ADDIS COLLEGE

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

ASSESSMENT OF CONSTRUCTION MATERIAL WASTE MANAGEMENT IN ADDIS ABABA: THE CASE OF SELECTED BUILDING CONSTRUCTION PROJECTS

BY

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ADDIS ABABA, ETHIOPIA

NOVEMBER 2024

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A MASTERS THESIS

BY

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A THESIS SUBMITTED TO ADDIS,COLLEGE IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN CONSTRUCTION TECHNOLOGY AND MANAGEMENT

ADDIS ABABA, ETHIOPIA

November 2024

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ID NO. CMGSR/098/2015B

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Addis Ababa Ethiopia

November 2024

DECLARATION AND CONFIRMATION

Declaration

I, the undersigned, declare that this thesis is my original work; prepared under the guidance and advice of doctor Belete Egigu. All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

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Confirmation

The thesis can be submitted for examination with my approval as an advisor.

Advisor`s Name:	Signature	Date
Belete Egigu (phd)	……..….	……

Addis college, Addis Ababa

November,2024

ACKNOWLEGEMENTS

Above all, my heartfelt gratitude is given to the almighty God and his mercy of hands who has given stamina and me healthy from the beginning of my stay in the institute of this thesis approval. Secondly, my appreciation extends to my advisor Doctor Belete Egigu who is willing to advise and guide me selflessly with lots of passion and initiation. His encouraging advice, eagerness in sharing knowledge, brotherly approach and shaping the study led to this end. Next to that, I would like to thank all of my families and friends for giving me the strength and support to carry on, especially my mother Keleme Muluneh, for their support, courage, and prayer from the beginning of my study to the end of this thesis. My genuine appreciation also goes to every respondent who participated in the data collection process. I am also deepest thanks to the staff of construction technology and management for their academic and scientific supervision throughout my study at the Addis College.

ACRONYMS

BC - Building Contractor

BOQ-Bill of quantity

CC –Contractor Company

C&D-Construction & demolition

CWM - Construction Waste Management

CWDCS-Waste disposal charging scheme

DS - Disposal System

EPD- Environmental Protection Department

EPA - Environmental Protection Agency

ESM-Engineering service management

GC-General contractor

GDP- Gross Domestic Product

SCM-Supply chain management

SWMP-Site waste management plan

US-United state

UN-United nation

WM-Waste management

ZW-zero waste

ABSTRACT

Construction industry plays an important role in social, economic and political development of a country. In many countries in the world, increase cost of building budgets because of rising population and urbanization generates to work and to facilitate human living houses. It consumes the higher percentage of the annual budget of a country; specifically, Ethiopia, it covers 59% of the annual budget. However, the industry has been experiencing such problems on identifying contributing factors of waste in the construction materials in the industry. In many regions of the world, rapid increase in building activities because of rising population and urbanization generates a large amount of construction waste. The objective of this study is to identify the major cause of construction material waste, to develop material waste minimization techniques, and to fill the gaps in material waste management. In Addis Ababa, to construct numerous of building constructions projects. The target populations of these studies were selected as construction workers on grade one, two and three construction companies. The data collection tools of these studies were used as document analysis, observation, questionnaire and interviews. Among the distributed 126 questionnaires on construction company workers were 103 relevant data collected. Secondary sources of data were obtained from relevant materials that covered research, journals on the subject area. The finding of this research indicates that lack of knowledge, design changes, poor specification and rework due to workers mistakes were the two major causes of construction material waste among the 22 major identified causes. In these cause construction waste are, high amount of economic, social and environmental impacts. The major material waste minimizing techniques is to use in construction sites prevention, reduce, reuse, and recycle and disposal of waste. The results of this study recommended that to establish strong communication towards the scope of work in the design stage detailing during designing, coordinating dimensions, phase of the project based on the client interest. In addition, to use different technologies like prefabrication and modern methods, and planning ahead to minimize design changes are sensible mechanisms. The study also recommends that managing waste need a serious attention from all the stakeholders involved throughout the construction process from planning to finishing stage of the works.

KEY WORDS: MATERIAL WASTE, IMPACTS OF WASTE, CAUSE OF MATERIALS WASTE, STRATEGIES OF WASTE, MINIMIZATION OF MATERIAL WASTE,

Table of Contents

List of table

List of figure

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The construction sector is very important for the development of every country. Its contribution to economic growth and long-term national development is widely acknowledged, highlighting its importance, particularly to developing countries Ofori, (2015). In construction, 4-M (Material, Manpower, Money, and Machine) and time play pivotal part. Depending on the type of a construction project, building materials regard for 60 to 70% of the total project cost. Construction material constitutes major cost elements in any construction project. Waste generated by construction activities, such as scrap, damaged or putrefied materials, temporary and expendable construction materials, and aids that are not included in the finished project, packaging materials, and waste generated by the workforce (Baird, 2016). Both processes include the construction and building materials industries, the construction industry is the highest user of natural resources, and demolition of buildings causes a large amount of waste. Saidu, and Shakantu, (2016) mentioned that construction material wastage on sites can contribute to cost overruns, the results on the research showed that the significant percentage contribution of material waste to project-cost overrun ranges from 1.96% to 8.01%, with an average contribution of 4.0% to project-cost overruns. Therefore, Construction wastage needs to be given more attention to minimize wastage. Construction waste management practices vary widely around the world due to differences in regulations, infrastructure, economic conditions, environmental, cultural attitudes and use of the limited resources towards sustainability. Building material wastage are defined as the difference between the value and quantity of those delivered materials accepted on site, and those properly used as specified and accurately measured in the work (Shen *et al*., 2002). It is important to manage all materials from the design stage, to the construction stage of the project as poor handling of construction materials affects the overall performance of construction projects in terms of time, budget (cost), quality and productivity (Bamidele and Festus, 2016).

According to the US Green Building Council, (2001), it accounts for up to 30% of total waste output in the United States alone, put at about 136 million tons per annual. In the United States, Gavilan and Bernold subdivided sources of construction waste into six categories: (1)

design; (2) procurement; (3) material handling; (4) operations; (5) residuals; and (6) others. These six were supported and also regrouped into categories by Ekanayake and Ofori: design, operational, material handling, and procurement. (C.T.Formoso, 2002) also, observation study of the materials delivered to construction sites in Brazil, materials withdrawn from storage, material movements, and construction processes in order to estimate the amount of waste that would be generated. (O.O. Fadiya, 2013) conduce on Quantitative analysis of the source of construction waste in UK also subdivided sources of construction waste into nine categories: Olusanjo O.Fadiya,Panos Georgakis, and Ezekies Chinyio (1) data error (2) design; (3) material handling; (4) operations; (5)weather ;(6) vandalism;(7)misplacement;(8) residuals; and (9) others.

The construction industry in developing country there are different limitation inconstruction management. Especially in construction site are different problems like time overrun, 70% of projects, cost overrun average 14% of contract cost, and waste generation approximately 10% of the material cost (Hussin, et al., 2013). Furthermore, waste can occur at any stage of construction not only because of construction conditioning but also due to external factors such as theft and vandalism (O.O. Fadiya, 2013).The construction material waste is the large volume of waste generated and inefficient way it is manages throughout the construction lifecycle. Construction materials waste causes serious environmental impact, construction delay problems and project cost overruns in many construction projects.

Construction industry is largest economic expenditure in India. Similarly, a study, which was carried out in Hong Kong, stated that about 5-10% of building materials are grouped as a waste (Yahya & Halim, 2006). Construction materials management is an important element in construction project management in the overall activities. Effective construction materials management process is a main to success of a construction project. Materials constitute a major cost component for construction Industry. The total cost of materials may be 60% or more of the total cost incurred in construction project dependent upon the type of project and the extent of mechanization and plant used (K V. Patel et al. 2011).

In the Nigerian BCS, material waste types are determined with their percentage composition by (Aboginije et al.2021) as concrete 16.5%, wood 14.5%, reinforcement 12.1%, asbestos 10.5%, glass 9.4%, asphalt 7.3%, tile ceramics 6.1%, soil and stone 5.4%, plastic and packaging 5.2%, rubbles 4.4%, drywall 3.7% and bitumen 2.8%. In addition to, (Mahayuddin

et al. 2010) state the material wastes and ratio in the Malaysian BCS as soil and aggregates, sand 44.3%, wood 12%, ceiling insulation materials 9.3%, concrete 7.2%, bricks 6.2%, tiles and ceramics 5.8%, lime 5.5%, cement 3.3%, metal 2.8%, glass 2.3%, gypsum board 1.2%. Through construction material waste management data's, we can reduce the overall project cost by waste minimization or maximum utilization of resources or Material. The consequences of materials waste are enormous because materials account for about 50% to 60% construction cost and they are scarce resources.

In Kenya, construction industries are increase in day to day activates, and high imitative economic growth. In this cause to study and considered material, waste in construction is not only focused on the quantity of waste of materials on site but also on several activities in design and construction phase one of serious issues (Kioko, 2007). Opine that if construction waste was managed properly, a saving of 6% of the project cost can be realized. The construction industry in Kenya predominantly employs the conventional method of construction.

The materials management in Ethiopian construction industry, especially on selected public building construction project in Addis Ababa is done mostly by experience and using traditional methods it's also viable that lack of proper construction materials management system within the country contributes to the high construction cost and poor quality of construction products in Ethiopia. Therefore, the mentioned issues indicate that require to develop an efficient constructions materials management system in Ethiopia construction projects, generally and handling construction materials was need attention for results of a completed project with good quality and within the schedule. Asmara, (2015). This shows that construction material waste in Ethiopia that gets a little attention is affecting major parameters of projects, which are cost time and quality. So having this in mind, this study, aims at assessing the for construction material waste, identifying the major causes of waste in the main construction materials in building projects and efficient minimizing strategies can be identified. In this three year, day-to-day construction material cost inflation due to this to focuses on waste. In the above researcher's book and their tittle were approaches to my studies research tittle within to use a references and add to being know different knowledge in material waste and their cause, influence and waste minimization. In this study, to propose best material waste minimization techniques in building construction projects.

1.2 Statement of the Problem

Different researchers around the world regarded material wastage are a serious problem in the construction industry. For instance, according to the study of (Bamidele and Festus,2016), material destruction is a serious challenge in the construction industry of the USA and has been linked as an adverse effect on the performance of the construction projects as a whole including in social economic and environmental aspects. Especially in construction site are different problems like time overrun, 70% of projects, cost overrun average 14% of contract cost, and waste generation approximately 10% of the material cost (Hussin, et al., 2013). According to these results, the additional cost incurred due to building materials waste ranges up to 10% of the total material purchased.

Construction material is very difficult to manage in the construction site; depend on the sensitivity of material inflation in highly day to day market cost variation, high cost and area coverage in the project cost, deep and wide material type and to direct related to the quality, time, cost. In these problems, material wastage is one of the major issues to focuses on in the world. In the main causes of construction material waste may be poor management, lack of proper design, and lack of awareness, dimension or measurement error, purchasing error, operational error, handling problems material quality and delivering system. The effects of material waste may be to reduce the quality of project, cost overrun, environmental pollution and time delay. In this cause may be to use different, measurements waste minimization management techniques such as, reduce, reuse recycle and remove the waste.

In Ethiopia, different researchers were studied in construction material waste, but the case not solved currently presents the problem of waste. However, in our country, material waste is a little attention and not a serious consequence ensues on construction companies. The previous studier problems to use improper target population, small sample size, improper data collection tools and analysis methods. Construction material is currently a serious issue and high cost coverage on high market inflation within day-to-day activities. The researchers' not focused on effective waste management strategies, to identify the impact of material waste in projects, and not used new construction technologies. However, the study aims to control or reduce material waste in building construction projects and to determine the impacts, efficient minimizing techniques and strategies to be developed. Therefore, construction wastage needs to eliminate or minimize wastage may be to minimize cost.

1.3 Research Objectives

1.3.1 General Objective

To assess the construction material waste management on selected building construction projects in Addis Ababa.

1.3.2 Specific Objectives

- To identify the major causes of materials waste on selected building construction projects.
- To determine the impact of material wastage on building construction projects.
- Evaluate the effectiveness of materials waste management strategies on building construction sites.
- To develop minimization techniques on construction materials waste management.

1.4 Research Questions

- What are the major causes of building construction material waste?
- What is the impact of material waste on building construction projects?
- How to measure the effectiveness of material wastes management strategies, on building construction projects?
- What techniques have been taken for minimizing material waste in building construction site?

1.5 Significance of the Study

This study intends to provide some framework for the development of policies and rules on building construction projects in the management of construction material waste based on to identified causes, strategies and minimization techniques of construction material wastage.

