

**JIMMA UNIVERSITY**

**JIMMA INSTITUTE OF TECHNOLOGY**

**FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**CONSTRUCTION ENGINEERING AND MANAGEMENT STREAM**

**DEFECTS ON LOW COST HOUSES A CASE IN 20/80 CONDOMINIUM**

**BUILDINGS IN MEKELLE**

**A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial  
Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering  
(Construction Engineering and Management)**

**BY: GEBREMESKEL ABIRHA GEBRU**

**JANUARY, 2020**

**JIMMA, ETHIOPIA**

**JIMMA UNIVERSITY**

**JIMMA INSTITUTE OF TECHNOLOGY**

**FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**CONSTRUCTION ENGINEERING AND MANAGEMENT STREAM**

**DEFECTS ON LOW COST HOUSES A CASE IN 20/80 CONDOMINIUM**

**BUILDINGS IN MEKELLE**

**A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial  
Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering  
(Construction Engineering and Management)**

**BY: GEBREMESKEL ABIRHA GEBRU**

**Main advisor: Dr. GETACHEW KEBEDE**

**Co-advisor: Ing. TAHIR KELIL**

**JANUARY, 2020**

**JIMMA, ETHIOPIA**

**JIMMA UNIVERSITY**  
**JIMMA INSTITUTE OF TECHNOLOGY**  
**SCHOOL OF GRADUATE STUDIES**  
**FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING**  
**CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR**

**DEFECTS ON LOW COST HOUSES A CASE IN 20/80  
CONDOMINIUM BUILDINGS IN MEKELLE**

**GEBREMESKEL ABIRHA GEBRU**

**APPROVED BY BOARD OF EXAMINERS**

1. Dr. Getachew Kebede Main advisor	 Signature	_____ Date
2. Engr. Tahir Kelil Co - advisor	 Signature	_____ Date
3. Dr. Bayou Chane Tegegne External Examiner	 Signature	07/02/20 Date
4. Engr. Kemal Ture Internal Examiner	 Signature	_____ Date
5. Engr. Moges Getahun Chairperson	 Signature	_____ Date

### I. DECLARATION

I declare that this research entitled "DEFECTS ON LOW COST HOUSE A CASE IN 20/80 CONDOMINIUM BUILDINGS IN MEKELLE "is my original work. I confirm that this is my own work and the use of all material from other sources has been properly cited.

Declared by:

GEBREMESKEL ABIRHA GEBRU

Signature  Date \_\_\_\_\_

Confirmed by:

1. Main advisor Dr. GETACHEW KEBEDE

Signature  Date \_\_\_\_\_

2. Co-advisor Ing. TAHIR KELIL

Signature  Date \_\_\_\_\_

## II. ABSTRACT

*Ethiopia has been implementing a large-scale housing program which aims to reduce housing supply shortage and improve the living standard of the urban low and middle income households. The study focused on assessment of condominium defect, causes of defect, effects of defect on occupant and performance of the building, and the remedial actions that had been taken to rectify the defect in Mekelle condominium buildings.*

*The study adopts descriptive research methodology and data were collected through field observations, questionnaire, and interview. Mekelle house development agency, main contractors participated in Mekelle condominium construction, and the condominium occupants were the population of the study and Results had been analyzed using qualitative and quantitative approach.*

*The most common condominium defects were ranked using RII value and the result indicated that Leakage, Roof defect, door and window defect, defects in building service installation, and building dampness with RII value of 0.9, 0.85, 0.84, 0.78, & 0.74 were the most common condominium defects whereas use of substandard material, construction fault, maintenance problem, design fault, and occupational fault were the major causes of the condominium defects.*

*Existence of building defect influences social, health and economic aspects of the occupant's in addition to this aesthetic value, performance of the building, and life span of the building component were affected by the defect. Roof defect, leakage, door and window defects, dampness, and defects in building services installation were top five defects that affects both the occupant and building performance. Adopting organized maintenance, facility management, and construction of extra facility were the solution used to detect the condominium defect.*

***Key word: condominium, condominium defect, maintenance practice***

### III. ACKNOWLEDGMENT

First of all, my thanks extends to the Almighty God, who gave me the commitment and tolerance to pass various obstacles and come up to the accomplishment of this research.

I would like to extend my sincerest and most heartfelt appreciation to my advisors Dr. Getachew Kebede and Ing. Tahir Kelil for their tireless supervision and guidance throughout the whole process of this research.

It is my pleasure to extend my sincere thanks and appreciations to my wife Ms. Tigst Atsbih and my family whom encourage and supports me in the whole process of this research.

I am thankful to Adigrat University, for giving me the opportunity to attend this MSc program in Jimma University. It is a pleasure to record my gratitude to all survey respondents for spending their time to respond to the questionnaire by giving such important information.

#### IV. ACRONYMS

BRI	Building Related Illness
CBE	Commercial Bank of Ethiopia
CMMS	Computerized Maintenance Management Systems
CSA	Central Statistical Agency
Ft	Feet
GNI	Gross National Income
IHDP	Integrated Housing Development Program
In	Inch
Km	kilometer
MHDA	Mekelle Housing Development Agency
Mm	Millimeter
MWUD	Ministry of Works and Urban Development
RII	Relative Importance Index
UN	United Nation

<b>Contents</b>	<b>Page</b>
I. DECLARATION .....	
II. ABSTRACT .....	II
III. ACKNOWLEDGMENT .....	III
IV. ACRONYMS .....	IV
CHAPTER ONE .....	1
1. INTRODUCTION.....	1
1.1 Background of the study.....	1
1.2 Statement of the problem.....	3
1.3 Research question .....	3
1.4 Objective of the study.....	4
1.4.1 General objective .....	4
1.4.2. Specific objective.....	4
1.5 Significance of the study .....	4
1.6 Scope and limitation of the study .....	4
1.7 Operational definition of terms.....	5
CHAPTER TWO.....	6
2. LITRATURE REVIEW .....	6
2.1 Introduction .....	6
2.2 Category of Defects .....	8
2.3 Common building defects.....	10
2.3.1 Dampness .....	10
2.3.2 Leakage .....	11
2.3.3. Defect in Plaster .....	11
2.3.4 Crack .....	12
2.3.5 Peeling paint.....	13
2.3.6 Efflorescence.....	14
2.3.7 Termite Attacks.....	15
2.3.8 Roof Defect.....	15
2.3.9 Door and window defects .....	16
2.3.10 Defects in Building Services Installation.....	16



2.4 Causes of building defects .....	17
2.4.1 Design fault .....	18
2.4.2 Construction fault.....	19
2.4.3 Use of substandard material.....	19
2.4.4 Occupational fault.....	20
2.4.5 Poor workmanship .....	20
2.4.6 Maintenance problem.....	20
2.4.7 Corruption .....	20
2.5 Building maintenance practice .....	21
CHAPTER THREE.....	24
3. RESEARCH METHODOLOGY .....	24
3.1 Study Area .....	24
3.2 Study design .....	24
3.3 Study Variables.....	25
3.4 Source of data .....	25
3.5 Data collection procedure.....	25
3.5 Research Population and Sampling .....	25
3.6 Data analysis.....	26
CHAPTER FOUR.....	27
4. DATA ANALYSIS AND DISCUSSION.....	27
4.1 Introduction .....	27
4.1.1 Survey response rate .....	27
4.1.2 Academic status of the occupant.....	28
4.1.3 Occupants Year of Residence .....	28
4.1.4 Description of Mekelle 20/80 condominium building.....	29
4.2 Common condominium defects in Mekelle.....	32
4.2.1 Roof defect.....	33
4.2.2 Leakage .....	34
4.2.3 Door and window defect.....	35
4.2.4 Defects in building service installation.....	36
4.2.5 Dampness .....	37
4.3 Causes of Mekelle Condominium Defect.....	38

4.3.1 Use of substandard material.....	39
4.3.2 Construction fault.....	40
4.3.3 Maintenance problem.....	42
4.3.4 Design fault.....	44
4.3.5 Occupational fault.....	45
4.4 Effects of Mekelle condominium defect on occupant and building performance.....	46
4.4.1 Effects of the defect on occupant.....	46
4.4.2 Effects of the defect on building performance.....	48
4.5 Remedy to the condominium defect.....	50
4.5.1 Maintenance.....	50
4.5.2 Facility management.....	51
4.5.3 Extra facility Construction.....	51
CHAPTER FIVE.....	53
5. CONCLUSION AND RECOMMENDATION.....	53
5.1 Conclusion.....	53
5.2 Recommendation.....	55
REFERENCE.....	56
APPENDIX.....	59
Appendix 1. Interview question for Mekelle Housing Development Agency & contractor.....	59
Appendix 2. Questionnaire for condominium occupants.....	62
Appendix 3. Detailed 20/80 Mekelle condominium sites.....	65

<b>List of figure</b>	<b>page</b>
Figure 2.1 Rising damp .....	10
Figure 2.3 Peeling paint .....	13
Figure 2.4 Efflorescence .....	14
Figure 2.5 Quality vs time.....	22
Figure 3.1. Map of Mekelle city.....	24
Figure 4.1 Occupant’s existence .....	28
Figure 4.2 Condominium location in Mekelle .....	29
Figure 4.3 Condominium house proportion .....	30
Figure 4.4 Roof defect in Edaga Bieray condominium.....	34
Figure 4.5 Septic tank leakage in Senet condominium .....	35
Figure 4.6 Window defect.....	36
Figure 4.7 Condominium dampness in Edaga Bieray.....	37
Figure 4.8 Revised causes of condominium defect.....	39
Figure 4.9 Management structure adopted in Mekelle condominium construction.....	41
Figure 4.10 Maintenance problem .....	43
Figure 4.11 Design deficiency in toilet window .....	44
Figure 4.12 Occupational fault in condominium buildings.....	45
Figure 4.13 Effects of defect on occupant.....	47
Figure 4.14 Quiha condominium building .....	49

<b>List of Table</b>	<b>Page</b>
Table 2.1 Income level .....	6
Table 4.1 Survey response rate .....	27
Table 4.2 Respondent's academic status .....	28
Table 4.3 1st round condominium projects detail .....	31
Table 4.4 2 <sup>nd</sup> round condominium projects detail .....	31
Table 4.5 Common condominium defect in Mekelle.....	33
Table 4.6 Occupant's response for causes of condominium defect .....	38
Table 4.7 Severity of defects on occupant .....	47
Table 4.8 Severity of defects on building performance .....	49

## CHAPTER ONE

### 1. INTRODUCTION

#### 1.1 Background of the study

Most cities in the developing world suffer from severe lack of adequate housing units for their residents. This is due to the increase in demand for housing from both a huge number of immigrants to the city as well as from the city residents searching for a new residence or wishing to move to a better district than the degraded areas in which they live. Since 2005, Ethiopia has been implementing a large-scale housing program which aims to reduce the housing supply shortage and improve the living standard of the urban low and middle income households through the construction of high-rise condominium houses equipped with basic services.

According to **UN-HABITAT (2010)** condominium housing is a name given to the form of housing tenure where each resident household owns their individual unit, but equally shares ownership and responsibility for the communal areas and facilities of the building, such as hallways, heating systems, and elevators. There is no individual ownership over plots of land and all of the land on a condominium site is owned by all unit owner. The program recognizes the opportunity for housing to stimulate the economy, create employment, and improve the capacity of the construction and financial sectors.

Several countries are still facing the challenges and problems like lack of policies, poor planning and design, improper facilities and services, unaffordability of housing, housing shortage, unavailability of low cost housing etc. from the above listed problems the researcher focuses on defects 20/80 condominium buildings in Mekelle city.

Defects are defined as the deterioration of building features and services for unsatisfactory quality levels of requirement of the users. Building defect can be considered as failing or shortcoming in the function, performance, statutory or user requirements of a building. Building defect is one of the major components of building problems that significantly needs quick attention. Defects and deterioration are common problems in any built structures; however, various defects are more common in an old structure.

