



AAiT, Addis Ababa University School of Graduate Studies
Civil and Environmental Engineering
Construction Technology and Management Stream

**BUILDING DEFECTS DUE TO POOR WORKMANSHIP IN
ADDIS ABABA: The Case Study on 20/80 Condominium Houses**

BY
YEBICHAYE DIRES

ADVISOR: - Abebe Dinku, Prof, Dr.- Ing.

October, 2016
Addis Ababa, Ethiopia

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**A Thesis Submitted to the School of Civil and Environmental Engineering in
Partial Fulfillment of the Requirements for the Degree of Master of Science in
Civil Engineering (Construction Technology and Management)**

October, 2016
Addis Ababa, Ethiopia

DECLARATION

I declare that this thesis entitled “**Building Defects due to Poor Workmanship in Addis Ababa, A Case Study on 20/80 Condominium Houses**” is my original work. And it has not been submitted partially or in full and presented by any other person anywhere and that all sources of materials used for this paper have been acknowledged.

Name of Researcher: Yebichaye Dires

Signature: _____ Date: _____

APPROVAL

As member of the board of examiners, we certify that we have read, evaluated the thesis prepared by **Yebichaye Dires** and examined the candidate. We recommended that the thesis is accepted as fulfilling the thesis requirement for the degree of Master of Science with specialized in Construction Technology and Management Stream.

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ABBREVIATIONS

BC= Building Contractor

CBE = Consulting Architects and Engineers

GC = General Contractor

HCB = Hollow Concrete block

IHDP= Integrated Housing Development Program

ISO = International Standardization Organization

MoWUD = Ministry of Work and Urban development

MSE =Micro and Small Enterprises

PSAM=University's Public Service Accountability Monitor

SPSS =Stats Practically Short and Simple

UNHABITAT =United Nations Human Settlement Program

ABSTRACT

The rate of construction project accomplishment is weak because of the rapid increasing rate of major defects in building as a result of poor workmanship and poor quality materials which have been identified as the major cause of defects in the construction industry. This paper aims to investigate building defect due to of poor workmanship in Addis Ababa 20/80 condominium housing construction projects. The objectives of this study are to investigate common building defects that mostly occur at housing projects due to poor workmanship, the factors that contribute to poor workmanship, its impact on the project performance and to established possible measures to minimize these problems.

After relevant literatures were reviewed both primary and secondary data collected through questionnaire, observation and case study. The sample was selected from Yeka Sub City by purposive sampling targeting under construction Yeka Abado (project 14) and residents in yeka 20/80 condominium houses from 5 sites within the sub city. Both quantitative and qualitative data analysis techniques were applied to ensure triangulation of information from different source tested with correlation analysis for agreement.

The most commonly occurring defects in 20/80 condominium housing were defects on floor/ wall finish, faulty door and windows frames with accessories, failure of service installation observed both during construction and after the houses transfer to the tenants. The causes for building defects that mostly occur at the houses are due to poor workmanship. Additionally, construction of condominium housing commonly suffers from low quality workmanship due to lack of skills and experience, poor project management and complicated role of subcontractors in the construction work. Major impacts of defect due to poor workmanship were project cost overrun and project delay. These significant impediments can be remedied by providing suitable construction management, giving training and education to the labourers as well as implementing strict supervision during construction work. The study also forwarded two recommendations in line with the need of further study and continuous capacity building mainly for micro scale enterprises based on impact assessment. Improvements on all project management phases need to be done by amend the existing contractual document including specification and guidelines with the nature of condominium projects.

Key Words: - Building defect, Construction industry, 20/80 condominium houses, and Poor workmanship.

1. INTRODUCTION

1.1 Background of the Study

Addis Ababa, the capital city of Ethiopia has on overwhelming dominance in the country's economic, socio-cultural and political affairs. There has been an ever growing mismatch between the size of the population and its demand for basic services. Many of the people in rural areas of the country seek the hope of better living conditions in larger cities such as the capital Addis Ababa. As a result, the city has become too wide horizontally without the housing situation being comfortable for living and working.

Owing to address the above problem, the Addis Ababa City Administration launched cost efficient condominium housing projects through IHDP in 2006 to minimize housing backlogs, clear slums, and provide decent shelter to middle- and low income groups. These are 10/90, 20/80 and 40/60 percent payment schemes, which is from the lower income to the middle income residents of the city. The program has tight costing and quantity surveying mechanisms that aim to minimize construction costs.

The MoWUD is responsible for purchasing all construction materials (in bulk) which is expected to be at low prices. Contractors are engaged on fixed-cost contracts, which reduce the burden of soliciting for, receiving, and choosing tenders for each job. The material requirements for each condominium block are calculated and the exact material quantities are given to contractors. This centralized system minimizes wastage, helps to keep records for material supplies and distribution, and enables any surplus materials to be used on other sites. City administration coordinates and finances the construction of infrastructure and services. Infrastructure elements include the roads, car parks, foot paths and grass areas and services are water, electricity, and mains sewerage connection for each unit (UN-HABITAT, 2011).

Even though the MWUD has planned to construct the houses with cost efficient methodology, the resources shows that there are challenges regarding to the affordability to the low income. According to Yewoinshet (2007), the housing development program has faced many

challenges and many failures. For example, the projected cost of housing estimation is far from their affordability. The program is not successful in addressing the very low income groups which usually had big family size and require larger rooms. Even if having problems of the modalities are arranged still the 'real-poor' has not been benefited to the expected level.

High total cost and down payment, low income of households and increase price of construction materials and transports are some challenges of condominium houses (Helen, 2010). Although condominiums are supposed to provide low-cost housing for the poor and middle-income households, they do not seem to meeting their initial goals, as costs are getting so high that even many middle-income earners cannot afford the payment (Yewoinshet, 2007). Since the government started transferring condominium housing units, for studio, one bed room, two bed room and three bed room types of houses, the price is going up. (Wondosen, 2013).

The other factor that makes the houses unaffordable to low income people was price increase due to delay i.e.it took from one up to one and half years to construct and distribute condominium houses. The other issue in construction and distribution of condominium houses is corruption. The government of Ethiopia is planning to continue the condominium housing construction project by itself using a single bank, Commercial Bank of Ethiopia (CBE). The government is involved starting from design preparation, awarding to contractors and distribution of houses to people. It also fixes prices of both inputs and houses (Kidst, 2014).

Ali and Wen (2011), found that, factors contributing to the lack of success and the non-achievement of quality in the low-income housing sector include lack of sufficient finance, use of unskilled labour, use of emerging contractors, lack of contribution by the private sector, lack of management commitment towards quality achievement, and substandard quality of workmanship. Rinker (2008), in his report on affordable housing issues, pointed out that public housing projects have deteriorated badly because of a combination of rushed construction, poor design, and insufficient maintenance.

A condominium, house as defined by Martha and Carol (2006:4) and PSAD (2006:18), as "a building for residential or other purpose with five or more units and common elements, in

high-rise building or a row of houses and includes the landholding of the building”. The concept originated from Europe and then was resettled to the United States. Even if the number was limited, the United States built some condominium houses immediately after II World War.

The purpose and concept of condominium houses are different in different countries. In most developed countries, condominiums, houses are costly and are primarily developed by the private sector in order to fulfill the market demand, for middle- to upper-income housing. For instance, in Ankara, Turkey, high-rise condominium houses are developed for middle- and upper-income residents. The space for recreational use and greenery to preserve environmental quality covers a higher percentage, that is, 13 percent of 30,000 square meters of the land are used for building up purpose (Martha and Carol, 2006).

Under Addis Ababa Housing Project Office, located at 6 kilos at city government in Addis Ababa education bureau building 20/80 and 10/90 condominium constructions are constructed and monitored. In this research 20/80 condominium housing project was investigated in which questionnaire survey was taken by examining the quality of the buildings and construction method and tried to identify the different types of construction defects observed in the buildings.

The housing scheme with a 20/80 percent payment is being introduced by the government for citizens with middle incomes who can make a down payment of 20percent of the home price before acquiring their house and the remaining 80percent within a specific period (10-20 years) that will be disclosed by the administration when the project is launched. There are four unit typologies incorporated into each condominium block: studio, 1-bedroom, 2-bedroom, and 3-bedroom unit types. Each unit includes a bathroom, which includes a shower, flush-toilet, and sink, and a separate kitchen. Each unit has water, sewerage, and electricity connections (IHDP, Addis Ababa, 2008).

However, in recent years, several issues have arisen involving construction on condominium houses. These have mainly involved quality problems in line with defects of condominium houses. Researchers had done on building defects in different countries are mostly due to

defective workmanship. In other words, those involved in the construction of buildings are generally to blame for human error leading to poor quality of work. Defects may be considered as a failing or shortcoming in the function, performance, statutory or user requirement of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building.

Therefore, this thesis focus on investigating common building defects due to poor workmanship and assessing factors that contributes to poor workmanship with a goal of establishing possible measures to overcome such problems in 20/80 condominium construction sites.

1.2 Statement of Research Problem

In most Addis Ababa condominium buildings which are constructed by the government there are many complaints about defects in the building elements of the house. One of the causes of this condition is due to poor workmanship during construction. This will affect the life of the occupants and also giving a bad image of the parties involved in the construction of condominium housing.

Therefore, the performance of good workmanship in the construction of condominium houses is a very critical issue in the execution of the Addis Ababa housing development program. It is against this backdrop that this research was carried out to examine the problem of poor workmanship as a cause of building defect, with the intent to recommend suitable solutions to the problem.

Number of researchers was undertaken similar studies related with my issue. Some of them are Yoseph Fekadu in 2007 under the title of Investigation of failure of the super structure of some buildings in the Addis Ababa, which focused on the existence of building failure at the construction site of different building projects only for superstructures; and Bedru in the year 2015 under the title of Construction Defects in Federal Government Office Building Projects in Addis Ababa for his MSc work. But unfortunately no one of the two addressed my issue. Therefore, this thesis focus on investigating common building defects due to poor

workmanship and assessing factors that contributes to poor workmanship with a goal of establishing possible measures to overcome such problems in 20/80 condominium housing projects in Addis Ababa.

1.3 Research Questions

In order to study the problem identified, the following questions have been stated in the study:

- ✚ What are the common type of building defects of 20/80 condominium building projects in Addis Ababa pre occupancy and post occupancy?
- ✚ What are the main causes for building defect during construction of 20/80 condominium housing project?
- ✚ What are the factors leading to poor quality of workmanship in 20/80 condominium housing projects?
- ✚ What are the impacts of building defect in the construction sector?
- ✚ What are the solutions to these problems of poor workmanship quality?

1.4 Objectives of the Study

1.4.1 General Objective

The main objective of the study is to investigate the common building defects due to poor workmanship in Addis Ababa condominium housing construction project sites taking the case of 20/80 condominiums.

1.4.2 Specific Objectives

The specific objectives of this study are:

- ✚ Assessing the type of building defects in 20/80 condominium houses during construction as well as post occupancy in Addis Ababa;
- ✚ Examining the main causes of building defect during construction of 20/80 condominium site;
- ✚ To examine the factors leading to poor workmanship, in the construction of condominium projects in Addis Ababa;

- ✚ To assess the impact of building defects due to poor workman ship in 20/80 condominium sites;
- ✚ To identify possible measures should be taken to prevent/minimize poor workmanship problems and; and
- ✚ To recommend possible solutions to alleviate workmanship problems which lead to building defects in the construction of 20/80 condominium buildings.

1.5 Significance of the Study

The output of this research will have administrative, policy and academic significances. Hence, it provides Addis Ababa Housing Development Office and other stakeholders with first hand information about the building defects in 20/80 condominium houses during construction as well as post occupancy, the type and main causes of building defect during construction, the factors leading to poor workmanship and the possible measures to prevent/minimize poor workmanship problems.

This helps the city administration to look for innovative approaches to minimize and alleviate the problems. Other urban centers in Ethiopia will also gain experience and will take the findings as an input in their effort to alleviate the problem related with the poor workmanship and improve the status of the construction sector.

Academically, the research output will complement other studies in the area of construction sector; and it will also be utilized as initial information for further detail research works. It is an initiative for other researchers on the related issue and related problems by contributing some findings that can possibly serve as spring board.

1.6 Scope of the Study

This study intends to analyze the building defects due to poor workmanship in 20/80 condominium houses in Addis Ababa. Therefore it is limited to the analysis of issue that concentrates on the stated objectives. The study is limited to in Yeka sub-city of 20/80 condominium houses. However the finding may apply to other condominiums of the same

situation with entire part of the city of Addis Ababa. Both the thematic and spatial scope delimited considering the above constraints.

Spatially the research limits itself only in the Yeka sub - city of Yeka Abado 20/80 condominium construction sites as well as residents in Kotebe, Kara Alo, Yeka Ayat two and Yeka Ayat three condominium sites to get direct information from beneficiaries regarding the extent of building defects through time.

Thematically the study delimits to the investigation of the common building defects due to poor workmanship in Addis Ababa condominium housing construction project sites taking the case of 20/80 condominiums. Specifically the study focuses on the type and main causes of building defect during construction of 20/80 condominium site, and the factors leading to poor workmanship, in the construction of condominium projects in Addis Ababa, and finally based on the findings, to provide possible solutions as remedial actions to solve the problem.

1.7 Limitation of the Study

It is unthinkable for any research process without limitations or challenges; the situation is similar to this research too. The process was not smoothly accomplished. There are different and many challenges the researcher faced while doing this research, especially at the data collection period. Among them the major limitations are:

- Absence of well organized secondary data, especially written literatures in Ethiopian context.
- Problem of willingness of some respondents,
- Financial and other social problems; and
- Resistance of the office workers to give secondary data.

So the aforementioned challenges limited the researcher to address more issues and study areas, and finally accomplish on time.

1.8 Organization of the Paper

This study organized into five chapters. The first chapter focused on the introductory part of the study, which includes background of the study, statement of the problem, objectives, significance, scope and limitation of the study. The second chapter contains literature review part of the study in which theoretical and empirical literatures related with the issue were incorporated. The third chapter deals about the research methodology: research design, approach and method; sampling design, sources of data, data collection methods, analysis and presentation were incorporated. The fourth chapter is all about the data analysis and interpretation, and finally the fifth chapter winds up by conclusion and gives recommendations as possible solution to solve the problem related with building defects due to poor workmanship.

2. LITERATURE REVIEW

2.1 Introduction

This chapter consists of basic definition and concepts of building defects, the methods to use for detection of building defect, reviewing studies which were conducted by different researchers on the major types of building defects and their causes, techniques used to repair some building defects. Besides that assessing one of the major causes building defects which is poor workmanship during construction its major causes and the extent of poor workmanship in the construction industry along different countries have been reviewed.

Finally impacts of poor workmanship, measures to minimize errors on workmanship by considering the different countries' experiences were assessed. Literature has been written on poor workmanship in building construction industry, but there is a need to establish the relationship between workmanship, quality in construction and how it is applied in Addis Ababa, especially in Government condominium housing projects.

2.2 Definitions and Concepts of Construction Defect

2.2.1 Definition of Defect

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

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

2.2.2 Construction Defect

A construction defect is generally defined as a defect or deficiency in the design, the construction, and/or in the materials or systems used on a project that may not be readily observable and results in a building, structure or component that is not suitable for the purpose intended.

In considering issues within the defect domain, it is important to define what constitutes faults, failure and defects, and what types of failures are evident. The Building Regulations and British Standards do not differentiate between faults and failures and define these as: Fault: A departure from design requirements where these were not themselves at fault. Failure is defined as deviation from original specifications which can or cannot be corrected prior to the handing over of the building. On the other hand, defect is termed as deficiency of the performance, which becomes apparent once the building is operational. Failing to differentiate the two terms may lead to inaccurate and incomplete measurements, cost determination and perhaps inappropriate methods to reduce its occurrence (Atkinson, 1999). Therefore, the term “construction defect” is broader than just defective construction. The term "construction defect" includes both defects during design (i.e faults during design) and defects under construction (i.e failures during construction) that result in financial harm to the owner (Frank, 2013).

I. Design defects

A design defect is typically the result of the design professional’s failure to produce a complete, accurate and well-coordinated set of design and construction documents. These design defects are categorized as a design error or omission and/or a combination of both.

A design error is defined as a mistake in the design where the design element was either constructed or under construction and required retrofitting and/or replacement of any component to correct the error. Under these circumstances, the entire cost of the change is attributable to the design profession as a result of its design error.

A design omission is defined as the scope that was either missed and/or omitted by the design professional in its design and construction documents but was later discovered and added to

the scope of work by a change order. A design omission also includes design items that were incorrect, but were corrected after award of the project and before the construction process was materially affected. Typically, it is understood that some premium costs over and above the actual cost of the changed work are paid for the work that was not competitively priced. These additional costs are directly attributable to the design professional as an omission (Frank, 2013).

II. Defects in construction

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

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

- i. Latent defects:** those defects that are concealed and are often not obvious or readily observable upon reasonable inspection. Even with the most comprehensive on-site inspections, sometimes defective construction may go unnoticed. After construction is complete, latent defects are unknown and generally undiscoverable and will only appear after the passage of time. Examples of latent defects are: soils that were not properly compacted, improperly installed flashing and/or the total lack of flashing within the building envelope assembly, lack of reinforcing in structural concrete footings, walls and/or slabs, lack of brick ties and/or masonry reinforcement in a brick/masonry veneer wall, an improperly installed weatherproofing system, improperly installed stucco exterior

wall system, improperly consolidated concrete, reinforcement not fully embedded in the concrete structure.

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

2.3 Methods of Building Construction Defect Detection

Construction defects usually include any deficiency in the performing of the design, planning, supervision, inspection, construction, or observation of construction of any new home or building. The building is deficient if there is a failure during construction – in other words, if the building does not perform in a manner that was intended by the buyer. According to Frank (2011), construction defect detection can be classified into three based on the time to be happening during the construction process.

2.3.1 Pre-construction Stage

One of the major causes of construction defects is designed inadequacy. This could happen due to inadequate data about the project site as a result of site investigation problems or due to professional's inadequacy. Site exploration (investigation) problems could arise due to uncomfortable site conditions for exploration or lack of well skilled man power and equipment. The exaggerated cost of exploration is also another problem.

Therefore, the design inadequacy of the service installation materials, substructure and superstructure of a building may lead to serviceability problems or worse to instability. Serviceability deficiency could arise due to problems with the structure or service installation. Inadequate design of sanitary pipes or drains such as the insufficient diameter of drains bends being too sharp, can lead to excessive pressure built up in the pipes causing failure. Serviceability defects with the structure include cracks, deflections, vibrations, etc. These can simply be reduced by fulfilling the requirements of building standards such as EBCS 95/ Euro cod.

Detailed preliminary study and site exploration is necessary for consideration of site condition in the design, as such field (In situ) exploration and tests and laboratory tests shall be conducted with necessary equipment and qualified professionals.

2.3.2 During Construction Stage

Construction techniques that may not be defect free, inconsistent or substandard workmanship, and use of unsuitable construction details can lead to shortly occur or long list defects. The large varieties of building materials may not be well similar to one another or under quality materials below the specified standards. Extreme site conditions may undermine performance standards during construction.

Thus, the use of standard materials helps in reducing defects caused due to inferior building materials. For example, for well-proportioned mix ratio selection of aggregates that are hard, rough, mineral free and well graded maintains the required strength, density, porosity, workability and curing time of concrete for the intended purpose. Thus, problems such as cracks caused due to shrinkage and/or overstressing can be held within limits. Leakage of slab floor, delaminating or worse collapse due to low concrete quality can be controlled.

Defects caused due to bad workmanship should be controlled as they can easily be avoided. Hence, problems caused due to low technical skills such as in concrete production mixture segregation leading to low concrete quality/strength, loose tie of reinforcement bars causing misplacement of the bars leading to over stressing of the structure. Service installation materials, fitting problem are also caused due to error workmanship. Fitting problems, inadequate design of sanitary pipes can lead to leakage, electrical installation problems and improper filings around windows and door frames are also caused due to bad workmanship. These problems can easily be avoided by monitoring the works closely and enhancing technical skills of the labor and providing good working condition.

