



Addis Ababa University

Addis Ababa Institute of Technology

Study of Construction Defects in Public Building Projects in Addis Ababa

(A Case study of Federal Government Office Building Projects)

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Declaration

I declare that this thesis entitled **“A Study of Construction Defects in Public Building Projects; A Case Study of Federal Government Office Building Projects in Addis Ababa”** is my original work. This thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree, and that all sources of material used for the thesis have been duly acknowledged.

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Abstract

Construction defect is a shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, materials, services or other facilities of the affected building. Most construction defects are avoidable; they occur, in general, not through a lack of basic knowledge but by non-application or misapplication of it. Occurrence of construction defect can decrease and affect the value of the buildings. A number of buildings in Addis Ababa are suffering construction defects. Therefore, this research tried to investigate the most frequent types of construction defects in Federal Government Office Building Projects in Addis Ababa next to that possible causes of construction defects were addressed. At the end effects of construction defects and defect reducing measures were investigated.

Questionnaire surveys together with case study were used to collect data on construction defect parameters. A total of 30 questionnaires from client & end users, consultants and contractors were collected and a case study of 7 building construction projects in Addis Ababa was investigated. From the results it was found a total of 55 types of construction defect and 4 common causes of construction defects were recorded. The first three most frequent types of construction defects were; broken or loose tiles on floors or wall; water seepage from external wall, roof, or from ceiling; broken or leaking sanitary fixtures. Similarly the results showed that the most common cause of construction defect was poor workmanship. 58% of construction defect were attributed to poor workmanship. Defective material takes the next role by causing 20% of construction defects. Design error causes 15% of construction defects and the remaining defects were caused by poor subsurface investigation and improper usage of building.

This research recorded a total of 8 effects of construction defect and project delay ranked as the first effect of construction defects. The next effect was construction cost overrun. The analysis ranked high maintenance cost as the 3rd effects of construction defects. Also the research found a total of 13 construction defect reducing measure and among them periodic and regular construction site supervision was the most important measure to decrease occurrence of construction defect. The next important measure was implementing a comprehensive quality control mechanism. Concurrently coordinating all building systems, starting with the planning phase and continuing into the programming and implementation phases was the third important measures

Chapter One: Introduction

1.1. General

A construction defect is the shortcoming of the building, structure or components to be erected in a reasonably workman-like manner or to perform in the manner intended by the manufacturer or reasonably or expected by the buyer, which probably causes damage to the structure. Now a days construction defects become common and often arising or seen in the construction project, especially in the project which has poor management or supervision in the construction site. Construction defect can be known as a problem in the construction industry that could cause the value of a building decrease eventually. Those defects incur a big cost & it 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. The cost is calculated irrespective of who pays.

The causes of these construction defects are either because of poor design, or low quality workmanship, or because the building was not constructed according to the design, or because it has been subject to factors not allowed for in the design or poor supervision. These primary causes suspected to be the causes of construction defects in building projects of Addis Ababa and might also operate singly or in combination and result in defects indicated by changes in composition of materials; in the construction itself; in the size, shape or weight of materials; or simply in appearances.

Construction defect can decrease and affect the value of the buildings. Defects are developments in construction that reduces the project's value instead of adding to it. Other than reduces the project value, where the construction defect is apparent, it also can cause the project to delay which means not complete with in the period stated in the contract. Cost overrun can be known as one of the effect when the construction defects happen in the construction site. Construction defect will also affect society at large due to possible danger posed and result in direct and indirect cost in repairs, abnormally high maintenance dispute and possible loss of building.

Only few previous studies have been dedicated to finding out the genesis of these construction defects in construction projects. These studies have been identified with the building industry as well as general engineering practices. A major factor necessitating construction defects are

attributable to poor design, or low quality workmanship, or because the building was not constructed according to the design, or because it has been subject to factors not allowed for in the design or poor supervision.

It is difficult to get researches which were done on effects of construction defects on building construction projects in Addis Ababa. But from foreign researches the consequences of construction defects on building projects resulted into a substantial increment in amount of funding budgeted for construction works and are responsible most cases of inability to complete and hand over project works as agreed initially at the commencement of the work. Also, increment in the project cost and an extended duration of completion are the two main effects observed for defects by not forgetting its adverse effect on society at large due to possible danger posed, abnormally high maintenance dispute and possible loss of structure.

Sometimes there are issues of construction defects, tenants relate to the quality of building, on public building projects around Addis Ababa and it became headlines in newspaper and electronic media and majority of defects were latent. Even if it was given attentions on media, it occurs again and again on building projects of the city. This is may be because of no scientific research done on this issue so far, so it is wise to do scientific research in this area.

So, the focus of this research was to investigate different types of construction defects in general and causes & effects of construction defects in particular and finally providing procedures which can reduce their occurrence.

1.2. Statement of problem

Construction defect in construction project is inevitable in building projects of Addis Ababa. Construction defects can be arising due to inadequate design, poor workmanships in the construction and lack of maintenance. The defects that in the construction project can become worst due to the reason of invisible defect that not detected by the builder or the occupants. Construction defect might affect the appearance of the building, health and safety of the occupant, construction industry of a country, reputation and etc. Thus, this problem can make occupant unhappy eventually. Obviously, these defects are reasons for delay, claim, disputes and are responsible for a significant construction cost raise and are common in these projects. Report at Federal Government Office Building Project Office shows construction defect can cause up to 10% time overrun and 2% project cost overrun.

1.3. Objective of the study

The objectives of this research were;

- To assess the extent of construction defects in building projects
- To investigate types and causes of construction defects in Federal Government Office Building Projects in Addis Ababa
- To investigate effects of construction defects in Federal Government Office Building Projects in Addis Ababa, and
- To provide measures that can reduce construction defects in public building projects.

1.4. Importance of the study

This research will have benefits to prevent construction defects that will occur in building projects of Addis Ababa. Thus, this thesis studied type, causes, effects and the methods to reduce the construction defects. Besides that, this study can also enhance the knowledge of the builders or any participants involved in the construction in order to increase the quality of the buildings.

1.5. Scope of the study

This research investigated different types, causes, effects of construction defects in Public building projects and at the end tried to forward construction defect reducing measures in building projects. The research was conducted from September, 2014 – December, 2015. Samples were taken from Federal Government Office Building Projects in Addis Ababa. The nature of study used is questionnaire and case study.

1.6. Limitation of the study

The issue of construction defect is vast. Even, the case project requires studies that are more intensive than what is presented. The reluctance of some of the stakeholder to give information during interview and desk study, unavailability of written literatures in Ethiopian context, the limited time and finance for preparing this thesis have also great bearing in limiting the scope of this study. Even though the thesis is limited, it is believed that such diagnostic approach on the study of construction defect in building projects will contribute to reduce construction defect in building projects of the country.

Chapter Two: Literature Review

2.1. Introduction

2.1.1. Extent of defect

In the building industry, words like „error“, „fault“, „failure“, „defect“, „quality deviation“, „non-conformance“, „quality failure“ and „snag“ are used interchangeably to describe imperfections in constructed buildings.^[11] But when we see these words each of them used to describe something different from the other. In this research the concern is to define and study “defect” in building projects.

Black’s Law Dictionary (7th edition) defines „*defect*“ as meaning „an imperfection or shortcoming“, without identifying how the imperfection or shortcoming should be judged. Cambridge Dictionary defines „defect“ as meaning „A fault or problem in something that spoils that thing“ this definition is narrow because a defect not necessarily spoils the building. „Non-conformance“ is the term used by ISO 9000:2005 to define „the failure to fulfill a requirement“. Those definitions are not solid by themselves, not addressing defect fully. Practical cases may give some clue on this ground.^[4]

Literatures in area of defects include the followings.^[4]

1. Defects can represent more than just bad workmanship and materials, and that quality is just one category of defective work. The previous understanding of defect emerges from only bad workmanship & a defective material was questioned. So, defect can come from different causes.
2. A defect was defined as meaning „A lack or absence of something essential to completeness“.
3. A defect in an item of plant included „anything which renders the plant unfit for the use for which it is intended, when used in a reasonable way and with reasonable care“.
4. A defect did not include a design defect.

These previous definitions of defects are analyzed as follows: the first case is comprehensive and shows defect can be manifested by bad workmanship, defective material and other flaw; the

second case is not sufficiently all including, building work can be complete but nonetheless defective; similarly the third case is potentially too wide, as a building can be unfit for use, yet not be defective in the sense that someone can be held responsible for its unfitness; fourth case was interesting this one should be treated with some caution because subsequent cases expose that a defect includes design as well as workmanship. So, this definition, perhaps, one of those cases that should be treated as confined to its own special facts.

The comprehensive definition is matched only by the variety of terms used to describe defects. These include: disconformity, non-conformity, noncompliant and incomplete. The phrase „temporary disconformity“ is also encountered, and has a special significance, as does the commonplace term „snagging“ (a much misused term, but one that generally refers to work that is in fact and in law defective). None of the above attempts throws any additional light on the meaning of the term „defect“.

Finally a definition given by Watt (1999) with little modification is used in this research and it was more comprehensive than other, that is: defect is the term used to define a shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building.

2.1.2. Defect & Failure

It is important to clarify the distinction between a building defect and a building failure. Strictly speaking, these two terms, although similar, should not be treated as being synonymous. A defect is a shortfall in function, performance, statutory or user requirements occurring at any time in the life of the product, element or building in which it occurs. It is also a departure from design requirements where these were not themselves at fault. A failure, in contrast, is the termination of a product or element's ability to perform its intended function. ^[12]

Generally defect shall be interpreted as a fault in an element, material or component of a building. For example, a flush cope on a parapet with little or no flashing would be termed a defect. On the other hand, a building failure is here meant as a consequence of such a defect/fault. A failure may be thought of as an unplanned or unintentional negative effect of one or a combination of defects, which leads to a shortfall in performance. Using the flush cope

given above, a typical failure would be rainwater penetration at the wall head due to the inadequate weathering of the cope, which results in spalling or lamination of the brickwork/rendering. It is this spalling that would be deemed the failure.

Moreover, in law a distinction would be made between a fault and a failure. The former would be classified as a defect, that which caused the failure. The latter would be classed as the damage resulting from such a defect. This is important for the courts when it comes to assessing the cost of remedying construction failures to find out the extent of damages awarded to the aggrieved party if a case has been proved against the contractor or designer.

Defects then can be real or perceived. Even if they are real, they are relative rather than absolute.^[12] Their origins are often not what they look like to be, but can be traced back to a complicated interaction between lack of knowledge, lack of education, lack of training, lack of experience, lack of definition, lack of care, or lack of enforcement. Because they are relative, defects cannot be avoided, but by the same argument, quality can always be improved and defectiveness can always be reduced. A defect may be described as something that:

- Does not come up to the expectations of the client;
- Falls below the prescribed standard for things of its kind;
- Is less acceptable than expected to be;
- Is the result of an error

Now a day it may be reasonably assumed that since the causes of most defects are fairly well known there should be an overall decline in building failures. Unfortunately, the reverse is the case. Some have argued that, building failures are increasing in frequency and severity.^[12] Reducing the incidence of building failures is not just important to control construction costs. Moreover, it is important to control building failures for the following main reasons:^[12]

- Increase the sustainability of buildings – make them last longer and more energy efficient.
- Achieve buildings that offer better value for money with lower maintenance costs.
- Make properties safer – reduce hazards and accidents in buildings.
- Combat poor indoor air quality – to avoid unpleasant odor and building-related illnesses.
- Reduce negligence and other legal consequences in construction.

2.1.3. Defect & Deterioration

Problems and failures in buildings can be caused by defects or deterioration. Defects arise due to error or omission, or negligence by a designer or contractor, but deterioration is a natural process which may be unavoidable, although reduced by care in design and the selection of materials. However, where the rate of deterioration is excessive it may be due to a defect, such as the selection and use of unsuitable materials, or an event such as a water leak resulting in fungal decay. A defect in such circumstances may be due to error or omission or negligence during construction or repair, or it may be a failure by a building owner or tenant to maintain the building adequately or to repair it promptly after accidental or weather damage.

When a problem or failure arises and a building owner or tenant decides to seek compensation, it may be very difficult to establish that it may be because of defect rather than normal deterioration, lack of maintenance or failure to repair promptly. This is mainly because a study for cause of action can only arise if a person or firm has suffered an actual loss.^[2]

2.1.4. Investigation

Identifying the precise causal factor(s) of building defects is frequently a difficult task for any investigator.^[12] Constraints of access, time and resources often make the investigator's job difficult and demanding. When problems occur in buildings it is extremely important that their root cause is properly identified. If the initial diagnosis is inadequate or mistaken, this may result in^[12]

- The significance of the defect being underestimated, leading to it being ignored, unattended or marginalized;
- The significance of the defect being overestimated, leading to excessive or unnecessary remedial work;
- The wrong or inappropriate repair leading to the defect not being effectively cured/rectified, this could even aggravate the problem.

Every type of building contains defects to some degree. The consequences of such defects may be minor, but others are more important and may affect the building's appearance and usage of the property. However, the cost of rectifying or not rectifying building defects could be

extensive. In more serious instances, they may cause a hazard to health and safety for those in and around the building.

In many cases, however, establishing the precise causal factor(s) of a building defect is neither simple nor straightforward. ^[12] There are several reasons for this. It is not easy to dismantle fully the part of the building where a defect has appeared to expose fully the extent and nature of the problem. This is complicated because of incomplete nature of information about the affected element or its history. Documents such as the original specification or drawings may be missing or only partially available.

A full breakdown description of the make-up of the materials originally used in a building is often unavailable. In addition, for obvious commercial reasons suppliers are often unwilling to expose the precise composition and manufacture of their materials. This often makes it difficult to achieve the correct diagnosis without a thorough investigation.

Thus the process of detecting faults in buildings is often made difficult in a specific situation because of the presence of relatively few symptoms but with a wide range of possible causes and defects. ^[12] Moreover, the precise causing mechanism of a building defect is not always apparent even though the cause may be obvious. The same symptoms can be caused by different agencies. A variety of agencies working in combination can cause a defect. For example, rainwater penetration can lead to dry rot, which is the most destructive form of timber decay in buildings. Dampness is the “cause” of the problem in this case, but the source of the moisture may not be so obvious.

Similarly, a single cause can result in several symptoms. For example, penetrating dampness through a blocked cavity wall can result in corrosion of the wall ties (leading to horizontal expansion of the mortar joints in the outer leaf) and moisture staining or soiling on the inside face of the inner leaf of brick work. ^[12]

When a problem occurs in a building it is crucial that the root cause is identified quickly. If the initial diagnosis is inadequate or erroneous, this may lead to the defect not being effectively rectified. It is also likely to result in a reoccurrence or aggravation of the problem.

