



**Addis Ababa University**  
**Addis Ababa Institute of Technology**

School of Civil and Environmental Engineering  
Construction Technology and Management  
(Post Graduate Study Program)

**Study of Contractors Materials Management in Private Building  
Construction Projects-A Study of Selected Building Sites, in Addis Ababa**

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**A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial  
Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering  
(Construction Technology and Management)**

December 2016  
Addis Ababa, Ethiopia



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## **Declaration**

I declare that this thesis entitled “Study of Contractors Materials Management in Private Building Construction Projects-A Study of Selected Building Sites, in Addis Ababa” is my original work. This Thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree, and that all sources of materials used for the thesis have been duly acknowledged.

Candidate:

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Signature: \_\_\_\_\_

## **Acknowledgements**

I have no words to express my special thanks to the Almighty God, for his help throughout my life and for enabling me to go one step up in my academic career.

My deepest gratitude goes to my advisor, Prof, Dr.-Ing. Abebe Dinku for his continuous support and guidance during this research. I would also like to thank the organizations, which participated in the research during the study, for their collaboration and willingness.

Finally, special thanks and love goes to my family and friends for all the love, understanding and for their encouragement mentally as well as financially throughout the research.

## Abstract

Material management is a very important and vital aspect for every company since construction materials usually constitute a major portion of the total cost in a building construction project.

In the study, the current material management practice, problems of material management, strategies for effective material management, congestion of site due to improper placement of materials as well as the ICT tools used for managing materials on building construction site were explored. A semi-structured interview was administered to respondents in ten different construction sites in each sub-city of Addis Ababa. The studies explored the current material management practice in terms of the material requirement planning, procurement, handling, inventory control, quality control and surplus materials. The findings reveal that the material schedule was not in alignment with the master schedule also reveals that the tasks of material management are under different departments making the control and identification difficult. Late delivery of materials was the major problem of poor material management. The attitude of the society, no proper procedure before mobilization, the urgency to meet the schedule, accepting rework and having no system for improvement or change were the reasons for the congestion of site. Putting into consideration the problems of material management, the study explored some of the strategies for effective materials management such as: the use of pre-fabrication, effective planning of site layout, the use of ready mixed concrete. Furthermore, the ICT tools used for managing materials in building construction projects were explored which the interviewees explained using the common basic ICT tools: Microsoft Excel Spreadsheet and phones. The ICT tools which can be one-off the tools for facilitating material management were not used due lack of awareness.

The study indicated that before making any drastic change either be it in ICT or any other, first the construction industry need to accept the congestion of site due to in proper placement of materials as a problem. After accepting the problem, the use of the Kaizen five approach could be applied which are: Sort (sort what is needed and remove the rest), Straighten (make things visible, location can be readily identified), Scrub (Clean to provide a pleasing appearance), Spread (Clean/check, give training and improve the work area), and Standardization and Self-discipline (Establish schedule to clean and straighten the area).

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## **List of Abbreviations**

GDP- Growth Domestic Product

MoFED- Ministry of Finance and Economic Development

ICT- Information and Communication Technology

BOQ-Bill of Quantities

ACI- American Concrete Institute

EBCS- Ethiopian Building Code Standard

JIT- Just in Time delivery Technique

PDA- Personal Digital Assistants

PDT- Portable Data Terminals

ESCAP- Expert System Advisor for Concrete Placing

CMPS- Construction Materials Planning System

COME - Construction Materials Exchange

IEPC - Internet-based Electronic Product Catalogue

VCMR - Virtual Construction Material Router

MHESA - Material Handling Equipment Selection Advisor

GIS - Geographical Information System

RFID – Radio Frequency Identification

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## CHAPTER ONE

### 1. Introduction

#### 1.1. General Introduction

The construction industry is the process in which physical development is achieved and is the major engine for the development of the national economy of a country. The increasing complexity of infrastructures and the environment, within which they are constructed, place a greater demand on construction managers to deliver projects on time, within planned budget and with high quality (Enshassi, 2003).

The construction industry is more than a single industry. It is a complex cluster of industries including banking and contracting organization, materials and equipment suppliers and so forth. The industry's delivery chain consists of many complex composite parts, often operating and/or resulting in difficult and complicated circumstances involving multiple participants operating from inside and outside the industry, systems that may be assembled with completely new and never ending combinations and variations (Kelly, 1984; UNIDO, 2009).

The under development of the physical infrastructures in developing countries; along with the significant tie it has with the social sector and economic indicators; the construction industry is currently one of the major development contributors in developing countries (Mengesha, 2004). According to Chitkara (2004), the contribution of the industry to the gross domestic product (GDP) of many countries ranges between 6-9%. According to MoFED (2014), the contribution of the construction industry accounted for 5.6 % of the economy of Ethiopia.

Construction projects, being unique in nature, are faced with many challenges and one of the challenges is material management on construction sites. Material management is a vital function for improving productivity in construction projects; it should be considered at all phases of a construction process mainly because poor material management can often affect the overall construction time, quality and budget (Bell, LC and Stukhart,G, 1986).

Tersine and Campbell (2004) define material management as the process to provide the right materials at the right place at the right time in order to maintain a desired level of production at

minimum cost. The purpose of material management is to control the flow of materials effectively.

Poor planning and control of materials, lack of materials when needed, poor identification of materials, re-handling and inadequate storage cause losses in labor productivity and overall delays that can indirectly increase total project costs. Effective management of materials can reduce both direct and indirect costs and contribute significantly not only to the success of the project but ultimately to the growth of a nation (Haddad, 2006).

## **1.2. Statement of the Problem**

Efficient use and control of construction materials is very important for every company and is vital aspect for every company and should be handled effectively for the successful completion of a project. Improper management of the flow of materials could lead to catastrophic loss as unavailability of materials when needed can affect productivity, cause delays and possible suspension of activities until the required material is available.

The construction industry in Addis Ababa is faced with delays, cost overruns and currently the redevelopment of the urban areas in confined construction site requires a considerable site material management practice. The construction industry is showing a considerable increase due to the countries growth and transformation program and there will be a need to address the above problems. Bell and Stukhart (1987) stated that 6% saving could be achieved with effective material management. However, Navon and Berkovich (2006), mentions that the construction industry only devotes 0.15% in material management and control.

According to Bidy (2009), the urban centers are not expanding, but instead, they are being redeveloped from within, with a large majority of construction in urban areas occurring on inner city congested site. This trend of urban development suggests that confined site construction is rapidly becoming the norm in the industry. The construction industry in Addis Ababa is also faced with similar concern and is becoming hard for managing materials. Unavailability of storage space for materials in a confined site and poor management of the site layout is leading cause for the congestion of the city. Either the construction of buildings be in a confined area or

a normal area, the construction of buildings in Addis Ababa are overcrowded due to improper placement of materials.

Hence; this study aims to understand the practice of material management among construction companies in various construction sites in order to bridge the information gap and to forward pertinent recommendations for key actors in the sector.

### **1.3. Objective of the Research**

The research objectives address building construction sites in Addis Ababa. The objectives of the research are: -

- To understand the current material management practice.
- To explore the problems faced in managing materials on a construction site.
- To explore some of the strategies that can be used to cope with the challenge of managing materials on a construction site.
- To understand the reason for the congestion of construction building sites and improper placement of materials.
- To explore the ICT tools used and understand the factor that hinder in using the ICT tools in managing materials.

### **1.4. Scope and Limitation**

The focus of this research is on the material management practice from the main contractor's perspective, as the interview questions were addressed only to building construction contractors in Addis Ababa. Clients, consultants and material suppliers were not included.

The research will not study the management of materials at the head office of the building contractors as it will focus in the material management practice at construction sites.

## CHAPTER TWO

### 2. Literature Review

#### 2.1. Introduction

Materials management is a process for planning, executing and controlling site and office activities in construction. The objective of materials management is to insure that construction materials are available at their point of use when needed. The materials management system attempts to insure that the right quality and quantity of materials are appropriately selected, purchased, delivered and handled on site in a timely manner and at a reasonable cost (Patel, 2011). Effective management of materials warrants their availability in adequate quantities and in time minimizing surplus materials at the end of the project and contributing to the success of the project (Thomas, *et.al*, 2005).

On the other hand, poor materials management can lead to unavailability of materials when needed, unnecessary items on site, time wasted to obtain the needed materials, and surplus at the end of the project, which could be the cause of low productivity due to the idle time in order to obtain the material needed, increase in cost of the project and delay in the schedule of the project (Patel, 2011; Arnold *et al.*, 2008). Therefore, Materials management is an essential function that improves productivity in construction projects (G.Kanimozhi, 2014).

Currently a more sophisticated solution of (ICT) Information Communication Technology tools are emerging such as wireless communication, bar-coding, Radio Frequency Identification. Thus, an appropriate implementation of ICT could benefit in facilitating a more effective and productive materials management process (Kasim, 2011).

In order to have a base on the research objective; the tasks of material management, the problems and strategies to be used in managing materials in a construction site, the benefits of effectively managing materials and ICT implementation in a construction materials management will be discussed in the following sections.

### 2.1.1. Classification of Construction Materials

Chandler, (2001), states that construction materials can be classified into five categories depending on their fabrication and in the way that they can be handled on site.

These categories are:

- **Bulk materials-** are materials that are delivered in mass and are deposited in a container.
- **Bagged materials-** are materials delivered in bags for ease of handling and controlled use.
- **Pallets materials-** are bagged materials that are placed in pallets for delivery.
- **Packaged materials-** are materials that are packaged together to prevent damage during transportation and deterioration when they are stored.
- **Loose materials-** are materials that are partially fabricated and that should be handled individually.

Some examples of commonly used materials in a construction and their classifications are shown in Table 2.1.

Material	Bulk	Bagged	Pallets	Packaged	Loose
Sand	X				
Gravel	X				
Topsoil	X				
Paving Slabs			X		
Structural Timber					X
Cement	X	X	X		
Concrete	X				
Pipes				X	X
Tiles				X	
Doors			X		
Electrical Fittings				X	

**Table 2.1:** Classification of Materials (Adopted from Chandler, 2001)

## 2.2. Material Management System

According to a study made in New York, in a typical construction projects, the cost of materials can constitute 50% to 60% of the total cost of the project. The total cost of materials will include, the cost of procurement (cost of purchasing and transportation of materials), and the site-handling costs (cost of receiving, storage, issuing, and disposal) (Stukhart, 2007).

The contractor should note that there might be discrepancy from the date the material is required, to the time the material will be delivered to the site. Therefore, the contractor should always consider the procurement of materials since it is a potential factor for delay of the construction project (Willis, 2008).

### 2.2.1. Definition of material Management

Different researchers provide different definitions for material management, therefore different definitions can be found in different references.

Some of the definitions are: -

- Cavinato (1984), states that material management is the combination of purchasing with production, distribution, marketing and finance.
- Plemmons *et al.*(1995), define material management as the plan and control of all activities to ensure the correct quality and quantity of materials and equipment to be installed are specified in timely manner, obtained at reasonable cost and are available when needed.
- Gossom (1999) indicates that a material management system is a standard procedure for planning, expediting, transportation, receipt, storage and ensures efficiency for materials control.
- Arnold *et al.* (2008), defines material management as a function responsible for planning and controlling of materials flow.
- Ballot (2006), defines material management as the process of planning, acquiring, storing, moving, and controlling materials to effectively use facilities, personnel, resources and capital.

- Stukhart (2007), defines material management as the activities involved to plan, control, purchase, expedite, transport, storage, and issue in order to achieve an efficient flow of materials and that the required materials are bought in the required quantities, at the required time, with the required quality and at an acceptable price.
- Bailey and Farmer (2009), define material management as a concept concerned with the management of materials until the materials have been used and converted into the final product. Activities include cooperation with designers, purchasing, receiving, storage, quality control, inventory control, and material control.
- Dobler and Burt (2009), state that material management is designed to improve the activities related to the flow of materials and should coordinate purchasing, inventory control, receiving, warehousing, materials handling, planning, and transportation.

In general, materials management is an integrated process of planning and controlling all necessary efforts to make certain that the quality and quantity of materials and the handling equipment are appropriately specified in a timely manner, are obtained at a reasonable cost and are available when needed. The materials management systems combine and integrate the planning, vendor evaluation, purchasing, expediting, warehousing, distribution and disposing of materials. It can also be defined as a process of management which co-ordinates, supervises and executes the tasks associated with the flow of materials to, through and out of an organization in an integrated fashion. It is concerned with planning, organizing and controlling the flow of materials from project start until project completion.

### **2.2.2. Organizational Structure of Material Management**

The responsibilities of managing the activities in material flow are divided into different departments in the traditional organizational structure of material management, making it difficult to manage and direct the actions related to material management (Dobler and Burt, 2009). Figure 2.1 shows the division between departments, each department having its own responsibility. For example, the finance department is in charge of the purchasing activities while the traffic department is in charge of the traffic route and delivery of materials and this needs continuous flow of information making it hard to coordinate. In addition, this division can make the control and identification of materials extremely difficult (Dobler and Burt, 2009).

Fig 2.1 also has a production manager department, which most contractors may not necessarily manufacture their own construction materials. Instead they procure from suppliers making the manufacturing manager unnecessary.

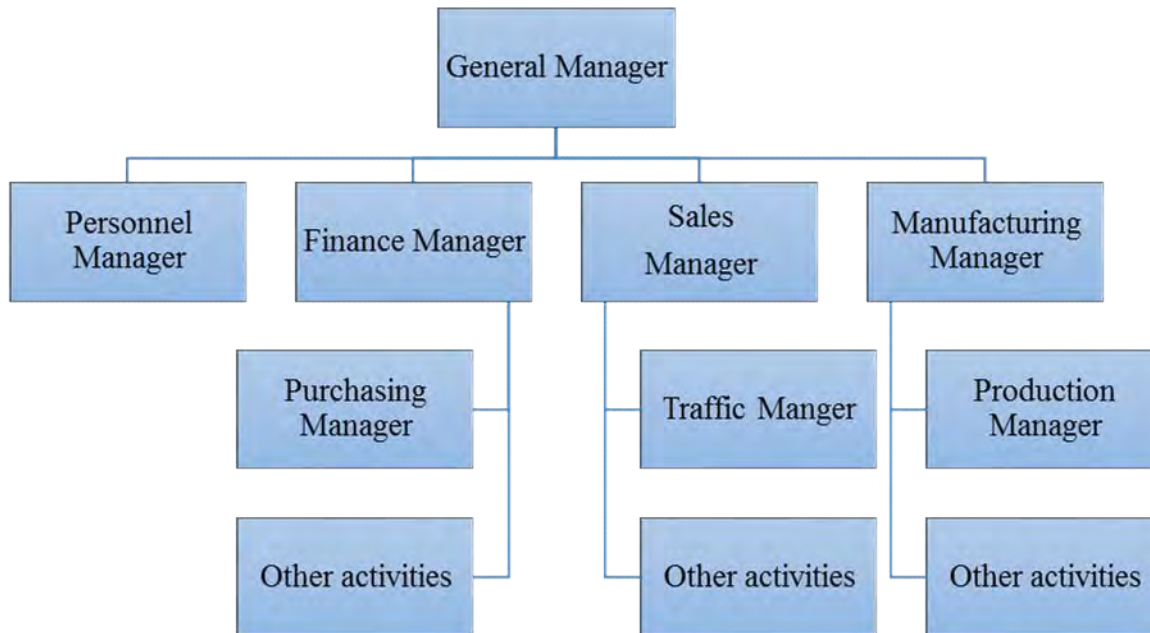


Fig.2.1 Division of responsibilities of material management for manufacturing organization  
(Adopted from (Ammer, 1999))

Fig.2.2 shows the integrated approach for material management having one department for material management by incorporating all the functions (planning, purchasing, inventory control, etc.) related to material management, which makes it easier to coordinate and control the material flow and cost. The structure of an organization must be designed so as to have the efficient management of materials (Sadiwala, 2006).



Fig.2.2 General Structure of a material management system in an organization (Adopted from Sadiwala, 2006).

Fig.2.1 and Fig.2.2 are similar in such a way that each organizational structure has their own department for personnel, finance, operational and manufacturing. They are different in that Fig.2.2 has its own material management department and all the tasks like purchasing, warehousing and transportation is under the material management department while in Fig.2.1 the tasks of material management are under different departments. For example, the purchasing department is under finance, traffic manager is under sales manager, making the flow of information disrupted.