Good construction management and technical skills are necessary to avoid unnecessary contamination and wastage of construction materials. Good management also helps in controlling workmanship errors, hence, avoiding defects caused due to bad workmanship. For example organized on-site material management and storage system can avoid contamination

of materials such as corrosion of steel or mineral attack of aggregates due to storing areas top soil. This avoids problems caused due to corroded steel material; once it is used as a reinforcing material for the steel cannot overcome the tensile stress on the reinforced concrete structure and leading to overstressing of the structure, structural cracks may occur undermining the stability of the whole structure. The spalling of the concrete cover may also occur due to the corroded steel making the concrete structure more susceptible to carbonation, seriously affecting the strength of the material.

2.3.3 Post-construction stage

Abuse or misuse of the building is another problem which causes serious defects on the structure or service installation system. Damage on the building while giving service can be rectified by proper maintenance. Neglect and poor quality maintenance are major influences on the incidence of important defects. So to reduce occurrence of defects that lead to failure, it should be a correct use of building and properly managed maintenance activities.

In addition, Rhodes & Smallwood (2002) stated that, the methods of defect detection include observation, inspection, checking work and test samples. The following are some warning signs of possible defects in houses.

- **Deep cracks in the foundation or basement walls:** This may be a sign that the foundation was laid on a poorly compacted base or poorly graded soil.
- **Sagging floors or leaning walls:** A shifting foundation or structural problems (with support beams) could be the problem.
- **Windows and doors that never sit well in frames or close properly:** This problem could be due to beams and joists not being correctly sized or assembled.
- **Cracks in interior walls:** Wide cracks could signal a foundation problem. Generally, fine cracks are cosmetic due to normal ageing. Ahzahar et. al. (2011) state that most structural defects which resulting in cracks are common types of building defects. A case study undertaken by Rhodes University's Public Service Accountability Monitor (PSAM) also identified that different kinds of cracks were a common structural quality defect in the houses within the Ngqushwa Local Municipality. A study undertaken by Fauzi, Yusof &

Abidin (2011) in Malaysia also identified cracking of walls and floors as the most common type of defect in the houses.

▪ **Water damage:** Warning signs include mould, rot, paint peeling, staining, corrosion, swelling or discoloration of interior walls. Possible causes: improperly installed roofing, no waterproof barrier or done incorrectly, lack of a drainage space behind a brick wall, poorly installed windows and doors. Although a study by Rhodes & Smallwood (2002) identified that cracking is the most common type of defect, they also state that dampness-related types of defects dominate the industry (Ahzahar et al, 2011).

2.4 Classification of Building Defects

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

A. Major defect: It is considered as those which cause the building to become unsafe, unsuitable for living in and not suitable to be used for the purposes for which the building was designed.

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

2.5 Types of Building Defects

According to Abdul Rahman et al (1996), describes defects in construction include either or a combination of the following; defects in structure, giving rise to cracks or collapse; defects or faults in electrical and plumbing installations; inadequacy of drains for proper disposal; insufficient provision for ventilation; poor cooling and/or heating system; poor sound insulation system, and insufficient fire prevention or protection mechanism. In addition,

defects in the building may also be as a result of the following; fungus, termite, or vermin infection, fungus, wood rot, wood rot, mould, and dry rot.

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

Lee (1987) described the most common type of defects that can be exists on new building element of housing are as follows:

2.5.1 Cracking

Cracks can be structural or nonstructural. A structural crack means any defect in a structural element of a building that commonly occur in areas such as interior walls, exterior walls, beams and columns. Such type of crack may be caused by many factors, e.g. excessive movement of the building structure, unwanted ground settlement, serious overloading, and weaknesses caused by corrosion/deterioration of materials, damage from accidents, or poor design/ construction, etc. Detailed investigation must be carried out to identify the causes which must be removed or rectified before the cracks are repaired. The other one is non - structural cracks. Such type of cracks usually occur in plaster or other finishes with cement, sand rendering as base due to shrinkage cracks in plaster or other forms of finishes .It will affect the appearance only and do not pose any safety concern. They are small hairline cracks developed within the finish layer not penetrating down to the reinforced concrete structure (Kasim, 2009).

2.5.2 Unstable Foundation

The foundation is necessary to support a building and all of its loads that are within or on it. Foundation should be made from material that will not fail and lost its stability in the presence of ground or surface water. When the building or property is designed, there should be little or no cracking in the foundation and of course zero water leaks.

Besides that, it is necessary to determine the total load to be supported. Foundations will be carrying out both the dead and live load and will transfer the load to the soil. Moreover, the function of the foundation is to avoid building from sinking due erosion or movement and also to stabilize the building. If there is presence of difficulty in the foundation, it will affect all of the building structure.

Some of the effects of foundation problem are building collapsing, crack on the floor and the wall, the wall leading and many others. Another unstable factor is the movement of the soil because of presents of the water flow. Besides that, the faulty design of the foundation also will cause it to overload. Apart from that, the using of material for the foundation is not being followed as the standard and requirement being agreed (David, 1988).

2.5.3 Deterioration of Roof Covering

Roof as usually exposed to different conditions, particularly to the extremes of temperature degree and change, solar radiation, and wind action. Roofing system contains many components, such as framing, plywood decking, felt underlayment, sheet metal flashing and other exterior roofing material. 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 may be greater effect of similar defect in a wall or other element (Cheun, 2008).

Roof defects are divided into structural faults and defects in waterproofing material. The majority of roof defects that occurs are distortion of either the roof or off the wall at roof level. Normally, structural defects can be identified from the visual inspection. For the defect of waterproofing material, it will provide the building to be durable under a wide range of exposure condition.

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

faulty installation is grammatically increasing the likelihood of problems and reduces a roof system's life expectancy (David, 1988).

2.5.4 Internal Staining, mould growth and fungal on external wall

If there is a water intrusion, the chances of mould growth are high. The terms fungi and mould are often used interchangeably, but mould is actually a type of fungi. Concerning about indoor exposure to mould has increased along with public awareness that exposure to mould can cause a variety of adverse health effects.

There are many thousands of species of mould and most, if not all of the mold found indoors comes from outdoor sources. It seems likely to grow and become bigger threat only when there is water damage, high humidity, or dampness. The presence of mold on a wall of a house can affect occupant's health. Once discovered, mold infestation should be remedied immediately in an effort to minimize the possibility of health issues (Roger, 2005).

2.5.5 Dampness

In general, damp is defined as unwanted water or moisture and its existence in the building is one of the most damaging failures that can occur. It can cause damage in brickwork by saturating it, decay and break-up mortar joints, rot timber structures, make iron and steel corrosion and damage to building equipment.

It can be a serious matter, particularly in the building located near water sources. Somehow, the water can enter the building bit by bit through different routes resulting in dampness. Furthermore, prevailing wet wind and rain will due to water penetrations that occur through the walls.

Dampness also occurs when water penetrates through capillaries or cracks between mortar joints and bricks or blocks before building up trap moisture behind hard renders. Moreover, the contribution of dampness is due to the existence of gravity. The other factor such as leaking gutters or down pipes, defective drains, burst plumbing, and condensation due to inadequate ventilation also can be the factors yielding (Roger, 2005).

2.5.6 Peeling Paint

Peeling paint usually occurs on building facades, mainly on plastered walls, columns and other areas that are exposed to excessive rain and dampness. Some buildings that are located near the sea may face a much higher risk once the signs of peeling paint are visible on the exterior walls. The majority of peeling paint problems occurs on surfaces exposed to the rain, sun, and the varying degree of temperature. Walls that have involved can be an unsightly mess in a home or building. It may result in embarrassment and frustration to the homeowner. The amount of the constant wind, rain and sun received can easily turn the surfaces of the paint to become chalky and wrinkled or blistered. This problem can become worse if the paint used during construction is low quality and mixed with excessive amount of water (Ghafar, 2004).

2.5.7 Leakage

Leaking is water that seeps out from behind walls, under concrete slabs and asphalts, basements, landscaping, water intrusion in roofs, irrigation systems, and radiant heat system. Leaking mostly happened due to improper installation of piping system that can cause dampness and mold growth, water penetration through external wall defects such as cracks, joints, honeycombs, spelling, weak points, holes, punctures, leftovers of debris, and movement of external wall components, water penetration through defective external wall finishes such as loosened mosaic tiles, cracked ceramic tiles and paint surface; through poor cladding or curtain walls constructions; or weaknesses in water-resisting components, Water leakage through party walls between units of pre-fabricated elements, or between buildings (Rojer, 2005).

2.5.8 Defects in doors, windows and external appendages

Windows and doors are perhaps the most vulnerable building element in external building envelopes, and the need for some windows to be openable further aggravates the problem. Glass panels should always be replaced once cracks occur. Common defects in traditional steel windows usually arise from rusty frames, and deterioration or loss of putty or sealant to hold the glass panels.

Aluminum doors and windows have been widely used in new developments and as replacement of steel windows in existing buildings, but recent incidents of their failure have aroused safety concerns. The aluminum window system involves the assembly of a certain number of components by rivets, screws, hinges and fixing anchors. These accessories, which are prone to failure, require regular servicing and maintenance to prevent failure (Ghafar, 2004).

The friction slide hinges are delicate parts of the window which demand close attention to avoid accumulation of dirt that obstruct the sliding motion and mild lubrication to reduce friction of the moving parts. Without the required servicing and maintenance, hinges may become too tight to operate, rivets may loosen up and screws may be corroded that shorten their lifespan. When excessive forces are applied to operate such windows or when they are subject to wind load, distortion of the window sashes or even the frame may result, causing fatal or serious injuries to the public.

External appendages are usually cantilevered structures which include eaves, moldings, architectural projecting features, air-conditioning hoods, canopies and balconies, drying racks, projecting panels and claddings. Although the structural designs of these elements have already catered for their cantilevered performance, lack of maintenance and repair of combat, natural weathering would attract development of defects, unduly shorten their lifespan and eventually result in collapse.

Common defects that have seen on doors, windows and external appendages are: Cracking at junctions, Bulging (gaps occurring between finishes and paint, wall) or peeling-off of finishes, spalling of concrete or uncovering of steel, reinforced rusting of metal parts, damage by fungus or vegetation growth, water seepage through the features, corrosion or loosening of attachments (Roger, 2005).

2.5.9 Insect or Termite Attacks

Termites are small, pale to brownish black in color, insect 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 (Ghafar, 2004).

Subterranean termites or underground termites are the most destructive insect pests of wood. The activity of them is often not readily noticed because it is hidden behind wallboards, sliding or wood trim. Basically, foraging of termites by dead trees and brush provides a natural food source. When natural vegetation is cleared and houses are built, termites often switch to feeding on wooden structures. Next, they will continue to enter the building through wood that is direct contact with the soil and by building shelter tubes over or through the cracks found in the foundation. Infestation of termites can do damage to any cellulose-based material in direct contact with the soil (Roger, 2005).

Most of timbers that are commonly affected by termites are plywood, Meranti, and Selangan beta and also ironwood. Any building that touches the soil and from tree branches will be attacked by termites. Besides that, dead wood, tree stumps and nearness to forest areas also increase the likelihood of the attack. To avoid this, the forest must be cleared for building, and the dead wood should be removed and are not left to rot under the residence. On top of that, the beams also should be supported on old stumps (Lipa, 2001).

Termites will survive as long as the situation or environments meet their chance of survival. They can spread easily in a blink of an eye into a larger area and build their nest there, in the building or property. The requirements in their chance of surviving are; moisture, source of food, dark, and low light Intensity, minimal flow of air.

2.5.10 Defective Plaster Rendering

Plaster or render is like mortar coating over the block work. The coating on the inside walls called plaster, then the coating outside the walls called reinder. Plaster and render is totaling different. The render is generally richer and mostly in cement than the plaster due to weather resistant.

The both of plaster and renders have different function. The plaster insides the walls to make the walls smooth, easy to clean, avoid from insect, and for better appearance. Apart from that, the plasters act as a protection against fire. The other functions are breathable for walls, abrasion resistant, and suitable for decorating or covering with coating, wallpaper and tiles. For the renders, is provided to protect them from the influences of the weather.

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. The mould or harmful growth, insect, animals, and traffic vibration also will contribution causes of defective plaster rendering. Prior to being decomposed and broken apart, rendering may crack due to either shrinkage or movement in the substrate. Ghafar (2004) classifies types of defective plaster rendering into four.

- i. Cracking in Plastering:** This is because of breaking away the section of the plaster. Penetration of rain to the external surface of structural, have allowed admittance of rain to the back of the intact plaster coat. So, any weakness in the bond between the plaster and background or between renders coats will make the further defect.
- ii. Holes in Plaster wall:** Holes usually occur because of, user or human made such as hanging family picture, shelves or other decorative item to the wall. It is easy to be filled in with a tad of sparkling compound.
- iii. Plaster falling off from the ceiling:** Often the vibration of people going up and down by the stair for many years is cause to plaster falling off from the ceiling. The vibration will travel through the plaster and cause hairline cracks between the wall and plaster.

iv. Shrinkage cracking: When strong mixes of render are used on weak or bad prepared background have due to shrinkage cracking. If the crack only in the topcoat, it caused the excessive cement in the finish coat or excessive thickness or if the renders are too wet.

2.5.11 Defects in Building Services Installation

Services installations have a relatively shorter life span than the building structure. Defects in the mechanical components usually lead to failure requiring repair or servicing. It is therefore necessary to have a planned schedule for foreseeable servicing and replacement of components. Avoid exhausting the designed lifespan of such components can prevent sudden breakdown of services that causes undesirable or even disastrous consequences. Common defects in building services installations are water supply (such as 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 (such as alarm wiring defect, short circuit, inadequate protection or poor management, inadequate maintenance), electricity supply (of fuse or circuit breaker, earth leakage, overloading, uneven distribution of phase set.),lift and escalator, air conditioning / heating (such as poor efficiency, leakage of refrigerant dust and dirt of heat, loosen parts, blowers or propellers breakage, insulation failure).

2.6 Causes of Building Defects

According to Rhodes and Smallwood (2002), the causes of defects can be related to design, construction, procurement and prevailing environmental conditions. They also describe the origin of defects as being inadequate management and technical skills. Weldon (1998) states that building defects or failures may arise due to a variety of factors, including poor design, failure of the material, poor workmanship, and lack of maintenance. Around 32 out of 55 federal building construction related defect were attributed by poor workmanship. Defective material takes the next role by causing almost 20 percent of construction defects. Deign error cause just more than 15 percent of construction defects and the remaining defects were caused by poor subsurface investigation and improper usage of building services (Bedru, 2015).

Manning (2005) mentions that all types of defects their causes can be grouped into the following seven major categories.

2.6.1 Design Defects

Buildings and systems designed by engineers do not always work as specified; this can result in a defect. Typical design deficiencies relate to buildings outside the specified code. A common design error is often made, usually in an effort to save initial construction costs. Project cost plays an important role in designing buildings. Reducing the size of columns, the size of reinforcement bars and foundations are the most common design error in construction. This situation will lead to uncertainty situation in the future where the structure cannot withstand the load and finally fails. Sometimes faulty design is also a result of misjudgment, leading to assumptions or decisions that are not consistent with the actual behavior of the structure.

2.6.2 Material Defects

The use of inferior building materials can cause significant problems such as windows that leak or fail to perform even when properly installed. Materials may easily be damaged during transportation, loading and unloading, inappropriate condition of storage on site and placing in position even though the materials may be flawless upon leaving the factory. The defects can be prevented with by taking greater care during all the stages during the construction project, providing appropriate training to all the workers and staffs, and ensuring closer supervision.

2.6.3 Poor Workmanship

Error in workmanship can result in long lists of defects, e.g. plumbing leaks. According to Gibbon (2010), poor workmanship in housing construction, poor management and control of building contractors has contributed to the housing problem. The installation of the roof will need number of skilled workers. If the roof is not installed properly, it is yielded to roof defect such as roof leakage and sagging. The causes of roof defect because the worker may be not having a license, or certificate apart from having a low level of experience. Poor

workmanship often leads to delays in projects. Lubisi & Rampedi (2010) contend that the primary causes of delays are related to the perception that emerging subcontractors with capacity challenges were always appointed to execute projects and poor performance by the contractor.

2.6.4 Subsurface Deficiencies

Many houses are built on hills or other areas where it is difficult to provide a stable foundation. Lack of a solid foundation may result in cracked foundations or floor slabs as well as other damage to the building. Subsurface conditions that are not properly compacted or prepared may cause problems; these include improper settling to the ground or the shifting of a structure.

2.6.5 User Activities

Defects may be caused by unintended misuse due to lack of knowledge of the correct method of usage or intentional acts of vandalism. This problem can be solved by providing more information such as the degree of severity of use and condition of use to the designer so that a better output can be yield. 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.

2.6.6 Maintenance

Building maintenance prepared through an accurate program of repeated maintenance plays a major role in preventing building defects. Buildings that neglect building maintenance may fall into several defects which may lead to structural failures. Any inspections carried out by either architects or surveyors should include checking for any signs of abnormal deterioration, cleaning out gutters of leaves or harmful growth, checking lighting conductors, cleaning out all voids and spaces; and changing tap washers. 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 problems. It is important that buildings continue to be properly maintained to ensure that they can function as

efficiently and effectively as possible in supporting the delivery of a wide range of services. At the same time, the deterioration of buildings due to the lack of maintenance could lead to future financial burdens, pose legal and other industrial relations issues and affect the delivery of services. Therefore, the maintenance of buildings is critical to the proper management of physical assets and the overall management of capital to achieve agency outputs and institutional outcomes.

2.6.7 Climatic Conditions

It is important to consider the climatic conditions of construction area and the effect to building materials. This implies that buildings in the country tend to weather rapidly, particularly in respect to external building materials which are exposed to external causes such as rain, wind, solar radiation including ultra-violet light; and atmospheric pollution. Fungal stains, harmful growth, peeling paint, erosion of mortar joints and defective plastered rendering are a few examples associated with this factor.

2.7 Methods to Repair Some Building Defects

It is defined as the process of restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition or state. Many different techniques for investigation and repair of the above defects are available in the market and needs consulting of the building professional, especially when the cause of the problem is not obvious or cannot be easily identified below are Some common types of repair techniques for defects observing on the building (Rebuild,2014).

I. Repair of cracks

- 1) **Nonstructural or surface cracks:**-They do not require elaborate measures as they prevail on the surface only. After removal of the rendering, cracks if observed in masonry are cut v shaped up to a depth of 12-30 mm and filled with cement mortar 1:4and then the surface is re-plastered.
- 2) **Very heavy cracks:** - If there are very heavy cracks all over the external load bearing wall along with signs of settlement the wall is considered beyond repair and needs

replacement. The load carried by the wall is supported on props; the old wall is demolished part by part and then rebuilt either in brickwork or suitably reinforced concrete framework.

- 3) **Cracks over arch openings:** - In old buildings we can see cracks over arch openings. It indicates that the arch has reached the limit of its load transfer mechanism.
- 4) **RCC columns and masonry wall:**-cracks appear due to difference in thermal coefficients of the two materials and can be prevented by inserting GI butterfly ties between RCC column and brickwork. The ties are provided at alternate layers of brickwork. If it is because of the dampness of the wall, the external plaster on the outer face, 100mm on either side of the crack may be taken out and replastered after fixing chicken wire mesh over the crack. In all cases of junctions rendering should be one after fixing chicken wire mesh.

II. Repair of plaster works

- 1) **Shrinkage cracks:** - shrinkage cracks in rendering plaster occur after the first dry spell. They may occur due to lack of bond with the masonry surface and is identified by tapping the affected surface which would produce a hollow sound. Crack due to sulphate action occur after 2 to 3 years from construction. Remedial measure would be to remove the plaster and renewing it after raking the joints 10 mm deep.
- 2) **Cracks around door frames:**-these types of cracks occur due to shrinkage of wood frames or due to loose fixing of door frames. Loose fixing causes vibration of the frame and cracks develop at the junction. Cracks may also develop when the timber of the frame is not properly seasoned. As a preventative measure the timber should be properly seasoned and the frame should be rigidly fixed. As a remedial measure the junction of frame and masonry should be concealed by architraves.

III. Repair of cracks in Rcc member of a structure

1) Nature and type of cracks

- **Random cracks in structure exposed to weather:**-these cracks occur after many years of construction may be 15 to 20 years; they are likely to be caused due to shrinkage from the carbonation of concrete.

- **Straight cracks in columns, beams and slabs:-** these cracks are parallel to reinforcement along with a sampling of cover. Exposure of reinforcement may occur in places
- **Straight cracks in RCC sun shades and balconies:-** these cracks are straight and along the length occurring at intervals of 3 to 5 meters.
- They are due to shrinkage along with thermal action.

