JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT STREAM

Investigation on the Factors Affecting Construction Materials Wastage on Building Projects in Jimma Town

A thesis submitted to the School of Graduate Studies of Jimma University in Partial fulfilment of the Requirements for the Degree of Masters Science in Civil Engineering (Construction Engineering and Management Stream).

BY:

EDEN HAFTU

October, 2016

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Advisor: Prof.Emer T. Quezon

Co-advisor: Eng. Getachew Kebede

October, 2016

Jimma, Ethiopia

DECLARATION

This thesis is my original work and has not been presented for degree in any other university

Name	**Signature**	**Date**
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This thesis has been submitted for examination with my approval as university supervisor

Name	**Signature**	**Date**
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ABSTRACT

Now a day's building construction industries are boosting globally and consuming huge amounts of resources. However, responsibly managing waste on a building construction project is a vital component of optimum use of the limited resources to sustain the ongoing development in the construction sectors. Waste on site is the difference between that used as specified and the quantity of material delivered to site as a percentage of such deliveries.

The Ethiopian construction activities were exponentially grown but the construction management practice are poor. The Construction industry in jimma, is an activities and crucial segment in economic development of the town. It generates tons of construction wastes per year, making construction wastes a cross cutting issue for in-depth investigation. Until now, there is no study in Jimma construction sites that has investigated this issue and addressed the main causes and factors that contribute to construction wastes.

Therefore, the general objective of this study was to investigate on the factors affecting construction materials wastage on building projects. This study also identifies the main causes, determine the percentage of construction materials, rank and analyses the main effect on the group of factors and to measure the minimization practices of construction materials wastage on building projects.

The data analyzed was calculated using relative importance index (RII) and the numerical formula to determine material quantity data as well as the percentage of construction materials wastage on building projects considering building schedules of rates (BSR) as the basis for analysing the level of percentage.

The research discovered that the major factors that causing construction waste in building projects are material storage and handling, design and documentation, procurement, operational respectively In addition, the key materials which quantified as per the percentage level wastage coarse aggregate (12.26%), fine aggregate (11.73%), HCB (11.65%), reinforcement steel (9.23%), concrete mix (7.52%), and cement (6.11%) are the key materials wasted on construction sites.

Therefore, the this study conclude that in order to minimize wastage on building projects were practicing good construction management, proper storage and handling of material, encourage re- using of waste materials and uses of appropriate software package to minimize design changes and over ordering.

Key words: ***Building projects, Material wastage factors, Wastage level, Material Management***

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ACRONYMS

BSR	Building Schedule of Rates
BRE	Building Research Establishment
C&D	Construction and Demolition
EPD	Environmental Protection Department
EPA	Environmental Protection Agency
GC	General Contractors
GCO	General Consultant
GERD	Grand Ethiopian Renaissance Dam
GTP	Growth and Transformation Plan
HCB	Hollow Concrete Block
MW	Megawatt
MoWUD	Ministry of urban Development and Construction
SWMP	Site Waste Management Plan
Rs	Spearmen- rank correlation coefficient
RII	Relative importance index
US	United States

CHAPTER ONE

INTRODUCTION

1.1 Background

Now a day's building construction industries are boosting globally and consuming huge amounts of resources. Responsibly managing waste on a building construction project is a vital component of optimum use of the limited resources to sustain the ongoing development in the construction sectors. In this context, managing waste means minimizing the construction waste.

Various researches are conducted within the existence of building material wastage in the context of different countries. Their research reports indicated; there only be cited percentage variation but all proofed the existence of wastage in one or another forms.

In Ethiopia a research has been conducted on wastage of materials in building construction; in the case of Addis Ababa. In most of the survey respondents result showed that 100% agreed up on the existence of material wastage **[9].**

Building material wastage 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 the material wastage **[41].**

The causes of construction material waste can be measured and evaluated using a large number of construction phase related factors such as design and documentation, materials procurement and management, site management practices and site supervision including environmental conditions. The first set is related to designers and client's requirements; the people who consider the functional requirement of the building. The second set is related to construction team and contractors; people who consider the build ability and maintainability of the building. The third set is related to the site supervisors and the site operatives; people who are directly involved in the art of putting the raw materials together to form the building envelop **[4].**

Control of material is relatively a new practice in the construction industry. In the present situation, the contractors and the designers are mainly concerned on how to control cost without any emphasis on waste control measures. Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, a critical control of materials on site together with good construction management is expected to decrease the cost of construction projects. Materials wastage on site cannot be treated fully without good construction management. In fact, material waste level on site is a measure of site management. It is also one of the enemies of contractors. This thesis tries to spectacle the level of the construction material wastage, its cause and effect and finally come up with recommendation how to minimize **[28].**

Construction and building activities contribute to extra construction materials are usually purchased due to material wastage during construction. Various countries have confirmed that waste represents relatively larger percentage of production **[46].**

A study conducted in the United Kingdom reported that an additional cost of 15% to construction project cost overruns as a result of material wastage **[45].**

Material wastage accounts for between 20-30% project cost overruns **[3].** It is therefore glaring that the economic losses from construction material waste could pose a great threat to the economic growth of a nation. There is a growing consensus within the built environment in Nigeria that building materials account for over 50% of the total cost of a building project **[7].**

1.2 Statement of the Problem

Currently, building construction activities are developed globally and consuming a lot amount of resources. It generates tons of construction wastes per year, making construction wastes a pressing issue for in- depth investigation. The major factor in managing and minimizing construction materials waste composition and to quantify is lack of data.

Construction activity in Ethiopia is not an exception ,Construction material waste is becoming a serious problem in materials wastage on site which cannot be treated fully without good construction management. In reality, material waste level on site is a measure of site management. The concrete materials wastage factors happen in many ways such as, all the materials purchased are not fully utilized during construction and this indicates that the left over's may remain as waste that may not be accounted for improper control of materials during different stages of construction.

Currently, there is no available study facing in Jimma construction sites that has been investigated the issue and addressed the main causes and factors that contribute to construction wastes. Therefore, the researchers believe there is a necessity to study this issue in details. Hence, the main goal of this research is to identify the factor that affects the construction materials waste on building construction sites and to provide a percentage level of waste on building construction materials as well as measures how to minimize materials wastage used in Jimma construction projects.

1.3 Research Questions

The three research questions that this study will attempt to clarify are as follows:

a. What are the major sources of wastage on construction materials on building projects?
b. How much percentage wastage of construction materials can be determined on building projects?
c. What are the possible measures to minimize construction material wastages?

1.4 Objectives

1.4.1 General objective

The general objective of this study is to investigate on the factors which affect construction materials wastage on building projects in Jimma town.

1.4.2 Specific Objectives

- To identify the main causes of construction materials wastage on building projects.
- To determine the percentage of construction materials wastage on building projects.
- To propose possible measures of the minimization of construction materials wastage on building projects.

1.5 Significance of the study

In the activities of construction sites there are a lot of wastages of construction materials but there were no more investigations in Jimma to minimize the wastage for. This study the output or findings will be to give more information about the factors affecting of construction materials wastage and to identify the percentage of material wastage basically on the concrete materials on building construction projects to identify the minimization methods on the projects.

1.6 Limitation of the research

This research were limited and focuses on selected building projects in Jimma with sources and Causes of construction materials and construction material wastages (concrete, aggregate, cement, sand, steel and HCB), because the major wastage in construction activates are on those material wastages.

1.7 Scopes of the study

This study was conducted in one selected area where it is around Oromia national regional state in Jimma town building projects only. This study also extend the investigation on the factors affecting construction material wastage in building projects were specifically focused. The output from this research can be used as a data for future researches related to construction of materials wastage and to know the major factors affecting construction materials wastage and to have waste minimizations measurements on construction site. This study will go on only at pre mentioned site. The study focuses on the concrete, fine and course aggregate, cement, steel reinforcement and HCB construction materials.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Many research were investigated the various reasons and factors of causing waste in construction building projects. Waste management can be taken into account in two different levels: first, through managing those factors that cause waste, and second, through managing the wasted materials by reusing or recycling them, and studying the effects of these materials on the environment. Basically, factors causing waste are categories mainly:

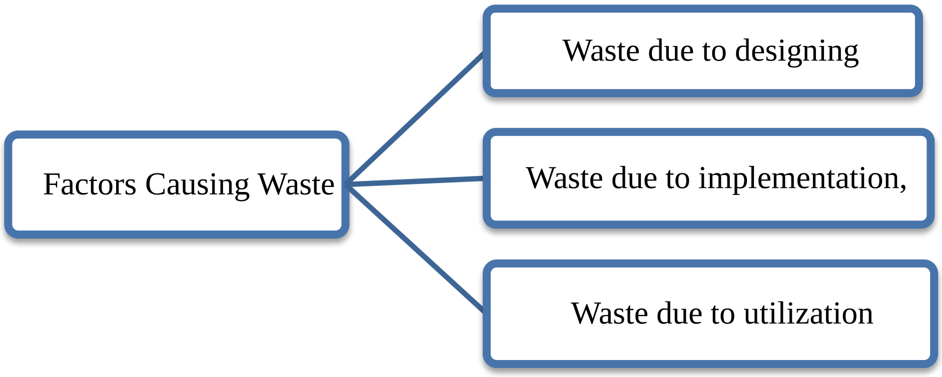


Figure 2-1: Factors Causing Waste [27]

This study particularly deals with the wastes due to implementation that stand among the first level wastes. Identifying the causes of waste can lead to codify policies to prevent them. Nowadays, the optimized use of the resources, and the selection of the best option is the most important activity of the construction managers. The main concern of the building sites is to gain the optimized use of the resources and the capital, and to thrash their wastage **[27].**

2.2 The Global Construction Industry

In most parts of the global, construction industry consumes huge amount of natural resources and often generates large quantities of construction waste.

Basically, Construction waste consists of unwanted material produced directly or indirectly by the construction industries. This includes inert and non-biodegradable building materials including: concrete, plaster, wood, metal, broken tiles, bricks, masonry, insulation, nails, electrical wiring, and rebar, as well as waste originating from site. These wastes are heavy, having high density, very often occupy considerable storage space. This can have a negative impact on the profit margin of contractors. Reducing construction site waste reduces not only the cost of raw material purchase but also the cost of disposing of the waste produced on the site.

It can also reduce wastage due to inefficiency on site. For instance source separation can reduce the amount of waste resulting from coming led disposal. Construction site waste management and minimization has a great potential to contribute to construction industry performance improvement as well as solve waste management problems caused by the construction sector.

A Site Waste Management Plan (SWMP) is simply a plan that details the amounts and types of wastes that will be produced on site and how they will be reused, recycled or disposed. Site SWMPs are an important tool for construction companies and their clients, of all sizes, to improve their environmental performance, meet regulatory controls and reduce rising costs of disposing of waste **[38].**

In the construction industry, it is well known that there is a relatively large volume of material being wasted due to a variety of reasons. The problem of material waste on construction sites is not an isolated issue and is of environmental concern **[44].**Construction Waste becomes a global issue facing by practitioners and researchers around the world. Waste can affect the success of construction project significantly more specifically; that major impact on construction cost, construction time, and productivity and sustainability aspects **[27].**Therefore, waste minimization has become an important issue in the construction industry.

In general waste minimization has been defined as: "***Any technique, process or activity which avoids, eliminates or reduces waste at its source or allows reuse or recycling of the waste*" [4].**

Minimization of waste at source must be prioritized when developing strategies for waste minimization. The other strategies are reusing and recycling waste which means putting the materials that are wasted into beneficial use. If the three strategies had not been applied, the generated waste will end up at landfill **[44].**

The three common waste minimization strategies used in construction projects:

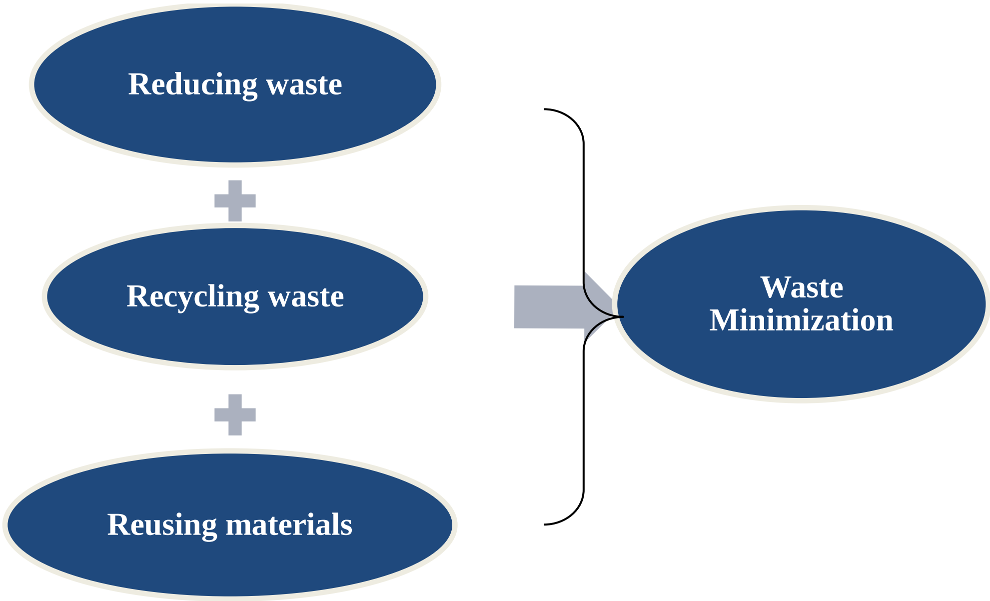


Figure 2-2: Common waste minimization strategies [44]

It can simply be recognized that the construction industry is a major consumer of natural resources. Best practiced of these are: cement, sand and aggregates, wood, steel and energy. Moreover, construction industry is generally project-based and these projects are specially made according to client requirements Thus, it can be said that these conditions and characteristics within construction industry can result in a serious waste of construction materials, which in turn will have major impacts on the country's economy as well as on the environment **[6].**

Development of infrastructural facilities is accompanied by construction, remodelling and demolition of buildings, roads, bridges, flyover, subways, runways, factories and other similar establishments. In most parts of the world, construction industry consumes huge amount of natural resources and often generates large quantities of construction waste. A Construction waste consists of unwanted material produced directly or indirectly by the construction industries **[36].**

2.2.1 The Ethiopian Building Construction Industry

The Ethiopian construction industry has been the biggest beneficiary of the government's Growth and Transformation Plan (GTP) 2010-15 **[46].** According to Access Capital's calculations, based on a subset of projects with high contractor use, the GTP will provide revenue opportunities to contractors to the order of US$20 billion p.a. and prospective profits of US$2 billion p.a. While the immense scale of public sector investment is crowding-out some private investment by exerting upward pressure on key non-food prices such as rental rates on construction equipment, the investment is desperately required in an under developed economy with historically low FDI. Ethiopia now has the highest capital expenditure as a percentage of government spending among African countries meaning more spending is being funnelled to capital projects and capital equipment, rather than to current expenditure items. The real value of Ethiopia's infrastructure stock increased by almost 15% p.a. over the past decade and its capital stock was the sixth-largest on the continent during 2012. **[46].**

The Ethiopian construction developed as described above but the construction management are poor. The resources of construction materials have a lot of wastage on the site. Some study has been conducted at different time on the material wastage only in Addis Ababa city but almost on the other city of the country no more study. Even in Addis Ababa the construction material management practices late to do in practical.

