Sudan University of Science and Technology

College of Graduate Studies

Waste Materials Management in Construction Industry in Khartoum State

إدارة مخلفات مواد البناء في صناعة التشييد بولاية الخرطوم

A thesis Submitted to the School of Civil Engineering in Fulfilment for requirements of the degree of (M.Sc.) in Construction Management

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July 2018

الآية

{أَمَنَ الرَّسُولُ بِمَا أُنْزِلَ إِلَيْهِ مِنْ رَبِّهِ وَالْمُؤْمِنُونَ كُلٌّ آمَنَ بِاللَّهِ وَمَلَائِكَتِهِ وَكُتُبِهِ وَرُسُلِهِ لَا نُفَرِّقُ بَيْنَ أَحَدٍ مِنْ رُسُلِهِ وَقَالُوا سَمِعْنَا وَأَطَعْنَا غُفْرَانَكَ رَبَّنَا وَإِلَيْكَ الْمَصِيرُ (285) لَا يُكَلِّفُ اللَّهُ نَفْسًا إِلَّا وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ رَبَّنَا لَا تُؤَاخِذْنَا إِنْ نَسِينَا أَوْ أَخْطَأْنَا رَبَّنَا وَلَا تَحْمِلْ عَلَيْنَا إِصْرًا كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِنْ قَبْلِنَا رَبَّنَا وَلَا تُحَمِّلْنَا مَا لَا طَاقَةَ لَنَا بِهِ وَاعْفُ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَا أَنْتَ مَوْلَانَا فَانْصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ (286)}

الآيتان (285) و(286) من سورة البقرة

Dedication

To My Mother …

To My Father …

To My Friends and Colleagues …

Acknowledgements

I would like to express my special appreciation to my supervisor

Dr. Osama Mohammed ahamed

For the guidance, assistance, criticism, and suggestions on this research

Appreciation is also extended to those contractors, consultants and owners whose.

Completed the documents used in this research and also i would like to thank …

My family members

And my friends whose had given a lot of encouragement and motivation to complete this study

Abstract

This research provides an overview of waste materials management in construction industry in Khartoum State – Republic of Sudan. Through the identification of the types of construction waste located in different construction sites and their causes and ways to minimize them. The purposes of this study are to give background information on construction waste problems in Khartoum and propose a practical guidance to building professionals on how to manage and minimise construction waste.

Data collected using questionnaire administered on selected sub-contractors and project managers in Khartoum state. In the process, 103 completed questionnaires received at response rate of 100%, and used (SPSS) for analysing and processing data.

The results indicate that the common waste materials been considered were steel with (51.5%), followed by Bricks, then come the Concrete, then wood and the less one was paper/bags. And notice that there's some awareness among contractors of the practice of managing waste materials on site in Khartoum states, using four factors were specified as measures to minimise waste on site such as: reducing as the highest value, recycling, solid waste management and reusing product.

Further developments are recommended to develop a scientific methodology to quantify construction waste. Furthermore, more practical support is required to enforce the implantation of Construction Waste management scheme in the construction and building field, It is also recommended to extend research on the area of recycling technique of building materials to induct feasibility studies, including cost and payback period analysis for each technique.

مستخلص

تناول هذا البحث نظرة عامة عن إدارة مخلفات مواد البناء في ولاية الخرطوم– جمهورية السودان, من خلال التعرف على انواع مخلفات البناء الموجوده في مواقع التشييد المختلفة وأسبابها وعن الطرق المتبعه لتقليلها.

الغرض من هذه الدراسة هو تقديم معلومات أساسية عن إدارة مخلفات مواد البناء في الخرطوم وعرض توجيه عملي للمهنيين حول كيفية إدارة وتقليل المخلفات.

تم تصميم إستبيان لجمع المعلومات، ويتكون مجتمع البحث من المقاولين ومدراء المشاريع الهندسية في قطاع التشييد بولاية الخرطوم، وتم توزيع 103 إستبيانا بمعدل إستجابة 100%، وتم إستخدام برنامج SPSS الإحصائي لمعالجة وتحليل البيانات.

من النتائج التي توصل إليها الباحث أن أكثر مخلفات المواد في البناء كان الحديد بنسبة 51.5%، يليه الطوب ثم الخرسانة والخشب وأخيرا الورق . ولوحظ أن هناك بعض من الوعي بين المقاولين ومدراء المشاريع عن ممارسة طرق إدارة مخلفات مواد البناء مثل طريقة الخفض (reduce) كأعلى قيمة، ثم إعادة التدوير (recycle) وإعادة الإستخدام (reuse) وأخيرا التخلص منهت في مكب النفايات (land fill).

يوصى بمزيد من التطور لتحسين المنهجية العلمية لتحديد أنواع مخلفات البناء، علاوة على ذلك، هناك حاجه لمزيد من الدعم العملي لفرض خطة إدارة مخلفات المواد في مجال الإنشاء والبناء، كما يوصى بتوسيع البحث في مجال تقنية إعادة التدوير لمواد البناء وتطبيقها عمليا، بما في ذلك تحليل التكلفة والمردود لكل تقنية.

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CHAPTER 1

INTRODUCTION

1.1 Background of study:

The construction waste has a main impact on the environment. With the demands in implementing major infrastructure projects in Khartoum, together with many commercial buildings and housing development programmes, a large amount of construction wastes are being produced by the construction sector. The construction industry is responsible for producing a whole variety of waste, the amount and type of which depends on several factors, such as the stage of construction, type of construction work, practices on site. Thus, waste minimisation is an important area of concern in the implementation of construction waste management in the construction industry in Khartoum.

The waste is an unavoidable consequence of human activities. The economic development, urbanization and improving living standards in cities, have led to increase in the quantity and complexity of generated waste. Inefficient waste management has aggravated to this problem which has resulted in the threats on natural resources. This clearly emphasizes the importance of effective and efficient waste management techniques. Considering the rapidly urbanizing world, most of the cities across the globe are suffering from the problem of managing the environmental outcomes of human activities .The economy of the world through the development of big cities, the waste management in those areas as becoming crucial for human existence in the big cities. Most of the developing cities in Africa particularly face the dual challenges of exploding population and scarce resources.

Beside the fact that the waste management is important in ensuring the parties knowing their responsibility and how they should manage the waste on the site and to reduce the waste on the construction industry which can give effect on cost of the project in the construction industry. The awareness of the parties involved is well important to safeguard our environment healthy in good conditions.

My study area is to get the information and knowledge regarding the importance of waste management and how it would affect contractor's profit and keeping the environment better. The construction waste should be managed properly because of limited dump area on site beside to avoid risk to the people and to the contractors because the wastage has been identified has one of the major problems in the construction industry. It also shows the knowledge and level of awareness of the contractors regarding the wastage on site.

1.2 Problem Statement

The construction materials waste is becoming a serious environmental problem in many large cities in the world. In Khartoum, the construction industry produces the vast construction waste which cause significant impact on the environment and increasing public concern in the local community the minimisation of construction waste has become an important issue. The waste management to economic drop is apparent to be increasing pressures to stimulate materials consumption, which in turn is seen to be increasing burdens to reduce materials consumption to achieve sustainable waste management. The main challenge therefore will be to break the linkage between consumption and waste generation, if sustainability in construction materials waste management is to be achieved.

1.3 Significant of Research

This research is expected to contribute solution regarding construction materials waste management in the Khartoum construction sites and this could be achieved by using holistic waste management system, which includes improving public health, reducing impacts to the environment, and increasing resource recovery through minimising waste generation combined with increasing materials recycling. These three divers are expected to be reached or recommend to the construction firms at the end of this study. In other words, to create safe and sustainable environment using methods in the most efficient way to avoid any unnecessary cost, this will be considered as a new and creative approach towards product and production processes.

If the waste material management not in involves any of the building construction projects, the waste material management plan cannot be implemented as per the schedule in order to complete the project, At the same time material requirements planning system and the materials storage system in the construction project cannot be managed for a project without MMP (Material Management Plan), Any project cannot be completed successfully within the allotted time and cost without construction material management, and a waste materials management budget of all the materials which are required to be used cannot be prepared for each project without MMP.

1.4 Hypotheses:

1. There are many types of waste materials generated in Khartoum state projects, (steel concrete, bricks, wood, bags/paper)
2. There is awareness to some extend about waste management practice among contractors in commercial project in Khartoum state.

3. Manage construction waste materials by (disposal (land fill), reduce, reuse, recycle) methods.

1.5 Objectives

1. To identify types of waste materials most generated during construction process in commercial project in Khartoum State
2. To evaluate the level of awareness on waste management practice among contractors in commercial projects
3. To investigate the best waste management practice that are being used among the commercial building projects contractors

1.6 Research Questions

1. What types of waste materials are being generated the most on site?
2. How to evaluate the level of awareness on waste management practice among contractors in commercial projects?
3. Which management practices are being used on site?

1.7 Scope of Study

This study will be carried out based mainly on the construction materials waste management of different commercial projects within construction sites in Khartoum, Sudan.

This study will be conducting covering all the construction site for commercial projects in Khartoum, and the target respondents of this study are meanly contactors and developers on construction sites.

1.8 Research Method

This research will be carried out by interviewing contractors and project managers using questionnaires among the sites to visit within the Khartoum state.

The chief research instruments that were used for this project includes the secondary resources e.g., website sources and books. The research revealed the materials wastage result in an additional cost to any on-going construction project and in turn reduces the contractor's profit as well as the quality of work. The concern of transportation and storage cost of the material wastage is undertaken while evaluating the financial profits and losses. Non reclamation of waste also leads to a bare loss of revenue of the contractor.

1-9 Research Organization:

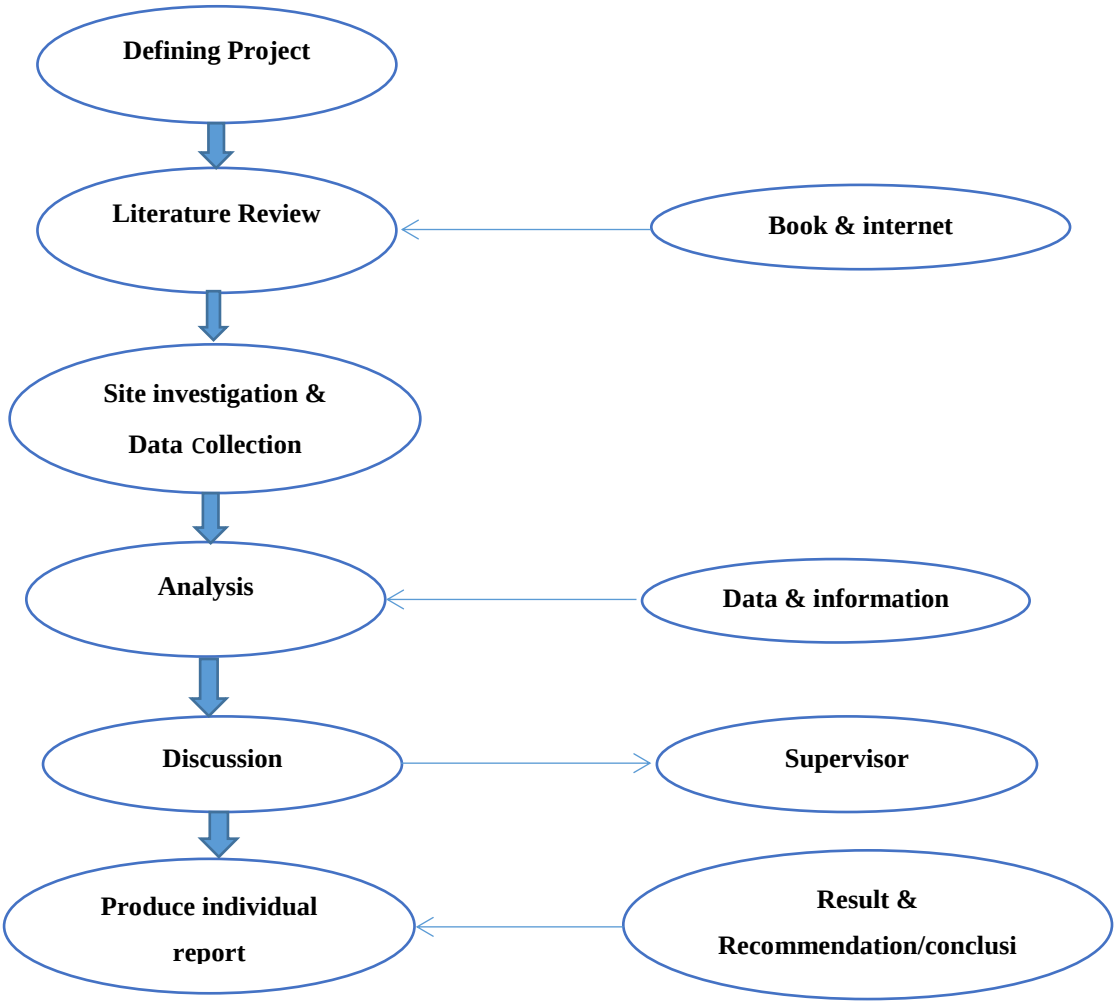

Fig. 1. 1 The research organization

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this literature review is to gain an understanding of construction materials waste management planning, concept, strategies, frameworks, and components that are current and evolving in the field. A particular focus is given to literature which pertains to the management of projects in Khartoum state, Sudan.

2.2 Construction Materials Waste Management

Construction materials management can be defined as the process whereby remains or surplus construction materials after been used are been managed to ensure work site more conducive for workers or reuse through recycle process to ensure e less waste of materials and as well save more cost for materials. In common parlance, waste is a product or material that is unwanted. In terms of practical waste management, waste is a legal term defined in European and UK law [1]. Anybody who is going to be involved in construction waste must start with the definition ‘What is waste’, when does a material become waste and when does it cease to be waste. The most important definition of waste comes from the EC framework directive which implies that waste is any material where the holder has an intention to discard the material as no longer pert of the normal commercial cycle chain of utility

There are many qualifications to the above definition which are subject to interpretation. Detailed below is an explanation of how the definition of waste evolved. Any reader can expect to obtain an understanding of the

definitions, but because of the legal complexity it is strongly recommended that the advice of your local waste regulation authority should be obtained on specific example of waste [2]. The Environmental Protection Act 1990 (EPA 90) Section 75 defines as:

- Any substance which constitutes a scrap material or an effluent, or other unwanted surplus substance arising from application of any process; and
- Any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled, but does not include a substance which is an explosive within the meaning of the explosive Act 1875; or
- Anything which is discarded or otherwise dealt with as if it were waste, shall be presumed to be waste unless the contrary is proved.

2.3 Common Wastes on Construction Sites

Considering the fact, in every construction site wastes are been generated and it all depend on the expert of performing each task and using the best measure to present that helps to reduce waste on site. There are differences types of waste generated on site, some of the common waste usually found on site are stated below [3].

- Steel/metal
- Block and bricks
- Wood
- Concrete
- Paper/bags

2.3.1 Steel

These are commonly used materials on which can greatly influence waste on site and it's very dangerous for workers. However it all rely on how the

workman handle this material that result the level of waste, job well done depends on optimum waste produced on site. In some rare situations, scaffolding contributes to the generation of metal waste in a construction site especially when it is a large building. But in most scenarios steel is the largest metal waste in construction sites and it is generated during the demolition of buildings. Iron is also another metal which is generated during trimming of iron sheets if there are oversized. A small percentage of metal waste which is present at a construction site comes from wiring and ventilation systems.

Fig. 2.1 Steel waste on site

source: (http://theconstructor.org/, 2014)

2.3.2 Bricks/block

Bricks are one of the main elements used in building up a structure, therefore the rate at which this material is used must be apparently high and the higher the usage the higher wastes are generated. Bricks become waste material due to a number of factors. Firstly since most of the construction sites work against time to finish the project, the need of already made bricks is of high demand. So due to such demand, damage to

the bricks might occur during transportation and this results into disposal of the damaged bricks when they reach the site. Secondly, bricks can become waste material due to sudden changes in the building plan which later forces the contractor to demolish the already built component of the structure. Thirdly it might be due to carelessness of the builders in handling the bricks during construction of the walls. Nevertheless; the rate these materials are been generated on site will be shown after my survey in the next chapter.

Fig. 2. 2 Bricks/block waste on site

source: (http://theconstructor.org/, 2014)

2.3.3 Wood

This is natural resources from forest and it has been in use from the early age of construction. It is use in difference components of the building such as doors, frame, tiles etc. following the natural principle of frequency it is based on the level at which the material is been used and handled that determined amount of waste generated. Wood has been used since the 1700's as a building material especially in the western part of the world [4]. This was so because of woods ability to repel cold during the winter

periods. In some parts of Malaysia (mostly in the rural areas), wood is still been used to build homes as it is part and parcel of the tradition. In today's modernised world, the use of engineered wood products with adhesive contents for instance plywood, oriented strand board (OSB) and laminated lumber, including glue-laminated beams and wood I-beams has increased in the construction industry. In small scale construction projects, the use of wood in form of timber for roofing trusses and scaffolding is widely increasing especially in developing countries. As a result, when such projects are completed, the timber remains are disposed of as waste since there is no more use for them [5].

Fig. 2. 3 Wood waste on site

source: (http://theconstructor.org/, 2014)

2.3.4 Concrete

Concrete is used as a construction material or where concrete dust and remains result from demolition activities Slurries containing Portland cement concrete (PCC) or asphalt concrete (AC) are generated, such as from saw cutting, coring, grinding, grooving, etc. At a construction site, concrete can be regarded as a waste due to several factors: Firstly it can be

due to calculation errors leading to overproduction of the pre-cast concrete which is needed in the construction project as a result the leftovers can be treated as waste; Secondly, concrete can be graded as waste due to demolition of buildings; Thirdly, concrete can become waste due to spillage during transportation and placing; and lastly concrete can become waste due to mixing materials on bare ground.

Fig. 2. 4 Concrete on construction

source: (www.redstone-cg.com, 2014)

2.3.5 Papers/bag

Bags or papers are greatly considered on construction site which can be of cement or powder bags for wood treatment. Papers become rigid when exposed to water and make work environment become contaminated. In most cases this materials cause accident on site when a walk man with heavy load walk on top such contaminated material.

Fig. 2. 5 Papers / bag rubbish on site

source: (http://greece.spanos-group.com, 2014)

Nevertheless, the above mentioned materials will be greatly considered during my survey and as part of my questionnaire, to which rate each of them is generated, best procedure to mitigate them on site and how often this materials are disposed on site.

2.4 Origin and Causes of Construction Waste

The table below displays the origin of waste coming from all stages of the construction process, and which is typically identified throughout the production phase. Various stages of the construction process directly or indirectly create physical waste. This becomes more complex when further parties involved add waste during the construction phases.

Table 2. 1Origin and causes of construction waste

Origin Of Waste	Causes Of Waste
Transportation	Damage during transportation. Difficulties for delivery vehicles accessing construction sites.

	Inadequate protection during unloading. Methods of unloading.
Design	Detailing and design complexity. Changes in design. Construction detailing and design errors. Incorrect or insufficient or incoherent specifications. Poor communication and coordination (late information, last minute client requirements, slow drawing revision and distribution).
Procurement	Lack of early stakeholders' involvement. Poor communication and coordination among parties and trades. Inadequate of allocated responsibility for decision making. Insufficient or Incomplete procurement documentation
Site Operation	Accidents due to negligence. Materials and products unused. Malfunction of equipment. Utilization of wrong materials resulting in their disposal. Poor work ethics.
Contractual	Waste client-driven/enforced. Contract documentation errors. Incomplete contract documents at commencement of construction.
	Lack of on-site waste management plans. Unsuitable planning for required quantities.

Planning On-Site Management	Delays in passing information on types and sizes of materials and components to be used. Insufficient supervision.
Ordering Of Materials	Errors in ordering (i.e. ordering items not in compliance with specification). Over allowances (i.e. difficulties to order small quantities). Suppliers and shipping errors.
Storage Of Materials	Improper site storage space leading to deterioration or damage. Inappropriate storing methods. Materials stored far away from point of application.
Handling Of Materials	Materials supplied in loose form. On-site transportation methods from storage to the point of application. Inadequate material handling
Residual	Packaging. Waste from application processes (i.e. over-preparation of mortar). Waste from cutting uneconomical shapes. Off-cuts from cutting materials to length.
Others	Theft. Vandalism. Weather.

2.5 Factors to be considered during Planning, Design and Construction Stages:

Construction of a building does not only consist of the construction stage. The most important issue in waste management is to be conscious of the building‘s life cycle in the planning and design stage, so that materials applied to the building does not become waste. In order words the surplus materials after used does not waste. In addition to physical durability of structure materials and building components, the building fixtures and finishes, most have the ability to be easily renewed [5].

Table 2. 2 Outline of Waste Management Plan

Project Stage	**Waste Management plan Actions (WMP)**
Project Set-Up	- Enter project details
Concept Design	- Record waste prevention actions
Detail Design	- Forecast waste - Record waste reduction actions
Pre-Construction	- Specify waste carriers - Plan waste destination - Record waste management and recovery action
Construction	- Enter actual waste arising, reduction, recovery and management activities - Carryout training, monitoring and recording
Post Construction	- Compare actual against forecast waste management activities - Assess performance based on KPIs*[1] - Suggest improvement for next project

Flexibility in building use and enough space to accommodate changes must be considered. Therefore, the open building concept that clearly separates

[1] * KPIs: measure your performance against key business objectives, Key Performance Indicator is a measurable value that demonstrates how effectively a company is achieving key business objectives. Resource: www.clipfolio.com/resources/article [18].

support/infill has attracted the attention of people all over the world and must be incorporated from the planning and design stage.

The consideration of environmental preservation has been indispensable in recent construction projects. This always includes both reduction of waste, reuse and recycling. It is referred as the 3R activities: the following are typically 3R activities in the construction stage.

- Minimizing packing material for building materials brought to the construction site.
- Reduction of waste through on-site manufacturing of material
- Reusing of scaffolding materials instead of scrapping them

More through separation of collected waste is contributing to reuse and recycling. Furthermore, some contractors are now adopting zero emission activities during the actual construction stage.

Generally speaking, when construction problems are discussed, not only materials but also construction systems must be taken into account. The research on recycling system has so far limited. However, based on previous reported research results, the following points are made, and the direction of the technological developments in the future is indicated. For connecting and dismantling, engagement and fastening systems are considered recyclable, whereas welding and adhesion are not. The proactive introduction of engagement and fastening systems is being encouraged.

Recently, developments of modernization in construction methods have accelerated. It was once customary for deteriorated building finishing materials to be removed and discarded as wastes. However, recently developed technologies have taken the global environment into consideration by avoiding the removal of existing finishing materials.