The identified major causes are one of the results, which are obtain from this study. Therefore, by identifying the major causes for construction material wastage within affect in building construction projects, the researcher can pave a way for construction professionals by proposing the action to be taken in order to minimize wastage. Because of this, different construction participants like project managers, consultants, contractors, site engineers, purchaser, and store handler will be conscious enough to consider about minimizing material wastage in the construction sites. In addition, the study will also introduce new concepts, plans and strategies of construction waste management, which will help construction project stakeholders and entities to properly managing waste in construction. It is significant as it

possibly leads to an in-depth study of the situation of construction waste management and motivates administrative legal and policy measures. The study will also be useful as a reference and steppingstone for academic and practical research on construction was management. The purpose of this study will clearly identify the cause of construction material waste also to select the best waste management techniques. For this study, the data will use from building projects in Addis Ababa to use primary and secondary data will use, the significant of economic benefits, sustainability goals and resource efficiency.

1.6 Scope of the Study

1.6.1 Thematic scope

The research focused on building construction projects in the construction wastages consist of different wastage types like material wastage, time wastage, human resource wastage, but this project focused on material wastage. So throughout this study, construction material wastage were the major wastage type that was considered the management phases. This study especially focused on building construction projects, with the objectives such as, identify on the cause affecting construction material wastage, there impacts, strategies and minimization techniques, but not study's in other areas, wastage types and environmental impacts.

1.6.2 Geographical scope

The research to studies located in Addis Ababa city on selected building construction projects to focuses on the contractor to select on highly depth, continuity and width projects to observe high-grade level contractor one two three. The selection criteria to full fill this objectives the contractors selected on, depth of buildings, width of projects above 1200m2 build up area, above G+9 building projects and above 120 million birr overall project cost.

1.6.3 Temporal scope

In this study I will use a cross-sectional period data collecting on single point of time between, July 21/2024 to September 21/2024 within two months collect data's. These researches will conduct the data collection period with focusing material waste on the building construction projects in Addis Ababa.

1.7 Limitation of the Study

The concept of wastage and waste management is very broad areas; it is not only about materials wastage but it is beyond that. However, only materials waste is consider in this study since the materials cost covers a great percentage of the project cost so in this study

consider the selection of best waste management plan techniques in building construction projects. Although building construction projects is a nation- wide problem that requires large scale and rigorous study, conditions such as material, financial as well as time constraints forced the researcher to limit the scope of the study in terms of time.

The respondent, not willingness in interview and quaternaries somewhat careless as they responded and low interest to observe the companies document, reluctance to provide information, gap and limitation of knowledge and the respondents not polite transfer companies profile and documents.

In this study, building construction is a wide range coverage in Addis Ababa, in this cause but not cover all depths of the sites depends on the factor of rain, limitation of cost and time.

In the above limitation to passes to use in different mechanisms such as, to interview more and more, to observe the site, to use different motivational things, to honest and translate freely ideas to respond and search more and more. In this cause to check different company to accurate data, information and knowledge in appropriate data collection tools.

1.8 Definition of key Terms

Management: is process of planning, organizing, controlling and actuating, performed to determine and accomplish stated objectives by the use of human beings information, technologies and other resources.

Material: Refers to, substances like wood, metal, plastic, fabric etc.

Wastage: refers to material that is after it discarded no longer useful or needed.

Storage: to put a material or the act of keeping goods safe and protected

Handling: The action of organizing and controlling something

1.9 Organization of the Study

The study contains five chapters, following this chapter; the first chapter includes the introduction part, background of study, problem statement, objectives, research question, significant, scope and limitation. In the second chapter incorporates Literature review part, shush as, introduction theoretical literature review, empirical literature review, policies and strategies, principle and experience, conceptual frame work and the gap of research, and chapter three comprises methodology part, chapter four deals about data presentation, analysis and interpretation and the last chapter deals with conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a detailed review of different works of literature related to the objectives of the study. The chapter commences by reviewing the term, construction management, construction material management, waste, construction waste, construction waste management, and material waste in construction on the point of view of different researchers to come up with the operational definition of the study. Then the review continues with different contributing factors of construction Material waste and reviewing the construction material wastes management from different departments and studies.

2.2 Definitions of key terms and concepts

2.2.1 Concept of construction

The construction sector is the largest waste creator on construction process in sites and at the same time the heavy consumer of resources. "Previous studies have shown that building construction consumes 40% of the global energy, contributes 5-15% of the GDP, and provides 5-10% of employment (DTIE, 2009); similarly, it consumes 40% of the world's raw materials (Sharma et al, 2011). Construction refers to the process of building or creating something involves planning, designing, organizing, and execution required to bring a project".

2.2.2 Definitions of waste

Waste is a serious trouble for not only the construction industry scale but also global scale, being aware of the wastes and managing them becomes mandatory day by day in terms of limited resources. Waste is one of the serious problems in construction industry in the world. Many researchers and practitioners indicate that there are many wasteful activities during design and construction process. Both the occurrence of material losses and the execution of unnecessary work, which produces extra costs but adds little benefit to the commodity, is examples of waste (Koskela, 1992). Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product (Koskela, 1992).

2.2.3 Define of Construction waste

Construction wastes are the results of evitable and ineluctable activities that do not create value, originate from different reasons such as stakeholders, building production processes, force majeure and occur in physical forms such as materials, labor, equipment or in nonphysical forms such as cost, time, quality (Can, 2020). Construction waste consists of unwanted material produced directly or incidentally by the construction or allied industries.

According to Ekanayake and Ofori (2000) design, operational, procurement, and material handling attributes contribute to be waste on construction site. Construction wastes generally classified as process and demolition wastes and demolition wastes further classified as natural, direct, indirect and consequential wastes. According to materials storehouse and handling, operational factors, design and documentation factors and procurement factors, errors by merchants, bought products that do not comply with specification and lack of onsite materials control are the major sources of construction wastes. Categorized source construction wastes as design and documentation, material and procurement, construction method and planning, and human resources. Waste in construction can be classified into two main types; waste of materials and waste of time (Agyerum, 2012). However, this research focuses on materials waste.

Material and equipment waste

Material wastes are evaluated as Constructed and demolishing wastes thanks to the highest resource usage level during the implementation process and the highest already used material production during the rework and demolition process. In the both process, material waste types can be evaluated in common perspective, but managing processes of them can be different due to resource usage and already used material production issues. Material waste response" is the fourth process to develop options, selecting strategies, and agreeing on actions to address overall project materials waste exposure, as well as to treat material wastes. The key benefit of this process is that it identifies appropriate ways to address overall project material wastes most of researchers to study on material waste because of high values in construction.

Time waste

The second type is time waste, a time duration of construction tasks consists of process, reprocess, or rework time, inspection time, move time, repair time and wait time. Only

process time is considering value-adding activity. The value adding activity is define as the activity that converts material and or information towards that which is required by the customer; non-value adding activity or also called waste as the activity that takes time, resources or space but does not add value. However, all value adding time belongs to process time, not all process time is value adding. Processes are also subject to wastes resulting from overproduction, wrong construction method, defects, and poor optimization in performance tasks (Al-Moghany, 2006)

2.2.4 Waste Management

Waste management is the collection, transport, processing, recycling or disposal and monitoring of waste materials and it deals with waste generated during construction and allied activities (Naik, 2016).

Implementation of construction waste management can be one of the apparent solutions for the industry to minimize waste and waste disposal, ultimately reducing costs incurred during the process and contributing to the global "environmental-friendly" movement (Hwang and Yeo, 2011). Good practice in material waste management generates favorable results with various benefits such as cost savings, effective source of usage, sustainability etc. Well-organized and implemented material waste management in the construction industry provides reduced demand for landfill spaces, improved resource management, productivity, and quality improvement as well as economic benefits.

2.2.5 Construction Waste Management

Construction waste management can be one of the main solutions for the industry to minimize waste and waste disposal, ultimately reducing costs incurred during the process, facilitate the construction and contributing to the global "environmental-friendly" movement (Hwang & Yeo, 2011). Good practices in material waste management generate favorable results with various benefits such as cost savings, effective source usage, sustainability etc. Well-organized and implemented material waste management in the construction industry provides reduced demand for landfill spaces, improved resource management, productivity, and quality and reduce project cost.

2.2.6 Material Waste in Construction

construction material wastages can be defined as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately

measured in the work, after deducting the cost saving of substituted materials transferred elsewhere, in which unnecessary cost and time may be incurred by materials wastage. Generally, wastages of building materials can be dividing into two types (Skoyles, 1987); one is direct waste and the other is indirect waste. Construction material wastes in terms of resources and circular economy is crucial step for all over the world. Material in site that have the highest level of wastage on building sites includes Concrete, steel, wood, ceramic, cement or mortar, timber, pvc and blocks (Agyekum, et al, 2013). (Bossink and Brouwers, 1996) indicated that in Brazil, 20%-30% of the purchased materials are not used well and end up as waste.

2.2.7 Source of Construction Materials Waste

Construction waste stems from construction, refurbishment, and repairing work. Many wasteful activities taken place during both design and construction processes, consuming both time and effort without adding value to the client (Love, 1996). Generation of the stream of waste is influence by various factors and different construction material sources.

Natural waste

Natural waste is the wastage that will cost more than what is saving if tried to prevent. There is a certain limit up to which, waste of materials can be prevents. Beyond that limit, any action taken to prevent waste will not be viable, as the cost of saving will surpass the value of materials saved. Thus, natural waste is allowed in the tenders. Amount of natural waste is subjective to the cost effectiveness of the approaches used to manage it. The approaches vary from one scenario to another and so do the natural waste. For instance, cost of preventing wastage in a project with a good material controlling policy will be lesser than that of a project, which lacks such a policy. Thus, the acceptable level of natural waste in the former situation will be lesser than the later.

Direct waste

Waste that can be prevented and involves the actual loss or removal and replacement of material" is called as direct waste (Skoyles and Skoyles, 1987). "Most of the time, the cost of direct waste does not end up in the cost of material, but followed with the cost of removing and disposing``. Thus, by preventing direct waste straightforward financial benefits can be obtained. Direct waste can be occurred at any stage of the construction process before the delivery of material to the site and after incorporating the materials at the building table 1.

Table 2.1: Categories of direct waste (Skoyles and Skoyles, 1987)

Category	Reason	Example
Delivery waste	During the transportation of material to the site, unloading, and placing in to the Initial storage	Bricks, glassing
Cutting and conventional waste	Cutting materials in to various sizes and uneconomical shapes	Formwork, tiles
Fixing waste	Dropped, spoiled or discarded material during fixing	Bricks, roof tiles
Application and residue waste	Hardening of the excess materials in containers and cans	Paint, mortar, plaster, finishing
Waste caused by other trades	Damages occurs by succeeding trades	Painted surfaces, surface tiles
Criminal waste	Theft and vandalism	Tiles, cement bags
Management waste	Lack of supervision or incorrect decisions of the management	Throwing away excess material
Waste due to wrong use	Wrong selection of material	Rejection of inferior quality marbles, tiles

Source in (Skoyles, 1987)

Indirect waste

In this type of waste, the material does not get waste physically, but the payments for the material are wasted partly or wholly. The indirect waste consists of the following categories as shown in Table 2.2

Table 2.2: Categories of indirect waste (Skoyles and Skoyles, 1987).

Category	Reason	Example
Substitution waste	Substitution of materials in work, which will incur losses to either contractor or client	Use of facing bricks for common bricks
Production waste	Contractor does not receive any payments for the work he has carried out	Use of excess plastering to rectify the uneven surfaces of brick walls
Negligence waste	Site errors because of the condemned work or use of additional material	Over excavation of foundation, resulting in the use of additional concrete
Operational waste	Unavailability of proper quantities in the contract document / the material that are left in the site	Formwork

Source (Skoyles, 1987)

2.2.8 Types of Construction Materials Waste

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. Construction material waste are any excess or unusable materials generated during the construction process. Construction projects will likely have a mix of both. Because of this, it is imperative to know the different waste types so you can identify them and be able to properly dispose of them. A huge part of safety at construction sites is knowing what materials are hazardous and how to work around them. 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).

Building Materials waste

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).

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.

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. 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 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.

2.2.9 Construction material waste management

BCS material waste management is a vital principle to figure out and manage the wastes in the construction project. It involves a systematic approach to plan, identify, assess, response, implement and monitor process during the project that prevent the exposure waste using some the tools and techniques (Gizem can,2022)

Figure 2.1: Material waste management.

2.3 Theories of construction material waste management

Many scholars have attempted to define waste from the industry based on a research context. Construction waste is defines differently worldwide in the construction industry. However, the purpose of this study are, the following definition are similar to one of (Ekanayake and Ofori 2000) was adopted: “Construction waste is any material which needs to be transported where from the construction site or used within the construction site itself for the purpose of land filling, recycling, or reusing other than the intended specific purpose of the project due to material damage, excess, non-use, or noncompliance with the specifications or being a by-product of the construction process`'.

