ASSESSMENT OF BUILDINGS MAINTENANCE MANAGEMENT PRACTICES:

(A CASE OF SELECTED TOWNS IN SOUTHERN NATIONS, NATIONALITIES, AND PEOPLE'S REGIONAL STATE)

MSc THESIS

YACOB BADENGA MINUTA

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

JUNE, 2019

ASSESSMENT OF BUILDINGS MAINTENANCE MANAGEMENT PRACTICES:

(A CASE OF SELECTED TOWNS IN SOUTHERN NATION NATIONALITIES AND PEOPLE'S REGIONAL STATE)

YACOB BADENGA

A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING

HAWASSA INSTITUTE OF TECHNOLOGY,

SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY

HAWASSA, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTERS OF SCIENCE IN CIVIL ENGINEERING

(CONSTRUCTION TECHNOLOGY AND MANAGEMENT)

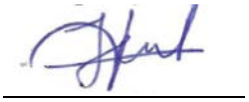
JUNE, 2019

SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY

ADVISOR'S APPROVAL SHEET

This is to certify that the thesis entitled "**Assessment of Buildings Maintenance Management Practices:** A Case of Selected Towns in Southern Nations, Nationalities, and People's Regional State" submitted in partial fulfillment of the requirements for the degree of Masters of Science with specialization in construction technology and management, the Graduate Program of the School of Civil Engineering, and has been carried out by **Yacob Badenga**, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence, hereby can submit the thesis to the school.

Denamo Addissie (Dr.)		May 17,2019
Advisor	**Signature**	**Date**
Abebaw Worku	_____	_____
Co-advisor	**Signature**	**Date**

DECLARATION

I declare that, this thesis is prepared for the partial fulfillment of the requirements for Msc. Degree in Construction Technology and Management entitled "**Assessment of Buildings Maintenance Management Practices:** The Case of Selected Towns in Southern Nations Nationalities and Peoples Regional State". This paper is my original work with own effort except for secondary sources which have been acknowledged, as listed in the bibliography.

Yacob Badenga

Signature: _____

Date: _____

Hawassa University

Hawassa

Ethiopia

ACKNOWLEDGMENTS

First of all I would like to thank the Almighty Allah, Who gave me the commitment and tolerance to pass various obstacles and come up to the accomplishment of this thesis. I would like to express my gratitude to all those who gave me the possibility to complete this thesis. I wish to express my deepest appreciation to my advisor Dr. Denamo Addissie for his expert guidance, timely response, encouragement and invaluable suggestion provided me throughout the thesis work. I am also grateful for my co-advisor Abebaw Worku for his invaluable comments and guidance throughout the thesis work.

I would like to thank the Ethiopian Roads Authority who gave me the chance to enhance my knowledge and education to MSc level and funding for successful accomplishment of my study.

I would also like to thank staffs of the Department of Civil Engineering, Faculty of Civil Engineering and Built Environment, Hawassa Institute of Technology for their professional support to enable me complete the academic program.

Last but not list, my gratefulness is due to all member of my family, friends, colleagues and all for their whole hearted cooperation, inspiration and encouragement without which, it would be impossible to complete this work.

Yacob Badenga

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BIM	Building Information Modeling
BoQ	Bill of Quantity
CMMS	Computerized Maintenance Management System
CSA	Central Statistical Agency
E.C	Ethiopian Calendar
F.F	Floor Finish
GDP	Gross Domestic Product
ICT	Information and Communication Technology
JBCC	Joint Building Contract Committee
HMSO	Her Majesty's Stationary Office
MS	Mean Score
NST	New Street Times
PMI	Project Management of Institute
PPM	Planned Preventive Maintenance
PVC	Polyvinyl Chloride
SNNPRS	South Nation Nationalities and People's Regional State
SS-EN	Swedish Standard English Narration of maintenance strategy
UK	United Kingdom
U.S	United States

ABSTRACT

Building defect is a failing or shortcoming in the function, performance, statutory or user requirements of a fabric, facilities in a building. Maintenance is an important program for the sustainability of buildings under occupancy. (The present buildings) Observed buildings in this study in SNNPRS were manifesting deterioration that should have been maintained long ago. In the region, defects in public buildings appeared and their impacts had been of high maintenance costs. Material and construction deficiency observed as the main causes of building defect under occupancy stage of buildings (Bedru M. , 2015). This research assessed the defects and maintenance management practices in the occupancy stage of public buildings in selected towns of SNNPRS. At the end, effects of defects and defect reducing measures were investigated. Interview survey, case study and desk study were used and analyzed by SPSS for research work. Thirteen buildings were considered during the interview, case studies and desk study. Building administrators, facility managers and other concerned body were considered in the selected buildings in the region for the interview questions. From the result, the main types of defects were identified; economic, functional and social consequences of defects were investigated; the practices of maintenance management in public buildings were assessed and defect reducing measures were finally recommended for buildings. The frequent types of defects identified in the study were; dampness; peeling of paint; leakage and defects in building service installation. Similarly the average results showed that the most common causes of building defect were construction and material deficiency with corresponding shares of **41.95 %** and **37.55 %** of the defects respectively. High amount of maintenance cost was consumed in a building in the desk study analysis in one time maintenance for a building defect. This implies there was no preventive mechanisms set for buildings. Before beginning of the actual maintenance work, maintenance directory (report) should be prepared for all defective items in team in order to know the severity of defects which enables to prepare maintenance BoQ for execution. Periodic maintenance shall be recommended for public buildings under occupancy.

KEY WORDS: Defect, Maintenance, Occupancy, SNNPRS

CHAPTER ONE

1. INTRODUCTION

1.1 General

The building industry is becoming more advanced, technologies advanced and developing day by day around the world. Construction Industry has a great impact on countries' economies (Leibing, 2001). According to Olawale. Y. & Sun. M. (2010), the construction industry contribute towards the GDP growth due to continuous development. It has also highly visible output and stimulates sizeable amount of economic growth through inter-sectoral linkages between construction and other sectors (Giang & Pheng, 2011), which makes construction sector powerful in the economy. Construction industry has a remarkable contribution to sustainable economic development by satisfying some of the basic objectives of development including output generation, employment creation, and income generation and re-distribution.

Building construction defect on the other hand can decrease and affect the value of building. Defects are developments in building construction that cuts down the project`s value instead of adding to it. Defects within buildings are areas of non-compliance with the building codes, Standards and published acceptable tolerances (Josephson & Hammarlund, 1999).

Building maintenance is described in British Standard 3811 as work done to keep a building in, or restore it to initial state or to a currently accepted standard (UK, 1993). The committee for building maintenance, Her Majesty's Stationary Office (HMSO) defined acceptable standard as one which sustain the utility and value of the building (Seeley, 2001). This concept broadens the scope of maintenance to include alterations to a building, but for the same use, conversions, which results in a change of use and value, extensions and renewal, and rehabilitation (Ikpo, 2006). In order to keep a building in acceptable condition, failures must be precluded. This implies that items that exhibit symptoms of failure have to be identified and renewed before failure occurs. This procedure is referred to as preventive

maintenance. It depends mainly on the ability to anticipate the lifetime span of all the elements.

Ahmed (2000) observed that the maintenance of public buildings in the developing countries has not been given the required attention. The government focuses more on the construction of new buildings, while the maintenance of the old structures which commences immediately after the construction completed is not given much attention.

Maintenance management method is the combination of technical, administrative and management activities of the post-construction life cycle of a facility. These activities overview is concerned with the technical specifications, administrative processes and management such as contract conditions, policy and maintenance strategy related issue. In addition, it considers the maintenance factors of labor skill, interpersonal relationship, maintenance performance, material quality control and investment control in order to support the sustainable maintenance of building facility (Abreu, 2013).

Besides, it is a continuous process of coordination and collaboration (e.g. designer and site engineer) to provide the effective service delivery of building maintenance to perform building facilities long-lived and reduction of life cycle cost (Hamzah S. a., 2013; Martinez-Moyamo, 2006). The method of processes start from identification, defect diagnosis, maintenance planning and execution of the facilities (Lung B. E., 2009).In general, maintenance management method is the larger service of post-construction activity and process.

Building defect is a shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building (Bedru M. , 2016). According to Bedru (2016) the major defects arises from poor workmanship while the design error takes lesser causes of defects.

1.2 Background of Study

Building construction is showing notable progress in different sectors in SNNPRS and throughout the country. While the projects are progressing and consuming considerable amount of budget, visible defects are available and the maintenance problem is observed during occupancy stage of buildings. For example Arba Minch teaching and referral hospital is under construction with an amount of **962,077,561.21**(Nine Hundred Sixty Two Million Seventy Seven Thousand Five Hundred Sixty One and 21/100) Birr which was started April 1/2015 for 930 calendar days. Maintenance schedule should be set after completion such big projects. Showing that one of the project objectives which is quality is not adequately met. Meeting project objectives requires a proper management throughout the different stages of projects through different stages of planning, organizing, securing and managing resources to bring about a successful completion of the project is very common.

Literature outlines that construction work passes through five stages that are briefing, designing, tendering, commissioning and maintenance (PMI, 2017). In the briefing stage the economic viability of the project is established. Summary of the project, construction method and cost estimation to obtain approval from the client done in the designing stage. Specification and working drawings are also prepared for inviting tenders. After that, tendering and commissioning stage continues. In the cyclical approach, the stages keep their cyclical pattern. After maintenance, the cycle starts again from briefing. Based on the feedback of the cycle, project plan and implementation is prepared.

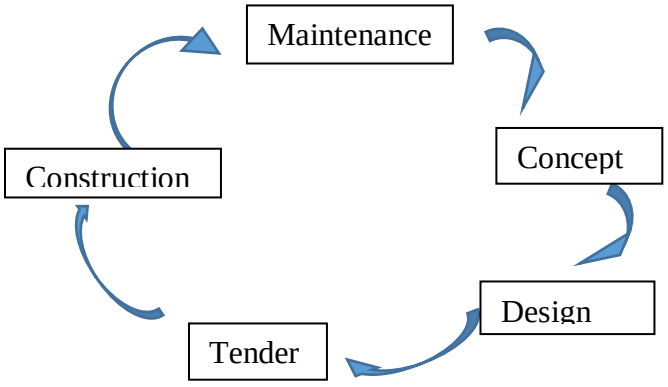


Figure 1.0. Cyclical approach of project implementation stages (PMI, 2017).

Every constructed projects should be inspected and routinely maintained for the duration of a structure life before replacement, upgrading or demolition is carried out. From observation of building in the occupancy period, public buildings seems less attended and periodic maintenance is not carried out in the locality. Assuring the cycle make buildings more functional and gives longer service year without affecting the user. Moreover it is also easier to monitor conditions of buildings.

A building defect is generally described as deterioration, damages, default or deficiency (Olanrewju & Abdul-Aziz, 2015). Broadly speaking, building defects fall into two categories: defects that affect the performance of the structure, and defects that affect the appearance of the structure. From the legal perspective, a building defect is defined in somewhat different terms. Legally, a building defect is a violation of the applicable building code, a violation of the standard of care in the community in which the project is located, or a violation of the manufacturer's recommendations (Robert, 2007).

Defect is the nonconformity of a component with a standard or specified characteristic (David, 2007). Defect is used sometimes as a synonym for "failure", but the preferred meaning is to indicate only a deviation from some (perceived) standard that may, but will not necessarily, result in failure (Ibid).

According to Ahmad (2004) there are usually various causes and types of defects that affect the performance of a building the examples of which are design deficiencies and construction deficiencies. The defects in the buildings also includes dampness, honeycomb, roof defects, erosion of mortar joint, corrosion of reinforced steel, foundation failure, peeling paint, defective plaster rendering, and timber rot. All these causes have given an impact of rework to the construction industry.

Rework is meant by doing something at least more than one time due to the reason not fulfilling the requirements as stated by the Construction Industry Development Agency (Felicity, 1995). In addition, the cost of rework is amount to 5% of the total construction costs (Construction Indutry Institute, 2005). For instance, the construction industry of

United States expended $1,502 billion in 2004 for total construction cost and $75 billion was wasted by rework cost in year 2004 (Construction Indutry Institute, 2005). The researcher couldn't find similar literatures done on rework cost of buildings in Ethiopian context. The reason why defect occurs in the buildings might have due to non-compliance with the Building Code and does not follow the standard procedure when constructing the work. Therefore, maintenances are needed in order to increase the useful life buildings and improving the efficiency at the occupancy period.

Maintenance of building is essential in order to sustain and preserve the building to an acceptable condition. Acceptable standards mean to sustain the utility and value of the facility. Moreover, the purpose of maintaining the building is to retain the value of investment, maintain the building in a good condition so that it can provides its function fully and have a good appearance (AL-Hammed, 2014). However, the expenditure cost for maintaining the building is high and it will continues or even to increase the cost in the future. According to (Rendeau, 2006; Booty, 2006); it shows that 70% of the operating costs from the building is contributed towards maintenance considering the fact that more than 90% of the life time of a building project, it requires maintenance work.

Defects may be observed as soon as buildings are constructed or may stay long period of time before detected. Based on manifestation of building defect, it may be latent or patent defects (J.Cama, 2004).Latent defect is a construction defect that is present but not readily detectable even with reasonable care. Hidden defect is meant by defects caused by failure in design, workmanship or materials. Besides, the defects are in concealed situation and not obvious and the errors will only be visible after the element is constructed and used for some time.

The example of latent defects are lack of reinforcing in the concrete structural, improper installation of waterproofing system, adulterated paint and corrosion of rebar, etc. Apart from that, patent stage defects are those defects that are visually obvious and can be seen easily. The example for patent stage defects are cracking occurs at the building envelope, handrails omitted at the stairways and etc. (Gatlin, 2013)**.** The patent and latent stage defects

normally can be seen in the new buildings and the contractors need to rectify the defects during the liability period.

Maintenance of a buildings is a process of reservation and restoration activity of the structure and components of a building. It covers the whole building which includes toilets, rooms, walls, roofs, drains, doors, windows, floors and also the fix furniture (Akasah, 2007). The issue of building maintenance is a universal issue and is highly considered in the early process of the construction (design) to assure the quality of the building (Arditi & Nawakorawit, 1999). Maintenance matters for buildings to sustain its purpose for long period of time, reduce breakdown, and improve efficiency in occupancy stage (Josephson & Hammarlund, 1999).

1.3 Statement of the problem

Building defect is one of the significant parts of building that required consideration. Before construction of buildings it would be better to consult with the client professionals and end users about functionality of a building. Sometimes it is a wrong trend to maintain the building defects without identifying types of defects. The right responses usually depend on various elements: the age of affected building, the nearness or non-attendance of human mistake or may be some combination of all. The present buildings are manifesting imperfections that should have been maintained long ago if a proper strategic maintenance techniques were performed in the right way from the plan and development stages.

Construction deficiencies such as poor workmanship and low quality of materials, design deficiencies like not according to the specification and faulty design, limited time and cost, external environment and etc. lead to various types of defects in buildings. In SNNPR region, defects in public buildings may appear and its impacts may be of high maintenance costs, poor user satisfactions, dangerous to the tenants and the buildings may not function properly. While there is information on defects in buildings in general, as such is not available for identified causes of building defect and maintenance management techniques of public buildings in the region.

Improper use of the building is another problem in the service period/occupancy which causes serious defects on the structure. Damage on the building while giving service can be rectified by proper maintenance. Neglect and poor quality maintenance are major influences on the incidence of important defects. So to reduce occurrence of defects that lead to failure, there should be a correct use of building and properly managed maintenance activities.

Common defects are observed in the regional town's buildings but unclear how it is maintained. Thus there is a need to assess the root causes of the aforementioned building defect problems through investigating the real defect types and maintenance management practices during occupancy stage of buildings.

1.4 Research questions

1. What are the major types of defects observed in buildings during occupancy stage?
2. What are economical, functional, environmental and social consequences of defects on buildings?
3. What are the current practices to maintain buildings in public projects in SNNPR?
4. What are the possible remedial measures to be taken to minimize building defects and improve maintenance management practices?

1.5 Objective of the research

1.5.1. General Objective

Assessment of defects, and maintenance management practices during occupancy stage of buildings on selected Southern Nations, Nationalities, and People's Regional State (SNNPRS) towns namely Dilla, Arba Minch, and Hawassa.

1.5.2. Specific Objectives

Toward attaining the main objective of the research, the following specific research objectives are formulated.

1. Identify the main defects observed during operation/occupancy stage of buildings.
2. Investigate economic, functional, and social consequences of defects on buildings.
3. Assess the current practices of maintenance management of public buildings under occupancy
4. Provide measures that can reduce building defects and improve maintenance management practices in building projects.

1.6 Significance of the Study

When a building suffer defects, the causes of that defect have to be properly identified before any remedial work can be undertaken. If building segment suffers some defects and maintained without knowing what types of defect, it may bring with additional large defects which bears unexpected maintenance cost. The study is going to be done to assist professionals who are involved in building construction maintenance to identify types of building defects and their maintenance system.

Thus, this study attempts to find out the major types of defects that occur in the buildings and directs to improved maintenance management techniques in order to minimize the effect of defects and improve the maintenance practices. The research is supposed to assess frequently observed defects and come up with various maintenance management techniques

for the owners, the public and other stakeholders involved in building maintenance in the region.

1.7 Scope and limitations of the Study

This research will mainly focus on assessing main types of defects and maintenance management practices for buildings in selected SNNPRS of towns in a case of Dilla, Arba Minch, and Hawassa. Towns are selected purposively. The study is limited to only the selected towns with mentioned project types under occupancy due to time and budget constraint.

A population of south regional state towns' with the top ten towns were taken for purposive selection. The top ten towns in population in SNNPRS are Hawassa, Wolayta Sodo, Arba Minch, Hosanna, Dilla, Mizan, Butajera, Areka, Yirgalem and Welkite in decreasing order (Central Statistics Agency, 2014). Only three towns are taken purposefully due to budget and time constraint. Universities school building, Public referral hospital buildings, City municipality building and Residential apartments are taken as case studies for the research from selected towns. These are of educational, health centre, administrative and residential buildings project types. As institutional public buildings, most of them were discussed. Poor Contract documents handling were a problem in the discussion of projects in relation to the objectives.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

Black's Law Dictionary 7th edition defines„ defect‟ as meaning „an imperfection or shortcoming‟, without identifying how the imperfection or shortcoming should be judged (Bryan A., 1999). Cambridge Dictionary defines „defect‟ as meaning „A fault or problem in something that spoils that thing‟ this definition is narrow because a defect not necessarily spoils the building.

JBCC series 2000 edition 5 describes defect as "any aspect of material and workmanship forming part of the works that, in the opinion of the principal agent, is due to the failure of the contractor to comply with his obligations in terms of the agreement" (JBCC, 2007).

In general terms, defects or defective work occurs when the standard and quality of workmanship and materials, as specified in the contract, are deficient. Defects may occur in any part of a construction project and at any stage of building. A defect is defined as 'the non-fulfillment of intended usage requirements' in which requirements are determined by law, regulations, building standards as well as in contract documents, site meeting records and other project documentation (Atkinson, 1999).