2.2.2 Jimma Building Construction Industry

The Construction industry in Jimma, there is an activities and crucial segment in economic development of the town, as in other parts of Ethiopia, world. It generates tons of construction wastes per year, making construction wastes a cross cutting issue for in- depth investigation. Until now, there is no study in Jimma construction sites that has investigated this issue and addressed the main causes and factors that contribute to construction wastes. Therefore, there is a necessity to study this issue in detailed to minimize the construction wastage in site. This work aims at identifying the main factors causing waste in construction materials, quantifying waste levels by percentage in various construction materials and producing suggestions to manage and minimize the negative impacts of construction wastes.

2.3 Definition of Waste

Waste in construction has been defined in different ways by different scholars:

According to the new production philosophy:

> "***Waste should be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building***"**[31].**

Waste includes both the incidence of material losses and the execution of unnecessary works, which generate additional costs but do not add value to the product.

Therefore, ***"Waste should be defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client"*****[23].**

Although various definitions are given for waste, there has been no exact comprehensive definition to the present day. Minimizing construction and demolition waste indicates that waste refers to those solid waste materials that result from the construction, repair, demolition, or scrape of the buildings and roads. The definition includes reconstructed places, and debris remained after cleaning up a site including concrete, bricks, asphalt, plaster, wood, soil, trees, and bushes **[26].**

Another definition introduces waste as those materials whose cause (its controller) means to eliminate it from the construction cycle **[13].**

The other defines it as "***unwanted materials that are created in construction industries either directly or indirectly***". The waste includes construction materials, such as insulations, nails, electric wires, or wastes caused during the preparation of sites such as dredging materials, uprooting trees or rubbles. Construction materials can maintain plumbic, asbestos, or poisonous materials **[38].** The majority of construction wastes result from the absence of need or the demolition of materials like bricks, concrete, and wood in the construction process **[43].**

2.3.1 Construction Waste

Construction waste has been defined in various ways. The Building Research Establishment in 1978 defined construction waste as 'the difference between materials ordered and those placed for fixing on building projects'. In 1981 another definition emerged from BRE stating that construction waste is 'any material apart from earth materials, which needed to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project'. In the 1990's the Environmental Act defined construction waste as: 'scrap material or an effluent or other surplus substance arising from the application of any process.' In Hong Kong, the definition by Polytechnic made it clear what construction waste is defining it as: 'The by-products generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures' **[8].**
Other scholars added the definition as time and process related waste as: 'any losses produced by activities that generate direct or indirect costs but do not add value to the product from the point of view of the client'. On adding value activities and how to minimize the waste they generate are the basis of the lean construction philosophy. Although inefficiency related waste has greater economic loss than material waste **[15].**

Construction waste is generally defined as the by-products generated from construction, renovation and demolition workplaces or sites of building and civil engineering works. The construction industry is a major contributor to the generation of waste and pollution **[32].**

In those densely populated cities such as Hong Kong where construction related works are among the major economic activities. For example, in 2001, 38% of the disposed solid waste in Hong Kong was generated by construction and demolition (C&D) activities .The report by Hong Kong Environmental Protection Department (EPD) (2003) also suggests that construction caused pollutions such as waste pollution, noise pollution; water pollution and air pollution are among the major pollution problems in Hong Kong **[47].**

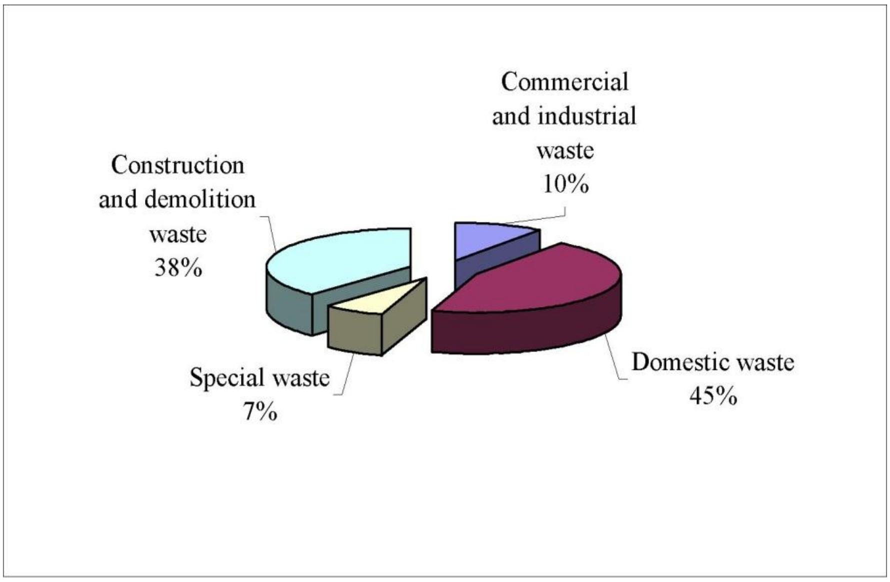


Figure 2-3: Solid Waste Disposal in 2001 [47]

Construction waste is normally combined with demolition waste and described as "construction and demolition" (C&D). There are many definitions for C&D. Virtually every state has a slightly different definition for C&D waste. The EPA's *Characterization of Building-Related construction and Demolition Debris in the United States* (EPA530-R-98-010) contains a partial list of these varied state definitions. For the purpose of this study, C&D waste is defined as the waste resulting from new construction, remodelling, or the demolition of a structure.

However, there are some differences between construction and demolition waste. Construction waste loads were usually transported to the landfill in open top roll-off containers, dump trucks, or open trailers. The construction loads tended to be lighter, less weathered, more homogeneous (all wood, dry wall, etc.), and contained more cardboard boxes (usually from fixtures) than the demolition waste loads. In most cases it was relatively easy to visually differentiate between the construction and demolition loads. The most difficult loads to identify were from remodelling projects. These loads contained some new material and some demolition materials. In those cases, the load was analysed and the waste components assigned percentages **[33].**

Waste of each type of material was measured in different ways:

- As percentage of the total amount of construction waste;
- As a percentage of purchased materials and
- As a percentage of the total waste's cost.

These methods are all illustrative of the level of waste generated and they can be used simultaneously. However, in order to calculate these percentages, the identification of waste streams and volume/weight of waste generated for each one is necessary**[14].**

2.3.2 Classification of Construction Materials Wastage on Site

Construction material waste can be recognized and classified as follows:

- Waste of materials as a result of damage which cannot be repaired and utilized anymore.
- Waste of materials as a result of loss during the construction process.
- Waste of materials as a result of errors in construction and excess of actual quantities compared to theoretical quantities in the drawings.

Construction and demolition waste materials consist mainly of concrete, masonry, limestone, sand, metal and wood depending on the construction type **[20].**

Construction waste is written as comparatively clean, heterogeneous unit generated from the varied construction activities. Do able sources of generating construction waste are aiming to be classified below six main classes.

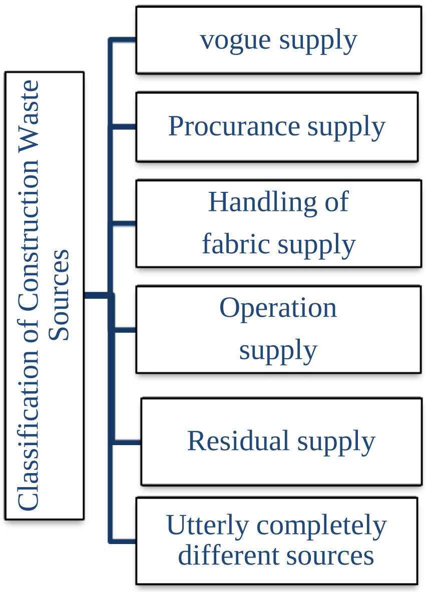


Figure 2-4: Classification of Construction Waste Sources [21]

Wastes are aiming to be either venturous or non-venturous. Construction comes typically generate many non-venturous wastes than venturous wastes. Sort of the categories of wastes found at a typical construction electronic computer unit of measure construction waste, domestic waste and regular waste **[21].**

The contractor is charge for the correct handling, storing, transporting and/or doing away with regular construction wastes. samples of normal or venturous wastes unit of measure used oil, hydraulic fluid, fuel, soil contaminated with toxic or venturous pollutants, waste paints, varnish, solvents, sealers, thinners, resins, roofing cement and lots of. It's the responsibility of the contractor to satisfy the regular the responsibility covers the correct handling, storing, transporting and disposal of those wastes. However, amount and quality of construction waste generated from any specific project would vary counting on the project's circumstances and forms of materials use. The annual production rate of construction and demolition waste from the general planet is around three billion tons **[11].**

A doable technique of breakdown the cringe is to develop and implement a comprehensive and wise property waste management strategy that manages the number and forms of construction waste. Property development for the event trade are aiming to be develop through the total life cycle of the building from to cradle, in conjunction with the first designing section**[21].**

Waste measures are the number of defects, rework, number of designer or and omissions, number of change orders, safety costs, excess consumption of materials and the percentage of non-value-adding time of the total cycle time for a particular work or material flow may be addressed **[23].**

2.3.3 Definition of Building Construction waste

Building material wastage 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 the material wastage **[43].**

The causes of construction material waste can be measured and evaluated using a large number of construction phase related factors such as design and documentation, materials procurement and management, site management practices and site supervision including environmental conditions. The first set is related to designers and client's requirements; the people who consider the functional requirement of the building. The second set is related to construction team and contractors; people who consider the build ability and maintainability of the building. The third set is related to the site supervisors and the site operatives; people who are directly involved in the art of putting the raw materials together to form the building envelop **[4].**

Wastages of building materials can be defined as the remains of the materials delivered on site after being used in the built work. The application of building materials can generate various types of wastes. The five major types of building material waste classification on-site is shown in figure 2.5 below. The sources where waste may present and the typical reasons why these materials can be wasted are highlighted **[45].**

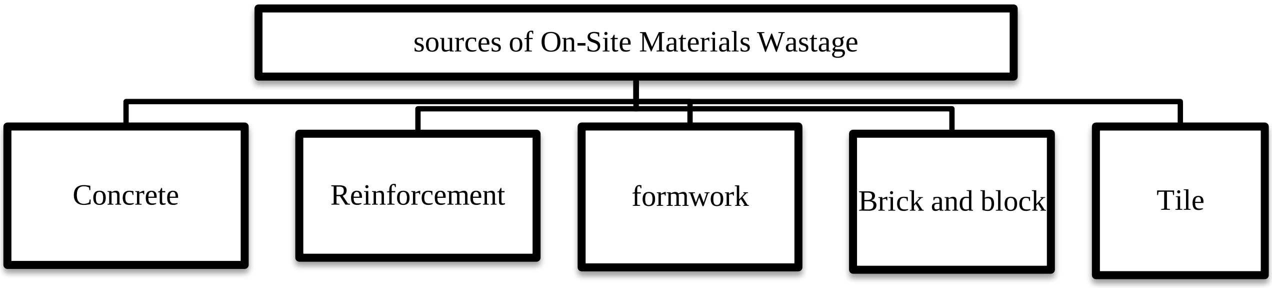


Figure 2-5: Classification of On-Site Materials Wastage [45]

Wastages of building materials can be divided into two types one is direct waste and the other is indirect waste Direct waste as the loss of those materials, which were damaged and could not be repaired and subsequently used, or which were lost during the building process; indirect waste was distinguished from direct waste because it normally represented only a monetary loss and the materials were not lost physically. Such losses arise principally from substitution of materials, from use of materials in excess of quantities allowable under the contract, and from errors. The failure to recognize and record waste from these causes makes accounting for materials meaningless. Therefore, a simple measure of waste on site would be the difference between that used as specified and the quantity of material delivered to site as a percentage of such deliveries **[43].**

2.3.4 Construction Building Management on Construction Projects

Waste management system differs for developed and developing nations, for urban and rural areas, and for residential and industrial, producers. Management for non-hazardous residential and institutional waste in metropolitan areas is typically the responsibility of authorities, whereas management for non-hazardous industrial and industrial waste is typically the responsibility of the generator (firm whose activities prove the waste).Waste management is that the assortment, transportation, processing, exercise or disposal of waste materials. The term waste is typically relates to materials made by act, and are usually managed to minimize their result on health, the setting or aesthetics (beauty). Waste management is additionally disbursed to recover resources from it **[28].**

Waste comes in forms like solid, liquid, vaporize or radioactive substances, thus management imply totally different ways and fields of experience. Waste is going to be the solid waste that's manufacture by the development activities. Waste isn't simply garbage; it's additionally energy, water, food, air, transportation, landscaping, time and money. Waste Management works toward reduction, apply and exercise of all resources. It encourages the reduction of energy consumption, conservation, the acquisition of reused and recycled product, and alternate transportation ways **[37].**

2.3.5 Magnitude of Waste in Building Construction

In construction, Material, Manpower, Money, Machine plays a crucial role. Depending on the type of a housing project, Building materials account for 60 to 70% of the project cost. Observational research has shown that this can be as high as 10 to 15% of the materials that go into a building, a much higher percentage than the 2.5-5% usually assumed by quantity surveyors and the construction industry **[36].**

2.4 Sources of Construction material Waste

Construction waste sources from construction, refurbishment, and repairing work. Many wasteful activities can take place during design and construction activities consuming time and effort. Generally the generation of the stream of waste is influenced by various factors.

2.4.1 Natural Waste

Natural waste in which the investment necessary to its reduction is higher than the economy produced.

2.4.2 Direct Waste

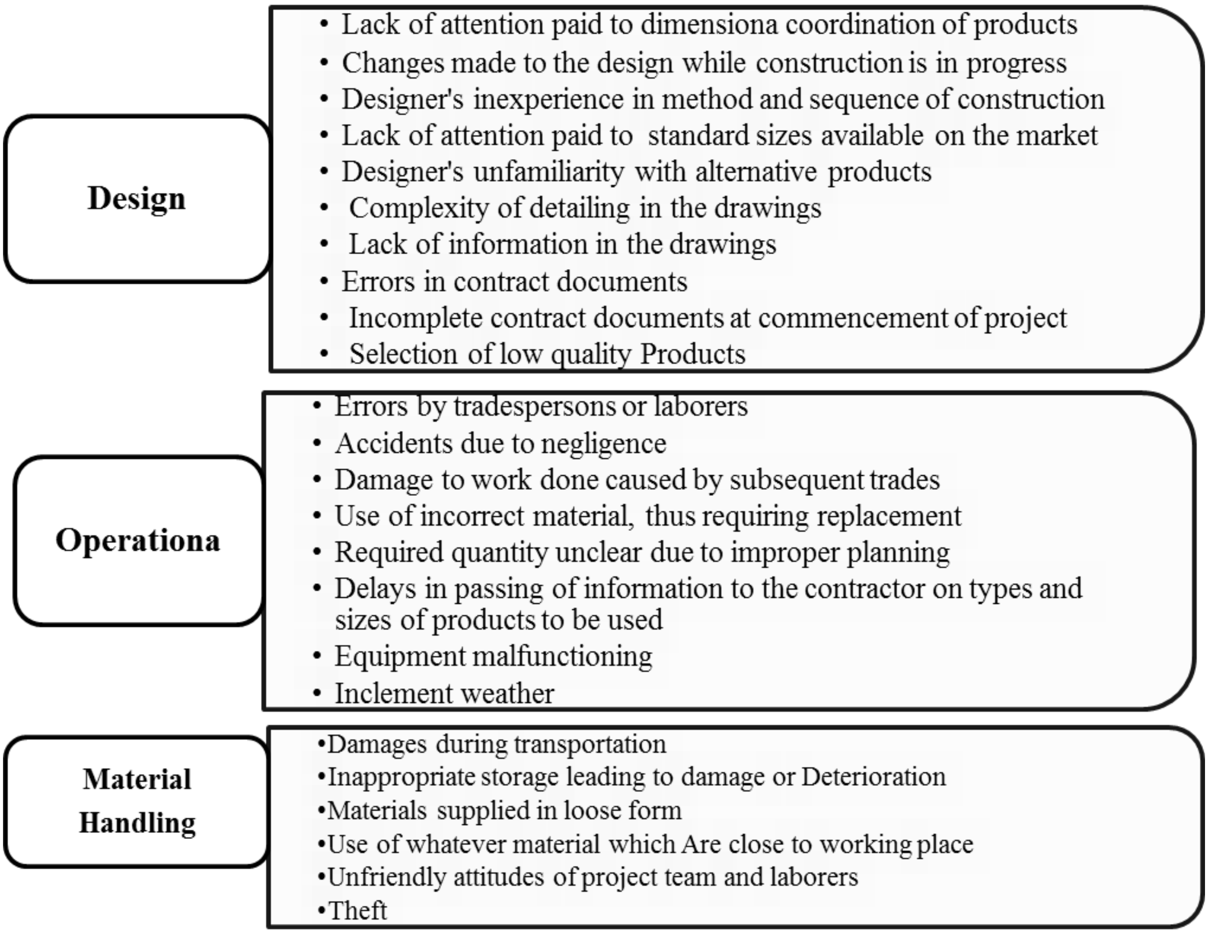
Direct waste consists of a complete loss of materials, due to the fact that they are irreparably damaged or simply lost. In this case, the wastage usually needs to be re-moved from the site **[14].**