According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the production of a building.

Construction waste includes unwanted materials produced during construction, such as rejected structures and materials, materials that have been over ordered or are excess to requirements, and materials that have been used and discarded, are all examples of construction waste (Environmental Protection Department, 2000).

According to (LY Shen; *et al*, 2000) Construction material wastages are described as the difference between the value of materials supplied and approved on site and those used properly as stated and accurately calculated in the work, after deducting the cost savings of substitutes materials transferred elsewhere, in which materials wastage can result in unnecessary cost and time. "Construction material waste is defined as any material apart from earth materials, which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process" (Agyerum, 2012)**.**

Building material wastage is defined as the difference between the value or quantity of those delivered materials accepted on site, and those properly used as specified and accurately measured in the work (Shen *et al*., 2002).

The management of construction materials should consider at all the phases of the construction process and throughout the construction and production periods. This is because poor materials management can often affect the overall construction time, quality, budget,

and environments. The important for planning and controlling of materials to ensure that the right quality and quantity within use and purchases of materials and installed equipment are appropriately specified in a timely manner, obtained at a reasonable cost, and are available when needed.

2.3.1 Cause of construction material waste

According to (Al-Hajj and Hamani, 2011) there are many factors, contribute to the generation of material waste. These factors have been under four categories: (1) design; (2) procurement; (3) handling of materials; and (4) operation. They have concluded that most of the causes of waste are due to design issues. In this regard, (Oladiran 2008) reveals causes of materials waste in Nigerian projects to include poor supervision, design error, defective materials, unskilled labor, wrong quality materials, changes in design, specification errors, poor storage facilities, poor handling process, poor material scheduling, poor product information, wrong suppliers advice and bulk purchase which leads to excess. They all contribute significantly to materials waste generation. Source: (Al- Hajj et. Al, 2011).

Table 2.3: Causes of construction material waste

Design	**Operational**	**Material storage and handling**	**Procurement**
(i) Lack of attention paid to dimensional coordination of products (ii) Changes made to the design while construction is in progress (iii)Designers inexperience and sequence of construction material specifications	(i) Errors by trades men or operatives (ii) Accidents due to negligence (iii) Damage to work done caused by consequent trades (iv) Use of incorrect material, thus requiring replacement	(i) Damages during transportation (ii) Inappropriate storage leading to damage or deterioration (iii) Materials supplied in loose form and Use of several weather	(i) Ordering errors (e.g. Ordering significantly more or less) (ii) Lack of possibilities to order small quantities (iii) quality error

Source: (Al- Hajj et. al. 2011)

2.3.2 The impacts of material wastages on building construction

Construction waste, especially material waste, negatively affects the environment and puts pressure on landfills, cost overrun and affect project compilation time. (Wahab and Alake 2007), mentioned that there is a fixed amount of materials required for a given unit of work or usually measured, the cost of the wastage that occur are therefore borne by the contractor. No matter how little, wastage of materials represents a loss. The higher level of waste, that affects the higher loss of contractor's profit. A very serious case of materials wastage can lead to a complete loss of profit and project delay. It should however be pointed out at this stage that it is not in all cases that the contractor alones bears the brunt of losses through wastage on contractor site. It leads to cost overruns, increase environmental effect, and extends the completion time.

2.3.3 Effectiveness of material waste management strategies on Site

Material strategies are relatively a new practice in the construction industry. In the present situation, the management and the designers are mainly concerned on how to control cost without any emphasis on waste strategies measures. Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Materials wastage on site cannot be treated fully without materials control. In fact, material waste level on site is a measure of site management. Site management is ultimately responsible for materials use and handling (Agyerum, 2012). Materials may be kept on site over long or short period of time until they are needed. Storage also means expenditure of capital, and money and contractors are reluctant to purchase materials in advance, except for those needed almost immediately (Addise, 2005). According to (Agyerum, 2012), the activities of materials control fall into four basic categories.

Materials Planning: includes the use of production plans to anticipate materials needs on a long-term basis. It also includes determination of materials and parts needed to fulfill customer orders or produce for stock with factors such as safety stock, investment and carrying costs taken into consideration and planning for balanced inventory levels.

Materials Availability: these include Requisitioning initial purchase and recorder of materials and parts from vendors in economic quantities as needed.

Materials Movement: to control materials movement, materials control must prepare requisitions to deliver materials to production in line with schedule needs and record

movement out of and into stock.

Materials Feedback: to assure proper feedback, procedures must be established to inform those who are affected when materials problems cause delay or loss of production, late deliveries and excess materials usage. In addition, reports must be made on obsolescence of materials for disposition, and timely inventory data must be issued to note the materials position.

2.3.4 Waste minimization techniques

Waste minimization is a shared responsibility between all parties of the supply chain, from the client down to the Contractor. This guidance focuses on the role of contractors and subcontractors, taking in to account the fact that they cannot work in isolation to reduce and manage waste. The most effective waste minimization strategies are those that developed throughout a project's design stages and agreed to by all parties involved. Concept of reduce, reuses, recycle and replace (4R), particularly in the context of production and consumption is important minimization techniques. Source (Sharif, et al., 2017)

Recommend the following, as measures for controlling materials waste and minimize wastages: (Enshassi 1996) and partly corroborated by (Agapiou et. al. 1998)

Materials control should start at the design stage, the second specification the standard sizes to minimize cutting, the third accurate scheduling of materials to programmed delivery dates, the fourth documentation should set out size, quality and delivery form of materials for estimators' consideration, the fifth must specify quality, quantity, delivery time and method, and packaging, the sixth effective communication between suppliers and recipient and the seventh preparation of effective planning programmers finally training of both management and other staff.

2.4 Empirical literature review

A study with the title of construction waste sources, management planning and practices: in the case of 40/60, condominium and real estate housing in Addis Ababa (Mahlete Alem Assefa 2021). The main objective of the research was to the general objective of the study 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. The specific objectives of these studies were identify the main causes of construction materials wastage on 40/60 condominium and real estate building construction projects at Addis Ababa,

identify the largest contribution of the construction waste on 40/60 condominium and real estate building construction projects at Addis Ababa, estimate the percentage of material wastage and investigate the side effect on the cost of the project and evaluate level of construction of waste minimization measures to waste reduction and levels of practice of same measures in the housing construction sites. The researchers used these study has probability sampling techniques within qualitative and quantitatively design approaches in questionnaires, interview and observation data collecting system in descriptive analysis, the sample population was distributed between all stakeholders: 45 contractors companies, 22 consultant companies and 13 clients the questioners distributed 9 General managers, 9 project managers, 9 resident engineers, 9 material engineers, 9 safety engineers, 9 quantity surveyors, and, 40/60 condominium and real estate building construction projects with total of 80. In addition, to used primary and secondary data source identify the various efforts that have been made in the past to evaluate and examine the causes and sources of construction materials waste on building construction project.

A study titled managing and minimizing wastage of construction materials on selected public building projects in Addis Ababa by (Shitaw Tafesse, 2021) was carried out to assess the current situation of managing and minimizing wastage of construction materials in Addis Ababa on selected public building construction projects and formulate and give proper recommendations with respect to handling of construction materials in accordance with the outcome of the paper. The researcher used questionnaires, interviews, and site visit to identify the various efforts that have been made in the past to evaluate and examine the causes and sources of construction materials waste on building construction project. A total of six construction sites in Addis Ababa, Ethiopia, were selected.

A study with the title Waste Management of Building Construction in India by (Rohan Ramchandra Chandanshive, Prof.A.B. Shelar in 2021) was carried out the objectives to identify and evaluate factors influencing construction waste, to find the causes by using literature and questionnaire survey, and to suggest the waste minimization techniques. The researcher methodology adopted in this study was quantitative research method in the form with 8 contractor in each of 20 samples to use used questionnaires and interviews, the target population and that focuses on contractor and project manager of questionnaire sample survey. The results of the study showed that the level of contribution of the waste sources to

the generation of waste saw differences between the perceptions of the respondents Contractors, consultants, and client. The results from analysis ranked from the first to fifth position by contractors, consultants and owners that the most significant factors causing construction waste on building construction projects are: -site supervision factors, materials handling and storage factors, design and documentation factors, site management and practices factors and operations factors.

The study recommended that there is a need to establish a new construction waste department to develop waste management policies and develop the effective strategy to reduce construction waste. The study recommended the owners to take the waste management history of the contractors as a criterion in awarding contracts. The study recommended the consultants to give attention to avoid design and planning errors at the design and planning stages. The study also recommended the contractors to assign qualification staff and workforce in construction projects and to prepare waste management plan.

2.5 Policy and strategies on wastages

The proposed material waste management policy and strategies focuses on sustainable practices to minimize waste during construction. It includes strategies such as encouraging economical design, controlling inventory, and optimizing supply chain management to reduce over-ordering and supplier errors. The policy also emphasizes on reusing materials, proper documentation, and training to avoid construction mistakes. By implementing these practices, it is expected to significantly reduce the generation of waste across various construction phases, thus achieving cost savings and environmental benefits. The policy aims to apply these strategies to control wastage during structural work, finishing work, and rubbish control, ultimately leading to a more sustainable construction process. Further, the World Bank (2005) stated the general aspects of an integrated waste management program are, thus: some of the waste management strategies and tools used in the construction industry.

Acknowledgement of the waste management hierarchy model, segregation of waste in categories after generation, waste management plan, providing authorized landfill encouraging recycling, use of material management frameworks/models (e.g. policy or regulations, public awareness, decision support) the control of waste management to listed below.

2.5.1 Construction material waste control policy and strategies

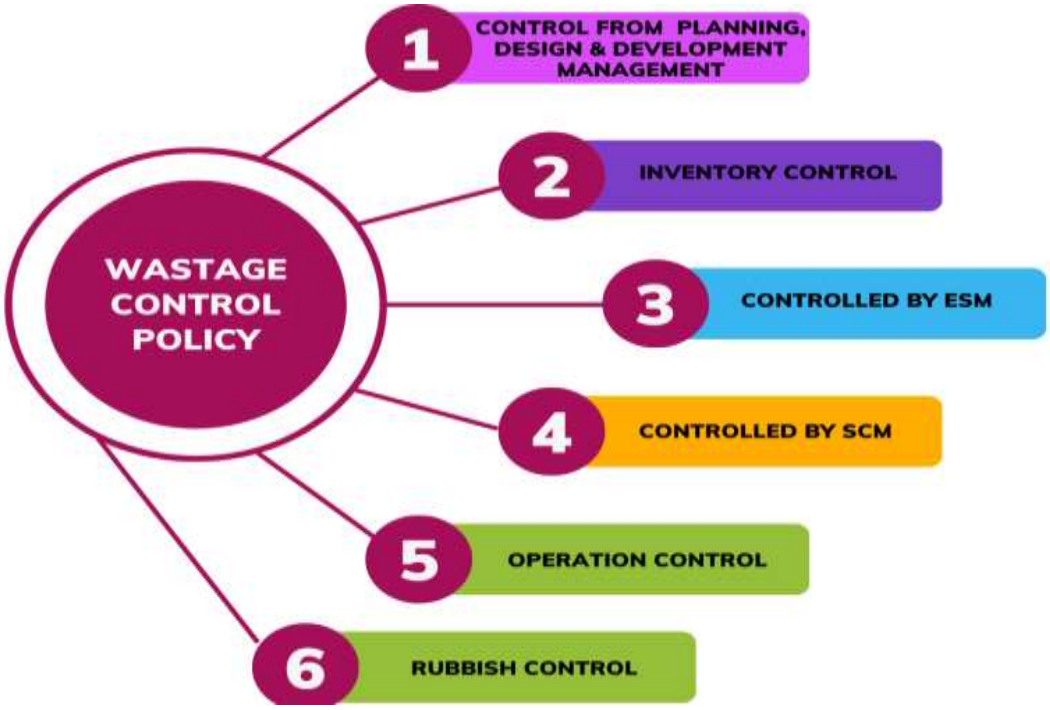

Figure 2.2. Wastage Control Policy Key Points. Source world bank (2005)

Controlling during Planning, Design & Development Management (PDDM)

To encourage architectural design that results economic structural design, changes in design during construction result in more wastage. Therefore, we should be conscious of changes in design, zero error in architectural and structural design and drafting that is delivered on site will reduce wastage

Inventory Control

Organizing our site will help us to minimize wastage. When site is organized and our team knows where everything is, it will cause us to spend less wastage for less unnecessary materials. When the project is organized properly, fewer mistakes are made which results less wastage, properly quantity and quality checking during receiving materials will reduce wastage, lack of onsite material control and wastage management plan increase wastage. We have to establish onsite procedure for receiving materials.