### 2.2.3. Tasks of Material Management

Different researchers mentioned the different tasks of material management using the term “task” of material management, even though other scholars named it as phases, steps and process. In this research the term tasks is mostly used to describe the material management system and other terms might also be used interchangeably. The typical tasks of material management are: -

- Material requirement planning
- Procurement of materials
- Inventory (stock) planning and control of materials
- Material handling
- Quality control of materials
- Surplus materials control

According to Thabet, (2001), the tasks in material management are dependent on one another. Fig.2.3 depicts the different phases of the material management process including the relationship and interdependency between the different activities in each. From the figure, it can be seen that decisions taken at each phase in the system directly affect the activities of the phases that follow. For example, decisions taken at the purchasing stage might affect the decision made at the later stage of supplier management activities. Organization and communication is very important between all material management team members in order to lessen the effect of decision made at one stage to the other and to make a better decision in managing the material flow.

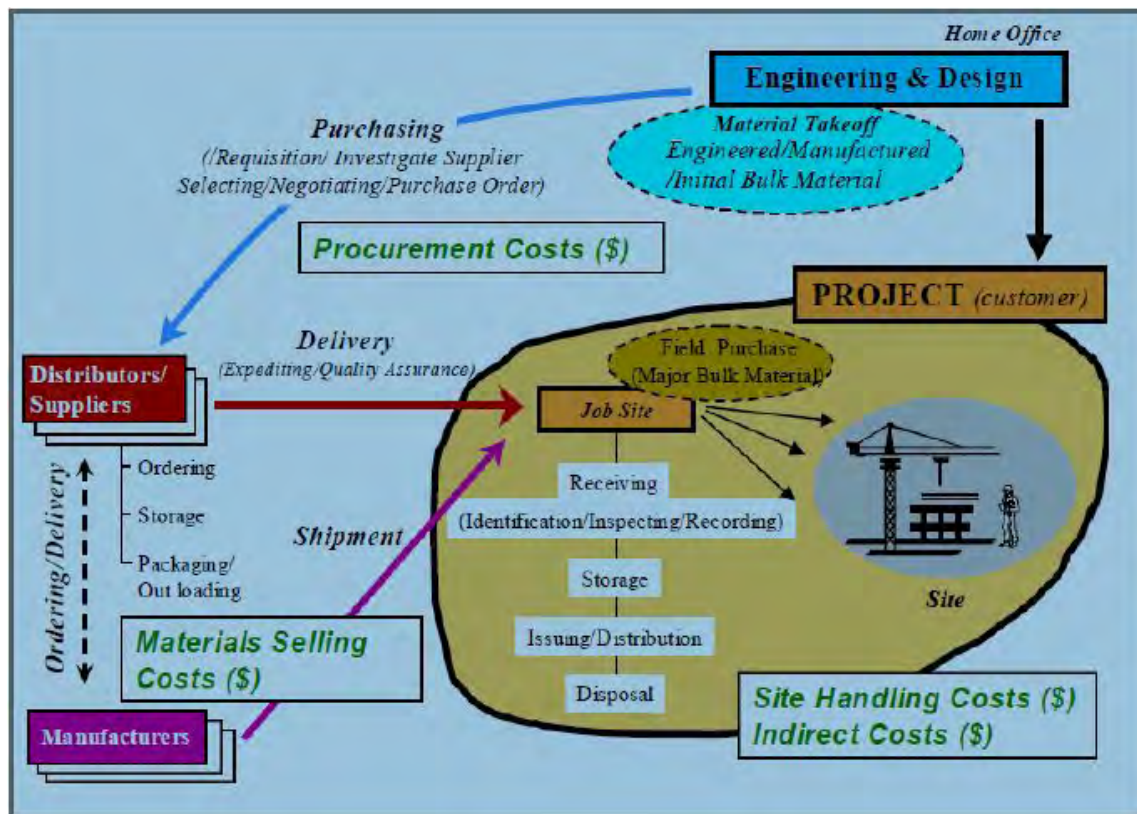


Fig.2.3 Typical Material Management in Construction (Thabet, 2001)

Ren *et al.* (2011), also described the construction material management process to be complex, integrated, and dynamic. Involved with almost all the major project participants, materials management for a contractor starts at the tendering stage and may not be ended until project close up. Fig.2.4 describes some of the key activities; material planning, site working and material monitoring, correlate information and control.

**Material planning:** Material planning is probably the most important part of the overall materials management process (O'Brien and Zilly, 1991). Typical material plans are developed based on a number of other project plans such as detailed project design, Bill of Quantities (BOQ), procurement plans, and resource plans; and then integrated into the project schedule. However, it is normally difficult to have all of the materials identified in the project buyout/planning stage due to the limited information. Even if it is very well planned, materials will still be short during the construction process. This is particularly severe for large, complex, concurrent, or new types of projects. Therefore, Mawdesley *et al.*, (1997) emphasizes that the

material planning process is not a static process; rather, it is dynamic and should be integrated with the monitoring and control process.

**Site working and material monitoring:** The site work should be done in a way which could ensure that all the materials meet the material schedule decided in the planning phase. Various preparation checklists may have been set and the details will depend on the level at which the material planning is being exercised. Material monitoring should track the status of material usage with all the key information and promptly report any changes. Only when this has been done, can the next phase, correlation of information, be carried out (Ren *et al.*, 2011).

**Correlate information:** The information here is the progress information (collected in the monitoring phase) which is to be correlated with the planning information. In this phase, the achievement is compared with the targets (Ren *et al.*, 2011).

**Control:** Control means avoiding shortage and waste. In order to achieve these two aims, detecting and realizing the problem in-time are necessary, which require the good cooperation of the project participant, from project manager to workers (Ren *et al.*, 2011).

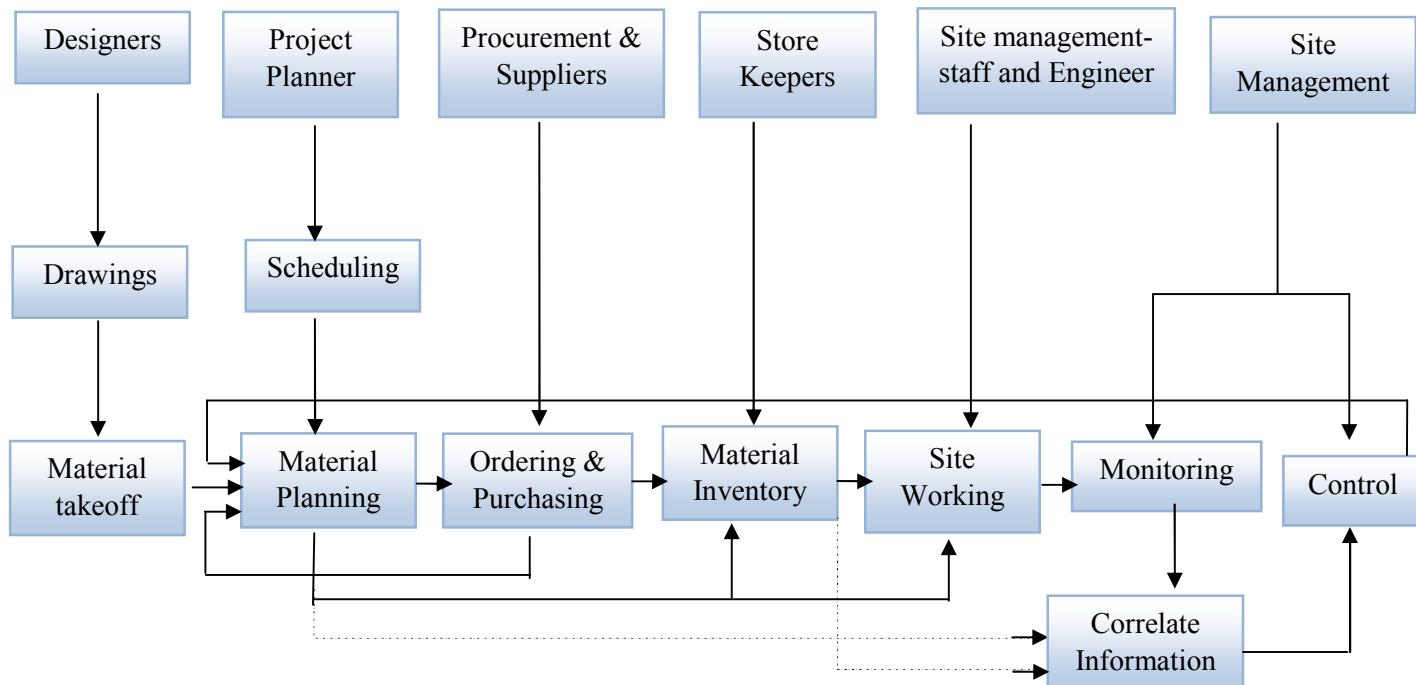


Fig.2.4 the Construction material management process (Ren *et al.*, 2011)

### 2.2.3.1. Material Requirement Planning

Planning for material comprises of computing the cost and quantity of materials, procuring of materials taking into consideration; delivery date, storage area and equipment needed to handle the materials also include controlling the flow of materials according to the schedule of the project to ensure the right materials are available when required (Wong and Norman, 1997; Tersine and Campbell, 2004; Stukhart, 2007).

The materials management process starts from the time that the contractor receives the drawings and specifications. The materials takeoff and identification process is the first step in this phase and involves identifying the materials needed as well as any special requirements or special materials to be used in the project (Perdomo,2004).

The involvement of the project managers in the estimating phase could lead to the preparation of a more realistic estimate due to project manager's knowledge and experience in materials and equipment's needed. The project team and procurement section or the person in charge of procurement should cooperate to generate a preliminary material requisition schedule in which the material types, quantity needed, dates when the material should be delivered and any other information are specified. This schedule will be considered the baseline by which the actual progress will be measured accordingly (Perdomo, 2004).

According to Stukhart (1994) cited by Kasim *et.al* (2005) stated that, appropriate materials planning need to be done concurrently with engineering, construction, and other project plans also mentioned that material planning would provide guide to all the subsequent activities and that this could have a great impact on the project plan.”

Different researchers, have stated that having a well thought material planning can have a considerable effect in: reducing waste, increase in productivity and profit and can assist in avoiding delays caused by materials hence making it possible to complete the construction project on time (Kasim *et al.*, 2005; Wong and Norman, 1997; Kasim, 2011).

### 2.2.3.2. Procurement of Materials

According to Kasim *et.al* (2005)

*“The term procurement encompasses a wide range of activities that include purchasing of equipment, materials, labor and services required for construction and implementation of a project.”*

Procurement is concerned with the acquirement of materials which are to be used in the construction with the primary purpose of getting the materials at the lowest possible cost or within the agreed budget, providing the materials at the right time and place and in the proper quality requirements (Tersine and Campbell, 2004; Stukhart, 2007; Kasim *et al.*, 2005). In order to provide the materials at the right time and place and in the proper quality requirements suppliers should be selected based on their capabilities, geographical location, prior experience, and owner preference (Stukhart and Bell, 1987). In selecting the supplier, verifying its capability to deliver the materials when needed is necessary and in order to get a reasonable price for the material, the request for quotation from different supplier is also necessary (Perdomo,2004).

According to Kasim *et.al* (2005), procurement is also engaged in organizing the purchasing and issue delivery schedules to suppliers and keeping track of whether suppliers deliver on time. As such, a detailed material schedule and co-ordination of the procurement and order of material are important in assuring material availability (Ademeso and Windapo, 2008).

*“Purchase order should leave no doubt as to what is wanted. Instructions should be a written order. Phone orders are subject to misunderstanding by suppliers; phone orders should be confirmed by fax or e-mail.*

*Written purchase orders should be checked before issue. In the construction industry, purchase orders are often in form of catalog cuts or specification. They need to define, as applicable: Scope, Timing, Constraints, Performance requirements, technical requirements, and acceptance criteria for the work, QMS requirements for suppliers and subcontractor; and Documentation to be provided and applicable controls to provide confidence to specified requirements”*(ACI, 2008, P.14).

According to Sadiwala (2006), the functions of purchasing can be stated as follows:

1. The requisition of material is necessary by proper authority to initiate its purchase.
2. To select proper supplier for the material requisitioned, before placing an order.
3. To negotiate about the price of the material from the supplier and it will be purchased at the cheapest price.
4. The quality of material must be assured and should not be compromised with the cost of the material.
5. The material should be purchased of right quantity and right quality at proper time at the cheapest cost.

Kasim *et al.* (2005) stated that failure in the purchasing process or in overseeing and organizing the buying functions could result in:

- Over-ordering of materials (wastage problems);
- Over-payments for materials (inadequate administration procedures);
- Loss of benefits (lack of skilled negotiating procedures);
- Lack of knowledge (when and where the best service/source might be available at any particular time).

### **2.2.3.3. Material Handling**

According to Lambert *et al.* (1998),

*“Materials handling as a broad area that encompasses virtually all aspects of all movements of raw materials, work in process, or finished goods within a plant or warehouse.”*

Material handling requires a critical thinking when scheming the material handling equipment since the selection process can enhance production process, provide effective utilization of manpower, increase production and improve system flexibility (Chan, 2002; Kasim *et al.*, 2005). It has been mentioned that nearly 50 % of the production cycle time in many industries is spent on handling materials. Therefore, poor material handling may result in delays leading to the idling of equipment (Gopalakrishnan and Sundaresan, 1977).

Materials must be delivered to site undamaged and without any wastage. Most common problems associated with materials supply is inadequate unloading and handling facilities, which attribute a high proportion of wastage (Canter, 1993). Therefore, handling with safety during

movement of materials at site, which reduce the percentage of materials wastage and finally foster significant improvement can often the total system productivity.

### **Objectives of Material Handling**

1. It increases space utilization by keeping the materials in racks one above the other. The material handling generally affects specific requirements. Storing various types of materials is facilitated by material handling devices and methods, and stored at proper spaces.
2. The operating efficiency is improved by reducing material handling. Material handling involves movement of materials mechanically using different equipment's or manually. By increasing load per movements using proper material carriages improves productivity and saves cost of material handling.
3. The timely delivery of materials to the site is essential criteria in material handling. Materials must be moved to their destination speedily and efficiently.
4. Reducing cost by increased capacity, improving working condition, increased equipment and space utilization and reducing cost of material handling (Sadiwala, 2006).

#### **2.2.3.4. Inventory (Stock) Control**

According to Prabu and Baker (1986),

*“Inventory control is classified as a technique devised to cover and ensure all items are available when required. Inventory control can include raw materials, processed materials, assembly components, consumable stores, general stores, maintenance materials and finished products.”*

Inventory control is concerned with maintaining the construction project from problems of waste, loss, damage and running out of stock of materials. Stock control should assure the proper storage and a protected area during delivery of materials. Some studies have showed that there is a problem in controlling stock on project sites with a small storage area while others argue that the size of the storage area doesn't matter if planning is done taking into consideration the storage area before initial buy then can problems such as running out of stock can be avoided (Kasim *et al.*, 2005).

Higgins (2006) explained that careful stock control assures the user that materials and supplies are not being wasted or stolen and can reduce costs of such goods and their storage. He further explained that the inventory of materials should be controlled from the times they are supplied until incorporated by the contractors. Areas of stock control include the following basic steps.

- a. Goods receiving and receiving the receipt.
- b. Storage of goods in good conductor.
- c. Controlled recording of incoming and outgoing construction materials as well as the supply on hand. Also control of incoming and issuing of construction materials as well as inventories of stock on hand and reserve stock records of issuing materials and the of inventory turnover.

Chandler (2008) explained that the degree of control on the inflow of materials and accompanying paper work will depend upon the size of the contract and the staff assigns to oversee this work. After all the planning ordering and buying process have been working to effect a tight control over the materials situations, the site can negate the whole system if it does not carry out its functions (to supervise the utilization of materials on the site). He stressed further that control on site must be exercised respect of waste deterioration, misuse etc. careful check should be made to ensure correction of orders and that materials delivery can be properly stretch and unnecessarily handling avoided.

**Control measures on site should include:**

1. Delivery: schedule of timing and contractual responsibility in delivery orders should be agreed with supplier. Order should be checked on arrive on site by competent storekeeper.
2. Security and storage: practical site security with fencing where necessary and a watched gateman, site store with lock. In addition, site manager's office should be situated in such a position that he could have an overview of the entire site where practicable.
3. Internal Transportation: This should be done in a way to avoid double handling.
4. Adequate supervision: should ensure that materials are not dropped, spoiled or discarded unnecessarily during operation.

5. Accounting: Records should be kept of all transactions – receipts, suppliers, waste, and transfers to other sites and so on.

However, this is not easy; First, if materials are purchased early, capital may be tied up and interest charges incurred on the excess inventory of materials. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. For example, electrical equipment often must be stored in waterproof locations. Second, delays and extra expenses may be incurred if materials required for particular activities are not available. Accordingly, ensuring a timely flow of material is an important concern of project managers (Harris and MacCaffer, 2001).

Perdomo (2004) elucidated that the quality received should confirm with the approved materials. The construction team should make a comparison between the ordered quantities and the received quantities. If there is a deviation, the construction team or the one who responsible for receipting the materials should inform the procurement section or the person in charge of procurement to follow up with the suppliers.

