JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF BUILDING CONSTRUCTION MATERIAL WASTES: - A CASE OF BUILDING CONSTRUCTION PROJECTS IN SEBETA TOWN

A Thesis submitted to School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

By:

Meseret feyera Abdi

February, 2022

Jimma, Ethiopia

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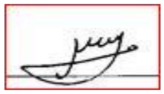
February, 2022

Jimma, Ethiopia

DECLARATION

I declare that this research entitled Assessment of Building Construction Material Wastes: - A Case of Building Construction Projects in Sebeta Town is my own work, and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere, and that all sources of materials utilized in this thesis have been properly acknowledged.

Meseret Feyera Abdi  10/2/2022

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As research Adviser, we hereby certify that, we have read and evaluated this thesis paper prepared under our guidance, by Meseret Feyera Abdi entitled Assessment of Building Construction Material Wastes: - A Case of Building Construction Projects in Sebeta Town and, recommend and would be accepted as a fulfilling requirement for the degree masters of science in construction engineering and management.

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Assessment of Building Construction Material Wastes: - A Case of Building Construction Projects in Sebeta Town

BY

MESERET FEYERA ABDI

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ABSTRACT

The construction material wastes include both the incidence of material losses and the execution of unnecessary works. These construction material wastes influences the project to consume additional material, costs and, produces losing of valuable land through filling with material wastes. Hence this research is aimed to investigate as well as ranked the material wastes causes, material waste minimization techniques and the possible critical actions for successfully minimizing construction material wastes in Sebeta town construction projects. The study uses both primary and secondary data and the research has covered a population of building construction which was under construction. The random sampling techniques were used for data collection. The data were analyzed and presented by using statistical package for social sciences (SPSS) and, ranked depending on the Relative Importance Index (RII) values. The questionnaires were designed, for causes of material wastes, for material waste minimization techniques implementation and for possible critical action needs for material waste control. As the result revealed that the major causes of material wastes are in the following orders: errors in contract documents (RII=0.846), complexities in design (RII=0.808), in correct quantity estimation (RII=0.814),over allowance RII=0.802). Others like, reusing concrete wastes for further work (RII=0.634) and, using concurrent engineering (RII=0.651) are those waste minimization techniques that are well employed within the project firms. However, design for standard material supplies (RII=0.500), using synergistic contractual arrangements for waste (RII=0.493), are those waste minimization techniques that are not well employed within the project firms. There is the availability of material wastes and, the efforts of project firms for focusing on construction waste minimization techniques were low. The construction project stakeholders should use material waste minimization specification and, low-waste technologies for construction material waste minimization and, should use synergistic contractual arrangements in contract documents for material waste minimization

Keywords: - *Building Construction, Construction material wastes, Sebeta town, Waste minimization,*

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ACRONYMS

CE	Concurrent Engineering
CII	Construction Industry Institute
CMP	Construction Management Plan
CPM	Critical Path Method
CPM	Construction Project Management
CSMP	Construction Site Management Practice
CWM	Construction Waste Management
H.C.B	Hollow Block Concrete
JIT	Just In Time
LC	Lean Construction
RII	Relative Importance Index
SPSS	Statistical Package for Social Science
VE	Value Engineering
WMP	Waste Management Plan
WRAP	Waste and Resource Action Program

CHAPTER ONE

INTRODUCTION

1.1.Background

The construction industry involves a significant values in the economy of the nation, and the accomplishments of the industry are also vigorous to the success of national socio-economic growth through providing shelter, infrastructure as well as, a construction industry is the complex industrial structure which compromises heterogeneous and fragment firms through containing the activities ranging from general building , civil engineering to material manufacturing ,property developments and trade organization as justified by Anaman .K. & Osei-Amponsah, C. (2007). In addition to this Oldinrim,T (2012) suggests that, the development of construction projects and infrastructure is very essential for boosting economic growth development. Likewise Thurnau .D (2013) stated that the construction industry contributes immensely to the development of any nation and brings benefits. similarly, it can produces immense amounts of wastes which needs responsibility for managing waste on a building construction project to make optimum use of the limited resources that can sustain the ongoing development of construction industry.

The construction work involve the activities like, preparation of sites for new construction, the building of new structures, rehabilitation, renovations, additions, alterations, maintenance, repair of buildings or engineering projects like building and utility systems which can produce wastes of material on the environment with regards to description of Behm.M (2008).

Ethiopia has a rich history of magnificent construction endeavors like the obelisks of Axum, the rock-hewn churches of lalibela and the castles of Gondar are a few examples of this expertise. With the adverse of modern civilization, particularly the Addis-Djibouti railway line is one example of the modern construction which is constructed in the past history of the country. Likewise during the Italian occupation of the 1930‟s there were some construction activities, particularly in the development of long truck roads. However after the Italian occupation of some modern construction from medium to small civil engineering projects and building projects were proceeded, as explained by Kahssay, (2003). Now a days the building industry in Ethiopia has been providing a extensive variety of buildings, like, high rise buildings ,schools ,hospitals

,factories and shopping centers, and has been carrying out many variety of engineering construction projects like, highways, hydro – electric dams and irrigation dams.

The construction material wastes includes both the occurrence of material losses and carrying out unnecessary work, which produces extra cost but does not increase value to the product which is stated by, Polat, G et al.(2004) this argument can support that additional unnecessary works such as excessive excavation can produce additional consumption of material which leads to be as material losses. The construction materials account for the largest input into construction activities in the range of 50-60% of the total cost of a project consumption as described by Ibn-Hamid, N.T.(2002). Likewise their the troubles of material cost fluctuation and market inflation in our country this construction material waste can produces the problem adding additional material consumption and cost increment to the construction projects.

The construction trade was contributing largely for socio-economic improvement of any country, is a major exploiter of natural non-renewable resources and whereby it subsidizes the environmental degradation through resource depletion, energy consumption air pollution and generation of waste in the acquisition of raw materials as stated by Watuka and Aligula, (2003).The other author also discussed that Waste sources during construction may be categorized into material procurement, material handling, operations, residual-related sources, and design-related as noticed by Ekanayaki.L.L. and Ofori,G. (2004).Accordingly Control of material is relatively a less practice in the construction industry. In the present situation, the contractors and the designers are mainly concerned on control costs without with less emphasis on waste control measures. Generally, it is real that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, critical control of materials on site together with good construction management is expected to decrease the cost of construction material projects and, materials wastage on site cannot be treated fully without good construction material management.

However the construction project is going on rapidly in Ethiopia there is the problem of understanding material waste causes and allocating the construction material waste minimization techniques with the industry. Although, several studies have suggested ineffective coordination of materials procurement process as a key cause of construction waste as clarified by Ajayi et al., (2017).Despite the fact that the design and construction strategies for minimizing construction waste, there have been fewer efforts to unravel materials procurement and logistic measures for mitigating waste minimization by construction activities. Even though the waste minimization consideration at the design stage and construction stages is essential for ordering the low waste formation material, through practicing modern method of construction material waste minimization techniques which is suitable for producing waste efficient project.

Accordingly the study was undertaken at the Oromia special zone surrounding Addis Ababa case of Sebeta town. Because of sebeta is one of the Oromia special zone surrounding Addis Ababa where different types of construction are going on and it is the economic hub places and located near to the capital city of the country. The province is the economic epicenter and there is always some construction work going on within the place. However the majority of building is ongoing with the province there is the occurrence of construction material wastes which needs to be minimized and, there is also fewer efforts with design and construction method, unravel materials procurement and logistic measures for mitigating material waste minimization by construction firms of the area. Material Waste minimization techniques involves any technique, process, or activity that avoids, eliminates, or reduces waste at its source or allows re-use or recycling of the waste as explained by yuan, (2013) Materials waste minimization involves assessing what steps could be employed to reduce the quantity and range of materials discarded. The minimization of materials wastage in construction is important because wastage will have a direct impact on the cost, time, and quality of a construction project. Generally this thesis is tries to assess construction material waste causes, material waste minimization techniques and possible significant critical action which can minimizes the construction material wastes .finally come up with suitable recommendation for material waste minimization techniques.

1.2. Statement of the problem

Building materials are viewed as the primary source for building activities, and without construction material there is no building construction project at all. More over Nagapan et al. (2012) pointed out that construction waste is a problem in many developing countries considering adverse effects on environment, economy and social aspects. Likewise building construction material are manufactured through utilizing natural resources extracted from the surrounding environment, requiring energy, manpower, and technology which means, economical cost. Therefore, any waste in construction materials implies waste in human effort and waste in natural resources, waste of valuable material and loose of nonrenewable resources. Likewise the material like concrete and its ingredient, ingredients for production of blocks are extracted from natural environment and its purchasing cost also expensive which needs high attention while using it to extend the availability of natural construction quarry for future construction project works. Similarly there is the wastages of material like reinforcement, tiles, pipes and timbers within the study area which is expensive and, needs hard currency for offering it.

The material wastes can decreases the productivity of construction project through exceeding the project costs. Similarly Similar to this Adewumi and Otali, (2013) suggests that construction material wastes contribute as high as 15% additional costs to construction projects. Moreover in our country there is the trends of damping the construction material waste to free spaces of lands which can produces the loose of valuable lands function and, destroying expensive land values. In addition to this there is the scarcity of landfills sites for material wastes, due to this the stake holders of the construction projects were affected by project cost increment for material waste dumping cost, additional transportation cost for dumping of material wastes to distances and, there is the problem of additional cost fee for communities (compensation) for using land fill sites for material wastes dumping places. Likewise there is the difficulty of reusing the land which is filled by material wastes for further function because of its health hazards of the places and unsuitability of the place for another function and which needs other land treatments methods for reusing of the land which is filled by construction material wastes. Similarly Fewster and Hearkeness, (2013) states that reuse options for landfill sites will be limited due to potential health hazards of the places.

Generally now days such construction material wastes are producing the problem like losing valuable land through filling with material wastes, increasing of material waste damping cost to stake holders of the project, increases the project costs, exceeds the project funding and increases addition material consuming of the project, producing environmental degradation and hazards and allowing the additional compensation fee for land users for using the land for material waste dumping place which can final produces socio-economic problems and affects the project stakeholders.`

Waste is a loss, it has to be managed to solve the problem construction material wastes within the construction projects. Even though many construction projects are going on within the study area there is the occurrence of construction material wastes .Finally this paper was come up with identifying causes of material wastes and through identifying building material waste minimizing techniques implementation within the project participants and, illustrates the possible techniques that need to be considered for minimization of material wastes for building construction projects

1.3. Research questions

- ✓ What are the causes of material wastes in construction projects of sebeta town?
- ✓ What are the construction material waste minimization techniques implemented in building construction projects of sebeta town?
- ✓ What are the possible critical actions which can successfully minimizing construction material wastes?

1.4. Research objectives

1.4.1. General objective

The general objective is to assess the building construction material wastes focus to sebeta town.

1.4.2. Specific objectives

- ✓ To assess the causes of material wastes in construction projects of sebeta town.
- ✓ To assess the construction material waste minimization techniques implementation in building construction projects of sebeta town
- ✓ To identify the possible critical actions which can successfully minimizing construction material wastes.

1.5. Significance of the study

The findings of this study will contribute to the benefit of the construction industry in light of the fact that for causes of material wastes and waste management on design, on construction, and after completion of the project through different techniques. Construction stakeholders are enlightened on what construction waste management techniques to employ on construction sites to better address the problem of construction waste. As mentioned in the literature, error consideration of construction waste during design and construction can leads to socio-economic and environmental issues, for example, additional funding and depletion of natural resources and environmental degradation should be avoided. Establishing techniques that can avoid such problems effectively is imperative. This study also will help the other researcher for future to understand the underlying issues with respect to construction material waste causes and, waste management on design and construction sites.

The advantages of this study in the future will be;-

- ✓ This study will encourage the knowledge of all stakeholders in the construction industry.
- ✓ This study will use as input data for Oromia special zone surrounding the Addis Ababa construction office and for related stakeholders in Oromia special zone surrounding Addis Ababa construction project workers.
- ✓ This study will use as references for the ministry of construction and urban development and for Oromia construction bureaus through informing the main current issues which can cause the construction wastes specifically in the Oromia special zone surrounding Addis Ababa.
- ✓ the merit of the study goes to every construction project in Oromia special zone surrounding Addis Ababa and all over the country area and for people involved in construction work

1.6. Limitation of the study

This study is focus on assessing causes of material wastages and minimization techniques implementation at the Oromia special zone surrounding Addis Ababa in the case of Sebeta town. Similarly the study is anchored causes of construction material wastes and construction material waste minimization techniques implementation and possible critical action needed for material waste minimization specifically for building construction during design stages and construction stages of sebeta town building construction projects. The study is limited to building construction projects it did not include the road and other civil engineering projects. Further, the generalizability of findings from sebeta building construction project to the entire province of the project around the Oromia special zone surrounding Addis Ababa or the whole construction industry may not be appropriate. However, in-depth insights regarding material waste causes and, Material waste management techniques and possible critical action needed for material waste reduction, during design and during construction concerning to sebeta town projects were studied. The study was carried out not wider because of the limitation of different constraints.

CHAPTER TWO
2. LITERATURE REVIEW

2.1. Construction Materials Management in construction projects

Construction materials are main constituents of the projects due to this construction materials management is mandatory to improving productivity in construction projects and, this management of materials should be taken at all the phases of the construction process, since, the construction material is a crucial for the success of a project as identified by Narimah Kasim, (2013).

2.2 Waste in the Construction Industry

2.2.1 Definition of waste

Construction material wastages can be definite as the alteration between the significance of materials transported and accepted on site and those appropriately used as specified and correctly measured in the work, after subtracting the cost saving of substituted materials transferred elsewhere, in which unnecessary cost and time may be incurred by materials wastage as stated by Agyerum, (2012).

2.2.2 Construction waste

Construction wastes are appears from different activities of include, formwork and false work wastes, unusable or excess cement mixes as stated by Al-Moghany,(2006). Moreover, Agyerum, (2012) Was classified construction wastes in to waste of materials and waste of time and the author described construction material wastes are materials from construction sites which is unusable for the purpose of construction and have to be discarded for whatever reason and non-using of material for intended specific purpose of the project due to damage, excess using, over production of material process and, due to non-compliance with the specifications.

2.4. Magnitude of Materials waste in building construction

The extent of waste at construction sites is significant. Similarly, many studies showed that the waste rate was different between developed countries and developing countries as follows

2.4.1. Magnitude of Construction Materials waste in developed countries

Study in Hong Kong indicates that about 5-10% of construction materials result in as waste on construction sites, there are many causative factors to this amount, human, mechanical as stated by poon, (2002). Babatunde, (2012).elaborates through quantifying amount of wastes for material like, reinforcement percentage of wastages of 19.03%, wires with wastage of 17.26% and, pipes both have 15.70% wastage. Moreover, the recognized construction materials under transfer waste showed that tiles had maximum percentage ratio of wastages 21.38%, window glazing and ceramic sanitary appliances with percentage ratio wastages 14.73% and 14.72% respectively. In addition, the author justifies that, construction materials below theft and vandalism for reinforcement, timber and, cement wastage reason and stated that construction materials wastage ranges to 15.32% percentages in the Nigerian construction projects.

2.5. Categories of material wastes

Different Authors are categorized the occurrences of material wastes to material wastes in to direct waste and indirect wastes

2.5.1. Direct waste

Ghanim.A (2014) separated material wastes to direct and indirect wastes .likewise the author described that the contents of direct material wastes like, loss of materials arising from damage during handling or site application or which were lost during the building process

2.5.2. Indirect waste

However, kulatunga(2006) also categorizes the material wastes to direct and indirect and describes direct wastes as delivery wastes ,cutting and conventional wastes fixing wastes waste caused by other trades ,criminal waste ,management waste ,waste due to wrong usage and indirect wastes as substitution waste ,production waste ,negligence waste ,operational waste.

2.6 Cause of material wastes

The primary step towards solving of the problem of construction material waste the identification of the problem as well as its causes and effects is mandatory. Likewise, Masudi et al.(2011) classified material waste sources in to design related sources ,like change of design, ,procurement related sources like ordering error, over ordering, under ordering and supplier error ,handling related sources like damaged during transportation to the site/ on site, inappropriate storage which is leading to damage or deterioration and, materials stored far away from point of application and, operational related sources like error by trades person or laborers, equipment malfunction, damage caused by subsequent trades, residual related sources like use of incorrect material requiring replacement, conversion wastes from cutting uneconomical shapes, off cuts from cutting materials to length, over mixing of materials due to lack of knowledge requirements, waste from application process and other sources like Waste from application process, and Criminal waste due to theft.

Similarly, Oladiran.O (2009), reveals causes of materials waste as: uneconomical shape of materials and components due to design; building failure/defects; workers' mistakes; theft; vandalism; inconclusive specifications; estimators' errors; ineffectual communication; less effort selecting with alternative products; design fluctuations; absence of proper supervision; error in loading and unloading of materials; poor materials; misunderstanding of drawings; trouble site conditions; setting out mistakes; and inappropriate transportation of materials.