Controlled by Engineering Service Management (ESM)

Less modification, less wastage. The modification should be stopped at a certain time, say, 6 months of the handover deadline, after receiving materials at the site, taking reselection of

that material increases wastage these materials may be tiles, marble, bath-ware or CP fitting, electric items a

Controlled by Supply Chain management (SCM)

Ordering error and over-ordering or under-ordering increase wastage, supplier`s error and mistakes in supply increase wastage, strong negotiation skills reduce wastage, choosing the right vendor or Suppliers wisely reduces wastage

Operation Control

Ordering right quantity and right size materials reduce wastage, reuse materials that are in good condition reduces wastage, use of cut piece or waste rod in ancillary works reduce wastage, studying drawing properly within finding out errors if any getting, correction before starting any construction can minimize mistakes and thus reduces wastage, documentation keeping properly at site can reduce mistakes, thus reduces wastage, error in construction documentation and incomplete contact documentation may increase wastage and over mixing of materials increases wastage, use of incorrect material requires replacement which increases wastage.

Wastage control during Structure work

Have to fill the periphery area of a project by the rubbish generated from construction rather than filling by the filling sand, ensure control over the thickness of slab casting, and over size of vertical concrete members due to bulging during construction, increase the lifetime of shutter by taking care. Reuse shutter many times more than the expectation and Ensure minimum thickness of scree ding concrete by proper leveling.

Wastage control during finishing work

Woodwork: Inferior quality wood requires replacement, which increases wastage.

Grillwork & railing work: Taking exact measurements of the opening and making as per design perfectly can reduce wastage. The design also should be cost-effective. Electrical work: We have control wastage of cable by keeping minimum extra cable in SDB and switchboard. Plasterwork or external and internal: We have to ensure possible minimum thickness in exterior plaster by improving RCC work and brick work and by proper alignment of plaster work and Aluminum work: Making the opening of window as per standard size can reduce wastage and high thick plaster which increases wastage and Paint & polish work.

Rubbish control

Minimum dismantling and demolishing generates minimum rubbish, immediate complete reuse of mortar that scattered during plaster and brick reduces rubbish and Leak proof form work minimize rubbish, mixing mortar on plain sheet rather than mixing on RCC main floor will reduce rubbish, use of rubbish for back filling or periphery of building may be the reuse of rubbish.

2.5.2 Examples on construction waste management policy in Hong Kong

There are various strategies, approaches, and measures of construction waste management practicing in the public and private sectors. Poon and Poon et al. have identified seven effective good, which are recommended to be included in the strategies for construction waste management in highly urbanized cities. Other approaches such as circular economy zero waste approach, and green rating system. It is found that Hong Kong is actively trying new CWM policies based on latest waste management philosophies available (e.g. reduce, reuse, and recycle principle, and polluter pays principle).

Construction Waste Disposal Charging Scheme (CWDCS)

Since the implementation of CWDCS in 2005, the total waste generation had significantly reduced but the effectiveness started to decrease after three years. Construction Since the implementation of CWDCS in 2005, the total waste generation had significantly reduced but the effectiveness started to decrease after three years.

Site Waste Management Plans

A waste management plan is required for all public projects and has proved that reuse and recycling can be improved .However, the effectiveness of SWMP is limited by site constraints and overhead costs. The majority of sites do not have enough areas to carry out on-site sorting, which is labor intensive. The enforcement of SWMP is not common in private projects. It is necessary to provide more sorting facilities and explore the means to reduce overhead costs.

Proper Design

Appropriate design can avoid waste generation at the very beginning stage of construction works, which includes dimensional coordination and standardization, minimizing the use of temporary works, design for use of recycled materials, avoiding late design modifications,

applying low-waste building technologies, backfilling cut and fill by the excavated soils, modeling design information, etc.

Deconstruction

Deconstruction, which is also called selective demolition, can effectively facilitate the reuse and recycling of construction waste. Deconstruction is carried out reversing the construction processes requiring planned sorting of the demolished materials according to their categories so as to prevent contaminating the recyclable materials such as wood, paper, cardboard, plastic, metal, and concrete aggregates. Concurrently the recycling market in Hong Kong is underdeveloped.

Prefabrication and Modular Construction

Prefabrication can reduce about 52% of construction waste by minimizing on-site wet trade and improving buildability and perform better than conventional construction methods in environmental, economic, and social aspects. The Hong Kong Housing Authority has been a pioneer in using prefabrication in building housing estates. Furthermore, prefabrication has some disadvantages including less flexibility with plans and manufacturing, and limitation on transportation.

On-Site and Off-Site Waste Sorting

On-site sorting is effective in reducing construction waste and recover valuable materials for reuse and recycling thus reducing disposal costs. However, contractors are reluctant to carry out on-site sorting in spite of high tipping costs due to congested site conditions, tight construction period, high labor demand, expensive operation costs, and lack of recycling outlets. Off-site sorting can be an alternative to promote reuse and recycling since the operating costs can be less expensive than direct disposal at landfills. How to select a proper location for off-site construction waste sorting facilities that can reduce transportation costs and prevent noise and dust is an important factor to be considered.

Reduce, Reuse and Recycling

Most of the C&D waste research is largely focused on the “three Rs” principle of waste (reduction, reuse, and recycling), also known as the waste hierarchy. EPD has pointed out in a 2005 report that “the burden of Hong Kong’s landfills can be reduced through reuse, recovery and recycling. Research on reusing waste glass as an aggregate in concrete or additive in cement pastes or mortar have been conducted. Though recycling technologies

have been developed in recent years, how to promote the use of recycled products is still an issue to be solved.

Circular Construction

Circular construction is based on the concept of a circular economy model, which tries to keep the products and materials "in flow" by means of effective reuse strategies, thus reducing the use of virgin materials and negative environmental impacts. This can be accomplished using smart design and circular value chains, which is crucial for a sector to reduce both its waste and the amount of virgin resources used.

Zero Waste Approach

Authorities need to look for alternative waste management systems due to the lack of landfill sites in urban areas. Zero waste (ZW), which is a perceptive system of waste management, has been introduced as an alternative solution for waste problems in recent decades in many cities such as San Francisco, Vancouver, and Adelaide. ZW concept motivates sustainable consumption and production, optimization of resource recovery and recycling, and prevents wastes from incineration and landfilling.

2.6 Good Practice and best experience on Building Materials Waste management

Construction material waste management are, various studies have identified management measures using the basic practice point in response to the causes and impacts of construction waste

United States

Construction waste issues have become a focus on a project in many countries due to cost and environmental awareness. Many countries keep trying to formulate effective regulations that can minimize the construction waste in order to protect the environment and to improve sustainability of the construction industry. Therefore, the government and other parties should give more attention to help reducing the amount of waste generated from the construction industry. There are several waste management models which are applicable in construction sites and projects. From their research, (Dajadian and Koch, 2013) suggested two types of waste management models that are suitable to be implemented in US. The first model is using a separate subcontractor for waste management. Besides making sure the project will be done properly, the main contractor also has to consider about waste management and other things in the project. Having a separate subcontractor to manage

waste on sites can reduce the company's responsibility on it. Waste management (WM) contractor has responsibility not only in charge of managing waste management, but also as an expert in estimating and calculating the amount of waste produced in the project. WM contractor is specialized in managing problems related to construction waste and also has sufficient staffs that are professionally trained and have comprehensive knowledge on construction waste. In every week, WM contractor also hold a weekly meeting to report and discuss about all issues according to waste management in the project.

China in Hong Kong.

Construction waste from development activities become prolong serious problem at several countries, including Hong Kong. In recent years, Hong Kong and related stakeholders attempt to construct policy strategy to reduce construction waste in the landfill.

The study from (Lu and Tam, 2013) proofed that Hong Kong contributed by Construction Waste Management (CWM) policy through concept of 3R and polluter pays. The policy creating policy framework that is relevant and effectively worked to manage CWM in Hong Kong. According to the "reduce, reuse, and recycle (3R)" principle, waste management tends to be performed in the construction processes in Hong Kong by implementing several effort starting from avoidance, minimization, recycling, treatment, and disposal. Before starting the construction process on site, contractors have to create a waste management plan including waste reduction targets and programmers. Contractors also need to organize on site sorting and proper waste disposal, if eventually there is still waste produced.

Kenya and other African country

The Kenyan construction industry is learning from the best practices all over the world and most designers are trying to design and build green buildings. Due to continuous increase in the quantity of waste being generated by Nairobi's construction industries, there is increased concerns by the regulatory authorities to manage the waste and make the environment friendlier (Jhankar, 2015).

In developing countries (Tanzania, Zambia, Zimbabwe and Botswana) the followings are estimated; 40% of construction is rework, 30 to 40% labor potential is used, 8% of total project costs account for accidents and 20 to 25% of materials are wasted (Datta, 2004). Research in Nigerian construction sites, indicated four major types of construction materials waste. These include cutting waste, transit waste, vandalism waste, and application waste.

Figure 2.3 shows the management hierarchy explaining the best ways to manage generated wastes by the construction activities.

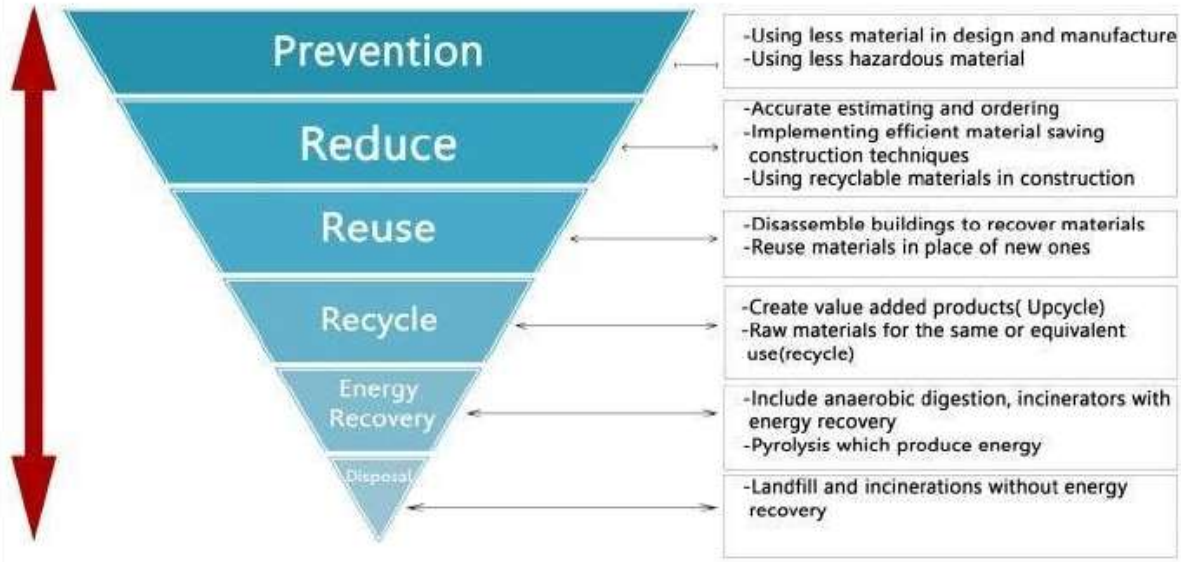

Figure 2.3: Waste Management hierarchy Source**;** (Demirbas, 2011**)**

According to (Shem et al, 2002), the establishment of good waste management practice will result in financial savings and will ultimately reduce the impacts upon the environment produced by construction and demolition works. Examples of good practice are given below:

Appoint a nominated waste manager for the site; Segregate the different types of waste arising from the work, which will make it easier to supply an accurate description of the waste for waste transfer purposes, label all waste skips to ensure that all personnel are aware of the type of waste to be deposited in each skip. Consider using color-coded skips, when ordering, avoid over-ordering and order the lengths required, the provision of storage facilities will avoid materials exceeding their shelf lives and damage or contamination from inadequate storage, on delivery, avoid damage during unloading and do not accept incorrect deliveries, specification or quantity, due care should be taken during the handling of materials to prevent damage.

