St. Mary's University

The role of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 low cost housing

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ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a University advisor.

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Declaration

I officially confirm that the research proposed in this paper, titled "The role of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 low cost housing " was conducted by Hiruy Samuel. It had never been seen or forwarded somewhere else.

Hiruy Samuel **Signature -----------------**

ACKNOLEDGMENT

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Hiruy Samuel

ABSTRACT

Construction industry is a major player in economy of any countries by generating employment and wealth. Construction material Waste can be defined as the byproduct generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures. Wastage can be classified in to two parts this are construction material wastage and time wastage however this paper focuses on construction material wastage. Minimizing materials waste in the construction projects could yield great cost savings and profit increment so the general objective of this paper is to assess the material handling and wastage controlling mechanism in project 13.

The main objective of this paper is to identify the causes and level of construction material wastage in Ayat branch 2 sites and it also investigates the impact of material wastage in the construction and finally it tries to recommend minimization and controlling methods.

This paper tries to assess which construction material is majorly exposed to material wastage and finally became conclusion, so coarse aggregate is majorly exposed to wastage relatively to other construction materials in Ayat branch 2.

In the Ayat branch 2 there are many reasons for the material wastage among this lack of workmanship and equipment are one of them means they use relatively traditional way of construction, on the other hand poor design, lack of supervision and poor quality of construction materials are the other reason for wastage in the project.

The data collection method used in this paper is integrated by observation, questionnaire survey and desk study also some of the data's are collected from different documents that are gathered from construction stake holders. Samples for the study have been randomly selected from a group of public employers, micro and small enterprises, consultants and contractors who are actively participating on construction works.

Finally, based on the findings of this research, possible solutions are recommended to minimize the generation of excessive material wastes in the low cost housing project.

Keywords: *The role of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 low cost housing.*

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ABBRIVATION

HCB = Hollow Concrete Block

C2G = Cradle to grave

UK = United Kingdom

AAHA = Addis Ababa Housing Agency

MSE = Micro and Small Enterprise

MCC= Material consumption of the contractor

MGM = Melese Girmay Melese consultant

MAMGMS = Material allowed by MGM standard

TMGMS = Total material consumed to complete the structure as MGM consultant estimates.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The growth of Ethiopian economy and population has brought a significant increase in the construction industry, especially in Addis Ababa. Besides, building projects are becoming progressively larger and more complex in terms of physical size and cost. Due to this, the building industry is using a considerable amount of material resources. On the other hand, if the life cycle of the materials on site is closely examined, it is generally known that there is a relatively large portion of the construction materials being wasted because of different reasons at building sites (Mulualem, et al., 2012).

Since some degrees of construction waste materials are inevitable in the construction process, all estimators allow wastage factors in pricing a bill of quantities. Over the years, experience has shown, however, that unless controlling measures are implemented, construction material wastage may frequently exceed often by a larger margin than the figure allowed in the tender document (Al-Moghany, 2006; Ofori, 2000).

As construction is a locomotive sector of the national economy, material waste in the construction industry affects the overall national economy. It is important therefore, to explore measures contributing to construction material waste minimization and assess the level of practice of such measures by the construction industry since cost reduction arising from minimization of construction waste materials is a direct benefit to all stakeholders. Material waste in the construction industry has been the subject of several research projects around the world in recent years. Many of them have focused on the environmental damage coming from materials waste in the process of construction. On the other hand, there have been some studies concerned with the economic aspect of waste in the construction industry. In our country study at undergraduate level also pointed out the existence of wastage at the construction site of condominiums and different building projects (Mulualem, et al., 2012). But these studies do not exhaustively worked out the approximate wastage level, the side effect and minimization techniques of materials wastage on condominium sites. However, to solve the housing problem, which is one of the major problems in Addis Ababa; the city administration has been working on affordable housing projects for the last ten years and starting from 2013 new affordable housing scheme by all levels of the city dwellers launched. The City Administration launched 10/90, 20/80 and 40/60 percent payment schemes from the lower-income up to the middle-income residents of the city. Therefore, in-depth investigation is vital to identify current condominium building construction materials wastage reduction techniques and the side effect of poor practice of material waste reduction on the project cost. The construction sites selected for this study are Ayat branch 2. Finally, based on the data gathered, the research draw conclusion and suggest how materials waste could be reduced at Ayat branch 2. Suggest how materials waste could be reduced at Ayat branch 2 projects.

1.2 Statement of the problem

The lack of data about managing and minimizing construction materials waste composition and quantities is a major factor, which has inhibited the development of construction material waste management in Ethiopia. Now a day's in Ethiopia construction industries are booming due to implementing major infrastructure projects together with many public buildings, commercial building and housing development programs (Getachew Kassa 2012). The construction material wastage affects the projects total cost of the construction, the schedule and in pricing a bill of quantities. Over the years‟ experience has shown that unless site management control is tight, wastage can frequently exceed often by a large margin than the figure allowed in the tender document. Effective materials control demands concentrated and coordinated action of numerous people performing a variety of functions within the industry. It further suggested that waste seen on site is not necessarily caused by failure or inadequacy of individual functions involved in materials management system. In the present situation, the contractors and the design consultants are mainly concerned on how to control cost without any emphasis on waste control measures (Kong, 2015).

Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, a critical control of materials on site together with good construction management is expected to decrease the cost of construction projects. Materials wastage on site cannot be treated fully without good construction management. In fact, material waste level on site is a measure of site management (Robert, 2010).

The Addis Ababa city administration was building large number of low cost housing in Ayat branch 2 and other project. In Ayat branch 2 there are 123 blocks among this 80 of them are ground plus seven (G+7) and the 43 are G+4 buildings, about 49 contractors are participated in the construction which are from level 6 up to level 4 and also there are two consultant (Addis Ababa housing agency project 13, 2016). The main supplier of material for the projects is Addis Ababa housing agency the contractor only provides equipment, form work, labor and sand. In the project effective materials handling and wastage control are not done at different level by numerous people performing a variety of activates in project. The major construction materials which exposed to wastage are Re-bars, blocks, cement, Corse Aggregate, and Pre-cast Beams are not properly handled on Site. This research assessed the forms, causes and factors incidental to construction waste and measures to effectively control construction waste. Therefore, this research were determine the current situation with regard to handling and minimizing construction materials waste in Ethiopia, especially in Ayat branch 2 low cost housing projects and assess the effectiveness of the waste control measures with a view to seeking for ways to minimize construction materials waste in future construction projects.

1.3 Objective

1.3.1 General Objective

The general objective is to know the source of construction waste by their contribution also find out and select the best waste management plan from housing construction sites in Addis Ababa.

1.3.2 Specific Objective

1. Identify the main cause of construction materials waste at the site

2. Identify the largest contribution of the construction waste

3. Estimate the percentage of material wastage and investigate the side effect on the cost of the project 4. Evaluate level of construction of waste minimization measures to waste reduction and levels of practice of same measures in the housing construction sites.

1.4 Significance

Significance of the Study:-The research will be essential to identify material handling and west control in Addis Ababa low cost housing the case of Ayat branch 2low cost housing projects .It has academic significance and municipality significance.

Academic significance: - the study will be significant for putting base line information to the next work who would like to conduct detailed and comprehensive studies either in Addis Ababa or in other study area.

Addis Ababa low cost housing project office: - The study will help Addis Ababa low cost housing project office to overcome or combat the material handling and wastage controlling mechanism in low cost housing construction. The study findings and recommendation will benefit as a guidance material for different data sources.

1.5 Scope of the research

The Concept of wastage is a very wide issue that is not only about material handling and wastage but it beyond. In this research we only focus on the role of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 project low cost housing. The research mainly concerned on activities of materials (storage and handling) and minimizing wastage of construction materials problems in which most of them are under construction.

1.6 Limitation

This study was delimited to show the construction material wastage incident in construction phase in the perspective of professionals on contractor‟s side due to time limitation. But the perspective of client and consultants need to be seen separately in detail.

1.7 Organization

The Organization of the study is divided in different chapters, as follows:

Chapter1. Introduction: - This section provides a background of the topic researched in this study. The main idea of this chapter is to explain the background of the problem, the objectives and the contribution made by this project.

Chapter2. Literature Review:-This chapter were provides information about the main subjects of this thesis; causes and sources of construction materials handling and waste on building construction project and to Providing the practical suggestions and recommendations to upgrade the knowledge of managing and minimize the construction materials handling and waste on Ayat low cost housing branch 2.

Chapter3. Methodology: - This chapter provides the plan of the research. In other words, this section explains the research paradigm, approaches, strategies and data collection methods. In this project, a case study strategy is used to confirm or reject the propositions.

