operational capacity but desirable to maintain quality (12 - 24 Months)	2	Minor defect, but could become serious if left unattended
Urgent	Work that affects operational capacity and may lead to serious deterioration if untreated (3 - 12 Months)	3	Serious defect, does not function at an acceptable standard
Emergency	Work needs to meet statutory obligations, ensure OH&S regulations and prevent serious disruption (0 - 3 Months)	4	Element/structure does not function at all; or presents risks that could lead to fatality and/or injury

Source: Adopted from; Che-Ani et.al., (2011)

Table 3.5: Condition Survey Matrix

Scale		Priority Assessment			
		E4	U3	R2	N1
Condition Assessment	5	20	15	10	5
	4	16	12	8	4
	3	12	9	6	3
	2	8	6	4	2
	1	4	3	2	1

Source: Adopted from; Che-Ani et.al., (2011) E4 – component is in worse condition and requires an immediate as emergency attention;

U3 – component has serious defects that need urgent attention;

R2 - component has no significant defects and just requires regular condition survey;

N1 – Component is in normal condition with no visible defects.

Table 3.6: Descriptive value according to score

Scale	Description	Matrix Score
1	Planned Maintenance	1 – 4
2	Condition Survey	5 - 12
3	Serious Attention	13 - 20

Source: Adopted from; Che-Ani et.al., (2011)

Table 3.7: Overall Building Rating

Scale	Building Rating	Matrix Score
1	Good	1 – 4
2	Fair	5 - 12
3	Dilapidated	13 - 20

Source: Adopted from Che-Ani et.al., (2011)

iii) Physical tests and measurement

This involved preliminary assessment of the selected building elements so as to ascertain defects in elements of the building envelop. These tests were used to evaluate and compare the defects in the components of the building envelope with established benchmark ratings and applicable building code requirements. The major test conducted included the test for strength of components using American Society of Tests and Materials for Schmidt hammer (ASTM C 805-79) procedure. An estimate to measure crack widths, percentage area of flaking paint, extent of damp stains on surfaces, weathering of plaster thickness was also physically assessed using simple linear measurement tools.

The test for the strength was carried out with an N-type Schmidt mechanical rebound hammer. The concrete surfaces that were to be tested were first prepared by smoothening using a carborundum stone. Honeycombed regions and wet surfaced concrete were avoided and no tests were conducted on such areas. A minimum of ten shots of the hammer were taken on each chosen member, and the mean rebound reading of each member was recorded, corrected and used to obtain the average compressive strength. No chiseling or hacking was done to remove plaster, since it was a nondestructive test. For linear measurement of cracks, patches were done using a calibrated tape measure and scale rule. Figure 3.1 shows the tools that were used for physical tests and measurements during the study.

Figure. 3.2: Tools used for tests and measurement

iv) Focused group discussions

A session of discussion about the building maintenance management in one of the planning meetings in the district was held. The target group was the District technical planning committee (DTPC) which comprises all the heads of department, sector specialists who are mostly middle managers involved in the planning and eventually in actual implementation of decisions. The objective was to share views together and get feedback on areas of improvement about the maintenance management system and how it would operate so as to help to the District stakeholders in the maintenance of the built asset portfolio.

3.7.2 Secondary data sources

Secondary data were collected from analysis of related and relevant literature, records of building maintenance activities, and government publications, reports and policies and construction contract documents.

i) Desk Studies

This method involved reviewing original design and construction documents for all the building envelop components that were included in the condition assessment. These documents provided the information regarding the strength of the concrete components as specified in the relevant items and as described in the relevant in technical specifications. The specified compressive strength of the concrete components was also established.

The grading of the common defects in the building elements and the rating standards for the final evaluation of the building were documented during this process as described in the Maintenance Management Framework for the Queensland Government Department of Housing and Public Works (2017). For ease of analysis, the building was decomposed into building components also called elements according to the Condition Survey Protocol (CSP) matrix adopted from Che-Ani et al., (2011). This condition survey protocol (CSP) matrix enabled the assessment of each condition for any building that was inspected.

3.8 Development of a maintenance system for building components

A building component may show more than one defect. The extent and the intensity of a defect combined with the importance of the defect lead to a condition rating. Calculating a condition rating using a "defect score" was based on the extent and intensity of a defect. This was adopted from a report by Che-Ani et al., (2011). The modeling was used to evaluate and grade the defects in the components of the building envelop. The different grading of the components was aggregated to have the rating of the entire building portfolio. The data obtained from visual inspection during the condition assessment of buildings were used for screening multiple building components to establish priorities for immediate, short-term, or long-term interventions. The Fuzzy Analytical Hierarchy Process (FAHP) was used in multi-criteria decision making to rank the defects in buildings components. The model for ranking the components or elements of a building that required to be maintained was developed following the procedure below:

i. Define the alternatives

   This involves breaking down the building into components or elements. The different elements of a building that were considered include: Roof, Ceiling, Walls, Floors, Beams, and Columns. The idea here is premised on the fact that each component has different defects affecting it and they cannot be ordinarily added up together.

ii. Establish the criteria

   The criterion considered in this case is the structural assessment of the components which included the defects, general appearance and the strength of the element.

iii. Attach weights to the alternatives

   The weights for the criteria of defects are considered to be ranging from 1 to 5 scales (Frangopol and Liu, 2012). For the strength of the components, the scale of 1 to 5 was considered in accordance to Lateef et al., (2009). These scales describe the extent of the assessment of the component. These weights according to fuzzy multi-criteria decision-making (MCDM) process are referred to as crisp values.

iv. Defuzzification

This was the process of normalizing the fuzzy numbers to crisp values so as to compare and rank the alternatives. Crisp values are values that range between 0 and 1. The normalized values always range from 0 to 1 and are also referred to as fuzzy numbers. 0 is a value that reflects the undesired situation or the one remote from the required and 1 represents the best scenario that is required.

v. Normalized Decision Matrix

The process of obtaining the normalized decision matrix, considers two criteria:

- Beneficial criteria; this is the criteria that considers the values for which the least figure is desired. According to Danyaro et al., (2010), 1 represents the material with the highest strength and 5 represent that with the least strength.

$$Beneficial\ Critera = \frac{Performance\ Value}{Maximum\ of\ performance\ values} \dots\dots\dots\dots (Equation\ 3.2)$$

- Non-beneficial criteria; this is the criteria whereby the values for which the least figure is not desired.

$$Non\ beneficial\ criteria = \frac{minimum\ of\ Performance\ Values}{Performance\ value} \dots\dots (Equation\ 3.3)$$

vi. Assign weightage to criteria, this will depend on the assessor or an agreed position by the organization. The sum of which should be 100%;

vii. Multiply the weightage value by the decision matrix;

viii. Sum up the product of the weightage value and the decision matrix to get the performance score;

ix. Rank the alternatives from the first to the last;

x. Relate the rankings with the priority assessment ranking to establish the possible time for the intervention according to the schedule by Che-Ani et al., (2011);

xi. Estimate the cost for correcting or rectifying the defects;

xii. Apply the time value of money formulae to establish the future costs. This formula is given by;

$$F = P(1+e)^n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Equation\ 3.4)$$

Where F = Future value

P = Present value

$e = Combined\ annual\ interst\ on\ capital\ i, and\ inflation\ rate, f$

$$e = \frac{i-f}{1+f}$$

$n = Period\ (Months)$

3.9 Data collection instruments

The common instruments used for data collection include questionnaires, desk review guide, checklists and coding sheets. During this study, a questionnaire and coding sheets were used to collect the information relevant for the development of the maintenance system. The questionnaires were administered to the respondents from all departments selected using stratified non probabilistic approaches. This targeted mostly the regular users of the buildings, those who were in-charge of the units and the Heads of departments that were involved in the planning, budgeting and management of the building stock in the department. Coding sheets were used to assess the condition of the components of the building. The defects and other properties of the component were considered during the study. Both the questionnaire and the coding sheets were pretested prior to their use. This was after determining the content and validity of the instruments.

3.9.1 Validity of the instruments

Validity instrument is the accuracy of the instrument to measure what it was intended to measure (John, 1995). The researcher sought for guidance from the supervisors to ascertain the face validity of the instruments. Content validity of the instruments was determined using the Content Validity

Ratio (CVR) given by equation 3.5 and the results compared to the minimum CVR in the Lawshe Table to determine the validity.

$$CVR = \frac{\left(N_e - \frac{N}{2}\right)}{\frac{N}{2}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (Equation\ 3.5)$$

Where N = Total number of panelists

$N_e =$ Number of panelists indicating "essential"

The values obtained in the pretest of the instruments indicated that the contents were valid and therefore the instruments were relevant to the study.

Table 3.8: Lawshe Table for determining Content Validity Ratio

Number of Professionals	**Minimum CVR value**
5	0.99
6	0.99
7	0.99
8	0.78
9	0.75
10	0.62

Source: (Jaechoon, 2019)

3.9.2 Reliability

Reliability refers to the ability of the instrument to have consistency of scores obtained by the same individuals when re-examined with same test on a different occasion (Anastasi, 1982). The researcher determined the reliability of the instrument using the Cronbach's α equation expressed as Equation 3.6.

Cronbach's $\alpha = 2[1 - (\sigma_{odd}^2 + \sigma_{even}^2)]\sigma_{Total}^2 \dots\dots\dots\dots\dots\dots\dots\dots (Equation\ 3.6)$

Where $\sigma^2_{odd} = Standard\ Deviation\ of\ Odd\ Items$

$\sigma^2_{even} = Standard\ Deviation\ of\ Even\ Items$

$\sigma^2_{Total} = Standard\ deviation\ of\ the\ Total\ number\ of\ items$

The value of 0.87 was obtained in the pretest of the instruments indicated that the contents were valid and therefore the instruments were relevant to the study. The results obtained indicated that the instruments used were in the acceptable range of the Cronbach's α coefficient of internal consistency as provided in Table 3.9.

Table 3.9: Cronbach's α value

Cronbach's α	**Internal Consistency**
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha \leq 0.9$	Good
$0.9 \leq \alpha \leq 0.8$	Acceptable
$0.8 \leq \alpha \leq 0.7$	Questionable
$0.8 \leq \alpha \leq 0.6$	Poor
$\leq \alpha\ 0.5$	Unacceptable

Source: Anastasi (1985)

3.10 Data analysis

Data collected from the field were checked for errors of omission. They were then classified and coded before entry. The data was then analyzed quantitatively using statistical analysis. The quantitative information was analyzed to determine trends and relationships between the dependent and independent variables as well as in-depth information used to draw conclusions and recommendations. The SPSS and MS EXCEL software were used to analyze the data.

3.11 Data Presentation

Data collected from the field with various tools was processed in analysis with the various software and presented in a logical appropriate format that included narratives, tabulation and graphical. The mechanistic prioritization of the components was derived by use of the models and equations obtained from several literatures revised about the Multi-Criteria Decision Model (MCDM) majorly from Saaty (2006).

