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COTM

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction: The Case of Addis Ababa



Mulualem Merid

Negatu Abera

Tedla Belachew

February 2012
Addis Ababa



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By

Mulualem Merid

TCE/3035/00

Negatu Abera

TCE/3037/00

Tedla Belachew

TCE/5850/00

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Management in Partial Fulfillment of the Requirements for the Degree of
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Addis Ababa University

Ethiopian Institute of Architecture, Building

Construction and City Development

February 2012

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By

Mulualem Merid

Negatu Abera

Tedla Belachew

Approved by Board of Examiners

Dr.Ing. Wubishet Jekale/ Ass.Professor/

Advisor

Date

Signature

Internal Examiner

Date

Signature

Internal Examiner

Date

Signature

February 2012

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Mulualem Merid

Negatu Abera

Tedla Belachew

February 2012, Addis Ababa

ABRSTACT

The thesis is aimed at the role of Construction Management Professional to minimizing material wastage in building construction projects in the case of Addis Ababa. The main focuses of the paper is to identify the existence of building materials wastage and vividly comprehend the extent of material wastage in building construction sites. It is also the intent of the thesis to show the causes and effects of the material wastage in building construction and come up with conclusion and recommendation to minimize wastage with regard to the role of construction management professional.

The methods employed for the thesis were; literature review, questionnaire followed by interview for further clarification, site visits to take measurement and observation. Various literatures locally available were reviewed and several web sites searched. Qualitative data collection techniques are used.

The thesis affirmed the existence of material waste in the building construction. 86.96% of the respondents have agreed the existence of material wastage in the respective projects. The observation on sties and assessment of archives reiterates the existence of material wastage. The thesis ascertained; design, procurement, material handling, operation, residual and sub-contract types are sources to cause material waste. It also depicted the extent of material wastage is significant. The economic impacts of material wastage are found to be very high that greatly contribute to the expensiveness of building cost which currently observed.

Finally; the thesis clearly defined the role of the Construction Management Professional to minimize material waste. The role is explained dividing in to two stages; the role of construction management professional at pre- construction and construction stage. In the final analysis in the case of Addis Ababa; Construction Management Professionals are expected to play the great role to minimize material waste in building construction project staring from inception to execution.

Key Words; Material, Wastage, Minimization, Role, Professionals, cause and effect

ABBREVIATIONS/ACRONYMS

FASC	The federation of African societies of chemistry
(L-O)	Labor only
(D-L)	Direct labor
(L-M)	Labor and material
MP	Purchased material
Mn	Material used for actual construction work
A/E	Architect and Engineer
REBRI	Resource Efficiency in the Building and related industries
HCB	Hollow concrete blocks
CSA	Central Statistics Authority

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PART 1 - INTRODUCTION

1.1 Introduction

Now a days building construction industries are boosting globally and consuming huge amounts of resources. Responsibly managing waste on a building construction project is a vital component of optimum use of the limited resources we have that sustain the ongoing development. In this context, managing waste means *minimizing* the construction waste or demolition debris that leaves the jobsite for landfill disposal.

Construction material waste disposal triggers a sequence of adverse effects that are not always apparent to building professionals. These include the loss of useful property wasted materials, and environmental stressors associated with producing new materials instead of using existing materials. The number of construction waste landfills is declining, which means fewer disposal options, greater hauling distances, and increased fuel consumption and vehicle emissions. Capping, closing, and monitoring landfills, and cleaning up leaking or contaminated landfill sites drain public funds.

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

1.2 Background

Waste material is a detrimental by-product of the building process in the construction industry and waste material management is an important process of identifying and processing waste in order to minimize it. The definition of waste is best described as any materials by-product of human and industrial activities that has no residual value. Construction and building activities contribute to approximately 30 percent of overall landfill volumes in the States, the UK adds more than 50 percent and Australia contributes 20-30 percent. Research indicated the construction and demolition waste accounts from about 15-30 percent all solid waste by weight and more than 90 percent of this waste is from landfill in the gulf region, particularly in pointed out that 20 million tons of construction waste was generated in Hong Kong, 12 percent disposed of at landfills and 88 percent at public fills.

With applications of advanced technologies and methods of construction during the last two decades, the construction waste has been numerously reduced by using these latest developments in construction project management processes. The process of construction is being considered as a way to reduce the waste in construction projects and improve the effectiveness of the construction process during construction. Policy and programs have been drawn up and developed to address reduction of construction waste. Programs and policies such as the lean thinking process were implemented to waste control and handling through construction process. The management system plays the biggest part in process, policy, waste generation and reduction. In Summary, this research has studied source of construction materials waste, role of construction management professional to avoid and reduce waste materials on building construction projects.

1.3 Problem Statement

The building construction industry in Ethiopia in general has been found to be among the main consumers of resources and energy. Moreover, the construction sector is reported to be generating unacceptable levels of material and manpower waste. Generally, construction activities which produce wastage can be grouped into off-site and on-site operational activities. Off-site activities include prefabrication, project design (architectural, structural, mechanical, Sanitary, Estimator and electrical design), manufacturing and transporting of materials and components. On-site construction activities relate to construction of a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process. All estimators allow wastage factors in pricing a bill of quantities. Over the years' experience has shown that unless site management control is tight, wastage can frequently exceed often by a large margin than the figure allowed in the tender document. Effective materials control demands concentrated and coordinated action of numerous people performing a variety of functions within the industry. It further suggested that waste seen on site is not necessarily caused by failure or inadequacy of individual functions involved in materials management system.

In the present situation, the contractors and the design consultants are mainly concerned on how to control cost without any emphasis on waste control measures. Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, a critical control of materials on site together with good construction management is expected to decrease the cost of construction projects. Materials wastage on site cannot be treated fully without good construction management. In fact, material waste level on site is a measure of site management.

Decision taken at the initial stage of any project that is the design stage, either by the manufacturer or supplier of materials is capable of increasing waste level. This can occur as a result of manufacturers not following strictly the buyers' specification and supplier not packaging the product for easy transportation. Since all the burden of waste lies solely on the contractor, it is important that the site management should ensure a good supervision of materials and apply an effective method of controlling waste. Waste normally emanates 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 overs 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. Hence, this research assessed the forms, causes and factors incidental to construction waste and measures to effectively control construction waste.

The study aims at identifying the sources of waste from inception to execution of the building projects, determine the current waste control measures, assess the effectiveness of the waste control measures with a view to seeking for ways to minimize building materials waste in future construction projects and to assess the role of Ethiopian construction management professionals in reducing construction material wastes.

1.4 Research Objective

The main objective of the study is to assess the role of construction managers in reducing wastes in building construction industry of Ethiopia; Addis Ababa case in particular; the specific objective of this study is:

- ❖ To identify the building materials wastage in the construction sites
- ❖ To vividly comprehend the extent of material wastage in building construction

- ❖ To show the causes and effects of the material wastage in building construction
- ❖ To come up with final recommendation how to minimize material wastage in building construction / with respect to the role of construction management professional

1.5 Research Question

- ❖ Is there material wastage in building construction?
- ❖ If yes how much is the extent?
- ❖ What is the cause and effect?
- ❖ What should be done for remedy? / What is the role of construction management professional to minimize material waste?

1.6 Research Method

The study undertakes a number of distinct but inter-related tasks to gain an insight into the status of the building construction and identify all relevant issues. In this study, primary data obtained from archival document and survey using structured questionnaires, interview, desk study and observation. Questionnaires has been designed on structural basis to get information about personal data of the respondents to depict their profile that may let them have experience on issues relating to waste management in construction process. The questionnaires were also designed to cover various factors that lead to wastages on construction sites, waste control measures, effectiveness of the waste control measures with regard to the role of construction management professional and existence of waste management plan in contractual process.

The reliability and validity of the questionnaire is based on the use of measurement scale to assess the causes of building construction material waste. Personal interviews will be conducted to complement the questionnaires administered to the respondents.

The interviews were conducted among construction personnel namely architects, Contractors, design engineers, foremen, store keeper by covering issues which not clarified in the questionnaire related to the order of site activities, waste handling methods, problems of waste management, waste reduction measures and likely suggestions to avoid and minimize waste. Site visits carried out to observe physically to take measurements and identify the methods used at the building construction sites to minimize material waste.

Questionnaires were sent to all the building construction professional personnel's who under taking the construction activities on the selected sample projects. Consulting firms/ Consultants who designed or supervised those projects also have been sorted for questionnaires. It is believed that the sample projects will shows the situations of the large scale construction in Addis Ababa; as the project selected based on the sampling technique.

1.7 Scope of the research

The Concept of wastage is a very wide issues that is not only about material wastage but it beyond. In this research we only focus on material wastage in building construction in Addis Ababa. Addis Ababa is the capital city of Ethiopia and the construction sectors are booming. It is believed that the construction practice can be represented well than other cities. Therefore we have chosen Addis Ababa construction projects undertaking with private sector; in particular commercial building in Addis Ababa. As shown in the Table 14 ; even though the numbers of commercial building projects are lesser than other projects; the project size and complexity are by far greater. So our research focuses on those projects.

1.7.1 Overview of Addis Ababa

As a chartered city, Addis Ababa has the status of both a city and a state. It is where the African Union and its predecessor the OAU are based. Addis Ababa is therefore often referred to as "the political capital of Africa", due to its historical, diplomatic and political significance for the continent. The city is populated by people from different regions of Ethiopia – the country has as many as 80 nationalities speaking 80 languages and belonging to a wide variety of religious communities. It is home city to Addis Ababa University. The Federation of African Societies of Chemistry (FASC) and Horn of Africa Press Institute (HAPI) are also headquartered in Addis Ababa.

1.7.2 Demographics

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), Addis Ababa has a total population of 2,739,551, of whom 1,305,387 are men and 1,434,164 women; all of the population is urban inhabitants. For the capital city 662,728 households were counted living in 628,984 housing units, which results in an average of 4.1 persons to a household. Although all Ethiopian ethnic groups are represented in Addis Ababa due to its position as capital of the country

In the previous census, conducted in 1994, the city's population was reported to be 2,112,737, of whom 1,023,452 were men and 1,089,285 were women. At that time not all of the population was urban inhabitants; only 2,084,588 or 98.7% were. For the entire administrative council there were 404,783 households in 376,568 housing units with an average of 5.2 persons per household.

According to the 2007 national census, 98.64% of the housing units of Addis Ababa had access to safe drinking water, while 14.9% had flush toilets, 70.7% pit toilets (both ventilated and unventilated), and 14.3% had no toilet facilities. Values for other reported

common indicators of the standard of living for Addis Ababa as of 2005 include the following: 0.1% of the inhabitants fall into the lowest wealth quintile; adult literacy for men is 93.6% and for women 79.95%, the highest in the nation for both sexes; and the civic infant mortality rate is 45 infant deaths per 1,000 live births, which is less than the nationwide average of 77; at least half of these deaths occurred in the infants' first month of life.