2.2. Types and Causes of Defects

Construction defects usually include any deficiency in the performing or furnishing of the design, planning, supervision, inspection, construction or observation of construction to any new home or building, where there is a fault to construct the building in a reasonably workmanlike manner and/or the structure fails to perform in the manner that is reasonably intended by the buyer. ^[7] In the building industry, there are different approaches to classify defects, like by its severity, by construction stage, by type, by cause, etc. ^[9] Generally, Western Countries categorize construction defects in one of four categories: design deficiencies, material deficiencies, construction deficiencies, or subsurface deficiencies. ^[7]

A literature analysis part of research done in Spain put different ways of classifications of building defects that are done by other researchers. Some of the researcher suggests classifying defects into major and minor categories, taking into account the severity, classifying the defect as technical, aesthetic or functional with technical meaning when the workmanship or material of an element reduces its capacity to fulfill the functional performance of a structure; aesthetic meaning when the appearance of a material or building element is adversely affected; or functional meaning when a dwelling fails to function in its intended manner. Other research distinguishes between defects due to the construction process or to natural degradation related to a lack of maintenance by the occupants of the house. ^[9]

Other researchers propose to classify defects in technical, omissions, and aesthetic with technical meaning when workmanship, material, or design of an element of the building reduces its ability to function properly; omissions meaning parts of a home that are simply omitted; or aesthetic meaning when the performance of a building element is adversely affected. ^[9]

Similarly a study done in the same country shows that the most common defects in residential buildings were: „inappropriate installation“, „bad surface appearance“ and „affected functionality“. „Inappropriate installation“ includes materials, elements or items incorrectly positioned, or those that do not satisfy project specifications or do not have the adequate characteristics. „Surface/appearance“ defects included bumps, dips, uneven surfaces, hit, scratches and efflorescence. The majority of the „surface/appearance“ defects detected during

construction were honeycombs in concrete elements, which were mainly caused by poor workmanship. „Affected functionality“ defects refer to disabled building elements or systems that must be replaced because their functionality is completely affected. ^[11]

Other study shows that defects in building projects have a number of causes. A study done in Malaysia shows that the contribution factor for causes of building defects & failures are: climatic conditions, this is a problem in most buildings which are located in tropical countries; location of building, buildings that are located near the sea or rivers tend to have common building defects; construction materials; building type and change in use, this is because some buildings were built to only hold certain loads and sometimes may not withstand additional loads; Lack of maintenance of building; faulty design; faulty construction; corruption and lack of supervision.^[10] A study undertaken by the Building Research Establishment (BRE) over a number of years in the UK indicated that 50 per cent of defects found on construction projects could be attributed to design issues, 40 per cent occurred during the construction phase (as a result of on-site practice), and 10 per cent were due to product failure. ^[14]

For the purpose of this research, the defects“ classification system will be based on the type of defect. Based on degree of visibility defects can be classified as patent & latent defects.

Patent and latent defects

Defects, whatever their qualitative nature may be patent or latent and its consequences may differ depending on whether defects are patent or latent. The fact that there may be different consequences means that it is important to be able to decide when a defect is patent and when it is latent. ^[4]

A straight forward definition of patent defect is a defect which is open or visible to the eye. But here the degree of visibility is the main concern and a defect was said to be patent if observable, whether or not actually observed.

Some researcher suggested that many building defects are latent in nature and do not appear early in the construction stage. However, other studies found important defects arising during the

first stages of the construction process and identified that the problems with the stability of the structure were the most important construction defects in residential building. ^[4]

Latent defects, on the other hand, are those that are hidden and, unlike to the above case, not observable. The concept of a latent defect is not a difficult one. It means a concealed defect. ^[4]

Structural and Non-structural defects

- **Structural defect**

Structural defect means any defect in a structural element of a building that is caused by defective design, defective or faulty workmanship or defective material and sometimes any combination of these. Building structure includes earth retaining walls, columns, beams and flat slabs. ^[19]

According to the Engineering Encyclopedia, structural defect can be categorized as cracks in foundations (Substructure), cracks in floor or slabs (superstructure), and cracks in walls (superstructure). ^[20] These defects can be caused by improper soil analysis, inappropriate site selection, and the use of defective materials. Most of the structural problem can be avoided by implying the exact and detail of the design and planning.

Structural defects in a building can occur over time due to deterioration, wear and tear, overloading, and poor maintenance. They must be repaired to maintain the building's structure and to prevent any further failures. Regular inspection is the key to protecting the „health“ of a building's structure. Structural defect that always occurs are steel corrosion, cracks, and deflection.

- **Non-structural defect**

Non-structural defect in a residential building is described as a defect in a non-structural element of the building as a result of defective residential building work. ^[19]

According to the Engineering Encyclopedia, non-structural defect includes defect in brick work, dampness in old structures, and defects in plaster works.

In general there are different types of building defects which are caused by different mechanism. In this research it is tried to see types, causes, effects & procedures to reduce main building defects and this is covered in subsequent sections.

2.2.1. Dampness

Dampness can be a serious matter, particularly to buildings subjected to water. Not only does it deteriorate building structures but also damages to furnishings. Moisture, of course, cannot be totally avoided from buildings. Its movement is a natural and common phenomenon affecting building components. It is also one of the most fundamental and major sources of defects in building components and elements. ^[12] It's needed for both the building itself and for the comfort of its occupants. Organic materials such as timber lack of moisture would be affected by drying. This in turn would cause them to shrink, crack and warp. The occupants, too, cannot inhabit a totally dry building (i.e. one in which the relative humidity is near or at 0%). ^[12] Moisture is water present in stuffs while humidity is the amount of water vapor present in atmosphere.

Too much moisture (i.e. >70% relative humidity) in a building can be damaging not only to its structure, fabric and contents but also to its occupants. The risks to health associated with dampness are well established. ^[12]

Knowledge of the main sources of moisture therefore is vital. It will enable steps to be planned to reduce the total amounts captured, entering or generated in a building, and so help reduce or prevent some of its harmful influences.

The main cause of dampness is water entering a building through different routes. Water penetration occurs commonly through walls exposed to prevailing wet wind or rain. With the existence of gravity, water may penetrate through capillaries or cracks between mortar joints, and bricks or blocks before building up trap moisture behind hard renders. Water may also drive further up the wall to emerge at a higher level. Dampness also occurs in walls due to other factors such as leaking gutters or down pipes, defective drains, burst plumbing and condensation due to inadequate ventilation. It may also occur flooding of under floor voids via air bricks or breaches in damp proofing materials, damp proofing claddings and/or their connections. Direct water penetration may also occur with plumbing or drainage. ^[12]

Generally, the main causes of dampness in building construction are as follow.

1. Rain

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

2. Condensation

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

3. Rising damp and flooding

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

4. Services leaks

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

5. Construction process

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

6. Use of the building

This may include the cleaning of the building, spills, and apparatus leaking.

7. Moisture in the air

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

2.2.2. Foundation Defect

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

Normal foundations comprise concrete strips on which the walls (columns) are erected, together with prepared foundations to support any solid floors. It is well recognized that strip foundations must have sufficient width to provide an adequate bearing area to support the imposed load on the ground support concerned; the depth of the foundation strip is important in terms of the ability of the foundations to resist local fluctuations in the bearing capacity of the ground without developing fractures, and the total depth of the foundations is important if it is necessary to excavate sufficiently deeply to provide bearings on better compacted soil or perhaps even rock at a greater depth. ^[2]

The importance of careful preparation of foundations for solid floors and the loads come from above is not so widely recognized, as floor loads are much less and the requirements much less severe, but problems commonly arise if the floor slab support is poorly compacted, or support varies on a sloping site between excavated ground at one end and inadequately compacted fill at the other. If the load bearing capacity of the ground is poor, construction on a large reinforced concrete raft may provide the best means for spreading the foundation load, and various piling systems may be preferred to excavating deep foundation trenches. ^[2]

2.2.2.1. Settlement & Subsidence

The differences between settlement and subsidence failures are not widely recognized, although the different causes are obviously important in relation to remedial works.

Settlement is due to normal compaction of the supporting ground as the building loads are imposed on the foundations. Some settlement always occurs during construction, but there is usually some further settlement or creep following completion. Settlement is normal and must be considered in design and it is only risky because the external walls, the internal walls and solid

floors impose different loads and therefore settle to a different extent, the most obvious damage being imposed in building. This may be manifested by an increase in height of the floors, or settlement of the heavily loaded peripheral walls in relation to the internal partition walls. [12]

Subsidence is a downward movement under applied load. It can occur as a large movement whereby the building progressively settles with the soil. This may be small, in the order of millimeters. According to the soil type, it may manifest itself in the first few years following construction or almost at once. Minimal subsidence occurring uniformly may produce little in the form of structural problems for the building. It is more common for partial or differential subsidence to occur, however, and it is this form of movement which is generally more destructive, especially to building services. This usually results in differential movement in the foundations, causing intense disruption to the structure and fabric of the building. Subsidence follows from some unexpected event following construction. Ground water percolation may result in removal of material and loss of support. [12]

Settlement is normal and must be anticipated in design, so that damage due to settlement is an indication of inadequate design in relation to ground conditions or failure to observe the design during construction. The cause of subsidence may be as straightforward as poor bearing capacity or soil erosion. It is distinguishable from settlement, which is a movement within a structure due to a redistribution of loading within the structure (or soil).

2.2.2.2. Tree root damage

Tree root damage results most obviously from the penetration of tree roots into masonry and beneath foundations, and rupturing due to progressive root growth. Such damage can usually be readily identified by excavation and does not justify special comment, except in relation to safe separation between trees and buildings. [12]

A more serious problem is the presence of trees in conjunction with shrinkable clay. Deciduous trees will remove water from the clay during the summer and the clay will shrink, but the tree will have no demand for water during the winter so that the clay moisture content will increase and it will expand.

2.2.3. Floor Defect

Floors exhibit a range of defects related to their expected performance in use. The main functions of flooring are structural adequacy, including the transfer of all loads (dead and imposed) to the ground or the walls/ foundations without deflecting excessively; to resist water penetration; to control thermal losses and to provide a safe and stable surface. Special requirements include fire resistance and control of acoustic transmission. Floors can be not good enough in any or all of these contexts. There may also be problems with the floor finish. ^[5]

- **Structural inadequacy in floors**

Floors may be structurally inadequate because of failures in their bearing at their end supports (or in the case of large spans, possibly at the mid-support also). They may also be defective through excessive span for their sizing, or overloading beyond design specification. Excessive sagging, especially in the sensitive middle third of the span, can produce bending as a result of overloading. ^[5]

In concrete suspended floors there may be problems with connectivity between the concrete and shear connections to the supporting beams, and also with inaccurately placed or incorrectly developed reinforcement. There may be similar inadequacies of bearing at walls, which can produce sagging at the perimeter of the floor. There is also the possibility of cold bridging with such details if the floor crosses the cavity or is supported in a solid wall. In upper floors, generally, there can be severe structural consequences of the installation of services using notching, especially where this has been accompanied by the movement of strutting. ^[5]

The main causes of structural inadequacy in floors are,

- i. Design defects
- ii. Material defects
- iii. Workmanship defects

- **Dampness in floors**

Dampness in flooring can produce a range of direct problems in the form of localized rot (dry or wet rot). If ignored, this rot can become extensive, especially where a lack of ventilation due to blockage or omission of air bricks and cross-ventilation occurs. It is important to be able to identify the sources of the damp. In general the causes of dampness in floors include flooding of

under floor voids via air bricks or breaches in DPMs, DPCs and/or their connections. Direct water penetration may also occur with plumbing or drainage. ^[5]

2.2.4. Wall Defect

The main function of the wall of a building is to isolate the interior from the exterior conditions.^[2] Just the presence of the wall is sufficient to achieve this function reasonably, as is demonstrated by the efficiency of a well-designed shelter. However, the efficiency of walls can be greatly improved in relation to excluding dampness and thermally insulating the interior.

A second function of a wall is structural and to support the load imposed by any suspended floors and the roof above. These basic functions have to be considered when designing walls to achieve a certain aesthetic effect, but these various requirements may conflict and may result in various wall problems. ^[2] Masonry like any other structural material requires an understanding of its strengths and weaknesses in order that an economic design can be produced in accordance with accepted statutory requirements.

The main wall defects are as follow, ^[6]

- **Dimensional instability**: - The dimensions of masonry elements in a building are continually changing. For example, bricks expand because of moisture absorption, and mortars contract as they harden. Unfortunately, there are still designers who are not aware of or choose to ignore the effects of masonry movements, and it is not uncommon to see long terraced buildings with no movement joints.
- **Defects related to masonry materials**: - Serious structural defects can result if the basic components used in the construction of masonry walls are defective or inadequate for the conditions of use.
- **Workmanship problem**: - Some workmanship defects are mortars with inadequate ratios of cement, failure to build walls plumb, using incorrect ties and inadequate tie embedment, using unauthorized workability admixtures, inadequate number of wall ties, poor lintel bearings, over-strong mortar, etc.

The main causes of dimensional instability or movements are

- Deformation or cracking due to loading
- Movement caused by temperature changes

- Movement caused by moisture expansion
- Movement caused by chemical reactions, The remaining causes of wall problems are because of defective material & poor workmanship

2.2.5. Door & Window Defect

Window and door design in construction is a complex part and it is not area of concern in this research instead a review of problems encountered with windows and doors in the hope that this information will assist in the diagnosis of defects on site.

Windows are perhaps the most vulnerable building element in external building parts. 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 windows have been widely used in new developments and as replacement of steel windows in existing buildings but recent incidents of their failure have cause to raise safety concerns.

Aluminum window system involves 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. 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 life-span. 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 serious injuries to the public. ^[13]

Common door & window defects are as follow,

- Water seepage through door & window frame
- Water seepage through joints between window & door frame and wall
- Difficulty in opening and closing of glass panel (for casement window)
- Difficulty in sliding of inner panel (for sliding window)
- Misalignment

- Untidy joints between window & door frame and wall
- Gaps at window & door frame corner
- Stained glazing
- Poor frame finish
- Mortar droppings and paint drips on frame
- Physical damages and scratches on frame and glazing
- Loose or improperly installed gaskets
- Physical damages

Many times doors and windows are twisted before they are installed causing them to be hard to operate. Settlement and poor framing can also cause the doors and windows to sit improperly. Either way this can be a problem that will only get worse over time. Defects associated with windows most often have to do with leaks, which can be a result of poor installation. This means the windows were not flashed properly, or the window product itself is defective and leaking. In some buildings windows are difficult to operate. This can be a sign of soil settlement, structural deficiencies or defective material. ^[17]

2.2.6. Roof Defect

Roofs are among the most difficult parts of a building to inspect in case defect occurs. These difficulties also lead to poor maintenance. As a generalization, it can be said that pitched roofs have given few problems and flat roofs have given many. ^[12] The best advice one can give is to use a pitched roof wherever possible. To top a wide-span building with a pitched roof often mean that the total roof height would be unacceptable in terms of both visual appearance and cost. For such a building, a flat roof may be the only feasible solution. To use flat roofs for buildings of comparatively small span, however, such as dwellings, is not a good option.

Roof usually exposed to the extremes of temperature degree and change, solar radiation, and wind action. Roofs have special risk due to the design of the building itself such as services passing through the roof covering, and internal gutters. The consequence small defective of roof will may be greater effect of similar defect in a wall or other element.

Roof defect are divided into structural faults and defect in the waterproofing material. The majority of roof defect that occurs is distortion of either the roof or of the wall at roof level.

Normally, structural defect can be identified from the visual inspection. For the defect of waterproofing material, it will provide the building to be durable under wide range of exposure condition. The pitch roof sagging result is from the slating or tiling that has dished appearance, and the ridge may also have sagged. This defect is more commonly found in older pitched and tiled or slated roof.

While there are many different types of roofing defects, most are known to be caused by:

- **Improper installation**

The installation of roof will need a number of skilled workers. If the roof is improperly installed, it will yield to roof defect such as roof leakage and sagging. The causes of roof defect are because the worker maybe not have a license, or certificate apart from having a low level of experience.

- **Poor workmanships**

Quality of workmanship is needed such as to maintain and construct the roof. The life expectancy will be reduced due to the poor workmanships which are can both bring to loss for both the dealer and the buyer.

- **Defective materials**

Materials themselves also may be the factors to the roof defect. The material too, may be not suitable to weather condition. Sometimes, it is not installed correctly also due to sagging and deformation.

2.2.7. Cladding Defect

Most modern non-residential and many residential buildings have cladding as the main form of wall finish. ^[12] Problems such as water ingress as a result of joint failure or surface degradation are likely to continue to pose as the main defects in claddings.

Generally, cladding defects are caused by differential movement between the cladding and its background; by failure to allow for the inaccuracies nature in construction; by inadequacy of the fixing and jointing methods used; and by premature failure of sealants. ^[12] The likelihood of failure has also been enhanced by not allowing for the dimensional deviations which occur in manufactured or site-cast products, and for the inaccuracies in setting-out and during erection.