2.7 Research gaps

Previous studies have demonstrated that material wastage has a large effect on the financial performance of construction projects. Besides, managing building materials waste can in fact achieve higher construction productivity, save on time, and improve safety while disposal of extra waste takes extra time and resources that may slow down the progress of construction. Construction material waste originates from various sources in the whole process of

implementing a construction project due to one or a combination of many causes. Various researches across the world have undertaken in order to know the contribution and environmental affect that lead to material waste in construction projects. This is because in order to reduce the amount of construction waste, the question occurs as to what the main contribution are. Therefore, by identifying the main contribution, construction industry players can avoid excessive waste generated on construction sites. In addition, there are different studies on influences of material, including reusing and recycling on construction projects. From each of the literature reviews on construction waste minimization, different gaps such as; lack of standardization, integration of technology, regulatory and policy and behavioral factors are some examples in identified the research literature review gap. The critical gaps identified these studies are lack of identifying the root causes of material waste in order to eliminate or minimize construction waste. On the other hand, wastage control needs serious consideration and due attention since the construction industry consumes large amount of raw material. Therefore, this research is necessary to full fill the gap of past researcher to identifying the main cause of construction material waste in building construction and develop an appropriate construction waste minimization practice that will set out procedures to fill the knowledge gaps mentioned above. An effective and proper identification of waste types and categories, predicting the waste quantity, establish causes and origins of these wastes and providing waste reduction strategies in order to effectively reduce the waste amount of construction sites. In my research, fulfill the gap of other researchers within to use accurate data collection techniques and design approach for this tittle to focuses on construction material waste because of material inflations and highly construction cost value and most sensitive values in construction. In the past researchers only consider cause and only minimizing of waste but in this research to identify root causes and to focuses on eliminating waste and strategies depend on a serious cause of material inflation To use waste reduction strategies exist, the is limited research into new or more effective waste minimizing techniques at different stages. Since there is a gap on the study of the top building contracting companies (GC1, GC2 and GC3)(BC1, BC2, BC3) and (CC1, CC2) which are located in Addis Ababa, the researcher in this study will aims to assess material waste in a wider range by considering current ongoing projects in GC1, GC2, GC3, and BC1, BC2, BC3 which are working so that an exhaustive and more reliable result.

2.8 Conceptual frame work

In this studies conceptual framework is guided by construction material waste management, more specifically, construction firms in Ethiopia practice construction material waste management measures employed in order to ensure that prevention, recycling, reusing, reduce and proper disposal. The main emphasis on the construction material wastes in county Ethiopia by big construction firms in the country. The key areas to be discussed include; cause of construction material wastes, the best practices of their management, both globally, locally and the legal framework governing the management of construction material wastes management. This research will be guided by the conceptual framework dependent and independent variables with represent in diagrammatic model shown in blow.

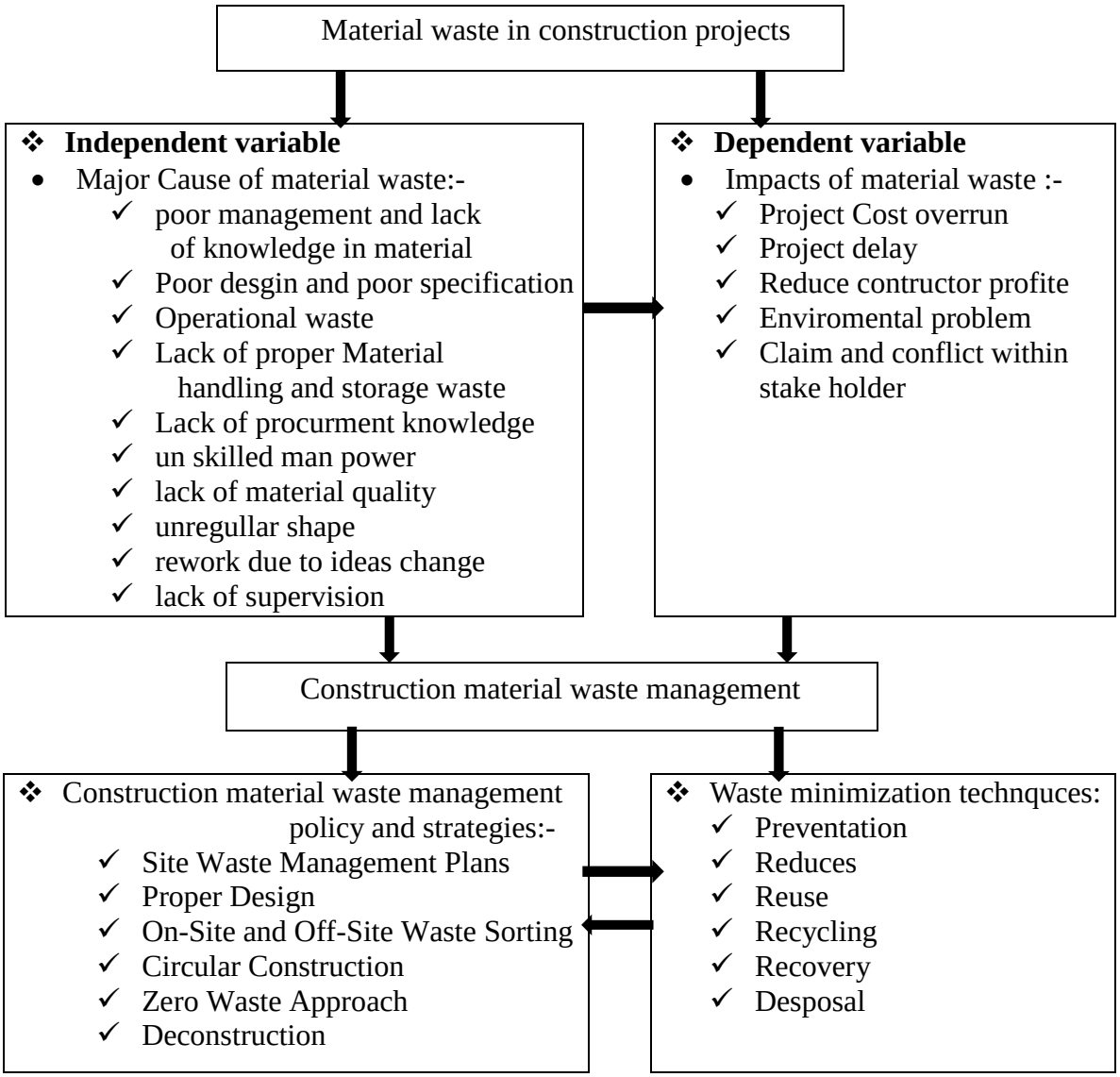

Figure 2.4: conceptual framework diagram

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology is an important procedure that allows researchers to collect and analysis data for a successful outcome. This chapter includes the methodology used in order to meet the objective of the study. This section specifically explains in detail about the research design, research approach, research type or methods, population and samples, sampling design and techniques, data sources, data collection tools used, data analysis and ethical considerations.

3.2 Research Design

Research design is a structured plan for conducting research. Outline the procures for collecting data, analyzing and interpreting data to address a specific research question. The research design used in this thesis was a descriptive research. According to (Naoum, 2007), Descriptive research aims to accurately and systematically describe of a specific population, situation or phenomenon. It can answer what, where, when and how questions, but not why questions. A descriptive research design can use a wide variety of research methods to investigate one or more variables. As it is stated earlier, the objectives of this study are mainly to identify the main cause of material wastage, determine the impact of material waste in building and to find out measures taken for minimizing construction material wastage. Based on this consideration case study method was appropriate due to the nature of the topic and exhaustively described by interlinking each research steps.

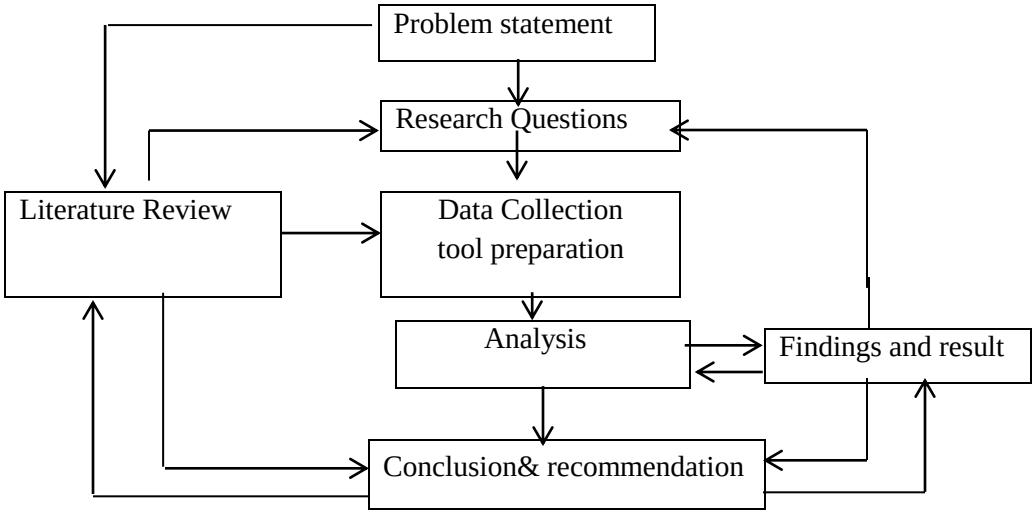

Figure 3.1 Research design flow chart paganism

3.3 Research approach

Research approach defines the overall strategy for investigation a research problem to consider how data will be collected, analyzed and interpreted. In this study, both quantitative and qualitative use mixed research approach is adopted. The advantage of using a mixed approach is to cover the weakness of each approach with the strength of the other approach (Mark, 2009). Qualitative research approach used in the form of interview, observation, focuses group and document analysis. It aims to understand deeper meanings, experiences and concepts. Lincoln,Y.S (2017) as a research strategy, a survey was used to answer the study questions. In addition, quantitative research approach used in the form of interview within focuses group sample survey research approach was use to collect the data. This approach is used to find facts based on evidence or records. The method relies on experiments and surveys to collect measurable data (Creswell, 2003). According to Creswell (2003), quantitative research approach count things, data statistically and quotes results in numeric forms. Quantitative research approach was used in this study because of determine the relationship between variable.

3.4 Population

The targeted populations of this study were to professional workers within a valid registration construction companies according to Ethiopia construction authority bureau know to works and build in Addis Ababa. The target data will collect on construction and consultant professional workers to work in Addis Ababa building construction projects.

3.5 Sample size, sample unit and sampling frame

Sampling is the process of selecting representative units of a construction parties for the study in this research investigation. The advantage of using a sample is that more practical and less costly. According to, Ethiopia construction authority bureau this was search from the construction license contractors registration to study in 2022. The general population of the study, selection with the criteria's are, well organized in workers, high capacity, more experienced, and construction continuity.

Sampling to select probability-sampling method within stratified; the general contractor, (GC1, GC2 and GC3), the building contractor (BC1, BC2 and BC3) and consultant companies (CC1 and CC2) were select as a sampling frame with a stratified for the study. Sample size has an effect on how the sample findings accurately represent the population

(Alvin C. Burns, 2010). In this selection the sample size for GC1select 4 companies, GC2 select 2 companies, GC3 select 3 companies, in BC1 select 4 companies,BC2 select 2 companies,BC3 select 3 companies and for consultant(CC1 and CC2) select 2 companies for each. Therefore, the targeted survey respondents were construction professionals and experienced who are working on these construction companies professional workers. This includes project managers, project engineer, site engineer, supervisor, site formal, material inspection, storekeeper, and purchaser. For each consulting company are select three professional and stakeholders workers such as, client, designer and quality and quantity specifications' worker. According to, Ethiopia construction authority bureau this was search from the construction license registration to study in 2022 approximately, total general contractor=2925, building contractor=1369 and consultant companies=113 registered.

Based on the obtained list of registered contacting companies from the Ethiopian Construction Bureau, the total number of registered contracting companies as building contractors one, two and three However, in our country Ethiopia especially in Addis Ababa in the current situation mostly works general contractors most apply in building in these samples:

GC1= 39	BC1= 27	CC1=10
GC2= 12	BC2= 9	CC2=8
GC3=21	BC3= 18	

In this sample determination both probability and non-probability sampling methods use in stratified and purposively in respectively. First, in probability method I select the sample study in stratified organization of GC1, GC2, GC3, BC1, BC2, BC3, CC1, CC2 depend on criteria grade, capacity, depth and organization. Second In non-probability method, I select the sampling frame purposively within professional and experienced.

Therefore, Slovin (2012) sample size formula was adopted to determine the estimated sample size using Creative Research Systems updating in (2016).

$n=\frac{N}{1+N(e^2)}$ (Equation.1) in each sample to use $\frac{Nn}{N}$*n

n= sample size

N= total population

Nn=each population

e=margin error where: Based on most studies, a 95% confidence level (Creative research Systems, 2016; precision, a confidence interval margin error (*e*) of 5% was also assumed for this study.

To ensure good representation of each stratum, the random probability selection was used within each kind. Therefore, the sample size of this study was calculated thus

3.6 Sampling Techniques

Sampling Techniques is refers to the nature of the topic the sampling techniques used for this study was applied non-probability sampling techniques. In the sample I select to get accurate data's and without bias accurate data has to get. In the non-probability sampling; purposive (judgmental) sampling was used by focusing on concerned bodies or stakeholders who directly involve preparation, implementation on management of building construction projects for professionals, sites, officials work in site, and office was selected in judgmental sampling technique.