1.7.3 Economy

The economic activities in Addis Ababa are diverse. According to official statistics from the federal government, some 119,197 people in the city are engaged in trade and commerce; 113,977 in manufacturing and industry; 80,391 homemakers of different variety; 71,186 in civil administration; 50,538 in transport and communication; 42,514 in education, health and social services; 32,685 in hotel and catering services; and 16,602 in agriculture. In addition to the residents of rural parts of Addis Ababa, the city dwellers also participate in animal husbandry and cultivation of gardens. 677 hectares (1,670 acres) of land is irrigated annually, on which 129,880 quintals of vegetables are cultivated. It is a relatively clean and safe city, with the most common crimes being pickpocketing, scams and minor burglary. The city has recently been in a construction boom with tall buildings rising in many places. Various luxury services have also become available and the construction of shopping malls has recently increased. According to Tia Goldenberg of *IOL*, area spa professionals said that some people have labeled the city, "the spa capital of Africa." Ethiopian Airlines has its headquarters on the grounds of Bole International Airport in Addis Ababa.

1.8 Limitation

In this research we have tried to overcome the challenges we faced, but we have limitation. The unavailability of the records with regard to material wastage in the construction sites and in office as well is one of the limitations. Apart from this time; shortage in taking measurement in a continuous manner like for months and language barrier for the questionnaires for the traders in the construction sites.

PART 2 - LITERATURE

2.1 Definition of building material waste

Various researcher and practitioner define building material in different ways. However, material wastage is of more concern because most of the raw materials from which construction inputs are derived come from non-renewable resources. Although “waste” is a familiar term in the industry world-wide, it is difficult to compare construction waste figures from different construction sites due to a number of reasons, including the use of varying definitions; and the use of different estimation approaches, by different groups.

A research conducted in *National University of Singapore* on construction material waste source evaluation by *Ekanayake & Ofori in 2000* defines material waste;

“Any material, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to material damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process.”

This definition denotes material waste is construction materials considered as a waste generated in due process of construction which needs to be transported from the site or used for other purpose. The definition gives more emphasis on direct material waste that can cause economic losses.

Tom Napier, Research Architect, in his research on Construction Waste Management, in U.S Army Corps of Engineer Research and Development Center, updated in 2011; defines construction waste as;

“Construction Waste: Waste materials generated by construction activities, such as scrap, damaged or spoiled materials, temporary and expendable construction materials, and aids that are not included in the finished project, packaging materials, and waste generated by the workforce.”

This definition more emphasis on the material waste expendable and aids material so as to be cast-off after wards.

Ato Getachew Araya Kassa, AAU School of Graduate Studies; in his Degree of Master of Science of Civil Engineering, Construction Technology and Management Major Thesis; Defines material wastage in building construction as;

“Material wastage is the use of excess amount of materials than those considered necessary in the production of building without adding value to the building construction.”

This definition; unlike to the above definition; gives more emphasis on the excess materials used in the construction of building component which don't add any value to the building.

Nehru institute of Construction & Enterprise Distance learning program defined construction material wastage as follow;

“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 in which unnecessary cost and time may be incurred by materials wastage. “

This definition focuses on the difference of value between the delivered materials on site and the actual material used in the construction is considered to be material wastage.

Various literatures define material waste in different perspective .Here under some the definition given;

In defining “Lean Production” principles , (Koskela 1992) defined waste as “any inefficiency that results in the use of equipment, materials, labor or capital in larger quantities than those considered as necessary in the production of a building.

” (Formoso et al. 1999), also defined waste as “any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client”.

Skoyles and Skoyles (1987) mentioned in (Formoso et al 2002) defined building material Wattages as:

“The difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work after deducting the cost saving of substituted materials transferred elsewhere, in which unnecessary cost and time may be incurred by materials wastage.”

According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the production of a building. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product (Koskela 1992).

Therefore, waste should be defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client. We can summarize that building materials waste is; any material losses produced during the construction activities that generate direct or indirect costs but do not add any value to the building.

For this thesis we define construction material waste as; the difference in quantity of construction material delivered and used for the intended purpose. In line with this using excess construction material is also considered as a waste. In other words excess of materials used than required quantities and the construction materials hauled away generated in the construction site that can be useful for the intended construction.

2.2 Existence and Extent of material wastage in building construction

Various researches conducted within the existence of building material wastage in the context of different countries. In their research reports indicated; there only be cited percentage variation but all proofed the existence of wastage in one or another forms. For instance; a waste diagnostic survey was carried out on a sample of 35 top contractors by three researchers at a national level recently. The contractors' selection was based on their size of capital and experience according to the classification of the Egyptian Union for Building and Construction Contractors. The survey focused on the waste rates and causes of the most dominant materials influencing the projects' costs. The survey revealed that the existence of material waste was unquestionable and found to be range from 4.5%to 13%. Despite the difference in construction techniques, culture, and work procedures between the countries under study, the result proofed the existence of material wastage at significant rates. (Netherlands', Brazil, UK, etc.)

In Ethiopia a research conducted by Ato Getachew Arya Kassa for his Master's thesis on wastage of materials in building construction; In the case of Addis Ababa, in 2009. In his survey; questionnaires were spread to 72 respondents and the analysis showed that 100% of the respondents strongly agreed up on the existence of material wastage.

The level of waste at construction sites is considerable. The resulting rising amount of construction and demolition waste has caused serious problems both locally and globally. Studies show that the waste rate in the Brazilian construction industry is 20 to 30% of the weight of total materials on site. On the other hand, work in the Netherlands found that the amount of waste for each building material lies between 1% and 10% of the amount purchased, depending on type of material. Furthermore, it was concluded that an average 9% (by weight) of the purchased construction materials end up as site waste in the Netherlands. In New Zealand waste generated from the construction and demolition sector accounts for around 26% of waste to landfill, and is estimated at around 50% of waste generated overall when volumes to clean fill are taken into consideration. In different country cases construction material waste is calculated with demolition materials; such as New Zealand.

Moreover, whereas the waste problem is well known, it seems not to be given the recognition it deserves. One reason may be the tendency to underestimate waste levels. Past studies have found that, most of the time, actual percentages of site waste generation have been much higher than the initial recommended waste norms for the projects. In the UK, the BRE studied the waste levels for specific materials on 230 different building sites and found that the actual waste level is consistently higher than the estimated level for all materials studied. New purchases to replace wasted materials rework to correct mistakes, delays, and dealing with generated waste cause heavy financial losses to the contractor.

Material is, indisputably, the most vital construction input, around which the efficiency or inefficiency of labor, plant and equipment spin, and the need for efficient material usage and control is getting greater attention in building construction industry.

As can be seen from Table 1 below, 13 to 30% of all solid waste deposited in land-fills world- wide comprises construction and demolition waste with a 1:2 ratio of construction to demolition waste.

Table 1: Construction and Demolition waste as percentage of all solid waste entering landfills in different countries. (Source: B.Bossink and H.Brouwers 1996)

Country	Construction and Demolition waste by weight (%)
The Netherlands	26
Australia	20-30
United States	20, 23, 24, 29
Germany	19
Finland	13 - 15

Quantification practices in many countries treat construction waste together with demolition waste. Although it appears to be difficult to generalize on the proportion of the waste generated by construction and demolition activities, it was reported that the ratio of construction waste in the US and Western Europe is about one-third the content of total construction related waste (Peng et al 1997, Bossink and Brouwers 1996).

Bossink and Brouwers (1996) confirmed that the level of material wastage at construction sites is considerable. As indicated in Tables 2.3 and 2.4 below, 9% by weight of the total purchased materials end up as waste, and the percentage of purchased construction materials that leave the construction site as solid waste ranges between 1 to 10% of every single purchased materials in the Dutch construction

industry. While 20 to 30% of the purchased materials are not used for the purpose they are intended and end up as a waste in the Brazilian construction industry.

Table 2: Construction waste of fraction as percentage of purchased amount of specific construction waste in (Bossink and Brouwers 1996)

Application of construction material	Construction wastage (By weight) %
Stone tablets	9
Piles	5
Concrete	3
Sand-lime elements	1
Roof tiles	10
Mortar	10
Bricks	6

It is also estimated that construction activity generates about 20-30% of all waste deposited in Australian landfills and 50% of the waste deposited in UK landfill. Corresponding figures for US, Netherlands, Germany and Finland are 29%, 26%, 19% and 3-15% respectively (Rogoff and Williams 1994, Craven et al. 1994, Brooks et al. 1994, Heino 1994, all cited in Bossink and Brouwers 1996).

Table 3: Cost of waste of fraction as percentage of total waste costs in Netherlands (Bossink and Brouwers 1996)

Application of construction material	Construction wastage (By weight) %
Stone cladding	26
Piles	13
Concrete	7
Sand-lime cladding	5
Roof tiles	13
Mortar	5
Bricks	3

The need for efficient use of construction materials is underpinned by the fact that material input constitutes as high as 60% of total project costs and estimators have doubled allowances for wastage in the 20-year period from 1974 to 1993 (Proverbs et al, 1995).

Table 4: Construction waste as percentage of total amount of purchased construction material in Brazil Source: B.Bossink and Brouwers 1996)

Reference:	Construction waste (By weight) %
Pinto and Agopayan (1994)	20 —30
Hamassaki and Neto (1994)	25
Formoso et.al. (1993)	20

Wyatt (1978) cited in (Formoso et al. 2002) stressed that the consequences of high levels of material wastage is reflected both in reducing the future availability of materials and energy and in creating unnecessary demands on the transportation system. Besides, some materials and their components are produced by using massive amounts of nonrenewable sources of energy, as well as resources that are in danger of depletion, like timber, sand, and crushed stone (Bossink and Brouwers 1996). Skoyles and Hussey (1974) asserted that the quantities of bricks wasted on housing sites were enough to build 15,000 houses.

Table below; Summarize the result of three different researches on material wastage between 1989 and 1994. It shows that there is huge variation in waste amount between

different construction materials, like 1% for concrete and 50% for mortar. While the difference in waste percentages for a specific material between different studies is relatively small.

Table 5: Construction waste of specific material as percentage of total purchased amount of specific construction material in Brazil (By Weight)

Construction Material	Pinto (1989)	Soibelman et.al (1994)	Pinto and Agopayn 1994)
Steel	21%	16%	26%
Cement	25 %	46 %	33 %
Concrete	1 %	12 %	2 %
Sand	28%	31%	28%
Mortar	50%	48%	46%
Ceramic Block	--	21 %	--
Brick	11%	23%	12%
Timber	--	--	32 %
Hydrated lime	--	--	51 %
Wall ceramic tile	--	--	9 %
Floor ceramic tile	--	--	7 %

As can be seen from Table below, the range of waste index in Brazil is wide and there exist big disparity in waste indices at different sites for the same material. Thus high variability of construction performance exists for a specific material between different sites. Assuming the nature of projects investigated were reasonably similar for this particular case, the small percentages of wastage at some sites indicate that a relatively large ion of material wastage can be avoided.