#### **2.2.3.5. Quality Control of Materials**

Sadiwala (2006) states quality control is a very important and necessary function of material management to purchase the right quality of materials. The inspection, quality control, specification, and standardization are the activities which are to be followed for the measurement of quality of the materials. The quality assurance is decided by inspection and checking the various properties of materials as per their specification and standard.

Quality is the totality of features and characteristics of a product that bear up on its ability to satisfy stated and implied needs. And quality control is the operational techniques and activities that are used to fulfill requirements for quality; it is a system for insuring quality of output involving inspection, analysis and action to make required standards (Nevile, 1985). It is the system of procedures and standards by which a contractor, product manufacturer, material processor etc. controls the properties of finished works (ASTM, 1993).

It is very well known that quality of construction work primarily depends on the quality of the construction materials to be used in the works taking design and workmanship quality for granted. Construction materials from various sources must be checked for quality. These include construction materials such as back fill materials, sand, red ash, stone which are found naturally and others such as reinforcement bar and cement etc., which are factory products. Therefore, before any purchase or supply is made to construction sites their quality must be checked by an appropriate procedure. Thus a body responsible for the purchase or supply has to inform the appropriate personnel for the checking before any purchase/delivery agreement of the material is conducted (EBCS-2, 1995).

IS Codes cited by Patel (2011) recommended on stacking and storage of construction materials at site as:

1. The materials should not be affected by impurities or atmospheric agencies.
2. Materials like cement should must be stored in covered sheds and stacked on timber raised platforms.
3. Reinforcing bars should be stacked yards away from moisture to prevent rusting and also away from oil and lubricants. Bars of different classification, sizes and lengths should be stored separately to facilitate issues.

#### **2.2.3.6. Surplus Material Control**

According to Stukhart and Bell (1987), various shortcomings in the engineering, materials control, procurement, and field materials management may result in surplus materials. Understanding and anticipating these potential problems are the first in minimizing surplus.

There are many causes for surplus materials, such as:

- Poorly performed materials take off.
- Engineering revision and changes, particularly if the materials take off occurs early and systems are not adequately responsive to changes.
- Inadequate construction materials management practices.
- Duplicate buying and poor control systems/procedures leading to procurement of unnecessary materials (Stukhart and Bell, 1987).

Minimizing surplus on a project requires a proactive and timely system of communication among all functions involved in the materials acquisition and installation cycle. Some of the minimization options for disposal of surplus materials include using the surplus materials on other projects, returning them to the vendor, or selling them to a third party. All options require complete records and timely reporting to achieve optimum results. The best option is to do the necessary planning and to implement the necessary materials management system to reduce surplus at the source (Ahuja *et al.*, 1994).

Construction activities can generate an enormous amount of waste and materials waste has been recognized as a major problem in the construction industry. The cause of waste in construction projects indicates that it can arise at any stage of the construction process from inception, right through to design, construction and operation of the built facility. Waste can be reduced through the careful consideration of minimization strategies and through better reuse of materials in both the design and construction phases (Kasim *et al.*, 2005).

### **2.3. Material Management in a Construction Site**

In a time where the urban population exceeds the growth of rural settlement, the construction industry is in point of transition. It has been noted that in a global scale urban growth will double from 2.86 billion in 2000 to almost five billion in 2030. Therefore, the construction industry is shifting towards increased growth in the area of urban construction and regeneration sector (Cohen, 2004).

As a consequence of urbanization, the construction industry is faced with the challenge of building complex and unique in nature buildings with little area. The construction project managers are expected to make possible and manage the construction within the confined project site (Wideman, 1990; Remington and Pollack, 2007).

According to Thomas *et al.* (2005), with the ever increasingly complex designs and countless materials required to construct these often intricate structures, endless quantities of materials are required at various times and in various locations, in order to complete a successful project.

Numerous writings have sought that site layout has effect on material management and that they considered the larger sites that pose the biggest problems due to the long distances for which materials must be transported, coupled with the additional burden of monitoring materials. But Chudley and Greeno (2006) outlines the importance of a well-designed site layout and its effects on material management. Material storage areas must be located close to off-loading areas and yet in close proximity to the works area. Harris, *et al.*, (2006) outlines the importance of material management on-site, including the importance of correct material storage.

### **2.3.1. Problems of Material Management in a Construction Building Site**

Problems related to management are present in contractors in developed as well as in developing counties. The problems are different in nature and intensity but are usually related to managing construction resources (Chan, 2002).

Choo and Tommelein ,1999); Bell and Stukhart ,1987; Li *et al.* ,2003; Poon *et al.*, 2004, assert that the biggest problem field workers face is coping with discrepancies between anticipated, actually needed, and available materials.

According to a study made by Al-Shorafa (2009) and Patel (2011), the following are identified as problems of material management during each phase of construction:

#### **1. Material identification**

The materials management problem starts from the time that the contractor receives the drawings and specifications. The materials takeoff and identification process is the first step and involves identifying the materials needed as well as any special requirements or special materials to be used in the project. During this phase, the following problems were identified:

- The scope is undefined: There is no clear description of what is wanted
- Lack of communication: Lack of information flow between parties involved
- Incomplete drawings: The drawings provided are incomplete and details are missing causing improper estimation of the materials
- Difference between plans and specification: make it hard for the contractor to know what he wants from the supplier

- No proper schedule of materials: not determining when and what materials are needed

## 2. Vendor selection

The second phase is the selection of reputable suppliers and manufacturers. The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified). During this phase the contractor may be faced with the following problems:

- Uncontrollable bid list: Have too many suppliers and too little information
- Incomplete proposals: Suppliers do not include all documents required
- Time spent in investigating non-qualified suppliers

## 3. Procurement problems

This phase of material management includes material requisition and expediting and it is considered very critical to the success of a material management process. The person in charge of procuring materials or the purchasing department, in the case of a large company, needs to ensure that the correct materials in the correct quantities are delivered. This person also needs to verify the release dates at which the material is needed and to clearly specify those delivery dates and the location of delivery to the supplier. In the procurement phase the following problems may arise:

- Unavailability of required material
- Unavailability of required quantity
- Matching price to competitor's price: Price reduction to match competitors price
- Materials not delivered as per schedule
- Poor communication: lack of communication between parties
- Lack of conformance to requirements: what is wanted is not what is prepared
- Unrealistic delivery dates: Delivery date impossible to meet
- Vague stated requirements: Lack of communication
- Storage of materials: storage areas are limited or are far from working area

## 4. Construction phase

The construction phase is the phase in which the delivery of materials usually occurs. Material is generally requested for delivery to the jobsite. In some instances, material delivery to the jobsite may not be feasible due to storage or access limitations. In this case, the material is delivered to other locations such as the contractor's warehouse, a prefabrication shop or another subcontractor storage area. Material requisition problems greatly affect the construction stage and failure to manage this phase effectively could result in project disruption and possible delays due to:

- Incorrect type of material delivered: Difference in material ordered and delivered
- Incorrect quality delivered
- Incorrect quantities delivered
- Keeping track of material: Not knowing where material is at a certain period of time
- Re handling of materials
- Storage of material
- Loss of material
- Damage
- No supplier quality assurance
- Poor communication

#### 5. Construction Closeout Phase

After the construction phase, the contractors have to manage any surplus material. The surplus is handled differently depending on the type of material and also whether or not the contractor has a warehouse. If the company has a warehouse, the surplus material is stored in the warehouse for use in future projects. Other companies return surplus material to the supplier for reimbursement. During this phase, the following problems occur:

- No storage for surplus materials
- No possibility that the surplus materials to be returned to the supplier

According to Formoso and Revelo (1996) the main problems detected were: problems related to design delays, incompleteness of designs, lack of details and inconsistencies, lack of planning and organization of transportation and delivery of materials, materials ordered on short notice or

verbally, incomplete or inconsistent materials specification, lack of estimation of the amount of materials needed, delays in price surveys and in ordering materials, delays in checking stocks.

Thomas *et al.*, (2005) identifies that failure to accommodate materials results in poor productivity and waste. Enshassi, *et al.*, (2007) also outlines the effect of unsuitable storage locations, as a leading factor in labor productivity, thereby indicating that not only is the presence of adequate storage space essential, but correctly located storage is also a factor in the overall productivity within a project.

A material not being delivered as per schedule is one of the problems of material management. Material is for example ordered earlier and with greater quantity than the actual need. Early deliveries and large order quantities contribute to disorder at site, extra handling, breakage and loss of material, which is costly and unnecessary waste (Bertelsen and Nielsen, 1997). Storage of material also increases the risk of theft, which in turn results in extra costs for new material and administration. In addition, extra handling of material might negatively affect health and safety conditions. Furthermore, late deliveries, which cause delays in the project, will impact on customer satisfaction (Formoso *et.al*, 2002).

Delivery of incorrect quantity often affects the time plan in a project and Ala-Risku and Karkkainen (2005) state that 8-25% of non-complete activities are due to delivery deviations. It is both costly and time consuming to go back and complete work activities later on and many construction sites take actions in advance to avoid situations like this.

Thomas and Riley (2006) outlines that mismanagement of material storage is a leading factor in spatial congestion and as a result, reduced levels of productivity on a construction project. Resulting from this, the lack of adequate storage space is directly linked to inadequate spatial management, particularly where space is a limited resource, as is the case in confined construction sites.

Horman and Thomas (2005) indicate that ensuring an adequate stockpile of materials on-site is essential in the management of production. Where there is a lack of storage space, this inventory

may become compromised, resulting in further negative results in productivity and materials management.

Horman and Thomas (2005) indicates that an overcrowded construction site leads to double handling of materials, again, reducing productivity and increasing damage to materials. Inadequate management of materials through over allocation also has been identified as impeding progress, workflow and overall productivity; due to overcrowding the limited work space available.

Darvik and Larsoon (2010) outlines that lack of communication was the most common reason for delivery deviations and many of the shortcomings inherent in the order-to-delivery process are related to lack of communication. The shortcomings in the order-to-delivery process that are most outstanding are: unreliable delivery time, inaccurate delivery information from suppliers, poor delivery notifications from logisticians, inadequate goods inspection and inconsistent ways of handling delivery deviations.).

### **2.3.2. Strategies for Effective Material Management in a Construction Site**

The effective management of materials both prior to and when delivered to site is fundamental to the success of any development. In cases where this process is made more difficult, that is, where space to accommodate these deliveries is limited, this process becomes even more important. Thomas, *et al.*, (2005) identifies that through the effective management of these storage areas, management can effectively supervise the delivery and allocation of materials on-site.

The American Institute of Architects (1994) gives a brief but concise insight into the management of construction materials and its effect on the management of its resulting waste. This topic is critical due to the limited space on-site, therefore any excess material or waste material is occupying space that could be better allocated to tasks requiring the allotted space.

Strategies for site material management: -

- The utilization of pre-fabrication and pre-assembly of materials prior to reaching site
- Providing adequate storage of materials on-site
- The utilization of space scheduling so as to maximize the usage of the available space

- The use of Just-In-Time delivery techniques to minimize the volume of materials on-site
- The effective design site layout so as to aid in the management of materials on-site
- Implementation of a materials management program to assist in the movement/storage of materials on-site
- Implement a traffic management program to aid in the overall management of the construction process
- The use of Ready mixed concrete for sites having stumpy working space.

**Some of the strategies are, as follows;**

### **1. Pre-Fabrication and Pre-Assembly**

A solution being utilized more prominently in the last number of years is pre-fabrication and preassembly. Due to the limited space on-site for the delivery, storage, assembly and transportation to the site, in some cases it is more beneficial to acquire the components delivered to site pre-assembled. A vast array of authors all identify and acknowledge the benefits of pre-fabrication and pre-assembly in construction projects (Ballard and Howell, 1995; Yeung *et al.*, 2005; Haas *et al.*, 2000; Alistair, 1999). Yeung *et al.* (2005) continues by identifying the benefits of prefabrication and that of the space saving characteristics of prefabrication due to the reduced requirement to store and manage excessive amounts of material on-site. Once materials are successfully delivered to site, they must be accommodated within the bounds of the site or stored appropriately.

Egan (1998) outlined the need to improve the construction industry in a number of areas with pre-fabrication being one of these areas. Leading authors (Yeung *et al.*, 2005; Blismas *et al.*, 2006; Gibb, 2001) all highlight the importance of such a technique in relation to materials management. The leading benefit was identified as savings in space allocated to materials storage. Due to the reduced material storage requirements, more space is made available to other tasks which require additional spatial considerations.

Blismas *et al.*, (2006) summarizes the benefits of pre-fabrication and pre-assembly through time, cost, quality, productivity, people and process groupings. Through pre-fabrication techniques,

the time spent locating various materials on-site are removed, therefore making the process more productive.

Bell and Stukhart (1987) reported that material management foremen often exceed 20% of their time in locating material on-site and an additional 10% of their time tracking purchase orders. Through substituting traditional material purchasing with pre-assembly, this non-productive time is reduced dramatically.

## **2. Effective design layout**

Effective storage of materials on-site is essential to the overall productivity of personnel on-site. Inadequate storage leads to congested workspaces, resulting in significantly reduced productivity (Thomas, *et al.*, 2006). To overcome such issues, management must ensure that adequate storage space is assigned for the various material requirements. Providing sufficient storage arrangements coincide directly with the design site layout, which invariably occurs prior to commencing on-site. It is at this stage that storage space for the various materials required, are accommodated. Elbeltagi, *et.al*, (2004) outlines that where specific site layouts are not considered prior to commencing on-site, the possibility of increased material waste and extra handling/double handling is more likely to occur. Furthermore, outlines the benefit of an effective site layout to contribute to the flow of materials, through providing adequate spatial considerations. This is highlighted further where adequate planning is required to avoid excessive movement of materials on-site, thereby, reducing the probability of double handling materials in adverse conditions. The overall site layout is critical to the success of this aspect of materials management. Chudley and Greeno (2006), highlights this point by outlining the importance of a well-designed site layout and its effects on material management. Material storage areas must be located close to off-loading areas and yet in close proximity to the works area. Harris *et al.*, (2006) outlines the importance of material management on-site, including the importance of correct material storage.

Thomas, et al., (2002) concludes by explaining that —Any interruption to the normal flow of materials will result in causing serious degradations on performance and labor productivity.

According to Sadiwala, 2006 site layout is very important for the following reasons:

- Easy receipt, handling and issue of materials

Material storage areas must be located close to off-loading areas and yet in close proximity to the works area.

- Maintaining continuity in flow of materials. It should have a minimum movement

Deciding the storage area location is important in reducing the time of travel and keeping the materials in the stores and withdrawing them with ease by the use of material handling equipment or manually.

- The space for storing and handling the materials should be fully utilized

The materials should be stored above safety stock and up to maximum capacity. The essential materials should not fall below the required minimum level.

- Proper place is selected for storing proper types of materials

Various types of materials stored will be affected by the atmosphere and the environment. These types of materials can be preserved by keeping them in proper environment which will not affect them. Some of the important methods necessary for every store are: protection of store against fire, dust protection, maintaining proper environment, protection against corrosion, prevention of theft.

- Location should be such that minimum time and labor will be necessary to locate and get the materials

The design of stores and methods of storing and withdrawing the materials will depend on how frequently the materials are received and stored inside the storing rooms and storing places. Large construction and fabrication projects needs bulk of materials of building construction like steel, cement, sand and other fabrication materials. For such materials site stores, are built up near the project places.

Therefore, the method of storing and layout must be such that it will eliminate wastage, erosion, rusting and deterioration.

### 3. Space Scheduling

Space scheduling aids in the management of materials and the available space on-site. Elbeltagi, *et al.*, (2004) outlines that space scheduling optimizes the site layout paying particular attention to the interrelationship of the other facilities on-site. Resulting from this, on-site storage is critically accessed and located accordingly, to benefit the end user on-site, thereby, reducing travel distances, improper/inadequate storage and incorrectly located storage facilities (Winch and North, 2006). Winch and North, (2006) furthers outlines the importance of space scheduling and materials management by indicating that materials management is one of the core task for execution of space scheduling which requires attention in construction project planning.

### 4. Just-In-Time Delivery Techniques

The use of particular management techniques within the construction industry is wide and varied. One of the better known techniques is the implementation of Just-In-Time delivery. Akintoye (1995) identifies the application and implementation of Just-In-Time management of building materials and encompasses total business management under the realm of Just-In-Time materials management. This technique is essential in the management of material, especially in cases where the availability of space is limited, as in the case of restricted sites. Opfer (1998) defines Just-In-Time materials management simply as ensuring materials only arrive to site just as they are needed. The benefits of Just-In-Time delivery techniques are widely acknowledged but seldom practiced, mainly due to the intricate and diverse nature of the construction industry.

