

**Assessment of Defects Maintenance Management Practices of
Public Buildings; in Case of Debre Birhan Town**



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A Thesis Submitted to the Department of Civil Engineering

School of Civil Engineering and Architecture

**Presented in Partial Fulfillment of the Requirement for the
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DECLARATION

I hereby declare that this Master Thesis entitled “Assessment of Defects Maintenance Management Practices of Public Buildings; in Case of Debre Birhan Town” is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

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RECOMMENDATION

We, the advisor of this thesis, hereby certify that we have read the revised version of the thesis entitled “Assessment of Defects Maintenance Management Practices of Public Buildings; in Case of Debre Birhan Town” prepared under my guidance by Henok Bayou submitted in partial fulfillment of the requirements for the degree of Master’s of Science in construction engineering and management. Therefore, we recommend the submission of the revised version of the thesis to the department following the applicable procedures.

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We, the advisors of the thesis entitled “Assessment of Defects Maintenance Management Practices of Public Buildings in Case of Debre Birhan Town” and developed by Henok Bayou, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Henok Bayou have read and evaluated the thesis entitled “Assessment of Defects Maintenance Management Practices of Public Buildings in Case of Debre Birhan Town” and examined the candidate. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and Management.

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LIST OF ACRONYMS

BM	Building Maintenance
FM	Facility Management
CBM	Condition Based Maintenance
RECC	Real Estate And Construction Centre
RII	Relative Importance Index
CMMS	Computerized Maintenance Management System
RII	Relative Importance Index
SPSS	Stasical Package For Social Science
IBM	International Business Machines

ABSTRACT

The construction industry all around the world is getting modern, advance, and growing day by day. Despite the continuous development of the construction industry, buildings will suffer from different defects that appear in different public buildings throughout their life cycle. Building defects can be caused by many factors, such as poor workmanship, use of defective materials, or lack of maintenance activities. The low performance of building maintenance has had a significant effect on building, and it has had a great impact on the social and economic development of the countries. This study aims to assess the current building defect maintenance management in the public buildings. The study was conducted in the Amhara region Debre Birhan town public building. To achieve the study objective, G+3 and above public buildings (public condominium houses, educational buildings, and government administration buildings) are taken as a population, and the sample size of these buildings is 68 by using the sample size general formula. Different techniques of data collection methods were used including questionnaires, interviews, and observational case study. The data for this work was obtained from government representatives, construction works participants in the area, and these public building users. Quantitative and qualitative analysis was also used. To analyze data, IBM SPSS (stastical package for social science)statics and Microsoft Excel using Relative importance index and frequency distribution method of analysis as well as case study analysis also used. In this paper the major defects that occurred in a public building and their challenges to maintain investigated as well as their maintenance management practices. And also it carried assessment of public building defects, conditions of the buildings. The findings of the study revealed that there is a serious lack of building maintenance plan and maintenance strategies, building facility management, professional experts in building maintenance management, organized building management, proper planning in facility management, training for building maintenance, regular building condition assessment.

Key words - building defect, building maintenance management, conditional assessment,

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The construction industry is an economic investment and its relationship with economic development is well posited. Many studies have highlighted the significant contribution of the construction industry to national economic development (Olanrewaju & Abdul-Aziz, 2015).

It is impossible to produce maintenance-free buildings, but maintenance work can be minimized by good design and proper workmanship carried out by skilled experts or competent craftsmen using suitable codes of installation, essential building materials, and methods. Management of any process involves assessing performance, and maintenance management of buildings is no exception. A prime aim of building maintenance is to preserve a building in its initial effective state, as far as practicable, so that it serves its purpose effectively. The best way to achieve excellent maintenance is to have maintenance management that matches as closely as possible the expected requirements of the user (Sahelu, 2015).

Ethiopia is one of the developing countries that grow in all sectors including the construction sector. Many large and complex projects have been built according to the demands of the public and private sectors. This is mainly because developing countries are considerably dependent on the growth and development of their physical infrastructures and because the linkage of the construction industry to both economic and social sectors is very significant. A wide range of buildings and construction facilities are required by our modern society, including residential and commercial property, manufacturing facilities, schools, hospitals, complex transport infrastructure, and so on. Thus, the construction industry is a major sector of the economy of the country (MOFED, 2010).

The main function of a building is to protect the occupants and contents from the weather, mainly rain, wind, and extremes of temperature. It is most important to provide the basic needs which will achieve all of these functions. Features such as windows, pipe, air conditioning system and finishes are only additional. A building must be structurally safe to survive, and the floors must be capable of resisting any normally imposed loads (Ahzahar et al., 2011).

Consistent and continuous performance measurement of building and building maintenance strategy is crucial to prevent the creation of an unsustainable artificial environment at the expense of our natural environment. To fulfill the demands of both sectors, many expected errors and defects will occur during the construction and that will result in a high cost of maintenance.

1.2 Statement of the problem

The construction industry presents a day's plays a significant part within the economy, and the exercises of the construction building have a major impact on national socio-economic advancement. But, Buildings cannot stay immaculate all through their whole life. In arrange to keep the building fit for proper use it requires maintenance.

Even though there are different studies conducted on the Ethiopian construction industry, there's a shortage of investigation within the area of building maintenance management. The accessible considers within the area: hospital building maintenance by (Sahelu, 2015) and building facility management practices in higher education institutes by (Nibret, 2015) indicate that the practice needs advancement.

Despite the development in technology, residential buildings still suffer from defects resulting from different causes of the defect and lack of building maintenance that making them vulnerable to unplanned maintenance during their life cycle (Waziri, 2016).

Hence, there are so many problems associated with the defects of buildings and maintenance management. Maintenance of buildings and the general infrastructures has not been given full recognition as an activity of primary importance in Ethiopia.

Currently, most of the public building doesn't properly maintain and so, it reduces the buildings life and affect the proper use of buildings. This research was carried out to assess building defects and the current building maintenance management practices.

1.3 Objective of the study

1.3.1 General objective

The General Objective of this study was to assess the Defects maintenance management practices in public Buildings.

1.3.2 Specific Objectives

- To investigate the major defects that occur in the buildings that have to be maintained.
- To identify the challenges of defects maintenance management of the public buildings.
- To assess the current public building maintenance management practices.
- To develop a public building maintenance management practice framework.

1.4 Questions

- What are the major defects occur in these public building?
- What are the major challenges to defect maintenance management in public buildings?
- How these buildings are maintained and their maintenance management?
- Is there any maintenance management framework that assures Building maintenance management?

1.5 Scope of the study

This study intends to assess the building defects and maintenance management practices only Debre birhan public buildings which is G+3 and above buildings of condominium, administrative and educational building in Debre birhan. Therefore, it was limited to the analysis of the issue that concentrates on the stated objectives. In the research paper much emphasis was placed on the public building aspect of building defects and maintenance management work.

1.6 Limitation of the study

Public buildings are constructed throughout the country, the study assesses these different types of public buildings located in Debre birhan town. Considering the similar function of condominium buildings, five sites are selected for the study. The study sites are selected from only condominium, educational and administrative buildings.

Lack of prepared maintenance document by these public buildings and lack of data are difficult to investigate satisfactory information. There is no Building maintenance management department in the in these public building except educational building in the study.

1.7 Significance of the study

Building maintenance play an important role in the life span of buildings. Buildings that are in a poor state of performance will increase the rate of capital consumption. The prosperity and well-being of a country, therefore, depend on buildings, because national building stock depends on the amount spent to maintain the buildings.

Maintenance offers the significant potential of improving efficiency, productivity, and profitability in any organization. However, maintenance service must be user-focused. Considering the condition of the building as the major focus of maintenance is to regard maintenance as a burden and to limit maintenance to the technological aspect of the process.

The findings of this study use to know the major defects that occurred in public buildings and the importance of building maintenance management and besides investigating the paper uses to give attention for enhance the Building maintenance management practice to keep the building fit for the proper use and its requirements.

1.8 Structure of the study

The thesis is divided into five chapters as follows:

Chapter one intends to give a brief background of research problem of building defects and assure the importance of maintenance in public buildings. As well as, it describes the significance of the study, scope, objectives, limitation of the study and thesis organization.

Chapter two includes a comprehensive literature review of buildings defects, types of building defect, causes of defects, maintenance management, maintenance definition, types, building maintenance management, and building characteristics.

Chapter three resents the research flow chart, sample size, questionnaire design, and data collection stage.

Chapter four shows the results of the questionnaire, case study, and interview on the status of the public buildings defects and building maintenance management.

Chapter five presents concluding remarks, main conclusions, and recommendations drawn from the research work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter consists of basic definitions and concepts of building defects maintenance management the methods to use for assessing building defect and their maintenance management practices, reviewing studies which were conducted by different researchers on the major types of building defects and their maintenance management techniques used to repair some building defects.

2.2 Definition of Defects

Defects are a common phenomenon in the construction industry in all countries. Contractors, as well as investors, should pay special attention to them as they can have a significant impact on the costs and required resources of the project (Plebankiewicz & Malara, 2020).

A building defect can be defined as a material, component, or finish which does not meet its accepted performance criterion. Technical knowledge and proficiency and an indulgence of building construction are necessary to accurately recognize the root of building defects and the remedial measures essential to put the defects right (Mydin et al., 2012). Building defect is one of the major components of building problems that need significant attention (Fekadu, 2017). According to Kasi et al (2018), has divided defects into three categories:

Technical. A defect is caused when the materials or building elements do not meet or reduce their functional performance. Technical defects may cause damage to human life and assets. The diagnosis of such defects might need some scientific tests and investigation.

Aesthetic. A defect that adversely affects the appearance of the building material or element. Defects like discoloration, dampness, corrosion, efflorescence, plaster or tile delamination, broken glass or graffiti are considered aesthetic defects. These defects usually affect the visual appearance and beauty of the building and might lead to deterioration of the building materials or elements in some cases. Such defects may not harm the asset, structure, and human life and needless amount to be fixed.

Functional. A defect which leads the building failure to function as it was planned and designed. These defects are related mainly to the planning, design, and location of the building.

The condition of a building may vary from one individual component to another. Building defects can be potential hazards to the occupants or users of the building and can also affect the safe operation and use of building facilities. It is imperative to understand not just different types of defects in the building but also the various factors, which influences the overall condition of the building. To understand the characteristics of the defects found in the building, it is important to understand the factors, which affect the condition of a building and its components (Faqih et al., 2020).

2.3 Building Defects

Building Defects; According to Webster's Dictionary, a defect is characterized as lack of something necessary for completeness; shortcoming. It is additionally defined as an imperfection; fault; blemish. Another term for defect is lack. Webster's Dictionary characterizes the word deficiency as a state or quality of being lacking or a deficiency; shortage. As for lacking, it is characterized as to be needing, missing in a few qualities vital for completeness; defective and one that's insufficient. Defect is "the nonconformity of a component with a standard of indicated characteristic" (Awol et al., 2016).

The defect is a non-fulfillment of an intended functional requirement or an expectation, including that of safety and health. The same defects that were addressed to the maintenance organization were also addressed to the students. The scale of measurement was also the same; the purpose of which was to compare whether there was a difference of opinion on the maintenance organizations' and the users. Any difference discovered would guide the maintenance organization towards a value based approach to maintenance management.(Olanrewaju & Abdul-Aziz, 2015)

Defective construction works can be defined as works that fall short of complying with the express descriptions or requirements of the contract. The majority of modern buildings and civil structures are complex and involve the use of a great variety of engineering methods and processes. Therefore, most projects face the possibility of defects and defective work, which generally result in structures that cannot perform their originally intended roles (Ojo, 2010).

Defective construction contributes to both the final cost of a project and the cost of maintenance, which can be substantial. Building defect occurs to either the new building or the old ones. Defect within new buildings is maybe of non-compliance with Building Code and published acceptable tolerances and standards. Meanwhile, the older buildings, or building out of warranty period, may not comply with these standards but must be judged against the standard at the time of construction or refurbishment (Bakri & Mydin, 2014).

Construction defects are the key concern of the construction industry. Differently constructed buildings can generate different types of defects and demands at different levels in construction projects and the types of quality depending on the function, system, methods and materials used (Sellakutty & Rajendran, 2017)

Construction defects can be the result of design error by the architect, a manufacturing flaw, defective materials, improper use or installation of materials, lack of adherence to the blueprint by the contractor, or any combination thereof. Common types of construction defects include: structural defects resulting in cracks or collapse; defective electrical wiring and/or lighting; faulty plumbing; inadequate or faulty drainage systems; inadequate or faulty ventilation, cooling or heating systems; inadequate insulation or soundproofing; and inadequate fire protection/suppression systems (Hasan et al., 2016).

2.4 Types of Building Defects

Taking into consideration that different definitions of building defects have been applied in various research studies, a building defect can range from a mere imperfection (for example, a chipped tile or mark on a wall) to a structural fault that could create instability in a building. It is important to classify defects to gain a better understanding of their impact (Wilde & Hook, 2019.).

According to Georgiou (2010), defective construction includes activities such as compaction not done to specifications, which leads to ground movement and eventual failure of foundations. This may lead to the complete failure of a structure. He classified defects into two main categories, namely patent defects and latent defects.

Latent defects: those defects that are concealed and are often not obvious or readily observable upon reasonable inspection. Even with the most comprehensive on-site inspections, sometimes defective construction may go unnoticed. After construction is

complete, latent defects are unknown and generally undiscoverable and will only appear after the passage of time. Examples of latent defects are: soils that were not properly compacted, improperly installed flashing and/or the total lack of flushing within the building envelope assembly, lack of reinforcing in structural concrete footings, walls and/or slabs, lack of brick ties and/or masonry reinforcement in a brick/masonry veneer wall, an improperly installed weatherproofing system, improperly installed stucco exterior (Wilde & Hook, 2019).

Patent defects: are the defects that are known or would be readily obvious upon reasonable inspection. Examples of patent defects are: weep holes not installed in brick veneer walls. , handrails omitted in stairways, missing control and/or expansion joints, cracking and/or signs of distress in the building envelope, lack of roof drainage and/or roof slope, lack of proper roof/attic ventilation (Tolera & Kumar, 2020).

According to (NehaVBagdiya & Wadalkar, 2015) building defects classified into:

- Structural defects
- Non structural defects

Structural defect: Structural defect means any defect in a structural component of a building that's inferable to defective design, defective or faulty workmanship or defective fabric and sometimes any combination of these. Building structure includes soil retaining walls, columns, beams and flat slabs (NehaVBagdiya & Wadalkar, 2015).

It happens to the structure of the buildings, such as columns, beams, walls, roofs, floors, and foundations. This sort of absconds happens due to building settlement, deformation, genuine splitting and bowing of the buildings (Wen, 2013).

Non-structural defect: A non-structural defect in a residential building is described as a defect in a non-structural element of the building as a result of defective residential building work. Non -structural defect includes defect occurs in the non-structural components of building, services like in brick work, dampness in old structures, and defects in plaster works.

2.4.1 Cracking

Cracking normally can occur in various elements in the buildings. For instance, walls ceiling, columns or beams. Moreover, cracking also is a sign of corroded reinforcement. Precaution steps can be used to reduce the cracking that appear in the buildings. The cracks can be classified as structural and non-structural cracks (Rajabather, 2017).

Cracks in a building are of common occurrence. A building component develops cracks non-structural categories. The structural ones are due to faulty design, faulty construction or overloading which may endanger safety of buildings. The non-structural cracks are due to internally induced stresses. Depending on width of crack, these are classified in to thin ($< 1\text{mm}$), medium (1mm to 2mm) and wide ($> 2\text{mm}$ wide). Internally induced stresses in building components lead to dimensional changes and whenever there is a restraint to movement as is generally the case cracking occurs (Rama & Pilani, 2016).

According to Rajabather (2017), Generally, cracks can be divided into two types : Structural cracks and Non-structural cracks.

Structural Cracks: Structural cracks may arise due to various reasons such as incorrect design, overloading of the structural components. Structural cracks endanger the stability of the building and may be difficult to be rectified.

Non-structural cracks (Hair cracks): Non-structural cracks are generally due to internal forces developed in the building materials due to moisture variation, temperature changes, and suitable remedial measures can be taken to control it.

According to Pathak & Rastogi (2015), The magnitude of the risk caused due to a crack can be characterized in terms of its direction, and dimensions. Cracks can be horizontal, vertical, diagonal, or random.

Horizontal crack horizontal crack or crack which runs zigzag 45-degree angle, reason for this zigzag form might be severe such as foundation shifting or water damage. Severe cracks usually require immediate attention and might include some reconstruction to prevent further damage.

Vertical crack whereas vertical crack starting near the junction where the wall and ceiling meet, it indicates that it developed when the foundation settled after construction. Vertical cracks run the same direction as drywall.

Stair-step crack a stair-step crack looks like a flight of stairs and runs in both vertical and horizontal directions across the wall. The continuous pattern usually follows the brick line or the stone block and can be seen in unfinished basements due to the result of soil settling beneath the center of the wall. For the rehabilitation of such cracks the soil test and the core test is recommended to encounter the probable damage to the building.

Doors and window it is a way to test the severeness of a wall cracks in wall by checking the swing of the doors and windows while opening and closing the internal doors and evaluate whether the door is obstructed. If so, ensure that the obstruction is not due to the recent paint work, faulty material if you determine nothing is obstructing the swinging motion of the door, it might be a sign of a moderate or severe foundation settlement, and may result in wall cracks. According to Real Estate, sticky doors could indicate that the frame has been twisted by a shifting house. If you notice a visible gap at the top of a sticky door where it meets the door frame and you see light shining through, that might also signal a serious settlement problem, often resulting in jagged, horizontal cracks on nearby walls.