Chapter4. Analysis and Discussions: - in this section were provides the results from the case studies and analysis to makes a comparison with the existing literature. In addition, these results are used in this section to see the way in which they help confirm or reject the hypotheses. On the other hand, this chapter also provides a critical evaluation of this work including the limitations of the research.

Chapter5. Conclusions and Recommendations: - This section will be summarizes the main issues of this research and it provides an overview of the main findings. It also concludes the project met the proposed objectives.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature

2.1.1 Definition Construction waste

Waste may be generated during both the extraction and processing of the raw materials and eventual consumption of final products there in. Rubbles and other waste materials arise from construction activity like demolition, renovation of buildings and new construction.
The construction industry is traditionally environmentally unfriendly. Construction cultural practice contributes to waste where trade contractors are rewarded for speed rather than their concern for the environmental impact of their work (Kofoworola, 2009).

Furthermore, construction activities consume a large quantity of materials and energy as well as generating unacceptable level of solid waste. The construction industry consumes 25% of virgin wood and 40% of raw stone, gravel, and sand globally every year. In the US, the production of building components and construction process itself use 40% of extracted material. Construction work leads to land development, land deterioration, resources depletion, waste generation, and various forms of pollution. The construction industry generates about 35% of industrial waste in the world. In the European Union, the construction industry generates a substantial amount of total waste output resulting in between two and five times the quantities of household waste (Kofoworola, 2009).

According to Sir Egan"s Rethinking Construction report on the state of UK construction industry, up to 30% of all construction is rework, labor is used to half of its potential efficiency, and at least 10% of building materials for every construction project is wasted. However, the huge waste generated by construction activities creates negative environmental, economic, and social impacts. The environmental impacts include soil and water contamination and deterioration of landscape by uncontrolled landfill.

Material waste significantly contributes additional cost to construction because new purchases are usually made to replace wasted materials; costs of rework, delays, and disposal because financial Losses to the contractor. Also, construction waste has social impacts such as health and safety of

Workers and societal image of the construction industry.

Construction waste reduction has the highest priority among waste management options which include reduction, recycling, and disposal. Construction management should enhance reduction, reuse, sorting, and recycling of waste before disposal.

Previous studies on construction waste reduction include operatives" attitudes towards waste reduction, direct observation of waste generation and sorting and weighing of waste materials. Recycling plays a crucial role in order to preserve areas for future urban development and to improve, at the same time, local environmental quality. In addition to recycling, inert end-of-life materials can be reused for purposes such as filling materials for land reclamation. Construction waste has a very high recovery potential in which 80% of total waste can be recycled.

Countries such as Denmark, The Netherlands, and Belgium have achieved the aforementioned recycling rate especially given the scarcity of raw materials and disposal sites. However, the vast majority of construction waste still ends up in landfills. In the UK, a total of 89.6 million tonnes of construction and demolition waste were generated in 2005 of which 28 million tonnes were sent to landfills. About 7 million tonnes of construction and demolition waste was disposed at landfills in Australia in 2006-2007 and 42% of total was attributed to construction waste. Also, in Hong Kong, the disposal of construction waste has become a social and environmental problem because there are acute shortages of landfill spaces (Kofoworola, 2009).

2.1.2 Sources of Wastes in Construction

Construction material waste arises from design, logistics, and physical construction processes. In the context of this study, construction wastes are some of the materials delivered to site which have been damaged and meant for disposal, reuse, or recycling. Studies indicate that waste of materials is usually higher than normal figures assumed by construction companies in their estimates. However, while some level of construction waste is unavoidable, the potential benefit of preventing waste generation on site can be substantial. Furthermore, among the objectives of sustainable development is waste reduction which incorporates both reduction at source and recycling so as to reduce quantities and risks there in (Fadiya, 2014).

Most previous studies on waste quantification have been focused on waste segregation for specific materials and the volume of waste generated rather than the impacts of the sources that generated the waste. Bossink and Brouwers conducted a waste segregation research on five construction sites in The Netherlands which demonstrated waste components in percentages of the total amount of waste generated and the research showed that between 1% and 10% of each material type delivered to the sites was wasted. Formosa et al. Conducted an observation study of the materials delivered to construction sites in Brazil, materials withdrawn from storage, material movements, an d construction processes in order to estimate the amount of waste that would be generated (Fadiya, 2014).

The study showed an average waste volume of 27.6% spreading across sources such as lack of quality control, handling, off-cuts, and labor error. In Spain, Solis-Guzman et al. developed a waste quantification model that allows total waste volume to be determined and categorized into demolished, wreckage (from construction processes), and packaging waste.

The model was tested on a typical new construction project and showed that wreckage forms 82% of waste that would be generated from the project. However, while the aforementioned previous studies focus on the volume of waste, this study uniquely measured the severity (in terms of volume) of contribution of the sources and the frequency of their contribution in order to derive the multiplicative impact of the contribution (Formoso et al, 1999).

In order to have adequate record of waste and then develop tools for waste reduction, there is a need to identify the sources of waste and assess their impacts on project outcomes. Despite the fact that considerable research efforts have been done for the identification of the sources of construction waste, there is a need for research targeting the analysis of the identified sources in terms of their waste contribution rates and impacts (Fadiya, 2014).

To be able to reduce the amount of construction waste, the question occurs as to what the main causes of the generation. By identifying the main causes, construction industry players can avoid excessive waste generated. Construction waste originates from various sources in the whole process of implementing a construction project due to one or a combination of many causes. Material waste can be categorized according to its source; namely the stage in which the root causes of waste occurs. Different studies in different countries identify these sources which cause Building material waste. Bossink and Brouwers (1996) organized the sources of waste during the construction process as: design, procurement, materials handling, operation and residual.

2.1.3 Source of Construction Materials Wastage

In addition, in Singapore, Ekanayake and Ofori (2000) organized the sources of construction waste under four categories: design, operations, material handling and procurement. Further, the most common causes of construction waste were identified from past researches by Sasitharan

Nagappan (2011). His study, conducted on causative factors of construction waste existing in construction field activities. The causes of construction waste are matrix and found that 63 wastes

Factors existed in construction activities. The waste causes were grouped into seven categories: Design, Handling, Worker, Management, Site condition, Procurement and External.

In this research the sources which cause waste on site were identified after a review of the literature, and placed in seven major categories.

1. Design
2. Procurement
3. Handling and storage
4. Operation
5. Weather
6. Vandalism
7. Others

2.2 Types of Construction Waste Materials

Construction is a business that tends to have many different sources of waste. This makes sense considering the many different materials that are used in construction work. There are materials that will need to be disposed of by special environmental services, and then there will be others that can be dumped normally. It is important to also know which materials can be recycled in order to work towards a more sustainable industry. Here, we will look further into the various types of construction waste materials (Lee Chin, 2013).

2.2.1 Building Materials

Building materials are some of the most prominent types of materials used in construction. There are many varieties of construction projects. Whether they are basic construction, demolition, restoration, or remodeling projects, there will always be a use of building materials, and with that comes building material waste. Some of the most common examples of these materials are nails, wiring, insulation, rebar, wood, plaster, scrap metal, cement, and bricks. When these materials turn into waste, a lot of times it's because they are damaged.

In some cases, though, it's because they were simply unused. The good news about these materials is that a lot of them can be recycled. A specific material that can be reused in many ways is wood. Any time there is wood waste, it can be recovered to be reused for new building projects. Disposal for these kinds of waste is usually pretty basic, but they still need to be disposed of in proper ways. Cement, plaster, and bricks are generally crushed down and can be used in future building projects. As long of the material is contained in a proper dumpster, a recycling or waste management company will come to collect it (Lee Chin, 2013).

2.2.2 Dredging Materials

Dredging materials are described as materials that get removed through the preparation of a demolition or construction site. To put it simply, these are parts of nature such as trees, tree stumps, rocks, dirt, and sometimes rubble. These are generally not materials that are considered hazardous, but they should be collected by a waste management company that can provide the proper waste disposal and trash removal for dredging materials. Specific materials that can be reused from this waste such as wood from uprooted trees can be taken to a plant for recycling.

Proper recycling and disposal of natural resources are some of the most important aspects of the disposal of dredging materials.

2.2.3 Hazardous Waste

Hazardous waste is one of the most important types of construction waste materials you must be able to identify and handle. Not only can this kind of waste be dangerous to those working around and handling it, but it can also present dangers to the general public if not managed properly. Hazardous waste can be produced at sites of construction, demolition, restoration, and remodeling projects. Much of the waste can come from the common material used for building. Some of the most prominent examples of the hazardous waste that comes out of construction are lead, asbestos, plasterboard, paint thinners, strippers, mercury, fluorescent bulbs, and aerosol cans. The proper disposal of these hazardous materials is an area where environmental cleanup companies come in handy. Hazardous material disposal is regulated under strict state and federal laws.