Dinesh, S. and Resmi, R. (2017) stated that common types of building defects include: structural defects resulting in cracks or collapse; defective or faulty electrical wiring or lighting, defective or faulty plumbing, inadequate drainage systems, faulty ventilation, cooling or heating systems, insufficient insulation or sound proofing, and also inadequate fire protection suppression systems. Plus, dry rot, wood rot, mold, fungus, or termite or vermin infestation may also be the result of a building defect. Those defects would happened due to faulty design, faulty construction, or faulty use of the building.

## **1.2 Statement of the problem**

**UN-HABITAT (2010)** states that the rapid population growth in Ethiopian urban areas due to high rate of population growth and migration from rural to urban together brings high demand of shelter which intends to imbalance house supply and demand. From the urban residents low and middle income households face the greatest challenges with getting decent housing they can afford. To solve the shortage of shelter for low and middle income the Ethiopian government introduces condominium houses in different cities of the country. To some extent the condominium building enables the citizen to own their home but the quality of the building still requires improvement.

Mekelle is one of the regional states that demonstrates the condominium construction. 20/80 condominium is one of the low cost building in which most low and middle income of household in Mekelle interested on; however, the success of the housing programs has been reduced since most of those condominium buildings had been defected earlier and the occupants were challenged to rectify those defects. Missing the impact of building defect on the occupant and building performance had brought failure in serving the proper function and in the dissatisfaction of the occupants. Therefore this research had assessed issues related to building defects found in 20/80 service providing condominium buildings in case of Mekelle city.

## **1.3 Research question**

1. What are the types of defect occurred on the 20/80 condominium buildings?
2. What are the root causes of the defects occurred on the condominium?
3. What are the effects of the defects on the building performance and the occupant?
4. How can be rectify the condominium defects?

## **1.4 Objective of the study**

### **1.4.1 General objective**

The general objective of this research was to assess the defects on 20/80 service providing condominium buildings in Mekelle.

### **1.4.2. Specific objective**

The specific objective of the research focus on defects in 20/80 condominium buildings in Mekelle was

- ✓ To identify the types of defects in 20/80 condominium buildings
- ✓ To determine the causes of the defects of the building
- ✓ To determine the effect of the defects on the building performance and the occupant
- ✓ To provide solutions for defects

## **1.5 Significance of the study**

This research had its own contribution for academic institution as a reference and bench mark for further study and for construction firms to take emphasis on the reduction of building defects during planning and construction stages. It also enables the occupants to develop their knowledge on identifying the type of defect, its cause, effect on the building performance and the occupants, and the mechanisms that had been taken to rectify the defects occurred.

In addition, the research would significant for the establishment of affordable, healthy, smart, and comfort living environment for the residents by applying waste minimization and applying the proper maintenance at the right time and right price.

Finally developing awareness of all concerned body on building defect and the techniques used to rectify those defects earlier enables to sustain the proper function of the building and increases the occupant satisfaction.

## **1.6 Scope and limitation of the study**

The research had assessed the types of defects, causes of defects, effects of the defect on the building performance, and remedies of defects on service providing 20/80 condominium buildings in Tigray regional state, Mekelle city. The study excludes buildings out of 20/80 condominium.



### 1.7 Operational definition of terms

- ❖ Building maintenance: is an activity carried out in order to keep or restore a building to its initial condition of completion
- ❖ Building performance or efficiency: is a measure of how well the building functions in relation to design criteria such as physical, social, operational, and aesthetic value.
- ❖ Construction fault: Any mistake or error in construction that reduces the value of a building
- ❖ Design: This is the totality of activities that are involved in actualizing the space requirement in a building and enclosing space
- ❖ Defects/Fault: Error in simulating what one wants to build or absence of something essential to completeness, lack or a deficiency
- ❖ Faulty design: Faulty design is a deficiency in design or error in design

## CHAPTER TWO

### 2. LITRATURE REVIEW

#### 2.1 Introduction

UN-HABITAT (2010) stated that the prominent current government approach to solving the low-income housing challenge in Ethiopia is the Integrated Housing Development Program (IHDP), initiated by the Ministry of Works and Urban Development (MWUD) in 2005. The IHDP aims to Increase housing supply for the low-income population, recognize existing urban slum areas and mitigate their expansion in the future, Increase job opportunities for micro and small enterprises and unskilled laborers, which will in turn provide income for their families to afford their own housing, and Improve wealth creation and wealth distribution for the nation. For the current year 2019 fiscal year World Bank categorizes peoples in to different income levels with a basis of gross national income (GNI) were shown in table 2.1.

Table 2.1 Income level

No	Income level	GNI (\$)
1	Low Income	$\leq 995$
2	Lower Middle Income	996-3895
3	Upper Middle Income	3896-12055
4	High Income	12,056

Hamzah, A. et.al. (2012) describes that apart from providing adequate housing for low-income groups, the housing policy also emphasizes the significance of comprehensive settlement planning to achieve safe and decent living conditions.

In accordance with Article 55 Sub Article (1) of the Federal Democratic Republic of Ethiopia it is here by proclaimed as Condominium Proclamation No. 370/2003. This proclamation defines condominium as a building for residential or other purpose with five or more separately owned units and common elements, in a high-rise building or in a row of houses, and includes the land holding of the building. The building together with the land holding and related rights, benefits, and obligations were governed by the Proclamation. Unit owners (declarant) were allowed to share common expense and common surpluses which related to the building unit.

Resom T. (2010) stated that Mekelle is a city which needs to construct 38,000 houses up to 2015 to solve the accumulated and emerging housing problem. As a result, the government has established IHDP and planned to construct 14,647 condominium houses.

Due to age, use of substandard material during construction, lack of consideration to building design, wrong construction method, improper use of the building, or unexpected natural accident different residential buildings were exposed to many defects. Building defect is defines as non-compliance with the building code for newly constructed buildings and non-compliance with maintenance standards for old buildings.

Building defects arise through inappropriate or poor design, specification and construction as well as to insufficient attention given to building maintenance. The effect of defects on the condition, appearance and performance of a building depends on the functional requirements of the buildings. The unique consequence of the defects in a building is that it affects the building's capability to function optimally and technically, and aesthetically. Defects cause inner psychological tension in the users, if the defect is not rectified.

Dinesh, S. and Resmi, R. (2017) states that Construction defects are most common and frequently arising in the construction projects, which occur due to poor design and construction in the construction site. Defects may cause various complications for the residents of the house which might lead to the damage to the property or human life. It is important to fix the building defects and carry out the necessary maintenance work for the proper functionality of a building.

## 2.2 Category of Defects

Based on the place they appeared defect can be categorized as structural and non-structural defect.

**Structural defect:** Dinesh, S. and Resmi, R. (2017) defines Structural defect as any defect in a structural element of a building including earth retaining walls, columns, beams and flat slabs that happened due to defective design, faulty workmanship or defective material or combination of these. According to the Engineering Encyclopedia, structural defect can be categorized as cracks in foundations, cracks in slabs, and cracks in walls. Structural defects in a building can occur over time due to deterioration, wear and tear, overloading, and poor maintenance.

**Non-structural defect:** According to Northern Territory Consolidated Regulation, a non-structural defect in a residential building is described as a defect in a non-structural element of the building as a result of defective residential building work. According to the Engineering Encyclopedia, non-structural defect includes defect in brick work, dampness in old structures, and defects in plaster works.

Georgiou, J et. al (2009) also Categorized building defects in to three categories as technical, aesthetic, and functional defects which are briefly described in the next page.

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

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

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

Defects can also classified into two main categories, namely patent and latent defects.

**Latent defects:** are defects that are concealed and are often not readily observable upon reasonable inspection. After construction is complete, latent defects are unknown and generally undiscoverable and will only appear after the passage of time. Improper compacted soils, lack of reinforcing in structural concrete footings, walls, and slabs, an improperly installed weatherproofing system, improperly consolidated concrete, and reinforcement not fully embedded in the concrete structure are among the Latent defects.

**Patent defects:** are defects that are known or would be readily obvious upon reasonable inspection. Handrails omitted in stairways, missing control of expansion joints, cracking signs of distress in the building envelope, lack of roof drainage and roof slope, lack of proper roof/attic ventilation are types of patent defects.

## 2.3 Common building defects

### 2.3.1 Dampness

Dampness is the occurrence of unwanted and excessive water or moisture inside the building. The existing of dampness in building is one of the most damaging failures that really must be taken care of. Kam S.C. (2016) divides dampness in to three classes as rising damp, penetrating damp or condensation

1. Rising Damp: This is the water absorption from the ground and there is only one reason which can cause this problem: the damp-proof course or damp-proof membrane are damaged

2. Penetrating Damp: This is the water leaking into the building through the building defects, sometimes the defect may be obvious. For example, a missing roof tile will allow the water to pass through the roof to the interior

3. Condensation: This is moisture generated in the internal. Many activities such as washing or drying of clothes, even breathing, are major sources of moisture generation. Other causes of moisture can be from bottle gas heaters, and un-vented tumble dryers. Condensation related problems such as mould growth generally occur during the winter months when the outside temperatures are colder than those inside a building. As shown in figure 2.1 Kam S.C. (2016) pointed out that rising dampness were happened due to weak damp proof course.



Figure 2.1 Rising damp

### **2.3.2 Leakage**

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

Kam, S.C. (2016) listed out reasons for water seepage as defective water pipes, sanitary fittings or drainage pipes; come from dilapidated pipes in adjacent flats or from inside the same flat; through common areas, such as roof or external walls due to poor workmanship or inadequate design. Arif, A. et. al. (2016) and Hamzah, A., et. Al. (2012) also discussed that Leaking of pipes was the top ranked type of condominium defect.

### **2.3.3. Defect in Plaster**

Mortar coating outside the wall of building structure is called reinder. Plaster and render is totaling different. The render is generally richer and mostly in cement than the plaster due to weather resistant. Mostly the defective plaster rendering occurs on the external walls, column and ceiling. Defective rendering is normally caused by biological attacks arising from penetrating rain, evaporation, condensation, air pollution, dehydration and thermal stress. Prior to being decomposed and broken apart, rendering may crack due to either shrinkage or movement in the substrate.

### 2.3.4 Crack

Crack can be appeared on structural or non-structural part of the building structure or its components such as wall, beam, column, slab, and floor. The nature of many construction materials to crack as they age and as they expand and contract, particularly with exposure to moisture as they get wet and dry out alternately. There are cracks in common areas, such as exterior walls, interior walls at corners of doors and windows.

Crack defect have classified of visible damage to walls. According to the construction, the occurrence of wall crack was due to overloaded or because of the structure had settled or heaved. Vertical and angled crack are usually caused by settlement or heaving. Nevertheless, for horizontal crack are more likely to be caused by lateral pressure. Cracks are usually the widest at the top of the building diminishing to a hairline crack at or near the foundation level. Figure 2.2 were taken from study conducted by Azree, O. M. and Nadia O. B. (2014) described that cracks are usually the widest at the top of the building diminishing to a hairline crack at or near the foundation level



Figure 2.2 Wall crack



### 2.3.5 Peeling paint

Peeling paint is always the result of poor surface preparation of the element to be painted. The majority of peeling paint problems occurs on surfaces exposed to the rain, sun, and the variation degree of temperature. When paint peels from an interior wall, the reason for the peeling paint is mostly often due to an improper preparation of the surface before painting. Buildings that are located near the sea may face a much higher risk once the signs of peeling paint are visible on the exterior walls.

Kam, S.C. (2016) describes that the main causes of peeling paint and plaster crack are that the moisture gets inside the paint surface through the crack or gap that are made by human or furniture. The moisture makes the plaster damp and dry, it will decrease the bonding strength between the plaster and concrete surface that may cause the plaster crack. And the plaster crack allows more moisture to seep inside between the plaster and paint and which can cause peeling of paint. Figure 2.3 were taken from Azree, O. M. and Nadia, O. B. (2014) which concludes that Peeling usually occurs on building facades, mainly on plastered walls, columns and other areas which are exposed to excessive rain and great dampness.