According to Watt (1999) post-handover defects on a building can be considered a failing or shortcoming in the function, performance, statutory or user requirements of a building and it might manifest itself within the structure, fabric, services or other facilities of the affected building. An immediate way to reduce and/or eliminate post-handover defects is to ensure that quality controls and inspections are implemented during design and construction (Ibid).

Quality in building construction can be defined as meeting the legal, aesthetic and functional requirements of a project. Requirements may be simple or complex, or they may be stated in terms of the end result required or as a detailed description of what is to be done. But,

however expressed, quality is obtained if the stated requirements are adequate, and if the completed project conforms to the requirements (David & Gunaydin, 1997).

Defects are one of the major causes of dispute and litigation with in defect liability period and warranty period of a building (Glover, 2000). There are observable types of defects and hidden defects in building. Some appear later on the occupancy period while others appear at early stages of building construction. Dealing with building failures requires various degrees of familiarity with law, building technology and practice. There is often disagreement when it comes to identifying what a building defect is. This, of course, will be due to the differing viewpoints and interests of those who are asking the question and/or making the determination. These parties typically include the contractor, consultant and the employer.

To prevent defects of any building project parties have to develop quality management plan. A Quality Management Plan is a project or contract specific plan developed by the service provider by applying an appropriate Quality Management System to plan and carry out the work involved, to ensure conformity with the requirements for the project/contract and to manage the quality risks. The Quality Management Plan is used and updated regularly during the life of the project or contract (Government, 2013).

Building imperfection jumps out at either the new building or the old ones. Imperfection inside new structures is perhaps of resistance with the Building Code and distributed satisfactory resilience's and principles. Then the more established structures, or working out of guarantee period, may not consent to these gauges but rather should be judged against the standard at the season of development or renovation (Corridor, 2017). Physical foundation constitutes a high extent of the nation's speculation. It is subsequently of essential significance that these offices which incorporate open structures are kept up all together that they can serve both the engineering and aesthetical capacities for which they are manufactured. Private building structures are inclined to abandon because of their perpetual and protracted utilization. All components of structures decay at a more noteworthy or lesser rate subject to materials and strategies for development, ecological

conditions and the utilization of the structures as cited by seeley from Her Majesty's Stationary Office (HMSO) (Seeley, 2001).

2.2 Classification of Building Defects

Georgiou et al (1999) stated that building defects are always under the spotlight and the grave concern of the construction industry. Different buildings or structures produce different types of defects and require numerous levels and types of quality, which rely on the building functions, the construction or maintenance systems and also materials adopted. Generally, defects can be classified as major defect or minor defect (Ibid).

A. Major defect: It is considered as those which cause the building to become unsafe, unsuitable for living in and not suitable to be used for the purposes for which the building was designed.
B. Minor defect: It is considered as those originate from poor workmanship or deficient materials used in the construction of the building, but do not cause the building to become unsafe, unsuitable for living in and not suitable to be used for the purposes for which the building was designed.

In the building industry, there are different approaches to classify defects, like by its severity, by type, by cause, etc. (Macarulla et al., 2013). Generally, Western Countries categorize building construction defects in one of four categories: design deficiencies, material deficiencies, construction deficiencies, or subsurface deficiencies (FindLaw, 2012).

A literature analysis part of research done in Spain put different ways of classifications of building defects that are done by other researchers (Chong & Low, 2005). Some of the researcher suggests classifying defects into major and minor categories, taking into account the severity, classifying the defect as technical, aesthetic or functional with technical meaning when the workmanship or material of an element reduces its capacity to fulfill the functional performance of a structure; aesthetic meaning when the appearance of a material or building element is adversely affected; or functional meaning when a dwelling fails to function in its intended manner. Other research distinguishes between defects due to the

construction process or to natural degradation related to a lack of maintenance by the occupants of the house (Macarulla et al., 2013).

According to Abdul Rahman et al (1996) describes defects in buildings include either or a combination of the following; defects in structure, giving rise to cracks or collapse; defects or faults in electrical and plumbing installations; inadequacy of drains for proper disposal; insufficient provision for ventilation; poor cooling and/or heating system; poor sound insulation system, and insufficient fire prevention or protection mechanism. In addition, defects in the building may also be as a result of the following; fungus, termite, or vermin infection, fungus, wood rot, mould, and dry rot (Abdurahman , 1996).

According to Bedru M (2015) the first five most frequent types of defect in federal building Ethiopian construction were broken or loose tiles on floors or wall; water seepage from external wall, roof, or from ceiling; broken or leaking sanitary fixtures; defective damp proofing at the roof; poor window framing and non-structural crack respectively.

Uneven floor and wall finish were the major type of defect occurred during case studies done on 20/80 condominium in Addis Ababa as per technical staffs from client point of view (Yebichaye, 2016). Poor workmanship is one of the major factors that lead to building defects and failures problems. Usually residential buildings are the one which experienced most of the defects or failures problems due to poor workmanship during construction phase (Government, 2013).

Wordsworth (2001) outlined the most common type of building defects that can exists on building elements as follows:

- Cracking
- Unstable Foundation
- Deterioration of Roof Covering
- Internal Staining, mould growth and fungal on external wall
- Dampness
- Peeling Paint
- Leakage

- Defects in doors, windows and external appendages
- Insect or Termite Attacks
- Defective Plaster Rendering
- Defects in Building Services Installation and etc…

Thus this study mainly focused on common types of building defects and assessing their root causes.

2.3 Building defect and maintenance management practices

Any building with electrical, electro-mechanical and other services when built has certain objectives and during its total economic life, it has to be maintained. Maintenance is a continuous process requiring a close watch and taking immediate remedial action. It is interwoven with good quality of housekeeping. It is largely governed by the quality of original construction. The owners, engineers, constructors, occupants and the maintenance agency are all deeply involved in this process and share a responsibility. Situation in which all these agencies merge into one is ideal and most satisfactory. There are two processes envisaged, that is, the work carried out in anticipation of failure and the work carried out after failure. The former is usually referred to as preventive maintenance and the latter as corrective maintenance. The prime objective of maintenance is to maintain the performance of the building fabric and its services to provide an efficient and acceptable operating environment to its users (Association, 2012).

Lee and Scott (2008) identify maintenance policy and strategy, strategic management, facility management and performance management as the four main aspects influencing the management of building maintenance operation processes. Nowadays building owners are more concerned about building maintenance performance as it reflects their buildings image as well as competitive advantages in terms of a marketing strategy to attract more people to buy and rent. Understanding the characteristics and considerations related to these four aspects are essential for the management of building maintenance operation for office high rise buildings (Lee & Scott, 2008).

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

It is a well-known fact that the primary objective of building maintenance is to preserve buildings in their initial functional, structural and aesthetic states (Adejimi, 2005). This is to ensure that such facility continue to remain in such state and retain their investment value over a long period of existence.

As it is observed in this study, maintenance program in public buildings have lack of maintenance practices in the Southern Nations Nationalities and Peoples' Regional State (SNNPRS). Only some of institutional buildings get maintenance recently. This is also in line with the statement of (Kunya U S, 2007) who observed that there is apparent lack of maintenance culture in Nigeria which is similar for this study area.

Method could be a pillar of fundamental importance for the implementation of an effective and efficient maintenance management component on construction site. Method of practice in managing maintenance activities has been a hot issue in recent years due to lack of progress in the area of computer-aided maintenance management and difficulties with accessing information and data in maintenance support systems (Duran, 2011).

Maintenance management method is defined as the combination of all technical, administrative and management activities of the post-construction life cycle of a facility. These activities overview are concerned with the technical specifications, administrative processes and management such as contract conditions, policy and maintenance strategy related issue. In addition, it considers the maintenance factors of labour skill, interpersonal relationship, maintenance performance, material quality control and investment control in order to support the sustainable maintenance of building facility (Abreu et al, 2013). Besides, it is the recursive process of coordination and collaboration (e.g. designer and site engineer) to provide the effective service delivery of building maintenance to perform building facilities long-lived and reduction

of life cycle cost (Martinez-Myano, 2006; Hamzah S. e., 2013). The method of processes start from identification, defect diagnosis, maintenance planning and execution of the facilities (Lung B. e., 2009). In general, maintenance management method is the larger service of post-construction activity and process.

A common overview of maintenance types and their relations is illustrated in the standard SS-EN 13306 below (SS-EN13306., 2001).

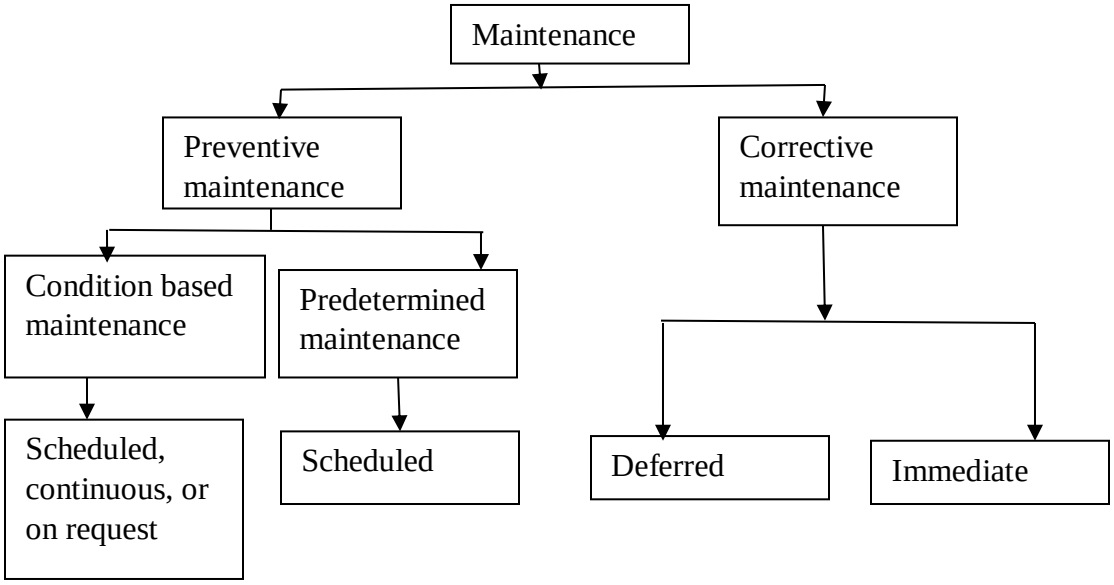


Figure 2.0 Overview of maintenance types and their relations *(*SS-EN13306., 2001)

As indicated in Figure 2.0 above, maintenance is divided in two main categories, preventive and corrective. Preventive maintenance is further divided into two main categories: Predetermined (periodic) maintenance and Condition based maintenance.

Corrective maintenance

One definition for Corrective maintenance is: "Maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function" (SS-EN13306., 2001). In other words, Corrective maintenance is essential for the repair of broken equipment. This approach is of course costly. The total cost for a breakdown or other unplanned outage of equipment includes the following (Wireman T., 1990) :

- Operator time loss
  - Time to report failure
  - Time for maintenance to arrive
  - Time for maintenance to make repairs
  - Time required to start equipment
- Cost of repairing or replacing the failed part or component
- Maintenance costs
  - Time to get to the equipment
  - Time to repair the equipment
  - Time to get back to dispatch area
- Lost production or sales costs or both
- Cost of scrap due to maintenance action

Preventive maintenance

One definition of Preventive maintenance is: "Maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item" (SS-EN13306., 2001). Another, similar definition is given by Wireman who defines preventive maintenance as "...any planned maintenance activity that is designed to improve equipment life and avoid any unplanned maintenance activity." (Wireman T., 1990).

According to Wireman (1990), the following types of preventive maintenance may serve as a progressive method of implementing a comprehensive preventive maintenance program:

- Routine – lubrication, cleaning, inspections, etc; aims to take care of small problems before they cause equipment failures.
- Proactive replacements; replacement of deteriorating or defective components before they can fail.
- Scheduled refurbishing; during a shutdown or outage, all known or suspected defective components are replaced.

- Predictive maintenance; an advanced form of routine inspections, using technologies like vibration analysis, and spectrographic oil analysis.
- Condition-based maintenance; maintenance based on “real-time” inspections through sensors installed on the equipment.
- Reliability engineering; design engineering studies performed to discover possible modifications of the equipment to prevent failures from occurring.

2.3 Strategic planning in maintenance management practices

Maintenance strategy in general includes corrective, preventive or condition-based maintenance. However, there are different views on choosing appropriate maintenance strategy. Among various maintenance strategies, the effectiveness of planned preventive maintenance (PPM) is more challenged by the top management. Moreover, maintenance standard is difficult to agree with top management. Acceptable maintenance standard depends very much on available maintenance resources with consideration of common factors such as characteristics related to building, tenant, technical, administrative and political factors (Chanter, 2008).

Studies done on building maintenance from different countries show that a maintenance process is complicated and requires a high cost (Akasah., 2007). But, if it is done according to the required time table, it can lengthen the life of the building and save the cost (David & Gunaydin, 1997).

Preventive maintenance is the routine, regularly scheduled maintenance of a piece of equipment to ensure its continued use and maximize its life expectancy. While, corrective maintenance is an emergency work orders which the maintenance activity done after damage occur (Deris, 2007). However, preventive maintenance is recommended to minimize equipment failure due to the time schedule. The cost associated with routine servicing of equipment is small compared to the cost of coping with unexpected and catastrophic breakdown which require not only major repairs but even the replacement of affected components and systems (U.S Department of Education., 2003). Figure below shows the different between preventive and corrective maintenance.

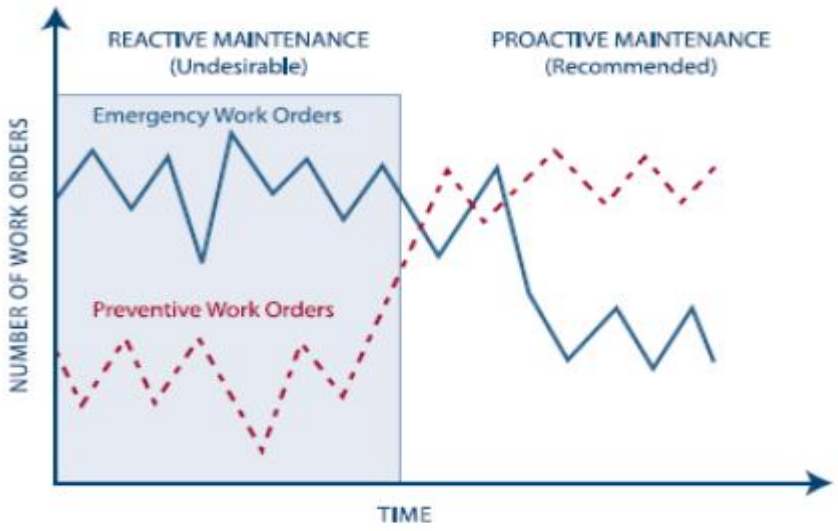


Figure 2.1 Preventive and corrective maintenance *(*U.S Department of Education., 2003*)*

In general, there have several building defects which usually happen to building parts such as roofs, walls, floors, ceilings, toilets, doors and windows (Cheun., 2008). Roofs are the most vulnerable part of a building.

As Ransom suggests, it can be said that pitched roof have given few problems and flat roofs have given many (Ransom & James, 2006). The roof's equipment is to protect the building from rain, sun, and wind and also the roof is used to keep water from getting into the building (Organization of American states, 2006), but there are roof problems arise such as roof leakage and ridge leakage (Cheun., 2008).

Figure 2.2 Roof structure collapsed in Kuantan (NST, 2005)

Figure 2.3 Ceiling deterioration by leakage through Ega in Dilla management building (image taken by the researcher).

Figure 2.4 Ceiling leakage *(*Bedru M. , 2015*)*

Figure 2.5 Leakage due to broken sanitary sewer (Yebichaye, 2016)

According to studies done by Bedru (2015) and Yebichaye (2016) , water seepage to internal parts of a building is the most frequent type of defect observed in buildings. The defect occurred because of poor prevention of moisture. Most of the time moisture becomes a threat to building and it can create plenty of problems and might cause building failure (Bedru M. , 2015; Yebichaye, 2016).

Whereas, wall is the widest part of building besides roof but wall failures are essentially of two types such as failure to provide adequate protection against moisture penetration and cracking of the walling materials (Ransom & James, 2006).

Figure 2.6 Rotting door due to moisture penetration effect (James & Ransom, 2006)

Floors have not been a high risk area in recent years but failures have occurred, particularly in concrete screeds, by chemical attack, usually by sulphates, on the concrete base slab and through insufficient support to the slab by inadequately compacted hardcore (Ransom H. , 2013). The types of floor defect are concrete floor cracking, floor moisturizing and floor finishes defect (Cheun., 2008).

Figure 2.7 Ceiling moisturizing (James & Ransom, 2006).

The function of ceilings is to cover the electrical, water pipe and fire resistance system which located between ceiling and roof structure. The types of ceilings defect are ceilings moisturizing, asbestos ceiling damage and peeling of ceiling paint (Cheun., 2008). The functions of windows and doors are to protect the building from rain and wind and to provide good ventilation for school building. Such defects are wet rot in the frames, attack by termites and peeling of doors and windows frame (Ransom & James, 2006). While, for the toilets, the common types of defect was leaking in pipe and clogging pipe (Cheun., 2008).

2.3.1. Relationship between building defects and maintenance management

Post-handover defects on a building defect can be considered a failing or shortcoming in the function, performance, statutory or user requirements of a building and it might manifest itself within the structure, fabric, services or other facilities of the affected building (Watt, 1999). Those defects arising from bad design or construction deficiency that are not solved during construction are not normally detected during the liability period (post-handover), but are manifested after some years of use (Chong & Low, 2005). Before occurrence of defects, institutions shall develop maintenance management practices taking

considerations of different strategies. Maintenance management of a building should be considered from inception period.

Zavadskas (1998) has presents the correlation between design of building and its life cycle. A better building life is only accessible with skillful design consideration at design stage and is important issue to its owner and dedicated designer. The design stage begins when owner or client presents the set of requirement to designer and designer defines the demands for building and specifies the limitation. At this stage maintenance strategies and objectives should be considered and means should be determined to allow the building to enjoy longer life cycle. If the decision regarding maintenance issue and their means are considered well before the construction phase, it will prevent the building to fall in pool of bad design and this timely decision helps to enhance the life cycle of building (Zavadskas E., 1998).

2.4 Problems and challenges in building defects maintenance management practices

The problems usually faced in public building defect maintenance management practice are lack of commitment for handling defect, poor quality work by contractor, defects repetition (surface cracking, leaking and jointing) and etc. (Ismail Z A et al, 2016).

Poor and improper building maintenance will definitely cause more damages and costly repair works if left unattended. In most developing counties buildings are built in accordance with some Standard and under strict supervision. Unfortunately the maintenance aspects of the building are still weak. Making it worse, sometimes building maintenance is perceived as merely about the mechanical and electrical system in the buildings without much consideration given to civil and structural elements (Douglas J., 2006).