3.7 Data source

The study used both primary and secondary data sources to obtain sufficient and relevant data that is use to answer the research questions. The primary sources were gathers through observation, key informant interview that includes a discussion made with the construction professionals, and select focuses group. The secondary data were collect from different source like books, reports, Journals and different articles from the internet.

3.8 Methods of data collection tools

Data collection tools are essential for gathering information systematically and accurately. In this research data, collected tools used in this study, which includes observation, interviews, quaternaries, within focus in position and documents analysis within surveys.

3.8.1 Questionnaire

As it is stated by (Mark et al, 2016), a questionnaire is the most widely used method in survey strategy. As the authors suggested, it is because the respondents, which will provide an effective way to, collects responses from a large sample before making quantitative analysis. To obtain the needed data, questionnaire was used as a data collection tool, due to the sample size and the quantitative approach of the study.

For General Contractor (GC1, G2, G3)

Total Number of GC1+G2+G3=39+12+21=72

$n=\frac{N}{1+N(e^2)}$, ⟹ $\frac{72}{1+72(0.05^2)}$ =61

To use $\frac{Nn}{N}$*n ⟹ GC1, $\frac{39}{72} * 61=33$

GC2, $\frac{12}{72} * 61=10.16=11$

GC3, $\frac{21}{72} * 61=17.79=18$

For Building Contractor (BC1, BC2, BC3)

Total Number of BC1= 27+9+18=54

$n=\frac{N}{1+N(e^2)}$, ⟹ $\frac{54}{1+54(0.05^2)}$ =47.57=48

To use $\frac{Nn}{N}$*n ⟹ BC1, $\frac{27}{54} * 48=24$

BC2, $\frac{9}{54} * 48=8$

BC3, $\frac{18}{54} * 48=16$

For General consultant (CC1, CC2)

Total Number of =8+10=18

$n=\frac{N}{1+N(e^2)}$, ⟹ $\frac{18}{1+18(0.05^2)}$ =17

To use $\frac{Nn}{N}$*n ⟹ CC1, $\frac{10}{18} * 17=9$ and

CC1, $\frac{8}{18} * 17=7$

The total population of sample size=33+11+18+24+8+16+7+9=126 samples

Therefor the population homogenous character has to reduce sample size.

GC1=4 companies, 7*4=28 pop	BC1= 4 companies, 6*4=24 pop
GC2=2 companies, 6*2=12 pop	BC2=2 companies, 6*2=12 pop
GC3=3 companies, 6*3=18 pop	BC3=3 companies, 6*3=18 pop
CC1=2 companies, 4*3 = 8 pop	CC2=2 companies, 3*2 = 6 pop

Total sample = 28+12+18+24+18+12+8+6 =126 sample population for questioner

3.8.2 Interview

Interviews are qualitative in-depth interviews with people who know what is going on in the community to use semi structure. The data is collect from 22 companies and 64 experienced in building construction professionals, which have more year of experience; the particular reason for circumstance is that since they are experienced they will recommend better

techniques to minimization of wastage. The researcher selected these methods because of this approach help me to collect rich information and saturated data by taking time.

3.8.3 Personal observation

Observation is to collect data through watching and recording behaviors or events as they occur within participant to use real time contextual information. In this study, to observe different building construction sites the material arrangement and store handling in construction sites.

3.9 Methods of data analysis and presentation

3.9.1 Methods of data analysis

There are two methods used to analysis the data of this study. First, thematic analysis is to identify and analysis themes from qualitative data to understand the qualitative aspects of different priorities. In this study flexible and suitable a research question and it provides a rich and detailed understanding of data.

Second, descriptive methods are used to summarize data and analysis and describe data collected from the survey. Since the research design used to meet the objectives is descriptive, statistics in questioner using quantitatively that involve to 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 present in chart, tables and graphs.

The analysis has combine all groups of respondent (general contractors, building contractors and consultants) in order to obtain significant results the data was analyze by calculating frequencies and relative importance index (RII). The relative importance index (RII) is calculate as follows

Relative Importance Index (RII)

Relative importance index (RII) was use for generating an index and used to show the level as perceived by research participants (Holt, 2014; Wahab and Lawal, 2011). To determine the relative ranking of factors, the scores were transforming into important indices based on the following equation (Tam, 2007) within impacts of material waste and effective management in site and overall total impacts in percentage quantitatively.

$$\text{RII} = \Sigma W/A*N$$

where *w* is the weighting given to each factor by the respondent, ranging from 1 to 5 in and overall impacts in percent which ‘1’ very low cause, ‘2 is low cause, 3, is medium cause, and

4 is high cause ‘5’ is very high cause. In the other objectives, 1’ is very low effectiveness, 2, is low effectiveness, 3 is medium effectiveness, 4 is high, effectiveness 5’ is very high effectiveness. The percentage of impact values 1-100% within intervals 5% or others to use in your option.;; *N* is the total number of samples, 126 for this study, and RII the relative important index, $0 \leq RII \leq 1$.and within the overall impacts and effectiveness in project cost, time, quality and budgets to indicate in percentage.

3.9.2 Method of data presentation

Data presentation referrers to the way of research finding to help complex data understanding presentation with table, charts, graphs, figures and diagrams. The data analysis was using qualitative techniques table, chart and textual written up of the data. In this techniques choosing the right methods depends on the nature of the data and the purpose of the presentation.

3.10 Data quality assurance

3.10.1 Validity

The validity of the measurement instrument of the study is conducted based on the literally accepted associated with conceptual framework that clearly indicate the theoretical construct and associated with the measurements valid to evaluate the relationship between all factors. Where possible this should be supported and consideration given to practical things. So those pre-questionnaires were distributed to check the validity of questions to further data collection process.

3.10.2 Reliability

A reliability test of Cronbach’s Alpha was made for the liker scale type questions on SPSS Cronbach’s alpha is a measure used to assess the reliability, or internal consistency, of a set of scale or test items the scale accurately represents the construct of interest.

3.10.3 Ethical Consideration

Throughout the process of doing 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.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Introduction

This chapter illustrates in detail the results, interpretation and discussion of the collected data using survey. It was done in three sections, such as descriptive data about respondent's demographic traits, inferential statistics and discussion of results. The main purpose of this survey is to identify the main cause of material waste in construction, and minimization of construction material waste within analysis data.

4.2 Respondents' profile

4.2.1 Respondent's rate

This section of the questionnaire was prepared to classify the respondents contracting firm.

Table 4.1 Respondents rate

Contractor's And consultant		Respondent's In each	Questioners And interview Distributed(N)	Filled and returned	Responses Rate (%)	Response From Total (%)	Rate Sample (%)
GC1w	4	4*7	28	25	85.71	24.27	22.22
GC2w	2	2*6	12	10	83.33	9.72	9.52
GC3w	3	3*6	18	15	83.33	14.56	14.29
BC1w	4	4*6	24	20	83.33	19.42	19.05
BC2w	2	2*6	12	9	75	8.74	9.52
BC3w	3	3*6	18	14	77.78	13.59	14.29
CC1w	2	4*2	8	6	75	5.82	6.35
CC2w	2	2*3	6	4	66.67	3.88	4.76
	22		126	103	81.74	100	100

Source: Own Survey (2024)

Out of 126 questioners and interview distributed in 18 construction companies, and 4 consultants, are 103 of them were received with a response rate of 81.74%. The rest of the questioners and interview were not used in the analysis process because 8 of them were not received and the rest 13 of the respondents gave incomplete and illogical responses. In interview to focused on in qualitative data's and in the main variables, within corresponding and to focuses on accurate, reliable datas.in this respondent select on without biasness. In this study, the contractor and the consultant works in Addis Ababa to select on grades of and focused on their capacity and levels. Most of the organization respondents work on site and some of respondents work on office to collect on data's.

4.2.2 Respondent's Position

The questionnaire and the interview was received from 103 and 64 professionals for respective who are working in different position within their construction company in my study to get a reliable data I select professional persons in different position.

Table 4.2 Respondent's Position

Position	Respondent's	Filled and returned	Response Rate (%)	Responses from total	Sample Rate (%)
Project manager	18	16	88.89	15.53	12.7
Project engineer	18	13	72.22	12.62	12.7
Site engineer	18	17	94.44	16.5	12.7
General formal	18	15	83.33	14.56	12.7
Material inspection	4	2	50	1.94	3.17
Storekeeper	18	16	88.89	15.53	12.7
Purchaser	18	15	83.33	14.56	12.7
Designer or Quantity engineer	4	3	75	2.92	3.17
Supervisor or	4	3	75	2.92	3.17
Quality engineer	3	2	66.66	1.94	2.38
Client	3	1	33.33	0.98	2.38
Total	126	103	82.54	100	100

Source: Own Survey (2024).

This illustrates that since I selected professional's workers to gate a reliable data related to the position., the data collected from them will be more reliable and validate the site engineers works more in to the action so they have practical experience on waste so collected data from those experienced site engineers will be more reliable. In this study to get appropriate and accurate data depends on respondent qualities and position in the study areas of construction materials waste management.

4.2.3 Academic Qualification of Respondents

The education background of the respondents, 50.47% of the respondents have first degree in fields of Engineering and social sciences whereas the second most of the respondents had master's degree.

Table 4.3Academic Qualification of the respondent

Education level	Number of response	Percent of Response	Position of response
PhD degree	3	2.92	Project manager, supervisor
Master's degree	27	26.22	Project manager, project engineer, site engineer, purchaser, designer ,supervisor, client
Degree	52	50.47	Project manager, project engineer, site engineer, supervisor, purchaser, designer, general formal, storekeeper
Diploma	21	20.39	General formal, storekeeper, purchaser
Total	103	100	

Source: Own Survey (2024).

4.2.4 Year of work experiences in construction

The data of the respondents have 5-10 and 10-15 years of experience, 63 (61.15%) have most respondents. In general, more that 50% of the respondents have 6-15 years of work experience. This illustrates that the data collected is more data that are reliable.

Table 4.4 Respondent's years of experience

Year of work Experience	Number of Response	Percent of Response	Position of response
1-5year	12	11.65	Site engineer, purchaser, designer, storekeeper
6-10 year	34	33.00	Site engineer, purchaser, designer, storekeeper
11-15 year	29	28.15	Project manager, site engineer, supervisor, Project engineer,, designer, purchaser
16-20 year	19	18.45	Project manager, , supervisor, general formal Project engineer,, designer, purchaser,
21-25 year	6	5.83	Project manager, General formal, client
Above 25 year	3	2.92	General formal

Source: Own Survey (2024

4.3 Major Cause of construction material waste

In this part the result of causes of material wastage that were gathered from interview, questionnaire survey and site observation are presented and discussed. This gives a good indication on which activities need to be focuses for each material in order to reduce waste.

The questionnaire and interview of this study considered major causes those causes were categorized into five sources as mentioned before, namely design and documentation, material handling, operation and workmanship, procurement, site management principles.

4.3.1 Source of construction material waste

In this study major sources of material waste are also been identified related to the respective construction material wastes from the wastes causes. In this data collected within interview to identify and related major source and causes of material waste in qualitatively.

As most of respondents within interview different sources have mentioned, the sources of waste classified under five categories: those are design and documentation, site management and practices, materials handling and storage, operation and procurement. However, some respondents are says a source of material wastes are, nature of waste, direct waste and indirect waste and vary some respondents add site supervisor in above five categories.

4.3.2 Cause of material waste in building construction site

In this study to identify, the major cause of material waste focused on building construction projects on site. The data collection system the respondents are experienced and professional in research methods in interview sampling techniques.

The major causes of construction material waste, the respondents of general contractor and building contractors, generally listed as

Reworks do to work mistake and reading drawing, design change and revision, lack of on-site material control, severe weather condition, select on poor quality product, use in correct material, untrained Construction worker, lack of material management system, improper handling, irregular shape of material, poor quality control,

Some of the general contractor and building contractors respondent, are the major causes in in construction, general says as inadequate supervision, choice of wrong construction methods, loss during transportation and applicant, delay in procuring technical expertise, law and order problems, contractors and labor problem, delay in material selection and approval, lack of finance, and breakdown in construction equipment

Most of the general consultant's respondent are, the major causes in in construction, general says as design changes, complicated design, inexperience designer, poor quality materials, improper material storage, lack of on-site material control, and reworks do to work mistake and reading drawing

Some of the general consultant's respondents are, the major causes in in construction, general says as delay during delivery, equipment failure, design errors, damage during transportation and interaction between various specialists

Questionnaires were designed to measure the level of their contribution to the selected major cause of material waste generation in the sites. There may be numerous causes responsible for the generation of waste in different systems. However, some general causes of material waste generation at different stage have been perceived in numerical data's within relative important index and rank.