Figure 2.2 Peeling paint

### 2.3.6 Efflorescence

Efflorescence is a white powdery deposit on exposed masonry surfaces caused by the leaching of soluble salts. Efflorescence occurs when soluble salts in the units or mortar are taken into solution by prolonged wetting. As the wall begins to dry, the salt solution migrates toward the surface through capillary pores. When the water evaporates, the salts are deposited on the face of the wall.

As shown in Figure 2.4 study conducted by Ahmad, S. (2013) stated that efflorescent (whitish bleeding) spotted on the external wall surface of social security organization office in Malaysian building were occurred due to chemical reaction of the wall materials and high moisture content on the wall prior to painting process.



Figure 2.3 Efflorescence

### **2.3.7 Termite Attacks**

States that termites are small, pale to brownish black in color, insects that capable of feeding on mostly anything including timber. The timber is easily deteriorated if exposed to water penetration, high moisture content and loading beyond its capacity as this greedy and colony-living insect is easily attracted to it. Insect or termite attacks pose a threat to damp and digested timber found in wall plates, the feet of rafter, bearing ends of beams and trusses. Affected timber can be treated by pressure-spraying with insecticide or fumigant insecticidal process.

### **2.3.8 Roof Defect**

Herbert W. (2010) stated that all roofs will leak; it is just a matter of when but pitched or high sloped roofs shed water better than flat or low-slope. High slope roofs with pitch greater than 3:12 have the advantage of shedding rainwater and reducing the potential of roof leaks into buildings since the roof doesn't actually have to be a water barrier.

Azree, O. M. and Nadia, O. B. (2014) describes that roof is usually exposed to the element extremes of temperature degree and change, solar radiation, and wind action. Roofs have special risk due to the design of the building itself such as services passing through the roof covering, and internal gutters. The consequence small defective of roof will cause greater effect of similar defect in a wall or other element. Roof defect are divided into structural faults and defect in the waterproofing material. The majority of roof defect that occurs is distortion of either the roof or of the wall at roof level

Construction defects in roof system can cause damage to personal property in the building, and also to the interior framing members, ceiling, drywall, and paint by allowing water into the building. Break roof tiles, damaged framing, exposed damage felt, improper flashing, raised shadow board and loose tiles were the common roof system construction defects.

### **2.3.9 Door and window defects**

Defect in door and window can be raised from material selection problem, problem in assembling their frame, wrong position, and improper use of the door and window during opening and closing. Hamzah, A. et. Al. (2012) describes that faulty door knobs was the fourth most frequently occurring defect in klang vally affordable houses originated from substandard materials being utilized and poor workmanship.

Yebichaye D. (2016) states that Common defects in traditional steel windows usually arise from rusty frames, and deterioration or loss of putty or sealant to hold the glass panels.

### **2.3.10 Defects in Building Services Installation**

Yebichaye D. (2016) categorized Building services installations defect as water supply defect, Fire services defects, electricity supply defect, and mechanical service defects.

Water supply defect can be blockage or leakage of components of the pipes or valves, rusty pipes, pump failure, breakage of supply pipe, defective water tanks, defective pipe joints or valves, leakage in the system after water meters.

Fire services defects which includes alarm wiring defect, short circuit, inadequate protection or poor management, inadequate maintenance.

Electricity supply defect were defects concerned with the problems in electrical supply problem to the structure such as fuse or circuit breaker, earth leakage, overloading, uneven distribution

## **2.4 Causes of building defects**

Building defect could occur due to the mistakes introduced throughout the life cycle of the structure starting from design up to the end of its life span. Defects in a building can occur due to fault in design, fault in construction, occupational faults, use of substandard material, lack of proper maintenance, age, and natural disaster.

Guesh D. (2017) summarized that poor selection of competent consultant and reliable contractors, lack of management commitment to continual quality improvement, poor quality of workmanship of supply of labor and equipment and raw materials, less quality techniques and mechanisms are adopted, unavailability and delay in supply of materials as planned and specification, low consultants commitment to ensure construction according to specification and design, insufficient training and payment to labor, lack of strong coordination between designers and contractors, improper integration and coordination and inspection by the participant of the projects were the factors affecting quality in construction of condominium housing.

Ahzahar, N. et. al. (2011) listed out contribution factors to building defects and failures as climatic conditions, location of building, construction materials, building type and change in use, maintenance of building, faulty design, corruption, and lack of supervision. They found that the low quality of construction material is most common factors that lead building defects and failures at northern region, particularly in Penang area.

Kam, S.C. (2016) categorized sources of defects into external and internal factors. Location of building, weather, maintenance of building, faulty design, faulty construction, lack of supervision, and impacts from occupants and loads are cause of defects from external factor while building age and height of the buildings are the cause of defects from building itself

Arif A. et. al. (2016) generalized that the major contributing causes of defects in jimma condominium houses were weakness in design, poor workmanship, low quality material and awareness by occupants about the maintenance of their houses.

Generally there are hundreds of reasons that contributes to building defects and failures. The occurrence of those source of building defects affects the life span, aesthetic value, and function of the building finally becomes unsuitable shelter for the occupants. The major root causes of building defects were described briefly below.

#### **2.4.1 Design fault**

The functions and abilities of building are decided by a building designer, each decision can affect the long term quality and life cycle of the buildings. Design faults are errors of computation, fail to take account the loads of the structure, reliance on inaccurate data and etc. Design defects are typically a consequence of the architects or engineers failing to produce an accurate or well-coordinated set of construction documents. It is critical that the plans and specifications are reviewed and followed. This is why the phrase “per plans and specifications” is often used in contract language. Engineers and architects detail products and methods to be used in the specifications. If the design fails to fulfill the requirement standard, it will cause the building to collapse.

Zarak, K.K et.al. (2017) found that Design deficiency contributes to the greatest number of defects, about 64% of design deficiencies were found in the selected houses in Quetta. The typical design deficiencies found were: cracks in slabs; leakages from walls and roofs; cracks in the structural elements.

Abdul Rahman, S. B. and Nurzaihan, A.A.S. (2013) stated that Faulty design contributed to the number of building defects and failure in the early stage of design would lead to deficiencies in

the later stage after construction. Uncomfortable conditions in the building such as noise, inadequate lighting, uncomfortable temperature, high humidity and other physiological sectors may cause lower job satisfaction and increase in building related illness (BRI) symptoms.

#### **2.4.2 Construction fault**

Well standardized and organized building design can't produce well-structured buildings unless the builder follows the exact construction procedure and method. Use of Poor workmanship and low quality material at construction stage leads to building defect and collapse. In order to gate the expected function of the building the builder should construct the structure as per its specification. Even where a structural design is not deficient, absence of proper supervision on the site by qualified personnel can lead to building failure and defects.

Zarak, K.K et.al. (2017) found that Construction deficiencies account 48% of the houses which is occur due to several reasons, such as, water addition to concrete in order to increase slump which will decrease its strength, improper framework, improper consolidation of concrete, improper curing of concrete, improper placement of reinforcement, formwork movements, concrete settling, subgrade settling etc.

#### **2.4.3 Use of substandard material**

In the materials management of buildings, understanding the nature of the building materials and accurate diagnosis of defects is most important. Materials are expected to perform up to required standards, however if they are exposed to higher impact they will not be poor in terms of quality. Akande, B.F. et. al. (2016) posted that use of Substandard material especially reinforcement rods, steel sections and cement can contribute immensely to failure.

#### **2.4.4 Occupational fault**

Defects may be caused by unintended misuse due to lack of knowledge on the correct method of usage or intentional acts of vandalism. Besides, some defects may be correlated to the users' financial conditions and also social attitudes for instance, condensation is affected by the amount of money spent on heating and ventilating, and occupancy pattern. Extraordinary load often natural such as repeated heavy snowfalls or shaking of an earthquake or the wind.

#### **2.4.5 Poor workmanship**

Poor workmanship may not have the ability to follow the instructions which was given in the specifications contributes for the occurrence of defects. Forcada, N. et. al (2013) finds that the high levels of inexperienced workers and the long chains of subcontracting contribute to poor quality of dwellings in Spain.

#### **2.4.6 Maintenance problem**

Yebichaye D. (2016) described that buildings that neglect building maintenance may fall into several defects which may lead to structural failures. The lack of maintenance or incorrect maintenance will leads to reduce the life span of the building and reduces the effective expected life of the materials. Many property owners build carelessly, they are not concerned about the maintenance of their property, and they hardly maintain the building. This will reduce the lifespan of the property.

#### **2.4.7 Corruption**

Ahzahar, N. et. al. (2011) stated that Corruption within the construction industry is a complex and sensitive issue. It is generally assumed that it occurs but the form and scale of corruption is by its nature difficult to establish. Corruption can occur during any phase of a construction project such as project identification, financing, designing, tendering and execution, noting that in each phase corruption may involve the project owners, funding agencies, consultants,



contractors, sub-contractors, joint venture partners, and agents. Corruption may lead to projects being authorized questionably because there could be bribery and fraud in the selection of contractors, project prices could be grossly inflated and the end product could thus be defective or dangerous

### **2.5 Building maintenance practice**

Straub, A. (2012) stated that Building maintenance is a combination of all technical and associated administrative actions during the service life to retain a building or its parts in a state in which it can perform its required functions. During their service life all building components have to resist the degradation and performance loss due to ageing, use, and external causes. The quality of each condominium houses were guaranteed by executing the right maintenance activities at the right time, preferably 'just-in time'. This assumes professional skill and a forward planning of maintenance and repair.

Generally maintenance can be divided into preventive and corrective maintenance. Preventive maintenance is carried out at predetermined intervals (e.g., time-based or use-based) or to other prescribed criteria (e.g., defects and condition) and intended to reduce the likelihood of an item not meeting an acceptable condition. Corrective maintenance is any maintenance activity which is required to correct a failure that has occurred or is in the process of occurring.

Homeowners and housing providers are free in choosing the appropriate instruments for the asset management and maintenance management being used in maintaining their house. Maintenance is mainly reactive and corrective. In several countries condominium owners are forced to make a preventive maintenance planning. Building maintenance is applied to maintain the design objective of the building and occupant's requirement.

Figure 2.5 describes that maintenance of service providing building were required to maintain the design requirement of the building while improvement were provided for encouraging the service quality of the building than the design requirement. Generally maintenance targeted to achieve the design objective whereas improvement targeted to upgrade design objectives

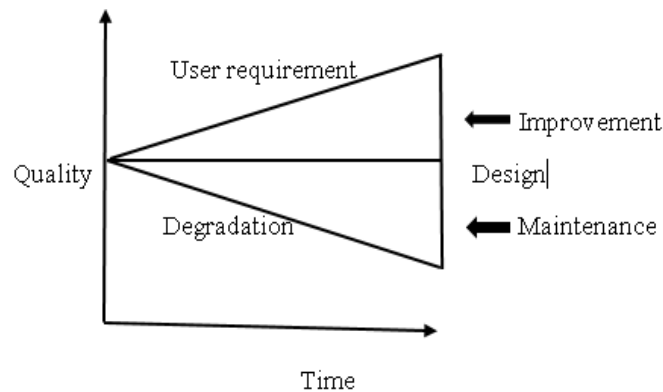


Figure 2.4 Quality vs time

During the design phase of the project and up to handover of the facility, Operation & Maintenance personnel should be involved in identifying maintenance requirements for inclusion in the design. The goal of effective Operation & Maintenance is to achieve the intent of the original design team, i.e., the systems and equipment delivery services to the user enhancing a comfortable, healthy, and safe environment.

Yebichaye D. (2016) point out that Building maintenance prepared through an accurate program of repeated maintenance plays a major role in preventing building defects while Buildings that neglect building maintenance may fall into several defects which may lead to structural failures.