2) Repairs for strengthening of RCC structure member

- **Cracks in the RCC member:-**when we see cracks due to excessive bending moment, the load causing the cracks is released as far as possible and the member is strengthened by adding reinforcing steel with proper key and bonding with the old member is doing.
- **Cracks due to shear:-**these cracks are at 45 angles to the axis of the member and are corrected by adding diagonal shear reinforcement in the form of stitching dowels.
- **Cracks at support or at mid span bottom:-** they occur due to insufficient steel or insufficient provision of displacement of steel. They are corrected by the addition of steel as required. The ends of the added steel are bent and inserted in the member by drilling.
- **Pressure grouting:-**this method is used when the concrete has become porous but has not decayed. To check this, holes are drilled in the member as per requirement and cement slurry and/or chemicals are grouted under pressure and forced into the holes.
- **Cracks in foundation due to settlement:-**these when detected is often beyond repair, the foundation has to be redesigned with a wider base and/or the foundation has to be taken on soil having adequate bearing capacity. Grouting by Cement slurry increase the soil bearing capacity.
- **Load relieving techniques:-** the member can be pre-stressed externally by placing pre-stressing wires on both sides and then inducing tension.

IV. Repair for water supply and sanitary system

In case of water supply and sanitary system, periodic surveys are necessary to observe how the system is functioning. Normally inspection should start from the top and proceed downwards. Drawings which indicate various services as laid should be obtained to facilitate survey.

V. Repairing of Electrical Installations

The electrical installation is made safe by getting it installed and maintained through licensed persons. It's necessary that the installation is checked periodically and a proper record of such work is maintained. Recommended periodicity of checking is as follows: Earthing test - Once a year, Insulation- Twice a year, Polarity- Once in five years.

VI. Repairing leakage surface

- **Roofs:-**Lack of proper slope thereby causing stagnation of water .Adequate slope should be provided to prevent stagnation of water. With expansion joint, clogged gutters are the most common cause of leaks.
- **Lack of proper drainage system:-**Sufficient drainage pipes should be provided and replaced the broken one.
- **Poor maintenance of water pipe connections and joints:-** Maintenance of water supply pipe connections and fitting should be leak proof.
- **Leakage on floor/slab:-**applying the waterproofing material on a floor before laying tiles or saced. Waterproof cement and sand screed or other similar materials are commonly used. The screed should be applied to have sufficient options at the base of the walls, and have an adequate fall to the floor drain to prevent water pounding. All the sewer line as well as water pipeline should be fixed properly, which gets leaked and to be installed on top of the waterproofing layer without penetrating it. The floor surface under the shower tray should be formed with a fall to avoid trapping water at their bases if water leakage ever occurs.

2.8 Building Defect Due to Poor Workmanship

2.8.1 Overview of Poor Workmanship

The American Heritage Dictionary defines workmanship as "The skill of a craftsperson or artisan or the quality of something made, as by an artisan or something made or produced by the workman or the product of an effort or endeavor."

According to Zietsman (2004) when human error occurs at the setting-out stage of the construction process, the result might be very costly and the ripple effect down the chain of activities may be disastrous in terms of time constraints.

Swain and Guttman (1983) found four types of errors in the construction industry. They are: time, qualitative, sequence and quantitative errors, which can take place. Time errors occur when a task must be performed within a specific time. Qualitative errors are such errors which include right action on the wrong object, wrong action on right objects, wrong action on the wrong object, information not obtained/ transmitted or substitution/ intrusion error. Sequence errors, however, occur when an activity is done or performed out of sequence. Quantitative errors are errors which are made in rates, prices, and mathematical errors.

Poor workmanship is one of the serious issues facing local contractors in most developing countries and a portion of the payments due to the contractors is almost always withheld as a guarantee against poor workmanship, hidden defects, and similar faults which might be observed only after project completion (Moavenzadeh et al.1995).

2.8.2 The Extent of Building Defect due to Poor Workmanship on Different Countries

Craig (2008) investigates that, list of common defects and provides insight into the extent of defects experienced by new homeowners at handover in UK. Ten common defects were identified in this study. These include: uneven painting surfaces, nail pops, poor finishes, poor flooring, poorly fixed door and window handles, poorly installed kitchen units, building cracks, poorly fixed toilet and locks and concreting. This list of defects was mostly of an aesthetic nature and the major causes of those defects are attributed primarily to poor workmanship and next due to omission.

A study by Kasim (2009) on building defects in Malaysia found that poor workmanship is the major contributor to poor quality of construction, and further recommended that contractors have to provide workers with the necessary experience and skills. Shittu et al. (2013) examined the problem of poor workmanship as a major cause of building defect in Minna, Nigeria. They found that limited cost or poor funding of public project as the major that cause poor workmanship quality out of eight factors. Assessed the defects at construction and occupancy stages in Singapore, and found out that the majority of human errors arise as a result of forgetfulness and carelessness, and about 30 percent were due to inadequate knowledge while the least error arises from the willingness of the contractor. All these factors are associated with poor quality workmanship in Singapore.

Poor supervision of the work and the use of inferior or adulterated materials were identified as the major causes of poor workmanship in the construction industry. In addition, the high cost of modern equipment was rated as the major cause of lack of equipment problem in Ghana.

Abdul Rahman et al. (1996) examined the cost of non-conformance on construction sites and established that workmanship was one of the most frequent non-conformances on construction sites and further identified eight variables that relate to the causes of poor quality of workmanship in construction projects.

Ali and Wen (2011) studied the factors contributing to poor workmanship and possible measures to minimize the problem in Malaysia. They found lack of experience and competency of labors, language barrier to communication and lack of communication, unsuitable of construction equipments, poor weather condition, limited time and limited cost as the causes of poor workmanship.

Iwaro and Mwashia (2012) investigated the effects of ISO 9001 certification on organization workmanship, performance using the construction industry as a case study in Trinidad and Tobago, which found that ISO 9001 certified organizations performed better in workmanship performance compared to non-ISO 9001 certified organizations. The use of ISO 9001 certification to improve workmanship on construction projects is a research area that is

presently receiving attention due to the competitive demand for quality projects and infrastructure in the market.

2.8.3 Factors Contribute to Poor Workmanship in Building Construction

Different studies conducted on factors contributing to poor workmanship in building constructions. Ali and Wen (2011) studied the factors contributing to poor workmanship and possible measures to minimize the problem in Malaysia. They found lack of experience and competency of labors, language barrier to communication and lack of communication, unsuitable of construction equipments, poor weather condition, limited time and limited cost as the causes of poor workmanship.

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According to Abdul Rahman et al. (1996), the workmanship was classified as one of the most frequent non-conformance of the construction site. Through his literatures, eight variables that related to the causes of poor quality in construction projects had been found out. The variables are listed in the Table 2.1 below.

Table 2.1: Factors contributing to poor workmanship in building construction

No.	Factors
1	Poor project management
2	Complicated role of subcontractor
3	Lack experience and competency of labors
4	Language barrier to communication and lack of communication
5	Unsuitable construction equipment's
6	Poor weather conditions
7	Limited time
8	Limited cost

I.Poor Project Management

Dai et al. (2009) mentioned that incompetence management is generally recognized as a major factor of poor construction productivity. He further stated that the management factors may due to the insufficient of supervision on site. In fact, poor supervision on site contributes to the poor workmanship on a construction site and it can be seen on many occasions on the job site. In addition, the ability of management of the construction site is the primary cause that affects labors' daily productivity. Kasun et al. (2006) stated that the quality of project manager is one of the causes in affecting project quality. Therefore, poor project management is one of the factors contribute to poor workmanship.

II.Complicated Role of Subcontractor

Khalid et al. (2006) agreed that the role of subcontractor is one of the factors contribute to construction deficiency (poor workmanship) and many people are not always focus on this factor. However, in fact, the role of subcontractor is important in construction work. This is because most of the site work is completed by subcontractors and the main contractors just depend on the subcontractors. He further stated that approximate 90percent of the site work is executed by variety of subcontractors whereas the main contractor is focused on management and coordination.

Besides, Chan et al. (2006) also mentioned that labor sub-contracting also arise severe problems in the co-ordination of work and attainment of quality standards. Since there are various types of subcontractor involve in the same construction project, the main contractor is difficult to inspect, supervise and control the works that have been done by the subcontractors. Therefore, complicated role of subcontractor in construction projects can contribute to poor workmanship.

III.Lack Experience and Competency of Labors

Kasun et al. (2006) mentioned that “productivity cannot be achieved by speed and harder work only without adopting better work practices”. Besides, industry stakeholders agreed that insufficient of skilled manpower is the most important matter that their concern about. According to Chan et al. (2006), some construction companies in Turkey usually prefer to employ short term unskilled labors and consequently cause the fault in the process of attaining the stability of quality associated issues. Hence, lack of experience and competency of labors must be taken into account as a factor contributes to poor workmanship.

IV.Language Barrier to Communication and Lack of Communication

Different language between the foreign labors and local supervisors causes the communication failure on the job site. From a research by Augusto et al. (2009), it was found that 82percent of the respondents in the survey mentioned that the most general trouble faced on the job site by the America supervisors is the language obstacle when communicating with the foreign labors. Additionally, from a survey of Kasun et al. (2006), showed that exceed 40percent of the respondents from the construction site protested about the insufficiency of communication. Indeed, language barrier indirectly causes the lack of communication between the supervisors and labors. This consequently causes the misunderstanding by the labors in their work scope and then lead to poor workmanship.

V.Unsuitable Construction Equipment's

Faisal et al. (2006) stated that Suitability of construction equipments can influence the workmanship quality in construction. Insufficiency of the latest information about the

obtainable equipments can influence the project quality. The poor quality of mass housing projects in Turkey mostly because low cost construction techniques which are totally disregarded. Therefore, unsuitable construction equipments can cause low quality of workmanship in construction.

VI. Poor Weather Condition

Dai et al. (2009) stated that the extreme climatic condition is one of the factors that affecting construction labor productivity and workmanship. From the research of Faisal et al. (2006), found that the climate of Saudi is hot and severe during summer that causes some of the construction works very hard to carry out, such as concreting. As a result, the quality of workmanship is affected.

VII. Limited Time

Insufficient time caused the construction projects executed to be rushed. According to Andrew (1999), a number of “show houses” on the site were required for many construction projects. Many concurrent works were carried out and inadequate checking had been carried out by the senior managers sequentially caused by the speed of working. As a result, the deficiency of workmanship had been happening. In short, limited time causes a low quality of workmanship in construction.

VIII. Limited Cost

Insufficient cost or budget would cause inadequate allocation of cost in construction project. Labor cost is included in construction cost. Proverbs et al. (1999) stated that Labor element is considered as the most difficult component to price within the reasonable level of accuracy. Obviously, labor cost estimation is considered as uncertainty. In addition, contractors who are not preparing the sufficient budget for the project will cause the labor cost cut down correspondingly. As a result, the labors supplied are not sufficient to complete a project and construction defects may appear.

2.8.4 Impacts of Poor Workmanship in Building Construction

Although eight variables that factors contributing to poor workmanship have been previously mentioned. In this paragraph describes the impact of poor workmanship on time, cost and quality in building construction. The following eight major effects of construction defect were shown on federal buildings. Project delay ranked as the highest effect of construction defects. The next effect was construction cost overrun. The analysis ranked high maintenance cost as the 3rd highest effects of construction defects. Construction defect negatively affect contractor and/or consultant reputation and decreases the value of project were the remaining effects of construction defect in top five list respectively (Bedru M. 2015) .However, when focusing on problems concerning poor workmanship in the construction process these three parameters are pivotal. Occurrences of defects in buildings lead to cost overrun, time overrun and lowering the customer's satisfaction level, to stand and progress with increasing reputation in market, customer oriented construction of buildings needs to be constructed to improve quality and service to end users.

i. Quality

The word quality has many meanings: a degree of excellence; conformance with requirements; fitness for use; delighting customers; freedom from defects, imperfections or contaminations. Chan and Chan (2004) confer that in the construction industry, quality is defined as a totality of features required by a product or service to satisfy a given need- "fitness for purpose". However the way in which quality is determined is by the extent to which a product or service successfully serves the purpose of the user during usage.

Price and delivery are both transient features, whereas the impact of quality is sustained long after the attraction or the pain of price and delivery has subsided. Nowadays, quality is the guarantee of the product that convinces the customer or the end-user to purchase or use. The meeting of specifications by good workmanship is one way of measuring quality (Chan and Chan, 2004).

Specifications act as workmanship guidelines provided to the contractor by the client or the client's representative at the commencement of the project. If quality assurance mechanisms, such as benchmarking is not in place during construction, poor workmanship will be the end result affecting the quality directly (Ashworth and Hogg, 2002).

▪ **Criteria of quality measurement in construction**

Manuel *et al.* (2008) quoted from Abdel-Razek (1998a) highlighted the significance of measurement of quality in the construction sector. Low and wee (2001) quoted from Chung (1999) stated that construction quality can be defined as the meeting of the requirements of the parties involved – “meeting contractual requirements of the client, legislative and regulatory requirements of the authorities, the social requirements of the public and even cost requirements of the contractor”. Therefore, construction quality can be measured based on these criteria. Besides, Tan (2009) quoted from Molenaar *et al.* (1999) stressed that there are three criteria of measurement of quality in construction, which are the conformity with expectations, administrative restriction and client's/ customers' satisfaction.

▪ **Conformity with expectations**

According to Robby *et al.* (2001), a construction project success as well as the quality of the project, can be emphasized on the implementation of expectations. These expectations could be the objectives have been created in the early phase of the project, such as “quality or zero defects” objectives.

▪ **Administrative restriction**

Many construction projects are bonded with the administrative system. Some of the standards and guidelines are enforced in many companies for the purpose to ensure that the products of contract projects are within the standards of quality.

Takim *et al.* (2003) also agree that the approved guidelines and standards is one of the objectives of quality assessment system in construction model which is recently applied by the construction industry development board of Malaysia to evaluate the quality measurement

in construction. He further pointed out that the evaluation of workmanship can be done derived from the approved specifications.

▪ **Clients' or customers' satisfaction**

Adnan et al. (2000) stated that nowadays the importance of quality has expanded to concentrate on the clients' or customers' satisfaction. Tatiana (2005) mentioned that the quality performance of a project is assessed by the client or project owner and also the buyer of the product. According to Takim et al. (2003), performance measurements apply to customer satisfactions, requirements, and needs meanwhile the customers may consist of the shareholders, buyers and workers. Chinny et al (2010) cited in Liu and Walker (1998) stated that the level of the satisfaction experienced decides the degree of the project success. Clearly, client satisfaction can be considered as common criteria in quality measurement in construction.

ii. Cost

The cost of a commodity, whether it is a simple one like a length of timber or a complex item like a building, is the sum of all payments made to the factors of production engaged in the production of that commodity. When manufacturing a quality product, providing a quality service, or doing a quality job- one with a high degree of customer satisfaction- is not enough. The cost of achieving these goals must be carefully managed, so that the long-term effect on the business, be it constructed, is a desirable one. These costs are a true measure of the quality effort Raftery, J. (1991). If a limited capital budget is the prime consideration of the client, then the quality in the form of reduced specifications as well as workmanship is likely to be restricted. If the clients cost increases, a higher standard of workmanship will be specified.

The defect cost is defined as the value of resource consumption for rework as a consequence of a defect. Work time, materials and equipment time are consumed to correct the defect. Time is lost in waiting as a consequence of a defect.

For the two decades, researchers have to estimate the cost of construction work that not correctly done the first time. Countries currently involved in such extensive rework studies

include Australia, Canada, Sweden, UK, USA, South Africa and Hong Kong. The extent of rework indicates the occurrence of the defect on a construction project. For example, in the UK, Wgan (2008) reported that up to 30 percent of construction work is related to rework while in the USA the annual loss due to rework could be as high as US\$ 15 billion for industrial construction. The study by Buratil et al. (1992) in the UK revealed that the cost of defect rectification varies between 0.4 percent -26 percent of total project cost resulting in an average cost of 12.4 percent. Similarly, the study by Barbar et al. (2000) on the cost of quality failures in two major road projects so that they were respectively 3.6 percent and 6.6 percent of the total project cost. Studies conducted in Sweden, the cost of defect on several buildings which were constructed from 1990-1996, covers 2.3 percent-9.4 percent of the contract value (Josephson et al, 2002).

The cost of defects occurring during production is stated to be 2-6 percent of the cost of production (Jackson, 1987, Ball, 1987, Hammarlund et al., 1990). The cost of defects occurring during the maintenance phase is stated to be 3-5 percent of the production cost (Tolstoy, 1984, SBR, 1988, STATT, 1989, Pintér, 1989). Studies on costs of defects occurring during the early phases of a project are unusual. The origin of defects occurring during production is principally in production, but also in design (Herbert et al., 1969, Kullstedt and Wirdenius, 1976, Bonshor and Harrison, 1982, Hammarlund et al., 1990). The origin of defects occurring during maintenance is principally in design, but also in production (Reygaerts et al., 1976, Matousek, 1977, Tolstoy, 1984, SBR, 1988, Pintér, 1989).

Different researchers states that the defect are increasing the cost of construction and reduces the life of the structure. Defective building construction not only contributes to the final cost of the product, but also to the cost of maintenance which can be considerable. The cost is calculated irrespective of who is going to pay. In addition, Defective construction may lead to complete failure of the structure.

iii. Completion Time

Various factors are measured like rework time, materials and equipments to correct the defects. Time is lost in waiting as a consequence of defects. Buildings are long-lived capital

assets. The period between decision and action, inception and occupation, use and obsolescence is rarely measured in months, usually in years or decades and occasionally, in centuries. More than in almost any other aspect of human activity, time is central to design, production and use of the built environment.

Chan and Chan. (2004) postulated that time in the construction industry refers to the duration for completing the project. It is scheduled to allow the building to be in use by a date determined by the client's future plans. In addition, time is related to effectiveness, which in construction refers to how well the project was implemented or the degree to which targets of time and cost were met from the start-up phase to full production. Ashworth and Hogg (2002) mention that project duration or completion dates may be critical to the success of a project, and in some situations if these dates are not met due to poor workmanship, it could lead to total failure in meeting the client's objectives.

Ashworth and Hogg (2002) further stated that while most clients' desire early building completion, it is important to distinguish between this and true need since attempting to meet the objectives of early completion is likely to have consequences such as poor workmanship which is not a project requirement.

2.8.5 Possible Measures to Minimize Workmanship Problem

Some building professionals have argued that workmanship problem will never be totally eliminated. Nevertheless, there are a number of measures that would go some way towards reducing if not avoiding this problem (David Hall 1988).

- An improvement in the "lowest tender" system, without generating excessive inflation of contract prices, should be sought. Cheapest price does not necessarily mean better value for money, particularly in the long term. This takes into account quality of product as well as lowest whole life cost.
- Increased/improved feedback from builders, research bodies, maintenance engineers/surveyors, and users to designers/specifiers and better feed-forward from designers/specifiers to maintenance managers and users. Increasing the accessibility of

information for building professionals, managers and technicians will go a long way to achieving this goal.

- Regular on-the-job training programs for operatives and site staff.
- Improvements could be made in the quality of graphics and written communications. In addition, training could be given to site staff on improving verbal communication skills.
- Better and more available guidance on commissioning buildings and their services and on defects avoidance.
- All building systems need to be coordinated concurrently, starting with the planning phase and continuing into the programming and implementation phases, Periodic and regular construction site supervision.
- Continuously evaluate the capacity of consulting and construction firms, Revoking licenses of more frequent defective firm.

Ashworth and Hogg (2002) mentioned that there were six possible measures that suggested by researchers in order to minimize workmanship quality problem. The six measures are listed in the Table 2.2 below.

Table 2.2 Measures to Minimize Poor Workmanship Problem

No.	Measures
1	Strict supervision
2	Training and education
3	Proper communication among parties involved
4	Proper construction management
5	Proper manpower management
6	Proper design

1.Strict Supervision

The quality by strict supervision at a construction site is one of the criteria of recent practices in the construction sector. Daily supervision should be carried out by the contractors or subcontractors so that workmanship problems can be identified and the remedial work can be executed immediately. Besides, when executing the supervision, contractor supervisory staff

must possess the knowledge, expertise, and capabilities to administer the construction work and superintend the craft worker efficiently (Maloney, 2002).

