Jimma University

Jimma Institute of Technology

School of Post Graduate Studies

Faculty of Civil and Environmental Engineering

Construction Engineering and Management Stream

Assessment of the Construction Resource Wastage Minimization Mechanisms on Concrete and Major Concrete Making Materials on the site: A Case Study in Jimma Town Building Projects.

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

By:

Leila Nuri

June, 2017

Jimma, Ethiopia

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June, 2017

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DECLARATION

I, the undersigned, declare that this thesis entitled: "**Assessment on the Construction Resource Wastage Minimization Mechanisms on Concrete and Major Concrete Making Materials: A Case Study in Jimma Town Building Project**." is my original work, and has not been presented by any other person for an award of a degree in this university or any other universities, and all sources of materials used for theses have been dully acknowledged.

Signed:

Ms. Leila Nuri ________________ ___________________

Signature **Date**

As Master Thesis Advisors, we hereby certify that we have reviewed carefully the document and prepared under our guidance by **Ms. Leila Nuri,** her thesisentitled: **Assessment on Construction Resource Wastage Minimization Mechanisms on Major Concrete and Concrete Making Materials: A Case Study in Jimma Town Building Project**."

Therefore, we recommend that this document would be submitted to fulfill the MSc Thesis requirements in this university.

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ABSTRACT

Most of the times, the actual percentage of waste generated is much higher than initially assumed, causing the additional cost of the project. Therefore, minimizing materials waste in the construction projects could yield great cost savings and profit increment.

This research was attempted to assess the current situation of minimizing wastage of construction materials. The general objective of this study was to assess construction resource wastage minimization mechanisms on concrete and major concrete making material in Jimma town building project This study also identifies the main causes wastes and rank, identify the effects of the wastes and finally provided minimization practices of concrete and concrete making material wastes .

The main tools for the collection of data included questionnaires, interviews, site visits and document collected is used to identify the various efforts that have been made in the past to evaluate and examine the causes and sources of construction materials waste. The data analyzed was calculated using the relative importance index (RII).

The findings of this research indicated that the level of contribution of the waste sources to the generation of waste saw differences between the perceptions of the respondents (Contractors and consultants). The results from analysis ranked from the 1st to 5th position by contractors and consultants that the most significant factors causing construction waste on building construction projects are Design and documentation, Operation, Site management and practices, material and Site supervisor factors. The survey focused on the four most dominant materials in terms of influencing the project costs which are concrete and major concrete making material such as cement, sand, aggregate. The variables were then ranked in their order of importance based on the response of the consultant's and contractors.

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.

Keywords: Construction materials waste, concrete making materials, influencing project cost, Minimization practice.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The construction industry is an industry, which is involved in the planning, execution and evaluation (monitoring) of all types of civil works. Physical infrastructures such as buildings, communication & energy related construction works, water supply & sewerage civil works etc. are some of the major projects (program) in the construction industry. Construction industry plays an important role in social, economical & political development of a country. Construction is not only one of the major sectors of an economy, but it is also the largest and accounts for 12% to 25% of the GNP of both developed & developing countries. It consumes the higher percentage of the annual budget of a country; specifically in our country Ethiopia, it covers 58% of the annual budget [1]. For example, in many developing countries, major construction activities account for about 80% of the total capital assets, 10 % of their GDP, and more than 50% of the wealth invested in fixed assets [2].

The growth of Ethiopian economy and population has brought a significant increase in the construction industry building projects are becoming progressively larger and more complex in terms of physical size and cost. Due to this, the building industry is using a considerable amount of material resources. On the other hand, if the life cycle of the materials on site is closely examined, it is generally known that there is a relatively large portion of the materials being wasted because of different reasons for building sites [3].

Construction material wastages can be defined as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work, after deducting the cost saving of substituted materials transferred elsewhere in which unnecessary cost and time may be incurred by material wastage. Construction waste has become a serious problem in many countries. Numerous reports and studies have investigated issues on waste which lead to negative impact to the environment, cost, productivity, time, social and economic. In addition, these issues contribute to a reduced value of construction productivity and reduce the performance of overall projects. The wastes, produced on construction sites, are in physical form and non physical form. The physical waste is mainly from broken concrete, bricks, metals, packaging waste, etc. Whereas the nonphysical wastes are cost overruns and time delays in construction projects [4].

Construction material contributes significantly to the cost of a construction project. Therefore, material wastage has an adverse impact on construction cost, contractor's profit margin, construction duration and can be a possible source of dispute among parties to a project [5]. The cost of material waste generated on building sites represents the avoidable cost of construction which can either be eliminated or reduced. [6] Stated that the extent to which waste can be prevented in the construction industry has been a long-debated issue. Whereas it is impossible to completely eliminate all wastage, the concern should be how practices in the local industry can be managed to minimize waste. The cost reduction achieved by preventing the generation of construction waste is equally of direct benefit to all stakeholders in a construction project.

This thesis research measure the actual levels of concrete and concrete making material waste occurring on Jimma town building project construction sites and compare the measured waste with theoretical concrete and concrete making material waste quantities that has been determined before the project's commencement. Studies identify and rank the causes of waste in concrete and concrete making materials, determine the effects wastes of concrete and major concrete making materials, determine the possible minimization mechanisms utilized. Finally, based on the data gathered, the research will draw conclusions and suggest how concrete and major concrete making materials waste could be reduced in the Jimma town building project.

1.2 Statement of the problem

Construction waste is becoming a serious environmental problem in many large cities in the world. In Europe, about 850 million tons of wastes are generated every year, and this represents the 31 % of the total waste generated. In recent years, several EU Member States have published results of analysis concerning the composition of Construction waste &Demolishing waste waste, and approximately one third of it consists of concrete [7],[8].Construction and demolition debris frequently makes up 10–30% of the waste received at many landfill sites around the world [9]. On Finland the Finnish Government as part of its 2002 National Waste Plan has also introduced a ban on waste containing more than 5% biodegradable matter being deposited in landfills without pretreatment. Continuing this practice, the Dutch Government also took a leading role in environmentally conscious building practices. In 1985 C&D recycling and reuse was 50 % [10].

Waste is normally emanates at different stages of construction which can be during planning, estimating or construction stage. In Ethiopia, all the materials purchased are not fully used during construction and this indicates that the left over may remain as waste that may not be accounted for improper control of materials during different stages of construction has caused waste and associated environmental problems. The lack of data about minimizing construction materials waste composition and quantities is a major factor, which has inhibited the development of waste management in Ethiopia. Now days in Ethiopia construction industries are booming due to implementing major infrastructure projects together with many public buildings, commercial building and housing development programs. The study indicated that the level of construction wastages on sampled public building construction projects in Ethiopia, Cement (13.64%), Reinforcement steel (10.64%), sand (14.26%), Coarse aggregate (10.55%) and HCB (11.64%) [11].

Since the cost of materials account a great percentage of the total cost of construction projects, construction materials waste has an impact in the overall project cost. This comprises mainly the cost of transporting and disposing of site waste and the material procurement cost. To sum up, wastage reduction needs serious consideration and due attention from the construction industry consumes large amount of raw materials and the city administration is building and planning to build large amount construction sites in Jimma towns. Therefore, this thesis aimed to provide an insight related to concrete and major concrete making materials wastage minimization mechanisms construction sites of Jimma towns.

1.3. Research Objectives

1.3.1 General objective

The study conducted on the assessment on Construction Resource Wastage Minimization Mechanisms on concrete and major concrete making materials: A case Study Jimma Town Building Project.

1.3.2. Specific objectives

- To identify and rank the causes of concrete and major concrete making material wastage on site.
- To determine the effects of concrete and major concrete making materials on construction costs.
- To determine the possible minimization mechanisms.

1.4. Research question

1. What are the major causes of concrete and major concrete making material wastage?
2. What are the effects of concrete and major concrete making material wastage?
3. What are the possible minimization mechanisms to improve the project implementation?

1.5. Scope and Limitation

The aim of the study is to assess the Construction Resource Wastage Minimization Mechanisms in concrete and major concrete making materials. The concept of wastage is very broad it is not only about material wastage but it's beyond that. However, only materials waste is considered in this study since the material cost covers a great percentage of the project cost. In addition, even though improvement in all kinds of construction material wastage is necessary, due to resource limitation this research is only undertaken on concrete and major concrete making materials such as concrete, cement, sand and aggregates in Jimma town building projects. These materials are selected as they accounted the great percentage of the total cost of materials. Surveys in the forms of questionnaires, site visit and personal interviews were conducted with the proponents who will undertake referenced projects. The study has common limitation such as time and resource constraints.

1.6. Significance of Research

This thesis gives further understanding of the cause of construction material wastage, and construction material waste minimization on building project site in Jimma town. The successful achievement of this study is hoped to become to the solution for problem. In addition, to help to have information about the cause and the solution and also, the result contributed large or wide advantage:

From this research it is expected to

1. Find out the main cause construction resources, waste in Jimma town
2. Provide minimization mechanisms

CHAPTER TWO
LITERATURE REVIEW

2.1. The Ethiopian Construction Industry

Ethiopia has a rich history of magnificent construction endeavors. The obelisks of Axum the rock- hewn churches of Lalibela and the castles of Gondar are a few examples of this expertise. With the advent of modern civilization, particularly during the reign of Emperor Menelik, there have been some significant developments in this regard. The Addis-Djibouti railway line is one example where such a venture has been successfully carried out. During the Italian occupation of the 1930‟s there were some construction activities, particularly in the development of long trunk roads. After the Italian occupation and before the 1960‟s, expatriate contractors generally dominated most of the medium and small civil and building projects [12].

Nowadays the construction industry in Ethiopia has been providing a wide variety of buildings, ranging from houses to high rise buildings and from schools and hospitals to factories and shopping centers, and has been carrying out an equally wide variety of engineering construction projects, ranging from highways to hydro – electric dams and irrigation dams / canals. Construction in Ethiopia is also affording various job opportunities. It keeps employees working full time, and thus, enables many to work over 40 hours a week to earn more money. The workers in the industry, even sometimes work evenings, weekends, and holidays to finish a job or take care of an emergency or offset the disruption caused by rain, snow, wind, etc. Since much of the work is done outside or in partially enclosed structures [13].

2.2. Contracting companies in Ethiopia

The construction industry in Ethiopia consists of various sectors. These are the building and residential development sector, civil engineering sector, professional services sector and self-building sector. Construction firms must be registered and licensed in order to undertake any construction work in Ethiopia. Basically, domestic construction capacity refers to the potential construction volume/value that could be undertaken by domestic construction companies in a given period of time. This, in turn, depends on number and quality of machinery and equipment that is available, and skilled man-power, ranging from design to supervision (Ethiopian, 2006/07).

According to (MoWUD, 2013) the local construction firms are broadly classified based on trend of work as follows: General Contractors, GC; Building Contractors, BC; Road Contractors, RC; Specialized Contractors, SC. The first three categories are again divided into ten grades based on equipment, man-power and turnover requirement. However, it is common to come across self-declared contractors without any professional competence and license registration in many construction sites. The self-building sector is characterized by an informal sector, consisting of informal groups that supply materials and labor. These informal groups are not licensed or registered. However, they employ a great number of people. Now a day according (MoWUD C. , 2014) there are over 4034 contracting companies registered under G1 up to G10 in Ethiopia.

The professional services sector consists off architects, civil engineers, electrical engineers, sanitary engineers, and mechanical engineers, quantity surveyors and surveyors who provided the design expertise (MoWUD, 2013). The services of these consultants are not utilized in the informal and self-build sectors. There exists a great separation between the design consultants and the contractors. This generates poor project management and wastage of materials in the construction process and results in project over cost and environmental impact due to poor waste management system.

2.3. Concept of Construction Waste

2.3.1 Definition of Construction Waste

Various researchers and experts define waste in different ways. [14]Defined 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. 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 process [15]. Furthermore, [15] describes waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product. In other words, waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers. Both [14]and [15] describes waste as a loss created through activities, but do not add value to the construction progress rather adds cost. So drawing from the views expressed above, the definition of construction waste to be used in this study is any losses in material, time and monetary result of activities but do not add value or progress to the construction.