As well as, Ekanayake and Ofori, (2004) describes the causes of material wastes to different category like design related, operational related, material handling related, procurement related causes. Consequently the author argues that the design related causes of material like ,design changes ,complexities in design ,lack of dimensional coordination ,poor project coordination ,unclear specification ,non-standardization of spaces and procurement related factors wastes due to different causative factor like, ordering errors, left over due to over estimation, packaging materials, incorrect quantity estimation, use of low-quality materials and external issues related material causes like; material damages due to weather ,accident ,theft and vandalism.

On the other hand, Poon et al., (2004) justifies cause of construction material wastes which can occurred due to site operation sources through listing different causes like reworks due to errors ,improper project planning ,poor workmanship ,leftover from cutting and shaping ,poor site conditions ,poor supervision ,materials off-cuts ,inadequate knowledge . Accordingly Lu et al., (2011) find out that the construction material waste causes like poor materials Storage, poor materials handlings through stating them under handling issues.

Furthermore, Ballard and Polat (2005) categorize the causes of construction material wastes under different waste sources . likewise the author categorized lack of information about types and sizes of materials on design documents, design changes and revisions error in information about types and sizes of materials, design documents determination of types and dimensions of materials without considering waste under design factor. Similarly the author categorized ordering of materials that do not fulfill project requirements defined on design documents, excess of ordering or less ordering due to faults in quantity surveys, excess ordering low ordering or due to deficiency of coordination between warehouse and construction teams under procurement factor of causes material wastes and, damage of materials due to poor stockpiling and error in holding of material under handling sources.

Likewise the author describes imperfect planning of construction workers' mistakes damage caused by subsequent trades operation factors and, conversion waste from cutting uneconomical shapes under residual waste sources and, the other like lack of onsite materials control, lack of waste management plans are also the causes which can produces material wastes. However Bossink and Brouwers, (1996) stated the sources and the causes of construction material wastes , the authors categorizes , errors in contract documents and, contract documents incomplete at commencement of construction causes under contractual sources and design changes, unsuitable specification poor coordination and communication ,slow drawing revision and distribution under design sources. In addition to this the author justifies the causes of material wastes like ordering errors, over allowances ,supplier errors as procurement related sources, and damage during transportation difficulties for delivery vehicles accessing construction sites ,insufficient protection during un loading .inefficient methods of unloading and loading, under transportation related sources. Bernold,M and Leonhard E. (1994),identifies and grouped the causes material wastes like lack of on-site waste management plans ,improper planning for required quantities, delays in passing information on types and sizes of materials and components to be used, lack of on-site material control. Other like,- lack of supervision categories under on-site management and planning origin of wastes and, inappropriate site storage space, improper storing methods, materials supplied in loose form, on-site transportation methods from storage to the point of application, inadequate material handling categorized under, material handling sources causes of construction material waste. similarly the authors recommends the causes of construction material wastes like, accidents due to negligence, unused materials and products, equipment malfunction, poor craftsmanship, weather, vandalism and, theft as causes of construction material wastes.

2.7. Types of material severely wasted on sites.

Some of, the materials that are wasted on the construction sites include steel reinforcement, concrete, formwork, blocks, cement, mortar, tiles, pipe, aggregate which is described by Formoso *et al.* (2002). Accordingly the author identified that reason for of reinforcement bar wasted due to unusable pieces that are produced when bars are cut and due to non-optimized cutting of bars. As well as the author described the causes of waste of electrical pipes, and hydraulic and sewage pipes is a fairly complex task. Another difficulty related to the measurement of waste is the fact that the plumbing and electrical service designs are often poorly detailed, and various modifications in the routings of pipes are made on the period of installation. The timber was carried to site for form work assembling were most of the time fully considered as waste after repeatedly which is identified by Poon et al., (2004). The research carry out on construction projects in Hong-Kong showed that the widely held of timber wastes was produced from timber formwork with a lesser quantity consequential from cutting timber for interior finishing and, the key causes of wastage of steel are produced from cutting, damages during storage and rusting as stated by Shen *et al., (*2002). Moreover, Tam. V. et al. (2007) states that concrete is the most widely used material for buildings structures. concrete wastage is mainly resulted errors in calculating the quantity of needed concrete because of improper planning or poor, the occurrence of settlement the concrete when concrete is styed over a long period after mix without application, handling problem and, reinforcement bar are wasted due to cutting error, damages and rusting during storage issues and, the causes of timber wastage include the natural deterioration resulted from usage and cutting waste and, the cause of blocks is cutting error , during loading /unloading and when unused blocks left on site it may end up in the trash and the ceramics tiles can be wasted when, sizes of the materials may not match what specified in the design and, during transportation.

2.8. Trends Construction material waste managements

Ding et al. (2016) stated to attain healthier environmental performance the attention should be taken to material waste reduction by employing techniques such as low waste technologies and on-site performance controlling. Improving practitioners' awareness of construction waste management can make a significant contribution to effective construction waste management and thus ameliorate waste management culture within the organization that is explained by yuan, (2013)

2.9. Implications of material Wastes

Different authors have unanimously agreed that construction materials waste has two major implications namely: environmental and cost performance implications

2.9.1. Environmental implication

As a result, Carlos et al.(2002) stated that, construction materials are extracted from the earth's but the method of its extraction during manufacturing and its application process can pollute the environment and contributes residues that fill the limited landfill spaces available. It is, therefore important that steps must be taken to reduce dependence on construction resources that have depleting potential as it will result to further reduction of the pollution generated during the manufacturing process and waste generated during conversion process and disposed to landfills.

Furthermore, Fewster and Hearkeness,(2013). Emphasized that the scarcity of landfill sites would result to increased cost of disposal in the limited landfill spaces for the contractor as costs to communities for operating and maintaining landfill sites increases due to unavailability of suitable land for replacement and, reuse options for landfill sites will be limited due to potential health hazards.

2.9.2. Cost performance implication.

Similarly, Adewumi and Otali, (2013) suggests that waste contributes as high as 15% additional cost to construction projects which leads the construction project to require additional material.

2.10. Construction material wastages minimization techniques

Even though, the occurrence of the construction material wastes is obvious from reality observing and additionally from past research indication this research is highly focus on material waste minimization techniques through referring the past material minimization technology implemented from different perspective and to justify how is key construction material waste minimization techniques is implementing in our country which is very crucial since the resource is limited and material wastes has the critical effects on, environment, on project costs and on the country economy also . Accordingly this research will make directive clues for the skill gap of adopting the best method of material waste minimization techniques in future. Likewise from different literatures material waste minimization techniques is identified as flows

2.10.1. Using Lean Construction method

Therefore, Koskela et al., (2004) stated that lean construction LC is the method of design construction arrangements to minimize waste of materials, time and effort to obtain the maximum potential amount of work results. As well as, Koskela and Howell, (2002)stated that lean construction (LC) is also a all-inclusive design and carriage attitude with an all-embracing goal of exploiting value to all stakeholders through using logical synergistic waste minimization contract and effective improvements in the contractual provisions, on product design and method of selection and making the supply chain and the workflow reliability of site operations. It is significant to carry out wide planning at the very commencement of any project in order to realize lean construction. The construction industry institute (CII) has defined lean construction as the continuous method of excluding material waste, satisfying all owner requirements, concentrating on the whole value stream, and resulting rightness in the operation of a construction project.

On other ways There are LC practice in project management, specifically which is identified by Abdul et al. (2012)

- ✓ LC considers on waste reduction in construction processes
- ✓ LC used to minimize abnormality and inconsistency of material information
- ✓ LC uses for preparing appropriate method of materials to deliver construction material to the site when it is essential for use.

Moreover, Ballard, G., & Howell, G. A. (1998) recommends lean construction techniques for material waste minimization like thinking production process during design, and, critical path method (CPM) for material scheduling and using appropriate software for material waste minimization . in addition to this the author states other three lean construction techniques for material waste minimization like; - following just-in-time (JIT) material delivery, optimizing material inventories according to backward requests, leveling construction sequences and decreasing the number additional none value adding material using. Accordingly Ballard (2000) justifies techniques of lean construction for uses for construction material waste minimization as follows at design stages of the project.

- ✓ allocating material lean supply consists with its detailed engineering specification,
- ✓ setting material lean Assembly consists , site installation techniques , and material testing method to avoid the material
- ✓ Developing material wastes control with work flow of the project.

On other hand, Koskela (1992) suggests LC has a lots of benefits for reduce the building construction cost by using precise materials, fewer material wastes and has proper strategic planning for completion of the construction project with schedule and also the author suggests that, the lean construction techniques like using Concurrent Engineering (CE) deal primarily with product design base, incorporating the restrictions at beginning phases into the conceptual phase and connecting of modification control towards the completion of the design procedure for minimizing the material wastages. Even though, Small et al. (2011) stated that making integrated construction material management and encouraging organization material quality waste controls is the best method of material waste minimization method of lean construction principles. In addition, Richard H.et all (2016) states lean construction used to decreasing the material and allied wastes in workflow that, the conservative methods are insufficient to eliminating them and recommended the techniques like developing of design in alignment with product design, structuring the material flow with supply chains, the allocation of resources.

2.10.2. Using the Value engineering method

Even though, Kelly and Male (2004) stated value engineering (VE) is implemented throughout the different project phases, starting from the conceptual planning phase until the construction phase. Likewise Ferry F. et all (2012) described value engineering uses in order to deliver better quality, faster completion, environmentally friendly practices, and less waste generation, adoption of ‘environmentally-aware building designs, the application of alternative and/or recycled and environmentally-friendly materials, a use of green technologies, and building systems featured are the value engineering methods which can minimize the construction material wastes. On other ways the adoption of prefabrication construction methods, intelligent excavation works, ‘reduce-reuse-recycle’ principles, and simple ‘environmentally-aware’ on-site practices can minimize waste produced and local environmental impacts emitted during project execution. Moreover, Kazanc, D. (2000) argued that value engineering concepts shall encompass in order to modernize the construction sector to achieve a sustainable construction industry and for material waste minimization through updating the following techniques like;-

- ✓ optimize the utilization of precast concrete elements, such as beams and slabs to reduce waste generated from formwork activities

- ✓ using steel formwork panel system in order to cast different sizes and shapes of structural elements and these are highly suitable for repeated use can save valuable time during concrete casting, to faster completion rate, significantly less waste and, concrete spillage, and better quality control, compared to conventional timber formwork.
- ✓ Constructing car stopper blocks in parking building by using leftover concrete spillage from casting works for an efficient use of concrete.
- ✓ Using related software's for coordination and scheduling in order to optimizing the construction schedule time and for perfect material delivery schedule which can be uses for material waste minimization for the issues of material over ordering wastages, un related material delivery time ordering , which can produces material on site wastages.

2.10.3. Skill of professional firms

The coordination skill of professional firms has effects on waste generated at the construction stage of project delivery. The efficacy of design process determines the extent to which various specialties are coordinated, level of communication between parties as well as stakeholders' meetings, all of which are found to be important to waste prevention which is described by Al-Hajj and Hamani, (2011). In addition to this, Al-Hajj and Hamani (2011) described that, drawings and other details are adequately coordinated between design disciplines which are very important to avoid miss understanding of the construction material in waste minimization procedures. Likewise, Osmani et al. (2008) identifies that careful coordination of contract documents to prevent error, early completion of contract documents before construction justifies adequate coordination of various specialties involved in the design process which is important to construction waste minimization techniques which can be made by active coordination of stake holders of the construction for making waste free projects.

2.10.4. Method of delivering the material

Some Percentages of, building material waste generated in construction activities have been traced to ineffective coordination of materials procurement activities as stated by Lu et al.(2011). And also the author justifies the value of construction materials could contribute up to 50% of project cost it is, therefore, important that adequate measures are taken to prevent material waste that could be due to ineffective materials purchase, delivery, handling and storage. Materials procurement factors that are capable of influencing construction waste are only available across scattered studies, which usually concentrate on construction and design stage of building delivery process. In addition to this, Bernold et al. (1991) also mention that Modification to products in conformity with design as per the specification of the design is important when purchasing the material to avoid excessive waste and, minimizing Procurement route. Moreover, Cha et al. (2009) recommends collecting package materials back by suppliers is the suitable method for minimizing material waste techniques which is useful for recycle the material properly. In addition to this Lu et al.(2011). Justifies setting material procurement as per schedule of work for avoid onsite material wastes though idle waiting for schedule of work and, avoiding purchasing the material without schedule of work that may cause for material wastes on site.

As a result, Bernold et al. (1991) justifies that, Optimization of Materials Purchase to avoid over/under ordering and excess waste allowance which needs early management for waste minimization mechanism and, using effective materials take-off , good quality materials to be purchased, Avoid frequent variation order. In addition to this, Buchan et al. (1991), justifies that within the construction projects it is obvious the certain proportion of materials are added as a waste allowance but, this allowance is usually in the range of 2.5 to 10% of the quantity of materials if the waste allowances is exceeded the material wastes can appeared. Consequently Khanh and Kim (2014) states that, Purchase repairable, reusable and durable materials for extend the material for further works. On other ways WRAP (2009) also support this idea through stating buying materials with reused packaging of the material pre-existed specification is the suitable method for using the material waste for reuse purposes which is recommended for optimizing the function of the material function for different purposes. Correspondingly, Muhwezi et al. (2012) also develops this idea through stating Purchase materials in conformity with carefully prepared specification for making the material waste efficient with series purchasing management. Correspondingly Cha et al. (2009) Order material with high content of recycled product which is suitable to access the material as recycle specification which already stated. More over, Marinelli et al. (2014) identifies that, adequate and efficient delivery schedule is very important for on time material delivery methods with without producing wastes.

2.11. Construction material waste minimization techniques through construction and design process

2.11.1. Providing Quality of design

Osmani et al. (2012) suggest that maximum waste management studies focuses on construction stage while confirmation shows that construction waste could be suggestively can minimized by taking attention to numerous design features toward material waste reduction. Even though, (Ekanayake and Ofori, 2004) stated that the earlier accuracy of design implemented in a project lifecycle, the more its positive impact, for minimizing the construction material wastes and, stated that construction material waste minimization techniques through design competences like design for standard material supplies at design stages. Even though, this concept is similarly applicable to dedicated effort towards construction material waste management. The earlier stages of building life cycle such material waste minimization has the more likely it would prevent waste occurring at a later stage. For instance, Oyedele at al. (2014) claim that there is quiet low recognition and for reusing reprocessed products within the construction industry due to a low obligation from designers who initiative materials choice and sustainability practices within the industry. Dainty and Brooke (2004) argued that the designer must have the ability to produce error free documents.

Furthermore, Faniran and Caban (1998) argued the competence techniques needed from designer like Careful dimensioning of design to avoid cutting to fit, careful attention to detail at planning/design. Correspondingly Yuan (2013) also stated this idea that dedicated measures to reduce waste through design process could reduce total waste and, justified the techniques like able to produce proper site layout planning at design stage is mandatory techniques which can be expected from designer through matching the design with topography of building area to minimize the excessive excavation wastes and to produce low material consumption of the project. Likewise, Baldwin et al. (2007) encourages this idea like clear and comprehensive information of the building places and the material standard information is other techniques need for construction material waste minimization that must be understood by design team at early design stages for making real mechanism for construction material waste minimization.

2.11.2. Design to reuse of material

Vleck. R(2001) recommends Material specific considerations needs for purposes of reusing construction material and lists the work techniques expected from stake holders of the projects for reusing the material wastes on site for minimizing material waste percentages like-

- ✓ Providing a central (convenient), yet separate, storage facility for reusable waste on site
- ✓ Providing for the separate storage of recyclables on site
- ✓ Estimating the quantities of each type of material that will be generated on site
- ✓ Determining recycling opportunities for various waste materials in the locality of the project
- ✓ Determining associated costs relating to waste container rental, waste transportation and waste disposal fees, and
- ✓ Training the labor crew on waste management.

Accordingly, as stated by Vleck. R(2001) wastage material like reinforcement ,concrete, brick, and wastages of masonry which can possible to use on site or off site for the purpose of such as site leveling, backfill and landscaping and landfill engineering. On other sides warp (2009) stated key action that must be considered for designing to reuse of material wastages, identify materials, structures which suitable for reusing.

2.11.3. Providing specification by quality

The quality of design specification has great impacts on overall effectiveness of the build process which is described by Andi and Minato, (2003).The extent to which attention is given to detail, as well as completeness of the whole documents, would affect waste output of a project. This is because; design specification do not only affect build ability of the project, its comprehensiveness and accuracy would go a long way in preventing errors that could lead to reworks as stated by Formoso et al., (2002).

Even though, Andi and Minato, (2003). Recommends the detailed specification devoid of under/over ordering is also the other techniques which can minimizes the construction material waste minimization by making strong the quality of design specification. on other sides Osmani (2013) also recommends accuracy of design information for construction material waste minimization techniques through stating consistency in detailing language/format which can be easily understandably by all construction worker which is more useful for making waste free project and which can avoid the rework of the detected error of construction. Even though, Osmani et al. (2008) described that this idea by describing design for standard dimensions, units, clear building forms and layout is the important method for construction material waste minimization. Moreover, Vleck R(2001) justifies that Waste minimization specifications for construction sites like, using waste reduction techniques during construction, reuse of construction waste material on site, recovery of construction waste material from site for resale and use elsewhere, return of unused construction material to vendors for credit; and recycling of construction waste during implementing the project

2.11.4. Construction methods for material waste minimization

In addition to this, Poon et al. (2003) recommends the contractor that construction techniques which can minimizes construction material wastes during construction like, use of hanging cradle, use of large panel formwork, drywall partition and infill, machinery sprayed plaster, Precast cladding, units of on works and modules needs for waste minimization.