Ballard and Howell (1995), states that the benefits of just-in-time materials management are significant, especially where the space required for the materials is greater than the space available on-site. Furthermore, significant savings in both monetary and time may be gained through Just-In-Time delivery, through saving on double handling and minimizing accommodating large quantities of materials that are required at a later date (Bertelsen, S. and Nielsen, J., 1997). Poppendieck (2000) details that Just-In-Time not only organizes the materials management of a project but co-ordinates the overall flow of work and the associated materials required rather than assessing individual work packages and their corresponding needs.

According to Kwakye (1991) cited by Kasim,*et al.*, (2005), outlines the strategy options for construction projects related to materials as follows:

1. Advance purchasing of essential materials

Require advance purchasing material and plant to ensure their availability on site when required.

2. High Preference for steel frame

Preference of steel frame rather than reinforced in situ concrete for reasons of speed of erection, reduced site labor requirements, prefabrication, standardization for versatility and dimensional accuracy, and easy site modification.

3. Avoiding wet trade operations

Use of prefabricated materials and components and avoid wet trades as possible to reduce waiting time at trade interfaces and maintain working tempo.

4. Standard and easily available components preferred

Maximize the utilization of standard components and easily available.

**5. The use of Ready mixed concrete**

Ready mixed refers to concrete that is batched for delivery from a central plant instead of being mixed on the job site. Each batch of ready-mixed concrete is tailor-made according to the specifics of the contractor and is delivered to the contractor in a plastic condition, usually in the cylindrical trucks often known as "cement mixers."

Ready mixed concrete greatly minimizes expenses as it cuts down on material consumption, labor and storage costs. In preparation of ready mixed concrete, the proportion of all ingredients used are accurately measured and maintained, which consequently diminishes a lot of waste. The manual labour involved in onsite concrete mixing is relatively significant and is not needed for ready mixed concrete.

**2.3.3. Kaizen's Principle**

In the decade of 1980, management techniques focusing on employee involvement, and empowerment through teamwork approach and interactive communications and on improving job design were not new, but Japanese companies seemed to implement such techniques much more effectively than others. The business lesson of the 1980's was that Japanese firms, in their quest for global competitiveness, demonstrated a greater commitment to the philosophy of continuous improvement than Western companies did (Bowles and Hammond, 1991). For such a philosophy the Japanese used the term Kaizen.

Kaizen means improvement, continuous improvement involving everyone in the organization from top management, to managers then to supervisors, and to workers. In Japan, the concept of Kaizen is so deeply engrained in the minds of both managers and workers that they often do not even realize they are thinking Kaizen as a customer-driven strategy for improvement. This philosophy assumes “our way of life – be it our working life, our social life or our home life – deserves to be constantly improved” (Imai, 1986).

Kaizen is a Japanese philosophy for process improvement that can be traced to the meaning of the Japanese words ‘Kai’ and ‘Zen’, which translate roughly into ‘to break apart and investigate’ and ‘to improve upon the existing situation’. The Kaizen Institute defines Kaizen as the Japanese term for continuous improvement. It is using common sense and is both a rigorous, scientific method using statistical quality control and an adaptive framework of organizational values and beliefs that keeps workers and management focused on zero defects. It is a philosophy of never being satisfied with what was accomplished last week or last year (Barnes, 1996).

Improvement begins with the admission that every organization has problems, which provide opportunities for change. It evolves around continuous improvement involving everyone in the organization and largely depends on cross-functional teams that can be empowered to challenge the status quo.

Thessaloniki, 2006 outlines that companies undertaking a Kaizen philosophy, place an emphasis on the processes- on “how” of achieving the required results. A process emphasis goes beyond designing effective processes; it requires the teams to understand why a process works, whether it can be modified or replicated somewhere else and how it can improve.

According to the Kaizen philosophy “not one single day should go by in the firm without some type of improvement being made in some process in the company”. Kaizen deals with the management of change and is a methodology in the right direction to improve manufacturing operations, on a continual and incremental basis following the right steps:

- Establish a plan to change whatever needs to be improved
- Carry out change on a small scale
- Observe the results and

- Evaluate the results and the process and determine what has been learned (Thessaloniki, 2006).

The starting point for improvement is to recognize the need. So Kaizen principles emphasis problem-awareness and provide clues to identifying problems. When identified, problems must be solved, so Kaizen is also a problem-solving process. But, most of all, Kaizen is a management philosophy that forces higher standards at all levels of the organization by encouraging continuous improvement in all processes. Kaizen approach is based on the premise that there is no perfection in a process, because no structure, product, or system ever achieves the ideal stage and where it can be improved by further reducing waste.

### **Kaizen- Three pillars**

According to Imai (1986), the three pillars of kaizen are summarized as follows:

1. Housekeeping
2. Waste elimination
3. Standardization

#### **1. Housekeeping**

This is a process of managing the work place for improvement purposes. For proper housekeeping a valuable tool or methodology was used, the 5S methodology. The term “Five S” is derived from the first letters of Japanese words referred to five practices leading to clean and manageable work area: Seiri (organization), seiton (tidiness), Seiso (purity), Seiketsu (Cleanliness) and Shitsuke (discipline) (Thessaloniki, 2006).

The English words equivalent of the 5S's are sort, straighten, sweep, sanitize, and sustain. 5S evaluations provide measurable insight into the

orderliness of a work area and there are checklists for manufacturing and nonmanufacturing areas that cover an array of criteria as i.e. cleanliness, safety, and ergonomics. Five S evaluation contributes to how employees feel about product, company, and their selves and today it has become essential for any company, engaged in manufacturing, to practice the 5S's in order to be recognized as a manufacturer of world-class status (Thessaloniki, 2006).

The following table briefly shows each one from the five activities:

Seiri	SORT what is not needed. Use the red tag system of tagging items considered not needed, then give everyone a chance to indicate if the items really are needed. Any red tagged item for which no one identifies a need is eliminated (sell to employee, sell to scrap dealer, give away, put into trash).
Seiton	STRAIGHTEN what must be kept. Make things visible. Put tools on peg board and outline the tool so its location can be readily identified. Apply the saying "a place for everything and everything a place".
Seiso	SCRUB everything that remains. Clean and paint to provide a pleasing appearance.
Seiketsu	SPREAD the clean/check routine. When others see the improvements in the Kaizen area, give them the training and the time to improve their work area.
Shitsuke	STANDARDIZATION and self-discipline. Established a cleaning schedule. Use downtime to clean and straighten area.

**Table 2.2:** Kaizen 5S approach

Some of the benefits of practicing the five S could be as follows: Creates cleanliness, sanitary, pleasant, and safe working environments; it greatly improves employee morale and motivation; it eliminates various kinds of waste by minimizing the need to search for tools, making the operators' jobs easier, reducing physically strenuous work, and freeing up space; it creates a sense of belonging and love for the place of work for the employees (Thessaloniki, 2006).

## 2. Waste (Muda) elimination

Muda in Japanese means waste. The resources at each process — people and machines — either add value or do not add value and therefore, any non-value adding activity is classified as muda in Japan.

In Kaizen philosophy, the aim is to eliminate the seven types of waste (7 deadly wastes) caused by overproduction, waiting, transportation, unnecessary stock, over processing, motion, and a defective part.

Muda (waste) elimination will cover the categories described as follows:

**Muda of overproduction:** Overproduction may arise from fear of a machine's failure, rejects, and employee absenteeism. Unfortunately, trying to get ahead of production can result in: tremendous waste, consumption of raw materials before they are needed, wasteful input of manpower and utilities, additions of machinery, increased burdens in interest, additional space to store excess inventory, and added transportation and administrative costs.

**Muda of inventory:** Final products, semi-finished products, or part supplies kept in inventory do not add any value. Rather, they add cost of operations by occupying space, requiring additional equipment and facilities such as warehouses, forklifts, and computerized conveyer systems. Also the products deteriorate in quality and may even become obsolete overnight when market changes or competitors introduce a new product or customers change their taste and needs. Warehouses further require additional manpower for operation and administration. Excess items stay in inventory and gather dust (no value added), and their quality deteriorates over time. They are even at risk of damage through fire or disaster. Just-in-time (JIT) production system helps to solve this problem.

**Muda of defects (repair or rejects):** Rejects, interrupt production and require rework and a great waste of resources and effort. Rejects will increase inspection work, require additional time to repair, require workers to always stand by to stop the machines, and increase of course paperwork.

**Muda of motion:** Any motion of a person's not directly related to adding value is unproductive.

Workers should avoid walking, lifting or carrying heavy objects that require great physical exertion because it is difficult, risky, and represents non-value added activities. Rearranging the workplace would eliminate unnecessary human movement and eliminate the requirement of another operator to lift the heavy objects. Analysis of operators' or workers leg and hand motions in performing their work will help companies to understand what needs to be done.

**Muda of processing:** There are many ways that muda can happen in processing. For example, failure to synchronize processes and bottlenecks create muda and can be eliminated by redesigning the assembly lines so, utilizing less input to produce the same output. Input here refers to resources, utilities, and materials. Output means items such as products, services, yield, and added value. Reduce the number of people on the line; the fewer line employees the better.

**Muda of waiting:** Muda of waiting occurs when the hands of the operator are idle; when an operator's work is put on hold because of line imbalances, a lack of parts, or machine downtime; or when the operator is simply monitoring a machine as the machine performs a value-adding job. Watching the machine, and waiting for parts to arrive, are both muda and waste seconds and minutes. Lead time begins when the company pays for its raw materials and supplies, and ends when the company receives payment from customers for products sold. Thus, lead time represents the turnover of money. A shorter lead time means better use of resources, more flexibility in meeting customer needs, and a lower cost of operations.

Another common type of muda in this category is time. Materials, products, information, and documentation sit in one place without adding value. On the production floor, temporary muda takes the form of inventory. In office work, it happens when documents or pieces of information sit on a desk or in trays or inside computer disks waiting to be analyzed, or for a decision or a signature.

**Muda of transportation:** Transportation is an essential part of operations, but moving materials or products adds no value. Even worse, damage often occurs during transport. To avoid muda, any process that is physically distant from the main line should be incorporated into the line as much as possible, because eliminating muda costs nothing, muda elimination is one of the easiest ways for a company to improve its operations (Thessaloniki, 2006).

### **3. Standardization**

Standards are set by management, but they must be able to change when the environment changes. Companies can achieve dramatic improvement as reviewing the standards periodically, collecting and analyzing data on defects, and encouraging teams to conduct problem-solving activities. Once the standards are in place and are being followed then if there are deviations, the workers know that there is a problem. Then employees will review the standards and either corrects the deviation or advice management on changing and improving the standard. It is a never-ending process and is better explained and presented by the PDCA cycle (plan-do-check-act) (Kilian, 1992).

The management plans, each employee follow the plan activities, the inspectors check, and the management correct or secure every step, systematically. It is important to be seen that each one employee follows his own PDCA cycle.

A successful PDCA cycle then is followed by the SDCA cycle where ‘S’ stands for standardization and maintenance of the new situation. So, PDCA stands for improvement and SDCA stands for maintenance (Thessaloniki, 2006).

### **2.4. Benefits of Implementation of Materials Management on building sites**

The main benefits of an efficient materials management and control System are: increased productivity and avoidance of delays, mainly due to the availability of the right materials prior to work commencement (Navon and Berkovich, 2005).Further more Significant savings could be made with the better management of materials on site and the use of technology systems leading to reduced waste of materials and better site productivity through more efficient handling of materials with lower wastage (Donyavi and Flanagan,2009).

Navon and Berkovich (2004) stated that reduction in the cost of materials can occur due to reduction in waste which is caused by manual and inefficient materials management and control.

Previous studies have shown the use of material management system effectively can improve labor productivity by 6% and can save up the project cost by 4-6%. Bring many benefits for a

company (Bernold and Treseler, 1991). Tam and Tam (2006), Kartam et al. (2004), and Tam (2008) list a range of benefits:

- Reducing the overall costs of materials
- Better handling of materials
- Reduction in duplicated orders
- Materials will be on site when needed and in the quantities required
- Improvements in labor productivity
- Improvements in project schedule
- Quality control
- Better field material control
- Better relations with suppliers
- Reduce of materials surplus
- Reduce storage of materials on site
- Labor savings
- Stock reduction
- Purchase savings

Normally problems arise due to improper storage materials when supplied to the site. Survey shows that purchasing and supply management can evaluate firm's financial performance. Timely demand for the materials is critical for leveling the required supply (Rong, *et al.*, 2012).

The material needed for the required activities to be properly scheduled in order to ensure supplier's demand. Space provided at a site for stocking of ample materials dramatically reduce procurement cost, wastes and other associated risks. Material management process establish framework for provision of scheduled materials required prior to commencement of the activity (Mohammed, 2004).

According to the study made by Stukhart and Bell, 1987 on twenty heavy construction sites, the following benefits were noted: -

- In one project, a 6% reduction in labor costs occurred due to the improved availability of materials as needed on site. On other projects, an 8% savings due to reduced delay for materials estimated.
- A comparison of two projects with and without a materials management system revealed a change in productivity from 1.92 man-hours per unit without a system to 1.14 man-hours per unit with a new system. Again, much of this difference can be attributed to the timely availability of materials.
- Warehouse costs were found to decrease 50% on one project with the introduction of improved inventory management, representing a savings of \$ 92,000. Interest charges for inventory also declined, with one project reporting a cash flow savings of \$ 85,000 from improved materials management.

According to the study made in Palestine by (Haddad, 2006), implementing construction materials management system can reduce issues such as: Materials not available, Materials not available with required quantity, late delivery to the site, deliver wrong materials, slow response from the consultant engineer about submittals and destroyed materials when deliver.

## **2.5. ICT in Material Management**

Information Technology (IT) can be defined as the use of electronic machines for the processing, storage, transfer and presentation of information. Communication technology is today an important part of IT (Arnold, 2004). Together; they make up for the term ICT. ICT tools include Mobile devices range from Laptop computers, Notebooks, personal digital assistants (PDA), portable data terminals (PDT), tablet personal computers to smart phones. Today, these devices have increased in style, functionality, capacity, application areas, features, usability, etc. (Kasim, 2011).

The growth of ICT has been very rapid in other areas of business (such as publications, advertisement and manufacturing) to expand their business operations globally (Kasim, 2008). In the construction industry, the development of ICT has improved through emerging technologies that can support any type of construction activities. Griffith et al, (2000) stated that, there are great opportunities if construction organizations can spend their money on technology

advancement in information and telecommunication. There are could also expand in ICT usage by powerful computer and better connectivity provided into construction industry (Sun and Howard, 2004).

It is gathered that current manual material management practices and control procedures are unsatisfactory as they are labor intensive, inaccurate and error prone. The implication leads to waste and surplus of materials, delays, decrease in productivity and lack of up-to-date and real-time information (Navon and Berkovich, 2004). Due to the fact that the problems in materials management will be never ending, it is plausible that ICT implementation may be the answer to overcome the challenge of materials management in the construction industry. The dilemmas faced in materials management can be overcome by adapting ICT-enabled solution that can help support the effective management of materials activities (Kasim, 2011).

Many items of different nature, overlapped design and construction, and increased rate and degree of changes characterize major projects. These features have exposed and attenuated shortcomings of the traditional clerically oriented price focused approach to managing project materials. Studies have showed main symptoms and cause illustrated the attended need for significant improvements and systematic approach. For instance, non-availability of items when needed on site identified as the major and most common and frequent cause of delays in projects and an integrated computer-based material management system is concluded to produce 10-12% saving in labor cost (Naief, 2002).

### **2.5.1. Current Technologies**

Implementation of ICT in materials management could facilitate the effective and efficient control of materials on site. Common use of communication technology in materials management is cost-estimating process by using database management software such as Microsoft Excel and Lotus 1-2-3 (Sun and Howard, 2004). Internet is widely used for electronic mail (e-mail) and electronic commerce including electronic invoicing, payments and receipt of materials process (Harris and MacCaffer, 2001). Accordingly, there is a need to make use of more computer-based systems to improve material management in construction sites (Faniran,

1998). For example, applications developed for this purpose by many researchers include the following:

- Expert System Advisor for Concrete Placing (ESCAP) - to assist in planning and controlling concrete-placing operations without much experienced personnel in charge (Alkass, S.*et al.*, 1993);
- Pen-Based Computer - to automate construction field-data collection (McCulloch, B.G. and Gunn, P., 1993);
- Construction Materials Planning System (CMPS)- for planning of construction materials to achieved the right materials in quantities, time and meet the work programs (Wong, E.T.T and Norman, G., 1997);
- Construction Materials Exchange (COME) – E-Commerce system for material procurement (Kong, S.C.W. and Li, H., 2001);
- Internet-based Electronic Product Catalogue (IEPC) - provide product information such as product category and other information related to the product by browsing or searching online (Kong, S.c.W.,Li, H. and L.Y., 2001);
- Virtual Construction Material Router (VCMR) - provides the decision support system for materials movement for assisting site managers and planner in complex construction site (Mahdjoubi,L. and Yang, J.L., 2001);
- Material Handling Equipment Selection Advisor (MHESA) - for material handling equipment selection (Chan, 2002);
- Bar-code system - for material storage application etc (Chen *et. al.*, 2002);
- Geographical Information System (GIS) and E-Commerce - for construction materials trading (Li et al, 2003);
- RFID-facilitated construction material management- for managing materials in the construction industry (Ren, Anumba and Tah,2010);
- Mobile application (Smart phones- Apple OS)-A model for logistics management in the construction industry (Abdulmohsen and Janaka,2011);

Many computer software and Information Technology in Construction (ITC) tools have been developed recently and are widely used in construction to help the process of the activities. The

use of ICT has increased as new software relating to the construction industry that supports the effective management of construction activities have been developed. Various opportunities for construction organizations to invest in advanced information technology and telecommunications systems are noted (Griffith *et.al*, 2000).