According to the Ethiopian condominium proclamation 370/2003 the unit owners association shall have a responsibility to maintain common elements whereas each unit owners shall have the responsibility to maintain the unit and limited common element reserved for their exclusive

use. The responsibility of maintenance shall mean wear and tear caused by normal use or old age.

Kam, S.C. (2016) stated that Building maintenance plays a major role in preventing building defects and if one ignores the building maintenance it may cause some defects then lead to structural failures. He also describes that adequate supervision during construction is one of the most effective mechanism that minimizes the occurrence of defect throughout the life span of the building structure. The experienced and well-trained supervisors can minimize the rework in construction defects.

Akande, B.F. et. al. (2016) states that even where a structural design is not deficient, absence of proper supervision on the site by qualified personnel can lead to building failure.

## CHAPTER THREE

### 3. RESEARCH METHODOLOGY

#### 3.1 Study Area

The study was conducted in Tigray regional state of Mekelle city. Mekelle was found 783 km apart from capital city of Ethiopia (Addis Ababa) to the northern direction. Mekelle lies at an elevation of 2,254 meters (7,395 ft.) above sea level with a mean annual rainfall of 714 mm (28.1 in). Administratively, Mekelle was considered as a Special Zone, which was divided into seven sub-cities: Hawelti, Adi-Haki, Kedamay Weyane, Hadnet, Ayder, Semien and Quiha. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), Mekelle had a total population of 215,914 people (104,925 men and 110,989 women).

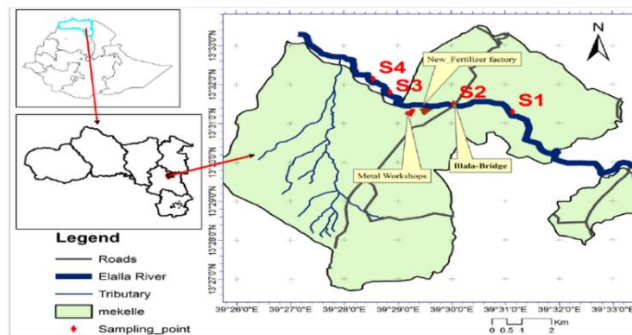


Figure 3.1. Map of Mekelle city

#### 3.2 Study design

In this study descriptive research method were employed. During the investigation reviewing related literatures, field observation, distributing close ended questionnaire for the occupants and open ended interview for Mekelle Housing Development Agency (MHDA) and the contractors who participate on condominium construction, were performed. Data obtained from the occupant were analyzed quantitatively using excel software version 2013 while the data gained from MHDA and contractors were analyzed qualitatively. Finally based on discussion of the result conclusion and recommendation were drawn.

### **3.3 Study Variables**

Study variables were classified as dependent variable and independent variables. For this research defects on 20/80 condominium buildings in Mekelle were the dependent variable.

Causes of the defect (substandard material, construction fault, maintenance problem), effects of the defect on the occupant and building performance (health social, economic, aesthetic, and functional), and the remedial actions used to detect the defect were the independent variables of the study.

### **3.4 Source of data**

The Primary data used for this study were collected through observation, questionnaire survey from the occupants and interview from Mekelle Housing Development Agency and the contractors who participate in condominium construction. Related books, journals, conference paper, and previous courses were the secondary source.

### **3.5 Data collection procedure**

Gathering and measuring information on condominium defect variables in an established systematic approach enables to answer stated research questions and evaluate the research outcomes. Reviewing literature on research issue field visit, preparing questionnaire, distributing and collect the questionnaire, interview, encoding, analysis of the result, result discussion, conclusion and recommendation were the activities conducted in their sequential order.

### **3.5 Research Population and Sampling**

For this research sampling has been introduced with a view to make the research findings economical and accurate. 20/80 condominium occupants, active contractors who participate in condominium construction in Mekelle, and Mekelle housing development agency were the population of the research.

All active contractors participated in condominium construction in Mekelle and Mekelle house development agency were interviewed. One person per one condominium building had been selected purposively from the newly establishing condominium associations.

There was 123 service providing 20/80 condominium buildings in Mekelle and the researcher decides to gather information's from each building by asking condominium association representatives. The association votes one person per a building which had better communication skill, building knowledge and experience. I had contact them in newly established condominium association meeting. From a total of 123 distributed questionnaire 112 were returned and the analysis was conducted on 112 peoples.

### **3.6 Data analysis**

The data obtained from the occupant were analyzed quantitatively using excel software version 2013 and qualitatively for the interview. Results were presented in graph, tabular, chart, and Bichat forms.

During the analysis Relative Importance Index were used to determine the relative importance of the effects of different defect on the occupant and building performance. The three-point scale were adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \Sigma W / (A * N)$$

Where, W is the weighting given to each factor by the respondents

A is the highest weight

N is the total number of respondents.

## CHAPTER FOUR

### 4. DATA ANALYSIS AND DISCUSSION

#### 4.1 Introduction

This chapter comprises the research findings and analysis. The findings here was an analysis of collective field visit, questionnaire, and interview. The analysis mainly focused on objectives of the research, but introduction to Mekelle condominium project and respondents back ground were also assessed

##### 4.1.1 Survey response rate

Two different questionnaires were administered, the first one was designed to the construction expert (active contractors participate in Mekelle condominium construction and Mekelle house development agency) and the 2<sup>nd</sup> questionnaire is designed to the condominium occupants. The research analysis and discussion had done based on the response from the distributed questionnaire. There is no specific survey response rate but survey response rate can be influenced by survey purpose, survey experience, survey length, survey audience, and survey incentives. From the distributed questionnaire about 93% of them were returned this and the analysis conducted on the basis of 93% study population result with additional field visit.

Table 4.1 Survey response rate

No	Respondent	distributed	returned	% of returned
1	contractors	17	15	88
2	MHDA	1	1	100
3	Occupants	123	112	91

#### 4.1.2 Academic status of the occupant

The respondents' academic status shown in table 4.1 revealed that 11.61 percent of respondents were MSc, 55.36 percent BSc, 24.11 Diploma, and 8.93 undergraduate. Generally 89% of the respondent had graduated from government and private institutions. This indicates respondents could answer the question confidentially.

Table 4.2 Respondent's academic status

No.	Academic Status	Quantity	Percentage
1	Undergraduate	10	8.93
2	Diploma	27	24.11
3	Degree	62	55.36
4	Master	13	11.61
	Total	112	

#### 4.1.3 Occupants Year of Residence

Understanding how long the respondent exists in the condominium building helps to know whether they are experienced in condominium defects or not. Figure 4.1 described that 16, 19, and 65 % of the respondent exists in the condominium building for 1-5, 6-10, and 11-15 years respectively. This means that residents have stayed enough time to notice defects in the condominium building.

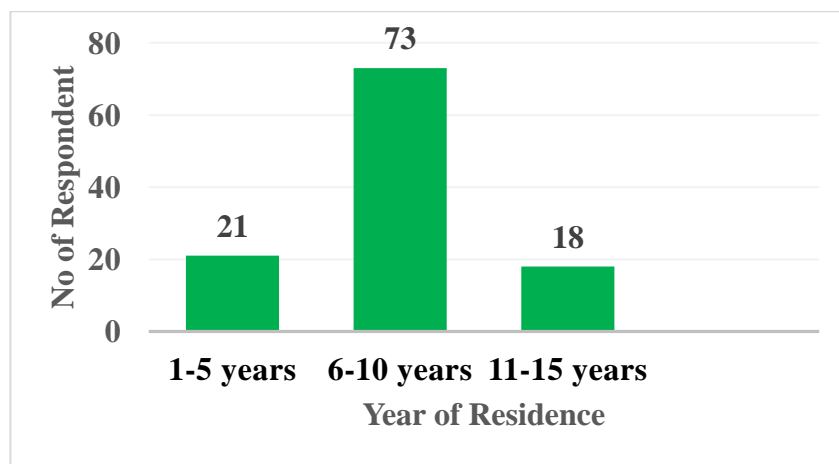


Figure 4.1 Occupant's existence



#### 4.1.4 Description of Mekelle 20/80 condominium building

The construction of condominium houses in Mekelle started in 1999 E.C through Mekelle Housing Development agency (MHDA). The program had an integrated approach to solve the housing shortage through mass construction of low cost houses and to reduce unemployment rate through engaging a large workforce in the construction process. In Mekelle a total of 3322 condominium houses were found in which the construction of 61 condominium buildings were began in the first round (1999) at six sub cities and 62 condominium buildings in the 2<sup>nd</sup> round in 2000 E.C. The condominium blocks were ground floor plus four stories (G+4) in height therefore avoiding the need for a mechanical lift, which minimizes associated construction and maintenance costs. As illustrated in figure 4.2 about 78% of the condominium building had been constructed in Hadnet, Ayder, and Adi-Haki sub cities while there was no condominium building in Kedamay Weyane sub city.

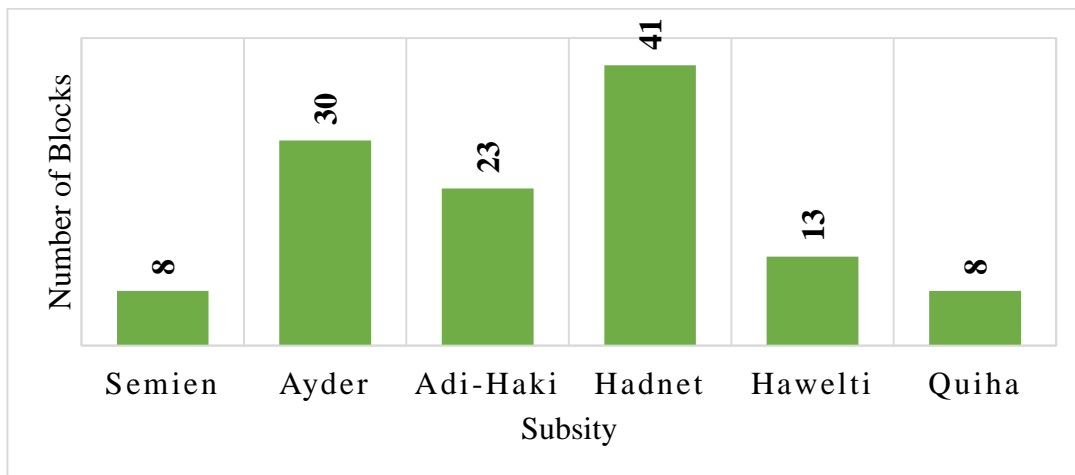


Figure 4.2 Condominium location in Mekelle

Mekelle house development agency had constructed the condominium projects through his own finance borrowed from commercial bank of Ethiopia (CBE). The occupant paid 20% of the house price when the projects were finished and the rest 80% of the house price were designed to repay within 20 years for residential and 25 years for commercial houses.

The estimated unit price for studio, one bed, two bed, and three bed rooms were sold 1451 birr per M<sup>2</sup> and initial bid price for commercial houses were 2177 birr per M<sup>2</sup> but the winning price for commercial houses were 6000 birr per M<sup>2</sup> and above.

The condominium blocks were constructed from a frame of reinforced concrete, ribbed slab, and HCB walls, plastered both inside and outside. In the first round Units were handed to beneficiaries with cement screed concrete floors with both side painted walls, but some of the beneficiary changes the screed floor finish in to tile and marble floor and the paint as their choice. In the 2<sup>nd</sup> round condominium projects floor and wall paint activities was left to the beneficiary. Windows and doors were made from metal frames with single glazing.

30 per cent of the total unit were allocated first without lottery system to women households, disable persons, and for minor groups. from 61 blocks 235 studio, 547 one bed room, 468 two bed room, 160 three bed room, and 126 commercial houses in the first round and from 62 blocks 336 studio, 652 one bed room, 499 two bed room, 116 three bed room, and 183 commercial houses in the 2<sup>nd</sup> round were allocated to the beneficiary. Figure 4.3 describes that the proportion of houses categories in which 10% of them were allocated for commercial purpose while the rest 90 % houses were allotted for residential.