Likewise, Khanh and Kim (2014} suggests that, use of appropriate and quality equipment which can produce the construction material waste minimization accordingly with types of work.

Furthermore, Formoso et al. (2002) elaborates that contractor must ensure conformity with design dimension to avoid excess and omitting of allowed works and making careful integration of building sub-system for purpose of waste minimization without compromising the standard design is also useful for construction material waste minimization. Even though Cha et al. (2009) states that construction with standard materials as per the specification of the work is advisable for minimizing the error of work which may need reconstruction. In addition to this Wang et al. (2015) recommends that using steel scaffolds is better for minimizing the scaffolding wastes on the site. Consequently, Al-Hajj and Hamani (2011) clarifies that reuse of off-cuts materials (such as wood) and other material for further uses) and, logistic management to prevent double handling for sequencing material ordering to avoid the fragment of material ordering

. In the other hand, Oyedele et al. (2013); recommends employing offsite construction techniques and, using prefabricated construction method for construction material waste minimization. On other ways perspectives Yuan (2013) recommends that ensure drawings consider and integrate site topography and existing utilities to match the topography of the building places with design layouts and, proposes using innovative and reusable formwork and false work to minimize the wastes of form works to use it for the next work which is useful for recycling the material function on the site which is harmonies advantages for construction material waste minimization.

2.11.5. Construction site management practice for material waste minimization

. Construction site management practices (CSMP) are capable of reducing building material waste and diverting substantial building material wastages from landfill which is highly implemented to day in different country. On the similar ways, Saez et al. (2013) justifies that, follow the project drawings designs to prevent carrying out unexpected mistakes is the serious mechanisms which expected from the contractor for to insure material waste minimization. Hassan et al. (2012) also states other mechanism like developing and implement waste management plans (WMP) by the contractors for different types of material for construction waste minimization issues.

Correspondingly, Khanh and Kim (2014) recommend effective coordination of project participants like contractor and other sub-contractor for issue of material waste minimization and, suggest preparing site layout before construction activities to simplify the material management on sites. Likewise, Cha et al. (2009) justifies that installing an information board to notify categories for separating waste jasper schedule of work types which is expected from contractor and, reports other idea like, commitment of contractors' representatives' onsite for issue of onsite waste handling techniques is very essential for material waste minimization mechanisms. Even though, wang et al. (2010) describes that dedicated space for sorting of waste is also expected from contractor and sub-contractor for sequencing and handling material wastes to make the project material wastes to the minimum. Likewise, faniran and caban (1998) timely and effective communication of design changes, review of the project specifications by the contractor at the construction stage, reuse material scraps from cutting stock-length those are things expected from the contractor for construction waste minimization techniques. As a result, Negapan, et al (2013) justifies that, adequate site access for materials delivery movement. In addition to this, Yuan (2013) notice that ensure effective communication of site activities, adequate on-site materials control system to make waste free project trough effective site management of the contractor's perspectives. Therefore, Marinelli et al.(2014) recommends maximization of onsite reuse of materials which is highly expected from the contractor for construction waste minimization techniques and Provision of waste management for specific materials for sequencing key construction material wastes which needs high controlling mechanism. . On other method , WRAP (2009) also develops this idea through stating that, discussion with sub-contractors other consultants on the reuse of materials components, well planned site layout prepared and discussed which is useful for material waste management professional coordination. In addition, Yeheyis et al. (2013) recommends contractors exceed to manage the material waste on the site through, Sorting and reuse and recycling of material waste for further uses to minimizing the construction material waste. Correspondingly, Yuan (2013) justifies other ideas that improving major project stakeholders' awareness about resource saving and environmental protection is useful for material waste minimization techniques.

Likewise, Del río M. et al. (2009) states that, detect the construction activities that can admit reusable materials from the construction which can be highly by actual management of the contractors. Muhwezi et al. (2012) recommends adequate knowledge of construction methods and sequence, carefully planned work sequence to prevent damages to previously complete that is, the work which is expected from the contractor. Despite to this WRAP (2007) justifies mechanical movement of materials is a solution for material waste minimization techniques rather than manual movement of the material.

2.12 The possible critical actions for construction material waste minimization

Lu,w and,Yuan, H (2010) identifies that using waste management regulation, waste management system, making awareness of construction and, demolition waste managements, ,using low waste building technologies, applying fewer design changes, exploring research developments in waste management and providing vocational training in waste managements as the critical success factors which is very important for construction material waste management in construction projects. Accordingly, Yuan (2013) find out that establish a task group for onsite construction waste management (CWM) is important method for onsite waste management techniques needs from the contractor.

Accordingly Ballard, (2000) justifies developing material wastes control with work flow of the project and, setting work structuring and post material waste evaluation method evaluation method is important through establishing task group for material waste minimization. Likewise, karavezyris et al. (2002) confirmed that the government plays a crucial role in promoting construction waste management regulation and enforcing regulations for the whole industry.

Moreover, Nagapan et al. (2012) states that a waste management and, having a waste management plan and assigning implementation responsibility to designated people helps to manage construction waste effectively in construction projects.

With regarding to this, Udawattaa et al. (2015) argued that construction waste can also be reduced by having clear communication between projects stakeholders. It has been pointed out that it is particularly necessary to concisely waste management policies at both the company and site level through clear communication channels. Further, construction workers can be more engaged in waste management issues by having regular meetings where environmental benefits of effective waste management can be communicated. It has been pointed out that common interests only prevail when the requirements for waste management are explained to people who are actually involved in waste management and when they are placed in contract specification.in addition to this, Domingo et al. (2009) suggests that providing the guidelines for material waste minimization and taking action of responsible for waste disposal for issue of material waste minimization through contract agreement is important.

similarly Jinkuang and Yousong (2011) recommends tax break for waste of material and, raising fees for mixed wastes, reducing fees for separated wastes, and using improved database management for construction wastes.

wang et al., (2015). recommends providing continuous vocational training and education for the stake holders of the construction project is another effective way of minimizing material waste generation and, the project staff should had training and education on material waste minimization and on advantages of material optimization which is critical for material waste minimization.

Accordingly, Osmani et al. (2008) stated that, using legislation by laws for construction waste minimization and applying the legislation is one of the key incentives for the implementation of material waste management as well as, reinforcing legislation and regulation related to construction waste management and having monitoring methods in place to check compliance helps to enhance waste management performance. The same authors argued that solid law, enforcement legislation for material waste minimization can be used as a tool to initiate changing worker's attitudes and in order to promote zero waste culture of using material with out wastages.

An investigation by, (Tam et al. 2006) also showed that the average level of waste generation of the conventional construction method is much higher than that of prefabrication in the trades of concreting, rebar fixing, plastering and tiling, such facts imply that a wider use of low-waste construction technologies would reduce construction waste occurrences due to this adopting of low waste construction material producing technology is important for construction project worker. Accordingly, Yeheyis et al.(2013) states adopting modern method of construction and other low-waste technologies and complexities which results complexities that result for material waste reduction. Even though, Jaillon et al. (2009) argue that use of precast materials could reduce waste output by up to 84%. Other low-waste technologies or modern methods of construction are also proven to reduce construction waste. Correspondingly Zhang et al. (2012) find out that, understanding and adoption of right work sequence and technology by the contractor is very important for construction waste minimization.

Moreover, Dainty and Brooke, (2004) justifies that contractual clauses could help significantly reducing waste generated by construction activities and recommends that, using additional tender contract for waste for material waste minimization is the best method of reducing techniques of material wastes as well as the authors justifies waste auditing to monitor material wastes which is mandatory to know the magnitude of material wastes and to take the additional action plan as per the auditing report. And also, Osmani (2013) develops this idea through recommending that using waste minimization clauses in contract documents is the most important techniques for construction material waste minimization. On other ways, Cha et al. (2009) recommends that making incentive in bidding for a contractor having a plan about decreasing material waste and increasing recycle and reuses opportunity.

CHAPTER TREE

RESEARCH METHODOLOGY

3.1. Study area

The study was conducted on a map of Oromia special zone surrounding Addis Ababa. From that town, Sebeta, was selected purposively as a case study sites the rationale for selecting the town sebeta is the most economic powerhouses from those other special zone surrounding Addis Ababa. Oromia special zone surrounding Addis Ababa is highly expanding high economy on building construction and infrastructure to support the economy among them Sebeta is the place where high ongoing building construction and different type of ongoing construction building are there and it is the highly economic hub from another special zone of the states Sebeta is rapidly growing population as a result of which there is high pressure on building construction infrastructure. Sebeta town is Located in the Oromia Special Zone Surrounding Addis Ababa of Oromia Region which is 16 km far from the central city of Addis Ababa with an estimated population of around 19,537. This town has a latitude and longitude of 8°54′40″N 38°37′17″E and Weather condition: 16°C, Wind at 8 km/h, 82% humidity an elevation of 2,356 meters above sea level

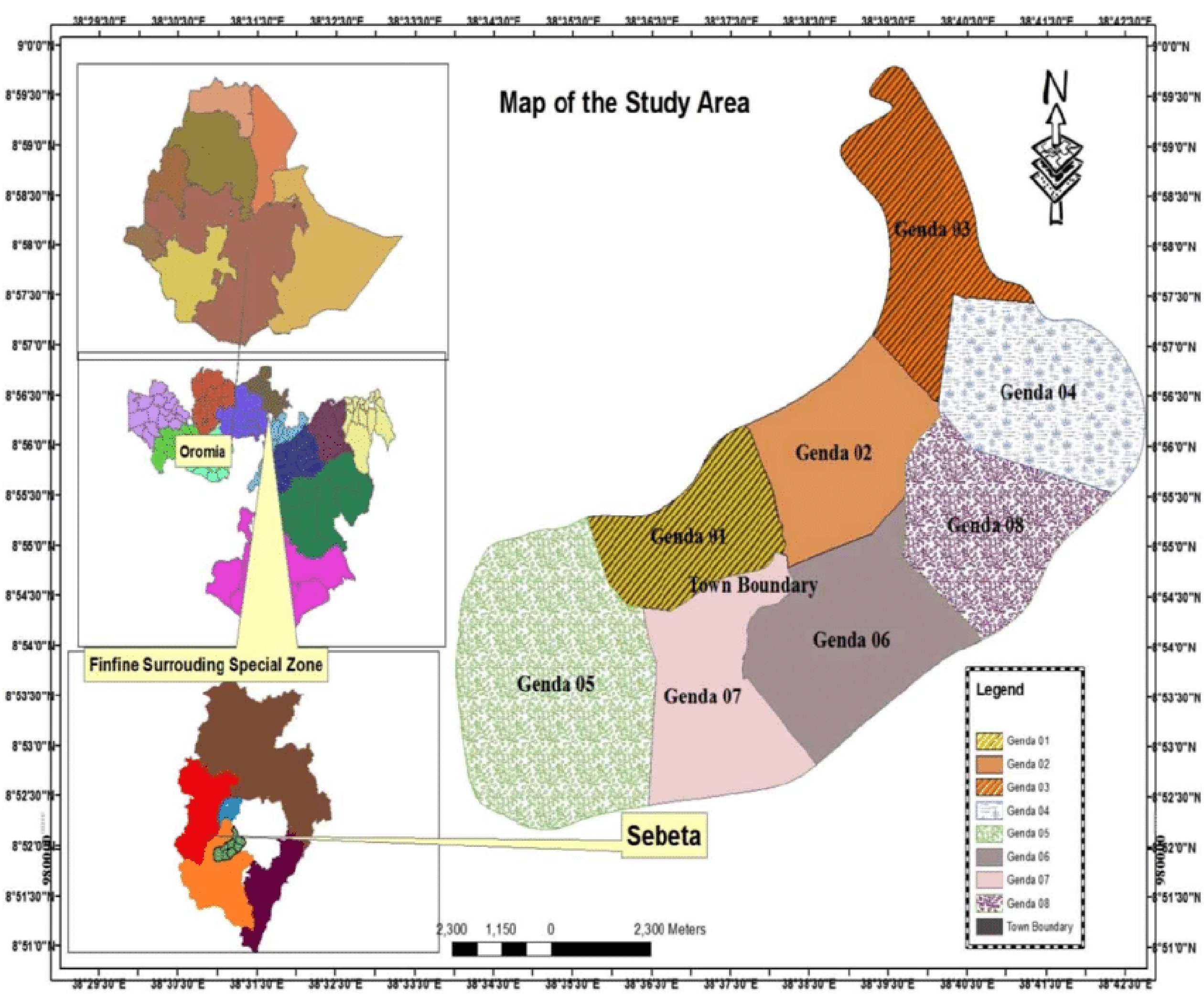

Figure 3. 1, Oromia special zone, sebeta, map Ethiopia.

3.2. Study period

The research study was conducted for seven months from April 1/2021 to October 30/2021

3.3. Study design

The study was employed a descriptive design and quantitative approach to describe the pattern of some situations and, to improve the existed problem. Data was collected by means of a questionnaire and through visual observing different construction sites, from design professionals, and from other respected bodies in the construction industry. Questionnaires were preferred because of anonymity and the flexibility they give subjects to complete at their own time and not being influenced by any pressure like face-to-face interviews. The Collected data was analyzed quantitatively through utilizing coding techniques to identify most causes of construction material wastes and for construction material waste minimization techniques during the design and construction stages and, for assessing the possible critical factors which can potential minimizes the construction material wastes of the projects at Sebeta.

3.4. Study variable

3.4.1 Dependent variables

- ✓ Building construction material wastes

3.4.2. Independent variables

- ✓ Construction method
- ✓ Lean construction
- ✓ Value engineering
- ✓ Quality of design
- ✓ Quality of specification
- ✓ Method of delivering the material
- ✓ Design for re-use of material
- ✓ the skill of professional firms

3.5. Population and sampling

Accordingly, the population data was taken from the Sebeta construction offices .There are 173 building construction projects which are under construction in sebeta town. Depending on this the size of the target population was determined.

3.5.1. Sample size and sample procedures

One hundred seventy three building construction projects are constructing by one hundred nine building contractors which includes grade one, grade two, grade three, grade four and, grade five contractors and sixty four Consultant companies. Among the one hundred nine contractor there were thirty five grade one contractors, twenty nine grade two contractors, seventeen grade three contractors, fifteen grade four contractors, thirteen grade five contractors and sixty four Consultants within sebeta building construction projects.

Therefore, the following equation is used to determine the sample size as described by Al-Moghany, (2006). Likewise the Cochran, W. G. (1977) stated that , the adjustments for obtaining the required sample size. Depending on Cochran, W. G. (1977) formula the sample size was determined as follows.

$$no = \frac{Z^2 * P * (1-P)}{C^2}$$

Where SS = Sample size

Z = Z value (e.g. 1.96 for 95% confidence level)

P = percentage picking a choice, expressed as a decimal (0.50 used for sample size needed).

C = margin of error (8%)

$$SS = \frac{Z^2 * P * (1-P)}{C^2}$$

$$SS = \frac{(1.96)^2 * 0.5 * (1-.5)}{(0.08)^2} = 150$$

Correction for required sample was calculated as follows;-:-

Where: Total sampled of construction parties = 173 match the proposed contracting companies

$$SS\ new = \frac{SS}{1 + \frac{(SS-1)}{POP}}$$

$$= \frac{150}{1 + \frac{(150-1)}{173}} = 81$$

This indicates that eighty one sample sizes were determined to use. Based on the determined sampling size and the pre-existed sizes of population by using proportional calculation the sample were categorized to different grades. While, the researcher selected, sixteen grade one building contractor, fourteen grade two building contractor, eight grade three building contractor, seven grade four building contractor, six grade five building contractor and thirty consultants were used for respondents . Generally 81 contracting companies which include 51 from grade one up to grade five building contractor companies and 30 consulting companies were selected for respondents . The detail sampling size proportional categorizing method was attached on the appendix. The random sampling techniques were used for selecting the categorized target population to their grades, depending on their sizes of the projects they had and the variety of the project staff they have among the available target population.

3.6. Source of data

Accordingly, this research data was collected from primary and secondary sources which include parts Questionnaires, the researcher made use of the participant observation method by visiting sites and observing what is being done concerning the line of study and related literatures. .