2.3.2 Construction Waste Categories

Besides a clear understanding of the general concept of waste, it is helpful to use a classification of waste in different categories, in order to understand the wide range of possible corrective actions related to its prevention. Construction waste can be categorized into two: material waste and time [16].

Wasted time is understood as the time that is perceived by the skilled workers as useless, or as a wastes use of time. The most common reasons for occurrence of time waste are: shortage of labour, unskilled or unproductive workers, the indecisiveness of clients, accidents on site, the conflict between sub-contractors, poor work flow layout, shortage of materials and inclement weather [14].Time is unnecessarily wasted due to reordering, re-delivery, waitingand handling of additional material. Therefore, time waste can be viewed as the extra amount of time needed for reordering, redelivery, waiting and handling of additional material which will lower productivity, delay completion time, raise labour and machinery costs, and bring on extra overhead costs, and hence reduce profit [14]. The other type of waste in construction projects is materials waste. Studies in different countries have shown that not all materials procured and delivered to sites are used for the purposes for which they are ordered because of a number of reasons and become wasted [18].

2.4 Construction Materials Waste

[19] construction material waste is defined as any material apart from earth materials, which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use. The above definition gives more emphasis on the excess, damage or nonuse materials used in the construction of building component which don’t add any value to the building and needs to be transported from the site or used for another purpose.

For many people the notion of material waste is directly associated with the debris removed from the site and disposed of in landfills. The main reason for this relatively narrow view of waste is the fact that it is relatively easy to see and measure.

However, other researchers define material waste as “the difference between the value of materials delivered and accepted on site and those properly used on specified and accurately measured in the work, after deducting the cost saving of substituted materials transferred elsewhere, in which unnecessary cost and time may be incurred by materials wastage” [20].

Therefore, the construction materials wastage definition used in this study is excess of materials used than required quantities and the construction materials hauled away generated in the construction site that couldn’t be useful for the intended construction. The extent of wastage varies from site to site. Sites that have high levels of wastage generally have a poor standard of material control. The site conditions are another factor that affects waste generated on the sites. Levels of waste at muddy sites are comparatively higher compared to clean and well – drain sites. Other factors such as the size of project, design of the building and method of construction also contribute to difference in waste levels. If the waste level of materials for a particular project is high relative to that of other sites, the performance level would be comparatively lower [20].

2.4.1 Classification of Construction Materials Waste

Construction materials waste can be classified based on nature and losses; these are elaborated and discussed below:

2.4.1.1 Based on Nature

According to [16] waste can be classified by nature as unavoidable and avoidable waste in construction projects. It is the wastage that costs more than what is saved if tried to prevent. There is a certain limit up to which, waste of materials can be prevented. Beyond that limit, any action taken to prevent waste will not be viable, as the cost of saving will surpass the value of materials saved. Thus, natural waste is allowed in the tenders. The amount of allowable waste is subjective to the cost effectiveness of the approaches used to manage it [14].

Avoidable waste is when the cost of waste is significantly higher than the cost to prevent it. Such kind of waste represents the waste amount beyond the acceptable level in the site. Therefore, these wastages could be controlled by implementing different waste minimization measures [14].

2.4.1.2 Based on Loss

Make a distinction between construction materials waste as direct and indirect waste. Waste that can be prevented and which involves the actual loss or removal and replacement of material is called direct waste. Direct waste consists of a complete loss of materials, due to the fact that they are irreparably damaged or simply lost[21].

In this case, the wastage usually needs to be removed from the site. Therefore, the cost of direct waste does not end up in the cost of material, but followed with the cost of removing and disposing. Thus, by preventing direct waste straight forward financial benefits can be obtained. Direct waste can occur at any stage of the construction process before the delivery of material to the site and after incorporating the materials at the building [14].

Forms of direct waste [21].

a. Delivery waste: -losses during the transportation of materials to the site, unloading and placing in addition to the initial storage. E.g. Bricks, glassing

b. Cutting and conventional waste:- cutting materials into various sizes and uneconomical shapes. E.g. formwork, tiles, reinforcement bars

c. Fixing waste:- dropped, spoiled or discarded materials during fixing. E.g. Bricks, roof tiles

d. Application and residual waste:- hardening of the excess materials in containers and cans. E.g. Paint, mortar.

e. Criminal waste: - theft and vandalism e.g. tiles, cement bags

f. Management waste: - lack of supervision or incorrect decisions of the management. E.g. throwing away excess material

g. Waste due to wrong usage:- wrong selection of materials. E.g. Rejection of inferior quality marbles, tiles

Indirect waste occurs when materials are not physically lost; causing only a monetary loss, for example, waste due to concrete slab thickness larger than specified by the structural design. Indirect waste arises principally from the substitution of materials, from use of materials in excess of quantities allowable under the contract, from errors, waste caused by over allocation, where materials are applied in superior quantity of those indicated or not clearly defined in contract documents, and waste caused by negligence, where materials are used in addition to the amount required by the contract due to the construction contractor's own negligence. A large part of these wastes have been hidden, and it has not been perceived as actionable [21], [14].

Forms of indirect waste [21].

a. Substitution waste: - substitution of materials at work, which will incur losses to either to the contractor or client. E.g. use of 20cm HCB in place of 10 cm HCB

b. Production and operational waste: - where materials are used in excess of those indicated or not clearly defined in the contract document. E.g. Additional concrete in trenches, use of excess plaster to rectify uneven surface

c. Negligence waste: - site errors because of the condemned work or use of additional material. E.g. Over excavation of foundation resulting in the use of additional concrete.

2.5. Magnitude of Materials waste in building construction

The magnitude of waste at construction sites is considerable. Studies showed that the waste rate was different between developed countries and developing countries as follows

2.5.1. Magnitude of Construction Materials waste in developed countries

a research conducted in the Netherlands that was concerned with the measurement and prevention of construction waste with regard to meeting sustainability requirements stated by Dutch environmental policies. Waste from seven materials was monitored in five house-building projects between April 1993 and June 1994. During the study, all material waste was sorted and weighed. The amount of direct waste by weight ranged between 1 and 10% in weight of the purchased amount of materials. Further, it was concluded that an average 9% (by weight) of the total purchased construction materials end up as site waste in the Netherlands.

A study in Malaysia shows, composition and percentage of material wastes: Soil 27%, wood 5%, brick and blocks 1.16%, metal product 1%, roofing material 0.20%, plastic and packaging materials 0.05%, concrete and aggregate 6.58% [17] Obtained percentage of waste in ten materials as plasterboard 36%, packaging 23%, cardboard 20%, insulation 10%, timber 4%, chipboard 2%, plastic 1%, electric cable 1%, and rubber 1% [18] .

A study carried out by [22] in Sri Lanka identified the main materials wastages as Sand (25%), Lime (20%), Cement (14%), Bricks (14%), Ceramic Tiles (10%), Timber (10%), Rubble (7%), Steel (7%), Cement Blocks (6%), Paint (5%) and Asbestos Sheets (3%). Research in Hong Kong indicates that about 5-10% of building materials end up as waste on building sites. There are many contributory factors to this figure, human, mechanical and others [23]

2.5.2. Magnitude of Construction Materials waste in developing countries

In developing countries (Tanzania, Zambia, Zimbabwe and Botswana) the followings are estimated; 40% of construction is rework, 30 to 40% labor potential is used, 8% of total project costs account for accidents and 20 to 25% of materials are wasted [24]. Research in Nigerian construction sites, indicated four major types of construction materials waste. These include cutting waste, transit waste, theft and vandalism waste, and application waste. The studies concluded that the identified construction materials under cutting waste indicated that reinforcement bars had highest percentage of wastages of 19.03%, followed by wires and cables with wastage of 17.26%, roofing sheets and pipes both have 15.70% wastage. Moreover, the identified construction materials under transit waste indicated that tiles had highest percentage of wastages of 21.38%, followed by window glazing and ceramic sanitary appliances with percentage wastages of 14.73% and 14.72% respectively [25]. In addition, the studies in Nigeria identified construction materials under theft and vandalism waste revealed that reinforcement bars, timber (hardwood and softwood) and cement had the highest percentage of wastages of 18.64%, 18.64% and 18.44% respectively. Furthermore, the identified construction materials under application waste showed that POP (Plaster of Paris) ceiling had the highest percentage of wastage of 15.70%, followed by mortar (through screeding) with wastage of 14.91% and concrete (through columns, beams, lintels and walls) had percentage wastages of 14.13%. Moreover, the study concluded that theft and vandalism waste had the highest average level of 16.58% followed by cutting waste with 15.44%. Application waste and transit waste had the least overall average wastage of 14.16 % and 14.89% respectively. The study finally concluded that construction materials wastage accounted for an average of 15.32% in the Nigerian construction sites. Therefore, the study recommended 15-20% allowance for construction materials waste in Nigeria [25].

2.6. Measuring of Construction Material Waste

Waste quantification is a primary requirement for the waste minimization process. In addition to the fact that recording and measuring waste is a prerequisite to its management, knowing how much waste generated can also be used as a benchmarking tool against other projects cost estimation and cost overrun control. Since the quantities produced are difficult to estimate and variable in composition, distinct measurement procedures are necessary for each of them. Some studies have been conducted in different countries to gain insight in the percentage of generated waste during construction operation for specific materials.

a research conducted in the Netherlands that was concerned with the measurement and prevention of construction waste, materials waste in construction studied in building projects in three views [21].

1. Construction waste of a specific material as percentage of total construction waste,

2. Construction waste of a specific material as percentage of its total amount,

3. Cost of construction waste of a specific material as percentage of total waste costs.

These methods are all illustrative of the level of waste generated and they can be used simultaneously. Amount of material waste generated in the projects found out by calculating the difference between the final estimated quantities and actual consumption.

Wastage quantity (in %) $\frac{(MP-MU*100\%}{MP}$…………………..….[Eq. 2.1]

Where: M p is the purchased material; and

M u is actually need material

2.7. Impact of Concrete Wastage on Building Construction Project Performance

Construction site waste management and minimization has great potential to contribute to construction industry performance improvement in addition to waste management problem caused by the construction sector. Wastage of materials in construction projects has an impact on quality of works, project cost, working time, safety and health of the workers [31].These impacts of material wastage described in detail below.

2.7.1 Effect on Quality of Work

Quality is one of the critical factors in the success of construction projects. Quality problems are considerable in all phases of construction. Achieving good waste minimization on construction projects helps to reduce the quantities of construction waste sent to landfill. Since most of the causes of material wastage are the causes for quality problem in construction projects, minimizing material wastage has a role in the improvement of quality of work. For example, the problem related to labour such as lack of skilled labour, a mistake by the workers, rework, etc. are the causes for material wastage and poor quality of work. Consequently, resolving these causes of materials wastage result also in achieving good quality of work [31].

2.7.2 Effect on Cost of Project

Concrete wastage significantly affects the total cost of a project. The true cost of material waste consists of direct and indirect costs. Direct cost consists of the purchase price of the material that ended up as waste and indirect costs consist of:

(i) Cost of transporting the waste off-site

(ii) Missed opportunity of not reclaiming reusable and recyclable material.

(iii) Lost time in terms of labour and management time.

(iv)Loss of ability to win contracts based on bad waste history

A construction company can thus be profitable by reducing the amount of waste it needs to dispose of. Due to this the construction materials wastage has significant influence on the overall project cost [31].

2.7.3 Effect on Work Time

The total time of construction project is usually specified prior to the commencement of construction. But construction projects are known to experience time delays due to various reasons. Material waste has a direct impact on the productivity and completion time of project which results in loss of a significant amount of revenue [31].The occurrence of material wastage in construction projects results in an unnecessary works like waste handling processes which are non-value adding activities to the project. These non-value adding activities consume a high percentage of overall working time and effort without adding value thus resulting in delay. Therefore, effective minimization of material wastage in construction project results in the avoidance of unnecessary works [33].