2.2.4 Demolition Waste Materials

There are specific types of waste that are prevalent in demolition projects. Due to this, they tend to get broken down into a few sub-types. Asbestos and insulation are major types of demolition waste, and they are also very hazardous materials. Asbestos can increase the risk of lung disease and cancers.

This is because asbestos can produce very fine flakes that can be easily inhaled. However, there is insolation that is not made entirely out of asbestos. The problem is that even if the insolation contains a small amount of asbestos, it‟ still incredibly hazardous. Another sub-type of demolition waste is non-asbestos- containing materials like concrete, bricks, tiles, and ceramics. Reinforced concrete is very valuable to recycle, as it can be reused to make new concrete.

This kind of material can be crushed up on the site of the project it is being used for. This will keep the costs of transport low as there will be less need for vehicle use. Wood, glass, and plastic fall under a third sub-type of demolition waste materials. Wood from these sites can be disposed of the same way as mentioned above Plastic is a major source of the volume of waste created on demolition and construction projects. Part of this is because plastic is mixed into many materials that are used to construct buildings. Many of the plastics that require proper disposal are Styrofoam, PVC siding, and PEX pipes.

2.3 Cause of construction waste

2.3.1 Steel reinforcement

Steel is used as reinforcement and structural integrity in the vast majority of construction projects. The main reason steel is wasted on a site is due to irresponsible beam cutting and fabrication issues. The worst sites usually end up being the ones that do not have adequate design details and standards, which can result in waste due to short ends of bars being discarded due to improper planning of cuts. Many companies now choose to purchase preassembled steel reinforcement pieces. This reduces waste by outsourcing the bar cutting to companies that prioritize responsible material use (M, 2019).

2.3.2 Premixed concrete

Premixed concrete has one of the lowest waste indices when compared to other building materials. Many site managers site the difficulties controlling concrete delivery amounts as a major issue in accurately quantifying concrete needed for a site. The deviations from actually constructed concrete slabs and beams and the design amounts necessary were found to be 5.4% and 2.7% larger than expected, respectively, when comparing the data from 30 Brazilian sites. Many of these issues were attributed to inadequate form layout or lack of precision in excavation for foundation piles. Additionally, site managers know that additional concrete may be needed, and they will often order excess material to not interrupt the concrete pouring (M, 2019).

Ready -mix concrete is concrete that is manufactured in a batch plan, according to a set engineered mix design. Ready -mix concrete is normally delivered in two ways.

2.3.3 Pipes and wires

It is often difficult to plan and keep track of all the pipes and wires on a site as they are used in so many different areas of a project, especially when electrical and plumbing services are routinely sub-contracted. Many issues of waste arise in this area of the construction process because of poorly designed details and irresponsible cutting of pipes and wires leaving short, wasted pipes and wires.

2.4 Environmental Impacts of Construction and Demolition Waste Management Alternatives

Construction and demolition waste (C&DW) arises mainly as by-products of rapid urbanization activities. C&DW materials have high potential for recycling and reusing. Despite its potential, landfilling is still the most common disposal method. In Malaysia, C&DW practices are principally guided by economic incentives such as low disposal cost or inexpensive virgin material outweighing recycling cost resulting in low recycling rate (A.Rani, 2017).

The purpose of this study is to access the environmental impacts caused by landfilling and the alternatives especially in assessing the damages to human health, ecosystems, and to the resources in the future 10year. It aims to identify the better alternatives in reducing the environmental impacts of landfilling C&DW. Life cycle assessment (LCA) used in this study assessed the environmental impacts associated with all stages, from waste production to end-of-life of waste material. LCA can help to avoid the short-sighted, quick-fix landfilling as the main solution for C&DW by systematically compiling an inventory of energy, fuel, material inputs, and environmental outputs.

The environmental impact of landfilling C&DW is estimated to increase 20.2 % if the business as usual (BaU) landfilling continues to the year 2025. Recycling will reduce 46.0 % of total damages and with the shorter travel distance; the environmental damage is further reduced by 82.3 %. Applying industrial building system (IBS) to reduce waste generation at-site reduced 98.1 % impacts as compared to landfilling scenario. The negative impacts derived from landfilling activity is significantly reduced by 99.5 % (scenario 8) through shifting to IBS, recycling, and shorter the travel distance from construction sites to material recycling facilities (MRF) (A.Rani, 2017).

The what-if scenarios illustrated the alternatives future circumstances, the inclusion of the uncertainty concept, and define the future path of C&DW industry outlook. The outcome of this study is informative and useful to policymakers, particularly in defining the way forward of C&DW industry in Malaysia.

2.5 Construction Waste source and management plan

Responsible management of waste is an essential aspect of sustainable building. In this context, managing waste means eliminating waste where possible; minimizing waste where feasible; and reusing materials which might otherwise become waste. Solid waste management practices have identified the reduction, recycling, and reuse of wastes as essential for sustainable management of resources.

Most construction and demolition waste currently generated in the U.S. is lawfully destined for disposal in landfills regulated under Code of Federal Regulations (CFR) 40, subtitles D and C. In some areas all or part of construction and demolition waste stream is unlawfully deposited on land, or in natural drainages including water, contrary to regulations to protect human health, commerce and the environment.

Businesses and citizens of the U.S. legally dispose of millions of tons of building-related waste in solid waste landfills each year. Increasingly, significant volumes of construction related waste are removed from the waste stream through a process called diversion. Diverted materials are sorted for subsequent recycling, and in some cases reused (Zeyad Khaled, 2015).

Volumes of building-related waste generated are significantly influenced by macroeconomic conditions affecting construction, societal consumption trends, and natural and anthropogenic hazards. In recent years, construction industry awareness of disposal and reuse issues has been recognized to reduce volumes of construction and demolition waste disposed in landfills.

Many opportunities exist for the beneficial reduction and recovery of materials that would otherwise be destined for disposal as waste. Construction industry professionals and building owners can educate and be educated about issues such as beneficial reuse, effective strategies for identification and separation of wastes, and economically viable means of promoting environmentally and socially appropriate means of reducing total waste disposed (Zeyad Khaled, 2015).

Organizations and governments can assume stewardship responsibilities for the orderly, reasonable, and effective disposal of building-related waste, promotion of public and industry awareness of disposal issues, and providing stable business-friendly environments for collecting, processing, and repurposing of wastes. Businesses can create value through the return of wastes back to manufacturing processes, promoting and seeking out opportunities for incorporation of recycled materials into products, and prioritizing reduction of building-related wastes through efficient jobsite practices.

Management Plan (SWMP) is a plan that details the amount and type of waste that will be produced on a construction site and how it will be reused, recycled or disposed of. The plan is updated during the construction process to record how waste is being managed and to demonstrate that any materials which cannot be reused or recycled are disposed of at a legitimate site.

2.6 Construction material waste minimization

Till the late 1900s, construction waste management has simply been seen as a disposal issue only. It has required a change in the state of mind to include waste reduction and recovery in each stage of the construction project life cycle mainly including design, procurement, construction, and disposal. Recently, the construction waste management approach has been diverged from a traditional to a holistic mindset by emerging a number of new concepts that have led to change in the overall mindset of waste management. These concepts can be summarized as follows (K.Agyekum, 2013). Works contribute significantly to pollution of the environment. Defined waste management as the discipline that encompasses solid waste generation, storage, collection, transport, processing, and disposal by considering the environmental, economic, aesthetics and public concerns. In addition, the management of waste includes monitoring, collection, transport processing and waste disposal. There are many efforts that have been carried out by the Malaysian government to minimize the generation of waste. Nevertheless, many contractors failed in implementing good waste management which led to the mismanagement of construction waste.There are several approaches to construction waste management. The process of managing construction waste goes far beyond the disposal of the wastes itself. It is encompassing a strategy to effectively utilize construction resources, with the view to reduce the quantity of waste and utilizing the generated waste in the most effective manner. In Malaysia, disposing the wastes directly to landfill sites is the most common approach in managing construction wastes (K.Agyekum, 2013).Construction waste management is efficient material handling, reduction, reuse, recycling and disposal of construction waste materials. The practice of waste management for construction activities has been promoted with economic reasons and the recognition that waste from construction and demolition works contribute significantly to the polluted environment (Shen etal, 2002, cited in Shen et al, 2004). According to Coventry and Guthrie (1998), there are two fundamental reasons for reducing, reusing and recycling waste: the economic advantages, and the environmental advantages. The environmental advantages include the minimization of the risk of immediate and future environmental pollution and harm to human health while the economic advantages include lower

product. In other words, waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers.