3.12 Ethical Consideration

Prior to reaching the respondents, permission was sought from the responsible persons through the district administration. To ensure that the study adhered to ethical considerations, the participants will be assured of confidentiality of whatever response they would give. Their names were not included on the questionnaires. Consent from the respondents was also sought before commencement of data collection. This was all done after explaining the aim and objectives of the study, the research methodology, the option not to participate and their right to anonymity and confidentiality to the participant and any queries and concerns that arise cleared. The research was approved by the department and an introductory letter was obtained.

3.13 Chapter Summary

This section of methodology described the strategies and approaches that were employed to collect the data required for the study. The description of the study area and population too detailing the structure of the entity and how it was managed in terms of her core business was presented. Various methods of information both primary and secondary were presented together with the tools that were sued to obtain the data. Closed ended questionnaires and filed assessment forms were pretested in Amuria District before being adopted for the interviews and observation surveys respectively. The ethical considerations while carrying out the research study were provided and elaborated.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This Chapter presents results of the study. The results were obtained using the methods that have been described in Chapter Three. This study was aimed at determining the common mechanisms used for condition assessment of the building stock, assess the defects causing deterioration of the building components, and determine the maintenance requirements of the building components and relating all these to how the maintenance management system would operate for decision making as regards to planning for maintenance interventions. The findings of the study are discussed in detail in this chapter in the subsequent sections herein after.

4.2 Common mechanisms used for condition assessment of buildings

The study focused on interviewing the staff from Amuira District Local Government. The purpose was to determine how often the condition assessment were conducted, the common methods used by the assessors and establish the budget allocation, and the use of the assessment reports during planning and budgeting for development projects.

4.2.1 Mechanism used for Condition Assessment

The findings from the study indicated that 95.2% of the respondents said that the common method used for condition assessment was visual observation as indicated in Table 4.1. This indicated that observation was the common method used for condition assessment and was majorly conducted by the Engineering Assistants.

All the eleven departments acknowledged that they depended on the reports and guidance from the works and Technical services department to plan during the budgeting process in the financial year for the interventions to be executed in maintenance. These reports were used as a basis for prioritization of the projects to be implemented in the subsequent financial year.

Condition Assessment of buildings components is largely conducted by the technical personnel in the organization. Collecting information about the condition of buildings was to enable building managers identify maintenance needs and qualify works that can be attended to immediately or differed. This duty was a domain of the engineering technical staff of Amuria district local government that conforms to the practice in almost all the managers of the building assets.

Table 4.1: Common mechanisms used for Condition Assessment

Respondents	Frequency	Common Methods	Percentage	Cumulative Percentage
Valid	79	Observation	95.2	95.2
Missing	4	Inspection	4.8	100
Total	83	Others	0	100

Source: Field data collection

4.2.2 Frequency of conducting condition assessment

The findings from the respondents during the study on how often the exercise of condition assessment conducted was conducted indicated that 74.7% were conducted annually as shown in Figure 4.1.

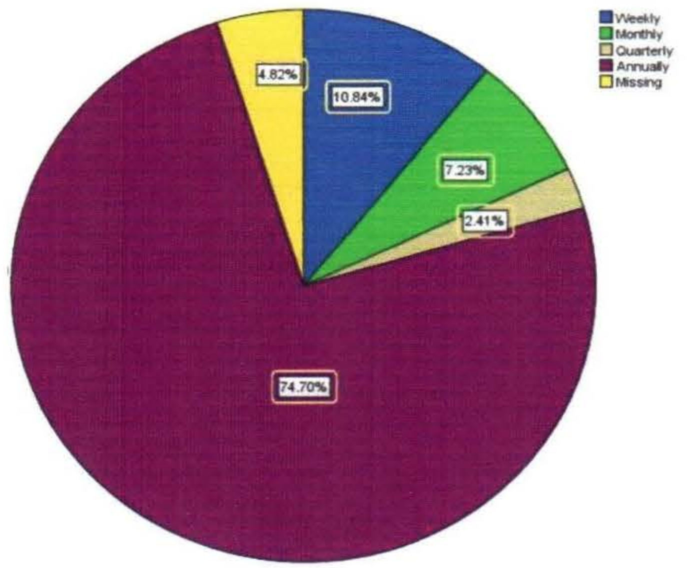


Figure 4.1. Frequency of conducting Condition Assessment

Conducting assessments frequently helps in the early detection of defects and hence remedial actions to addressed the cause or even rectify the defect can be planned for timely. Although frequent condition assessment provides accurate information about the status of the building components, it is a very costly exercise to conduct. Departments require to plan for the condition assessment to be conducted frequently so as to have an updated inventory of the status of the building stock. Condition assessments were candied by the staff in the engineering department. However, most defects that affected components were reported by the building users as soon as they were recognized to the respective departmental heads.

4.2.3 Maintenance Budget Allocation

The percentage of the development budget allocated for the maintenance of the buildings varied per department as shown by the responses from the staff in various departments as summarized in Table 4.2.

Table 4.2: Maintenance Budget Allocation

S/N	Maintenance proportion of Development Budget (%)	No. of Respondents	Percentage of Respondents from Departments (%)
1	0 – 5	41	49.40
2	5 – 10	17	20.48
3	10 – 20	8	9.6
4	>20	2	2.41

Source: Field Data collection

The results in Table 4.2 indicated that most departments did not prioritize maintenance of buildings. This was evidenced by only 2.41% of the departments allocated more than 20% of the development budget for maintenance interventions. This signified a poor culture towards maintenance of the built environment and this could result to more funds being spent to address the defects after further deterioration can no longer be avoided. The maintenance activity was viewed by the various stakeholders as being of relative disadvantage in respect to the new construction in competing for resources. In Chanter and Swallow (2008), maintenance has to compete for resources in another market, that of the general business environment. Within both markets the supply of financial resources is clearly important, but within the construction industry itself there should also be some concern with regard to the supply of physical resources, such as an adequate and properly trained workforce.

4.2.4 Frequency of Condition Assessments

The frequency of conduction condition assessments was directly related to the amount of the maintenance budget allocated. By inspection, the gradient of the curve in Figure 4.2 showed that there was a positive correlation between the development budgets allocated to maintenance and the number of visits to buildings conducted to assess the building components condition. This implied that the more the maintenance budget, the more condition assessments were conducted.

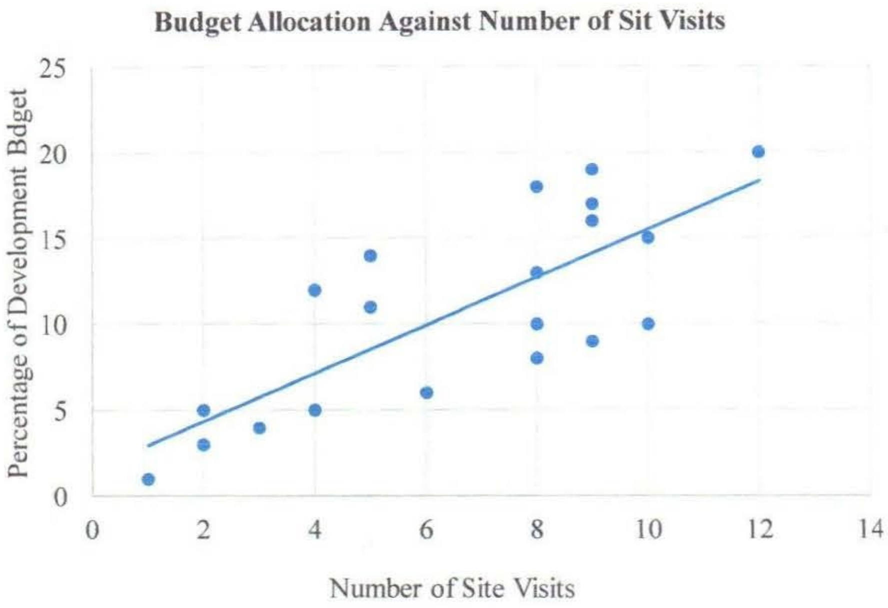


Figure 4.2: Relation of Budget Allocation against Number of Assessments

Adequate financial resources allocated to the maintenance of buildings have a great positive impact in the maintenance activities. While relating to Chanter and Swallow (2008), it was evident that financial resources are some of the major requirements to effective management of buildings.

4.3 Establishing common defects that caused the deterioration of building components

The purpose of this assessment was to determine the common defects observed in the building elements. This assessment was later on used to determine the crisp values of defects in the process of developing a maintenance management system.

4.3.1 Defects

The defects affecting the components of buildings were established after conducting assessment of a sample of 32 (as determined under section 3.5.1.2) buildings were assessed. The building components that were assessed included the ground floors, walls, concrete beams and lintels, concrete columns, ceiling, roof cover and roof structure. The list of the buildings that the components were assessed has been included in Appendix D.

i) Cracks

These were observed to have affected most the floor finishes, walls and reinforced concrete beams as shown in Figure 4.3.

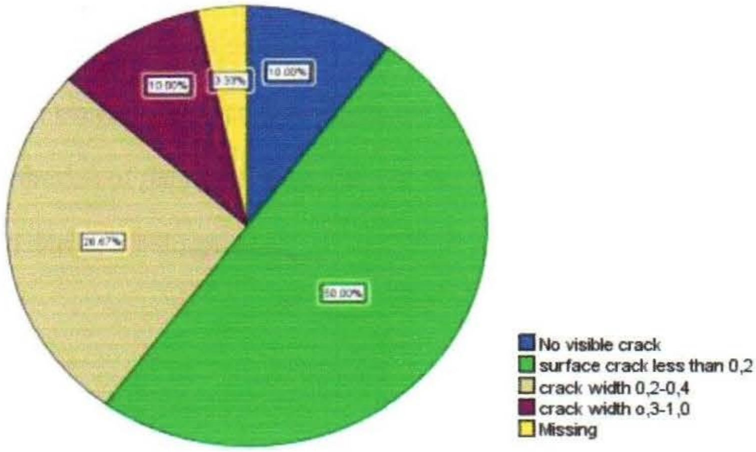


Figure 4.3: Percentage distribution of floor crack width

The findings from the study indicated that more than half of the buildings had floors that were still in a good. This just required regular monitoring so as to detect early defects. Early detection of defects informs planning of remedial actions and funds can be allocated appropriately.

ii) Surface deterioration

This was a defect noted to have affected the face of the component that is exposed to the environment. The researcher observed that the surface of floors and wall finishes were the most affected. The assessment conducted indicated that the floors were the components that exhibited the highest percentage of deterioration.