2.7.4 Effect on Safety of Workers of a Project

Another material wastage effect on the building project is lack of safety and health on the workers. Decreasing the amount of waste on site and managing more effectively what remains will lead to cleaner and safer sites. For instance high winds might lift unclear debris such as iron sheeting into the air which could be a potential threat to people [32].Good waste management on site, which includes, for example, encouraging your workers to think about where they place their waste, will also result in a better site image. More importantly, it could also lead to improved health and safety as there are likely to be fewer accidents if material waste is minimized. This can be achieved by providing:

- Safe access to people and vehicles on site that they can reach the allotted workplace
- Walkway which are free from obstructions of waste materials
- Tidy sites and storing materials in safe places and ensuring that all projecting nails are hammered down flat or removed completely
- Proper arrangement for gathering and disposing off waste materials

2.7.5 Concrete Waste Minimization

Concrete waste minimization is one of the most effective approaches to respond to the waste problem in the construction industry. Waste minimization is defined by the Environmental Protection Agency of USA (2000) as “any method that reduces the volume or toxicity of a waste that requires disposal". [34]Also studied how to reduce building waste at construction sites in Hong Kong, and defined waste minimization as "any technique, process or activity which avoids, eliminates or reduces waste at its source or allows re-use or recycling of the waste". In both sense waste minimization is a method that reduces the amount of waste generated on site.

Construction Material wastage has been recognized as a major problem in the construction industry that has important implications both for the efficiency industry and for the environmental impact of construction projects. Moreover, waste measurement plays an important role in the management of production systems since it is an effective way to assess their performance, allowing areas of potential improvement to be pointed out [14].

Waste management for construction activities has been promoted with the aim of protecting the environment and the recognition that wastes from construction and demolition works contribute significantly to the polluted environment. The construction industry plays a vital role in meeting the needs of society and enhancing the quality of life. However, the responsibility for ensuring the construction activities and products in consistent with environmental policies needs to be defined and good environmental practices through reduction of wastes need to be improved. Normally, the best way to deal with material wastes is not to create it in the first place [17].

2.8. Benefits of Construction Waste Minimization

2.8.1. Financial benefits

Waste has a cost. This simple relationship has historically been overlooked as commonly the cost of waste is usually included in the project tender price and paid for by clients. Main contractors have the responsibility for waste disposal although in most cases waste is generated by sub contractors. Clients, main contractors and sub contractors have now started to focus upon this issue from both an environmental and a cost perspective. This is partly due to fact that the cost of waste disposal has increased significantly due to the escalation applied to landfill tax (www.wrap.org.uk/construction).

According to [35] waste minimization can provide financial benefits, and in some cases can even save cost and time. The financial benefits can be appreciated over a short term or long-term period. Overall, cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. Financial benefits include:

- Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.
- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials when considering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

Long term benefits through optimizing the building life concept, by avoiding expenses from demolition and construction of new buildings. Use of recycled materials has reduced waste storage costs and minimized the dereliction of land. Sometimes, reuse and recycling may not always be financially viable, hence other considerations should considered such as environmental benefits [32].

I. Benefits to sub contractors

Reducing the wastage of materials should result in either a total saving to the project or an increase in profit for sub contractors. The former would be realized through a drop in tender prices and a resultant commercial, competitive advantage being achieved. The latter by maintaining tender prices with reduced materials costs. Either way, the sub contractors stand to benefit from using their materials more efficiently. In addition, if sub contractors can demonstrate a willingness to support and engage in waste reduction measures and demonstrate that these have an effect on their waste, then they improve their chances of being identified as preferred bidders as they could help main contractors meet their waste targets.

Sub contractors therefore have the opportunity to be pro-active and in doing so, reap the benefits from growing pressure for reduced material waste (www.wrap.org.uk/construction)(36).

II. Benefits to clients and contractors

The cost of waste is usually built into project tenders and therefore clients end up paying for material wastage. By reducing the total volume of waste generated, a reduced cost for the project can be achieved. This cost saving may be shared by main contractors, sub contractors and clients. This already happens in partnering arrangements and it could be introduced in other forms of procurement as well [36].

2.8.2. Environmental benefits

There are two important aspects of materials efficiency: product selection and waste management. Each of these can then be broken down into constituent parts which themselves have an impact on both [36].

Minimizing environmental damage: Reduced waste means less quantity of landfill space used and reduced environmental impacts (e.g. embodied CO2) associated with extracting, transporting, and manufacturing / processing the raw materials of construction products.

- Conserving natural resources:- Recycled packaging and waste results in a reduced demand for virgin materials thereby stimulating demand for recycled materials amongst product manufacturers and hereby encouraging higher levels of recycling throughout the economy.

Waste minimization can provide environmental benefits, which are important to be considered due to the alarming situation of materials waste on construction sites. These environmental benefits are [35] .

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.
- Reduced transportation of waste to be disposed of (hence less noise, vehicle production pollution, and energy used).
- Increased site safety.
- Increased work efficiency.

- Increased image of the company.

The benefits could be improved if green buildings and sustainable designs are considered at the same time [32], they include:

- Direct benefits (economy on fuel bills, market advantage, lower long-term exposure to environmental or health problems, greater productivity of workplace).
- Indirect benefits (healthier to use, psychological advantage, enhance company image).

2.9. Construction Materials Waste Minimization Strategy on Building Construction Sites

Waste minimization is a shared responsibility between all parties of the construction process from the client down to the contractor. The best strategies of construction materials waste minimization identified from past research and discussed below.

a. Design for offsite construction

Off-site construction refers to structures built at a different location than the location of use. Off-site construction occurs in a manufacturing plant specifically designed for this type of process. Off-site processes have been proved to decrease waste by optimizing cutting patterns and schedules. Its application also has the potential to significantly change operations on site, reducing the amount of trades and site activities and changing the construction process into one of a rapid assembly of parts that can provide many environmental, commercial and social benefits [37].

• Reduce construction related transport and movements;

• Improved workmanship quality and reducing on site errors and re-work, which themselves cause considerable amount of waste on site

• Improved health and safety on site through avoidance of accidents and

• Reduce construction timescales and improved program

b. Standardization of design

Standardization means to design items with generally accepted and uniform procedures, dimensions or materials. Standardization has the potential to dramatically reduce the current production of construction waste. This is by designing the building size and space to eliminate unnecessary elements, and to reduce off-cuts resulting from the construction process. Standardization of design in building construction ensures compatibility between market supply and specification. For example, by designing room areas and ceiling heights in multiples of standard material sizes a substantial reduction in off-cuts can be achieved [27, 38, 37].

c. Proper detailing during design

This is perhaps one of the most crucial skills needed in the building design process. This is because the nature and quality of detailing in the design document contribute to how the building is built, what it will look like, what it will cost, and how long it may take to build. Thus, design document should be specified in precise and brief ways so that the contractor can avoid excessive material ordering and estimate properly the possible amount of waste to be generated [38].Correct material planning and ordering Creating an effective schedule of material ordering, fabrication and delivery of all building materials and components helps to reduce material wastage [40]. Precise scheduling in building construction enables

• Purchasing raw materials that are just sufficient

• Just-in time delivery of materials, reducing potential for damages

• Good coordination between store and construction personnel to avoid over ordering

• Gives enough time for checking materials supplied for right qualities and volumes

e. Just-in-time delivery strategy

Just in time delivery strategy is arranging deliveries to match work stages in order to avoid materials being stored on site longer than necessary. Implementing just-in-time delivery strategy in the construction projects ensure materials arrive on site when they are needed, thereby avoiding damage while stored on site and additional mobilization of materials. Besides, it reduces the potential for over-ordering materials on several projects [43];[41].

f. Proper storage and handling of materials

Once what materials need for the project established, there should be work on how those materials will be received and stored on the site. The site manager should plan in advance suitable storage space to protect materials degradation or damage from weathering or moisture [42].There should be a strategy in place which makes the best use of a central storage area with procedures for moving materials to the workplace as moving materials increases the risk of damage. Top tips for materials storage on construction projects [42].

• Designating storage areas for plant, materials, waste, flammable substances separately

• Stored materials shall not spread in an uncontrolled manner on footpaths and other Walkways. Further materials do not store where they could obstruct access routes or where they could interfere with emergency escape;

• All storage areas should be tidy, even in the site itself;

• Storage areas should be safe, secure and weatherproof (where required)

• Excess vegetation should be controlled

The use of proper equipment for material handling and advance planning for minimizing multiple handling will result in direct cost reduction and time savings. Careful handling of materials reduces risk of wastage of materials on site. This will begin with the provision of suitable vehicles or delivery plants for transporting material from the storage area in the workplace so as to make the damage to the minimum. In addition, avoid double handling that the points of unloading should be the final position of stacking area [34].

g. Improved the skill of the workforce

The construction industry, especially in our country, it is labor-intensive. Thus, the skill and perception of workers influence its progress. It is argued that the causes of construction waste are directly or indirectly affected by the skills of the personnel involved in the construction industry

[37].As a result, training is absolutely required that the contractor train employees and subcontractors on material wastage minimization practices. In addition, conducting the following methods on the construction sites helps to reduce the amount of material waste due to the ability and perception of the workforce [32].

• Periodic monitoring to ensure compliance

• Commending employees that adhere well to site policy and offer advice to those that are not meeting the requirements

• Motivating workers by establishing targets and offering bonuses or incentives

• Conducting regular meetings to reinforce effective practices

h. Using low waste building technology

Buildings are usually constructed by the conventional cast in-situ method. But material wastage can be minimized in buildings construction project through the use of the following technologies and practices described below.

Drywall partition

Dry wall is a system of factory made wall panels. It replaces the traditional brick and block walls. It has a number of advantages. It requires less labour and skill for installation, and provides better product qualities and higher flexibilities for future layout changes. Full height panels are assembled and conduits can be easily installed through its tubular spaces with minimal cutting, jointing and patching. The surface of the panel can be easily finished with a thin coat ofskim plaster in place of the thick cement sand plaster in traditional block walls. Hence, much less wet trade work is involved in the assembly process and less construction waste is generated at the end [34].

Precast concrete element

The Precast concrete system is commonly applied to beams, facades and staircases. These precast elements may be cast in a factory or cast at the site. In precast concrete construction the materials can be better utilized and wastage can be kept to a minimum because its effectiveness in replacing traditional wet-trade practices [37], [43], [44], and [45].

Machinery sprayed plaster

Machine sprayed plaster now replaces traditional cement mortar in developed countries building projects. The major difference between the mechanized plaster and the traditional cement mortar is that the former is mixed and applied mechanically whilst the latter is applied and trowelled smoothly by hand. The use of mechanized spraying has the merits of high productivity, low labour demand and less waste [43].

i. Develop site waste minimization plan (SWMP)

A site waste minimization plan is a simple checklist that provides the contractor with information about [36].

- The waste streams
- Decisions to be made respective volumes of waste generated
- To enable strategic reuse and recycle options and
- Disposal options

In addition, site waste management plan is generally effective if there is a waste manager with overall responsibility. The waste manager should be given power to:

- Select his waste team
- With the help of his team instruct, oversee, record and feedback on day-to-day waste practice
- Delegate responsibility to sub-contractors where necessary and
- Coordinate with suppliers, service providers and sub-contractors to prioritize waste prevention and salvage on site.

2.10. Who should take action to reduce construction waste?

Waste is a shared responsibility between all parties of the supply chain, from the client down to the waste contractor. This guidance focuses on the role of contractors and sub contractors, taking into account the fact that they cannot work in isolation to reduce and manage waste. In order to ensurethat everybody works towards a common goal leadership is required from clients together with effective interaction between main contractors and sub contractors [46].

Clients

The client's role is to:

- Demonstrate leadership by setting requirements for the efficient use of materials,
- Communicate requirements on waste to the project team;
- Ensure that waste issues are considered and addressed;
- Ensure that all parties fulfilling their roles in the effort to reduce waste.

Main contractors

The main contractors „role is to:

Deliver the clients requirements by developing a site waste management plan which:

- has clear estimates and targets of waste that will be generated,
- has a clear strategy to reduce the waste
- Has a clear strategy to ensure the recycling of residual waste is maximized.

Monitor waste data and ensure continuous improvement via:

- Gathering site waste data
- Comparing against estimates and targets
- Collating sub contractor's quantitative records on actual waste performance.