There were many problems related to the conventional method at most buildings such as, defect repetition (leaking, jointing and cracking) and less competent contractor. The conventional method also led to inaccurate design and construction information, late updating of the required information, lack of coordination and integration (Ismail Z., 2014). Now a days Building Information Modeling (MIB) as a sixth dimension of its component, is being a good technique of building maintenance.

2.5 International building defects and maintenance management practices

2.5.1. Building defects and management practices in Malaysia

Maintenance ensure the facilities are in a good condition for a life time. In achieving the sustainability of facilities condition, maintenance management is required for the efficiency and effectiveness for strategic planning. There are many existing theories, models and framework related to maintenance management. According to Lateef et al (2010) maintenance management system used conventional method in many universities campuses in Malaysia.

The system is using paper-based form to provide defect report from student and staff. Meanwhile, improper database such as Microsoft Excel and Microsoft Word contribute to the irregularities in the university's maintenance management system. The lack of comprehensive maintenance management also is due to not providing the decision making process to solve complicated problems of building and infrastructure defect. Therefore, a computerized maintenance management system (CMMS) is the suggested solution for that problem in Malaysian university.

According to Lazim and Samad (2011) , the management system implemented by Polytechnic in Malaysia is also using the conventional method. Polytechnic has the department to coordinate maintenance and repair of equipment, buildings, infrastructure and facilities related work, including support services at Polytechnic. The conventional method applied at the institute like telephone, email, paper based have seen ineffective and full of bureaucracy. This bureaucratic way of dealing defects takes much time to report to the responsible body and extends the period of maintaining building defects and lead failure (Hassan, 2010; Lazim & Samad, 2011). The implementation of conventional method provides ineffective and poorly organized maintenance management (Ismail, 2012). The losses incurred by breakdowns or failures of operating system, for example, electrical and mechanical utilities.

Many buildings and infrastructures need to be refurbished to enhance the effectiveness in maintenance management processes (Awang et al, 2011). The conventional method

has to be improved for better maintenance of building and infrastructure, and to provide good environments. The technical and managerial defects are the main problems in the conventional method in maintenance management. The technical defect is the lack of technical expert to operate and monitor the facilities of building and infrastructure with new technology. This is related to the knowledge exposed to the Information and Communication Technology (ICT).

Recently, CMMS application is widely used in maintenance management processes of building facility. CMMS can reduce the negligent management due to problems emerging as a result of the need to manage huge and complicated data. For instance, the causes of data loss through unsuitable places for file storage and excessive retrieval time in the recovery of data files (Ismail, 2012). The managerial defect consists of project management, resource management defect and economical and financial defects (Saghatforoush et al, 2011). Maintenance management at Polytechnic revealed a number of shortcomings as it still use paper-based form and unsystematic database to manage a complex and huge amounts of data including data analysis and tracking of complaints. Thus, the new system is proposed in order to improve the conventional method that tends to be cumbersome at Polytechnics (Ismail, 2012). Essentially, the new system has the potential to transform maintenance management processes to foster the professionalism and excellent working culture for successful transformation agenda.

Maintenance management in the private and public sectors has been rapidly changing throughout the years. This is due to several factors such as enhancement of sophisticated technologies, globalization and economic changes (S.Ali., 2009). There are many definitions of maintenance. 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 (G. C. Hua & W. Sher, 2005; H H. Y.Lee, 2009) .

The best way to achieve excellent maintenance is to have a maintenance management that matches as closely as possible the expected requirements of the user (N.E.M.Nik et al, 2011). Although this study aims to unveil the problems that occur in the performance

assessment of maintenance practices of building maintenance in some government offices and to determine the client's or user's level of satisfaction, it is also used to fulfil other objectives. Other than that, the building management has to ensure that the buildings have facilities that provide services to the people. These services include electricity, piping, lifts for high rise buildings, maintenance, and workers who handle cleaning, security and others (N.E.Myeda, 2012).

Effectiveness in building maintenance and being able to determine the level of customer satisfaction are some aspects of good building maintenance practices. These approaches may increase the potential performance of building maintenance practices by using a strategic performance to achieve the best quality. This study evaluated the integration of the behaviors, perceptions and opinions of building occupants as users of the building. This required a high level of professional skills in meeting the end user needs for a proactive and high quality service (A.I.Hussain, 2011).

There have several problems faced by Malaysian school maintenance team. For the maintenance team they faced problems from two sides which are from school maintenance community and Malaysian Department of Education. The study suggested several suggestion for solving future maintenance problem related to school building. Researcher found that, the main effects is inadequate of funding due to major defects. A building with numerous design defects will increase budget of maintenance. The respondent also strongly believe that design defect strongly affected on maintenance budget, effect on maintenance policy and planning, increasing in maintenance frequency and works and also affect to increasing in maintenance time duration. Based on analysis conducted, researcher found that most of management prefers to use a preventive maintenance rather than others approach (Akasah, 2007).

2.5.2. School Building Maintenance Trends in USA

A school maintenance programme is an organizational activity carried out by the school community in order to prolong the life expectancy of school buildings, its furniture and equipment. In order to start a school maintenance programme the school

building should meet a minimum standard of condition. The school maintenance programme should be systematic and pro-active to prevent the need for repairs. It has a sufficient staff and budget for proper maintenance. The maintenance programme is comprised of three basic components: organization, inspection, and maintenance plan (Organization of American states, 2006).

2.5.3. Public Building Infrastructure Maintenance Management Practices in Ghana

The purpose of public building infrastructure is to satisfy social and administrative needs as a means to the fulfilment of economic responsibilities for the general public (Sani, 2012). In spite of this, the proper maintenance of public property has not been given the deserved attention. As a result, Ghana's development is restricted by a gaping infrastructural deficit and apparently poor maintenance of existing public property.

Maintenance is an important aspect of projecting quality management. With regard to facility management in particular, Khan regarded this as flexibility management and explained that construction projects require flexible management as these projects are unpredictable and managers need to cope with changes and challenges that sometimes are unexpectedly (Khan, 2013). Next to this, continuous maintenance activities are necessary to maintain or improve project quality. This means that proper maintenance is a good project management practice that contributes to project quality (Khan, 2013). The management perspectives gave a deeper insight to maintenance practices as managers vented their concerns in more interesting detail (Nkrumah, 2017).

2.5.4. Hospital Building Maintenance Management Practices in Malaysia

Buildings can be constructed to life supports. A building's performance contributes to the wellness, productivity, behavior, satisfaction, and security of its occupants. Hospital buildings are unique with regards to purpose, complexity, and size. Hospital buildings are important for any community and the way the building are designed, constructed and operated have profound impact on users health and the health of the environment (Guenther & Vittori G, 2008). Hospitals are large enterprises and are one of the most challenging buildings to construct and operate. The construction, operation, and

maintenance of hospitals depend on the functional and psychological needs of the main occupants [i.e. Patients]. Furthermore, hospital buildings contain various types of equipment, plants, laboratories, more so than any other types of buildings. Hospital buildings have a diverse range of uses and serve multiple purposes. A hospital building requires continual maintenance to meet its design and construction functions and to maintain the satisfaction levels of its users. As a result, hospital Building maintenance departments are under severe pressure. Despite this pressure, allocations to hospitals are being slashed and buildings are aging (Olanrewaji Al & Abdul aziz A-R, 2014). The maintenance management of hospital buildings has been investigated in countries like Israel, UK and US, the maintenance of Malaysian hospital buildings has yet to receive any practical investigations. Despite this, recently it has been noticeable that there has been a growing concern on the subject. Similar to many developed and rapidly developing countries, the hospital buildings in Malaysia are becoming increasingly complex and sophisticated in terms of design, construction, and function (Plan[2010-2015], 2010).

Hospitals seldom relocate to new places, the need for maintenance will increase. In addition to this, technological factors as well as refurbishments and extensions of existing buildings are common in Malaysia, which creates a need for more building maintenance. Maintenance is high at points of intersections between old and new parts of buildings. Regardless whether a new building is free from defects, maintenance is required to increase productivity of a building, otherwise a building will be too expensive to own and operate. In financial management terminology, this is where inputs are more than outputs, or expenditure exceeds revenue/profit. In this context, maintenance services will not have an acceptable value. Hence, the maintenance process the terms how, when, what and why are very critical, as it will explain the essentials of maintenance management. What explain maintenance demand depend on these critical areas (RS, 2001; van den Berg & Wagner , 2006).

2.6 Local Building defect maintenance practices

Research finding show that the types of low cost housing (Jimma town condominium) defects included cracking, peeling paint, damp, leaking pipes, timber decay, sagging or deformation (roof), mold or fungi, termites, broken tiles, and faulty electrics, were identified. The majority defect occurring in low cost housing was cracking. (Awol et al, 2016).

According to study done by Awol (2016) the major contributing causes of building defects in the selected building were also identified and ranked based on the level of importance as;

1. Low quality of material

2. Poor workman ship

3. Weakness in design

4. Lack of awareness by occupants about maintenance

Defects were occurred not only due to termite attacks, timber decay, sagging, or deformation. Furthermore, the cause of defects was also due to lack awareness by occupants about the maintenance of their house.

According to Awol et al (2016) the consequence of faulty design affects the structure of building through vertical cracks, damp, sagging and deformation of roofs, and drainage systems. Cracks, paint problems, leaking pipes, and faulty electrics are caused by poor workmanship. Unskilled workers were probably used to construct low cost housing projects due to minimal costs. The defects that cause material problems are paint, leaking pipes, faulty electrics, and broken tiles. The maintenance strategy for all the condominium was corrective maintenance with no planned preventive maintenance. All respondents agree that the Jimma housing development agency have formulated a strategic plan for maintenance of the Condominium buildings. Type of maintenance strategy of the Jimma town housing development agency was the condition base type of maintenance. This type of maintenance is performed after one or more indicators shows that the building needs maintenance.

Maintenance. Due to rain if the roof of the building is removed the urgent maintenance will be required. This one is the most frequent in the study area. A good practice for this type of maintenance was the roofing (Awol et al, 2016) .

According to Belaynesh (2015) study lack of proper planning, building operation and maintenance policy, detail record of the building, specific organization or association, regular training for building management staffs and facility management experts have an effect on building facility management.

Breakdown building maintenance type is the most frequently practice in the studied universities. Marine campus in Bahir Dar University has better building facility management practice. The organizational structure of the facility management department in the studied region needs rearrangement (Ibid).

According to the Study done by Bedru (2015) on Federal Government Office Building Projects, from the results of the thesis a total of 55 types of construction defect and 4 common causes of construction defects which are contributory to building failure were recorded (Ibid). The first five most frequent types of construction defects on mentioned project were; broken or loose tiles on floors or wall; water seepage from external wall, roof, or from ceiling; broken or leaking sanitary fixtures; defective damp proofing at the roof; poor window framing; non-structural crack. Similarly the results showed that the most common cause of construction defect was poor workmanship. At least more than 58% of construction defect were attributed by poor workmanship. Defective material takes the next role by causing almost 20% of construction defects. Design error causes just more than 15% of construction defects and the remaining defects were caused by poor subsurface investigation and improper usage of building services (Bedru M. , 2015).

2.7 Summary of Literature Review

Literature review was done on previous studies, internet, building management books, and engineering journals on the topics of building defects and maintenance management practices. By reviewing the previous studies, types and causes of building defects, effects of building defects, maintenance management practices and reducing measures of building

defect was investigated. This would be used to do case study, develop the interview questions, observations and document analysis in order to collect data from the targeted population.

Studies done in foreign countries identify maintenance policy and strategy, strategic management, facility management and performance management as the four main aspects influencing the management of building maintenance operation processes (Lee & Scott, 2008). Nowadays building owners are more concerned about building maintenance performance as it reflects their buildings image as well as competitive advantages in terms of a marketing strategy to attract more people to buy and rent.

Studies done on building maintenance from different country say that the maintenance process is complicated and requires a high cost. But, if it is done according to the required time table, it can lengthen the life of the building and save the cost. In most studies preventive maintenance is chosen over corrective maintenance in maximizing the life expectancy of building, less maintenance cost and minimize equipment failure due to time schedule.

2.8 Research Gap Identification

Building defects are identified as the cause of building failure in the building projects. However, much researches are not done on the defects and maintenance management trends aspect of Ethiopian building in the occupancy stage. And also, the mitigation strategy is not clearly stated whether condition-based, planned preventive or corrective maintenance technique. Major and minor defects types should be clearly stated as well so as to provide adequate maintenance based on the severity and level of the problems and ensure economic, functional and social crisis of effect of building defects in the region. Annual Rework maintenance cost of Ethiopian building is not found and still this research could not find the rework cost of buildings due to limitations but, will try to indicate how to reduce the rework cost by improving buildings defect maintenance.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Introduction

This chapter describes the methodology of the thesis. The main topics included in this chapter are research design, research strategy, description of study areas, data collection and method and analysis.

3.2 Research strategy

Within research methodology, research strategy assumes as the "*general plan of how the researcher will go about answering the research questions*" (Saunders et al, 2009). There are three, frequently used approaches of inquiry. These are quantitative approach, qualitative approach, and mixed methods approach (Creswell, 2009). Each of these approaches has its own strengths and weaknesses. The basic features of the three approaches are summarized below to select the methodology that best suits the research objective.

Qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data (Creswell, 2009). Qualitative data are not numerical nor are they usually subjected to statistical methods of analysis. Rather they are examined in their raw form (Dunn, 1999). Hence, in qualitative methodology the researcher follows induction, as the researcher collects open-ended data with the primary intent of developing theory from the data (Dunn, 1999). The disadvantages of qualitative researches are the fact that the data cannot be quickly, easily, or efficiently summarized nor is it often possible to generalize from given qualitative observation to another situation (Dunn, 1999).

Quantitative research is an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. Like qualitative researchers, those who engage in this form of inquiry have assumptions about

testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings (Creswell, 2009). As the data in quantitative approach are numerical, the numbers are readily collected, coded, summarized and analyzed. The major weakness of a quantitative research is that the researcher knows only about the collective or average experience of study participants but not their individual experiences (Dunn, 1999).

Mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone (Creswell, 2009).

The research strategy adapted for this research is both quantitative and qualitative research of exploratory type which diagnoses a situation, assess the practices, and recommend better techniques. The methodology followed for the research has four main parts as described hereunder.

i. Establishing the basis of the research: aimed at assessing different works done related to topic and formulating the research questions through the following steps.

- Literatures were reviewed to obtain a theoretical background for the research and formulating the research questions and defining the scope. To this effect, the main authors of textbooks in the field of building defects, and maintenance management practices were identified. Journals, thesis papers and dissertations were then reviewed in order to get a general understanding of the research area. Thereafter relevant articles from journals and other publications were searched to conceptualize the defect maintenance management practices of buildings. The search was made by using the following keywords: Building Defects, Building Maintenance Management, and Building Maintenance Practices. Apart from searching in libraries, internet sources were used to obtain recent articles and research papers in the area.

- Defect exposed building projects that are completed and giving service were selected for the case studies to examine whether poor maintenance practices were contributory to poor maintenance management of buildings at the occupancy stage.
- Interview schedule was prepared based on the findings of the literature review.

ii. Conducting the study: aimed at assessing defects, and maintenance management practices at the occupancy stages of buildings with approaches discussed in the data collection method:

iii. Analyzing the findings; aimed at analyzing the findings of case studies in relation to theoretical propositions, observations conducted, desk study (document analysis) and that of the interview using exploratory method of analysis.

iv. Conclusion and recommendation: aimed at concluding the research findings, and drawing recommendations.

3.3 Study Subject

In this research, determined number of project buildings are included. The study is intended to get enough information about defects and maintenance management practices in the occupancy stage of public buildings in SNNPR. The sample size is fixed as explained in the limitation due to time and budget constraint to represent the population in SNNPRS towns' buildings. The informants included in this research are professional facility managers and building administrators.

3.4 Research Design

"Research design" refers to the plan or organization of scientific investigation, designing of a research study which involves the development of a plan or strategy that will guide the collection and analyses of data (Polit & Hungler, 1999). The overall approach, as described in chapter 1 of this thesis, followed a five stage process; having established the basis of the research, literature reviewed, necessary data to be collected, analyzed, and conclusions and recommendations are to be made based on the findings.

The methods of data collections employed for the research are case study, desk study, and interview. These three methods were chosen for data collection since one cannot find a best single method. Using three methods helps to triangulate data and come to a better output.

The case study and desk study results are analyzed in relation to identification of main defects and investigation of economic, functional, and social consequences of effect of defects on buildings respectively. Responses obtained from the interview are also analyzed using descriptive statistics method for assessing the current maintenance management practices of defects on buildings in the area.

3.5 The description of study areas

The study area was selected as South Nations, Nationalities, and people for sake of proximity for the researcher. Then tows are sequentially put in order of population size as top ten towns listed Hawassa, Wolayta sodo, Arba Minch, Hosanna, Mizan, Butajira, Areka, Yirgalem and Welkite (Central Statistics Agency, 2014). Addressing all towns were difficult due to time and budget constraint so three towns were purposefully selected like Hawassa being capital city, Dilla towns due to its old formation and Arba Minch town is due to its location being south west of capital city, Hawassa.

3.5.1. Description of Study Area of Arba Minch Town

Arba Minch town is the third densely populated town in SNNPRS next to Hawassa and Wolayta sodo (Central Statistics Agency, 2014). Thus better infrastructures are also available like old universities school buildings, hospitals, and residential buildings and taken for study.

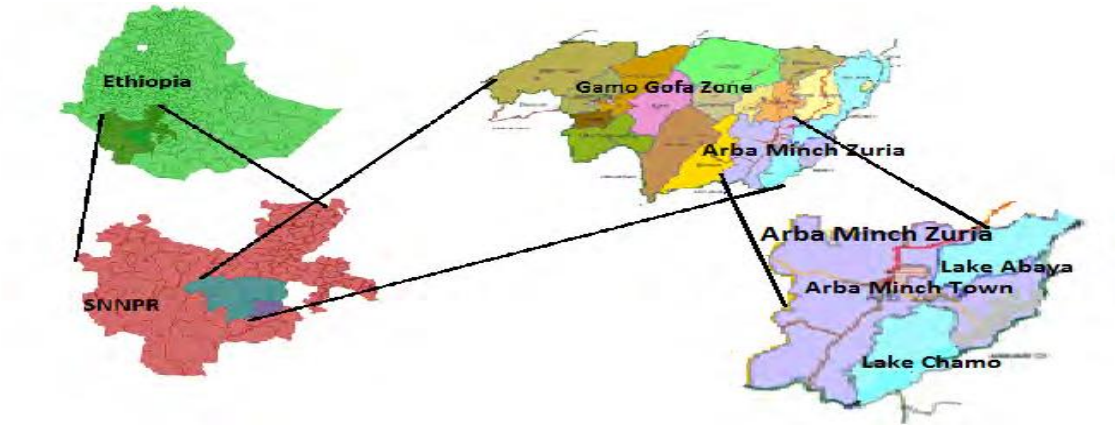


Figure 3.0 Map of study area of Arba Minch (Department of Finanace and Economy., 2014).