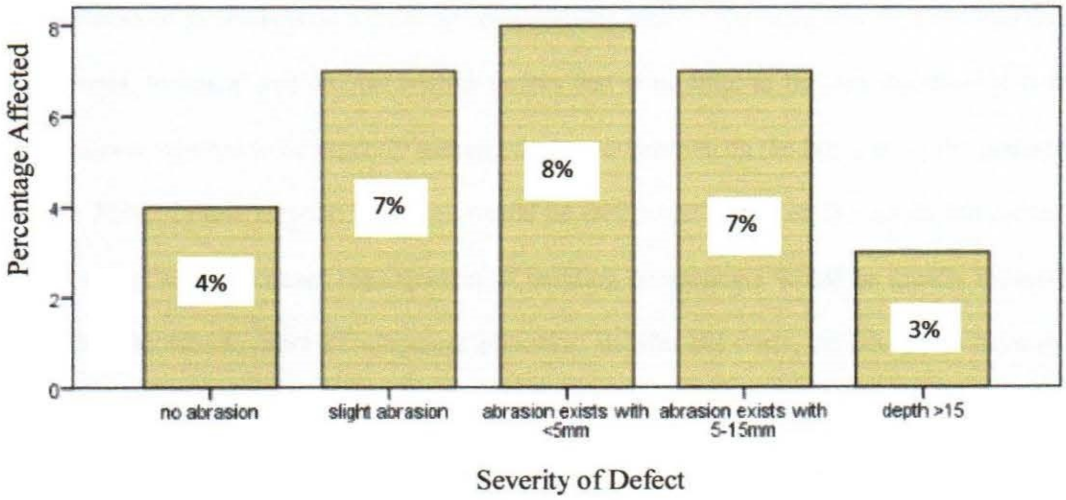


Figure 4.4: Surface deterioration

Figure 4.4 presents the results of the floor components that were greatly affected by the surface deterioration. The causes of defects were summarized as illustrated in Figure 4.5 showing the percentage distribution of the causes that affected the building components of the buildings that were considered during the study.

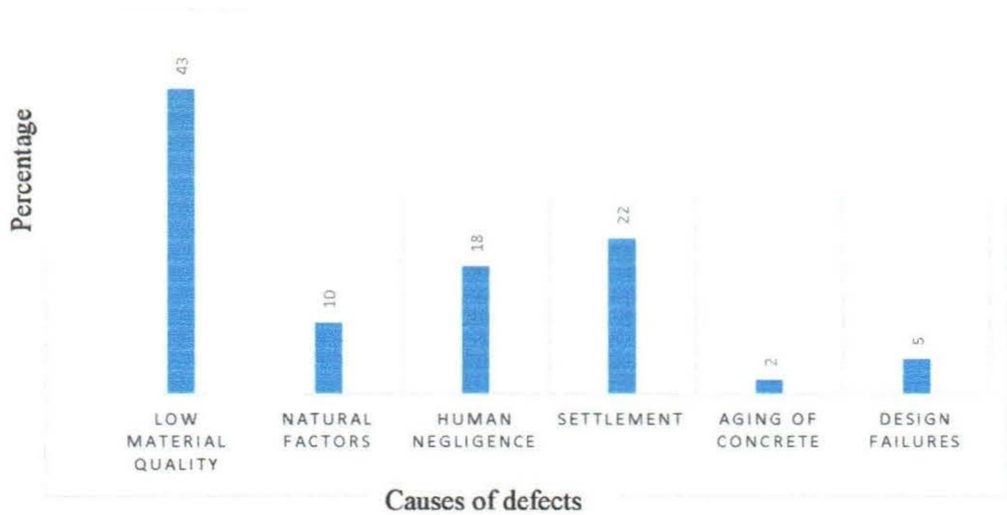


Figure 4.5: Classes of defects affecting the building Components

The severity of the defects on a building component is greatly aggravated by the causes of defects. The social, technical and environmental factors that contribute to the deterioration of building components required to be urgently addressed to as to improve on the life span of the components (Chan, 2014). In this way the buildings would be well attended to and the whole life cycle costs involved in the maintenance management of building components would be greatly reduced and could be allocated to other development priorities. Besides the costs, the occupants have no risk exposure to the health and safety conditions of the buildings.

iii) Other defects

There were numerous defects that affected the building components. The study could not fully exhaust but during the assessment, a few of defects and possible causes were documented as presented in the Table 4.3.

Defects that were not addressed timely during the process of construction often showed up as evident during the use of the building. Buys and Le Roux (2013) affirm that some defects occur as a result of the departure from good construction practices.

Table 4.3: Defects affecting Building Components

S/N	Component	Defect	Possible Cause
1	Floor finish	Cracks	Poor Curing, Poor materials, Poor mix ratios during casting, settlement
		Wearing	Abrasion, Weak Surface finish, Poor materials
		Patches	Poor quality materials, Workmanship, inadequate maintenance operations
		De-bonding	Moisture ingress, poor quality materials, Workmanship, inadequate maintenance operations
2	Walls	Moisture stains	Moisture ingress, improper roof drainage lack of gutters in the component
		Plant growth	Inadequate maintenance operations,
		Spawling	Moisture ingress, weak material mix.
3	Beams	Cracks	Settlement, impact forces
4	Columns	Cracks	Heavy loading, poor construction materials
5	Roof cover	Tearing Rust stains	Impact forces, Aging material
6	Roof structure	Broken Timber	Timber defects, Aging material, Impact forces
7	Ceiling	Cracks	Settlement, working of timber
		Moisture Stains	Leaking Roof
		Sagging	Broken timber structure,

4.4 Strength

The assessment of the strength was conducted to determine the extent defects affected the performance of the components. The strength of any material or composite material was considered as a beneficial factor whose higher crisp value is a desired scenario. The components whose strength was assessed included the floor slab, walls, concrete columns and beams. The Schmidt hummer tests were conducted and the observations compared with the specifications in the description of the items in the Bills of Quantities.

4.4.1 Floors

The strength of the floors was determined using a Schmidt hummer and the test observations indicated that the average strengths had a range between 20MPa and 38MPa of all the 29 buildings assessed. Figure 4.6 presents the distribution of the mean strength of the floor components of the 29 buildings that were assessed.

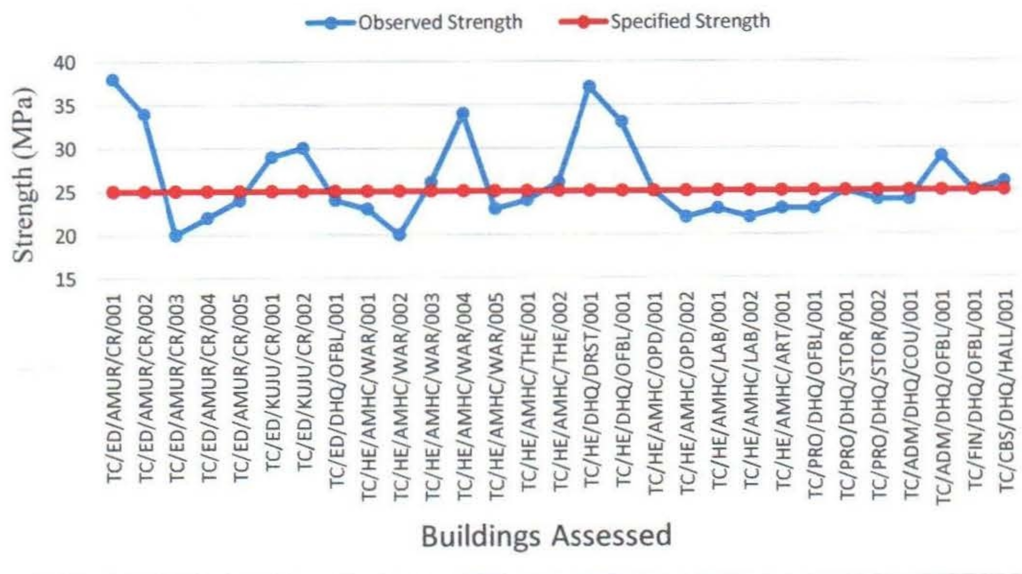


Figure 4.6. Average strength of floor components

The results indicated that 51.7% of the floor components for the buildings assessed had the mean strength below the minimum specified strength of 25MPa, 10.3% had the strength of 25MPa and 37.9% had more than the specified strength. This implied that the components with less strength to that specified required an affirmative action to have the components rehabilitated so as to meet the minimum specified strength to avoid deterioration of the component. Most of the floor finishes in the buildings that were assessed were of cement sand screed, ceramic floor tile and terrazzo finish. Figure 4.7 shows the distribution of the floor finishes of the buildings assessed. The floor component of the buildings that had the strength below the specified one were observed to have been as a result of human negligence that resulted to poor workmanship and use of low quality materials.

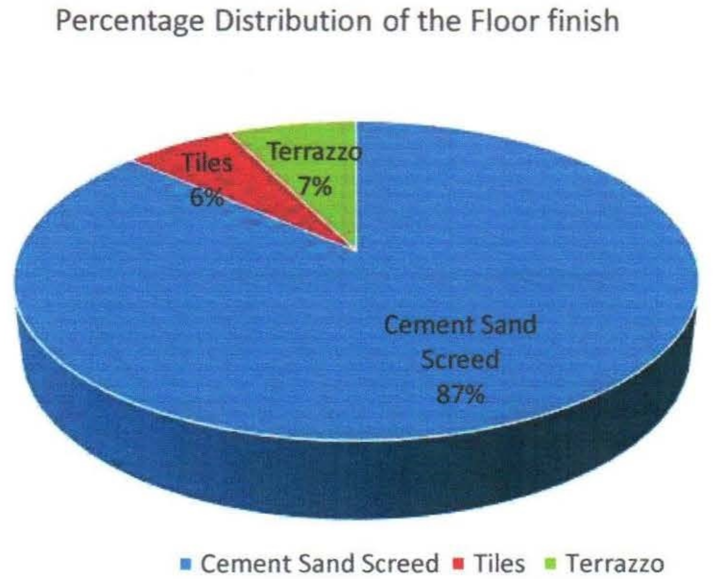


Figure 4.7: Distribution of the floor finishes by building

From the findings of the study, the strength of floors was attributed to the good workmanship, use of quality materials and frequency of routine maintenance activities done on the component. Smith (2003) confirmed that the best practice to keep the component in a good functioning condition is carrying out regular routine maintenance activities. These cement sand floor screeds that had the strength of 25MPa and above were regularly mopped as compared to those that were not did not receive any such treatment.

4.4.2 Beams

The beams whose strengths were assessed were of reinforced concrete. The assessment of the strength of beams was conducted to establish the compressive strength. These were observed to be in the range of from the results of the rebound Schmidt hummer that had a range from 22MPa to 29MPa. Figure 4.8 presents results of the average beam strength for the buildings assessed were compared with the specified concrete strength of C25 for all the contract documents that were reviewed.

The results indicated that 55.2% of the components had the minimum specified strength of 25MPa and 44.8% had less than the specified strength. This implied that the components with less strength than the specified required more and regular attention to rectify any defects noticed as a measure to maintain the building component.