Both Formoso et al. (2002) and Koskela (1992) describes waste as a loss created through activities, but do not add value to the construction progress rather adds cost. So, drawing from the views expressed above, the definition of construction waste to be used in this study is any losses in material, time and monetary result of activities but do not add value or progress to the construction.

Construction Waste Categories Besides a clear understanding of the general concept of waste, it is helpful to use a classification of waste in different categories, in order to understand the wide range of possible corrective actions related to its prevention. Construction waste can be categorized into two: material waste and time waste (Al-Moghany, 2006; Ekanayake and Ofori, 2000).

Wasted time is understood as the time that is perceived by the skilled workers as useless, or as wastes use of time. The most common reasons for occurrence of time waste are: shortage of labor, unskilled or unproductive workers, the indecisiveness of clients, accidents on site, the conflict between sub-contractors, poor work flow layout, shortage of materials and inclement weather (Bo Terji, 2010). Time is unnecessarily wasted due to reordering, re-delivery, waiting and handling of additional material.

Therefore, time waste can be viewed as the extra amount of time needed for reordering, re-delivery, waiting and handling of additional material which will lower productivity, delay completion time, raise labor and machinery costs, and bring on extra overhead costs, and hence reduce profit (Formoso et al, 1999). The other type of waste in construction projects is materials waste. Studies in different countries have shown that not all materials procured and delivered to sites are used for the purposes for which they are ordered because of a number of reasons and become wasted (Bossink and Brouwers, 1996; Sagoe, 2011; Al-Moghany, 2006).

2.7 Empirical literature reviewed

2.7.1 Best International Practice on Building Materials Wastage Minimization

While construction and demolition wastes are usually grouped together under the title "C&D waste" in many countries in the world, the minimization strategy also undergone for waste of both processes. Throughout the construction cycle, and especially at the end of a structure‟s life, large quantities of material waste are produced. The increasing problems associated with construction and demolish waste have led to a complete rethinking in some of the industrialized countries. The current tendency in several industrialized countries is to view wastes as resources or by-products, which become new products that can be used for a variety of useful purposes (Begum et al., 2006; Zebau, Simona, Weisleder and David, 2006). This is because a large proportion of the waste produced on construction sites is recoverable for reuse and recycling.

2.7.2 Experience from Germany

Construction and demolition waste management in Germany is a mature and well-integrated sub industry within the broader German construction market. In 2002, German construction and demolition activity generated 214 Megatons of waste composed two thirds of excavated material, nearly another third of building and road demolition waste and a smaller fraction of mixed zxx construction site waste. Despite these high numbers, only 15% of these materials were disposed of in landfills, while the remaining 85% was recovered and reused in further applications or recycled (Zebau, Simona, Weisleder and David, 2006).

Germany‟s high material and waste disposal costs favor the economics of recovering, reusing and recycling as much construction and demolition waste as possible. Additionally, strong waste management systems have long been required by laws and regulations at all levels of government in order to minimize the impact of construction and demolition waste in the waste stream. More recent versions of these regulations focus on the complete material cycle, working towards a closed loop substance cycle in construction and demolition. This combination of regulatory pushes from the government and economic pulls from the market have helped Germany establish an effective construction and demolition waste management infrastructure. The disposal of waste is only permitted when recycling is much more expensive.

2.7.3 Experience from Australia

A number of states, including Victoria, South Australia and Western Australia, have „towards zero‟ waste strategy documents. The strategies set state wide targets for waste reduction, resource recovery and littering (Chris and Emily, 2013). Many local types of council require waste management plans before granting development consent. They usually require the builder or designer to estimate the total waste stream volumes from both demolition and new construction. In addition, nominate the means of disposal, including the recycling contractor, recycling waste station or landfill site. The site plan is often required to show waste storage facilities on site during construction and provide a schedule for delivery or pickup.

or impossible and the waste is unavoidable. In Germany the following major construction materials are commonly recovered.

The time and cost of waste plan preparation is usually recouped through reductions in waste disposal costs or dividends from the sale of salvaged resources. The following list demonstrates some reuse and recycle options in Australia.

2.7.4 Experience from South Africa

The C&DW stream in South Africa (SA) alone is estimated at around 5-8 million tons. This shows that there is a massive opportunity for growth in the recycling industry worldwide as well as in SA with regards to the recycling of C&DW. SA still has vast open spaces and natural aggregate resources are still available, therefore it is not surprising that SA is lagging behind in terms of its development of measures to promote the recycling of C&DW. However, as the available area for landfill sites are reduced, natural resources that are depleting and the pressures from global markets increase, such as with the need for ISO 9000 and ISO 14000 requiring more companies to have quality environmental management systems, SA might soon see the need for effective recycling of C&DW.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The research methodology gives justification in the choice of methods used to achieve the objective of the study which is specified at the beginning. Further, it gives the research population, sample size and statistical tools used for data analysis. With this background, statistical results obtained from the data‟s have been discussed in chapter four.

3.2 Research Design

The strategy followed in this research was first started with problem identification which has been done through unstructured literature review, archival study and informal discussion with colleagues and professionals in the sector and then the research design were formulated. Then data and information sources were determined based on the formulated research design. On the basis of the data and information sources the research instruments were decided and available documentary sources relevant to the research were reviewed. The review includes books and journal. Finally, after an in-depth review of literature, a questionnaire was designed and distributed to parties participating in (AAHA) Addis Ababa housing agency project in Ayatbranch 2sites to get their opinion based on their experience. Upon obtaining the desired data, checking and sorting of data has been done. The data‟s were then analyzed for extracting the information obtained through the overall research work. This was followed by thorough discussions in order to draw a conclusion and to forward recommendations based on the findings of the study. A descriptive survey design was used in this study. It was attempted to collect data from the relevant population (client, consulting firms and contractors) to evaluate their perception on the issues of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 projectlow cost housing.

3.3 Sources of data

The study depended on both primary and secondary data. Primary data was made up of first-hand data collected by the candidate through the use of questionnaires and site visits (observation). The secondary sources of data were obtained using relevant books, journals, magazines and research papers.

3.4 Research Instrument

The research data were collected mainly through open and closed questionnaires. Field observations through site visits were also employed to gather data on high waste generating building materials.

3.4.1 Questionnaire Design

The questionnaire design was undertaken to determine the opinion of contractors, consultants and client regarding the causes of material wastage and handling .Ayat branch 2 low cost housing projects in Addis Ababa.

3.4.2 Structure of questionnaire

The questions were constructed using the Likert scale. The respondents were asked to rank on a scale of 0%-100% factors that cause materials waste on construction sites where E.S. = extremely significant [100%-80%], V.S. = very significant [79%-60%], M.S. = moderately significant [59%-40%], S.S. = slightly significant [39%-20%] and N.S. = not significant [19%-1%] and also the questioner contains open ended question.

3.4.3 Sample Size

There are 94 stakeholders; (consultant, contractor, Micro and Small Enterprises (MSE) and client) the study area from which the sample population size is selected. According to Kothari (1990) if the sample populations are less than 10,000 the required representative sample size were computed by the proportion of sample size formula. According to Kothari (1990), n=Z2 PQ/d2 was used, where n=the desired sample size Z=Standard nominal deviate at required confidence level P=the proportion in the target population estimated to have a particular characteristic q=1-p, and d=statistical significance

Here let the population with particular characteristics from the sample population is 50% thus P=50% =0.5and q=1-p=1-0.5=0.5 the researcher considered to be 93% level of Confidence. The Corresponding standard nominal deviate is Z=1.81 and desired level of significance was 0.07 then sample size is

$$n = \frac{(1.81)2(0.5)\,(0.5)}{(0.07)2} = 167$$

So that, according to Kothari (1990) if N <10,000 the formula is, ***fn=*** $\underline{n}$

$$1+n/N$$

Where= the desired sample size when the population is less than 10,000 n=the sample size of the population N= the estimated population size.

Accordingly n=167, N=60

$$fn = \frac{167}{1+\frac{167}{94}} = \frac{167}{1+1.78} = \frac{167}{2.78} = 60$$

The researcher will select 60 samples from the total of 94 population size in Ayat branch 2 low cost housing projects in Addis Ababa.

3.5 Methods of data analysis

Since the research design used to meet the objectives is descriptive, descriptive statistics that involve both measures of central tendency (mean, median, and mode) and measures of dispersion (standard deviation) were used to analyze the data using SPSS software. At last, the collected data were presented in tables and graphs.

3.6 Validity and Reliability

A. Validity, in essence, refers to the appropriateness of the measures used, the accuracy of the analysis of the results and generalizability of the findings" (Mark *et al.*, 2016). According to the authors, validity in terms of questionnaire refers to the ability of the instrument to measure what was intended to measure. Among the different types of validity, content validity is one of the types which show whether the investigated questions are covered by the instrument or not. To do this a 31 pilot study was carried out before distributing the questionnaire. The process involves giving the questionnaire to some number of respondents who have knowledge of that area to give comments on it. To test the content validity, the questionnaire was distributed by attaching it with the objective and research questions to ten experienced professionals who are currently working on the construction industry and academic areas. After that, the questionnaire was modified based on the received comments and distributed to the targeted populations.