Arba Minch town is located in the Gamo Gofa Zone of the Southern Nations, Nationalities, and Peoples Region about 500 kilometers south of Addis Ababa, at an elevation of 1285 meters above sea level and 6°2′N 37°33′E with a total population of 200,373 (Projected population of 2017). It is the largest town in Gamo Gofa Zone and the second town in SNNPR next to Hawassa. It is selected deliberately for the study the region (Department of Finanace and Economy., 2014).

3.5.2. Description of Study Area of Dilla Town

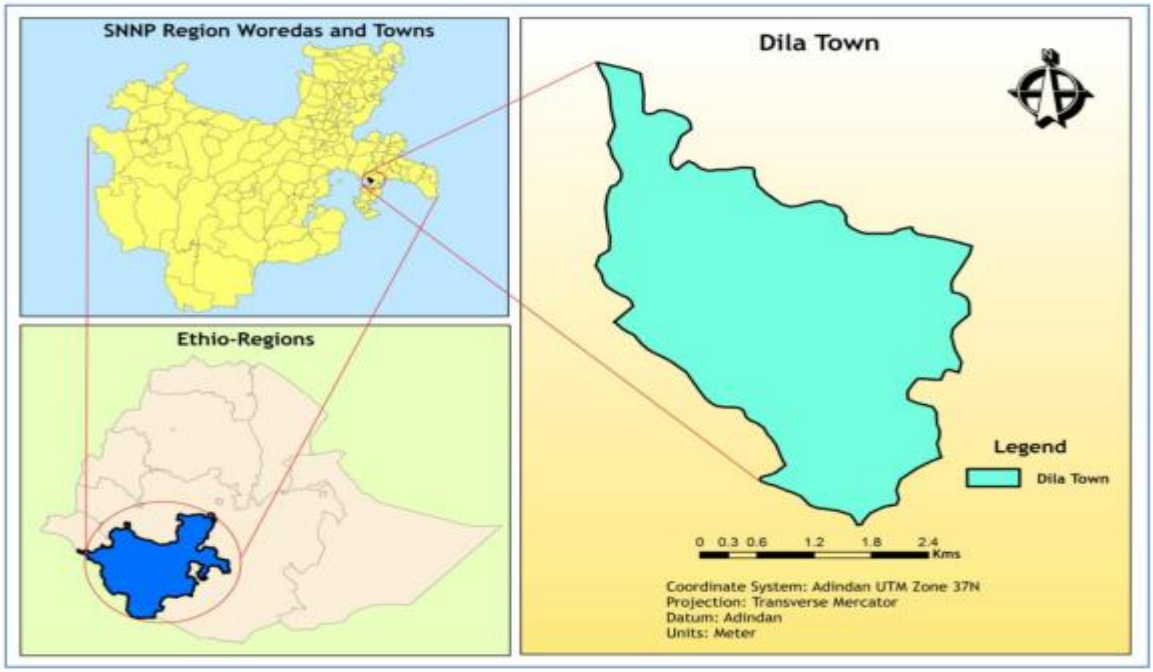


Figure 3.1 Map of Dilla town and surrounding regions (Debela & Muhye, 2017).

Dilla is purposely selected due to its location south east of SNNPRS and similarly hospital, universities buildings, residential apartments are available. The study is conducted in Dilla town, Gedeo Zone, Southern Nations Nationalities and Peoples' Region. Dilla is found in 360 km away from Addis Ababa, the capital of Ethiopia, situated at 6° 21'-6° 24' north latitude and 38° 17'-38° 20' east longitude. It is found in kola agro ecological zone with an altitude of 1400m above sea level and annual temperature ranging from 22°C-29°C. Dilla town is surrounded by different rural areas/kebeles such as Waleme, Chichu, Gola, Amba, Tumticha, Sisota, Chito etc, and, they have been included in Dilla zuria woreda. Dilla town administration has 03 sub cities (kifle ketemas), which includes 09

kebeles. It has the total population of 91,534 (Gedeo Zone Health Bureau, 2014). Thus Dilla is purposively selected as a town from south nations.

3.5.3. Description of Study Area of Hawassa Town

Hawassa city is purposively selected for study because it is the capital city of the region and several public buildings are situated in the city. Universities school buildings, administrative buildings, referral hospital and residential apartments are available.

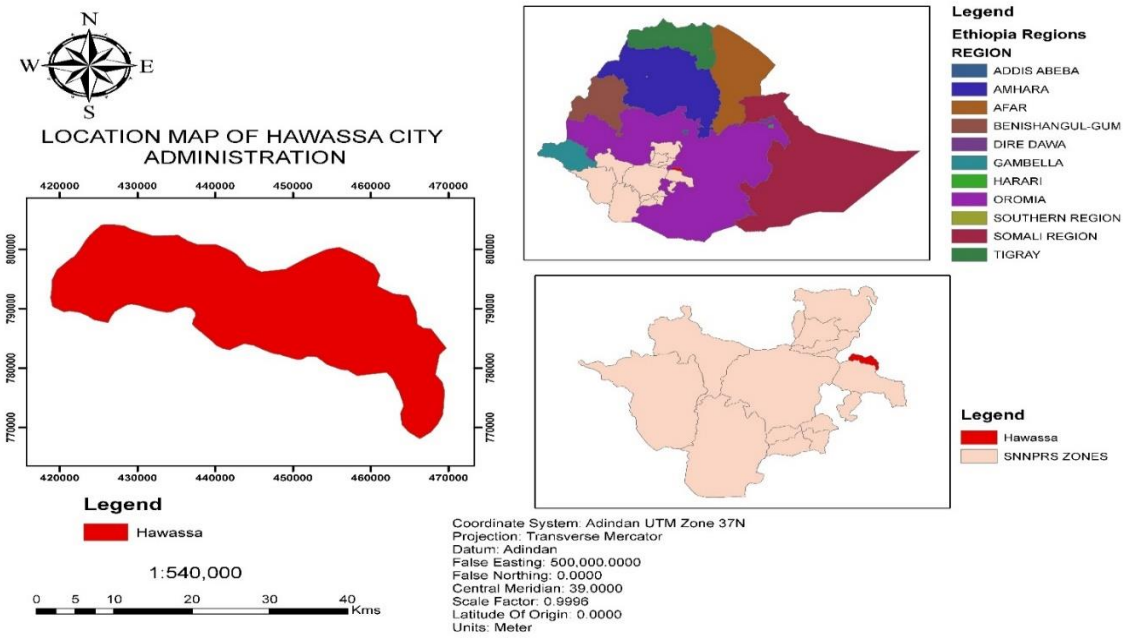


Figure 3.2 Location map of Hawassa city administration (City Land Administration , 2014).

Hawassa is a young emerging city established as the capital city of southern nation's nationalities and people (Hawassa City Administration, 2017). Hawassa can be considered as one of the best developed cities in the country. So far there is remarkable progress in the socio economic development with an integrated effort of government bodies, residences and other organizations in Hawassa and abroad since its establishment.

Currently Hawassa City consists of 8 sub cities and 32 villages/kebelles each having its own administration. The sub cities are listed below:

1. Misrak sub city
2. Menaheria sub city
3. Tabor sub city
4. Mahal Ketema sub city
5 .Haik Dar sub city
6. Addis Ketema sub city
7. Bahel Adarash sub city
8. Hawella Tulla sub city

Each sub city consists minimum of 2 and maximum of 12 villages. The City with an estimated area of 157.21 square kilometers and population of 369,781(2016 projection), is one of rapidly growing urban centers in Ethiopia (Central Statistics Agency, 2014).The City is located at 273 km south of Addis Ababa at absolute Location: 7’29’’ latitude, 80'29" longitude.

3.6 Data Collection

In this study different tools like interviews, case study and desk study by preparing respective checklists of defect types, & desk study are used to collect all relevant data to respond the research questions.

3.6.1. For the interview

The responses from all the research questions and supplementary information were searched from key informants in order to deepen the findings of the case study and desk study. A total of 39 informants were contacted. Among these 13 were interviewed and others were addressed in accordance with interview schedule. All the interviewee were general managers and building administrators. Other informants were facility team. The interview schedule was consisting of four main questions as enumerated from No. 2 to 5, Question 1 being inquiry about the informants’ profile. The questions (2-5) focus on the following issues which are put in the annex A1.

Question No. 2 is focused on identifying the main defects and sources of defects in buildings in the occupancy stage of buildings. These questions are intended to achieve the 1st specific objective of a research to find out whether main defects are purely identified.

Question No.3 focused on whether a formal defect maintenance management system is in place for the selected buildings in SNNPR. If not, "What are economical, functional, environmental and social consequences defects on buildings and how it is managed?", and "what are the reasons for not establishing a system?" are the questions raised for the key informants. These questions are intended to achieve the 2nd and 3rd specific objectives of the research to assess whether building defects are managed with formal defect maintenance management system and economical, functional, environmental and social consequences of effects of defect on buildings.

Question No. 4 deal with assessment of existing practices on how defects maintenance management handled. The instruments employed to manage defects, whether there are experiences to restore damages by parties(Contractor, designer or client) if warranty period is issued, the practice in managing defects in buildings arising from force majeure are the questions raised to the informants. These questions are intended to achieve the 3rd specific objective of the research to evaluate building defects maintenance management practices.

Question No. 5 look into the existing practices to reduce defects in buildings and improve maintenance management practices, the reason to adapt the practice, and explores the opinions of informants on different maintenance strategy concepts. These questions are intended to achieve the 4th specific objective of the research to assess reduction/mitigation of building defects, and improve maintenance management practices.

The following steps are followed in preparing the semi-structured questionnaire for the interview schedule:

i. *The general purpose and specific requirements are first determined:* The general purpose of the interview is to assess the practices and perceptions of key informants who influence the process of defect maintenance management, and building defect maintenance management in particular. The specific requirements are focused on performances of selected buildings in SNNPR.

ii. *The questions that need to be asked are then developed:* Semi-structured questions with open and closed-ended questions are formulated so that they can generate relevant answers to the research questions.

iii. *The questionnaire is structured in two main parts:* The first part is a covering letter with information about the research project, contents of the questionnaire, and how the responses will be utilized. The second part is the questionnaire.

The type of sampling to be adapted for this research is purposive sampling. The key informants targeted for this research are professionals from Building Facility Management and contract implementation departments of selected building project. Those professionals who specifically worked in building facility management and contract implementation departments are selected for the interview. Accordingly, 13 key Informants are to be interviewed with pre-distributed questionnaire.

3.6.2. Case Study

- Case study of 3 towns namely Hawassa, Dilla and Arba Minch were selected with defect experienced projects of health Centre, educational buildings, and residential buildings are taken to identify main defects observed and maintenance management practices at the occupancy stage of buildings. Defect exposure (experienced) building projects are projects that are usually defect experienced under occupancy in more of their service life.
- In order to obtain answers for the 1st and 2nd research questions, study of cases of projects under occupancy are chosen as one of the tools to find out the answers. The approach used to select samples/projects for the case study is Non probability of sampling (Criterion-based sampling) in which, a case that serves the real purpose and objectives of the research is selected. Thus, 13 building projects which experienced building defects selected. In Hawassa six building projects were taken as a capital city of the SNNPRS occupying many public building projects, four building projects from Arba Minch which is located south west of SNNPRS and three building projects from Dilla is located at south east of SNNPRS.

- Observation (notice using a full range of appropriate senses); of selected building projects will also enable to identify main defects on buildings.

3.6.3. Desk Study

The 3rd and 4th research questions examine "what are the current practices to maintain building projects?" and "what are the possible remedial measures to be taken to minimize building defects and improve maintenance management practices?" respectively. Desk study was chosen as one of the instruments to assess the practices from relevant studies, reports and documents.

3.7 Data measurement

In order to be able to select the appropriate method of analysis, the level of measurement must be understood. For each type of measurement, there is/are an appropriate method/s that can be applied and not others. In this research, ordinal scales are used. Ordinal scales as shown in the tables are a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels. Based on Likert scale we have the following tables.

Ordinal scale used for the measurement of rate of occurrence of building defects under occupancy age.

Table 3.0 Rating scale for building defects

Item	Never occur	Low	Moderate	High	Very High
Scale	1	2	3	4	5

Ordinal scale used for the measurement of the importance of factors that affects building defects

Table 3.1 Rating scale for factors affecting building defects

Item	No Impact	Insignificant	Quite Impact	Significant Impact	High Impact
Scale	1	2	3	4	5

Ordinal scale used for the measurement of the effect of the occurrences of defects related problems to determine the key building defect indicators of projects:

Table 3.2 Rating scale for key building defect indicators

Item	No Impact	Insignificant	Quite Impact	Significant Impact	High Impact
Scale	1	2	3	4	5

The procedure used in analyzing the results aimed at establishing the mean score of the various parameters of construction defects. The score for each factor is calculated by summing up scores assigned to it by respondents. Therefore, the level of importance as indicated by the clients were used to measure the mean score of each factor.

The mean score (MS) for each variables of construction defect was computed by using the following formula;

$$Msi = \sum (f*s)/N \quad \text{.........} \quad 1$$

Where;

s = score given to each type, effect & reducing measure of building defect by respondents;

f = frequency of responses to each type, effect & reducing measure of building defect;

N=total number of responses in the respective type, effect and reducing measures of building defect.

Table 3.3 Summary number of informants for interview schedule

Towns	**Number of buildings from each town**	**Respondents from each buildings**	**Total**
Hawassa	6	3*6	18
Arba Minch	4	3*4	12
Dilla	3	3*3	9
Total Respondents			**39**

3.8 Reliability and Validity of Data Collection Instrument

Sound measurement must meet the tests of reliability and validity. In fact, these are the two major considerations one should use in evaluating a measurement tool.

In the widest definition, reliability can be described as clearness degree of measurement results from random errors (Cohen et al., 2007). Up to today, lots of reliability coefficients have been recommended for estimating reliability of measurement tools. Alpha coefficient developed by Cronbach (1955), is generally used in acquiring reliability in terms of internal consistency regarding a single test especially in combined measurements. This coefficient is also known as Cronbach's alpha coefficients.

The classification performed by Cohen et al., (2007) was used while interpreting the significance of influence quantities in the study. According to this classification, influence quantities are classified as,

1. Weak between 0.00 and ±0.10

2. Small between ± 0.10 and 0.30

3. Moderate between ± 0.30 and 0.50

4. Strong between ± 0.50 and 0.80

5. Very strong over ± 0.80

In this study Cronbach's alpha coefficients was used to check the reliability of the data collection tool and the internal consistency was indicated according to Cohen et al., (2007) classification.

Validity refers to how fairly you can generalize your findings to other groups or other situations. Also it can refer to the most critical criterion and indicates the degree to which an instrument measures what it is supposed to measure. But the question arises: how can one determine validity without direct confirming knowledge? The answer may be that we

seek other relevant evidence that confirms the answers we have found with our measuring tool (Kothari, 2004).

In this study the researcher applied the following validity strategies to make the research trustworthy and accurate. First comparison between the research findings and the reviewed literature was done to test whether the interview, case study, and desk study support the objectives of the research. Second prolonged time was spent on the visited building projects. In this way, the researcher developed an in-depth understanding of assessment of defects. Third triangulation of data was made; by doing this data was collected through different source (i.e. interviews, observation/site visit and document analysis).

3.9 Method of Data Analysis and Tools Applied

The case study, interview and desk study are analyzed in relation to the theoretical background. The tools used to analyze the interview data is SPSS and excel sheet. These methods of analysis helps to analyze the responses in actual numbers. Accordingly, Frequency distribution is used to distribute the data into categories and determine the number of individual or cases belonging to each category, which are presented in the form of table.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Introduction

This section discusses the findings from the analysis of the data collected. It uses methods of data analysis discussed under the previous chapter. A thorough analysis is done using simple descriptive statistics in terms of percentages and frequencies. Again the mean score ranking is employed in the data analysis. The results and discussion sections of the research is devised in four main parts in line with the objectives of the research and also the sections of the interview questions, cases taken and desk study.

The first part presents the finding for the first specific objective of the research identifying the main defects observed during occupancy stage of buildings. The second part of the results and discussion contains the findings of the interview questions and desk study directed towards investigating economical, functional, environmental and social consequences of effect of defects on buildings. The third part is focused on assessing the current practices of defect identification and maintenance management practices in buildings in the SNNPR. The last part will present providing measures that can reduce building defects and improving maintenance management practices in any building projects under occupancy stage.

From the interview questions, responses from all the research questions and supplementary information are searched from key informants in order to deepen the findings of the case study and desk study. The case study is conducted in three towns; Hawassa with six buildings, Arba Minch with four buildings and Dilla with three buildings. From Hawassa more buildings are included in the case study due to capital city of SNNPRS and many public buildings existed. From the desk study thirteen buildings under occupancy are surveyed in the selected towns of SNNPRS. During the desk study the actual maintenance cost of a building defect in the occupancy age is investigated. This helps to know the economic impact of defects on the buildings.

4.2 Defects in building projects under occupancy

Several literatures identified major defects of building under occupancy from different perspectives. Wordsworth (2001) described the most common type of building defects that can exist on building elements are as follows;

- Cracking
- Unstable Foundation
- Deterioration of Roof Covering
- Internal Staining, mould growth and fungal on external wall
- Dampness
- Peeling Paint
- Leakage
- Defects in doors, windows and external appendages
- Insect or Termite Attacks
- Defective Plaster Rendering
- Defects in Building Services Installation and etc…

The Informants were asked to identify the common types of building defects under occupancy stage and their probable causes. In order to rank the defects, the questions were formulated to seek responses in terms of probability of occurrences and causes of defect on buildings. The responses obtained are shown in the next sections.

4.2.0 The General Information of respondents and interview response

In this research a total of thirty nine (39) interview schedule were distributed to the client or owner; the general response rate for owner was 79.5% and Table 4.1 below shows the summary of questionnaires distributed and the responded rate.

The profile features of the respondents for this study had three components, namely, level of education, position in the company, and experience in the building projects shown in Table 4.0. The educational level of the respondents was also examined. From the majority of the respondents Bsc holders dominated the study with 67.7%% from owners.

Table 4.0: Profile of survey respondents

Profile		All building projects	
		Frequency	**Percent (%)**
Education	Diploma	3	9.7
	B.sc Degree	21	67.7
	Msc Degree	7	22.6
	PhD	0	0
Position	General Manager	4	12.9
	Building Administrator	11	35.5
	Facility Manager	16	51.6
Experience	Less than 5 years	5	16.1
	5 to 10 years	16	51.6
	Above 10 years	10	32.3

Table 4.1: Summary of interview schedule distributed and responded

Category	Number of interviews Distributed		Number of interviews Returned	
	Number	Percentage (%)	Number	Percentage (%)
Client (Owner)	39	100	31	79.5
Total		100		79.5

4.2.1 Types of defects from interview respondents

The informants' responses with regard to types of building defects are shown in table 4.2 below. The numbers indicated in the table are the actual number of responses that fall in same category.