## 2.6. The Material Management Issues of Different Countries

According to study made on three separate case studies, located in Ireland, England and the United States of America, the following material management factors were highlighted with order of occurrence: -

1. Lack of adequate storage space
2. Workplace becoming over-crowded
3. Lack of adequate room for the effective handling of materials
4. Difficult to transport materials around site
5. Lack of available space on-site to facilitate the effective storage and removal of material waste from site
6. The increased difficulty in getting large material deliveries onto site
7. Damage occurring due to confined space in which materials are to be handled
8. The storage space for materials on-site is not sufficient, resulting in poor quality materials
9. Increased security risks due to the lack of adequate space to safely facilitate the storage of materials
10. Lack of adequate room to account for materials. Materials becoming —buried on-site (John *et al.*, 2011).

The construction industry of UK is also faced with the same material management problems. Few main materials management problems were being identified in the construction industry in the UK are summarized below (Kasim *et al.*, 2005):

- Lack of site storage space
- Problems with tower crane distribution
- Problems on logistic of materials

- Small loading area
- Problem with one site access point
- Difficulty in delivery of materials on site during aircraft operation
- Operation limitation due to security considerations
- Inadequate loading area at consolidation center
- Problems with congestion time at loading area

A survey in the construction productivity in Iran reveals the major causes of the lack in productivity boils down to the improper deposited material, improper material handling, improper material application and improper material deliveries (Zakeri *et al.*, 1996).

Other researchers also found that scheduling delays occurred in 70%, 40% and 50% of government contracted construction projects in the United Kingdom, India, and United Arab Emirates (UAE) respectively due to improper material management (G.Kanimozhi, 2014).

According to Machete (1997), a study made in South Africa, showed the lack of awareness of material management on site which lead to misuse of materials, excessive use of material, ordering incorrect materials and issue on the scheduling of delivery of materials.

Currently all over the globe the main reason in cost variance and problematic management of material are:

- due to overstocked materials because of improper planning,
- damaged materials due to logistics, handling or in application,
- loss of materials because of improper supervision,
- waiting of the materials to arrive in location due to improper tracking systems,
- frequent moving of materials due to improper site layout,
- inflation, material changes in buying/purchasing situation starting from the prepared cost estimation,
- the shortages and changes of construction materials quantity required,
- materials inefficiency on site,
- stealing and loss of construction materials,
- material shipment,

- work repairing,
- delay in updating/posting storage system on site,
- inaccurate measurement of work location on construction projects,
- material off-take, inaccurate estimation of shipment quantity of materials,
- uneconomic order quantity of materials,
- poor shipping time,
- inadequate tools/equipment needed on site,
- increasing transportation cost of materials,
- material over usage in location of project,
- choosing the wrong materials for construction,
- the increasing storage cost of materials,
- the poor buying ability of managers,
- delay of payment for materials, and
- the poor policy in purchasing the materials (Alin Veronika *et al.* 2006; Kasim *et al.*, 2013).

Other literatures, have concentrated in improving material management using ICT tools showing the advancement of material management. The current scholarly papers concentrate more in managing materials by using ICT tools such as Radio Frequency Identification, bar-coding system, mobile application etc. The researcher also found the major challenge currently arising on the construction industry is the increase in urban development which is faced with the challenge of constructing buildings in a confined area. The constructing of buildings in a confined area is faced with lack of area for storage space (Spilliane, 2010).

According to the preliminary study made by the researcher the construction of building sites in a confined area is being a norm in Addis Ababa due to the re-development of the major areas in inner cities. Hence the contractors of Addis Ababa need to acknowledge the material management system in normal areas so as to be able to manage materials in the near future in confined construction area.

Fig.2.5. shows the placing of fine and coarse aggregates aside roads exposed to moisture which has an impact on the water to cement ratio due to the absorption of water by the aggregates. It can also be said that the fine aggregates might have silt content. Fig.2.6 shows the placement of sand on the side of the road leading to the congestion of the road. Fig.2.7 shows the placement of coarse aggregate on a side of roads because of unavailability of storage space inside the site.



Fig.2.5 Fine and Coarse Aggregates stored aside roads



Fig.2.6 Fine Aggregates stored on side of roads



Fig.2.7 Coarse Aggregates stored on side of roads

## 2.7. Summary of Literature Review

The literature consists of seven sections which were in depth reviewed to have a basic understanding of the research objective.

Based on this, the first part of the literature review introduced general ideas about material management system, material classification and some definitions of material management. The second part of the literature compared the traditional and integrated approach of the organizational structure of material management. The organizational structure shows the different information flow and hierarchy between the two organizational structures. In the traditional approach the tasks of material management (traffic manager, purchasing manager and production manager) are in different departments while in the integrated approach, the tasks are under one department i.e. material manager. The literature reviews then identified the tasks in material management. The tasks identified from different scholarly papers were material requirement planning, procurement, inventory (stock) control, handling, quality control of materials and surplus materials, which then will be compared to the current practice of material management in Addis Ababa. The above tasks mentioned are interrelated and decisions made at one stage affecting the other. The researcher has sought the effective management of the task in materials management can lead to better productivity, avoid delays and decrease the overall project cost.

The third part of the literature review gives the general concept about material management on building construction site and reviews in depth the problems encountered in material management, the strategies that could be adapted to effectively manage the materials in a building construction site and the congestion of construction sites. The fourth part of the literature continues on identifying the benefits of material management on a building site. Recognizing the problems faced in material management in building sites the researcher tries to show ICT tools for material management. The researcher has seen that the traditional way is error prone, labor intensive and not efficient and the researcher also has seen that ICT is not a new concept and has been used in different material management practices in different parts of the world but the question lies in knowing the factors that hinder in using the ICT tools that can facilitate material management of the building contractors in Addis Ababa.

The last section of the literature reviews the practices and problems of some countries. The researcher has identified that many of the developed countries are faced with managing materials of complex buildings in a confined area, which the construction industry of Addis Ababa is currently facing. Due to the high development rate of Addis Ababa, it is easy to predict that after a while construction projects are going to take place in a confined site, which makes it vital for implementing the best practice of material management in a normal site currently.

## CHAPTER THREE

### 3. RESEARCH METHODOLOGY

#### 3.1. Introduction

This chapter describes the research methodology adopted throughout the research project. It justifies the selection of the research methodology. It starts with an introduction to research, research approaches, and source and data collection approach, selection of sample and then finally, it explains the methods of analysis used for this research.

#### 3.2. Research Approach

The overall study approach is summarized in Figure 3.1 below. It explains how the entire study is planned and implemented to achieve the research objectives in the research processes.

The first phase of the research, research proposal, included identifying and defining the problems, establishing the objectives of the study and developing the research plan. The second phase included a summary of a comprehensive literature review. The third phase included the selection of sites and undergoing interviews to get in-depth understanding of the research objective. Upon obtaining the desired data from interviews, transcribing and organizing of data has been done. This was followed by reporting the findings and thorough discussion of the findings in order to draw a conclusion and to forward recommendations based on the finding of the study.

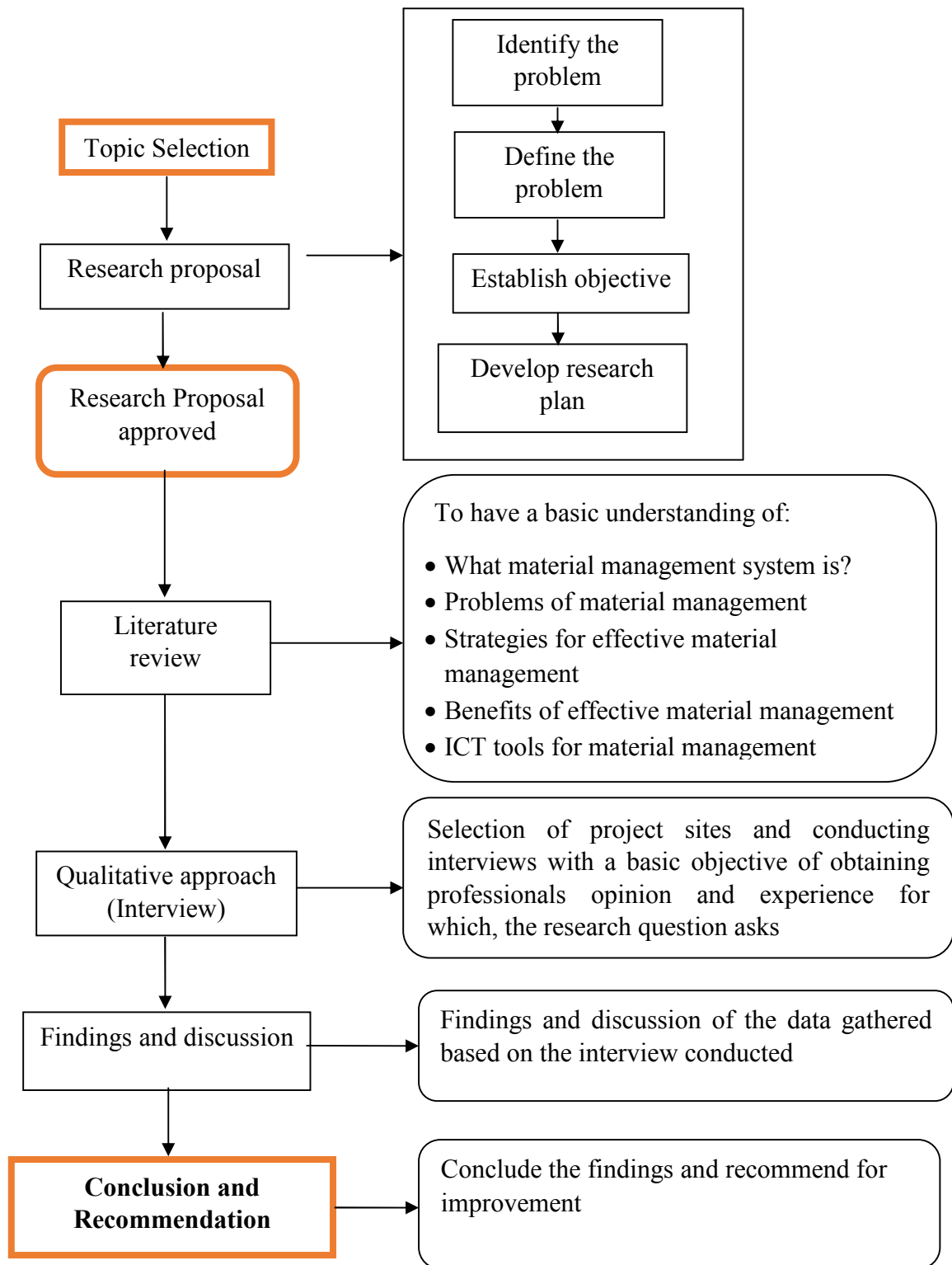


Fig. 3.1: The methodology flowchart

### 3.3. Sources of Data and Data Collection Approach

The Data collection approach is concerned with the types of evidence to be collected and the sources of such evidence, as well as the process of interpretation used to obtain satisfactory answers being posed (Easterby-Smith, 2002).

Amaratunga (2002) stated that, qualitative data, with its emphasis on peoples lived experience, are fundamentally well suited for locating the meanings people place on the events, processes and structure of their lives: their perceptions, assumptions, prejudgments, and presuppositions.

The objective of a qualitative research is to study issues in-depth and seeks to gain insight and understand people's perception. The position of the research favors more towards qualitative approach. Qualitative approach uses different techniques or research design, of which, phenomenological research is one of them. The researcher used this approach for this research. Phenomenological research is the study of phenomena: their nature and meanings i.e., the descriptive study of how individuals experience a phenomenon. The underlying principle of the phenomenological approach is to elucidate and identify the specific phenomena through how they are perceived by the samples in a situation. This approach is used to gain an insight into people's experience, perception and understanding of materials management in detail. The nature of this study intends to explore the explanation of the perceptions of the construction industry in the materials management processes and the implementation of ICT into their practices of managing materials on site.

Interview method is adopted for this research in order to get individuals perception and lived experience on material management and the use of ICT tools. In- depth interview with key informants were used as techniques for gathering data for the study. This data collection method was preferred as it yielded the maximum information required pertaining to material management in construction sites. All interviews were carried out by the principal investigator, and a semi structured interview guide was prepared prior to data collection to aid the interview process. Upon getting the consent of individuals; the interviews were also recorded.

The semi-structured interviews contained six parts. Part 1 aimed to capture general information about the project and the respondent such as the total project cost, number of storey of the

building, respondents' designation, and work experience. Part 2 aimed at getting general information of the material management practice. Part 3 aimed in exploring the material management practice through the tasks of material management. Part 4 aimed at exploring the problems of material management on the building site. Part 5 aimed to look at the benefits of effective material management. Part 6 aimed to identify ICT tools used for materials management. Key findings from the interviews were essentially used to make a judgment of the material management practices and problems, and improve aspects of materials management practices through strategies.

Observation has been made during site visit to identify the material management issue like lack of storage area, congestion of the site and working space.

### **3.4. Selection of Samples**

The research used a mixed sampling technique, which are stratified and purposive sampling. Stratified sampling was used to divide Addis Ababa into different categories by using strata, which are the sub-cities, and each sub-city is treated independently as a separate group. All the ten sub-cities of Addis Ababa were considered. Purposive sampling was used to choose a project from each sub-city, where one private building construction site was selected from each sub-city. Adding to this, only mid and high-rise buildings were considered, due to the complexity of managing materials compared to low-rise buildings. Mid-rise buildings are buildings having four to seven stories while high-rise buildings are defined as having eight or more stories (MAT).

The variation in the study participants would ensure construct validity and reliability of the study's results and will account for variation in different scenarios, since more than one case would be analyzed.

### **3.5. Method of Data Analysis**

The data analysis was concerned with gathering information and analyzing data on the current practices of materials management, problems of material management in building sites, the strategies used for addressing material management problems, the current ICT tools used for material management and factors that hinder the use of ICT tools.

The result of the study was presented in the following thematic areas:

- Materials management practice: This explores the practice of material management of different contractors based on the tasks involved in material management reviewed from different literatures;
- Materials management problems: This explores the most significant problems that occur in materials management;
- Strategies for effective material management: This explores some of the strategies that can be used to effectively manage construction sites;
- Congestion of construction site: This aims to understand the reason for the congestion of sites and improper placement of materials; and
- ICT implementation: This aims to explore the ICT tools used for managing materials on construction site and aims to understand the obstacles in implementing emerging technologies in material management.

The above thematic areas will be statistical analyzed using frequency and percentage. The problems of material management will be ranked according to the frequency and percentage. The congestion of sites will be discussed.

## CHAPTER FOUR

### 4. Findings and Discussions

#### 4.1. Introduction

In this part of the research the result of the data gathered from both interview and site observation were presented and discussed in detail. The interviews were conduct so as to explore the current material management practice, to understand and explore the problems faced in managing material, to examine the benefits of material management and to explore the usage of ICT tools in managing materials. In addition to the interviews, a site observation was conducted to explore the placement of materials within the site and to see the available space for material storage.

#### 4.2. General Background and Information

This section presents the general information about the project and the respondent from one project site from each of the sub-city in Addis Ababa. It includes the number of storey of the building, the total project cost, respondents' designation, and respondents' work experience.

##### 4.2.1. The Number of Storey of the Building

Table 4.1 shows that 60% of the project sites under study were mid- rise buildings with a storey ranging from G+4 up to G+7, 40% of the projects were high-rise buildings with storey of G+8 and more.