Table 6: Wastage of Materials by weight in Brazil (Adapted from Soibelamn 1993)

Material	Material Wastage (%)			
	Mini.	Mea n	Max.	Nominal
Steel Reinforcement	7.9			20.0
Cement	34.3	84.1	151.9	15.0
Premixed Concrete	0.8	13.2	25.2	5.0
Sand- Lime mortar	40.4	91.2	152.1	15.0
Sand	21.0	45.8	109.8	15.0
Blocks	39.9	26.7	39.9	10.0
Bricks	15.2	29.9	45.2	10.0

It was indicated that the wastage of materials in building construction tends to be far higher than the nominal figures assumed by construction companies in their cost estimates. At some sites the waste of some building materials is greater than 100% indicating the severity of the problem.

Studies has further evidenced managing building material waste can achieve higher construction productivity, save time and achieve the safety improvement, while additional wastes take extra time and resources for disposal that may slow down the construction progress.

2.3 Classification of material wastage in building construction

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. Regarding the possibility to control the incidence of waste, this study admits that there is an acceptable level of waste,

which can only be reduced through a significant change in the level of technological development.

Formoso et al. classified waste into unavoidable waste (or natural waste) and avoidable waste.

2.3.1 Unavoidable waste (or natural waste)

This type of material wastage in which the investment necessary to its reduction is higher than the economy produced. The percentage of unavoidable waste in each process depends on the company and on the particular site, since it is related to the level of technological development.

2.3.2 Avoidable waste

This happens when the cost of waste is significantly higher than the cost to prevent it. That is to say the cost of the material is much higher than the cost which is required to minimize the waste.

Waste can also be classified according to its origin, i.e. the stage that the main root cause is related to. Although waste is usually identified during the production stage, it can be originated by processes that precede production, such as materials manufacturing, training of human resources, design, materials supply, and planning. The main classification of waste proposed in this study is by its nature, since it helps managers to understand the different forms of waste, why they occur and how to act in order to avoid them. The following classification resulted from a study developed at UFRGS, based on Shingo's seven wastes (Shingo, 1989) and on the analysis of some Brazilian building sites:

2.3.3 Transportation

Concerned with the internal movement of materials on site, excessive handling, the use of inadequate equipment or bad conditions of pathways can cause this kind of waste. It

is usually related to poor layout, and the lack of planning of material flows. Its main consequences are; waste of man hours, waste of energy, waste of space on site, and the possibility of material waste during transportation.

2.3.4 Processing

Related to the nature of the processing (conversion) activity is which could only be avoided by changing the construction technology. For instance, a percentage of mortar is usually wasted when a ceiling is being plastered.

2.3.5 Inventories

Related to excessive or unnecessary inventories which is lead to material waste (by deterioration, losses due to inadequate stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up to inventory wastage. It might be a result of lack of resource planning or uncertainty on the estimation of quantities.

2.3.6 Movement

Concerned with unnecessary or inefficient movements made by workers during their job this might be caused by inadequate equipment, ineffective work methods, or poor arrangement of the working place.

2.3.7 Production of defective materials

It occurs when the final or intermediate product does not fit the quality specifications. This may lead to rework or to the incorporation of unnecessary materials to the building (indirect waste), such as the excessive thickness of plastering. It can be caused by a wide range of reasons: poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc.

2.3.8 Others

Waste of any nature different from the previous ones, such as burglary, vandalism, inclement weather, accidents, etc.

Skoyles and Skoyles (1987) mentioned in (Formoso et al 2002 classified waste as direct and indirect material wastages and defined them as follows:

2.3.9 Direct waste:

Direct waste is a complete loss of materials due to the fact that they are irreparably damaged or simply lost during the building process. In this case the wastage usually needs to be removed from the site.

2.3 10 Forms of Direct material wastage

Deliveries waste; comprises all losses in transit to the site, unloading and placing into the initial storage.

Site storage and internal site transit waste: comprise losses due to bad stacking and initial storage, including movement and unloading around the site, to stack at the work place or placing into position.

Conversion waste: comprises losses due to cutting uneconomical shapes, e.g. timber. Sheeted goods...

Fixing waste: comprises materials dropped, spoiled, or discarded during the fixing operation.

Cutting waste: includes losses caused by cutting materials to size and to irregular shapes.

Application waste: includes materials such as mortar for brickwork, paint spilled or

dropped during application. Similarly, materials left in containers or cans which are not resealed. Mixed materials like mortar and plaster left to harden at the end of the working day.

Management waste: includes losses arising from an incorrect decision or from indecision and not related to anything other than poor organization or lack of supervision.

Waste caused by other trades: this includes losses arising from events like ‘borrowing’ by trades for purposes other than the work, and not returning the material or damage by succeeding trades.

Criminal waste: covers pilfering, theft from sites and vandalism.

Waste due to the incorrect type or quality of materials: this includes waste stemming from materials wrongly specified, waste due to errors, particularly in the bills of quantities and specification.

Learning waste: that is usually caused by apprentices, unskilled ‘tradesmen’, and tradesmen on new operations.

2.3.11 Indirect material wastage:

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

Deviations in the sizes of cast in-situ structural elements like of footings, slabs, beams, and columns are an important source of concrete indirect waste. Based on the study of

30 building construction sites in Brazil; it was found that thickness of slab and beam width were on average 5.4% and 2.7% larger than the sizes specified in the design respectively (Formoso et al. 2002).

Another type of indirect material waste is observed in brick and block work due to excessive consumption of mortar in joints. A study by Soibelman (1993) quoted in (Formoso et al., 2002) revealed that the average thickness of mortar was 19.1% greater in the vertical joints and 35.6% in the horizontal joints. While Formoso et al. (2002) found a much higher values and the average divergence in thickness was 52% for horizontal joints and 56% for vertical joints.

Furthermore, Soibelman (1993) measured plaster thickness and reported that the actual thickness exceeded the design one by 17.8% for ceilings, 76% for internal walls and 93.3% for facades. Corresponding deviation results by formoso et al. (2002) are an average of 46.8% and 32.7% for internal and external plasters respectively.

The two principal types of waste categories, direct and indirect, identified by Skoyles and Skoyles (1987) were further expanded by Brent et al (2006) and described the forms of their occurrence.

2.3.12 Forms of indirect material wastage

Production waste: where materials are used in excess of those indicated or not clearly defined in contract documents. e.g. additional concrete in trenches, which are dug wider than was designed, because no appropriately sized digger bucket is available

Operational waste: where materials are used for temporary site work for which no quantity or other allowances have been made in the contract documentation. e.g. tower-crane bases, site paths, temporary protection.

Negligent waste: where materials are used in addition to the amount required by the contract owing to the construction contractors own negligence

2.4 Causes and effect of material wastage in building construction

2.4.1 Causes of material wastage

Among the total project cost around 67% is covered by the material cost from the building project.

Many factors contribute to construction waste generation at site. Waste may occur due to one or a combination of many causes. Gavilan and Bernold organized the sources of construction waste under six categories:

In this research, the factors which cause waste on site were identified after a review of the literature, and placed in four major sources as shown in Table 7

2.4.1.1 Design,

2.4.1.2 Operational,

2.4.1.3 Material handling

2.4.1.4. Procurement, mainly for the practical purpose.

Table 7: Sources and causes of construction waste (Authors 2000)

Design	Operational	Material handling	Procurement
* Lack of attention paid to dimensional coordination of Products * Changes made to the design while construction is in progress	*Errors by tradespersons or laborers *Accidents due to negligence *Damage to work done	*Damages during transportation *Inappropriate storage leading to damage or	*Ordering errors (e.g., ordering significantly more or less) *Lack of

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Design	Operational	Material handling	Procurement
* Designer's inexperience in method and sequence of Construction * Lack of attention paid to standard sizes available on the Market * Designer's unfamiliarity with alternative products * Complexity of detailing in the Drawings * Lack of information in the Drawings * Errors in contract documents * Incomplete contract documents at commencement of project * Selection of low quality products	caused by subsequent trades *Use of incorrect material, thus requiring replacement *Required quantity unclear due to improper planning *Delays in passing of information to the contractor on types and sizes of products to be used *Equipment malfunctioning *Inclement weather	deterioration *Materials supplied in loose form *Use of whatever material which are close to working place *Unfriendly attitudes of project team and laborers *Theft	possibilities to order small quantities *Purchased products that do not comply with specification

2.4.1.5 Subcontracting

Due to recent structural changes in the construction sector in many countries, production much more subcontracted these days than the past. As a result, supply chain management became more important, including the management of subcontractors.

Subcontracting, as defined by Pagnani (1989) quoted in (Cardoso and Shirnizu 2002), is a legal-economic relationship between two agents, in which the characteristic criteria are substitution and subordination.

The substitution criterion means that the subcontractor executes the operation with technical and financial risks, instead of the job assignor; the subordination criterion signifies the subcontractor must follow the direction given by the contractor.

Beards worth (1988) cited in (Cardoso and Shimizu 2002) described also subcontracting as an organizational alternative for some economic activities. While Veltz (2000) Cited in the same points out that the firm does not need to have the control of all the value string, being to externalize non-strategically activities, aiming to reduce costs.

Firms are decentralizing their jobs more and more, allowing subcontracting to become a basic part of the construction work organization.

Owing to this fact, it was stated that 80-90% of the work of building projects in the United States is performed by subcontractors while less than 5% of the building work in UK is executed by the main contractor itself (Hinze and Tracey 1994, bodun and Kwanga).

Some literatures also describe sub- contracting can magnify material waste. Subcontractors tend to finish the job as fast as possible, without controlling the use of materials.

Tam et al (2002) conducted a survey to study the material wastage levels in adopting various sub-contracting arrangements. Their study focused on three major sub-contracting arrangements, namely

- Direct labor (D-L),
- Labor only (L-O) and
- Labor and material (L-M).

The Study results indicate that the levels of material wastage in L-M (Labor- Material) Arrangements of sub-contract are less than those in L-O (Labor-Only) and D-L (Direct Labor) Arrangements. Table 8 shows the characteristics of different subcontracting arrangements.

Table 8: Types of sub- Contracting arrangements and their relationships to material waste Generation (Tam et al 2002)

Sub-Contracting arrangement	Responsibility in material wastage
Direct Labor (D-L)	Main contractors provide their in-house staff to purchase materials directly. Hence, main contractors directly control and pay for the wastage
Labor only (L-O)	Main contractors purchase materials and sub-contractors provide labor force only. Hence, main contractors directly control and pay for the wastage.
Labor and Material (L-M)	Sub-Contractors purchase materials and hire labor. But the main contractor indirectly pays for wastage through higher sub-contract prices.

Sub-contractors who were bound into a supply and install contract, the main contractor lose control on material applications including purchasing, installation and element (Chan 1998). Thus sub-contractors would take the responsibilities of all al wastage.

The L-M subcontractors will be much aware of the generation of wastage levels since they did take care of the material cost which will be finally wasted and directly affected their profit gained from the project. However, this sub-contracting arrangement sometimes would shift the materials related risk to the sub-contractors and increase the

sub-contract (Skoyles and Skoyles 1987).