Visible nails inspect the area surrounding the crack on wall and look for nail heads or screw heads that might be visible on the surface of the wall. The nail or screw might not have damaged the drywall, but it has likely pulled away from the wooden stud beneath. This phenomenon is often known as "nail pops" or "nail popping" and might be a sign of structural problems. Nail pops are frequently associated with more serious wall cracks and often signal significant drywall shear movement.

The commonly observed crack pattern in building can be group as, cracks in: Walls, RCC members, Renderings and plasters, Concrete and terrazzo floors, and Roof terrace.



Fig 2. 1 Horizontal cracks (Othuman Mydin et al., 2014)

Table 2. 1 Classification of cracks by Visual damage (Defect in Building, 2003)

Crack Width (mm)	Degree of Damage	Description
< 0.1	Negligible	No actions are required
Up to 1	Very Slight	The formation of fine cracks arises and can be treated easily. These are generally visible in external brickwork.
1 to 5	Slight	By appropriate linings, cracks can be filled. For external walls, a repointing method is required.
5 to 15	Moderate	The requirement of mason takes place for closing cracks. For replacing, the repointing method and a small amount of brickwork is necessary.
15 to 25 (depends on number of cracks)	Severe	For doors and windows replacing should be adopted due to distortion. Floor sloping, leaning of walls, failures in bearing resistance for beams, and disruption of service are noticeable.
> 25	Very Severe	A partial or complete reformation of the building is required due to the structural damage.

2.4.2 Foundation Defect and settlement

Foundations must be designed to support the loads from a structure, taking proper account of ground conditions. The design of foundations and the calculations involved will not be considered in detail, but only the diagnosis of foundation defects which may be observed in the course of investigations into defects in buildings (Fekadu, 2017).

Footers (the things foundation sits on) may be built on loose material. It might expand or contract over time because of the weight on it. In any case, settling results from the shifting. So, cracks that develop from that settling will be seeing. Loose backfill that has been placed around the house can also settle and exert extra pressure on the walls, creating the same problem, especially if that backfill is comprised of lots of dense clay materials.

Cracks on the lower parts of the structure indicated the crisis of settlement. The gap of the cracks was large, about 10mm and the cracks appeared along the wall of the building. This may be associated with the movement of the ground beneath the foundations due to self-weight of the building. Settlement occurred where a structure found in various ground conditions or

foundation failures. Other possible causes of this problem were soil erosion by flowing water, changes in ground water level, uneven bearing capacities of soils and poor soil condition (Othuman Mydin et al., 2014).

2.4.3 Dampness

Dampness happens due to irritating and intemperate water or dampness. It causes harm in the brickwork by inundating, rotting nature of mortar couplings, decomposing timber structures, disintegration to press out and steal things, and annihilating the gear. The sources are rain, condensation, services leaks, construction process, use of buildings, and dampness in the air (Sravani et.al, 2020).

According to Fekadu (2017), The main causes of dampness in building construction are as follow.

Rain-Precipitation can be wind-driven that it penetrates joints that remain watertight in normal weather condition. The gutter overflow also can collect and be the aspects of dampness against walls.

Condensation - Humid air condensation on cooler surface or within, or between, building materials also can result to dampness. Air can become humid in several ways, including from the occupants' water vapors.

Rising damp and flooding- It may contact with groundwater or floodwater. It also the groundwater may be absorbed by the walls and transported up the wall by capillary action.

Services leaks-It might not just from pipes and tanks, but also the overflowing of condensation forming together with ventilation systems.

Construction process -The construction process too can play its role in this scenario. It is where the process of mixing water to form mixtures that dry out for the construction purpose before the building is start to give service, but sometimes by retaining moisture (sealed in by impermeable finishes) that shows and causes problems in the completed building.

Use of the building - this may include the cleaning of the building, spills, and apparatus leaking.

Moisture in the air - It is in contrast with condensation. Hygroscopic salts can extract moisture from the air in condition that would not allow that moisture to undergo the process of condensation. Dampness comes and goes according with the change of condition. Dampness also may leave stains or traces of mold and lichens and also in certain cases, mosses.

2.4.4 Termite Attacks

Termite attacks normally occur in a damp and digestible timber at which the structure is composed of timber materials such as wall plates, rafters, beams and battens. It is dangerous when the timber become softer and form further crack . The use of wood in building structure can lead to termite attack. Moreover, wood is the choicest food for termites to build shed or deck in the backyard. Another important element in termite infestation is the moisture content because moisture is very attractive for the termite infestation(Wen, 2013).

2.4.5 Leakage

Leaking is water that seeps out from behind walls, under concrete slabs and asphalts, basements, landscaping, water intrusion in roofs, irrigation systems, and radiant heat system. Leaking mostly happened due to improper installation of piping system that can cause dampness and mold growth (Kassaye, 2019).water penetration through external wall defects such as cracks, joints, honeycombs, spelling, weak points, holes, punctures, leftovers of debris, and movement of external wall components, water penetration through defective external wall finishes such as loosened mosaic tiles, cracked ceramic tiles and paint surface; through poor cladding or curtain walls constructions; or weaknesses in water-resisting components, Water leakage through party walls between units of pre-fabricated elements, or between buildings.

2.4.6 Peeling paint

Peeling paint usually occurs on building facades, mainly on plastered walls, columns and other areas that are exposed to excessive rain and dampness. Some buildings that are located near the sea may face a much higher risk once the signs of peeling paint are visible on the exterior walls. The majority of peeling paint problems occurs on surfaces exposed to the rain, sun, and the varying degree of temperature. Walls that have involved can be an unsightly mess in a home or building.

2.4.6 Erosion of Mortar Joints

The primary function of mortar joint is to balance irregularities of individual blocks, whether they are of stone or bricks. It also provides some adhesion between the blocks. Defective mortar can be removed easily by the use of a mechanical disc or raked out by knife manually. Generally, erosion of mortar joints is caused by weathering action, salt crystallization, unaccommodated building movement and effect of the freeze/thaw cycle(Wen, 2013).

2.4.7 Mold and Fungi

The growth of mold and fungi are ordinary consequences caused by excessive dampness. Mold and fungi will grow when they gain enough moisture and nutrients . However, the growth of mold causes a lot of problems to the school environment. It not only physically affected the appearance of the building structure, but also led to plenty of health illnesses to the students and staffs (Awol et al., 2016).

2.4.8 Plumbing & Drainage

Defective drainage systems occur in various forms and to different extents in all types of buildings, irrespective of age. Building owners should regularly inspect and maintain the drainage systems of their buildings in a safe and sound condition in order to help create a safe environment.

2.4.9 Electricity supply

The electrical work (including new installation, addition, alteration and repair) is completed, the qualified building services engineer and registered electrical contractor should inspect and test the electrical installations and certify that the installations are safe and comply with the safety requirements of the Electrical Ordinance stated in the Work Completion. Electrical system design and workmanship issues are a frequent component of disputes arising out of building fires.

It is important to maintain a safe working environment in a place where electrical installations are carried out. The line between safe and unsafe environment is very thin, which can be the difference between preventing accidents and causing them. Faulty wiring or old wires are the leading causes of electrical fires and accidents. The wiring needs to be checked every few years and if there is any damage, get it replaced immediately.

2.4.10 Defective plaster rendering

Plaster or render is like mortar coating over the block work. The coating on the inside walls called plaster, then the coating outside the walls called render. Plaster and render is totaling different. The render is generally richer and mostly in cement than the plaster due to weather resistant. The both of plaster and renders have different function. The plaster insides the walls to make the walls smooth, easy to clean, avoid from insect, and for better appearance. Apart from that, the plasters act as a protection against fire. The other functions are breathable for walls, abrasion resistant, and suitable for decorating or covering with coating, wallpaper and tiles. For the renders, is provided to protect them from the influences of weather (Bakri & Mydin, 2014).

Plastering gives strength to the structural members and helpful to reduce dampness in masonry during rainy season. It also helps in keeping the home clean from germ and dust. In exterior, it protect from heavy rains dusty winds, large variation in temperature or corrosive atmosphere (Omer, 2016)

Mostly the defective plaster rendering occurs on the external walls, column and ceiling. Defective rendering are normally caused by biological attacks arising from penetrating rain, evaporation, condensation, air pollution, dehydration and thermal stress. The mold or harmful growth, insect, animals, and traffic vibration also will contribution causes of defective plaster rendering. Prior to being decomposed and broken apart, rendering may crack due to either shrinkage or movement in the substrate.

2.4.11 Roof defects

Besides being one of the main structures in a building, roof may act as a weather shield, giving protection to users or occupants from rain and sun. Therefore, it is important to treat any aging roof tiles.

The roof tiles had been put downward towards the gutters and the growth of plants consequently blocked the runway of rainwater. As the result, the rainwater will overflow when there was a heavy rain. However, it was also discovered that gutters were not constructed along during the construction stage at some of the school buildings(Othuman Mydin et al., 2014).

2.5 Cause of building defects

Buyis and Roux (2013), stated that the causes of defects fall into the following basic categories:

- Natural phenomena such as storms, resulting in damage from floods, exceptionally high winds, lightning, earthquakes;
- Design errors;
- Workmanship errors;
- Faulty materials;
- Procedural errors;
- Failure to maintain properly, and
- Abuse or misuse of the building.

They also mention that, although defects caused by ‘natural phenomena such as storms, resulting in damage from floods, exceptionally high winds, lightning, earthquakes’ ‘failure to maintain properly’ and ‘abuse or misuse of the building’ are not the direct responsibility of the designer or builder. It is important to recognize and be aware of these types of problems, as they also provide causes of possible defects.

Tolera and Kumar,(2020), stated that the common types and the causes of the construction defect can be included: improper design poor workmanship that leads to poor finishing quality, improper means or methods of installation, improper or poor quality of the materials, defective material or poor material performance, missing or inadequate protection from weather or environmental condition in the construction site and soil subsidence, movement and settlement, those causes of defects listed above can be grouped in to 4 categories which are: design deficiencies, material deficiencies, construction deficiencies and subsurface/geotechnical problem.

2.5.1 Poor workmanship

Workmanship defects typically result from the contractor’s failure to follow the construction documents, industry quality standard practices, or the manufacturer's installation instructions. Poor quality in construction projects may be a common wonder within the world. Numerous disputes happened among clients, house proprietors and parties included in development (particularly contractors) on construction defects cases.

The project quality, cost, and timely delivery of completed structure in the construction industry depend on workmanship. The workman's skill, experience, and personal ability go a long way in determining the workmanship quality, measuring their efficiency and effectiveness. The failure in buildings structure comes in various forms and degrees of severity, the worst of which is a collapse. Poor workmanship makes it difficult for workers to perceive and apply quality control concepts and building production tolerance limits. This results in inferior construction methods and techniques, which may finally lead to building collapse(Ararsa & Quezon, 2020).

According to (Ntuli & Allopi, 2014) the causes of poor quality of workmanship in construction projects had been found out. These are:- Poor project management ,Complicated role of subcontractor ,Lack of experience and competency of labors ,Language barrier to communication and lack of communication ,Unsuitable construction equipment's ,Poor weather condition ,Limited time and Limited cost

2.5.2 Construction material

Most buildings use building materials which are easily available locally. Such building materials include timber, stone, brick and plaster. In the materials management of buildings, understanding the nature of the building materials and accurate diagnosis of defects is most important. This is because buildings are, like older people, vulnerable to all sorts of diseases. Therefore, in order to tackle the diseases, architects, contractors, engineers and those involved in building management should be familiar with the building materials in common use and have deeper understanding into the proper techniques of preservation of the materials and structures (Ahzahar et al., 2011).

Defective construction materials can result within the untimely failure of basic and other components, driving to direct and indirect property harms as a result. When builders use substandard materials within the development of a domestic or commercial property, they expose property owners to the chance of untimely disappointment of the structure or its components. A flawed fabric may be the blame of the producer or may be the result of a conscious choice on the portion of a designer or builder.

2.5.3 Design deficiencies

The success of a project pivots on the plan and building. Design defects are regularly a result of the planners or engineers failing to produce an accurate or well-coordinated set of development archives (Waziri, 2016). It is basic that the plans and determinations are surveyed

and taken after. This is why the state “per plans and specifications” is often utilized in contract dialect. Engineers and modelers detail products and strategies to be utilized within the details. Unexpected site conditions may require the planner and engineer to redesign areas of the project, such as changes to establishment footings coming about from destitute soil conditions.

A common design error is often made, usually in an effort to save initial construction costs. Project cost plays an important role in designing buildings. Reducing the size of columns, the size of reinforcement bars and foundations are common design error in construction. This situation will lead to an uncertain situation in the future where the structure cannot withstand the load and finally fails. Sometimes faulty design is also a result of misjudgment, leading to assumptions or decisions that are not consistent with the actual behavior of the structure (Ahzahar et al., 2011).

2.5.3 Proper construction management

Proper construction management would enhance the workmanship quality in construction. The capability of construction managers to manage, arrange and lead the work would affect the construction labor productivity. If a construction manager fails to lead and control the construction project, quality problems may arise and it leads to building defects (Yirgalem & Abdulkadir, 2019).

2.5.4 Lack of maintenance

Incorrect identification of the true cause of a defect, and inappropriate remedial work, will not only do nothing to rectify the original defect but may substantially worsen the condition of the building. Similarly, lack of care in carrying out repairs and inspections may be the cause of defects in previously satisfactory elements. The life of building elements and components can be extended considerably by adopting a planned maintenance approach, so that problems can be identified in their early stages and preventive maintenance carried out to avoid early failure (Ahzahar et al., 2011).

2.5.5 User activities

Defects may be caused by unintentional misuse through a lack of information on the correct mode of use, or by deliberate acts of vandalism. Also, certain defects may be related to the social attitudes and financial circumstances of the user. The building occupant's or user's lack of awareness about defects has a great impact on the condition and lifespan of buildings.

2.5.6 Climatic condition

Buildings can be vulnerable to climate change. In the future there may be an increase in the risk of collapse, declining health and significant loss of value as a result of more storms, snow or subsidence damage, water encroachment, deteriorating indoor climate and reduced building lifetime. In the short term stronger storms are the greatest challenge.

Weathering is inescapable. Wind and rain dissolve mortar. Mortars lacking Portland cement are particularly helpless to weathering from corrosive rain. On extreme exposures, the mortar joint can be weathered absent to a profundity of a few inches. Usually, weathering of mortar is went with by disintegration of masonry.

2.6 Building Maintenance Management

Alves Tenório de Moraes and Casado Lordsleem Júnior (2019), Define maintenance as the set of activities to be carried out throughout the life of the building to conserve or recover its functional capacity and its constituent systems to meet users' needs and security.

The Oxford Dictionary of English, define maintenance as “the process of keeping something in good condition”. Building maintenance, more specifically, is defined as “a combination of any actions carried out to retain an item in, or restore it to an acceptable condition”(Lau & Ho, 2010).

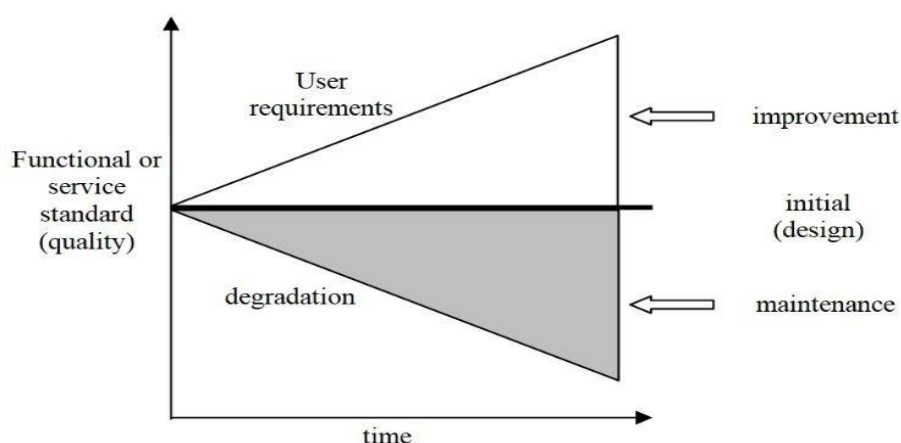


Fig 2. 2 Time relationships with building functions (Stanford, 2010)

Building maintenance plays an important role among other activities in building operation. Building defect and damages are part of the building maintenance ‘bread and butter’ as their

input indicated in the building inspection is very much justified, particularly as to determine the building performance (Zulkarnain et al., 2011).

The definition of building maintenance and management can vary across disciplines; however, the processes involved in the discovery, capturing, sharing, and application of the management and maintenance process will still be present. Building maintenance is defined as “work” in order to keep, restore or improve every part of a building, to maintain the performance of building fabric and its services and surrounds, to accepted standard and to sustain the utility and value of the building. It includes improvement, refurbishment, upgrading as well as repair works of the existing facilities (Puķite and Geipele, 2017).

According Nuratirah et al. (2019), Maintenance can be defined as a work on existing buildings undertaken with the intention of: Re-instating physical condition to a specified standard, Preventing further deterioration or failure, Restoring correct operation within specified parameters, Replacing components at the end of their useful/economic life with modern engineering equivalents, Making temporary repairs for immediate health, safety and security reasons (e.g. after a major building failure), Mitigation of the consequences of a natural disaster, Assessing buildings for maintenance requirements.

According to: Puķite and Geipele, (2017), The purposes of BM : To ensure that the buildings and their associated services are in a safe condition, the buildings are fit for use, the condition of the building meets all statutory requirements, to carry out the maintenance work necessary to maintain the value of the physical assets of the building stock and the work necessary to maintain the quality of the building.