Table 4.2 Common types of defects observed during occupancy stage of buildings.

Building Defects	Rate of Occurrence					MSI	Causes of defect			
	1	2	3	4	5		Design Problem	Sub-surface deficiency	Construction deficiency	Material deficiency
1. Cracking	8	6	15	2	-	**2.35**	4	-	12	15
2. Unstable Foundation	19	8	3	1	-	**1.45**	16	8	7	-
3. Deterioration of Roof Covering	2	6	7	8	8	**3.45**	4	-	12	15
4. Internal Staining, mould growth and fungal on external wall	6	10	10	4	1	**2.48**	11	4	11	5
5. Dampness	3	4	4	8	12	**3.71**	2		13	16
6. Peeling of Paint	3	-	9	13	6	**3.61**	-	-	16	15
7. Leakage	3	2	10	16	-	**3.26**	7	-	9	15
8. Defects in doors, windows and external appendages	2	4	12	13	-	**3.19**	14	-	7	10
9. Insect or Termite Attacks	9	7	8	7	-	**2.42**	-	-	15	16
10. Defective Plaster Rendering	6	9	10	6	-	**2.52**	-	-	16	15
11. Defects in Building Services Installation	12	8	7	2	2	**2.16**	4	-	18	9

1=Never occur **2**=Low **3**=Moderate **4**=High **5**=Very high **MSI**=mean score value

From the value of mean scores of these responses, defects are further categorized in the form of defect assessment matrix; i.e. high impact-low probability of occurrence, low impact-low probability of occurrence, high impact-high probability of occurrence, and low impact-high probability of occurrence. The defect matric in Figure 4.1. Below show the impact from the causes and main observed types of defects on building under service age.

Impact		-Dampness -Peeling off paint -Leakage -Defects in building service installation.
	-Unstable foundation -Insect or Termite attacks	-Cracking -Internal staining, mould growth and fungal on wall.
Probability of Occurrence		

Figure 4.1 Types of defects that have impacts on buildings

Percent share of each of causes were calculated as shown below which is almost similar to the SPSS output.

N= $(\sum_{i=1}^{n} xi+\sum_{i}^{n} yi+\sum_{i}^{n} zi+\sum_{i}^{n} qi)$ = 62+12+136+131=**343**

x= number of defects by design problem

y= number of defects by sub-surface deficiency

z= number of defects by construction deficiency

q= number of defects by material deficiency

N= total number of defects

x %=(62/343)*100=**18.08%**

y %=(12/343)*100=**3.5%**

z %=(136/343)*100=**39.9%**

q%= (131/343)*100= **38.2%**

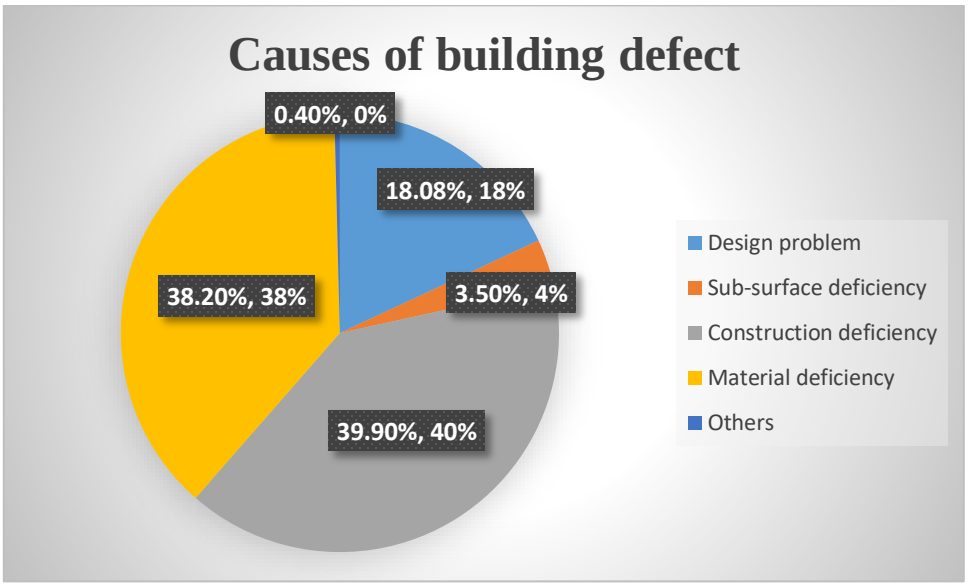


Fig 4.2. Causes of defects by respondents

The matrices reveal that leakage, dampness, peeling off paint and defects in building service installation are identified as major types of defects observed during occupancy stage of public buildings since high probability of occurrence with high impact on the buildings. As seen above from table 4.2, **39.9%** of defects are attributed by construction deficiency, **38.2%**of defects are from material deficiency, and **18.08%** of defects are due to design problem and **3.5%** sub surface deficiency. Therefore, the need to look into the underlying causes of these defects is worthwhile in order to minimize the impacts. Although the causes of defects are interrelated, emphasis is given to major types as the focus of this research lies on identification of major types of defects and maintenance management practice under the service period of a building.

4.2.2 Cronbach Alpha Coefficient Test Result for Reliability Statistics

Reliability pertains to the consistency of scores. The less consistency within a given measurement, the less useful the data may be in analysis. In this study the researcher need to understand score reliability because of the possible impact reliability has on the interpretation of research results. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. Table 4.3 below indicates the result of Cronbach Alpha Coefficient on the effects of rate of occurrence of defects on building projects.

According to the classification performed by Cohen et al., (2007) the result on the table 4.3 indicates that there was strong internal consistency for items in the scale.

Table 4.3: Cronbach Alpha Coefficient Result on the Effects of rate of occurrence of defects

Case Processing Summary

		N	%
Cases	Valid	31	100.0
	Excluded[a]	0	.0
	Total	31	100.0

a. List wise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
0.768	32

4.2.3 Impact of defects

The Informants responses with regard to impact of defects are shown in Table 4.4 below. The numbers indicated in the table are the actual number of responses that fell in same category.

Table 4.4 Impact of defects on economic, functional, and social consequences of buildings under occupancy

No.	Degree of Impact / Types of Consequences	1	2	3	4	5	MSI
1	Disputes among parties if any,	21	10	-	-	-	**1.32**
2	High maintenance cost	-	6	10	6	9	**3.58**
3	Functional failure	-	10	7	8	6	**3.32**

4	Additional expense for residences	6	10	10	5	-	**2.45**
5	Depreciation of assets	7	-	13	8	3	**3.00**
6	stress and health impacts	-	8	14	7	2	**3.09**

1= No impact 2= Insignificant 3= Quite impact 4= Significant impact 5= Major impact MSI=Mean Score Value

From the value of Mean scores of these responses, types of consequences are further categorized in the form of impact-consequences matrix; i.e. high degree of impact-low probability of consequence, low degree of impact-low probability of consequence, high degree of impact-high probability of consequence, and low degree of impact-high probability of consequence. The consequence matrices shown in Figure below, are drawn in order to see the impact of defects on buildings.

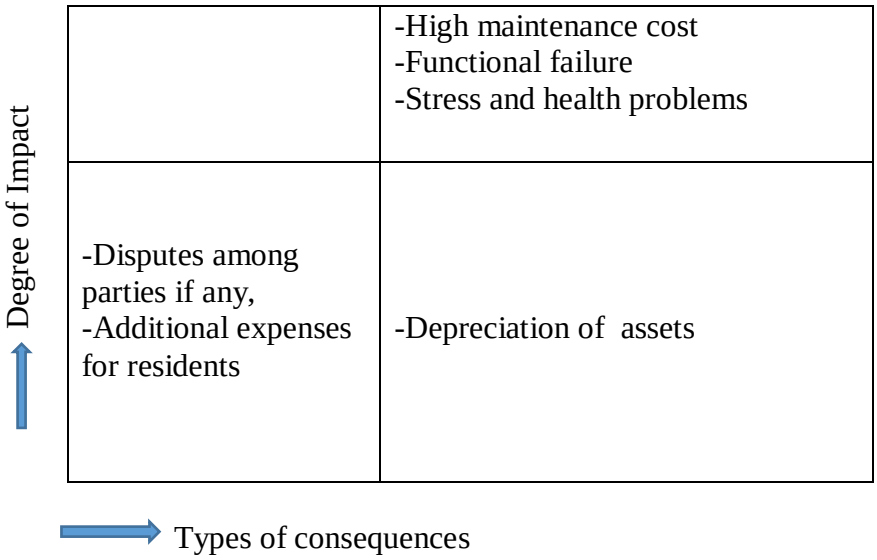


Figure 4.3 Matrices of degree of impact

It can be learnt from the matrices that:

- High maintenance cost,
- Functional failure,

- Stress and health problems are of high impact-major consequences, and these

Consequences subject to building failure and indicate poor maintenance management practices. Therefore, the need to address these consequences, in particular, and building defect consequence in general is paramount in order to minimize the impacts. Particularly in health centre buildings defects lead to stress and health problems which affects the society at large by creating unsightly appearances in patient rooms.

Table 4.5 Do you have, as an owner, a defect maintenance management technique in your company?

Company's maintenance management technique	**Yes/No**
1. Hawassa comprehensive referral hospital building	No
2. Arba Minch hospital building	Yes
3. Dilla hospital building	No
4. Hawassa city administration building	No
5. Ethio-telecom building	Yes
6. Dilla university administration building	No
7. Hawassa university main campus school building	No
8. Arba Minch institute of technology school building	No
9. Dilla university school building in semera campus	No
10. Arba Minch university staff residential (Ethio-fishery) building	No
	No

11. Hawassa university staff apartment in main campus	
12. Arba Minch institute of technology dormitory building	No
13. Hawassa university main campus dormitory building	No

From the building maintenance practices, questions formulated to know the existing practices in the area shows that 85 % (11) out of 13 buildings, there is no defect maintenance management technique. All owners of public buildings need maintenance management plan to be outsourced to designers.

The practices adapted to improve maintenance management and reduce building defects in all cases of thirteen buildings are as follows;

Table 4.6 Percentage of maintenance strategies taken in case study buildings

Maintenance Strategies	**Numbers**	**%**
Preventive maintenance	1	7.7
Corrective maintenance	6	46
Routine maintenance	4	30.8
Others	2	15.5

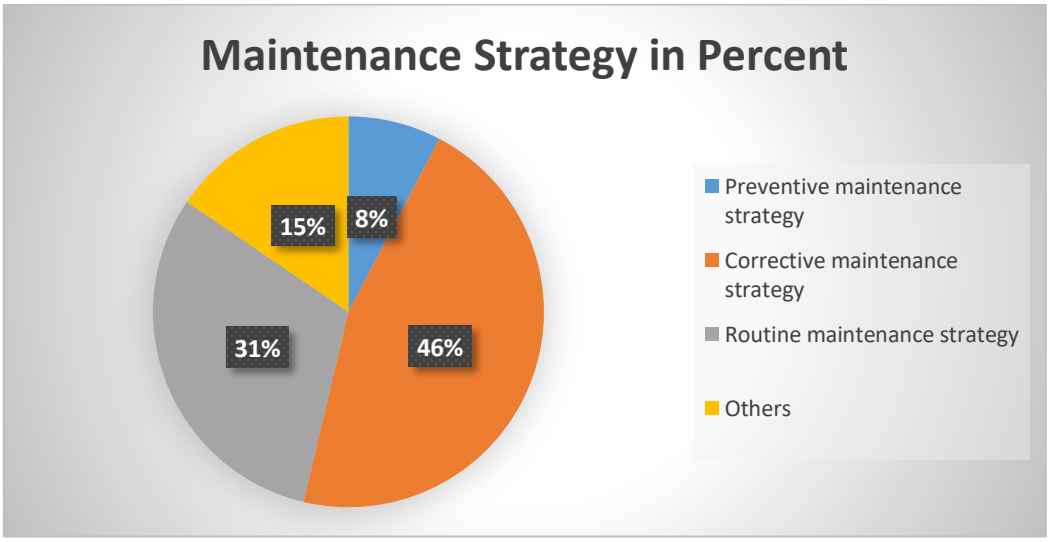


Figure 4.4 maintenance strategy technique in selected buildings

As seen from the pie chart the most adapted techniques by buildings are corrective maintenance strategy followed by routine maintenance strategy. Which implies that maintenance is done after problem appeared and this in fact lead to high cost.

Besides the interview, case studies are undertaken to further examine whether defects are contributory to the failures of buildings at the occupancy stage; maintenance practice. The findings are discussed hereunder with an introduction of overview of selected public buildings in SNNPRS towns.

4.2.4 Result and Discussion of the case study

During case study which is done on thirteen buildings are organized in table 4.7 to 4.12, a total of 260 building defects are recorded. The record was done based on the prepared checklist for each building. The buildings are of type health centers, school buildings, administrative and residential. Numbers of buildings in each town are situated as per scope and location. Defect types are categorized under defect on walls/floors finishing; defects on roof; defects on slab, beam and column and defects on doors. Peeling of painting and seepage or leakage underside of roof are the most frequent types of building defects observed in all case study buildings. Most of the time peeling off painting and seepage or leakage underside of roof becomes a danger to building and it can create plenty of problems and might cause building failure. The next frequent defects are dampness on concrete structures, broken doors, hinges, latch/lock and distortion of roof or wall at roof level observed on 12 buildings.

Buildings can be categorized under health centre service buildings, administrative buildings, school buildings and residential buildings consecutively.

The case studies under health centers are discussed as follows with on-site observation on the buildings. The existing floor finish material used in the main buildings of health centre under study in Hawassa comprehensive referral hospital is of three types which are terrazzo tile, PVC tile & monolithic terrazzo floor finish. Monolithic terrazzo tile is used at the main entrance & waiting area of a block under study in the hospital.

Figure 4.5 Damaged ceramic wall cladding and terrazzo tile in Hawassa referral hospital (image taken by the researcher).

Additionally, it is also used at the circulation area of inpatient blocks. The floor tile is extremely damaged, patches exist here & there. Terrazzo floor finish is used for the corridors of all the blocks. Moreover, terrazzo floor finish is also used for wet area (toilets, showers etc.). As per observation the terrazzo floor finish used for the corridor is in a good condition. But the floor tiles at wet areas are extremely damaged. Terrazzo floor finish is also used as a floor finish for all the balconies in all buildings. It is extremely damaged at these areas, since it is exposed to moisture.

Figure 4.6 damaged ramp Figure4.7 Corroded PVC tile in hospital (image by researcher)

Moreover, the entire floor finish used in the cafeteria is terrazzo f.f. & it is severely damaged. In some toilets, the floor is modified by overstepping the floor for putting Turkish

Seats. These toilets shall be modified to properly finish with a ceramic floor finish. This is the same in the case of Arba Minch hospital.

Building resistance to moisture seepage should be enhanced by using different mechanisms. Like providing damp proofing materials at areas which will often experience moisture. Not only the mechanisms but also method of maintaining damp proofing work is very important to prevent moisture leakage. This is because usually this type of defect is attributed by poor workmanship and material deficiency. Spalling and dampness of concrete are observed on almost in all types of buildings which is implication of leakage and leads building failure.

Ethio-fishery staff apartment located in Arba Minch is experienced with cracks and settlement effect. This is because of sub-surface deficiency. Some cracks observed in Hawassa buildings are, due to 4.2 rector scale earthquake happened in 2008 E.C (Mathew, Atalay, & J.Michael, 2016).

Ethio-telecom building was one of the cases visited and practices were observed on it. Almost all cracks on the building was seen after earthquake incidents. There was also poor quality of damp proofing membrane on roof and it causes for related building defects like dampness, leakage, peeling of paint and etc.

When assessing Dilla hospital building, defects are increased and forced to restore it by preparing temporary shelter for inpatients, doing expansion work as well. In addition to maintenance cost, the cost of temporary shelter is very significant.

Figure 4.8 Damaged damp proof membrane on concrete slab roof in ethio-telecom building in Hawassa (Image taken by researcher).

Figure 4.9 Damaged PVC floor finish at wards inpatient blocks in Dilla hospital building (Image taken by researcher).

Table 4.7 Summary of defect with foundation related, from case study under occupation

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Subsurface deficiency**
Settlement	-	-	-	1
Subsidence	-	-	-	-

Table 4.8 Summary of building defects on slab, wall, beam and column from case study under occupation.

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Subsurface deficiency**
Cracks on beam	-	-	1	-
Cracks on column	-	-	-	-
Cracks on wall	-	2	4	-
Cracks on slab	2	-	-	-
Excessive deflection on beams and/or slabs	2	-	-	-
Spalling of concrete	1	6	4	
Dampness on concrete structures	-	5	4	-
Exposed steel reinforcements	-	-	-	-

Table 4.9 Summary of building defect of roof from case study under occupation

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Sub-surface deficiency**
Improperly sloped gutters /down pipe	6	2	5	-
Damaged or missing gutter/down pipe	-	3	3	-
Seepage or leakage underside of roof	3	2	5	-
Distortion of roof or wall at roof level	5	4	4	-
Damaged roof trusses	2	2	5	-

Table 4.10 Summary of building defects related with walls/floors finishing from case study under occupation

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Subsurface deficiency**
Broken or loose tiles on floors or wall	-	7	5	-
Detachment of plastering	-	8	-	-
Displacement of walls	-	1	-	-
Water damage on walls or floors	3	3	7	-
Unevenness floor finishing	6	2	5	-
Unevenness wall finishing	1	5	5	-
Peeling of painting	1	8	4	
Dampness on wall/ground floor	2	6	5	-
Defects on stairs rise and width	3	3	2	-

Table 4.11 Summary of building defects of doors and windows from case study under occupation

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Subsurface deficiency**
Broken doors, hinges, latch/lock	2	7	4	-
Broken window glazing, frames	2	7	3	-
Water seepage through windows /doors	3	4	1	-
Gap between door/window edge & wall	1	1	2	-
Broken /absence of window sill	-	3	1	-
Slanted window/door frames	3	1	1	-

Table 4.12 Summary of building defects of service installation from case study under occupation

Observed Defects	**Causes of defects**			
	Design problem	**Material deficiency**	**Construction deficiency**	**Subsurface deficiency**
Signs of leaks or clogged drains	2	2	1	-
Broken or leaking water supply fixtures	1	2	-	-
Broken waste water removal fixtures	1	-	1	-
Defects on kitchen fixtures	-	1	-	-
Defective shower or water fixtures	3	5	2	-
Inadequate pressure at fixtures	4	2	1	-
Uncovered manhole	-	1	7	-
Electric wires not properly protected	2	2	-	-
Uncovered junction boxes	1	1	-	-

For case study, the frequency table of SPSS output ranked the observed defects accordingly. From the table most frequent defects are seepage or leakage underside of roof, peeling of painting; dampness on concrete structures; distortion of roof or wall at roof level; spalling of concrete. Among causes of defects, from SPSS output **36.9%** are observed to be from material deficiency, **44 %** from construction deficiency, **18.5 %** defects are from design related problem while subsurface deficiency is insignificant for appearance of defects. The categorizations are also done by using following formula.