Number of Storey of building		Mid-rise Building (G+4 Up to G+7)	High-rise building (G+8 and more)
	Frequency		6
Percentage		60%	40%

**Table 4.1:** Number of Storey of Building

#### 4.2.2. Cost of the Project Site

Table 4.2 shows that 50% of the projects under study had a total project cost with less than 200 million Birr, 20% of the projects were with value in between 200-300 million birr, and 30% of the projects were more than 300 million birr.

Cost of the project sites	Frequency	Percentage
Less than 200 million Birr	5	50%
200-300 million Birr	2	20%
More than 300 million Birr	3	30%

**Table 4.2:** Cost of the project sites

#### 4.2.3. Designation of Respondents' and Experience in the Construction Industry

Out of the ten interviews conducted, 20% of the interviews conducted were with project managers with experience of 10-20years, 40% with project managers of 20-35 years, 20% with the site engineers with experience less than 10 years and 20% with site engineers with experience of 10-20 years. The details of the respondents are summarized in Table 4.3.

Respondents designations		Experience in construction projects		
		Less than 10 years	10-20 years	20-35 years
Project Managers	Frequency	0	2	4
	Percentage	0%	20%	40%
Site Engineers	Frequency	2	2	0
	Percentage	20%	20%	0%

**Table 4.3:** Respondents designation and experience in construction

### 4.3. Current Practice of Material Management

The main objective of this section is to understand material management practice. The first section tries to understand the structure of the organization mainly; the material management department. The second section consists of the tasks of material management. The respondents

were presented with a group of questions for each of the tasks to achieve the first objective of the research.

#### 4.3.1. Organizational Structure of Material Management

This first step in this research was to check whether the existence of the material management department and to know the person responsible for managing materials at the construction site.

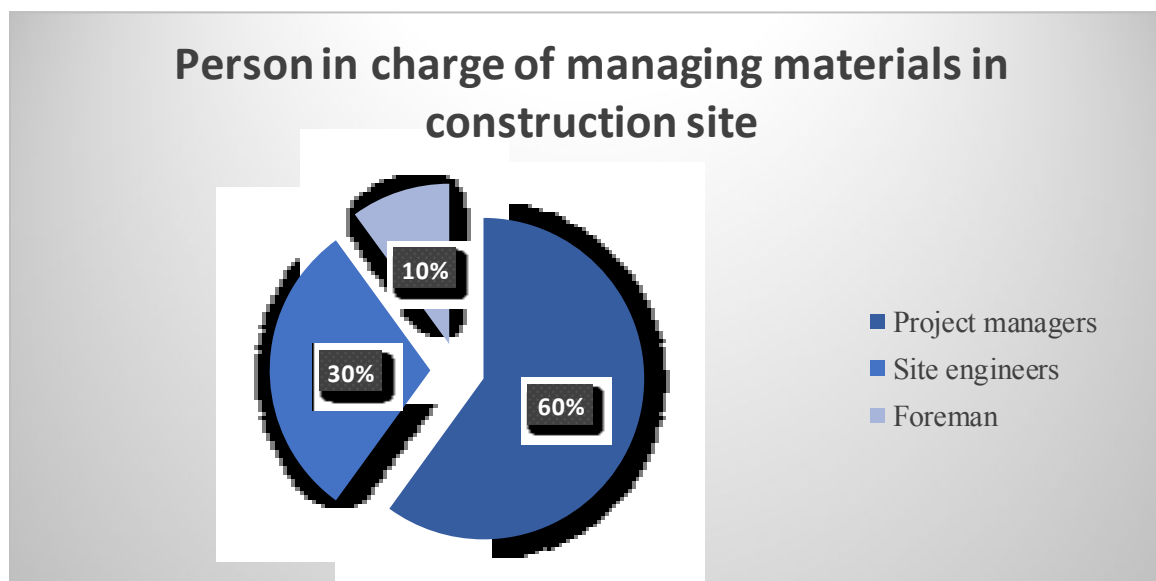
As it is indicated in Table 4.4 below 70% of the sites under study described the non-existence of material management department with all the functions integrated into one department. 30% (projects A, B & C) acknowledged the existence of a material management department. However, it was not responsible for managing material management tasks. Project C explained that the responsibility of the material management department was to prepare tender documents for selling of surplus materials. Projects A and B also highlighted that the purpose of the department was for estimation (preparing takeoff) and quality approval of materials, respectively.

Previous researchers have explained that having the tasks of material management in different department makes it difficult to control and identify materials (Ammer, 1991), while integrating the tasks into one material management department makes the coordination and control of materials manageable (Sadiwala, 2006).

No.	Material Management Practice	Management										Freq.	Per.
		A	B	C	D	E	F	G	H	I	J		
1	Yes	x	x	x								3	30%
	No				x	X	x	x	x	x	x	7	70%

**Table 4.4:** The existence of a material management department in the project sites

Figure 4.1 shows that 60% of the projects, material management was done by the project managers, 10%stated that the foreman was in charge managing materials, 30% of managing materials in a construction site was done by site engineer. Studies show that the involvement of the project managers in the estimating phase could lead to the preparation of a more realistic estimate due to project manager’s knowledge and experience in materials and equipment’s needed (Perdomo, 2004).



**Fig.4.1:** Person in charge of managing materials

#### 4.3.2. Tasks of Material Management

The main objective of this section was to study the current practice of material management in terms of the tasks involved in managing materials. This section contains six phases (tasks) of material management which are: material requirement planning, procurement, handling, inventory (stock) control, surplus material and quality control.

As illustrated in the literature review that the main objective of the material management is to have the right materials in the right quantities at the right place at the right moment at minimal cost. Thus, the main attributes of the material management are: quality, quantity (inventory), location, time and cost. Each task of material management has direct or indirect relation to these attributes.

The tasks of the material management used in this study are derived from similar scholarly papers developed by other researchers. Hence the findings of each of the tasks were compared to that developed by other researchers.

#### 4.3.2.1. Material Requirement Planning

This section contains four items that form the material requirement planning. The interviewees were asked about the application of this task in managing their materials. Table 4.5 presents the findings.

Item No.	1. Material requirement planning	A	B	C	D	E	F	G	H	I	J	Freq.	Per.
1.1	Identifying the needed materials for each item once you receive the projects' drawings and specification	x	x		x	X	x	x	x	X	x	9	90%
1.2	Planning for materials in terms of delivery date, storage area and equipment needed	x	x		x		x			X	x	6	60%
1.3	Involving the project manager or construction team in the estimation process	x		x	x	X			x		x	6	60%
1.4	Considering the master schedule when planning for materials	x	x		x					X		4	40%

**Table 4.5:** Material requirement planning

As shown in Table 4.5, the response on item 1.1 show that 90% (9) of the project sites under study, identify the materials required after receiving the project drawings and specifications. While 10% (1) project site was dependent on the quantity found on the bill of quantity. Perdomo (2004) stated that, material requirement planning should start immediately after receiving drawing and BOQ.

The frequency and percentage for item 1.2 shows 60% (6) of the projects considered storage area, delivery date and equipment needed, due to unavailability of space, while storage area was not a major factor in projects 40% (4). Instead they were more concerned on materials being delivered to the site then find storage space for the delivered materials. Wong and Norman (1997) mention that the planning for material should comprise computing the cost and quantity of materials, procuring of materials taking into consideration delivery date, storage area, and

equipment needed so as to avoid late delivery of materials, re-handling of materials and time spent in identifying the equipment to be used to handle materials upon delivery of materials.

The percentage and frequency for item 1.3 shows 60% (6) of the projects involve the project managers, while 40% (4) of the projects the estimation was prepared by the site engineers or the foreman. Perdomo (2004) states that, the project estimate should not be prepared only by the company owner or manager but the project manager and the field personnel should be involved in preparing the estimate; this will lead to preparation of more realistic and good estimate due to their knowledge and experience in the construction works.

The percentage and frequency for item 1.4 shows 40% (4) of the projects considered the master schedule when preparing the materials required. The rest 60% (6) project sites are dependent on the available storage space than the master schedule. Wong and Norman (1997) highlight the control of the flow of materials according to the master schedule of the project, to ensure the right materials are available at the time they are required. The project team and procurement section or the person in charge of procurement should cooperate to generate a preliminary material requisition schedule in which the material types, quantity needed, dates when the material should be delivered and any other information be specified. This schedule will be considered the baseline by which the actual progress will be measured accordingly (Perdomo, 2004). Mawdesly *et al.* (1997) further outlines typical material plans are developed based on a number of other project plans such as detailed project design, Bill of Quantities (BOQ), procurement plans, and resource plans; and then integrated into the project schedule.

#### **4.3.2.2. Procurement of Materials**

This section contains two items that form the task of procurement in material management. The interviewees were asked about the application of procurement in terms of selection of their supplier and the method of purchase order. Table 4.6 presents the findings.

Item No.	2. Procurement	A	B	C	D	E	F	G	H	I	J	Freq.	Per.	
2.1	Select your suppliers based on	Quality	x			x	x			x		X	5	50%
		Capability	x			x	x			x		X	5	50%
		Credit		x	x			x	x		X		5	50%
2.2	Conduct the purchase order	Phone	x	x	x		x	x	x		X		7	70%
		Written				x				x		X	3	30%

**Table 4.6:** Procurement of materials

As shown in Table 4.6, the percentage and frequency for item 2.1 indicates that 50% (5) of the projects select their suppliers based on the quality of material they provide and on their capability such as: delivering materials as per schedule and within the specified quantity. While the other 50% (5) select their suppliers which can deliver materials with credit for a longer period of time and choose those suppliers which will not disturb their cash flow. Previous researches indicate that, suppliers be selected based on their capabilities, geographical location, prior experience so as to provide materials at the right time and in the proper quality and quantity requirements (Stukhart and Bell, 1987).

The percentage and frequency for item 2.2 shows that 70% (7) of the projects give purchase order from site to head office by phone, 30% (3) had a written format for ordering materials to the head office. Purchase order should leave no doubt as to what is wanted. Instructions should be a written order. Phone orders are subject to misunderstanding; phone orders should be confirmed by fax or e-mail (ACI, 2008, P.14).

#### 4.3.2.3. Material Handling

This section contains one item that forms the task of handling in material management. The interviewees were asked about the planning of material handling in terms of planning for the equipment needed for handling materials and the availability of storage space before delivery of materials. Figure 4.2 shows the findings.

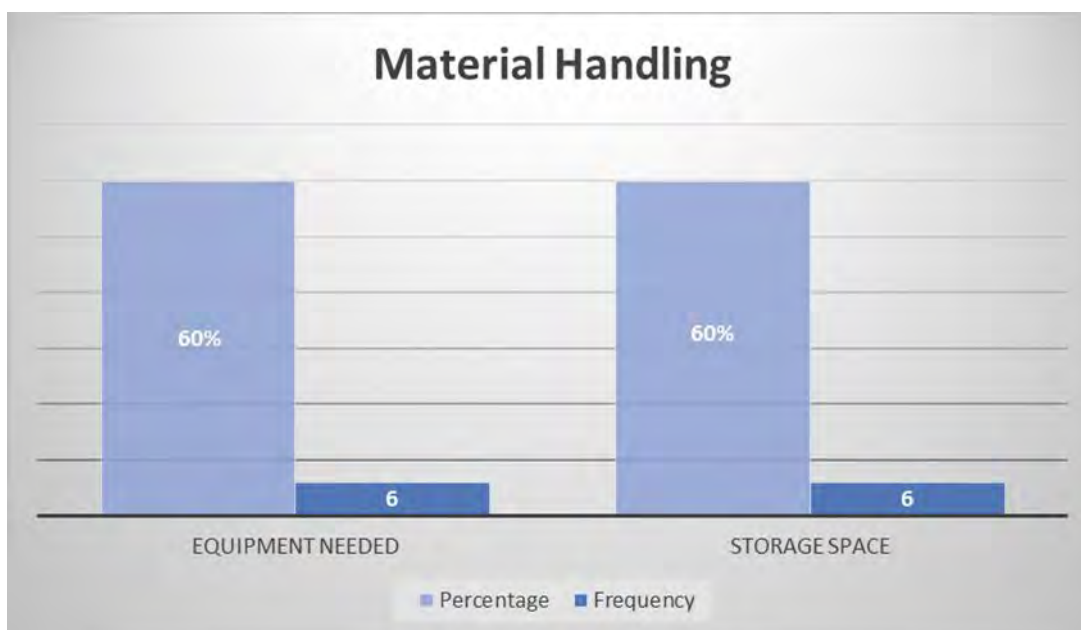


Fig. 4.2: Material handling in terms of equipment needed and storage space

As shown in Fig. 4.2. 60% (6) of the project site planned for material handling in terms of equipment needed and storage space before receiving of materials. The storage space should be provided before delivery of materials and the materials at hand should be used up or moved to another space. While 40% (4) don't consider equipment needed and storage space, but instead, they were more concerned about the delivery of materials. Previous studies state that material handling requires critical thinking, when scheming the material handling equipment's, since the selection process can enhance production process, provide effective utilization of manpower, increase production and improve system flexibility (Chan, 2002; Kasim *et al.*, 2005). The timely delivery of materials is also important since materials need to be moved to their destination speedily and efficiently (Sadiwala, 2006).

#### 4.3.2.4. Inventory (stock) Control

This section contains three items that form the task of inventory control in material management. The interviewees were asked about inventory control of in terms of storage and site space, verifying the material received against the quantity order and keeping a track record of the supplied materials, remaining balance and the installed materials. Table 4.7 shows the findings.

Item No.	4. Inventory control	A	B	C	D	E	F	G	H	I	J	Freq.	Per.
4.1	Managing inventory in terms of storage and site space		x		x		x	x	x		X	6	60%
4.2	Verify the material received against the quantity order and with the specification required	x	x	x	x	x	x	x	x	x	X	10	100%
4.3	Keeping a track record of the supplied materials, remaining balance and the installed materials		x		x		x		x		X	5	50%

**Table 4.7:** Inventory control of materials

As shown in Table 4.7, the percentage and frequency for item 4.1 shows 60% (6) of the projects considered storage space in terms of inventory control. This projects run out of stock due the limited space for storing materials, while 40% (4) of the projects are not limited by available space on site, so inventory control was not an issue in terms of storage space. However re-handling of materials is an issue since they considered the storage area upon delivery of materials. Studies show that stock control should assure the proper storage and a protected area during delivery of materials. They also showed that there is a problem in controlling stock on project sites with a small storage area as well as large storage area. However, the size of the storage area doesn't matter if planning is done taking into consideration the storage area before initial buy. Then problems such as running out of stock can be avoided (Kasim *et al.*, 2005).

The percentage and frequency for item 4.2 shows 100% (10) of the projects, the quantity of the materials received is checked by the storekeeper while the quality is checked by the resident engineer from the consultants and the site engineer/office engineer/project manager from the contractor. A study indicated that the quality received should confirm with the approved materials. The construction team should make a comparison between the ordered quantities and the received quantities. If there is a deviation, the construction team or the one who responsible for receipting the materials should inform the procurement section or the person in charge of procurement to follow up with the suppliers (Perdomo, 2004).

The percentage and frequency for item 4.3 shows 50% (5) of the projects have a system for recording the supplied materials, the remaining balance and installed materials either be it in Excel sheet or on rough paper. Chandler (2008) suggests that records should be kept of all transactions – receipts, waste, and transfers to other sites. Higgins (2006) further explained that careful stock control assures the user that materials and supplies are not being wasted or stolen and can reduce costs of such goods and their storage. He further explained that the inventory of materials should be controlled from the times they are supplied until incorporated by the contractors.

#### 4.3.2.5. Quality Control

This section contains five items that form the task of quality control in material management. The interviewees were asked about the implementation of quality control. Table 4.8 shows the findings.

Item No.	5. Quality control	A	B	C	D	E	F	G	H	I	J	Freq.	Per.
5.1	Delivery of aggregates from different quarry sites	x	x	X	x	x	x		x	X	x	9	90%
5.2	Quality checking of aggregates for each delivery				x							1	10%
5.3	Covered storage space for cement	x	x	X	x	x	x	x	x	X	x	10	100%
5.4	Cement stacked on timber raised platform		x		x		x				x	4	40%
5.5	Storing reinforcement bars for a long period of time	x		X	x	x		x	x	X		7	70%

**Table 4.8:** Quality control

As shown in Table 4.8 the percentage and frequency for item 5.1 shows that 90% (9) of the project sites receive aggregates from different quarry sites. One of the projects (project G) has a particular quarry site which supply aggregates. Item 5.2 indicates that 10% (1) that is project D does quality checking of aggregates for each delivery but it is done for the sake of procedure. All the projects have a different approach of quality checking for aggregates. Project A and I perform quality checking based on the agreement of the contract but not for each delivery. Project B carry out the quality checking by simple on site tests. Project C tests the aggregates

from each quarry site but, not upon delivery. Project D stated the quality checking is done for the sake of procedure but not for each delivery. Projects E and F stated that the aggregates being delivered from different sites, but the quality checking is not done for each delivery. Project G having one particular quarry site for aggregates delivery, the quality checking is done for that particular quarry site. Project H performs the quality checking if the delivered materials do not comply with the quality-checked materials. Project J stated that, quality checking might not be done for each delivery.