Maintenance management is an orderly and systematic approach to planning, organizing, monitoring and evaluating maintenance activities and their costs. A good maintenance management system coupled with knowledgeable and capable maintenance staff can prevent health and safety problems and environmental damage; yield longer assets life with fewer breakdowns and result in lower operating costs and higher quality of life for the occupants and users. Building maintenance has consistently been treated as the “poor relation” of the construction industry, attracting only a tacit recognition of its importance, both within the industry and among building owners. This manifest itself in a general lack of understanding of both its scope and its significance by all parties to the building procurement, construction and management processes (Blessing et al., 2015).

Building management system is an important component in the fields of civil engineering and building now. Management system is a form of building systems used in the management of maintenance of a building. Building Maintenance is an activity of repair the damage, protect and monitor the building to continue to be in good condition. Thus, the construction of a good management system will be able to influence the quality of work, cost, time, and staff satisfaction Maintenance is an activity to conserve, preserve, manage and regulate buildings, facilities, equipment, services (services) and its surrounding buildings to meet current standards, the usefulness and value of defense facilities and security of the institution (Paper et al., 2017).

2.7 Importance of Building Maintenance

Building maintenance is an important program for the sustainability of infrastructural development. It plays a central role among other activities in building operations (Zulkarnain et al., 2011).

Maintenance management transforms resources or input into output or value. Users' needs and wants are used continuously to modify or adjust the factors in the transformation process, and this usually affects the input. However, the transformation process must be effective and efficient, i.e. the output must be greater than the input; thus, the essence of maintenance management is to create value and this is a value-added process (Olanrewaju and Abdul-Aziz, 2015).

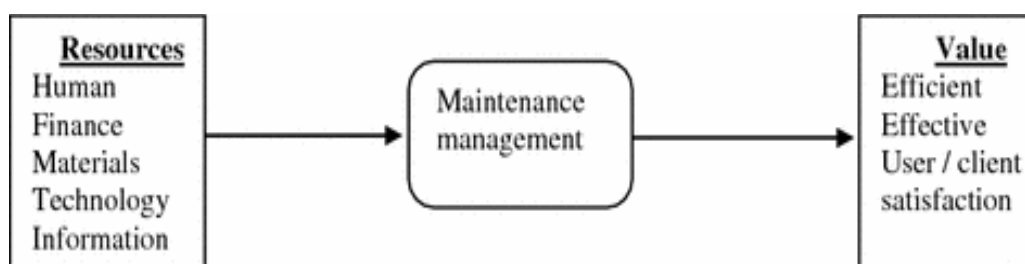


Fig 2. 3 Importance of maintenance management (Olanrewaju and Abdul-Aziz, 2015)

Maintenance is needed throughout the entire period that the building remains in use or occupation as well as building inspection which is conducted from the inception of construction to the occupants living. Both of them are aiming to provide safety for users and building owners (Md Azree Othuman Mydin, 2017).

The objectives of building maintenance are explained below:

- To ensure the building and its services are under a safety conditions.
- To ensure the buildings are available for use.
- To ensure the condition of the building meets all statutory requirements.
- To maintain and retain the value of the physical assets of building stock by carrying out the building maintenance
- To ensure and retain the quality of building

2.8 Causes of Building Maintenance

Building maintenance is required only quite later after the building is completely handed over. At the early stage, defects may occur due to the design of the building. Throughout the construction process, the design changes, negligence in construction and supervision and so on become the sources of maintenance problems. Normally six or twelve months warranty period against defects will be set as provision of the construction contract. During this period, the contractor shall repair any defect, if found, with its own cost. After that period ends, the building manager should be responsible to provide more maintenance program. It is expected to respond that the building is fully functional and producing gains in economic life (Nawi et al., 2017).

Poor maintenance of public buildings and infrastructure can lead to accidents and injuries. Buildings and facilities that are not properly maintained can cause discomfort and lead to accidents and injury to people. The consequences of poor maintenance and causes of the incident like bad service problem, improper work implementation, poor management, poor maintenance culture and lack of work ethic among those involved in maintenance (Dahal and Dahal, 2020).

According to Talib et al. (2014), major factors affecting building maintenance of public buildings which are: lack of preventive maintenance, insufficient funds to maintain the building, lack of building maintenance standard, non-availability to replacement parts and components and non-response to maintenance request.

2.9 Building Maintenance Strategies

Maintenance policy is a tool for maintenance personnel to plan their appropriate maintenance strategies. However, before a maintenance program is prepared, maintenance personnel and top management are required to agree on maintenance policy because it requires strategic

directions, as well as resources. The maintenance policy consists of five major components, and different maintenance strategies are developed from these components (Lee & Scott, 2009).

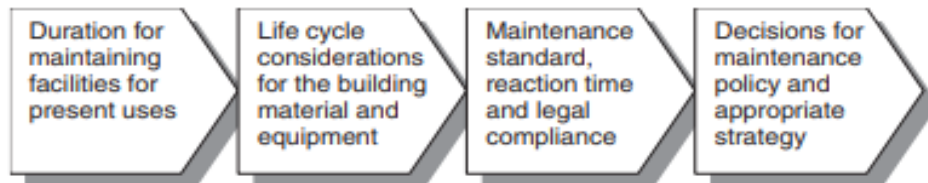


Fig 2. 4 Sequences for formulating building maintenance policy and strategy (Lee and Scott, 2009)

2.10 Classification of Building Maintenance Strategies

BS3811 subdivides maintenance into planned and unplanned with their sub-aspect indicated under planned maintenance, there are several strategic possibilities available to management, and many alternative decisions to be considered. Planned maintenance specifically is a type of maintenance organized and carried out with forethought, control and the use of records to a scheduled (Ofori. I.. Duodu, 2015).

Classification of building maintenance simply into routine or remedial, or planned and unplanned categories is clearly of rather limited value. The Audit Commission considered a better division of maintenance to be the following (Chanter & Swallow, 2008).

The possibility of lowering the call for upkeep through addressing the real cause of failure and figuring out its consequences. It can also be for instance, vital to determine whether to repair or replace a component, or perform periodic upkeep at constant periods, or surely reply to the requests of the users. The four most predominant upkeep types below planned maintenance are preventive, corrective, scheduled, and condition-based maintenance.

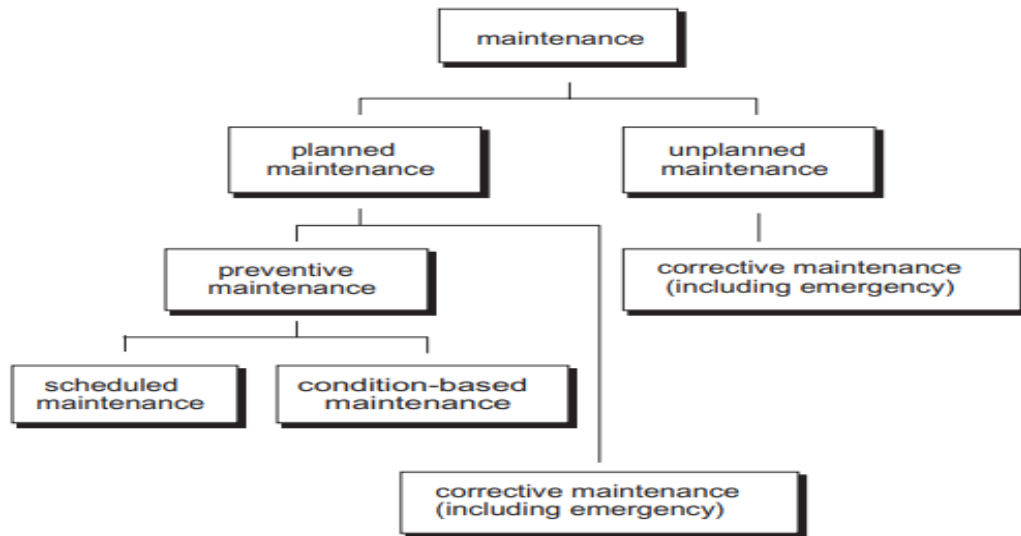


Fig 2. 5 types of building maintenance (*Whole Building Design Guide, 2008*)

2.10.1 Corrective Maintenance

This is the work required to rectify failures caused by incorrect design, incorrect installation, or use of faulty materials. it is a type of maintenance carried out to avoid serious consequences. This is sometimes referred to as day-to-day maintenance or emergency maintenance work.

Corrective maintenance has a lawful role to play in the entire maintenance program, although a limited one. The advantages of corrective maintenance can be viewed as a double-edged weapon, and thus skill and care is necessary when determining which assets should be authorized to run to breakdown. Corrective maintenance is most accepted to be the suitable maintenance approach for non-significant items and utility significant items whose condition cannot be monitored and for which the cost of applying time-based preventive maintenance is less than the cost of pertaining the corrective maintenance procedure(Mydin, 2016).

2.10.2 Preventive Maintenance

It is also referred to as time-based maintenance or cyclic maintenance is performed under a predetermined plan at regular, intervals, which may be based on operating time. Such a strategy is frequently applied to external or internal paint work.

On the other hand, the preventive maintenance is established to surmount the disadvantages of corrective maintenance, by reducing the likelihood of the incidence of malfunction and avoiding unexpected failure. Preventive maintenance task is done in agreement with a prearranged plan at regular, fixed intervals, which may be based for example on an operating

time. There are some advantages of preventive maintenance in excess of corrective maintenance such as the maintenance could be intended in advance and executed when it is expedient to the building's user, the cost could be diminished by avoiding the cost of significant damage, the point in time that a component of the building or the entire building is out of service, can be diminished, the health and safety of the user can be improve and the planned maintenance task are frequently very challenging in terms of spare parts and the labour cost (Mydin, 2017).

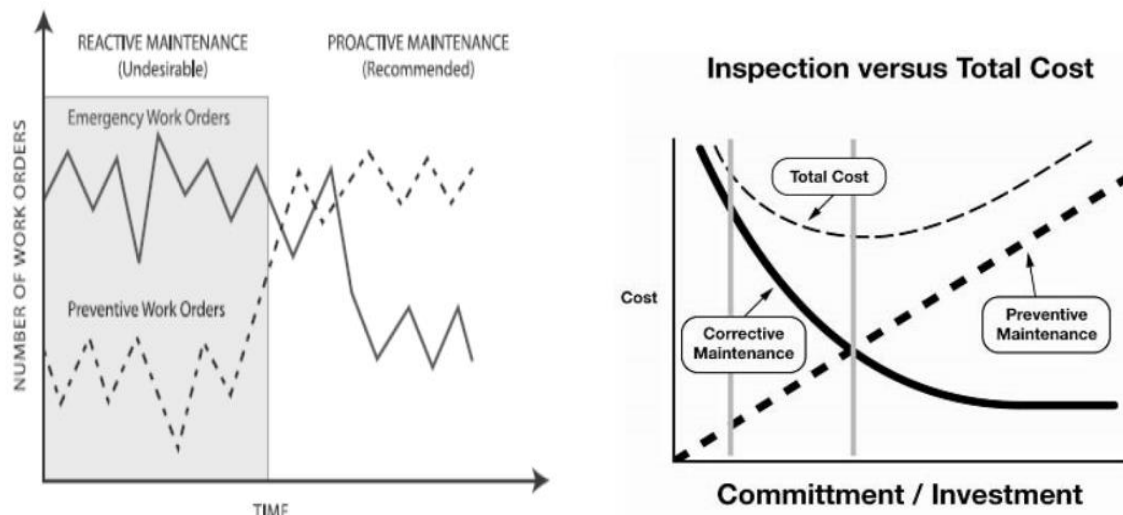


Fig 2. 6 Relationship between Preventive and Corrective Maintenance (Mydin, 2016)

2.10.3 Schedule Maintenance

It is a sort of preventive maintenance that takes place at predetermined interval of time while corrective maintenance is the simplest type of maintenance strategy, in which an element in a building is used till it breaks down or defects. It covers all activities, which includes alternative or repair of an element that has failed to a factor at which it can't carry out its required function. Corrective maintenance is from time to time called failure-based or unplanned maintenance.

The performance of the scheduled maintenance relies on the criteria such as: Skilled labor, Spare part and material, predetermined interval for maintenance, Cost allocation for failure or downtime(Au-Yong et al., 2014).

2.10.4 Condition-based maintenance

Condition-Based Maintenance (CBM) is characterized as: support carried out in reaction to a significant deterioration in a unit as demonstrated by a change in checked parameter of the unit condition or performance. CBM addresses failures that can be measured by one or several indicators. When applying maintenance efforts (people, processes, and tools) in a CBM

environment, maintenance is based on the actual condition of the equipment versus the age of the equipment, so that equipment in good condition does not need to be maintained as frequently as equipment that has reached the predicted age of deterioration (Gillespie, 2015).

The condition-based maintenance concept recognizes that a change in condition and/or performance of an item is the principal reason for carrying out maintenance. Thus, the optimal time to perform maintenance is determined from a condition survey used to establish the actual state of each constituent item in a building. Condition assessments can vary from simple visual inspections to more advanced inspections using a variety of condition monitoring tools and techniques. Unplanned Maintenance on the other hand, is a type of maintenance that takes place at no predetermined plan. It is also referred to as semi emergency maintenance. The three most major types of unplanned maintenance are include; emergency maintenance, corrective maintenance and unpredictable maintenance.

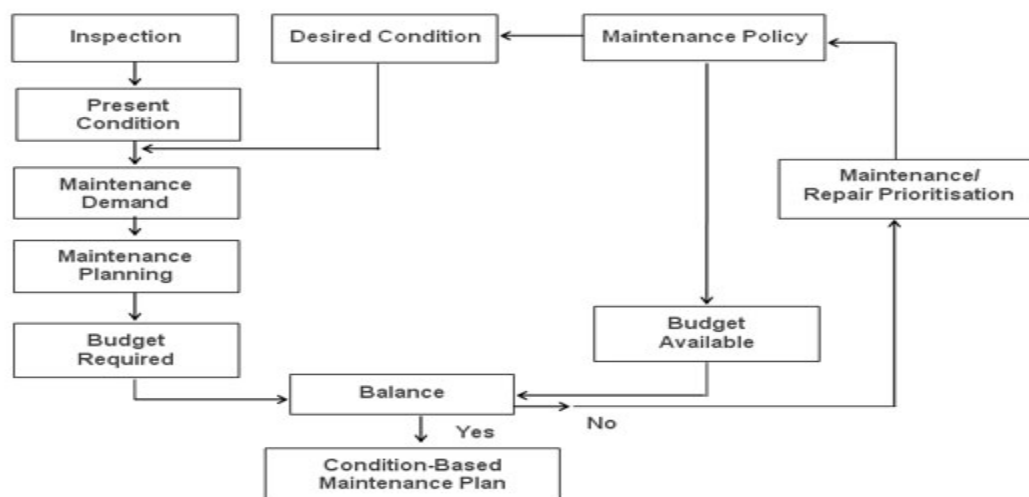


Fig 2. 7 condition based maintenance of building (RECC, 2013)

2.11 Conditional assessment of building

Buildings are primarily designed to provide shelter and safety to its occupants or users. However, physical condition and working environment change over time. It is imperative to evaluate the physical conditions of building elements to measure any significant changes in their condition which could impact building performance and also to assess the maintenance requirements of the building (Faqih et al., 2020). A condition survey is a detailed inspection of a building to establish its maintenance and repair condition at that time. It is done at a level that surveys each building element, describing it and providing detail of its current state.

Building performance is used to denote the physical performance characteristics of a building as a whole and its parts. Building performance relates to a building's ability to contribute to fulfilling the functions of its intended use (Linggar et al., 2019).

Building condition is very important to supports decision making and it is also critical to the management in achieving the service standards for maintenance. Building condition reflects the physical state of the buildings hence its performance. So the organizations, buildings, and maintenance managers must know about monitoring the condition of their buildings to prevent defects and failure of the buildings. Inefficiencies of the system of building maintenance work can give rise to defects and damage to the building. Defects and damage is a problem faced in any building regardless of the age of buildings and construction type. Besides that inefficiency in handling defects or damage buildings systematically generate a variety of effects and negative impact to users and is also the owner of the building. The data of defects collected and registered during the assessment or inspection on-site is crucial for maintenance decisions. All building components have to contend with performance loss through aging, use, and also external causes(Yacob et al., 2016).

According to Australia, Queensland Department of Housing (2017), Condition assessment generally comprises:

- physical inspection of a building to assess the actual condition of the building and its elements and services (e.g. air conditioning, fire protection), in comparison to the asset owner's specified condition standard
- identification of maintenance works required to bring the condition of the building and its services up to, or maintain it at, the specified condition standard 1
- ranking of maintenance works in order of priority
- Determination by the assessor of actions to mitigate any immediate risk until remedial works (or other actions) can be taken to address problems.