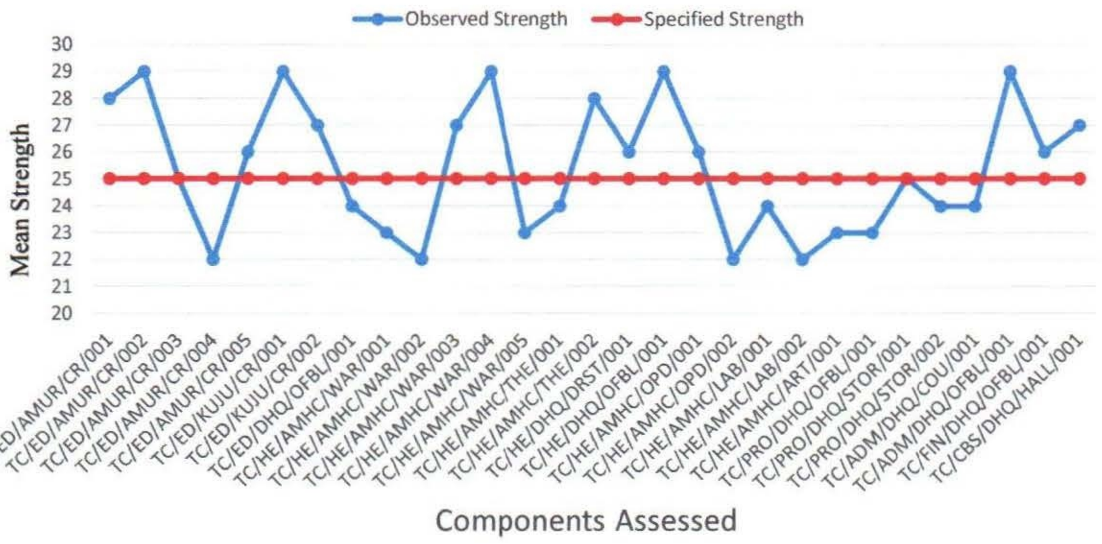


Figure 4.8: Average strength of beam components

4.4.3 Columns

The columns assessed were the vertical components of a building meant to support the beams over a span. These elements were majorly seen at the verandah. The columns whose strengths were assessed were of reinforced concrete. Strength of the column like the previous strength assessments is not a defect. This assessment was conducted to establish the compressive strength of the column component.

The results indicated that 100% of the concrete columns assessed had strength above the minimum specified strength of 25MPa as seen in Figure 4.9. These results signified that none of the components had the requirement for immediate maintenance intervention. As observed from the results of the rebound Schmidt hummer, the strengths had a range from 27MPa to 29MPa. The results indicated that the quality of concrete used was good according to Table B – 5 in Appendix B.

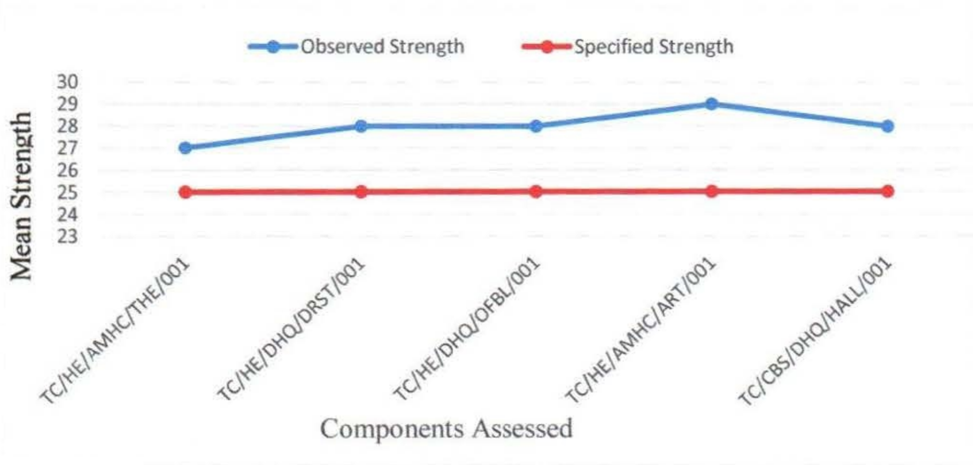


Figure 4.9: Average strength of Column components

The observations of strengths of the building components results were considered as necessary in the defuzzification stage of the multi criteria decision model as beneficial factors. The values obtained were called crisp values that were converted to fuzzy numbers during the defuzzification process as elaborated in section 4.6.

4.5 Assessing the maintenance requirements of the building components

The assessment of the building components was conducted based on the guidance of tables in Appendix B. Priority assessment was based on the extent the component required attention of corrective measures and condition assessment majorly emphasized on how the defect affected the building component.

The product of the priority and condition assessment resulted to a matrix score of the component and these were averaged to obtain the overall mean matrix score for the building. The mean matrix score for the building was then used to determine the building rating when ranked among all the buildings assessed.

Appendix H presents a summary of the matrix score and building component rating which was used to determine the maintenance requirements of the elements in each building. The Values of matrix score were obtained using Equation 4.1. The building rating and the description of the maintenance requirements were obtained with reference to Table 3.3, 3.4 and 3.5.

$$Matrix\ score = Priority\ Assessment\ X\ Condition\ Assessment \ldots\ldots\ldots\ldots\ldots (Equaion\ 4.1)$$

The values of Priority and condition assessment were obtained from Table A-1. The matrix score of components were in aggregated to give an average condition of the entire building as provided in Table H-1. During the study, it was observed that 72.4% of the components were in a good condition and required regular maintenance operations. A total of 17.2% of the components were in a fair condition that required some maintenance interventions and therefore attracted a substantial budget allocation to cater for the corrective activities. Only 10.3% of the components assessed were in a dilapidated condition. These components required major repairs and replacement of defective parts to be conducted. A deliberate budget allocation required to be allocated to cater for the maintenance of these components to restore the buildings to the original state of functionality.

4.6 Developing a maintenance system for building components

The development maintenance management system follows a logical systematic flow that is illustrated in the flow chart in Figure 4.10. The input data was obtained from condition assessment of the building elements. The flow chart is a summary of how the decision was made resulting from a number of parameters. The procedure below explains the stages in the flow chart that deliver the outcome of the MMS.

i) Decompose/Breakdown the building in to components

This involves breaking down the building into components or elements. The common elements of a building that were considered include: Roof, Ceiling, Walls, Floors, Beams, and Columns. Since different building elements were affected by a number of defects, they cannot be ordinarily added up together to give the final score that is considered during ranking of elements. These elements are considered as the "criteria" in the decision matrix computations.

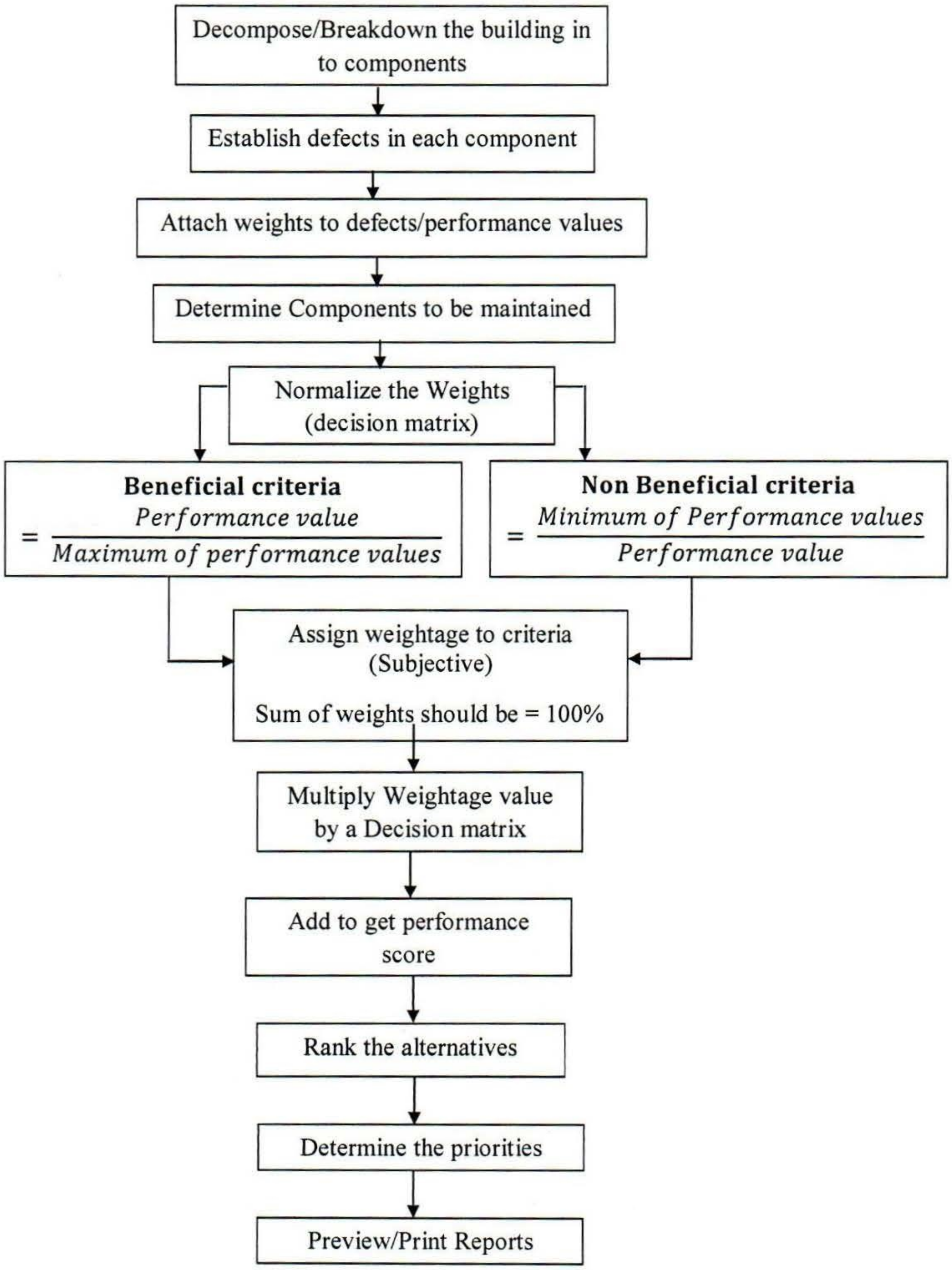


Fig. 4.10: Developed Maintenance Management System

ii) Establish defects in each component

The common defects that affected the building components were determined during the condition assessment. These were assessed and coded according to their severity and priority required to be rectified. The other factors considered during the assessment that were considered vital in the multi criteria decision making process included general appearance and the strength of the element. The defects and general appearance of the component formed the "alternatives" in the decision matrix.

iii) Assign weights to defects/performance values

The weights assigned to defects were considered according to the criterion scale in Appendix B Tables B-1, B-2 and B-3. Strength of the components was assigned weights according to the criterion in Table B-4. These values were attached to conditions of the components with scale value 1 represented the best component situation and 5 being the worst condition. These scales describe the extent of the condition assessment of the component. These weights according to fuzzy multi-criteria decision-making (MCDM) process are referred to as crisp values.