2. Training and Education

According to Chan et al. (2006), many researchers agreed that appropriate training and enlarging experience is necessary in transferring the quality project. Labor productivity is becoming significant in construction because of its impact in the process of completing projects. They also stated that the construction quality can be enhanced by increasing the capability of site labors.

3. Proper Communication between Parties Involved

Proper communication is a necessary in construction. From a research had been done by Augusto et al. (2009), 80 percent of the Hispanic workers in the U.S. construction sector mentioned that the communication with the supervisors is vital and need to be improved. Therefore, American supervisors suggested that the training in communication skills is essential to eliminate the language gap between themselves and the foreign labors. Augusto et al. (2009) no communications means any management apart from the communication between supervisors and construction and subcontractors. Through a continual communication between parties involved, working relationship between the construction parties can be closer.

From a research of Proverbs (1999), it found that better quality performance of Japanese construction projects can be attained attribute to steady and durable working relationship between Japanese contractors and subcontractors. Therefore, proper communication is very important to improve the relationship between the construction team and consequently improve the workmanship quality in construction.

4. Proper Construction Management

Proper construction management would enhance the workmanship; quality in construction. Dai et al. (2009) stated that the capability of construction managers to manage, arrange and lead the work would affect the construction labor productivity. If a construction manager

fails to lead and control the construction project, the quality problems may arise. Therefore, a proper construction management is very crucial for every construction project.

5. Proper Manpower Management

Robby et al. (2001) have proposed that manpower management in term of amount and quality of skill workers is an important determinant of contractor performance and extremely prioritized by employers. A construction project which has a well arrangement of manpower will produce a high quality of the project. Besides, he also mentioned that manpower is the sole productive resource; hence construction productivity is essentially relying on human endeavor and performance. Therefore, the management of manpower in every construction project should be arranged skillfully.

6. Proper Design

Wai Kiong and Sui Pheng (2005) found that good design can get rid of workmanship defects and help to avoid the defects. Inadequately worded specifications and uncertain designs always cause the low construction. A better design may correct some defects which due to workmanship in masonry work. In addition, they stated that well-prepared designs and drawings affect the future works to become easier and the defects can be identified and rectified more effectively.

2.9 Summary on Identification of Gaps of the Literature

The Literature is revised about building defects, type of defects, and the main causes of the building defect and possible solution to minimize the problem. Moreover, it gave emphasis on the building defect due to workmanship. The main reason of the literature review is to study from the others either developed or developing countries, to adapt the best experiences for our construction of 20/80 condominium houses and to identify the gap on researches to fill in this research.

From the literature review, building defect is either design or/and construction defects; the reason is include any deficiency in the performing of the design, planning, supervision,

inspection, construction, or observation of construction of the building. This design defect is the result of professional's failure to produce a complete, accurate and well-coordinated set of design and construction documents more over construction defects result of unskilled labor not able to construct buildings.

Moreover, it compiles about method of building construction defect detection. And the building defect can detect on pre-construction stage: by (In situ) exploration and tests and laboratory tests; during construction stage: low concrete quality/strength, loose tie of reinforcement bars causing misplacement of the bars leading to over stressing of the structure should be supervised; and on post-construction stage methods for defect detection include observation, inspection, checking work and test samples are methods of detection of defects.

In addition to that, there are various causes of defects like design deficiencies, material deficiencies, poor workmanship, subsurface deficiencies, user activities, maintenance, climatic conditions are some of the causes of building defects.

From the above causes the literature gave emphasis on defect due to poor workmanship; because as reviewed literature from developed and developing countries. Poor workmanship is the major contributor to poor quality of construction; with various impacts like poor quality, high cost, and delay completion time. Therefore, the literature revised factors contribute to poor workmanship in building construction or lack of experience and competency of labors, language barrier to communication and lack of communication, unsuitable of construction equipments; poor weather condition, limited time and limited cost are some of factors for contributing for poor workmanship. In addition, revised about measures to minimize workmanship problems to adapt these measures to our country is regarding to defect due to workmanship problem.

During the literature review there are worked researches in our country which is related with building defect but there is no research related with defects due to workmanship problem especially in 20/80 condominium houses, therefore the research is tried to fill the gap by giving emphasis on building defects due to poor workmanship in Addis Ababa, a case study on 20/80 condominium houses to recommend better solution.

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides how to do the research with appropriate methods, which includes the research approach, method, sampling design, sources of data, how to collect data from the target population, analyze and present the analyzed data, so that enable the researcher to address the set objectives.

3.2 Research Design

There are three types of research approaches, namely: quantitative, qualitative, and mixed research. Quantitative study is a study where purely quantitative data and analysis techniques are adopted while qualitative approach makes use of purely qualitative data and analysis. The mixed approach on the contrary adopts the combination of both quantitative and qualitative approaches. The main criteria to decide which type of research to follow depends on the type of study and availability of the information which is required for the study (Naoum, 19980).

In this study, mixed method research approaches were used. Because, this approach is useful the best to capture both qualitative and quantitative data. To employ mixed method, a questionnaire survey was conducted and analyzed which was followed by an in-depth case analysis from qualitative data source.

In line with the above strategies the research was carried out using a four phased approach in order to achieve the objectives of the research. The first was to undertake a literature search on previous publications on building defects, especially poor workmanship as a major cause. Although the review of related literature was carried out as a standing alone chapter, the researcher used literature throughout the whole research process to substantiate arguments and claims.

In the second phase, questionnaires were developed and distributed to two groups: a) clients¹, contractors² and consultants³, and b) the residents of 20/80 condominiums who are living in

¹ It includes office manager ,senior officer, junior officer

² It includes project manager, assistant project manager, site engineer ,Forman

³ It includes project coordinator, resident engineer ,site supervisor

Yeka Sub City to get their opinion based on their experiences and to get the extent of building defect after occupancy. Upon obtaining the desired data, checking and sorting of data has been done.

In the third phase, case studies were conducted in some selected blocks which are ready to transfer to the residences. For case study analysis data were gathered employing site observation. Site observation was supported by a photo camera and a structured checklist which is annexed in Annex B-1. The data were then analyzed extracting the information obtained through the overall research work. Finally, this was followed by thorough discussions in order to draw conclusions and to forward recommendations based on the findings of the study.

3.3 Source of Data and Research Instrument

3.3.1. Primary Data

Primary data were through questionnaire, were from clients, consultants and contractors. Most of the data collected through questionnaire survey are ordinal in nature and used to rank the problems in their order of significance with the intention of finding additional variables beyond those found out from the literature review.

The answers to the structured part of the questionnaire are based on Likert-scale of five ordinal measures of agreement towards each statement (from 1 to 5). The reasons for adopting this scale are: a) to provide simplicity for the respondent to answer; and b) to make the evaluation of collecting data easier. As discussed earlier Likert's scale of five ordinal measures of agreement towards each statement (1, 2, 3, 4 and 5) is used to calculate the mean score for each factor that is used to determine the relative ranking. The mean score (MS) for each variables is computed by using the following formula;

$$\sum((f * s) / N) \dots \dots \dots [Eq3.1]$$

Where: MS = Mean Score

F= frequency of responses for each score

S =scores given to each factor (from 1 to 5)

N=total number of responses concerning each factor

Certain cases study will also be investigated to demonstrate how serious the problem with the 20/80 condominium housing construction sites by conducting site observation. It is simple to substantiate the existence of the problem and its extent by presenting the status of some of the major building defects using pictures captured during the field observation.

3.3.2. Secondary Data

Secondary data which involves information from published text such as journals, government publications, dictionaries, dissertations and reliable internet resources were used to compliment the primary data. In this regard, resources in the Addis Ababa University Library and Ethiopian Civil Service University Library were consulted.

3.4 Research Population and Sampling

In Addis Ababa, there are 15 20/80 condominium construction sites across all sub cities of the City Administration (see Anex D2). This study takes the condominium housing projects undergoing in Yeka Sub-City. While the projects in other Sub-cities have been completed, some projects in Yeka Sub-City are not yet completed and this was found to be a good reason for selecting the projects in Yeka Sub-City for this particular study. Unfinished projects creates a good opportunity for the researcher to get access to contractors and consultants before they transfer the project and leave the site which enables the researchers to detect construction defects before transferring to the client. Yeka sub-City constitutes two project sites; namely Yeka Ayat and Yeka Abado Sub-Cities. Due to the fact that unfinished projects are existing in Yeka Abado project site which constitutes 289 blocks the researcher was inclined to select Yeka Abado from the purpose of the study that Yeka Ayat. In Yeka Abado Project, there are three target groups from which the data were collected. These include: contractures', consultants' and clients'. Employing the sample size determination formula for small sized population suggested by Kotari (2012). Accordingly from the total of 161 contracting companies and questionnaires were distributed for 42 contractors' and for the two consulting firms, 23 questionnaires were distributed to professionals who are working for the tow consulting firms randomly. Likewise, 16 questionnaires were distributed to professionals'

for clients working on the sites. The appropriate formula to determine sample size based on small population is as follows:-

$$n = \frac{Z^2 pqN}{e^2(N-1)+Z^2 pq} \dots\dots\dots [Eq3.2]$$

Where: - n= Sample size required

N= Number population of registered contractors/ consultants

Z= Level of confidence considers 95 percent and the reading result taken from the Z chart is 1.61

p = sample proportion, q = 1 – p and p=0.02

e = Sampling error which shows precision taken 3 percent.

Figure 3.1 illustrates the below shows the sample for this study is determined information briefly.

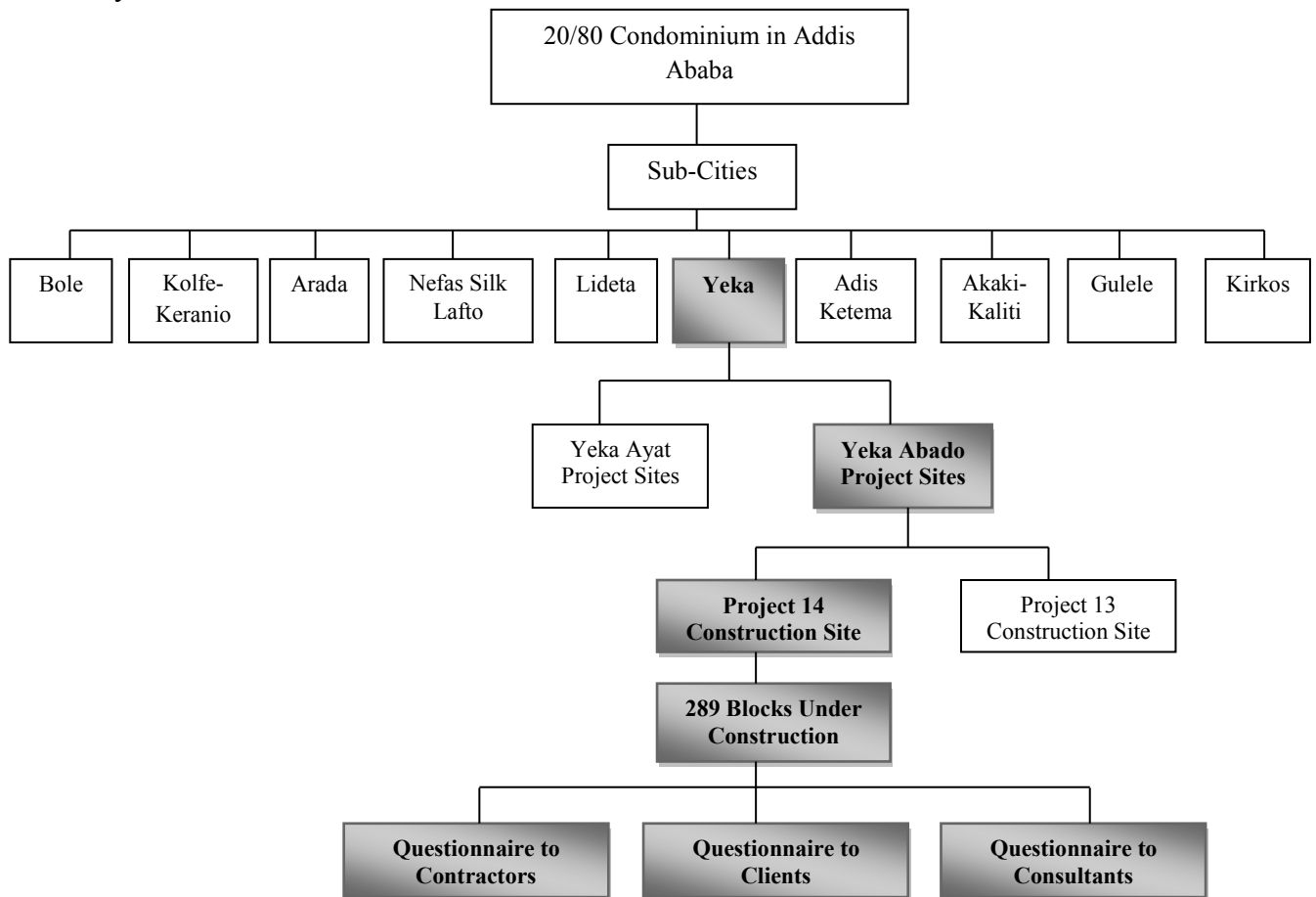


Figure 3.1 Procedure of Sample Selection for the Site

In order to explore the extent of the building defects after transfer, dwellers were also communicated through questionnaire. Questionnaires for residents were distributed for different condominium sites to investigate different types of defects and their extent across the houses through their ages. In other words, the age of housing was grouped into 4 categories; namely below 1 year, 1-3 years, 3-6 years and above 6 years. Accordingly, 56 questionnaires were distributed to the residents based on their availability during the distribution of the questionnaire. Table 3.1 reveals the distribution of data gathered from residents.

Table 3.1: Study Population Data on 20/80 Condominium Housing

No	Site	Year(E.C)		Age Category (years)	Number of Houses
		Construction Started	Transfer to the Resident		
1	Kotebe	1997	2001	>6 years	266
2	Kara Alo	1999	2003	3-6 years	180
3	Yeka Ayat 2	2002	2006	1-3 years	9230
4	Yeka Ayat 3	2004	2007	<1 year	536
Total					10,212

At the time of research, 207 homeowners were intensifying claim regarding to the quality of their houses which were received from the housing agency. The residents claim was related to two reasons: First, construction works were not completed by the contracting parties, for example absence of window glass, absence of door keys, to mention, but few. Second was because defective works. Detailed information regarding the number of homeowners who raise claim is presented in Appendix A5. Table 3.2 shows that general information of blocks is taken to rectified defect by the responsible body.

Table 3.2: General Information of Case Study Blocks

Study area	Case study 1	Case study 2
Project name	20/80 Condominium, project-14	20/80 Condominium, project-14
Block number	Block no. 59	Block no.178
Project start time	2013	2013
Floor height	G+7	G+4
Number of residence offered claims	32	15
Project cost	17,845,421.97	4,724,384.97
Project status	Almost completed	Almost completed
Location	Yeka Abado,woreda/kebele 12	Yeka Abado,woreda/kebele 12
Consultant grade	CA-1	CA-2
Contractor grade	GC-3	GC-5

3.5 Method of Data Analysis

Finally, the results of the questionnaires and case studies were analyzed using quantitative data analysis software known as SPSS version 20. Frequency tables and descriptive statistics were constructed to display results with respect to each of the questions of general information and cause of defects. Ranking analysis was used to rank the common types of defects, the degree of importance of the factors contributing to poor workmanship and the degree of effectiveness of measures to overcome quality problems using mean score value.

Besides, correlation analysis (Spearman's rank correlation coefficient) was used to identify the significance of relationship between the mean responses of the respondents in this research. The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula..

$$\text{Rho (rcal)} = 1 - \frac{6 \times (\sum di^2)}{N(N^2 - 1)} \text{-----[Eq. 3.3]}$$

Where: Rho (rcal) =Spearman rank correlation coefficient

di=Difference between ranks given by two respondents for each variable

N =Number of pairs of values in the data set.

3.5.1 Questionnaire Design

A questionnaire was developed to assess the perceptions of clients, consultants, and contractors due to the importance index of common type of construction defects in 20/80 condominium houses during the construction phase and for residences after handover. The need for distributing questionnaires, for the residents were to identify the severity as well as to show defects which are observed after occupancy and through age. Causes and impact of construction defects in building construction projects in general were first examined and identified through a relevant literature review and then based on the questionnaire data review the perceptions of clients, consultants, and contractors. Finally, the factors contributing to

poor workmanship and possible measures to minimize the problem were assessed by the client, contractor and consultant.

From literature review it has been discussed about types, causes, impact and reducing measures of construction defects, factors contributing to poor workmanship and possible measures to minimize poor workmanship in building projects in various countries around the world. But not all of these types, causes, effects and reducing measures of construction defects in 20/80 condominium houses projects are practical in Addis Ababa. Therefore, only 64 factors relevant to Addis Ababa condominium housing projects were selected and included in the questionnaire.

The questionnaire includes 38 types of construction defect, 4 causes of construction defect, 6 effects of construction defect, 10 factors contributing to poor workmanship and 6 possible measures to minimize to poor workmanship. The respondents were asked to fill the questionnaire and it was promised that any information they provide would be treated in a highly confidential way and used only for academic purpose.

For the case study, a checklist consisting 42 types and 4 causes of construction defects were developed. Then site visit was done on selected two blocks (The checklist is included in Annex B1).

3.5.2 Respondent Profile

Six items were prepared for a client, consultant and contractor profile for obtaining information about the respondent's organization such as the name of the organization, company type (client, consultant or contractor) and respondents' job position and two items was prepared for residents (The Respondent profile is included in Annex A1 and A2).

3.5.3 Types and Causes of Construction Defects

This part of questionnaire consists 14 common types of construction defect observed during the construction period and 24 common defects observed on residential houses, these categories are foundation related defect, beams, column and slab related defect; ceilings,

walls, floors, door and windows related defect; roof related defect; water supply system related defect; electrical system related defect (The questionnaire is included in Annex A1).

3.5.4 Impact of Construction Defects

This part illustrates the impact of construction defects in building construction project, these factors are the farther of previous studies and literatures written in similar areas. A total of 6 major factors were included in this part (The questionnaire is included in Annex A1).

3.5.5 Factors Contributing to Poor Workmanship

This part illustrates common factors for poor workmanship in building construction projects, by considering of previous studies and literatures written in similar areas. A total of 10 factors were included in this part (The questionnaire is included in Annex A1).

3.5.6 Possible Measures to Minimize Poor Workmanship

This part illustrates possible measures to minimize poor workmanship in building construction projects. It is also constructed by referring to studies and literatures written in similar areas. A total of 10 factors were included in this part (The questionnaire is included in Annex A1).

4. ANALYSIS AND DISCUSSION

4.1 Introduction

This Chapter describes the analysis of the data collected through questionnaires, case study, site observation and literature review concerning types, causes, effects and reducing measure of construction defects in 20/80 condominium project is presented. The data are presented using appropriate data presentation tools (tables, graphs and photos).

4.2 Questionnaire Response Rate

Two different questionnaires were administered, the one of 20/80 condominium construction participants; clients, consultants and contractors and the other for 20/80 condominium house's residents. The questionnaires comprised of five parts for 20/80 condominium construction participants and two parts for the residents as the study aimed to do thorough research investigation. The research analysis and discussion is done based on the response from the distributed questionnaire representing 71.50 percent response rate that indicates a good confidence limit; as shown below in Table 4.1.

Table 4.1 Response Rate of the Questionnaire

No	Respondents	Questionnaire Distributed	Returned Questionnaire		Unfinished Questionnaire		Analyzed Questionnaire	
		No.	No.	percent	No.	percent	No.	percent
1	Client	16	13	81.25	1	6.25	12	75.00
2	Consultant	23	19	82.60	1	4.35	18	78.26
3	Contractor	42	30	71.43	5	11.90	25	59.52
4	Residents	56	41	73.21	0	0.00	41	73.21
Total		137	103	77.12	7	5.10	96	71.50

Note: -No=number and percent=Percentage

A total of 81 questionnaires were sent to a selected sample of respondents in the 20/80 condominium construction which comprise the following: 16 client, 23 consultants and 42 contractors. Form those questioners 12 clients', 18 consultants' and 25 contractors' questioners were analyzed. Besides, in order to differentiate different common types of defects seen after construction 56 questionnaires were distributed to residents of 20/80 condominium who are living on different sites under Yeka sub city.