Table 9: Levels of material wastage among different Sub-Contracting arrangements (Tam et al 2002)

Trade	Subcontracting arrangements		
	D-L	L-O	L-M
Concrete	4.86%	8.99%	4.48%
Reinforcement	5.00%	7.70%	4.11%
Formwork	-	20.00%	4.97%
Block/Brick	6.02%	8.90%	5.87%
Tiles	6.67%	15.58%	6.62%

The expression used in calculating the wastage level is

$$\text{Wastage Level (in \%)} = \frac{M_p - M_u}{M_p} \times 100\%$$

Where M_p = Purchased material and

M_u = Material used for actual construction work.

Table 9 above indicates that using L-O sub-contract arrangement has the highest material wastage level across all the building materials considered in the study. For instance the wastage level of formwork under the L-O arrangement goes up to 20% of the total material and is at least four hundred percent higher than the wastage level in L-M sub contract arrangement (4.97%).

The study reported that L-O subcontractors were less concerned about the material wastage as the materials are not supplied by themselves. It was further revealed that L-M. Subcontractors re-use formwork for up to fifty times while L-O subcontractors only

use for the same material of form work. And therefore, the wastage of formwork for L-O subcontract arrangement is much higher than that of other subcontracting arrangements. Thus, generation of material waste in building construction sites has a relation with the sub-contracting arrangements used.

2.4.2 Economic effect of material wastage

Significant Economic and environmental benefits can be gained by controlling and managing building construction waste. Waste minimization practice can also increase the competitiveness of contractors through lower production costs and a better public image. Despite these facts, Lam (1997) cited in (Tam et al.) reaffirmed about the results of previous studies that show very few contractors spent efforts in considering the economic and environment implications of waste and in developing new concepts of controlling waste generation. The Generation of waste from construction sites, as indicated above, is considerable. Figures from Germany Hanisch et al (1991) and Kohler (1993) both cited in (Bossink et al and Western Europe Buchner (1992) indicate that the ratio between the weight of construction waste and demolition waste is 1:2. This implies there is a huge absolute amount of construction waste in many countries.

Material waste minimization can provide financial benefits, and some cases can even save time. The financial benefits can be appreciated over a short term or long term). An overall cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. According to Poon (2002) financial fits associated with the minimization of material wastage include:-

- Reduced purchase quantity and price of raw materials by minimizing wastage
- Reduced transportation cost for materials wasted to and from the site and disposal
- Reduced disposal costs of waste materials

- Reduced purchase price of new materials when considering reuse and recycling
- Long term benefits through optimizing the building life concept, by avoiding expenses from demolition and construction of new buildings.

The insight into the causes of the generation of construction waste in construction projects is growing. For economic reasons people in the construction industry need to have an insight into the financial consequences of construction waste. Substantial savings could be obtained by reducing the amount of construction waste.

Purchase losses, dumping costs, and transportation costs can be reduced by minimizing construction waste. Financial benefits can be an incentive for stakeholders in construction projects to put more efforts into preventing construction waste. According to Bossink et al 1996), the costs of construction waste consist of purchase losses, collection costs, transportation costs, recycling costs and dumping costs.

2.4.2.1 Purchase losses; are the purchase costs of the materials that leave the site as waste. The total purchase losses for a specific building can be calculated as;

Total purchases loses = the sum of [the purchase costs per unit for all particular construction materiel X the amount of particular construction materials that left the site as waste]

2.4.2.2 Collection costs; the costs for extra manpower to collect the construction waste and to separate it into construction debris and remainder.

Total collection costs per house= [the cost for extra manpower to collect the construction debris and remainder X the amount of generated construction debris and remaining per project]

2.4.2.3 Transportation costs; the costs of transporting construction debris to waste recycling or dumping facilities. The total transportation cost per project is expressed as;

Total transportation costs per project= [the sum of the transportation costs per ton for construction debris and the remainder per project]

2.4.2.4 Recycling cost; the fees for processing the construction debris at a recycling facility. The total recycling cost per project is calculated as;

Total recycling costs per project= [the recycling costs per ton for construction debris X the amount of construction debris per house]

2.4.2.5 Dumping costs; the fees required for dumping the remainder at landfill sites. The total dumping costs per project is calculated as;

Total dumping costs per project= [the dumping costs per ton for the remainder X the amount of generated remainder per house]

Total costs of construction waste for a project consist of the sum of the purchase collection costs, transportation costs, recycling costs and dumping costs per house.

Bossink et al (1996) studied the costs incurred through waste generation in the Construction industry and found that the purchase losses constitute about two third of the ultimate total costs. As indicated in Table below, purchase losses constitute about three of the ultimate total costs of material wastage and reduction in the amount of construction waste generation enables a savings of about 2.8% of the overall project cost.

Table 10 Proportion of economic losses in material wastage (Adapted from Bossink et al.)

Cost item	% of the total cost of waste
Purchase losses	76.86%
Collection costs	1,92%
Transportation costs	9.24%
Recycling costs	2.3 7%
Dumping costs	9.61 %

Although it seems that there exist some unavoidable residual level of material waste, the potential cost saving that may be achieved by a reduction of the material waste at the building construction site is substantial. Thus, the possible financial paybacks represent an incentive for participants in construction projects to put more efforts into minimizing construction waste.

2.5 Material waste minimization in building construction

It is noticeable that if the existence of material waste in building projects granted; causes and effects analyzed; the next question would be how will be minimize the waste? In this regard many literatures recommended different strategies. In New Zealand; Waitakere City Council's Sustainable Home Guidelines defines and recommended the means how to minimize material waste as follow.

2.5.1 Material waste minimization

The guidelines of Waitakere City Council articulate what waste minimization mean and i deal with as;

“Waste minimization is about commonsense and a change of attitude, rather than new technologies “.

Wikipedia defined what waste minimization as;

“Waste minimization is the process and the policy of reducing the amount of waste produced by a person or a society.”

The cost of waste is not just the disposal cost of getting the waste skip collected, it is the cost of the original raw material, plus the labor time wasted on it, plus the disposal cost. Additionally the lifecycle of the building should be considered: what happens at the end of the building’s life? Future uses, flexibility of design and deconstruction also have a solid waste impact on the environment. Waste generated overall when volumes to clean fill are taken into consideration.

Often waste minimization options cost nothing to implement and give benefits straightaway with little or no effort. It is important to understand the principles of waste minimization. Recycling is actually the last option after rethinking to eliminate the waste all together, reducing the amount of waste produced, and reusing waste that are produced.

2.5.2. Pre- designing

When designing a resource-efficient building, the designer should first understand the features and limitations of the building site. Record microclimates, wind directions, sun angles, slopes, and vegetation and soil types. Also study the wider surroundings, taking note of neighboring buildings, roads and trees. Make sure the architect or designer visits the site, ideally more than once. Study the site at different times of the day. Think what will change at different seasons.

2.5.2.1 Consider the size of the building

How large do rooms really have to be? How many rooms are needed? Can rooms be used for more than one purpose, such as office and guest-room, or garage and

workshop? Smaller buildings use fewer resources and cost less to build. A reduction in floor space gives you the opportunity for greater quality.

2.5.2.2 Picture the building in years' time

How will the use change? With the help of technology, for example, many more people could work from home in the future – you could plan for a home office. Will the materials you have chosen last that long? Will they stay in fashion? By building a flexible home with durable materials, you will not face the costs of future repairs, alterations or even demolition. Allow your home to grow and develop as your household and your needs change.

2.5.2.3 Consult your project team

Involve the entire project team in the design: the owner, the architect/designer, the builder and sub-contractors. Are the things you want practical? How can you tune the design to minimize waste? What works and what do not? By involving everyone, problems can be solved early. The more innovative your design, the more important it is that everyone is empowered to contribute, to understand the objectives, and to avoid misunderstandings. Communication is the key to a successful development.

2.5.2.4 Research

Talk to many people, read books and trade magazines, and have a look on the internet. Find out about new practices and materials which may reduce wastage. Visit your local demolition yard – second-hand materials and components might offer better quality and character than new ones. Consult third parties, such as the Waitakere City Council. You need to keep up with the constant new developments to make the best informed decisions.

Source : (Waitakere City Council's Sustainable Home Guidelines, New Zealand)

2.5.3 During the design

2.5.3.1. Design buildings in harmony with their surroundings

Paying attention to waste potential in the building's design stage can lead to less waste on the site. Some issues to consider in the design phase of a building are:

- Optimize building dimensions to correspond to standard lumber dimensions.
- Modify framing details to optimize lumber use and reduce waste and costs when ordering.
- Develop framing layouts to avoid waste and costs when ordering lumber.
- Order drywall in optimal dimensions to minimize cut-off waste. Drywall is available in different lengths, and designed dimensions should correspond to standard sizes.
- Minimize the number of blueprints and reproductions necessary during the design and construction.
- When remodeling, evaluate if salvaging used lumber is possible.

Plan the building to reduce vegetation clearing and earthworks. Reduce driveway length and paved surfaces. Consider piles or poles – especially on sloping sites - to avoid excessive excavations. Reduced disturbance to the land reduces waste and resource use. It also reduces environmental damage and the cost of clearing - usually with expensive machinery.

2.5.3.2 Consider module sizes in the design

Design room-sizes to co-ordinate with the standard sizes of floor, roof and external cladding materials. In New Zealand many materials are sized as multiples of 600mm, because this is the maximum stud width – standard wall panels, for instance, are 1200mm wide by 2400 or 3000mm high. So if you design to a module of 300 or 600mm, fewer panels need to be cut, they're easier to fit, and there's lesser waste – the overall cost of a house can be reduced significantly. You can also arrange window and door spaces to co-ordinate with the layout of studs to eliminate the need for extra studs.

2.5.3.3 Service efficiency

Group wet areas, such as kitchens, laundries and bathrooms close together and place the hot water cylinder, solar collector, or hot water heat pump centrally in this group. Reduced pipework lengths and sharing of gulley traps, etc, result in major savings. You can also work out efficient circuits for electrical and telephone cabling.

2.5.3.4 Use pre-fabricated and pre-cut components

Wall framing and roof trusses can be pre-cut, pre-nailed, and delivered as a correctly sized unit ready to be installed. Construction is faster, no waste is generated on site, and resource use is more efficient at the factory compared with a building site, where off-cuts are often dumped or burnt.

2.5.3.5 Less is more

Design for simplicity and user-friendliness. Find low-technology solutions. Options which require certain occupant behavior or even training should be avoided. These solutions are much less likely to break down or require maintenance; and will be simpler to use.

They also cost less and use fewer resources. People might not behave how you expect them to and the occupants will change over time.

2.5.3.6 Use fewer finishes

Use materials which do not need finishes applied to them. Examples are natural wood ceilings, bricks and tiles, pigmented and densified concrete or plaster, or roofing steel with the color baked on at the mill. Fewer materials are used and less work is required finishing. Materials that don't require finishes don't require maintenance later on either. Reducing finishes can also mean fewer health and environmental risks.

2.5.3.7 Consult and plan well

Take all the time you need to plan the project carefully. Talk the design through with your project team and ask them to find ways that use fewer materials and produce less waste. Estimate what wastes will be produced for your project and develop a Construction Waste Management Plan. Estimate the types and quantities of waste the project will generate and determine a schedule of when the wastes will be developed.