In this study the cause of material waste are very diferent factors listed but the respondates generally listed in and the other factors incluiding in 22 major cause of construction material waste in building construction projects are listed below within and put within rank:

Table 4.5: Major causes of material wastage on construction site

Source of waste	**Causes of material waste**	**Relative important index(RII)**			
		Contractor	Consultant	Average	
		RII	RII	RII	Rank
Design and documentation	Poor design, redesign ideas change, poor specification and design error	0.73	0.76	0.74	1
Operation and workmanship	Rework due to personal error, change client ideas	0.72	0.74	0.73	2
Design and documentation	Lack of knowledge interpretation and information in the complexity of the drawings and material	0.7	0.72	0.71	3
Site management and practices	Poor management and distribution of labors, materials and equipment	0.67	0.7	0.68	4
Design and documentation	Selection of low quality products and use incorrect material	0.66	0.68	0.67	5
Operation and workmanship	Using excessive quantities of materials more than the required	0.64	0.66	0.65	6
Design and documentation	Selecting the lowest bidder contractors and tendering subcontractor	0.64	0.66	0.65	7

Site management and practices	Lack of proper waste management plan and control and minimization techniques	0.64	0.64	0.64	8
Material handling	Cutting materials in to various sizes and uneconomical shapes	0.63	0.64	0.63	9
Material handling	Wrong handling and storing of material	0.63	0.62	0.62	10
Design and documentation	Lack of attendance paid to standard sizes, dimension, coordination, elevation and poor site layout	0.63	0.62	0.62	11
Material handling	Damages during transportation, loading and unloading	0.63	0.6	0.61	12
Operational Waste	Untrained labors, lack of labor, and Shortage of manpower (skilled, semiskilled, unskilled labor	0.63	0.58	0.60	13
Design and documentation	Inadequate experience to read drawings and material ordering error	0.62	0.58	0.604	14
Operational Waste	Lack of knowledge within material and lack of team work	0.62	0.56	0.59	15
Material Handling	Lack of onsite materials control and lack safe store	0.62	0.54	0.58	16
Material handling	Severe weather condition and moisturizing condition	0.62	0.52	0.57	17
Site management and practices	Lack of a quality management system aimed at waste minimization	0.61	0.5	0.55	18
Operational Waste	Choice of wrong construction method	0.61	0.48	0.54	19
Site management and practices	Ineffective planning and scheduling of the project by the contractor	0.602	0.46	0.53	20

Site management and practices	Lack of supervision or incorrect decisions of the management	0.58	0.44	0.51	21
Material handling	Vandalism and thief	0.56	0.3	0.43	22

Source own survey (2024)

From the above table 4.5, was ,37.9% of respondents from the total revealed that design changes error revisions and poor specification are the major causes of material waste in construction site, 33.2% respondent's from the total are rework due to idea change personal error are and 20.1% of the respondents are lack of knowledge, interpretation and lack information in the complexity of drawings and material specification are the causes of material wastage but 8.8% of respondent's believes lack of supervisor or incorrect decisions of the managements are the least rank of cause of wastage on construction sites in this research. In these, the main cause of material waste is not different from other researchers but in use these study to identify the main and major cause and finalized ted cause within diferent values from the past researchers.

In this, study the interview data support the questionnaires data's, and my observation most of respondent's are both qualitative and quantitative data's design changes, revisions and poor specification are major cause of material waste and are the minor cause un economical or irregular shapes. In these data to identify, the major cause and sources of material waste and focuses on in this major cause.

4.4 Impact of material waste on construction project

In this study to determine, the major impacts of material waste focused on in building construction site. Most of the interview respondent's it has a major impact of material wastes are economic, social and environmental impacts, such as construction projects to increase construction cost, construction time delay, loss of construction quality's and environmental impacts and some of respondents says list the above and add productivity and sustainability aspects. Currently in Addis Ababa in every corner, various constructions are under way specially, building construction to observe material wastes. In this study, most of the interview respondents are the impact of material waste of the main and major impact was increase construction cost loose contractor profitable, the second impacts was environmental impact, the third impacts are construction time and the fourth impact was quality. In this study most of respondents was says material waste are high impacts of building budget cost.

4.4.1 Impacts of material waste in environmental pollution

Construction material wastes are affects the environment in different dust particle and carelessness' work producer. In these study 54% of respondent was material waste are affects environment in subjected though the depend on material waste, are to increase 10% to factor polluted, and the others are 5% environmental impact in social, healthily impacts in due to construction processes. Material wastage in building construction projects are impacts mostly cost, quality, environment, time totally affects social economic and environmental impact in the world. These impacts are to happened in different causes and sources of construction waste.

4.4.2 Impacts of material waste in building construction projects

Construction material wastes are affects in overall building construction budgets depend on time delay, high waste material quality and quantity. As described in the methodology used in the numerical formula for wastage level (percentage) and selected 18 projects that have just in progress. Materials difference was carried out by comparing the difference between the stored (purchased) material and the actual requirement of material according to the bill of quantity.in this study 82% of respondent's the total cost budgets to increase 15-25% overall cost. In these study the respondent listed main impacts of building construction material waste are numerical data's are list below within percentage.

Table 4.6 Impacts of construction material waste in percentage

Impacts of construction waste	**Contractor**	**Consultant**	**Average**	**Impacts**
Projects cost overruns and loose contractor profits	20-25%	10-15%	15-20%	Economical &social
Environmental pollution impact	10-15%	10-15%	10-15%	Economical &social
Projects delays	10-15%	5-10%	10%	Economical &social
Project quality	1-5%	5-10%	5%	Economical &social

Source own survey (2024)

In In the above table (4.6), 82% contractor and consultant of respondents subjected though the material waste impacts 15-20% increase the total budgets, the second 10% of

respondent's subjected though the waste impact the overall cost on time delay and the third environmental impacts increased by 10-15% and other respondent says 5% increased loose of quality. In this cause the impact of waste are loos profits, time delay, environmental impact and loos quality of construction. In these cause, all construction impacts are to influence project budget. In these study, the interview data support the questionnaires data's and to triangulate within the paste researcher especially (Sharon Jepkemboi, 2017) but it is not similar within variables and values.

Generally, in the above data's construction, material wastes are high impacts in social, economic, environmental and health impact. Depend on above data's material waste are a serious things and to focuses in how to minimize or eliminate the material waste in building construction. Building construction projects budgets are more sensitive for construction materials in this cause an attention in waste.

4.5 Effective construction material waste management strategies

In these studies, the respondents listed deferent various strategies, approaches, and measures of construction waste management practicing in the public and private building construction sectors. Most of respondents to use different characterize identify five effective good and best-recommended use strategies for construction waste management in Addis Ababa cities. The strategies approaches apply on site such as economy zero waste approach, site waste management plan, use 4 Rs techniques (reduce, reuse, recycle and replace), proper design and prefabrication and modular construction system. But some others respondent to use in building construction waste management strategies are apply in different waste control methods such as, inventory control, operational control, controlled by engineering service management, controlled by supply chain management, controlling during planning, design & development management and others. The interviewer listed below five strategies:

4.5.1 Zero waste approach

Zero waste (ZW), which is a perceptive system of waste management, has been introduced as an alternative solution for waste problems in recent decades in many cities. ZW concept motivates sustainable consumption and production, optimization of resource recovery, recycling, and prevents wastes from incineration, landfilling and within construction. In this, research most construction organization to use zero waste management to prevent wastes in before happen depend on materials high cost and values.

4.5.2 Proper disposal, Recycling, Reuse, Reduce, prevention

Most of the construction waste research is largely focused on the "three Rs" and others strategies of waste (reduction, reuse, and recycling), also known as the waste principle. Though recycling technologies have been developed in recent years, how to promote the use of recycled products is still an issue to be solved.

4.5.3 Prefabrication and modular construction

Prefabrication can reduce construction waste by minimizing on-site wet trade and improving constructability, buildability and perform better than conventional construction methods in environmental, economic, and social aspects. Prefabrication and modular means to prepare in industry and to construct in install mechanisms in this cause the waste to minimize.

4.5.4 Site Waste Management Plans

A waste management plan is required for all public private projects and has proved that to plans different waste minimization and waste management can be improved. However, the effectiveness of SWMP is limited by site constraints, overhead costs and to plan their procedure. The majority of sites do not have enough areas to carry out on-site sorting, which is labor intensive. In these studies, the most respondent listed best waste management techniques to reduce and use in their company site waste management plan.

In this study in quaternaries data, survey the respondent least in six material waste strategies

Table 4.7 Strategies for construction material waste in percentage

Strategies material waste	**Contractor**	**Consultant**	**Average**	
	RII	RII	RII	Rank
Proper disposal, , Recycle, Reduce, Reuse, prevention	0.74	0.76	0.75	1
Zero waste approach	0.73	0.74	0.73	2
Site waste management plan	0.72	0.72	0.72	3
Waste control management	0.66	0.64	0.65	4
Proper design	0.65	0.46	0.55	5
Prefabrication and modular construction	0.71	0.7	0.708	6

Source own survey (2024)

From the above table 4.7 the quaternaries 52% of respondents most organization to use here Rs techniques and other the second rank organization are use zero waste approach and the third rank organization to use site waste management plan and the least rank the organization to use prefabricate construction method. In interview most of high respondents in building construction site in theirs organization use zero waste management strategies system and the second most respondents in theirs organization to use four Rs techniques. The study lasted in stapes by stapes within the respondent's number but all of strategies are used to minimizing wastage. In these studies, the interview data support the questionnaires data's and to triangulate within the paste researcher especially (Sharon Jepkemboi, 2017) but it is not similar within variables and values.

4.6 Material waste minimization techniques in building construction projects

Most researchers, waste minimization are the solution for reduce wastage of materials on site because wastage cannot avoid 100% but we can minimize waste by different measurements. However, in this research depend on construction material inflation to focused on material wastage to eliminate or very vary reduce wastages.

Common waste minimization techniques are avoiding waste production, reducing cause and source of waste, reducing materials through repair or finding new purposes and recycling materials like paper, plastic and metal.

In these researches, the most respondents are listed the best minimization techniques of material wastage such as, prevent, reduce, reuses, recycle and replace and disposal waste stratifies and principles to use their organization. The "4R" concept, which refers to reduce, reuses, recycle and replace,

Prevention of waste: to use effective material managements to identify source and cause of waste and to eliminate and minimizing waste.

Reducing the waste: The developed system employs the trendy principles of supply chain method (SCM) with the concept of 'just-in-time 'delivery (JIT) to supply construction materials to construction sites to use different site waste management system efficient ordering, minimize mistakes and strong design.

Reusing the waste: The developed system offers possible ways to reuse waste materials in the same project and type through functioning as an expert system. The system can be refilling, returning and updated with new possible reuse options.

Recycling the waste: The developed system provides possible options for recycling construction materials waste in fabricate and treatment that cannot be reused. The system can be updated with new possible recycling options whenever emerged.

Replace or recovery the waste: To choosing renewable materials over nonrenewable materials. It is alternative resources or recovering material for reuse, recycling, essential for reducing, promoting sustainability and minimizing environmental impacts.

Disposal: the collection, sorting, transport and treatment of waste and to remove wastes for site. This criteria of waste management as improper disposal can have negative environmental, economic and social consequences.

In these, the above waste minimization techniques are the most of respondent's says best of mechanism for to minimizing construction material waste. These research approaches to Selam Hilemariam (2016) assessments of construction material waste in Addis Ababa but not similar and not studies these deep investigation in minimizing of waste.

4.6.1 Material waste management on site

In this study most contractor and the consultant used their organization waste management techniques listed below

Good construction management practices: to cover all major aspects of the construction process including construction contract, documentation, stockholder, material, equipment and others to manage. In this study good management in construction to reduce waste, cost and time.

Good Planning and site management: construction projects run smoothly, proper use of material, work force arguments within efficiency and to plan before starting the work. In these study construction company to use different waste site management respondents listed, for proper storage of materials on site, minimizing design error, adoption of proper site management techniques, appropriate waste management on site, ,accurate and good specifications of materials to avoid wrong ordering, Accurate measurement of the size and quantity of material on site and Provide incentives to motivate personnel to minimize material wastage.

Good construction material waste management policy: to proper strategies with minimize waste due to reduce, reuse and recycling. In this study the contractors applies different waste minimization policies and strategies in building construction to use proper construction waste

management polies and to protect environmental protection polies.

In this study the material waste minimization techniques the most respondent to listed the main material waste minimization techniques prevention, reduce, reuse, recycle, replacement, remove, and good and best practices managements for construction and proper used and the other respondent says waste management policy's and strategies is first. Most of respondents in interview, says best material waste minimization techniques, are prevention, reduce, reuse, recycle, and removing.