Sometimes, mistakes during construction, such as forgetting to remove packing spacers after final fixing, have also contributed. The main causes of movement are due to temperature effects, moisture changes and creep.

Many cladding systems have proved incapable of preventing the entry of rain. ^[12] In part rain penetration has followed the cracking, spalling and dislodgement of cladding caused mostly by the differential movement. Lack of attention to joints and to rain-shedding features has also been a cause. There are many forms of joint associated with the various claddings used, some complex in geometry.

2.2.8. Plaster rendering defect

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

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

Mostly the defective plaster rendering occurs on the external walls, column and ceiling. Defective rendering are normally caused by biological attacks arising from penetrating rain, evaporation, condensation, air pollution, dehydration and thermal stress. The mold or harmful growth, insect, animals, and traffic vibration also will contribution causes of defective plaster rendering. Prior to being decomposed and broken apart, rendering may crack due to either shrinkage or movement in the substrate. ^[18] Common types of defective plaster rendering and causes are listed below in table.

Table 2.1: – Common defective plaster rendering & causes. ^[17]

Common defective plaster rendering	Possible causes
<ol style="list-style-type: none"> 1. Cracking in Plastering, 2. Holes in Plaster wall, 3. Plaster falling off from ceiling, 4. Shrinkage Cracking 	<ul style="list-style-type: none"> • Loss of bond between coats, • Surface cracking, • Friable powdery surfaces, • Water damage, • Movement of structure, • Non suitable of renders and plasters, • Chemical attacks, • Efflorescence, • Lime bloom, • Thickness of render • Popping or Pitting

2.2.9. Ceiling Defects

The type of defects that normally occur at ceilings and its causes are listed below in the table. ^[11]

Table 2.2: – Ceiling defects & causes

Common defects	Possible Causes
<ul style="list-style-type: none"> • Cracking and loss of adhesion. • Shrinkage cracks. • Full thickness of plaster loose. • Top coat of plaster loose. • Damp. • Dirty patches. • Peeling and flaking finishes. 	<ul style="list-style-type: none"> • Movement of foundations, • Changes in moisture content of subsoil, • Extend roots of trees under foundations • Continuing structural movement • Use of unsuitable undercoat, • Weak or shrinkable undercoat • Condensation of water vapor, Residual of entrapped water, Direct rain penetration, • Defective tiles or slates • Leaking water tank, Leaks from joints or defective pipes, • No insulation between joists, Air currents caused by heat, Efflorescence.

2.2.10. Building service Defect

2.2.10.1. Plumbing & Drainage

The soils through which cold-water supply services pass can vary considerably, from comparatively non-aggressive light sand and chalk to heavy clays containing organic matter suitable for the development of bacteria which can assist corrosion. Some sulphates and chloride bearing soils can be very aggressive. Ground to a depth of up to 1200mm is of main interest and here the natural soil may be contaminated, anyway, by a wide variety of builders' rubble. [12] When corrosion or other faults do occur in buried pipework, repair work to be costly. Protective tapes and wrappings are used for in many areas where galvanized steel is used. The solution to avoiding the problems referred to above concerning scale build up and corrosion in pipes is to use a modern plumbing material such as polybutylene for the pipework. [12]

2.2.10.2. Electricity supply

All electric cables give off heat in use and this is usually dissipated without any difficulty. However, cables can get overheated if placed beneath loft insulation, behind insulated dry lining or if placed in a position where the temperature of the surrounding environment is high. The insulation of the cable will then be damaged and there can be a risk of a short circuit and possibly fire. Cable in power circuits is more at risk than cable in lighting circuits, for the former is more likely to be loaded near to full capacity. Electric cable should not be covered by thermal insulation and shouldn't it be used where ambient temperature regularly exceeds 30°C. Where this is not feasible, cables will need to be de-rated in accordance with the regulations prepared by electrical engineers. There can also be an interaction between PVC cables and expanded polystyrene often used for insulation and this can cause degradation of the PVC. The two should be kept apart. [12]

Loose connections can cause an electrical fire as well as cause malfunction of the electrical system. In addition, an inadequate cable rating to appliances such as shower units and cookers can also cause heat build-up, thus increasing the fire risk.

2.3. Summary of causes of construction defect

The causes of building defects can be of the results of either party that involve in the construction industry. Construction is done in an environment that is far from ideal. Everything that happens cannot be controlled. Human errors and communication gaps are causes to defects. In this part of the study explained the main causes of construction defects. Such as defects due to design error, workmanship error, defective material and subsurface related.

2.3.1. Design error

This could be due to lack of motivation of the designer and carelessness. Besides this design error may be due the lack of properly collecting and organizing data, unqualified designers and lack of experience in order to consider and understand the output of the programing design software. ^[24]

Some researcher argued that, because design firm are taking short cut and not performing their usual checks, design error are occurring. They are not undertaking design audit, review and verification because they are getting low fees as it is very competitive out there. ^[24] This might be the case in western countries. Lack of communication between designer and contractors could be one of the factors that design errors to be created.

Sometimes architects can design a structure that is aesthetically pleasing yet with structural deficiencies that can lead to defects. In order to keep this from occurring, other architects should evaluate the design for flaws before the design is implemented in a structure. However, some design flaws are not evident until the structure is built, which means that testing a design with a scale model or building a test house prior to marketing the design should be a requirement. ^[24]

2.3.2. Workmanship error

Workman ship error could arise due a number of acts at construction site. Unethical acts of worker like chewing “chat” at site may cause not to give full attention at their work. In addition to that most work men are not professional and not skillful about how to use their work machine, tools and they didn’t update their skill. Sometimes the workers doing the actual building work are not careful to take their construction duties, those all error that arises due workman ship can be the result of a contractor not overseeing the building process as they should or simply not

carrying about the work being done. At other times, even though the contractor was watching the error that happened due to their workmanship problem, in order to save money and time they didn't return back rather use short cut. While short cut solution can work out to the contractor's advantage, but it can be result in a construction defect in the structure.

2.3.3. Defective Materials

Constructing a building using defective material can be the cause of many construction defects in a structure. An example could be a building built with defective, out of date, paint could lead to peeling and a building built with defective roofing material that allowed water to leak into the structure. The result could be a number of defects such as the wood decay, grey growth and moisture stains on the wall and ceiling.

Metal fixings associated with stonework can fail because of corrosion, or an inability of the fixings to accommodate thermal, moisture and load-related movement. In addition to that limestone can deteriorate when exposed to acidic rainwater or any other sulphurous source and the sulphurous acids can combine with the calcium carbonate to produce soluble calcium sulphate and hygroscopic calcium nitrate in the surface region of the stone. Water run-off from limestone can cause deterioration of sandstone by carrying calcium sulphate and calcium nitrate onto the sandstone surface. This can cause contour scaling.^[24]

2.3.4. Subsurface Related

Owner is responsible for investigation of soil and if unable to do so might lead to variety of construction defects. One of the first steps in a building project is to perform proper soil analysis and preparation. Proper soil analysis helps the builder to know the right strategy to use in preparing the land prior to construction. Poorly investigated or analyzed soil can have damaging effects on a structure. An example of this is building a house on expansive soil. In order to prevent damages to a structure built upon expansive soil, a builder would need to build a foundation that would be able to withstand the changes in soil consistency. Builders who unknowingly build upon expansive soil can experience cracks throughout the structure and on the outside pavement as well.

Houses and foundations go through a settling period, especially during the first years after they were built. Expansion and contraction with hot and cold weather changes along with normal settling can change wall-to-ceiling alignment and can cause cracks in both these areas. Ceiling cracks generally follow the joints between drywall sheets, and as long as they remain minor, with widths of less than 0.32 cm, you can patch them with tape and joint compound. [24]

2.4. Effects of Construction Defects

Construction defect can decrease and affect the value of the buildings. Accordingly defects are developments in construction that reduces the project's value instead of adding to it. [1]

Other than reducing project value, where the construction defect is apparent, it also can cause the project totally delay which mean not complete with in the period state in the contract. Cost overrun can be known as one of the effect when the construction defects happen in the construction projects. Construction defect will also affect society at large due to possible danger posed and result in direct and indirect cost in repairs, abnormally high maintenance dispute and possible loss of building. Besides to these, construction defect affect project functionality which leads to high maintenance cost. The contractor and/or consultant who engaged in defective act may highly affect their reputation.

2.5. Failure Pattern and Control

Avoidable building defects occur again and again. The reasons involve consideration of the structure of the industry, the particular problems associated with innovation, and control systems. These essentially “software” aspects of the avoidance of building failures needs as much attention as the “hardware” aspects dealt with already. It is probable that the greatest scope for improvement in building performance lies more with the former than the latter. [12]

Every type of building contains defects to some degree. The consequences of such defects may be minor but others are more important and may affect the appearance, value and usage of the building. However, the cost of rectifying or not rectifying building defects could be extensive. In more serious occasions, they may pose a hazard to health and safety.

2.5.1. Visible building defect

- **New Buildings**

Why is it, despite our increasing understanding of construction technology and materials, that building failures still occur? The reasons are not hard to find. Modern buildings are more sophisticated, as are their systems and facilities. Many of these advances make the chances of mistakes occurring in the construction process greater. The use of innovative materials and new construction techniques may not be fully tried and tested for every situation.^[12] This can also result in unforeseen problems immediately after a building's commissioning as well as during its occupancy.

Fast track building and shorter construction times are becoming increasingly common difficulty for the industry. All of these changes have put many pressures on designers and contractors to produce defect-free buildings that meet the needs of property users.

- **Old Buildings**

Re occurrence of building defects is often caused by acts of omission. Neglect and poor quality maintenance are major influences on the incidence of important defects such as dry rot.^[12] Moreover, failure to repair properly or on time can also activate further defects.

Buildings that are partially or totally vacant are more vulnerable to deterioration because of age and defects. In particular, empty dwellings pose a direct risk of damage to adjoining properties through dampness and other infestations. According to Ransom (2007), "the longer a property is empty, the greater the likelihood that its physical condition will deteriorate, making it more difficult to bring back into occupation at a later date and increasing the likelihood that it will impact on neighboring properties".

Acts of commission comprise a range of factors that can also contribute to the ongoing nature of building defects.^[12] Poor quality of original construction has a destroying impact on the aftercare of a building. This can be even worse by inappropriate repairs. Climate change, resulting in increased flooding or precipitation, may lead to unforeseen water ingress. Deliberate damaging of things and other forms of abuse can make all of these problems worse.^[12]

Ransom (2007), for example, showed where misguided application of waterproof lining repairs to a building can cause the rise of moisture in a wall. If the wall is lined on both sides, this can lead to wicking of moisture up the masonry. ^[12]

2.6. Reducing Building defects

Given the problems of diversity of participants and techniques used, uniqueness of every building project, outside working conditions, and so on, it is not too difficult to appreciate why defects in construction are more prevalent than those in other industries. ^[12] Indeed it is the very nature of the building industry itself, which makes it difficult to eliminate such problems totally. Moreover, some building professionals, such as Puller-Strecker (1990), have argued that building defects will never be totally eliminated. Nevertheless there are a number of measures that would go some way towards reducing if not avoiding common construction defects:

- An improvement in the “lowest tender” system, without generating excessive inflation of contract prices, should be sought. ^[12] Cheapest price does not necessarily mean best 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 to 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 graphical 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.
- Implement a comprehensive quality control mechanism in each stage of the construction

- 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
- Creating awareness of low-skilled laborers
- Revoking license of more frequent defective firm
- Continuously evaluate the capacity of consulting and construction firms
- Develop the capacity of universities and training institution

Besides to measures stated above here are procedures that could be followed in each stage of buildings to reduce the occurrence of defect.

2.6.1. Pre-construction stage

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

Therefore, 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 rise due to problems with the structure or service installation. Inadequate design of sanitary pipes or drains such as insufficient diameter of drains, bends being too sharp, etc. can lead to excessive pressure built up on 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 code.

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.

2.6.2. During construction stage

Construction techniques that may not be defect free, inconsistent or sub-standard workmanship, and use of unsuitable construction details can lead to shortly occurring 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 oversteering can be hold within limits. Leakage of slab floor, delamination 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 ill workmanship. Fitting problems inadequate design of sanitary pipes can lead to leakage, electrical installation problems and improper fillings around windows and doors frames are also caused due to bad workmanship. These problems can easily be avoided by monitoring the works closely and enhancing technical kills 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 onsite material management and storage system can avoid contamination of materials such as corrosion of steel or mineral attack of aggregates due to storing area"s top soil. This avoids problems caused due to corroded steel material; once it is used as a reinforcing material since the steel cannot overcome the tensile stress on the reinforced concrete structure and leading to oversteering of the structure, structural cracks may occur undermining the stability of the whole structure. 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.

2.6.3. Post-construction stage

Abuse or misuse of the building is other 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 leads to failure it should be a correct use of building and properly managed maintenance activities.

2.7. Summary of literature review

Literature review was done on previous studies, internet, construction management books, and engineering journals on the topics of building defects. By reviewing the previous studies, types and causes of building defects, effects of building defects, and reducing measures of building defect was investigated. This would be used to do case study and to develop the questionnaire survey in order to collect data from the targeted respondent.

Construction defects usually include any deficiency in the performing or furnishing of the design, planning, supervision, inspection, construction or observation of construction to any new home or building, where there is a fault to construct the building in a reasonably workmanlike manner and/or the structure fails to perform in the manner that is reasonably intended by the buyer.

In the building industry, there are different approaches to classify building defects, like by its severity, by construction stage, by type, by cause, etc. Unfortunately no previous studies were done in Ethiopia in the area of building defects but a research done in Spain put different ways of classifications of building defects that are done by other researchers. The study classified building defects into major and minor categories, taking into account the severity, classifying the defect as technical, aesthetic or functional with technical meaning when the workmanship or material of an element reduces its capacity to fulfill the functional performance of a structure; aesthetic meaning when the appearance of a material or building element is adversely affected; or functional meaning when a dwelling fails to function in its intended manner. Similar research

distinguishes between defects due to the construction process or to natural degradation related to a lack of maintenance by the occupants of the house. Other researchers propose to classify defects in technical, omissions, and aesthetic with technical meaning when workmanship, material, or design of an element of the building reduces its ability to function properly; omissions meaning parts of a home that are simply omitted; or aesthetic meaning when the performance of a building element is adversely affected. In this research building defect classification by type were dealt.

Previous foreign studies shows that defects in building projects have a number of causes. A study done in Malaysia shows that the contribution factor for causes of building defects & failures are: climatic conditions, location of building, construction materials, building type and change in use, lack of maintenance of building, faulty design, faulty construction, corruption and lack of supervision. A study undertaken by the Building Research Establishment (BRE) over a number of years in the UK indicated that 50 per cent of defects found on construction projects could be attributed to design issues, 40 per cent occurred during the construction phase (as a result of on-site practice), and 10 per cent were due to product failure

Occurrences of building defect pose a number of impacts on the building and its users. Construction defect can decrease and affect the value of the buildings and reduces the project's value instead of adding to it. Other than reduces the project value, where the construction defect apparent, it also can cause the project totally delay which mean not complete with in the period state in the contract. Cost overrun can be known as one of the effect when the construction defects happen in the construction site. Construction defect will also affect society at large due to possible danger posed and result in direct and indirect cost in repairs, abnormally high maintenance dispute and possible loss of building.

Given the problems of diversity of participants and techniques used, uniqueness of every building project, outside working conditions, and so on, it is not too difficult to appreciate why building defects in construction are more prevalent than those in other industries. Indeed it is the very nature of the building industry itself, which makes it difficult to eliminate such problems totally. Moreover, some researchers have argued that building defects will never be totally eliminated. Nevertheless there are a number of measures that would go some way towards

reducing if not avoiding common construction defects. According to previous studies the most important defect reducing measures are: an improvement in the “lowest tender” system, without generating excessive inflation of contract prices; 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; regular on-the-job training programs for operatives and site staff; better and more available guidance on commissioning buildings and their services and on defects avoidance; improvements could be made in the quality of graphical and written communications at the project site and so on.