Sub-contractors

The sub contractor's role is to therefore support the main contractor in delivering the client's requirements. This includes:

- Producing accurate waste estimates for their trade and supplying this information to the main contractor for the Mandatory requirement for Site Waste Management Plans (SWMP)
- Developing actions to reduce waste and supply this information to the main contractor so that it can be recorded in the SWMP (Note – these mitigating actions may include site wide solutions which could radically affect the performance of the site – i.e. Just in time delivery strategy)
- Using materials in an efficient manner during construction and wherever possible, ensure that waste is minimized, and
- On completion, providing accurate data on the actual level of wastage and feedback on why wastage was generated and how it could be reduced.

2.11. Factors Affecting Recovering of Construction Waste Materials

The choice of what and how construction waste materials can be recovered depends on many factors, including the type of project, space on the building site, the existence of markets for materials, the cost-effectiveness of recovery, the time allowed for the project, and the experience of the contractors [32].

i. Space on the building site

Materials recovery is often easiest if the building site is spacious enough to allow on-site sorting of materials. Having separate containers for each type of materials can reduce contamination.

ii. Materials markets

While it is possible to reuse and /or recycle many of the waste materials generated on site, the feasibility will depend on the market conditions for each type of material. Contractors can maximize recovery by taking advantage of all available markets for recovered materials.

iii. Cost-effectiveness

Hauling and disposal costs, the value of recovered materials, and labor costs contribute to whether materials recovery is more or less cost-effective than disposing of materials. Recovery of low value materials may be cost-effective if disposal costs are high and removal and sorting are not labor intensive. The labor cost incurred to remove items for reuse may be offset by savings from both the avoided costs of purchasing new materials and avoided disposal costs.

iv. Project timeline

Source separation of materials for reusing and recycling can take more time than disposing of all the generated wastes and often projects are on a tight schedule due to different reasons. Contractors can maximize materials recovery in the time allowed by planning ahead. If necessary, contractors can focus waste reduction efforts on off-site source separation and recycling.

v. Contractor experience

Contractors well experienced in recovery methods and local markets may be able to recover more materials than contractors unfamiliar with reuse and recovery techniques.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area.

The study area of this research was conducted Jimma town. It is one of the ancient and the 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 the area of average, of about 5400ft (1780 m) above sea level.

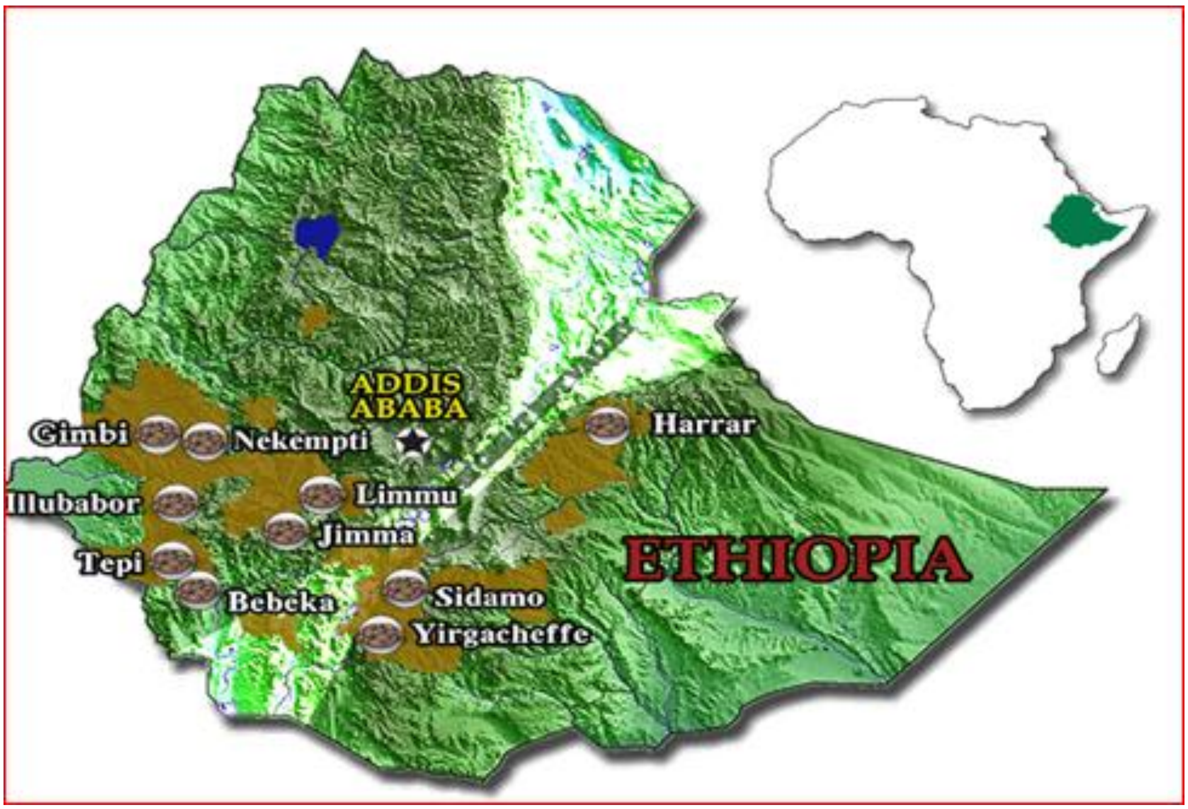

Figure 3.1. Location of Jimma

3.2 Study design

In the case of research design which were designed to obtain in-depth Construction Resource Wastage Minimization Mechanisms on concrete and major concrete making materials in Jimma

Town Building Project. Various causes and minimization mechanisms of construction recourses wastage minimization mechanism for building sites were identified from the available literature. A total of 37 questionnaires were purposefully administered to key client, contractors and consultant because to differentiate by grade of construction companies.

3.3 Sources of Data

The study depended on both primary and secondary data. Primary data were made up of first-hand data collected by the candidate through the use of questionnaires and site visits (observation).The secondary data was obtained through a review of existing material such as journal publications, dissertations, newspapers, unpublished theses, books, and internet and conference papers. Secondary data was selected according to its relevance to the research.

3.4 Source and Causes of Materials Waste

Sources and causes of waste materials as well as 12 waste minimization measures which have been extensively studied were extracted from the literature. The sources and causes of materials waste gathered from literature was pre-tested through interviews of ten selected construction practitioners to evaluate their applicability to the current study

3.5 Research Instrument

3.5.1. Structure of questionnaire

The questions were constructed using the Likert scale. The respondents were asked to rank on a scale of 0-4 factors that cause materials waste on construction sites where 4= Very high causes, 3= high causes, 2= moderate causes, 1= low causes, 0 = not causes at all.

The respondents were also asked to rank on a scale of 0-4 factors that cause materials waste on construction sites where 4 = Very high causes, 3 = high causes, 2 = moderate causes, 1 = low causes, 0 = not causes at all.

3.5.2. Interview

The semi-structured approach to the interviews and the open ended questions were chosen because they would allow the individuals to discuss and share their own opinions, while the researcher will adapt the questions to the interviewee’s relative level of understanding of the investigated topic. The conversation was always started with the researcher defining the concept of wastage in the construction industry. The researcher recorded the conversation and also took notes. Whenever there were additional questions or a need for clarification, the researcher got in contact with the interviewees directly in person.

3.5.3. Document collection

The collected documents adopted for conducting this research include official documents ranging from internal and external correspondence, internal memos, meeting minutes, consultancy reports, designs, specification, manuals, bid documents etc. The collected documents were derived from organizational sources and have been used in order give multiple evidences. Archival documents, correspondences and other related documents have been reviewed to understand the background of contract provisions, problems and practices in construction works. These secondary sources provide a general understanding of the subject area by presenting a wide range of ideas in the field which help to supplement other specific information obtained from the primary data sources.

3.6. Target Population

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

There are over 25 contracting companies participating currently and these 25 contracting companies registered under G1 – G5 in Jimma town. Therefore, the populations this research, includes general contractors classified as GC1-GC5,randomly selected from 5 GC1-GC5 Consultant company that by reconnaissance survey in Jimma town and have valid registration by MoWUD and randomly selected five client there contract amount above one hundred million birr and including two client there contract amount less than one hundred million birr . Because those selected categories have experienced, efficiency and managerial and financial capability.

3.7. 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 minimization mechanisms of wastage in building projects in Jimma town. In this research work the population includes contracting companies of G1-GC5 and G1-GC5 consultants' company that works in Jimma town building. Because those selected populations have more activated and having sufficient experience in construction. There are thirteen (25) total numbers of GC1-GC5 and five (5) consultant companies activated in Jimma. The sample population was distributed between 25 contracting companies takes all the population because the population size is small, five consulting companies and seven clients.

3.9 Study Variables

3.9.1 Dependent variable:

- Waste minimizing mechanisms on concrete and major concrete making materials

3.9.2 Independent variables:

- Design and documentation
- Materials
- Operation
- Site management and practices
- Site supervisor

3.10 Data Collection

In this study methodology of data collection included a questionnaire, interview, site visit and document collection. 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 (4months) on 7 building construction projects and observed the flow activities of materials (design and specification, operational, material storage and handling, procurement). The questionnaire survey revealed that the high waste generating construction material is concrete, aggregates, cement and sand.

A survey was conducted to collect information on the causes 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 by project managers working for companies.

3.11 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 material wastage on building projects according to the bill of quantities work items. The 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:

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

$$\boldsymbol{material\ wastage}(\%) = \frac{\boldsymbol{material\ waste\ quantity}}{\boldsymbol{actual\ material\ requirements}} * \mathbf{100}$$ ---------------------- **{Equation 3.1}**

The sample for this study is relatively small as a result; the analysis had combined all groups of respondent (contractors, client 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.

$$\text{RII} = \frac{4n1+3n2+2n3+1n4+0n5}{N}$$ --- {Equation 3.2}

Where:

N = Total number of respondents

ni = the variable expressing the frequency of the ith response.

n1= extremely significant response,

n2= very significant response

n3 = moderate significant response

n4 = slightly significant response.

n5 = not significant response.

The levels of response are:

E.S. = extremely significant [4]

V.S. = very significant [3]

M.S. = moderately significant [2]

S.S. = slightly significant [1]

N.S. = not significant [0]

Spearman's-rank correlation coefficient for measuring the agreement/or difference in ranking amongthe four material 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. 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. A 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].

$$rs = 1 - \frac{6\sum d2}{N(N2-1)} * 100 \text{-- \{Equation 3.3\}}$$

rs =Spearman's rank correlation coefficient.

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

N= is a 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).

CHAPTER FOUR

RESULTS AND DISCUSSION

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 the relative index method and numerical formula for wastage level estimation that was described in the research methodology.

4.2. Part 1: General Organization Information

4.2.1 Respondents' profile

This study selected seven (7) building construction projects in Jimma which constructed and supervised by different contractors and consultants and has project costs more than 10 million Birr. In this part, the respondents were asked to identify the main causes of material waste. Therefore, 25 contractors, 5 Consultant Company and 7 clients are participating in response the questionnaires.

Table: 4.1 case study client respondents' information

No.	Project Name	Project Location	Project duration	Project cost (ETB)	Current status
1	Jimma university hospitality and tourism project	Jimma	700 days	791,244,083.85	8.2%
2	Jemila Sherif	Jimma	450 days	107,520,000	10%
3	Abdusomed real estate	Jimma	500 days	350,433,026.32	50%
4	Dire industry	jimma	365 days	12,800,00	73%
5	Jemila Adem	jimma	450 days	25,600,000	85.6%
6	Jimma zone education	Doyyo	365 days	13,857,397.20	79%
7	Mole preparatory	Jimma	365 days	13,585,632.62	46.3%

Table: 4.2 case study contractors respondents information

No	Name of the contractors	level	No	Name of the contractors	level
1	Afro tshone construction plc.	1	14	Mengesha construction plc.	5
2	Rama construction plc.	1	15	Abiy Abate construction plc.	5
3	Yotek construction plc.	1	16	Aliy Mam construction plc.	5
4	Varnero construction plc.	1	17	Yosef Hiruyu construction plc.	5
5	China construction plc.	1	18	Ibrahim Kelil construction plc.	5
6	Meseso construction plc.	1	19	Kemal Arabu construction plc.	5
7	Bockra construction plc.	1	20	Graitec construction plc.	5
8	Wabcon construction plc.	2	21	Bekele Debele construction plc.	5
9	Bitacon construction plc.	4	22	Taye Habte construction plc.	5
10	Tsegaye birrafu construction plc.	4	23	Gizachew Dibela construction plc.	5
11	Naol construction plc.	5	24	Ayalneh construction plc.	5
12	Tolosa Wani construction plc.	5	25	Fidaqlu construction plc.	5
13	Said Mohammed construction plc.	5			

Table: 4.3 Case study consultant respondents information

No.	Consultant Name	level
1	Construction design share company	1
2	Savar consulting architects and engineers plc	1
3	Habtamu international consulting architects and engineers plc	1
4	Mickael shiferaw consulting architects and engineers plc	2
5	Seada sani consulting architects and engineers plc	5

Table 4-4: Response number of the questioner

No		Questionnaire distribute		Returned questionnaire	
		No.	%	No.	%
1	Consultants	5	13.51	4	10.81
2	Contractors	25	67.57	24	64.86
3	Client	7	18.91	7	18.91
Total		37	100	35	94.58

4.2.2. Classification of sample size

The sample consists of GC1-Contactors (7), GC2-Contactors (1), GC4-Contactors (2), GC5-Contactors (15), consultants (5) and client (7).