B. Reliability As stated by Mark Saunders *et al.*, (2016) reliability refers to "replication and consistency" which means if a study can be replicated by an earlier design and one can achieve the same results, that study can be seen as reliable. According to the authors, Cranach‟s alpha is a value that ranges between 0 to 1 and used to measure the internal consistency by checking if the items in the data collection instrument measure similar things or not. In this study, this coefficient was used to measure the reliability of the questionnaire.

3.7 Ethical Consideration

Throughout the process of doing the study, the ethical requirements of a study were carried out. First, when reviewing secondary data from journals, articles, proceedings and related sources, every source used was acknowledged both in-text citation and referencing. Secondly, making any interaction with participants was carried out after giving the letter the university prepared for this purpose. It is specifically declared on the questionnaire that the participation of the respondents is purely voluntarily. Finally, the respondent's name and the organization were not stated in any of the study parts, so every respondent was anonyms and their responses were confidential.

CHAPTER FOUR

DATA PRESENTATION ANALYSIS AND INTERPRETATION

4.1. Introduction

This chapter illustrates in detail the results and discussion of the collected data using survey. The contributing factors of construction material waste, the major factors of waste in the main construction materials during construction operations and the measures taken for minimizing construction material wastage were identified in the survey results.

4.2 Description

This chapter describes the results that have been obtained from processing of sixty (60) questionnaires. The results are prepared to present the information about the causes of wastage in the projects, effects of the wastage on the project and on the environment, method of controlling mechanisms; in addition to the causes of wastage this research assesses the magnitude of waste, waste minimization strategies and the relative significant of construction waste sources.

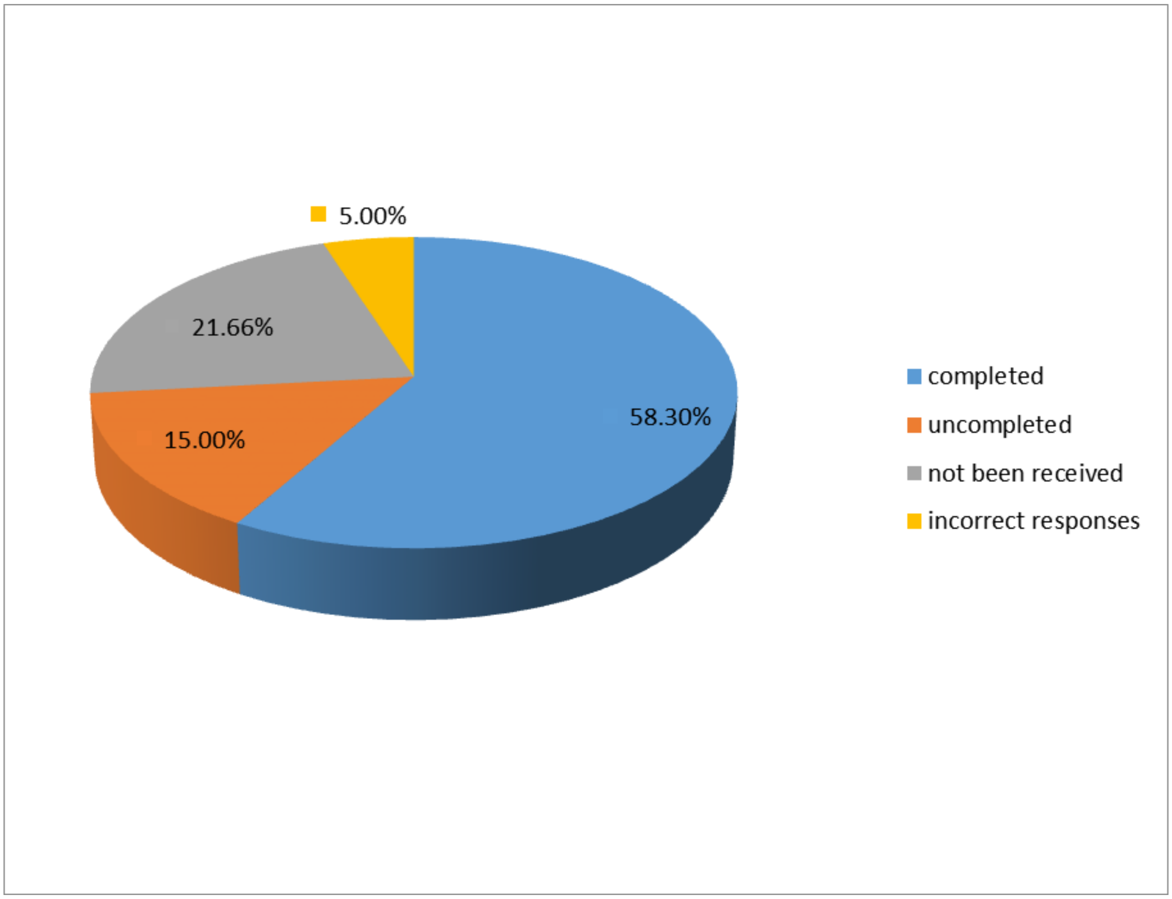
Table 4.1 case study information

<table>
<tr><td colspan="2" rowspan="2">Project name</td><td colspan="2">Low cost housing project 13</td></tr>
<tr><td>G+4</td><td>G+7</td></tr>
<tr><td colspan="2">Project location</td><td>Addis Ababa/ Ayat Branch 2</td><td>Addis Ababa/ Ayat Branch 2</td></tr>
<tr><td colspan="2">No of blocks</td><td>43</td><td>80</td></tr>
<tr><td colspan="2">Typology</td><td>OTT G+4</td><td>SIS G+7</td></tr>
<tr><td rowspan="2">Project cost(ETB)</td><td>Labor cost (it includes sand & equipment)</td><td>881,353,727.6</td><td>1,857,625,749.8</td></tr>
<tr><td>Material cost</td><td>832,368,325.7</td><td>1,325,592,910.4</td></tr>
<tr><td colspan="2">Project duration</td><td>1.6 year</td><td>2 years</td></tr>
</table>

4.3 Response rate

With regards to response rate, the questionnaires were distributed to the selected 94 target group. Out of the total 94 questionnaires distribute 60 of the questionnaires are filled and returned. From the respondents are 11 Client, 22 Contractor, 25 Consultant and 4 Micro & small enterprise also accordingly from the 60 questionnaires are filled and returned, 63 % was collected. 5% were rejecting because of analysis due to many unrepaired questions observed in the questionnaire contained therein.

Chart 4.1 Questionnaires general response rate



The below table (Table 4.2) Gives detail information or data about the response rates among the groups of contracting companies;

Table 4.2 Response rates among the groups of construction parties

Companies classification	No. of Selected company sample	No. Relevant Responded	Not been received	uncompleted responses	incorrect responses
Consultant side	25	20	4	0	1
Client side	11	5	4	2	0
Micro Small	4	1	1	2	0
Contractor	20	9	4	5	2
Total	60	35	13	9	3

4.3.1 Characteristics of the Respondents

The demographic characteristics of the responders it's surveyed in this research include gender, age, education background experience and professions.

4.3.2 Academic Qualification of Respondents

The education background of the respondents, 47 of the respondents 27 have first degree in fields of Engineering and social sciences, 7 of the respondents had masters, 9 have diploma whereas 4 had no educational background.

Table 4.3 Respondents Educational Background

	Consultant side	Client side	Contractor	Micro and small enterprises
Other	-	-	2	2
Diploma	2	2	4	1
Degree	14	4	9	-
MSc	5	1	1	-

4.3.3. Respondent's experience

The data in chart 4.3 revealed that 23 (48.93%) of the respondents have 1 -5 years of experience, 16 (34.04%) have 6-10 years of experience and 8 (17.02%) have 11-15 years of experience In general, more that 50% of the respondents have ≥ 10 years of work experience. This illustrates that the data collected is more reliable data.