In Ethiopian context the problem of building defect can nearly be noticed in many building, both completed and under construction. This indicates that this problem didn't receive enough attention by both researchers and responsible authorities. No previous studies undertaken on the area of building defect shows how the society didn't give due attention to this problem. But studies which were done out of Ethiopia shows building defect should receive attention because its occurrence can affect cost, time and quality of building projects. By taking this in to consideration this thesis mainly focus on types, causes, effects and reducing measures of construction defects in public building projects in Addis Ababa.

Chapter Three: Research Methodology

3.1. Introduction

This chapter describes the methodology of the research. The main topics included in this chapter are research strategy, research design and data collection. The objectives of this thesis were to identify types, causes, effects & reducing measures of construction defects in Federal Government Office Building projects in Addis Ababa and makes conclusions and recommendations based on findings.

In the capital Addis Ababa there are different public buildings and those buildings are constructed and regulated by different government offices. Government Construction Bureau, located at 6 kilo next to Addis Ababa Education Bureau, administer construction of some of public building. In this bureau construction of city administration office, school and health centers are monitored. City housing projects constructions are monitored by Addis Ababa city Administration Integrated Housing Development Program (IHDP). Government building construction office, located at Beherawi in Ministry of Urban Development, Housing & Construction buildings 10th floor, is another office established for monitoring Federal Government Office Building in the capital city. There are also other public buildings in the capital city but because for ease of administration there constructions are monitored by sub-city administration office. In this research Federal Government Office Buildings in Addis Ababa were investigated. So, in this research a case study of stated public buildings and questionnaire survey were taken by examining the quality of the buildings and construction method and tried to identify the different types of construction defects observed on the buildings. Projects are listed on table 3.1

3.2. Research design

Two types of research strategies are used at studies, quantitative and qualitative research. Quantitative approach is used to gather factual data and to study relationships between facts and how such facts and relationships accord with theories and the findings of any research executed previously, but the qualitative approach seek to gain insights and to understand people's perception of "the world" whether as individuals or groups ^[26]. The research strategies adapted for this research were both qualitative and quantitative research.

Table 3.1:- List of investigated projects

No.	Project name	Contractor	Consultant	Project Status
1	Ministry of Agriculture	Giga Construction	MH Engineering	Completed
2	Custom & Revenue Authority	Emnetu Endeshaw Building Contractor	MH Engineering	Completed
3	Ministry of Health	Samuel H/Mariam Building Contractor	MH Engineering	Completed
4	Ministry of Justice	Prefabricated Building Parts Production Enterprise	MH Engineering	Completed
5	Ministry of Agriculture II	Prefabricated Building Parts Production Enterprise	MH Engineering	Completed
6	Ministry of Foreign Affairs	Prefabricated Building Parts Production Enterprise	MH Engineering	Completed
7	Ethiopian Press Agency	Flintstone Engineering		Completed
8	Central Statistics Agency	Giga Construction	MH Engineering	Completed
9	Custom & Revenue Authority II	Zamra Construction	MH Engineering	Completed
10	Ethiopian Road Authority	Samuel H/Mariam Building Contractor	MH Engineering	Under construction
12	Information & Network Security Agency	Defense Construction Enterprise	MH Engineering	Under construction
13	Federal Prison Administration	Flintstone Engineering	ETG Designers & Consultants	Under construction
14	Ministry of Science & Technology	Prefabricated Building Parts Production Enterprise	ETG Designers & Consultants	Under construction
15	Ministry of Industry	AMB Construction	ETG Designers & Consultants	Under construction
16	Ministry of Civil Service	Samuel H/Mariam Building Contractor	ETG Designers & Consultants	Under construction
17	Federal Main Auditor office	Radar Construction	ETG Designers & Consultants	Under construction
18	Ministry of Foreign Affairs Conference Hall	Rama Construction	Muluget Asfaw Consulting Architects & Engineers	Under construction

19	Information & Network Security Agency II	Defense Construction Enterprise	MH Engineering	Under construction
20	Central Statistics Agency II	Radar Construction	MH Engineering	Under construction
21	Government Higher Officials & Head of State Residence	Teklebirhan Ambaye Construction	Defense consulting Enterprise	Under construction
22	Urban Integrated Land Information System Development	Teklebirhan Ambaye Construction	Defense consulting Enterprise	Under construction

3.3. Thesis Structure

This research consists of five phases; the first one is the proposal for identifying and defining the problems and establishment of the objectives of the study. The second phase of the research includes literature review. Literatures on construction defects in general, building defects in particular, were reviewed.

The third phase of the research included a methodology of the thesis. The fourth phase of the research includes result and discussion. In this phase the result of case study and questionnaires were discussed. The last phase of the research includes the conclusions and recommendations.

3.4. Data collection

Both primary and secondary data were included in this research. Primary data were gathered from observation, checklist and questionnaire with study participants such as consultants, contractors and client & users. Secondary data used include literatures, reference books, journals, previous studies etc. written on similar topic.

Check list, questionnaire used as a checklist for case study, was prepared to gather data for the most common types of construction defects and their causes. Questionnaire was developed and distributed to consultants, contractors, and client and building users. The questionnaire was close ended and general and were helpful as an additional guidance in the inspection process. On the active projects, sites visit was done as much as possible on the process of construction.

The study has used the data sources to produce the following basic documents: respondents' documents and case study documents. The respondents' documents were collected using questionnaire from client and end users, contractors and consultants. Case study documents were mostly from both completed and active projects, in which site observation was done.

3.5. Sampling Method

To generalize validity of the findings from a sample to all area of the research, samples were drawn from the Federal Government Office Building Projects in Addis Ababa. For case study seven buildings were investigated. Method of sampling used was random sampling. Samples were categorized to two based on status, completed and under construction, because defects are manifested as age of building increase four buildings were randomly selected from completed buildings and the remaining three buildings were randomly selected from under construction buildings.

For the second part of the study, survey study, questionnaires were developed and distributed to all consultants, contractors, clients and users engaged on federal government office buildings were addressed. And to assure the quality of data only professionals which have engineering knowledge were included.

3.6. Questionnaire used in the research

The methodology used for this study was using case study and questionnaire. For case study checklist having 74 factors, 70 types of construction defects and 4 causes of construction defect, was developed. Then thorough site visit was done on selected seven building. For survey study a questionnaire of 91 factors was carefully designed from literatures conducted in building construction projects. It was organized in the form of a priority scaling (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree and 1 = not important, 2 = less important, 3 = moderately important, 4 = important, and 5 = very significant).

The procedure used in analyzing the results aimed at establishing the mean score of the various parameters of construction defects. The score for each factor is calculated by summing up scores

assigned to it by respondents. Therefore, the level of importance as indicated by the client & end users, contractors and consultants were used to measure the mean score of each factor.

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

$$Msi = \Sigma (f*s)/N \dots\dots\dots \text{Equation 3.1}$$

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

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

N = total number of responses in the respective type, effect & reducing measure of construction defect.

Weighted Average was calculated by using the following formula;

$$\text{Weighted Avg.} = w_a x_a + w_b x_b + w_c x_c \dots\dots\dots \text{Equation 3.2}$$

Where; w = relative weight (%)

x = mean score

a, b & c represent client & end users, contractor and consultant respectively

The Spearman (rho) rank correlation coefficient was used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors).

The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula ^[28].

$$\text{Rho } (\rho_{cal}) = 1 - \frac{6 \Sigma d_i^2}{N(N^2 - 1)} \dots\dots\dots \text{Equation 3.3}$$

Where:

Rho (ρ_{cal}) – Spearman rank correlation coefficient

d_i – The difference in ranking between respondent for each factors

N – Number of factors (variables)

Procedure for hypothesis testing:

1. Define the null hypothesis (H0) and the alternative hypothesis (HA)

2. Choose a value for ρ . (i.e. choose the significance level)
3. Calculate the value of the test statistic, Rho (ρ_{cal}).
4. Compare the calculated value with a table of the critical values of the test statistic.
5. If the calculated value of the test statistic is less than the critical value from the table, accept the null hypothesis (H_0). If the absolute (calculated) value of the test statistic is greater than or equal to the critical value from the table, reject the null hypothesis (H_0) and accept the alternative hypothesis (H_A).

This was used to check the level of agreement between different groups of respondent during assigning score for different factors of the questionnaire. This was clearly mentioned on the analysis part of the research.

3.6.1. Questionnaire approach

A questionnaire was developed to assess the perceptions of client and end users, consultants, and contractors due to the importance index of causes and effects of construction defects in Federal Government Office Building Projects in Addis Ababa. Types, causes, effects & reducing measures of construction defects in building construction projects in general were first examined and identified through a relevant literature review and then by preparing questionnaire the case was assessed in Federal Government Office Building Projects in Addis Ababa.

3.6.2. Questionnaire design

From literature review it has been discussed about types, causes, effects & reducing measures of construction defects in building projects in various countries around the world and at intervals of time, but not all of these types, causes, effects & reducing measures of construction defects in Federal Government Office Building Projects in Addis Ababa, so it has been selected (91) factors that has an impact in Addis Ababa projects.

The questionnaire questions 70 types of construction defect, 4 causes of construction defect, 8 effects of construction defect and 13 defect reducing measures. The respondents were asked to fill the questionnaire and they were assured that the information will be confidential and used only for research purpose only.

The questionnaire included four parts that are related to types, causes, effects & reducing measures of construction defects in Addis Ababa construction projects, these parts are respondent profile, types and cause of construction defect, effect of construction defect and defect reducing measures.

3.6.3. Respondent profile

Four items were prepared for obtaining information about respondents' organization such as the name of organization, company type (client, consultant or contractor) and respondents' job position. (The questionnaire is included in annex 1)

3.6.4. Types and causes of construction defect

This part of questionnaire consist of 8 categories related to types of construction defect, the categories included 70 types of construction defect, these categories are Foundation related defect; Basement, Beams, Column & Slab related defect; Ceilings, walls, floors, doors and windows related defect; Roof related defect; Water supply system related defect; Electrical system related defect; Fire system related defect; Lift & Escalator related defect; Air condition/Heating system related defect. (The questionnaire is included in annex 1).

3.6.5. Effects of construction defect

This part illustrates the effects of construction defects in building construction project, these factors are the harvest of previous studies and literatures written in similar areas. A total of 8 factors were included in this part. (The questionnaire is included in annex 1).

3.6.6. Construction defect reducing measures

This part illustrates construction defect reducing measures in building construction projects, and similar to effects of construction defect these factors were the harvest of previous studies and literatures written in similar areas. A total of 13 factors were included in this part. (The questionnaire is included in annex 1).

3.7. Respondents' attitude measurement

In this research, Likerts' ordinal scales were used to measure respondent attitude. Ordinal scale is a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned to the agreement or degrees of influence (1, 2, 3, 4 and 5) do not indicate that the intervals between scales are equal nor do they indicate absolute quantities. They are merely numerical labels. Below are Likerts' scale used in this research.

Table 3.2: - Scales that represent level of agreement

Chances of occurrence	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Scale	5	4	3	2	1

Table 3.3: - Scales that represent level importance

Chances of occurrence	Very Important	Important	Moderately Important	Less Important	Not Important
Scale	5	4	3	2	1

3.8. Analysis and Interpretation

Analysis of data collected using check list, questionnaire and reports was done. Based on the analysis there were in depth discussions on the analysis and then finally conclusions were made from the discussion made in the research and recommendations are given for reducing construction defects. In addition some areas of further research were suggested.

Chapter Four: Results and Discussion

4.1. Introduction

This chapter describes the results and discussion of case study and questionnaire survey concerning types, causes, effects and reducing measure of construction defects in Federal Government Building Projects in Addis Ababa from contractors, consultants and client viewpoints. The effects of construction defect on the various stakeholders, on the construction industry, and on the national economy in general were dealt. Finally lists of proposed measures to reduce construction defects were included.

For case study four completed & three under construction a total of seven federal government buildings in Addis Ababa were surveyed, method of sampling was addressed in chapter three (their profile is attached in appendix B). Case study was done by developing checklist to gather data on types and causes of construction defects. During the case study thorough site observation of each building was done and besides to that start of construction, method of construction, completion time and schedule of maintenance of each project was investigated. These were done because construction defects are manifested with age of building, defective method of construction and poor maintenance.

For survey parts of the research questionnaire was developed and distributed to all clients, contractors, consultants & end users of Federal Government Building Projects were included. Their experiences in area of construction defect were investigated. Finally comparison was done between case study & survey study.

4.2. Result and analysis of the case study

During case study which was done on seven buildings and organized in table 4.2 and summarized in table 4.1, a total of 73 construction defects were recorded. Water seepage from external wall, roof, or from ceiling and non-structural crack were the most frequent types of construction defects observed in all case study buildings. Most of the time moisture becomes a danger to building and it can create plenty of problems and might cause building failure. Building resistance to moisture seepage should be enhanced by using different mechanisms. Like providing damp proofing materials at areas which will often experience moisture. Not only the

mechanism but also method of construction for damp proofing work is very important to tackle moisture leakage. This is because usually this type of defect is attributed to poor workmanship. Non- structural crack, usually shrinkage crack, is common in building projects and attributed to poor workmanship. The next frequent defect was broken or loose tiles on floors or wall at toilet and it was observed in 5 buildings. Material quality and method of lining are important for even floor lining finish. This type of defect was observed at area which experienced relatively larger traffic which means not this defect was attributed by large traffic rather this defect was attributed by poor lining of tiles. Three defects, broken or leaking fixtures; defective damp proofing at the roof and poor window frame finish were the third frequent defect with frequency rate of 4 buildings. On occupant buildings defective ceramic wall & floor finish at toilet, defective floor drain at toilet, defective floor finish and poor sanitary fixture were frequent defects. On active projects defective & honeycombing concrete and defective sanitary & electric installation were frequent defects.

Case study analysis showed that 67.8% of the defects were attributed by poor workmanship, 19.7% of the defects were caused by design error. The remaining 8.2% and 4.3% of the defects were attributed by defective material & improper usage respectively.

Table 4.1: - Summary of construction defect from case study

Observed defect	Frequency	Rank
Water seepage from external wall, window, roof, or from ceiling	7	1
Non-structural cracks	7	1
Broken or loose tiles on floors or wall at toilet.	5	2
Broken or leaking fixtures	4	3
Defective damp proofing at the roof	4	3
Poor window frame finish	4	3
Defective floor drains at toilet	3	4
Broken Turkish toilet basin	3	4
Defective skirting	3	4
Water leakage from lift case	3	4
Defective waste water drainage system	3	4

Defective floor finishing	3	4
Defective & Honeycombing concrete	3	4
Uneven floor	2	5
Improper electric conduit installation	2	5
Improper installed drainage down pipe	2	5
Electrical system break down	1	6
Defective fire system equipment	1	6
Defective water pump	1	6
Lack of gate valve that control each toilet room.	1	6
Broken gutter	1	6
Improper junction box location	1	6

Some of the defects, which is important to be explained and respective causes are described below the remaining defects with sources, causes and symptoms of them are summarized in table 4.2.

1. Water seepage through window frames and unpleasant odor

Water seepage through window frame and unpleasant odor was frequent defect in old buildings. In old buildings of mentioned projects window frame used was PVC. This material exhibit dimensional instability when exposed to external weather. Because window is external building parts usually exposed to sunlight, rain and etc.

Fluctuation of temperature causes PVC to exhibit dimensional change and this behavior of PVC cause to loosen window frame connection with wall. Through time tiny openings will be created between window frame and wall and through that opening moisture will leak. The same phenomenon observed on these projects. Similarly, when PVC exposed to sunlight make unpleasant odor and this make occupant unhappy. Long time exposure might cause health problem, like cancer.