The numbers were determined on the basis of the available engineers employed by the contractors and consultants on the sites when the time available for conducting the research works. Questionnaire has been designed considering the result would be analyzed quantitatively. Consequently, the responses of the questionnaire survey were coded in SPSS-20 and Microsoft Excel spreadsheet. The descriptive statistics function such as: mean, frequency distribution, which shows the frequency of observation of each response to each variable under investigation is used to analyze the result of some questions. Computation of mean score and relative importance index is also used to analyze the results of 'rating scale' type of questions. Consequently a spearman correlation is employed to analyze the correlation between the ranking of the respondents' response, such as clients, contractors and consultants. The following findings are obtained and discussed below.

4.2.1 Respondents from 20/80 Condominiums Construction Participants

4.2.1.1 Classification of Organization

As shown in Figure 4.1, 12 from 18 (66.7 percent) of consulting companies are Class 2 while only 6 (33.3 percent) of them are Class 1.

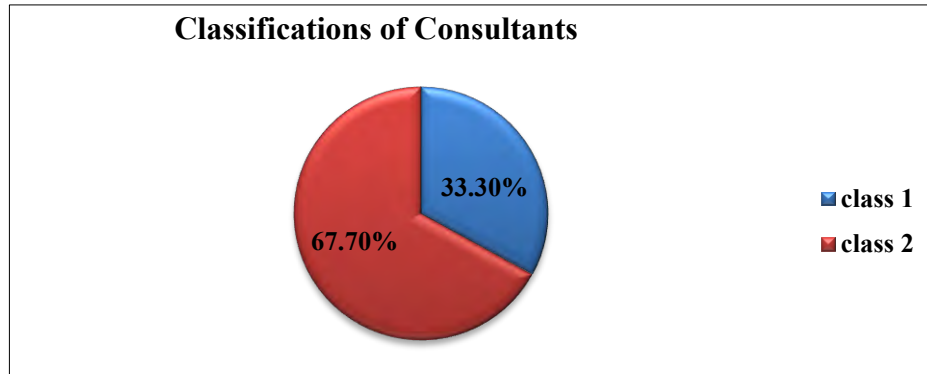


Figure 4.1 Classifications of Consultants

Table 4.2 represents classification of contracting companies. Further, 48 percent of contracting companies are grade 3 up to grade 4 buildings and general contractors. The reason behind grade one and grade two contractors were not involved in this project sites might be the profit margin not attractive by them.

Table 4.2 Classification of Contractors

Classification		Number		Percentage		Cumulative
Grade 3	GC	1	5	4.0	20	20
	BC	4		16.0		
Grade 4	GC	3	7	12.0	28	48
	BC	4		16.0		
Grade 5	GC	5	10	20.0	40	88
	BC	5		20.0		
Grade 6	GC	1	3	4.0	12	100
	BC	2		8.0		
Total		25	25	100.0	100	

4.2.1.2 Respondent's Position in the Site

Table 4.3 illustrates that from the clients 8.33percent are office managers, 66.67percent senior officers and 25percent are junior officers. Whereas from the consultants 16.6 percent are project coordinator, 27.78percent resident engineers and 55.56percent are site engineers. Further, from the contracting companies, 52percent are site engineers and 36percent are project managers. Most of the respondents were site supervisors and site engineers. Therefore

the reliability of the questionnaire responses were accepted since their scope of work is in the site; and has certain experience and expertise.

Table 4.3 Respondent’s Position in the Site

Client			Consultant			Contractor		
Position	No.	Percent	Position	No.	Percent	Position	No.	Percent
Office manager	1	8.33	Project coordinator	3	16.67	Project manager	9	36
Senior officer	8	66.67	Resident engineer	5	27.78	Assistant project manager	1	4
Junior officer	3	25.00	Site supervisor	10	55.56	Site engineer	13	52
Total	12	100	Total	18	100	Forman	2	8
						Total	25	100

4.2.1.3 Educational Level of Respondents

The respondent’s Educational level is shown in Figure 4.2 below. 25.45 percent of respondents have M.Sc and 60 percent have B.Sc. Generally, 85.45 percent of them have B.Sc and M.Sc. This indicates great confidence in their answers.

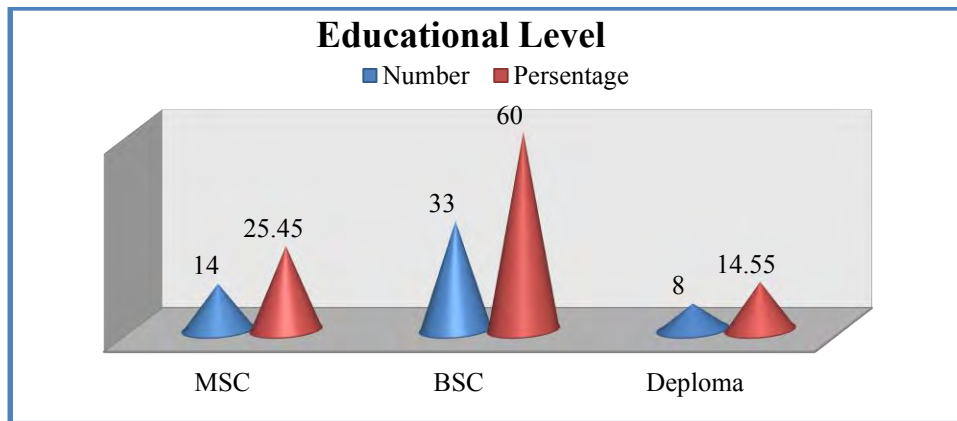


Figure 4.2 Educational Levels of Respondents

4.2.1.4 Years of Experience in Construction Industry and Condominium Construction

Out of the 55 respondents, the data depicted below shows that 40percent of the respondents had 5 or less years of working experience in the construction industry. Whereas, in the condominium construction 27.27percent and 25.45 percent of them had from one up to three

years and from three to five years of experience. This implies that the respondents have quite a reasonable working experience.

Table 4.4 Respondents Work Experience

Experience in the construction industry			Condominium housing construction		
Year	No.	percent	Year	No.	percent
<1	3	5.45	<1	8	14.55
1 – 3	10	18.18	1 – 3	15	27.27
3 – 5	8	14.55	3 – 5	14	25.45
5 – 10	22	40.00	5-8	10	18.18
10-15	8	14.55	8-10	6	10.91
15 - 20	2	3.64	>10	2	3.636
> 20	2	3.64	Total	55	100
Total	55	100			

4.2.2 Respondents of 20/80 Condominiums Residents

4.2.2.1 Age and House Ownership of Respondents

The distribution of respondents' age is shown in Table 4.5 illustrates that from 41 respondents 34 (82.92 percent) are between thirty and thirty nine years of age.

Table 4.5 Age of Respondents from 20/80 Condominium Residents

Age (years)	Number	Percentage	Cumulative	
			Number	Percentage
>60	2	4.88	2	4.87
50-59	6	14.63	8	19.51
40-49	11	26.83	19	46.34
30-39	15	36.59	34	82.92
<30	7	17.07	41	100
Total	41	100		

As shown Figure 4.3, regarding to owning of the housing, 63.44percent of residents are living in their own house and 36.56 percent are tenanted. This indicates the answer from the respondents comes from a reliable source.

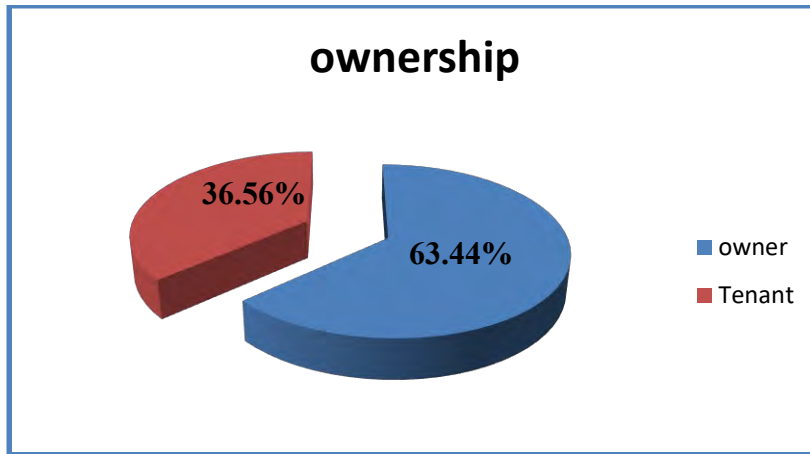


Figure 4.3: Ownership of the House

4.2.2.2 Length of Residence of Respondents

As shown in table 4.6, more than 75percent of the residents in which the questionnaire assesses lived in the houses from three to six years. This means that residents have stayed enough time to notice defects in the houses.

Table 4.6 Length of Duration of Respondents of the Residents

Years	Number	Percentage	Cumulative	
			Number	Percentage
>6	10	24.39	10	24.39
4-6	8	19.51	18	43.90
1-3	13	31.71	31	75.60
<1	10	24.39	41	100
Total	41	100		

4.2.2.3 Residents Educational Level of Respondents

Figure 4.4 illustrates the educational level of respondents of 20/80 residents, 13 (31.71percent) have a B.Sc and 10 (24.39percent) have greater than B.Sc.

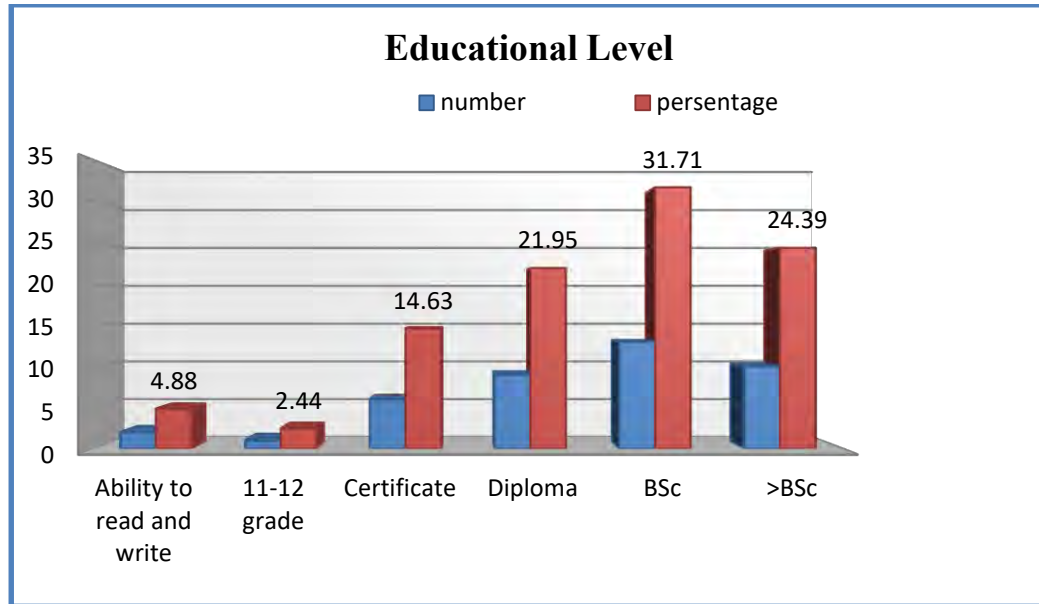


Figure 4.4 Residents Educational Levels

4.3 Common Types of Building Defects in 20/80 Condominiums

In this part the result of common types of building defects in 20/80 condominiums that are gathered from questionnaire, case study and site observation are presented and discussed. As it known defects in the building could be seen during construction and after construction. Therefore, in order to address defects at both stages using two different types of questionnaires were distributed to professionals and residents, tried to measure its extent in 20/80 condominium housing.

4.3.1 Major Types of Building Defect Respond from Construction Site

The questionnaire of this study considered 11 common types of building defects seen during construction and respondents were required to determine how frequently the listed defects occurred in 20/80 condominiums construction projects in Addis Ababa.

4.3.1.1 Respondents respond regarding to common type of defect

Common types of defects in the 20/80 condominium construction projects are identified from the returned questionnaires based on the mean scores (MS) of the three groups of respondents;

clients, consultants and contractors. In this research defects which have a mean score of greater than 3 ($MS > 3$) are considered as the most common types of defects observed by the respondents'.

The most frequently occurring defect has been uneven floor/wall finishes (mean value, 3.51); respondents acknowledged that this defect has been frequently a problem in the housing area. This included both ground floor as well as slabs along the building. The second most common defect reported by respondents was faulty door/window frame, knobs (mean value, 3.21); professionals claimed that uneven wall/floor in the housing unit failed frequently during supervision. Such kind of defects will have consequence especially during finishing work though it is the responsibility of residents. For example, uneven wall require gypsum work prior to painting which incur extra cost as reported from 80.4 percent of residents (45 out of 56) opinions. If we take the case of uneven floor finish, one has to remove screed surface which is a risk in affecting ribbed slab section besides cost. According to report from 75percent of respondents (42 out of 56) opinion floor related defect also cause dispute with neighbor during finishing as well as changing surface material. In addition to these, the esthetic value of the building decline before ageing.

Any defect on door or window frame/ knobs can be related to issues of security and seepage of rainwater concern from residents' side. Even though the carpentry and glazing works are subcontracted for micro scale enterprise and liable to rectify all necessary corrections during defect liability period, these issues also concern the client due to wide range of claims from residents regarding faulty door and window knobs after transfer. The above discussed construction defect types were also indicated in a study on federal buildings in Addis Ababa where defect on floor/ wall surface and faulty door/window units were shown in top five rank (Bedru M, 2015). The results are supported in Table 4.7 below.

Table 4.7 Common Types of Defects during Construction Stage

No	Types of building defect	Client		Consultant		Contractor		Weighted Average	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank
1	Surface cracks on ground floor	1.83	8	2.50	9	1.92	10	2.08	10
2	Cracking in external wall	2.25	9	2.83	8	2.28	9	2.45	8
3	Deformation/displacement of roof	2.08	10	2.22	10	2.56	8	2.29	9
4	Distortion/cracking of partition	2.42	7	3.17	5	2.80	7	2.79	7
5	Fracture /displacement of drains	3.08	3	3.28	3	2.96	6	3.11	4
6	Uneven floor /wall finishes	3.50	1	3.38	1	3.64	1	3.51	1
7	Broken floor/wall tiles	2.83	4	3.33	4	3.40	2	3.19	3
8	Faulty door/window frame, knobs	3.17	2	3.36	2	3.08	4	3.21	2
9	Faulty sanitary installation	2.83	5	3.17	6	3.07	5	3.03	5
10	Faulty electrical fittings	2.82	6	2.89	7	3.12	3	2.95	6

4.3.1.2 Tests for Agreements on Types of Building Defects among Stakeholders on the Construction Site

One of the purposes of this thesis is to investigate whether there is an agreement or not on the attitudes of stakeholders towards the common types of building defects in 20/80 condominium housing in Addis Ababa. Hence, in this section respondents' response will be tested for correlation using Spearman rank correlation coefficients, to see if there is difference in ranking between two groups of respondents; these are clients versus contractors; contractors versus consultants; and clients versus consultants, on the different variables of construction defect and their rate of occurrence. The purpose of a hypothesis test is to avoid being deceived by chance occurrences. The tests also helped to evaluate whether the consensus of opinions exists among respondents.

Table 4.8 Summary of Correlation Test on the Ranking of Common Types of Building Defects

Respondents	Rho (ρ) = $1 - \frac{6(\sum di^2)}{N(N^2-1)}$	A Critical value of r (Appendix B)
Client Vs Consultant	0.951	0.536
Client Vs Contractor	0.793	0.536
Consultant Vs Contractor	0.757	0.536

In this case, with a significance level of 95 percent ($P = 0.05$), the calculated value of ρ (rho) for all the three group cases is greater than the critical values of r , so it can be concluded that there is a strong correlation between the attitudes of respondents. This indicates that the majority of the respondents agreed on common building defect types severe on 20/80 condominiums houses.

4.3.2 Major Types of Building Defect Observed on Resident Houses

20/80 condominium house's residents were asked to identify the type of defect that most frequently occurred in their homes according to the scales provided. The mean score and rank of a total of 24 defects which become visible after construction are listed in Table 4.9. Most of the respondents agreed on service installation as first top defect type that encompasses water supply and sewer plumbing defect both related to system layout and installation with as well as defects on electric system in stallion(improper placing of electric meter ,faulty electrical fitting and distribution box)with mean value of 3.46.

Based on the analysis, (mean value, 3.24 and 3.20) defect on floor/ wall and faulty door/window (mean value 3.18) reported as second, third and the forth most type of defect respectively. Even though, defect observed during and post construction differ for different respondents, as some defects propagate in time whereas some might change their form. The above reported major defected as ranked by residents also supported by observation as presented in figure.

Table 4.9 Means Score and Rank of Common Types of Defects after Construction.

No	Type of Defect	MS	Rank
I	Floor defects		
	Uneven floor finishes, broken floor tiles, floor dampness, surface cracking of the ground floor	3.24	2
II	Wall defects		
	Cracking in external wall, internal staining, mold growth and fungal decay of the wall, distortion and cracking of partition wall, uneven wall finishes, broken wall tiles, dampness of concrete wall	3.20	3
III	Roof defects		
	Seepage of the roof covering, deformation or displacement of the roof truss, deterioration of the roof cover	3.13	5
IV	Door/window defects		
	Faulty door fixing, faulty window fixing, broken glasses	3.18	4
V	Defects on service installation		
	Failure of water line, failure of drainage system, faulty electrical fittings, failure of sewer line.	3.46	1

During observation most of the door and window defects were somehow corrected and not visible as the residents might adjust or change for security reason. By the same taken, the fact that electric installations are not visible it cannot be supported by photos. To support those defect observed on the resident palace, photos below were captured to show the extent of defects on some residential houses.

▪ **Leaking on different part of the building**

Figure 4.5 below shows, leakages have seen on roof ceiling and slabs. Leaking seen on the roof, ceiling mostly happened due to improper installation of roof cover, distortion of either the roof or off the wall at roof level, the ceiling rot may have been due to exposure to water leakage from above the roof cover. Whereas leaks on slabs it might be leaking pipe because of plumbing that is not installed properly, water penetration through external wall defects (such as cracks, joints), water penetration through defective external wall finishes (such as loosened mosaic tiles, cracked ceramic tiles).

Leakage from the bathroom or kitchen above usually caused by seepage from fittings, bathtubs, shower trays, buried pipes or drains due to improper construction of joints, installation of sealants or occurrence of cracks waterproof cement rendering underneath floor tiles for the floor above not installed/specified, or such waterproofing features damaged by installation of sockets or conduits malfunction of waterproofing in nearby external features such as balconies or external walls above. Besides that, the gutter of the roof also can cause the mold that will attach itself to the wall, therefore quality of workmanship is needed such as to maintain the roof or construction of the roof and besides that using of quality construction material will reduce those defects.

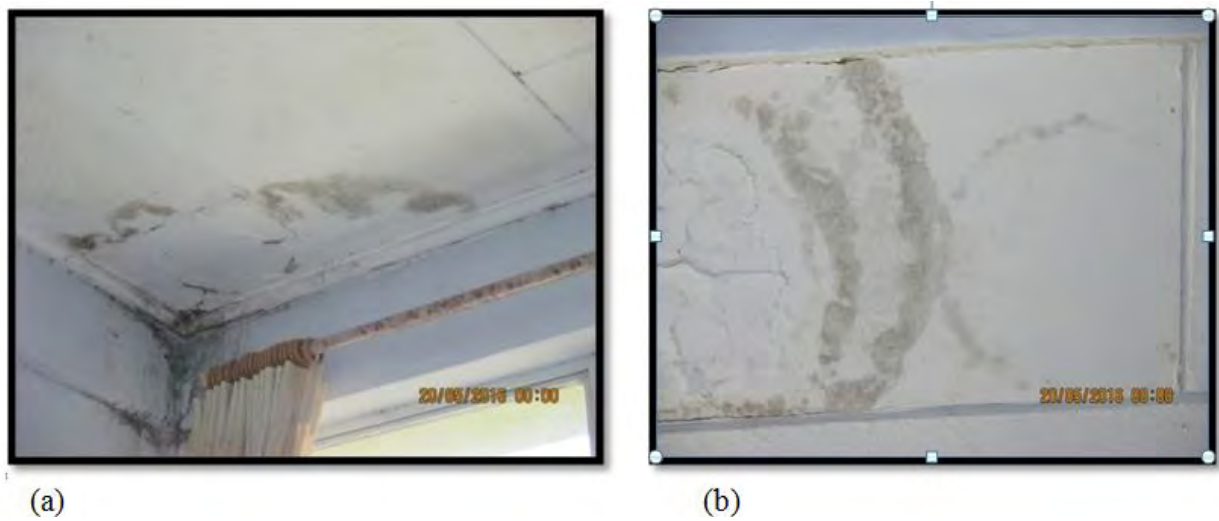


Figure 4.5 (a and b) Leaking on Roof Ceiling and Top Slab Respectively

▪ **Defects observed on Plaster/ rendering walls**

Mostly the defective plaster rendering occurs on the external walls, column and ceiling. Figure 4.6 shows the existence of vertical and horizontal cracks in rendering external walls and plaster internal well as diagonal cracks at 20/80 condominium resident house. According to the construction, defective plaster rendering is normally caused by loss of bond between coats, surface cracking, water damage, movement of structural, non suitable of renders and plasters, and other factors. Such type of defect categorized under non-structural defect, it will affect the appearance only and do not pose any safety concern. These problems happen mostly due to material quality, mix proportion as well as workmanship problem during construction.