4.2.3. Response rate

Out of the 37 questionnaires distributed to the contracting companies, 35 responses were received with 94.58% return rate in this study. The other 2 questionnaires as follows: 2 (5.41%) have not been received.

Table: - 4.5 Response rates among the groups of construction parties

Companies classification	No. of Selected company sample	No. Relevant Responded	Not been received	uncompleted responses	incorrect responses
GC-1Contractors	7	6	1	0	0
GC-2Contractors	1	1	0	0	0
GC-4Contractors	2	2	0	0	0
GC-5Contractors	15	14	1	0	0
Consultants	5	5	0	0	0
Clients	7	7	0	7	0
Total	37	35	2	7	0

4.2.4. Respondent's experience

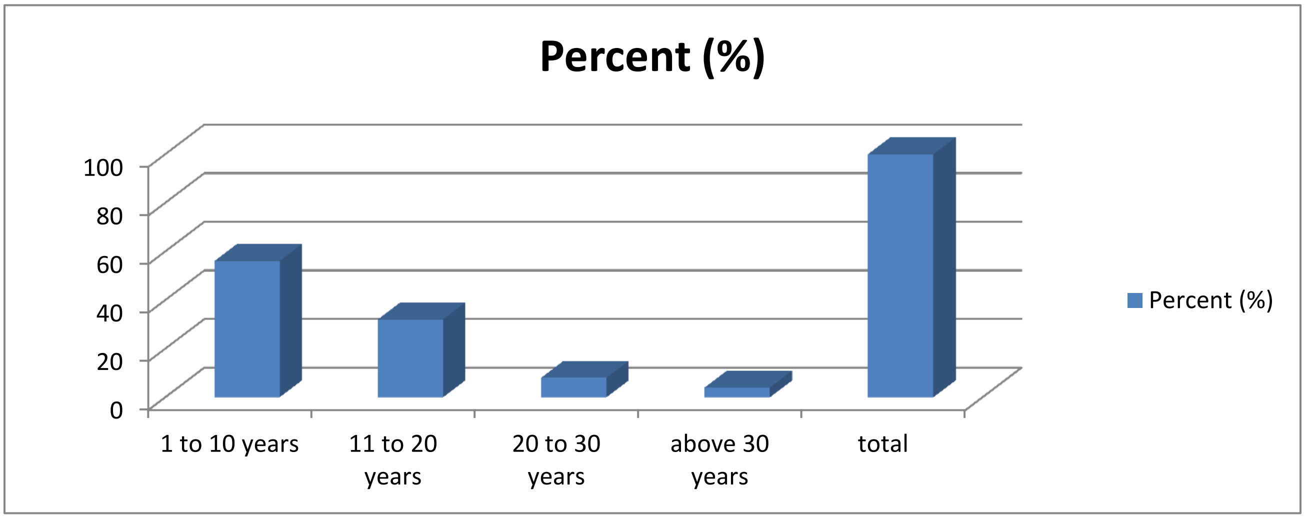

Chart: - 4.1 Respondent's experience on selected construction companies in Jimma.

4.2.5. Executed projects and their value during the last five years The value of the executed projects during the last five years is illustrated in chart 4.2 (29.55%) the executed projects up to 50 Million ETB, (38.64 %) of the executed projects up to 100 Million ETB, (22.73%) executed projects up to 120 Million ETB and while (9.09 %) of them with more than 120 Million ETB.

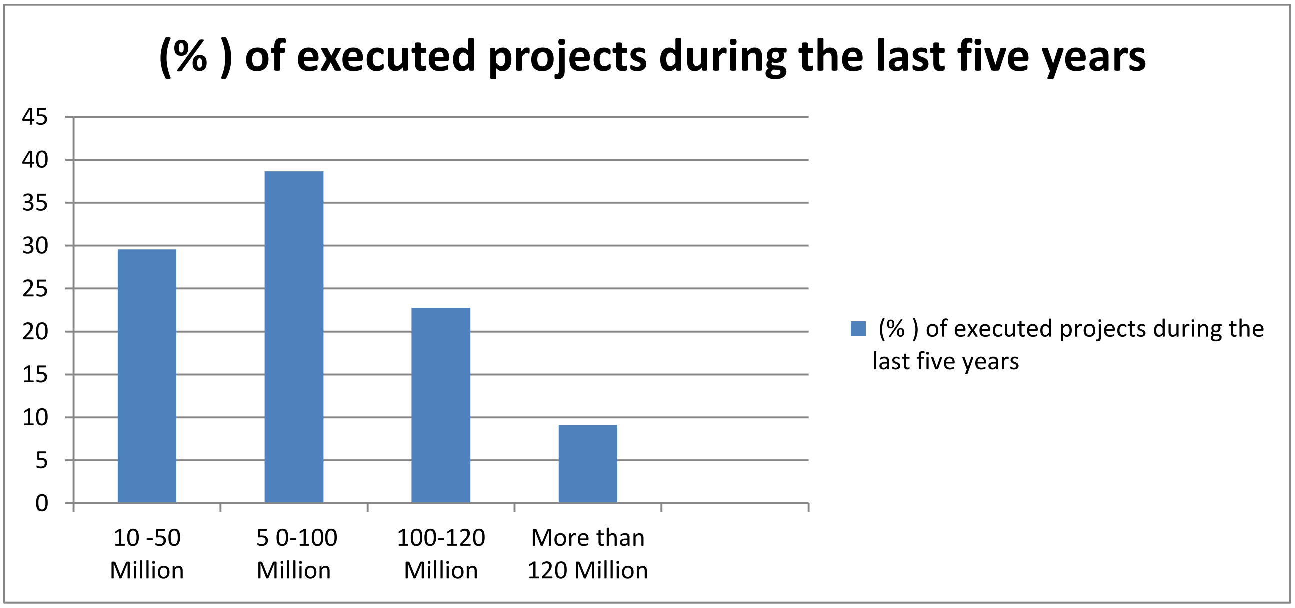

Chart: - 4.2 value of the executed projects during the last five years construction companies in Jimma.

4.2.6 Distribution of Respondents' Position on the Site

The distribution of respondents' position for both consultants and contractors is shown in chart 4.4. It illustrates that 9 (42.85%) of respondent's occupation for the contracting companies are project manager, 7 (33.33 %) were office engineer, 5 (23.88%) were site engineer and 0 (0%) quantity surveyor. On the other hand, in the case of consultant's side 4 (8%) 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.

4.2.7 Respondents Educational Background

Table 4-6: Educational background of respondents

Educational background	Contractor		Consultants	
	No.	Percentage (%)	No.	Percentage (%)
MSc	4	17.39	0	0
BSc	16	69.56	5	100
Diploma	3	13.04	0	0
Total	23	100	5	100

4.3 Effect of Client Material Supplying on Material Wastage Generation

This part was aimed at evaluating the effect of providing construction material by the client on waste generation in Jimma town building sites. From the results, the perception of consultants and contractors about its effect is similar. It has been found that 17 (68%) of contracting companies and 3 (75%) of the consultants have agreed to client material supplying at their site increase the amount of material wastage. The reason for this increasing effect of client material supplying also has been assessed by this study.

In this regard also the contractors and the consultants give 28.57% and 25% percentage for the reason that because the client doesn't deliver good quality material. The detail of the result of both groups of respondents in chart 4.3 below.

How does client material supplying in this project increase the amount of wastage?

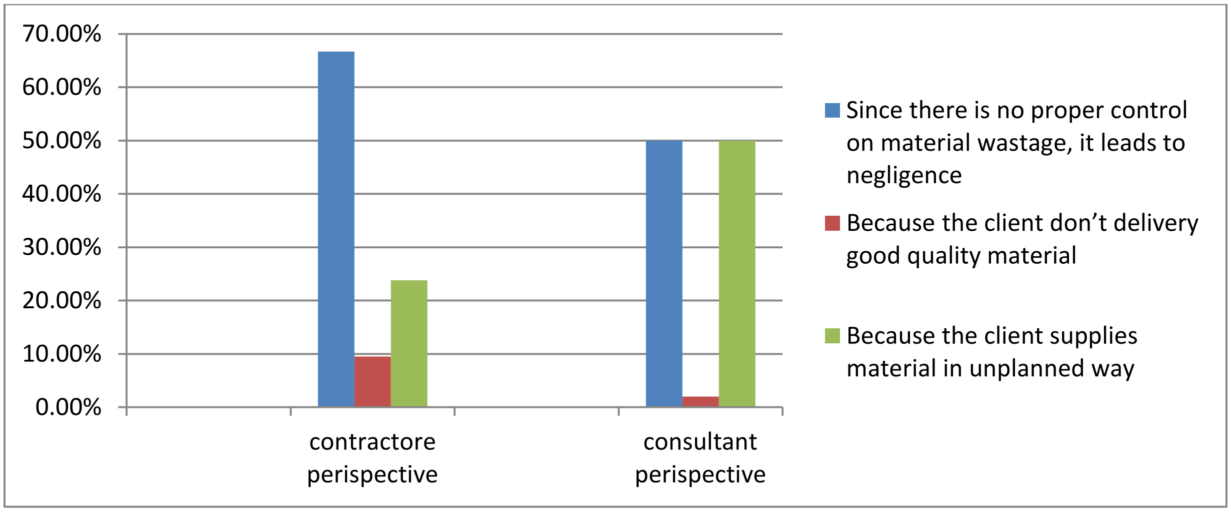

Chart 4.3reasons for the wastage increasing effects of the client's material supplying

According to the contractors since these no proper controls on material wastage, it leads to negligence has the second highest response while client supplies material in unplanned way has the least percentage of response. Contrary to the response of contractors, consultants give the least response to since there is the client don't deliver good quality material, it leads to negligence.

4.4. Sources and causes of construction materials waste on construction projects

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

The questionnaire of this study considered 48 causes of concrete and concrete making material waste in construction, and those causes were categorized into five sources as mentioned before, namely, design and documentation; material; operation; site management and site supervisor and others. Questionnaires were designed to measure the level of their contribution to the selected concrete and major concrete making material waste generation in the sites.

For each material this study surveyed the data for the major categories of waste and top ten causes of waste presented and discussed. Causes with relative mean value of 2 and above under

Each category indicates that they have significant effects on waste generation, thus they consider as waste causing factors.

As discussed earlier having established the perceptions of the consultants, client and contractors differently, there was also a need to further ascertain if consultants' perceptions were statistically different from the contractors' perception and also clients' perception. This leads to the use of Spearman rank correlation coefficients.

Respondent's response tested for correlation using Spearman rank correlation coefficients, to see if there is difference in ranking between two groups of respondents. Accordingly, when the responses of the professionals (consultants and contractors) on the causes of waste in the surveyed materials compared, except for concrete the results showed no significant difference at the 5% significance level. Hence, the result of causes of concrete waste presents separately while the result of the rest materials was presented collectively.

Finally, the results of site observation also presented for each material under the result of a questionnaire survey.