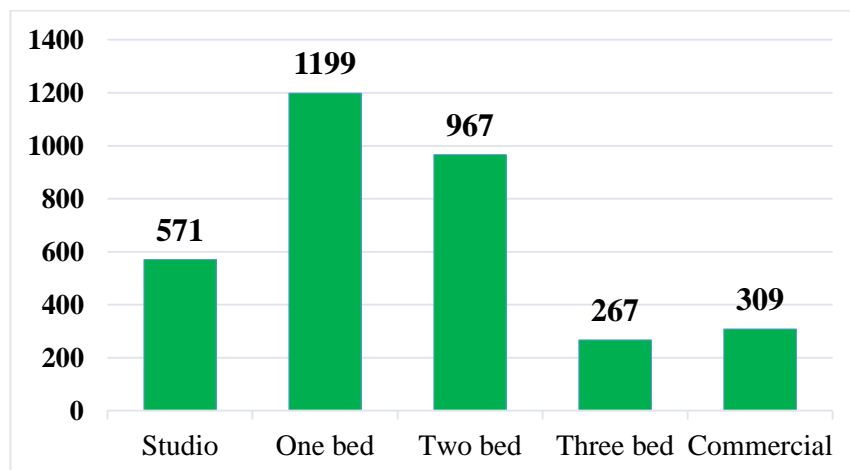


Figure 4.3 Condominium house proportion

The detailed location of both first and 2<sup>nd</sup> round of condominium buildings found in each Mekelle sub city except Kedamay Weyane sub city and their quantity had been mentioned in the table 4.3 and 4.4 consecutively. All condominiums found in Mekelle were designed from studio to three bed room for residential and commercial houses.

Table 4.3 1st round condominium projects detail

sub city	site	No block	House category				
			Studio	1 bed	2 bed	3 bed	Commercial
Semien	May Duba	2	10	31	28		6
Ayder	Ayder	17	83	136	146	41	27
	Business	2	20	10	-	10	-
Hawelty	Dejen	2	-	15	24	4	4
	Dedebit	2	11	16	5	7	5
	Merha Tibebe	9	21	72	65	29	24
Hadnet	Kelkel Debri	12	22	120	94	30	24
	Edaga Bieray	5	24	60	38	9	17
	Kasech	3	14	16	10	10	6
Adi-Haki	Enda Mariam	4	16	40	20	12	8
Quiha	Quiha	3	14	31	38	8	5
<b>total</b>		<b>61</b>	<b>235</b>	<b>547</b>	<b>468</b>	<b>160</b>	<b>126</b>

Table 4.4 2<sup>nd</sup> round condominium projects detail

Sub city	Site	No block	House category				
			Studio	1 bed	2 bed	3 bed	Commercial
Semien	Enda Tsaba	2	16	24	16		6
	05 Station	2		12	18	4	6
	05 Senit	2		32	16		12
Ayder	Old Business	7	50	87	64	8	20
	Ayder	4	8	64	28	8	22
Hadnet	Adi Hawsi	9	62	84	66	15	28
	May Gba	12	103	130	115	19	19
Adi-Haki	Srawat	13	65	103	58	45	32
	Adi Hawsi	6	9	68	37	9	29
Quiha	Quiha	5	23	48	81	8	9
<b>Total</b>		<b>62</b>	<b>336</b>	<b>652</b>	<b>499</b>	<b>116</b>	<b>183</b>

#### **4.2 Common condominium defects in Mekelle**

The important factor in construction of condominium projects is to complete the facility per scope of works to meet customer satisfaction within the estimated budget and achievement of defined purpose. Defects in the condominium building occurred in various form to a different extent in all types of buildings irrespective of age.

The main function of a building is to protect the occupants and their property from weather, mainly rain, wind, and extremes of temperature. It is most important to provide the basic needs which will achieve all of these functions. Successful companies need to meet their customer expectations through superior implementation of their quality policies; however, currently many residents were still not satisfied with the quality of condominium buildings.

Water leakage (through roof washer, window, and water pipes), sanitary leakage, miss fixed electrical fixtures, water inclination through doors, and septic tank leakage and over flow discharged due to small size septic tank were the most common defects illustrated by MHDA. Respondents were required to determine the defects occurred in their buildings.

The researcher observed that most defects identified by respondent were similar to those identified in the literature review. Data from occupant were analyzed using RII method and the result described in Table 4.5 revealed that roof defect, leakage through roof and water supply line, door and window defects, defects in building service installation, and building dampness were the most common defect in Mekelle condominium building. High RII value indicates the defect were most common while small RII value shows less abundant defect.

Table 4.5 Common condominium defect in Mekelle

No	Type	Occurrence			RII	Rank
		More	Medium	Less		
1	Dampness	51	36	25	0.74	5
2	Leakage	67	38	7	0.85	2
3	Defect In Plaster	31	25	56	0.59	7
4	Wall Crack	26	23	63	0.56	8
5	Peeling Paint	41	34	37	0.68	6
6	Efflorescence	11	19	82	0.46	9
7	Termite Attacks	13	15	71	0.42	10
8	Roof Defect	86	18	8	0.9	1
9	Door And Window Defects	71	28	13	0.84	3
10	Defects In Building Services Installation	63	23	26	0.78	4

#### 4.2.1 Roof defect

The primary function of Roof for any building were designed to had the efficiency to resist the pressure from rain, wind, and sun since a properly designed and constructed roof protects the peoples and their properties from the external pressures. But as shown in figure 4.4 the roof of the condominium buildings especially those constructed in the first round couldn't protect the occupant and their property from rain water.

The main problem of roof defects in the condominium buildings was that it allow the water to go inside the building through the roof connection. A drop of rain water enters to the building through the hole provided to fix the sheet metal with the purlin. Roof washer used to protect leakage through the connection were drilled manually fit with the J-bolt and it had larger diameter than the bolt.

The gutter used to collect the water from the roof and transmitted to the down pipe were not properly fixed by steel strap with the facial board. This becomes a reason to disconnect from the roof and fall down to the ground. As shown in figure 4.4 the researcher also observed that roof defect was most common condominium defects in Mekelle.



Figure 4.4 Roof defect in Edaga Bieray condominium

#### 4.2.2 Leakage

Leakage in Mekelle condominium building was originated from storm water and waste water sources. Leakage of storm water were originated from rain penetration through roof connection, inclination through windows, and from the connection of water supply line while waste water leaked from sewer line, septic tank manhole and the septic tank itself. The leakage from the urine were most common in the condominium buildings and it was the first case for water and air borne diseases.

The Ethiopian public health proclamation 200/2000 article 12 states that no person shall dispose solid, liquid, or and other wastes in a manner which contaminates the environment or affects the health of the society. But as shown from the figure 4.5 most of the septic tanks in Mekelle condominium sites couldn't serve the community and liquid waste leaks through the manhole.

The capacity of septic tank constructed in the condominium projects was 98 M<sup>3</sup> for 25 householders and 50.4 up to 67.73 M<sup>3</sup> for 20 households but it didn't serve the occupants sufficiently. Occupants were required to pump 2-3 times per a year, but still leakage of the septic tank had not stopped. Figure 4.5 explains that waste water leakage from septic tank and manhole in most condominium building demands quick attention unless it becomes the sever defect on the condominium occupant than the current condition.



Figure 4.5 Septic tank leakage in Senet condominium

#### 4.2.3 Door and window defect

Window and door of the condominium buildings were made from LTZ frames and the plane was covered with glazing for window as well as a composite of metal sheet and glass for doors. The gap between the glass and window frame were not properly filled by putty in which a drop of rain water enters to the building through the gap.

In most of the windows there was no window sill and the hole were poured with insufficient mortar this becomes easy to enter the water to the wall or inside the building. In some houses the external doors were not easily accessible since Hinge used to connect the frame with the plane were not properly welded. As shown in figure 4.6 most windows in Mekelle condominium



factory produced window sill or rich cement mortar were not provided before window had been assembled. Corroded LTZ window and door frame were also found in the condominium.



Figure 4.6 Window defect

#### **4.2.4 Defects in building service installation**

Deficiency in electrical service wiring, socket, switch, and light lump and plumbing problems were observed in the condominium buildings. Those defect happened frequently and occupant incurred high cost for inspection. System breakdown, sudden circuit breaker cut off leading to stoppage and larger power consumption were common electric installation problems in the condominium buildings.

Defect in service installation were linked with day to day activity of the condominium occupants which means defect on those component affects their daily activity. In certain sites there was an interruption of electric power for two or more weeks because occupant couldn't get urgent solution from the technicians.



#### 4.2.5 Dampness

Dampness in building is one of the important aspects to consider during building design. The existing of dampness in the condominium building was one of the most damaging factor that really must be taken care of. It causes damage in decaying and loosing up of plaster and paint, rotting in the timber structures, corrosion metals in door and window and also destroying the equipment in the building.

As a wall affected by dampness, the water enters to the surface and trapped by the paint or cement-mortar. The evaporating of water from the surface lifts the film in bubbles that eventually break to leave the blisters. Even if dampness was the fifth most common condominium defect, the value of the building were highly affected. As shown in the figure the defected down pipe crossed the toilet window and the water laid on the bottom part of the window which cause dampness to the wall surface. Figure 4.7 describes that the defect in down pipe and roof gutter were the main source for building dampness. Down pipe crossing the toilet window indicated that there was a problem in fixing the drainage.



Figure 4.7 Condominium dampness in Edaga Bieray

### 4.3 Causes of Mekelle Condominium Defect

Defects in the condominium building were the problem faced in most of the building regardless of building construction techniques or age but it depends on to the factors causing the defects. Condominium defect happened in Mekelle were the consequence of different contributing factors. Figure 4.8 described the rank of factors contributing to the building defects in which use of substandard material as the most significant contributing factor with 32.23% and the use of substandard material during construction increase the building defects and lead to high maintenance during operation. Construction faults were the second highest ranked factor which covers 30.45% from all factors contribute to the defect. The third factor were followed by maintenance problem which scores 13.93 % contribution to overall the condominium defects while design fault and occupational fault were ranked 4<sup>th</sup> and 5<sup>th</sup> respectively. Those contribution factors for every defect occurred in condominium building were briefly in table 4.6.

Table 4.6 Occupant’s response for causes of condominium defect

No	Type	Cause of defect				
		Design fault	Construction fault	Substandard material	Occupants fault	Maintenance problem
1	Dampness	10	43	31	13	15
2	Leakage	12	29	38	14	19
3	Defect In Plaster	9	26	35	10	32
4	Wall Crack	16	31	42	11	12
5	Peeling Paint	18	22	45	12	15
6	Efflorescence	19	25	36	9	23
7	Termite Attacks	22	20	29	33	8
8	Roof Defect	8	44	39	5	16
9	Door And Window Defects	9	53	27	13	10
10	Defects In Building Services Installation	14	48	39	5	6
	total	137	341	361	125	156
	percentage	12.23	30.45	32.23	11.16	13.93
	rank	4	2	1	5	3

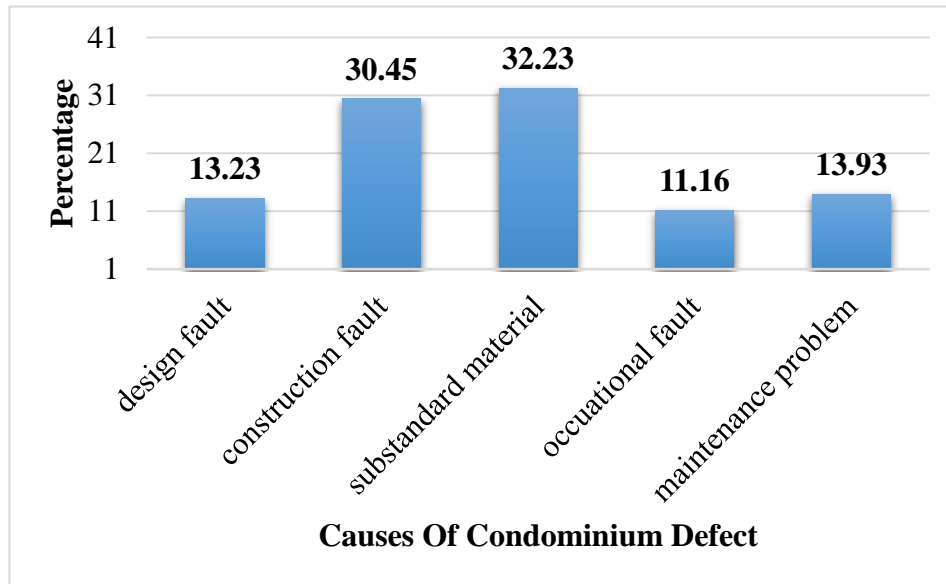


Figure 4.8 Revised causes of condominium defect

Result from the interview also revealed that low quality material, construction fault, and maintenance problem was the most common causes of the condominium defect

#### 4.3.1 Use of substandard material

In the materials management of buildings, understanding the nature of the building materials and accurate diagnosis of defects is most important. From the contribution factors of building defects the highest rated factor was use of substandard material. The effects of using low quality materials do not take place earlier but the use of inferior or sub-standard materials in the condominium was a key factor that leads to early deterioration of building components or the whole condominium buildings in Mekelle during its operation.