These technologies utilize an application of anchoring pins to prevent the delamination of finishing layers. Some representative methods are as follows:

- A new renewal method for external walls by net overlaying.
- A new renewal method for roof waterproofing by PRP panel with anchoring.
- A new renewal method for roof waterproofing by galvanized steel sheet with anchoring.
- A new renewal method for external metallic walls using plastic film.

According to Woolley, Goumans, & Wainwright [6], the continuous growth of municipal solid waste generation, especially from construction activities, has been responsible for the appearance of many and efficient municipal waste management laws enforcement from local authorities, an efficient waste management program can avoid inappropriate waste disposal, which can cause damage to both environmental and public health. Additionally, it may even lead to the development of recycling programs. Giving special attention to solid waste from civil construction enterprises, it is important to develop environmentally active practices among construction companies with a view to reduce waste generation, increase reuse and recycling in order to develop alternatives to construction waste recycling, it is important to provide efficient solid waste characterization studies. An experimental study was been carried out in the city of Salvador, Brazil. At of then 1450 tons every day of construction waste was been produced in Salvador. Solid waste has variable physical characteristics that depend on the construction aspect involved, the techniques employed the construction stage and the social economic characteristics present in the urban area in question.

2.6 Common Construction Materials Waste Management Methods

There is a growing concern of the impacts of product production and associated waste materials. With increasing support of improving a country's economic, environmental and social impact of our actions material efficiency and waste management have been a primary focus of much research [7]. In the USA, it is estimated that approximately 6% of all raw materials used end up as product, while only 1% ends up as durable products and the rest ends up as waste. Although the differences in waste management strategies and definitions of waste are significantly different between countries, waste management remains to be a prominent issue with common methods of achieving certain goals and objectives [8]. basic methods of construction materials waste management are highlighted below;

- Solid waste management
- Reduce, Reuse and Recycle (3R's)
- Integrated Waste Management

2.6.1 Solid Waste Management

It is recognized that solid waste management is one area in which construction industry participants can improve their environmental performance considerably [9]. Argue that effective waste management and the minimisation of site waste is essential if a sustainable construction industry is to be achieved. Vast management is one of the pressing issues in managing the environmental consequences of construction because the increasing scarcity of new, virgin materials has made the reliance on non-renewal resources untenable.

The practice of solid waste management is underpinned by a hierarchy of waste control measures. The principle of the hierarchy that is shown below control measures that aim to reduce waste at source (reduction and reuse) are preferable to recycling,

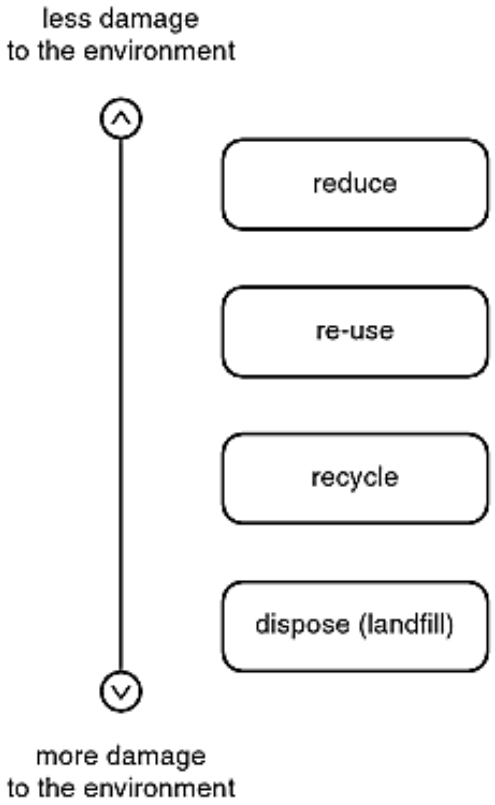

Fig. 2. 6 The waste management hierarchy

Source: [10]

Which requires that waste is reprocessed before it can be reused. In return, recycling is preferable to the disposal of waste either by incineration or as landfill. The implicit in this hierarchy is the need to re-examine the life cycle assessment of the building materials and components. Life cycle assessment is the framework within which a material or product is examined through its entire existence from raw material extraction, through manufacture, construction, use, maintenance and disposal. It is imperative that the emphasis must shift ‘a cradle to grave’ analysis to ‘a

cradle to grave' approach in which materials and components do not flow in one direction from extraction to disposal but instead follow a circular path from 'birth to re-birth'. In order to achieve this circular flow, however; an integrated effort must be made by all participants in the construction process (Best and De Valence, 2002). For example, there must be a secondary market for reused or recycled materials if it is to be feasible for construction or demolition operators to embark upon salvage or recycling process. This requires the designers be willing to specify products that are salvaged or whose content is partially or wholly recycled, that there is a processing, supply and distribution network for these materials and that they are recognized to be compliant with the requirements of building regulations and environmental health standards. Effective waste management therefore requires a collaborative effort through the construction supply chine in which the client, designer, materials manufacturer and suppliers, construction and demolition contractors and waste disposal contractors all have an important role to play (Best and Langston et al., 2002).

2.6.2 Reduce, Reuse and Recycle (3R's)

The three R's are commonly used terms in waste management; they stand for "reduce, reuse, and recycle". As waste generation rates have risen, processing costs increased, and available landfill space decreased, the three R's have become a central tenet in sustainable waste management efforts [11].

The concept of waste reduction, or waste minimization, involves redesigning products or changing societal patterns of consumption, use, and waste generation to prevent the creation of waste and minimize the toxicity of waste that is produced. Common examples of waste reduction include using a reusable coffee mug instead of a disposable one, reducing

product packaging, and buying durable products which can be repaired rather than replaced. Reduction can also be achieved in many cases through reducing consumption of products, goods, and services. The most effective way to reduce waste is by not creating it in the first place, and so reduction is placed at the top of waste hierarchies. In many instances, reduction can be achieved through the reuse of products. Efforts to take action to reduce waste before waste is actually produced can also be termed pre-cycling.

- It is sometimes possible to use a product more than once in its same form for the same purpose; this is known as reuse. Examples include using single-sided paper for notes, reusing disposable shopping bags, or using boxes as storage containers.

Reusing products displaces the need to buy other products thus preventing the generation of waste. Minimizing waste through reduction and reuse offers several advantages including: saving the use of natural resources to form new products and the wastes produced in the manufacturing processes; reducing waste generated from product disposal; and reducing costs associated with waste disposal. Not all waste products can be displaced and even reusable products will eventually need to be replaced. It is inevitable that waste will be created as a by-product of daily human living [12]. But in many cases it is possible for this waste to be diverted and recycled into valuable new materials. Glass, plastic and paper products are commonly collected and reformed into new materials and products. Recycling products offer many of the benefits of waste reduction efforts (displacing new material usage, reducing waste generated and the costs associated with disposal) but recycling requires energy and the input of some new materials, thus placing it lower on the waste hierarchy than reduction and reuse (United Nations Environmental).

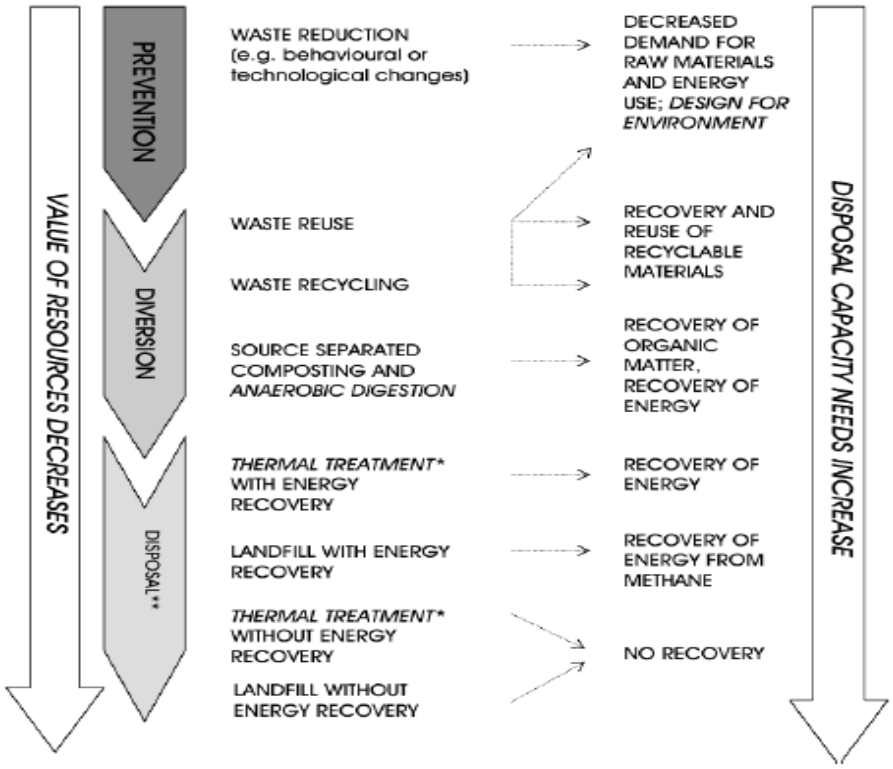

Fig. 2. 7 Waste management hierarchy

Source: (Chertow, 2007)

Many waste management frameworks seek to incorporate the three R's in some capacity. In the UK, North America, throughout Europe and in parts of Asia, waste hierarchies are being unified which promote the adoption and use of "reduce, reuse and recycle" initiatives (Allwood, 2010). Waste management hierarchies (Figure 8) place the highest priority on waste prevention, reuse, and then waste recovery. Disposing materials in a landfill is the least desirable of the options.

2.6.3 Integrated Waste Management

The term integrated waste management (IWM) is often used to describe and approach in which decision on waste policies and practices takes account of waste streams, collection treatment and disposal methods, environmental benefits, economic optimisation and social acceptability. IWM allows decisions to be based on best practice and cost transparency

(Hester and Harrison, 2002). The smaller the amount of waste put into the system the lower the costs apportioned to the generator of the waste. This provides incentives for users to reduce the amount of waste they generate.

Waste management methods cannot be uniform across regions and sectors because individual waste management methods cannot deal with all possible waste materials in a sustainable way [13]. Conditions vary; therefore, actions must also vary hence to ensure that these conditions can be met successfully. Waste management systems must remain flexible in light of changing economic, environmental and social conditions [14]. In most cases, waste management is carried out by a number of processes, many of which are closely unified; therefore it is reasonable to design holistic waste management systems, rather than alternative and competing options

A diversity of approaches has been developed to tackle waste issues. A well designed framework can help managers address waste management issues in a cost-effective and timely manner. It can branch the improvements of existing plans or aid in the design of new ones Agency, U.S Environmental Protection).

A waste management framework provides [15];

- Flexibility to frame and analyse quantitative and qualitative information across different scales
- Structure to clearly identify key goals and values

Logic to consider the potential probability and consequences related to a particular option Communicability to clearly communicate key ideas to key stakeholders. Integrated waste management (IWM) has appeared as a holistic approach to managing waste by combining and applying a series of suitable techniques, technologies and management programs to achieve

specific objectives and goals [14]. The concept of IWM arose out of recognition that waste management systems are comprised of several interconnected systems and functions, and has come to be known as “a framework of reference for designing and implementing new waste management systems and for analysing and optimising existing systems” Programme, United Nations Environmental). Just as there is no individual waste management method which is suitable for processing all waste in a sustainable manner, there is no perfect IWM system Individual IWM systems will vary across regions and organizations, but there are some key features which characterize IWM: employing a holistic approach which assesses the overall environmental burdens and economic costs of the system, allowing for strategic planning; [14].