Construction materials from various sources must be checked for quality. These include construction materials such as back fill materials, sand, red ash, and stone, which are found naturally, and others such as reinforcement bar etc., which are factory products. Therefore, before any purchase or supply is made to construction sites, their quality must be checked by an appropriate procedure. Thus, a body responsible for the purchase or supply has to inform the appropriate personnel for the checking before any purchase or delivery agreement of the material is conducted (EBCS-2, 1995).

The percentage and frequency for item 5.3 shows 100% (10) of the projects, having a covered shade for cement. Item 5.4 shows that 40% (4) of the projects stack their cement on timber raised platform. Patel (2011) stated that materials like cement should must be stored in covered sheds and stacked on timber raised platforms.

The percentage and frequency for item 5.5 shows that 70% (7) of the projects, the reinforcement bars were stored for a long period of time being exposed to moisture and were prone to rust. While 30% (3) of the projects stated that, due to the unavailability of space for storing of reinforcement bars, the reinforcement bars are delivered to the site when they are required and are not stored for a long period of time being exposed to moisture. Patel (2011) indicated that the storage of reinforcement bars should be in such a way that they are not exposed to moisture to prevent rusting.

#### 4.3.2.6. Surplus Material Control

This section contains three items that form the task of surplus control in material management. The interviewees were asked on how they manage surplus materials at the end of a project. Table 4.9 shows the findings.

Item No.	6. Surplus control	A	B	C	D	E	F	G	H	I	J	Freq.	Per.
6.1	Storing the surplus materials to be used in other projects	x	x	X	x	x	x	x	x	X	x	10	100%
6.2	Returning back the surplus materials to the suppliers											0	0%
6.3	Selling the surplus materials											0	0%

**Table 4.9:** Surplus control

Table 4.9 shows that 100% (10) of the surplus material can be used in other projects in particular: cement and reinforcement bars, returning back the surplus materials to the suppliers and selling the surplus materials was not practiced in the project under study. Some of the project sites stated that the problem with surplus materials is the poor and ill-timed record keeping of the materials used and the left over, while other project sites stated that surplus finishing materials are not used for other projects since they are unique for every project. They can be used as sample for other projects or considered as wastage.

Researchers have stated that in order to minimize surplus on a project, a proactive and timely system of communication among all functions involved in the materials acquisition and installation cycle is required. Some of the minimization options for disposal of surplus materials include using the surplus materials on other projects, returning them to the vendor, or selling them to a third party. All options require complete records and timely reporting to achieve optimum results. The best option is to do the necessary planning and to implement the necessary materials management system to reduce surplus at the source (Abuja and Dozzi, 1994).

#### 4.4. Problems of Materials Management in Construction Building Sites

The findings from the interviews conducted on the problems of material management in a construction building site are shown in Table 4.10. The researcher found that understanding the

existing problems is an absolute necessity for resolving them effectively. Many problems may be encountered by the contractors in managing materials during the phases of construction. This section aims to determine the most occurred problems of material management encountered by the contractors during the four phases of construction which are: the material identification phase, the procurement phase, the construction phase, the post construction phase.

#### 4.4.1. The Material Identification Phase

The interviewees were given three problems that may face contractors in the material identification phase and were asked which one occurs. Table 4.10 presents the findings.

Item No.	1. Material identification phase	Projects										Freq.	Per.	Rank
		A	B	C	D	E	F	G	H	I	J			
1.1	Not a good definition of what is wanted from the owner and suppliers				x	x						2	20%	3
1.2	Incomplete drawings and details are missing	x	x	x	x	x	x		x	x	x	9	90%	1
1.3	Difference between plans and specification	x		x	x	x	x					5	50%	2

**Table 4.10:** Problems encountered in material identification phase

Table 4.10 shows “incomplete drawings and details are missing” were ranked the first with percentage and frequency 90% (9). “Difference between plans and specification” were ranked second with percentage and frequency of 50% (5). The results indicate that tender documents are not well prepared by the consultants. Ambiguities in the tender documents and incomplete drawings and details may not enable contractors to prepare good estimate. Furthermore, differences between plans and specifications will lead to many problems and disputes between the involved parties during the construction phase which may consequently lead to disruption of project activities on site.

#### 4.4.2. The Procurement Phase

The interviewees were given three problems that may face contractors in the procurement phase and were asked which one occurs. Table 4.11 presents the findings

Item No.	2. Procurement phase	Projects										Freq.	Per.	Rank
		A	B	C	D	E	F	G	H	I	J			
2.1	Unavailability of required material and required quantity	x	x	x		x	x		x	x		7	70%	1
2.2	Poor communication between the parties involved			x	x		x					3	30%	2
2.3	What is wanted is not what is prepared				x	x						2	20%	3

**Table 4.11:** Problems encountered in procurement phase

Table 4.11 shows “Unavailability of required material and required quantity” was ranked the first with percentage and frequency 70% (7). Previous studies identified that the unavailability of the required quantity and quality of materials in the procurement phase as problems of material management in construction (Al-Shorafa, 2009; Patel, 2011). Unavailability of the materials when needed can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying the completion of the project.

#### 4.4.3. The Construction Phase

The interviewees were given seven problems that may face contractors in the procurement phase and were asked which one occurs. Table 4.12 presents the findings.

Item No.	3. Construction phase	Projects										Freq.	Per.	Rank
		A	B	C	D	E	F	G	H	I	J			
3.1	Late deliveries (Materials do not arrive as scheduled)	x	x	x	x	x	x	x	x	x	x	10	100%	1
3.2	The delivered materials do not comply with the required	x		x						x		4	40%	4
3.3	Re-handling of materials- Materials have to be moved	x	x	x	x	x	x	x	x	x		9	90%	2
3.4	Limited storage area		x		x		x	x	x		x	6	60%	3
3.5	Loss and damage of materials		x	x	x							3	30%	5
3.6	No assurance of quality from suppliers	x										1	10%	6
3.7	No proper schedule of materials	x	x					x	x	x	x	6	60%	3

**Table 4.12:** Problems encountered in construction phase

Table 4.12 shows “Late deliveries (Materials do not arrive as scheduled)” was ranked the first with percentage and frequency 100% (10). “Re-handling of materials- Materials have to be moved” was ranked second with percentage and frequency of 90% (9). Previous researchers also highlighted similar material management issues such as materials not being delivered as per schedule (Bertelsen and Nielsen ,1997; Patel, 2011; Al-Shorafa ,2009), extra handling of materials (Formoso *et al.*, 2002 ;Patel, 2011; Al-Shorafa,2009). Zakeri *et al.*, (1996) stated that among other factors, improper materials handling results in lack of productivity.

The third most occurring problem was “Limited storage area “and “No proper schedule of materials “with percentage and frequency 60% (6). Some scholarly papers indicated that having a limited storage area in a construction site was their main problem in material management (Kasim *et al.*, 2005; Enshassi, *et al.*, 2007). Horman and Thomas (2005) outlined the lack of storage area as having a negative result in productivity. Enshassi *et al.*, (2007) also outline the effect of unsuitable storage locations as a leading factor in labor productivity, thereby indicating that not only is the presence of adequate storage space is essential, but correctly locating storage is also a factor in the overall productivity within a project. Improper schedule of material delivery was also identified as problems of material management in construction (Al-Shorafa,

2009; Patel, 2011). Improper schedule of materials, early deliveries and large order quantities contribute to disorder at site, extra handling, breakage and loss of material, which is costly and causes unnecessary waste (Bertelsen and Nielsen, 1997). Furthermore, late deliveries cause delays in a project (Formoso *et al.*, 2002).

#### 4.4.4. The Construction Closeout Phase

The interviewees were given two problems that may face contractors in the construction closeout phase and were asked which one occurs. Table 4.13 presents the findings.

Item No.	4. Construction Closeout phase	Projects										Freq.	Per.	Rank
		A	B	C	D	E	F	G	H	I	J			
4.1	No storage for the surplus materials		x		x		x	x	x		x	6	60%	1
4.2	No possibility that the surplus materials to be returned to the supplier	x			x		x		x			4	40%	2

**Table 4.13:** Problems encountered in construction closeout phase

Table 4.13 shows “No possibility that the surplus materials to be returned to the supplier” was ranked the first with percentage and frequency 70% (7). “No storage for the surplus materials” was ranked second with percentage and frequency of 60% (6). Al-Shorafa (2009) stated similar problems of material management in the construction closeout phase.

Fig 4.3 shows a site having limited area and were faced with the problem of storing materials on main roads. Thomas and Riley (2006) outlines that mismanagement of material storage is a leading factor in spatial congestion and as a result, reduced levels of productivity on a construction project. Resulting from this, the lack of adequate storage space is directly linked to inadequate spatial management, particularly where space is a limited resource, as is the case in confined construction sites.



Fig.4.3: limited storage area on site

Fig 4.4 shows the congestion of site due to unavailability of space and the reinforcement bars being exposed to moisture. Horman and Thomas (2005) indicates that an overcrowded construction site leads to double handling of materials, again, reducing productivity and increasing damage to materials. Inadequate management of materials through over allocation also has been identified as impeding progress, workflow and overall productivity; due to overcrowding the limited work space available.



Fig.4.4: Congestion of site

Fig 4.5 shows the stacking of different sizes of reinforcement bars and the damaged reinforcement bars. Reinforcing bars should be stacked yards away from moisture to prevent rusting and also away from oil and lubricants. Bars of different classification, sizes and lengths should be stored separately to facilitate issues (Patel, 2011).



Fig 4.5: stacking of different sizes of reinforcement bars and the damaged reinforcement bars

Fig 4.6 shows the problem with site having one access route. Previous research done on UK also identified the problem of having one site access point since the delivery of materials with one access point may not be feasible and makes the handling of material difficult.



Fig. 4.6: Site having one access route

#### 4.5. Strategies for Effective Construction Material Management

The strategies that can be used for effective construction material management are shown in Table 4.15.

Strategies for effective material management	Projects										Freq.	Per.
	A	B	C	D	E	F	G	H	I	J		
The utilization of pre-fabrication and pre-assembly of materials	x		x	x	x	x	x	x	x		8	80%
Providing adequate storage of materials on-site	x	x		x		x		x			5	50%
The utilization of space scheduling		x		x		x	x	x	x	X	7	70%

The use of Just-In-Time delivery techniques				x				x		X	3	30%
The effective design site layout	x	x	x		x		x		x	X	7	70%
Implementation of a materials management program		x	x	x	x					X	5	50%
Implement a traffic management program		x		x		x	x				4	40%
The use of Ready mixed concrete	x		x	x	x	x	x	x	x		8	80%

**Table 4.14:** Strategies for effective construction material management

As shown in Table 4.14 80% (8) of the project sites agreed that the use of prefabrication and pre-assembly of materials before delivery of materials as one of the strategies for effective material management. Yeung *et al.* (2005) outlines the benefits of prefabrication and that of the space saving characteristics of prefabrication due to the reduced requirement to store and manage excessive amounts of material on-site. Once materials are successfully delivered to site, they must be accommodated within the bounds of the site or stored appropriately. Blismas *et al.*, (2006) further summarizes the benefits of pre-fabrication and pre-assembly through time, cost, quality, productivity, people and process groupings. Through pre-fabrication techniques, the time spent locating various materials on-site are removed, therefore making the process more productive.

The use of Ready-mixed concrete was agreed by 80%(8) of the project sites as being one of the strategies for effective material management. Ready mixed concrete greatly minimizes expenses as it cuts down on material consumption, labor and storage costs. In preparation of ready mixed concrete, the proportion of all ingredients used are accurately measured and maintained, which consequently diminishes a lot of waste. The manual labor involved in onsite concrete mixing is relatively significant and is not needed for ready mixed concrete.

70%(7) of the project sites agreed that the use of space scheduling in maximizing the usage of the available space. Elbeltagi, *et al.*, (2004) outlines that space scheduling optimizes the site layout paying particular attention to the interrelationship of the other facilities on-site. Resulting from this, on-site storage is critically accessed and located accordingly, to benefit the end user

on-site, thereby, reducing travel distances, improper/inadequate storage and incorrectly located storage facilities (Winch and North, 2006).

Also 70%(7) of the project sites agreed that the effectively designing site layout as strategies for effective material management. Elbeltagi, *et.al*, (2004) outlines the benefit of an effective site layout to contribute to the flow of materials, through providing adequate spatial considerations. Further Sadiwala (2006), explains that effective design site layout can facilitate the handling and issue of materials and for selecting proper place for storing proper types of materials.

#### **4.6. Congestion of Sites and Improper Placement of Materials**

To understand the reason for the congestion of sites and improper placement of materials, the effects of having a congested site and the solutions that could be applied to avoid the congestion of site, interviews were conducted to project managers and site engineers of ten different construction sites from each ten sub-cities of Addis Ababa.

The interviewees explained the reason for the congestion of sites and improper placement of materials as follows:

- Attitude of the society (The society has accepted things as they are and do not believe it to be a problem)
- No proper procedure before mobilization of site
- The urgency to meet the schedule
- Accepting re-work (repair)
- No system for improvement or change
- Lack of experience
- The workers(laborers) were not well trained
- The workers as well as the engineers at site do not understand the value of having a well-organized working site.
- Not certified workers
- Owners of the organization don't believe in change because change means resource allocation and resource allocation means cost.

From the answers of the interviews, five of the reasons for congestion of site will be discussed below:

- One of the reasons for congestion of site was the attitude of the society since the society accepted the congestion of the site to be normal. The laying of materials all over the site was not an issue. Thessaloniki (2006) states that improvement begins with the admission that every organization has problems, which provide opportunities for change.
- The second reason for congestion of site was having no proper procedure before mobilization of site. However, Kaizen philosophy place an emphasis on going beyond designing effective procedure or having a procedure; it requires the teams to understand why a procedure works, whether it can be modified or replicated and how it can improve.
- The third reason was the urgency to meet the schedule of the project. From the Kaizen philosophy, trying to get ahead of production (in case of construction industry trying to meet the project schedule) can result in: tremendous waste, consumption of raw materials before they are needed, wasteful input of manpower and utilities, additions of machinery, increased burdens in interest, additional space to store excess inventory, and added transportation and administrative costs.
- The fourth reason was accepting re-work, Kaizen philosophy states that defects require rework and a great waste of resources and effort. One of the ways to avoid waste is avoiding rework.
- The fifth reason was having no system for improvement or change. Kaizen philosophy states that management should set standards or have some kind of system which must be able to change when the environment changes. Companies can achieve dramatic improvement as reviewing the standards periodically, collecting and analyzing data on defects, and encouraging teams to conduct problem-solving activities. Once the standards are in place and are being followed then if there are deviations, the workers know that there is a problem. Then employees will review the standards and either corrects the deviation or advice management on changing and improving the standard. It is a never-ending process and is better explained and presented by the PDCA cycle (plan-do-check-act) (Kilian, 1992).

The second interview question was on the effect of having a congested site. The interviewees described the effect as follows:

- Delay
- Confusion at the site
- Accident /safety of workers
- Damage of materials/waste of materials
- Decrease in productivity
- Decrease in quality
- Double handling of materials
- Increase in project cost
- Uncomfortable spatial arrangement
- Poor aesthetical appearance

Thessaloniki (2006) states that the benefit of practicing the 5S approach of the Kaizen principle (Sort, Straighten, Scrub, Spread and standardization or Self-discipline) as follows: Creates cleanliness, sanitary, pleasant, and safe working environments; it greatly improves employee morale and motivation; it eliminates various kinds of waste by minimizing the need to search for tools, making the operators' jobs easier, reducing physically strenuous work, and freeing up space; it creates a sense of belonging and love for the place of work for the employees.

The third interview question was on the solution that could be used to avoid the congestion of site. The interviewees suggested the following solutions:

- Being procedural and understanding the need of being procedural (planning before mobilization)
- Building work ethics
- Accepting the congestion of site due to poor material management as a problem and make improvements.
- Training through
  - Regulatory body
  - Academic body
  - Professionals

- Policy enforcement
- Training the coming generation from elementary level to be organized
- Continuous improvement
- Specialization of works
- Creating awareness

#### 4.7. ICT Tools in Material Management

The ICT tools used and the factors that hinder in using the emerging ICT tools for material management are shown in Table 4.16.