Result from the interview reveals that manually produced roof washer, use of zinc coated pipe lines fitting instead of galvanized steel pipe fitting, substandard electrical fixtures were used during the construction that intentionally reduce the quality of the condominium building.

Material supplier's for water line, electrical accessory, and roof interest to encourage their capital cut off without compromising quality of material, and delay of cement material were the major problems shown during Mekelle condominium construction.

#### **4.3.2 Construction fault**

Materials obtained from suppliers or work performed percentage were expected to be within the acceptable quality level. The primary objective of condominium construction in Ethiopia is to improve the shortage of shelters for low and middle income urban society, create employment opportunity for local contractors, and stimulate the country economy. But the involvement of multi unexperienced cooperatives during the construction becomes a critical factor for the condominium defects.

The nature of the contracts between the parties plays a dominant part in the quality system required from the project, and the responsibility for fulfilling them must therefore be specified in the project documents. Multi-contractual agreement in condominium construction with contractors, suppliers, producers, and cooperatives leads the quality control problems. Mekelle house development agency had signed contractual agreement with main contractors for the structural part, cooperatives for roof and all non structural parts, material supplier and producer. Patriating less experienced cooperatives during the construction plays pivot role in delaying and reducing the quality of the condominium projects.

There was no any contractual agreement between contractor, supplier, producer, and the cooperative since all participants signed an agreement with MHDA and they were responsible only for the agent. As shown in figure 4.9 the management structure were active only vertically but not horizontally which indicated that contractors couldn't directly ordered the material supplier this brought disrespect among the participants and difficulty in the achievement of the project objectives.

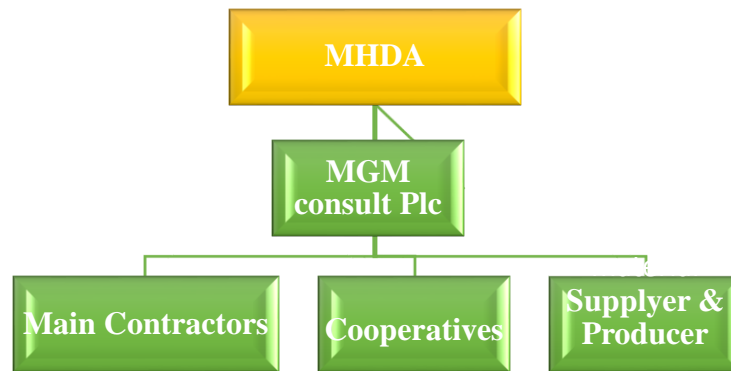


Figure 4.9 Management structure adopted in Mekelle condominium construction

The provision of communal buildings to condominium sites was an attempt to respond the cultural needs of residents which was used to provide a protected space for residents to perform traditional tasks such as slaughtering goats, handwashing, laundry, and cooking extensive meals: activities the housing units. But MHDA described construction of this communal building had been omitted to reduce construction cost of condominium building. The exclusion of communal building during construction affects the quality of service expected from the condominium.

In a certain buildings the elevation of floor level was lower than the corridor floor level in which during rainy season water runs from corridor to the building and the occupant were challenged to drain the water since there was no floor drain in the building.

### **4.3.3 Maintenance problem**

One of the most important issues in the context of condominium construction concerns with maintenance management. It is important to fix the building defects and carry out the necessary maintenance work for the proper functionality of a building. The involvement of operation and maintenance personnel during design of condominium projects supports to identifying maintenance requirements at the planning stage. Condominium maintenance seeks to extend the life of the building elements through day to day work

Result from the interview and observation described that the absence of taking into consideration in design for maintenance of roof, external elements of the building highly affects the building performance and the occupant's financial stability. Most of the occupants had not applied property scheduled or preventive maintenance but they carried out emergency maintenance when defect reaches at critical stage.

Condominium proclamation 370/2003 describes that the external maintenance of the roof and walls should be undertaken by a Condominium Association that jointly represents ownership, but there was no any maintenance activity for common elements like roof and external walls taken by the association. All resident highly emphasizes on internal quality of the house but not committed to maintain the external part of the structure. Mekelle house development agency maintains once for roof and external paint for the first round condominium buildings.

Residents' participation in terms of reporting disrepair and monitoring building defects was an important aspect in improving the existing housing conditions and in avoiding deterioration but Residents were not highly aware on maintenance procedure, maintenance strategy, and maintenance of common elements of the building. Poor and improper building maintenance in

the condominium sites affects the proper serviceability of the building and requires higher maintenance cost.

Occupants had not establish strong association which helps them to resolve their problem cooperatively and complains were raised by affected or voluntary persons. There was no common deposit for common element maintenance purpose. Mekelle house development agency describes that the occupant lefts the maintenance of roof and external walls to the government and those who live in the top story were challenged financially to maintain the roof defect.



Figure 4.10 Maintenance problem



#### 4.3.4 Design fault

Design of condominium building were expected to fulfil the requirement of standard design parameters. If the design errors were not corrected at the design stage it is not easy to tolerate those mistakes easily. Defects arising from design and construction were recognized to have substantial consequences on the level of maintenance during occupancy of buildings which often translate to high costs causing dissatisfaction of users.

Miss match of structural plan with architectural plan, architectural with sanitary and electrical plan, small size septic tank design, exclusive of vertical access for roof and external wall maintenance, narrow corridor size in some condominium blocks, and provision of toilet window beside the stair were the critical problems shown in design of the condominium buildings. Ladder have been constructed for water tanker only but there was no vertical access used for roof maintenance of the building.



Figure 4.11 Design deficiency in toilet window



#### 4.3.5 Occupational fault

Using the building and its component for the desired and planned purpose plays a vital role in achieving the expected function of the building. Careless ness and miss use of the building component leads to a building defect and reduce the quality of service. Occupants fix the TV signal dish on the window frame and providing holes on the wall in different places, miss use of corridor draying cloths were the most occupational faults in the condominium buildings. As shown in the figure bellow Exclusion of communal building in the construction and non-consideration of the place for TV signal dish in design leads the occupant miss use the building component for other purpose. Figure 4.12 illustrated that absence of communal building and permanent fixing place for TV signal dish leads occupants to miss use the building component.



Figure 4.12 Occupational fault in condominium buildings

The city administration were note committed to encourage the awareness of the occupant how they could use the condominium wisely. They should hold them as his community and occupants should be benefited from the infrastructure construction like cobble stone and recreation areas.

#### **4.4 Effects of Mekelle condominium defect on occupant and building performance**

Missing the impacts of the condominium defect on the occupant and building performance results failure in serving the proper function and in the satisfaction of the occupants. Defects occurred in the condominium buildings affects both the building performance and the occupants. Inefficiency in handling defects in a condominium building becomes as a cause for various effects and negative impact to occupants and the performance of the building. Inabilities in handling the building defects systematically provided negative impact to users and building owners as well.

Due to the occurrence of building defect occupants were imposed socially, economically and health. Respondent reply's impacts magnitude of the defect on the building performance and them as high, medium, and low. Leakage, roof defect, dampness, door and window defects, defect in building service installation were the top ranked sever defects affecting the condominium buildings as well as the occupant.

##### **4.4.1 Effects of the defect on occupant**

Housing has a great social and economic impact on our lives and the way we live. It has direct and immediate effect on health, education, economic, environmental, and social life of the society. Due to the existence of different defects on the condominium buildings 74% of the occupant were not satisfied by the quality of service they gained. The various defects which occur in the post-construction stage in Mekelle condominium buildings were directly linked to resident's quality of life, social life, and economic losses. Figure 4.13 described that 83 percent of the occupant affected their health, economic, and social aspect by the condominium defect.

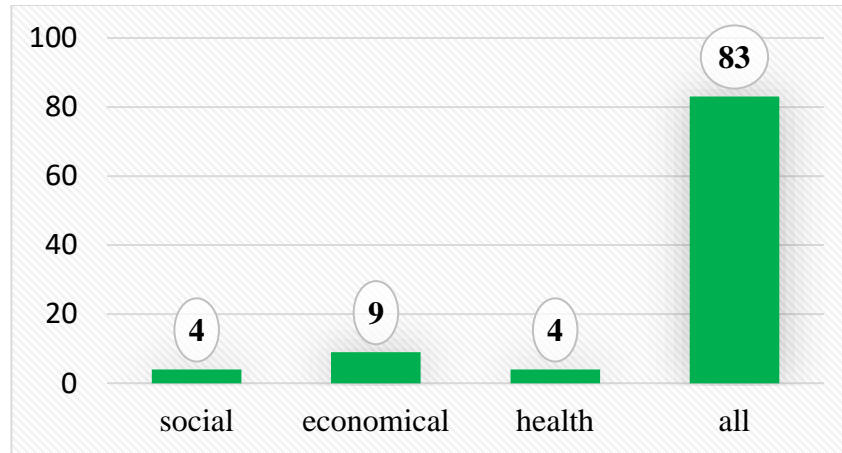


Figure 4.13 Effects of defect on occupant

Results from the interview also indicates that the existence of those defects on the condominium building highly imposed social, economic, and health aspects of the occupants. Leakage of waste water from the septic and sanitary line brought water and air borne diseases. Table 4.7 described severity of each defect on social, economic, and health aspects of the building occupants.

Table 4.7 Severity of defects on occupant

No	Type	Severity of defect on occupant			RII	rank
		high	medium	low		
1	Dampness	42	30	50	0.7	4
2	Leakage	61	38	13	0.81	2
3	Defect In Plaster	32	45	35	0.66	6
4	Wall Crack	21	38	53	0.57	7
5	Peeling Paint	20	32	60	0.55	8
6	Efflorescence	16	22	74	0.49	10
7	Termite Attacks	21	28	63	0.54	9
8	Roof Defect	72	29	11	0.85	1
9	Door And Window Defects	53	32	27	0.74	3
10	Defects In Building Services Installation	46	28	38	0.69	5

As shown from the table 4.7 roof defect, leakage, door and window defects, dampness, defects in building services installation were the most sever defects with RII value of 0.85, 0.81, 0.74, 0.7, and 0.69 consequentially.

Most of Mekelle city access road was paved by cobble stone and asphalt but yet for condominium projects. Even through there was electrical interruption electric power office told them to ask for Mekelle house development agency instead of solving the problem by the experts this indicates the condominium community was neglected from the city administration.