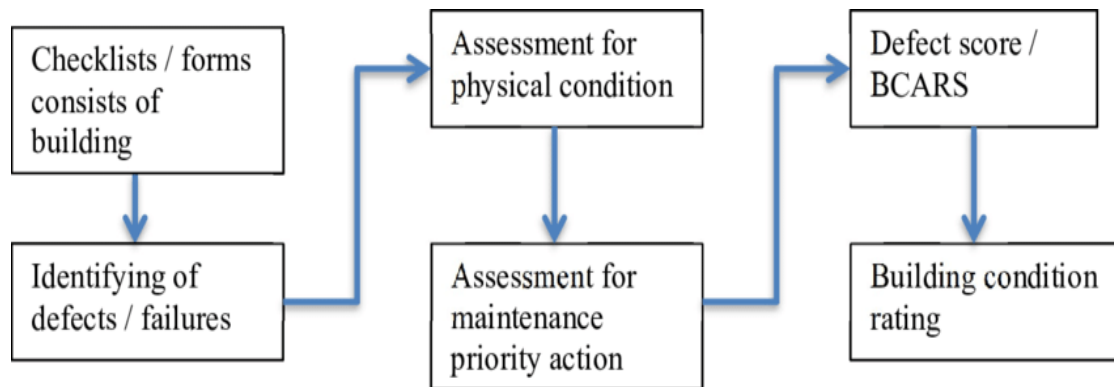


Fig 2. 8 Condition assessment process (Mohd Noor et al., 2019)

2.11 Summary of literature review and research gaps

A detailed literature review was carried out using international journals, conferences, proceedings, Books, and the internet. Most of the researchers were done different works on these defect building maintenance management about which maintenance strategy was needed to the building but building maintenance management especially for the public buildings like condominium buildings which many people's lives together in a building apartment these users do not know the building defects and their causes through the lifetime of the building. The other research gap in the topic is the causes of defects studied mostly due to defective construction material, faulty design, and poor workmanship but User's activities, misuse of the building, and maintenance problems have a great impact on building condition.

The importance of conditional assessment of building and building maintenance management in public buildings hasn't been given attention in developing countries. The lack of these practices in such building decrease the lifespan of public buildings.

During the literature review there are worked researches in our country which is related with building defect causes defects studied mostly due to defective construction material, faulty design, and poor workmanship but User's activities, misuse of the building, and maintenance problems have a great impact on building condition. But there is no research related with defects building maintenance management practices in the public building especially in condominium, administration and educational buildings ,therefore the research is tried to fill the gap by giving emphasis on building defects maintenance management in Debre birhan. In the condition of our countries building maintenance has not given any attention because of these things the condition and life span building is decreasing throughout a time.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter deals with the various methods or sources of data used in obtaining materials and information needed for the research for writing the project to obtain and achieve meaningful, accurate, and correct results in carrying out the research work.

3.1 Study area

The study will be conducted in the Amhara region, north shoa zone, Debre Birhan city public buildings. Debre Birhan is a town located in the North Shewa administrative zone of Amhara regional state situated 130 km northeast of Addis Ababa as shown in fig 3.1.

This research evaluates the Building maintenance management practice of public buildings located at Debre Birhan town. In this research a case study of stated public buildings and questionnaire survey were taken by examining the buildings and types of Building maintenance method and tried to identify the different types of building defects observed on the buildings. Projects are listed on table 3.1.

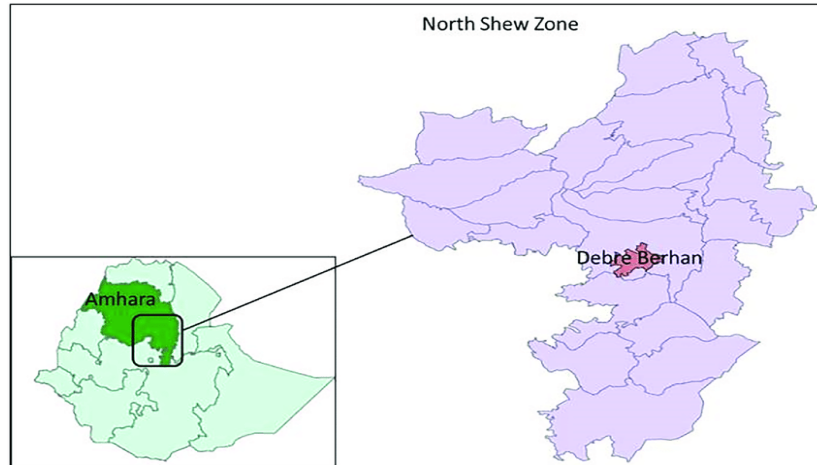


Fig 3. 1 Map of Debre Birhan town

3.2 Research Design

The procedural stages are applied in this research, namely, the secondary data examination from the literature on Defect building maintenance management, primary data collection from current building maintenance management practices and trends, through observations at public

building sites in Debre birhan town and questionnaire method, the evaluation of the two data from the two sources.

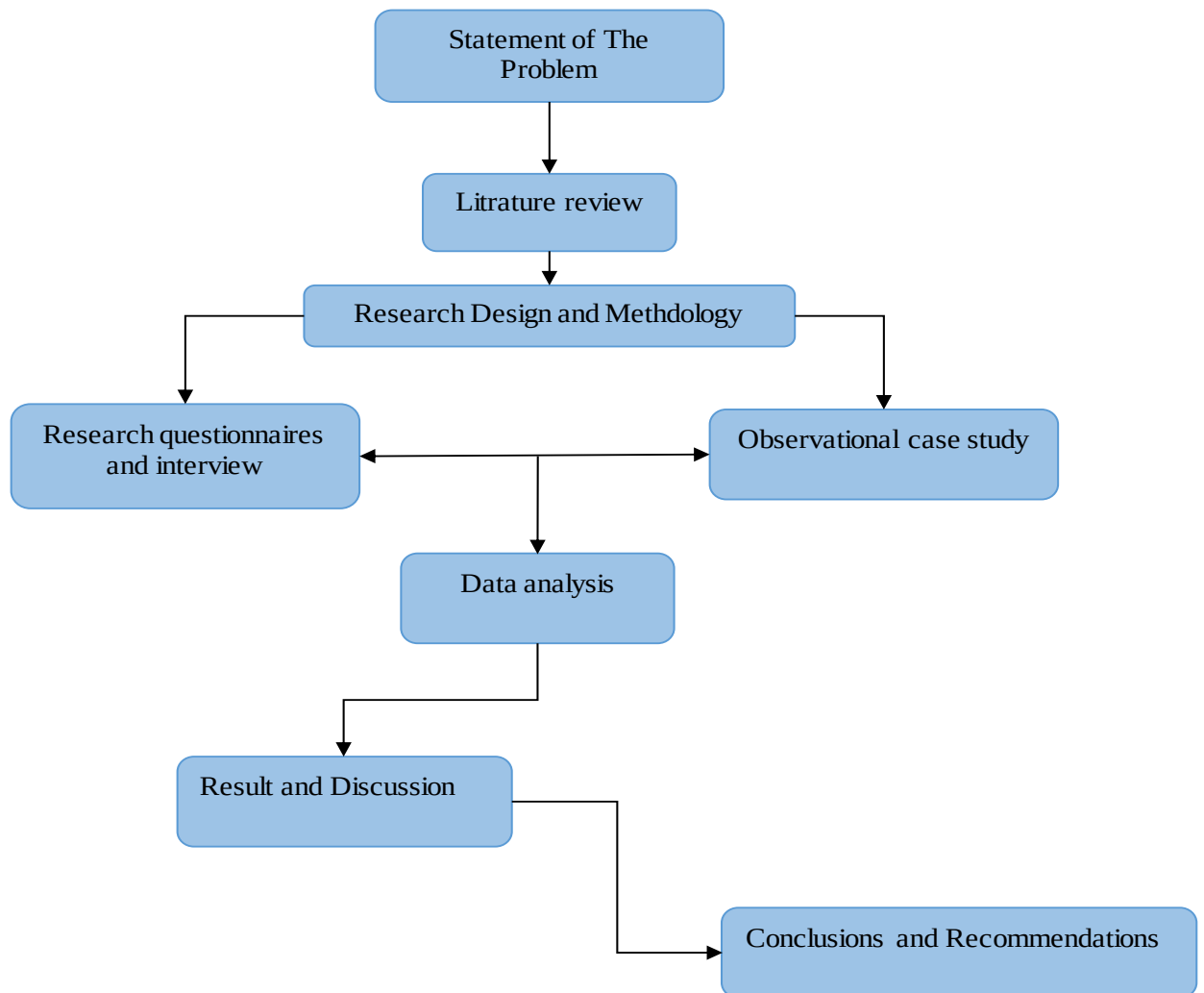


Fig 3. 2 Research design flow chart

3.3 Population and sampling

In carrying out the research work, the sampling method used in the collection of data in this project research was purposive sampling method which is a sampling technique in which the study relies on judgment when choosing samples logically from the total population to carry out the study. It is the method in which all the buildings within the population of the study have been selected by their purpose building and the selection is proportional with the sample calculated from the Cochran method sample size.

Table 3. 1 Population of the study

No	Population(List of buildings)	Blocks no
1	kebele 01 condominium	6
2	kebele 02 condominium	5
3	kebele 04 condominium	4
4	kebele 08 condominium	5
5	kebele 09 ketena 1 condominium	7
6	kebele 09 ketena 2 condominium	8
7	Hibr condominium	12
8	Jiru mesmer condominium	9
9	megenteya condominium	5
10	Debre birhan university condomnium	2
11	Debre birhan university	23
12	Debre birhan municipality	1
13	North shoa zone administration office building	2
14	Debrebirhan hospital condominium building	3
	Total No of buildings	92

The general formula to select the sample size from Debre birhan public buildings:-

$$no = \frac{z^2 pq}{e^2} \dots\dots\dots \text{equation 3.1}$$

$$no = \frac{1.65^2 * 0.5 * (1 - 0.5)}{0.05^2}$$

$$no = 272.25$$

Where:

Z is z-Value (e.g. 1.65 for 90% confidence level)

e is the desired level of precision (i.e. the margin of error 5%),

p is the (estimated) proportion of the population that has the attribute in question,

q is 1 – p.

New correction

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}} \dots\dots\dots \text{Equation 3.2}$$

$$n = \frac{272.25}{1 + \frac{(272.25 - 1)}{92}}$$

Sample size (n) =68 buildings

Where: N is number of population

Table 3. 2 Purposive sampling classification of sample buildings

Buildings	Frequency	Percentage
condominium buildings	50	74%
administration buildings	3	4%
educational buildings	15	22%
Total	68	100%

3.4 Data collection Technique

Both primary and secondary data were included in this research. Primary data were gathered from observation and questionnaire with study participants such as Engineers, consultants, contractors, Government body and building users. Secondary data used include literature, reference books, journals, previous studies, etc. written on the thesis topic. The data used in this research work data will collect by different data collection methods such as:

3.4.1 Questionnaires

Questionnaire distributed and collected back by hand. Most of the questions were answered by the public building users and construction contractors, consultants, and government bodies involved in construction works in the area of the study. From the literature review, it has been discussed about common defects, challenges, and defect building maintenance management practices and related concepts of construction defects and maintenance plans of construction buildings.

The questionnaires include different categories to assess the study these are used to identify the major defect that occurred in the public buildings, major building areas that defects occurred, challenges of building maintenance management, and the strategy that used to manage these defects.

Part one was about general information of the respondents and buildings about name, Educational background, category of company, years of experience and ages of building.

Part two of the questionnaires was about the major defects occurred in the public building

Table 3. 3 Degree of severity for major defect occurred

Common defect occurred in public building	Very low	Low /minor	medium	High	Very high
Scale	1	2	3	4	5

Part three of the questionnaire was about Challenges of defect maintenance management

Table 3. 4 Levels of agreement for challenges of building maintenance management

challenges of building maintenance management	Very low	Low /minor	medium	High	Very high
Scale	1	2	3	4	5

Part Four of the questionnaire including types of maintenance, condition of the building and defect detection methods in public buildings.

Table 3. 5 Condition index

Good	Performing as intended and operating efficiently, no significant visible defects and no history of repairs.
Satisfactory	Performing as intended but minor repairs are required.
poor	Exhibits major defects. Widespread deterioration of the fabric requiring the replacement of significant parts of the element. Not able to perform correctly without regular repairs.
Bad	Life expired, serious risk. The fabric has defects that cannot be alleviated by minor reactive maintenance and may lead to the imminent closure of a facility.

3.4.3 Interview

Face-to-face conversation with the building user and construction involving parties in the area of the study. Interview uses to get deep information which needs more information than

questionnaires. The data collected from government building development and office workers, contractors, consultants, and end building users.

3.4.4 Observational case study

This data collection method by which information is gathered through observation, and it is easy to overlook defects in building elements as they are usually elusive to the naked eye. Failure to address them timely will result in the continued exacerbation of the condition that puts users and the public at risk helps to do desk study on the investigating the defects and in this method, photometric data's will collect, and also it helps to investigate the severity of the defects in the buildings. In this case study five public buildings was assessed as shown in table 3.6.

Table 3. 6 Observational cases studied buildings

Building Types	Nos of Buildings
Educational Building	2
Public Condominium Buildings	2
Administration Building	1
Total	5

3.5 Methods of Data Analysis

This study is mainly concerned with the defects particularly structural and system defects. No scientific investigation was performed to find out the severity of the defect's resources. The study is mainly based on basic knowledge and understanding of the defects as per the available literature.

This research is considering questionnaires, observation, and interviews to collect data. The method of analyzing the collected data is based on ranking the frequencies of responses to the factors (requirements) which have influences or significance on public building defect maintenance management. And the ranking is based on the relative importance index (RII) or Likert scale, which is expressed as follows.

$$R_{II} = \frac{\sum W}{A*N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5*N} \dots\dots\dots\text{equation 3.3}$$

Where,

W - Weighting given to each statement by the respondents and ranges from 1-5;

A - Higher response integer (in this case 5); and

N - Total number of respondents

n_i - the variable expressing the frequency of the ith response

3.6 Validity and Reliability

The opinion of experts, as well as the pilot test, will be explored to checking the content and face validity of the instruments in this study. To ensure instrument reliability, will exert every effort in writing items, providing clear instructions, ensuring fair administration, and the like. In addition to that based on a pilot sample, the reliability of the questionnaires was tested using Cronbach's alpha.

$$\alpha = \left(\frac{k}{k-1} \right) \left(1 - \frac{\sum_{i=1}^k \delta_{Yi}^2}{\delta_X^2} \right) \dots\dots\dots\text{equation 3.4}$$

Where **k** is the number of indicators or number of items:

δ_{Yi}² Refers to the variance associated to i

δ_X² Refers to the variance associated with the observed total score

The questionnaire was structured to ask similar questions in different sections. This test-retest method of assuring the reliability of the questionnaire was an indication of whether the answers given were coherent. Questionnaires were grouped to check for consistency in responses.

Table 3. 7 Reliability test

Cronbach alpha	
Types of defect	0.842558
Major area of defect occurs	0.791433241
Challenges of defect	0.77051

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discusses and analyses the data gathered intended to attain the objectives of this research. It explains the background information of respondents, the major defects that occur in the buildings, the challenges of defects maintenance management of public buildings, and current building maintenance practices.

4.2 Respondent profile

The first section of the distributed educational qualifications, roles, and the corresponding information of the contracting firms the respondents.

4.2.1 Educational Background

From the summary Table 4.2, it can be seen that most of the respondents are with a Bachelor's degree qualification. From the total sample, 59% of the respondents have a Bachelor's degree. Similarly, eight of the total respondents (10%) hold a Master's degree while the remaining twenty-five respondents have a college diploma and below.

Table 4. 1 Respondents educational background

Educational Background	No. of Respondent	percentage	Remark
Below first degree	25	31%	
Bsc degree	48	59%	
MSc degree	8	10%	
PhD	0	0%	
Total	81	100%	

4.2.2 Role of Respondents

The positions held by the respondents were grouped into 5, namely, contractors, consultants, Engineers, End Building users, and governmental bodies.

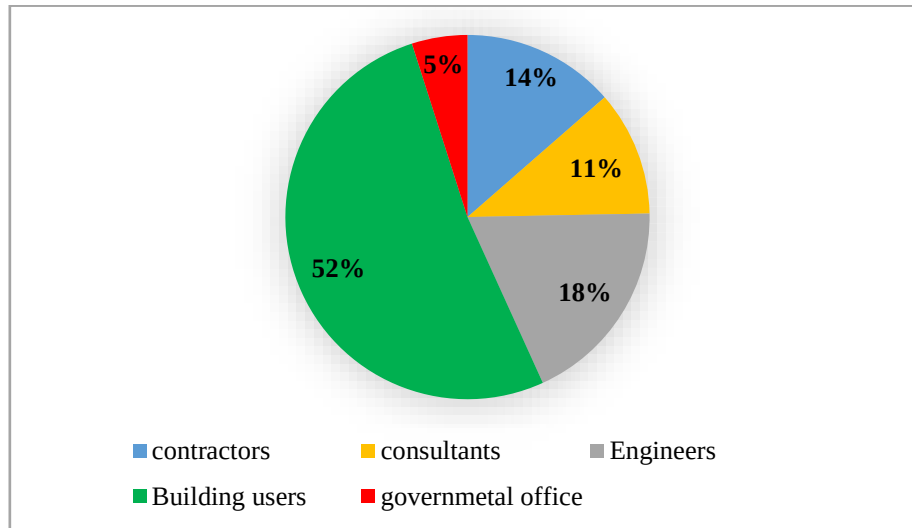


Fig 4. 1 Role respondents

Accordingly, 42 of the respondents were End building users (condominium building users, students, staff members, and administration office government use), 11 were found to be in the construction site and office engineering works in the building construction position (14%) 9 were Construction consultants (11%), 15 were Engineers working in the government construction office and academically engineers (18%) and the remaining 4 were occupied governmental sector (5%).

Table 4. 2 Respondants response percentage

respondants	No of respondants	responded	percentage
contractors	11	7	63.64%
consultants	9	8	88.89%
Engineers	15	11	73.33%
Building users	42	39	92.86%
governmental office	4	4	100.00%
total	81	69	85.19%

4.3 Age of Buildings

Age of buildings Is one of the factors that leads buildings to defect, In this study the buildings age assessed as shown in Fig 3.3 50% these building are above than 5 years, 43% between 5-10 years and 7 % of less than 5 years.