Figure 4.6 (a and b) Diagonal as Well as Horizontal Crack Seen on Walls

- **Peeling paint**

There were many causes of peeling paint observed in condominiums house. This defect mainly observed on the internal part of plastered walls, slabs and areas which are exposed to water and great dampness on the corridors. Figure 4.7 shows below peeling paints both in external and internal walls. This might happen due to incorrect preparation of the surface, the paint used during construction is low quality and mixed with excessive amount of water. Therefore, it is very important to adopt good workmanship, use good quality of paint, apply waterproofing materials to the surfaces for those have exposed to wet.

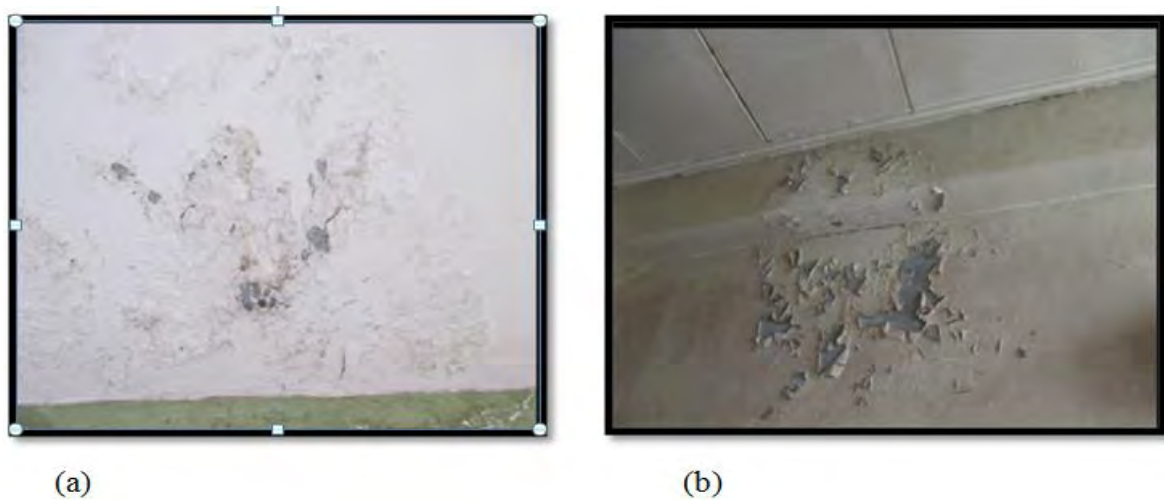


Figure 4.7 Peeling of Paints Seen in the Shower and Kitchen Room Respectively

▪ **Dampness**

Figure 4.8 shows below slab as well as internal walls have been wetted. The water can enter the building bit by bit through different routes resulting in dampness. This may happen due to Water leakage through slabs and walls by the plumbing that is not installed properly, some time water leakage also comes from the toilet, absence of using water proofing materials like applying of water proof on watery areas. The other factor such as leaking gutters or down pipes, defective drains, burst plumbing, and condensation due to inadequate ventilation also can be the factors yielding. The gutter of the roof also can cause the mold that will attach itself to the wall. Using of proper material as well as good workmanship will reduce these problems.



Figure 4.8 Damped wall/slab Surface

▪ **Defective Tile and Flooring**

Such type of defect was noticed at many residential houses, where floor finish is ceramic floor tile. The defect was a breakdown of ceramic floor tile after getting loose. This problem was observed in the area which experienced relatively at corridors this defect was attributed by the poor lining of tiles as a result of the defective method of construction. Similar problem was observed at toilet wall finish there the ceramic tiles become loose and then fallen down. Screed thickness depends on the type of screed to be laid, and must be sufficient for the type of flooring to be installed and the type/intensity of traffic acting on it when in service. The

screed must be compacted and homogeneous on the surface and through the whole thickness. The presence of layers or areas of crumbly, lower consistency is a sign of poor mechanical characteristics which could cause breakage or detachment of the flooring. Figure 4.9 is building defect visible on the shower room floor and wall tiles; it may happen due to poor material quality, workman problem and /or absence of maintenance.



Figure 4.9 Bulged and Cracked Floor /wall Tile

4.3.3 Major Types of Building Defect Observed by the Case study

The case study on a total of 94 households from two blocks G+7 and G+4 presented in Table 4.10 below five categories and supported by figures in subsequent section. Defect on door and windows were the first residents concern from questionnaire analysis. During case study a total of 117 different defects were recorded under door and window and 35 of them were on door lock. Budged window sills as well as distorted frames were recorded 53 out of 117. Defect on door and window were the most frequently reported type of defect by residents. These results were also indicated on the response of residents during survey. This particularly raised related to defective door locks and broken window and door glasses which were cause for insecurity to residents. A considerable figure about 11 m² areas observed loosens or broken terrazzo tiles in the corridors on both blocks. These problems were also observed on bathroom walls and floor ceramic with a total area of 33m². The challenge in such type of defect is that there is a probability of affecting slab which is roof for lower floor and cause leakage. Defect in various service installations related to uncovered system units were recorded that include

junction box at various level and sewer including storm drain as well as sanitary sewer. In addition to this, broken drainage lines observed.

Table 4.10 Major Construction Defects Observed in Case Study Blocks*

Observed Defect		Block 59 (G+7)	Block 178 (G+4)	Total
I	Defective Floor Finishing			
1	Broken / loose terrazzo tiles in corridors	5.8m ²	5.4m ²	11.2m ²
2	Broken/loose ceramic tiles in bathroom	14.22m ²	18.9m ²	33m ²
3	Broken riser of the stairs	11 risers	7 risers	18 risers
4	Broken thread on the stairs	13 threads	10 threads	23 threads
5	Surface cracks in floors/slab	32 rooms	20 rooms	57 rooms
5	Uneven floor finish	32	15	47
II	Defects On Wall			
6	Openings seen on the top beam and roof	5	4	9
7	Surface cracks in walls	32	15	47
8	Peeling off of paint of external wall	Most external wall	Most external wall	Most external wall
9	Uneven and different painting		All external walls	-
10	Uneven wall finish	32	15	47
11	Exposed steel reinforcements	-	long column, beam	-
III	Defect door and window fixings			
12	Imbalanced window frame finish	20	10	30
13	Broken of window sill	14	9	23
14	Defective door lock	26	9	35
15	Broken window/door glass	19	10	29
IV	Water leakage			
16	Leakage form water pipes or valves	15	6	21
17	Leakage of the roof, roof fishing	7	4	11
18	Fracture and displacement of drains	Most down pipes	Most down pipes	Most down pipes
V	Defects in electrical installation			
19	Uncovered main junction box location	Main box=1, Individual =14	Individual =9	Main box=1, Individual =23
20	Exposed wiring	Along the building	Along the building	Along the building

▪ **Defects in Door and window Fixings**

Common defects that have seen on windows and doors of the case study blocks were :- Cracking at junctions, Bulging (gaps occurring between finishes and parent, wall) or peeling-off of finishes, absence of window ceiling, absence of windows, absence of doors , rusting of

metal parts, water seepage through the features, broken keys, broken window glass .All the above type of defect was observed at many rooms, this is happening may be due to beams and joists not being correctly sized or assembled, improper fillings around frames, deformation of frame, defective gasket, sealant or putty for window glass setting.

Figure 4.10 (a, b) shows below that major windows and door defects observed respectively. Improper filings around windows and door frames are also caused due to bad workmanship. Since there are various types of subcontractor involving, the main contractor is difficult to inspect, supervise and control the works that have been done by the subcontractors. These problems can easily be avoided by monitoring the works closely and enhancing technical kills of the labor and providing good working condition. Good management also helps in controlling workmanship errors, hence, avoiding defects caused due to bad workmanship.



(a) Distorted window frame



(b) Tilt, improper filings around window frames



(a) Slanted and poor door fixing



(b) Broken door handle

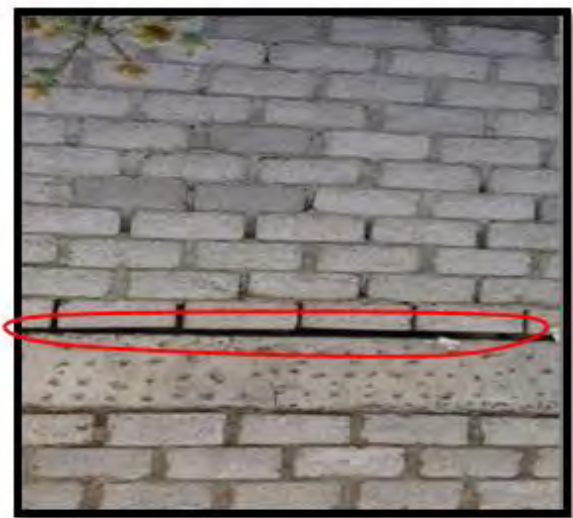
Figure 4.10 (a&b) Defects on Door/Window Frames, Handles

▪ **Defects in column, beam and HCB walls**

Concrete cover for reinforcement is required to protect the rebar against corrosion and to provide resistance against fire. The thickness of cover depends on environmental. Figure 4. 11 (a) below, slipping of the concrete cover may also occur due to the corroded steel making the concrete structure more susceptible to carbonation, seriously affecting the strength of the material. Similarly, figure (b) shows that columns as well as beam have been chiseled and HCB blocks are lying less providing of mortar. When concrete structures have been chiseled, the stirrups may have been detached and defect will occur. Besides that material wastage will be significant as well as time. Causes for the above defect will be poor workmanship, material deficiency, and poor quality of formwork. Defects caused due to bad workmanship should be controlled as they can easily be avoided. Hence, problems significant for workers who have low technical skills such as in concrete production mixture segregation leading to low concrete quality/strength, loose tie of reinforcement bars causing misplacement of the bars leading to over stressing of the structure.



(a) Spill of the concrete cover



(b) Lesser mortar usage in HCB laying

Figure 4.11 (a&b) Defects in Column, Beam and HCB Walls

▪ **Defects in wall and floor finishing**

The use of standard materials helps in reducing defects caused due to poorer building materials. For example, for well-proportioned mix ratio selection of aggregates that are hard, rough, mineral free and well graded maintains the required strength, density, porosity, workability and curing time of concrete for the intended purpose. Thus, problems such as cracks caused due to shrinkage and/or overstressing can be held within limits. Floor preparation involves steps that must be followed before any actual installation. Checking for flatness or securing loose wood subfloors are all key aspects making sure the subfloor is in sound condition before it is covered with any new final floor.

Figure 4.12 (a, b, c, d) shows below that poor floor finishing observed at all case study blocks. Where floor finish along the corridor is a terrazzo floor tile, it was laid on floor surface which haven't prepared well and also the tiles were broken down and detached on the floor. It might be using of mortar for screed will have material quality problem/poor workmanship. Uneven and multidimensional cracking observed on floor slabs were some of the defects identified on it. While bulging of external walls, cracking of internal/external walls, broken Agro stone were defects on wall finishing.



(a) Broken terrazzo tiles



(b) Loosen terrazzo tiles



(c) Reworking on floor finish



(d) Cracks seen at floor slabs

Figure 4.12 (a,b,c&d) Defects in Floor Finishing



(a) Bulged external wall



(b) plastered to fill opening along walls

Figure 4.13 (a&b) Defects on Wall

▪ **Improper placing and broken water pipeline**

Water leaks and broken pipes were a big problem for both buildings. Figure 4.14 (a , b) shows that water pipe lines are not fixed at suitable and proper level, even they are not covered with floor tile. Besides that water pipe lines are broken, it might be because of poor communication among stakeholders, poor construction management and weak supervision. Pipeline fitting problem, defective or missing water meter, leakage in the system were also one of the defect which issued by the residents. Poor workmanship, inadequate design of water pressure line can lead to the above problem. These problems can easily be avoided by monitoring the works closely and enhancing technical skills of the labor and providing good working condition.



(a) Improper placing of water line



(b) Broken water pipeline

Figure 4.14 Defects on Installation of Pipe

▪ **Defects observed in the sewer and drainage system**

Coming-out water from gutters, down pipes in the building area were observed in both case studies, leaking, mostly happened due to improper installation of piping system that can cause water penetration through external wall defects such as cracks, movement of external wall components, peeling paint surface. Similarly broken sewer line, uncovered manhole and openings of floor slabs which sewer lines placed where the most problems happening in the buildings. The use of inferior building materials can cause significant problems such as down pipes that fail to perform even when properly installed; workers may have a low level of experience, will yield to defect such as roof leakage and sagging. On the other hand, design defect may lead to problems in the building such as pipes or drains which have insufficient diameter of drains, bends being too sharp, etc. Can lead to excessive pressure built up in the pipes causing failure. Figure 4.15 shows below are defect observed on sewerage line and drainage line of case study buildings.



(a) uncovered floor slab along with the pipeline



(b) leakage due to broken Sanitary sewer



(c) Broken down pipe at the junction

(d) Uncovered Manhole

Figure 4.15 (a,b,c&d) Defects Observed the Sewer and Drainage System

▪ **Defects observed on the electric line**

All electrical systems have the potential to cause harm. It is important that any electrical installation work is carried out only by people who are competent. This means people who have the knowledge, skills and experience needed to avoid dangers to themselves and others that electricity can create. Figure 4.16 (a) and (b) shows below main electric lines were not covered with books. The electrical wires need to put in a box or something that can protect the material inside the meter unit, but it hasn't fixed in good manner, similarly even the box is make contact with to the surface and it is exposed to corrosion respectively. All the above causes might be poor workmanship during installation, poor controlling and supervision have significant for such type of defective.



(a) Inadequate protection of electric line



(b) Electric boxes have been corroded



(c) Inappropriate electrical box fixing



(d) Exposed electrical wire on floor area

Figure 4.16(a,b,c&d) Defects on Installation of Electric Line

4.4 Causes of Building Defects in 20/80 Condominiums through Questioner

In this section response of engineers from client, contractor and supervisor side on causes of condo defect during construction presented by supporting with figures from case study. Hence, in this part of the analysis different causes for the top three defect types reported by them in section 4.3 above.

I) Causes for Uneven Floor Finishes

Uneven floor finish were the usual type of defect in 20/80 condo sites as reported by professional. Table 4.11 below shows that 38.2 percent for causes for uneven floor finish was

subsurface deficiency and poor workmanship. The next frequent cause is poor workmanship & poor quality material and accounts 30.9 percent of the total. Also the respondents replied that Poor workmanship is the 3rd most causes for uneven floor finish which burr 16.4 percent. We can articulate that poor workmanship is the most serious causes for uneven floor finish. The result is suggestive of the need of industry to focus on its quality of workmanship. One of the major causes of construction defect of federal buildings in Addis Ababa were poor workmanship (Bedru, 2015).

Table 4.11 Response for Causes of Uneven Floor Finish

Causes	Client	Consultant	Contractor	Number	Percentage
Subsurface deficiencies	1	0	4	5	9.1
Poor workmanship	1	5	3	9	16.4
Poor quality material	0	0	1	1	1.8
Subsurface deficiency & poor workmanship	4	7	10	21	38.2
Subsurface deficiency & Poor quality material	1	1	0	2	3.6
Poor workmanship & Poor quality material	5	5	7	17	30.9
Total	12	18	25	55	100

II) Causes for uneven wall Finishes

According to the respondents the 2nd defect that occurs most often in 20/80 condominium construction is uneven wall. Table 4.12 below shows that client, consultant and contractor consent that the major reason for uneven wall is poor workmanship which consists of 65.5 percent of the total. The next frequent cause is poor workmanship and poor quality material which accounts 32.7 percent. Implementing training and education of labors pursue strict supervision, generating proper communication between the parties and also using of suitable construction management before and during construction phases can minimize workmanship problem.

Table 4.12 Response for Causes of Uneven Wall

Causes	Client	Consultant	Contractor	Number	Percentage
Poor workmanship	9	14	13	36	65.5
Poor quality Material	0	0	1	1	1.8
Poor workmanship & Poor quality material	3	4	11	18	32.7
Total	12	18	25	55	100

III) Causes for faulty door/window defects

Further, faulty door/window defect is select as the third defect. As shown in Table 4.13 below, Poor workmanship and Poor quality material together were ranked 1st having 49.1 percent. Poor workmanship, Poor quality material alone takes the 2nd and the 3rd ranks each 32.7 percent and 18.2 percent respectively. As argued above implementing training and education of labors, pursue strict supervision, generating Proper communication between parties involved, and also using of suitable construction management can minimize workmanship problems as well as poor quality material.

Table 4.13 Response for Cause of Faulty Door/Window Defects

Causes	Client	Consultant	Contractor	Number	Percentage(percent)
Poor workmanship	2	9	7	18	32.7
Poor quality material	2	2	6	10	18.2
Poor workmanship/Poor material	8	7	12	27	49.1
Total	12	18	25	55	100

The overall causes of defect from client, consultant and contractor point of view as shown Figure 4.17 below that the client agrees that 51.33 percent of construction defect were caused by poor workmanship, 27.75 percent because of defective material and the remaining 10.65 percent and 10.27 percent of construction defect were caused by design problem and subsurface deficiencies respectively. And consultants agree that 53.47 percent of construction defects were caused by poor workmanship, 25.96 percent because of defective material, whereas 11.83 percent and 8.74 percent of construction defect were caused by design problem and subsurface deficiencies respectively. On the other hand contractors also thought that

51.27 percent of construction defects were caused by poor workmanship, 29.71 percent because of poor quality of material and 10.51 percent and 8.51 percent of construction defect were caused by design problem and subsurface deficiencies respectively. The overall analyses show that 52.02 percent of construction defects were caused by poor workmanship, 27.80 percent were because of defective material and the remaining 10.99 percent and 9.71 percent of construction defects were caused by design problem and subsurface deficiencies respectively.