3.7. Data collection techniques and procedures

The data was collected through structuring the questionnaire through focusing on the research objectives to build the validity and reliability of the research. The survey questionnaire was prepared through categorizing the factors under different groups. Similarly the questionaries' for identifying the causes of material wastes were grouped under eight different causative factors like design, procurement, site operation, on-site management and planning, material handling, ,transportation ,contractual, external .Similarly, for addressing the implementation of construction material waste minimization techniques the questionnaires were grouped under four techniques of material waste minimization techniques like;-Lean construction, value engineering, material delivering, skill of professional firms. As well as, for testing level of practicing the construction material waste minimization techniques the questionnaires were grouped under five techniques of construction material waste minimization like under Waste efficient design, waste efficient specification, design for reuse of material, construction method and construction site management practices and the possible significant critical action that can minimizes the construction material wastes were assessed. The factor that can causes construction material wastes and construction material waste minimization techniques were developed and tested from previous research's which is described on the literature reviews of this study's. Generally all research questionnaires for data collection were derived from the literature reviews this research and the detail research questionnaires were attached on appendixes.

3.8. Research process

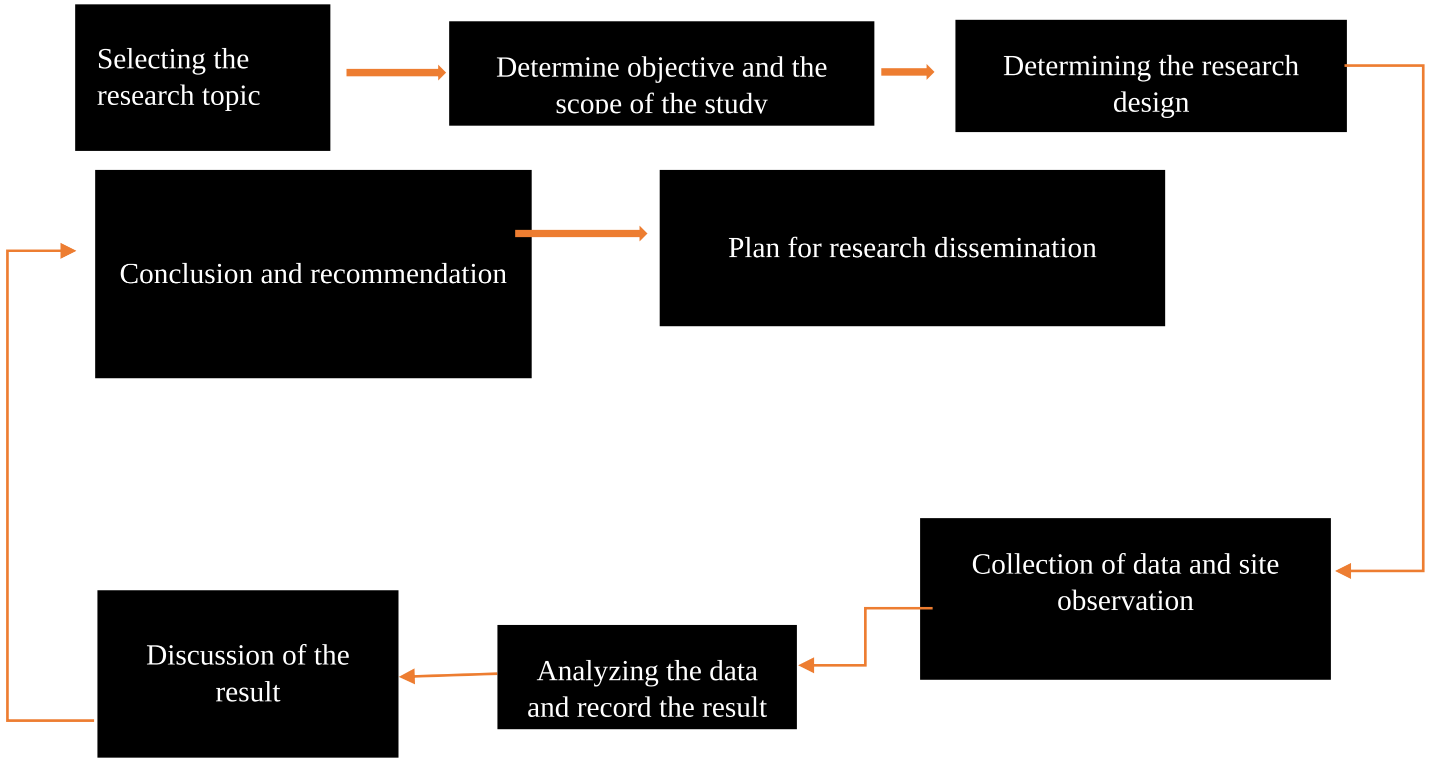

Figure 3. 2 Research process

These data are processed to turn them into information and make them useful. Quantitative analysis techniques such as graphs, charts, and statistics used to explore, present, describe, and examine relationships of the data as stated by Saunders et al., (2009). Even though this research was analyzed quantitatively and described through graph and tabular forms. The review of literature provided theoretical concepts and frameworks for the subject of causes of construction material wastes and construction material waste minimization techniques were understood. The Collected data was analyzed in a way that established links of existed evidences in the literatures. Further, the choice of quantitative methods is also driven by the context of the collected data. The data were analyzed by counting the respondent answer from the provided questionaries' then; the data was processed for editing and coding as part of the analysis. Accordingly, errors and incompleteness the responses were examined and, the responses were analyzed on the basis of equal merit as much as possible. Likewise the respondent's answer which is biased and complex and the respondent answer which is not set appropriate answer of the questionnaires in a good manner, was left out from the analysis. Consequently, responses were coded, the frequencies were computed and analyzed by Statistical Package for Social Science (SPSS) software and the relative importance(RII) was computed based on their frequencies. All the evidence was analyzed from the respondent responses and, the analysis was done in a systematically and logically manner as per the concerned issues**.**

3.10. Analysis and Findings

The analysis had combined all responses from, groups of respondents (, consultants, and contractors) in order to obtain significant results. Data were analyzed by calculating frequencies and Relative Importance Index (RII) then ranked. The Relative Importance Index (RII) is calculated as follows with referring the clarification of Mbamali and,okotie(2012) for the likert points of the scale 1-5 or 1-4 depending on the cases indicates.

$$RII = \frac{1n1+2n2+3n3+4n4+5n5}{5N}$$

The weight for the values of n was interpreted as the following:-

- ✓ N = Total number of respondents
- ✓ n1 = Number of frequency 'not significant' responses.
- ✓ n2 = Number of frequency 'slightly significant' responses.
- ✓ n3 = Number of frequency 'moderately significant' responses.
- ✓ n4= Number of frequency 'very significant' responses.
- ✓ n5= Number of frequency 'extremely significant' response.

The ranking and evaluation of the factor was done based on degree of importance of the relative importance indexes. The determination procedure for degree of importance's for used relative importance indexes was proceed as described by Mbamali and,okotie(2012). The authors were justified the value determination for relative importance's indexes (RII) as the following:-

- ✓ $RII<0.6$ values is evaluated as less significant values.
- ✓ $0.60\leq RII\leq 0.80$ values are evaluated as significant values.
- ✓ $RII\geq 0.80$ values are evaluated as high significant values

The responses obtained from the contractor and consultants were analyzed separately. But the rank of response results for the contractors and consultant results were correlated by spearman's rank correlation formula as justified by kinnear and gray, (1999).

3.11. Ethical consideration

The Data collection process was proceed after getting the letter of permission from Jimma University, specifically from Jimma Institution of Technology postgraduate's research and publication director office. The requirement and the purpose of this study were clearly mentioned to the organization and to the concerning bodies to support the researcher for reliability fact of study result. This letter of permission should be clearly defined for the respected stakeholders needed for this study. Particularly the study was executed in a way that follows the principles of the research ethics like:-

- ✓ This research was designed, reviewed, and undertaken to ensure integrity and quality.
- ✓ Research subjects or participants were informed fully about the purpose, methods, and intended possible uses of the research, what their participation in the research entails.
- ✓ Confidentiality of information supplied by research subjects and the response of respondents was guaranteed;
- ✓ Efforts were made to make sure that research subjects participating in a voluntary way, free from any unnecessary opinion.
- ✓ The independence of the research process was ensured. No conflicts of interest or partiality on the part of the researcher.

3.12. Data reliability assurance

For test validity and reliability of the results which was collected from respondents cornbachs's alpha data reliability were tested in order to evaluate the internal consistency of the answers provided from the respondents.

3.12.1 Cronbach's alpha reliability test

As described by Gliam (2003) the cronbach alpha (α) as the individual connection coefficient that evaluates the average of all the relationship coefficients of the items within a tests. For the factors of questionnaires responses the author defines as the following;-

- ✓ When the values of cronbach's alpha is$\alpha \geq 0.8$ it is justified as the responses of the factor has the excellent internal consistence's.
- ✓ When the values of cronbach's alpha is $0.8 > \alpha \geq 0.7$ it is justified as the responses of the factor has a good internal consistence's.

- ✓ When the values of cronbach's alpha is $0.7>\alpha\geq0.5$ it is justified as the responses of the factor has satisfactory internal consistencies.
- ✓ When the value of cronbach's alpha is $\alpha<0.5$ it is justified as the responses of the factor has poor internal consistence's.

However the data was analyzed separately for the contractors and consultant responses, for the whole each item of asked questions the value of Cronbach's alpha internal consistency data reliability test results was taken for the contractors and consultants responses. Accordingly the value of Cronbach's alpha internal consistency data reliability test results for the contractors responses was 0.936 and, the value of Cronbach's alpha internal consistency data reliability test results for the consultants was 0.848. This shows that the questions answered by the respondents for the whole each item of asked questions factors has excellent reliability of 93% for contractor responses and, excellent reliability of 84.8% for consultant's responses also. For categories of the questions cases factors of each item of asked questions separately, the value of Cronbach's alpha data reliability test values was shown on the appendixes.

CHAPTER FOUR
RESULT AND DISCUSSIONS

4.1. Respondents demography characteristics

4.1.1 Questionnaires response rate among the project organization

The questionnaires were designed and distributed for assessment of building construction material wastes on building construction sites in sebeta town. In line of this purpose, total 81 questionnaires were distributed among the major construction stake holders for the contractors and consultants. Among these total 81 questionnaires 51 questionnaires were distributed for the contractors and, 30 questionnaires were distributed for the consultants. However, among distributed questionnaires, for the contractors and consultants, eight questionnaires from the contractors responses and, four questionnaires responses from the consultants were rejected due to incompleteness. Hence, out of distributed 81 questionnaires 69 questionnaires' were properly used for data analysis consisting of 43 from the contractors responses and 26 from the consultants responses. The overall questionaries' response rate was (85.2%).

Table 4. 1 contractors and consultants respondent position in construction company

Respondent position in the construction company		
Respondent position	Frequency	Percentages (%)
deputy manager	2	4.7
Project manager	7	16.3
Site engineer	13	30.2
Site quantity surveys	9	20.9
Site Forman	2	4.7
Sub-contractor	1	2.3
Site office engineer	9	20.9
Total	43	100
Respondent position in consulting firms		
Respondent position	Frequency	Percentages (%)
Project manager	2	7.7
Resident Engineer	6	23.1
Architecture	10	38.5
Structural Engineer	4	15.4
Genera design super visor	2	7.7
Others	2	7.7
Total	26	100

The above table illustrates that, the detail numbers and lists of the professional categories respondents those are involved in this study. Inline of this, the majority of professional respondents like:- site engineer, site quantity surveyor, office engineer , resident engineers, architectures and structural engineer were involved from the contractors and consultant firms.

Which implies that the professional key respondents which can able to understand and describes the issues of construction material wastes were involved in this studies.

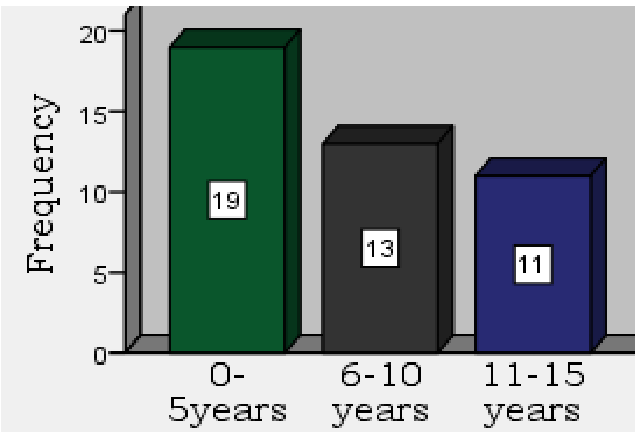

Figure 4.1. the contractors respondents work experiences

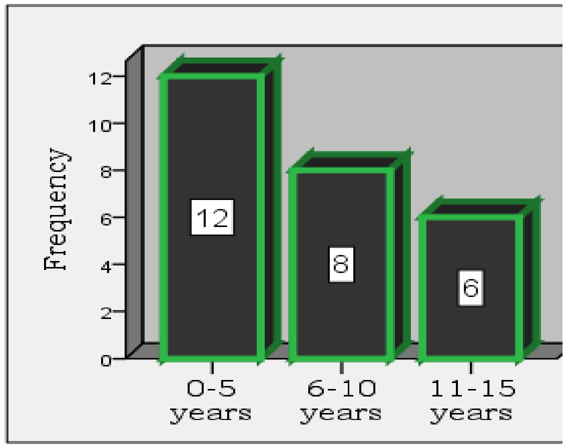

Figure 4. 2 The consultant respondent work experiences

However, the participation of the different professionals which has different work experiences were essential for encouraging research finding through using different integrated knowledge of professional respondent involvements. Likewise, as stated on the above figure, the key professionals respondents which has different work experiences were participated in this research for respondents.

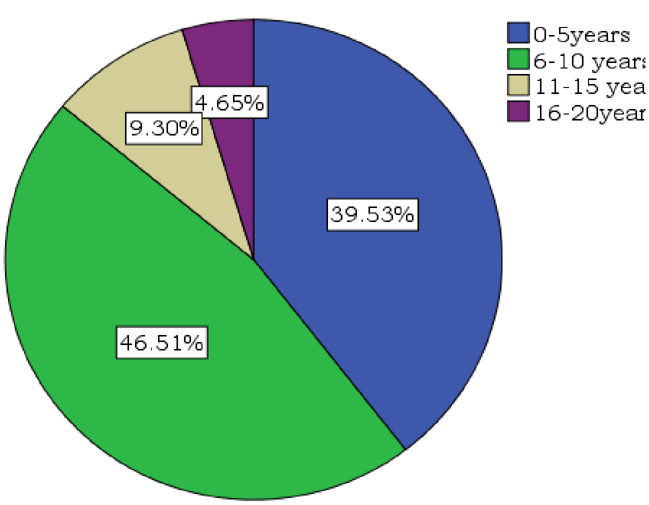

Figure 4.3 year of contractor company establishment

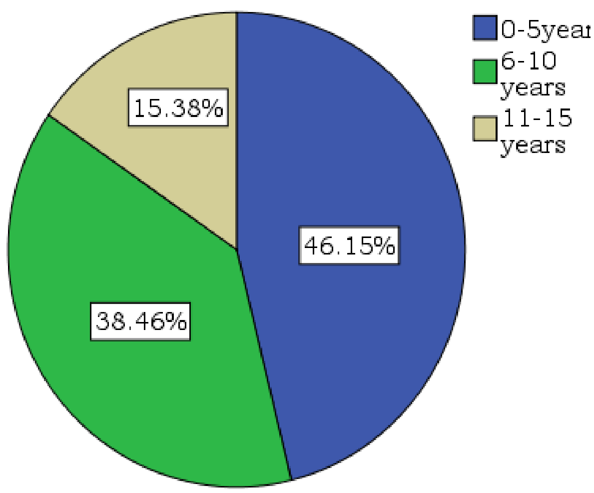

Figure 4.4 year of consultant company establishment

The figure above reveals the project company establishment years. Thirty nine point fifty three percentages of the company were established in the past 0-5 years, forty six point fifty one percentages of the company were established in the past 6-10 years, nine point thirties percentages of the company were established in the past 11-15 years and four point sixty five percentages of the company were established in the past 16-20 years, for the construction companies. Similarly, forty six point fifteen percentages of the company were established in the past 0-5 years, thirty eight point forty six percentages of the company were established in the past 6-10 years, fifteen point thirty eight percentages of the company were established in the past 11-15 years for the consultant companies. the ability of holding the construction projects from simple to complex project were concerned on company establishments and the company's annual turnover with executing of different projects. Likewise it is real that the company's which executed the construction project from simple to huge projects are mandatory for clarifying the construction material wastes , since the material wastes can occur on different size of construction projects. In line of this the construction company which had different company establishment years were involved in this study.

4.2. Causes of construction material waste

Table 4. 2. Design-related causes of material wastes

Origin of wastes	Causes of construction material waste	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Design	Design changes	0.785	2	0.750	1
	Complexities in design	0.808	1	0.731	2
	Lack of dimensional coordination	0.756	4	0.712	4
	Unclear specification	0.727	5	0.731	2
	Non-standardization of building spaces	0.692	6	0.673	7
	Design and construction detail errors	0.762	3	0.712	4
	Slow drawing revision and distribution	0.663	7	0.683	6

The above table illustrates that the causes of material wastes with regard to design related causes. The causes which had the values of RII $\geq$ 0.8 was considered as very high significances causes because of the relative importance index (RII) is greater than 0.8. Based on this on the behalf of the contractors responses, complexities in design is the highest ranked on the first level with the value of (RII=0.808). While design changes (RII=0.785), design and construction detail errors (RII=0.762), lack of dimensional coordination (RII=0.756), unclear specification (RII=0.727), non-standardization of building spaces (RII=0.692) and, slow drawing revision and distribution (RII= 0.663) were ranked from second to seventh sequence order as high causes of the design related factors of construction material with RII values greater than 0.6, as clarified on the contractors responses. Similarly, consultants side responses, complexities in design(RII= 0.731), design changes (RII=0.750), design and construction detail error (RII=0.712) were ranked first, second and third as causes of material waste. As well as, lack of dimensional coordination (RII=0.712), unclear specification(RII= 0.731), non-standardization of building spaces (RII=0.673) and, slow drawing revision and distribution (RII=0.683) were also ranked as the causes of the design related factors of causes of construction material with RII values of greater than 0.6 .