2.4.3 Indirect Waste

Indirect material wastage occurs when materials are not physically lost but causes a financial loss only. Such losses arise principally from substitution of materials, from use of materials in excess of quantities allowable under the contract and from errors. Concrete slab thickness larger than specified by the structural design is an instance of such a waste **[14].**

2.5 Causes of Material Waste

Among the total project cost majority of it covered by the material cost from the building project. Many factors contribute to construction waste generation at site. Waste may occur due to one or a combination of many causes. Factors which cause waste on site were identified and placed in four major sources (Design, Procurement, Handling of materials, Operation) as shown in figure bellow **[25].**



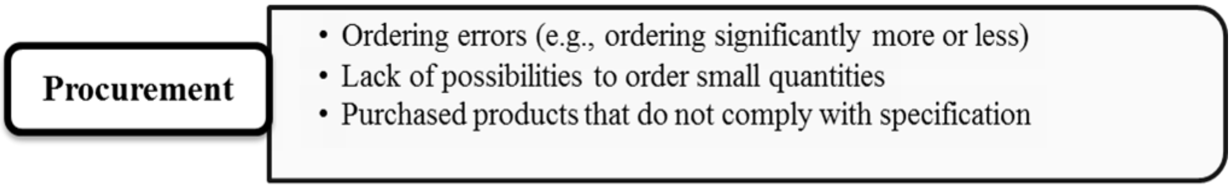


Figure 2-6: Sources and causes of construction waste **[25]**

Most causes of the production of sand-lime waste resemble those mentioned in connection with stone tablets. In both cases, cutting is a factor. Unpackaged delivery means that sand-lime bricks and elements may become wet and dirty because of inclement weather and storage in the open air **[3].**

The causes of waste can be grouped as: Causes and problems of design, Causes and problems of utilization, and Causes and problems of implementation **[27].** The supply of fabric waste will exist throughout the development project, whether or not within the initial stage, style stage, and construction stage until the operation have divided the supply of waste into 5 classes that are **[16]:**

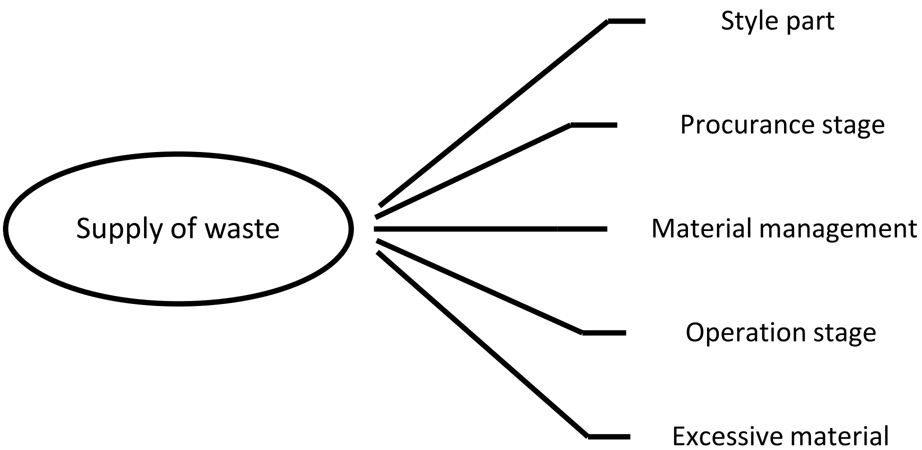


Figure 2-7: Supply of waste **[16]**

2.5.1 Design

Designers have to be compelled to embody rationalization of specification in every material and element that's required within the contract. However typically, they solely submit nation commonplace code that's ordinarily used together with the final comment. Sometimes, ordered material cannot attain the location on time, forcing them to use substitute material terribly very short time. With a restricted time, designers are susceptible to opt for material that's low in quality rather than the initial demand. The method of selecting material and element is vital besides the planning itself and smart work talent so as to realize the simplest result. If the fabric opt for does not meet the need of the designers, this may eventually cause a conflict between the rapturous worth and sensible demand. This facet is vital and wishes to be stress to new designers **[21].**

In the early stage of construction, style's thought to apply a design that's property. Before the designers known the materials that need to be use, designer can take into account many aspects of it and it sources, however guaranteed to the manufacturer that been acknowledge solely. Supported this manufacturer, the designer can selected the fabric victimization catalogue equipped to them. However, the catalogue provided is sometimes not often updated and therefore, can a rouse complication once works need to start out at website **[15].**

If the designers need to minimize waste to the optimum level, designers have to be compelled to take into account the development method for every component once work has begun styles have to be compelled to make sure that there'll solely be a minimum amendment of design and every one the knowledge required for the development have to be compelled to be end from the first stage of the project. Material utilization and low waste made is depends to a decent style and description **[21].**

2.5.2 Operational

The operational category comprises 14 factors for physical and non-physical waste generation. The major factors of waste by workers mistakes during construction while too much overtime for workers, lack of awareness and abnormal wear of equipment major factors the lowest place in the workers category. Unskilled workers tend to make more mistakes due to lack of skills and poor working attitude. For example most of workers fail to read the blueprint or drawing. The mistakes include wall frame improperly cut or assembled. At the same time, workers mistakes also contribute to non-physical waste Mistakes during concreting works can cause rework. These improper works need to be repaired and time consuming. Besides that, mistakenly handle of equipment can cause damage. This will contribute to a sudden stop of work and overrun of project cost. Waiting period to get back for the equipment or machine leads to delay. Thus, workers mistakes can generate lots of physical and non-physical waste. This can be avoided by selecting experienced or trained workers for site works **[38].**

2.5.3 Material handling

Wrong material storage and poor materials handling become key factors for waste. The examples of wrong material storage for waste generation are aggressive handling of bricks and blocks during construction leads to cracks and spoil. Apart from this, waste does occur due to inappropriate protection strategy used during materials storage. For examples, cements wrongly stored under bridge or stored at any open space. These cause the materials to be exposed to moisture and rain **[47].**

Another key factor generating physical waste is poor materials handling and score equals to wrong material storage factor. For example, mistakenly handle construction material cause material loss or damage to bricks or blocks. Notwithstanding, contractor should need an effective materials handling strategies, which include educating the workers on waste minimization and always communicate with supplier **[38].**

Storage are sometimes not properly prepare and dangerous and generally the fabric are hold on in many completely different places. Material that expose to wet condition and unsuitable places whereas machineries and vehicle continually pass can injury the fabric can cause the fabric to deteriorate and eventually are going to be injury. This may raise the proportion of loss and waste as a result of the injury material. This type of state of affairs required to be prevented to minimize waste **[21].**

2.5.4 Procurement for practical purpose

Category on procurement consists of factors contributing to waste. Ordering errors factor for scores the highest frequency. The examples of waste generated over ordering materials in construction projects are excessive orders of bricks and concrete mixture that end up as waste. Sometimes, poor ordering of material without specification details and low quality materials also cause waste. There are the shortages of materials during construction activity which can lead to stoppage of works. Another example is the lack of concrete premix in concreting works, can also cause delay during ordering time. Hence, ordering of enough construction material plays an important part and helps to reduce waste during construction works **[3].**

Material waste additionally cause by the look demand and specification. As an example, brick size is thought of for the elevation style for masonry works. Over purchase thanks to failure in observation the fabric amount additionally causes waste. Generally it's additionally cause by the manufacturer thanks to communication failure between the contractor and provider. Failure in designing material schedule can end in failure of providing adequate and correct order of fabric. Contractor continually taken without any consideration the importance of fabric schedule **[21].**

It is an important element in material management, it continually being neglected thanks to the dearth or inadequate of knowledge within the early stage of construction. Moreover, different issue like ignorance material computer hardware, incomplete contract drawing and unknown amount affected the method of creating the fabric schedule. A whole waste schedule that has all the essential data will make sure the step-down of waste throughout procure **[49].**

2.6 Factors Affecting of Construction Material

The most common factors that cause design variations that are incidental to wastages in order of importance are: Last minute client requirement, complex design, lack of design information, unforeseen ground condition, lack of communication, long project duration. The factors that affect selection of construction method are construction cost, construction time, developer's requirement, and familiarity with the construction technology, labour dependence, and Waste reduction **[34].**

The factors affecting the selection of construction materials that are incidental to wastages are (in order of importance) as Cost, ease of construction, Client requirement, Materials availability ,Site space, Availability of equipment, Efficiency, and Production of waste which is the least important **[2].**

2.7 Wastage of key material on building construction sites

The application of building materials can generate various types of wastes. Five major types of building material, including concrete, reinforcement, formwork, brick and block, tile are under examination. The sources where waste may present and the typical reasons why these materials can be wasted are highlighted **[3].**

2.7.1 Steel reinforcement

Steel reinforcement bars are commonly used materials in building construction. The main cause of steel wastage is resulted from cutting. Damages and rusting during storage also form a major part of steel wastage **[45].**

Controlling the use of steel reinforcement in building sites is relatively difficult because it is weighty to handle due to its weight and shape.

There are reasons can be pointed out for steel reinforcement waste: some short unusable pieces are produced when bars are cut; some bars may have an excessively large diameter due to fabrication problems; and trespassing. The worst-performing sites were usually the ones in which the structural design was poor in terms of standardization and detailing, causing waste due to non-optimized cutting of bars. Many problems related to poor handling of materials were also observed, resulting in large disorganized stocks, which often caused waste for substitution that is, unnecessary replacement of some bars by others of larger diameter **[14].**

2.7.2 Concrete (Fresh Concrete)

Concrete is used for the superstructure and substructure of the buildings. The causes wastage of concrete mainly concern the quantity of concrete used. The building contractor may not know the necessary quantity because of imperfect planning. This leads to over ordering and overfilling of the means of transport and the form-work. If the formwork is overfilled, skimming becomes necessary, i.e., levelling off the concrete poured into the formwork. This cannot be avoided when a poured concrete foundation is required **[3].**

Concrete is the most widely used material for buildings structures. Concrete wastage is mainly resulted from excess quantity of ready mix concrete. There are variations and errors in calculating the quantity of needed concrete because of improper planning or poor communication, which results in over-ordering. A certain amount of concrete wastages also occurs during transportation, in which it may settle over a long period and cannot be used for construction activities. Settlement of long transportation time affected around 1.5% of the total mixed concrete materials, which is a quite significant issue. Furthermore, significant concrete wastes involve difficult waste handling processes, which request significant labour hours and time. Poor formwork may also cause wastage of concrete **[45].**

Concrete is the most widely used material both for substructure and superstructure of buildings. The wastage is mainly resulted from the mismatch between the quantity of concrete ordered and that required in the case of ready mix concrete supply. The contractor may not know the exact quantity because of imperfect planning, leading to over-ordering. Wastes are also resulted project delays and unnecessary waste handling processes **[40].**

2.7.3 Premixed Concrete

Despite having one of the lowest waste indices among all materials, the relatively poor performance of premixed concrete was fairly surprising, due to the relatively high cost of this material. In contrast, in most construction companies' waste of premixed concrete is negligible **[14].**Site managers often complain about the difficulty of controlling the amount of premixed concrete deliveries. The obvious solution seems to be the installation of a site scale to control the delivery of materials or to place an inspector in the concrete plant. However; this might not be economically feasible for small companies. One alternative adopted by companies was to establish a deal with the suppliers whereby the purchased premixed concrete is paid for based on the amount measured in loco, that is, after the concrete is placed in the formwork **[3].**

Deviation in the dimensions of cast in place structural elements slabs, beams, and columns is an important source of concrete indirect waste. The main causes for this problem were lack of constructability of some structural elements, poor design of the concrete formwork system, imprecision of the measuring device, and flaws in the formwork assembling process.

Fairly often, some waste of concrete was also observed during the handling and transportation operations on site, mostly related to site layout problems and to the use of inadequate equipment, although it was difficult to quantify its magnitude due to the relatively high cost of measurement. At a few sites, the excessive dimensions of concrete foundation piles and curtain walls also caused unexpected waste. This problem was mainly related to the lack of precision in excavation methods. Finally, due to uncertainty related to material consumption, site managers often order an additional allowance of concrete in order to avoid interruptions in the concrete-pouring process. Sometimes these results in a surplus of concrete that is not used **[14].**

2.7.4 Sand (fine aggregate) and course aggregate

Fine and course aggregates are usually delivered in trucks, and so there may be additional losses related to the lack of control in the delivery operation and the necessary handling it demands. In recent years, some companies have started using packed ready-to-use mortar mix, which tends to eliminate many of the problems related to delivery control, handling, and transportation. Although not enough data are available, there are indications that such changes have reduced the waste of mortar, in comparison to the traditional method of producing mortar on site **[14].**

2.7.5 Cement

The main causes of cement waste can also explain most of the problems related to sand, lime, and premixed lime and sand mortar.