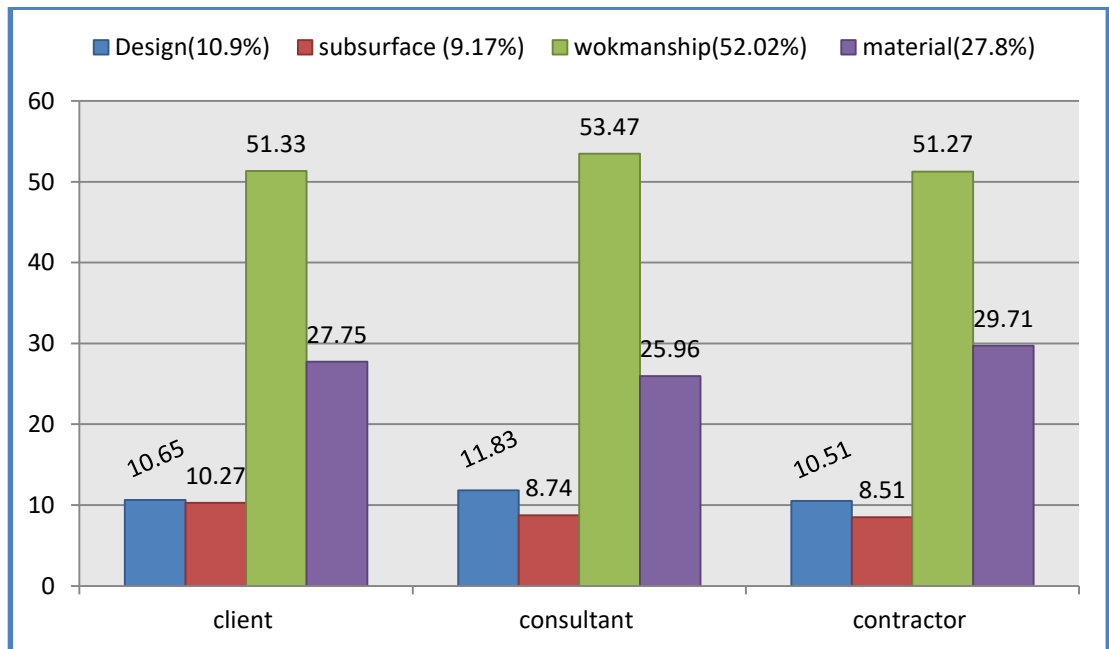


Figure 4.17 Overall Causes of Defect from Client, Consultant & Contractor Point of View

4.5 Causes of Building Defects in 20/80 Condominiums through the Case Study

Table 4.14 below shows that 69.2 percent of the defects were attributed by poor workmanship. An improvement on offering of contract prices to the contractors, contractors capable to hired workers who have better skill because the contractor awarding system in 20/80 condominium construction are fixed price, giving regular on-the-job training programs for operatives and site staff, carried out daily supervision by the contractors or subcontractors might have a reduced workmanship problem and the remedy work can be executed

immediately. 23.1 percent of the defects were caused by defective material and the remaining 7.7 percent of the defects were attributed by design error.

Table 4. 14 List of Construction Defects, Symptoms and Main Causes on Case Study

Block	Observed defect	Symptoms	Possible causes
Block 59 & 178	Broken / loose tiles in corridors /stairs and toilet	Leaving and broke down of terrazzo/ceramic tiles	Poor workmanship/ Defective material
	Surface cracks in floors/slab	Multi-directional/shrinkage cracks in the floor	Poor workmanship
	Uneven floor finish	Come away of tiles, rough surface	Poor workmanship
	Openings on the top beam and roof	Opening on top of the beam/broken HCB wall	Poor workmanship
	Surface cracks in walls	Hairline cracks, Cracks between walls and structural elements	Poor workmanship
	Uneven and Peeling off of paint	The Paint becomes chalky and wrinkled.	Poor workmanship/ Defective material
	Uneven wall finish	Bulge and rough wall surface	Poor workmanship
	Doors/window not closing properly,	Angled, not alien to the wall	Poor workmanship
	Poor window frame finish	Passing of wind, water seepage	Poor workmanship
	Broken window sill	Falling down window sill	Poor workmanship
	Defective door keys	Unable to open/close the key	Poor workmanship/ Defective material
	Broken window/door glass	Broken/absence of glass	Poor workmanship
	Leakage of the water supply pipes or valves	Water dripping at fixtures and lacking in slabs, wall, floor area	Poor workmanship/ Defective material/ design problem
	Leakage of the roof, roof fishing	Water drips at the roofs, rusting	Poor workmanship
	Improperly fitted drainage down pipe, Broken gutter	Water drips on walls, slack of fixings, Nonfunctional gutter	Poor workmanship defective material/ design problem
	Water seepage from slabs, walls	Dumped the area and deteriorate the surface, Peeling off of paint	Poor workmanship/ Defective material
	Uncovered junction box location	Uncovered junction box	Poor workmanship
Improper electrical conduit installation	Electric conduit installed in the hazardous place /not cover	Poor workmanship	

4.6 Factors Contributing to Poor Workmanship in 20/80 Condominiums

4.6.1 Tests for Agreements on towards the Factors Contributing to Poor Workmanship

In a similar way the correlation test is done, whether there is an agreement or not on the attitudes of the respondents towards the rate of occurrences of factors contributing to poor workmanship. The Spearman correlation coefficient (ρ) calculated value tabulated as shown below in Table 4.15

Table 4.15 Summary of Correlation Test on the Ranking of Causes of Poor Workmanship

Respondents	$\text{Rho } (\rho) = 1 - \frac{6(\sum di^2)}{N(N^2-1)}$	A Critical value of r (Appendix B)
Client Vs Consultant	0.847	0.648
Client Vs Contractor	0.986	0.648
Consultant Vs Contractor	0.972	0.648

In this case, with a significance level of 95percent ($P = 0.05$), the calculated value of ρ (rho) for all the three group cases is greater than the critical values of ρ , so there is an agreement between the respondents. Thus, the responses of both groups of respondents were combined for the descriptive analysis. In this study the factors with mean score value of 3.0 and above indicate that they have significant effects on poor workmanship thus they consider causing factors.

4.6.2 Respondent's Response to the Factors Contributing to Poor Workmanship

Table 4.16 below indicates the ranking of each factor's priority based on mean readings of the contributing factors of poor workmanship. From this data, it was found that Lack of skills and experience were the most important factor contributing to poor workmanship (mean value 4.26). Most contractors working in the construction of condominium houses are beginners with low levels of construction skills and capacity to discharge their duties. The contract prices of those contractors are fixed; they are forced to hire low skilled laborers with low price to get better profit.

Similarly, most of the site work and finishing works are subcontracted for SMEs with the objective of creating job opportunities to the urban poor, SMEs are assigned without

qualification and proper on-the-job training. The cumulative effects of these are manifested by poor workmanship on the buildings. UN Habitat (2010), construction quality has been affected by micro and small enterprises who seek more and more profit by using cheaper substandard fixtures. According to AAHCPO's Communications Head Ato Kassa Woldesenbet, "The projects are given to small & micro enterprises (SMEs) and they, no doubt, have some limitations in doing these jobs, as is the case with many of our country's construction workers. We do not expect perfect works, but we train our workers to have better capacity before and after they are contracted to do the job." (Fortune News Letter, Wednesday, October 08, 2014).

Poor project management as well as the complicated role of subcontractor, ranked second and third ranked (mean value 4.21 and 3.62) respectively. The ability of management on a construction site is the primary cause that affects laborers' daily productivity (Chan, P et.al. 2006). In fact, poor supervision contributes to poor workmanship and it can be seen in many instances on such Jobsites. However, Poor weather condition was rated as the factor having the least effect on poor workmanship.

Table 4.16 Mean Score and Ranking of Causes of Poor Workmanship

No	Factors for Poor Workmanship	Client		Consultant		Contractor		Total	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank
1	Poor project management	4.42	2	3.89	4	4.32	1	4.21	2
2	Complicated role of subcontractor	3.83	3	3.72	5	3.32	5	3.62	3
3	Lack of skill & experience	4.58	1	4.06	2	4.15	2	4.26	1
4	Language barrier to communication	2.00	8	2.06	9	1.80	8	1.95	8
5	Inappropriate construction equipment	2.00	7	3.72	6	2.56	6	2.76	6
6	Poor weather conditions	1.50	9	2.11	8	1.72	9	1.78	9
7	Inadequate time	2.17	6	2.67	7	2.08	7	2.30	7
8	Restricted budget	2.83	4	4.00	3	3.92	3	3.58	4
9	Unsuitable materials used	2.75	5	4.11	1	3.68	4	3.51	5

4.7 Measure to Minimize Building Defects due to Poor Workmanship in 20/80 Condominiums

There were several possible measures that can be implemented in order to overcome the issue of poor quality workmanship in the construction of 20/80 condominium construction. For this purpose on the questionnaire part six possible measures are proposed survey undergone.

4.7.1 Tests for Agreements on towards the Measure to Minimize Building Defects due to Poor Workmanship

The responses of the respondents on measures to minimize building defects due to poor workmanship compared, except for client and consultant the results showed a significant difference at the 5 percent significance level. Hence, the aggregate result of client and consultant presents while the result of the contractor was presented separately. In my opinion since the consultant works at 20/80 condominium housing is both designing and supervision, and also they are representative of the client, their idea will be much comparable to that of client.

Table 4.17 Ranking to Minimize Building Defects due to Poor Workmanship

No	Measures	Client		Consultant		Contractor	
		MS	Rank	MS	Rank	MS	Rank
1	Strict supervision	4.08	3	4.18	3	3.24	5
2	Training and education of labors	4.50	1	4.28	2	3.24	1
3	Proper communication among parties involved	4.07	4	3.89	5	3.76	4
4	Suitable construction management	4.17	2	4.33	1	4.36	2
5	Appropriate manpower management	4.00	5	4.00	4	4.04	3
6	Accurate and proper design	3.58	6	3.78	6	3.08	6

Table 4.18 Summary of Correlation Test to Minimize Building Defects due to Poor Workmanship

Respondents	$Rho (\rho) = 1 - \frac{(6 \sum di^2)}{N(N^2-1)}$	A Critical value of r (Appendix B)
Client Vs Consultant	0.887	0.886
Client Vs Contractor	0.771	0.886
Consultant Vs Contractor	0.771	0.886

From the aggregate result of client and consultant the highest ranking measure that can be used to overcome poor workmanship is strict supervision. Periodic and regular construction site supervision as very important measures daily supervision should be carried out by the contractors or subcontractors so that workmanship problems can be identified and a remedy can be executed immediately. When actively supervising construction, contractor supervisory staff (site supervisor) must have the knowledge, expertise, and capability to monitor and superintend the construction work efficiently. In contrast, accurate and proper design received the lowest ranking of the possible measures.

4.7.2 Respondent’s response for Measure to Minimize Poor Workmanship

Whereas, as we can see from Table 4.19 below contractors select that Suitable construction management and Training of labors was ranked first and second highest respectively. Many respondents agreed the capability of construction managers to manage, arrange and lead the work would affect the construction labor productivity. If a construction manager fails to lead and control the construction project, the quality problems may arise. Therefore, a proper construction management is very crucial for every construction project. Other possible measures that appropriate training and sufficient experience are necessary to increase the capability of construction site workers.

On the other hand, as shown Table 4.20 below Suitable construction management is ranked first by the consultant and client, and also the contractors ranked it second. This demonstrates that Suitable construction management is major to minimize the problem. While both ranked accurate and proper design is the list option, minimize building defects due to poor workmanship.

Table 4.19 Mean Score and Ranking of Client and Consultant Response on Measures to Minimize Poor Workmanship Problem

No	Measures	Client		Consultant		Total	
		MS	Rank	MS	Rank	MS	Rank
1	Strict supervision	4.08	3	4.18	3	4.13	3
2	Training and education of labors	4.50	1	4.28	2	4.39	2
3	Proper communication among parties involved	4.07	4	3.89	5	3.98	5
4	Suitable construction management	4.17	2	4.33	1	4.25	1
5	Appropriate manpower management	4.00	5	4.00	4	4.00	4
6	Accurate and proper design	3.58	6	3.78	6	3.68	6

Table 4.20 Mean Score and Ranking of Contractor's Response on Measures to Minimize Poor Workmanship Problem

No	Measures	Contractor	
		MS	Rank
1	Strict supervision	3.24	5
2	Training and education of labors	4.24	1
3	Proper communication among parties	3.76	4
4	Suitable construction management	4.36	2
5	Appropriate manpower management	4.04	3
6	Accurate and proper design	3.08	6

4.8 Impact of construction defects as of questionnaire survey

4.8.1 Respondent's Response Impact of Defect to the Construction Industry

Rework and delay have an impact on cost of construction and price of houses to be transferred to beneficiaries. As shown in Table 4.21 below, cost overrun is the major impacts of construction defect and which ranked 1st by the client and consultant side with a mean score

of 4.08 and 4.39 respectively. Consequently, occurrences of construction defects highly affect the construction project budget. Contractor consent of that by ranking construction cost overrun as the 2nd effects of construction defect with a mean score of 3.88.

As per the arrangement made with contractors“ poor workmanship and inferior quality outputs detected during construction time or before transfer to beneficiaries should be reworked and rectified by contractors or SMEs at their own expenses. This process delays delivery of housing units to beneficiaries which in turn results in a significant amount of financial loss. Client as well as consultant ranked project delay as next biggest impact with a mean score of 3.33 and 4.0 respectively, which was the first according to contractors and with a mean score 4.12. This shows the occurrence of construction defect highly affect project time. It causes the project to delay and then because of that, the client forced to aside additional budget for projects. This may cause disputes between contracting parties and the contractor rank disputes among parties 3rd with a mean score of 3.44 while client and consultant rank it 6th. This show unlike types of construction defects respondent shows some degree of agreement on effects of construction defects.

Both the client, consultant and the contractor’ ranked additional expense for residences as the last effects of construction defects with a mean score of 3.0, 3.16 and 2.46 respectively.

Table 4.21 Impact of Construction Defects from Client, Consultant and Contractor Point of View

No	Impact of construction defects	Client		Consultant		Contractor		Total	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank
1	Poor quality achievements	4.08	3	3.83	3	3.08	4	3.66	3
2	Project delay	3.33	2	4.00	2	4.12	1	3.81	2
3	Construction cost overruns	4.50	1	4.39	1	3.88	2	4.25	1
4	High maintenance cost	3.33	4	3.72	4	2.72	5	3.25	4
5	Dispute among parties	2.41	6	3.11	6	3.44	3	2.98	5
6	Additional expense for residences	3.00	5	3.16	5	2.46	6	2.87	6

4.8.2 Tests for Agreements on Towards the Impact of Construction Defects Due To Poor Workmanship

Similar to the above tests respondents' response tested for correlation using spearman rank correlation coefficient .so the respondents' response doesn't show significant difference towards Impact of construction defects due to Poor Workmanship. Table 4.22 shows that correlation test on impacts of defect due to poor workman ship.

Table 4.22 Summary of Correlation Test to Towards Impact of Construction Defects

Respondents	Rho (ρ) = $1 - \frac{6(\sum di^2)}{N(N^2-1)}$	A Critical value of r (Appendix B)
Client Vs Consultant	1	0.286
Client Vs Contractor	0.6	0.286
Consultant Vs Contractor	0.6	0.286

4.8.3 Impact of construction Defects from Case Study Discussions

Most of the time contractors fail to fulfill man power (key personnel) according to the amount specified in the contract agreement. So they execute the works of the project by assigning limited no of key personnel. These result in the overburden of works on limited professionals, skilled and unskilled laborers, which create negligence on the works of the project which need hard work, proper attentions and cares. The above issue also line up with inspection or follow up problems and negligence of consultant supervisors towards the structure of the staffs, monitoring and evaluation and sudden site visit with the owner.

The defect cost for a specific element of the building has been related to the production cost for the element during the observation period.. The cost of defects occurring during production is stated to be 2-6% of the cost of production and 20% of the defect cost originated in either workmanship or material delivery (Rhodes and Smallwood, 2002).

Considering the above data, the probable defect cost on average will be more than 535,362 ETB and 141,731ETB form the total project cost estimation for G+7 and G+4 buildings respectively. As well 107,065 ETB and 28,341 ETB of defect cost is due to poor workmanship. Hence, occurrences of construction defects highly affect construction project budget, 20/80 condominium housing project have facade problems on implementing the program. In addition occurrence of construction defect highly affect project time, it can causes the project to delay and then because of that the client forced to aside additional budget for projects, this may cause disputes between contracting parties.

Occurrence of construction defect reduces the value and functionality of projects and highly affects tenants and/or users comfort (Bedru,2015).Similarly the residents satisfaction are directly proportional to the number of defects found in construction at occupancy stage .These become burdensome and even though Addis Ababa housing development office are liable to rectify some of the visible defects in new homes, getting them to fix the problem could be challenging. The authors believe that no matter the stage at which home owners become involved in the residential building process, it is important that inspection and quality control be carried out on these buildings. Such practice will aid the overall quality process in residential buildings.

Even if it is difficult to identify defects cost specifically poor workmanship, Table 4.23 shows sample cost estimation incurred to reworks defective work on different items of works.

Table 4.23 Sample cost estimated to rework defects in the two case studies

Items are rework	Unit	Unit price	Average cost for rework				Total rework cost
			Case 1		Case 2		
			Quantity	Cost (Birr)	Quantity	Cost (Birr)	
1. BLOCK WORK (Class C, 200mm thick HCB)							
-Uncovered wall area b/n top beam and roof	m ²	133.07	15.2	2022.67	12.8	133.07	3725.96
2- FINISHING							
-Defect terrazzo tiles on corridors	m ²	192.11	5.8	1114.24	5.36	1018.18	2132.42
-Broken/loose shower, ceramic tile	m ²	203.71	3.56	725.22	4.72	961.51	1686.73
Broken stair riser	ml	89.29	13.75	1227.74	8.75	781.29	2009.03
Broken stair thread	ml	139.62	16.25	2268.83	13.25	1849.97	4118.80
3.GLAZING							
-Broken window glass	m ²	249.31	8.1	2019.41	10.44	2602.79	4622.2
-Broken door glass	m ²	280.0	0.9	252	2.7	680.4	932.4
Total				7607.44	7894.14	19227.5	

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The objectives of the research had been achieved based on the literature review from articles, journals and books; findings from questionnaire survey; and case study results. This study addresses a gap around workmanship, quality for achievement level of new 20/80 condominium housing in Ethiopia context. The study adds data to existing literature, with respect to current condominium housing performance in the housing sector. This chapter has three sections; the first section presents stand on the result of the analysis the conclusions have been unwearied, the second section outlines a list of recommendations that could facilitate to improve workmanship, quality in the condominium housing sector, the last section outlines suggestion of area for further research that could extend the current study.

5.2 Conclusions

In this study the following major conclusion were drawn based on findings in line with each specific objective.

Uneven floor and wall finish were the major type of defect occurred during construction of 20/80 condominium as per technical staffs from client, contractor and consultant point of view. The other defects were related to faulty doors and window frame and accessories like knob and lock. Defect on service installation that include water supply line, drainage line (sewer and down pipe) and electric line got prior attention in post construction assessment by dwellers even though professional put in third place.

Poor workmanship is one of the major factors that lead to building defects and failures problems. Usually residential buildings are the one which experienced most of the defects or failures problems due to poor workmanship. Form questioner survey senior officer of the client, project manager and resident engineer from contractor and consultant side respectively reported poor workmanship as a major cause over poor quality material usage. Poor workmanship on plastering and rendering, block work and metal work was pointed out. There

were materials used in the construction having poor quality for example sand, gravel, and metal and accessories for door and window.

Three major factors responsible for poor workmanship in condominium building were identified. The first one was lack of skill and experiences of workers directly engaged in different parts of the project work were found linked with cost effective nature of the current housing program. The second factor was poor project management scheme among client, contractor and consultant. Micro scale enterprises engaged in most of finishing and installation work besides manufacturing prefabricated wall and door and window units.

Poor workmanship led to project cost overrun for all entities participating in project management. There were cases client has to handle rectifying defects after the houses transferred usually with extra cost when the contractor not willing. Project delay was other impact again for all parties however; it was very challenging to contractors and consultants as it affects performance and carrier.

5.3 Recommendations

The following intervention areas identified and recommended in order to alleviate workmanship problems which lead to building defects in the construction of 20/80 condominium building Based on the findings of this study.

- Improvements on all project management phases need to be done by the client including amending the existing contractual document like specification and guidelines with the nature of condominium projects and current problems seen regarding building defects.
- Different capacity building programs like trainings and workshops has to be designed on regular basis for micro scale enterprises, semi skilled and unskilled employees of contractors by Addis Ababa housing development office and contractors in order to minimize workmanship problem in the 20/80 condominium houses.

- Right from the planning stage to the completion of a project, the client is recommended to have continual program evaluation for timely corrective measure throughout the project duration with respective government body.
- Construction supervisors on the site should be aware that they have shared on improving the causes of construction defects and many complaints arise when the owners hand over the houses. So, they should follow strict supervision during construction.
- Since the incidence of building defects affects all the parties in the construction, shall have continuous communication in order to improve the problem.

5.4 Recommendation for Further Studies

This study identifies areas requiring further studies. These potential areas of investigating are highlighted in the paragraphs:

- Additional studies should be done more on causes of condominium building defect related to material quality test in different phases of the project like purchasing and handling at project site etc.
- The current cost effective approaches followed in condominium project and possible linkage with the existing defect need to be investigated.