Table 4.4: Assigning Weights

Criteria	Alternatives					
	Appearance	Strength	Crack	Patch	Moisture Stains	Plant growth
Roof Component	2	2				
Walling		3	3	4		
Beams		2	2			
Floor		3	3	4		

Source: Field data Assessment sheets

In Table 4.4 the values of the "alternatives" refer to the assigned weights of defects as observed from the filed assessment with reference to Appendix B Tables B-1 to B-5. The "criteria" comprise the components of the building structure that was considered for assessment during the study.

iv) Determined Components to be maintained

The decision of components to be maintained was determined by ranking the weighted scores. These weighted score values were derived from the product of scale values of defects Table B-1 to B-5 and the priority scores in Table B-6 (See Appendix B) conducted during the condition assessment. The weighted score values have a range between 1 to 20 which are values of the condition survey matrix (Table 3.5). The final decision to have the component proceed to be ranked for assessment would be taken based on the descriptive values in Table 3.6.

v) Defuzzification

In the Multi Criteria Decision Matrix (MCDM), it is often not realistic to compare defects of different components together. For ease of comparison, the crisp values are converted to normalized values commonly known as Fuzzy numbers in a process called defuzzification. These Fuzzy numbers range from 0 to 1. This was the process of normalizing the crisp values so as to compare and rank the alternatives. 0 is a value that reflects the undesired situation or the one remote from the required and 1 represents the best scenario that is required.

vi) Normalized Decision Matrix

The process of obtaining the normalized decision matrix, considers two criteria;

a) Beneficial criteria;

This is the criterion that considers the fuzzy set of values for which the least or lowest value is desired. From Tables Appendix B, 1 represents the desired scenario and the scores distributed through to 5 represent that with the least strength.

$$Beneficial\ Critera = \frac{Performance\ Value}{Maximum\ of\ performance\ values} \dots\dots\dots\dots (Equation\ 4.1)$$

Where Performance Value refers to the Assigned weight according to Tables in Appendix B

b) Non-beneficial criteria

This is the criteria whereby the least value is not desired and thus considered the worst scenario. It is criteria of weighting whereby the value of 1 represents the worst scenario and 5 represents the best or desired scenario.

$$Non\,Beneficial\;criteria = \frac{minimum\;of\;Performance\;Values}{Performance\;value} \;...\;(Equation\;4.2)$$

The conversion of crisp values to Fuzzy numbers is illustrated in Table 4.5. Table 4.4 provides the summary of the average assessment for the components with defects having assigned weights. These values have been reflected in the scale column in Table 4.5. The values in the column of Fuzzy numbers were computed using Equations 4.1 and 4.2 depending on the desired scenario. The working below provides a procedure of fuzzy numbers in Table 4.5 as Example 1.

Example 1

The assigned weights to the strength as a beneficial criterion were 2, 3, 2 and 3 for the roof, walling, beams and floor components respectively. The Fuzzy numbers were computed with the walling as an illustration, has the performance value of 3 which is actually the assigned weight. The maximum performance score of the strength is 3., Therefore by applying equation 4.1, the Fuzzy number was obtained as $\frac{3\;(Performance\;value)}{3\;(Macximum\;of\;performance\;values)} = 1$. The same procedure was repeated for all the other components.

The assigned weights to crack width as a non-beneficial criterion were 3, 2, 3 for the walling, beams and floor respectively. Considering the wall component as an illustration, the minimum of the performance values was 2 and performance value 3 was the assigned weight. The fuzzy number was obtained using equation 4.2 as $\frac{2\;(minimum\;of\;performance\;values)}{3\;(performancec\;value)} = 0.667$. The same procedure was done for all components.

vii) Weighting

The Weighting of defects and strengths (alternatives") was subjectively determined based on the understanding and judgment of the assessor. The weights were determined by ascertaining the number of the "alternatives" and assigning weights that sum up to a total of 100%.

A simple illustration of the computations was illustrated in the calculations below considering the "alternatives" in Table 4.5. Since there are four alternatives, we use $\frac{100\%}{4} = 25\% = 0.25$

The crisp values attached to the components also called the "Criterions" are then multiplied with the weighs attached to the defects known as "alternatives". This product gives the values that are uniform and the components were ranked based on the "normalized" or uniform basis. Table 4.5.

Table 4.5 Conversion of Crisp values to Fuzzy numbers

Criteria	**Alternatives**							
	Appearance (Beneficial)		Strength (Beneficial)		Crack (Non-Beneficial)		Patch (Non-Beneficial)	
	Scale	Fuzzy number	Scale	Fuzzy number	Scale	Fuzzy number	Scale	Fuzzy number
Roof Component	2	$\frac{2}{2} = 1$	2	$\frac{2}{3} = 0.667$				
Walling Component			3	$\frac{3}{3} = 1$	3	$\frac{2}{3} = 0.667$	4	$\frac{4}{4} = 1$
Concrete Beams			2	$\frac{2}{3} = 0.667$	2	$\frac{2}{2} = 1$		
Floor			3	$\frac{3}{3} = 1$	3	$\frac{2}{3} = 0.667$	4	$\frac{4}{4} = 1$

Table 4.6: Computation of Component Weights

Criteria	**Alternatives**											
	0.25			0.25			0.25			0.25		
Roof Component	1	0.25	0.25									
Walling				1	0.25	0.25	0.667	0.25	0.1668	1	0.25	0.25
Beams				0.667	0.25	0.1668	1	0.25	0.25			
Floor				1	0.25	0.25	0.667	0.25	0.1668	1	0.25	0.25

iv) Ranking

The total score in the decision matrix ranges from 0 to 1 since they are fuzzy numbers. Through inspection, the component with the highest score is ranked first and follows a descending order until the component with the least score ranked last. This is when the priority for the component to be rectified firs is determined and resources allocated to it. A computation of the ranking of the elements is illustrated in Table 4.7

Table 4.7: Ranking of Components

Criteria	Weighted score				Total Weighted Score	Rank
Roof Component	0.25				0.25	4
Walling		0.25	0.1668	0.25	0.6668	1
Beams		0.1668	0.25		0.4168	3
Floor		0.25	0.1668	0.25	0.6668	1
	AVERAGE				**0.4501**	

viii) Summary of Costs

During the condition assessments, the estimates for rectifying the defects were obtained. The costs of materials and the associated resources of tools, equipment and personnel were obtained. Appendix G presents the actual computation of the costs of rectifying the defects.

In the event that the time for rectifying the defects was deferred to a later date, the future cost would be compounded using Equation 4.3.

$$F = P(1+e)^n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (Equation\ 4.3)$$

Where $F = Future\ Cost$

$P = Present\ Cost$

$e = Combined\ annual\ interest\ on\ capital\ i, and\ inflation\ rate, f$

$$e = \frac{i-f}{1+f}$$

$n = Period$ (Months)

ix) Print Reports

The reports that can be obtained from the print include;

i. Condition of elements in their index
ii. Building stock inventory
iii. Unit cost of rectifying components

The reports obtained from the maintenance management system are used for the planning for the maintenance interventions of the buildings in the District. Planning of the building components to be maintained helps in the prioritization of timely interventions, thus reducing the costs of maintenance incurred mostly as a response measure to failures in building components. Figure 4.10 presents the logical flow of the maintenance management System (MMS) comprising the procedures that have been elucidated above.

4.7 Chapter Summary

The results presented and discussed in this chapter indicated that a few departments have not been planning for maintenance interventions despite the aging building stock. The officers who were majorly involved in the condition assessment of buildings are those from the Engineering Department. A number of buildings indicated that some regular maintenance interventions required to be planned for since they had showed signs of defects affecting them. Most defects that were observed to have affected the building components were attributed to technical, social and environmental factors.

The inputs from the condition assessments that were referred to as crisp values through a process of defuzzification were converted to fuzzy numbers. These fuzzy numbers were normalized and used to determine the components to be ranked. These resulted into the multi criteria decision making model.

The process of condition assessment, identifying the maintenance requirements of the building components and later incorporated in the decision making of the maintenance interventions resulted in the maintenance management system. This system does not only give a building inventory but also ranks the building components and entire buildings to be maintained.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter includes the conclusions and recommendation resulting from the observations and discussions during the study. The conclusions and recommendations are not exhaustive but peculiar to the study. The chapter also provides for areas of further study in addition to this one so as to come up with a commercial product for the maintenance of buildings.

5.2 Conclusions

Amuria District Local Government maintains a large public built asset portfolio which required maintenance interventions. The planning and budgeting for maintenance of buildings was the responsibility of the user departments. Allocation of resources during budgeting was more biased to new buildings and maintenance had less than 20% budgetary allocation. Most buildings constructed would deteriorate faster as there seemed to be less priority to address the defect timely.

The building condition assessments were conducted annually by the staff in the engineering department who majorly relied on observation as a mechanism for assessment. During assessment, the common defects that affected building components included cracks, wearing, debonding, patches and moisture stains caused majorly by use of low quality materials and human negligence. These defects would be addressed by conducting regular monitoring to ascertain the severity of defects and plan for remedial interventions by the respective departments. The components that were in good condition required regular routine maintenance and a few exceptions that were dilapidated needed immediate attention that were prioritized using the Maintenance Management System (MMS) that was developed.

The District initially had no system for prioritization of maintenance intervention used during planning and budgeting process. It was, therefore, necessary that the District needed to adopt Maintenance Management System (MMS) to enable proper planning and budgeting of maintenance interventions of the building stock. This system required the establishment and regular update of the buildings inventory so that the information of the buildings condition would be used during the planning and budgeting process in the prioritization of building components and subsequent allocation of funds for maintenance of buildings. This practice could improve the reduction of the life cycle costs of the built asset portfolio.

5.3 Recommendations

i. Improve the mechanisms of building condition assessment and establish a building stock inventory that should be updated regularly by recruiting adequate staff to conduct routine building condition assessment and provide.
ii. Departments with the responsibility to plan and budget for buildings need to allocate more resources to maintenance of buildings during the planning budgeting process so as to timely restore the defects affecting components from further deterioration.
iii. Improve on the supervision during the construction process to reduce human negligence and ensure quality and not defective works are done.
iv. More research can be done to automate the maintenance management system and develop a computerized software application that can be periodically reviewed and upgraded to address challenges and limitations of the system and include more components.
v. There is need to adhere to the existing legal frameworks on the maintenance of assets.

5.4 Study Limitations

i. There are no available maintenance standards or requirements for the building components to regulate the maintenance of public buildings.
ii. Inadequate equipment for assessing building components. This limited the study to only nondestructive tests to be conducted.
iii. The strength of walls could not be assessed independently so the results obtained are combined with wall finishes.

iv. Records of the past maintenance works done on buildings was inadequate. Thus, the researcher relied mostly on the verbal information that the respondents could avail.