Analysing the waste of cement is relatively complex due to the fact that this material is used as a component of mortar and cast in place concrete in several different processes, such as brick works, plastering, and floor screed. By contrast this is a relatively expensive material that has high levels of wastes. Its main sources of waste are as follows:

- In site production of mortar: much waste of cement was observed in the production of mortar on site. Cement and other materials are usually loaded manually in the mixer using inadequate equipment. Another typical cause of waste in this stage is the lack of information available to construction labour for producing different mixes of mortar **[23].**

- Handling and transportation of mortar: waste of mortar was observed in most sites during the handling and transportation operations, although no quantification was possible. Multiple handling of the same batch of mortar, due to intermediate stocks along the process flow, is also fairly common. Such waste was mostly related to site layout problems, lack of properly maintained pathways, and use of in-adequate equipment **[14].**
- Brickwork joints: the production of brickwork was also responsible for some waste of cement, due to the excessive consumption of mortar in joints. There is usually a combination of reasons for the excessive thickness of joints, which may include lack of modular coordination between concrete structure and brick walls, inadequate training of labour, insufficient information available about process standards, inadequate super-vision, variations in the size of blocks, and lack of process standardization**[3].**

- Plaster thickness: the excessive thickness of plaster was identified as a major cause of cement waste. The main causes for this problem are deviations in the dimensions of structural elements, flaws in the integration between different designs, lack of modular coordination in design, and omissions in the design in terms of defining the exact sizes of components, such as door frames and blocks **[30].**
- Floor screed: excessive thickness for concrete floor screed was also detected as causes for waste for cement. On average, the actual thickness of this element exceeded the designed one. The main causes for this problem

were deviations in the concrete slab level in relation to design and the need to inlay pipes in the floor **[3].**

2.7.6 Hollow Concrete Block (HCB)

HCB are the most common walling materials. The main cause of these wastes is by cutting. In the case of unpacked supply, wastage can also be induced due to damages to these fragile materials. On the other hand, unused bricks left on site may end up in the trash skip ultimately, and such wastes can be significant in those projects where materials planning are poor **[45].**

In most poorly performing sites, a combination of causes was related to the waste of HCB. At several sites, there were problems related to the delivery of materials, such as the lack of control in the amount of HCB actually delivered and the damage of HCB during the unloading operation. Poor handling and transportation were the major sources of waste for HCB. As in the case of mortar, multiple handling of the same batch of HCB, due to intermediate stocks along the process flow, was observed at many sites. Insufficient planning of the site layout, lack of properly maintained pathways, and the use of inadequate equipment were among the main causes of waste **[5].**

It seems that most of the problems related to delivery, handling, and transportation could be eliminated by supplying HCB on pallets. In fact, some of the sites adopted this strategy and were able to reduce waste to some extent. However, it was also observed in the same study that the use of pallets does not improve performance on its own **[14].**They have a positive impact only if other measures related to flow management are also implemented, such as planning the layout, keeping pathways unobstructed and minimizing inventories. Another source of waste was the need to cut HCB, due to the lack of modular coordination in design. Indeed, the percentage of cut pieces at some sites was higher than cut ceramic blocks. The waste tends to be higher if the cutting operation is not planned and needs to be executed at the installation locale **[3].**

2.8 Estimation and Auditing Of Waste

Material reconciliation was carried out by comparing the difference between the store records and the actual requirement of the material according to the bill of quantities work item. Norms of the building schedule of rates (BSR) were taken as the basis for analysing the work items of bill of quantities. This is justifiable as most contractors use BSR for estimating and material requisitions. Wastage allowances are expressed usually in proportion to the actual quantity of work. Accordingly, this study considers wastage as proportionate to the actual work, as shown below **[18].**

$$material\ waste\ quantity = store\ records - actual\ material\ requirements$$

$$material\ wastage(\%) = \frac{material\ waste\ quantity}{actual\ material\ requirements}\ x\ 10\ldots\ldots\ldots\ldots\ (1)$$

2.8.1 Waste Rate Estimation

A construction company always valued a project by its profit and loss. In order to ensure that the contractors get the maximum profit out of the project, it is hard to ensure that the method used will succeed. Thus this estimation rate will serve as a guidance to help the management to improve the method of handling material, reduce the waste rate and improve productivity. Theoretically, performances of waste management in construction site are depending on the quantity surveyor decision on site. They will record all the material used on-site and all the material sent to site. It is important for the quantity surveyor to estimate material waste for all the material that has been purchase **[21].**

Any loss of material is usually shown in percentage form without analysing the factors that contributing towards those percentages. It is important for the quantity surveyor to evaluate the factors involved, the material used and type of project for future reference so that waste rate can be reduce and create more sustainable construction. The used of waste rate estimation from other sector are not practical and less accurate due to difference diversity of work and the dynamic of the sector **[15].**

2.9 Material management

Material waste also can happen once the fabric don't seem to be been handled properly. Material handlings are continually handled victimization mechanical instrumentality associate in nursing typically by an unskilled employee. Fashionable material and element is often harming throughout material handling and installation of the fabric. Typically the fabric is repaired if the harm is tokenize, however a number of the fabric are twenty irreparable once harm. Waste rate are totally different completely different on different project. Several of its cause throughout construction section wherever time is important and work got to be done quick. This is often once the standard management is difficult to watch. However the most reason of waste turn out is cause from weak management and observation, angle and no adequate incentive **[21].**

2.9.1 Waste Minimization

Waste minimizations process is systematic way of manage material of constructions. This involves in the flow of materials into in the site activities and out of site.

2.9.2 Material Control on Site

Control of material is 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 control measures. Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, a critical control of materials on site should be adopted. Materials wastage on site cannot be treated fully without materials control. In fact, material waste level on site is a measure of site management. It is also one of the enemies of contractors. Most loss of materials occurs as a result of the decision of the site management. Decision taken at the initial stage of any project that is the design stage, either by the manufacturer or supplier of materials is capable of increasing waste level. This can occur as a result of manufacturers not following strictly the buyers' specification and supplier not packaging the product for easy transportation. Since all the burden of waste lies solely on the contractor, it is important that the site management should ensure a good supervision of materials and apply an effective method of controlling waste. Waste normally emanates during different stages of construction which can be during planning, estimating or construction stage. In Nigeria, not all the materials procured are used during construction and this indicates that the left-over's may remain as waste that may not be accounted for **[2].**

CHAPTER THREE

RESEARCH METHDOLOGY

3.1 Study Area

The study area of this research was jimma town.it is one of the ancient and largest towns in the country which located 335km in the southwest of Addis Ababa. Its geographical coordinates are approximately 7041'N latitude and 36''50''E longitude. The town is found in area of average, of about 5400ft (1780 m) above sea level.

Figure 3-1 : Map of Jimma Town (Google Maps, 2016)

3.2 Study Period

The research has taken five (5) months and it was started on April 2016 and it was ended on August 2016, which including from investigation up to questioner and data collection.

3.3 Research Design

In the case of research design which were designed to obtain in-depth factors affecting construction material wastage on building projects in the specific site, Jimma town. Various factors affecting construction material waste generation on building sites were identified from the available literature. A total of 40 questionnaires were purposively administered to key construction consultants and contractors because to differentiate by grade of construction companies.

3.4 Sources of Data

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

3.5 Sources and Causes of Materials Waste

Sources and Causes of construction materials waste, the major material wastage and waste measures of minimization which have been extensively studied were extracted from the literature. The sources and Causes of construction materials waste gathered from literature were pre-tested through investigation of the construction sites.

3.6 Research Instrument

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

3.6.1 Questioners Design

The questionnaire, which consisted of five major sets of closed-ended questions, was designed to obtain data on the sources and causes of materials wastage and waste minimization measures. The data collection used to obtain more to know the wastage level in construction.

3.6.2 Structure of questionnaires

Interview questions were designed in the form of a structured questionnaire. It consists of two parts: In the first part, the interviewee was asked to give information about his/her position, experience, and project size and company grade.

In the second part, the questionnaires were designed using likers scale. The respondents were asked to rank on scale of 1-5 which of waste sources provides major waste on construction sites and which of these activities is major provider of waste where 1= no waste ,2= insignificant waste ,3= neutral , 4= significant waste ,5= major waste .

For some selected materials which are wasted on construction sites also rank on scale of 1-5 which of these materials is severely wasted on site where 1=not severe, 2=less severe, 3=quite severe, 4=severe, 5=very severe. For each possible measures that contribute to the minimization of materials waste on the scale of 1-5 where 1=very low contribution, 2= low contribution, 3=medium contribution, 4=high contribution, 5=very high contribution. The respondents were further asked to score each measure according to the level of practice in their organization on scale of 1-5 where 1=not practiced at all, 2= sometimes practiced, 3= practiced, 4= frequently practiced, 5=most frequently practiced.

3.6.3 Target Population

The target population for the data collection using the questionnaires consisted of consultants and contractors. Building construction organizations which are available in Jimma construction sites is primarily considered. The contractors companies had valid registration according to ministry of urban Development and Construction (MoWUD) and purposively selected consultants companies which participated on public building projects.

There are over 30 contracting companies registered under G1 – G10 in Jimma town. Therefore, the populations this research, includes general contractors classified as (GC1-GC5) and G1 Consultant company that by reconnaissance survey in Jimma town and have valid registration by MoWUD. Because those selected categories are have experience, efficiency and managerial and financial capability.

3.6.4 Sampling Procedure

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. In order to evaluate the percentage of construction wastage and to know the major factors affecting construction materials wastage in building projects in Jimma town.

In this research work the population includes contracting companies of G1-GC5 and G consultants' one company that works in Jimma town. Because those selected population have more activated and having sufficient experience in construction. There are thirteen (30) total numbers of GC1-GC5 and five (5) G consultant one companies activated in Jimma. The sample population was distributed between contracting companies: 10 for GC1, 5 for GC2, 5 for GC3, 5 for of GC4, 5 for GC5 and 10 for G consultant one companies. The sample size of GC1-GC5 construction organizations was determined using purposively selected from the specified target site based on the availability and upright of the companies.

3.6.5 Selected Sample Construction Parties

Based on the sampling method and critters a sample of six (6) GC1 – GC5 and two (2) general consultants were considered for the questioners and data collection on building projects in Jimma town.

3.7 Study Variables

3.7.1 Dependent variable:

The dependent variable which was the construction materials wastage in building projects

3.7.2 Independent variable:

The independent variables which were investigated are Design and documentation; material storage and handling, operational and procurement.

3.8 Data Collection

In this study methodology of data collection included questionnaire and site investigation. The investigation involved observations the major factors affecting construction material and how materials were wasted on the selected public building construction projects. The research spent time(4 months) on 6 building construction projects and observed the flow activities of materials(design and specification, operational, material storage and handling, procurement).The questioner survey revealed that the high waste generating construction material are concrete, aggregates, cement, sand, steel reinforcement and HCB. The photographs were taken to document how the materials wasted.

A survey was conducted to collect information on the causes/factors of construction material wastage and their contribution to this wastage. The questioner structured was employed to collect data from construction professionals. The questioners were carried out with project managers working for companies.

3.9 Analysis and Findings

The completed questionnaires were edited to ensure completeness, consistency and readability. Once the data had been checked, they were arranged in a format that enabled easy analysis. The numerical formula to determine materials quantity data the percentage of construction materials wastage on building projects according to the bill of quantities work items. Norms of the building schedules of rates (BSR) **[19]** were taken as the basis for analyzing the work items of bill of quantities, as shown below:

$$material\ waste\ quantity = store\ records - actual\ material\ requirements$$

$$material\ wastage(\%) = \frac{material\ waste\ quantity}{actual\ material\ requirements} x\ 100 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

The sample for this study is relatively small as a result, the analysis had combined all groups of respondent (contractors and consultants) in order to obtain significant results the data was analyzed by calculating frequencies and relative importance index (RII). The relative importance index (RII) is calculated as follows **[6].**

$$RII = \frac{4n1+3n2+2n3+1n4+0n5}{4N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where N=Total number of respondents

ni= the variable expressing the frequency of the ith response

nl=Number of frequency ‘extremely significant’ response.

n2=Number of frequency 'very significant' response.

n3=Number of frequency 'moderately significant' response.

n4=Number of frequency 'slightly significant' response.

n5=Number of frequency 'not significant' response.

The levels of response are:

E.S=extremely significant [100%] V.S= very significant [75%]

M.S = moderately significant [50%] S.S = slightly significant [25%]

N.S =not significant [0%]

Spearman's-rank correlation coefficient for measuring the agreement/or difference in ranking between two groups of respondents scoring each factor is applied; because of its advantages of not requiring the assumption of normality and or homogeneity of variances. In this research it is used to show the degree of agreement between the different parties involved in the survey: contractors, clients and consultants [**10].**

The ranking correlation coefficient ranges from -1 to +1. A correlation coefficient of 1 indicates a perfect linear correlation i.e. good or strong correlations while -1 indicates negative correlation implying high ranking in one group is associated with low ranking on the other. Correlation coefficient value near to zero indicates little or no correlation. This correlation coefficient is used to measure and compare the association between the rankings of two parties, while ignoring the ranking of the third one.

The Spearman's- rank correlation coefficient (rs) for agreement in ranking between the two parties is given by the following formula **[10].**

$$rs = 1 - \frac{6\sum d^2}{N(N^2-1)} \text{.....................} \quad (3)$$

rs =Spearman's rank correlation coefficient.

d =the difference in ranking between the contractors, consultants and clients and

N= is number of variables

The rank correlation coefficient is used for measuring the differences or agreement in ranking between two groups of respondents scoring the various factors (i.e. Consultants versus contractors).

To sum up the research methodology used in this study was discussed as above. A description of how the questionnaire was administered and the various sections in the questionnaire were highlighted. Subsequently, the statistical tools for data analysis were discussed. With this background, statistical results obtained from the data are discussed in chapter four.

CHAPTER FOUR

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter includes all the discussions from survey findings after the questionnaire survey was carried out, statistical analysis were undertaken on the responses using relative index method and numerical formula for wastage level estimation that was described in the research methodology.

4.2 Respondents' profile

This study selected six (6) building construction projects in Jimma which constructed and supervised by different contractors and consultants .In this part, the respondents were asked to identify the main causes of material waste and to identify the major construction material wastage. Accordingly, thirty (30) from contractors, and ten (10) from consultants was participated to respond the questioner. As show in appendix -c the distribution of number of questioner to the consultants and contractors:

Under this section the results that have been obtained from processing of 40 questionnaires using Excel and the results are prepared to percent the information about the sample size, responses rate and contracting company's characteristics in Ethiopia especially, in Jimma. It also includes the ranking of factors affecting the wastage on construction projects based on relative important index, In addition to the causes of wastage in some construction materials, and there percentage level of wastage of selected materials as well as measurement and minimization of construction material wastages on site is also included.

4.3 General Organization of information

4.3.1 Classification of sample size

Appendix-c shows the characteristics of the sample size for the construction companies. The sample consists of General Contractors (GC1) = 10, General Contractors (GC2) =

5, General Contractors (GC3) = 5, General Contractors (GC4) = 5, General Contractors (GC5) = 5, General Consultants (GCO) = 10.

4.3.2 Distribution of Respondents' Position on the Site

The distribution of respondents' position for both consultants and contractors is shown in appendix-c It illustrates that 6 (20%) of respondent's occupation for the contracting companies are project manager, 6 (20 %) were office engineer, 9 (30%) were site engineer and 9 (30%) were quantity surveyor. On the other hand, in the case of consultants side 2 (20%) were resident engineer and 8(80%) were site supervisors. Thus, all respondents are the responsible body about the construction practice in their project than any other person. Therefore, they are expected to give reliable information for the specific project they work.

4.3.3 Respondents Educational Background

Appendix-c illustrates the level of education of respondents during the questionnaires survey. From the total 40 questionnaires analyzed, 8 (20%) of the respondents had MSc, 24 (60%) hold a BSc. degree while 8 (20%) of them had a diploma. This result in the level of education indicate that site personnel were qualified enough to give reliable information by understanding each of the question of the questionnaire about construction materials waste produce on site and how it could be minimized.

4.3.4 Respondent's Experience

Appendix-c shows the respondent's years of experience, the highest years of experience during the questionnaire survey were belongs in the year of 0-5 which is almost cover the majority of the respondent 46. 67 % followed by the range of 5-10 this cover about 36.67 % in the construction site. Furthermore during the survey in the specified site the researcher were couldn't find a respondent of having greater than 20 years while considering the contractors. In the same fashion about 40 % of consultant were in the year of 0- 5 and also 40% for the case of 5-10 years. In case of experience greater than 20 years were almost no respondent to the questionnaire survey.

4.4 Sources of Waste

There are many factors which contribute to construction materials waste generation on site. Waste may occur due to one or combination of many causes. Previous works organized the sources of waste under six categories: design, procurement, handling of materials, operation, residual related and others [3].

4.4.1 Level of contribution of the sources to the generation of waste

When the responses of the professionals (consultants and contractors) were considered during the questionnaire survey on the level of contribution of material waste sources on the construction site were compared, the results showed significant difference in between the categories of construction sources of wastage. Accordingly, the highest source of material waste is material storage and handling. Therefore, a relative index (RII) of about 0.79 in case of contractor and about 0.89 were scored in case of consultant for the specified target site. Accordingly table 4.1 show relative weight and ranking sources of construction waste and Figure 4.1 shows comparison of relative weight of source of construction waste for both contractors and consultancy.