Using a range of collection and treatment methods which focus on producing less waste and in effectively managing waste which is still produced;

Handling all materials in the solid waste stream rather than focusing solely on specific materials or sources of materials (Hazardous materials should be dealt with within the system, but in a separate stream)

Being environmentally effective through reducing the environmental burdens such as emissions to air, land and water;

Being economically affordable by driving costs out and adopting a market-oriented approach by creating customer-supplier relationships with waste products that have end uses and can generate income;

- Social acceptability by incorporating public participation and ensuring individuals understand their role in the waste management system.

Due to the varying needs and encounters faced by organizations in the construction sector, a flexible yet comprehensive approach is needed to

manage waste properly. Using a wide range of waste management options as part of a comprehensive integrated waste management system allows for improved ability to adjust to changing environmental, social and economic conditions [14].

Forming an IWM plan can be a complex undertaking. Those responsible for designing IWM systems must have a clear understanding of their goals and objectives and ensure that terminology and activities are clearly defined in the plan. The next step requires identifying the range of possible options that are suitable for managing waste with cost approximations, risk assessments, available processing facilities and potential partners, and the product standards which exist for the recycling of certain wastes. Public feedback in this step can help to assure the accuracy of assumptions made, and help to build public acceptance. The final step involves examining the trade-offs which exist among the available options given what is known about the risk, cost, waste volumes, and potential future behaviour changes [16]. Once these details are known, a comprehensive IWM strategy can be formed.

Systems analysis can provide information and feedback that is useful in helping to define, evaluate, optimize and adapt waste management systems [17]. There are two main types of systems analysis techniques relevant to waste management systems:

- systems engineering models such as cost benefit analysis, forecasting models, simulation models, optimization models, integrated modelling systems
- system assessment tools such as management information systems, decision support systems, expert systems, scenario development, material flow analysis, life cycle assessment, environmental impact

assessment, strategic environmental assessment, socioeconomic assessment [17].

Table 2. 3 Researchers pin points for justification

APPLICATION CRITERIA	SPECIFICATIONS OF DIFFERENT AUTHORS				
	Allwood et al.	El-Haggar	Tchobanoglous et al.	McDougall et al, 2001.	Stokoe et al
Solid Waste management plan(SWMP)	✓				
Reduce, recycle and reuse (3R's)	✓	✓			
Integrated management plan (IWM)			✓	✓	
Landfill					✓

Source: (Author, 2013)

2.7 Previous Study:

In Malaysia, alongside the high demands in requesting main groundwork undertakings, cooperative lying conjunction with countless business constructing and housing progress programmes, a massive number of construction waste is being produced by the construction sector. In present scrutiny, statistics display that concerning 28.34% of the finished waste produced annually is approximated to come from the construction and

manufacturing sector. Out of the 28.34%, 60% of the construction rubbish is reused and reprocessed as the rest is disposed of (Begum et al, 2006) Even nevertheless the construction industry of Malaysia attempts hard to battle construction, present studies indicate that construction material waste yet poses a little menace to the environment. In Peninsular Malaysia in 2001, the amount of solid waste produced was described to be 16,200 tonnes each date and it increased to 19,100 tonnes in 2005. Out of the preceding, construction material waste constituted 20% of the annual solid waste produced in 2001 and it increased to 25% in 2005 (Rassia and Pardalos, 2012). Exceedingly urbanized spans inside innate power borders such as Kuala Lumpur, Pulau Pinang and Johor Bahru produce larger number of construction waste in analogy to rural settings beyond the power of innate powers who produce concerning less than two periods the percentage produced in urbanized spans (Altman and Resti et al., 2005).

- According to Singh & University (2007). In the construction industry, the movement of lean construction emerged in the early 90s as a response to increasing waste and rework in construction processes. Lean construction theorists support the integrated view of transformation, flow, and value for managing construction processes that tend to eliminate waste and improve their efficiency and effectiveness.

These theorists have criticized the traditional project management practices of the construction for being narrowly focused on transformation, transactional contracts and activities while ignoring the flow of and value aspects of operations. Having a holistic approach on site is the most effective measure to tackle issues in the construction industry.

- According to Henry A, (2009) , the construction sector represents one of the most dynamic and complex industrial developments all over the world. The construction activities in the context of the Malaysia economy cannot be treated with a wave of hand. And also (Obadan MI, 1996) emphasis on the same fact that the construction industry contributes between 3 to 6% of the gross development product (GDP) in developing countries and records from the federal office of statistics specifically ascertain that the contribution of construction industry to Malaysia's gross development product (GDP) has hovered around 2% for the past 15 years and this accounts for about 69% of the Nation's Gross Fixed Capital Formation. Practical studies had also reinforced the fact that 1% increase in the stock of infrastructure generates 1% increase in the GDP across all countries.

He also posited that the cost of materials accounted for 50 to 60% of the total cost of construction of any project, while (Skoyles, 2000)came out with the most recent information that cost of material alone in the building construction project is 55 to 65%. To reduce cost of construction projects, an optimum material control on site should be therefore adopted. Construction waste is a growing problem in many countries. Stokoe MJ, (1999) reported that construction waste took up about 65% of Malaysia's landfill space at its peak in 1995.

- According to Craven DJ, (1994)over 50% of the waste in a typical United Kingdom landfill could be construction waste. His further emphases' was that construction activity generates 20 to 30% of all waste deposited in Australian landfills. In the United State, Construction waste represents about one-third of the volume of materials in landfills. Serpell A, (2003) reported that of the 3.5

million tons of Construction waste generated in Chile, only 10% is placed in authorized and controlled landfill sites. In the European Union, it is estimated that 0.5 to 1 ton per capital of Construction waste is generated annually. At the project and corporate levels, materials waste implies loss of profit and competitiveness for the contractor as I said in earlier paragraph. Wastage may also lead to delays that cause costly idle time for other resources (Neo RB, 1995).

At the national level, waste causes environment related problems, the cost and environmental implications of construction activities are now well known. The construction industry in particular and the built environment in general has become one among the main consumers of resources and energy. Moreover, the construction sector is reported to be generating unacceptable levels of material and manpower waste. Generally, construction activities which produce wastage can be grouped into on-site and off-site operational activities. Off-site activities include prefabrication, project design (structural, architectural, mechanical and electrical design), manufacturing and transporting of materials and machineries. Onsite construction activities relate to construction of a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process (Enshassi,1996). All estimators allow wastage factors in pricing a bill of quantities.

- Over the years, experience has shown, however, that unless site management control is effective, wastage can frequently exceed, often by a large margin, than the figure allowed in the tender document. Enshassi, (1996)propped the need for re-unification when he suggested that effective materials control demands concentrated

and coordinated action of numerous people performing a variety of functions within the industry. He further suggested that waste seen on site is not necessarily caused by failure or inadequacy of individual functions involved in materials management system. Control of material is relatively a new practice in the construction industry. In the present situation, the management and the designers are mainly concerned on how to control cost without any emphasis on waste control measures. Generally, it is accepted that cost of materials accounted for a great percentage of the total cost of construction projects. Therefore, a critical control of materials on site should be adopted. Materials wastage on site cannot be treated fully without materials control. In fact, material waste level on site is a measure of site management. It is also one of the enemies of contractors. Most loss of materials occurs as a result of the decision of the site management.

Decision taken at the initial stage of any project that is the design stage, either by the manufacturer or supplier of materials is capable of increasing waste level. This can occur as a result of manufacturers not following strictly the buyers' specification and supplier not packaging the product for easy transportation. Since all the burden of waste lies exclusively on the contractor, it is important that the site management should ensure a good supervision of materials and apply an effective method of controlling waste. Waste normally springs during different stages of construction which can be during planning, estimating or construction stage.

In Malaysia, not all the materials procured are used during construction and this indicates that the left overs may remain as waste that may not be accounted for. Over the years, there has been an increase in the rate of construction activities in the country. This has inevitably led to the

generation of waste at different stages of projects. Currently in Seremban, little consideration has been paid to the control of generation of construction waste in the last decade. This can be attributed to the availability of relatively low means of waste disposal and the generally, low environmental awareness of the construction industry wastes in the country. And despite being a major generation of significant waste, the construction industry in Malaysia, has been slow to embrace environmental friendly practices. The study aims at identifying the sources of waste on construction sites, knowing the current waste control measures and assess the effectiveness of the waste control actions with a view to seeking for ways to control waste generation in future construction projects(Staniškis, 2005).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter will be focusing on how the research was carried out within Khartoum state and this survey was made using questionnaires to different sites as mentioned in the literature review to get the opinion of both workers and the project manager's .evaluation and analysis were made based on their responds.

RESEARCH PROCESS (FLOW CHART)

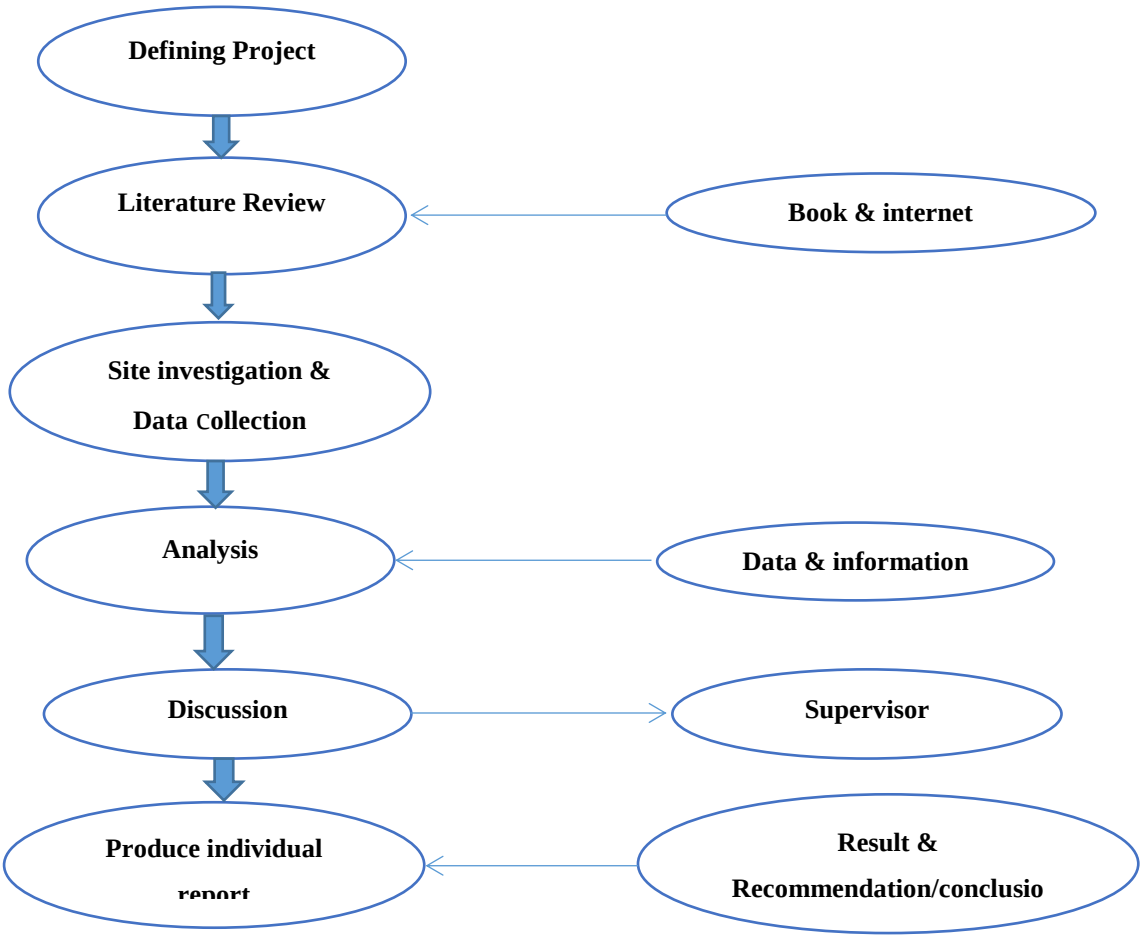

Fig. 3. 2 The study or Research process

3.2 Background of Study Area

This survey is carried out at Khartoum, which is the capital of the republic of Sudan.