5.5 Further research

More studies could be considered to enrich the concept and have a more robust system for the maintenance management buildings.

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Appendix A: Condition Assessment Form

TABLE A-1:

Details of Building:	Date of Inspection:	Name of Assessor:
Location:	User Department:	
Name of Building:		

ASSESSMENT

S/N	Component/ Element Cord	Defect	(Tick as Appropriate) Condition 1	2	3	4	5	Priority 1	2	3	4	Weighted Score	Weighted Average
1.	Floor Component												
2.	Wall Component												
3	Ceiling Component												
4	Roof Component												
5	Concrete Beams												
6	Concrete Columns												

LEGEND:

Scale		Condition Assessment
1	Good	No defects, As new condition and appearance
2	Fair	Minor defects, Superficial wear and tear, some deterioration to finishes, Major maintenance not required
3	Poor	Average condition, Significant defects are evident, worn out finishes require maintenance, Services are functional but need attention, Deferred maintenance work exists
4	Very poor	Badly deteriorated, Potential structural problems, Inferior appearance, Major defects Components fail frequently
5	Dilapidated	Building component has failed, Not operational, Not viable, Unfit for occupancy or normal use

Priority Assessment/Ranking

1	Normal	Functional, cosmetic defect only
2	Routine	Minor defect, but could become serious if left unattended
3	Urgent	Serious defect, does not function at an acceptable standard
4	Emergency	Element/structure does not function at all; or presents risks that could lead to fatality and/or injury

Notes: Refer to "Look- Up" Tables for Scale Coding and Definitions.

Appendix B: Look-up Tables

BUILDING CONDITION ASSESSMENT (BCA) LOOK-UP TABLES

Table B-1: Cracks

Scale	Description
1	No visible cracks on the floor surface
2	Surface Cracks < 0.2 mm and less than Surface finish.
3	Cracks width 0.2 - 0.4 mm but not penetrate the whole structure.
4	Crack width 0.4 - 1.0 mm
5	Crack width > 1.0 mm

Adopted: Fahim and Esko (2015)

Table B 2: Surface Deterioration

Scale	Description
1	No abrasion, scaling or cracking networks on the surface.
2	Slight abrasion, scaling but inner martials not visible.
3	Abrasion exist, loosened cover < 5 mm deep.
4	Abrasion exist, loosened cover 5 15 mm.
5	Depth of the loosened cover > 15 mm.

Adopted: Fahim and Esko (2015)

Table B-3: Corrosion

Scale	Description
1	Reinforcement in concrete is in passive state
2	Corrosion has initiated but no visible damage exists
3	Visible corrosion spots, < 0.2 mm deep.
4	Cracking of concrete cover 0.2 - 1.0mm deep
5	Cracking and spalling >1.0mm deep.

Adopted: Fahim and Esko (2015)

Table B-4: Water leakage

Scale	Description
1	No sign of water leakage.
2	Precipitation of lime distinctive from surrounding surfaces.
3	Surface is moist distinctive from the surrounding surfaces.
4	The structure is leaking water.
5	The structure is leaking at many places, damage is extensive.

Adopted: Fahim and Esko (2015

Table B-5: Quality of concrete according to rebound number

Scale	Rebound Number	Quality of Concrete
1	>40	Very good hard layer
2	30 – 40	Good layer
3	20 – 30	Fair
4	< 20	Poor
5	0	Delaminated

Adopted: Pardeep et.al.,(2015).

Table B-6: Priority Assessment/Ranking

Scale	Priority	Description
1	Normal	Work can be safely and economically deferred beyond 3 years (24 - 36 Months)
2	Routine	Work that has minimal effect on operational capacity but desirable to maintain quality (12 24 Months)
3	Urgent	Work that affects operational capacity and may lead to serious deterioration if untreated (3 - 12 Months)
4	Emergency	Work needs to meet statutory obligations, ensure OH&S regulations and prevent serious disruption (0 - 3 Months)

Adopted from, Ifran,et.al., (2011), Queensland (2017)

Appendix C: SAMPLE QUESTIONNAIRE

Survey form to determine the commonly used mechanisms for condition assessment of buildings

Part 1 Consent

Hello, My Name is **Julius Eonya Elolu**, I am a student of Kyambogo University conducting a research in developing a Maintenance Management System for Public buildings in District local Governments. This Questionnaire is meant to collect data from the Staff of Amuria District Local Government. Any information provided in this Questionnaire will be used for purpose of research only and will not be divulged or availed to unauthorized persons.

Write brief answers where explanation is required. You need not write your name on the questionnaire. Please answer the questions as accurately as possible

Respondent Department	
Sector	

Part 1: - Work experience of respondent *Instructions: Write the numbers in the space provided.*			
Qn. No.	**QUESTION**	**TICK**	**RESPONSES/ OBSERVATIONS**
	How long have you spent in the employment		<1
			1 - 5
			5 - 15
			15 - 50

Part 2: - General Information

Instructions:

1. *Tick the appropriate response in the options/ category given*

Qn. No.	QUESTION	TICK	RESPONSES/ OBSERVATIONS
1	Is your department responsible for maintenance of any buildings in the District?		• Yes
			• No
			• Not Sure
			• Do not know
2.	What stage of building maintenance activities are you in involved in?		• Budget Planning
			• Condition Assessment
			• Works Supervision
			• None
3.	For how long have you been involved in the activities mentioned in 4 above?		• 0 – 2 Year
			• 2 – 5 Year
			• 5 – 10 Year
			• > 10 Year

Part 3: - Condition Assessment

Instructions:

1. *Tick the appropriate response in the options/ category given*
2. *Specify 'Others' and units in the space provided*

Qn. No.	QUESTION	TICK	RESPONSES/ OBSERVATIONS
4.	Does your department have an updated building inventory that is incorporated in the District Asset register?		• Yes
			• No
			• No Sure
			• I have no Idea
5.	Do some of these buildings that your department maintains have defects?		• Yes
			• No

			• Not Sure
			• I have no idea
6.	Have you ever identified some of the defects in the buildings?		• Yes
			• No
			• Not Sure
			• I have no idea
7.	How did you identify the defects that affected the buildings in your department?		• Observation
			• Visual Inspections
			• Test and measurement
			• Others
8.	How often do you go out to identify the defects affecting buildings in your department?		• Weekly
			• Monthly
			• Quarterly
			• Annually
9.	What are some of the factors attributed to the defects affecting buildings in your department?		• Technical
			• Social and Economic
			• Environmental
			• Others (Specify)
10.	Which category of buildings in your department are most affected by defects?		• Residential
			• Institutional
			• Administrative
			• Others
11.	In your report after identifying the defects, do you include any remedial actions for defects		• Yes
			• No
			• Sometimes
			• I have no idea of remedial actions
12.			

	What method is commonly used by your department to rectify the defects in the buildings?		• In-house using force account
			• Contracted
			• Both In-house and Contracted
			• Others (Specify)

Part 4: - Evaluating the use of Building Condition Assessment

Instructions:

1. *Tick the appropriate response/ observation in the options/ category given.*
2. *Specify /Record 'Others' and units in the space provided.*

Qn. No.	QUESTION	TICK	RESPONSES/ OBSERVATIONS
13.	Does your department have a specific budget for maintenance of buildings?		• Yes
			• No
			• Not sure
			• I have no idea
14.	What percentage of the development budget in your department is always allocated for the maintenance of buildings?		• 0 - 5
			• 5 - 10
			• 10 – 20
			• > 20
15.	How often do you update the information on the buildings inventory?		• Monthly
			• Quarterly
			• Annually
			• Never
16.	Do you share this information with other departments and stake holders?		• Yes
			• No
			• Sometimes
			• I am not sure
17.	Who receives the reports that you make after condition assessment activities?		• The Accounting Officer
			• The District Engineer

			• The Head of Department
			• All the above
Part 5: - End of Interview			
19	Interview Result	Completed .... 1 Incomplete .... 2 Refused .... 3 Others (Specify) 4	

Appendix D: Buildings in Amuria Town Council

Table D-1

S/N	DEPARTMENT	CATEGORY OF BUILDING		LOCATION
	Education	Classroom blocks	7	Kuju and Amuria P/S
		Office blocks	1	District Head quarters
	Health	Ward	5	Amuria H/C IV
		Theatre	2	Amuria H/C IV
		Medical Store	1	District Head quarters
		Office block	1	Amuria H/C IV
		OPD block	2	Amuria H/C IV
		Laboratory	2	Amuria H/C IV
		Antenatal Clinic	1	Amuria H/C IV
	Production	Office Block	1	District Head quarters
		Store	2	District Head quarters
	Finance and Planning	Office Block	2	District Head quarters
	Works	Office Block	1	District Head quarters
	Administration	Office block	1	District Head quarters
		Council hall	1	District Head quarters
	Community	Hall	1	Town Council
	TOTAL		**32**	

Appendix E: Selected Pictures of component defects

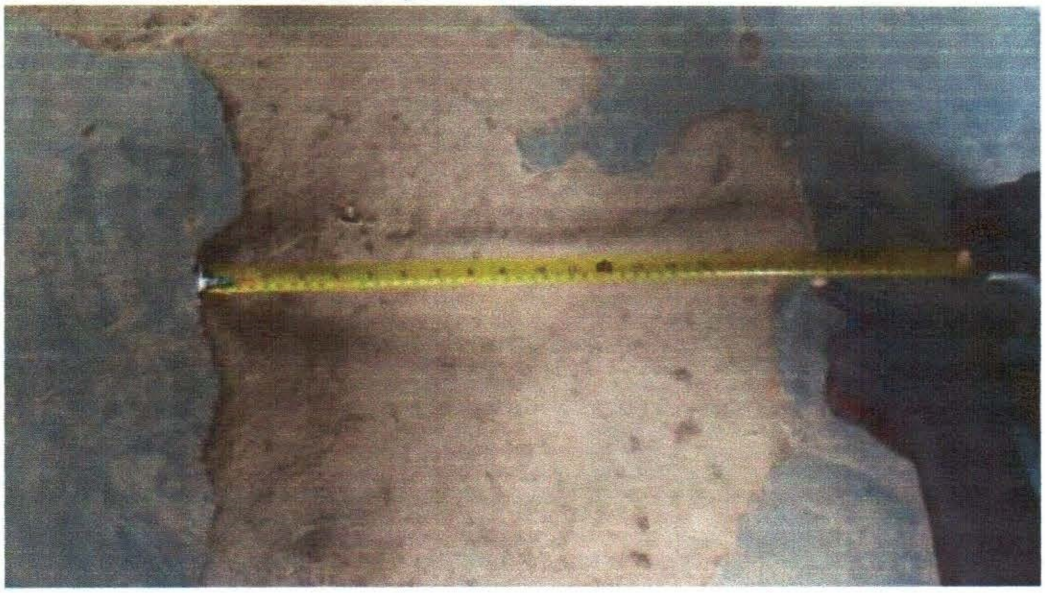


Figure 7.1. Patches on the Council Chambers Cement Sand Screed Floor Finish

Figure 7.2. Patches of missing Floor tiles at the District Water Office

Figure 7.3: Cracks at the bottom of the Column at the District Health Drug Store.