- Work with all suppliers to reduce waste on a project by asking them to buy back unused product.

Ask suppliers to deliver supplies using sturdy, returnable pallets and containers. Then have the suppliers pick up the empty containers when delivering new building materials.

- Ascertain if storage and handling practices prevent loss from weather and other means and make revisions as needed.

The conventional separation of design and construction is the biggest barrier to waste reduction. A good way to avoid this is to have an intensive brain-storming meeting with all parties involved. Eco-friendly building takes time. Time invested in the planning stage will be paid back during the construction and lifetime of the building. Making changes during or after construction can be very costly.

2.5.3.8 Document your design

Keep records of the design, including all details. This needs to continue throughout the building process. Where are the water pipes, studs, electrical cables? How much insulation is there, and what type was installed? By whom? When? This “house-book” should stay with the house when ownership changes to make future repairs and maintenance easier and should contain all the appliance guarantees. Less waste is created trying to locate leaking pipes or faulty cables, your consumer guarantee is more enforceable if defects can be identified accurately, and alterations and extensions can be planned more cost effectively. It also means that potential buyers know what they are buying. The asking price can be increased if extra features, such as good insulation, were fitted and well documented.

2.5.3.9 Design for the future

Use durable, low maintenance materials. Design houses to make alterations and repairs easy through good access. Choose materials and components that can be re-used and install them in a way that allows disassembly – use screws instead of nails. People’s needs change, but buildings which can adapt and are durable will be valued for a long time.

2.5.3.10 Design for green living

Design homes in a way that will make 'green' living easy. Allow space in the kitchen for the separation of recyclables, paper, compostable material, and refuse, and provide room for a compost pile or a worm farm. The way buildings are designed influences the lives of their occupants.

Source; Seattle/King -2001, County Contractors' Guide to Preventing Waste and Recycling

2.5.4 During Contract Signing

2.5.4.1 Dealing the waste minimization at contract signing stage

Negotiate waste minimization issues before contracts are signed - re-negotiation of contracts later often results in additional costs. If you don't feel that the person understands what you are talking about, find someone who does. One session of briefing all interested bidders can save you time and ensures that all parties have understood the issues. Ask contractors to supply a construction waste management plan with their bid. Use the REBRI tools to assist this process and let prospective contractors know that these tools are available.

2.5.4.2 Getting involved the stake holders

Ask your contractors for advice about the maintenance of the building. This information should go into the "house-book" with their information and guarantees on the work undertaken. Good contractors have the expertise to provide this information and take pride in their work. Their maintenance advice will help to increase the life-span of the building and assist financial planning for replacement. Guarantees and documentation of their work will assist you and future owners.

2.5.4.3 The costs and benefits

It is important to cost out waste minimization options to ensure you are gaining maximum benefit for your efforts. There might be additional costs because of more time spent on the project. Who will carry these? There will also be benefits from the reduction in material waste. Who will benefit, and can these savings be accounted for? These issues should be sorted out before contracts are signed. However, some flexibility is needed because it is a complex, collaborative process and miscalculations may occur. Unless you know what the costs and benefits are, you will never know if the new methods are viable and who gains the benefits.

Source: (Waitakere City Council's Sustainable Home Guidelines, New Zealand)

2.5.5 During Construction

2.5.5.1 Keep the building site tidy

Make sure that the building site is kept tidy. There should be a suitable area to store materials – covered if possible. Waste should be separated and recycled or, better still, reused. You could ask suppliers to take packaging back – it is preferable to avoid waste in the first place rather than have to recycle it. Think about your contractors: your site will be their workplace.

A tidy site is good for a builder's image – it also means that materials are less likely to be damaged or lost. It's also safer, because workers are less likely to trip over things.

2.5.5.2. Central cutting areas

If possible, materials should be cut and their off-cuts stored at a central location. It is much easier to re-use off-cuts if you don't have to hunt for them all over the site. This simple technique can reduce waste by 15%.

2.5.5.3 Reuse temporary works

Temporary works, such as formwork for concrete or scaffolding, should be reused. By selecting more durable materials, such as metal, waste can be avoided. This is particularly useful when building several identical houses. This also includes reusing packaging. Reusable crates are better than plastic or cardboard wrapping.

2.5.5.4. Ordering materials

Estimate materials correctly and arrange for them to arrive just in time. Materials are often wasted because they are damaged during storage. Do not plan for 10% wastage – if you over order there is no incentive for the contractor to use resources efficiently. Tell your suppliers that you are keen to reduce waste and ask them not to over-package materials. If you ask suppliers to provide less packaging they will eventually do it through customer demand.

2.5.5.5 Waste management

Ask your waste contractor if they will provide a discount if waste materials are pre-sorted for individual collection. Some contractors may supply several small bins to make sorting easier. Another option may be to use a company that sorts waste after collection and on sells recyclable and re-usable materials.

2.5.5.6 Documentation

It is important that work is documented 'as built' in the 'house-book', with special attention to those details changed from the original plans. Ask contractors to complete the Resource Efficiency in the Building and Related Industries .REBRI waste transfer forms and take photos of the site.

- Keep accurate project records of the costs and savings associated with Waste Prevention. Provide the information to the building owner and, if possible, estimate the cost savings and the corresponding environmental impacts.
- Develop a list of suppliers and recycling contacts for easy reference and use in future projects.

2.5.5.7 Learn from the experience

Visit the building site and ask contractors how they are getting on. Find out what worked well and what didn't. Have a look in the skip to see what materials are being wasted and why. You could do a waste audit, either by separating all wastes into different categories and weighing them, or doing a visual estimate of the percentages of different categories in the skip, to show exactly what is being thrown away. How much money have you saved by reducing waste? Was it worth it? What did you learn? Can you pass on the experience to others?

Source : (Waitakere City Council's Sustainable Home Guidelines, New Zealand)

2.6 Construction Management Professional and the role in minimization of building material waste

Construction Management Professional refers to a project management team consisting of a professional construction manager and other participants; such as; **program management, scheduling, estimate preparation, budget and resource control, Contract administration; that will carry out the tasks of project planning, design and construction in an integrated manner.** Some literature classified construction management professional into pre- construction and construction period professionals team. Contractual relationships among members of the team are intended to minimize adversarial relationships and contribute to greater response within the management group. A professional construction manager is a firm specialized in the practice of professional construction management which includes:

- Toil with owner and the A/E firms from the beginning and make recommendations on design improvements, construction technology, schedules and construction economy.
- Propose design and construction alternatives if appropriate, and analyze the effects of the alternatives on the project cost and schedule.
- Monitor subsequent development of the project in order that these targets are not exceeded without the knowledge of the owner.
- Coordinate procurement of material and equipment and the work of all construction contractors, and monthly payments to contractors, changes, claims and inspection for conforming design requirements.
- Perform other project related services as required by owners.

Professional construction management is usually used when a project is very large or complex. The organizational features that are characteristics of mega-projects can be summarized as follows:

- The overall organizational approach for the project will change as the project advances. The “functional” organization may change to a “matrix” which may change to a “project” organization (not necessarily in this order).
- Within the overall organization, there will probably be functional, project, and matrix sub organizations all at the same time. This feature greatly complicates the theory and the practice of management, yet is essential for overall cost effectiveness.
- Successful giant, complex organizations usually have a strong matrix-type sub organization at the level where basic cost and schedule control responsibility is assigned. This sub organization is referred to as a “cost center” or as a “project” and is headed by a project manager. The cost center matrix may have participants assigned from many different functional groups. In turn, these functional groups may have technical reporting responsibilities to several different and higher tiers in the organization. The key to a cost effective effort is the development of this project sub organization into a single team under the leadership of a strong project manager.
- The extent to which decision-making will be centralized or decentralized is crucial to the organization of the mega-project.

Consequently, it is important to recognize the changing nature of the organizational structure as a project is carried out in various stages.

Best Management Practices how waste minimization management is accomplished, and to what extent, depends on specific project requirements and conditions. Several issues contribute to an overall waste minimization strategy.

Material waste management should be an integral part of a project's development. Each of the principal project participants—the Owner, their Architectural and Engineering (A/E) services (or Construction Management consultant), the Contractor, and Subcontractors—will engage in waste minimization management to some degree throughout the project. Initially, the Owner and their A/E must establish waste reduction goals and define what levels of minimization strategies are achievable and reasonable under the project's conditions.

The Contractor is responsible for the means, methods, techniques, sequences, and procedures of construction, which include waste minimization & disposal methods. However, the A/E's design team can contribute to waste reduction in several ways. These include:

- Performing multiple functions with one material rather than requiring multiple materials to perform one function. Design to optimize systems' and components' use. Avoid extraneous materials that do not contribute to function.
- Being efficient in area and volume. If less material is required by the design, less waste is generated at the jobsite.
- Observing standard material and product dimensions. Locate features "on module" to the extent possible to reduce cutting and special fitting, which creates scrap.
- Where possible; select construction systems that do not require temporary support, shoring, construction aids, or other materials that will be disposed of as debris during the project.
- Where possible, select materials that do not rely on adhesives, which require containers and create residue and packaging waste. Furthermore, adhesives inhibit salvage and recycling at the end of the component's or building's life.

- Where possible, reduce requirements for applied finishes, laminates, coatings, adhesives, and the associated scrap, packaging, and waste. Select materials with integral finishes.
- Where possible, avoid materials which are sensitive to damage, contamination, environmental exposure, or spoilage on-site, which increase the potential for jobsite waste.

The Owner and their A/E (or CM consultant) must determine how their waste management requirements to minimize waste will be represented in the contract documents and incorporated into the project. Several provisions are relevant to the project's overall waste reduction performance. There are essentially three ways to represent waste reduction requirements in the contract documents.

- Describe the waste reduction goals and rely on the Contractor's own initiative to achieve them. This may be effective if the Owner and Contractor share a good working relationship, and encouraging the Contractor is sufficient for them to "do the right thing."
- Specify definitive minimum waste and debris diversion criteria. This is commonly incorporated into the Demolition specification as a numerical criterion, such as "divert from landfill disposal a minimum of 75% of the non-hazardous construction waste generated at the jobsite."
- Develop incentives to reward the Contractor. This may be implemented as an award-type incentive based on the diversion rate, or by including Options in the Bid Schedule for each of several ranges of diversion rates.
- Describe the waste reduction goals and rely on the Contractor's own initiative to achieve them. This may be effective if the Owner and Contractor share a good

working relationship, and encouraging the Contractor is sufficient for them to "do the right thing."