The study included a literature review on sustainable development, the effects of human activities on the environment, the solid waste management systems used in Khartoum and their impact to the nation's development and environment. Construction Waste Management from developed countries was reviewed to identify their main elements and how they affect a project for contractors.

An outline Construction Waste Management was created by simplifying the elements in the site waste management plans from other countries, extracting the perceived best practices and combining them into one proposed framework to be tested in Khartoum. many semi-structured questions were conducted as part of this research to determine the uptake of any form of Construction Waste Management by Sudanese contractors, the suitability of existing Construction Waste Management in relation to the local environment, and their impact on the actual project and the environment as a whole (cidb.org.za n.d.)

According to the literature review carried out, Solid Waste Management Plans are relatively new in Sudan and levels of awareness and adoption by contractors are low. Therefore, the target sample chosen were (103) project managers and contractors on site including their workers located around the Khartoum city, who might have being using solid waste management plans on site. The selected contractors were seen as a representation of the Sudanese construction industry which does not have an official system or guidelines for managing construction wastes on site, yet. The contractors

interviewed, were randomly chosen and are considered a convenience sample.

The selected companies had different backgrounds and experiences, and are assumed to be reliable samples by the researchers; the respondents interviewed were experienced project managers and sub-contractors with extensive involvement in construction projects.

The interviews were conducted to obtain reviews for the outline Construction Materials Waste Management produced by the researchers based on literature review. The selected contractors were asked to review and comment on the proposed framework, in particular the perceived benefits to a project and its effectiveness.

There were limitations to this research which could have inadvertently affected the results. Some of the selected firms were unresponsive and unsupportive, therefore making the data for the research incomplete and possibly biased. There were also time limitations to complete the research, thus fewer interviews were conducted than initially planned for. One the main barriers to this study were the low level of awareness amongst Sudanese contractors regarding sustainable resource and waste management.

The lack of knowledge about Solid Waste Management Plan (SWMP) made contractors more unwilling to implement any form of a SWMP. Finally, this study was conducted as a preliminary investigative exercise to measure the industry's level of awareness and commitment to sustainable waste management, identify current barriers and suggest future recommendations for an implementation strategy. Further investigations would be required to build on the findings of this study.

3.3 Data Collection

Data collection for this research was conducted by quantitative method. *[2] The questionnaires would be distributed to Project managers, and subcontractors on site. They were selected as the respondents because they were in-charge in the construction site management. After the objectives of the study have been established and the scope of the research has been set, the set of questionnaire can be formulated. All the questions in the questionnaire had been designed to achieve the research objectives. Moreover, interviews with the subcontractors and Managers on site were carried out to see the waste management processes performed by the site staffs. Mainly, there are three commonly known practices in the questionnaires which are;

- Reduce, recycle and reuse (3R's)
- Solid waste management (SWMP)
- Landfill.

These will incorporate with the objects of this research and to be able to evaluate the level of construction waste management in the study area.

3.4 Sampling and Population

Sampling refers to the study of a population by gathering information's and analysing it. On the other hand population can be defined as the total number of people or as any precise set of people or gathering of items which are under consideration (Collis and Hussey, 2003). This research

[2] * Quantitative Method: its emphasize objective measurements and statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulation pre-existing statistical data using computational technique.

study is based on specified selection of the population in construction sites within the state Khartoum State.

However, at the construction sites workforces were randomly selected from various organizational levels to represent the sampling frame, one hundred and three (103) samples were used in the survey and all were fill-up by respondents and return back to the researcher. The following areas were highlighted in the sample; common waste materials on sites, measures to minimise, best practices, awareness and period of disposal.

The study sample (n) is calculated as single, exceeding the minimum required according to the statistical equation determined for the sample size.

$$N = \frac{z^2(P[1-P])}{e^2}$$

At a confidence level of 95%, z^2 = 1.96

Where N = sample size.

Z^2 = the standard score corresponding to the 1.96 confidence level

(P) = success rate 50%

(e) ^{2} = standard error ± 0.05%

The sampling incorporates employees from different construction firms (sites) in Khartoum State that randomly participated in the following research strata.

3.5 Required Data

In the course of this research project, the data needed was generated from two different sources, namely primary and secondary source. The primary data are the ones that were collected from the construction sites. While secondary data are source comprised of data generated from internet sources, company websites, previous student's thesis and books related to the field of study. Some of the data was accessed from journal papers.

3.6 Development of Questionnaire

The figure (3-2) shows chronological order of the researcher questionnaire, how each section was formed corresponding to the research literature review, which was used for the investigation and with these questions research hypothesis, was achieved.

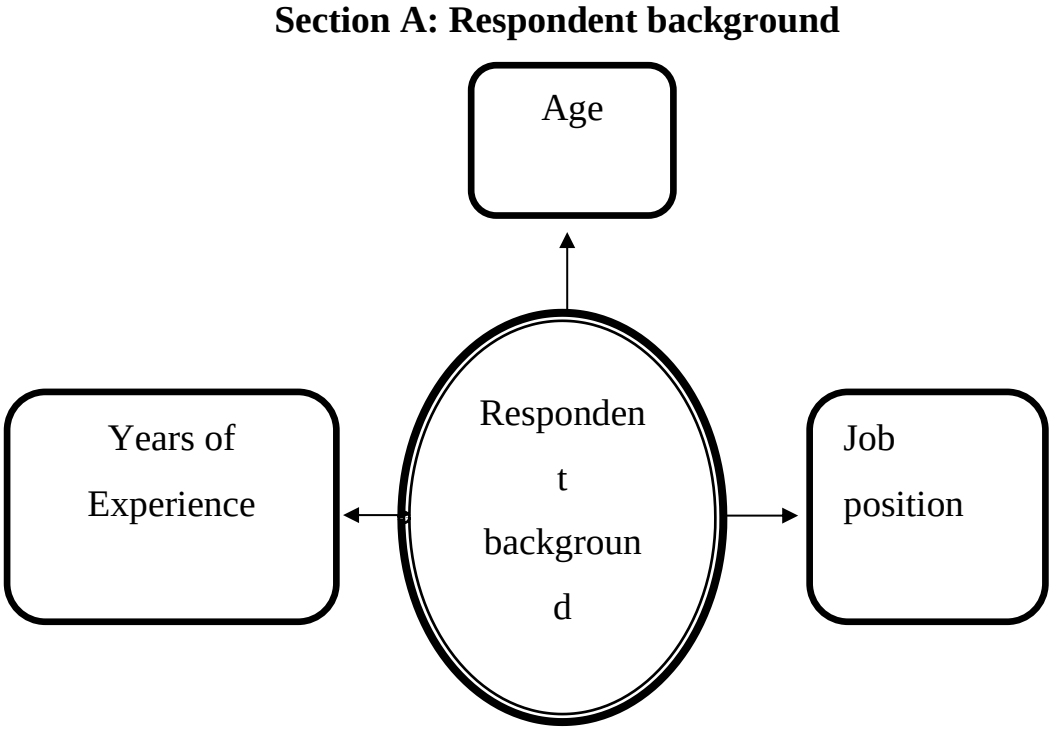

Fig. 3. 3 respresent background

Section B: The Questionnaire (the research axes)

The first axis:

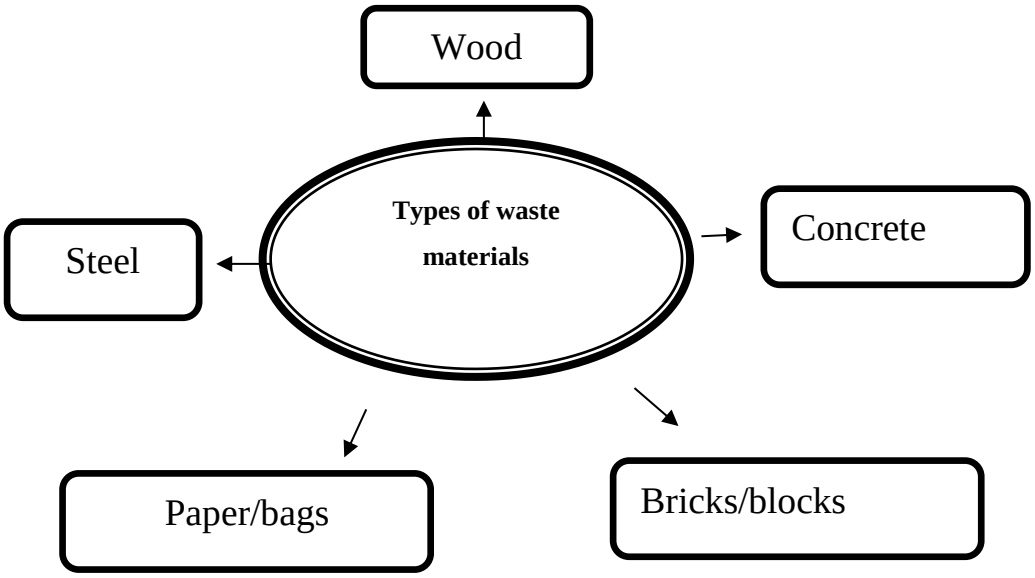

Fig. 3. 4 Illustrate qusetions about first Axis

The second axis:

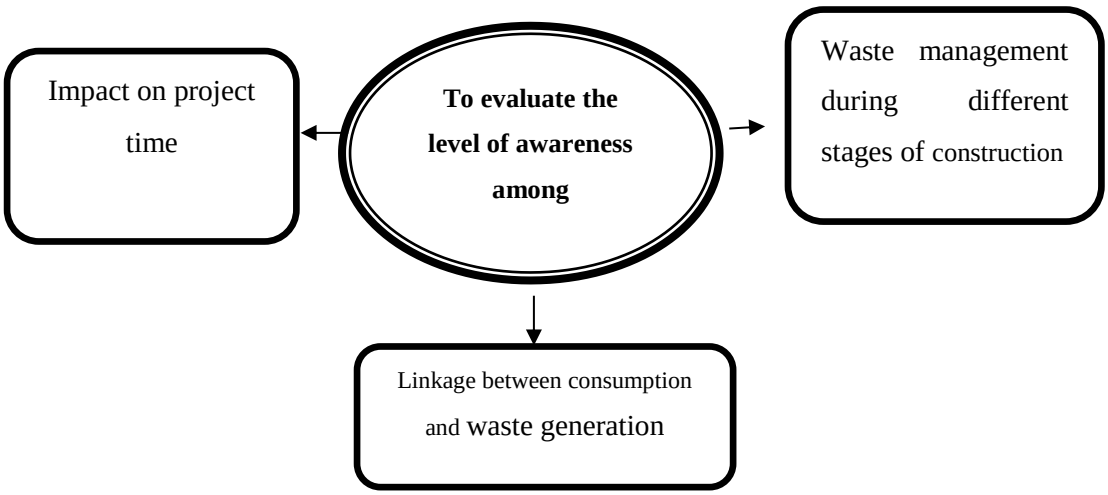

Fig. 3.4 Illustrate qusetions about second Axis

The third axis:

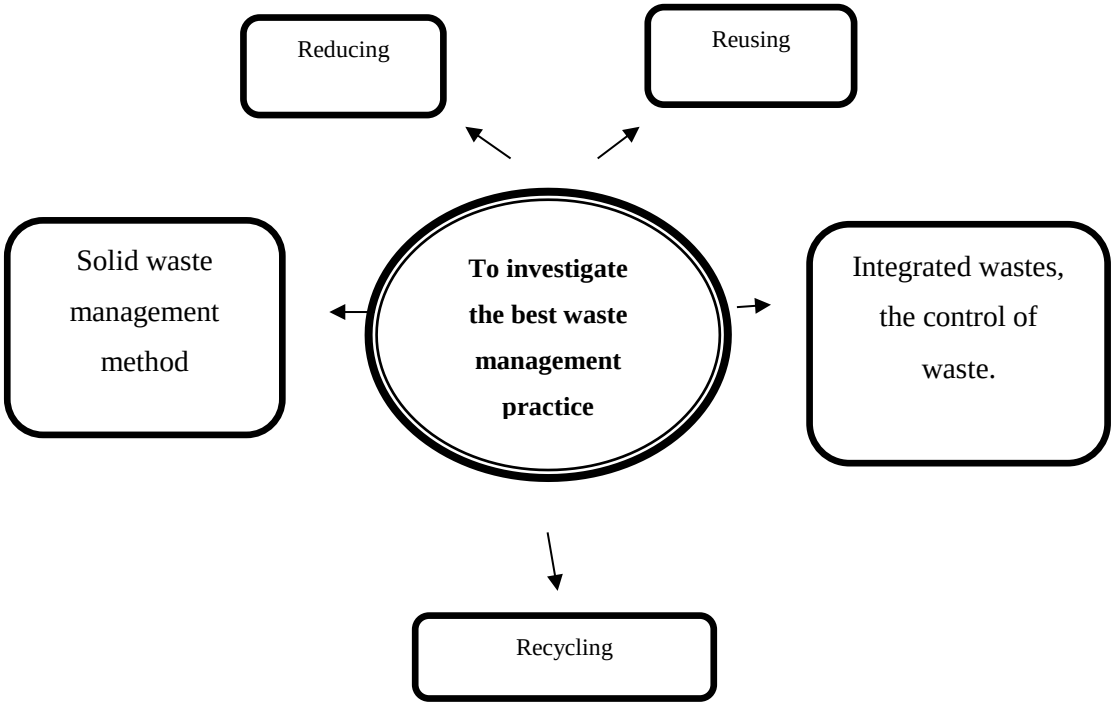

Fig. 2. 5 Illustrate qusetions about third Axis

3.7 Data Analysis

Statistical data are analyzed by computer using the Statistical Package for Social Sciences (SPSS). A chi-square test for independence was used to test the statistical significance of the study hypotheses. This test was used to answer the hypotheses and was limited before. The probability value of the chi test calculated at the moral level is less than 5% of the study hypothesis (if the value of chi). At a moral level greater than 5%, it means acceptance of nullification. Design the alternative hypothesis (the study procedure) is not correct. Where in some factors it can reach up to 20% of the expected values less than 5.

3.8 Validity and Reliability of the Research Instrument

In other to ascertain the validity of a questionnaire, researcher would obtain an objective through concept, construct, operational definition and specific

table. Validity means the ability of a scale or index to measure what it is supposed to measure (Holmes et al, 2005).

This test is very important to carry out as an instrument can be reliable but might not be valid. According to Holmes et al, (2005) reliability means that measurement will give same result all the time. In order to prove the reliability of the questionnaire constructed, this statistical package for social science (SPSS) software will be employed.

Stability of the test to give the scale the same results if used more than once under similar circumstances. Stability also means that if a test is applied to a group of individuals and their scores are monitored and the same test is re-applied to the same group and the same score is obtained, the test is completely stable. Stability is also known as the accuracy and consistency of the measurements obtained from the test. The most commonly used methods for estimating the stability of the scale are:

1. The method of fragmentation half - using the equation of Spearman - Brown.
2. Alpha equation - Kronbach.
3. Method of re-application of the test.
4. The method of equal images.
5. Gutman equation.

In order to test the availability of consistency and internal consistency between opinions on the expressions, the Alpha-cronbach reliability factor was calculated. The alpha-cronbach coefficient is statistically acceptable. The credibility test was conducted on respondents' responses to the questionnaire for all its interlocutors. Honesty is also a measure used to determine the degree of sincerity of the respondents through their answers on a given scale. Honesty is calculated in many ways, the easiest one is that

it represents the square root of the stability coefficient. The value of honesty and consistency ranges from zero to one.

In this study, the median split method was used to calculate the stability of the scale. The responses of the sample members of the study were separated on the individual-numbered statements from their responses to the marital terms. Hence, Pearson correlation coefficient between their responses to the individual and marital phrases according to the following formula:

$$r = \frac{N(\sum R\,P) - (\sum P)(\sum R)}{\sqrt{[N(\sum P^2) - (\sum P)^2] * \left[N\left(\sum R^2\right) - (\sum R)^2\right]}}$$

Where:

r: Pearson correlation coefficient.

N: Sample size.

ΣP: The total score of responses to individual phrases.

ΣR: Total number of responses to marital statements.

ΣP ^ 2: Total boxes of score answers on individual statements.

ΣR ^ 2: The sum of boxes is the degree of answers to the even statements.

ΣPR: The sum of the number of answers to the individual statements in the answers to the marital phrases.

And finally according to the coefficient of stability according to the formula of Spearman-Brown as follows:

$$\text{Coefficient of stability} = \frac{2 * \mathrm{r}}{1 + \mathrm{r}}$$

The coefficient of stability is the square root of the credibility coefficient Alpha Karnbach, and the range of honesty and stability between zero and 100%, the closer the result to 100% that showed the stability and honesty in the high responses of the sample study.

CHAPTER 4

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Analysis, Results and Discussion of Hypnosis:

In this Chapter, the researcher will evaluate and analyse findings from the questionnaires which were generated by the use of SPSS software.

The disscusion and interpretection of the results on the field study through the information generated by analysis tables of statistical data, through the distrbution 103 questionnaires according to the methodology used, as well as the results of statistical analysis to test hyposises field study.

In order to test hypotheses, statuses related to hypotheses were tested using Chai Square tests to test the statistical signficane of the hypotheses at the a signficant level of 5%, statistical analysis of the data is designed to test the foullowing hypotheses:

1. There are many types of waste materials generated in Khartoum state projects, (steel concrete, bricks, wood, bags/paper)
2. There is awareness to some extend about waste management practice among contractors in commercial project in Khartoum state.
3. Manage construction waste materials by (disposal (land fill), reduce, reuse, recycle) methods.

Below are results after analysing with the software;

Table 4 .1 Illustrates realibility and statistical for the quesitionnaire axes

Statement	Cronbach`s alpha	Stability
axis one	0.406	0.637
axis two	0.370	0.608
axis three	0.583	0.763
All axes	**0.620**	0.787

The coefficient of credibility Cronbach's Alpha in the responses of the sample of the study sample on the terms of the questionnaire (0.620%) while the coefficient of stability (0.787%), These two values indicate the great consistency and honesty in the responses of the sample of the study, leading to confidence and acceptance of the results that will result in this study, which enables us to rely on these views in achieving the objectives of the study and analysis of the results.

4.2 Analysis, Results and Discussion of field study:

4.2.1 Respondent profile:

The Table and the Figure below show the stand of subcontractors and project managers who are the main target of researchers' survey.

Table 4.2 Status of Respondents

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Top management	19	18.4	18.4	**18.4**
support staff	46	44.7	44.7	**63.1**
Junior management	38	36.9	36.9	**100.0**
Total	**103**	**100.0**	**100.0**	

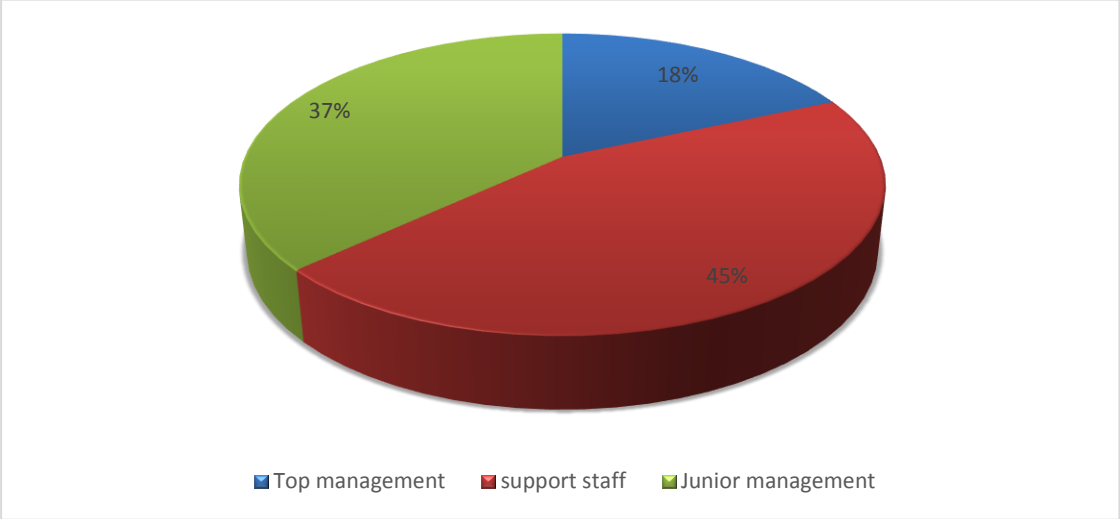

Fig. 4. 1 Status of Respondents

It is clear from the Table (4-2) above that the most who participate in filling this form are (support staff) with percentage about 45%, and this guarantee to get accurate answers, as this category is the heart of the job structure and its fully aware of the field of work and development and what is happening on the sites.

Table 4.3 Illustrate Age

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Below 30 years	67	65.0	65.0	**65.0**
31 to 40 years	29	28.2	28.2	**93.2**
41 to 50 years	4	3.9	3.9	**97.1**
above 51 years others	3	2.9	2.9	**100.0**
Total	**103**	**100.0**	**100.0**	

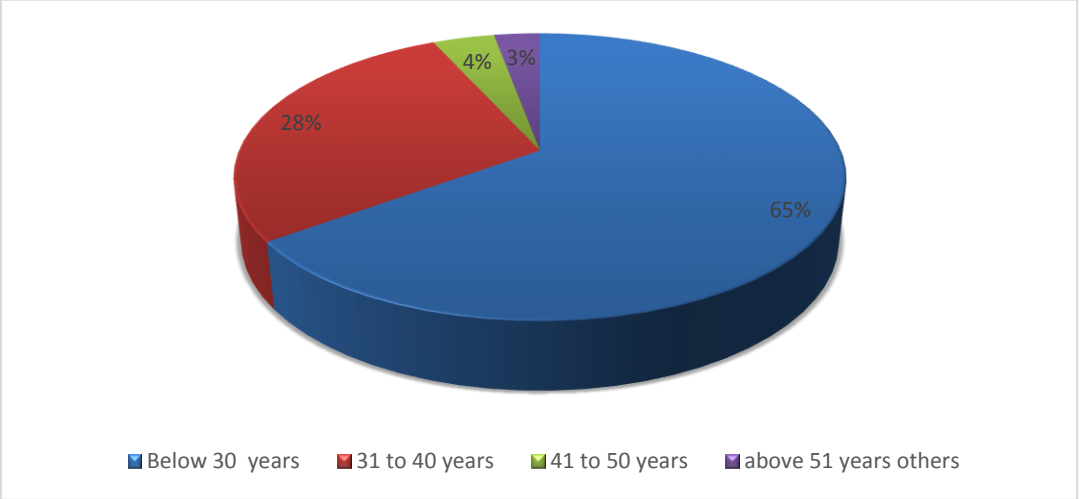

Fig. 4. 2 Illustrate Age

It is clear from the Table(4-3) above that the most of the respondents are young (below 30 years) with percentage 65%, which ensures to get deep answers because they are the most knowledgeable about what is happening on the sites and are facing problems and solve them.