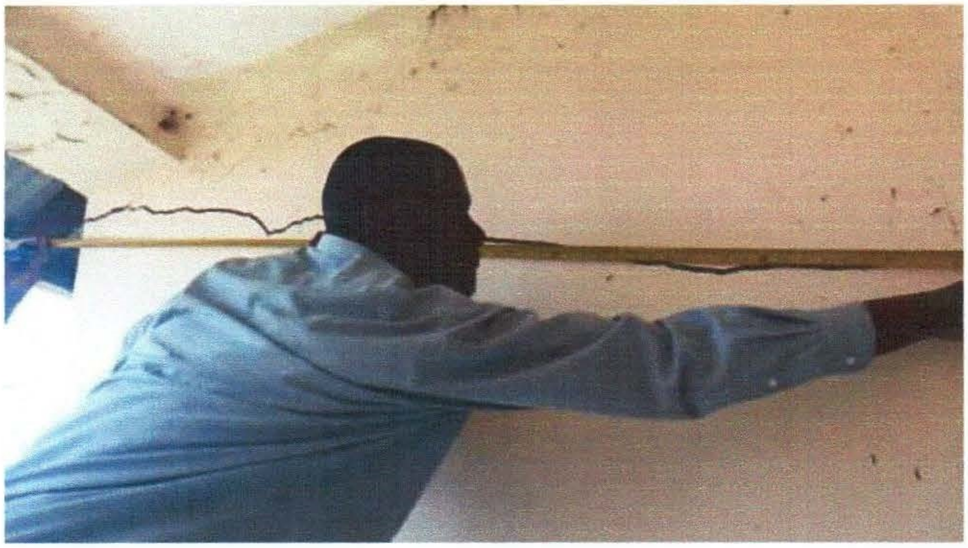


Figure 7.4: Crack along the partition wall of a theatre at Amuria H/C IV.

Figure 7.5: Plant growth at the External wall of the Operating Theatre at Amuria H/C IV.

Figure 7.8: Dampness at the External wall of the District Health Drug Store

Figure 7.9: Cracked beam at the District Drug Store.

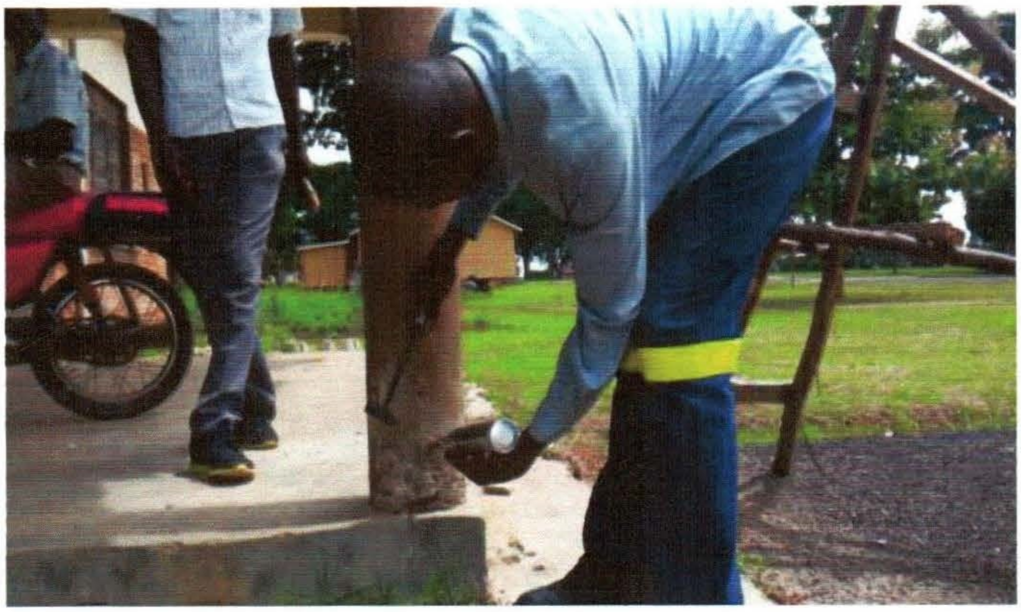


Figure 7.10: Cracks at the bottom of the Column at the District Health Drug Store.

Figure 7.11: Algal growth at ceiling of Amuria District Health Drug Store

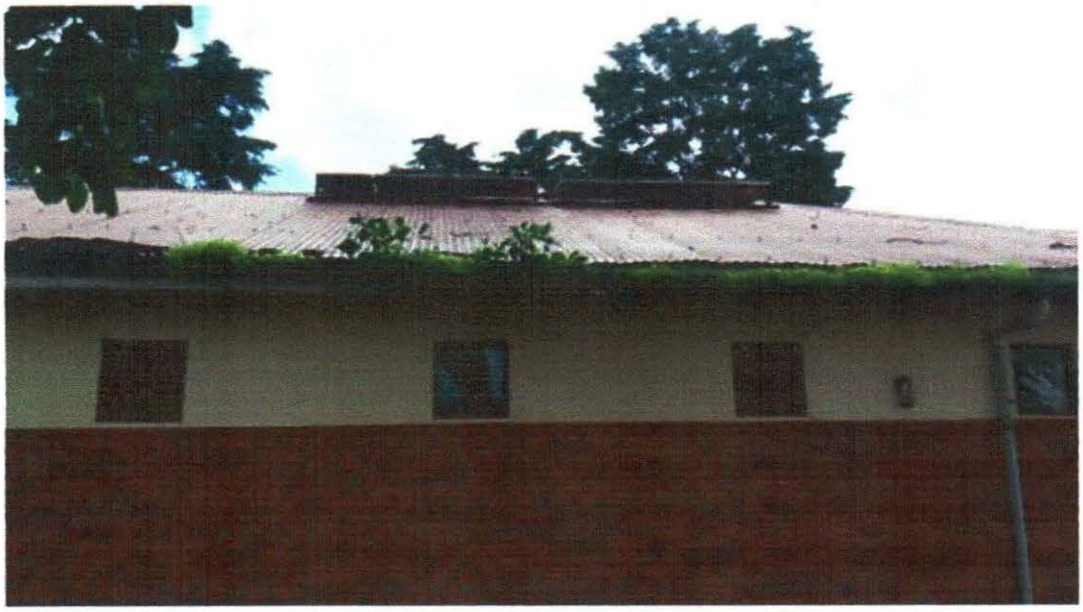
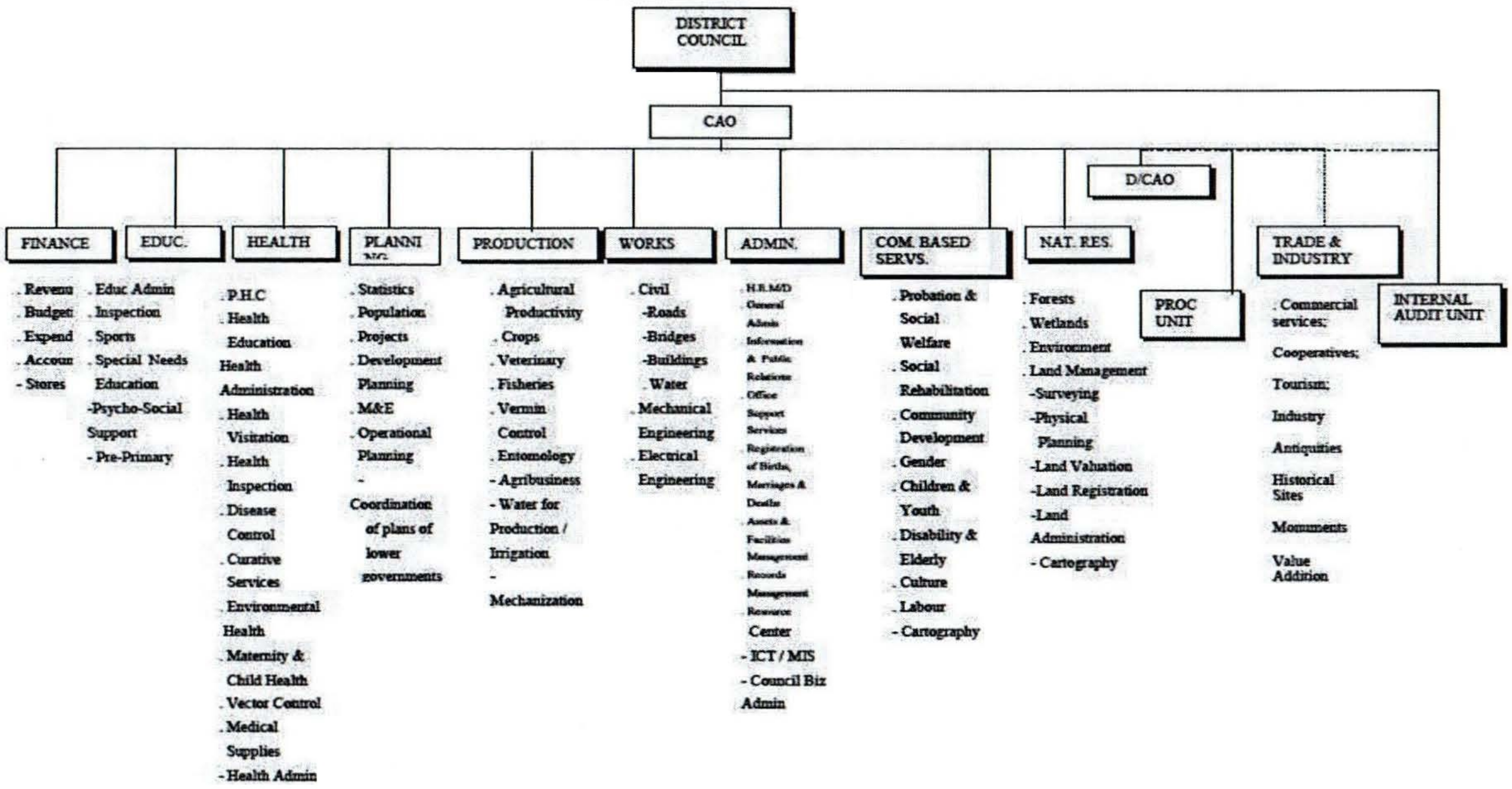