Likewise, the spearman rank correlation for the responses of contractor and consultant ranks were 0.75. This means that there is the strong positive relationship between the ranks of the contractors and the consultant response's. This indicates that, the correlation of ranks between respondents working in the contractors sectors and those working in the consultants sectors indicates high level of consistence's between the two category of professional in the ranking for seven cause of construction material wastes which was grouped under design deficiency factor.it reveal a high relationships among two professional firms, regarding to the ranking of the causes of material wastes which was related to design issues.

Table 4. 3 Procurement-related causes of material wastes

Origin of wastes	causes of construction material waste	RII for contractor response	Rank for contractor response	RII for consultant response	Rank for consultant response
procurement	Ordering Errors	0.779	3	0.635	5
	Left over due to over estimation	0.727	5	0.601	6
	Incorrect quantity estimation	0.814	1	0.740	1
	Using low-quality materials	0.715	6	0.712	2

	Over allowances	0.802	2	0.673	3
	Supplier errors	0.750	4	0.663	4

Table above presented the factors concerning procurement related causes of construction material wastes. On the behalf of the contractor the illustration of the responses clarifies using in correct quantity estimation has been ranked first with relative importance index (RII) of 0.814 and, performing over allowances for material procurement has been ranked second with the relative importance index (RII) of 0.802 which implies very high causes for construction material wastes. Similarly, for ordering error, Supplier errors, Left over due to over estimation, using low quality material, the result of the relative importance index(RII) was greater than 0.6 and, less than 0.8, from both the contractor and, the consultant firms which is considered as causative factor for the occurrences of construction material wastes concerning to the procurement related factors. However, in correct quantity estimation (RII=0.814) and,over allowance (RII=0.802) were ranked as very high causes by contractor side but on the behalf of the consultant responses for in correct quantity estimation with relative importance (RII=0.740) and over allowance with relative importance index (RII=0.673) were ranked as high causes. Generally for the procurement related causes which can produces construction material the RII results from both consulting and, contractor firms which is presented on the above table indicates, the all listed causes were considered as possible consequences for the construction material wastes. The spearman rank correlation for the responses of contractor and consultant ranks was 0.39. This shows a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that among six causes' which was grouped under procurement related causes there is slightly similar opinion between the contractor and the consultant professional for ranking the causes of construction material wastes related to procurement factors.

Table 4. 4 Site operation -related causes of material wastes

Origin of wastes	Causes of construction material waste	RII for contractor response	Rank for contractor response	RII for consultant response	Rank for consultant response
Site operation	Reworks due to errors	0.797	1	0.702	4
	Improper project planning	0.785	2	0.721	2
	Poor workmanship	0.767	4	0.644	8
	Leftover from cutting and shaping	0.715	5	0.721	2

	Poor site conditions	0.698	6	0.654	10
	Poor supervision	0.692	7	0.731	1
	Materials off-cut	0.785	2	0.692	5
	Inadequate knowledge	0.663	8	0.692	5
	Using wrong materials	0.651	9	0.692	5
	Unused materials and products	0.640	10	0.644	8

As described on the above table the results of the causes of construction material wastes with respect to site operation factor, reworks due to error of work was ranked first with relative importance index (RII=0.797) ,improper project planning was ranked second, with relative importance index (RII=0.785) ,materials off-cut was ranked third with relative importance index (RII=0.785), poor workmanship was ranked forth with relative importance index (RII=0.767) ,leftover from cutting and shaping was ranked fifth with relative importance index (RII=0.715) as causes of construction material wastes as described on the contractor perspective . In addition to this the contractors responses clarified, site conditions, poor supervision, inadequate knowledge and, use of wrong materials resulting , and, unused materials and products as causes of material wastes with relative importance index (RII)value greater than 0.6. Likewise the consultant values indicates that poor super vision (RII=0.731), left over from cutting and, shaping (RII=0.721),improper project planning(RII=0.721) and, rework due to error of work(RII=0.702) first, second and third sequence order ranks as causes of construction material wastes. As well as materials off-cut, poor workmanship, poor site conditions, inadequate knowledge, using wrong materials and, unused materials products also ranked as construction material wastes on the side of consultants. The spearman rank correlation for the responses of contractor and consultant ranks was 0.29. This indicates a less positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among ten cause's construction material wastes grouped under site operation, the causes which was ranked as causes of material wastes on contractor perspectives has less association rank with the causes ranked by consultant's sides.

Table 4. 5 On-site Management and Planning-related causes' material waste

Origin of wastes	Causes of construction material waste	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response

On-site management and planning	Absence of on-site attention for material waste consideration	0.698	4	0.673	3
	Improper planning for required quantities	0.727	2	0.654	4
	Delays in passing information on types and sizes of materials to be used	0.733	1	0.721	1
	Lack of on-site material control and, supervision	0.715	3	0.721	1

Table above showed the causative factors allied under onsite management and planning factor for construction material waste occurrences. On the contractors perspectives, delays in passing information on types and sizes of materials to be used, improper planning for required quantity, lack of onsite material control and, super vision and, absences of on-site for material waste consideration were ranked as the highly causes of construction material wastes with the relative importance index values greater than 0.6. But among the causes on contractors perspective responses, delays in passing information on types and sizes of materials to be used were ranked first as causes of construction material wastes with relative importance index value (RII=0.733) and , followed by improper planning for required quantity with relative importance index value (RII=0.727). Likewise delays in passing information on types and sizes of materials to be used and Lack of on-site material control and supervision were ranked first as highly causes of construction material wastes with the same relative importance index value (RII=0.721) on the sides of consultant response description. The spearman rank correlation for the responses of contractor and consultant ranks was 0.1. This indicates a less positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among four causes of construction material wastes which was grouped under site operation factors , the causes which was ranked as causes of material wastes on contractor perspectives has less association rank with the causes ranked by consultant's sides.

Table 4. 6 Material handling-related causes of material wastes

Origin of wastes	Causes of Construction Material waste	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response

Material handling	Poor materials storage	0.744	1	0.750	1
	Materials supplied in loose form	0.703	3	0.712	4
	On-site transportation methods from storage to the point of application	0.733	2	0.721	3
	Inadequate material handling	0.674	4	0.750	1
	Materials stored far away from point of application	0.640	5	0.644	5

Also the table above shows the cause of construction material concerning to handling of material causes. However the result of all RII of the contractor and the consultant shows greater than 0.66 which can be considered as causes. Among the presented causes, Poor material storages (RII=0.744) and, materials stored far away from point of application (RII=0.733) were ranked as the causes of construction material waste on the view of contractor side results with high RII values. On other hands the consultant result shows that, poor material storages (RII=0.750), inadequate material handling (RII=0.750) were ranked as first and second with high RII values. The spearman rank correlation for the responses of contractor and consultant ranks was 0.45. This shows a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that among five causes' which was grouped under material handling related causes there is slightly similar opinion between the contractor and the consultant professional for ranking the causes of construction material wastes related to material handling factors.

Table 4. 7. Transportation-related causes of material wastes

Origin of wastes	Causes of construction material waste	RII for contractor response	Rank for contractor response	RII for consultant response	Rank for consultant response
Transportation	Damage during transportation	0.6510	3	0.673	3
	Difficulties for delivery vehicles accessing to construction sites	.709	1	0.683	2
	Insufficient protection during loading and, un loading	0.663	2	0.750	1

The table above illustrates the causes of the construction material wastes due to transportation while, difficulties for delivery vehicles accessing to construction sites (RII=0.709) and insufficient protection during loading and, unloading (RII=750) were first ranked by the contractor and the consultant responses respectively with high amount of RII values among the other causes. However, insufficient protection during unloading (RII=0.663) and, damage during transportation (RII=0.651) were ranked as on second, third levels as causes on the sides of contractors responses with RII values greater than 0.6. Likewise, on the behalf of the consultant clarification, difficulties for delivery vehicles accessing to construction sites (RII=0.683), damage during transportation (RII=0.673) were also ranked on second and, third level of causes of material wastes due to transportation factors, with RII values greater than 0.6. The spearman rank correlation for the responses of contractor and consultant ranks was 0.66. This indicates strong relationship between the ranks of the contractors and the consultant response's. This indicates that, the correlation of ranks between respondents working in the contractors sectors and those working in the consultants sectors indicates high level of consistence's between the two category of professional in the ranking for three cause of construction material wastes which was grouped under transportation .it reveal a high relationships among two professional firms, regarding to the ranking of the causes of material wastes which was related to transportation.

Table 4. 8 Material handling-related causes of material wastes

Origin of wastes	Causes of construction material waste	RII for contractor response	Rank for contractor response	RII for consultant response	Rank for consultant response
Contractual	Errors in contract documents	0.628	1	0.846	1
	Contract documents incompleteness at commencement	0.587	2	0.654	2

The above tables describes that the causes of material wastes due to contractual related factors. Error in contract document (RII=0.628) and, contract documents incompleteness at commencement (RII=0.587) were ranked as causes and less causes with the contractor perspective responses. As well as errors in contract documents (RII=0.846) and contract document incompletes at commencement (RII=0.654) were ranked as high causes and causes for material wastes as shown on consultant side clarifications. The Spearman Rank Correlation for the responses of contractor and consultant ranks was 1. This indicates a perfect positive relationship between the ranks of the contractors and the consultant response's. This indicates that, the correlation of ranks between respondents working in the contractors sectors and those working in the consultants sectors indicates perfect level of consistence's between the two category of professional in the ranking for two cause of construction material wastes which was grouped under contractual .it reveal a perfect associations among two professional firms, regarding to the ranking of the causes of material wastes which was related to contractual factors.

Table 4. 9. External-related causes of material wastes

Origin of wastes	Causes of construction material waste	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
External	Material damages due to weather	0.698	2	0.654	2
	Accident	0.581	3	0.673	1
	Theft	0.564	2	0.606	3
	Vandalism	0.715	1	0.606	3

As demonstrated on the above table, vandalism (RII=0.715) and theft (RII=0.698) were ranked as causes of construction material wastes while accident (RII=0.581) and, damages due to weather (RII=0.564) were ranked as less causes as shown on the contractor RII value descriptions. But, the consultant responses reveal that, accident (RII=0.673) , damages due to weather(RII=0.654) , vandalism(RII=0.606) and, theft(RII=0.606) are the causes which can consequences to construction material waste occurrences. The spearman rank correlation for the responses of contractor and consultant ranks was 0.1. This indicates a less positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among four causes of construction material wastes which was grouped under external factors , the causes which was ranked as causes of material wastes on contractor perspectives has less association rank with the causes ranked by consultant's sides. However the spear man rank correlation for the responses of contractor and consultant minimum positive value, since the correlation rank value between contractor and consultant is positive values the ranked causes can consequences the material wastes.

4. 3. Material waste minimization techniques

Figure 4.10 The importance's of material waste minimization techniques

Construction material waste	%(Percentage) Of response	%(percentage) Of response

minimization techniques	by contractor		by consultant	
	yes	No	yes	No
Construction method	83.7	16.3	53.8	46.2
Lean construction	62.8	37.2	65.4	34.6
Applying value engineering	67.4	32.6	57.7	42.3
Quality of design	76.7	23.3	88.5	11.5
Quality of specification	72.1	27.9	92.3	7.7
Method of delivering the material	55.8	44.2	80.8	19.2
Design for re use of material	93.0	7.0	84.6	15.4
Skill of professional firms	79.1	20.9	80.8	19.2

Most of the stake holders are agree with those selected construction material waste minimization techniques has the ability for construction material waste minimization through answering yes accordingly design for re use of material(93%), construction method(83.7), are those techniques selected with the highest percentage by the contractor side responses . As well as quality of specification (92%), quality of design and design(88.5%) for re use of material those techniques which has the highest percentages with respect to consultant perspective responses.

4.4. The level of implementation and, practicing for construction material waste minimization techniques, within the stakeholders of the project firms.

Table 4.11 Lean construction

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Lean construction	Using synergistic contractual arrangements	0.506	10	0.493	10
	Developing of alignment of material design with product design	0.541	8	0.498	9
	Structuring the material flow with supply chains	0.576	4	0.500	8
	Extensive planning at the very beginning	0.541	8	0.644	2
	Using critical path method (CPM) for material scheduling	0.564	5	0.606	5

	Using appropriate software for material waste minimization.	0.558	6	0.654	1
	Setting material lean assembly system	0.558	6	0.510	7
	Using concurrent engineering (CE)	0.651	1	0.644	2
	Material wastes control with work flow of the project.	0.651	1	0.529	6
	Just-in-time (JiT) material delivery	0.634	3	0.625	4

The above table illustrates that the implementation status of material waste minimization techniques which was concerned under lean construction techniques within the building construction stakeholders. Among the described lean construction techniques in the table Material wastes control with work flow of the project (RII=0.651), using concurrent engineering (CE)(RII=0.651), just-in-time (JIT) material delivery(RII=0.634) were implemented with RII Of greater than 0.60 within the contractors firms. While lean construction techniques like:- structuring the material flow with supply chains (RII=0.576), using critical path method (CPM), for material scheduling (RII=0.564), using appropriate software for material waste minimization(RII=0.558) , setting material lean assembly consists(RII=.588) developing of alignment of material design with product design(RII=541) ,extensive planinning at very beginning (RII=0.541)and, using synergistic contractual arrangements for material waste minimization (RII=0.506), were considered as less implemented with their RII values less than 0.60 on the side of contractor. Moreover, using appropriate software for material waste minimization (RII=0.654), extensive planning at the very beginning (RII=0.644),using concurrent engineering (CE),(RII=0.644),just-in-time material delivery (RII=0.625), and, using critical path method (CPM) for material scheduling(RII=0.606) were the lean construction techniques which was implemented within the consultant firms with high RII values of above 0.60 respectively. Likewise, for material wastes control with work flow of the project(RII=0.529),Setting material lean assembly consists(RII=0.510),Structuring the material flow with supply chains(RII=0.500),developing of alignment of material design with product design (RII=0.498) and, using synergistic(additional) contractual arrangements for material waste minimization (RII=0.493) their RII values indicates on the consultant sides were less than 0.60 respectively which indicates that the techniques where less implemented within the consulting firms. The spearman rank correlation for the responses of contractor and consultant ranks was 0.33. This shows a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that among ten techniques which was grouped under lean constriction method of waste minimization there is slightly similar opinion between the contractor and the consultant professional for ranking lean constriction techniques implementation for material waste minimization.

Table 4. 12 Value engineering

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Value engineering	Using concrete spillage for parking area.	0.634	1	0.673	1
	Using software for material delivering schedule	0.599	4	0.625	6
	Performing intelligent excavation works	0.587	6	0.663	3
	Reduce-reuse-recycle' principles	0.605	3	0.635	4
	Creating alternative material reuse	0.570	7	0.635	4
	Faster completion	0.628	2	0.673	1

The above table describes construction material waste minimization techniques those related to value engineering techniques to assess the techniques implementation level. Likewise, using concrete spillage for parking area (RII=0.634), performing reduce-reuse-recycle' principles (RII=0.605), faster completion (RII=0.628) were employed with the contractors firms, while using software for material delivering schedule(RII=0.599), performing intelligent excavation works(RII=0.587)and, creating alternative material reuse(RII=0.570) were less practiced with contractors firms. Moreover, with the consultant firm perspective the techniques like faster completion (RII=0.673), using concrete spillage for parking area (RII=0.673), performing intelligent excavation works (RII=0.663) were employed with consultant perspectives which is ranked from first to third ranks. Likewise creating alternative material reuse reduce-reuse-recycle' principles (RII=0.635) and, using software for material delivering schedule (RII=0.625) were also employed with the RII values of greater than 0.6 on the behalf of the consultants. The spearman rank correlation for the responses of contractor and consultant ranks was 0.3. This indicates a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that among six techniques which was grouped under lean constriction method of waste minimization there is slightly similar opinion between the contractor and the consultant professional for ranking value engineering techniques implementation for material waste minimization.