Murphree et al. (1994) divides the role of construction management professional in materials management to minimize waste in to two as' Pre-construction and Construction site people. List of construction professional and stakeholders who are involved before and after the materials arrive on site and the roles they play in effective materials management are given in Table 11

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction The Case of Addis Ababa

Table 11: Rthlt219 Pie-construction professionals involved in materials management
(Adapted from Murphree et al.1994)

Team Member	Role in Materials Management to Minimize Wastage
Architect	<p>Designs for best use of standard sizes,</p> <p>Designs for multible applications and for their recyclability</p>
Engineer	<p>Ensures appropriate structural component dimensions, quality and spacing fur use of standard fasteners and materials for multiple applications and recyclability</p> <p>Specifies materials with recycled content and from renewable resources</p>
Estimator	<p>Uses latest materials takeoff technologies and exercises accuracy in estimates</p> <p>Reviews actual waste generation data and updates actual waste factors regularly.</p>
Purchaser	<p>Plans purchases and deliveries to reduce surplus and to balance Materials maintenance during on – site Storage versus Transportation energy consumption</p>

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction The Case of Addis Ababa

Table 12: Construction site professional involved in materials management (Adapted from Murphree et.al.1994)

Team Member	Role in Materials Management to Minimize Wastage
Site construction management	<p>Applies the materials management plan to the site and oversees its implementation.</p> <p>Takes into consideration physical space available and ensures subcontractors are familiar with and committed to the plan.</p>
Site material manager	<p>Keeps track of new materials, cuts and used materials</p> <p>Organizes and stores them for availability by the various trades throughout the project in accordance with the materials management plan.</p>
Subcontractor management	<p>Communicates with site management and materials Manager regarding the types of materials they may be able to use for various purposes, even if temporarily.</p> <p>Ensures trades follow the Plan's practices</p>
Trade workers	<p>Use materials properly</p> <p>Store new materials properly</p> <p>Handle and cut them careful Is for maximum use and minimum waste.</p> <p>Consider using cuts before new pieces.</p>

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction The Case of Addis Ababa

Although people like suppliers, haulers and recyclers not employed by the owner, contractor or subcontractor, they are considered to be part of the materials management team and have a role to play in the successful reduction of material wastage and optimum utilization of materials.

Table 13:Off-Site professional involved in the materials management (Adapted from Murpheree et.al.1994)

Team Member	Role in Materials Management to Minimize Wastage
Suppliers	Use recyclable packaging and returnable containers and pallets, and accept the returned containers and pallets or informs the site of others who will accept them
Recyclers and Haulers	Provide containers for convenient materials storage and retrieval if appropriate Instruct the site personnel in separation and quality requirements.

PART 3 - RESEARCH METHODOLOGY

3.1 Population

According to the data obtained from Central Statistics Agency, 5400 commercial and non-commercial buildings have obtained building permits over the period 2004/05 - 2007/08, of which the number of commercial buildings accounts for only 12.22% or 660 buildings.

The number of buildings which received permits increased from 373 buildings in 2004/05 to 3947 buildings in 2005/06 but drastically dropped to 546 and 534 buildings in 2006/07 and 2007/08, respectively. The decrease in issuance of building permits is attributed to the shortage of building materials and unaffordability of their prices. In any case, this situation shows what the building supply position looks like and measures should be taken to minimize the material waste so as to reduce the building project costs.

3.2 Building Permits in Addis Ababa by Type of Multi-Stories Building and Service Type (Table 14)

No. of Stories	2004/05			2005/06			2006/07			2007/08		
	Non Commercial Building	Commercial Building	Total	Non Commercial Building	Commercial Building	Total	Non Commercial Building	Commercial Building	Total	Non Commercial Building	Commercial Building	Total
1 st	68	18	86	938	122	1060	85	5	90	74	5	79
2 nd	48	5	53	868	33	901	45	-	45	42	1	43
3 rd	44	8	52	598	33	631	77	3	80	91	2	93
4 th	18	5	23	290	34	324	55	2	57	55	5	60
5 th	56	31	87	401	135	536	105	5	110	109	11	120
6 th	12	10	22	126	58	184	32	3	35	44	8	52
7 th	9	8	17	52	37	89	9	-	9	18	-	18
8 th	8	3	11	43	24	67	6	4	10	10	2	12
9 th	8	1	9	38	31	69	8	1	-	18	3	21
10 th	4	2	6	30	8	38	6	-	6	16	-	16
11 th	2	-	2	8	6	14	3	1	4	3	-	3
12 th	2	-	2	6	-	6	1	-	1	5	-	5
13 th	1	2	3	9	7	16	6	-	6	2	-	2
14 th	-	-	-	-	4	4	-	1	1	3	-	3
14 th +	-	-	-	7	1	8	3	-	3	7	-	7
Unspecified story	-	-	-	-	-	-	76	4	80	-	-	-
Total	280	93	373	3414	533	3947	517	29	546	497	37	534

Source: - CSA Statistical Abstracts

3.3 Sample size determination

In line with other identification criteria; sample size determination formula was in use.

Successively;

- ✓ Year of permit obtained , in the year 2006
- ✓ Type and rise of building; 7 and above stories
- ✓ Completion statuses; 60% and above

Accordingly; we took the 7th and above stories commercial building projects that the building permit obtained in the year 2006/07. After getting building permits; tendering, bid evaluation, bid award, contract signing, site handover and mobilization will followed. In the context of Addis Ababa these processes will take not less than a year time. The construction trends in the city shows that; the civil works will take more than three years for high rising buildings. Therefore; we have been convinced that taking buildings projects which building permits obtained in the year 2006/07 are in the appropriate stage to observe and measure the level of material wastage. We have used appropriate formulas derived by C.R.KOTHARI, Former Principal, College of Commerce University of Rajasthan, Jaipur (India) in the determination of sample based on the population data shown in the **table 14**;

$$n = \frac{Z^2 p q N}{e^2 (N-1) + Z^2 p q}$$

Where

n= sample size required

N= number of building in the population (29)

Z= level of confidence consider 65% and the reading result taken from the

Z chart 0.39

pq= degree of variability both taken 50%

e = sampling error which shows precision taken 7%

Therefore;

$$n = \frac{0.39^2 \times 50\% \times 50\% \times 29}{0.07^2 \times (29-1) + 0.39^2 \times 50\% \times 50\%}$$

$$\underline{n = 6}$$

3.4 Selected Sample Projects

Based on the sampling method and criteria cited above we have selected six commercial building projects in Addis Ababa which has 7 stories and above buildings with the completion status of 60 % and above.

3.5 Archive Review

As it has been defined material wastage in building construction; the difference in quantity between the estimated material delivered and the actual quantity used for the execution of the building elements. Therefore we have referred documents such as purchase order referred to the respective projects available in the constructions site; delivery reports and/or standard material break down with respect to the actual measurement or payment certificate.

3.6 Questionnaire Survey and Interviews

The survey has been conducted on selected projects constructors, consultants and building construction management professionals. The purpose of the survey was to identify the existence, extent, causes and effect of material wastage in private commercial building.

Interviews are one of the ways which we have used in this research to collect data from contractors and consultants through conversations on some selected details. The researchers use open questions.

To be able to survey, and ask questions that can clarify the subject associated with wastage of materials in building construction, semi-structured (non-standardized)

interviews have been used on some selected issues that require further clarification on the questionnaire from construction stakeholders.

3.8 Observation

We have made sites visit and take sample measurement of the actual execution with regard to the planed quantity so as to identify the extent of material wastage. We have taken the variables that are cited in the literature review to measure the % of wastage Of material waste in those selected commercial building projects. We have also able to see debris and landfill from material waste generated in the project site.

3.9 Respondents Composition

Professionals participated in the questionnaire and interview were; Project Manager, Resident Engineer, Office Engineer/Quantity Surveyor, General Forman and Store Admin/Storekeeper. All respondents have a direct involvement in the building construction and management.

3.10 Research Analysis and Findings

Observation, interview, document review and questionnaires responded by the respondents were gathered ,compiled and sorted towards putting the data into quantitative form All relevant data were then be translated into tables, charts or graphs and summarized, analyzed and concluded.

The questionnaire was formatted to properly address the research question; as the research question directed to explore to attain the main objective of the research. Prior to other inquiry we believed that it is important testing the agreement of the respondents

with regard to the existence of material waste in the building construction in their respective projects. Subsequently the other question deal with the extent of material waste followed by cause to generate waste in the project site. The extent is compared to the value of wastage allowance in the cost estimate based on the variables indicated in the literature review. Identification of the cause was measured in accordance with the parameter set in the questionnaire.

The impact of the material wastage of the construction projects are also considered in the questionnaire. Finally we have incorporated the question that can touch the role of construction management professional in minimizing waste in building construction.

In order to address the issues properly; the questionnaire holds precise and reasonable number of questions. We have tried to weight questions being adequate to address the issues without creating inconvenience to the respondents.

There are two methods; qualitative and quantitative; to analyze data collected based on the research requirements. (Maxwell and Loomise, 2002 cited in Dunna and Burela). Each method has its own premises and often used to address a data collected through an interview and questionnaire. The research has engaged inductive as the study is focused on specific case; consequently using qualitative method would be appropriate. The questionnaire has been designed considering the result would be analyzed quantitatively.

Primarily the data collected were segregated to answer research question and then categorized under different variables to represent the result of the research objectives. Among different statically analyzing method; descriptive statistics method has employed. Accordingly, frequency distribution and relative weight were used to assign the data into categories and determine the number of response belonging to each category, which were presented in the form of table.

PART 4 – ANALYSIS RESULT AND DISCUSSION

4.1 Material Wastage in Building Construction in Case of Addis Ababa

As it has been said the case of Addis Ababa construction practice can portrait the construction situation in Ethiopia at large. From the result of analysis we have been convinced that our wastage norms are similar with that of the developing country. Through questionnaire, sties visits/ and observation have employed using variables which viewed in the literature; we came up with the understanding of the existence o of material wastage and the extent is extensive magnitude that need series attention. Accordingly, the first question that the respondents were asked is whether they agree or not about the existence of materials waste in building construction and more than 99% of the respondent have agreed up on the existence.



Figure 1 Ceramic tiles wastage in the construction site.

Figure 1 is taken from Addis Ababa building project and portrait material wastage generated in the construction sites from ceramic tiles. One can easily observe the level of material waste is getting worsen in the construction project site.

Subsequent questions structured in such a way that to detect the extent of the waste, cause, effect and the role of the construction management professional in minimizing. The responses frequency of the questionnaire was very good and out of the respondent who received the questionnaire 83% were responded satisfactorily. We have tried to simplify and easy to responded. The observations we have made on sites were substantial to ascertain the existent and the extent of building material wastage.

The construction practices in the sites which we have visited still are labor intensive and constructed by the conventional cast in situ method with the use of scaffolding .Even though labor intensive project is economical but it is subjected to material wastage as the precision highly depend on the level of the work force skill.



Figure 2 This Figure poor work man ship that cuase bulged out beam & over sized thinkness of plastering.

4.2 Existence and Extent of Material Wastage in Building Construction

Prior to the proceeding to depict the extent of material wastage in building construction sites which we have selected and dispatched questionnaire subsequent with interview to get clarification; we have raised inquiry on the existence of material waste on respective sites to the respondents. The result analyzed and found to be as follow; Figure 3.