This defective was attributed by poor material selection but might be enhanced by defective window frame construction. Because of complaint from users of old building and bad reputation of PVC as a window frame in construction industry, PVC window frame of current building projects was changed to aluminum window frame. In old buildings too it was replaced by aluminum frame.

2. Sewerage line blockage

Typical sewer system of old buildings (Ministry of Health, Ministry of Agriculture and Custom and Revenue Authority) was as follow in the Fig 4.1 below. As shown on the figure after the sludge entered to the septic tank at the inlate allowed passing through compartments with aiming to trap solid waste & letting the water to the soak away pit and there through filtration it joins to ground water. In rainy season the ground water table is raised and it filled the soak away pit. When this happen the soak away pit is no more in function and flowing of water to soak away pit was blocked, then the compartments being full. Finally the sewer line stops functioning.

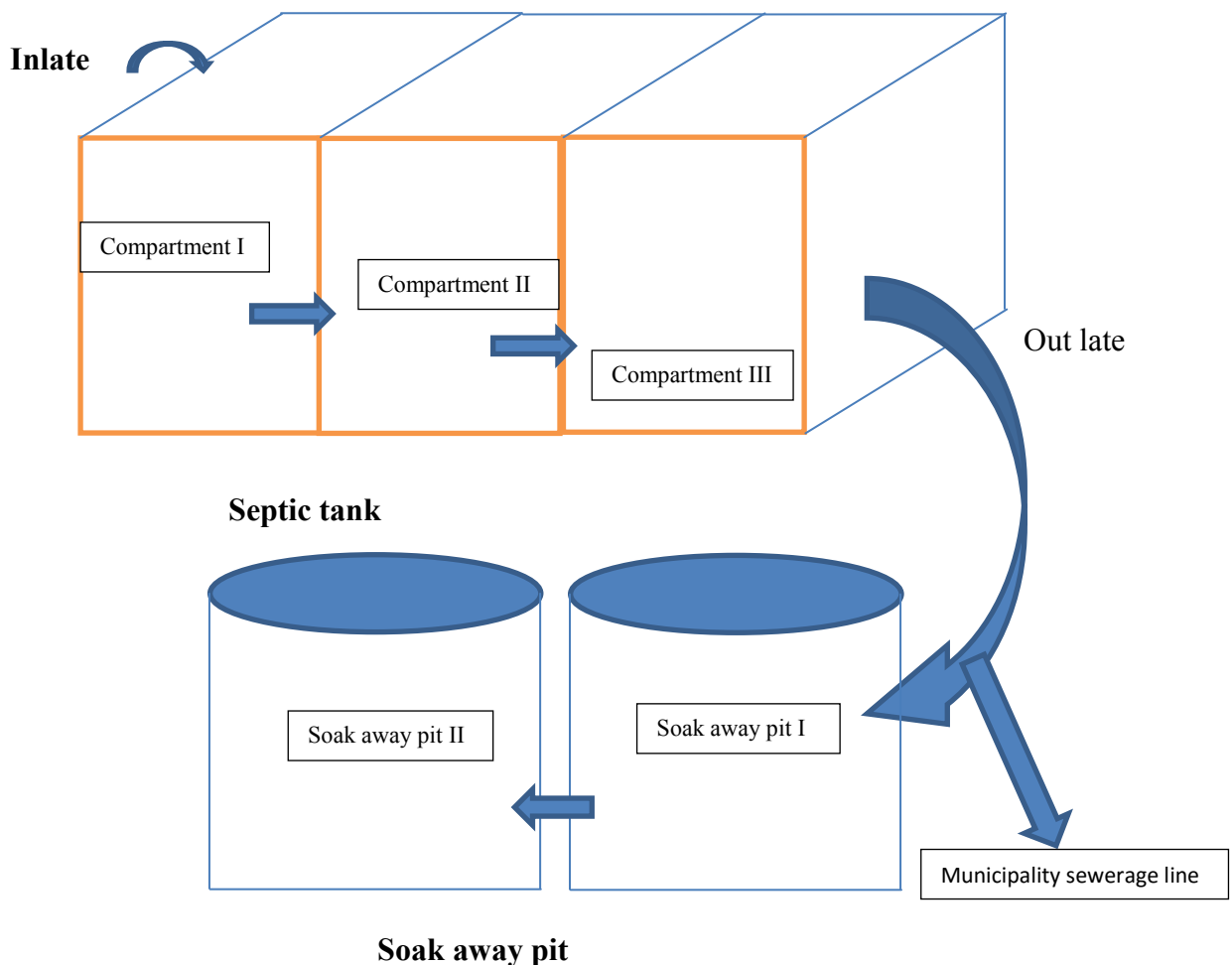


Fig 4.1: – Typical sewerage line

This type of defect was observed in all three buildings. At Custom and Revenue Authority the problem was not because of ground water table raising rather it was because the septic tank and soak away pits were constructed in hard rock. As shown in the fig 4.2 the water flowing to soak away pit cannot drain to the ground rather it drained to the surface



Fig 4.2: – Sludge drains to the surface

At Ministry of health the problem was solved by connecting building sewer line directly to municipality sewer line. At Ministry of Agriculture and Custom and Revenue Authority the problem was not solved and the proposed temporary solution was sucking the waste. Also the client proposed permanent solution which is connecting the sewer line to municipality sewer line at the locality. But this will work if and only if city administration constructs sewer line at that locality. For remaining project design modification was done, connecting building sewer line to municipality sewer line.

The cause of such a defect was design error, not considering the sub-soil condition of the area during design stage of the projects and at the construction stage

3. Defective floor finish

This type of defect was observed at many case study buildings, where floor finish is ceramic floor tile. The defect was break down of ceramic floor tile after getting loose. This problem was observed at area which experienced relatively larger traffic which means not this defect was attributed by large traffic rather this defect was attributed by poor lining of tiles as a result of defective method of construction. Similar problem was observed at toilet wall finish there the ceramic tiles become loose and then fallen down. Unfortunately the same defect was observed in recent projects too. For clarity bellows are pictures captured at these building



Fig 4.3: – Loosen floor tile



Fig 4.4: – Fallen ceramic wall tile

The method of construction adapted was after chiseling the floor pour 1:3 cement to sand ratio mortar then fix tile on it. According to senior site engineers, this method of construction requires highly experienced workmanship unless otherwise it is difficult to attain level surface beneath the tile which in turn after continuous trafficking cause tile break. According to senior engineers

the method of construction which will reduce this problem was leveling the sand first to required lift thickness then pour the paste on it finally tiles should be laid on it. This method of construction is good for drain too. For under construction projects this method was adapted.

4. Water leakage to lift case

Water leakage to lift case was among one of common defects observed in case study building. This defect was observed in buildings constructed respectively in low areas and the defect was seasonal. In rainy season, when the ground water raised, the water leaks to the lift case. Then cause frequent lift stoppage and electric shock.

This defect was attributed by design error, poor soil investigation, which was manifested in low capacity water proofing material selection. Asphalt lining in the internal part of the lift case was applied as water proofing material but because the pressure is relatively high the water easily leaks to the lift case. Instead membrane lining or cementitious waterproofing materials have high water resisting capacity. Other possible cause to this problem was not providing drain pipe at the periphery masonry of the building. As shown in the figure below the lift case was filled with water. The solution proposed and expected to be implemented soon is lining water proofing materials in layers to the internal parts of the lift case.



Fig 4.5: - Lift case filled with water

5. Defective floor drain

It is common to experience floor drain problem in many buildings in Addis Ababa. And this defect was observed in case study projects. The defect occurred because of poor floor finish at the toilet, not providing optimum slope which can let the water flow to floor drain. The water dripped from hand wash basin and urine set accumulate on the floor then cause unpleasant odor. This defect was attributed by poor workmanship.

The solution proposed to this problem was after removing the existing ceramic floor tiles adjust the slope then providing a floor finish.

6. Unpleasant odor spell out from floor drain

Unpleasant odor coming out from floor drain was observed in old case study buildings; there the floor drain was not constructed by providing S-trap. This problem happened because of fermentation of sewage at septic tank. During fermentation (chemical reaction which forms gases) gases have been produced and then search opening to escape. During this journey the gases come to water closet and floor drains before reaching a tube, which was constructed for this purpose. At water closet the gases were entrapped by water at S-trap but it escaped from floor drain.



Fig 4.6: - Defective floor drain

The possible cause of such a defect was design error, not providing S-trap at floor drains during design. Also the contractor should be responsible for this defect because the contractor shall notice such obvious design error. The possible solution to this problem was re-constructing floor drain by providing S-trap.

7. Frequent stoppage of electric power

Frequent stoppage of electric power is type of defects on building service. In case study buildings it was observed. The cause to frequent electric stoppage was unbalance of electric power provided and required. Provided electric power was less than required. Usually this type of defect was attributed by design error, poor estimation of required electric power.

The designer blames the client on bases of that it was not given the estimated number of building users. Interview held with client representative assure the blame was right. According to the interviewed majority of buildings constructed by Federal Government Building Project Office have similar typology which was adapting a single design. That is incorrect because every project is unique by itself, situation which work on one building might not work on other. So, building end users shall participate on the project starting from design stage. The solution implemented was installing a new electric system that can supply required electric power. Some parts of the previous electric line were demolished.

8. Water seepage from external wall, roof, toilet or from ceiling

Water seepage to internal parts of a building was the most frequent type of defect observed in case study buildings. The defect occurred because of poor prevention of moisture. Most of the time moisture becomes danger to building and it can create plenty of problems and might cause building failure. Building resistance to moisture seepage should be enhanced by using different mechanisms. Like providing damp proofing materials at areas which often experience moisture. Not only the mechanism but also method of construction for damp proofing work is very important to tackle moisture leakage. It is difficult to stop moisture leakage but it can be reduced by implementing defect free construction.

Observed defective prevention areas were at parapet wall, roof & external wall. There the copping, damp proofing & external wall finishing were defective. Literarily this defect was

attributed by poor workmanship. Small portion of this defect might be caused by improper usage of building service, like putting large mass on the top of the roof and accumulations of dusts at gutter openings. Below are figures taken from defective building. For ease of understanding the remaining defects were tabulated next to it.



Fig 4.7: – dust accumulated at gutter opening



Fig 4.8: – Fractured water proofing membrane



Fig 4.9: – Ceiling leakage



Fig 4.10: – Roof slab leakage

Table 4.2: – List of construction defects on case study projects

No.	Project Name	Observed defect	Symptoms	Main causes
1	Ministry of Health	Broken or loose tiles on floors or wall at toilet.	Departing and falling down of ceramic tiles from wall, Water stagnating on the floor	Poor workmanship
		Defective floor drains at toilet	Unpleasant odor because of not providing S-trap & nonfunctional	Poor workmanship & Design
		Broken or leaking fixtures	Water dripping at fixtures	Poor workmanship
		Broken Turkish toilet basin	Water & waste flows out to floor at the time of flushing	Defective material
		Defective skirting	Loosen & fallen down of skirting	Poor workmanship
		Electrical system breakdown	Nonfunctional & loose light point	Defective material
		Non-functioning of fire system equipment	Nonfunctional fire hose mostly because of can't get water from the reservoir	Poor workmanship
		Defective water pump	Nonfunctional water pump	Defective material
		Water seepage from external wall, roof, toilet or from ceiling	Water staining, Peeling off of paint or wall paper, Water dripping, Defective concrete, plaster or tile, Rust staining	Poor workmanship
		Water leakage to lift case	Lift case filled with water	Design error
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Lack of gate valve that control each toilet room.	Difficulty at time of maintenance	Design error
		Defective waste water drainage system	Unpleasant odor, toilet basin getting filled, Nonfunctional septic tank, Nonfunctional soak away pit	Poor workmanship
Defective damp proofing at the roof	Water staining, Peeling off of paint or wall paper, Water dripping,	Loading a big mass at the roof & un proper usage		

No.	Project Name	Observed defect	Symptoms	Main causes
2	Ministry of Agriculture	Broken or loose tiles on floors or wall at toilet.	Departing and falling down of ceramic tiles from wall, Water stagnating on the floor	Poor workmanship
		Defective floor drains at toilet	Unpleasant odor because of not providing S-trap & non functional	Poor workmanship & Design error
		Broken or leaking fixtures	Water dripping at fixtures	Poor workmanship
		Broken Turkish toilet basin	Water & waste flows out to floor at the time of flushing	Defective material
		Broken or loose tiles on floors	Loosen & broken down of floor tile	Poor workmanship
		Broken gutter	Nonfunctional gutter	Un proper usage
		Water seepage from external wall, roof, or from ceiling	Water staining, Peeling off of paint or wall paper, Water dripping, Defective concrete, plaster or tile, Rust staining	Poor workmanship
		Water leakage from lift case	Lift case filled with water	Design error
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Defective damp proofing at the roof	Water staining, Peeling off of paint or wall paper, Water dripping,	Loading a big mass at the roof, poor maintenance & un proper usage
		Defective waste water drainage system	Unpleasant odor, toilet basin getting filled,	Poor workmanship
		Electric system breakdown	Frequent stoppage of electric power	Design error
Poor window frame finish	Water seepage through window frames and bad odor	Defective material, poor workmanship		

No.	Project Name	Observed defect	Symptoms	Main causes
3	Custom & Revenue Authority	Broken or loose tiles on floors or wall at toilet.	Departing and falling down of ceramic tiles from wall, Water stagnating on the floor	Poor workmanship
		Defective floor drains at toilet	Unpleasant odor because of not providing S-trap & non functional	Poor workmanship & poor design
		Poor sanitary system fixture	Water dripping at fixtures	Poor workmanship
		Broken Turkish toilet basin	Water & waste flows out to floor at the time of flushing	Defective material
		Uneven floor	Loosen & broken down of floor tile	Poor workmanship
		Poor window frame finish	Water seepage	Poor workmanship
		Water seepage from external wall, roof, or from ceiling	Water staining, Peeling off of paint or wall paper, Water dripping, Defective concrete, plaster or tile, Rust staining	Poor workmanship
		Water leakage from lift case	Lift case filled with water	Design error
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Defective damp proofing at the balcony	Water staining, Peeling off of paint or wall paper, Water dripping,	Poor workmanship
		Defective waste water drainage system	Unpleasant odor, toilet basin getting filled, Nonfunctional septic tank, Nonfunctional soak away pit	Poor workmanship
Defective skirting	Loosen & fallen down of skirting	Poor workmanship		
Improper junction box location	Number of socket lines on the floor	Design error		

No.	Project Name	Observed defect	Symptoms	Main causes
4	Ministry of Foreign Affairs	Broken or loose tiles on floors or wall at toilet.	Departing and falling down of ceramic tiles from wall, Water stagnating on the floor	Poor workmanship
		Poor sanitary system fixture	Water dripping at fixtures	Poor workmanship
		Uneven floor	Loosen & broken down of floor tile	Poor workmanship
		Water seepage from external wall, window, roof, or from ceiling	Water staining, Peeling off of paint or wall paper, Water dripping, Defective concrete, plaster or tile, Rust staining	Poor workmanship
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Defective skirting	Loosen & fallen down of skirting	Poor workmanship
5	Ministry of Foreign Affairs (Conference Hall)	Uneven floors	Very thick mortar under floor tile	Poor workmanship
		Poor damp proof membrane lining	Folding at parapet wall, accumulation of dusts	Poor workmanship
		Untidy joints between window frame and wall	Gaps at window frame corner	Poor workmanship
		Defective & Honeycombing concrete	Exposed steel reinforcement, spalling of concrete	Poor workmanship
		Water seepage from external wall, roof, or from ceiling	Water staining	Poor workmanship
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Improper electric conduit installation	Demolishing the previous and then installing new line	Design error

No.	Project Name	Observed defect	Symptoms	Main causes
6	Ministry of Science & Technology	Broken or loose tiles on floors or wall at toilet.	Departing and falling down of ceramic tiles from wall	Poor workmanship
		Defective stair marble flooring	Loosen & broken marble at stair	Poor workmanship
		Untidy joints between window frame and wall	Gaps at window frame corner, rain water entering	Poor workmanship
		Defective & Honeycombing concrete	Exposed steel reinforcement, spalling of concrete	Poor workmanship
		Water seepage from external wall, roof, or from ceiling	Water staining	Poor workmanship
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Fire system not included in the design	Chiseling for installation	Design error
		Defective electric conduit installation	Demolishing the previous and then installing new line	Design error
7	Urban Integrated Land Information System Development	Improperly installed drainage down pipe	Chiseling at new installation point	Design error
		Defective & Honeycombing concrete	Exposed steel reinforcement, spalling of concrete	Poor workmanship
		Water seepage from external wall, roof, or from ceiling	Water staining	Poor workmanship
		Non-structural cracks	Hairline cracks, Multi-directional cracks (shrinkage cracks), Cracks between walls and structural elements	Poor workmanship
		Uneven floors	Chiseling the excess	Poor workmanship
		Defective sanitary installation	Sanitary line installed over concrete slab.	Design error
		Improperly installed drainage down pipe	Chiseling at new installation point	Design error

4.3. Results of Questionnaire Analysis

The types, causes, effects & proposed measure to reduce building defects from the questionnaire survey were identified based on respondents' response on each type of construction defects. Construction defects identified in different books & research outputs, as indicated in the literature review part of this thesis, might not be the types of construction defect occurred in federal government building projects, hence it is important to ask the respondents for their agreement on each types of building defects, then this was accompanied by identification of causes of construction defects based on their occurrence. Finally effects of construction defect & measures should be adapted to reduce the impact of construction defect were identified based on respondent response rate.