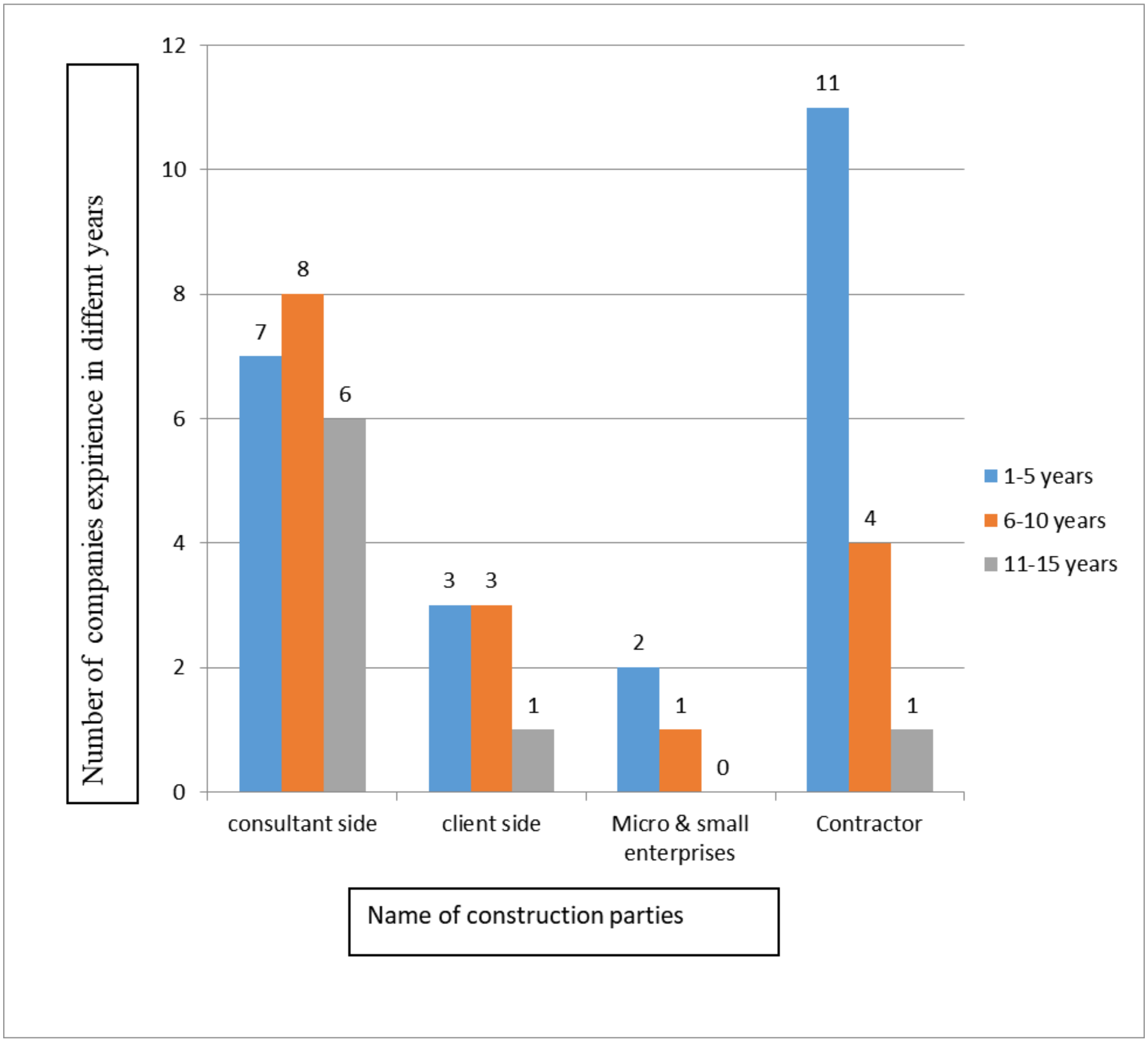


Chart 4.3 Respondent‟s experience

4.4 Part 2 Causes, Sources and extent of construction materials waste on construction projects

4.4.1 Wastage factors

This section of the questionnaire was designed to obtain data about the top major rework causing factors among the three construction companies. In order to obtain that, a list of frequent wastage factors were identified from literature review and modified based on the feedbacks collected from the pilot study. Five groups of wastage factors were selected which are related to Design and Documentation, Material handling, Operation, Supervision and Site management practice and Procurement.

The rank of the five categories and each 18 wastage factors were analyzed and ranked. According to the obtained results the five groups were ranked as follows.

Table 4. 4 Construction material wastage factor categories

Construction wastage factors categories	N	Mean	SD	Rank
Procurement	18	5.74	0.75	1
Operation	18	5.63	0.66	2
Material handling	18	5.61	0.71	3
Supervision & site management practice	18	5.58	0.62	4
Design and Documentation	18	5.39	0.7	5

As shown in the table 4.4, each of five groups is discussed in detail.

4.4.2 Procurement

Respondents were asked to indicate their level of influence on listed wastage factors. Based on the received responses the factors were ranked as indicated in the table 4.5.

Table 4. 5 Procurement

Procurement	Mean	SD	Rank
Over ordering or under ordering due to mistake in quantity surveys	4.8	2.24	1
Purchased materials that don't comply with specification	3.6	3.22	2
Poorly schedule to procurement the materials	3.6	2.62	2

The first factor identified based on the responses was *"Over ordering, under ordering* due to mistake in quantity surveys*"* with mean value of 4.8. Ordering material error have an impact on wastage, for instance the excess material because of over ordering material will be damaged until there will be another reason to use the extra material. A study related wastage mentioned that over ordering is a major cause of materials leftover and subsequent waste generation in construction projects (Faniran and Caban, 1998). Apart from this, sometimes poor ordering of materials does not fit in terms of quality, type and dimensions for the actual works at site. This type of mistakes happen and at last ends up as material waste. Thus, proper material ordering plays an important part and helps to reduce material losses and damage for construction projects.

4.4.3 Operation

Under Operation 3 wastage factors were selected. Respondents were asked to indicate their level of influence on the list of wastage factors. Based on the received responses the factors were ranked as indicated in the table 4.6.

Table 4.6 operation

Operation	Mean	SD	Rank
Rework due to workers mistakes	5.4	2.3	1
Use of incorrect materials, thus requiring replacement	4.5	2.1	2
Lack of coordination among crews	4	2.4	3

Respondents ranked *"Rework due to workers mistakes"* as the first wastage factor with the mean value of 5.4. As stated by (Saker, 2006). Workers' mistakes may be as a result of their inefficiency, inexperience, or the contractor's bad supervision. As indicated by (Ekanayake and Ofori 2000), Errors by trades persons or labors were considered the main cause of material waste in operational group in Singapore construction industry. According to (Yadeta and Eshetie, 2019) Workers mistake may result from different issues such as lack of knowledge and negligence of workers. This actively demonstrates that workers need to have knowledge, experience as well as supervision from the contractor.

The wastage factor ranked second in this category was *"Use of incorrect materials, thus requiring replacement"* with mean value of 4.5. Using the incorrect material is one of the major factors this illustrates that use of incorrect materials and replacing the materials will form wastage on the materials used before (Ofori 2000), also indicates that the use of incorrect material that requiring replacement was considered the main cause of material waste. Their study about the causes of waste generation in the Dutch construction industry that the use of incorrect material requiring replacement more frequently and was the main cause of waste in operation group (Bossink and Brouwers 1996).

4.4.4 Material Handling

A total of four material handling were identified. Respondents were asked to indicate their level of agreement on the listed wastage factors. Based on the received responses the factors were ranked as indicted in the table 4.7.

Material Handling	Mean	SD	Rank
Inappropriate storage leading to damage or deterioration	5.4	1.8	1
Unnecessary material handling	4.5	2.8	2
Insufficient instructions about handling	3.3	2.3	3
Conversion material waste from cutting un economical shapes	3.1	3.3	4

As indicated in Table 4.7, "*Inappropriate storage leading to damage or deterioration*" ranked first from the category with the mean value of 5.4. This illustrates inappropriate storage leads to wastage since the material will be damaged and deteriorated. This illustrates that adequate storage of material is one of the significant waste minimization measures. (Sasidharani, *et al*., 2015) mentioned wrong material storage as a key factor for waste generation on its own category the same as this study.

4.4.5 Supervision and site management practice

A total of 4 factors attribute to Supervision and site Management practice categories were identified. Respondents were asked to indicate their level of influence on the listed wastage factors. Based on the received responses the factors were ranked as indicated in the table 4.8

Table 4.8. Supervision and site Management practice

Supervision and site management practice	Mean	SD	Rank
Change orders by the client	3.6	3.2	1
Owner‟s poor communication with the construction parties and government authorities	3.3	2.2	2
Lack of strategy to material waste minimization	3.1	2.3	3
Lack of good site supervision	2.9	2	4

Respondents ranked *"Change orders by the client"* as the first wastage factor with the mean value of 3.6. This illustrates that the change orders by the clients is the major factor for construction material wastage. According to the study of (Ghanim., (2014) one of the major cause factor of material wastage on construction site in Jordan are change orders by the client. In fact, clients may request any change or additional requirement and facility in their project; however, if the request happens during the construction work is in progress, this may result in demolishing and rework activities which will lead to construction material wastage.