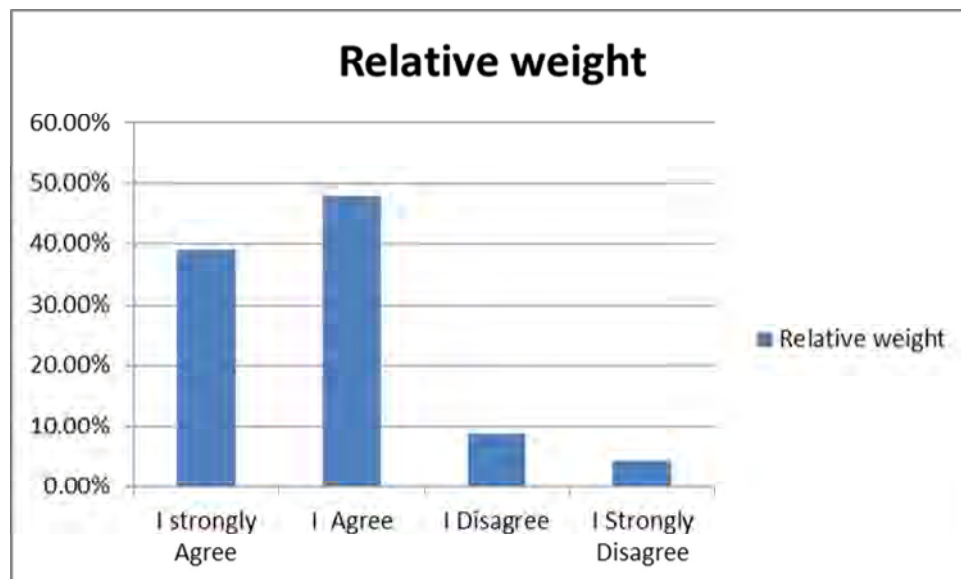


Figure 3: Relative weight of respondent who agreed the existence of material wastage

As it possible to observe from the figure more than 86% of the construction professionals are aware of material wastage or at least sense the occurrence. Above

50% of the respondent have confirmed that they consider 5% wastage for most of the materials such as HCB, Sand, Cements, and Ceramics and steel to compute the required material quantity for purchase. From the analysis, interview and observation we came to realize that; Hollow Concrete Block, Steel, Ceramic building materials and External Plastering works are relatively subjected to high level of material wastage.



Figure 4: This figure shows the extent of HCB wastage in the site

This picture has been taken from Addis Aababa and illustrate the extent of wastage in hollow concrete block partly. This is also comprehended in the site visit and observation that one of highly exposed material to wastage. Operational error found to be the causes for the generation of material wastage. Figure 5 indicate this problem partly.



Figure 5: which shows operational error

In our observation in the sites external plastering is relatively exposed to wastage for high rising building. In the interview we made to the construction professional; why the external plastering relatively exposed to wastage? The reason behind is the question of safety as the plasterer scared while there is no protection on the scaffolding.

From the observation, assessment of archives, questionnaires and interviews we have tried to measure the extent of material wastage in those projects. The measurements have taken for the work items of block works, plastering ,concrete and ceramic in particular .We have limited to those building materials as of the construction stages where the projects reached. The other variables are collected data from the sites using the methods mentioned and analyzed.

Table 15: Extent of material wastage found from the observation, assessment of archives, questionnaires and interviews in those projects.

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction The Case of Addis Ababa

Construction Materials	Planned Qty	Actual Qty	Difference	Wastage by weight %
HCB	36660 pcs	40070 pcs	3410 pcs	9.3
Cement in Block works	228 Qt	261 Qt	33Qt	14.5
Sand in block works	112m ³	129m ³	17m ³	15.2
Cement in plastering external	497 Qt	574.5Qt	77.5Qt	15
Sand in plating	124 Qt	145Qt	21Qt	16.67
Ceramics	13,000 pcs	14808 Pcs	1808 Pcs	13.91
Steel in C-25 concrete	2530 Qt	2909Qt	379Qt	15
Cement in C-25 concrete	100 Qt	105 Qt	5 Qt	5
Sand in C-25 concrete	187 m ³	197 Qt	10m ³	5.5
Coarse aggregate in C-25 concrete	270m ³	283.8m ³	13.8m ³	5.12

Table 16: portrait the extent of material waste in building construction in those selected sample projects and believed that can show the case of Addis Ababa. As it can be seen from the table; block works particularly HCB wall, external wall, steel and ceramic tiles are relatively the most vulnerable to wastage and high. It is understandable these relative weights may vary from the nature and management efficiency of the project; but it will not be too far from these figures as indicated in the literature review.

In the case of Brazil as indicated from page 17 to 19; the extent of material wastage is almost similar with ours. Let us take these five construction materials such as; HCB, Steel, Cement, Sand and Ceramic to analyze the extent comparatively in table form.

Table 16:- Data obtained from the analysis compared with the literature review variables

Item No.	construction Materials	In the case of Brazil Relative Weight %	In Case of Addis Abab Relative Weight %
1	Blocks HCB	10	9.3
2	Cement	15	15
3	Steel	20	15
4	Ceramics	7	13
5	Sand	15	16.67

4.3 Causes of Material Wastage in Building Construction

Many researchers categorized factors that cause material wastage in the building construction sites in many ways. In this research paper we took the classification arranged in to five sections. Such as Design, Procurements, Material handling, Operational and Residual. In addition to these types of sub-contracting has its own impact on the waste generation. That is to say; sub – contracting in form of direct labor, labor only and labor with material have their own extent of material waste generation.

Questionnaires were designed in such a way that to measure the level of their contribution to material waste generation in the construction sites. Figure 6 shows the relative weight of the respondent asked to respond their agreement to the existence of material wastage in their respective projects.

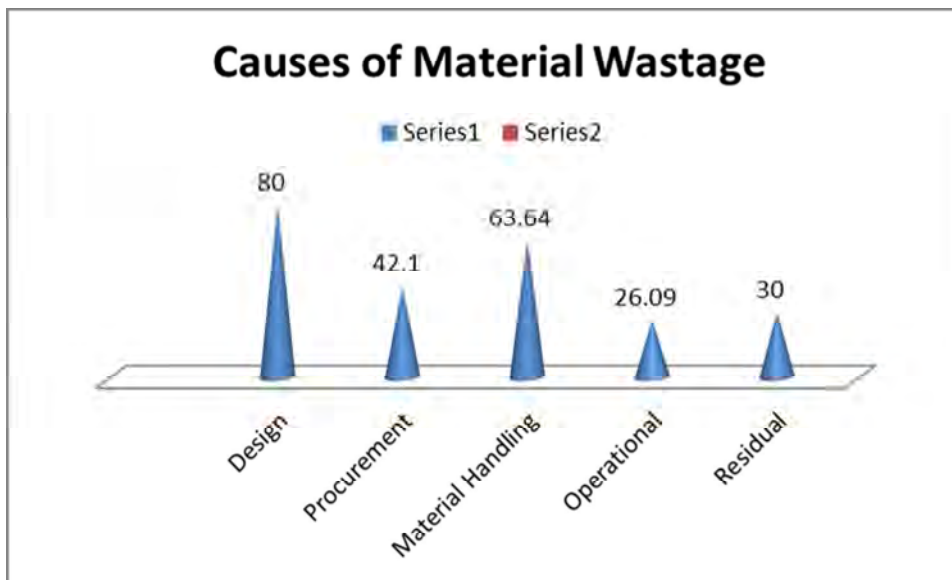


Figure 6

The question raised to the respondent was which factor contributes much to the generation of material waste in the building construction sites. The chart above shows the respondent relative weight. The respondents have responded in such a way that Design is taking the lead and Material handling followed being the factor to cause waste generation. In the questionnaire each factors that cause material wastage have comprise various variables.

Design:, The term design comprise design change, incomplete contract document, errors in design and lack of details. 80 % respondents have agreed that those can factor could be a cause for material wastage.

Procurement: under this category material ordering error, over ordering and supply error, are grouped and 42.1% of the respondents are convinced this could be the case for the material wastage.

Material Handling: Damage during transport, inappropriate storage, criminal- waste due to damage or theft and lack of waste management plan are grouped under this category and 63.64 % of the respondents affirmed this could be the most cause of material wastage.

Operational: Error by workmen, equipment inclement weather, accident and use of incorrect material requiring replacement and 26.09 % respondent agreed this could the most factors for material wastage.

Residual: Trim losses from cutting material to required lengths, conversion waste from cutting uneconomical shapes, and waste from application process and 30 % of the respondents have agreed this could the most cause for the material wastage.

Sub-contracting: One of the other factors that can be a cause for material wastage is the type of sub- contracting. The respondent have asked which type of subcontracting arrangement is mostly cause material wastage among ; direct labor, labor only and labor with material.77.27 % of the respondents have confirmed that labor only arrangement of sub- contracting is the mostly cause material wastage as shown in the figure 7.

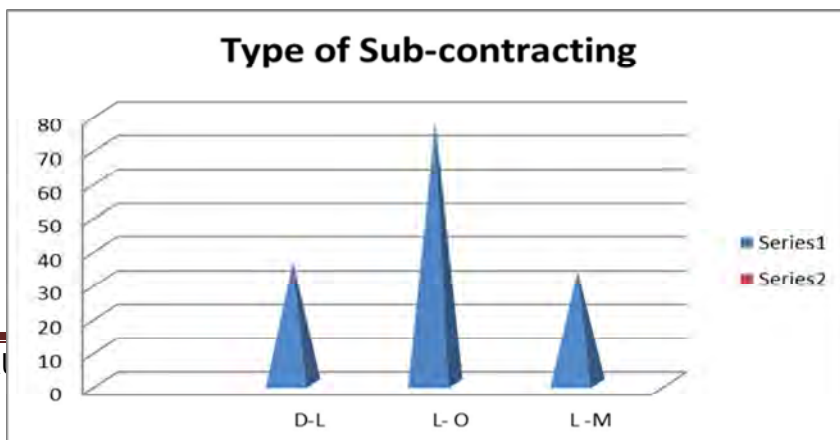


Figure 7

We have also observed in the site visit that material handling contribution to the generation of waste in the construct site is significant. The figure 8 is portraying the negligence in material handling as an example. The picture taken one of the project in Addis Ababa how they store hollow concrete blocks.



Figure 8: poor material handling

In the interview and sites visits we have made the following relevant points were reflected;

- The inadequacy of space for mobilization and work follow is contributing a lot for material wastage in the project sites.

- We observed dimensioning problem for window height that can take as a case. The height of the window is set to be 1meter and the building has a number of windows and wall is with HCB. If we compute the number of HCB per height it will be between 5 and 6pcs considering the joints. Therefore will be forced to break the HCB into half. One can imagine the extent of material wastage occurred. But if the height of window could have been 1.1meter considering the standard of the materials this wastage easily be avoided and the material could be saved.
- Based on the result obtained from the data analysis becoming curious we have made interview consulting and design office what consideration do they take to minimize material waste during design? In their response; door size, precast element governs but other than these design governs in determination of the dimensions.