Table 4-1: Relative weight and ranking sources of construction waste

Category	Contractor		Consultant		Average	
	RII	Rank	RII	Rank	RII	Rank
Design and Documentation	0.61	3	0.78	2	0.69	2
Operational	0.7	2	0.53	4	0.61	4
Material storage and Handling	0.79	1	1	1	0.89	1
Procurement	0.6	4	0.75	3	0.67	3

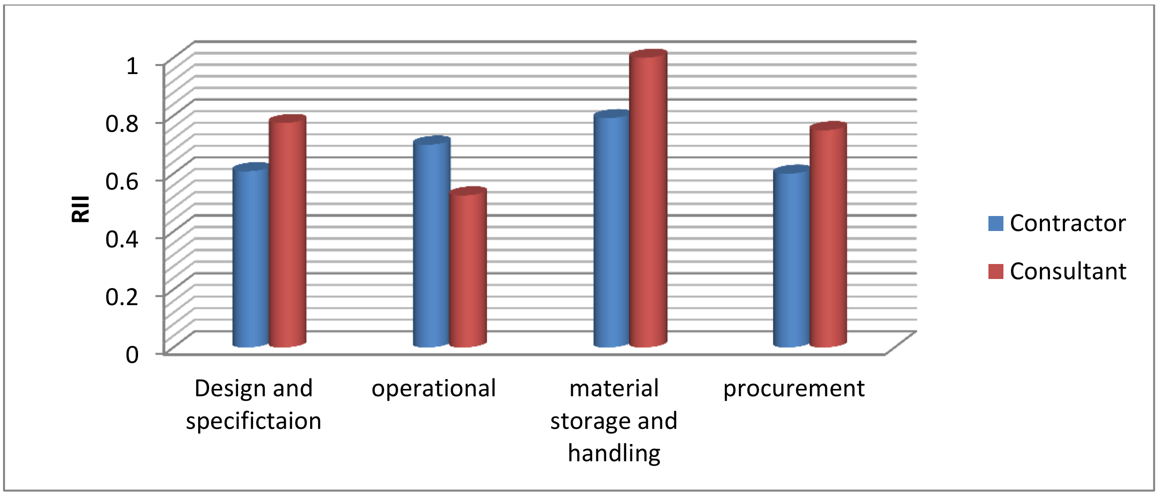


Figure 4-1: Comparison of relative weight of source of construction waste for both Contractors and consultancy

As shown on the above table 4.1 and figure 4.1 the main sources of construction waste ranked that compare to contractor and consultant, contractors results that material storage and handling, operational ,design and specification ,procurement and the consultants rank that material storage and handling , design and specification , procurement , operational.

As shown on the above table 4.1 the main sources of construction waste ranked that the main sources of wastage are material storage and handling, design and specification, procurement, operational.

4.4.2 Sources and Causes of construction waste

For the purpose of this study, the four wastage sources were further broken down into sources and causes of construction wastage. These factors were grouped in to four (4) categories.

Group1 Design and documentation

Respondents were asked to score which factors are considered to be major causes of waste arising from design and documentation. Table 4.2: shows that the relative importance index of all the 17 causes of waste and rank for the respondents (consultants and contractors).

Design and documentation						
Group of factors	Consultant		Contractors		Average	
	RII	Rank	RII	Rank	RII	Rank
Variations in the design while construction is in progress	0.93	1	0.73	2	0.83	1
Overlapping of design and construction	0.83	3	0.76	1	0.79	2
Poor communication leading to mistakes and errors	0.83	3	0.73	2	0.78	3
lack of knowledge about construction techniques during design activities	0.85	2	0.70	3	0.78	3
Poor/ wrong specifications	0.78	4	0.67	4	0.72	4
Lack of attention paid to dimensional coordination of products	0.75	5	0.58	7	0.67	5
Complexity of detailing in the drawings	0.73	6	0.61	5	0.67	5
Lack of information in the drawings	0.73	6	0.58	8	0.65	6
error in contract documents	0.65	7	0.61	5	0.63	7
Selection of low quality products	0.58	9	0.57	9	0.57	8
Incomplete contract documents at commencement of project	0.58	9	0.53	11	0.55	9
contract documents incomplete at commencement of construction	0.55	10	0.54	10	0.55	9
Designer's inexperience in method and sequence of construction	0.58	9	0.49	12	0.53	10
Lack of attention paid to standard sizes available on the market	0.60	8	0.46	14	0.53	10
Designer's unfamiliarity with alternative products	0.55	10	0.48	13	0.52	11
Last minute client requirement (resulting in rework)	0.43	12	0.60	6	0.51	12
poor site layout	0.48	11	0.43	15	0.45	13

Table 4-2: Ranks of construction materials wastage due to design documentation factors.

As shown the above table 4.2 the major causes due to design and documentation from the group of factors are Variations in the design while construction is in progress ,Over lapping of design and construction ,Poor communication leading to mistakes and errors and lack of knowledge about construction techniques during design activities.

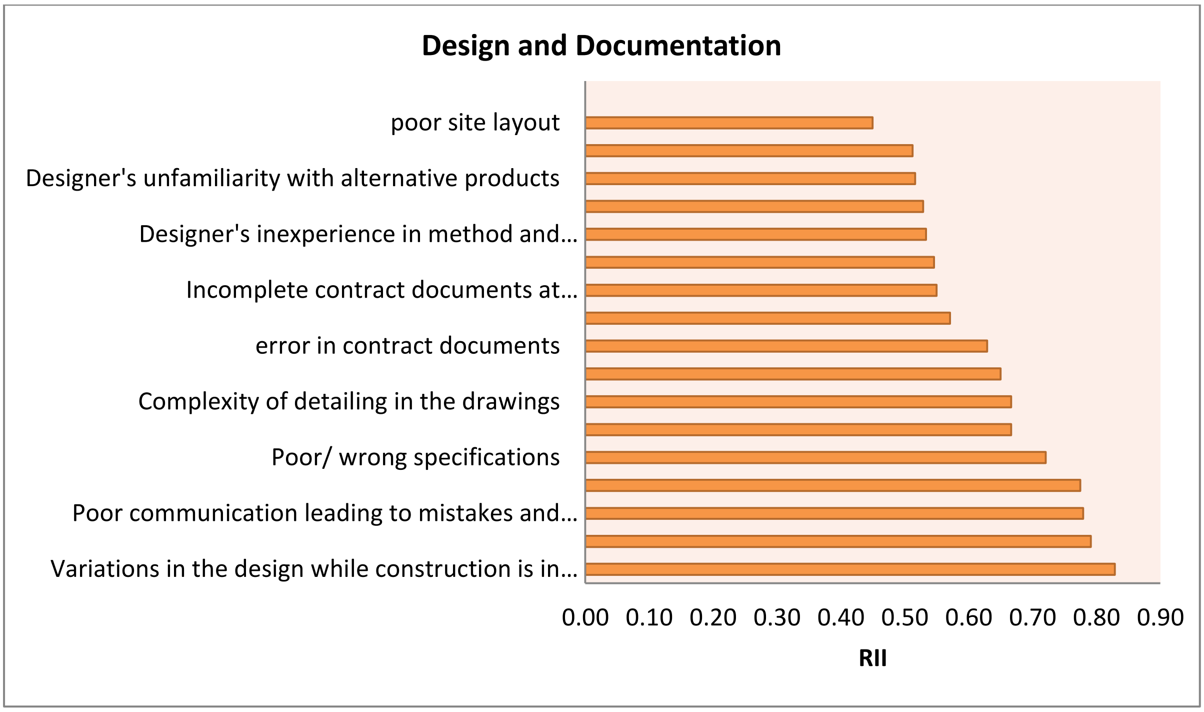


Figure 4-2: Ranks of construction materials wastage due to design and documentation factors

As shown on the above table 4.2 and figure 4.2 considering design and documentation the results from the survey revealed on the second ranks that the respondents consider all the seventeen factors as causes of waste arising out of design and documentation activities on construction sites. The results further revealed that variations in the design while construction is in progress, overlapping of design and construction, poor communication leading to mistakes and errors , lack of knowledge about construction techniques during design activities, poor/ wrong specifications, lack of attention paid to dimensional coordination of products, complexity of detailing in the drawings, lack of information in the drawings, error in contract documents, selection of low quality products, incomplete contract documents at commencement of project, contract documents incomplete at commencement of construction, designer's inexperience in method and sequence of construction, lack of attention paid to standard sizes available on the market.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.2 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.8 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (rs) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% ($\rho = 0.05$) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-3: Summary of spearman's rank correlation coefficients from group of factors on design and documentation factors

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.83	1
Number of pairs of values in the data set	n=17	

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs. contractor were 0.83. In this case, with a level of significance of 95% ($\rho = 0.05$), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.488), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in Jimma town selected building project.

Where:

r_s = Spearman's rank correlation coefficient

S_L = Critical value of r_s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

Group 2 Operational

Respondents were asked to score the major causes of wastes arising from operational activities on construction sites. Table 4.4 shows that the relative important index each of sub-factors of the operations on site groups. This causes of construction material waste.

Table 4-4: ***Ranks of construction materials wastage due to operation on site factors***

Operational						
	Consultant		**Contractor**		**Average**	
Factors	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Damage to work done caused by subsequent trades	0.90	1	0.68	1	0.79	1
Accidents due to negligence	0.90	1	0.66	3	0.78	2
Delays in passing of information to the contractor on types and sizes of products	0.85	2	0.67	2	0.76	3
Shortage of tools and equipment required	0.83	3	0.64	5	0.73	4
Required quantity unclear due to improper planning	0.83	3	0.63	6	0.73	4
Use of incorrect material, thus requiring replacement	0.75	6	0.67	2	0.71	5
Poor technology of equipment	0.80	4	0.61	7	0.70	6
Inappropriate placement of the material	0.75	6	0.65	4	0.70	6
Choice of wrong construction method	0.78	5	0.60	8	0.69	7
Inclement weather	0.75	6	0.59	9	0.67	8
Errors by tradesmen or operatives	0.73	7	0.57	10	0.65	9
Equipment malfunctioning	0.70	8	0.59	9	0.65	9
Unfriendly attitudes of project team and labors	0.75	6	0.54	11	0.65	9
Difficulties in obtaining work permits	0.73	7	0.53	12	0.63	10
Poor interaction between various specialists	0.65	9	0.51	13	0.58	11
Frequent breakdown of equipment	0.60	10	0.53	12	0.57	12
Accidents	0.55	11	0.475	14	0.51	13
Effects of political and social conditions	0.33	12	0.33	15	0.33	14

As shown the above table 4.4 the major causes due to operational from the group of factors are Damage to work done caused by subsequent trades, Accidents due to negligence, Delays in passing of information to the contractor on types and sizes of products and Shortage of tools and equipment required.

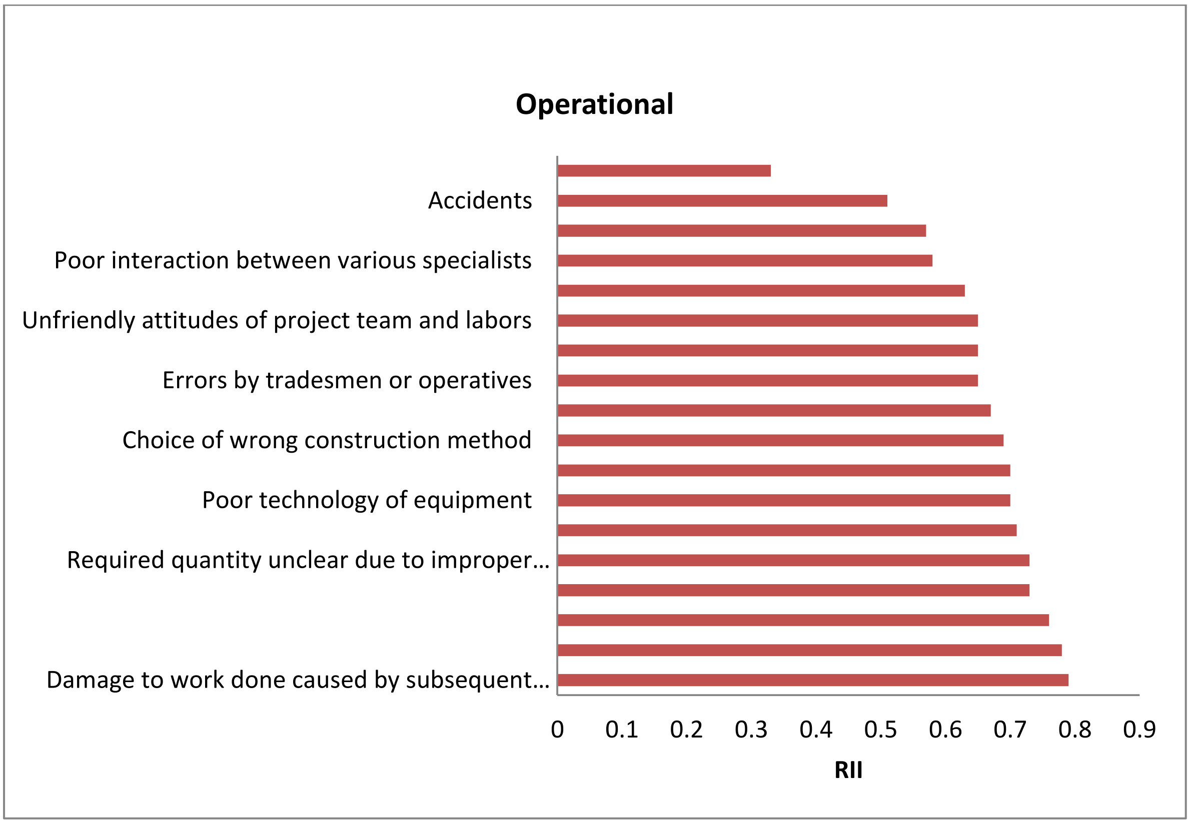


Figure 4-3: The highest factor of construction materials wastage in case of operations factors

As the above table 4.4 and figure 4.3 shows that results from the survey revealed on the fourth ranks that the respondents all the seven factors as causes of waste arising out of operational on construction sites. The results further revealed that damage to work done caused by subsequent trades, Accidents due to negligence, delays in passing of information to the contractor on types and sizes of products, Shortage of tools and equipment required, required quantity unclear due to improper planning, Use of incorrect material, thus requiring replacement, Poor technology of equipment, Inappropriate placement of the material, Choice of wrong construction method, Inclement weather, Errors by tradesmen or operatives, Equipment malfunctioning, Unfriendly attitudes of project team and labors, Difficulties in obtaining work permits, Poor interaction between various specialists, Frequent breakdown of equipment, Accidents, Effects of political and social conditions.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.4 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.5 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (r s) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% ($\rho = 0.05$) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-5 : Summary of spearman's rank correlation coefficients from group of factors on operational

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.83	1
Number of pairs of values in the data set n=18		

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs contractor were 0.83. In this case, with a level of significance of 95% ($\rho = 0.05$), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.472), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in Jimma town selected building project.

Where: r s = Spearman's rank correlation coefficient

S L = Critical value of r s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

Group 3 Materials Storage and Handling

Respondents were asked to evaluate causes of construction materials waste arising from materials storage and handling. Table 4.6 shows that the relative important index of all the 14 causes of waste evaluated for the respondents (contractors and consultants).