According to the responses collected ***"****Owner's poor communication with the construction parties and government authorities****"*** *was* ranked 2nd from the category with mean value of 3.3 .A similar result was found by (Al-Khalil and AL-Ghafly 1999) which indicated that the owner‟s poor communication with the construction parties and government authorities both interests are versatile

4.4.6. Design and Documentation

Four wastage factors were selected under design and documentation category. Respondents were asked to indicate their level of influence on the listed wastage factors. Based on the received responses the factors were ranked as indicated in the table 4.9

Table 4.9. Design and Documentation

Design and Documentation	Mean	SD	Rank
Frequent design changes at construction stage	4.8	2.83	1
Lack of information in the drawings	3.9	2.24	2
Error in contract documents	3.6	2.52	3
Complexity and error of drawing detail	3.13	2.51	4

Respondents ranked *"Frequent design changes at construction stage"* as the first wastage factor with the mean value of 4.8. This result indicates that during the design stages, the client and the contractor must sit down and agree on the project's final decision. This is very important during the construction phase as it will affect the building projects by having material wastage. Therefore, to overcome this problem, more attention should be given in waste reduction during design phase. The parties, who involve in any construction projects, should always have a good communication with clients to avoid the last minutes changes (Nagapan, *et al.*, 2007). Found frequent design changes as the most dominant cause for generating construction wastage. (Osmani and Price, 2008).

Based on the responses, *"Lack of information in the drawings"* Who is ranked as the second wastage factor with mean value of 3.9.Similarly Said (2006), ranked it as third major factor for construction material wastage. Correspondingly it is found out that lack of information in the drawing is the most significant cause for construction material waste. This factor illustrates the fact that lacking information in the drawing is the major contributing factor for construction material wastage.

4.5 Causes of key material wastage on building construction sites

The respondents were asked to identify the main factors for construction material wastage. So, by this the researcher will identify the major factors of waste in the main construction materials during construction operations

4.5.1 Concrete

Concreting is a major building process. Site managers often express about the difficulty of controlling the amount of concrete deliveries. 46 Nine wastage factors were selected under Concrete. Respondents were asked to indicate their level of influence, based on the received responses the mean and rank of each factor of the concrete waste are presented in the table 4.10.

Table 4. 10 Concrete wastage factors

Concrete	Mean	SD	Rank
Ordering an additional allowance of Concrete	4.29	2.7	1
Poor performance leading to rework	3.71	2.3	2
Far distance between place of mixing and casting	3.5	1.9	3
Inadequate use of vibration which leads to Honey combing	3.42	1.7	4

As shown in the table 4.10, Poor performance leading to rework and far distance between place of mixing and casting. Respondents ranked *"Ordering an additional allowance of Concrete"* as the first factor for concrete wastage with the mean value of 4.29. As per the respondents this is the major factor for concrete wastage, site managers often order and additional allowance of concrete in order to avoid interruptions in the concrete-pouring process, sometimes these results in surplus of concrete that is not used(Kazaza, *et al.*, 2015) In their study stated that compared to various categories of the concrete waste, over-order of concrete is the major contributor among others, According to (Kou, et al2012) about 8-10 tons of the fresh concrete waste can be produced every day from a batching plant with a daily output of 1000m2 of concrete.

Based on the responses, *"Poor performance leading to rework"* was ranked as the second wastage factor with the mean value of 3.71. The factor illustrates about the poor performance of workers which leads to redoing and material wastage due to poor concrete placement quality. For instance, the building contractor may not know the necessary quantity because of imperfect planning. This leads to over ordering and overfilling of the means of transport and formwork. If the formwork is overfilled, skimming becomes necessary, which is leveling off the concrete poured into the formwork.

4.5.2 Reinforcement bar

Under this material, seven wastage factors are selected. Respondents were asked to indicate their level of influence on the listed wastage factors.

Table 4. 11 Reinforcement bar

Reinforcement bar	Mean	SD	Rank
Damage during storage and rusting	4.9	2.4	1
Non optimized cutting of bars	3.1	2.1	2
Structure design was poor in terms of standardization and detailing	3.0	1.9	3
Short unusable pieces are produced when bars are cut	2.9	1.7	4

Respondents ranked “*Damage during storage and rusting”* as the first wastage factor for reinforcement bar with the mean value of 4.9.Exposing materials to extreme weather such as steel bars which rust needs to have proper storage to avoid construction material wastage (Formoso, *et al*., 2002).

4.5.3 Cement

A total of four factors were identified. Respondents were asked to indicate their level of agreement on the listed wastage factors. Based on the received responses the factors were ranked as indicated in the table 4.12.

Table4.12. Cement

Cement	Mean	SD	Rank
Wrong storage	4.25	2.53	1
Loading the cement manually in the mixer using in adequate equipment‟s and tools	3.9	2.4	2
Inappropriate way of transportation	3.41	2.2	3
Damage the external plaster due to rainfall	3.13	2.1	4

Respondents ranked “*Wrong storage*” of cement at the first wastage factor with the mean value of 4.25. Unshackling cement bags on pallet and disorganized stocks which leading to broken bags (Khorate & Pataskar, 2014). In their study raked this factor as the 3 rd factor. According to the responses collected, “*Loading the cement manually in the mixer using inadequate equipment’s and tools*” was ranked 2nd from the category with mean value of 3.9.

4.5.4 Sand

Under this category four factors were selected. Respondents were asked to indicate their level of influence on the listed wastage factors. Based on the received responses the factors were ranked as indicate in the table 4.13.

Table 4.13

Sand	Mean	SD	Rank
Poor storage	4.3	2.72	1
Excessive consumption of sand	3.13	2.14	2
Weather condition	2.9	1.97	3
Damage the remained quantities in the place work	2.5	1.8	4

Respondents ranked "Poor storage" as the first wastage factor with the mean value of 4.3. Based on the responses, "Excessive consumption of sand" was ranked as the second wastage factor with mean value of 3.13.

4.5.5 Aggregate

Three wastage factors were selected under Aggregate. Respondents were asked to indicate their level of influence, based on the received responses the mean and rank of each factor of the concrete waste are presented in the table 4.14.

Table 4.14.

Aggregate	Mean	SD	Rank
Mixing quantities greater than the required	5.1	2.4	1
Excessive quantities during mixing	4.35	2.3	2
Poor distribution of material in site	3.5	2.1	3

As shown in the table 4.14, respondents ranked for concrete wastage factors are Mixing quantities greater than the required, Excessive quantities during mixing and poor distribution of material in site. Respondents ranked ***"****Mixing quantities greater than the required****"*** as the first factor for concrete wastage with the mean value of 5.1. This is due to lack of information available to construction labor for producing the required quantities.

4.6 Figurative illustration of key construction materials waste arising through storage and handling on project site

In the above part, respondents were asked to assess construction materials waste in Ayat Branch 2 project. The results exposed that the key materials, which are wasted most on the construction site, are reinforcement steel, coarse aggregate and cement. So this part will try to illustrate the above part by using pictures that are taken from site.

4.6.1 Wastage of Reinforcement bar

Reinforcement is known and most commonly used material in building construction. The main causes of wastage of steel are as a result of cutting and damages during storage.

Figure 4.1 a, wasted reinforcement bar due to cutting problem

Source: Photo by the researcher (2023)

Figure 4.1b reinforcement placed in the wrong way

Source: Photo by the researcher (2023)

4.6.2 Improper storage of coarse aggregate

Coarse aggregate is one of concrete making material. Coarse aggregate is majorly wasted at the storing place.

Figure 4.2 wastage of aggregate due to poor storage

Source: Photo by the researcher (2023)

4.6.3 Storage of cement

Cement is one construction material which is used as an adhesive material in the construction industry and also used to fill the gaps between sands. In construction works cement is stored at the store.

Figure 4.3 improper way of storing cement

Source: Photo by the researcher (2023)

Figure 4.4 Demolished RCC columns due to poor workman ship

Source: Photo by the researcher (2023)

CHAPTER FIVE

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

According to the collected data through questionnaires and key informant interviews the study revealed the following results based on different categories in order of their contribution to construction material waste.

Supervision and site management

Practice the finding shows that change orders by the client, owner‟s poor communication with the construction parties and government authorities and lack of strategy to material waste minimization contributing factor in construction material wastage in managing and supervising.

Design and documentation

The results of the study demonstrate that frequent design changes at construction stages, lack of information in the drawings and error in contract documents are the key contributing factors in building construction projects in the category of design and documentation.

Procurement

Poor quality of material, ordering error over or under ordering and damage during transport and delivery presented as the main factors causing wastage in building construction projects in the procedure of procuring a material for use in operation. 59

Operations

The study indicates rework due to workers mistake, use of incorrect material which requires replacement and lack of coordination among crews increased the generation of waste in operating and working on site.