4.4 Effect of Material Wastage in Building Construction

The construction sector is one the huge sector which consume lion share of the counties budge. Currently in Addis Ababa in every corner various constructions are under way specially building construction. Commercial buildings in the city are high rising and relatively the project costs are huge. The projects are located in the down town with limited spaces. The economic impacts caused by the material wastage are so extensive in two standpoints. To analyze the case we have taken the cost estimate and bill of quantity of the project among the six projects we have visited. As shown in the figure the net economic effect of the material wastage is 6.89 % of the project cost. Accordingly 6.89% material wastage can be saved so as the construction cost reduced with this percentage.

Table 17: Computation of the net effect of material wastage on the project

Construction Materials	Wastage by weight %	Material pre- output in line with Proj.Cost	Net effect by weight
HCB	9.3	0.0231	0.22
Cement in Block works	14.5	0.0033	0.05
Sand in block works	15.2	0.0011	0.02
Cement in plastering	15	0.0200	0.30
Sand in platering	16.67	0.0072	0.12
Ceramics	13.91	0.0424	0.59
Steel in C-25 concrete	15	0.3690	5.54
Cement in C-25 concrete	5	0.0088	0.04
Sand in C-25 concrete	5.5	0.0019	0.01
Coasre aggregate in C-25 concrete	5.12	0.0019	0.01
Total total net effect			6.89

In addition to this the hauling cost is very high as it has been said above; most of commercial building located in the down town and the area reserved for cart way is far from the project sites. Not only theses; it has also an impact for the delay of the project. In line with these the environmental socio economic impacts are unforgettable

4.5 The Role of Construction Management Professional in Minimizing Material wastage

The construction project required integrated effort of various constructions professional from the inception to the execution. As indicated in the literature review (Murphree et.al.1994); classified Construction management Professional in to pre – construction and construction stage professionals. As it has been described in the 4.5 section; even

though the wastage generated observed in construction sites the cause for the genesis of material wastage begin at pre-construction stage and goes to the construction stage. Therefore the roles of construction professionals are very decisive in minimization of material wastage in building construction projects.

From the questionnaire, interview and observation we have realize that construction management professional are aware of the existence of material waste in building construction. Subsequently the respondents have asked whether Structural and Architectural designer take consideration of standard material sizes or modular design to minimized material wastage. 12.5% and 62.5% respectively, shows sometimes they do take consideration. In the same token other question forwarded to the respondents whether Construction professionals do take measurements and monitor material wastage in the construction material wastage in the construction sites. The response shows that only 25% do take measurements and monitor. This gives a clue that a lot has to be done to enhance the role of Construction Management Professionals to minimize material wastage in the building construction projects. Even those who claimed that they are aware of the occurrence of material wastage; we couldn't observe their effort towards material waste minimization in our assessment.

PART 5 - CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

As it has been said in the first chapter the objectives of this thesis are to identify the building materials wastage in the construction sites, to vividly comprehend the extent of material wastage in building construction, to show the causes and effects of the material wastage in building construction to come up with final recommendation how to minimize material wastage in building construction with respect to the role of construction management professional. Therefore we believed that all these objective properly in the body of the thesis.

The research methodology has been designed in such a way that to meet the objectives adequately. The research questions were design to properly address the main objectives of the thesis. From questionnaire, interview, observation and assessment the required data's were collected and analyzed. The result obtained discussed in depth and come up with the conclusions followed by the recommendation.

Conclusions

- One of the objectives of the research is to ascertain the existence material wastage in the building construction sties. In the result of the findings confirmed the existence of material sites in the case of Addis Ababa. This can also replicate the existence of material wastage in the Ethiopian context.
- In the final findings the extent of material wastage in building construction found to be 6.86 % with respect to the project cost and this amount of costs can be saved so as to reduce the construction cost by this extent.

- The causes for construction material wastage are classified into Design, Procurement, and Material handling, operational, residual and subcontracting.
- The top three for cause of material wastage found to be Design, material handling and procurements.
- The role of Construction Management Professional to minimize material wastage in the building construction projects found to decisive in the thesis findings. The awareness of construction management professional about the existent of material wastage is found to more than 86 %. This is encouraging but the problem is with efforts to minimize the waste. In this regard the effort which the professional undertaking is found to 25 % in the findings.

5.2 Recommendation

Based on the finding of this thesis ; various recommendation are given with regard to The Role of Construction Management Professional to minimize wastage of materials in building Projects; in the Case of Addis Ababa as follows.

A. Design

- Existing landscaping and contours should be used to avoid over excavation.
- Minimize waste by designing standard window, doors and ceiling heights and building dimensions. Simply building geometry.
- Design with standard sizes for all building materials. This avoids creating waste when standard sized materials are cut to unusual lengths.
- Design spaces to be flexible and adaptable to changing uses. This avoids creating waste during remodels.

- Avoid waste from structural over-design (Use optimum-value engineering/advance framing)
- Durable materials should be specified for the construction and finishes..
- Specify reusable or recyclable materials for hoarding, scaffolding and formwork.
- Adopt innovative technology like prefabrication and precast units when possible. It is the key to minimize waste from wet trade.
- Communications between the designer and contractor is important so that each realizes how the design decisions will effect on site operations and waste generation.
- Try to be involved early in a project to encourage designs that cause less waste to be created. Use standard sizes and quantities of materials, and plan ahead to reduce off cuts.
- Select a contractor with proven waste reduction experience. An experienced contractor will keep the bid the same or may even lower the bid. If the contractor is inexperienced, they may increase the bid.
- Use a Construction Waste Management Specification. A Construction Waste Management Specification written with legally enforceable language is your most effective tool to ensure waste reduction happens successfully on your project.

B. Operational

- Minimize rework from errors and poor workmanship

- Establish requirements for waste reduction. Begin with making waste reduction a priority from the start of the project and planning for it throughout all phases of design, construction, installation, and occupancy.
- Set goals. Set specific waste reduction goals for each project and assemble a team of qualified professionals experienced in environmentally sound design and construction practices. Include these goals and requirements for experience in requests for proposals and other contract documents. Identify materials that can be salvaged and reused.
- Monitor and support the program. Monitor the progress of waste reduction efforts by requiring contractors to submit the waste management plan and waste management progress reports. Support these efforts by identifying locations to collect and store recyclables on-site.
- Monitor the waste reduction program. The consultant play an important role in assuring the contractor's compliance with the waste reduction program by requiring and reviewing waste management progress reports and invoices from recycling and garbage haulers and recycling facilities.
- Monitor the success of the program and potential barriers by including a discussion about the waste reduction program during the project meetings.

C. Material Handling

- Preparing monthly materials re-conciliation statements should be made mandatory to all projects,
- Engineer-in-charge should be held responsible and accountable for preparation and submission of monthly re-conciliation statements.
- Ensure storage areas are safe, secure and weatherproof.

- Don't remove protective packaging from materials before they are needed

D. Procurement

- Avoid over-ordering.
- Arrange deliveries to match work stages, to avoid materials being stored on site longer than necessary.
- Don't accept poor quality or damaged deliveries.

E. Residual

- Collect off cuts and use first instead of new materials. Co-ordinate trades so left over materials from one can be used by another. Fix temporary materials (e.g. timber hoarding) so they can be dismantled and reused many times. If you can't reuse materials on the same project aim to use on others.

F. Sub-contracting

- In the selection of sub- contractor needs to consider their wastage reduction plan as part of assessment criteria
- Award of work on turnkey lump sum contracts or material and labor sub-contracting found to less material wastage norms. We recommend this in the sub-contracting employment.

In general the extent of material wastage in our findings in building construction projects need proper attention by the stakeholder and further research shall be conducted with different professionals. On top of this; Construction Profession associations have the duty of organizing workshops and seminars to create awareness to contractors and members of construction design team on the importance of material wastage minimizing in the building construction industries.

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7 - Appendices

- 7.1 Thesis Proposal
- 7.2 Questionnaire and Interview
- 7.3 Activities/trade of work/ observation form
- 7.4 Archive and Observation Manual

Interview and Questionnaire

Dear Messrs.'

We kindly request your participation and support in the research on "The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction" by responding the questionnaire . Any information you can provide would be greatly appreciated.

1. General Information

1.1 Objective

The objective of this research is to identify material wastage actuality, extent, cause & effect in commercial building construction in Addis Ababa and spectacle the role of construction management professional to minimize material wastage.

1.2 The Intention of the survey

The purpose of this survey is to obtain necessary data for the consumption of final thesis of BSc. degree in Construction Technology and Management at Addis Ababa University ;Ethiopian Institute of Architecture, Building Construction and City Development. All data's found from the survey will be confidential and only used for academic purpose.

For the purpose of this research "Material Wastage" is defined as;

... the difference in quantity of construction material delivered and used for the intended purpose. In line with this using excess construction material is also considered as a waste.

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The attached questionnaires are derived for the literature review and from the group observation on material wastage in construction sites. You can tick, write in words or rank when it is required on the space provided at your convenience to respond to the questionnaire.

The research will be conducted in group with three members as part requirement for the completion of BSc degree in the Construction & Management under the supervision of Dr. Ing. Wubishet Jekale / Ass. Prof./

The identity of the respondent shall be kept confidential. We would like to extend our gratitude for your helpfulness taking your precious time to respond to questionnaires.

If you have any inquiry please contact any of the group through the following addresses.

- Tedla Belachew
Mobile phone number: 251-911-235674
Email address: tedbela@yahoo.com

- Negatu Abera
Mobile Phone number: 251-920-203440
Email address: negatuabera@gmail.com / negatu_abera@yahoo.com

- Muluaem Merid /Wro/
Mobile phone number: 251-911-627268
Email address: Mamemerid@yahoo.com

1.3 Respondent Identification

Please provide the name of;

Your organization; -----

Your profession-----

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Your position -----

Activities / Trades of works /Form for observation

Item	Activities	Planned Qty	Actual Qty	Differnce
1	Block Work			
	HCB			
	Bricks			
	Cement			
	Sand			
2	Plastering			
	Cement			
	Sand			
3	Tiles			
	Cement			
	Sand			
	Ceramics			
	Pvc			
4	Concrete			
	Steel			
	Cement			
	Coase aggregate			

7.4 Archive & Observation

7.4.1 Archive Manual

- *Contact document*
- *Site records*
- *Payment certificate*
- *And other waste related documents of the respective projects shall be assessed*
- *The intent of assessments are to evaluate how much attention are given to material wastage control*
- *The obtained data will be evaluated to measure the extent of material wastage*

7.4.2 Observation Manual

- *Physical measurement shall be taken on construction sites*
- *Physical observation on the construction sites should done*
- *The observation is aimed on collecting data to measure the extent of material wastage on construction sites*

8. DECLARATION

We declare that this thesis entitled “**THE ROLE OF CONSTRUCTION MANAGEMENT PROFESSIONAL TO MINIMIZING MATERIAL WASTAGE IN BUILDING CONSTRUCTION PROJECTS IN THE CASE OF ADDIS ABABA.**” is our original Work to best of our knowledge, this thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree, and that all sources of material used for the thesis have been duly acknowledged.

.

Candidates:

Name: _____
Signature:

Name: _____
Signature

Name: _____
Signature

The Role of Construction Management Professional in Minimizing Wastage of Material in Building Construction The Case of Addis Ababa