4.3.1. Population characteristics

This part mainly designed to provide general information about the respondents in terms of the name of company type, position and experience of contact person.

4.3.1.1. Type of respondent's organization

In this study, 40% (16) owners & end users, 30% (12) contractors and 30% (12) consultants participated in the questionnaire; method of selection was addressed in chapter three. The general response rate for contractors, owners and consultants was 75% and the total numbers of respondents for the three parties were 30 out of 40 expected respondents. The response rate of contractors were 75 % (9 out of 12 respondents), for the owners & end users 75 % (12 out of 16 respondents) and 75 % (9 out of 12 respondents) for consultants.

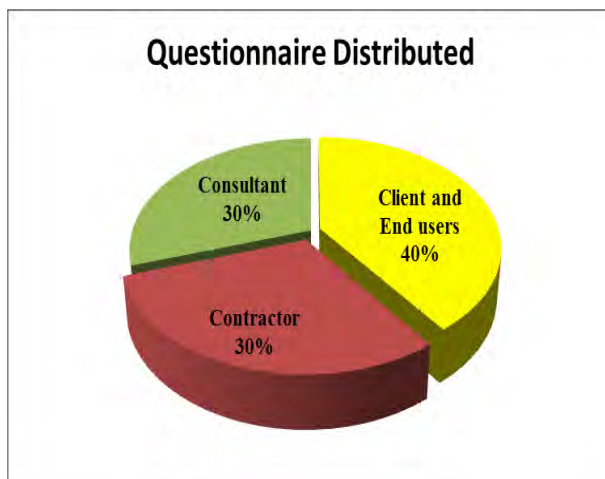


Fig 4.11: – Questionnaire distributed

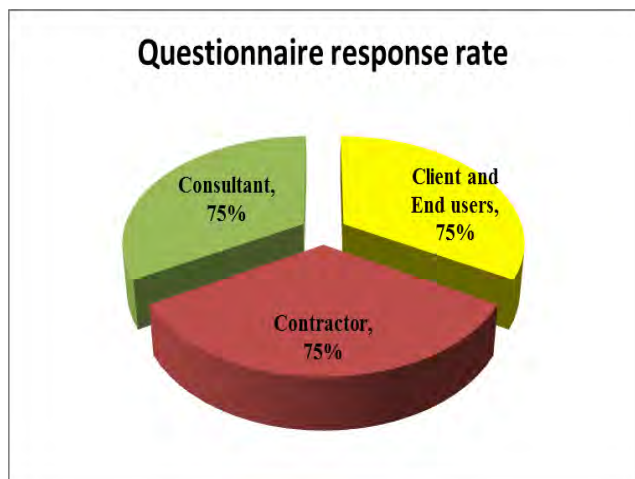


Fig 4.12: – Questionnaire response rate

Table 4.3: - Respondent organization

Name of Respondent Company	Questionnaire Distributed	Questionnaire Returned	Response Rate
Client and End users	16	12	75%
Contractor	12	9	75%
Consultant	12	9	75%

4.3.1.2. Respondents job positions

Table 4.4 shows that 91.67 % (11) of clients & end users respondents were site engineers and 8.33 % (1) was project manager. It has been found that 22.2 % (2) of contractors respondents were project managers, 77.8 % (7) were site engineers. It has been found that 88.8 % (8) of the consultants respondents were resident engineers, 11.1 % (1) was assistant resident engineer. Totally out of 30 respondents of the three parties, 60.0 % (18) of the respondents were site engineers, 26.67 % (8) were resident engineers, 10.0 % (3) were projects managers and 3.33 % (1) was assistant resident engineer.

Table 4.4: - Respondent job position

Respondents job positions	Client and End users	Contractor	Consultant
Resident engineer	--	--	8
Project manager	1	2	--
Assistant resident engineer	--	--	1
Site engineer	11	7	--

4.3.2. Types and causes of construction defect

4.3.2.1. Clients' view

Table 4.5 shows that clients & end users ranked broken or loose tiles on floors or wall as the most frequent types of defect with a mean score of 4.45 which is also the most frequent defect according to consultants with a mean score of 3.33. On the case study it was among frequent defect. Usually this problem might be observed at area which experienced relatively larger traffic which means not this defect was attributed by large traffic rather this defect was attributed by poor lining of tiles. Sometimes this defect may be attributed by defective material. The next frequent

defect was water seepage through windows and doors with a mean score of 4.42. Even if contractors ranked it 10th, in the opinion of consult it was the third frequent defect and on the case study it was observed. Mostly this defect is attributed by poor workmanship, poor installation of window and door frames. Water seeps through openings between window or door frame & wall or window sill.

The third frequent defect in the opinion of client & end users was defective floor, wall & external finish with a mean score of 4.25. This shows even the floor beneath broken tile (the most frequent defect) was defective. Contractor didn't agree with this but consultants ranked as the third frequent defect. On the case study it was the most frequent defect and cause of the defect is poor workmanship. The fourth frequent defect was doors, hinges, and latch/lock mechanisms needing adjustment or repair with a mean score of 4.17. Consultants & contractors didn't agree with this, in opinion of them there are other defects which occur more frequently than this. This defect occur either because of defective material or poor installation of window or door set. The fifth frequent defects were shrinkage cracks on plastering and broken or leaking sanitary fixtures both with a mean score of 4.08. Consultants agree with this even in the opinion of consultant the third frequent defect. On the case study it was the most frequent defects observed on all buildings. The cause of defects is poor workmanship. Broken or leaking sanitary fixtures at toilet pose health problem on the tenants.

Client and end users ranked three defects as the sixth frequent defect with a mean score of 4.0, floors moisture leakage, exposed steel reinforcements and defective shower or water fixtures. These defects attributed by poor workmanship. The most frequent defects in the opinion of client and end users were often caused by poor workmanship, this shows the causes are emerged from labors & workforce employed by contractor.

4.3.2.2. Consultants' view

Table 4.5 shows that consultant ranked broken or loose tiles on floors or wall as the most frequent types of defect with a mean score of 3.33 which is also the most frequent defect in the opinion of client & end user with a mean score of 4.45. On the case study it was among frequent defect. The causes of the defect was mostly because of poor workmanship, sometimes it may attributed by defective material. The next frequent defect was floors moisture leakage with a mean score of 3.25. Even if

contractors ranked it 19th, in the opinion of client it was the 7th frequent defect and on the case study it was observed. Mostly this defect is attributed by poor workmanship, poor concreting of slabs.

Five defects ranked as the third frequent defect with a mean score of 3.17, water seepage through windows & doors; defective floor, wall & external finish; shrinkage cracks on plastering; water damage or stains on ceilings, walls or floors; structural cracks on floors and/or wall. The first two were the 2nd & 3rd frequent defects in the opinion of client and often attributed by poor workmanship. Causes of structural cracks on floors and/or wall are design error, defective material or poor workmanship. This shows how frequent these defects are but contractors didn't agree with consultants, contractors ranked above 10th.

Similar to client & end users, the most frequent defect in the opinion of consultant too often attributed by poor workmanship. This shows contractor take a highest share on attributing construction defects on building projects.

Table 4.5: - Types of defect from client & end users, consultant & contractor point of view

Construction defect	Client & End user		Contractor		Consultant		Weighted Average	
	Msi	Rank	Msi	Rank	Msi	Rank	Msi	Rank
Broken or loose tiles on floors or wall	4.45	1	4.13	6	3.33	1	4.02	1
Water seepage through windows and doors	4.42	2	4.00	10	3.17	3	3.92	2
Defective floor, wall & external finish	4.25	3	3.88	19	3.17	3	3.81	3
Doors, hinges, latch/lock mechanisms needing adjustment or repair	4.17	4	4.00	10	3.08	8	3.79	4
Shrinkage cracks on plastering	4.08	5	3.88	19	3.17	3	3.75	5
Broken or leaking sanitary fixtures	4.08	5	3.88	19	3.00	12	3.70	9
Floors moisture leakage	4.00	7	3.88	19	3.25	2	3.74	6
Exposed steel reinforcements	4.00	7	4.00	10	3.00	12	3.70	8
Defective shower or water fixtures	4.00	7	3.88	19	3.00	12	3.66	10
Non-structural cracks	3.92	10	3.88	19	3.00	12	3.63	11
Toilets not securely anchored	3.92	10	3.88	19	2.92	22	3.60	14
Lift occasional overrun	3.92	10	3.88	19	2.83	32	3.58	16
Honeycombing of concrete	3.83	13	4.00	10	2.75	39	3.56	19
Water damage or stains on ceilings, walls or floors	3.83	13	4.13	6	3.17	3	3.72	7
Paint peeling on façade faces of wall	3.83	13	4.00	10	2.92	22	3.61	13
Bathroom sinks not securely fastened or functioning properly	3.83	13	3.88	19	3.08	8	3.62	12

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Signs of leaks or clogged drains	3.75	17	3.88	19	2.83	32	3.51	21
Dampness on basements, beams, columns and/or slabs	3.75	17	3.75	32	2.92	22	3.50	22
Non-functioning of fire resisting equipment	3.75	17	3.88	19	2.75	39	3.49	25
Detachment of plastering	3.67	20	4.00	10	3.00	12	3.57	17
Broken or damaged exterior doors, locks, handles or hinges	3.67	20	4.25	1	2.83	32	3.59	15
Improperly sloped gutters	3.67	20	3.75	32	3.00	12	3.49	24
Defective lift & escalator functioning	3.58	23	3.75	32	2.75	39	3.38	29
Seepage or leakage underside of roof	3.58	23	4.00	10	2.83	32	3.48	26
Wall dimensional instability	3.50	25	4.25	1	2.92	22	3.55	20
Ceiling and wall joint separation	3.42	26	3.63	44	2.92	22	3.33	33
Displacement of walls	3.42	26	3.63	44	2.75	39	3.28	38
Broken window glazing, frames, locks or opening mechanisms	3.42	26	4.25	1	3.08	8	3.57	18
Rainwater runoff from roof not channeled away from entrances	3.42	26	3.63	44	2.92	22	3.33	33
Small cracks on basements, beams, columns and/or slabs	3.33	30	4.13	6	3.08	8	3.50	23
Structural cracks on floors and/or walls	3.33	30	3.50	50	3.17	3	3.33	31
Straps missing or not nailed properly	3.33	30	3.75	32	2.92	22	3.33	32
Roof sagging	3.33	30	3.50	50	3.00	12	3.28	35
Sudden rise in water consumption	3.33	30	3.75	32	2.75	39	3.28	37
Lift & escalator stoppage	3.33	30	3.50	50	3.00	12	3.28	35
Ceiling unevenness and unevenly applied texture	3.25	36	4.00	10	3.00	12	3.40	28
Gutters clogged with debris	3.25	36	3.63	44	2.75	39	3.21	47
Insecurely fastened, damaged or missing gutter or leader sections	3.25	36	3.75	32	2.75	39	3.25	43
Loose junction boxes for switches Or convenience outlets	3.25	36	4.25	1	2.75	39	3.40	27
Electrical switches or outlets not working	3.25	36	4.25	1	2.67	50	3.38	30
Not cool enough and/or warm enough of air conditioning	3.25	36	3.50	50	2.67	50	3.15	52
Noisy, no air movement of air conditioning	3.25	36	3.88	19	2.67	50	3.26	41
Poor functioning of heat system	3.25	36	3.63	44	2.67	50	3.19	49
Salt attack on structural members	3.17	44	3.50	50	2.75	39	3.14	53
Damaged roof sheathing	3.17	44	3.75	32	2.83	32	3.24	44
Roof cracking	3.17	44	3.50	50	2.75	39	3.14	53
Distortion of roof or wall at roof level	3.17	44	3.50	50	2.92	22	3.19	48
Inadequate pressure or water flow at fixtures	3.17	44	3.75	32	2.92	22	3.27	40
Stoppage of electrical supply	3.17	44	3.88	19	2.67	50	3.23	45
Uneven floors	3.08	50	3.63	44	3.00	12	3.22	46

Damaged roof trusses	3.08	50	3.50	50	2.92	22	3.16	51
Poor protection of service entrance electrical wires	3.08	50	4.13	6	2.67	50	3.27	39
Fire alarm not working	3.08	50	3.75	32	2.75	39	3.18	50
Electrical system breakdown	3.00	54	4.00	10	2.83	32	3.25	42
Stoppage of heating system	3.00	54	3.75	32	2.67	50	3.13	55

4.3.2.3. Contractors' view

Table 4.5 shows that contractor ranked five types of defect, broken or damaged exterior doors, locks, handles or hinges; wall dimensional instability; broken window glazing, frames, locks or opening mechanisms; loose junction boxes for switches or convenience outlets; electrical switches or outlets not working as the most frequent types of defect with a mean score of 4.25, which were ranked 8th and above by clients & end users and consultants. The majority of the defects were caused by defective materials and some of the defects were attributed by poor workmanship.

The next frequent defects in the opinion of contractor were broken or loose tiles on floors or wall (The most frequent defect in the opinion of clients & end users); water damage or stains on ceilings, walls or floors (the 3rd frequent defects in the opinion of consultant); small cracks on basements, beams, columns and/or slabs; poorly protected service entrance electrical wires with a mean score of 4.13. Often the causes are because of poor workmanship.

Similar to other respondent, the most frequent defect in the opinion of contractors too often attributed by poor workmanship. This shows contractor witnessed on themselves, majority of defects on building are caused because of contractor related fault.

Table 4.6 shows causes of construction defects according to respondent, client & end users said 58.16% of construction defect were caused by poor workmanship, 26.84% because of defective material and the remaining 12.11% and 2.89% of construction defect were caused by design error and poor subsurface investigation respectively. According to contractor 47.85% of construction defects were caused by poor workmanship, 37.82% because of defective material and the remaining 8.31% and 6.02% of construction defect were caused by design error and poor subsurface investigation respectively. According to consultants 51.23% of construction defects

were caused by poor workmanship, 26.40% because of defective material and the remaining 18.79% and 3.58% of construction defect were caused by design error and poor subsurface investigation respectively. Over all 52.41% of construction defects were caused by poor workmanship, 30.35% were because of defective material and the remaining 13.07% and 4.16% of construction defects were caused by design error and poor subsurface investigation respectively.