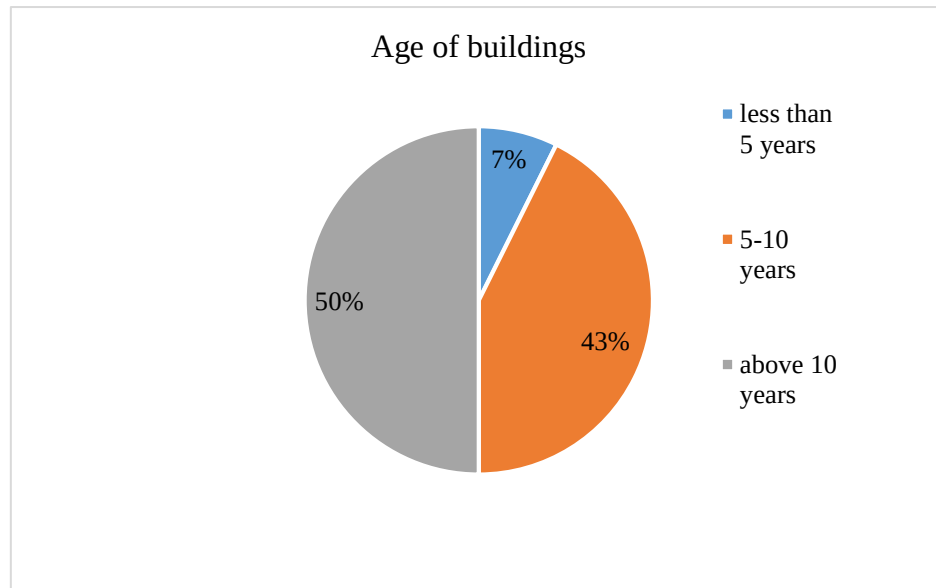


Fig 4. 2 Age of buildings

4.4 Analysis and Discussion of Defects occur in public buildings

4.4.1 Common Defects Occurred In Building

The objective of this study is to assess defect building maintenance management practices in public buildings to identify major defects in public buildings one of the specific objectives to study the severity of defects on buildings

From all the defects stated in the literature review and by using discussion I identified the top ten major defects that occur in the building. These defects are ranked according to their mean; a factor with the highest relative Importance index is ranked first.

Table 4. 3 Common defects of public buildings

No	type of defects	Mean	RII (%)	Rank
1	cracking	3.17	69%	1
2	Dampness	3.00	63%	2
3	peeling paint	2.70	56%	5
4	leakage of pipe	2.76	58%	4
5	Honeycomb	1.91	38%	9
6	defect in door and window	2.68	55%	6
7	deterioration of roof	2.46	54%	7
8	insect and termite attack	1.71	34%	10
9	defective plaster rendering	2.75	60%	3
10	unstable foundation	1.92	38%	8

4.4.1.1 Cracking

Cracking in public buildings is one of the major defects that occurred because Most of the building materials used within the buildings (concrete and mortar) are porous in their structure within the frame of inter-molecular space, and they expand on absorbing moisture from the atmosphere and shrinks on drying.

From the survey, data cracking is ranked at first which is identified with an RII value of 69% as the first factor or defects that occur in public. Cracks can happen due to different reasons chemical reactions in construction materials, foundation movements, and settling of buildings, changes in temperature and climate, natural stresses just like the nearby movement of trains, seismic tremors, etc. Defective and defective design, poor quality materials, inaccurate methods of construction, climate, and loads of wear and tear can make cracks.70% of respondents answered cracking has a high and medium degree of severity in the public buildings as shown in fig 4.2.

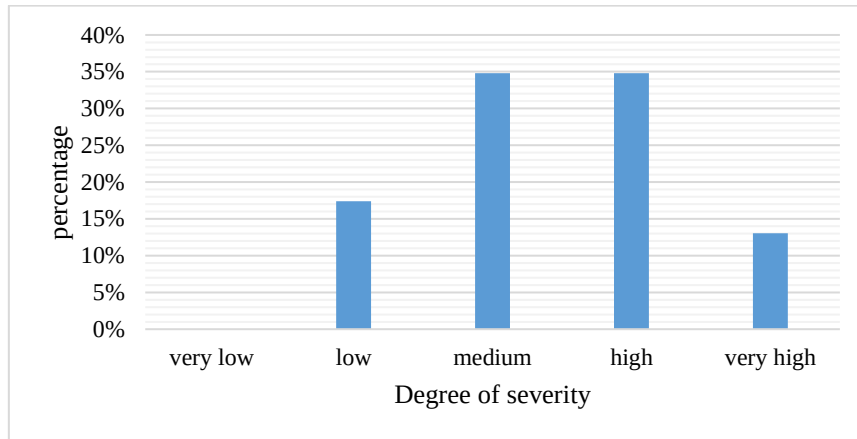


Fig 4. 3 Cracking in a public building

4.4.1.2 Dampness

The second-ranked defects in building from the survey data with an RII value of 63% the respondents agreed to the fact that dampness has been occurring frequently in most residential buildings. the dampness of the structure on the building occurs due to the Rise of moisture from the ground due to capillary activity, the action of water, Entrance of water from the top of the building, Condensation due to air moisture, Various sources or causes like poor drainage of a building site, the imperfect orientation of a building, defective construction and maintenance problems.

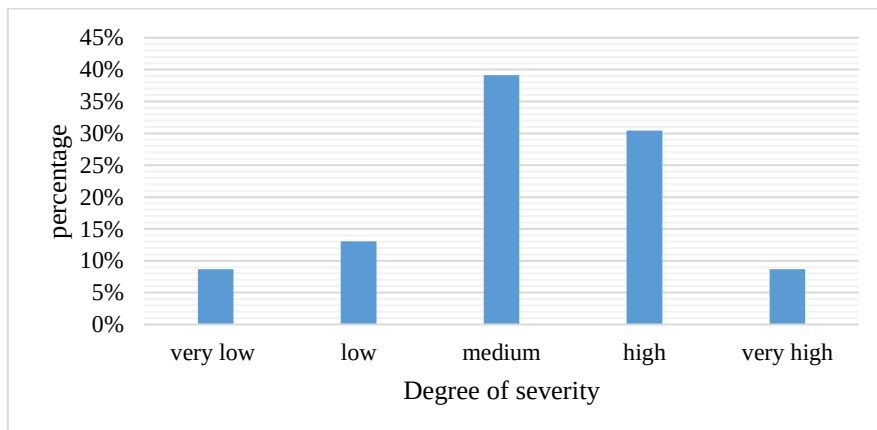


Fig 4. 4 Dampness of the buildings

4.4.1.3 Defective plaster rendering

The third-ranked defect in the building from the survey data with an RII value of 60% is defective plaster rendering on the structure on the building which occurs due to biological attacks arising from entering rain, vanishing, condensation, air contamination, lack of

hydration, and thermal stretch. The form or harmful growth, insect and traffic vibration moreover will contribution causes of inadequate mortar rendering.

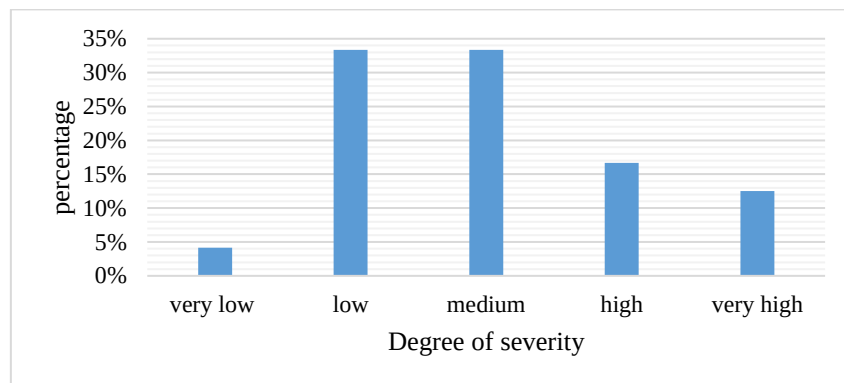


Fig 4. 5 Defective plaster rendering in buildings

4.4.1.4 Leakage of pipes

Leakage of pipe is one of the major defects that occur in most public buildings According to survey result which is analyzed from the respondent leakage of pipe ranked at fourth with the RII value of 58%. Leakage of pipe defects occurred because of poor workmanship and faulty material in construction are the main causes also the temperature and user activities have a significant effect on the pipe.

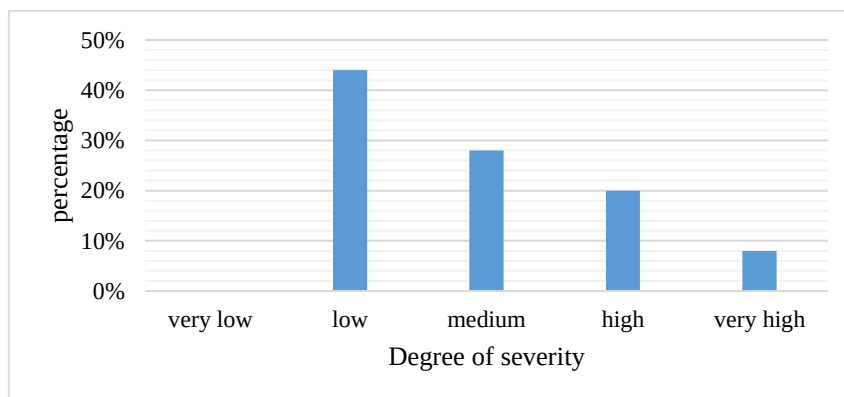


Fig 4. 6 Leakage of pipe in buildings

4.4.1.5 Peeling paint

The fifth type of defect from the survey with RII value of 56% is the peeling paint of the building structure. Peeling paint occurred causes of many factors such as water, high humidity, and excessive condensation, poor surface preparation, dirty surface, high temperatures, and intense sunlight, using a paint incompatible with the surface, many different coats on the same surface,

too many layers of paint, low-quality paint brands, using the wrong paint or primer, expired paint, corrosive substances.

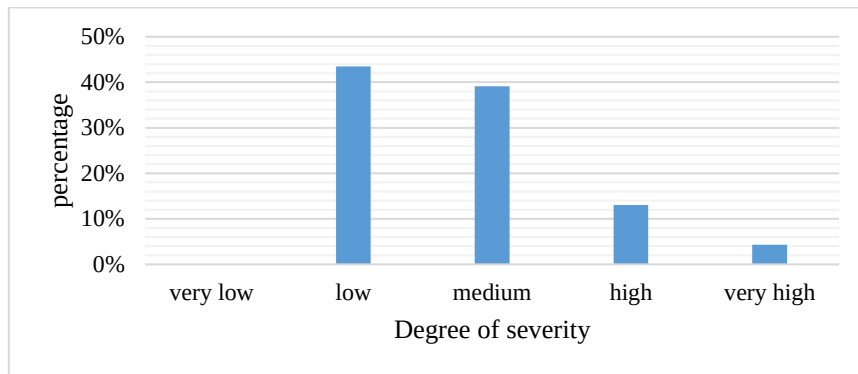


Fig 4. 7 Peeling painting in buildings

4.4.1.6 Defect indoor and window

In this study, the survey will usually find that the building's windows and doors are also one of the defects that occurred in these public buildings, and all suffer similar faults mostly brought on by lack of maintenance and ranked number six with RII value of 55%.

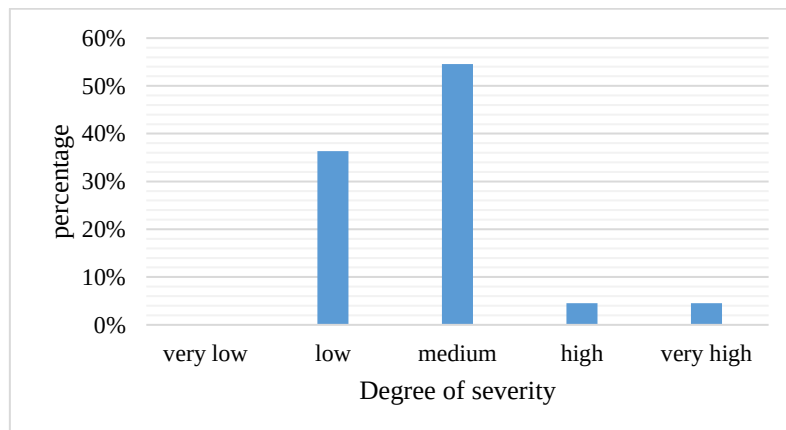


Fig 4. 8 Defective doors and window

4.4.1.7 Deterioration of roof

Most of the building roofs in the area are constructed by metal sheet cover and resting and defects of the roof structure are noticed due to poor workmanship and construction material defects. Deterioration of roof ranked number seven with RII value 54%.

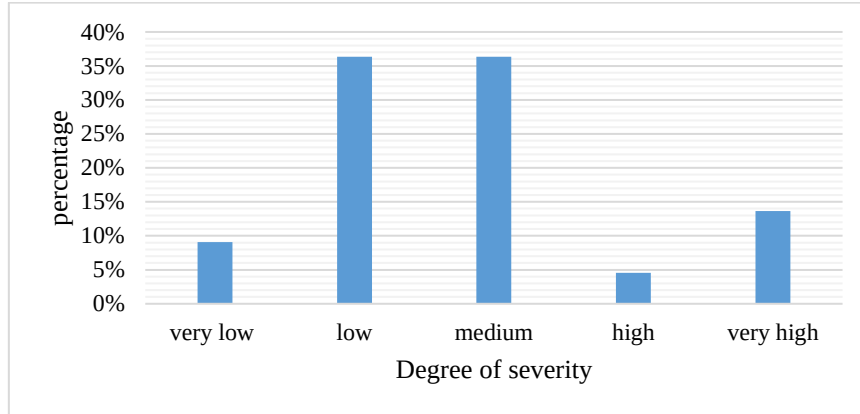


Fig 4. 9 Deterioration of roof structure

4.4.1.8 Unstable Foundation

The unstable foundation of the building also a major and severe defect in the building so the foundation of the building was designed by considering the site condition and environmental factors besides concerning the loads carried out to avoid the failures. Unstable foundation defect is ranked eighth with RII 38% Foundation movement, such as settlement is the problem often occurred to the building such as a public building.

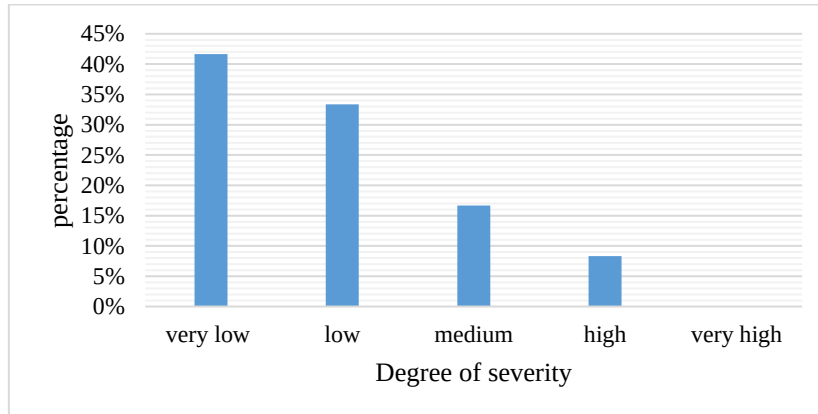


Fig 4. 10 Unstable foundation of buildings

4.4.1..9 Honeycomb

Honeycomb defects occurred in the building due to the non-reaching of concrete to all places due to which cavities and hollow pockets are created, main reasons are Improper vibration during the concrete, less cover to reinforcement bars, Use of very stiff concrete.it ranked number eight with RII value of 38%.

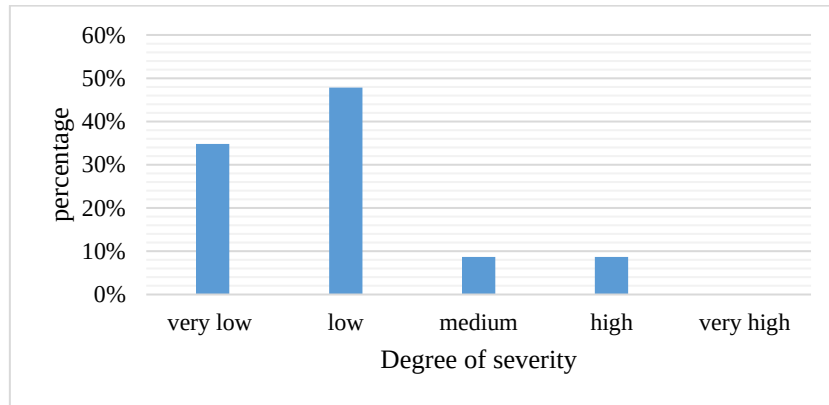


Fig 4. 11 Honeycomb defect in buildings

4.4.1.10 Insect and termite attack

Mostly insect and termite attack occurs on timber material and using defective material in the building affected by water penetration or dampness into the structure due to these factor termite affect the building. Insect and termite attack defect in this survey ranked at tenth defects with RII value 34%.