In this study are appropriate to (Selam Hilemarim 2011) in item of cause and waste minimization but different from ranks of major cause of waste, values of impacts, strategies and minimizing techniques depend on research years variation. This research and other researches are similarity in some kinds such as, cause of waste item, impacts, strategies, and minimization but it differently, their data, values, list of items in different mechanisms such as, duration of time, sampling size, data collection mechanisms, and selection of target population. In these studies, the interview data to triangulate within the paste researcher especially (Sharon Jepkemboi, 2017) but it is not similar within variables and values.

Most of construction companies mostly to use all waste techniques, that means mostly to use prevention, site waste management, reduce and reuse techniques, but the second construction companies mostly to use site waste management plan and the other construction companies to use zero waste management or prevention mechanize and same companies to use recycling and or replacement removing disposal the waste.

Finalizing in these studies, to the most respondents construction companies data sets in best and to use construction material waste minimization techniques on building projects to add other mechanisms from the paste researchers and listed out, site waste management plan, zero waste management techniques, prevention, reduce, reuse, recycle, remove for disposal system and other mechanisms on site.

Different researchers are studies in waste in different time but the results are also different and not focused an attention. In these studies to focused an attention depend on material inflation cause in own country to investigate and focused the accurate data collection systems within identify the main causes and best waste minimization mechanisms, strategies, polices, and principles for this research. All construction site workers focused on eliminate or reducing of waste in all days.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter is consisted of three sections. The first section presented explained about the general conclusions reached depending on the findings and finally gave recommendations for concerned in construction waste management and reducing construction material wastage in building construction projects.

5.2 Conclusion

The purpose of this study was to identify the major causes and source of construction material waste, a problem of waste in construction site is facing but does not obtain sufficient attention depend on serious high material inflation. Before coming to construction material wastage to use minimization techniques, strategies and principles, to identifying the major root causes of the problem is the first and helpful intervention. The study identified the major cause of construction material waste that needs a serious intervention by the construction professionals. According to the identified causes, the top cause's construction material wastage mainly sources in the category design and documentation, material handling and procurement operation and workmanship and site management principles. In the design and documentation category, ranking design changes and errors at construction stage were the major causes for the occurrence of construction material wastage. It has been categorized stated that communication is vital for the success of a project especially for a construction project, which needs teamwork. Therefore, this requires the collaboration and sufficient communication between the client and skilled manpower, consultant and contractor before the construction begins in order to avoid frequent design changes, error and rework at the construction stage.

Moreover, this study also provided empirical evidence on the contribution and the levels of practice of waste minimization techniques for each of the above main causes of construction materials waste in building construction projects. It has shown that for all of the main construction project materials measures, which have high impacts in building project. In this construction building project, to use the best waste minimization, techniques, strategies and principles to reduce overall budget and time delay. In this study to get best minimizing material waste management strategies and techniques for researching such as; prevention,

reduction, reuse, recycle, and their management zero waste management, proper site waste management and others.

5.3 Recommendation

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

In the design phase of the project, the consultant and the client need to communicate and agree exhaustively towards the scope of work based on the client's interest and refer modernity design.

There is a need to develop a scientific methodology and techniques to quantify waste; set an acceptable and approved rate of material waste and develop materials waste minimization plan and strategies, an effective construction materials management system and implement in construction projects.

The consultant need to be sure the quality of materials delivered on the site is as stated in the specification, drawing and construction supervisors and contractors on the site shall start refusing to accept substandard material and to employ knowledgeable and skilled man power and check to work in the design.

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 perishables material.

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

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

Advice good site controlling strategy and principles to ensure adequate material planning and ordering, and procurement on-site material handling and storage, which are helpful for controlling excessive material wastage. In order to facilitate this, supervisors should also give

emphasis to different parameters of these building projects in allocating the site supervisors so as to make easy the site controlling and supervision work.

Another useful measure is strengthening the enforcement of existing relevant laws. Strengthening the enforcement of laws such as the solid waste proclamation and environmental impact pollution which imposes penalty in cases of violation should be considered. The public body should strengthen supervision to make contractors live up to their contractual obligation. As an implementing governmental body, it has the obligation to enforce constitutional provisions pertaining to environmental protection as well as other relevant laws.

To recommend new effective material waste strategies and principles in construction site, and the government is to prepare their waste management policies.

5.4.1 Recommendations for further study areas

This study with its limitation has investigated the assessment of material waste management in building construction projects in Addis Ababa in selected contractor's and consultant level. Nevertheless, the following issues are identified and suggested for future studies.

This study was carried out in the general and building contractor companies of one, two and three and consulting companies one two so further studies should be made on the rest of the construction companies to identify additional root causes of construction material wastage and there methods. Besides, further studies should include additional level perspective of consultants, owner and clients in this area.

It is required study practices of material and construction materials management in Ethiopian Construction Industry and applies on site this principle and strategies.

It is necessary to repeat this research every two years to observe the new trends of contractors and to eliminate the waste because of increase day-to-day marketing inflation.

It required the research of innovation, new technology of recycling waste, modern construction use wastage in other function and managing mechanism for applying to construction companies in Ethiopia, especially in Addis Ababa.

To recommends, the researchers to use inferential analysis method specially milt logistic regression in the relation with cause and effects. In this study to used different mechanisms for collecting data's and target population but the future researchers used new technologies, the results other statics analysis methods.

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APPENDIX A

Data collection instrument for Questionnaire

Construction technology and Management Department

MSc thesis on construction technology and Management

Dear Respondent,

I am kindly requesting your willingness to participate in this research Building Construction Projects" by filling this questionnaire. Any information you are willing to provide will be greatly appreciated.

- The objective of this research is to identify the major cause of material waste in building construction projects, there impacts of material waste in building projects effectiveness of strategies of material waste in construction and during construction operations and to examine for minimizing construction material wastage.
- All the data collected will only be used for academic purpose. If you have any inquiry, please feel free to contact me through the provided addresses.

Thank you for giving 30 minutes of your time and your kind cooperation for the research.

Contact Address

Mekuanet Hunegnaw

E-mail: mekuanet16@gmail.com

Phone No: 0912780157

Please note that it is very important and focuses that each question is read carefully, and answered consciously.

Please tick or write in words as required on the space provided at your convenience to respond the questions.

SECTION A: RESPONDENT'S IDENTIFICATION

1. Category of your firm: Level

1. GC1 ☐	4. BC1 ☐	7. CC1 ☐
2. GC2 ☐	5. BC2 ☐	8.CC2 ☐
3. GC3 ☐	6. BC3 ☐	

2. Your position in the company

1. Project Manager ☐

2. Project engineer ☐
3. Site Engineer ☐
4. General Forman ☐
5. Purchaser ☐
6. Material inspection or quality engineer ☐
7. Storekeeper ☐
8. Supervisor ☐
9. Designer or Quantity engineer ☐
10. Office Engineer ☐
11. Client ☐

3. For how long have you been working on the construction industry?

[1] 1-5 years ☐
[2] 6-10 years ☐
[3] 11-15 years ☐
[4] 16-20 years ☐
[5] 21-25years ☐
[6] Above 25 years ☐

4. Educational background

1. PHD ☐
2. Masters ☐
3. Degree ☐
4. Diploma ☐

SECTION B: MAJOR CAUSES OF WASTAGE

1. The following are selected that major cause for construction material waste in Addis Ababa building construction projects. Please indicate the level of causes or influence on the following statements regarding to your project. Please note that: 1= Very low cause; 2= Low cause; 3 = Moderate cause; 4 = High cause; and 5 = Very high cause

No	**A. Design and Documentation**	Very low Cause	Low cause	Medium Cause	High cause	Very High cause
		1	2	3	4	5
1	Poor design, redesign, ideas change, poor specification and design error					
2	Lack of knowledge interpretation and information in the complexity of the drawings and material					
3	Selection of low quality products and use incorrect material and blue print error					
4	Selecting the lowest bidder contractors and tendering subcontractor complexity error of drawing					
5	Lack of attendance paid to standard sizes, coordination, elevation and poor site layout					
6	Inadequate supervision and material ordering Error					
	B. Material handling and Procurement	Very low cause	Low cause	Medium Cause	High cause	Very High cause
1	Cutting materials in to various sizes and uneconomical shapes					
2	Wrong handling and storing of material					
3	Damages during transportation, loading and Unloading					
4	Lack of onsite materials control and lack safe store					
5	Severe weather condition					

	C. Operation and workmanship	Very low cause	Low cause	Medium Cause	High cause	Very High Cause
1	Rework due to personal error, change client Ideas					
2	Using excessive quantities of materials more than the required					
3	Untrained labors, lack of labor, and Shortage of manpower (skilled, semiskilled, unskilled labor					
4	Lack of knowledge within material and lack of team work					
5	Choice of wrong construction method					
6	Cutting the material and un proper material Use					
	D. Site management and Practices	Very low cause	Low cause	Medium Cause	High cause	Very High Cause
1	Lack of supervision or incorrect decisions of the management					
2	Lack of proper waste management plan and control and minimization techniques					
3	Poor management and distribution of labors, materials and equipment					
4	Ineffective planning and scheduling of the project by the contractor					
5	Lack of a quality management system aimed at waste minimization					

Section B: The main Impacts of material wastage on building construction projects

1. How much percent affects the overall building construction project in material wastage and put their reasons?.....

2. On a scale of 1 to 100% how would you rate over all impacts of material waste on your building construction projects?

Use in your percentage interval option 1-5%, 5-10, 10-15%, 15-20%, 25-30%, 30-35%, 35-40%, 40-45%, 45-50%, 50-55%, 55-60%, 65-70%, 70-75%, 75-80%, 80-85%, 85-90%, 90-95%, 95-100% put below table but 1-20%=low impact,21-40% medium affect,41-60% moderate affect,61-80% high affect,81-100% very high affect or to use other percentage ……..

No	Impacts of construction waste	Low affect	medium affect	moderate affect	High affect	Very high affect	Other value
1	Projects cost overruns and loose profits						
2	Projects delays						
3	Environmental pollution impact						
4	Project quality						

SECTION C: Effectiveness of material waste management on building projects

1. Measure the effectiveness of material waste management strategies in your organization (reduction in waste volume or cost saving and How much effectiveness do you rate)?

1= very low effectiveness, 2= low effectiveness 3= medium effectiveness 4= high effectiveness 5= very high effectiveness or others to use in your option

No	Strategies material waste	Very low	low	medium	high	Very high
		1	2	3	4	5
1	Three Rs (Reuse, Reduce,					

	Recycle|),proper disposal, prevention					
2	Zero waste approach					
3	Site waste management plan					
4	Waste control management					
5	Proper design					

APPENDIX B

Key informant Interview Questions

Data collection instrument for interview

SECTION A: Causes of material waste on building construction

1. How do you define and measure material waste in your building projects?

- ✓ ……
  ……
- ✓ ……

2. What are the primary and common sources of material waste in your construction site? List and describe?

- ✓ ……
  ……
- ✓ ……

3. What do you see as the primary or major causes of material waste in building construction projects? List and describe?

- ✓ ……
  ……
- ✓ ……
  ……

4. In your experience, which sources are more causes of material wastage in building construction site?

- ✓ ……
- ✓ ……

5. In your experience, which construction phase more material wastage has happen in building construction site?

- ✓ ……
- ✓ ……...

SECTION B: Impacts of material waste on building construction

1. How would you describe the overall impacts of material waste on your construction projects?

✓ ……
……
✓ ……
……

2. Can you share specific examples of how material waste has affected your project budgets?

✓ ……
……
✓ ……

3. How does material waste contribute to delays in project timelines? Can you provide an examples?

✓ ……
✓ ……
……

SECTION C: Effectiveness of material waste management on building projects

1. Can you describe the material waste management practices currently used on your construction projects? In addition, how do you assess their effectiveness in your construction project?

✓ ……
……...
✓ ……

2. What are the biggest challenges you faced in managing construction material waste? And how does the challenges or barriers affect your ability to implement effective waste management practices?

✓ ……
✓ ……

3. Can you share examples of successful waste management strategies that used on your experience?

✓ …….....
✓ ……
✓ ……

SECTION D: Measures Taken for Construction Material Wastage Minimizing techniques

1. Is there any kind of techniques used to minimize this material wastage in your site?

Yes ☐ No ☐

A. If your answer is yes, please list some of them and describe

- ✓ ……
- ✓ ……
- ✓ ……

B, What is the best techniques of eliminate or minimizing material waste? And what is 4 Rs minimizing waste?

- ✓ ……
- ✓ ……
- ✓ ……

2. What are your recommendations to minimize material wastage in Ethiopian building projects?

- ✓ ……
  ……

3. Based on your experience, what are some effective strategies or practices to minimize material wastage management during construction?

- ✓ ……
- ✓ . ……

4. In your experience, what innovation or technology have you used to minimize material waste?

- ✓ ……
  ……