Table 4. 13 Waste efficient material delivering

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Waste efficient material delivering	Minimizing procurement route	0.622	3	0.625	3
	Avoiding purchasing the material without schedule	0.640	5	0.673	1
	Buying materials with reused packaging	0.541	8	0.567	7
	Use effective materials take-off	0.709	1	0.663	2
	Baying material as per specification of work	0.651	2	0.625	3
	Reduced waste allowance	0.581	7	0.577	6
	Planning onsite good delivery system	0.605	6	0.548	8
	Avoiding the issue of over and under quantity of material	0.622	3	0.587	5

As presented on the table above among the techniques of material waste concerned under waste efficient material delivering techniques, using effective materials take-off (RII=0.709) baying material as per specification of work(RII=0.651), minimizing procurement route (RII=0.622),avoiding the issue of over and under quantity of material(RII=0.622), avoiding purchasing the material without schedule(RII=0.640) and, planning onsite good delivery system(RII=0.605) were ranked as employed within the concerned contractors firms. But reducing material waste allowance (RII=0.581) and buying materials with reused packaging (RII=0.541) were the techniques ranked as less employed with contractor perspectives responses with low RII values. Furthermore the techniques like avoiding purchasing the material without schedule(RII0.673) , use effective materials take-off(RII=0.663), baying material as per specification of work(RII=0.625)and, minimizing procurement route are employed by consultant firms in this study. Likewise, on the behalf of the consultants the illustration of the responses result shows that there were tendency of less implementation for the techniques like avoiding the issue of over and under quantity of material (RII=0.587), reducing material waste allowance (RII=0.577), buying materials with reused packaging (RII=0.567) and, planning onsite good delivery system(RII=0.548) material waste minimization techniques. The Spearman Rank Correlation for the responses of contractor and consultant ranks was 0.67. This means that there is the strong positive relationship between the ranks of the contractors and the consultant response's. This indicates that, the correlation of ranks between respondents working in the contractors sectors and those working in the consultant sectors indicates high level of consistence's between the two category of professional in the ranking for the eight techniques of wastes efficient material delivery method techniques for material waste minimization , it reveal a high relationships among two professional firms, regarding to the ranking of the wastes efficient material delivery techniques implemented and not implemented within the organizational firms.

Table 4. 14 Skill of professional firm's

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Skill of professional firms	Adequate involvement of various specialties in the project work performing.	0.616	2	0.548	3

	Making active harmonization among project stake holders for considering martial wastes	0.616	2	0.538	4
	Design and construction management to prevent over specification and avoid wastages.	0.674	1	0.615	1
	Adequate coordinating drawings and other details between project participants	0.581	4	0.558	2

Accordingly as illustrated on the above table there is the trend of implementing the techniques of material waste minimization techniques which is grouped under competence skill of professional firms like ,making drawings and other details are adequately distributing between project participants (RII=0.674), adequate involvement of various specialties in project work employing (RII=0.616), making active harmonization among project stake holders for considering martial wastes (RII=0.616) within contractor firms with RII values greater than 0.6. while design and construction management to prevent over specification and avoid wastages (RII=0.581) was ranked as less implemented with RII less than 0.6. On the behalf consultant response, design and construction management to prevent over specification and avoid wastages(RII=0.615) ranked first as employed with the value of RII greater than .6. But the techniques like, distributing drawings and other details adequately between project participants(RII=0.588) and, adequate involvement of various specialties in the project work performing. (RII=0.548) and, making active harmonization among project stake holders for considering martial wastes, (RII=0.538), were ranked as less practiced with RII values less than 0.6 on the consultant perspectives. The Spearman Rank Correlation for the responses of contractor and consultant ranks was 0.1. This indicates a less positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among four techniques grouped under skill of professional firms for material waste minimization techniques, which was ranked as implemented and less implemented on contractor perspectives has less association rank with the techniques ranked by consultants sides.

Table 4. 15 Waste efficient design

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Waste efficient design	Design for standard material supplies	0.526	7	0.500	7
	Careful dimensioning setting	0.581	3	0.546	5
	Avoiding cutting off material to fit	0.535	6	0.546	5
	Careful attention to detail design	0.581	3	0.562	4
	Matching the design with topography of building area	0.619	1	0.577	3
	Having the material standard information	0.581	3	0.600	2
	Clear and comprehensive information of the building places	0.609	2	0.638	1

On the above table the result of the of material waste minimization techniques which is considered under waste efficient design clarifies that contractor's was performed the practice with the techniques of material waste minimization with respected to waste efficient design techniques like; matching the design with topography of building area (RII=0619), clear and comprehensive information of the building places(RII=0.609). Likewise having the material standard information (RII=0.581), careful attention to detail design (RII=0.581), avoiding cutting off material to fit (RII=0.535)and design for standard material supplies(RII=0.526) were the techniques which was less practiced by the contractor of the firms with less RII values less than 0.60. In addition to this the competence techniques expected from the consultant professional like having the clear and comprehensive information of the building places before design (RII=0.638) and, having the material standard information(RII=0.600) were practiced with RII values greater than 0.60. While the techniques which has low RII values less than 0.60 like:- matching the design with topography of building area(RII=0.577), careful attention to detail design(RII=0.562), avoiding cutting off material to fit(RII=0.546), careful dimensioning setting(RII=0.546) and, design for standard material supplies(RII=0.500) were reflects less practiced waste minimization techniques within the consultant firms. The Spearman Rank Correlation for the responses of contractor and consultant ranks was 0.8. This indicates a strong positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among seven techniques grouped under waste efficient design for material waste minimization techniques, which was ranked as practiced and less practiced on contractor perspectives has strong association rank with the techniques ranked by consultants sides.

Table 4.16 Waste efficient specification

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Waste efficient specification	Use of standard detail and specifications	0.605	1	0.615	1
	Using detailed specification for material waste minimization	0.521	5	0.569	3
	Adequately coordinated/integrated works on specification work	0.549	3	0.562	4
	Legible to minimizing ambiguity of the design	0.535	4	0.577	2
	Using clear detailing language/format	0.553	2	0.531	5

As described on the above table among the waste efficient specification related techniques using standard detail specification (RII=0.605), is ranked as on first level with high RII values as ranked by contractors firms. But, using clear detailing language/format (RII=0.553), legible to minimizing ambiguity of the design(RII=0.535), adequately coordinated/integrated works on specification work(RII=0.549)and using detailed specification for material waste minimization(RII=0.521) were considered as less practiced with the contractor perspectives with less RII values less than 0.60. Similarly, on the behalf of consultants, using standard detail specification,(RII=0.615), were ranked first with high RII values. While, legible to minimizing ambiguity of the design (RII=0.577), using detailed specification for material waste minimization (RII=0.569), adequately coordinated/integrated works on specification work(RII=0.562) and, using clear detailing language/format(RII=0.531) techniques RII values where less than 0.60 which was considered as less practiced on the consultant response clarification of the above table. The spearman rank correlation for the responses of contractor and consultant ranks was 0.13. This indicates that, among five techniques grouped waste efficient specification for material waste minimization techniques, which was ranked as practiced and less practiced on contractor perspectives has less association rank with the techniques ranked by consultants sides.

Table 4.17. Design to re-use of material wastes

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Design for reuse of material	Determining reuse opportunities for various waste materials through design	0.563	1	0.554	1
	Design to use key material wastes to reuse for further work.	0.530	2	0.554	1
	Setting markets for construction materials wastes which cannot be reuse.	0.488	3	0.438	4
	Avoiding the waste of material from land filling	0.434	4	0.492	3

The illustration of material waste minimization techniques grouped under design to re- use material waste the above table shows that there is the trend of less practicing the techniques like; avoiding the waste of material from land filling(RII=0.563) , setting markets for construction materials wastes which cannot be reused (RII=0.530),design to use key material wastes to reuse for further work(RII=0.488) and, determining reuse opportunities for various waste materials through design(RII=0.434) were less practiced by contractor sides. However the effort the consultants to practices determining reuse opportunities for various waste materials through design(RII=0.554),design to use key material wastes to reuse for further work (RII=0.554), setting markets for construction materials wastes which cannot be reuse(RII=0.438) and, avoiding the waste of material from land filling(RII=0.492) techniques was less, as described on the above table the results of RII indicates less than 0.60 values. The spearman rank correlation for the responses of contractor and consultant ranks was 0.72. This indicates a strong positive relationship between the ranks of the contractors and the consultant response's. Which mean that, among four techniques grouped under waste efficient design for material waste minimization techniques, which was ranked as practiced and less practiced on contractor perspectives has strong relationship rank with the techniques ranked by consultants sides

Table 4. 18 Construction method

Construction material waste minimization techniques	Content of the techniques	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Construction method	Use of steel panel formwork	0.614	4	0.600	5
	Construction with standard materials as per the specification of the work	0.642	2	0.662	1
	Using steel scaffolds	0.586	7	0.608	3
	Reuse of off-cuts materials (such as wood and steel)	0.605	5	0.608	3
	Use of mechanical construction equipment's	0.651	1	0.592	6
	Using prefabricated construction method	0.595	6	0.569	7
	Ensure drawings consideration with site topography to minimize material consumption	0.637	3	0.615	2
	Logistic management to prevent double handling	0.572	8	0.562	8

As presented on the above among material waste minimization techniques which was considered under construction methods the contractor results elaborates that , use of mechanical construction equipment's(RII=0.651), construction with standard materials as per the specification of the work(RII=0.642), ensure drawings consideration with site topography to minimize material consumption(RII=0.637), use of steel panel formwork (RII=0.614) and, reuse of off-cuts materials(RII=0.605) are ranked respectively as practiced with high RII result greater than 0.60. While the technique's like:-using prefabricated construction method (RII=0.595) logistics management to prevent double handling(RII=0.572) and, using steel scaffolding(RII=0.586) were less practiced with less results RII values on the sides of contractor perspectives. But in advances the consultant results demonstrates that, construction with standard materials as per the specification of the work(RII=0.662), ensure drawings consideration with site topography to minimize material consumption(RII=0.615), reuse of off-cuts materials(RII=0.608), using steel scaffolds(RII=0.608),use of steel panel formwork(RII=0.600) were practiced with RII values of greater than 0.6. But also there was less trends of practicing the techniques like;-use of mechanical construction equipment's(RII=0.592), using prefabricated construction method(RII=0.569),)and, logistic management to prevent double handling(RII=0.562) for issues of material waste minimization through using such construction method techniques on behalf of the consultants organization responses as described on the above table with less result of RII. The spearman rank correlation for the responses of contractor and consultant ranks was 0.42. This indicates a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that, among eight techniques grouped under construction method for material waste minimization techniques, which was ranked as practiced and less practiced on contractor perspectives has medium association rank with the techniques ranked by consultants sides.

Table 4.19. Construction site management practice

Construction material waste minimization techniques	Content of the techniques	RII For contractor response	RANK for contractor response	RII for consultant response	RANK For consultant response
` CSMP	Notifying information	0.493	8	0.515	8

	categories for separating waste which suitable for reusing				
	Providing dedicated space for sorting of waste	0.484	7	0.554	5
	Adequate site access for materials movement	0.563	2	0.531	7
	Making attention for key construction material to avoid from wastages	0.553	4	0.623	1
	Adequate on-site materials control system	0.563	2	0.623	1
	Improve the stakeholders' awareness about resource saving and environmental protection	0.498	6	0.592	3
	Admit reusable materials from the construction	0.544	5	0.554	5
	Carefully plan of work sequence to prevent damages and minimize wastages	0.572	1	0.592	3

The table above demonstrates the construction material waste minimization techniques with respect to construction site management practiced (CSMP) practices.amoung the techniques clustered under construction site management practice But, carefully plan of work sequence to prevent damages and minimize wastages(RII=0.572) , adequate on-site materials control system(RII=0.563), adequate site access for materials movement(RII=0.563), sequencing key construction material wastes(RII=0.553), admit reusable materials from the construction(RII=0.544), manage the material waste on the site through, sorting and reuse/recycling(RII=0.530) and ,reuse material scraps from cutting stock-length(RII=0.513), improve the stakeholders' awareness about resource saving and environmental protection (RII=0.498), providing dedicated space for sorting of waste(RII=0.484) and, notifying information categories for separating waste(RII=0.493) which suitable for reusing are those techniques less practiced within contractor firms with less RII values. However, the material waste minimization techniques which was clustered under construction site management practices (CSMP) respect to consultants responses indicates that there is a trend of practicing the techniques like , assure effective communication of site activities(RII=0.654) , manage the material waste on the site through, sorting and reuse/recycling(RII=0.646), adequate on-site materials control system(RII=0.623), sequencing key construction material wastes(RII=0.623) and, reuse material scraps from cutting stock-length (RII=0.615)with consulting firms. In adverse the trend of practicing to improve the stakeholders' awareness about resource saving and environmental protection(RII=0.592), carefully plan of work sequence to prevent damages and minimize wastages(RII=0.592), admit reusable materials from the construction(RII=554), providing dedicated space for sorting of waste(RII=0.544), adequate site access for materials movement(RII=0.531) and, notifying information categories for separating waste which suitable for reusing(RII=0.515) were the techniques those are not practicing within the consultant stake holders. The spearman rank correlation for the responses of contractor and consultant ranks was 0.40. This indicates a medium positive relationship between the ranks of the contractors and the consultant response's. This indicates that, among eight techniques grouped under construction site management practices for material waste minimization techniques, which was ranked as practiced and less practiced on contractor perspectives has slightly medium relationship rank with the techniques ranked by consultants sides.

4.5. The possible critical action for construction material wastes minimization.

Table 4.20 The possible critical actions for construction material waste minimization.

Possible critical action for material waste minimization.	RII for contractor response	RANK for contractor response	RII for consultant response	RANK for consultant response
Establishing construction waste management regulations	0.616	6	0.663	6
Using waste management plan	0.652	2	0.730	1
providing waste minimization guide lines for worker	0.616	6	0.682	4
Establishing staff for evaluation of material waste control.	0.651	3	0.710	2
Providing continuous training for worker on material waste minimization.	0.623	5	0.615	8
Using legislation by laws for controlling	0.628	4	0.688	3

construction waste minimization				
Adopting low-waste technologies for construction material waste minimization	0.680	1	0.682	4
Using contractual clauses in contract document for material waste minimization.	0.587	8	0.622	7

As described on the above table adopting low-waste technologies for construction material waste minimization (RII=0.680) and using waste management plan(RII=0.652) were ranked first and second as the significant possible critical action should be taken for material waste minimization on behalf of the contractor. Similarly, the contractors were ranked establishing staff for evaluation of material waste control, using legislation by laws for controlling construction waste minimization and providing continuous training for worker on material waste minimization as third, fourth and fifth with high RII values greater than 0.6 as significant possible action should be taken with stake holders of the construction projects for minimizing material wastes successfully. Likewise, using waste management plan (RII=0.730) and, establishing staff for evaluation of material waste control (RII=0.710) were ranked first and second as the significant possible critical action should be taken for material waste minimization on behalf of the consultant perspectives. Similarly, the consultant were ranked using legislation by laws for controlling construction waste minimization, adopting low-waste technologies for construction material waste minimization making and, providing waste minimization guide lines for worker third, fourth and fifth with high RII values greater than 0.6 as significant possible action should be taken with stake holders of the construction projects for minimizing material wastes. The spearman rank correlation for the responses of contractor and consultant ranks was 0.69. This shows strong positive relationship between the ranks of the contractors and the consultant response's. This indicates that, the correlation of ranks between respondents working in the contractors sectors and those working in the consultant sectors shows high level of consistence's between the two category of consultants and contractors professional in the ranking for eight types of possible critical actions for construction material wastes minimization , it reveal a high relationships among two professional firms, regarding to the ranking of possible critical actions recommended for material waste minimization in building construction projects.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This study focuses on identifying causes of construction material wastes and assesses the material waste minimization techniques being employed. It also assesses possible significant critical actions for construction material wastes minimization. Among the verified causes of responses which had strong correlation association from the contractors and consultants were considered. While, complexities in design was the highest ranked with the value of RII=0.808 for causes of construction material wastes. Similarly among causes of construction material wastes, design changes (RII=0.785), design and construction detail errors (RII=0.762), lack of dimensional coordination (RII=0.756), unclear specification (RII= 0.731) and, non-standardization of building spaces (RII=0.692) were the causes of the design related factors of causes of construction material with RII values greater than 0.6 and with strong spearman rank correlation association between contractors and, consultant of 0.75 values. Likewise, damage during transportation (RII=0.709) and insufficient protection during loading and, unloading (RII=750), were also the causes of material wastes with RII values greater than 0.6 and, with strong spearman rank correlation relationships of 0.66 between contractors and consultants ranks.

Moreover, Absenteeism of the contract document for considering control system of waste minimization (RII=0.846) and, contract document incompleteness at beginning which covers the hole project contents (RII=0.654) were also the causes of material wastes with high values of RII values and, has perfect association with contractor and consultant responses. Generally using in correct quantity (RII=0.814) and, performing over allowances for material procurement (RII= 0.802) was considered as very high causes of construction material wastes and, poor material storages (RII=0.750), inadequate material handling (RII=0.750) and, storing material far away from point of application (RII=0.733) were also the causes of construction material wastes with high RII values and, with moderate spearman rank correlation relationships values between (0.39-0.50) from both contractor and consultant replies.

Moreover, the techniques of material waste minimization were grouped under lean construction, value engineering, waste efficient material delivery, skill of professional firms, waste efficient design, waste efficient specification, design to reuse material, construction method and, construction site management practice. The techniques which had moderate and strong spearman rank correlation relationships between the contractors and consultants were considered.