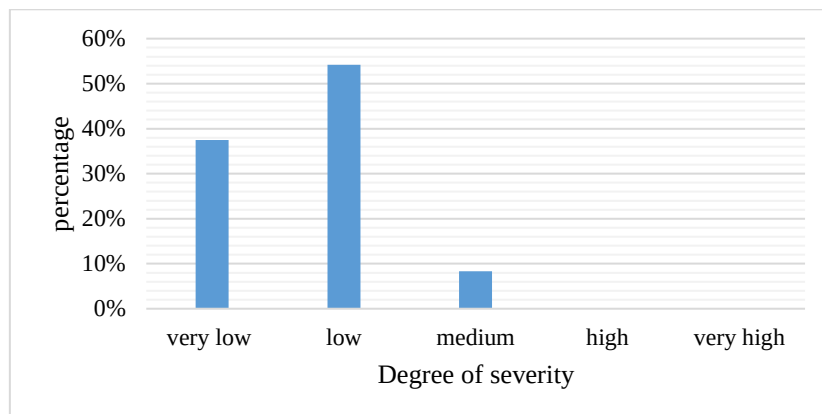


Fig 4. 12 Insect and termite attack in buildings

4.4.2 Major areas defect occurred in the building

Defects of building occurred in different areas of the structure and building system, it affects the building condition and decreases the technical, aesthetical, and functional value of the building.

Questions were asked about the major building areas mainly defect occurred and exposed to defect in building structure and building system which identified from literature review and knowledge-based and ten areas were identified and conducted the questionnaire survey these are: Internal surface, Exterior surface, mechanical system, electrical system, plumbing system,

wastewater, and drainage system, structural defect, Roof system, window and door, and foundation defect. From the obtained data as shown in figure 4.13, each factor was analyzed by the Relative importance index (RII).

These surveys were collected from the end building users of these three types of buildings in the study and analyzed individually.

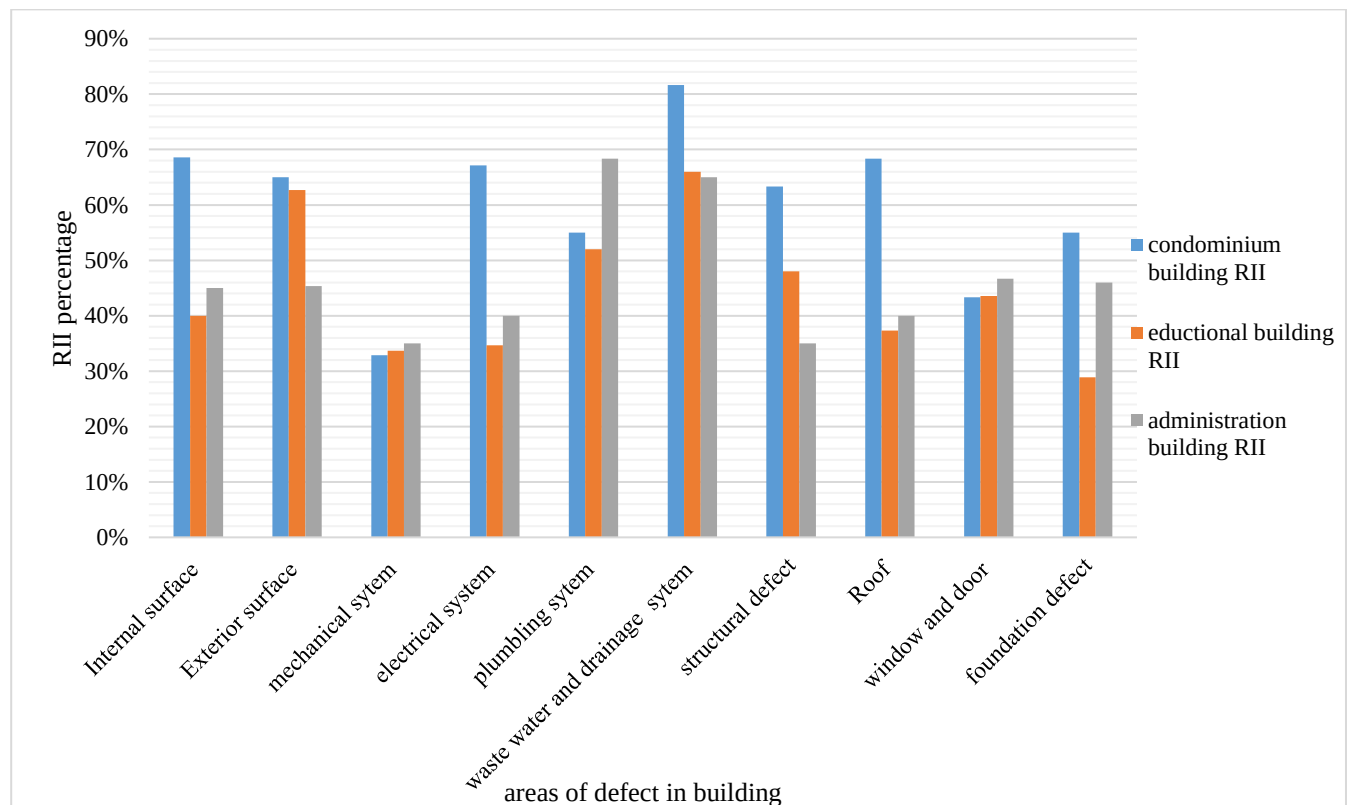


Fig 4. 13 Areas of defect occurred in public buildings

In the condominium Buildings, the major areas from the survey are wastewater and drainage system with a value of RII 82% many sewerage and drainage systems in the building are defected and lose their initial condition. the second internal surface area of the building is the main area which defects occurred with RII value of 69% from this most of the building surfaces are defected or deteriorated in the condominium buildings the other areas are roof system, external surface, structural defect, electrical system defect, plumbing fixtures defect, foundation defect, window and doors, and mechanical system defects with RII value 68%, 65%, 63%, 63%, 55%, 54%, 43%, 33% respectively. From this, we can summarize these occurred defects in public buildings need maintenance and building maintenance management plan.

4.5 Result and Discussion of Defects Maintenance Management Challenges of Public Building

In this study, the second specific objective is to identify the challenges of defects maintenance management of public building from the literature review and discussion ten challenges are identified to conducting the survey data in the questionnaires and each factor ranked with relative importance index (RII) method in Table 4.5.

Table 4.4 Challenges of defects maintenance management of public building

No	challenges of defect maintenance management	RII (%)	Rank
1	lack of Engineers and specialist	57.39%	4
2	lack of supervision	70.00%	2
3	human resources	54.67%	9
4	financial problems	56.52%	5
5	training and motivation	55.22%	8
6	government rule and regulation	55.65%	7
7	lack of awarness	56.52%	5
8	shortage of maintaiining material	50.87%	10
9	lack of maintenance plan	79.57%	1
10	high cost of building maintenance	64.78%	3

The most significant challenges or problems in building maintenance management from the survey analysis in table 4.5 majority of respondents remarked the following important factors that challenge to carry out building maintenance management. From these factors, lack of maintenance plan in these public buildings ranked 1st with RII value of 79.57%. From this lack of maintenance plan in public buildings is a major challenge the authorities and the occupants of the building haven't any maintenance plan so, the buildings exposed to different defects due to the lack of planned maintenance problems. Lack of supervision is ranked 2nd with RII value of 70 % this shows these public buildings are not supervised by the building authorities or any experts because of not giving attention to building maintenance. At the 3rd place, high cost of maintenance is ranked with RII 64.78 % especially at condominium public building most of the end building users and building representatives mentioned that to maintain the building it is a

major challenge that has the high cost of maintenance in these building and because of financial resource problem and lack of maintenance specialist or experts. Lack of Engineers and specialists, financial problems, lack of awareness, government rule and regulation, training and motivation, human resources, high cost of building maintenance these factors ranked 4th to 10th by their RII value respectively. Generally, these challenges of the building have a significant challenge on public building maintenance management.

4.6 Building maintenance practices

4.6.1 Types of maintenance

According to the Debre birhan Housing Development Project Office, maintenance, inside finishing of the houses, and any works after the provision of these condominium houses should be done by the beneficiaries. So, in the public buildings, the maintenance management works done by its users and there wasn't any maintenance strategy from the government side.

This study objective is to discover the defect building maintenance methods in these public buildings and the survey collected from contractors, consultants in the area the government bodies, and the end building users. From these surveys, as shown in fig 4.14 these five types of maintenance are listed and analyzed by their frequency percentage from the survey.

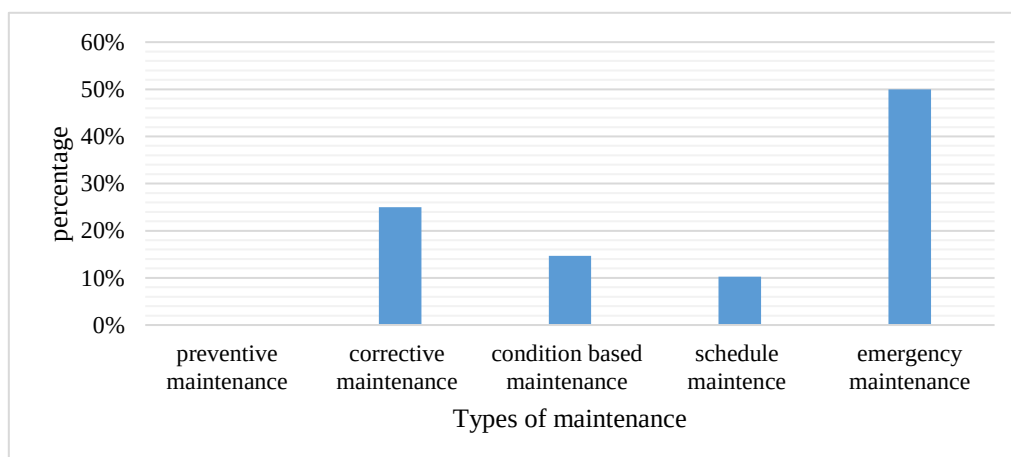


Fig 4. 14 Maintenance type or strategy of public buildings

From the survey in the area, 50% of the respondents answered the emergency type of building maintenance is mainly used. Emergency maintenance is performed as it said in the literature review when the building system or structure stop or fail it has to be maintained. This type of maintenance mostly applied to unexpected defects that occurred. Corrective maintenance is

ranked second with a 25% percentage of respondent's answers. This type of maintenance is a planned maintenance type and it uses to maintain defective structures or systems in the building.

Condition-based maintenance and scheduled maintenance also applied in these public buildings mostly for educational buildings and administration buildings. This type of maintenance ranked 3rd and 4th with percentages of 15% and 10% respectively. Condition-based maintenance is a good maintenance practice especially for these public buildings because of maintenance works done by the condition of the building. Scheduled maintenance is mainly applied in government administration buildings.

As discussed before for condominium public buildings there wasn't a maintenance strategy from the government side and hasn't structured building management systems from data in questionnaires' and interview these buildings maintained by individual users when it stopped service or not functional. The external problems were maintained by emergency work by collecting finance for maintenance work mostly, but the educational and administration buildings have their maintaining system when any defects occur in the building. Especially the educational buildings have their maintenance department for these purposes but they use the corrective and emergency method to maintain the buildings.

4.6.2 Condition of building

The condition of the building has a great impact on the performance of the building and also increases the life span of the building. From the defects that occurred in the building and the case study, we can analyze the building conditions. The survey was also conducted from the end building user to know how the building conditions were rated by the following table 4.5 in the questionnaire.

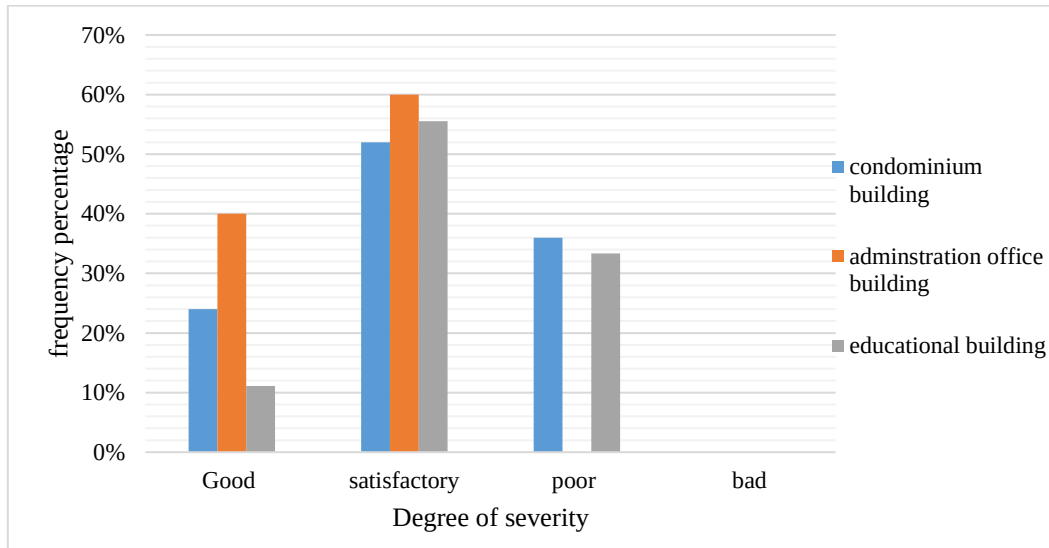


Fig 4. 15 Conditions of buildings

From the survey data, most of the respondents answered the condition of these buildings are satisfactory with frequency percentage 52%, 60%, 56% in Condominium buildings, Administration office buildings, and Educational buildings respectively. Therefore it is important to assess it for current defects or the susceptibility of future problems.

4.6.3 Building maintenance plan and conditional assessment practices

This section of the survey assesses do these public buildings have a maintenance plan and condition assessment practices of these buildings. The building maintenance plan does not only help to minimize budget and manage costs associated with facilities, it paints a clear picture of the condition, care, and considerations of a building's essential systems.

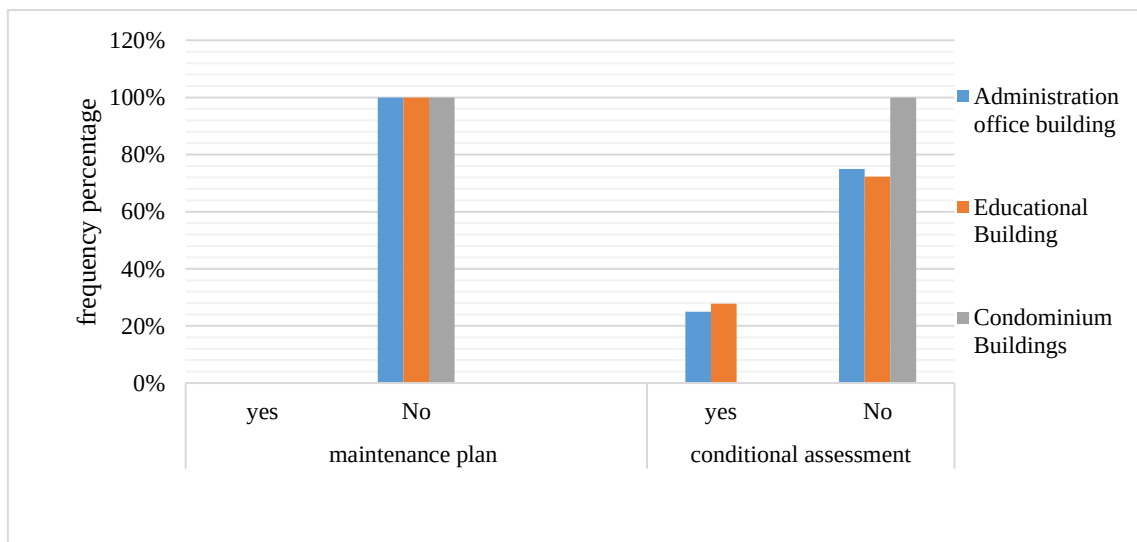


Fig 4. 16 Building maintenance plan and Condition assessment practices

From the above fig 4.16, the building maintenance and conditional assessment of these public buildings practices are very poor all the buildings have not any maintenance plan. All the respondents in the survey commented all these buildings need a maintenance plan for the type of defects and the condition building for a better economic, social and sustainable environment.

In most of the public buildings from the survey, there is no conditional assessment conducted especially in public condominium houses all respondents respond “No” for conditional assessment are carried out in the buildings. in the educational and administration building 25% and 28% respondents respectively answered conditional assessment were taken for the building but most respondents responded “No”, Generally the conditional assessment practices of all the building is very poor.

4.6.4 Defect detection method

Conditional assessment of building has great importance in performance and health of building by detecting these building defect and damage which occurred and may occur in the future life of the building. Mostly in public buildings, the facility management practices are poor and many of them didn’t have the plan or methods to know the building defect before it was damaged and it leads to high maintenance cost and other social consequences.

This section tries to discuss how these defects were detected in the public buildings and have the closed type questionnaires’ whether these defects were identified by supervision of building, after losing its initial condition or utilizing maintenance requisition.