Table 4-6: *Ranks of construction materials wastage due to materials handling and storage factors*

Materials storage and handling						
	consultant		Contractor		Average	
Group of factors	RII	Rank	RII	Rank	RII	Rank
Lack of site control materials	0.95	3	0.83	1	0.89	1
Waste resulting from cutting uneconomical shapes	1.00	1	0.77	2	0.88	2
Poor method of storage on site	0.98	2	0.77	2	0.87	3
Poor handling	0.95	3	0.77	2	0.86	4
Damage to materials on site	0.90	4	0.77	2	0.83	5
Overproduction/ production of a quantity greater required or earlier than necessary	0.90	4	0.72	3	0.81	6
Use of wrong method of transport	0.95	3	0.58	8	0.77	7
Using excessive quantities of materials than required	0.83	5	0.71	4	0.77	7
Overloading of transport equipment	0.80	6	0.64	5	0.72	8
Unnecessary supply of (stock)goods on site	0.75	7	0.61	6	0.68	9
Insufficient instructions about handling	0.73	8	0.59	7	0.66	10
Use of whatever material close to working place	0.73	8	0.58	8	0.65	11
Manufacturing defects	0.63	9	0.54	9	0.58	12
Theft	0.53	10	0.48	10	0.50	13

As shown above table 4.6 the major causes due to material storage and handling from the group of factors are Lack of site control materials, Waste resulting from cutting uneconomical shapes, Poor method of storage on site and Poor handling are the major causes of waste in the construction site.

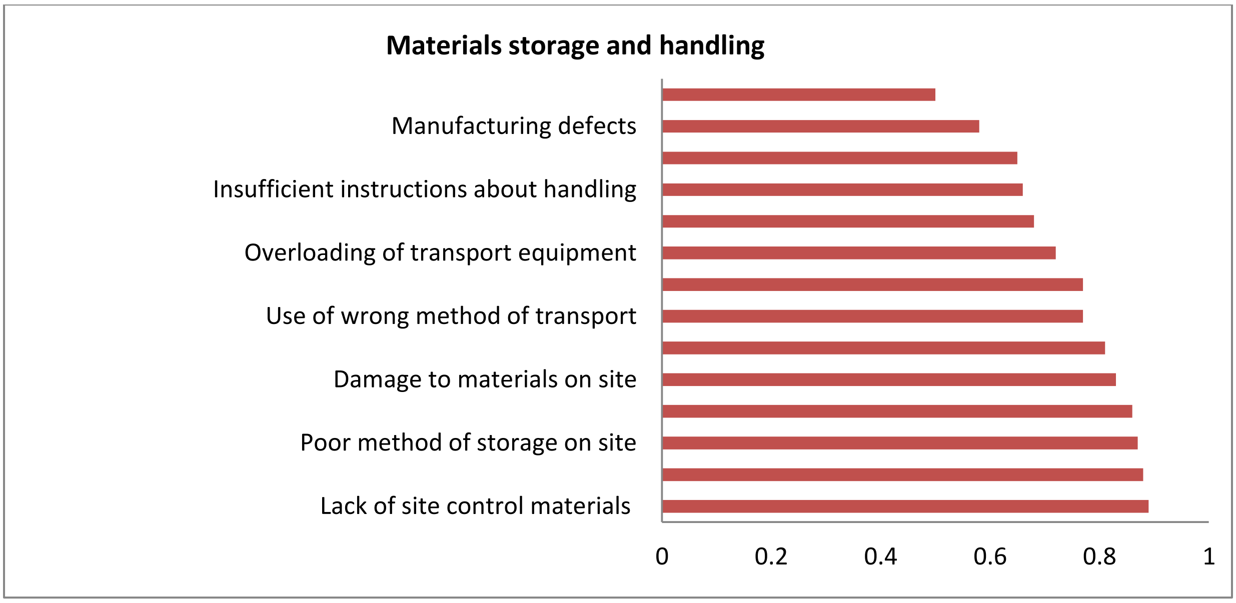


Figure 4-4: The Highest Factor of Construction Materials Wastage in Case of Materials Storage and Handling Factors

As shown above table 4.6 and figure 4.4 considered all the 15 factors evaluated were considered as major factors and causes of material storage and handling are ranks on the first factor for waste on construction sites. The results ranked as by contractors and consultants as showed that Lack of site control materials, Waste resulting from cutting uneconomical shapes, Poor method of storage on site, Poor handling, Damage to materials on site, Overproduction/ production of a quantity greater required or earlier than necessary , Use of wrong method of transport , Using excessive quantities of materials than required, Overloading of transport equipment, Unnecessary supply of (stock)goods on site, Insufficient instructions about handling, Use of whatever material close to working place , Manufacturing defects ,theft.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.6 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.7 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (r s) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% (ρ = 0.05) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-7: Summary of spearman's rank correlation coefficients from group of factors

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.91	1
Number of pairs of values in the data set	n=14	

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs contractor were 0.91. In this case, with a level of significance of 95% (ρ = 0.05), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.538), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in Jimma town selected building project.

Where:

r s = Spearman's rank correlation coefficient

S L = Critical value of r s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

Group 4 Procurement

Wastes arising from procurement factors on construction sites were evaluated by respondents. Table 4.8 shows that the relative important index of all the 7 causes of waste evaluated for the respondents (contractors and consultants).

Table 4-8*: Ranks of construction materials wastage due to procurement on site*

Procurement						
	Consultant		Contractor		Average	
Factors	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Ordering errors (ordering significantly more or less)	0.83	1	0.65	1	0.74	1
Suppliers errors	0.78	2	0.61	2	0.69	2
Under ordering	0.65	3	0.54	3	0.60	3
Unsuitability of materials supplied to site	0.60	4	0.48	4	0.54	4
Substitution of a material by a more expensive	0.53	6	0.44	5	0.48	5
Changes in material prices	0.53	5	0.43	6	0.48	5
Purchased products that do not comply with specification	0.50	5	0.42	7	0.46	6

As shown the above table 4.8 the major causes due to procurement from the group of factors are Ordering errors (ordering significantly more or less), Suppliers errors , Under ordering and Unsuitability of materials supplied to site.

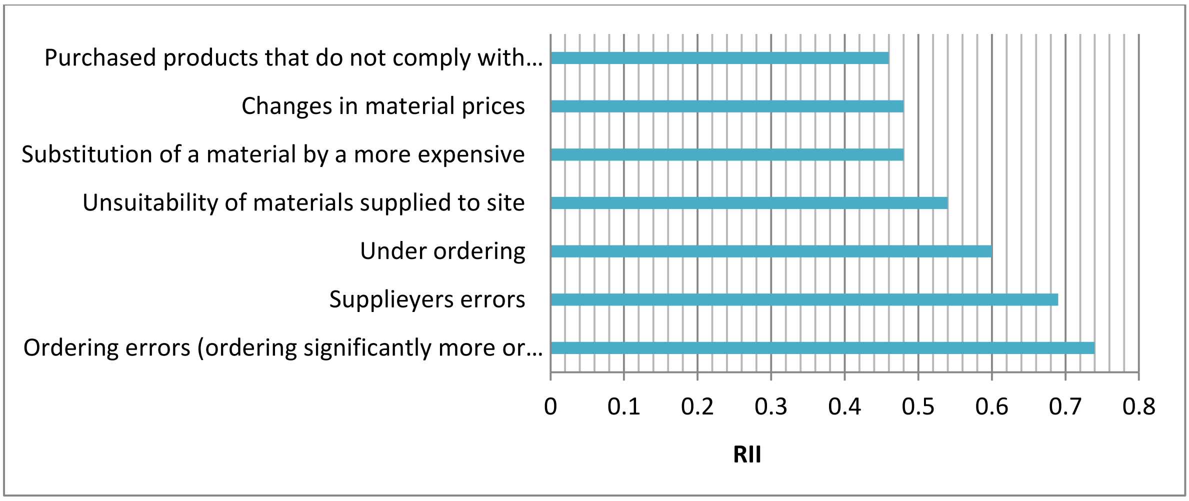


Figure 4-5: The Highest Factor of Construction Materials Wastage in Case of Procurement

As the above table 4.8 and figure 4.5 shows the highest factor of construction materials wastage in case of procurement actors are due to The results from the survey revealed on the third ranks that the respondents all the seven factors as causes of waste arising out of procurement on construction sites. The results further revealed that ordering errors (ordering significantly more or less, Suppliers errors, under ordering, Unsuitability of materials supplied to site, Substitution of a material by a more expensive, Changes in material prices, Purchased products that do not comply with specification.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.8 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.9 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (r s) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% ($\rho = 0.05$) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-9: Summary of spearman's rank correlation coefficients from group of factors

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.89	1
Number of pairs of values in the data set n=7		

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs contractor were 0.89. In this case, with a level of significance of 95% (ρ = 0.05), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.786), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in Jimma town selected building project.

Where:

r s = Spearman's rank correlation coefficient

S L = Critical value of r s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

In general, Construction process waste can be caused by 4 different groups of factors such as design and specification, operational, materials storage and handling and procurements. The construction stake holders (consultants and contractors) evaluated by respondents based on the questionnaire. When the responses rank by order causes are materials storage and handling, design and specification, operations and procurements.

Material storage and handling: - lack of site control materials, waste resulting from cutting uneconomical shapes, poor methods of storage on site and poor handling grouped under this factor and 89% of respondents agreed those are major causes of factors.

Design and specification;- Variations in the design while construction is in progress Overlapping of design and construction , Poor communication leading to mistakes and errors under this groups 80% of respondents agreed the causes of material wastage.

Operations:- Damage to work done caused by subsequent trades and accidents due to negligence under this group of factors 79% of respondents agreed those are the major cause of material wastage.

Procurement:- factors due to ordering errors and Suppliers errors under ordering are grouped under this factors and 74% of respondents agreed those are causes of factors.

4.5 Assessment of wastage of key construction materials

The results revealed that the five key materials which are wasted most on construction sites are concrete mix, , fine aggregate , coarse aggregate ,cement ,steel reinforcement and HCB. Table 4.10 shows level of contribution of key construction materials to wastage on construction sites. Compendium on wastage of key construction materials and recommended ways of waste minimization were also forwarded.

Table 4-10*: Wastage of key materials on building construction sites*

Key materials on building projects						
	consultant		**contractor**		**Average**	
Materials	RII	Rank	RII	Rank	RII	Rank
Steel Reinforcement	0.95	1	0.7417	1	0.85	1
HCB	0.9	2	0.7083	2	0.80	2
Cement	0.75	3	0.6167	3	0.68	3
Concrete Mix	0.7	4	0.55	4	0.63	4
Coarse Aggregates	0.575	5	0.425	5	0.50	5
Fine Aggregates	0.525	6	0.3833	6	0.45	6

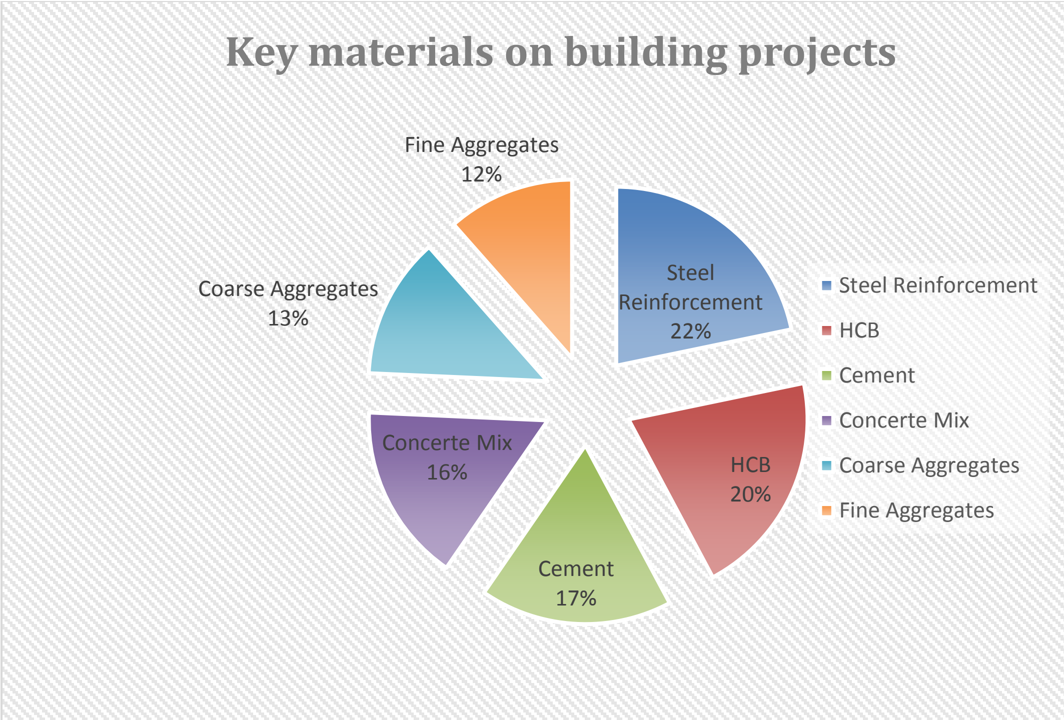


Figure 4-6: Percentage of Key material waste on building projects

As the above table 4.10 and figure 4.6 shows the very severely problem for material waste on site are steel reinforcement and HCB as well as the small waste is fine aggregates and coarse aggregates.

4.6 Quantity Wastage Level

As described in the methodology used the numerical formula for wastage level (%) and selected three projects that have just completed or in the completion time. 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. this study considers wastage as proportionate to the actual of works, as shown below

$$\text{materialwastequantity} = \text{storerecords} - \text{actualmaterialrequirements}$$

$$\text{materialwastage}(\%) = \frac{\text{materialwastequantity}}{\text{actualmaterialrequirements}} \text{x } 100$$

As shown below table 4.11 summarizes the percentage of waste materials analysis, for the common used materials for concrete on building projects are concrete, cement ,fine and course aggregate ,steel reinforcement and HCB.