Depending on this the techniques such as using concrete material wastes for parking area (RII=0.673), avoiding purchasing the material without schedule (RII=0.671) using effective materials take-off (RII=0.709) were implemented within the project firms. Others like using mechanical construction equipment's(RII=0.651), involving concurrent engineering(CE) during the work(RII=0.651), extensive planning at the very beginning(RII=0.644), having the clear and comprehensive information of the building places before design (RII=0.638) minimizing procurement route(RII=0.625) adequate on-site materials control system(RII=0.623), avoiding the issue of over and under quantity of material(RII=0.622), matching the design with topography of building area(RII=0619) were practiced within the project firms with high value of RII greater than 0.60. While, reducing material waste allowance (RII=0.581) and buying materials with reused packaging (RII=0.541),setting material lean assembly consists (RII=.588) developing of alignment of material design with product design(RII=541) , and, using synergistic contractual arrangements (RII=0.506), using software for material delivering schedule(RII=0.599), performing intelligent excavation works (RII=0.587)and, creating alternative material reuse (RII=0.570) techniques were less implemented within the project firms. Others like avoiding cutting off material to fit(RII=0.535), and, design for standard material supplies(RII=0.500) using steel scaffolding(RII=0.586) using prefabricated construction method(RII=0.569),notifying information categories for separating waste(RII=0.493) techniques were less practiced within the project firms with less value of RII less than 0.60.

Accordingly, the construction firms also recommends the following possible significant critical actions should be needed for construction material wastes minimization like using waste management plan (RII=0.730),establishing staff for evaluation the material waste control during and after the construction was complete (RII=0.710),using legislation by laws for controlling construction waste minimization (RII=0.688), providing waste minimization guide lines for worker(RII=0.682)and, adopting low-waste technologies for construction material waste minimization (RII=0.680) .

5.2. Recommendations

A ,In the recommendation of this research, the following points are listed for government.

- The government bodies should prepare manuals and guidelines on the practice of new management mechanisms for material waste minimization
- Should establish contractual clauses in contract document for material waste minimization for stake holders of building construction
- The government should establish construction materials waste management department.
- The government should uses Legislation by laws for controlling construction material waste minimization to manage the material wastes effectively and to change the attitude of stakeholders discipline through exercising punishment for stakeholders who produces material wastages during work.
- The government should setting necessary strategy for adopting technology which is practicable in other country for construction material waste minimization.

B ,In the recommendation of this research, the following points are listed for consultants.

- Should use synergistic contractual arrangements with contract document for construction material waste minimization during performing the project agreement at beginning.
- The consult should be develop alignment of material design with product design of material size specially for building space division and for steel works
- Should adopt prefabrication construction methods which are more applicable for construction material waste minimization in different country.
- The consultants able to develop reduce-Reuse-Recycle material wastages for further work with using design technology
- The consultant should prepare detailed specification for material waste minimization techniques during producing of the project design.
- Establishing Waste auditing at the end of the project to monitor environmental performance and material wastes.
- The consultant should use contractual clauses in contract document for material waste minimization

- The consultant should provide Continuous training and develop employee's knowledge with different world wide construction material waste minimization technologies.

C ,In the recommendation of this research, the following points are listed for contractors.

- The contractor should use appropriate software for material waste minimization like Microsoft project scheduling for material ordering as per schedule.
- The contractor should perform the ability of creating alternative material reuse opportunities during site work operation
- The contractor should develop the knowledge for exercising prefabrication construction methods
- The contractor should consider and develop through detailed specification for material waste minimization techniques.
- The contractor should have the ability to use key material wastes to reuse for further work
- Establishing information board for worker to notify categories for separating waste which suitable for reusing
- Establishing Waste auditing at the end of the project to monitor environmental performance and material wastes.
- The contractor should establish a task group for onsite for construction material waste management strategies.

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APPENDIXES

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT DEPARTMENT

Survey questionaries' on master's thesis of assessment of construction material waste causes and minimization techniques:-a case of building construction project in Sebeta town

The aim of this questionnaire is to study construction material waste minimization techniques implementation on different projects sites on behalf different respective consultant firms and contractors around Sebeta town. Please answer all questions where possible. all the information gathered will be kept strictly confidential and will be used only for academic research and analysis will be perform without mentioning the names of individuals companies involved. Thank you in advancing for your time and kind cooperation.

Yours Faithfully

Name of the researcher :- Meseret Feyera
Advisor : Prof. Dr. Ing. Esayas Alemayehu
Co-Advisor Engr. Fitsum Alemayehu (MSc)

Part 1: Information and Experience of the stake holders

1) Name ____________________
2) project/site ____________________
3) Email ____________________

4) Respondent position in your construction company

Deputy Manager ☐ project manager ☐ site Engineer ☐
Site quantity servers ☐ site Forman ☐ sub-contractor ☐ Resident engineer at site ☐

Site supervisor ☐ site office engineer ☐ other_____________

5, Respondent position in your consulting firms

Resident Engineer ☐ architecture ☐ structural engineer ☐ Project manager ☐

quantity surveyors ☐ General design super visor ☐ other________________

6, Year of professional Work Experience

0-5years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ above 20 years ☐

5) Year of the company establishment

0-5years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ above 20 years ☐

Part 2 closed end questionaries'

1, Select from the following construction material waste causes which is causes for occurrences of construction building material wastes in your organization? Rank the causes on the scale of 1-4 on the provided space

1	2	3	4
Not causes	Less causes	causes	Highly causes

Origins of waste	Causes of waste	1	2	3	4
Design	Design Changes				
	Complexities in Design				
	Lack of dimensional coordination ,				
	Unclear specification				
	Non-standardization of building spaces				
	Design and construction detail errors				
	Slow drawing revision and distribution				
Procurement	Ordering Errors				
	Left over due to over estimation				
	Incorrect quantity estimation				
	Use of low-quality materials.				
	Over allowances				
	Supplier errors				
Site operation	Reworks due to errors				
	Improper project planning				
	Poor workmanship				
	Leftover from cutting and shaping				
	Poor site conditions				
	Poor supervision				
	Materials off-cuts				
	Inadequate knowledge				

	Using wrong materials				
	Unused materials and products				
On-site Management and Planning	Absence of on-site attention for material waste consideration				
	Improper planning for required quantities				
	Delays in passing information on types and sizes of materials to be used				
	Lack of on-site material control and Lack of supervision				
Material handling	Poor Materials Storage				
	Materials supplied in loose form, and				
	On-site transportation methods from storage to the point of application				
	Materials stored far away from point of application				
	Inadequate material handling				
Transportation	Damage during transportation				
	Difficulties for delivery vehicles accessing construction sites				
	Insufficient protection during unloading				
Contractual	Absenteeism of contract document for material waste minimization.				
	Contract documents incomplete at beginning				
External	Material damages due to weather				
	Accident				
	Theft				
	Vandalism				

3, Dou you think that the following construction material waste minimization techniques are the best techniques for construction material waste minimization techniques? Thick under provided spaces through answering yes or no?

Construction material waste minimization techniques	yes	no
Construction method		
Lean construction		
Applying value engineering		
Quality of design		
Quality of specification		
Method of delivering the material		
Design for re use of material		
Skill of professional firms		

4, below are possible techniques of construction material waste minimization. Which of these construction material waste minimization techniques are employed in your organization? Rank on a scale of 1-4

1	2	3	4
Not employed	Less employed	employed	Highly employed

Construction material waste minimization techniques	Content of the techniques	`1	2	3	4
Lean construction	Using synergistic contractual arrangements				
	Developing of alignment of material design with product design				
	Structuring the material flow with supply chains				
	Extensive planning at the very beginning				
	Using CPM for material scheduling				
	Using appropriate software for material waste minimization.				
	Setting material lean assembly consists				
	Using concurrent engineering (CE)				
	Material wastes control with work flow of the project.				
	just-in-time (JiT) material delivery				
Value engineering	Using concrete spillage for parking area.				
	Using Software for material delivering schedule				
	Performing intelligent excavation works				
	Reduce-reuse-recycle' principles				
	Creating alternative material reuse				
	Faster completion,				
Waste efficient material delivering method `	Minimizing procurement route				
	Avoiding purchasing the material without schedule				
	Buying materials with reused packaging				
	Use effective materials take-off				
	Baying material as per specification of work				
	Planning onsite good delivery system				
	Avoiding the issue of over and under quantity of material				
	Reduced waste allowance				
Skill of professional firms	Adequate involvement of various specialties in the project work performing.				
	Making active harmonization among project stake holders for considering martial wastes				
	Design and construction management to prevent over specification and avoid				

	wastages.				
	Drawings and other details are adequately coordinated between project participants				

5, from the following possible construction material waste minimization techniques through design and construction, choice the construction material waste minimization techniques which are practicing during implementation of your construction project? Rank on a scale of 1-5 the level of practice of these material waste minimization techniques in your firms

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

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5
Waste efficient design	Design for standard material supplies					
	Careful dimensioning setting					
	Avoiding cutting off material to fit					
	Careful attention to detail design					
	Matching the design with topography of building area					
	Having the material standard information					
	Clear and comprehensive information of the building places					
Waste efficient specification	Use of standard detail and specifications					
	Using detailed specification for material waste minimization					
	Adequately coordinated/integrated works on specification work					
	Legible to minimizing ambiguity of the design					
	Using clear detailing language/format					
Design for re use of material	Determining reuse opportunities for various waste materials minimization through design					
	Design to use key material wastes to reuse for further work.					
	Setting markets for construction materials wastes which cannot be reuse.					
	Avoiding the waste of material from land filling					
Construction method	Use of steel panel formwork,					
	Construction with standard materials as per the specification of the work					
	Using steel scaffolds					
	Reuse of off-cuts materials (such as wood and steel)					

	Use of mechanical construction equipment's					
	Using prefabricated construction method					
	Ensure drawings consider and integrate site topography					
	Logistic management to prevent double handling					
Construction site management practice	Notifying information categories for separating waste which suitable for reusing					
	Adequate site access for materials movement					
	Sequencing key construction material wastes					
	Assure effective communication of site activities					
	Adequate on-site materials control system					
	Manage the material waste on the site through, sorting and reuse/recycling					
	Improve the stakeholders' awareness about resource saving and environmental protection					
	Admit reusable materials from the construction					
	Carefully plan of work sequence to prevent damages and minimize wastages					

6 What do you recommend that, from the following possible significant critical action for material waste minimization which can successfully minimizes the construction material wastes? Rank on the scale of 1-4 based on their significant level as possible critical action for material waste minimization.

1	2	3	4
Not significant	Less significant	significant	Highly significant

Possible critical action for material waste minimization.	1	2	3	4
Using construction waste management regulations				
Using waste management plan				
Providing waste minimization guide lines for work				
Establishing staff for evaluation of material wastes				
Providing continuous training and development of employees				
Using legislation by laws for controlling construction waste minimization				
Adopting of low-waste technologies construction material waste minimization				
Using contractual clauses in contract document for material waste minimization.				

Results from the questionaries' that provided for the contractors company

1, Select from the following construction material waste causes which is causes for occurrences of construction building material wastes in your organization? Rank the causes on the scale of 1-4 on the provided space

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Design	Design changes	0	9	19	15	0.785	2
	Complexities in design	1	2	26	14	0.808	1
	Lack of dimensional coordination	2	6	24	11	0.756	4
	Unclear specification	1	8	28	6	0.727	5
	Non-standardization of building spaces	5	10	18	10	0.692	6
	Design and construction detail errors	1	4	30	8	0.762	3
	Slow drawing revision and distribution	5	12	19	7	0.663	7

Origin of wastes	Causes of Construction Material waste	1	2	3	4	RII	Rank
procurement	Ordering errors	0	6	26	11	0.779	3
	Left over due to over estimation	0	9	29	5	0.727	5
	Incorrect quantity estimation	2	5	16	20	0.814	1
	Use of low-quality materials	0	15	19	9	0.715	6
	Over allowances	4	6	30	8	0.802	2
	Supplier errors	2	5	27	9	0.750	4

Origin of wastes	Causes of Construction Material waste	1	2	3	4	RII	Rank
Site operation	Reworks due to errors	1	1	30	11	0.797	1
	Improper project planning	1	7	20	15	0.785	2
	Poor workmanship	1	7	23	12	0.767	4
	Leftover from cutting and shaping	4	7	11	18	0.715	5
	Poor site conditions	3	16	11	13	0.698	6
	Poor supervision	0	15	23	5	0.692	7
	Materials off-cut	0	6	25	12	0.785	2
	Inadequate knowledge	2	18	16	7	0.663	8
	Using wrong materials	7	10	19	7	0.651	9
	Unused materials and products	7	10	21	5	0.640	10

Origin of wastes	Causes of Construction Material waste	1	2	3	4	RII	Rank
On-site Management and Planning	Absence of on-site attention for material waste consideration	0	16	20	7	0.698	4
	Improper planning for required quantities	2	3	35	3	0.727	2
	Delays in passing information on types and sizes of materials to be used	2	5	30	6	0.733	1
	Lack of on-site material control and lack of	3	9	22	9	0.715	3

	supervision						

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Material handling	Poor materials storage	0	7	30	6	0.744	1
	Materials supplied in loose form, and	3	6	30	4	0.703	3
	On-site transportation methods from storage to the point of application	0	6	26	9	0.733	2
	Materials stored far away from point of application	3	13	27	0	0.640	5
	Inadequate material handling	0	15	26	2	0.674	4

Origin of wastes	Causes of Construction Material waste	1	2	3	4	RII	Rank
Transportation	Damage during transportation	0	19	22	2	0.651	3
	Difficulties for delivery vehicles accessing construction sites	0	7	36	0	0.709	1
	Insufficient protection during unloading	0	19	20	4	0.663	2

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Contractual	Absenteeism of contract for material waste minimization	4	18	16	5	0.628	1
	Contract documents incomplete at beginning	7	16	18	2	0.587	2

Origin of wastes	Causes of Construction Material waste	1	2	3	4	RII	Rank
External	Material Damages Due to Weather	2	11	24	6	0.698	2
	Accident	5	24	9	5	0.581	3
	Theft	8	21	9	5	0.564	4
	Vandalism	2	13	17	11	0.715	1

Results from the questionaries' that, provided for the contractors company and consulting firms.

2, Dou think that the following construction material waste minimization techniques are the best techniques for construction material waste minimization techniques? Thick under provided spaces through answering yes or, no?

Construction material waste minimization techniques	Number of response by contractor		%(Percentage) of response by contractor		Number of Response by consultant		%(Percentage)of response by consultant	
	yes	no	yes	no	yes	no	yes	No

Construction method	36	7	83.7	16.3	14	12	53.8	46.2
Lean construction	27	16	62.8	37.2	17	9	65.4	34.6
Applying value engineering	29	14	67.4	32.6	15	11	57.7	42.3
Quality of design	33	10	76.7	23.3	23	3	88.5	11.5
Quality of specification	31	12	72.1	27.9	24	2	92.3	7.7
Method of delivering the material	24	19	55.8	44.2	21	5	80.8	19.2
Design for re use of material	40	3	93.0	7.0	22	4	84.6	15.4
Skill of professional firms	34	9	79.1	20.9	21	5	80.8	19.2

3.below are possible techniques of construction material waste minimization. Which of these construction material waste minimization techniques are employed in your organization? Rank on a scale of 1-4

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	RII	Rank
Lean construction	Using synergistic contractual arrangements	10	22	11	0	0.506	10
	Developing of alignment of material design with product design	8	20	15	0	0.541	8
	Structuring the material flow with supply chains	4	22	17	0	0.576	4
	Extensive planning at the very beginning	5	26	12	0	0.541	8
	Using CPM for material scheduling	6	23	11	3	0.564	5
	Using appropriate software for material waste minimization.	7	19	17	0	0.558	6
	Setting material lean assembly consists	9	18	13	3	0.558	6
	Using concurrent engineering(CE)	7	14	23	3	0.651	1
	Material wastes control with work flow of the project.	2	13	28	0	0.651	1
	Just-in-time (JiT) material delivery	8	17	13	5	0.634	3

Construction material waste minimization techniques	Content of the techniques	`1	2	3	4	RII	Rank
Value engineering	Using concrete spillage for parking area.	6	9	27	1	0.634	1
	Using software for material delivering schedule	5	20	14	4	0.599	4

	Performing intelligent excavation works	4	21	17	1	0.587	5
	Reduce-reuse-recycle' principles	6	15	20	2	0.605	3
	Creating alternative material reuse	6	21	14	2	0.570	6
	Faster completion	5	12	25	1	0.628	2

Construction material waste minimization techniques	Content of the techniques	`1	2	3	`4	RII	Rank
Waste efficient material delivering	Minimizing procurement route	3	20	16	4	0.622	5
	Purchase to avoid over/under ordering	4	14	20	5	0.651	2
	Buying materials with reused packaging	9	20	12	2	0.541	8
	Use effective materials take-off	0	15	20	8	0.709	1
	Baying material as per specification of work	0	19	22	2	0.651	2
	Planning onsite good delivery system	3	23	13	4	0.605	7
	Avoiding the issue of over and under quantity of material	3	19	18	3	0.622	5
	Reduced waste allowance	0	20	20	3	0.581	4