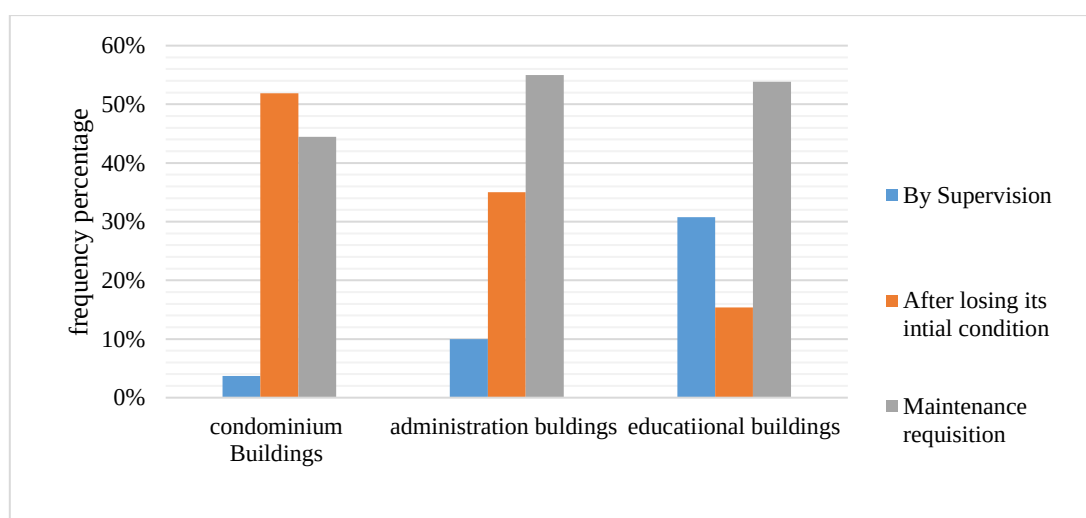


Fig 4. 17 Defect detection method in public buildings

From the respondent's answer in condominium buildings defect was identified after losing its initial condition with frequency percentage of 52%. From this, these condominium building's maintenance works are not preventive and planned and it costs highly to maintain. The second method applied in the condominium buildings with a 44% frequency percentage is maintenance requisition for correcting the defect before it defected or immediate action take for repair or fix. Supervision or inspection for building in condominium building ranked at last with 4% frequency percentage almost these building didn't use this method.

In administration office buildings these detections of building defect are ranked by maintenance requisition, after losing condition and supervision works with frequency percentage of 55%, 35%, 10% respectively. From this analysis, these administrative building defect detection methods are using maintenance requisition.

In educational building the maintenance management system have little difference with the condominium and administrative buildings because of the method they use is mostly the maintenance requisition and the supervision works in the building with the percentage of 54% and 31% respectively. These buildings are the only public building having a maintenance staff in their structures to the facility management purpose and this building maintenance.

4.7 Case study analysis

In order to conduct building defects the observational case study was carried out. Data collection will be presented by visual observation on the common building defects located at Debre birhan public buildings listed in table 3.6.

Table 4. 5 Case study on defects severity and their condition of the building

No.	Project Name	defect types	Defects occurred	degree of severity and maintenance required
1	Debre birhan condominium kebele 02	structural crack	Cracks that occurred on slabs, structural column, and beam the crack.	• it hasn't high severity for the building and it's easily maintainable • low defect severity
		Non-structural crack	Most of the cracks defect are non-structural in the building structures Narrow cracks measuring 1-2 mm wide(hair cracks) Cracks on plaster	• Due to the age of the building and condition these cracks not much severe. • Medium defect severity and needs condition-based maintenance
		Defective floor finish	The floor finishes mostly the outside of the living room which is the balcony or verandah are exposed to different kinds of defect cracks on the floor mostly hair crack and erosion of mortar from the floor and it creates potholes on many parts of the floor.	• Highly severe in the building • Needs emergency corrective maintenance
		Spalling of concrete on the structure	On some parts of the building part of the surface peels	• Medium severity on the wall of the building • Need corrective maintenance
		Defective plaster rendering	Occurred on walls finishing of plaster due to poor workmanship of the plastering work or defective material.	• Have medium severity of defect on the building • Needs corrective maintenance

		dampness of wall	In some parts of the building Dampness occurred such as on the wall and slab because of water pass through these structure	• High severity of defect and it affect the building mostly • Needs planned corrective maintenance to reduce the dampness in the wall
		peeling paint	Peeling paint occurred in each of the building parts	• Most of the paint peels by water and defective paint and user activity on wall • Medium severity of defect
		Electrical system breakdown	Installation problems damaged switch, socket, junction box, breakers and Nonfunctional & loose light point	• Most of the junction box, switch and sockets are broken also breakers are not protected • Have high installation problems • Due to the complexity of installation, it needs scheduled maintenance
		water seepage	Passing water through door and window frame and it causes to rusting of metal frame and affect the structure of the wall	• High defect and it affect the window and door frame because of water entering • Needs corrective maintenance to prevent the rainwater.
		fungi	Due to water leakage and fungi on the wall of the	• Because of the defective plaster rendering and paint water absorbed by the structure and caused to fungi on the structure • Medium severity on the building • Needs corrective maintenance

		rusting and defective stair	resting guard rail and crack occur in staircase of the building	• Medium severity of defect on the stair structure and needs the maintenance for metal guard rail
		window and door	Broken doors and window Poor building occurred frame finish	• Most of the doors and windows have broken glass and not working • Needs corrective maintenance
		roof ceiling defect	The ceiling experiences the most serious defect. The ceiling exposed to rainwater and it decayed.	• Very high problems in the roof ceiling It affects a lot and severe • Needs emergency corrective maintenance
		shower and toilet (plumbing)	Unfunctional and broken Plumbing fixtures in the building and broken ceramic of shower and toilet defected	• high defect in plumbing and some unfunctional fixtures • need corrective maintenance
		Defective wastewater drainage system	High problem with sewerage pipe and have no drainage to remove the waste and also it hasn't a manhole for the waste that comes from the building users so it causes for high smell and affects the environment and the building.	• Very high problems related to wastewater and drainage in the building • Emergency maintenance needed
		Defective damp proofing at the roof and broken gutter	Most of the roof part at the edge defected and the rain directly contact with the roof structure and the wall Many gutters are broken	• High severity of defect on the roof and gutter which affect the building • Need corrective and condition-based maintenance

No.	Project Name	defect types	Defects occurred	degree of severity and maintenance required
2	Debre birhan condominium kebele 09 ketena 2	structural crack	Cracks on slabs, and structural column and beam	- it hasn't high severity for the building and it's easily maintainable - low defect severity
		Non-structural crack	Most cracks defects are non-structural in the building structures.	- The Condition of these cracks not much severe. - Medium defect severity and needs condition based
		Defective floor finish	The floor finishes mostly the outside of the living room which is the balcony or verandah are exposed to different kinds of defect cracks on the floor mostly hair crack and erosion of mortar from the floor.	- medium severe in the building - Needs emergency corrective maintenance
		Spalling of concrete on the structure	On some parts of the building part of the surface peels	- the low defect on the wall of the building - Need corrective maintenance
		Defective plaster rendering	Occurred on walls finishing of plaster due to poor workmanship of the plastering work or defective construction material.	Low defect
		dampness of wall	In some parts of the building, Dampness occurred such as on the wall and slab because water passes through these structures	High dampness on the wall and some parts of the structural part

		peeling paint	Peeling paint occurred in each of the building part wall and structural part	• Medium defect occurred in the wall
		Electrical system breakdown	Installation problems damaged switch, socket, junction box, breakers, and Nonfunctional & loose light point	• Most of the junction boxes, switches, and sockets are broken also breakers are not protected
		water seepage	Passing water through door and window frame and causes to rusting of metal frame and affect the structure of the wall	• Medium effect water seepage in the building
		fungi	Due to water leakage and fungi on the wall of the building occurred	• Some fungi defect on the wall of the building
		rusting and defective stair	resting guard rail and crack occur in the staircase of the building	• Low defect in resting guard rail and have medium cracks on the landing of stair
		window and door	Broken doors and window	• Have low defect
		roof ceiling defect	Ceiling experiences the most serious defect. Ceiling exposed to rainwater and it decayed.	• High severity of the defect
		shower and toilet (plumbing)	Unfunctional and broken Plumbing fixtures in the building and broken ceramic of shower and toilet defected	• Medium defect on plumbing and fixtures
		Defective wastewater drainage system	problem with sewerage pipe and have no drainage to remove the waste and also it hasn't manhole for the waste that comes from the building users so it causes for high smell and affects the environment and the building.	• High severe defect in the building sewerage system
		Defective damp proofing at the roof and broken gutter	Most of the roof part at the edge defected and the rain directly contact with the roof structure and the wall Many gutters are broken	• High problems with the roof and most of the gutters are broken

No.	Project Name	defect types	Observed defect	degree of severity and maintenance required
3	Debre birhan university classroom	structural crack	Cracks on slabs, structural column, and beam	• Medium cracks and needs to be maintained
		Non-structural crack	Most cracks defect are non-structural in the building structures due to the age of the building and condition these cracks not much severe.	• High non-structural cracks in the building • Require routine maintenance
		Defective floor finish	The floor finish classroom which is exposed to different kind of defect cracks on floor crack and erosion of mortar from the floor.	• High defective floor finfish
		Spalling of concrete on the structure	On some parts of the building part of the surface peels	• Medium concrete spalling
		Defective plaster rendering	Occurred on walls finishing of plaster due to defective caused by plastering work or material.	• Medium defect plaster on the wall
		dampness of wall	In some parts of the building Dampness occurred such as on the wall and slab because water pass through the structure	• Very high dampness in some structural parts and the water penetrate through the wall
		peeling paint	Peeling paint occurred in each of the building parts	• Low defect of peeling paint

		Electrical system breakdown	Installation problems damaged switch, socket, junction box, breakers and Nonfunctional & loose light point	• High defect and installation problem due to design and workmanship errors
		water seepage	Passing water through door and window frame and it causes to resting of metal frame and affect the structure of the wall	• Low water seepage in the structure
		fungi	Due to water leakage and fungi on the wall of the building occurred	• Low defect
		rusting and defective stair	resting guard rail and crack occur in stair case of the building	• Highly rusting metal stair nearly to damage and medium crack on RC stair
		window and door	Broken doors and window	• Highly broken and defected doors and window
		roof ceiling defect	The ceiling experiences the most serious defect. Ceiling exposed to rainwater and it decayed.	• high defect on ceiling • need corrective action
		shower and toilet (plumbing)	Unfunctional and broken Plumbing fixtures in the building and broken ceramic of shower and toilet defected	• Needs immediate maintenance or • Emergency maintenance
		Defective wastewater drainage system	some problems with sewerage pipe and defected drainage system the manhole for the waste comes from the building are also not properly working	• Need corrective maintenance for the drainage system
		Defective damp proofing at the roof and broken gutter	Most of roof part at edge defected and the rain directly contact with the roof structure and the wall Many gutter are broken	• High defect of roof structure collapse and broken gutter

No.	Building types	defect types	Observed defect	degree of severity and maintenance required
4	Debre birhan university student dormitory	structural crack	Cracks on slabs and structural columns most of the crack types are hair crack and it hasn't high severity for the building and it's easily maintainable.	Medium crack defect in some structure of the blocks
		Non structural crack	Most of cracks defect are non-structural in the building structures due to the age the building and condition these cracks not much severe.	High non-structural crack
		Defective floor finish	Defected dormitory rooms in the building and the balcony are exposed to different kind of defect cracks on floor mostly hair crack and erosion of mortar from the floor and it creates pot hole on many parts of the floor.	High defect on the wall inside and outside of the door
		Spalling of concrete on the structure	On some parts of the building part of the surface peels	Medium Surface peels defects on the building
		Defective plaster rendering	Occurred on walls finishing of plaster due to defective caused by plastering work or material.	Medium plastering defect
		dampness of wall	In some parts of the building Dampness occurred such as on the wall and slab because of water pass through these structure	Medium defect
		peeling paint	Peeling paint occurred in each of the building part	Low defect of peeling paint

		Electrical system breakdown	Installation problems damaged switch, socket, junction box, breakers and Nonfunctional & loose light point	• A medium defect on the installation and broken switch fluorescent lamp socket and breakers. • Needs corrective and routine maintenance
		water seepage	Passing water through door and window frame and causes to rusting of metal frame and affect the structure of the wall	• Medium severity defect
		fungi	Due to water leakage and fungi on the wall of the building occurred	•
		rusting and defective stair	rusting guard rail and crack occur in the staircase of the building	• Low defect of rusting and crack
		window and door	Broken doors and window	• Medium severity
		roof ceiling defect	The ceiling experiences the most serious defect. The ceiling exposed to rainwater and it decayed.	• Low defect of ceiling
		shower and toilet (plumbing)	Unfunctional and broken Plumbing fixtures in the building and broken ceramic of shower and toilet defected	• Very high defect most of shower and toilets are not functional
		Defective wastewater drainage system	Has problem with sewerage pipe and drainage system to remove the waste and also manhole are so it causes for high smell and affects the environment and the building.	• Medium defect of wastewater and drainage problem in the building needs conditional maintenance
		Defective damp proofing at the roof and broken gutter	Most of the roof part at the edge defected and the rain directly contact with the roof structure and the wall Many gutters are broken	• Low severity defect of damp proofing and highly broken gutter on the building

No.	Project Name	defect types	observed defect	degree of severity and maintenance required
5	Debre birhan Administration office	structural crack	Cracks on slabs and structural column most of the crack types are hair crack and it hasn't high severity for the building and it's easily maintainable.	• Very low cracks on structure • No need of maintenance
		Non-structural crack	Most of the cracks defect are non-structural in the building structures due to the age the building and condition these cracks not much severe.	• Very Low non-structural cracks
		Defective floor finish	balcony or verandah are exposed to different kinds of defect cracks on the floor mostly hair crack	• Low floor finish defect
		Spalling of concrete on the structure	On some parts of the building part of the surface peels	• Low spalling on the wall of the building
		Defective plaster rendering	Occurred on walls finishing of plaster due to defective caused by plastering work or material.	• Low defective plaster rendering work
		dampness of wall	In some parts of the building, Dampness occurred such as on the wall and slab because of water pass through these structure	• Low dampness occurred in the building
		peeling paint	Peeling paint occurred in each of the building part	• Low defect peeling paint

		Electrical system breakdown	Installation problems damaged switch, socket, junction box, breakers and Nonfunctional & loose light point	• Medium defects on installation and system break down • Needs condition-based maintenance
		water seepage	Passing water through door and window frame and it causes to rusting of metal frame and affects the structure of the wall	• Low Water seepage through window and door
		fungi	Due to water leakage and fungi on the wall of the building occurred	• Low defect
		rusting and defective stair	resting guard rail and crack occur in the staircase of the building	• Low defect
		window and door	Broken doors and window	• Medium defect occurred on doors such as broken glass and
		roof ceiling defect	Almost have no defects in the ceiling	• Low defect
		shower and toilet (plumbing)	Not Functional and broken Plumbing fixtures in the building and broken ceramic of shower and toilet defected	• Low defect
		Defective wastewater drainage system	problem with sewerage pipe	• low defect on drainage system due to design problems
		Defective damp proofing at the roof and broken gutter	some of roof part at the edge defected and the rain directly contact with the roof structure and the wall Many gutter are broken	• low defect on damp proofing and some of the gutters are broken and not fully functional

Table 4. 6 Summary of case study

defect types	degree of severity and maintenance required					RII (Relative importance index) (%)	Rank
	1	2	3	4	5		
structural crack		1		3	1	76.00%	7
Non-structural crack			1	3	1	80.00%	3
Defective floor finish		1		2	2	80.00%	3
Spalling of concrete on the structure			1	3	1	80.00%	3
Defective plaster rendering			3	1	1	72.00%	8
dampness of wall		1		2	2	80.00%	3
peeling paint		1	1	3		68.00%	11
Electrical system breakdown		1		4		72.00%	8
water seepage	1		1	2	1	68.00%	11
fungi		1	2	2		64.00%	15
rusting and defective stair		1	2	1	1	68.00%	11
window and door		1	1	3		68.00%	11
roof and ceiling defect		1		1	3	84.00%	2
shower and toilet (plumbing)		1	1	2	1	72.00%	8
Defective wastewater drainage system			1	1	3	88.00%	1

Based on the data gathered from the case study of these buildings defective sanitary and drainage system is a major defect because of sanitary pipelines lot of water is leaking and it causes the dampness of the floor to decrease the dampness at the time of construction we should go for fix material and fixing the joints of sanitary pipes must be well checked. Dampness poses serious risks to the execution of the building. If buildings affected by moistness are not treated such buildings will deteriorate with time and pose serious health risks to occupants.

**Fig 4. 18** Sewerage and Roof ceiling defects on building

As shown in the summary Table 4.8 the listed building defects Relative importance index (RII) indicates these have high severity of defects so the buildings are not safe and loses their initial condition or performances.

As a comparison of these buildings the educational and administration public buildings have low defects compared than condominium buildings because of the maintenance action taken in the building, ages and the usage of buildings mostly not exposed to defect like condominium buildings. Misuses of buildings and users activities in the condominium buildings affect the performance and condition of the buildings.

From the summary of the case study, most of the public buildings were exposed to defects which decreases the lifespan of each building. The most frequent and serious defects were Defective wastewater drainage system, roof and ceiling defect, dampness of wall, spalling, defective floor finish, and cracks respectively as shown in Table 4.8.

4.8 Framework for defect building maintenance management for public buildings

In order to identify the best public building maintenance practices, a literature review was conducted to identify the public building maintenance in the study area and these factors should be considered to achieve the best building maintenance management as shown in fig 4.19.