Table 4.4 .Year of experience

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Below 5 years	48	46.6	46.6	**46.6**
6 to 10 years	36	35.0	35.0	**81.6**
11 to 15 years	12	11.7	11.7	**93.2**
16 to 20 years	7	6.8	6.8	**100.0**
Total	**103**	**100.0**	**100.0**	

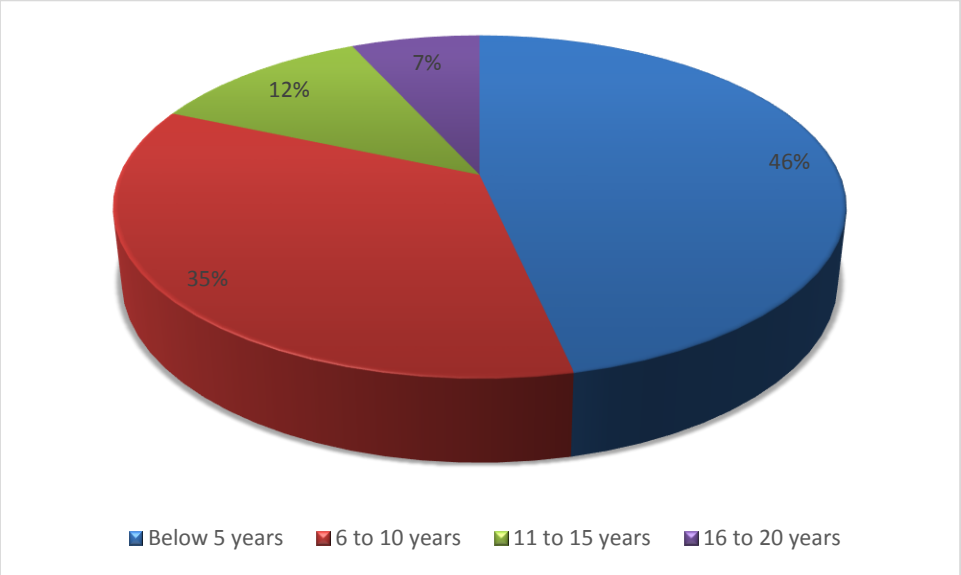

Fig. 4. 3 Year of experience

Fig.4.3 shows that the respondents experience largest percentage is less than five years, followed by from 6 to 10 years, with rapprochement between the other categories of years of experience.

Table 4.5 Relation between the age and the experience

Age	Experience				Total
	Below 5 years	6 to 10 years	11 to 15 years	16 to 20 years	
Below 30 years	42	25	0	0	67
31 to 40 years	6	11	12	0	29
41 to 50 years	0	0	0	4	4
above 51 years others	0	0	0	3	3
Total	48	36	12	7	103

The table 4.5 shows the relation between the age and the experience is positive relationship, when age increases, experience increases as well.

4.2.2 The Questionnaire:

Common Waste Materials in Construction Site

Bellow materials are been identified as the main materials which waste are been generated and it was analysed using SPSS to know the level at which each of them is been generated and managed in the construction, the respondents were interviewed with a piece of questionnaire to fill up their experience of construction waste management on site.

Table 4 .6 The frequency distribution of the study sample for the hypothesis about (material types on site)

Statement	Strongly Disagree		Disagree		Neither Agree or Disagree		Agree		Strongly Agree	
	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	**Frequency**
Steel are commonly used materials on which can greatly influence waste on site and it's very dangerous for workers.	%1.9	2	%5.8	6	%2.9	3	%37.9	39	%51.5	**53**
Bricks &blocks waste material might be due to carelessness of the builders in handling the bricks	0	0	%1.9	2	%6.8	7	%48.5	50	%42.7	**44**

during construction of the walls.										
Wood remains disposed as wastage since there is no more use for them in construction site	%2.9	3	%11.7	12	%15.5	16	%38.8	40	%31.1	**32**
concrete can be graded as waste due to demolition of buildings	0	0	%2.9	3	%12.6	13	%45.6	47	%38.8	**40**
Papers/bag as types wastage in construction site, are also used in purpose of commercial building	%18.4	19	%20.4	21	%24.3	25	%17.5	18	%19.4	**20**

Table 4.6 illustrates steel as a common waste material on site and it shows that **51.5 %** out of 100% choose (strongly agree) followed by the bricks with **48%** choose (agree), then come the concrete with **45.6%** choose (agree), which means that the most of the respondents agreed to consider them as the most waste materials found on the construction sites, It was clear that a strong reason to focus on the importance of practice waste materials management on sites.

But regarding to wood 38% choose (agree), and the least among them is Paper/Bags is 24.3% (neither agree or disagree) so (Steel ,bricks and concrete) are the most dangerous materials that can cause injury to labourers when they carry heavy load on head ,and paper is being exposed to water it will slip the worker and cause accident.

Bellow materials are been identified as the way to evaluate the level of awareness on waste management practice among contractors in commercial projects and this was analysed using SPSS to know the level at which each of them is been generated and managed in the commercial projects, the respondents were interviewed with a piece of questionnaire to fill up their experience of construction waste management on site.

Table 4.7 The freaquency distribution of the study sample for the hypothesis about (the level of awareness on waste management practice among contractors)

Statement	Strongly Disagree		Disagree		Neither Agree or Disagree		Agree		Strongly Agree	
	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	**Frequency**
Any project cannot be completed successfully within the allotted time and cost without construction material	0	0	%4.6	5	%19.4	20	%44.7	46	%31.1	**32**

management.										
waste management practice and the main challenge therefore will be to break the linkage between consumption and waste generation	%1.0	1	%2.9	3	%9.7	10	%41.7	43	%44.7	**46**

Waste management normally springs during different stages of construction which can be during planning, estimating or construction stage.	%1.0	1	%4.9	5	%13.6	14	%31.1	32	%49.5	**51**

Table 4.7 illustrates that the most of the respondents agreed that the Waste management normally springs during different stages of construction which can be during planning, estimating or construction stage with 49.5%, and they are believed in that any project cannot be completed successfully with in the allotted time and cost without construction material management, and the waste management practice is the main challenge therefore will be to break the linkage between consumption and waste generation with percentage 44.7% .

This indicates the awareness of the importance of practicing the management of waste materials among the contractors in commercial projects in Khartoum.

Whenever there is awareness among the contractors, the less problems and a better development on field work.

This was one factor which research greatly consider in the research, bellow there are factors highlighted to identify the level of consideration on site if the contractors of Khartoum projects are implementing this factors on their site and to what extent this management principles is being exercised.

Table 4.8 The freaquency distribution of the study sample for the hypothesis about (the best waste management practice that are being used among contractors).

Statement	Strongly Disagree		Disagree		Neither Agree or Disagree		Agree		Strongly Agree	
	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	**Frequency**
Solid waste management means material such as household garbage includes, yard wastes, and demolition or construction debris.	%1.9	2	%4.9	5	%21.4	22	%51.5	53	%20.4	**21**
Reducing waste really means making more	0	0	0	0	%5.8	6	%27.2	28	%67.0	**69**

efficient use of materials.										
Reusing products displaces the need to buy other products thus preventing the generation of waste.	0	0	%4.9	5	%12.6	13	%35.9	37	%46.6	**48**
Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials	%1.0	1	%1.9	2	%6.8	7	%35.9	37	%54.4	**56**
Integrated wastes management	%1.0	1	%8.7	9	%18.4	19	%34.0	35	%37.9	**39**

Table 4.8 illustrates that the most of the respondents strongly agreed that reducing waste really means making more efficient use of materials with percentage 67% (strongly agree)which it is the highest value, followed by 54% (strongly agreed) for recycling ,while 51.5% (agree)goes to the solid waste management, 46.6%(strongly agree) goes to reusing products and the least among them goes to the Integrated wastes the control of waste and disposal methods such as source reductions, recycling, reuse to minimize commercial and industrial wastages with percentage 37.9%(strongly agree). As seen above, the extend of awareness of the contractors about the measures to minimize material waste on sites, and it is a good result that shows the correct form that must follow in the field of work.

Table 4.9 illustrate chi square test for the hypothesis about (material types on site)

Table 4.9 Illustrate chi square test for the hypothesis about (material types on site)

Statement	Chi-Square(a,b)	Df	Conclusion
Steel are commonly used materials on which can greatly influence waste on site and it's very dangerous for workers.	109.57	4.00	Function
Bricks &blocks waste material might be due to carelessness of the builders in handling the bricks during construction of the walls.	71.33	3.00	Function

Wood remains disposed as wastage since there is no more use for them in construction site	44.23	4.00	Function
concrete can be graded as waste due to demolition of buildings	51.84	3.00	Function
Papers/bag as types wastage in construction site, are also used in purpose of commercial building and landfill and other construction works	1.42	4.00	Not Function

From the Table 4-9 It was find that the probability value of the test of the square is a statistical function,, the probability value of the test of the square for the first, second, third and fourth terms is less than 0.05 on which there are differences of statistical significance. Therefore, the opinions of the respondents were taken by the approval side. The fifth terms, of 0.05 which is not statistically significant, there is no Papers/bag as types wastage in construction site.

Table 4-10 illustrate chi square test for the hypothesis about (the level of awareness on waste management practice among contractors)

Table 4.10 Illustrate chi square test for the hypothesis about (the level of awareness on waste management practice among contractors)

Statement	Chi-Square(a,b)	Df	**Conclusion**
Any project cannot be completed successfully within the allotted time and cost without construction material management.	35.45	3.00	Function

waste management practice and the main challenge therefore will be to break the linkage between consumption and waste generation	94.82	4.00	Function
The awareness of the parties involved is well important to safeguard our environment is healthy in good conditions and as well as to prevent the entire society	83.75	4.00	Function

From the Table 4-10 It was found that the probability value of the test of the square of Kai is less than 0.05 on which there are differences of statistical significance. Therefore, the opinions of the respondents were adopted by approving all the statements of the second hypothesis, so there`s a high level of awareness on waste management practice among contractors.

Table 4-11 illustrates chi square test for the hypothesis about (the best waste management practice that are being used among contractors)

Table 4.11 Illustrate chi square test for the hypothesis about (the best waste management practice that are being used among contractors)

Statement	Chi-Square(a,b)	Df	**Conclusion**
Solid waste management means material such as household garbage	79.67	4.00	Function

includes, yard wastes, and demolition or construction debris.			
Reducing waste really means making more efficient use of materials.	59.55	2.00	Function
Reusing products displaces the need to buy other products thus preventing the generation of waste.	47.18	3.00	Function
Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials	118.31	4.00	Function
Integrated wastes the control of waste and disposal methods such as source reductions, recycling, reuse to minimize commercial and industrial wastages.	51.81	4.00	Function

From the table above we find that the probability value of the test of the square of Kai is less than 0.05 on which there are differences of statistical significance. Therefore, the opinions of the respondents were adopted by approving all the statements of the third hypothesis, so the contractors used different method of waste material management.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This is the last Chapter of the research; in which the researcher will basically emphases on the result of the findings to see if the objectives and the hypothesis are obtained achieved at the end of the survey. Comparisons of some of the questions e.g. common waste materials on site, benefits of implementing construction material waste management and measures to minimise waste will be shown, whether the questions set for the survey is interrelated and how effective they are, then recommendation and conclusion will be made based on the above mentioned components of the research.