Table 4.6: - Causes of defect from client & end users, consultant & contractor point of view

Causes of defect	Client and End users (%)	Contractor (%)	Consultant (%)	Overall Analysis
Design error	12.11	8.31	18.79	13.07
Workmanship error	58.16	47.85	51.23	52.41
Defective material	26.84	37.82	26.40	30.35
Poor subsurface investigation	2.89	6.02	3.58	4.16

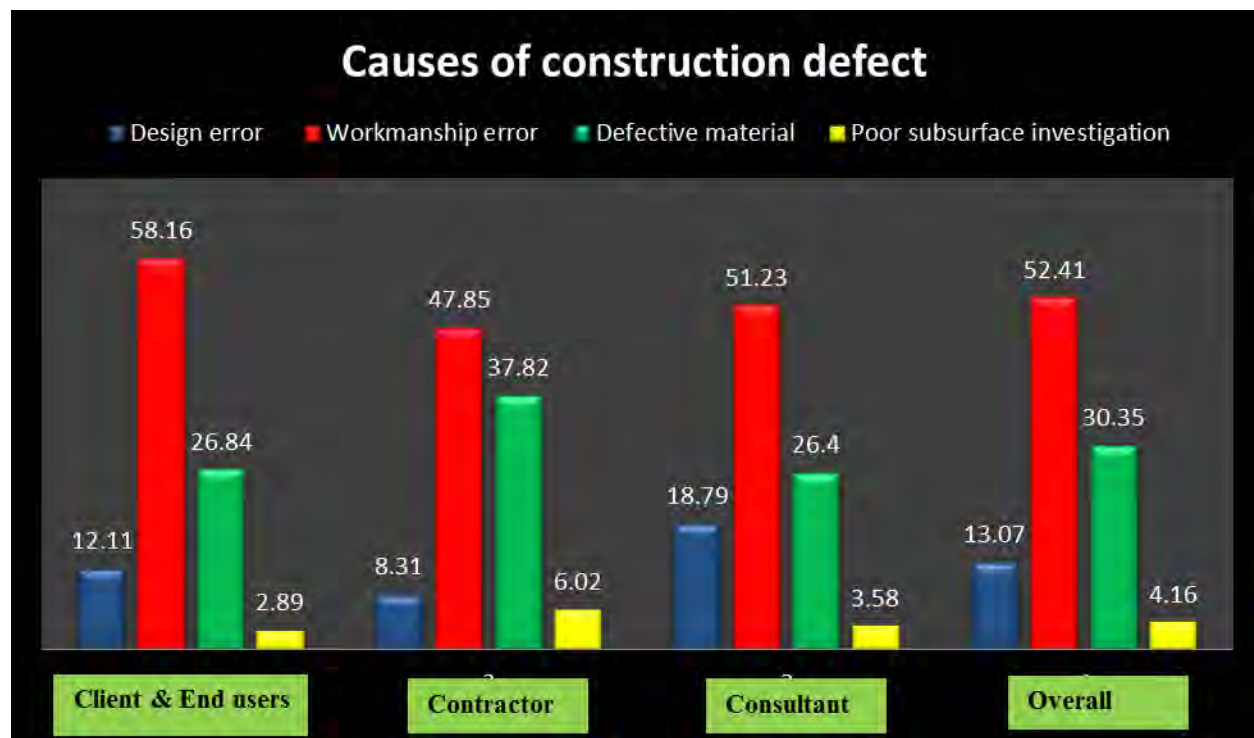


Fig 4.13: – Causes of construction defects

4.3.3. Effects of construction defects

Table 4.7 shows that clients and end user ranked construction cost overrun as the biggest impacts of construction defects with a mean score of 4.15. Hence, occurrences of construction defects highly affect construction project budget. Contractors & consultants agree on that by ranking construction cost overrun as the 3rd & 2nd effects of construction defect with a mean score of 4.13 & 4.25 respectively. Client & end users ranked project delay as next biggest impact with a mean score of 4.42, which was the first according to contractors and consultants with a mean score 4.25 and 4.38 respectively. This shows 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. Finally this may cause disputes between contracting parties.

Clients and end user ranked high maintenance cost as the third effects of construction defects with a mean score of 4.33. This was ranked as 1st and 3rd according to contractors & consultants with a mean score of 4.25 and 4.13 respectively. This shows client incurred additional expense for maintenance because of construction defect, which might not be parts of original budget. Often maintenance cost is not budgeted for project. Literarily, occurrences of construction defects increase clients'' expense on the project. The 4th effect of construction defect on sight of client & end users was negatively affect contractor and/or consultant reputation with a mean score of 4.08, this was the 4th and 8th effect in the opinion of contractor & consultant with a mean score of 3.88 and 3.75 respectively. Defective construction firm will suffer bad reputation then might lose competitiveness on market. Often construction firms are business companies, loss of competitiveness forced companies to close, and then affect the industry.

Clients and end user ranked decrease the value of project & decrease project functionality as the fifth effects of construction defects with a mean score of 4.00. Which were 5th & 4th and 8th and 6th in the opinion of contractors and consultants with a mean score of 3.25 & 4.00 and 2.88 & 3.88 respectively. Occurrence of construction defect reduces the value & functionality of projects. And highly affects tenants and/or users comfort. Unlike types of construction defects respondent shows some degree of agreement on effects of construction defects.

Table 4.7: - Effects of defect from client & end users, consultant & contractor point of view

Effects of construction defects	Client & End user		Contractor		Consultant		Weighted Average	
	Msi	Rank	Msi	Rank	Msi	Rank	Msi	Rank
Construction cost overrun	4.50	1	4.13	3	4.25	2	4.31	2
Project delay	4.42	2	4.25	1	4.38	1	4.35	1
High maintenance cost	4.33	3	4.25	1	4.13	3	4.25	3
Negatively affect contractor and/or consultant reputation	4.08	4	3.88	4	3.75	8	3.92	4
Decrease the value of project	4.00	5	3.25	5	4.00	4	3.78	5
Decrease project functionality	4.00	5	2.88	8	3.88	6	3.63	6
Risk of possible danger on the tenant and/or passenger	3.42	7	3.13	6	3.88	6	3.47	7
High disputes and possible loss of building	3.17	8	3.00	7	4.00	4	3.37	8

4.3.4. Defect reducing measures

Table 4.8 shows that clients and end user ranked periodic and regular construction site supervision as very important measures to reduce occurrence of construction defects with a mean score of 4.58, which was ranked 5th and 1st in the opinion of contractors and consultants with a mean score of 4.13 and 4.75 respectively. This shows periodic and regular construction site supervision is very important factor to reduce construction defects. Often consultants are responsible for site supervision. Majority of defects were attributed by poor workmanship and this problem might be highly reduced by periodic and regular construction site supervision. Clients and end user ranked all building systems need to be coordinated concurrently, starting with the planning phase and continuing into the programming and implementation phases as the next important measure with a mean score of 4.50, which was the 1st and 6th important measure in the opinion of contractors & consultants with a mean score of 4.38 and 4.38 respectively. Construction projects require team works of different parties engaged on the project. So, coordination of different stage of construction plays a vital role to reduce construction defects.

Implement a comprehensive quality control mechanism was ranked as the 3rd important measure in the opinion of clients & end users to reduce occurrence of construction defects with a mean

score of 4.42, which was the 2nd according to contractor and consultants with a mean score of 4.25 and 4.63 respectively. This shows how quality control mechanism is important to reduce construction defect on building projects. Contract documents shall fully incorporate quality control mechanism in order to implement defect free construction and contractors shall implement and consultants shall check its effectiveness. Increased and improved feedback to the designer from all concerned bodies was ranked as the 4th important measure by clients & end users to reduce occurrence of construction defects with a mean score of 4.08, contractors and consultants ranked 7th and 4th with a mean score of 4.00 and 4.50 respectively. Architects & engineers might make errors during design stage of projects, which might cause construction defect unless otherwise revised. To reduce occurrence of construction defects designers should receive feedbacks from contractors, client engineers or other concerned bodies.

The fifth important measure to reduce construction defect in the opinion of client & end users was creating awareness to low-skilled laborers with a mean score of 4.00. Laborers are not professionals and have little knowledge of engineering, so providing training before allowing working on project is important to reduce occurrence of construction defects. Better and more reliable guidance on commissioning building and their services and on defect avoidance; developing capacity of universities and training institution were the 2nd important measures according to contractors with a mean score of 4.25. Continuous evaluation of the capacity of consulting and construction firm was ranked 2nd and regular on-the-job training was ranked as the 4th important measure by consultants with a mean score of 4.63 and 4.50 respectively.

Table 4.8: - Building defect reducing measure from client & end users, consultant and contractor point of view

Defect reducing procedures	Client & End user		Contractor		Consultant		Weighted Average	
	Msi	Rank	Msi	Rank	Msi	Rank	Msi	Rank
Periodic and regular construction site supervision	4.58	1	4.13	5	4.75	1	4.50	1
All building systems need to be coordinated concurrently, starting with the planning phase and continuing into the programming and implementation phases.	4.50	2	4.38	1	4.38	6	4.43	3

Implement a comprehensive quality control mechanism	4.42	3	4.25	2	4.63	2	4.43	2
Increased and improved feedback to the designer from all concerned bodies	4.08	4	4.00	7	4.50	4	4.18	4
Creating awareness to low-skilled laborers	4.00	5	4.00	7	4.25	9	4.08	7
Proper and periodic maintenance	3.83	6	3.88	9	3.63	12	3.78	10
Regular on-the-job training	3.83	6	4.13	5	4.50	4	4.12	5
Better and more reliable guidance on commissioning building and their services and on defect avoidance	3.83	6	4.25	2	4.25	9	4.08	6
Continuous evaluation of the capacity of consulting and construction firms	3.83	6	3.75	11	4.63	2	4.05	9
Develop the capacity of universities and training institution	3.67	10	4.25	2	4.38	6	4.05	8
License cancelling of more frequent defective construction organs	3.25	11	3.13	13	2.75	13	3.06	13
An improvement on the lowest tender system	3.17	12	3.25	12	3.75	11	3.37	12
Improving the quality of graphical and written communication	3.17	12	3.88	9	4.38	6	3.74	11

4.3.5. Tests for Agreements on Types, Effects and Reducing measures of Construction Defect Among Stakeholders in the Construction Industry

One of the purposes of this thesis is to investigate whether there is an agreement or not on the attitudes of stakeholders towards the types, effects & reducing measures of construction defects in Federal Government Building Projects 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 & End users versus Contractors; Contractors versus Consultants; and Clients & End users 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 consensus of opinions exist among respondents.

The Null Hypothesis (H₀) is: -There is no agreement in the ranking of types, effect & reducing measures of construction defects between two groups of respondents.

The Alternative Hypothesis (H_A) is: -There is agreement in the ranking of types, effect & reducing measures of construction defects between two groups of respondents.

The spearman correlation coefficient (ρ) is calculated using Equation 3.3 and tabulated as shown below in Table 4.9

In order to decide whether to accept or reject the null hypothesis, the level of significance 95% ($P = 0.05$) is used. This allows to state whether or not there is "agreement" between respondents response.

If the calculated value of ρ is greater than the critical value, H_0 is rejected, i.e. there is evidence of a statistically significant agreement between the groups. If the calculated value of ρ is less than the critical value, H_0 is accepted, i.e. there is no evidence of a statistically significant agreement between the two groups.

Table 4.9: - Summary of correlation test on the ranking of types of construction defects

Respondents	Rho (ρ_{cal}) = $1 - \frac{6 \cdot (\sum d_i^2)}{N \cdot (N^2 - 1)}$	Critical value of ρ (Appendix B)	Significance for $P < 0.05$
Client & end user Vs. Contractor	0.424	0.225	significant reject
Client & end user Vs. Consultant	0.604	0.225	significant reject
Contractor Vs. Consultant	0.162	0.225	significant accepted

In this case, with a significance level of 95% ($P = 0.05$), the calculated value of ρ for the first two group cases are greater than the critical values of ρ , so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected and for the last group case the calculated value of ρ less than the critical value of ρ , so the hypothesis that there is no significant agreement between the respondents is accepted i.e. the null hypothesis is accepted.

From table 4.9 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors, clients & end users and consultants and hence the null hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that

the respondents on these groups have the same perception about types of construction defects. It can be also concluded that there is no correlation between the attitudes of contractors and consultants and hence the null hypothesis should be accepted. This means that contractors and consultant have different perception about types of construction defects.

Table 4.10: - Summary of correlation test on the ranking of effects of construction defects

Respondents	Rho (ρ_{cal}) = $1 - \frac{6 \cdot (\sum d_i^2)}{N \cdot (N^2 - 1)}$	Critical value of ρ (Appendix B)	Significance for $P < 0.05$
Client & end users Vs. Contractor	0.762	0.6429	significant reject
Client & end users Vs. Consultant	0.560	0.6429	significant accepted
Contractor Vs. Consultant	0.583	0.6429	significant accepted

In this case, with a significance level of 95% ($P = 0.05$), the calculated value of ρ for the first group cases are greater than the critical values of ρ , so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected and for the remaining two group case the calculated value of ρ less than the critical value of ρ , so the hypothesis that there is no significant agreement between the respondents is accepted i.e. the null hypothesis is accepted.

From table 4.10 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors and hence the null hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that the respondents on these groups have the same perception about effects of construction defects. It can be also concluded that there is no correlation between the attitudes of clients & end users and consultants, contractors and consultants and hence the null hypothesis should be accepted. This means that clients & end users and consultants, contractors and consultants have different perception about effects of construction defects.

Table 4.11: - Summary of correlation test on the ranking of defect reducing measures

Respondents	Rho (ρ_{cal}) = $1 - \frac{6 \cdot (\sum d_i^2)}{N \cdot (N^2 - 1)}$	Critical value of ρ (Appendix B)	Significance for $P < 0.05$
Client & end users Vs. Contractor	0.563	0.4825	significant reject
Client & end users Vs. Consultant	0.574	0.4825	significant reject
Contractor Vs. Consultant	0.396	0.4825	significant accepted

In this case, with a significance level of 95% ($P = 0.05$), the calculated value of ρ for the first two group cases are greater than the critical values of ρ , so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected and for the last group case the calculated value of ρ less than the critical value of ρ , so the hypothesis that there is no significant agreement between the respondents is accepted i.e. the null hypothesis is accepted.

From table 4.11 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors, clients & end users and consultants and hence the null hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that the respondents on these groups have the same perception about reducing measures of construction defects. It can be also concluded that there is no correlation between the attitudes of contractors and consultants and hence the null hypothesis should be accepted. This means that contractors and consultants have different perception about reducing measures of construction defects.

4.4. Comparison between case study & survey analysis result

Analysis above clearly shows results of case study and questionnaire analysis. Result of case study shows water seepage from external wall, roof, or from ceiling and non-structural crack were the most frequent defects, which were the 2nd and 11th frequent defects on questionnaire analysis respectively. But results of questionnaire analysis show broken or loose tiles on floors or wall was the most frequent defect, which was the 2nd frequent defect on the case study. Broken or leaking sanitary fixtures were in the first five lists of the most frequent defects in both case study and questionnaire analysis. Defective damp proofing at the roof & poor window framing were the 5th frequent defect on the case study. Doors, hinges, latch/lock mechanisms needing adjustment or repair and shrinkage cracks on plastering were the 4th & 5th frequent defect on the questionnaire analysis.

Analysis of the case study shows 67.8% of the defects were attributed by poor workmanship, 19.7% of the defects were caused by design error. The remaining 8.2% and 4.3% of the defects were attributed by defective material & improper usage respectively. While survey study shows 52.41% of construction defects were caused by poor workmanship, 30.35% were because of

defective material and the remaining 13.07% and 4.16% of construction defects were caused by design error and poor subsurface investigation respectively.