#### **4.4.2 Effects of the defect on building performance**

Building defects affect both performance and appearance of the structure. The occurrence of defects on the condominium buildings reduces the aesthetic value, function, and life span of the building component. Condominium appearance is one of the most important aspects of building performance. It pertains to the aesthetic perception of the building by the occupants. The quality of construction and selection of building materials should be compatible and complement with the existing physical environment.

Leakage through the roof distorts the life time of the cheap wood ceiling since wood product losses their aesthetic and quality when they have a direct contact with water and the occupant had demolished it within two year. There was also erosion of the surface finish by the water drained through the broken down pipe. As shown in the table below occupants answer towards the effects of defects on building performance, aesthetic value, and life span of building component were analyzed using relative importance index which reveals that leakage, roof defect, dampness, door and window defect, defect in building service were the top five sever defects in the condominium sites. As shown from table 4.8 severity of the defect were higher on the occupant than the building performance.

Table 4.8 Severity of defects on building performance

No	Type	Severity of defect on building performance			RII	rank
		high	medium	low		
1	Dampness	27	39	47	0.61	3
2	Leakage	31	56	25	0.68	1
3	Defect In Plaster	20	28	64	0.54	8
4	Wall Crack	20	41	51	0.57	6
5	Peeling Paint	18	37	57	0.55	7
6	Efflorescence	10	18	84	0.45	10
7	Termite Attacks	17	31	64	0.53	9
8	Roof Defect	29	38	45	0.62	2
9	Door And Window Defects	26	36	50	0.6	4
10	Defects In Building Services Installation	25	37	50	0.59	5

As shown in figure 4.14 mistakes happened starting from design up to operation and absence of taking well organized solutions to the defect Mekelle condominium buildings looks like elder and nasty.



Figure 4.14 Quiha condominium building

#### **4.5 Remedy to the condominium defect**

The remedy discussed below were based on observation and the respondent's idea. Up to date well organized and effective remedial or preventive actions had not taken by the occupant as well and MHDA. The measures described here would be effective if applied effectively.

##### **4.5.1 Maintenance**

A structure needs to be maintained after a lapse of certain period from its construction completion. Some structures may need a very early look into their deterioration problems, while others can sustain themselves very well for many years. Preventive maintenance for the condominium buildings should be carried out at predetermined intervals like time-based or condition based and intended to reduce the likelihood of an item not meeting an acceptable condition. Corrective maintenance were also required to correct a failure that has occurred or in the process of occurring.

Applying condominium maintenance prepared through an accurate program of repeated maintenance plays a major role in preventing building defects while Buildings that neglect building maintenance fall into several defects which lead to structural failures. Therefore providing the right and effective maintenance for plays vital role in the creation of sustainable and durable condominium building.

Result from the interview reveals that when a building suffers defects, the causes of that defect have to be properly identified before any remedial work had been undertaken. To secure the general structural stability and life of a building, it is important to regularly inspect not only the main structural elements including foundations, walls and roofs; but other common building components. Continues proper condominium maintenance enables to provide wide range of services efficiently and effectively.



#### **4.5.2 Facility management**

The stage of exploitation of a condominium building is related to the broadly understood management which is multi-faceted. The most important are the technical, economic and social aspects. It is also noted that the type of object determines the share and scope of the mentioned aspects of management. The technical condition of the facility was a result of many activities both during the operation of the facility as well as activities and factors occurring before the operation stage like design errors, execution errors, and low quality of materials.

Facility management is precisely the activity that occurs during the operation stage by which it is possible to maintain or more generally influence the technical condition of the building. This is done through actions such as ongoing maintenance, repairs as well as modernization. Each of these activities requires defining the purpose, identifying the phenomenon and external factors, developing the way of action, choosing the best course of action, and reporting the results of the action.

#### **4.5.3 Extra facility Construction**

Construction of communal building, mobile or permanent access for roof and external wall maintenance, public septic tank were required to minimize the condominium defects. A construction of communal buildings to condominium building would respond the cultural needs of residents which was used to provide a protected space for residents to perform traditional tasks such as slaughtering goats, handwashing, laundry, and cooking extensive meals.

Considering easy access to maintenance during design for each component of the condominium building allows to provide easy and economical maintenance measure but if those factors were not considered during design the maintaining parts of becomes difficult and the defect would

consequence property damage economic loss, and low quality of service. Even if the access for roof and external walls were not considered during the design still it was still necessary.

To ensure the building safe and in a long term quality, the factors that caused the defects should be prevented. To rectify the condominium defect Mekelle house development agency had taken roof maintenance for first round 61 blocks and constructed additional septic tank as corrective measure. To prevent leakage through roof in the 2<sup>nd</sup> round condominium buildings factory produced roof washer were used instead of manually produced washer.

Mekelle house development agency planned to provide technical support and encourage occupant's awareness on building operation through association meeting. 24 condominium association having separate legal entity had being established in which 10 of them were certified, 12 waiting to be certified and 2 of them were on progress.

Generally detecting the defects through carefully analyzed maintenance measure, developing the community awareness, stimulating the community association, provide technical advice for the occupant, constructing the communal building were the remedial actions illustrated by the Contractors.



## CHAPTER FIVE

### 5. CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusion

Condominium housing is a form of housing tenure where each resident household owns their individual unit, but equally shares ownership and responsibility for the communal areas and facilities of the building. Low-cost house program had a large-scale approach to address the current housing deficit, tolerates low- and middle-income households, access to home ownership, recognizes the opportunity for housing to stimulate the economy, employment opportunity, and improve the capacity of the construction and financial sectors.

The study focused on the assessment of defects occurred on 20/80 service providing Mekelle condominium buildings, causes of the defects, effect of the defect on the occupant and building performance, and their remedy. A total of 123 condominium buildings were found in six Mekelle sub cities.

According to results of the survey and my observation there were more defects in Mekelle condominium buildings but Defect in Roof washer, downpipe and gutter, leakage of septic tank, door and window defect, deficiency in electrical fixture, and dampness were the most abundant condominium defects.

Investigating on key factors contributing to condominium defect was fundamental in ensuring sustainability and maintainability of buildings. Condominium defects in Mekelle were the consequence of use of substandard material, absence of strict quality control during construction, absence of periodic maintenance, mistakes in design consideration, operational faults. Multi contractual agreement with main contractors, cooperatives, material supplier, and producers were also the critical problem quality control process during the condominium construction.

Occupants were also not strongly motivated to maintain and sustain the serviceability of the condominium building cooperatively through the adopting of proper maintenance practice. Mekelle condominium building serves a minimum of ten years but the occupants didn't had common deposit for the maintenance of common units of the building. Occupant didn't had the habit to overcome their problems through the establishment of strong association and working cooperatively. Still private units were maintained frequently but not permanently solved the problem.

Due to the occurrence of condominium defects, lack of periodic maintenance practice, omission of communal building, and occupant's wrong practice to fix television signal dish, and absence of vertical access for roof and external wall maintenance condominium buildings in Mekelle looks like elder and nasty. Those defects brought social, economic, and health effect on the occupants as well as aesthetic, function, life span of the building component. Leakage and roof defect were the most sever Mekelle condominium defects that needs urgent solution.

According to results from respondent and observation the occupant tried to detect the defects on private unit but not well motivated on the maintenance of common unite of the building. Even if MHDA had maintained the roof defect and external paint for the first round 61 condominium buildings the defects were not still rectified. Providing well organized preventive and corrective maintenance, adoption of facility management, and construction of extra facility such as communal building and vertical access were the described solutions for the defect minimization.

## 5.2 Recommendation.

- ✓ Sufficient communal buildings for laundry, common kitchen, and goat slot as well as permanent or mobile access for roof and external wall maintenance should be constructed for all condominium buildings.
- ✓ The government should construct public septic tanks that could serve all the condominium sites and Urine waste from the occupant should be used as green material for power generation through biogas system.
- ✓ Unity is strength so occupants should inspire their association and save money for the maintenance of common units through common deposit and free spaces found in all condominium sites should be used for income generation.
- ✓ Occupants should rectify the sever defects prior in well-organized manner cooperatively and should be focus on defect prevention rather than defect rectification.
- ✓ A common place should be fixed for TV dish holder and occupants should be trained on how they use and maintain the condominium building wisely.
- ✓ In order to sustain effective and efficient service quality the functional operation of the building component should be checked with in time interval by facility management expert.

## REFERENCE

- ✓ Abdul Rahman, S. B. and Nurzaihan, A.A.S. (2013). A study on design defects affecting maintenance. The 5th Undergraduate Maintenance and Facilities Maintenance Conference.
- ✓ Ahmad, S. (2013). Some Common Maintenance Problems and Building Defects: Our Experiences. The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering. Malaysia
- ✓ Ahzahar, N., Karim, N.A., Hassan, S.H., and Eman, J. (2011). A Study of Contribution Factors to Building Failures and Defects in Construction Industry. The 2nd International Building Control Conference. University Technology MARA: Pulau Pinang.
- ✓ Akande, B.F., Debo-Saiye B., Akinjobi, S. D., Alao T.O., and Akinrogunde, O. (2016). Causes, Effects and Remedies to the incessant Building Collapse in Lagos State, Nigeria. International Journal of Basic & Applied Sciences. 16 (04).
- ✓ Arif, A., Tamene, A., Alemu, M. (2016). Assessment on causes of defect and the maintenance management practices on low cost building (A case study of Jimma Town Condominium). International Journal of Engineering and Technical Research. 5(3): 2454-4698.
- ✓ Azree, O. M. and Nadia, O. B. (2014). General Building Defects: Causes, Symptoms and Remedial Work. European Journal of Technology and Design. 3(1).
- ✓ Condominium Proclamation 370/2003. Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia. September 11<sup>th</sup> Addis Ababa.
- ✓ Dinesh, S. and Resmi, R. (2017). A Review on Construction Defects. International Journal of Informative & Futuristic Research. 4 (8).

- ✓ Environmental pollution control proclamation 300/2002. Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia. December 3<sup>rd</sup> Addis Ababa.
- ✓ Forcada, N., Macarulla, M., Gangolells, M., Casals, M., Fuertes, A., Roca, X. (2013). Post-handover housing defects: sources and origins. *Journal of Performance of Constructed Facilities*. 27(6): 756-762.
- ✓ Georgiou, J. (2010). Verification of a Building Defect Classification System for Housing. *Structural Survey*. 28(5): 370-383.
- ✓ Georgiou, J., Love, P., & Smith, J. (2009). A Comparison of Defects in Houses Constructed by Owners and Registered Builders in Australian State of Victoria. *Structural* 17(03): 160-169.
- ✓ Guesh D. (2017). The Assessment of 20/80 Condominium Housing Projects in Addis Ababa: The case of Bole and Akaki Kaliti Sub cities.
- ✓ Hamzah, A., Lincoln C., Chen, W., and You, M. K. (2012). Defects in Affordable Housing Projects in Klang Valley, Malaysia. *Journal of performance of construction facility*.
- ✓ Herbert, W. (2010). *Effective Building Maintenance: Protection of Capital Assets*. The Fairmont Press, Inc. united states America.
- ✓ Kam S. C. (2016). *Study of Defects in Residential Buildings*. Systems and Process Engineering Centre. Swansea University, Swansea UK.
- ✓ Perkins, P.H. (1997). *Repair, Protection and Waterproofing of Concrete Structures*. Third edition. E & FN Spon, an imprint of Chapman & Hall. London SE1 8HN UK.
- ✓ Resom, T. (2010). *Assessment of Condominium Housing: Fitness to the Intended Purpose (The Case of Mekelle City)*.
- ✓ Rojer, E. G. (2005). *Subterranean Termites, House and Landscape Pest*.
- ✓ Straub, A. (2012). *Maintenance and Repair*.