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ANNEXE

ANNEX A1

QUESTIONNAIRE

FOR 20/80 CONDOMINIUM CONSTRUCTION PROJECT STAKEHOLDERS

**Assessment of Building Defects Due to Poor Workman Ship in Addis
Ababa20/80 Condominium Housing Construction Sites**

Dear respondent, this questionnaire prepared to obtain necessary data for the partial fulfillment of an MSc thesis in Construction Technology and Management at Addis Ababa University. The objective of this thesis is to assess building defects due to poor workmanship on 20/80 condominium housing construction sites. Therefore, the information you are going to give will help me to assess the impact of poor work man ship on condominium building and suggest possible solutions. In this respect, you are the one who can give the correct information; 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.

YEBICHAYE DIRES

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

Thank you in advance for your valuable cooperation!!

Part One: General Information

1. Type of organization

Client

Consultant

Contractor

2. If your answer for question no. 1 is consultant and contractor please specify classification of your organization _____

3. Please specify your position on this site _____

4. Educational Background

Graduate (MSC)

Undergraduate (BSC)

Diploma,

if other, please specify _____

5. Years of experience in the construction industry

< 1 year

1 - 3 years

3 - 5 years

5 - 10 years

10 - 15 years

15 - 20 years

> 20 years

6. Years of experience in the condominium construction site

<1 year

1-3 years

3 - 5 years

5-8 years

8-10 years

>10

years

PART TWO: - Common Types of Building Defects Observed in Condominium Houses during construction phase

Below are the common types of building defects observed during construction phase? Please think the frequency of occurrence of the under listed defects on 20/80 condominium projects and rank on a scale of 1-5 by ticking (X or √) in the column representing your selection.

NO	Building Defects	Rate of occurrence					Causes of Defect			
		1	2	3	4	5	Design Problem	Subsurface Deficiencies	Poor Workmanship	Material Deficiencies
		Never Occur	Low rate of occurrence	Moderate rate of occurrence	High rate of occurrence	Very high rate of occurrence				
1	Surface cracking of ground floor									
2	Cracking in external wall									
3	Deformation or displacement of roof									
4	Distortion and cracking of partition									
5	Fracture and displacement of drains									
6	Uneven floor/ wall finishes									
7	Broken floor tiles									
8	Broken wall tile									
9	Faulty door /window knobs, handels									
10	Faulty sanitary installation									
11	Faulty electrical fittings									

Please specify if there are any other types of building defects in your 20/80 condominium construction site.

PART THREE: Factors Contributing to Poor Workmanship in 20/80 Condominium Houses.

Below are common factors which lead to poor workmanship in building construction projects which results in defects of building. Rank on a scale of 1-5 to what level these factors contributes to the generation of waste on your site by ticking (X or √) in the box representing your selection.

No	Factors	1	2	3	4	5
		Not a factor	Insignificant factor	Quite a factor	Significant factor	Major factor
1	Poor project management					
2	Complicated role of subcontractor					
3	Lack of experience					
4	Lack of skill					
5	Language barrier to communicate					
6	Inappropriate construction equipment					
7	Poor weather condition					
8	Inadequate time					
9	Restricted budget					
10	Unsuitable materials used					

Please specify if there are any other possible factors contributing to poor workmanship which leads to the formation of defects in your 20/80 condominium construction site.

PART FOUR: - Possible Measures to Minimize the Problem

Below are possible strategies that contribute to the minimization of defects in building construction projects. Please rank on a scale of 1-5 the level of contribution of these strategies for minimization of construction defects in 20/80 condominium construction sites by ticking (X or √) in the box representing your selection.

No	Common Types of Building Defects	1	2	3	4	5
		Very low contribution	Low contribution	Medium contribution	High contribution	Very high contribution
1	Strict supervision					
2	Training and education of labors					
3	Proper communication among parties involved					
4	Suitable construction management					
5	Appropriate manpower management					
6	Accurate and proper design					

Please specify if there are any other possible measures to minimize these defects in your 20/80 condominium construction site.

PART FIVE: Impact of Building defects in 20/80 Condominiums construction.

Below is Impact of defects in building construction projects. Please rank on a scale of 1th-5th level of regarding to the impact in 20/80 condominium construction sites by ticking (X or √) in the box representing your selection.

No	Impacts of defect	1	2	3	4	5
		Not impact	Insignificant impact	Quite impact	Significant impact	Major impact
1	Poor quality achievement					
2	Project delay					
3	Construction cost overrun					
4	High maintenance cost					
5	Disputes among parties					
6	Additional expense for residences					

Please specify if there is any other Impact of defects in your 20/80 condominium construction site.

Thank you for your cooperation!!

ክፍል ሁለት: በኮንዶሚኒየም ቤቶች ላይ የሚከተሉት የህንፃ አሰራር ግድፈቶች

የሚከተሉት ዓረፍተ ነገሮች በኮንዶሚኒየም ቤቶች ላይ የሚያታዩ የህንፃ አሰራር ግድፈቶችን ይመለከታሉ። እርሶም የተዘረዘሩት ዓረፍተ ነገሮችን መሰረት በማድረግ እርሶ በሚኖሩበት የጋራ መኖሪያ ቤቶች ላይ የሚያታዩ የህንፃ አሰራር ግድፈቶችን ከዚህ በታችከ 1 እስከ 5 ከተሰጡት አማራጮች ደረጃ በመስጠት የችግሩን መጠን ይግለጹ።

1= የለም 2= በጥቂቱ አለ 3=አለ 4= በጣም አለ 5= እጅግ በጣም አለ

ተ.ቁ.	የግንባታ ግድፈት	1	2	3	4	5
		የለም	በጥቂቱ አለ	አለ	በጣም አለ	እጅግ በጣም አለ
1	የመሰረት መዛባት፣ ወጣ ገባ ያለ ወለል					
2	የግድግዳ መሰነጣጠቅና ወጣ ገባ የሆነ ግድግዳ					
3	የግድግዳው የቀለም መቀየርና ሽጋታ ማሳየት					
4	የጣሪያ ወ.ሀ ልክ መዛባት, ማፍሰስ, የጣሪያው ልባስ መበላሸት					
5	የወለል ንጣፍ ችግር					
6	የወ.ሀ መስመር ቱቦዎች የአገጣጠም ችግር					
7	የፍላጎ መስመር ቱቦዎች የጥራት ችግር					
8	የፍላጎ መስመር ዝርጋታ ችግር					
9	የኤሌክትሪክ መስመር ዝርጋታ ችግር					
10	የበሮች /የመስኮቶች የአገጣጠም ችግር					

1. ከላይ ከተዘረዘሩት በተጨማሪ የሚገልፁት የህንፃ አሰራር ግድፈቶች ካሉ

ስለትብብርዎ ክልብ አመሰግናለዎ!!

ANNEX B 1

SECTION ONE: Checklist for types of construction defects and it causes to the case study. By ticking (X or √) on column of type of defect and its cause determines the frequency of the occurrence defects on the case study blocks.

Frequency of Type of Defect		Frequency for Causes of Defect			
		Design problem	Material deficiency	Poor workmanship	Subsurface deficiency
1.Foundation related defect					
	Settlement				
	Subsidence				
2.Defects on slab, wall, beam and column					
	Cracks >1.5mm on beam				
	Cracks >1.5mm on column				
	Cracks >1.5mm on wall				
	Cracks >1.5mm on wall slab				
	Cracks <1.5mm on beam				
	Cracks <1.5mm on column				
	Cracks <1.5mm on wall				
	Cracks <1.5mm on wall slab				
	Excessive deflection on beams and/or slabs				
	Spalling of concrete				

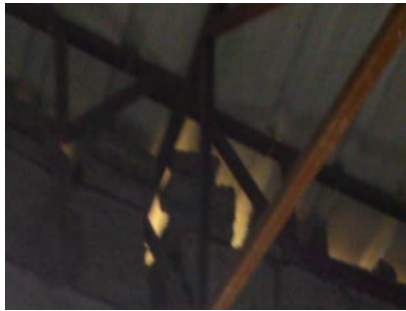
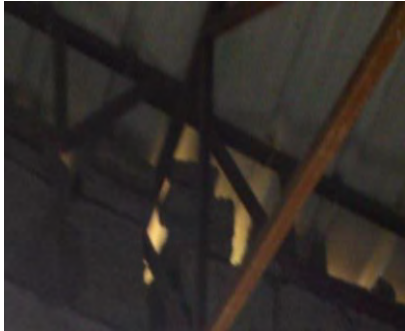


Dampness on concrete structures					
Exposed steel reinforcements					
3.Roof defect					
Improperly sloped gutters /down pipe					
Damaged or missing gutter/down pipe					
Seepage or leakage underside of roof					
Distortion of roof or wall at roof level					
Damaged roof trusses					
4. Defects on walls/floors finishing					
Broken or loose tiles on floors or wall					
Detachment of plastering					
Displacement of walls					
Water damage on walls or floors					
Unevenness floor finishing					
Unevenness wall finishing					
Peeling of painting					
Dampens on wall/ground floor					
Defects on stairs rise and width					
5 .Doors and windows defect					
Broken doors, hinges, latch/lock					
Broken window glazing, frames					
Water seepage through windows /doors					

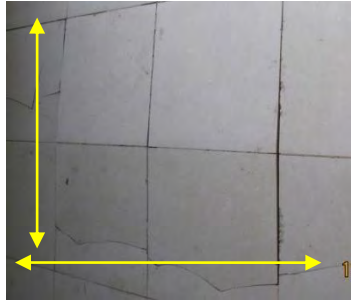
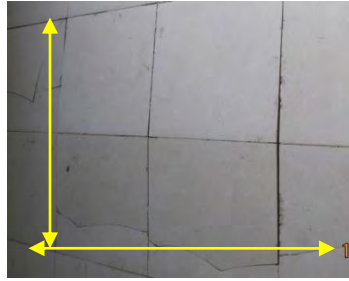


Gap between door/window edge & wall					
Broken /absence window sill					
Slanted window/door frames					
5.Service installation defects					
Signs of leaks or clogged drains					
Broken or leaking water supply fixtures					
Defects on kitchen fixtures					
Defective shower or water fixtures					
Inadequate pressure at fixtures					
Uncovered manhole					
Electric wires not properly protected					
Uncovered junction boxes					





ANNEX B 2



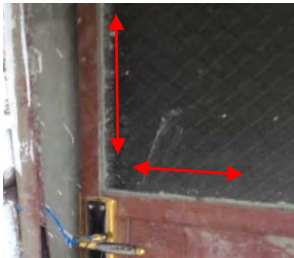

Resident Claim Reporting Sheet

Building Defects due to Poor Workmanship in Addis Ababa: A Case Study on 20/80
Condominium houses

TAKING OFF SHEET				ANNEX C-1			
TITLE :Items of work to be rework				TITLE :Items of work to be rework			
Tim	Dim	Squ	Description	Tim	Dim	Squ	Description
2/	L 0.2	2222	CASE STUDY 1(block 59) BLOCK WORK <u>Class C, 200mm thick HCB)</u> Openings seen on the top beam and roof A1=Area for longer side of wall 	2/	L W		CASE STUDY2 (block 178) BLOCK WORK <u>Class C, 200mm thick HCB)</u> Openings seen on the top beam and roof A1=Area for longer side of wall 
			L=Length of wall= W=height of HCB=0.2 Total area of rework for HCB 2.FINISHING <u>A=200x200x20mm Terrazzotile</u> <u>flooring</u> 				L=Length of wall= W=height of HCB=0.2 Total area of rework for HCB 2.FINISHING <u>A=200x200x20mm Terrazzotile flooring</u> 
145/	0.2 0.2		N=number of tile=145 N=145 Total area of Terrazzo floor tiling	134/	0.2 0.2		N=number of tile=145 N=145 Total area of Terrazzo floor tiling
		5.8				5.36	

TITLE :Items of work to be rework				TITLE :Items of work to be rework			
Tim	Dim	Squ	Description	Tim	Dim	Squ	Description
158/	0.15 0.15		CASE STUDY 1(block 59)	210/	0.15 0.15		CASE STUDY2 (block 178)
			<p>2.FINISHING</p> <p><u>B=150x150mmX6 mm ceramic</u></p>  <p>N=number of tile N=158</p>				<p>2.FINISHING</p> <p><u>B=150x150mmX6 mm ceramic)</u></p>  <p>N=number of tile N=210</p>
		3.56	Total area of ceramic wall tiling			4.73	Total area of ceramic wall tiling
		13.75	<p><u>C=Riser on stairs</u></p> <p><u>Fix 130X30mm thick pre-cast terrazzo Riser (1:3)</u></p> 			8.75	<p><u>C=Riser on stairs</u></p> <p><u>Fix 130X30mm thick pre-cast terrazzo Riser (1:3)</u></p> 
11/	1.25		<p>one pcs=1.25m length</p>	7/	1.25	8.75	<p><u>a</u></p> <p>-one pcs=1.25m length</p>
		13.75	Total length of riser				Total length of riser

TITLE :Items of work to be rework				TITLE :Items of work to be rework			
Tim	Dim	Squ	Description	Tim	Dim	Squ	Description
13/	1.25		<p>CASE STUDY 1(block 59)</p> <p>2.FINISHING D= Thread on stairs Fix 330X30mm thick thick pre-cast terrazzo thread (1:3)</p>  <p>one pcs=1.25m length Total length of thread</p>	10/	1.25		<p>CASE STUDY2 (block 178)</p> <p>2.FINISHING D= Thread on stairs Fix 330X30mm thick pre-cast terrazzo thread (1:3)</p>  <p>-one pcs=1.25m length Total length of thread</p>
		16.25	<p>3.GLAZING A=Fix 4mm thick clear glass glazed to Metal shower windows</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5</p>			12.25	<p>3.GLAZING A= Fix 4mm thick clear glass glazed to Metal shower windows</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5</p> <p>Area for shower window glass</p>
10/	0.5 0.5	2.5	Area for shower window glass	9/	0.5 0.5	2.25	Area for shower window glass

TITLE :Items of work to be rework				TITLE :Items of work to be rework			
Tim	Dim	Squ	Description	Tim	Dim	Squ	Description
2/		22	<p>CASE STUDY 1(block 59)</p> <p>3.GLAZING B=Fix 4mm thick clear glass glazed to PVC windows</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5 Area for glazed pvc window glass</p>	4/		22	<p>CASE STUDY2 (block 178)</p> <p>3.GLAZING B= Fix 4mm thick clear glass glazed to PVC windows</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5 Area for glazed pvc window glass</p>
			<p>Total Area for window glass</p> <p>C=Fix 4mm thick figureglazed to Metal doors</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5 Total Area for window glass</p>				<p>Total Area for window glass</p> <p>C=Fix 4mm thick figureglazed to Metal doors</p>  <p>A1=L1xW1 L1=length=0.5 W1=width=0.5 Total Area for window glass</p>
1/				3/			

BOQ		ANNEX C-2			
Item No	Description	Unit	Qty	Unit Rate	Amount
	1. BLOCK WORK				
1.00	Class C, 190mm thick HCB wall which can satisfy the designed strength , bedded in cement mortar (1:3).Price shall include mortar bedding.	M2	28.0	133.07	3725.96
	2.FINISHING				
2.00	200x200x20mm Terrazzo tile flooring bedded on and including cement sand mortar mix 1:3 and joints grouted in cement mortar. Price shall include 30mm thick cement mortar bedding.	M2	11.16	192.11	1027.95
3.00	Supply and fix 6 mm thick & 150x150mm white glazed ceramic wall tiles with cement mortar (1:2) backing with 5mm joints to be grouted with white cement.	M2	8.28	203.71	1686.72
4.00	Fix 130X30mm thick pre-cast terrazzo Riser (1:3)	ML	22.5	81.29	1829.03
5.00	Fix 330X30mm thick pre-cast Terrazzo Thread (1:3)	ML	30	139.62	4188.62
	3.GLAZING				
6.00	Fix 4mm thick clear glass glazed to PVC windows.	M2	3.7	249.31	933.40
7.00	Fix 4mm thick figured glazed to metal doors with putty. Price includes approved type putty.	M2	18.54	280	4622.20

Spearman's rank table

ANNEX D-1

Spearman's rank table

Sample size (n)	p = 0.05	p = 0.025	p = 0.01
4	1.0000	-	-
5	0.9000	1.0000	1.0000
6	0.2860	0.8857	0.9429
7	0.7143	0.7857	0.8929
8	0.6429	0.7381	0.8333
9	0.6000	0.7000	0.7833
10	0.5636	0.6485	0.7455
11	0.5364	0.6182	0.7091
12	0.5035	0.5874	0.6783
13	0.4825	0.5604	0.6484
14	0.4637	0.5385	0.6264
15	0.4464	0.5214	0.6036
16	0.4294	0.5029	0.5824
17	0.4142	0.4877	0.5662
18	0.4014	0.4716	0.5501
19	0.3912	0.4596	0.5351
20	0.3805	0.4466	0.5218
21	0.3701	0.4364	0.5091
22	0.3608	0.4252	0.4975
23	0.3528	0.4160	0.4862
24	0.3443	0.4070	0.4757
25	0.3369	0.3977	0.4662
26	0.3306	0.3901	0.4571
27	0.3242	0.3828	0.4487
28	0.3180	0.3755	0.4401
29	0.3118	0.3685	0.4325
30	0.3063	0.3624	0.4251
40	0.2640	0.3128	0.3681
50	0.2353	0.2791	0.3293
60	0.2144	0.2545	0.3005
70	0.1982	0.2354	0.2782
80	0.1852	0.2201	0.2602
90	0.1745	0.2074	0.2453
100	0.1654	0.1967	0.2327

Sample size selection

ANNEX D-2

A) Study population data on 20/80 condominium housing under construction

No	Project name	Number of blocks	Number of houses	Construction starts	Project duration (month)	Construction progress in %
1	Basa welde chlot	22	583	2012	36	100
2	Bole Bulbula	151	5002	2012	36	100
3	Bole Arabsa	675	20072	2012	36	100
4	Bole Ayate	71	1805	2012	36	100
5	Bole Semit	59	1635	2010/2012	36	100
6	Dgenet	28	704	2012	36	100
7	Gelan	213	5350	2010/2012	36	100
8	Genet menafesha	47	1335	2012	36	100
9	Gomo	33	714	2010/2012	36	100
10	Kara kore	71	1969	2012	36	100
11	Kuyu fichu	416	10028	2012	36	100
12	Kilinto	289	7295	2012	36	100
13	Lideta	4	378	2012	36	100
14	Tuli dimtu	408	10726	2012	36	100
15	Yeka Hayat and Yeka Bado	1507	25205	2010/2012		90

Source (Addis Ababa Housing Construction Project Office)

B..Condominium Houses which Transferred to the Dwellers of Yeka Sub City.

No	Site	Year(E.C)		Number of Houses
		Construction Started	Transfer to Residents	
1	Eyesus I	1996	2000	138
2	Eyesus I	1997	2001	150
3	Yeka Signal	1997	2001	96
4	Yeka I	1997	2001	240
5	Yeka I	1997	2001	1580
6	Enderase	1997	2001	88
7	Adewa Brige	1997	2001	190
8	Mirt Zer	1997	2001	60
9	Biruhi Tesfa I	1997	2001	220
10	Biruhi Tesfa I	1997	2001	90
11	Yeka Michel I	1996	2000	120
12	Yeka Michel 2	1997	2001	70
13	Kotebe	1997	2001	266
14	Turist	1997	2001	296
15	Kara Alo	1999	2003	180
16	Yeka Ayat 1	2000	2004	508
17	Yeka Ayat 2	2002	2006	9230
18	Yeka Ayat 3	2004	2007	536

C. Types of Defect Claimed by the Residents during Hand Over

NO	Type of Defect	Claim frequency	Solved	Unsolved
1	Gaps around window/door frames	124	57	67
2	Surface crakes on floors/slabs	155	31	124
3	Uneven internal and partition wall	134	-	134
4	Uneven external wall	89	-	89
5	Broken Agro stone wall	23	8	15
6	Broken floor tile	122	69	53
7	Broken wall tile	81	34	47
8	Surface cracks on walls	121	20	101
9	Broken /loosen door keys	135	110	25
10	Openings seen on the top beam and roof	62	34	28
11	Seepage through window, roof, wall	56	25	31
12	Leakage from sewer line	24	9	15
13	Improper electrical conduit installation	107	41	66
14	Detached, broken drainage down pipe	78	23	55
15	Uncovered junction box location	113	58	55
16	Broken window/door glass	56	24	28
17	Broken window/door frame	18	8	10
Total		1498	551	947