N= $(\sum_{i=1}^{n} xi + \sum_{i}^{n} qi + \sum_{i}^{n} zi + \sum_{i}^{n} yi)$ = (48+96+115+1) =260

x= number of defects by design problem

q= number of defects by material deficiency

z= number of defects by construction deficiency

y= number of defects by sub-surface deficiency

N= total number of defects recorded

x %=(48/260)*100=**18.5%**

q%= (96/260)*100= **36.9%**

z %=(115/260)*100=**44%**

y%-insignificant

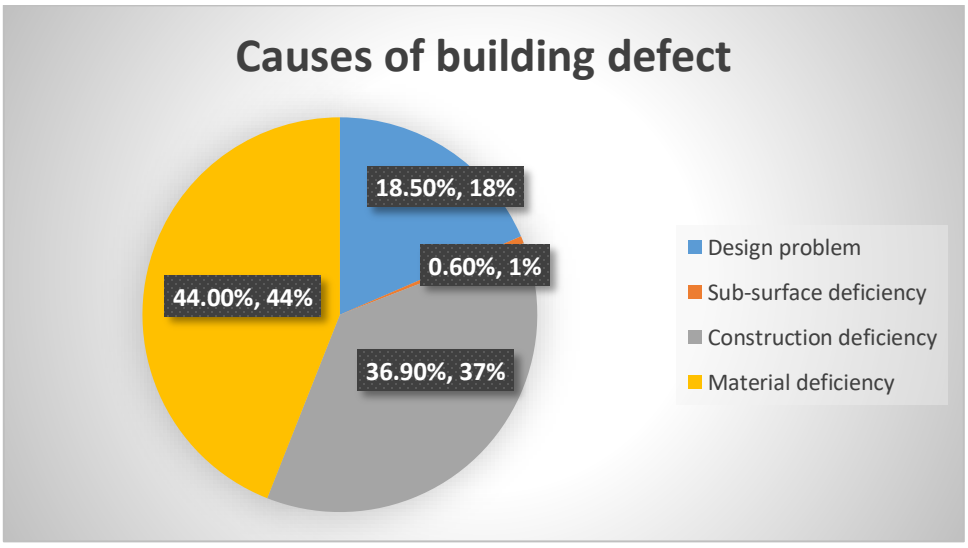


Figure 4.10 Causes of building defect in percent by case study.

Some of the defects, which are ranked as the most observed ones are explained and respective causes are discussed below.

1. Seepage or leakage underside of roof

In Hawassa hospital building, the roof is made of EGA roof cover & concrete roof. The outpatient block is mainly of concrete roof, while the other blocks are of both roof types. The concrete roof in these blocks is provided basically for the purpose of placing the water tankers. The EGA roof cover is corroded around edges. Moreover, some of the washers are dismantled. The concrete roof has a proper slope. But the waterproofing membrane is faded & looks old. Especially around AC machine & parapet walls, the membrane is extremely damaged and loose. The concrete gutter is coved by metal sheet. Since it has worked for so long and it is damaged because of long term decay of dirt & tree leafs. The flashing is observed as loose in some places which enhances leakage underside of the roof. At roof level the ceiling show dampness in most areas mainly because of the impaired waterproofing on the concrete roof.

Figure 4.11 Damaged EGA roof cover at inpatient block in Hawassa referral hospital building (pictures taken by researcher).

Figure 4.12 Damaged water proofing membrane Figure 4.13 Leakage effect underside roof in Dilla building (pictures taken by researcher).

2. Peeling off painting

Three types of finishes are used for the external wall of all case study buildings. Most of a building wall is treated by plastering & paint. The paint on most of the wall is extremely damaged because of natural causes like rain & etc. Some minor (hair) cracks were observed on the plastered face of the wall. Some spaces at front & side are marble cladded. During the visit, it is noticed that some of the claddings are peeled off. The third wall material is masonry. Some part of walls is made of masonry wall to enhance & decorate the building. Since the masonry was sculpted nicely, pointing was not done. This leads the wall to not be water resistant. And as a result, wet looks were observed even in the internal face of the wall. Ceramic wall claddings are used in wet areas. The walls in most of the toilets are peeled off. Additionally, most of the claddings in the toilet are damaged.

Figure 4.14 Damaged plastered and fallen off marble cladding at referral building (pictures taken by researcher).

3. Dampness on concrete structures

Dampness in most of buildings were identified due to leakage through roofs and window sills. It affects the structural part of buildings like slabs, columns, and beams which promotes building failure if not treated timely. Wall dampness is also observed in most buildings.

Figure 4.15 Internal dampness in ethio-telecom building in Hawassa (pictures taken by researcher).

4. Broken doors, hinge, latch/lock

In all case study building, most of the internal doors are wooden doors. Aluminums are used for recently replaced doors only. All the wooden doors are covered by rubber sheet for protection & to reduce contamination. And in most doors the rubber sheets are peeled off. But mainly there exist damage on the wooden doors itself like hinges, frames, handle & locks, etc. There are also dismantled doors in some areas. So major maintenance shall be done to damaged doors & the rubber sheet shall be changed accordingly. All the external doors are LTZ doors. They are extremely damaged & corroded etc.

Figure 4.16 Broken doors, hinges, latch/lock (picture taken by researcher).

4.2.4. Results and Discussion of Desk Study

During desk study thirteen buildings are selected and evaluated their actual service period with their maintenance management practice. In most of buildings, there is no proper documentation system for buildings under occupancy for their actual service period. Once the contract period is completed, the contract documents is not handled properly for further maintenance purpose. As built drawings are not considered for the ongoing maintenance purpose. Almost in all buildings as-built drawings are not existed. Data related to building types, occupancy period, maintenance cost, maintenance management practices done on that buildings are tabulated below.

Table 4.13. The maintenance practices of buildings in selected buildings of SNNPRS

No.	Selected SNNPR towns buildings	The service year	Frequency of major maintenance for the building since service period.	Maintenance costs incurred in the activity(Birr)
1.	Hawassa Comprehensive specialized Hospital	14 years	One time	207,129,054.18
2.	Ethio-telecom	9 years	One time	1,952,225.00
3.	Dilla university school building and administration building maintenance	9 years	One time	59,749,141.18
4.	Arba Minch Ethio-fishery staff residential buildings	8 years	One time	1,610,906.99
5.	Arba Minch main library roof maintenance work	20 years	One time	2,826,842.60
6.	Converting classrooms to offices in Arba Minch University	20 years	One time	3,316,929.82

From table 4.13 above of desk study (document analysis) clearly shows that frequency of maintenance practice in all buildings under occupation (service period) in the SNNPRS is once in the service period. This bears huge amount of maintenance work to be done on such buildings at a time and indicating poor corrective maintenance with high maintenance cost. The reason for poor maintenance management practices is that there is no scheduled maintenance program (techniques). Periodic maintenance should be applied as a defect reducing measures.

4.3 Triangulation of results

Analysis above clearly shows results of interview response, case study, and desk study. Results of interview responses shows that the frequent defects identified are ranked as dampness, peeling of painting, leakage, defects in building service installation and roof deterioration. While case study shows seepage or leakage under roof, peeling of painting, dampness, distortion of roof and spalling of concrete took the first five ranks of defects types building under occupancy.

Interview questions analysis show that **39.9%** of defects are attributed by construction deficiency, **38.2%** are due to material deficiency and **18.08%** of defects types are caused by design problem while **44%** of defects are caused by construction deficiency, **36.9%** of defects are attributed by material deficiency, and **18.5%** of defects are caused by design related problem during case study analysis. Both in the interview result and case study analysis, construction deficiency is identified as major causes followed by material deficiency observed in the public buildings under occupancy.

More or less the two methods have similar indications on identified defects and their causes. Corrective maintenance strategy is the mostly adapted techniques in the interview result analysis which bears high maintenance cost. Desk study depicts that public buildings do not have frequent maintenance practice.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This research project focused on four specific objectives: identifying the main defects observed; investigating economic, functional, social consequences of effect of defects during operation/occupancy stage of buildings; assessing the current practices of maintenance management of buildings, and providing measures that can reduce building defects and improve maintenance management practices in any building projects. The following conclusion and recommendations are, therefore, presented in line with the specific objectives designed to meet the main objective.

5.2 Conclusion

The results obtained in the analysis of the interview questions, case studies and desk study have been discussed and presented in the previous chapter. Therefore, based on the results from the analysis, the following major conclusions have been derived and summarized below.

Specific research objective one:

- The first specific objective was to identify the main defects and sources of defects observed on buildings during operation/occupancy stage. From case study results and interview responses, main types of defects were identified as seepage or leakage underside of roof; peeling of painting; dampness on concrete structures; broken doors, hinges, latch/lock; distortions of roof or wall at roof level took the priority at buildings under occupancy while foundation related defect, displacement of walls, defects on columns are rarely appeared defects. As analyzed in chapter four the main causes of identified defects are 41.95% from construction deficiency, 37.55% from material deficiency and 18.29% from design related problems as an average of two analysis.

Specific research objective two:

- The second specific objective was to investigate economic, functional, and social consequences of defects on buildings. Economic, functional and social consequences of impacts of building defects under occupancy from respondents show that maintenance cost and functional failure depicts high degree of impact with large consequences. From desk study results from table 4.13 of chapter four, it is seen that large amount of cost is invested for maintenance at a time. If not treated, that creates a failure in the function of a building. Especially leakage observed in the roof in health centre buildings create health stress on patients. For such public buildings, the government plan to maintain and restore buildings. During maintenance period, the owner forced to build temporary shelter for patients which incur additional cost.

Specific research objective three:

- The third specific objective was assessing the practices of maintenance management of public buildings under occupancy in SNNPRS. This is evaluated through interview questions, case study and desk study. It enabled data to be triangulated and forward a good conclusion. Among the study in all cases, poor maintenance practices are existed on public buildings. Once in 8 to 20 years of occupancy have only given maintenance in almost all selected building projects.

Specific research objective four:

- The last objective was providing measures that can reduce building defects and improving maintenance management practices. Based on the interview and desk study analysis building client are forced to apply corrective maintenance technique but clearly mentions preferring period maintenance and routine maintenance strategy for non-structural defects. This is due to absence of maintenance strategy plan by the client.
- In general defects in public buildings under occupancy are existed but given insignificant attention for maintaining and keeping it from failure. Even if most of defects are minor, the collective effect after a period of time may bring total failure.

5.3 Recommendations

The following recommendations are made based on the findings in this research and are forwarded to stakeholders and practitioners in the building construction industry to reduce defects and improve maintenance management practices in public buildings.

- Material deficiency and construction deficiency is identified as the major causes of building defects. So, in order to minimize the problem, the material supplier shall act correctly according to material specification. In addition during construction phase, all stakeholders shall pay due attention in testing materials quality. This can reduce the defects on buildings under occupancy stage. In the same way, poor workmanship is the main reason of construction deficiency. Well-trained labors should be deployed during construction phase of a building.
- The poor building maintenance practices subjects to unexpected amount rework cost. So, to prevent from such damage, periodic maintenance shall be recommended for public buildings under occupancy keeping in mind that routine maintenance shall be in progress.
- Buildings shall have maintenance directory so that maintenance report can be easily accessed. And the building condition can be followed in any time. When needed maintenance BOQ report is easily retrieved from the directory and can know the maintenance severity at any time of a building.
- As built drawing should be well documented for maintenance purpose of a building under occupation.

5.4 Suggestion for Future Study

1. Future research efforts need to focus on actual rework cost for building defects maintenance under occupancy in comparison with other countries.
2. More towns and buildings need to be included for strong conclusion about assessing defects and improving maintenance practices in the region.

REFERENCES

A.I.Hussain, A. (2011). Performance Assessment of Maintenance Practices in Government Office Buildings.

Abdul Rahman, H., Thompson, P., & Whyte, I. (1996). Capturing the Cost of Non-conformance on Construction sites-An Application of the Quality Cost Matrix ,. *International Journal of Quality & Reliabilty Management,*, 13(1), 1996, 48-60.

Abreu et al, ,. J. (2013). *Business Processes Improvement on Maintenance Management* . Procedia Technology.

Ahmad, A. (2004). *Understanding Common Building Defects:The Dilapidation Survey Report.* Penang: Universiti Sains Malaysia,.

Ahmad.A. (2000). *Management System in Maintenance of infrastracture.* . Kadina,Nigeria: Fahmta Publishing Company.

Akasah, Z. A. (2007). *school building maintenance strategy:PhD Thesis.* Malaysia: Universti Teknologi.

AL-Hammed, A.-H.-M. (2014). Assessment of Architectural Defects Attributed to Lack of Maintenace feedbach to the Design Team. pp.132-138.

Arditi, D., & Nawakorawit, M. (1999). Designing Building For Maintenance:Designers' Perspective. *Journal of Architectural Engineering*, 107-108.

Association, B. N. (2012). Construction Practices and Safety Code. pp. 7-69.

Atkinson, A. (1999). The Role of Human Errors in Construction Defects , Structural Survey ,. *Journal of Engineering Science*, 17(4):231-236.

Awang et al, M. B. (2011). Facilities Management Competency Imperatives to Realize Polytechnic Transformation Goals. *Proceeding of the International Conference on Management (ICM 2011)*, 480-496.

Awol et al, D. I. (2016). Assessment on Causes of Defects and the Maintenance Management Practices on Low Cost Buildings. *International Journal of Engineering and Science*, Volume -5,Issue-3 July 2016.

Bedru, M. (2015). *Study of Construction Defects in Public Building Projects in Addis Ababa.* Addis Ababa: AAU.

Belaynesh, N. (2015). *The Study of Building Facilty Management Practices in Higher Institutions.* Bahir dar.

Booty, F. (2006). *Facility Management/3rd edn: Oxford : Butterworth-Heinemann.* London: Oxford.

Bryan A., G. (1999). *Black's Law Dictionary:7th edition.* Texas: West Group;.

Central Statistics Agency. (2014). *Population Projectionof Ethiopia from all Regions at Wereda Level-www.csa.gov.et Retrieved 2016-08-25.* Addis Ababa: Central statistics office.

Chanter, B. a. (2008). *Maintenance Organization in Building Maintenance Management.* London: Blackwel Science.

Cheun., T. W. (2008). *School building defects* . Malaysia: Universiti Teknologi.

Chong, O., & Low, S. (2005). Assessment of defects at construction and occupancy stages. *Journal of Performance of Constructed Facilities* , 19(4), 283-289. https://doi.org/10.1061/(ASCE)0887-3828(2005)19:4(283).

City Land Administration . (2014). LAND ADMINISTRATION. *Tetra Tech.*

Construction Indutry Institute. (2005). *Making Zero Rework A reality: RS 203-1 (Nov.),The University of Texas at Austin.* Austin: TEX.

Corridor, O. (2017). *Common Building Defects . Causes, Types. and Examples.* Munich: Grin Publishing.

Creswell, J. (2009). *Research Design: Qualitative, Quantitaive, and Mixed methods approaches: 2nd.* California: Library of Congress Cataloging-in-Publication Data.

D. A., & Gunaydin, H. M. (1997). International Journal of Project Management. Vol.15.No 4,. pp .235-245.

David, S. (2007). *Building Pathology, Second Edition.* London: WILEY BLACKWEL.

Debela, M. C., & Muhye, H. K. (2017). *Water supply and demand scenario of dilla town ,southern ethiopia.* Dilla.

Department of Finanace and Economy. (2014). *Department of Finanace and Economy Development of Gamo Gofa Zone.* Arba Minch.

Deris, M. S. (2007). *Tahap kaberkesanan pengurusan penyeggaraan Faciliti* . Universiti Teknolgi Malaysia .

Douglas J., R. B. (2006). *Understanding Building Failures.* London: Talor and Francis.

Dunn, D. (1999). *The Practical Researcher: A Student Guide to Conducting Psychological Research.* Pennsylvania Plaza: McGraw-Hill College.

Duran, O. (2011). Computer-aided Maintenance Management Systems Selection Based on a Fuzzy AHP Approach. *Advances in Engineering Software* , 42(2011), 821-829.

Felicity, I. (1995). *Measuring Up Or Muddling Through: Best Practice in the Australian Non-residential Construction Industry,.* Sydney: Construction Industry Development Agency, 1995.

FindLaw. (2012). Types of construction defects. *Retrieved October 15, 2014, from FindLaw:http:/www.realstate.findlaw.com/construction-defect/types-of-constructiondefects.html*.

Gatlin, F. (2013). *Identifying & Managing Design and Construction Defects.* AIA: NCARB.

Gedeo Zone Health Bureau, E. (2014). *Annual report of malaria.*

Geogiou et al, J. (1999). Verification of a building defect classification system for housing. 370-383.

Giang, D., & Pheng, L. (2011). Role of construction in economic development: review of key concepts in the past 40 years. *Habitat Intern 2011*, 35:118-125.

Glover, J. (2000). *Liabilty for Defects in Construction Contracts.* UK.

Government, P. P. (2013). *Quality Management Systems Guidelines for Construction,Third Edition 15 August 2013.* NSW: Procurment Policy Framework of the NSW Government,.

Guenther, R., & Vittori G. (2008). Sustainable healthcare Architecture. *Journal of Engineering and Scince*, Jhon Wiley.

H H. Y.Lee, D. S. (2009). Overview of Maintenance Strategy , Acceptable Maintenance Standard and Resources From Building Maintenance Operation Perspective. *Journal of Building Appraisal*, 269-278.

Hamzah, S. e. (2013). Utilizing Mid-Long Term Maintenance Management Policy for Sustainable Maintenance of Infrastructures Facilities. *Procedia Environmental Sciences, ,* 17(2013),478-484.

Hassan, S. (2010). *Developing Online Help Desk for Politeknik Tuank Sultanah Bahiyah. Master thesis Universiti of Utara Malaysia, Johor.* Johor.

Hawassa City Administration. (2017, 7 17). Retrieved from Hawassa city web-site: http://www.hawassacity.gov.et

Ikpo, I. J. (2006). *Building Maintenance Management* . Calaber ,Nigeria: Manson Publishing Company.

Ismail Z A et al, A. M. (2016). Case study to analyse problems and issues in IBS building maintenance. *International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 1(2016),* pp 226-233.

Ismail Z. (2014). System Development Toward Effective Maintenance management practices. *Built Environment* , 406-422.

J.Cama. (2004). *Who pays to fix building defects?* USA: Berrymans Legal Consultants.

James, D., & Ransom, R. (2006). Understanding Building Failures. 3rd Edition. *Taylor and Francis*, 222-232.

JBCC. (2007). *JBCC Serious 2000:N/S Sub contract agreement edition 5.* Johannsberg: Johannsberg:(JBCC).

Josephson, P. E., & Hammarlund, Y. (1999). The causes and costs of defects in building: A study of building projects. *Autom*, 681-687.

Khan, L. (2013). *The Potential impact of implementing project management strategies.* London: University of East London.