Table 4.7 Spearman's rank correlation coefficient for the level of contribution of waste minimization measures

Material	$\text{Rho (rcal)} = \frac{1 - (6(\Sigma \text{di2}))}{(\text{N}(\text{N2} - 1)}$
Concrete	0.19
Cement	0.81
Sand	0.62
Aggregate	0.87

4.4.1 Causes of Concrete Wastage

Since the responses of the contractors and consultants on the level of contribution of waste causes for the generation of concrete and major concrete making material waste showed a significant difference at the 5 % significance level, the data are presented separately.

a. Level of contribution of the waste causes for the generation of waste

The relative importance index and rank of each cause of the concrete waste according to the contractors and consultant's perspective are presented in the Table 4.8.

Table 4.8 Relative weight and ranking of concrete waste causes

Level of contribution	1. Causes of concrete waste	Source	contractor		consultant		Weighted average (all groups)	
			RII	RANK	RII	RANK	RII	RANK
High	Using excessive quantities of materials more than the required	Operation	0.78	5	0.82	1	0.80	1
	Poor management and distribution of labors, materials and equipment	Site management and practices	0.785	4	0.81	2	0.79	2
	Selecting the lowest bidder contractors and subcontractor	Design and documentation	0.83	3	0.72	4	0.77	3
	Selection of low quality products	Design and documentation	0.72	9	0.66	5	0.69	4
	Lack of information in the drawings	Design and documentation	0.72	9	0.62	11	0.67	5
	Accidents due to negligence	Operation	0.71	11	0.615	12	0.66	6
	Using untrained labors	Operation	0.62	16	0.658	6	0.639	7
	Rework that don't comply with drawings and specifications	Design and documentation	0.86	1	0.4	23	0.63	8
	Lack of proper waste management plan and control	Site management and practices	0.6523	13	0.58	15	0.616	9
	Poor qualification of the contractor's technical staff assigned to the project	Site management and practices	0.58	18	0.65	7	0.615	10
Medium	Damage materials on site	Materials	0.837	2	0.37	26	0.598	11
	Poor provision of information to project participants	Site management and practices	0.56	19	0.63	9	0.595	12
	Design changes and revisions	Design and documentation	0.649	15	0.51	18	0.579	13
	Wrong handling of materials	Materials	0.745	6	0.41	22	0.577	14
	Lack of a quality management system aimed at waste minimization	Site management and practices	0.52	22	0.633	8	0.576	15

	Poor/ wrong specifications	Design and documentation	0.421	30	0.73	3	0.575	16
	Shortage of manpower (skilled, semiskilled, unskilled labor	Operation	0.533	21	0.61	13	0.571	17
	Poor communication leading to mistakes and errors	Design and documentation	0.73	7	0.38	25	0.555	18
	Ambiguities, mistakes, and changes in specifications and drawing	Design and documentation	0.68	12	0.42	21	0.550	19
	Choice of wrong construction method	Operation	0.39	31	0.625	10	0.507	20
Low	Ineffective planning and scheduling of the project by the contractor	Site management and practices	0.422	29	0.566	16	0.494	21
	Lack of team work	Site management and practices	0.5	24	0.465	20	0.482	22
	Designer's inexperience	Design and documentation	0.434	28	0.53	17	0.482	23
	Poor quality of materials	Materials	0.362	32	0.6	14	0.481	24
	Problems between the contractor and his subcontractors	Operation	0.47	27	0.48	19	0.475	25
	Slow response from the consultant engineer to contractor inquiries	site supervisor	0.61	17	0.3	28	0.455	26
	Lack of onsite materials control	Materials	0.514	23	0.36	27	0.437	27
	Poor site layout	Design and documentation	0.48	26	0.39	24	0.435	28
	Poor technology of equipment	Operation	0.65	14	0.21	30	0.430	29
	Damage during transportation	Materials	0.721	8	0.06	32	0.390	30
	Change orders by owner	site supervisor	0.5	24	0.26	29	0.380	31
	Poor qualification of consultant engineer's staff assigned to the project	site supervisor	0.54	20	0.2	31	0.370	32

Both the contractors and consultants consider 32 causes as having contributed in the concrete waste generation in their sites. The average relative importance index of the two respondents greater than 0.5 is considered as high or very significant cause of concrete waste. These causes are Using excessive quantities of materials more than the required, Poor management and distribution of labors, materials and equipments, Selecting the lowest bidder contractors and subcontractor, Selection of low quality products, Lack of information in the drawings, Accidents due to negligence, Using untrained labors, Rework that don't comply with drawings and specifications, Lack of proper waste management plan and control and Poor qualification of the contractor's technical staff assigned to the project.

b. Major categories of waste and rank

Table 4.9 illustrates the relative mean and ranking of each category of waste for concrete by both groups of respondents

CATEGORY	RII	RANK
Site management and practices	0.597	1
Design and documentation	0.594	2
Operation	0.583	3
Materials	0.498	4
Site supervisor	0.402	5

The results show that both groups of respondents have the top three sources of waste categories are Site management and practices, Design and documentation and Operation contribute highly to the generation of concrete waste on the sites.

4.4.2 Causes of Cement Wastage

For comparison of the ranks of all the causes of cement waste showed no significant differences between the responses of the contractors and the consultants at 5% significance level, responses of the two groups of respondents pooled together and presented below.

a. Level of contribution of the waste causes for the generation of waste

Analyzing the waste of cement is relatively complex because this material is used as a one component of concrete The Relative Importance index and rank of each factor of the cement waste are presented in Table4.10 in a descending order.

Table: - 4.10 Relative Importance Index and ranking of cement wastage on building construction sites.

Factors	**Source**	**Contractors**		**consultants**		**Weighted average (all groups)**	
		RII	RANK	RII	RANK	RII	RANK
2. Cement							
Loading unloading the cement manually to the mixer using inadequate equipments and tools	Materials	0.86	1	0.9	1	0.880	1
Excessive quantities during mixing more than the required	Materials	0.8	2	0.7	3	0.750	2
Wrong storage	Materials	0.7	3	0.75	2	0.725	3
Mixing in unsuitable places	Materials	0.65	4	0.6	4	0.625	4
Inappropriate way of transportation	Operation	0.51	6	0.5	6	0.505	6
Excessive thickness for concrete structure members	Operation	0.5	7	0.4	7	0.450	7

It indicated that the three highest causes of cement are Loading the cement manually to the mixer using inadequate equipments and tools, Excessive quantities during mixing more than the required and Wrong storage with relative mean of 0.880, 0.750 and0.725respectively. It has been noticed that mixing in unsuitable places, inappropriate way of transportation and Excessive thickness for concrete structural members are the lowest three factors that cause cement waste with relative mean of 0.625, 0.505 and 0.45.

b. Major categories of waste and rank

The study revealed that the major waste categories for cement are mostly from the material and operation Table 4.11 indicates the aggregate percentages of the relative mean and ranks of cement waste categories

Table 4.11Illustrates the relative mean and ranking of each category of waste for cement by both groups of respondents

CATEGORY	RII	RANK
Materials	0.695	1
Operation	0.52	2

4.4.3 Causes of Sand Wastage

For comparison of the ranks of all the causes of sand waste showed no significant differences between the responses of the contractors and the consultants at 5% significance level, responses of the two groups of respondents pooled together and presented below.

a. Level of contribution of the waste causes for the generation of waste

Analyzing the waste of sand is relatively complex because this material is used as a one component concrete.

The relative importance Index and rank of each factor of the sand waste are presented in Table 4.12 in a descending order. The major cause can be pointed out for sand wastes where Poor storage, excessive consumption of sand and Damage the remained quantities in the place work.

Table: - 4.12 Relative Importance Index and ranking of sand wastage on building construction sites.

Factors	**Source**	Contractors		Consultants		Clients		Weighted average (all groups)	
		RII	R	RII	R	RII	R	RII	R
3. Sand									
Poor storage	Material	0.75	2	0.86	1	0.75	1	0.79	1
Excessive consumption of sand	Operation	0.77	1	0.79	2	0.65	2	0.74	2
Damage the remained quantities in the place work	Operation	0.71	3	0.61	3	0.6	3	0.64	3
Damage the fall mortar during plastering	Operation	0.56	4	0.54	4	0.55	4	0.55	4

The main causes of this material were: -poor storage, Excessive consumption of sand, Damage the remained quantities in the place work and Damage the fall mortar during plastering.

b. Major categories of waste

The study revealed that the major waste categories for sand are mostly from the materila and operation categories. Table 4.13 indicates the aggregate percentages of the relative mean and ranks of cement waste categories

Table 4.13 illustrates the relative mean and ranking of each category of waste for sand by both groups of respondents

CATEGORY	RII	RANK
Materials	0.79	1
Operation	0.68	2

4.4.4 Causes of aggregate Wastage

For comparison of the ranks of all the causes of aggregate waste showed no significant differences between the responses of the contractors and the consultants at 5% significance level, responses of the two groups of respondents pooled together and presented below.

a. Level of contribution of the waste causes for the generation of waste

The mean and rank of each factor of the course aggregate waste is presented in Table 4.14 in a descending order.

Table: -4.14 Relative Importance Index and ranking of course aggregate wastage on building construction sites.

Factors	Source	Contractors		Consultants		Clients		Weighted average (all groups)	
		RII	R	RII	R	RII	R	RII	R
4.Aggregate									
Excessive quantities during mixing	Operation	0.79	2	0.86	1	0.75	1	0.8	1
Mixing quantities greater than the required	Operation	0.8	1	0.82	2	0.65	2	0.76	2
Wrong handling	Material	0.6	4	0.68	3	0.6	3	0.63	3
Far distance between place of mixing and casting	Material	0.62	3	0.64	4	0.55	4	0.6	4
Losing the aggregate during passing the equipments on it	Material	0.52	5	0.61	5	0.5	5	0.54	5

b. Major categories of waste

The study revealed that the major waste categories for aggregate are mostly from the material and operation. Table 4.15 indicates the aggregate percentages of the relative mean and ranks of cement waste categories

Table 4.15 illustrates the relative mean and ranking of each category of waste for cement by both groups of respondents

CATEGORY	RII	RANK
Operation	0.817	1
Materials	0.621	2

4.5. Impacts of Material Wastage on Building Construction sites and Environment

Construction waste becomes a global issue facing by practitioners and researchers around the world. Wastes can affect the success of construction project significantly. More specifically, it has a major impact on construction cost, construction time, and productivity and sustainability aspects. Currently in Jimma in every corner, various constructions are under way specially, building construction.

At the time of the site visit the highest environmental impact of construction materials waste is believed in terms of contamination. Although, construction activities also pollute the soil, the main areas of concern are air, and noise pollution. Construction activities that contribute to air pollution include land clearing, operation of diesel engines, demolition, burning and working with toxic materials. Construction sites are generating high level of dust (typically from concrete, cement and wood) and this can carry a large distance over a long period.

4.6. Auditing wastage of key construction materials on selected public building projects in Jimma

Seven public building sites were randomly selected in Jimma town, for periods of three months. Most of those sites were under construction. The results indicated that the level of construction wastages on selected public building construction projects in Jimma town is as follows.

As described in the methodology used in the numerical formula for wastage level (%) and selected seven projects that have just in progress. Materials difference was carried out by comparing the difference between the stored (purchased) material and the actual requirement of material according to the bill of quantity. This study considers wastage as proportionate to the actual of works, as shown below

$material\ waste\ quantity = storerecords - actualmaterialrequirements$

$$\boldsymbol{material\ wastage}(\%) = \frac{\boldsymbol{material\ waste\ quantity}}{\boldsymbol{actual\ material\ requirements}} * \mathbf{100}$$

Table 4.16 summarizes the percentage of waste materials analysis, for the common used materials for concrete on building projects are concrete, cement, sand and aggregate.