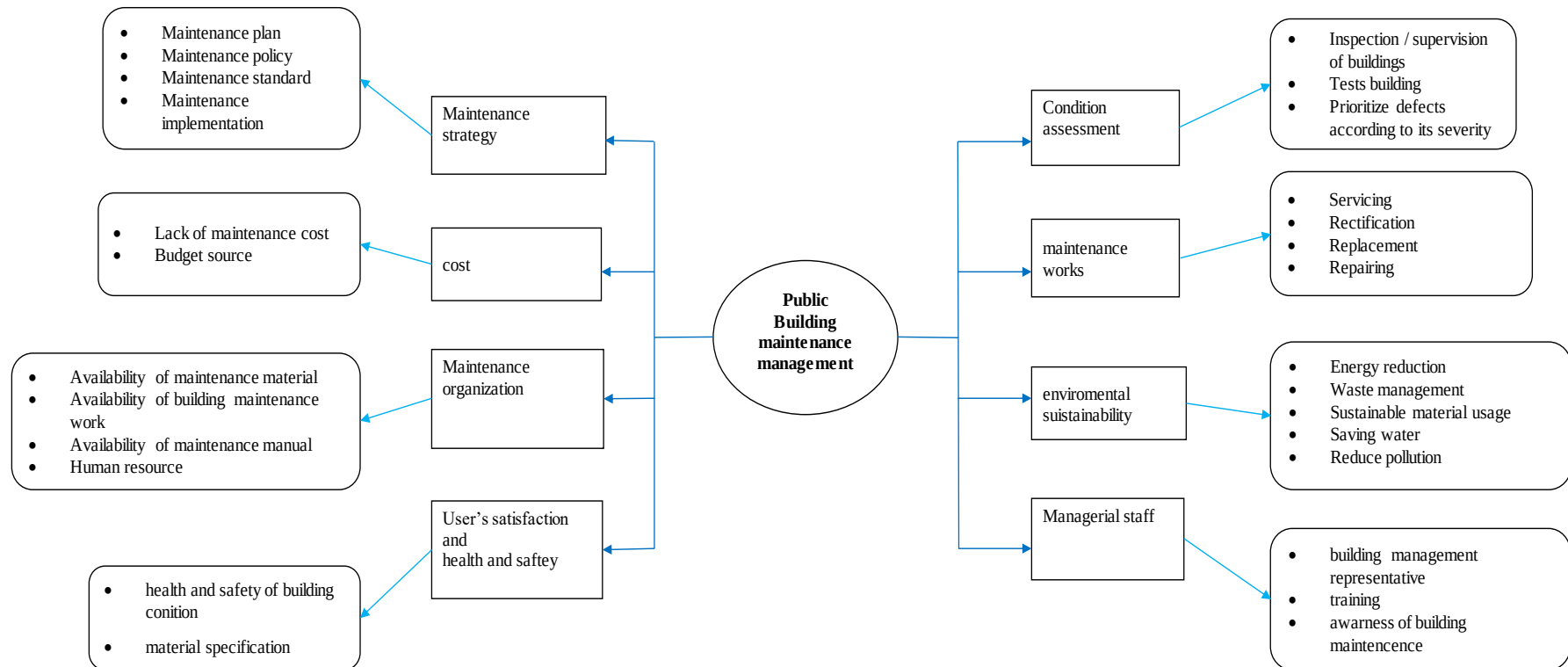


Fig 4. 19 Conceptual Public building maintenance management framework

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, the following major conclusion was drawn based on findings in line with each particular objective. The primary point of the study was to assess the common type of building defect. By investigating literature and research done on building defects and case studies, the degree of building defects was assessed.

- Most public buildings are exposed to defects from the finding of this study the major defects of building occurred in the public buildings was cracking and dampness. From the case study and questionnaires dampness of the building are a major serious defect that leads to the building different crack types and other common defects. This occurred due to the defects of such roof and other finishing works are not properly functional, and it exposed the building structure to water. The waste sewerage system of public buildings was highly defective and not properly functional for the building users or occupants the material and the workmanship of this system is the main cause due to this it affects the building user's health and environmental pollution.
- The challenge in building maintenance management practices assessed from the study the main challenges are: Lack of maintenance plan, Lack of supervision, and high cost of maintenance of buildings are the major factors or challenges that affect the practices of building maintenance management. Unavailability of maintenance plan and strategy for the buildings reduce the lifespan of the building. From the survey, the supervision works aren't worked in the building from the government side especially for the public condominium building houses, and also have not the maintenance strategy for the future. The high cost of maintenance works because of not having a maintenance management plan and strategy for the buildings.
- Building maintenance in public buildings mainly experienced the lack of maintenance management policy and strategy by authorities and occupants of these facilities often leads to reduced lifespan of these buildings. The current building maintenance practices in the public building are poor from the finding of the study the most practiced type of building maintenance type is an emergency and corrective maintenance so buildings maintained after losing the initial condition or after deteriorated of the structures. However, educational and administration office buildings practice condition-based and

schedule maintenance types also. Conditional assessment of the building's practice is poor and all the public buildings haven't a maintenance plan for the occurring defect in the building. Generally, in a public building, the facility management and building management haven't given attention and its practices are poor that leads to social, environmental, and economic impacts in the country.

Finally, for the summary of conclusion of this study the defect building maintenance management practices in public buildings are very poor especially for condominium buildings serious lack of defects maintenance and haven't any building management systems. Also, the condition of most buildings in the study area is exposed to different major defects that decrease the life span of the building. The challenges discussed in the study can be minimized by an effective maintenance management strategy developed by the governments and building occupants with the help of construction organizations.

5.2 Recommendations

Based on the finding of the research the following recommendations are

- The proper supervision needs to be implemented to ensure that the maintenance work is performed under the work order conditions and based on standard maintenance procedures.
- It is recommended that a building maintenance manual provided by the higher institution to the maintenance departments and the users of the building facilities.
- Create Awareness of both users and top management on maintenance culture. Especially for public condominium houses, the government should give attention to these building conditions.
- It is better taking a yearly building condition survey carried out on all public buildings.
- Make provision for training personnel in emergency procedures for the failure in the building.
- The government needs the facility management department for these public buildings for regular supervising and assessing the condition of the building so, it is better to have a facility management department for these building management.
- All public and governmental institutions should give attention to building maintenance management and facility management.
- For Condominium building houses needs plan and activities for Source of finance for building maintenance by a different method such as regular monthly or annually

collected from occupants and by using the area around the buildings build small shops or any other for renting purpose so, it helps to the maintenance of the building.

- Government should construct the public buildings with the plan of future social, economic, and environmental impacts.
- An effective maintenance management team should be implemented to control overall maintenance issues during the design, initial stage of construction, and after the provision or functional years of the buildings.

5.3 Recommendation for further research works

This study mainly focused on the study of major defects of buildings and it assessed practices of defect maintenance management in public buildings.

- Hence, future studies on defects building maintenance management could be done constantly with different measures for different public or private to determine the trends that represent the practices in our countries.
- It recommend for others researchers do their study on developing the building maintenance management practice model by prioritizing the severity or impact of each defect on the buildings.
- Also, comprehensive studies of defect building maintenance management in other public and private buildings may result in remarkable findings to a better building and facility management to increase the performance and condition of these buildings.

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APPENDIXS

Appendix I: pictures



Fig 1. Roof and ceiling defects



Fig 2. Defective plaster rendering on buildings



Fig 3. Electrical installation defects occur on buildings



Fig 4. Plumbing and drainage defects



Fig 5. Fungi caused bay excessive dampness



Fig 6. Peeling paint on wall



Fig 7. Leakage of water



Fig 8. dampness on the wall



Fig 9. Cracking on buildings

Appendix II: Debre birhan university maintenance request from

በደ/በርሃን ዩኒቨርሲቲ ግቢ አገ/ያ/ስ/ሂደት የተለያዩ የጥገና ኪነ ምች መጠየቂያ -46

402

በጠቅላላ ጥገና አገልግሎት ገቡሉ የሥራ ሂደት

ክፍል 1፡ በእገልግሎት ጠያቂው የሚገኝ

1.1.የአገልግሎት ጠያቂው፡- የሥራ ብድር

QC 475

0:00

५११३३

-2500

1. 10

1.2 የተጠቀሱት የጥገና ዓይነቶች፡

1.3. 2006-07-09 09:00:00 0379 4:11

ከፍለ 2-ሰዓት ስር ይቀጥል፡

21. A7A5A-4.7 A7B.01 E+208.00m 00.00.00 0.00

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Page 214 243 6007

2. 012 40 970 63257 17-01-1970 1.2 7C7C 20/78

7	92500-5050	mail	date	5345
6				
5				
4				
3				
2				
1				
0				
9				
8				
7				

23. 1652 240-654 473 ----- 1612 260 0134

24 እኔ ----- ከባቢ የተዘረዘሩትን የጥገና ስራዎች እና ስራዎች በአዲስ ተራራር የሚከናወኑትን ስራዎች ለተረጋገጠ ተረጋግጦታቸው፡፡

ክፍል 3፡ ሥራው ሲተገበር የሚፈጸሙ የሥራ ስልጣኖች፡

37. በሐገረግላት ተሰጥጦ ሳይ ያስወጥጥ አስተያየት በእጭሩ ይገለጻል።

2000 000000 3227000 7460000

የጥያቄው ይገኛል፡፡

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ns^c

6.1.7-

A.C. =

4.9

43

ማሳሰቢያ፡-1. የተቀረሩ አሮጌ እቃዎች ተመልስጦቸዋል፡፡ ንብረት ኮፍላል፡፡ ለምሳሌ፡፡ 10 ገቢ ከገደባችኋል፡፡

2. ይህ ቅጽ በ2 ኮፒ እየተሰራ ፣ ኮፒ ሰጠቀሰሳ ጥገና በራ ዘርፍ እየሰራ ሲሆን ሌላው በሌላ ርዕሰ

አገ/ደ/ባ/ሂደት ያላቀጠ ::

Appendix III: Questionnaire survey



Adama Science and Technology University
School Of Civil Engineering and Architecture
Construction Engineering and Management
Questionnaire for Thesis

Title: Assessment of Defects Maintenance Management Practices of Public Buildings
in north Shoa zone Debre birhan.

This research survey is designed to fulfill an academic requirement for MSc program in Construction Engineering and Management at the Adama science and technology university. Those who involve in the construction participants of public building projects and users of the building in debre birhan are kindly requested to contribute to this research work.

This study intends to assess the building defects and maintenance management practices debre birhan public buildings.

The result of this survey is intended to serve only for academic purpose and will be treated with strict confidentiality. The name of institutions participated will be recorded confidentially and you will not be individually identified and your responses will be used for Statistical. Purposes only. Thank you in advance for your willingness to fill the questionnaires and returning them back on time. Your open response is highly appreciated.

Prepared by: Henok Bayou

 0926174782

Advisor - Bahiru Bewuket (PhD)

Signature

➤ **Questionnaires to the construction participants**

Please kindly respond to the following questions by ticking (✓) the appropriate box or writing your answer in the space provided.

1. Name of company (Optional) _____

2. Educational Background

☐ Master's degree or above

☐ College Diploma

☐ Bachelor's Degree

☐ High school Completed

☐ Other (Please specify _____)

3. Category and class of company _____

4. How long has the organization been operating?

☐ Less than 5 years

☐ 5 to 10 years

☐ 10 years and above

5. Major defects in public building

Degree of severity

1-very slight 2-minor 3-medium 4-high 5-very high

type of defects	degree of severity				
	1	2	3	4	5
cracking					
Dampness					
peeling paint					
leakage of pipe					
Honeycomb					
defect in door and window					
deterioration of roof					
insect and termite attack					
defective plaster rendering					
unstable foundation					

6. Challenges of defect maintenance management

Degree of importance

1-very low 2-low 3-medium 4-high 5-very high

No	challenges of defect maintenance management	degree of importance				
		1	2	3	4	5
1	lack of Engineers and specialist					
2	lack of supervision					
3	human resources					
4	financial problems					
5	training and motivation					
6	government rule and regulation					
7	lack of awarness					
8	shortage of maintaiining material					
9	lack of maintenance plan					
10	high cost of building maintenance					

6. What Types of maintenance work have been carried out in the public building

- ☐ Preventive maintenance
- ☐ Corrective maintenance
- ☐ Condition based maintenance
- ☐ Schedule based maintenance
- ☐ Emergency maintenance

7. Do you carry out building condition survey on the public buildings?

- ☐ Yes ☐ No

8. How Defects are detected on buildings

- ☐ By supervision works
- ☐ After losing its initial function
- ☐ Maintenance Requisition

9. How the maintenance works done in the public building?

.....

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.....

10. What do you suggest or recommend for these building defect and maintenance management problems?

.....

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.....

መጠይቅ ለሕንፃዎች ተጠቃሚ

➤ እባክዎን ለሚከተሉት ጥያቄዎች ተገቢውን ሳጥን (✓) ላይ ምልክት በማድረግ ወይም መልስዎን በተጠቀሰው ቦታ ላይ በመፃፍ በደግነት ይመልሱ ::

1. የትምህርት ደረጃ

- | | |
|--|---|
| ☐ ማስተርስ ዲግሪ ወይም ከዚያ በላይ | ☐ የኮሌጅ ዲፕሎማ |
| ☐ የባችለር ድግሪ | ☐ ሁለተኛ ደረጃ ትምህርት ቤት ተጠናቅቋል |
| ☐ ሌላ (እባክዎን ይግለጹ) | |

2. የህንፃው ዓይነት

- | | | | |
|---|--|---------------------------------------|------------------------------|
| ☐ የህዝብ የጋራ መኖሪያ ቤት | ☐ አስተዳደር ጽ / ቤት | ☐ የትምህርት ሕንፃዎች | ☐ ሌሎች |
|---|--|---------------------------------------|------------------------------|

3. የህንፃው ዕድሜ

- | | | |
|--------------------------------------|---|--|
| ☐ ከ 5 ዓመት በታች | ☐ ከ 5 እስከ 10 ዓመት | ☐ ከ 10 ዓመት እና ከዚያ በላይ |
|--------------------------------------|---|--|

4. በሕንፃዎች ግንባታ ውስጥ ያሉ ዋና ዋና ጉድለቶች

1- በጣም ትንሽ 2-ጥቃቅን 3-መካከለኛ 4-ከፍተኛ 5- በጣም ከፍተኛ

ተ.ቁጥር	ጉድለቶች ዓይነት	የስምምነት ደረጃ				
		1	2	3	4	5
1	የውስጥ ገጽታ					
2	የውጭ ገጽታ					
3	ሜካኒካዊ ስርዓት ችግር					
4	የኤሌክትሪክ ዝርጋታ ችግር					
5	የዉሃ ዝርጋታ ችግር					
6	የፍሳሽ ማስወገጃ ችግር					
7	የመዋቅር ጉድለት (ቐሚ ፣ አግዳሚ ፣ ግድግዳ ፣ ደረጃ)					
8	ጣሪያ ጉድለት					
9	በሮች እና መስኮቶች					
10	የመሠረት ችግሮች (foundation)					

5. የጥገና አያያዝ ፈታኝ ሁኔታ ወይም ችግሮች

አስፈላጊነት ደረጃ

1-በጣም ትንሽ 2-አናሳ 3-መካከለኛ 4-ከፍተኛ 5-በጣም ከፍተኛ

No	ጉድለት ጥገና አያያዝ ችግሮች	አስፈላጊነት				
		1	2	3	4	5
1	የኢንጂነሮች እና የልዩ ባለሙያ እጥረት					
2	ቁጥጥር አለመኖር					
3	የሰው ሀይል አስተዳደር					
4	የገንዘብ ችግሮች					
5	ስልጠና እና ተሳታፊነት					
6	የመንግስት ደንብ እና ደንብ					
7	የንቃት እጥረት					
8	የማቆያ ቁሳቁስ እጥረት					
9	የጥገና እቅድ እጥረት					
10	የህንፃ ጥገና ከፍተኛ ዋጋ					

6. በሕዝባዊ ሕንፃ ውስጥ ምን ዓይነት የጥገና ሥራዎች ተካሂደዋል

- ☐ የመከላከያ ጥገና
- ☐ የማረሚያ ጥገና
- ☐ ሁኔታ ላይ የተመሠረተ ጥገና
- ☐ መርሃግብር መሠረት ያደረገ ጥገና
- ☐ የድንገተኛ ጊዜ ጥገና

6. በህንፃ ሁኔታ ምን ያህል ረከተዋል?

	ጥሩ	እንደታሰበው ማከናወን እና በብቃት መሥራት ፣ ምንም ጉልህ የሚታዩ ጉድለቶች እና የጥገና ታሪክ የላቸውም ።
	አጥጋቢ	እንደታሰበው ማከናወን ግን አነስተኛ ጥገና ያስፈልጋል ።
	ደካማ	ዋና ዋና ጉድለቶችን ያሳያል። የኤለመንቱን ጉልህ ክፍሎች መተካት የሚያስፈልገው ሰፊ መበላሸት ። ያለ መደበኛ ጥገና በትክክል ማከናወን አለመቻል።
	መጥፎ	ሕይወት አብቅቷል ፣ ከባድ አደጋ ። በጥገና ሊወገዱ የማይችሉ ጉድለቶች አሉት

7. ህንፃው ለጥገና እንቅስቃሴ እቅድ አለው?

- ☐ አዎ ☐ አይ

8. በህንፃው ውስጥ ያሉት የህንፃ ሁኔታዎች ከዓመት ወደ ዓመት ተቀባይነት ባላቸው ደረጃዎች ተሻሽለዋል?

- ☐ አዎ ☐ አይ

9. በሕንፃዎች ላይ እንዴት ጉድለቶች ተገኝተዋል?

- ☐ በክትትል ሥራዎች
- ☐ ከተበላሸ እና ተግባር ካቆመ በኋላ
- ☐ የጥገና ጥያቄ

10. በእነዚህ ህንፃዎች ውስጥ የተከናወነውን ጉድለት በተመለከተ ሁኔታዊ የሆነ ግምገማ አካሂዷል?

☐

አዎ

☐

አይ

አዎ ከሆነ እባክዎን ስንት ጊዜ እና እንዴት ይጥቀሱ?

.....

11. ለጥገና ሥራዎች ተጠያቂው ማነው?

.....