Construction material waste minimization techniques	Content of the techniques	`1	2	3	4	RII	Rank
Skill of professional firms	Adequate involvement of various specialties in the project work performing.	2	22	16	3	0.616	2
	Making active harmonization among project stake holders for considering martial wastes	2	22	16	3	0.616	2
	. Design and construction management to prevent over specification and avoid wastages.	0	16	24	3	0.674	1
	Drawings and other details are adequately coordinated between project participants	3	22	18	0	0.581	4

4.from the following possible construction material waste minimization techniques through design and construction, choice the construction material waste minimization techniques which is practicing during implementation of your construction project? Rank on a scale of 1-5 the level of practice of these material waste minimization techniques in your firms

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Waste efficient design	Design for standard material supplies	5	13	18	7	0	0.526	7
	Careful dimensioning setting	2	7	27	7	0	0.581	4
	Avoiding cutting off material to fit	2	14	23	4	0	0.535	6
	Careful attention to detail design	0	10	27	6	0	0.581	4
	Matching the design with topography of building area	0	11	20	9	3	0.619	1
	Having the material standard information	0	10	27	6	0	0.581	3
	Clear and comprehensive information of the building places	0	11	21	9	2	0.609	2

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Waste efficient specification	Use of standard detail and specifications	0	9	26	6	2	0.605	1
	Using detailed specification for material waste minimization	4	15	20	2	2	0.521	5
	Adequately coordinated/integrated works on specification work	3	10	25	5	0	0.549	3
	Legible to minimizing ambiguity of the design	0	17	23	3		0.535	4
	Using clear detailing language/format	0	22	12	6	3	0.553	2

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Design for reuse of material	Determining reuse opportunities for various waste materials minimization through design	4	16	10	10	3	0.560	1
	Design to use key material wastes to reuse for further work.	7	14	12	7	3	0.530	2
	Setting markets for construction materials wastes which cannot be reuse.	2	27	7	7	0	0.488	3
	Avoiding the waste of material from land filling	9	16	7	11	0	0.288	4

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Construction method	Use of steel panel formwork,	0	9	22	12	0	0.614	4
	Construction with standard materials as per the specification of the work	0	7	20	16	0	0.642	2
	Using steel scaffolds	3	12	16	9	3	0.586	7
	Reuse of off-cuts materials (such as wood and steel)	0	14	17	9	3	0.605	5
	Use of mechanical construction equipment's	0	7	24	6	6	0.651	1
	Using prefabricated construction method	0	14	19	7	3	0.595	6
	Ensure drawings consider and integrate site topography	0	12	14	14	3	0.637	3
	Logistic management to prevent double handling	0	14	21	8	0	0.572	8

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Construction site management practice	Notifying information categories for separating waste which suitable for reusing.	3	25	7	8	0	0.493	9
	Adequate site access for materials movement	2	12	21	8	0	0.563	3
	Sequencing key construction material wastes.	5	13	15	7	3	0.553	5
	Assure effective communication of site activities.	2	10	16	15	0	0.605	1
	Adequate on-site materials control system.	5	11	14	13	0	0.563	3
	Manage the material waste on the site through, sorting and reuse/recycling	5	14	15	9	0	0.530	7
	Improve the stakeholders' awareness about resource saving and environmental protection	8	13	15	7	0	0.498	8
	Admit reusable materials from the construction	2	12	25	4	0	0.544	6
	Carefully plan of work sequence to prevent damages and minimize wastages	2	10	23	8	0	0.572	2

5, What do you recommend that, from the following possible significant critical action for material waste minimization which can successfully minimizes the construction material wastes? Rank on the scale of 1-4 based on their significant level as possible critical action for material waste minimization.

Possible critical action for material waste minimization.	1	2	3	4	RII	Rank
Using construction waste management regulations	8	17	8	10	0.616	6
Using waste management plan	7	15	9	12	0.652	2
Providing waste minimization guideline for work.	4	10	17	12	0.616	6
Providing site space available for performing waste management	8	10	16	9	0.651	3

Providing continuous training and development of employees	8	15	10	10	0.623	5
Using legislation by laws for controlling construction waste minimization	10	10	11	11	0.628	4
Adopting of low-waste technologies construction material waste minimization	3	17	12	11	0.680	1
Using contractual clauses in contract document for material waste minimization.	8	17	13	5	0.587	8

Results from the questionaries' that, provided for the consultant firms.

1, Select from the following construction material waste causes which is causes for occurrences of construction building material wastes in your organization? Rank the causes on the scale of 1-4 on the provided space

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Design	Design changes	1	5	11	9	0.750	1
	Complexities in design	0	8	12	6	0.731	2
	Lack of dimensional coordination ,	1	8	11	6	0.712	4
	Unclear specification	0	6	16	4	0.731	2
	Non-standardization of building spaces	2	8	12	4	0.712	7
	Design and construction detail errors	2	4	16	4	0.712	4
	Slow drawing revision and distribution	2	8	11	5	0.683	6

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Procurement	Ordering errors	3	9	11	3	0.635	5
	Left over due to over estimation	1	6	1	6	0.601	6
	Incorrect quantity estimation	2	6	9	9	0.740	1
	Use of low-quality materials	2	7	10	7	0.712	2
	Over allowances	2	8	12	4	0.673	3
	Supplier errors	3	9	8	6	0.663	4

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Site operation	Reworks due to errors	0	10	11	5	0.702	4
	Improper project planning	1	8	10	7	0.721	2
	Poor workmanship	2	11	9	4	0.644	10
	Leftover from cutting and shaping	0	8	13	5	0.721	2
	Poor site conditions	1	10	13	2	0.654	8
	Poor supervision	0	6	16	4	0.731	1
	Materials off-cut	1	9	11	5	0.692	5
	Inadequate knowledge	0	9	14	3	0.692	5
	Using wrong materials	2	6	14	4	0.692	5

	Unused materials and products	2	10	11	3	0.644	10

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
On-site Management and Planning	Absence of on-site attention for material waste consideration	2	9	10	5	0.673	3
	Improper planning for required quantities	2	9	12	3	0.654	4
	Delays in passing information on types and sizes of materials to be used	0	5	15	5	0.721	1
	Lack of on-site material control and lack of supervision	0	6	17	3	0.721	1

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Material handling	Poor materials storage	0	4	18	4	0.750	1
	Materials supplied in loose form, and	0	8	14	4	0.712	5
	On-site transportation methods from storage to the point of application	0	6	17	3	0.721	3
	Materials stored far away from point of application	1	10	14	1	0.644	3
	Inadequate material handling	0	4	18	4	0.750	1

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Transportation	Damage during transportation	0	10	14	2	0.673	3
	Difficulties for delivery vehicles accessing construction sites	0	9	15	2	0.683	2
	Insufficient protection during unloading	1	5	13	7	0.750	1

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	Rank
Contractual	Absenteeism of contract documents for material waste minimization.	0	4	16	8	0.846	1
	Contract documents incomplete at the beginning.	1	10	13	2	0.654	2

Origin of wastes	Causes of construction material waste	1	2	3	4	RII	RANK
External	Material damages due to weather	2	12	6	6	0.654	2
	Accident	2	8	12	4	0.673	1
	Theft	2	14	7	3	0.606	3
	Vandalism	3	13	6	4	0.606	3

5.below are possible techniques of construction material waste minimization. Which of these construction material waste minimization techniques are employed in your organization? Rank on a scale of 1-4

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	RII	Rank
Lean construction	Using synergistic contractual arrangements	22	4	0	0	0.493	10
	Developing of alignment of material design with product design	12	11	3	0	0.498	9
	Structuring the material flow with supply chains	7	14	3	2	0.500	8
	Extensive planning at the very beginning	3	7	14	2	0.644	2
	Using CPM for material scheduling	3	11	10	2	0.606	5
	Using appropriate software for material waste minimization.	1	6	15	2	0.654	1
	Setting material lean assembly consists	6	13	7	0	0.510	7
	Using concurrent engineering (CE)	2	8	15	1	0.644	2
	Material wastes control with work flow of the project.	6	11	9	0	0.529	6
	Just-in-time (JiT) material delivery	2	12	9	3	0.625	4

Construction material waste minimization techniques	Content of the techniques	`1	2	3	4	RII	Rank
Value engineering	Using concrete spillage for parking area.	1	8	15	2	0.673	1
	Using software for material delivering schedule	1	12	12	1	0.625	6
	Performing intelligent excavation works	2	8	13	3	0.663	3
	Reduce-reuse-recycle' principles	2	10	12	2	0.635	4
	Creating alternative material reuse	3	8	13	2	0.635	4
	Faster completion,	3	5	15	3	0.673	1

Construction material waste minimization techniques	Content of the techniques	`1	2	3	`4	RII	RANK
Waste efficient material delivering	Minimizing procurement route	2	9	15	0	0.625	3
	Avoiding purchasing the material without schedule	2	7	14	3	0.673	1
	Buying materials with reused packaging	4	11	11	0	0.567	7
	Use effective materials take-off	1	8	16	1	0.663	2
	Baying material as per specification of work	2	11	11	2	0.625	3
	Planning onsite good delivery system	6	9	11	0	0.548	8
	Avoiding the issue of over and under quantity of material	1	9	14		0.587	6
	Reduced waste allowance	5	9	11	1	0.577	5

Construction material waste minimization techniques	Content of the techniques	`1	2	3	4	RII	Rank
Skill of professional firms	Adequate involvement of various specialties in the project work performing	4	13	9	0	0.548	3
	Making active harmonization among project stake holders for considering martial wastes	4	14	8	0	0.538	4
	Design and construction management to prevent over specification and avoid wastages.	4	6	16	0	0.615	1
	Adequate coordinating drawings and other details between project participants	5	10	11	0	0.558	2

5. From the following possible construction material waste minimization techniques through design and construction, choice the construction material waste minimization techniques which

is practicing during implementation of your construction project? Rank on a scale of 1-5 the level of practice of these material waste minimization techniques in your firms

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	Rank
Waste efficient design	Design for standard material supplies	2	10	13	1	0	0.500	7
	Careful dimensioning setting	2	5	17	2	0	0.546	5
	Avoiding cutting off material to fit	2	8	11	5	0	0.546	5
	Careful attention to detail design	0	8	15	3	0	0.562	4
	Matching the design with topography of building area	1	7	12	6	0	0.577	3
	Having the material standard information	1	6	11	8	0	0.600	2
	Clear and comprehensive information of the building places	1	3	13	8	1	0.638	1

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	RANK
Waste efficient specification	Use of standard detail and specifications	0	7	11	7	1	0.615	1
	Using detailed specification for material waste minimization	3	5	12	5	1	0.569	3
	Adequately coordinated/integrated works on specification work	1	9	11	4	1	0.562	4
	Legible to minimizing ambiguity of the design	1	8	11	5	1	0.577	2
	Using clear detailing language/format	3	7	13	2	1	0.531	5

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	RANK
Design for reuse of material	Determining reuse opportunities for various waste materials minimization through design	1	8	14	2	1	0.554	1

	Design to use key material wastes to reuse for further work.	2	10	7	6	1	0.554	1
	Setting markets for construction materials wastes which cannot be reuse.	8	10	4	3	1	0.438	4
	Avoiding the waste of material from land filling	5	8	9	4	0	0.492	3

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	RANK
Construction method	Use of steel panel formwork,	2	5	13	3	3	0.600	5
	Construction with standard materials as per the specification of the work	1	2	14	6	3	0.662	1
	Using steel scaffolds	1	7	9	8	1	0.608	3
	Reuse of off-cuts materials (such as wood and steel)	1	4	15	5	1	0.608	3
	Use of mechanical construction equipment's	0	6	15	5	0	0.592	6
	Using prefabricated construction method	1	7	14	3	1	0.569	7
	Ensure drawings consider and integrate site topography	1	8	7	8	2	0.615	2
	Logistic management to prevent double handling	0	11	10	4	1	0.562	8

Construction material waste minimization techniques	Content of the techniques	1	2	3	4	5	RII	RANK
Construction site management practice	Notifying information categories for separating waste which suitable for reusing	1	12	10	3	0	0.515	9
	Adequate site access for materials movement	2	10	9	5	0	0.531	8

	Sequencing key construction material wastes	1	6	8	11	0	0.623	3
	Assure effective communication of site activities	1	5	8	10	2	0.654	1
	Adequate on-site materials control system	3	5	6	10	2	0.623	3
	Manage the material waste on the site through, sorting and reuse/recycling	1	5	9	9	2	0.646	2
	Improve the stakeholders' awareness about resource saving and environmental protection	0	8	12	5	1	0.592	5
	Admit reusable materials from the construction	2	9	8	7	0	0.554	7
	Carefully plan of work sequence to prevent damages and minimize wastages	1	6	12	7	0	0.592	5

6 What do you recommend that, from the following possible significant critical action for material waste minimization which can successfully minimizes the construction material wastes? Rank on the scale of 1-4 based on their significant level as possible critical action for material waste minimization.

Possible critical action for material waste minimization.	1	2	3	4	RII	RANK
Using construction waste management regulations	2	10	9	5	0.663	6
Using waste management plan	3	6	8	9	0.730	1
Providing waste minimization guide lines for work	2	6	12	5	0.682	4
Providing staff for evaluation of material waste.	3	9	6	8	0.710	2
Providing continuous training and development of employees	3	11	9	3	0.615	8
Using legislation by laws for controlling construction waste minimization	2	10	7	7	0.688	3
Adopting of low-waste technologies construction material waste minimization	2	7	8	9	0.682	4
Using contractual clauses in contract document for material waste minimization.	5	7	11	3	0.621	7

The following equation is used to determine the sample size as described by Al-Moghany, (2006) and, Cochran, W. G. (1977)

$$SS = \frac{Z^2 * P * (1-P)}{C^2}$$

Where SS = Sample size

Z = Z value (e.g. 1.96 for 95% confidence level)

P = percentage picking a choice, expressed as a decimal (0.50 used for sample size needed).

C = margin of error (8%)

$$SS = \frac{Z^2 * P * (1-P)}{C^2}$$

$$= \frac{(1.96)^2 * 0.5 * (1-.5)}{(0.08)^2} = 150$$

Correction for Finite Sample:-

Where: Total sampled of construction parties = 173 match the proposed contracting companies

$$SS\ new = \frac{SS}{1 + \frac{(SS-1)}{POP}}$$

$$= \frac{150}{1 + \frac{(150-1)}{173}} = 81$$

To select the grades the proportion were proceeded as shown below. finally the determined proportion were selected randomly, depending on the project which more working method, which had variety staff and has more budget among each other.

Grade one building contractor company (BC1)=35

$$SS\ new\ for\ BC1 = \frac{35*81}{173} = 16.387 = 16$$

Grade two building contractor company (BC2)=29

$$SS\ new\ for\ BC2 = \frac{29*81}{173} = 13.587 = 14$$

Grade three building contractor company (BC3)=17

$$SS\ new\ BC3 = \frac{17*81}{173} = 7.95 = 8$$

Grade four building contractor company (BC4)=15

$$SS\ new\ BC4 = \frac{15*81}{173} = 7.023 = 7$$

Grade five building contractor company (BC5)=13

$$SS\ new\ BC5 = \frac{13*81}{173} = 6.086 = 6$$

Consultant companies =64

$$SS\ new\ for\ consultant\ companies = \frac{64*81}{173} = 29.96 = 30$$

The kinnear and gray, (1999) formula which was used for correlation of consultants and, contractors, respondents rank results were stated as the following :-

$$p = 1 - \frac{6\sum(di)^2}{n(n^2-1)}$$

Where p=Spearman rank correlation

di= the differences between the ranks of corresponding variables

n= number of observation

When the value of correlation coefficient was between 0.1 and 0.29 represents small association, the value of correlation coefficient between 0.3&0.49 represent medium association and the value of correlation coefficient between 0.5& above represent high association.

The Values of cronbach's data reliability responses for over whole number of each item of questions responses of contractors ,from spss outputs.

Case Processing Summary

		N	%
Cases	Valid	43	100.0
	Excluded[a]	0	.0
	Total	43	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.936	117

The Values of cronbach's data reliability responses for over whole number of each item of questions responses of consultants, from spss outputs.

Case Processing Summary

		N	%
Cases	Valid	26	100.0
	Excluded[a]	0	.0
	Total	26	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.848	117

The Values of cronbach's data reliability responses for responses of contractors and consultants, from spss output, depending on sub categories factors for number of each item of questions, as prepared on the questioners separately.

For Data of The Contractors Responses		
Factors	Number of each item of questions	Cronbach's alpha values
For causes of construction material wastes	41	0.854
For importance level of techniques of material waste minimization	8	0.699
For material waste minimization techniques	60	0.952
For possible significant critical action which can successfully minimizes the material wastages	8	0.810
For Data of The Consultants Responses		
factors	Number of each item of questions	Cronbach's alpha values

For causes of construction material wastes	41	0.648
For importance level of techniques of material waste minimization	8	0.682
For material waste minimization techniques	60	0.904
For possible significant critical action which can successfully minimizes the material wastages	8	0.873