Jimma University hospitality and tourism project						
No.	Materials	UNI T	Estimated Quantity (Purchased)	Actual quantity	Material waste quantity	Material wastage (%)
1	Concrete	m3	13771.00	13126.20	644.80	4.91%
2	Cement	Qtl	49575.60	46629.09	2946.51	6.32%
3	Sand	m3	7160.92	6963.10	197.82	2.84%
4	Aggregate	m3	10603.67	9944.65	659.02	6.63%
Jemila Sherif						
1	Concrete	m3	2230.80	2016.15	214.65	10.65%
2	Cement	Qtl	8030.88	7514.91	515.97	6.87%
3	Sand	m3	1160.02	1058.07	101.94	9.63%
4	Aggregate	m3	1717.72	1537.11	180.60	11.75%
Abdusomed real estate						
1	Concrete	m3	6692.40	6148.45	543.95	8.85%
2	Cement	Qtl	24092.64	22544.72	1547.92	6.87%
3	Sand	m3	3480.05	3174.22	305.82	9.63%
4	Aggregate	m3	5153.15	4711.33	441.81	9.38%
Dire industry						
1	Concrete	m3	307.79	277.77	30.01	10.80%
2	Cement	Qtl	1000.30	920.26	80.04	8.70%
3	Sand	m3	153.89	141.58	12.31	8.70%
4	Aggregate	m3	229.30	198.34	30.96	11.61%
Jemila Adem						
1	Concrete	m3	1181.60	1119.95	61.66	5.51%
2	Cement	Qtl	4253.76	3973.81	279.95	7.04%
3	Sand	m3	614.43	562.37	52.06	9.26%
4	Aggregate	m3	909.83	886.96	22.87	2.58%
Jimma zone education						
1	Concrete	m3	420.65	391.98	28.66	7.31%
2	Cement	Qtl	1514.33	1451.45	62.88	4.33%
3	Sand	m3	218.74	196.99	21.74	11.04%
4	Aggregate	m3	323.90	304.78	19.12	6.27%
Mole preparatory						
1	Concrete	m3	382.41	379.61	2.80	0.74%
2	Cement	Qtl	1376.67	1306.78	69.89	5.35%
3	Sand	m3	198.85	196.61	2.24	1.14%
4	Aggregate	m3	294.45	283.32	11.14	3.93%

Table 4-17: Average Material wastage percentage (%)

No	Material	Average Material wastage of all the seven building (%)
1	Concrete	6.97%
2	Cement	6.50%
3	Sand	7.46%
4	Aggregate	8.02%

4.7 Level of Minimization Measures

4.7.1 A future Framework for Minimizing Materials Wastage on Construction Sites

The framework proposed is emphasized how principles could be applied to minimize material wastage on construction sites. The objectives of the framework are to help construction parties to:

- Identify what could be done to tackle or counter-balance these challenges (what to do),
- Identify how to address these challenges (how to do it) and
- Realize the possible outcome (results), which is minimized material wastage

Based on the questionnaire survey, the respondent identifies the major causes of materials waste and its future framework to minimize.

Table: - 4.18a framework for minimizing concrete waste

Causes of concrete waste	**What to do to minimize wastage of construction materials**	**How to do it**	Result
Using excessive quantities of materials more than the required	Using actual quantities of materials for the proposed concrete work	• Check the quantity of the based on the drawing material before using	**Construction materials waste minimization**
Poor management and distribution of labors, materials and equipments	Prepare good management and distribution of labors, materials and equipments	• Deals with uncertainties & fears • Train employers on lean concept	
Selecting the lowest bidder contractors and subcontractor	giving for the winner of the bidder submitted contractors and subcontractor	• Checking the quality of the contracture and subcontractor	
Selection of low quality products	Selection of proper quality product achieved that works	• Using proper quality of material	
Lack of information in the drawings	full of information in the drawing should prepared for contractor	• The designer give for detail drawing for each parts of the drawing	
Rework that don't comply with drawings and specifications	the labors should have trained for the work		
Lack of proper waste management plan and control	Prepare effective waste management planning and control	• Prevent detective production • Timely delivery of materials • Understand client needs and expectation • Government should be embark on applicable	

		polices	
Poor qualification of the contractor's technical staff assigned to the project	Enhancement of technical capabilities	• Promote standard construction element • Giving timely training for the staff	
Damage materials on site	good handling materials on site	• Train the labor about handling of the material	
Poor provision of information to project participants	Prepare good communication between parties	• Improve communication among the parties	
Design changes and revisions	Design should not changed and revised once it is designed	• Before construction work stared revise the drawing and detail • Once the design change is needed change the design before work is stared	
Lack of teamwork Prepare	good teamwork	• Managers should be committed to change • Be able to work in team • Change organization cultures • Empower members in decision making	

Successful project requires careful planning, organization and control throughout the project to achieve the correct result for the client. For the contractor, good planning, organization and control are essential in order to achieve a timely and satisfactory outcome for the client, and to ensure a financial profit. To ensure the successful implementation of construction projects there should be an effective teamwork between all parties. To ensure proper teamwork on construction sites, managers should be committed to change, workers should be able to work in teams, companies should be more clients focused, firms should be willing to change organizational cultures that do not promote lean construction, partnering to maximize team building and team members should be empowered in decision-making to make partnerships meaningful.

Managing a construction project depends on how parties in a construction project interpret the construction process. Main strategies such as training of employees on lean concepts and dealing with uncertainties and fears that cause organizations to conceal information instead of sharing it should be employed to enhance the implementation of the main principles. The enhancement of technical capabilities is very important in order to effectively implement the managing materials on construction sites. To ensure that technical capabilities are enhanced, the managers should understand and use standards to define normal and abnormal conditions and develop clear, user friendly, visual controls at all levels to help monitor and improve standards.

The lack of standardization can be viewed as one of the reasons for the inefficiency of the construction sector. There is also the need for managers maintain personal discipline, direct and coach others to keep within standards and procedures and always react to off standard and off target situations with immediate investigation. In addition, standardized construction elements should be promoted to reduce the amount of materials wasted on construction sites. In an organization, communication is carried out in several ways, including verbal and signs. Authority, control and motivation are the functioning of an organization. Workers communication needs to be effective for coordinating efforts, leading to improvement in the quality of the works. Communication quality which has characteristics of being timely, accurate and useful and complete enhances productivity and quality of work. Communication should be improved among players to enhance the successful implementation of lean strategies.

4.7.2 Handling and storage of Concrete making materials on site

During the study period different contractor and consultant were giving the opinion how to handle, transporting, batching concrete making materials and storing of concrete and concrete making material. Their opinion as follows:

Recommended ways of storing aggregates on site

- Store aggregates in separate bunkers when many gradations and types of aggregate are required in small quantities for relatively low-production operations.
- Otherwise, store aggregate in open stockpiles

Recommended ways of batching concrete making materials

To avoid wasting the aggregates (course and fine), proper equipment should be used.

To assist in minimizing the wastage of concrete making materials resulting from batching, it is recommended that the following procedures be adhered.

- Use separate aggregate basket for each size of coarse aggregate. Bins should be capable of shutting off material with precision.
- Maintain mixer blades. Watch for wear and coating.
- Do not load mixer above rated capacity.
- Operate mixer at manufacturer-recommended speed.
- Mix all concrete, thoroughly until it is uniform in appearance, with all ingredients evenly distributed.
- Take samples from different portions of a batch to ensure that the whole batch has the same air content, slump, unit weight, and aggregate proportions

Recommended methods of transporting concrete to avoid wastage

- Concrete should be transported from the mixer to the place of casting as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients and maintaining the required workability.
- During hot or cold weather, concrete should be transported in deep containers, other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted

Recommended ways of storing cement to minimize wastage

Portland cement that is kept dry retains its quality indefinitely. Portland cement stored in contact with moisture sets more slowly and has less strength than dry Portland cement. A warehouse or shed used to store cement should be as air-dry as possible. All cracks and openings should be closed. Cement bags should not be stored on damp floors. Bags should be stacked close together to reduce air circulation, but they should not be stacked against outside walls. Bags to be stored for long periods should be covered with tarpaulins or other waterproof covering.

Standard strength tests or loss on ignition tests should be made whenever the quality of the cement is doubtful. Bulk cement is usually stored in waterproof bins. Ordinarily, it does not remain in storage very long, but it can be stored for a relatively long time without deterioration

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The general objective of this study is to investigate ways of minimizing concrete and major concrete making material wastage in the Jimma town building project by assessing the causes, its extent and effect on the project Cost. Therefore, based on the results obtained, the following major conclusions have been made in accordance with the objectives of this thesis research.

1. The results of the case study demonstrate that the level of materials waste in Jimma town building project is fairly high in all of the assessed construction materials. The survey result also reveals that cost effect extent up to 11 % of the project cost. Therefore, if proper waste minimization measures are devised, this amount of costs can be saved potentially, so as to increase the profit .

2. Client material supplying in the construction of the Jimma town building project has increased the generation of material waste. This was happening by since there is no proper control on material wastage; it leads to negligence, because the client did not deliver good quality material, and supplied material in an unplanned way.

3. The major causes of concrete waste differ for the two groups of respondents. The reason behind the difference in the result of responding by the two groups of respondents may be due to not to be responsible since concrete uses in larger quantity in these construction sites. However, both groups of respondents indicate that the causes are Using excessive quantities of materials more than the required, Poor management and distribution of labors, materials and equipments, Selecting the lowest bidder contractors and subcontractor, Selection of low quality products, Lack of information in the drawings, Accidents due to negligence and Using untrained labors are the top signifying causes of concrete waste in Jimma town building project. For cement, sand and aggregate the study have revealed that waste generated on site is directly related only to material and operation. The top three causes of cement to be loading, unloading the cement manually to the mixer using inadequate equipments and tools, Excessive quantities during mixing more than the required and wrong

storage. The significant causes of Sand to be Poor storage, Excessive consumption of sand, Damage the remained quantities in the place work and during transportation respectively.

4. Moreover, this study also provided empirical evidences on the levels of contribution and the levels of practice of waste minimization measures for each of the above four materials in Jimma town building project. It has shown that for all of the four materials measures which have a high level of contribution in the minimization of waste are not practiced on the basis of their level of significance on the sites.
5. From the result of the questionnaire survey, it is unveiled that the allocation of site supervisors to the respective projects is not well considered to see the adequacy. Besides, it shows poor performance of the construction supervisors in standardization and modularization of design during a design revision period.

5.2 Recommendation

Based on the findings of this study, the following recommendations are forwarded in order to minimize material Jimma town building project.

1. To minimize wastage happened due to design problem in minimizing material Jimma town building project, practicing highly off-site construction by adopting different technologies like prefabrication and precast units, proper detailing during designing, coordinating dimensions between materials and the design, and planning ahead to minimize design changes are sensible mechanisms.
2. Make sure the quality of materials delivered on the site is as stated in the specification and construction. Material ordering practice needs to be improved in order to reduce waste comes from excessive quantity of material used that could be addressed by introducing just in time material delivery system.
3. Storage facility on the sites needs to be improved by planning the details of material delivery and their storage space on site. Besides, all workers shall practice careful handling and usage of tools in all courses of the construction process.
4. Contractors need to develop waste management plans and to address material wastage problem and to enjoy the likely benefit. In addition, they shall start providing short term and long term trainings and workshops for the workers.

5. Devise good site controlling strategy to ensure adequate material planning and ordering, on-site material handling and storage which are helpful for controlling excessive material wastage. In order to facilitate this, supervisors should also give emphasis to different parameters of these building projects in allocating the site supervisors so as to make easy the site controlling and supervision work.

REFERENCES

[1] Semere, T. A. (2006). Assessment of Delays in Building Construction Projects in Ethiopia. B.Sc. Degree Thesis paper in Construction Technology & Management,Addis Ababa University, Faculty of Technology (South), Department of Construction technology & management. Shen.

[2] Yimam, A. H. (2011). Project Management maturity in the construction industry of developing country (the case of Ethiopian contractors). Thesis submitted to the Faculty of the Graduate School of the University of Maryland, College Park, in partial fulfillment Of the requirements for the degree of Master of Science

[3] Getachew Araya Kassa, November, 2009 AAU School of Graduate Studies; Master of Science of Civil Engineering, Construction Technology and Management Major Thesis.

[4] Pataskar, A. R. (2013). Analyzing Material Management Techniques on Construction Project. International Journal of Engineering and Innovative Technology (IJEIT) Volume 3 , pp,96-100.

[5] Enshassi, A. (1996), "Material Control and Waste on Building Sites", Building Research Information. 24(1), 31-34.

[6] Hoe .(2005). Construction waste: quantification and source evaluation; J. Construction Eng. Manage., 122(1): 55-6

[7] Enshassi, A. (1996), "Material Control and Waste on Building Sites", Building Research Information. 24(1), 31-34.