Kunya U S, A. E. (2007). Evaluation of Factors Affecting Maintenance . *European Journal of Educational and Development Psychology*, 30-39.

Lateef et al, O. A. (2010). *Building Maintenance Management in a Malaysian University Campus: A Case Study.* Australasian Journal of Construction Economics and Building, 1(2), 76-89.

Lazim, M. M., & Samad, N. A. (2011). Masalah Melaporkan Kerosakan Komputer di Jabatan Teknologi Maklumat dan Komuniski,. *PTSS Digest*, 206-209.

Lee, H. H., & Scott, D. (2008). Identification of main aspects in management of building maintenance operation processes. *'Surveyors Times' Hong Kong Institute of Surveyors*, 17(6): 37-41.

Lee, R. (1987). *Building Maintenance Management.* Collins.

Leibing, R. (2001). *The Construction Industry: Processes, Players and Practices. Upper Saddle River, .* New Jersey:: Prentice Hall.

Lung, B. E. (2009). Coceptual Framework for E-maintenance. Illustrations by E-maintenance Technologies and Platforms. 220-229.

Lung, B. e. (2009). *Conceptual Framework for E- Maintenance:.*

Macarulla et al., F. C. (2013). Standardizing Building Defects:Classification, Validation and Benefits. *American Society of Civil Engineers*, 139(8), 968-976.

Martinez-Moyamo, I. (2006). *Exploring the Dynamics of Collaboration in Interorganizational Settings.*

Mathew, W., Atalay, A., & J.Michael, K. (2016). *Implications for seismic hazard in the main Ethiopians Rift.* Hawassa.

N.E.M.Nik et al, M. S. (2011). Assessing the Maintenance Aspect of Management through a Performance Measurement System:. *The 2nd International Building Control Conference*, 20(2011) 329-338.

N.E.Myeda. (2012). Tehe Sphere of Performance Measurement in Strategic Facilites Management . *Journal of Facilties Management*, 10(3) (2012).

Nkrumah. (2017). Punlic Building Infrastracture Maintenance Management Practices. *Review Pub Administration Manag 5:*, p 234.

NST. (2005, october 8th). Roof Collapse. Kuantan, Sekolah Menengah sains, Malaysia.

O'Donoghue, C. D., & Prendergast, J. G. (2004). Implementation and Benefits of Introducing a Computerised Maintenaance Management System into a Textile Manfacturing Company. *Journal of Materials Proceeding Technology* , 153-154(2004), 226-232.

Olanrewju, A., & Abdul-Aziz, A. (2015). Building Maintenance Processes and Practices. Malaysia: Springer. *Journal of Management in Engineering*, Pp 12(2), 81-84.

Olawale. Y. & Sun. M. (2010). Cost and time control of construction projects: Inhibiting factors and mitigating measures in practice. Construction Management and Economics. *Construction Management and Economics*, (pp. pp. 509-526). Nottingham trent University.

Organization of American states. (2006). *Maintenance Manual For School Buildingsin the Caribbean.* Maryland: AC Collins.

Plan[2010-2015], E. p. (2010). *Economic planning unit :2010.* Putrajaya.

PMI, M. (2017). *PMBOK GUIDE.* Pennsylvania: Project Management Institute,inc.

Polit, D. F., & Hungler, B. P. (1999). *Research, Principles and Methods 6th edition.* Philadelphia: J.B.Lippincott.

Ransom, H. (2013). *Building Failures Diagnosis and Avoidance ,F.N.Spon ;62.* London: Routledge.

Rendeau, E. B. (2006). *Facility Management, 2 nd edn.* New Jersey:: Wiley and Sons.

Robert, M. S. (2007). *Defect-Free Buildings: A construction Manual for Quality control and conflict Resolution.* Newyork: McGraw-Hill.

RS, U. (2001). *Effects of healthcare Environmental design on medical outcomes.* Stockolm: Syensk Byggitianst.

S.Ali. (2009). Cost Making In Building Maintenance Practice In Malaysian. *Journal of Facilities Management*, 7(4) (2009) 298-306.

Saghatforoush et al, E. T. (2011). Extending Constructability Concept to include Operation and Maintence Issues. *International Construction Business & Management Symposium (ICBMS 2011) Proceeding*.

Sani. (2012). *Determinant factors in developement of maintenance culture in managing public asset and facilities.* Int Cong Interdisc Bus Soc Sci.

Saunders et al, M. P. (2009). *Research Methods for Business Students 5th Ed.,*. Essex,England: Pearson Education Limited.

Seeley, I. H. (2001). *Building Maintenance, 2nd Edition,*. London: Macmillan Publishers plc.

SS-EN13306. (2001). *Maintenance Terminology.* Stokholm: Swedish Standards Institute.

U.S Department of Education. (2003). *National Center for Education Statistics and the National Cooperative Education Statistics System.* U.S.

UK, N. S. (1993). *BS 3811:1993 Glossary of terms used in terotechnology.* London: British Standards Institution.

van den Berg, A., & Wagner , C. (2006). The architecture of Rotterdam. *Healing by Architecture*, 254-7.

Watt, D. (1999). *Building Pathology: Principle & Practice. UK: Blackwell Science.* UK: Blackwell Science.

Wireman T. (1990). *World class maintenance management* . New York: Industrial Press.

Wordsworth, P. (2001). *Lee's Building Maintenance Management, 4th Edition.* Liverpool: Wiley.

Yebichaye, D. (2016). *Building Defects due to Poor Workmanship in Addis Ababa.* Addis Ababa.

Zavadskas E. (1998). Raising the Efficiency of building life time. *Facilities Volume 16, Number 11,* 334-340.

Zulkarnain et al, S. H. (2011). A Review of Critical Success Factor in Building Maintenance management Practice for University Sector. *World Academy of Science ,Engineering and Technology*, 195-199.

ANNEXES

ANNEX A1

Interview schedule

Introduction

This interview schedule is prepared to obtain information from key informants with semi-structured questions. The information is required for the academic research entitled "**Assessment buildings maintenance management practices**" which is being conducted as partial fulfillment of MSc in construction technology and management. The main objective of the research is to assess defects, and maintenance management practices during occupancy stage of buildings in SNNPRS and make recommendations based on the findings.

The schedule consists of five sections with a total of **20** questions. **Section 1** contains general information about the informant. **Section 2** focused on identifying the main defects and sources of defects in buildings in the occupancy. **Section 3** examines economical, functional, and social consequences of defects on buildings. **Section 4** assesses the existing practices of building defect maintenance management, and the methods employed to manage the defects. **Section 5** look into the practices to reduce building defects and improve maintenance management practices. **Section 6** is left for general comments on the research.

Your response, in this regard, is highly valuable and contributory to the outcome of the research. All feedback will be kept strictly confidential, and utilized for this academic research only.

Thank you,

Yacob Badenga

Post graduate student, Construction Technology and Management

Hawassa University, Institute of Technology, Civil Engineering Department

Tel: +251-913146763

Hawassa,

Ethiopia

Section One: General Information

1. General profile of the respondent
   1.1. Name(optional):_____
   1.2. Position:_____
   1.3. Organization:_____
   1.4. Address:_____
2. Type of organization
   ☐ Client ☐ Consultant ☐ Contractor
3. Building Types
   ☐ Public ☐ Private
4. Educational Background
   ☐ Graduate (MSC) ☐ Undergraduate (BSC) ☐ Diploma,

If other, please specify_____

5. Years of experience in the profession of building construction industry
   ☐ < 1 year ☐ 1 -3 years ☐ 3 - 5 years ☐ 5 - 10 years
   ☐ 10 – 15 years ☐ 15 - 20 years ☐ > 20 years

Section Two: Building defects

Several literatures define a building defect can be considered a failing or shortcoming in the function, performance, statutory or user requirements of a building and it might manifest itself within the structure, fabric, services or other facilities of the affected building. An immediate way to reduce and/or eliminate post-handover defects is to ensure that quality controls and inspections are implemented during design and construction.

It follows that dealing with building defect involves identifying main defects, assessing causes of defects, developing defect maintenance strategies, and monitoring defects to determine how they are managed. The following questions are, therefore, intended to identify main defects, develop maintenance strategies and monitoring defects on selected buildings in SNNPR.

Common types of building defects are observed during operation stage of buildings. Please tick the frequency of occurrence of listed defects on your selected building. A scale of 1-5 by ticking (X or √) in the column representing your selection.

Building Defects	Rate of Occurrence					Causes of defect			
	1	2	3	4	5	Design Problem	Sub-surface deficiency	Poor Workman ship	Material deficiency
➢ Cracking									
➢ Unstable Foundation									
➢ Deterioration of Roof Covering									
➢ Internal Staining, mould growth and fungal on external wall									
➢ Dampness									
➢ Peeling Paint									
➢ Leakage									
➢ Defects in doors, windows and external appendages									
➢ Insect or Termite Attacks									
➢ Defective Plaster Rendering									
➢ Defects in Building Services Installation									
1=Never Occur 2= Low 3=Moderate 4=High 5= Very High									

Please specify if there are any other types of building defects in the project

_____

_____

Section Three: Economical, functional, and social consequences of defects on buildings

Below is Impact of defects in buildings. Please rank on a scale of 1-5 th level of regarding to the impact your buildings by ticking (X or √) in the box representing your selection.

No.	Impact of defects	1	2	3	4	5
1	Disputes among parties if any,					
2	High maintenance cost					
3	Functional failure					
4	Additional expense for residences					
5	Depreciation of assets					
6	stress and health impacts					
1=No impact 2= Insignificant 3= Quite impact 4= Significant impact 5= Major impact						

Please specify if there is any other Impact of defects in your buildings._____

_____

Section Four: Building Defect Maintenance Management Practices.

From different literatures, building defect maintenance management is the combination of technical, administrative and management activities of the post-construction life cycle of buildings. These activities overview is concerned with the technical specifications, administrative processes and management such as contract conditions, policy and maintenance strategy related issue. The method of processes start from identification, defect diagnosis, maintenance planning and execution of the facilities. The following questions are intended to assess the existing practice of maintenance management and the method employed.

4.1.Do you have **maintenance management** consisting of the foregoing processes?

☐ Yes ☐ No

4.2.Do you, as an Owner, require a **defect maintenance management plan** for projects as part of designers' services?

☐ Yes ☐ No

4.3.If you have a **defect maintenance management**, what **methods/tools** do you use to identify, assess, respond, and monitor project risks?

a) Defect identification

……

……

b) Defect assessment/analysis

……

……

c) Defect response planning

……

……

d) Defect monitoring

4.4.If you conduct an existing defect maintenance technique,

a) What **types of defect** do you concentrate on?

.....

……

b) How do you **manage** it?

Tick on the box.

☐ By designating facility management team

☐ Outsourcing

☐ Other arrangement, please describe …….

.....

4.5.If you don't have an existing defect maintenance technique,

a) Would you like to share **your experience on how you deal with defects** that may have an impact economy, function, environment and social consequences?

…….

…….

b) What are the **main problems** to practice the technique?

…….

……

Section Five: Practices to reduce building defects and improve maintenance management

Building defects reduction or mitigation implies a reduction in the probability and/or impact of an adverse effect to an acceptable threshold (Caltrans, 2007). This section focuses on existing practices to reduce defects, and explores the opinions of informants on maintenance strategy.

5.1. What are your **practices to reduce/minimize defects in buildings**?

☐ Apply preventive maintenance strategy

☐ Adapt corrective maintenance technique

☐ Adapt routine maintenance strategy

☐ Outsourcing building defect maintenance

If any, other, please describe ……..

- **General comment on the research …….**

Thank you for your cooperation!!

ANNEX B 1

Checklist for types of building defects at the occupancy stage and it causes to the case study on the selected buildings. By ticking (X or √) on column of type of defect and its cause determines the frequency of the occurrence of defects on the case study on selected buildings.

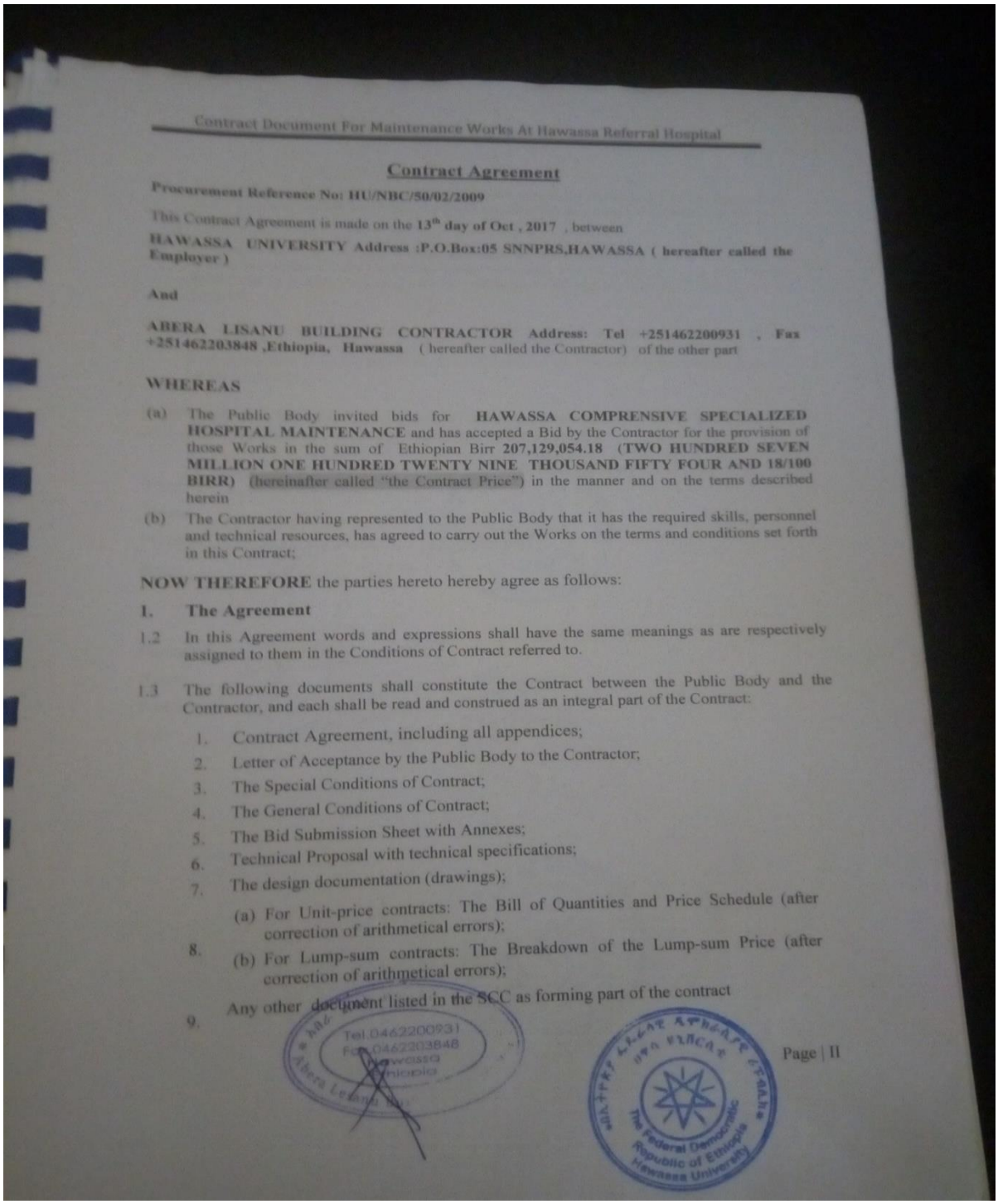
Type of Defects	Frequency	**Frequency for Causes of Defect**			
		Design problem	Material deficiency	Construction deficiency	Subsurface deficiency
1. Foundation related defect					
Settlement					
Subsidence					
2. Defects on slab, wall, beam and column					
Cracks on slab					
Cracks on beam					
Cracks on column					
Excessive deflection on beams and/or slabs					
Spalling of concrete					
Dampness on concrete structures					
Exposed steel reinforcements					
3. **Roof defect**					
Improperly sloped gutters /down pipe					
Damaged or missing gutter/down pipe					
Seepage or leakage underside of roof					
Distortion of roof or wall at roof level					

Damaged roof trusses					
4. **Defects on walls/floors finishing**					
Broken or loose tiles on floors or wall					
Detachment of plastering					
Displacement of walls					
Water damage on walls or floors					
Unevenness floor finishing					
Unevenness wall finishing					
Peeling of painting					
Dampens on wall/ground floor					
Defects on stairs rise and width					
5. **Doors and windows defect**					
Broken doors, hinges, latch/lock					
Broken window glazing, frames					
Water seepage through windows /doors					
Gap between door/window edge & wall					
Broken /absence window sill					
Slanted window/door frames					
6. **Service installation defects**					
Signs of leaks or clogged drains					
Broken or leaking water supply fixtures					
Broken waste water removal fixtures					
Defects on kitchen fixtures					
Defective shower or water fixtures					
Inadequate pressure at fixtures					

Uncovered manhole					
Electric wires not properly protected					
Uncovered junction boxes					

ANNEX C1

Desk study (documents) materials found from offices were shown hereunder.