In general, analysis of case study and survey study showed some degree of agreement both on the types and causes of construction defects. Top five most frequent defects of case study and questionnaire study were almost similar.

Similarly, results of both studies agree on causes of construction defects which were accordingly the majority of construction defect in building projects were caused by poor workmanship. The factors contribute to poor workmanship are:

- poor project management,
- complicated role of subcontractor,
- lack of experience and competency of labor,
- language barrier to communication and lack of communication,
- unsuitable construction equipment,
- poor weather condition,
- limited time and limited cost, etc.

Similarly measures that can reduce workmanship quality problem are:

- regular and periodic construction site supervision,
- training and education,
- proper communication among parties involved,
- proper construction management,
- proper manpower management and proper design,

And as the result of the analysis the most important measure to reduce occurrence of construction defect is periodic and regular construction site supervision that is also reducing measure to poor workmanship construction. Daily supervision should be carried out by the contractors or subcontractors and resident engineer so that workmanship problem can be identified and the remedy 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.

Chapter five: Conclusion & Recommendation

5.1. Conclusion

Based on results from case study analysis and respondents analysis the following conclusions were drawn by due attention to the objectives of the study.

- The first objective was to assess the extent of construction defect. By reviewing literatures and research done on construction defect and site observation the extent of construction defect was assessed. So, construction defect is a shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building.
- The second objective was to investigate types and causes of construction defects in Federal Government Office Building Projects in Addis Ababa. From the results of the thesis a total of 55 types of construction defect and 4 common causes of construction defects were recorded. The first five most frequent types of construction defects on mentioned project were; broken or loose tiles on floors or wall; water seepage from external wall, roof, or from ceiling; broken or leaking sanitary fixtures; defective damp proofing at the roof; poor window framing; nonstructural crack. Similarly the results showed that the most common cause of construction defect was poor workmanship. At least more than 58% of construction defect were attributed by poor workmanship. Defective material takes the next role by causing almost 20% of construction defects. Design error cause just more than 15% of construction defects and the remaining defects were caused by poor subsurface investigation and improper usage of building services.
- The third objective of the research was to investigate effects of construction defects on Federal Government Office Building Projects in Addis Ababa. From the results of the thesis a total of 8 effects of construction defect were recorded. 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.

- The fourth objective of the research was to forward measures which can decrease occurrence of construction defect in Federal Government Office Building Projects in Addis Ababa. From the results of the thesis a total of 13 construction defect reducing measures were recorded. Periodic and regular construction site supervision was the most important measure to decrease occurrence of construction defect. The next important measure was implementing a comprehensive quality control mechanism. Concurrently coordinating all building systems, starting with the planning phase and continuing into the programming and implementation phases; increased and improved feedback to the designer from all concerned bodies and regular on-the-job training were the remaining defect reducing measures in top five lists.

5.2. Recommendations

The following points are recommended to all parties in order to reduce occurrence of construction defects in building projects.

- Majority of construction defects occurred because of poor workmanship. So, skilled, semi-skilled and unskilled laborers shall be trained on regular basis on stages of construction in general and on method of construction, required quality level of workmanship and quality of material in particular.
- Material supplier shall provide the right material as per the specification and contractor have the responsibility to check the quality at the time of delivery and engineers shall approve each material type before installing. This chain can reduce occurrence of construction defects caused by defective materials.
- Designers should be aware that they have share on the cause of construction defects and should up-to-date their design with the new technology and method of construction. Designer shall receive feedbacks from concerned parties of the project.

- Better and more reliable guidance on commissioning building and their services and on defect avoidance shall be developed. Project owner shall arrange awareness creation program on way of using completed building services.
- Main parties of construction projects shall have continuous communication since first stage of project, which will eliminate design discrepancies and errors as well as omissions in design and also provide an opportunity to review the contract documents thoroughly. This would help in reducing gaps between them.
- Lastly, pertaining to defective construction, professionals must ensure that they reduce defective work within the industry. Competent people must be appointed to ensure that the technical requirements are being met. Professionals must be familiar with the relevant requirements of building standards and codes; if they are not, they must be educated or trained. Experienced construction-industry professionals must be utilized to educate the youth to ensure that lessons learnt in the past can be applied in future.
- This research was focused on types, causes, effects & reducing measures of construction defects on Federal Government Office Building Projects in Addis Ababa. The owner of projects is government and all the contractors & consultants are category I. Which means financial shortage is not that much to the extent of degrading the quality of the projects and the work was executed by category I firms but still there are plenty of construction defects. Even if this is the case it is difficult to conclude every building works in Addis Ababa were defective. So, it is recommended that researchers to work on construction defect in private owned building projects and building works executed by other than category I firms.
- The research output shows that the majority of construction defect in building projects were attributed by poor workmanship. So, I recommend researchers to work on possible solution for poor workmanship construction.
- Finally, it is important to do research on rework costs of defective acts. This is important to show the magnitude of rework cost with respect to project cost. The finding of this research might force concerned parties of the project to give due attention to construction defects.

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Appendix A: Profiles of selected project

Project name: ----- Ministry of Agriculture
Location ----- Megenagna, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Giga Construction Plc
Consultant: -----MH Engineering
Original contract amount: ----- Birr 32,211,934.45
Variation amount: ----- Birr 2,443,888.00
Total amount: ----- Birr 34, 655,822.45
Contract time: ----- 18 months
Commencement date: ----- April 4, 2007
Project completion date: ----- October 4, 2009
Current status: ----- Completed
Actual project completed date: ----- September 15, 2010
Schedule of maintenance: ----- No

Project name: ----- Ministry of Health
Location -----Goma quteba, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Samuel H/Mariam Building Contractor
Consultant: -----MH Engineering
Original contract amount: ----- Birr 33,444,468.11
Variation amount: ----- Birr 2,443,888.00
Total amount: ----- Birr 335,888,356.11
Contract time: ----- 18 months
Commencement date: ----- April 4, 2007
Project completed date: ----- October 4, 2009
Current status: ----- Completed
Actual project completed date: ----- October 10, 2010
Schedule of maintenance: ----- No

Project name: ----- Custom and revenue authority
Location -----Megenagna, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Emnetu Endeshaw Building Contractor
Consultant: -----MH Engineering
Original contract amount: ----- Birr 33,502,448.99
Variation amount: ----- Birr 2,443,888.00
Total amount: ----- Birr 35,946,336.99
Contract time: ----- 18 months
Commencement date: ----- April 4, 2007
Project completed date: ----- October 4, 2009
Current status: ----- Completed
Actual project completed date: ----- October 4, 2010
Schedule of maintenance: ----- No

Project name: ----- Ministry of foreign affairs
Location -----Hilton area, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Prefabricated Building Parts Production Enterprise
Consultant: -----MH Engineering
Original contract amount: ----- Birr 21,552,386.05
Variation amount: ----- Birr 4,254,863.94
Total amount: ----- Birr 25,807,249.99
Contract time: ----- 18 months
Commencement date: ----- February 6, 2008
Project completed date: ----- September 6, 2011
Current status: ----- Completed
Actual project completed date: ----- June 23, 2012
Schedule of maintenance: ----- No

Project name: ----- Ministry of foreign affairs conference hall
Location -----Hilton area, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Rama construction
Consultant: ----- Muluget Asfaw Consulting Architects & Engineers
Original contract amount: ----- Birr 144,621,072.08
Variation amount: ----- Birr 17,988,189.74
Total amount: ----- Birr 162,609,261.82
Contract time: ----- 18 months
Commencement date: ----- September 6, 2012
Project completion date: ----- March 6, 2014
Current status: ----- 65%

Project name: ----- Ministry of Science & Technology
Location -----Commercial printing, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Prefabricated Building Parts Production Enterprise
Consultant: ----- ETG Designers & Consultants
Original contract amount: ----- Birr 29,308,940.15
Variation amount: ----- Birr 4,740,433.26
Total amount: ----- Birr 34,049,373.41
Contract time: ----- 18 months
Commencement date: ----- May 16, 2012
Project completion date: ----- November 7, 2013
Current status: ----- 73%

Project name: ----- Urban Integrated Land Information System Development
Location -----National theatre, Addis Ababa
Client ----- Ministry of Urban, Housing Development and Construction
Contractor: ----- Teklebirhan Ambaye construction
Consultant: ----- Defense consulting enterprise
Original contract amount: ----- Birr 166,258,403.47
Variation amount: ----- Birr 0.000
Total amount: ----- Birr 166,258,403.47
Contract time: ----- 18 months
Commencement date: ----- August 11, 2014
Project completion date: ----- February 2, 2016
Current status: ----- 50%

Appendix B: Questionnaire

Addis Ababa University

Addis Ababa Institute of Technology

M.sc thesis on Construction Technology & Management

Dear respondent,

I am a postgraduate student in stream of Construction Technology & Management in Addis Ababa Institute of Technology, School of civil & Environmental Engineering. I am conducting a research with a topic “*A study of Construction Defects in Public Building Projects: A case study of Federal Government Office Building Projects*”

Now a day building construction defect become a problem that the construction industry faces. Among the things that worsen the problems is lack of awareness on the area of construction defect. Hopefully, the result of this study will reduce the problem, for that your experience on this area is a good input.

Here are list of questionnaires expected to be answered by respondent. As with all Knowledge Networks surveys, your response to this survey, or any individual question on the survey, is completely voluntary. You will not be individually identified and your responses will be used for statistical purposes only.

If you have questions related to the study please don't hesitate to contact me at +251920813939 or through email address mskmslbzbb@gmail.com. Thank you for your collaboration.

SECTION ONE: RESPONDENT PROFILE

1. Name (optional): _____

2. Which organization are you working currently?

• Client

• Contractor

• Consultant

• Other (specify) :

3. What is your job position in your organization (optional)?

SECTION TWO: Questions Related to Types of Construction Defects in Federal Government Office Building Projects

2.1. Below are lists of construction defects which are noticed during assessment on Federal Government Office Building Projects. From your experience on these projects, please tick your level of agreement on the listed construction defects and the possible causes. (Please tick the approximate cell).

Agreement:

- 1 - Strongly agree 3 - Neutral, 5 – Strongly disagree
 2 - Agree 4 - Disagree

Cause:

- 1 – Design error 3 – Defective material
 2 – Workmanship error 4 – Poor subsurface investigation

No.	Defect type	Agree					Cause				
		1	2	3	4	5	1	2	3	4	
1	Foundation related defect										
	Settlement										
	Subsidence										
	Tree root defects										
2	Basement, Beams, Column & Slab										
	Active cracks (>1.5mm) on basements, beams, columns and/or slabs										
	Small cracks (<1.5mm) on basements, beams, columns and/or slabs										
	Excessive deflection on beams and/or slabs										
	Spalling of concrete from slabs, beams and/or columns										
	Dampness on basements, beams, columns and/or slabs										
	Exposed steel reinforcements										
	Salt attack on structural members										
	Honeycombing of concrete										
	Floors moisture leakage										

	Twisted and buckled columns																				
	Twisted beams																				
	Uneven floors																				
3	Ceilings, walls, floors, doors and windows																				
	Water damage or stains on ceilings, walls or floors																				
	Ceiling unevenness and unevenly applied texture																				
	Ceiling and wall joint separation																				
	Structural inadequacy of floors																				
	Structural cracks on floors and/or walls																				
	Non-structural cracks																				
	Defective floor, wall & external finish																				
	Doors, hinges, latch/lock mechanisms needing adjustment or repair																				
	Broken or loose tiles on floors or wall																				
	Detachment of plastering																				
	Wall dimensional instability																				
	Shrinkage cracks on plastering																				
	Displacement of walls																				
	Paint peeling on façade faces of wall																				
	Broken window glazing, frames, locks or opening mechanisms																				
	Water seepage through windows and doors																				
	Broken or damaged exterior doors, locks, handles or hinges																				
4	Roof related defect																				
	Improperly sloped gutters																				
	Gutters clogged with debris																				
	Insecurely fastened, damaged or missing gutter or leader sections																				
	Rainwater runoff from roof not channeled away from entrances																				

	Straps missing or not nailed properly																		
	Damaged sheathing																		
	Roof cracking																		
	Distortion of roof or wall at roof level																		
	Roof sagging																		
	Damaged roof trusses																		
	Moisture or water stains noted in attic area																		
	Seepage or leakage underside of roof																		
5	Water supply system																		
	Inadequate pressure or water flow at fixtures																		
	Sudden rise in consumption																		
	Signs of leaks or clogged drains																		
	Broken or leaking fixtures																		
	Bathroom sinks not securely fastened or functioning properly																		
	Toilets not securely anchored																		
	Defective shower or water fixtures																		
	Noisy water pipes and water hammer																		
5	Electrical system																		
	Service entrance wires not properly protected																		
	Loose junction boxes for switches Or convenience outlets																		
	Stoppage of supply																		
	System breakdown																		
	Heating & Switches																		
	Electric sparks																		
	Exposed branch circuit wiring noted																		
	Electrical switches or outlets not working																		
6	Fire system																		
	Alarm not working																		
	Non-functioning of equipment																		

7	Lift & Escalator									
	Stoppage									
	Occasional overrun									
	Defective functioning									
8	Air condition/Heating system									
	Not cool enough and/or warm enough									
	Noisy, no air movement									
	Stoppage of supply									
	Poor functioning									
	Indicate other types of construction defects that have not been captured above and tick causes of them accordingly. Any feedback is greatly appreciated.									
1										
2										
3										
4										
5										

If you have any comments regarding to causes of construction defect please note below

SECTION THREE: Questions Related to effects of construction defects on Federal Government office Building Projects

Below are lists of effects of construction defect which will be noticed in building construction projects. From your experience, please tick the appropriate cell by indicating how much you agree to listed effects of construction defects in federal government office building project.

Agreement:

- 1 - Strongly agree 3 - Neutral, 5 –Strongly disagree
 2 – Agree 4 - Disagree

No.	Effects of construction defects	Agreement				
		1	2	3	4	5
1	Project delay					
2	Construction cost overrun					
3	Decrease the value of project					
4	Risk of possible danger on the tenant and/or passenger					
5	High maintenance cost					
6	High disputes and possible loss of building					
7	Decrease project functionality					
8	It negatively affect contractor and/or consultant reputation					
	Indicate other effects of construction defects that have not been captured above and rank them accordingly. Any feedback is greatly appreciated.					
1						
2						
3						
4						
5						

If you have any comments regarding to effect of construction defect please note below.

SECTION FOUR: Questions Related to construction defects reducing method on Federal Government office Building Projects.

Below are lists of reducing procedure of construction defect on building projects. From your experience, please tick the appropriate cell by indicating how important each method is in reducing building construction defects on federal government office building project.

Importance:

- 1 – Not important 2 – Less important, 3 – Moderately important
 4 – Important 5 – Very important

No.	Defect reducing procedures	Relative importance				
		1	2	3	4	5
1	An improvement on the lowest tender system					
2	Regular on-the-job training					
3	Improving the quality of graphical and written communication					
4	Better and more reliable guidance on commissioning building and their services and on defect avoidance					
5	Increased and improved feedback to the designer from all concerned bodies					
6	Proper and periodic maintenance					
7	Implement a comprehensive quality control mechanism					
8	All building systems need to be coordinated concurrently, starting with the planning phase and continuing into the programming and implementation phases.					
9	Periodic and regular construction site supervision					
10	Creating awareness of low-skilled laborers					
11	Revoking license of more frequent defective firm					
12	Continuous evaluate the capacity of consulting and construction firms					

13	Develop the capacity of universities and training institution					
	Indicate other construction defects reducing procedures that have not been captured above and rank them accordingly. Any feedback is greatly appreciated.					
1						
2						
3						
4						
5						

If you have any comments regarding to defect reducing technique of construction defect please note below,

Appendix C: Spearman's rank table

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