[8] Shen, V. T. (2002). Material wastage in construction activitie a Hong kong survey. Department of Building & Real Estate, The Hong Kong Polytechnic University, Hong Kong , pp,2.

[9] fishbein. (2001). A Guide for Managing and Minimizing Building and Demolition Waste. The Hong Kong polytechnic University.

[10] International Investment and Services Directorate Industry. (1999). The Canadian Construction Industry; A Consultation Paper in Preparation for World Trade Organization (WTO) General Agreement on Trade in Services (GATS)Negotiations. , pp 10-12.

[11] Asmara Syoum(2015)managing and minimizing wastage of construction materials on selected public building projects in addis ababa

[12] Kahssay, G. (2003). Claims in International project in Ethiopia:Case study. A Thesis Submitted to School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree of Master of Science in Civil Engineering (Structures) , pp,8

[13].Centeral Statistical, a. (2008/09). The Federal Democratic Republic of Ethiopia. Report on Contract conistruction survey .

[14] Carlos Torres Formoso, L. S. (2002). Material Waste in Building Industry: Main Causes and Prevention. Journal of construction Engineering and Management, Vol. 128, No. 4, , pp,316-317.

[15] Koskela, L. (1992). Application of the New Production Philosophy to Construction. CIFE, Technical Report No. 72, Stanford, USA.

[16] Al-Moghany, S. S. (2006). Managing and Minimizing Construction Waste in Gaza Strip. A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Construction Management The Islamic University of Gaza - Palestine **.**

[18] Bo Terje Kalsaass “Work-Time Waste in Construction” 18th Annual Conference, International Group for Lean Construction, Haifa, Israel, July14-16, 2010.

[19] Bossink BAG, Brouwers HJH (1996). Construction waste: quantification and source evaluation; J. Construction Eng. Manage., 122(1): 55-60.

[20] Ekanayake, L.L. & Ofori, G. (2000). Construction material waste source evaluation, Proceedings of the 2nd South African Conference on Sustainable Development in the Built Environment, Pretoria, South Africa

[21] Enshassi, A. (1996), "Material Control and Waste on Building Sites", Building Research Information. 24(1), 31-34.

[22].Skoyles, E.R. & Skoyles, J.R. (1987). Waste prevention on site. Mitchell Publishing, London. S. Nagapan, et al., "A Review of Construction Waste Cause Factors, in Asian Conference of Real Estate: Sustainable Growth Managing Challenges (ACRE),

[22] Rameezden, R. a. (2004). Materials wastage on construction sites:identification of major causes. Journal of Built Environment, Sri Lanka, vol (4) , pp 35-41.

[23] Datta, M. (2004). Challenges Facing the Construction Industry in Developing Countries. Proceeding of 2nd International Conference on Construction in Developing Countries, 15-17 November, Gabarone, Botswana.

[24].Babatunde, S. O. (2012). Quantitative Assessment of Construction Materials Wastage in the Nigerian Construction Sites,Department of Quantity Surveying,Obafemi Awolowo University, Ile- Ife, Nigeria. Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 3(3) , pp 238-241

[25] Kulatunga, A. D. (2006). Attitudes and Perceptions of construction workforce on Construction Waste in Sri Lanka. Management and Environmental Quality: An International Journal. Emerald Group Publishing Limited. United Kingdom. Vol 17, No. 1 , pp57-72.

[26] Getachew Araya Kassa, November, 2009 AAU School of Graduate Studies; Master of Science of Civil Engineering, Construction Technology and Management Major Thesis.

[27] Ekanayake, L. L. (2000). Construction Material Waste Source Evaluation. Proceedings of the 2nd Southern African Conference on Sustainable Development in the Built Environment, Pretoria, South Africa.

[28] Sasitharan Nagapan, Ismail Abdul Rahman, Ade Asmi, March 2012, Factors Contributing to Physical and Non-Physical Waste Generation in Construction Industry, International Journal of Advances in Applied Sciences (IJAAS) 1(1), 1-10

[29] Sasitharan Nagapan, Ismail Abdul Rahman, Ade Asmi, March 2012, Factors Contributing to Physical and Non-Physical Waste Generation in Construction Industry, International Journal of Advances in Applied Sciences (IJAAS) 1(1), 1-10

[30].Sagoe, A. (2011). Managing waste and cost in the construction industry: A case study of the Road construction industry in Ghana. A thesis submitted to the Institute of Distance Learning, Kwame Nkrumah A thesis submitted to the Institute of Distance Learning, Kwame Nkrumah requirements for the degree of common welth excutive masters of Business Adminstration .

[31] Al-Moghany, S. S. (2006). Managing and Minimizing Construction Waste in Gaza Strip. A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Construction Management The Islamic University of Gaza - Palestine **.**

[32] Poon, C. Y. (2001). A Guide for Managing and Minimizing Building and Demolition Waste. The Hong Kong polytechnic University .

[33] Agyerum, K. (2012). Minimizing Materials Wastage at The Construction Stage of a Project through the implementation of lean construction. A Thesis submitted to the Department of Building Technology, Kwame Nkrumah University of Science and Technology , pp,11-12.

[34] www.wrap.org.uk/construction. (n.d.). Reducing material wastage in construction. Guidance for clients, contractors and sub contractors on how to deliver good practice in materials procurement and usage.

[35] Andrew R.J. Dainty and Richard J. Brooke (2204) "Towards improved construction waste minimization" Structural Survey 22(1) 20–29

[36] Tam C. M., Vivian W. Y. Tam, John K. W. Chan and William C. Y. NG, (2005), Use of Prefabrication to Minimize Construction Waste - a Case Study Approach, The international journal of construction management, 91-101

[37] Faniran, 0.0 and Caban, G. (1998) Minimizing Waste on Construction Project Sites. Engineering, Construction and Architectural Management, Vol. 5, No. 2, pp. 182-188.

[38] C.W.F. Che Wan Putra, A. Ahmad, M.Z. Abd Majid, and N. Kasim, (1999) "Improving material scheduling for construction industry in Malaysia," In Malaysian Science & Technology Congress 99, 6-8, Johor Bahru, Malaysia

[39] Narimah Kasim, A. A. (2013). RFID Technology for Materials Management in Construction Projects - A Review. International Journal of Construction Engineering and Management,Faculty of Technology Management & Business, Universiti Tun Hussein Onn Malaysia, Johor, 86400, Malaysia , pp,7-8.

[40] Dennis S. Macozoma (2002) "Construction site waste management and minimization" International council for research and innovation in building and construction.

[41] Vivian, Tam, C. M. and Drew, D., (2004). Mapping Approach for Examining Waste Management on Construction Sites. Journal of Construction Engineering and Management, 130(4), 472-481.

[42] Jones and Greenwood. (2003). Construction Waste Minimization in Housing. Center of Research in the Built Environment, Cardiff University, Wales UK .

[43] William C. Y. NG, (2005), Use of Prefabrication to Minimize Construction Waste - a Case Study Approach, The international journal of construction management, 91-101

[44] WRAP, (2007), Reducing material wastage in Construction Guidance for clients, contractors and sub contractors on how to deliver good practice in materials procurement and usage

[45] MoWUD. (2013). (Ministry of Urban Development and Construction) Directives for the Registration of Construction Professionals and Contractors. Amended,Directive No 19

[46] MoWUD, C. (2014). Ministry of Urban Development and Construction. List of Registrer Contractor's from Mesker 2 /2006 E.C. Sene 30 /2006 E.C

APPENDIX-A

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

PROJECT TITTLE "Assessment on the Construction Resource Wastage Minimization Mechanisms on Major Concrete Making Materials on site: A Case Study of Jimma Town Building Project"

QUESTIONNAIRE FOR CONSTRUCTION FIRMS

1. Company name: ………………………………………………

2. Year of establishment: ……………………………………………

3. Profession:

Project manager □ office engineer □ site engineer □ Quantity Surveyor □ Site supervisor □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.

0	1	2	3	4
No waste	Insignificant waste Cause	Neutral	High significant waste cause	Very High significant waste cause

Waste Cause	**1**	**2**	**3**	**4**	**5**
Design and documentation					
Materials					
Operation					
Site management and practices					
site supervisor					

B. Below are possible sources and causes of construction waste. Rank on a scale of 0-4 which of these activities is a major provider of wastes

Causes of concrete waste	source	**0**	**1**	**2**	**3**	**4**
Using excessive quantities of materials more than the required	Operation					
Poor management and distribution of labors, materials and equipments	Site management and practices					
Selecting the lowest bidder contractors and subcontractor	Design and documentation					
Selection of low quality products	Design and documentation					
Lack of information in the drawings	Design and documentation					
Accidents due to negligence	Operation					
Using untrained labors	Operation					
Rework that don't comply with drawings and specifications	Design and documentation					
Lack of proper waste management plan and control	Site management and practices					
Poor qualification of the contractor’s technical staff assigned to the project	Site management and practices					
Damage materials on site	Materials					
Poor provision of information to project participants	Site management and practices					
Design changes and revisions	Design and documentation					
Wrong handling of materials	Materials					
Lack of a quality management system aimed at waste minimization	Site management and practices					
Poor/ wrong specifications	Design and documentation					
Shortage of manpower (skilled, semiskilled, unskilled labor	Operation					
Poor communication leading to mistakes and errors	Design and documentation					
Ambiguities, mistakes, and changes in specifications and drawing	Design and documentation					
Choice of wrong construction method	Operation					
Ineffective planning and scheduling of the project by the contractor	Site management and practices					
Lack of team work	Site management and practices					
Designer's inexperience	Design and documentation					
Poor quality of materials	Materials					
Problems between the contractor and his subcontractors	Operation					

Slow response from the consultant engineer to contractor inquiries	site supervisor					
Lack of onsite materials control	Materials					
Poor site layout	Design and documentation					
Poor technology of equipment	Operation					
Damage during transportation	Materials					
Change orders by owner	site supervisor					
Poor qualification of consultant engineer's staff assigned to the project	site supervisor					

Causes of cement waste	**Source**	0	1	2	3	4
Loading unloading the cement manually to the mixer using inadequate equipments and tools	Materials					
Excessive quantities during mixing more than the required	Materials					
Wrong storage	Materials					
Excessive consumption of cement during mixing	Materials					
Demolishing of structure members	Operation					
Mixing of quantities greater than the required	Materials					
Inappropriate way of transportation	Operation					
Excessive thickness for concrete structure members	Operation					

Causes of Sand waste	**Source**	0	1	2	3	4
Poor storage	Material					
Excessive consumption of sand	Operation					
Damage the remained quantities in the place work	Operation					
During transportation	Material					

Causes of Aggregate waste	Source	0	1	2	3	4
Excessive quantities during mixing	Operation					
Mixing quantities greater than the required	Operation					
Wrong handling	Material					
Far distance between place of mixing and casting	Material					
Losing the aggregate during passing the equipments on it	Material					

Appendix B

Critical Values of Spearman's Rank Correlation Coefficients

Number of subjects (data set)	**Level of significance for one tailed test**			
	0.05	**0.025**	**0.01**	**0.005**
	Level of significance for two tailed test			
	0.1	**0.05**	**0.02**	**0.01**
5	**0.9**	**1**	**1**	
6	**0.829**	**0.886**	**0.943**	**1**
7	**0.714**	**0.786**	**0.893**	**0.929**
8	**0.643**	**0.738**	**0.833**	**0.881**
9	**0.6**	**0.683**	**0.783**	**0.833**
10	**0.564**	**0.648**	**0.746**	**0.794**
12	**0.506**	**0.591**	**0.712**	**0.777**
14	**0.456**	**0.544**	**0.645**	**0.715**
16	**0.425**	**0.506**	**0.601**	**0.665**
18	**0.399**	**0.475**	**0.564**	**0.625**
20	**0.377**	**0.45**	**0.534**	**0.591**
22	**0.359**	**0.428**	**0.508**	**0.562**
24	**0.343**	**0.409**	**0.485**	**0.537**
26	**0.329**	**0.392**	**0.465**	**0.515**
28	**0.317**	**0.377**	**0.448**	**0.496**
30	**0.306**	**0.364**	**0.432**	**0.478**