The major factors of waste from the main construction materials

The major causes of concrete waste demonstrate that ordering an additional allowance of concrete, poor performance leading to rework and far distance between place of mixing and casting is among the major factors of waste in concreting process. As a result, high amount of concrete wastage was identified as the top major contributing factors in the performance of building construction projects since concrete uses in larger quantity in these construction sites. For reinforcement bar, the study has revealed that waste generated on site is directly related to design process. Damage during storage and rusting, non-optimized cutting of bars and poor design of structure in terms of standardization and detailing is the key factors in depletion of steel reinforcement. Use of low-quality timber, wrong storage and deterioration resulting from unpainted before use and unclean after use are the main factor in wasting timber formwork. wrong storage, manual loading process inappropriate ways of transportation and excessive consumptions and poor distributions are among the major wastage causing factors of the main constituting ingredients of concrete (cement, sand, and aggregate) The top three causes of hollow concrete block wastage found to be lack of half and quarter of blocks damage of unused quantities left on site and Damage the block during unloading and transportation operation or improper storage of materials, respectively.

5.2. Conclusions

The purpose of this study was to identify the major contributing factors of construction material waste, a problem the construction industry is facing but does not obtain sufficient attention. Before coming to construction material wastage minimization strategies, identifying the major root causes of the problem is the first and helpful intervention. The study identified the major contributing factors of construction material waste that needs a serious intervention by the construction professionals. According to the identified causes, the top construction material wastage factors mainly lay in the category Design and documentation and Operation. In the Design and documentation category, frequent design changes at construction stage were the major contributing factor for the occurrence of construction material wastage. It has been frequently stated that communication is vital for the success of a project especially for a construction project which needs team work. So this requires the collaboration and sufficient communication between the client, consultant and contractor before the construction begins in order to avoid frequent design changes at the construction stage. Lack of supervision and management, inefficiency in procurement, inefficient storage facilities and system, mishandling of materials, design and ordering errors and, lack of skill, material deterioration, absence of modern waste management strategy, lack of proper attention by management, weak enforcement of contractual obligation, weak security /theft and vandalism, lack of awareness and knowledge of waste management practices underlie the causes of waste. Moreover, this study also provided empirical evidences on the levels of contribution and the levels of practice of waste minimization measures for each of the above main construction materials in building construction projects. It has shown that for all of the main construction project materials measures which have a high level of contribution in the minimization of waste are not practiced on the basis of their level of significance on the sites.

5.3 Recommendation

Based on the obtained results, the following recommendations were given to the major project participants to reduce construction material wastage on construction phase of building projects.

- In the design phase of the project, the consultant and the client need to communicate exhaustively towards the scope of work based on the client's interest. They need to make a scheduled meeting program with a specific time interval like at the beginning of the design, after the completion of 20% of the design, after the completion of the 60% of the design and after the final completion. In these processes, if the client is not able to do this, he/she can hire a professional consultant to do the task who will facilitate the communication between the contract parties. This will be helpful to minimize the client's change instruction and frequent design changes after work had been carried out. Much work needs to be carried out in the design stage because it is better to change the design before the construction begins to minimize construction material wastage.
- To minimize wastage happened due to design problem in building construction projects, practicing highly off-site construction by adopting different technologies like prefabrication and precast units, proper detailing during designing, coordinating dimensions between materials and the design, and planning ahead to minimize design changes are sensible mechanisms.

- The consultant need to be sure the quality of materials delivered on the site is as stated in the specification and construction supervisors and contractors on the site shall start refusing to accept substandard material.

• Material ordering practice needs to be improved in order to reduce waste comes from excessive quantity of material used that could be addressed by introducing just in time material delivery system, especially for hollow concrete block.

• Storage facility on the sites needs to be improved by planning the details of material delivery and their storage space on site. Besides, all workers shall practice careful handling and usage of tools in all courses of the construction process.

• Contractors need to develop waste management plans and to hire site waste manger to address material wastage problem and to enjoy the likely benefit. In addition, they shall start providing short term and long-term trainings and workshops for the workers.

5.4 Further research

The following some issues are identified and suggested for future studies.

- Similar type research to carry out in other areas of country to collect data to implement suitable Construction waste management system.
- Recycling methods for construction waste and to identify marketable products.
- Further investigation on material wastage of other types of building like commercial industrial and school building projects.

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Appendix A Questionnaire

The role of Material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 low cost housing

Dear respondent, the aim of this questionnaire is to obtain necessary data for the partial fulfillment of a MPM thesis in Project Management at St. Mary‟s University. The objective of this thesis is to study the role of material handling and wastage management for project success: the case of in Addis Ababa Housing Agency Ayat branch 2 low cost housing construction sites. Therefore, you are kindly requested to contribute to this research work by completing this questionnaire. The identity of the respondent and that of the company you represent shall remain confidential and all data‟s found from the survey will only be used for an academic purpose. We would like to extend our gratitude for taking your precious time to respond to this questionnaire.

A. General Organization Information

Please, put √ (€) as appropriate

1. Type of Organization (Respondents designation)

ϒ Owner	ϒ Contractor	ϒ Consultant	□MS Enterprise

2. Your position on this site

□Project Coordinator	□Resident Engineer	□Site Supervisor	ϒ For man

3. Educational Background

□Graduate (MSC)	□Undergraduate (BSC)	□Diploma	ϒ Others

4. Relevant working experience (Years)

ϒ 1-5	ϒ 11-15
ϒ 6-10	ϒ 16 and above

B. **Sources and causes of construction materials waste on construction project.**

The given below are numbers of Sources and causes of construction materials handling and wastage in Ayat branch 2 project Condominium housing construction sites. Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions.

E.S. = extremely significant [100%-80%] V.S. = very significant [79%-60%]

M.S. = moderately significant [59%-40%] S.S. = slightly significant [39%-20%]

N.S. = not significant [19%-1%]

Causes of construction materials waste	E.S. [100%-80%]	V.S. [79%-60%]	M.S. [59%-40%]	S.S. [39%-20%]	N.S. [19%-1%]	Remarks
1. Design and documentation						
Frequent design changes at construction stage						
Lack of information in the drawings						
Error in contract documents						
Complexity and error of drawing detail						
2. Materials Handling						
Inappropriate storage leading to damage or deterioration						
Unnecessary material handling						
Insufficient instructions about handling						

Conversion material waste from cutting un economical shapes						
3. Operation						
Rework due to workers mistakes						
Use of incorrect materials, thus requiring replacement						
Lack of coordination among crews						
4. Supervision and site management						
Change orders by the client						
Owner‟s poor communication with the construction parties and government authorities						
Lack of strategy to material waste minimization						
Lack of good site supervision						
5. Procurement						
Over ordering or under ordering due to mistake in quantity surveys						
Purchased materials that don't comply with specification						
Poorly schedule to procurement the materials						

C. Causes of key material wastage on building construction sites.

Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions.

E.S. = extremely significant [100%-80%] V.S. = very significant [79%-60%]

M.S. = moderately significant [59%-40%] S.S. = slightly significant [39%-20%]

N.S. = not significant [19%-1%]

Causes of key construction materials waste	E.S. [100% -80%]	V.S. [79% - 60%]	M.S. [59% - 40%]	S.S. [39% - 20%]	N.S. [19% -1%]	Remarks
1. Concrete						
Ordering an additional allowance of Concrete						
Poor performance leading to rework						
Far distance between place of mixing and casting						
Inadequate use of vibration which leads to Honey combing						
2.Reinforcement bar						
Damage during storage and rusting						
Non optimized cutting of bars						
Structure design was poor in terms of standardization and detailing						
Short unusable pieces are produced when bars are cut						

Causes of key construction materials waste	E.S. [100% -80%]	V.S. [79% - 60%]	M.S. [59% - 40%]	S.S. [39% - 20%]	N.S. [19% -1%]	Remarks
3.Cement						
Wrong storage						
Loading the cement manually in the mixer using in adequate equipment‟s and tools						
Inappropriate way of transportation						
Damage the external plaster due to rainfall						
4.Aggregate						
Mixing quantities greater than the required						
Excessive quantities during mixing						
Poor distribution of material in site						
5. Sand						
Poor storage						
Excessive consumption of sand						
Weather condition						
Damage the remained quantities in the place work						

D. Open Questioners

1. What are the major impacts of construction materials waste?

2. Which construction parties beneficial by managing and minimizing material wastage of construction materials on building construction? And how?

3. Who should take action to reduce construction materials waste?

4. What is future Framework for Minimizing Materials Wastage On? Construction Sites?

THANK YOU!!