- ✓ Sulieman, M.Z., Omar N.N., Othuman M.A. (2014). Structural Component Defects of Low Cost Housing: A Case Study at Taman Bandar Perdana, Sungai Petani, Kedah, Malaysia. MATEC Web of Conferences, Penang, Malaysia.
- ✓ UN-HABITAT (2010). The Ethiopia Case of Condominium Housing: The Integrated Housing Development Programme. United Nations Human Settlements Programme: Nairobi.
- ✓ YEBICHAYE, D. (2016). Building Defects Due to Poor Workmanship in Addis Ababa: The Case Study on 20/80 Condominium Houses. AAiT.
- ✓ Zarak, K.K., Waqas, A.M., and Jalal, F. K. (2017). Structural defects in residential buildings: A study of Quetta, Pakistan.

## APPENDIX

### **Appendix 1. Interview question for Mekelle Housing Development Agency & contractor**

Dear respondent, this questionnaire is prepared to obtain necessary data for partial fulfillment of MSc thesis in Construction Engineering and Management in Jimma University, Jimma institute of technology. The objective of this thesis is to assess building defects on service providing 20/80 condominium buildings. Therefore, the information you are going to give will help me to assess the type and cause condominium defect, effects of defect on the performance of the building, and suggest possible solutions used to rectify as well as minimize the occurrence of the defect. With respect to this, you are the one who is experienced in building construction; hence I kindly request you to respond to the questions. I would like to confirm that the information you provide me will be kept strictly confidential and will not be shown to other persons. As such the quality of this study highly depends on the information provided by you. If you have any inquiry please contact through the following addresses.

*Phone: +251942728382*

*Email: Sunriseat27@gmail.com*

GEBREMESKEL ABIRHA

Post Graduate Student at Jimma University, School of Civil and Environmental Engineering,  
Construction engineering and management stream.

*Thank you in advance for your valuable cooperation!!*

1. What are the common defect that occurred in condominium buildings in Mekelle?

---

---

---

2. What design and construction problem do you observe when you are constructing the condominium?

---

---

---

---

3. What will be the root causes of those condominium defect in Mekelle?

---

---

---

---

---

---

---

---

4. Describe the effect of the defects on the condominium performance and the occupants?

---

---

---

---

---

---

---

---



5. Discuss the measures used to rectify/solve the defects that are already occurred?

---

---

---

---

---

---

---

6. What measure should be taken during design and construction stages that could be used to minimize the occurrence of defect in service life of the condominium?

---

---

---

---

---

---

---

7. What will be your contribution in reducing the occurrence of condominium defects?

---

---

---

---

---

8. How can be encourage the awareness of the residents on use of the condominium wisely?

---

---

---

## **Appendix 2. Questionnaire for condominium occupants**

Dear respondent, this questionnaire is prepared to obtain necessary data for partial fulfillment of MSc thesis in Construction Engineering and Management in Jimma University. The objective of this thesis is to assess building defects on service providing 20/80 condominium buildings. Therefore, the information you are going to give will help me to assess the type and cause condominium defect, effects of defect on the performance of the building, and suggest possible solutions used to rectify as well as minimize the occurrence of the defect. With respect to this, you are the one who can give me the actual information on the current status of the building; hence I kindly request you to respond to the questions. I would like to confirm that the information you provide me will be kept strictly confidential and will not be shown to other persons. As such the quality of this study highly depends on the information provided by you. If you have any inquiry please contact through the following addresses.

*Phone: +251942728382*

*Email: Sunriseat27@gmail.com*

**GEBREMESKEL ABIRHA**

Post Graduate Student at Jimma University, School of Civil and Environmental Engineering,  
Construction engineering and management stream.

*Thank you in advance for your valuable cooperation!!*

1. Respondent academic status\_\_\_\_\_

2. For how many years do you live in this condominium?

- A. 1-5            B. 5-10            C. 10-15

3. Are you satisfied by the quality of the condominium services?

- Yes            No

4. Common building defects are listed in tabular form below. If the defect is present in the building mark [√] select one from the option based on their abundance.

No	Type	Occurrence		
		More	Medium	Less
1	Dampness			
2	Leakage			
3	Defect In Plaster			
4	Wall Crack			
5	Peeling Paint			
6	Efflorescence			
7	Termite Attacks			
8	Roof Defect			
9	Door And Window Defects			
10	Defects In Building Services Installation			

5. Mark [√] on the factors that will be a cause for the defect occurred in your building?

- Note 1.Design fault            2.Construction fault            3.Substandard material  
4. Occupational fault            5. Maintenance problem            6. Natural disaster

No	Type	Cause of defect					
		1	2	3	4	5	6
1	Dampness						
2	Leakage						
3	Defect In Plaster						
4	Crack						
5	Peeling Paint						
6	Efflorescence						
7	Termite Attacks						
8	Roof Defect						
9	Door And Window Defects						
10	Defects In Building Services Installation						

6. How many times do you maintain the buildings as whole?

- A. No B. Once C. Twice D. More than two

7. Due to the presence of the defect what negative impact does happen on you?

- A. social B. economical C. health D. all

8. What is the effect of the defect on the building performance and you?

No	Type	Severity of defect on building performance			Severity of defect on occupant		
		High	Medium	Low	High	Medium	Low
1	Dampness						
2	Leakage						
3	Defect In Plaster						
4	CRACK						
5	Peeling Paint						
6	Efflorescence						
7	Termite Attacks						
8	Roof Defect						
9	Door And Window Defects						
10	Defects In Building Services Installation						

Appendix 3. Detailed 20/80 Mekelle condominium sites

ጠቅላላ ናይ አባይቲ መረዳኢታ 1999 ዓ.ም									
ክፍለ ከተማ	ሳይት	በዝሒ ህንፃ	ስቱድዮ	በዓል ሓይ	በዓል ክልተ	በዓል ሰለስተ	ጠቅላላ ድምር	ናይ ንግዲ	ጠቅላላ መንበርን ንግድን
ዓይደር	ዓይደር	17	83	136	146	41	406	27	433
ሓድነት	ቐልቐል ደብረ	12	22	120	94	30	266	24	290
ሓወልቲ	ደጀን	2	0	15	24	4	43	4	47
ሓወልቲ	ደደቢት ማይክሮፋይናንስ	2	11	16	5	7	39	5	44
ሓድነት	ዕዳጋ ብዕራይ	5	24	60	38	9	131	17	148
ዓዲ ሓቂ	እንዳ ማርያም	4	16	40	20	12	88	8	96
ሓድነት	ካሰች	3	14	16	10	10	50	6	56
ሰሜን	ማይ ዱባ	2	10	31	28	0	69	6	75
ሓወልቲ	መርሀ ጥበብ	9	21	72	65	29	187	24	211
ዓይደር	ቢዝነስ	2	20	10	0	10	40	0	40
ኩሓ	ኩሓ	3	14	31	38	8	91	5	96
<b>ጠቅላላ ድምር</b>		<b>61</b>	<b>235</b>	<b>547</b>	<b>468</b>	<b>160</b>	<b>1410</b>	<b>126</b>	<b>1536</b>

ጠቅላላ ናይ አባይቲ መረዳኢታ 2000 ዓ.ም									
ክፍለ ከተማ	ሳይት	በዝሒ ህንፃ	ስቱድዮ	በዓል ሓደ	በዓል ክልተ	በዓል ሰለስተ	ጠቅላላ ድምር	ናይ ንግዲ	ጠቅላላ መንበርን ንግድን
ሰሜን	እንዳ ፀባ	2	16	24	16	0	56	6	62
ሰሜን	መወዳኢታ ታክሲ 05	2	0	12	18	4	34	6	40
ሰሜን	05 ሰኒት	2	0	32	16	0	48	12	60
ዓይደር	አልድ ቢዝነስ	7	50	87	64	8	209	20	229
ዓይደር	ዓይደር	4	8	64	28	8	108	22	130
ዓዲ ሓቂ	ስራዋት	13	65	103	58	45	271	32	303
ሓድነት	ዓዲ ሓውሲ	9	62	84	66	15	227	28	255
ዓዲ ሓቂ	ዓዲ ሓውሲ	6	9	68	37	9	123	29	152
ሓድነት	ማይ ገበል	12	103	130	115	19	367	19	386
ኩሓ	ኩሓ	5	23	48	81	8	160	9	169
<b>ጠቅላላ ድምር</b>		<b>62</b>	<b>336</b>	<b>652</b>	<b>499</b>	<b>116</b>	<b>1603</b>	<b>183</b>	<b>1786</b>

ጠቅላላ ናይ አባይቲ መረዳኦታ 1999 ዓ.ም - 2000 ዓ.ም									
ክፍለ ከተማ	ሳይት	በዝሒ ህንፃ	ስቱድዮ	በዓል ሓደ	በዓል ክልተ	በዓል ስለስተ	ጠቅላላ ድምር	ናይ ንግዲ	ጠቅላላ መንበርን ንግድን
ሰሜን	እንዳ ፀባ	2	16	24	16	0	56	6	62
ሰሜን	መወዳኦታ ታክሲ 05	2	0	12	18	4	34	6	40
ሰሜን	05 ሰኒት	2	0	32	16	0	48	12	60
ሰሜን	ማይ ዱባ	2	10	31	28	0	69	6	75
<b>ድምር</b>		<b>8</b>	<b>26</b>	<b>99</b>	<b>78</b>	<b>4</b>	<b>207</b>	<b>30</b>	<b>237</b>
ዓይደር	አልድ ቢዝነስ	7	50	87	64	8	209	20	229
ዓይደር	ዓይደር	4	8	64	28	8	108	22	130
ዓይደር	ዓይደር	17	83	136	146	41	406	27	433
ዓይደር	ቢዝነስ	2	20	10	0	10	40	0	40
<b>ድምር</b>		<b>30</b>	<b>161</b>	<b>297</b>	<b>238</b>	<b>67</b>	<b>763</b>	<b>69</b>	<b>832</b>
ዓዲ ሓቂ	ስራዋት	13	65	103	58	45	271	32	303
ዓዲ ሓቂ	ዓዲ ሓውሲ	6	9	68	37	9	123	29	152

DEFECTS ON LOW COST HOUSES A CASE IN 20/80 CONDOMINIUM IN MEKELLE

ሓድነት	ማይ ገበል	12	103	130	115	19	367	19	<b>386</b>
ሓድነት	ቀቆልቀቆል								
ሓድነት	ደብሪ	12	22	120	94	30	266	24	<b>290</b>
ሓድነት	ዓዲ ሓውሲ	9	62	84	66	15	227	28	<b>255</b>
ሓድነት	ዕዳጋ								
ሓድነት	ብዕራይ	5	24	60	38	9	131	17	<b>148</b>
ሓድነት	ካሰች	3	14	16	10	10	50	6	<b>56</b>
<b>ድምር</b>		<b>41</b>	<b>225</b>	<b>410</b>	<b>323</b>	<b>83</b>	<b>1041</b>	<b>94</b>	<b>1135</b>
ሓወልቲ	ደጀን	2	0	15	24	4	43	4	<b>47</b>
ሓወልቲ	ደደቢት								
ሓወልቲ	ማ/ፋይናንስ	2	11	16	5	7	39	5	<b>44</b>
ሓወልቲ	መርሀ								
ሓወልቲ	ጥበብ	9	21	72	65	29	187	24	<b>211</b>
<b>ድምር</b>		<b>13</b>	<b>32</b>	<b>103</b>	<b>94</b>	<b>40</b>	<b>269</b>	<b>33</b>	<b>302</b>
ኩሓ	ኩሓ	5	23	48	81	8	160	9	<b>169</b>
ኩሓ	ኩሓ	3	14	31	38	8	91	5	<b>96</b>
<b>ድምር</b>		<b>8</b>	<b>37</b>	<b>79</b>	<b>119</b>	<b>16</b>	<b>251</b>	<b>14</b>	<b>265</b>
<b>ጠቅላላ ድምር</b>		<b>123</b>	<b>571</b>	<b>1199</b>	<b>967</b>	<b>276</b>	<b>3013</b>	<b>309</b>	<b>3322</b>