Table 4-11: Material waste quantity

Sample 1						
No.	Materials	UNIT	Estimated Quantity (PURCHESED)	Actual quantity	Material waste quantity	Material wastage (%)
1	concrete	M3	8690.43	7939.9	750.53	9.45
2	sand	M3	1018.78	885.9	132.88	15.00
3	aggregate	M3	1071.65	931.87	139.78	15.00
4	cement	Qtl	6600	6122.13	477.87	7.81
5	steel RF	KG	110782.16	98379.84	12402.32	12.61
6	HCB	PCS	67416.74	57304.23	10112.51	17.65
Sample 2						
1	concrete	M3	56605	53606.12	2998.88	5.59
2	sand	M3	6120	5642.82	477.18	8.46
3	aggregate	M3	8750	7989.26	760.74	9.52
4	cement	Qtl	41735	39974.04	1760.96	4.41
5	steel RF	KG	1503507.35	1420350	83157.35	5.85
6	HCB	PCS	317941	300941	17000	5.65

Table 4-12: Average Material wastage percentage (%)

No	Material	Sample 1 Material wastage (%)	Sample 2 Material wastage (%)	Average Material wastage (%)
1	aggregate	15	9.52	12.26
2	Sand	15	8.46	11.73
3	HCB	17.65	5.65	11.65
4	steel RF	12.61	5.85	9.23
5	Concrete	9.45	5.59	7.52
6	Cement	7.81	4.41	6.11

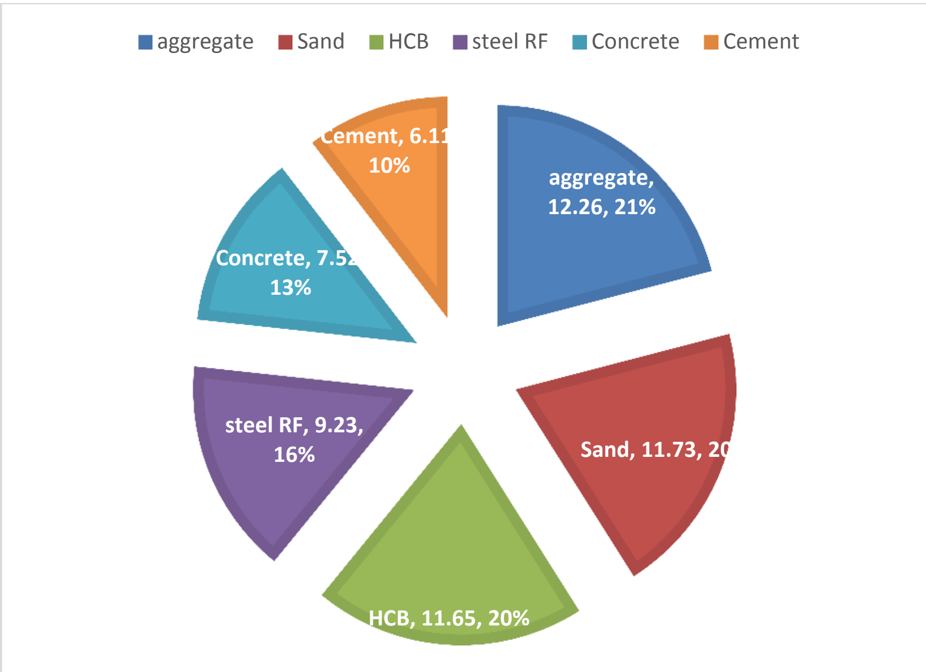


Figure 4-7: The percentage of waste materials

4.7 Wastage Materials for Group of Factors on Building Construction Sites

This section discuss regarding causes of material because of the poor at the design and documentation , Operational ,materials storage and handling and procurement of the key construction materials identified as constituting to high wastage on site and there measurement to minimize the wastage of the materials.

4.7.1 HCB

HCB commonly used as for walling and finishing materials on building construction sites. As the questioner respondents agree 20% HCB severely wasted on site because of the following cases.

One of the most highly contributors were material storage and handling of blocks on construction sites. The causes for this kind of waste on sites are usually because of: improper use of products that size does not suitable, damaged during transportation, unpacked supply, internal movement of materials on site, delivery of materials (handling and transportation), waste due to the nature of the material simply crushed, lack of control of material usage by contractors and carelessness of workers, lack of modular coordination in design and finally material quantity for purchased required more than that needed.

Incorrect transportation of push bricks the discharge of push bricks, throwing them, moving them by hand remarkably increases the waste.by Manual transportation of bricks become wasted.

Figure 4-8: Poor handling of HCB during manufacturing and storage at Afro-Tsiyone storage site

As shown on figure 4.8 there becomes due to manufacturing and poor storage on site. The nature of HCB is highly liable to become wasted. Because increasingly popular in construction projects due to their light, quick, and easy nature.

Figure 4-9*: Good handling of HCB during storage at* *VARNERO* ***on site***

The highly recommended ways to minimize the HCB wastages are proper storage of materials on site, take care of materials in transportation and on the site movements, control of data that delivered on site and actually used, produced actual sizes that we needed.

4.7.2 Concrete

Concrete mix, coarse and fine aggregates and cement should be stored properly. As the questioner respondents agree 16% concrete mix severely wasted on site because of below so many factors. The actual causes of concrete wastage on sites because of: over order exact quantity of concrete required is unknown per poor due to deficiency in planning or without specification, loss during concreting-methods of placing use of aged timber boar, low quality of materials, waste using unsuitable templates, excessive or unnecessary stock of an item which lead to materials waste, demolition due to no response experimental results and poor design of the concrete form work system were the highly responsible reasons for wastage of concrete on construction sites.

Using low-quality materials because High- quality materials are so expensive this creates the tendency for low- quality but cheaper materials that remarkably increase the amount of waste. The concrete wasted using unsuitable templates.

Prefabricated concrete parts materials whose suitable packing would prevent waste largely.

Demolition due to no response of experimental results when the experimental results of concrete do not correspond, the experimented part must be demolished that causes waste. Accidental mistakes are usually observed in all stages of construction.

Figure 4-10: Concrete wastage during on construction activities on *VARNERO* **site.**

In the case of premixing concrete the movement concerned with unnecessary or inefficient movements made by workers during their job, lack of control, specialized equipment and knowledge over implementation issues and poor control of site managers, wrong estimations of materials, lack of constructability of some structural elements, imprecision of the measuring device, flaws in formwork assembling process, the difficulty of controlling the amount of premixed concrete deliveries, operational error to external plastering relatively exposed to wastage and lack of recording materials supplied on site and used on site are the reasons for waste of premixing concrete.

Figure 4-11*: Poor handling of premixing concrete at Yotek construction project site*

On the other hand, fine and course aggregates are the row materials for concrete as the questioner the respondents agree 12% fine aggregates and 13 % coarse aggregates were severely wasted on site because of: poor management on construction companies, during bad storage and handling of concrete on site and oversized building components during construction were some of the reasons.

Figure 4-12*: Poor handling of fine and course aggregates at Yotek construction project site*

Figure 4-13: *Good handling of fine and course aggregates at VARNERO construction project site*

The other material that available in large quantity was cement which largely exposed for wastage in the construction site**.** The main cases of cement waste in site were: incorrect packing of the cement stock, improper deporting of materials in transportation, use insufficient equipment during construction activities lack of control in the delivery operation and the necessary handling it demands, bad storage in store, frequency transportation of materials on site and poor material management in construction sites.

Improper packing of the materials becomes increase wastage. Proper packing is one of the ways of reducing the waste cement.

Improper deporting of cement becomes waste. The correct deporting of materials, especially the sensitive materials to atmospheric conditions can prevent waste. Cement are deporting is very effective on their becoming waste. Cement highly increases the vitality of proper deporting. Figure-4.14 indicates how improper deporting causes waste.

Figure 4-14: Unsuitable stock location of cement

Recommended ways to avoid wastage concrete and concrete materials on construction sites were to minimize the concrete wastage on sites are ordering the exact quantity, good construction management practices, using efficient construction equipment's, proper storage of materials ,ordering materials that fit the required needed ,packing cements carefully and protecting from moisture ,good coordination between store and construction personnel, Using efficient construction methods and minimizing design changes , mixing, transporting and placing concrete at the appropriate time.

4.7.3 Steel Reinforcement

Steel reinforcement is the backbone of any building construction and the most expensive material during the project life time. Therefore, proper handling of steel reinforcement is big challenge on project construction sites. Actual there were a lot of reasons for wastage of steel reinforcement during constructions. The main cases of Steel reinforcement waste in site were: poor construction techniques lost during installation(poor workmanship), Cutting-use of steel bars that sizes does not fit with the design, some excessively large diameter due to fabrication problems and trespassing, Poor structural design due to standardization and detailing, causing waste due to no optimized cutting of bars, with internal movement of materials on site excessive handling, the use of inadequate equipment or bad conditions of pathways, poor layout, lack of planning of materials flows, over time work, and exhausted workers

A B

C D

Figure 4-15*: Poor Storage and handling of Steel Reinforcement on construction sites*

Recommended ways to avoid or minimize waste of steel reinforcement on construction sites are using good construction techniques, using software to order cutting, minimize design changes and good handling and storages to avoid corrosions.

Figure 4-16*: Good Storage and handling of Steel Reinforcement on construction sites***

As shown in the figure 4-16 they have a good storage and handling of steel reinforcement ordering by shape and size .but they did not cover by shades, so they must be cover the material because expose to the environment.

4.8 Waste Minimization Measures

Waste minimization is the solution for wastage of materials on site because wastage can't avoid 100% but we can minimize waste by different measurements.

4.7.1 Measures of minimization of material wastes

Respondents were asked to score the high contributor from those measures minimization technics of material wastages. Table 4.17 shows that the relative important index each of measures that contribute the minimization of materials wastes.

Table 4-13*: Ranks of measures of contribution to the minimization of materials waste*

Measures of minimization of material wastes						
	Consultant		Contractor		Average	
Measures	RII	Rank	RII	Rank	RII	Rank
Good construction management practices	0.98	1	0.89	1	0.93	1
Proper storage of materials on site	0.98	1	0.89	1	0.93	1
Mixing, transporting and placing concrete at the appropriate time	0.93	3	0.89	1	0.91	2
Minimizing design changes	0.95	2	0.87	3	0.91	2
Good coordination between store & construction personnel to avoid over-ordering	0.93	3	0.88	2	0.90	3
Accurate and good specifications of materials to avoid wrong ordering	0.90	4	0.83	3	0.87	4
Use of more efficient construction equipment	0.88	5	0.85	4	0.86	5
Adoption of proper site management techniques	0.88	5	0.82	5	0.85	6
Change of attitude of workers towards the handling of materials	0.90	4	0.78	8	0.84	7
Accurate measurement of materials during batching	0.85	6	0.80	6	0.83	8
waste management officer or personnel employed to handle waste issues	0.83	7	0.78	8	0.80	9
Just in time operations	0.80	8	0.77	7	0.78	10
Employment of skilled workmen	0.78	9	0.74	8	0.76	11
Careful handling of tools and equipment on site	0.78	9	0.71	11	0.74	12
Adherence to standardized dimensions	0.73	10	0.73	9	0.73	13
Early and prompt scheduling of deliveries	0.70	11	0.72	10	0.71	14
Using materials before expiry dates	0.70	11	0.68	12	0.69	15
Attentiveness of supervisors	0.70	11	0.67	14	0.68	16
Checking materials supplied for right qualities and volumes	0.70	11	0.67	14	0.68	16
Training of construction personnel	0.68	12	0.68	12	0.68	16
Access to latest information about types of materials on the market	0.68	12	0.68	12	0.68	16
Purchasing raw materials that are just sufficient	0.65	13	0.68	13	0.66	17
Encourage re-use of waste materials in projects	0.65	13	0.65	15	0.65	18
Recycling of some waste materials	0.60	15	0.70	17	0.65	18
Weekly programming of works	0.65	13	0.63	16	0.64	19
Regular education and training of personnel on how to handle	0.63	14	0.65	15	0.64	19

As shows above table 4.13 the list of measures to minimize wastage on projects the respondents considered all the 26 measures as important for minimizing wastage of materials on site. The results ranked as showed that are good construction management practices, proper storage of materials on site, mixing, transporting and placing concrete at the appropriate time, minimizing design changes, good coordination between store & construction personnel to avoid over-ordering, accurate and good specifications of materials to avoid wrong ordering, Use of more efficient construction equipment, adoption of proper site management techniques, change of attitude of workers towards the handling of materials, accurate measurement of materials during batching, waste management officer or personnel employed to handle waste issues, Just in time operations, Employment of skilled workmen, careful handling of tools and equipment on site, Adherence to standardized dimensions, Early and prompt scheduling of deliveries, Using materials before expiry dates, Attentiveness of supervisors, Checking materials supplied for right qualities and volumes, Training of construction personnel, Access to latest information about types of materials on the market, Purchasing raw materials that are just sufficient, , Encourage re-use of materials in projects ,waste Recycling of some waste materials, , Weekly programming of works, Regular education and training of personnel on how to handle.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.13 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.14 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (rs) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% ($\rho = 0.05$) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-14: Summary of spearman's rank correlation coefficients for Measures of minimization of material wastes

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.98	1
Number of pairs of values in the data set n=26		

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs contractor were 0.98. In this case, with a level of significance of 95% (ρ = 0.05), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.39), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in Jimma town selected building project.

Where:

r s = Spearman's rank correlation coefficient

S L = Critical value of r s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

4.7.2 Measures of minimization practices

Respondents were asked to score the highest level of practice of these waste minimization measures on their projects if wastages happens on the site. Table 4.15 shows that the Relative Important Index of each of measures the most frequently practiced of these waste minimization measures on projects.

Table 4-15: The measures of waste minimization practices on the project

Measures of Waste minimization practices						
	Consultant		Contractor		Average	
Measure	RII	Rank	RII	Rank	RII	Rank
Good construction management practices	0.725	2	0.75	1	0.74	1
Proper storage of materials on site	0.65	3	0.65	3	0.65	2
Good coordination between store & construction personnel to avoid over-ordering	0.625	4	0.6667	2	0.65	2
Use of more efficient construction equipment	0.625	4	0.65	3	0.64	3
Just in time operations	0.6	5	0.65	3	0.63	4
attentiveness of supervisors	0.775	1	0.425	16	0.60	5
Mixing, transporting and placing concrete at the appropriate time	0.575	6	0.5833	4	0.58	6
Accurate and good specifications of materials to avoid wrong ordering	0.525	7	0.5833	4	0.55	7
Careful handling of tools and equipment on site	0.475	9	0.575	5	0.53	8
Training of construction personnel	0.5	8	0.5416	6	0.52	9
Change of attitude of workers towards the handling of materials	0.5	8	0.525	8	0.51	10
Adherence to standardized dimensions	0.45	10	0.5167	9	0.48	11
Checking materials supplied for right qualities and volumes	0.425	11	0.5333	7	0.48	11
Accurate measurement of materials during batching	0.45	10	0.5083	10	0.48	11
Early and prompt scheduling of deliveries	0.425	11	0.5167	9	0.47	12
Weekly programming of works	0.425	11	0.5083	10	0.47	12
Adoption of proper site management techniques	0.4	12	0.5333	7	0.47	12
Using materials before expiry dates	0.425	11	0.4916	12	0.46	13
Minimizing design changes	0.4	12	0.5	11	0.45	14
Purchasing raw materials that are just sufficient	0.375	13	0.5167	9	0.45	14
Employment of skilled workmen	0.4	12	0.4333	15	0.42	15
Recycling of some waste materials	0.4	12	0.4166	17	0.41	16
Regular education and training of personnel on how to handle	0.35	14	0.45	14	0.40	17
Access to latest information about types of materials on the market	0.325	15	0.4583	13	0.39	18
waste management officer or personnel employed to handle waste issues	0.325	15	0.45	14	0.39	18
Encourage re-use of waste materials in projects	0.325	15	0.3833	18	0.35	19

As table 4.15 shows most of construction projects undergo at jimma town when got wastage during site activities. The respondents considered all the 26 the measures of waste minimization practices on the projects. The results ranked as showed that are practiced often Good construction management practices, Proper storage of materials on site, Good coordination between store & construction personnel to avoid over-ordering, Use of more efficient construction equipment, Just in time operations and on the least practiced on the projects of jimma site are Encourage re-use of waste materials in projects, waste management officer or personnel employed to handle waste issues, Access to latest information about types of materials on the market, Regular education and training of personnel on how to handle, Recycling of some waste materials.

Test for Agreements on group of factors Among Respondents

This part of the study checks whether there is a significant degree of agreement among the two parties (contractors and consultants) of the project. Spearman rank correlation coefficient is used as a measure of agreement among raters based on the relative importance index. Using the formula given in equation 3 section 3.12 of this research; degree of agreement between consultant and contractor were checked and presented in the Table below. Spearman's correlation works by calculating correlation on the ranked values of this data. Using the Table 4.15 and equation 3, Spearman correlation coefficients (rs) are calculated and tabulated as shown in Table 4.16 a significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (r s) is assessed, in order to see whether there is agreement between two groups of respondents in ranking the factors; the level of significance 95% ($\rho = 0.05$) is used. This allows verifying whether there is "agreement" between respondents' response.