Figure 7.12: Plant growth along the gutters at Amuria District Health Drug Store

Figure 7.13: Damaged roof structure of Amuria District Health Drug Store

Appendix F: Struture of departments in Local Governments in Uganda

APPROVED DISTRICT MACRO STRUCTURE



Appendix G: Bills of Quantities

RENOVATION OF A TWO CLASSROOM BLOCK

AT

AMURIA PRIMARY SCHOOL

Item	Description	Unit	Qty	Rate	Amount (U shs)
	CLASSROOM BLOCK				
	Element A (Preliminaries)				
	Preliminaries				
a	Mobilisation of personnel ,equipment,construction of temporal structures	Item	1	100,000	100,000
b	Provisional sums for lightening protection and all its accessories	Item	1	3,200,000	3,200,000
c	Provisional sums for environmental restoration, tree planting and two month manitenance	Item	1	200,000	200,000
	Total to be carried to collection				**3,400,000**
	ELEMENT B (Demolitions)				
a	Hack off the existing damaged floor screed and prepare surface to receive new screed(measured seperately) as directed by the Engineer	Item	1	50,000	50,000
b	Carefully remove the existing G.I. roofing sheets and ridge covers and store directed by the Engineer.	Item	1	200,000	200,000
c	Remove existing damaged timber Rafters, battens and replae with new members(measured separately) as directed by the Engineer	Item	1	100,000	100,000
d	Demolish existing damaged ceiling structure and prepare surfaces to receive new ceiling (measured separately)	Item	1	N/A	
e	Demolish existing wooden doors size 900 X 2400 and and transport to stores as directed by Engineer	Item	1	120,000	120,000
f	Demolish existing delapidated wall plaster and prepare surface to receive a new cement-sand plaster (measured separately) as directed by the Engineer	Item	1	250,000	250,000
g	Demolish existing delapidated wall rendering and prepare surface to receive a new cement-sand render (measured separately) as directed by the Engineer	Item	1	130,000	130,000
	Total to be carried to collection				**800,000**
	Element C (Roof)				
a	100X75 mm Wall plate	m	14	8,000	112,000
b	150X50 mm Timber Rafters	m	40	8,000	320,000
c	75 x 50 mm timber Purlins	m	120	5,200	624,000
d	Pre-painted Iron sheets gauge 28 (Maroon)	sm	9	32,000	288,000
e	Ditto ridges	m	3	17,000	51,000
f	Re-apply wood presavative to timber trusses to look good	Item	1	250,000	250,000
g	225 x 22 mm Fascia and barge board	m	49	11,000	539,000
h	Prepare and paint one undercoat and two finishig coats of gloss oil paint to timbers 100-300mm girth	m	49	2,200	107,800
	Total to be carried to collection				**2,179,800**

Item	Description	Unit	Qty	Rate	Amount (U shs)
	Element D (Windows) ***Purpose made Solid Metal windows comprising of 2mm mild steel plate on standard MHS sections***				
a	Demolish wall to make opening and prepare surfaces to receive new window (measured seperately)	Item	N/A		
b	Window size 1200 x 1200 mm high PVO	No	12	210,000	2,520,000
c	Ditto BUT size 1000x1500mm High PVO	No	4	N/A	
d	Ditto but size 600x900mm high overall	No	4	N/A	
e	Painting to General surfaces of windows	sm	36	N/A	
f	Remove old vents and replace with kajjansi vent bricks	Item	1	120,000	120,000
g	4mm thick clear sheet glass panes	sm	36	24,000	864,000
	Total to be carried to collection				3,504,000
	Element E (Doors) ***Purpose made steel casement doors manufactured from pressed steel sections, with 300 mm vent over and fixing lugs cast into walling as specified : Supply and fix approved hinges and all necessary ironmongery: apply one coat of red oxide primer before delivery.***				
a	1000 X 2400mm high	No	2	270,000	540,000
b	3 lever mortice lock	No	2	75,000	150,000
c	Metal door frame size 900x2100mm high manufactured from 1.2mm thick bottle frame section and primed with one coat of red oxide	No	N/A		
d	Solid core flash door shutter	No	N/A		
e	3 lever mortice locks ("UNION" or equal and approved)	No	N/A		
f	***Prepare and apply three coats of high gloss paint:*** General surfaces of wooden doors	sm	N/A		
g	Ditto but metal door surfaces	sm	2	4,200	8,400
	Total to be carried to collection				698,400
	Element F (Internal Finishes)				
a	12 mm thick cement and sand (1:4) wall plaster,steel trowelled hard and smooth on walls internally	sm	66	5,500	363,000
b	Prepare surface and apply one undercoat and two coats of silkvinyl emulsion paint on plastered walls internally	sm	66	4,200	277,200
	Total to be carried to collection				640,200
	Element G (CEILING)				
a	100 x 50mm soft wood joists and branderings	m	N/A		
b	Galvanised expanded metal lath gauge SL 1 secured firmly to ceiling frame with 2" "U"- nails	sm			
c	12mm thick cement-sand mix (1:4) ceiling plaster coats steel toweled hard and smooth to ceiling	sm	N/A		
d	Ditto but 200mm cornice	m	N/A		
e	Prepare and apply one undercoat and two coats of emulsion paint to ceiling plaster	sm	N/A		
f	Ditto but cornice	m	N/A		
	Total to be carried to collection				

Item	Description	Unit	Qty	Rate	Amount (U shs)
	Element H (Floor finishes)				
a	25 mm cement and sand (1:3) screed finished smooth	sm	96	9,000	864,000
b	Ditto but 200mm high skirting	m	56	6,000	336,000
	Total to be carried to collection				**1,200,000**
	Element I (External finishes)				
a	12 mm thick two coat external rendering finished with wooden float to walls	sm	212	7,000	1,484,000
	Prepared and apply three coats of weather guard paint on:				
b	Plastered walls externally	sm	212	5,500	1,166,000
	Total to be carried to collection				**2,650,000**
	Element J (Splash apron)				
a	150 mm thick burnt clay brick wall 300 mm high in cement sand (1:4 mortar as toe to splash apron including rendering excavation and necessary back filling.	m	34	23,000	782,000
b	Provide 150mm bed of approval imported hard core well spread, rammed and consolidated under, slab and blinded with 50 mm layer of sand well watered and rolled to receive concrete	sm	21	18,000	378,000
c	Provide 100mm thick concrete mix 1:3:6	sm	21	35,000	735,000
d	Provide 25 mm thick cement and sand (1:3) screed trowelled smooth.	sm	21	11,000	231,000
e	25 mm thick ditto to edge of apron 300 high	m	34	5,500	187,000
	Total to be carried to collection				**2,313,000**
	COLLECTION				
	CHIEF'S HOUSE				
1	Preliminaries	A			3,400,000
2	Demilitions	B			800,000
3	Roof Element	C			2,179,800
4	Windows	D			3,504,000
5	Doors	E			698,400
6	Internal Wall Finishes	F			640,200
7	Ceiling finishes	G			-
8	Floor finishes	H			1,200,000
9	External Wall Finishes	I			2,650,000
10	Splash Apron	J			2,313,000
	SUB TOTAL I				**17,385,400**
	Add 5% Contigencies				869,270
	SUB TOTAL II				**18,254,670**
	Add 18% VAT				3,285,841
	TOTAL TWO CLASSROOM BLOCK				**21,540,511**

Appendix H: Building Assessment

Table H-1: Summary of Building Rating and Maintenance Requirements

S/N	BUILDING	MATRIX SCORE	BUILDING RATING	REQUIREMENT
1	TC/ED/AMUR/CR/001	15	Dilapidated	**Serious Attention** The Classroom needs repairs on the on the Floor to provide new screed, seal of wall cracks and provide new finishes and replace defective timber and selected roof covering.
2	TC/ED/AMUR/CR/002	10	Fair	**Condition Survey** Carry out a condition survey of the components so as to plan and budget for the corrective action.
3	TC/ED/AMUR/CR/003	8	Fair	**Condition Survey** Carry out a condition survey of the components so as to plan and budget for the corrective action.
4	TC/ED/AMUR/CR/004	4	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
5	TC/ED/AMUR/CR/005	4	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
6	TC/ED/KUJU/CR/001	4	Good	**Planned Maintenance**

				Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
7	TC/ED/KUJU/CR/002	2	Good	**Planned Maintenance** Recently renovated. The components are still in good condition.
8	TC/ED/DHQ/OFBL/001	1	Good	**Planned Maintenance** Recently renovated. The components are still in good condition.
9	TC/HE/AMHC/WAR/001	6	Fair	**Condition Survey** Carry out a condition survey of the components so as to plan and budget for the corrective action.
10	TC/HE/AMHC/WAR/002	4	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
11	TC/HE/AMHC/WAR/003	3	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
12	TC/HE/AMHC/WAR/004	4	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
13	TC/HE/AMHC/WAR/005	3	Good	**Planned Maintenance** Periodic maintenance interventions of painting, hammering back popped out roofing nails and regular floor mopping.
14	TC/HE/AMHC/THE/001	2	Good	**Planned Maintenance**

				Recently renovated. The components are still in good condition.
15	TC/HE/AMHC/THE/002	16	Dilapidated	**Serious Attention** The cracks at the walls need urgent repairs to avoid further widening and or eventual falling off. The poor waste water drainage system from the sluice and operating rooms possess a threat to the entire facility.
16	TC/HE/DHQ/DRST/001	15	Dilapidated	**Serious Attention** The damaged roof assembly, ceiling, beam and columns require replacement to avoid further degradation of the compotes. Replace the gutters and rendering on the lower wall below the facing brick wall cladding.
17	TC/HE/DHQ/OFBL/001	2	Good	**Planned Maintenance** Recently renovated. The components are still in good condition.
18	TC/HE/AMHC/OPD/001	2	Good	**Planned Maintenance** Recently renovated. The components are still in good condition.
19	TC/HE/AMHC/OPD/002	2	Good	**Planned Maintenance** Recently renovated. The components are still in good condition.
20	TC/HE/AMHC/LAB/001	1	Good	**Planned Maintenance** Recently renovated and expanded. The components are still in good condition.
21	TC/HE/AMHC/LAB/002	1	Good	**Planned Maintenance** New construction. The components are still in good condition.
22	TC/HE/AMHC/ART/001	1	Good	**Planned Maintenance**

				New construction. The components are still in good condition.
23	TC/PRO/DHQ/OFBL/001	3	Good	**Planned Maintenance** Plan to renovate seal the floor crack and improve on the dialing cleaning operations
24	TC/PRO/DHQ/STOR/001	3	Good	**Planned Maintenance** Plan to renovate seal the floor crack and improve on the dialing cleaning operations
25	TC/PRO/DHQ/STOR/002	1	Good	**Planned Maintenance** Newly construction. The components are still in good condition.
26	TC/ADM/DHQ/COU/001	12	Fair	**Condition Survey** Carry out a condition survey of the components so as to plan and budget for the corrective action.
27	TC/ADM/DHQ/OFBL/001	2	Good	**Planned Maintenance** Recently Renovated. Most elements are still in good condition
28	TC/FIN/DHQ/OFBL/001	2	Good	**Planned Maintenance** Recently Renovated. Most elements are still in good condition
29	TC/CBS/DHQ/HALL/001	12	Fair	**Condition Survey** Carry out a condition survey of the components so as to plan and budget for the corrective action.