5.1 Conclusion:

I. The most who participate in filling this form are SUPPORT STAFF with percentage (45%).

II. The most of the respondents are young (below 30 years) with percentage (65%).

III. The respondents experience largest percentage is (less than five years), followed by (from 6-10 years).

IV. The relation between the age and experience is positive relation, when the age increases, experience increases as well.

V. The common waste materials been considered were Steel with (51.5%), followed by Bricks (48%), then come the Concrete (45.6%), then Wood (38%).

VI. Papers/Bags where indicated as the most unmanaged waste on site in Khartoum with (24.3%).

VII. There’s some awareness among contractors of the practice of managing waste materials on site in Khartoum states.

VIII. Four factors were specified as measures to minimise waste on site such as: reducing as the highest value (67%), recycling (54%), solid waste management (51.5%), and reusing product (46.6%).

5.2 Recommendations:

5.2.1 Recommendations arising from the study:

From the results of the statistical analysis of the study, the recommendations can be inferred as follows.

- Good supervision of materials during the implementation phase to use the most of the available materials and reduce the waste materials.
- To promote awareness of the waste material management as a basic subject taught by specialized experts for its importance and need to be applied.
- Keep abreast of global technical developments in the waste material management.
- Assigning specific authorities to implement the methods of reducing the damaged materials, such as (re using, recycling, land fill) methods, in the construction sector in Khartoum.

5.2.2 Recommendations for future research:

- The study recommends a broader future research on the waste material management in construction sectors outside Khartoum, including a larger inventory of waste materials.
- Conducting practical experiments on methods of reducing waste materials specifically for the recycling and re using methods and obtaining practical results.

I. To reach the obstacles that may face the application of the waste material management in Khartoum.

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APPENDICES

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

M.Sc. in Construction management

QUESTIONAIRE FORM

The purpose of this investigation is to identify from the sub-contractors and project managers to what extend construction materials management is adopted in their work place based on the three indications of workable site. The indicators are types of waste generated, best waste management practice and awareness of waste management. The aim is to know which of the indicators is most effective on subcontractor's and project managers' adoption on construction site to achieve the concept of sustainable workplace. The investigation will provide recommendations for the main contractors to improve and create best practice of waste management to the construction site.

Achieve the concept of sustainable workplace. The investigation will provide recommendations for the main contractors to improve and create best practice of waste management to the construction site.

Section A

Respondent background:

Please tick (√) the correct information in the box given

a) Respondent profile

I. Job position

Top management ☐ support staff ☐

Junior management ☐ others…….....

II. Year of experience

Below 5 years ☐ 6 to 10 years ☐

11 to 15 years ☐ 16 to 20 years ☐

21 to 25 years ☐ above 25 years others…….

III. Age

Less than 30 years old ☐ 31 to 40 years old ☐

41 to 50 years old ☐ more than 15 years old ☐

Section B

Objective: To identify types of waste materials most generated during construction process in construction project

Please state your opinion and perception related to the following statements by circle (O) on one of the number

No	Statement	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	Steel are commonly used materials on which can greatly influence waste on site and it's very dangerous for workers.	1	2	3	4	5
2	Bricks &blocks waste material might be due to carelessness of the builders in handling the bricks during construction of the walls.	1	2	3	4	5
3	Woodremains disposed as wastage since there is no more use for them in construction site	1	2	3	4	5
4	concrete can be graded as waste due to demolition of buildings	1	2	3	4	5
5	Papers/bag as types wastage in construction site, are also used in purpose of commercial building and landfill and other construction works	1	2	3	4	5
6	Others, please specify					

Section C

4. Objective: To evaluate the level of awareness on waste management practice among contractors in commercial projects

   Please state your opinion and perception related to the following statements by circle (O) on one of the number

No	Statement	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	Any project cannot be completed successfully within the allotted time and cost without construction material management.	1	2	3	4	5
2	waste management practice and the main challenge therefore will be to break the linkage between consumption and waste generation	1	2	3	4	5
3	The awareness of the parties involved is well important to safeguard our environment is healthy in good conditions and as well as to prevent the entire society	1	2	3	4	5
4	The construction waste should be managed properly because of limited dump area on site beside to avoid risk to the people and to the contractors	1	2	3	4	5
5	Waste management normally springs during different stages of construction which can be during planning, estimating or construction stage.	1	2	3	4	5
6	Others, please specify					

Section D

5. Objective: To investigate the best waste management practice that are being used among the commercial building projects contractors

Please state your opinion and perception related to the following statements by circle (O) on one of the number

No	Statement	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	Solid waste management means material such as household garbage includes, yard wastes, and demolition or construction debris.	1	2	3	4	5
2	Reducing waste really means making more efficient use of materials.	1	2	3	4	5
3	Reusing products displaces the need to buy other products thus preventing the generation of waste.	1	2	3	4	5
4	Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials	1	2	3	4	5
5	Integrated wastes the control of waste and	1	2	3	4	5

	disposal methods such as source reductions, recycling, reuse to minimize commercial and industrial wastages.					
6	Others, please specify					

Thanks you for your support and cooperation

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

ماجستير في إدارة التشييد

<u>نموذج استبيان</u>

دراسة استقصائية عن إدارة مخلفات مواد البناء في صناعة التشييد بولاية الخرطوم – جمهورية السودان

الغرض من هذه الاستبيان هو مشاركة مقاولي الباطن ومدراء المشاريع في تحديد ومعرفة المفاهيم والممارسات الخاصة بإدارة مخلفات مواد البناء الناتجة عن مشاريع التشييد والمستخدمة في مواقع اعمالهم وذلك بالاعتماد على ثلاثة مؤشرات في مواقع العمل. هذه العوامل هي نوعية المخلفات الناتجة، أفضل الطرق والممارسات لإدارة تلك المخلفات والوعي بأهمية إدارة المخلفات.

ويهدف هذا الاستبيان أيضا إلى معرفة أي من هذه المؤشرات هو الأكثر تأثيرا على مقاولي الباطن ومدراء المشاريع.

سينتج عن هذا الاستبيان توصيات للمقاولين الرئيسيين لتحسين وتطوير وايجاد حلول وممارسات أفضل لإدارة مخلفات مواقع التشييد.

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

برنامج ماجستير الهندسة المدنية – تخصص إدارة تشييد

تحية طيبة وبعد،

أرجو من سيادتكم تعبئة الإستبيان المرفق بالمعلومات المطلوبة والتي تهدف لمعرفة **إدارة مخلفات مواد البناء في صناعة التشييد بولاية الخرطوم**، علماً بأن هذه الدراسة هي بحث تكميلي لنيل درجة الماجستير في إدارة التشييد.

أثمن لكم جهودكم للإجابة على الأسئلة المطروحة في الإستبيان علماً بأن جميع المعلومات التي يتم الحصول عليها من سيادتكم سوف تستخدم لغرض الدراسة العلمية بهدف التطوير مع الإلتزام بالسرية التامة.

أشكر سيادتكم على التعاون وتقبلوا مني فائق الإحترام والتقدير،،،

الباحث

أولاً : البيانات الشخصية:

الرجاء وضع علامة (√) أمام الإجابة المناسب

1. العمـر:

(أ) أقل من 30 ☐ (ب) 31 وأقل من 40 ☐ (ج) 41 وأقل من 50 ☐

(د) 51 فأكثر ☐

2. المستوى الوظيفي:

(أ) إدارة عليا ☐ (ب) دعم وإشراف ☐ (ج) مبتدئ تنفيذي ☐

3. سنوات الخبرة :

(أ)- أقل من 5 سنوات ☐ (ب)- من 6 وحتى 10 سنوات ☐

(ج)- من 11 وحتى 15 سنة ☐ (د)- أكثر من 16 سنة ☐

ثانياً: الاستبانة:

ضع علامة (√) امام الخيار الذي تراه مناسباً من خلال الخيارت المقدمة:

المحور الأول : أنواع ملخلفات مواد البناء

يهدف هذا المحور لمعرفة وتحديد أهم أنواع المخلفات الناتجة عن مواد البناء في مواقع التشييد.

م	العبارة	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق بشدة
1	يعد الحديد من المواد المستخدمة في مواقع التشييد كما تعد مخلفاته أحد أبرز المخلفات بمواقع البناء وتشكل خطورة بالغة على العاملين بالموقع.					
2	تكمن خطورة مخلفات الطوب والبلوكات الخرسانية في التعامل معها بإهمال من قبل العمال خلال مرحلة تشييد الحوائط.					
3	تصنف بقايا الخشب في مواقع التشييد كأحد مخلفات مواد البناء نظرا لعدم إمكانية استغلالها أو الاستفادة منها.					

4	يمكن ادراج الخرسانة كأحد مخلفات عملية هدم المباني.					
5	الأوراق/الأكياس المصنفة كأحد مخلفات مواد البناء في مواقع التشييد يمكن استغلالها في أعمال أخرى كعمليات ردم المواقع.					
6	اضافات أخرى خلاف ما تم ذكره (إن وجد).					

المحور الثاني: التوعية بأهمية إدارة مخلفات مواد البناء :

يهدف هذا المحور لقياس وتقييم مستوى الوعي بممارسات وتطبيقات إدارة مخلفات مواد البناء في مواقع التشييد.

م	العبارة	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق بشدة
1	لا يمكن انجاز أي مشروع بنجاح ضمن التكلفة والجدولة الزمنية المحددة له من دون إدارة لنفايات مواد البناء.					

2	التحدي الأكبر والأهم في ممارسات إدارة نفايات مواد البناء هو إيجاد الرابط بين كمية المواد المستهلكة والنتاجة كنفايات.					
3	إدارة مخلفات مواد البناء يمكن ان تطبق في مختلف مراحل المشروع والتي يمكن أن تكون خلال مرحلة التخطيط، التقدير أو التشييد.					
4	اضافات أخرى خلاف ما تم ذكره (إن وجد).					

المحور الثالث: ممارسات إدارة مخلفات مواد البناء

يهدف هذا المحور لايجاد ومعرفة أفضل الممارسات المطبقة من قبل المقاولين لإدارة مخلفات مواد البناء في المشاريع.

م	العبارة	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق بشدة
1	إدارة المخلفات الصلبة تعني مواد النفايات المنزلية متضمنة مخلفات المواقع وبقايا الهدم وأعمال البناء.					

2	إعادة استخدام مخلفات مواد البناء هي إحدى الطرق الفعالة لتقليل هذه المخلفات.					
3	إعادة استخدام المواد يقلل من الحاجة لشراء مواد جديدة، بالتالي منع انتاج وتكوين المخلفات.					
4	التدوير هي عملية إعادة ادخال المخلفات كمكونات أولية في تصنيع المواد وبالتالي يتم تقليل هدر المواد المفيدة.					
5	التكامل، التحكم في الهدر وطرق التخلص من المخلفات مثل تقليل المصادر، إعادة التدوير وإعادة الاستخدام تعد من الممارسات المطبقة لتقليل مخلفات المواد في صناعة التشييد.					
6	اضافات أخرى خلاف ما تم ذكره (إن وجد).					

شكرا لدعمكم وتعاونكم ،،،