Table 4-16: Summary of spearman's rank correlation coefficients for waste minimization practices

Respondent Category	Consultant	Contractor
Consultant	1	
Contractor	0.87	1
Number of pairs of values in the data set	n=26	

The Table above showed that the calculated spearman rank correlation coefficient values for consultant vs contractor were 0.87. In this case, with a level of significance of 95% (ρ = 0.05), the calculated values of r s for the Groups are greater than the critical values of r s (S L = 0.39), therefore, it can be said that there is a significant degree of agreement among the respondents regarding factors affecting construction materials wastage on building projects in jimma town selected building project.

Where:

r s = Spearman's rank correlation coefficient

S L = Critical value of r s (appendix B)

ρ = Probability that rejects the null assumption wrongly (usually =0.05)

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

The causes of construction material waste can be measured and evaluated using a large number of construction phase related factors such as design and documentation, materials procurement and management, operational and material storage and handling on site management practices. The first set is related to construction team and contractors; people who consider the build ability and maintainability of the building. The second set is related to the consultants (site supervisors and the site operatives); people who are directly involved in the art of putting the raw materials together to form the building envelop.

From the results of analysis, it was concluded that the group of most important factors contributing to construction material waste generation on building sites in jimma and the key material wastage level.

The Sources and causes of materials waste on construction sites are

From the results its can be concluded that the most factors that causing construction waste in building projects are material storage and handling (0.89), design and documentation (0.69), procurement (0.67), operational (0.61) using relative important index respectively.

As table 4.6 and figure 4.4 shows highest factor of construction materials wastage in case of materials storage and handling factors are due to lack of site control materials (0.89) and waste resulting from uneconomical shapes (0.88) those are the most significant factors. On the other hands the least contributor were due to theft (0.50) and manufacturing defects (0.58) using relative important index respectively.

While considering design and documentation the results from the survey revealed on the second ranks that the respondents consider all the seventeen factors as causes of waste arising out of design and documentation activities on construction sites. As table 4.2 and Figure 4.2 shows the highest factor of construction materials wastage in case of design and documentation factors are due to variations in the design while construction is in progress (0.83) and poor communications leading to mistakes and errors (0.79) were the most significant factors however the slightest contributor were due to poor site layout (0.45) followed by last minute client requirement or resulting in rework (0.51) using relative important index respectively.

On the other group of factor results from the survey revealed that table 4.4 and figure 4.3 shows the highest factor of construction materials wastage in case of operations factors are when there is damage to work done caused by subsequent trades (0.79) and accidents due to negligence (0.78). On the other hands the slightest contributor was due to accidents (0.51) and effects of political and social conditions (0.33) using relative important index respectively.

When procurement is considered in table 4.8 and figure 4.5 shows the highest factor of construction materials wastage in case of procurement factors are due to ordering errors (0.74) and Suppliers errors (0.69) on the other hands the slightest contributor when there is purchased products that do not comply with specification (0.46) and changes in material prices (0.48) using relative important index respectively.

All the five key materials evaluated were considered as which are wasted most on construction sites. Table 4.10 and figure 4.6 summarizes the results of data analysis. Accordingly, the most commonly used materials on building projects in jimma sites the results ranked as revealed that concrete mix (16%), fine aggregate (12%), coarse aggregate (13%), cement (17%), steel reinforcement (22%) and HCB (20%) are the key materials wasted on construction sites using relative important index respectively.

Materials account for the largest input into construction activities. As table 4.12 and figure 4.7 this paper summarized the results of a study which quantified the material wastage in jimma sites. Course Aggregate was found to be having the highest wastage (12.26%) followed by fine aggregate (11.73%), HCB (11.65%), steel reinforcement (9.23%), concrete (7.52 %) and cement (6.11%). The statistical spread of those materials were found to be high signifying variation in results.

In general, to minimize wastage on building construction the researcher were concluded to practice all the 26 measures as important for minimizing wastage of materials on site. The good practices are good construction management, Proper storage of materials on site, mixing, transporting and placing concrete at the appropriate time and minimizing design changes and re- use of different construction materials. Equally important measurements of minimization technics of material wastages are regular education and training of personnel on how to handle materials. This study also come up with practical observation on most construction site available in jimma town that did not practiced recycling or re use of material on site.

5.2 Recommendations

Based on the data analyzed results and observations carried out with in the study area findings ,the following recommendations are made to effective waste management practice of construction projects in Jimma sites.

In general to decrease extent of material wastage in construction projects this study would like to recommend that the construction companies should be able to:

5.2.1 Consultants

- They should have given considerations to avoid design and planning errors.
- They should have any type of implementation, its specified standards should be defined to Minimizing design changes.
- They should have an attentiveness on site supervisions.

5.2.2 Contractors

- Use good construction techniques using software like cutting optimization pro for order cutting to produce in the exact volumes to avoid over ordering.
- Good coordination between store and construction personal to have good handling and storage material to avoid wastage.
- Use efficient construction equipment’s for mixing, transportation and placing concrete at the appropriate time and Using new and modern machinery have much higher efficiency, whose purchase or rent is economical in long term.
- Encourage reuse or recycling of some waste materials in projects.

- Have the good construction management practices and plans in all construction companies. ex. use scheduling
- Produce the actual sizes that we need based on the drawing and good qualities.
- Packing cement and HCB materials carefully from rusting and moisture and take care of those materials in transportation and proper storage of material on site, Adoption of proper site management techniques.
- Use modern storage for reinforcement wisely from rusting and moisture to avoid corrosion.
- Employment of skilled manpower like construction material engineer or waste management officer or personnel employed to handle materials and waste issues.

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APPENDIX-A

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

PROJECT TITTLE "INVESTIGATION ON THE FACTORS AFFECTING CONSTRUCTION MATERIALS WASTAGE ON BUILDING PROJECTS IN JIMMA TOWN"

QUESTIONNAIRE FOR CONSTRUCTION FIRMS

1. Company name: …………………………………………………
2. Year of establishment: ……………………………………………
3. Profession

Project manager ☐ office engineer ☐ site engineer ☐Quantity Surveyor ☐ Site supervisor ☐resident engineer☐other, please specify…………………………………

4. Level of education

Certificate and Diploma ☐Bachelor's Degree ☐Master's Degree ☐other, please specify…………………………………

5. Level of experience in years

0-5 ☐ 5-10 ☐ 10-15 ☐ 15-20 ☐> 20 ☐

6. Who are your major clients?

Governmental organizations ☐ Private individuals and organizations ☐

Both public and private figures ☐

Others, please specify……………………………………………

1. SOURCES AND CAUSES OF WASTE

A. Below are possible sources of construction waste. Rank on a scale of 1-5 which of these waste sources provides major waste on your site.

1	2	3	4	5
No waste	*Insignificant waste Cause*	*Neutral*	*Significant waste cause*	*Major waste cause*

Waste Cause	*1*	*2*	*3*	*4*	*5*
Design and specification					
Operational					
Materials storage and handling					
Procurement					

B. Below are possible sources and causes of construction waste. Rank on a scale of 1-5 which of these activities is a major provider of wastes.

1	2	3	4	5
No waste	*Insignificant waste*	*Neutral*	*Significant waste*	*Major waste*

DESIGN AND DOCUMENTATION	*1*	*2*	*3*	*4*	*5*
Lack of attention paid to dimensional coordination of products					
Variations in the design while construction is in progress					
Designer's inexperience in method and sequence of construction					
Lack of attention paid to standard sizes available on the market					
Designer's unfamiliarity with alternative products					
Complexity of detailing in the drawings					
Lack of information in the drawings					
Poor/ wrong specifications					
Incomplete contract documents at commencement of project					
Selection of low quality products					
Last minute client requirement (resulting in rework)					
Poor communication leading to mistakes and errors					

Overlapping of design and construction					
Lack of knowledge about construction techniques during design activities					
Poor site layout					
Error in contract documents					
Contract documents incomplete at commencement of construction					

OPERATIONAL	*1*	*2*	*3*	*4*	*5*
Errors by tradesmen or operatives					
Accidents due to damage					
Damage to work done caused by subsequent trades					
Use of incorrect material, thus requiring replacement					
Required quantity unclear due to improper planning					
Delays in passing of information to the contractor on types and sizes of products					
Equipment malfunctioning					
Inclement weather					
Inappropriate placement of the material					
Poor interaction between various specialists					
Choice of wrong construction method					
Unfriendly attitudes of project team and labors					
Effects of political and social conditions					
Difficulties in obtaining work permits					
Frequent breakdown of equipment					
Poor technology of equipment					
Shortage of tools and equipment required					
Accidents					
MATERIALS STORAGE AND HANDLING	*1*	*2*	*3*	*4*	*5*
Overloading of transport equipment					
Use of wrong method of transport					
Poor method of storage on site					
Poor handling					
Use of whatever material close to working place					
Theft					
Damage to materials on site					
Waste resulting from cutting uneconomical shapes					
Unnecessary supply of (stock) goods on site leading to waste					
Overproduction/ production of a quantity greater required or earlier than necessary					
Manufacturing defects					
Lack of site control materials					
Using excessive quantities of materials than required					
Insufficient instructions about handling					
procurement	1	2	3	4	5
Ordering errors (ordering significantly more or less)					
Purchased products that do not comply with specification					
Unsuitability of materials supplied to site					
Substitution of a material by a more expensive					
Supplieyers errors					
Changes in material prices					

Under ordering					

C. Below are some selected materials which are wasted on construction sites. Rank on a scale of 1-5 which of these materials is severely wasted on site.

1	*2*	*3*	*4*	*5*
Not severe	*Less severe*	*Quite severe*	*severe*	*Very severe*

Material	*1*	*2*	*3*	*4*	*5*
Concrete mix					
Fine aggregate					
Course aggregate					
Cement					
Steel reinforcement					
HCB					

D. Below are possible measures that contribute to the minimization of material wastes.

1	*2*	*3*	*4*	*5*
Very low contribution Contribution	*Low contribution*	*Medium contribution*	*High contribution*	*Very high contribution*

MEASURES	*1*	*2*	*3*	*4*	*5*
Recycling of some waste materials on site					
Good construction management practices					
Training of construction personnel					
Good coordination between store and construction personnel to avoid over-ordering					
Use of more efficient construction equipment					
attentiveness of supervisors					
Proper storage of materials on site					
Just in time operations					
Early and prompt scheduling of deliveries					
Adherence to standardized dimensions					
Change of attitude of workers towards the handling of materials					
Regular education and training of personnel on how to handle					
Checking materials supplied for right qualities and volumes					
Employment of skilled workmen					
Accurate measurement of materials during batching					
Accurate and good specifications of materials to avoid wrong ordering					
Encourage re-use of waste materials in projects					
Careful handling of tools and equipment on site					
Weekly programming of works					
Mixing, transporting and placing concrete at the appropriate time					
Waste management officer or personnel employed to handle waste issues					
Adoption of proper site management techniques					
Access to latest information about types of materials on the market					
Minimizing design changes					
Purchasing raw materials that are just sufficient					
Using materials before expiry dates					

1	*2*	*3*	*4*	*5*
Not practiced at all	*Sometimes practiced*	*Practiced*	*Frequently practiced*	*Most frequently practiced*

MEASURES	*1*	*2*	*3*	*4*	*5*
Recycling of some waste materials on site					
Good construction management practices					
Training of construction personnel					
Good coordination between store and construction personnel to avoid over-ordering					
Use of more efficient construction equipment					
attentiveness of supervisors					
Proper storage of materials on site					
Just in time operations					
Early and prompt scheduling of deliveries					
Adherence to standardized dimensions					
Change of attitude of workers towards the handling of materials					
Regular education and training of personnel on how to handle					
Checking materials supplied for right qualities and volumes					
Employment of skilled workmen					
Accurate measurement of materials during batching					
Accurate and good specifications of materials to avoid wrong ordering					
Encourage re-use of waste materials in projects					
Careful handling of tools and equipment on site					
Weekly programming of works					
Mixing, transporting and placing concrete at the appropriate time					
Waste management officer or personnel employed to handle waste issues					
Adoption of proper site management techniques					
Access to latest information about types of materials on the market					
Minimizing design changes					
Purchasing raw materials that are just sufficient					
Using materials before expiry dates					

E. Rank on a scale of 1-5 the level of practice of these waste minimization measures in your site.

Table for quantity wastage of material

no	Material	Unit	estimated quantity	actual quantity	material waste quantity
1	Concrete	M3			
no	Material	Unit	Purchased quantity	Actual quantity	Material waste quantity
2	Course aggregate	M3			
3	Fine aggregate(sand)	M3			
4	Cement	Qtl			
5	Steel reinforcement	KG			
6	HCB	PCS			

APPENDIX B

Table The Spearman rank correlation coefficient

The table gives the critical values of the spearman rank correlation coefficient, for different numbers of pairs of observations.

	significance level: two-tailed/non-directional			
	0.20	0.10	0.05	0.01
	significance level: one-tailed/directional			
Number of subjects(data set)	0.10	0.05	0.025	0.005
5	0.800	0.900	1.000	-
6	0.657	0.829	0.886	1.000
7	0.571	0.714	0.786	0.929
8	0.524	0.643	0.738	0.881
9	0.483	0.600	0.700	0.833
10	0.455	0.564	0.648	0.794
11	0.427	0.536	0.618	0.755
12	0.406	0.503	0.587	0.727
13	0.385	0.484	0.560	0.703
14	0.367	0.464	0.538	0.679
15	0.354	0.446	0.521	0.654
16	0.341	0.429	0.503	0.635
17	0.328	0.414	0.488	0.618
18	0.317	0.401	0.472	0.600
19	0.309	0.391	0.460	0.584
20	0.299	0.380	0.447	0.570
21	0.292	0.370	0.436	0.556
22	0.284	0.361	0.425	0.544
23	0.278	0.353	0.416	0.532
24	0.271	0.344	0.407	0.521
25	0.265	0.337	0.398	0.511
26	0.259	0.331	0.390	0.501
27	0.255	0.324	0.383	0.492
28	0.250	0.318	0.375	0.483
29	0.245	0.312	0.368	0.475
30	0.240	0.306	0.362	0.467
35	0.222	0.283	0.335	0.433

Critical Values of Spearman's Rank Correlation Coefficients for Different Number of Data Set Note: when there is no exact number of subjects, use the next lowest number Source: (Naoum, 2001)

APPENDEX C

Response number of the questioner

No	Stakeholder	Questionnaire distributed		Returned questionnaire	
		No.	(%)	No.	(%)
1	Consultants	10	25	10	25
2	Contractors	30	75	30	75
Total		40	100	40	100

Classification of Sample size Construction Parties in Jimma

Company classification	No.	Percentage (%)
GC–1	2	25
GC–2	1	12.5
GC–3	1	12.5
GC–4	1	12.5
GC-5	1	12.5
GCO	2	25
Total	**8**	**100**

Respondents' position on the site

Respondents	Position on the project						Total
	Contractors				Consultants		
	Project manager	Office Engineer	Site Engineer	Quantity	Resident Engineer	Site supervisors	
No.	6	6	9	9	2	8	40
Percentage (%)	20	20	30	30	2	80	200

Educational background of respondents

Educational background	Contractor		Consultants		Total	
	No.	**Percentage (%)**	**No.**	**Percentage (%)**	**No.**	**Percentage (%)**
MSc	6	20.00	2	20	8	20
BSc	16	53.33	8	80	24	60
Diploma	8	26.67	0	0	8	20
Total	30	100	10	100	40	100

Respondent's experience

Experience in	Contractor		Consultants		To	
	No.	**Percentage (%)**	**No.**	**Percentage (%)**	**No.**	**Percent age**
0-5	14	46.67	4	40	18	45
5-10	11	36.67	4	40	15	37.5
10-15	4	13.33	2	20	6	15
15–20	1	3.33	0	0	1	2.5
>20	0	0	0	0	0	0
Total	**30**	**100**	**10**	**100**	**40**	