Contract Document For Maintenance Works At Hawassa Referral Hospital

Contract Agreement

Procurement Reference No: HU/NBC/50/02/2009

This Contract Agreement is made on the **13th day of Oct , 2017** , between

HAWASSA UNIVERSITY Address :P.O.Box:05 SNNPRS,HAWASSA (hereafter called the Employer)

And

ABERA LISANU BUILDING CONTRACTOR Address: Tel +251462200931 , Fax +251462203848 ,Ethiopia, Hawassa (hereafter called the Contractor) of the other part

WHEREAS

(a) The Public Body invited bids for **HAWASSA COMPRENSIVE SPECIALIZED HOSPITAL MAINTENANCE** and has accepted a Bid by the Contractor for the provision of those Works in the sum of Ethiopian Birr **207,129,054.18 (TWO HUNDRED SEVEN MILLION ONE HUNDRED TWENTY NINE THOUSAND FIFTY FOUR AND 18/100 BIRR)** (hereinafter called "the Contract Price") in the manner and on the terms described herein

(b) The Contractor having represented to the Public Body that it has the required skills, personnel and technical resources, has agreed to carry out the Works on the terms and conditions set forth in this Contract;

NOW THEREFORE the parties hereto hereby agree as follows:

1. The Agreement

1.2 In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract referred to.

1.3 The following documents shall constitute the Contract between the Public Body and the Contractor, and each shall be read and construed as an integral part of the Contract:

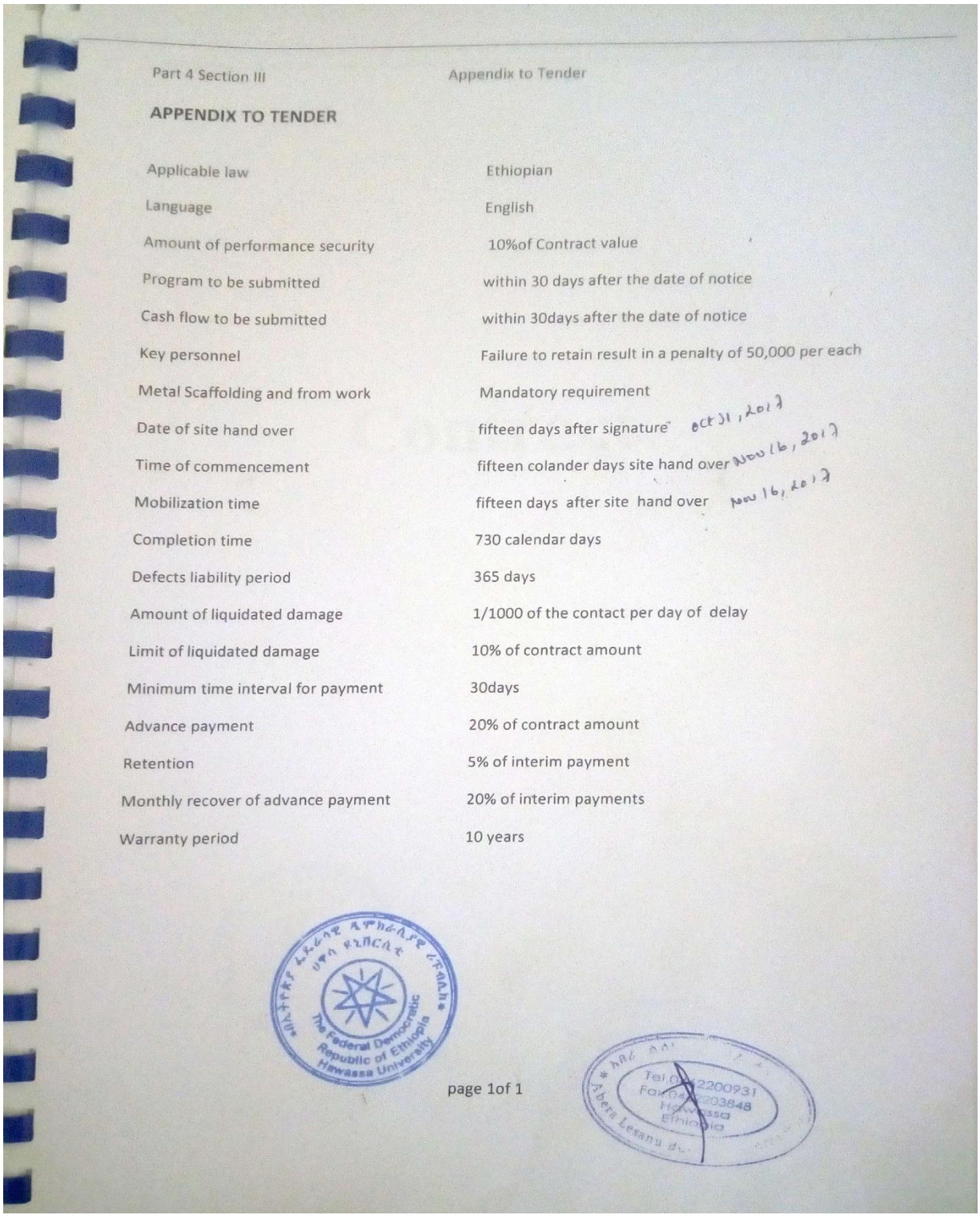
1. Contract Agreement, including all appendices;
2. Letter of Acceptance by the Public Body to the Contractor;
3. The Special Conditions of Contract;
4. The General Conditions of Contract;
5. The Bid Submission Sheet with Annexes;
6. Technical Proposal with technical specifications;
7. The design documentation (drawings);
8. (a) For Unit-price contracts: The Bill of Quantities and Price Schedule (after correction of arithmetical errors);
   (b) For Lump-sum contracts: The Breakdown of the Lump-sum Price (after correction of arithmetical errors);
9. Any other document listed in the SCC as forming part of the contract

Tel.046220093
Fax.046220384
Hawassa
Ethiopia

The Federal Democratic Republic of Ethiopia Hawassa University

Page | II

Contract agreement of maintenance work of referral hospital



Part 4 Section III Appendix to Tender

APPENDIX TO TENDER

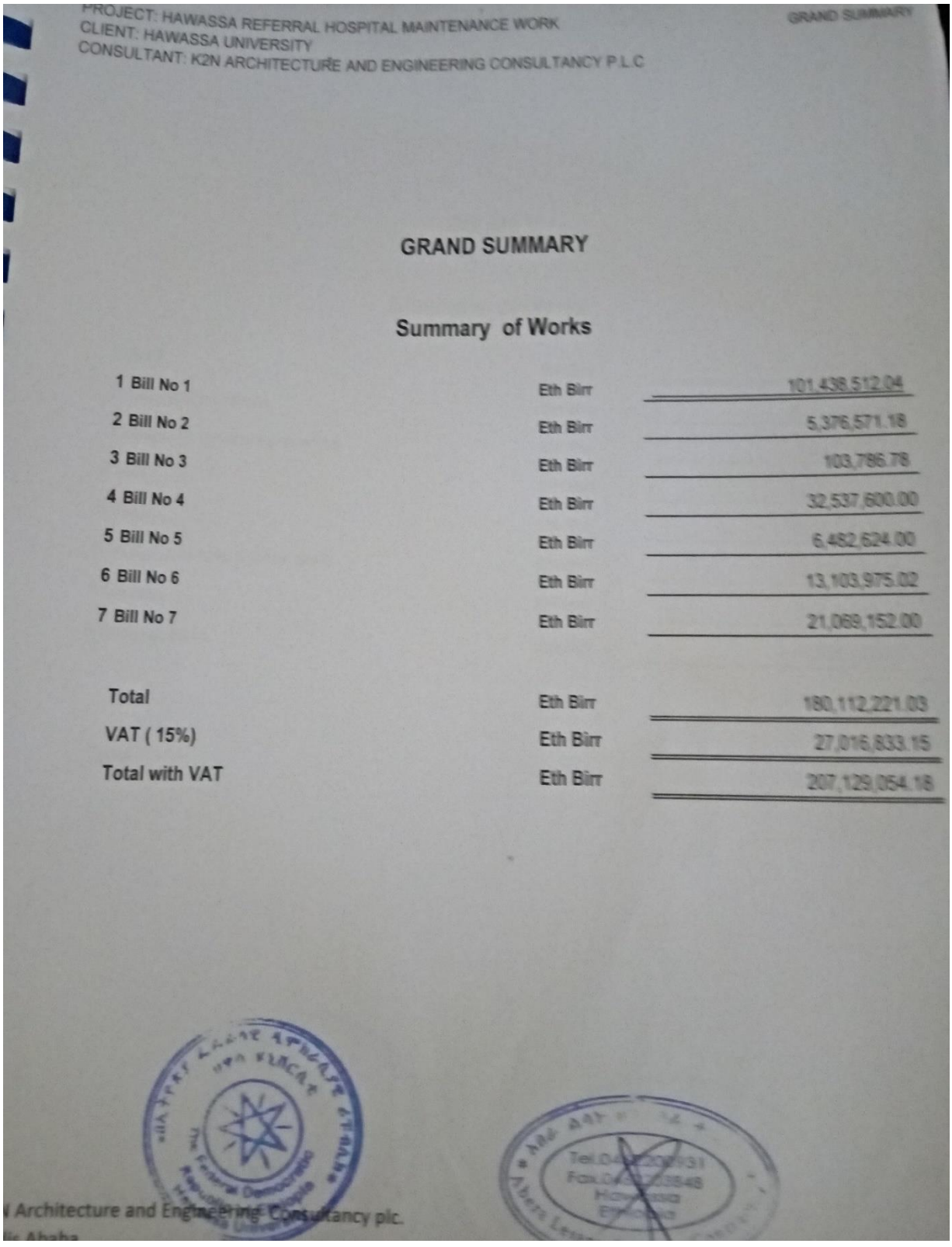
Applicable law	Ethiopian
Language	English
Amount of performance security	10%of Contract value
Program to be submitted	within 30 days after the date of notice
Cash flow to be submitted	within 30days after the date of notice
Key personnel	Failure to retain result in a penalty of 50,000 per each
Metal Scaffolding and from work	Mandatory requirement
Date of site hand over	fifteen days after signature Oct 31, 2017
Time of commencement	fifteen colander days site hand over Nov 16, 2017
Mobilization time	fifteen days after site hand over Nov 16, 2017
Completion time	730 calendar days
Defects liability period	365 days
Amount of liquidated damage	1/1000 of the contact per day of delay
Limit of liquidated damage	10% of contract amount
Minimum time interval for payment	30days
Advance payment	20% of contract amount
Retention	5% of interim payment
Monthly recover of advance payment	20% of interim payments
Warranty period	10 years

The Federal Democratic Republic of Ethiopia Hawassa University

page 1of 1

Tel 0 2200931
Fax 046 2203848
Hawassa
Ethiopia

Project information on contract agreement



PROJECT: HAWASSA REFERRAL HOSPITAL MAINTENANCE WORK
CLIENT: HAWASSA UNIVERSITY
CONSULTANT: K2N ARCHITECTURE AND ENGINEERING CONSULTANCY P.L.C

GRAND SUMMARY

GRAND SUMMARY

Summary of Works

1	Bill No 1	Eth Birr	101,438,512.04
2	Bill No 2	Eth Birr	5,376,571.18
3	Bill No 3	Eth Birr	103,786.78
4	Bill No 4	Eth Birr	32,537,600.00
5	Bill No 5	Eth Birr	6,482,624.00
6	Bill No 6	Eth Birr	13,103,975.02
7	Bill No 7	Eth Birr	21,069,152.00
	Total	Eth Birr	180,112,221.03
	VAT (15%)	Eth Birr	27,016,833.15
	Total with VAT	Eth Birr	207,129,054.18

Architecture and Engineering Consultancy plc.

Total summary of contract amount

1: The following Documents attached hereto shall be deemed to form an integral part of this Contract:

a) The General Conditions of Contract

b) The special Conditions of Contract

c) Technical specification

d) Priced bill of Quantities

e) Drawings, and

f) The completed schedules.

2: Contract Amount and Completion Time

The Contract amount is 59,749,141.18 **(Fifty Nine Million Seven Hundred Forty Nine Thousands One Hundred Forty One Birr 18/100 cents only)** including 15% VAT.

The completion time is 365 **calendar days.**

3: The mutual rights and obligations of the Client and the Contractor shall be as set forth in the contract, in particular:

a) The Contractor shall carryout the works in accordance with the provisions of the Contract;

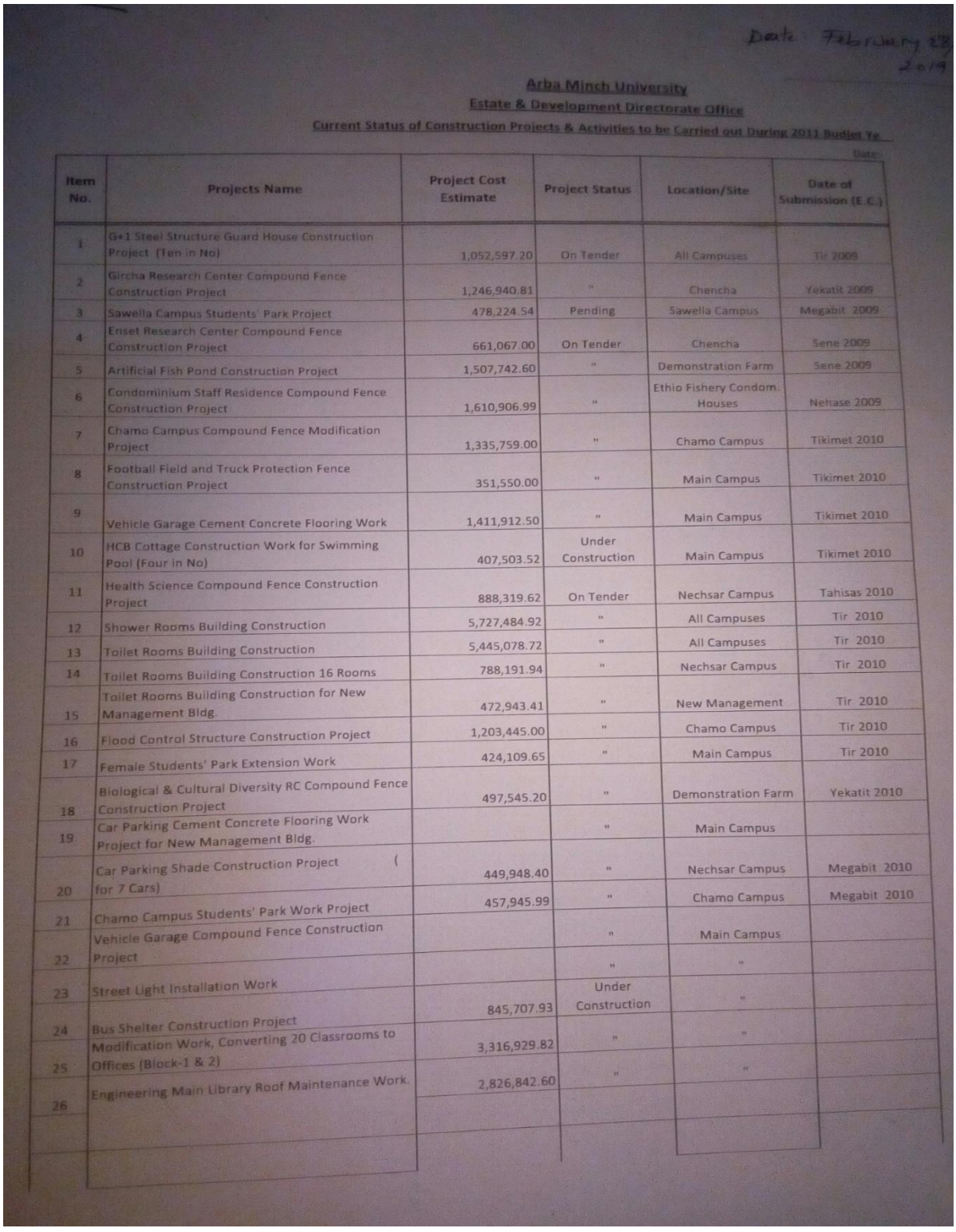
b) The Client shall make payments to the Contractor in accordance with the provision of the contract; and

c) Both the Client and the contractor shall comply with their respective obligations so that the project can be implemented as schedule.

INWITNESS WHEREOF, The parties hereto have caused this contract to be signed in their respective names as of the day and year first above written

0911-517492

Contract agreement of maintenance works at Dilla



Arba Minch University

Estate & Development Directorate Office

Current Status of Construction Projects & Activities to be Carried out During 2011 Budget Ye

Date: February 28, 2019

Item No.	Projects Name	Project Cost Estimate	Project Status	Location/Site	Date of Submission (E.C.)
1	G+1 Steel Structure Guard House Construction Project (Ten in No)	1,052,597.20	On Tender	All Campuses	Tir 2009
2	Gircha Research Center Compound Fence Construction Project	1,246,940.81	"	Chencha	Yekatit 2009
3	Sawella Campus Students' Park Project	478,224.54	Pending	Sawella Campus	Megabit 2009
4	Enset Research Center Compound Fence Construction Project	661,067.00	On Tender	Chencha	Sene 2009
5	Artificial Fish Pond Construction Project	1,507,742.60	"	Demonstration Farm	Sene 2009
6	Condominium Staff Residence Compound Fence Construction Project	1,610,906.99	"	Ethio Fishery Condom. Houses	Nehase 2009
7	Chamo Campus Compound Fence Modification Project	1,335,759.00	"	Chamo Campus	Tikimet 2010
8	Football Field and Truck Protection Fence Construction Project	351,550.00	"	Main Campus	Tikimet 2010
9	Vehicle Garage Cement Concrete Flooring Work	1,411,912.50	"	Main Campus	Tikimet 2010
10	HCB Cottage Construction Work for Swimming Pool (Four in No)	407,503.52	Under Construction	Main Campus	Tikimet 2010
11	Health Science Compound Fence Construction Project	888,319.62	On Tender	Nechsar Campus	Tahisas 2010
12	Shower Rooms Building Construction	5,727,484.92	"	All Campuses	Tir 2010
13	Toilet Rooms Building Construction	5,445,078.72	"	All Campuses	Tir 2010
14	Toilet Rooms Building Construction 16 Rooms	788,191.94	"	Nechsar Campus	Tir 2010
15	Toilet Rooms Building Construction for New Management Bldg.	472,943.41	"	New Management	Tir 2010
16	Flood Control Structure Construction Project	1,203,445.00	"	Chamo Campus	Tir 2010
17	Female Students' Park Extension Work	424,109.65	"	Main Campus	Tir 2010
18	Biological & Cultural Diversity RC Compound Fence Construction Project	497,545.20	"	Demonstration Farm	Yekatit 2010
19	Car Parking Cement Concrete Flooring Work Project for New Management Bldg.		"	Main Campus	
20	Car Parking Shade Construction Project (for 7 Cars)	449,948.40	"	Nechsar Campus	Megabit 2010
21	Chamo Campus Students' Park Work Project	457,945.99	"	Chamo Campus	Megabit 2010
22	Vehicle Garage Compound Fence Construction Project		"	Main Campus	
23	Street Light Installation Work		"	"	
24	Bus Shelter Construction Project	845,707.93	Under Construction	"	
25	Modification Work, Converting 20 Classrooms to Offices (Block-1 & 2)	3,316,929.82	"	"	
26	Engineering Main Library Roof Maintenance Work.	2,826,842.60	"	"	

Total amount project costs in Arba Minch building and infrastructure maintenance.

ANNEX D1

Sample photos taken from different buildings under study.

Figure D1.1 Leakage observed under side of slab on Dilla admin. Building (Image taken by researcher).

Figure D1.2. Damaged water proofing material in Ethio- telecom building Hawassa. Image taken by researcher).

Figure D1.3. Peeling of wall clinker in Ethio-telecom building Hawassa. (Image taken by researcher).

Figure D1.4. Uncovered switch board on Hawassa University School building (Image taken by researcher).

.

Figure D1.5. Uncovered manhole in Arba Minch University school building.(Image taken by researcher).

Figure.D1.6 Spalling off concrete and dampness observed under staircase of building in Arba Minch (..Image taken by researcher).

Figure D1. 7. Crack observed on Arba Minch referral hospital (Image taken by researcher).

.

Figure D1.8. Displacement of wall observed on Arba Minch ethio-fishery apartment (Image taken by researcher).

Figure D1.9. Roof deterioration on Dilla University Administration building due to EGA leakage (Image taken by researcher).

Fig D1.10. Temporary shelter deterioration in Dilla hospital building (Image taken by researcher).

Figure D1.11. Hawassa Referral hospital peeling of painting, fissure cracks (Image taken by researcher).

Figure D1.12. Maintenance work in Hawassa referral hospital building (Image taken by researcher).

.

Figure D1.13. Staining and mold around expansion joint of building (Image taken by researcher).

.