ICT implementation	Projects										Freq.	Per.
	A	B	C	D	E	F	G	H	I	J		
1. ICT tools												
Microsoft Excel	x	x	x	x	x	x	x	x	x	x	10	100%
Telephone	x	x	x	x	x	x	x	x	x	x	10	100%
E-mail				x							1	10%
2. Factors that hinder the use of emerging technologies												
Lack of awareness	x	x			x	x	x	x	x	x	8	80%
Aware of the ICT tools			x	x							2	20%

**Table 4.15:** Implementing ICT tools and factors that hinder the use of emerging ICT tools

As shown in Table 4.15 100% (10) of the project sites utilized the basic ICT tools such as phones and Microsoft Excel in their material management process. 10% (1) used E-mail. In all the projects except projects A, D, and G, the order of materials was done through phone. Project A used smart phones to order materials while projects D and G used a material requisition form for ordering materials which is sent via E-mail or delivery by a clerk. Projects A, D and G used phone for communication. ACI (2008), suggest that orders be placed in written order since phone orders are subject to misunderstanding. Some scholars further outline the current manual material management practices and control procedures are unsatisfactory as they are labor intensive, inaccurate and error prone. The implication leads to waste and surplus of materials, delays, decrease in productivity and lack of up-to-date and real-time information (Navon and Berkovich, 2004). In all the projects, the use of the major ICT tools emphasized on preparing

takeoff, but not for other tasks of material management, even though the use of an integrated computer based material system can produce 10-12% saving in labor cost (Naief, 2002).

The projects under study didn't apply any current ICT tools mentioned in the literature. Faniran (1998) explains that the construction industry needs to make use of more computer based systems to improve material management.

As shown in Table 4.15 80% (8) of the interviewees were not aware of the ICT tools, which can be used to assist material management except projects C and D. The interviewee in project C was aware about the ICT tools and their importance in facilitating material management but was not able to find the software's. Project D was also aware of the ICT tools and believed that the major obstacle in implementation of ICT tool in the construction industry of Ethiopia is it being labor intensive and lacking in upgrading itself with the technology.

## CHAPTER FIVE

### 5. Conclusion and Recommendation

#### 5.1. Conclusion

The following conclusions could be drawn from the research work:

- The material management functions (planning, procurement, handling, inventory control, surplus materials and quality control) are under different department, making the control and identification of materials extremely difficult
- Negligence in coordinating the material requirement planning with the project delivery date and the equipment needed.
- The project sites spatial requirements exceed the available space and are challenged with running out of stock.
- Master schedule was done for formality and the material schedule does not go in accordance with the master schedule leading to delay of the project.
- The selection of suppliers was based on the ability of the supplier to provide materials with credit instead of the suppliers' capability, capacity and geographical location.
- The order of materials by phone was the cause for incorrect delivery of materials.
- The projects have poor inventory control system for managing their materials
- The major problems occurring in managing materials in project sites are as follows:
  - Late delivery being the most occurring problem in all the projects
  - Re-handling of materials and incomplete drawings and missing details were the second most occurring
  - Unavailability of required materials and within the required quantity was the fourth most occurring
  - No proper schedule of materials, limited storage area, and no storage for the surplus materials were fifth most occurring problem
- The strategies for effective material management are as follows:
  - Acquiring materials Pre-fabricated and pre-assembled
  - The use of ready- mixed concrete

- The effective utilization of space scheduling
- The effective design of site layout
- Sites having one access route were faced with the challenge of loading and unloading materials.
- Some of the project sites were overcrowded and disorganized due to negligence, procrastination, attitude, accepting re-work and carelessness.
- The projects utilized the basic ICT tools such as: Phone, Microsoft Excel, and E-mail. There was lack of awareness on the ICT tools that can be used to facilitate material management.
- Before making any drastic change either be it in ICT or any other, first the construction industry need to accept the congestion of site and improper placement of materials as a problem.

## 5.2. Recommendation

The following measures could be taken for effective material management:

- The material management functions (planning, procurement, handling, inventory control, surplus materials and quality control) can be integrated into one department (material management department), for ease of coordination and control of materials cost and flow
- The selection of suppliers must be based on their capability. Phone call order should be avoided and written forms such as material requisition form should be prepared for ordering materials
- Inventory control is a major issue since it affects the schedule of the project. The received materials, remaining balance and installed materials should be recorded properly by the concerned body by some kind of system.
- To avoid surplus materials, the estimation for the material needed should be done with care by professionals and double checking should be done before ordering
- A detailed construction planning of activities and a proper material schedule, that goes in accordance to the master schedule, with sufficient lead time should be done to avoid late delivery of materials

- The design of site layout should be done effectively so as to avoid material waste and extra handling/double handling of materials
- In case the drawings are incomplete and details are missing, which described in previous section (i.e. review of literature), the material schedule as well as the master schedule should not be static but revised constantly based on any change
- Just-in-time delivery of materials can be applied for sites with limited storage area
- It could be beneficial to acquire the components delivered to site pre-assembled. The use of pre-fabricated help in reducing inventory control, storage of reinforcement bars for a long period of time, and help in saving space allocated to material storage. Due to the reduced material storage requirements, more space is made available to other tasks which require additional spatial considerations.
- The contractors should update themselves on the ICT tools used for managing material because it can be one of tools that can help in facilitating the material management system.
- Further study can be made on adopting the Kaizen principle for the construction industry.
- Academic bodies from elementary level should teach and make it a culture to apply the five's': Sort, straighten, scrub, spread and standardize (self-discipline).

## References

- Abdulmohsen Almoshen and Janaka Ruwanpura. (2011). Logistics Management in the Construction Industry. *International Conference-Sophia Antipolis*. France.
- Ahuja,H.N., Dozzi, S.p., and AbouRizk, S.M. (1994). *Project management: Techniques in planning and controlling construction projects*. John Wiley and Sons.
- Akintoye, A. (1995). Just-In-Time Application and Implication for Building Material Management. *Journal of Construction Management and Economics*, 105-114.
- Ala-Risku, T., & Karkkainen, M. (2005). Material delivery problems in construction projects: A possible solution. *International Journal of Production Economics*, Vol.104(1), 19-29.
- Alistair, G. G. (1999). *Off-Site Fabrication: Prefabrication, Pre-assembly and Modularisation*. (3rd, Ed.) John Wiley and Sons.
- Alkass, S., Aronian, A. and Moselhi, O. (1993). Computer- aided Equipment Selection for Transporting and Placing Concrete. *Journal of Construction Engineering and Management*, Vol.119(Issue 3).
- Al-Shorafa, A. A. (2009). A Framework for Construction Materials Supply Chain Process in the Local Construction Industry. Unpublished Thesis: For Degree of Master in Construction Management.
- Amaratunga. D., B. D. (2002). *Quantitive and Qualitative Research in the Built Environment: Application of 'Mixed' Research Approach*.
- Ammer, D. S. (1999). *Materials Management and Purchasing* (3rd ed.). Homewood, Illinois: Richard D. Irwin, Publication.pp 154-162.
- ASTM, S. (1993). *Concrete and Mineral Aggregates (Part 10)*.
- Bailey, Peter and Farmer, David. (2009). *Materials Management Handbook* (2nd ed.). Aldershot,Hants, England: Gower Publishing Company Limited.
- Ballard, G. and Howell, G. . (1995). Towards Construction JIT. *Proceedings of the 1995 ARCOM Conference, Association of Researchers in Construction Management* . Sheffield, England.
- Ballot, R. B. (2006). *Materials Management: A Results Approach* (2nd ed.). USA: American Management Association Inc.
- Barnes, T. (1996). *Kaizen Strategies for Successful Leadership*.London: Pitman Publishing.
- Bell, L.C. and Stukhart, G,. (1987). Cost and Benefits of Materials Management Systems. *Journal of Construction Engineering and Management*, Vol. 113(No.2), pp 222-234.
- Bell, LC and Stukhart,G. (1986). Attributes of Materials Management Systems. *Journal of Construction Engineering and Management*, Vol. 122(Issue 1), 14-22.
- Bernold, Leonhard E. and Treseler, John F. (1991). Vendor Analysis for Best Buy in Construction. *Journal of Construction Engineering and Management*, Vol. 117.
- Bertelsen, S. and Nielsen, J. (1997). Just-In -Time Logistics in the Supply of Building Materials . *1st International Conference on Construction Industry Development: Building the Future Together*. Singapore.
- Biddy, P. (2009). Land use in Britain. *Land Use Policy*, Vol. 26(No. 1), 2-13.
- Blismas, N., Pasquire, C. and Gibb, A. (2006). Benefit Evaluation for off-sit production in Construction. *Construction Management and Economics*, 24(No. 2), 121-130.
- Blumberg. B.; Cooper. D.R.; Schindler.P.S. (2005). *Business Research Methods*. Berkshire: McGraw Hill Education.

- Bowles, J. and Hammond, J. (1991). *Beyond Quality How 50 Winning Companies Use Continuous Improvement*. New York: Putnam
- Bryman, A. (2004). *Social Research Methods* (2nd ed.). UK: Oxford University Press.
- Canter, M. (1993). *Resource Management for Construction an Integrated Approach*. London.
- Cavinato, J. L. (1984). *Purchasing and Materials Management*. Minnesota: West Publishing Company.
- Chan, F. (2002). Design of Material Handling Equipment Selection System: An Integration of Expert System with Analytic Hierarchy Process Approach. *Integrated Manufacturing Systems, Vol. 13*(Issue 1), pp.56-68.
- Chandler, I. E. (2001). *Materials Management on Projects* (1st ed.). Lancaster, England: The Construction Press Ltd.
- Chen, Z., Li, H. and Wong, C.T.C. (2002). An Application of Bar-code System for Reducing Construction Wastes. *Automation in Construction, Vol. 11*(Issue 5), pp. 521-533.
- Chitkara, K. (2004). *Construction Project Management, Planning, Scheduling and Controlling*. Tata McGraw Hill.
- Choo, H.J., & Tommelein, I.D. (1999). Space scheduling using flow analysis. *7th Annual Conference, International Group for Lean Construction* (pp. 299-311). Berkley: University of California.
- Chudley, R. and Greeno, R. (2006). *Advanced Construction Technology* (4th ed.). UK: Pearson Education.
- Cohen, B. (2004). Urban Growth in Developing Countries: A Review of Current Trends and a Caution Regarding Existing Forecasts. *World Dev., 31*(1), 23-51.
- Creswell, J. (1998). *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. Thousand Oaks, California: Sage Publications.
- Dobler, D. W. and Burt, D. N. (2009). *Purchasing and Supply Management: Text and Cases* (6th ed.). USA: The McGraw-Hill Companies Inc.
- Donyavi, S. and Flanagan, R. (2009). The impact of effective material management on construction site performance for small and medium sized construction enterprises. *Annual ARCOM Conference* (pp. 11-20). UK: Association of Researchers in Construction Management.
- E.T.T. Wong and G. Norman. (1997). Economic Evaluation of Materials Planning Systems for Construction. *Construction Management and Economics, Vol. 15*, 39-47.
- Easterby-Smith, M. T. (2002). *Management Research: An Introduction* (2nd ed.). London: Sage Publication.
- EBCS-2. (1995). *Ethiopian Building Codes and Standard, Structural use of Concrete*.
- Egan, J. (1998). *Rethinking Construction: the Report of the Construction Task Force*. London : The Stationery Office.
- Elbeltagi, E., Hegazy, T. and Eldosouky, A. (2004). Dynamic Layout of Construction Temporary Facilities Considering Safety. *Journal of Construction Engineering and Management, 130*(No.4), 534-541.
- Enshassi, A., Mohammed, S., and Abel -Hadi, M. (2007). Cost estimation Practice in the Gaza Strip : A Case Study. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 153-176.
- Faniran, O.O. and Caban, G. (1998). Minimizing Waste on Construction Project Sites. *Engineering, Construction and Architectural Management, 5*, 182-188.

- Fellow R. and Liu A. (1999). *Research Methods for Construction*. London: Blackwell Publishing.
- Formoso, C.T., Soibelman, L., De Cesare, C. and Isatto, E.L. (2002). Material Waste in Building Industry: Main Cause and Prevention. *Journal of Construction Engineering and Management*, 128(No. 4), 316-325.
- G.Kanimozhi. (2014). Material Management in Construction Industry. *Indian Journal of Applied Research*, 4(4).
- Gambhir, M. (2002). *Concrete Technology* (2nd ed.). McGraw-Hill.
- Gibb, A. (2001). Standardization and Pre-Assembly- Distinguishing Myth from Reality Using Case Study Research. *Construction Management and Economics*, 19(3), 307-315.
- Gopalakrishnan, P. and Sundaresan, M. (1977). *Material Management: An Integrated Approach*. New Delhi: Prentice-Hall.
- Gossom, W. (1999). *Control of Projects, Purchasing, and Materials*, (4th ed.). Tulsa, Oklahoma,: PennWell Publishing Company,.
- Griffith, A., Stephenson, P. and Watson, P. (2000). *Management Systems for Construction*. England.
- (2014). *Growth and Transformation Plan*. Addis Ababa: Ministry of Finance and Economic Development.
- Haas, C., O'Connor, J., T., Tucker, R., L., Eickmann, J., A. and Fagerlund, W., R. (2000). *Prefabrication and Pre assembly – Trends and Effects on the Construction Workforce*. Centre for Construction Industry Studies, Austin, USA.
- Haddad, E. A.-Q. (2006). A Construction Materials Management System for Gaza Strip Building Contractors. *A Thesis Submitted in partial Fulfillment of the Requirements for the Degree of Master Of Science in Construction Management*. Gaza, Palestine.
- Harris, F. and MacCaffer, R. (2001). *Modern Construction Management*. London: Blackwell Science.
- Harris, F., McCaffer, R., and Edum-Fotwe, F. (2006). *Modern Construction Management*. (6th, Ed.) England: Wiley-Blackwell.
- Horman, M.J. and Thomas, R.H. (2005). Role of Inventory Buffers in Construction Labour Performance. *Journal of Construction Engineering and Management*, 131(No. 7), 834-843.
- J.J. O'Brien and R.G. Zilly. (1991). *Contractor's Management Handbook*. New York: McGraw-Hill.
- J.R. Tony Arnold; Stephen N. Chapman and Lloyd M. Clive. (2008). *Introduction to Material Management* (6th ed.). New Jersey: Pearsons Prentice-Hall.
- John P. Spillane, Lukumon O. Oyedele, Jason Von Meding, Ashwini Konanahalli. (2011). Confined site construction: A qualitative investigation of critical issues affecting management of health and safety. *Journal of Civil Engineering and Construction Technology*, 2(7), 138-146.
- Kasim, N. (2008). *Improving Materials Management on Construction Projects*. UK: Thesis, Loughborough University.
- Kasim, N. (2011). ICT Implementation for Materials Management in Construction Projects: Case Studies. *Journal of Construction Engineering and Project Management*.

- Kasim,N.B, Anumba, C J and Danity, A R J. (2005). Improving materials Management Practices on Fast-Track Construction Projects. *ARCOM Conference*. London: Association of Research in Construction Management.
- Kilan, C., S., (1992). *The World of W. Edwards Deming*. (2<sup>nd</sup> ED), Knoxville: Press. Inc.,
- Kelly, H. (1984). Technology and the construction industry: An introduction. *Proceedings: The Panel on Technical Change and the US Building Construction Industry.*, (pp. 2-10). Washington, D.C.
- Kong, S.C.W. and Li, H. (2001). An E-commerce System for Construction Material Procurement. *Construction Innovation, Vol. 1*, PP.43-54.
- Kong, S.c.W.,Li, H. and L.Y. (2001). An Internet- Based Electronic Product Catalouge of Construction Materials. *Construction Innovation, Vol.1*, PP. 245-257.
- Kothari, C. (2004). *Research Methodology* (2nd Edition ed.). Jaipur, India: New Age International Limited Publishers.
- Kulkami. (1985). Laboratory Manual for Concrete Technology.
- Lambert, D.M, Stock, J.R. and Ellram, L.M. (1998). *Fundamentals of Logistic Management*. United States: McGraw-Hill.
- Leedy, P.D. and Ormrod, J.E. (2001). *Practical Research Planning and Design* (7th ed.). New Jersey: Prantice-Hall.
- Lisa Darvik and Julia Larsoon. (2010). The Impact of Material Delivery Deviations on Costs and Performance in Construction Projects. *Unpublished Thesis: Master's Thesis in the Design and Construction Project Management*. Gotteborg, Sweden.
- M. Mawdesley, W. Askew, M. O'Reilly. (1997). *Planning and Controlling Construction Projects the Best Laid Plans*. England: Addison Wesley Longman Limited.
- Mahdjoubi,L. and Yang, J.L. (2001). An Intelligent Materials Routing System on Complex Construction Sites. *Logistics Information Management, Vol.14*(Issue 5/6), PP. 337-343.
- McCulloch B.G. and Gunn P. (1993). Construction Field Data Acquisition with Pen-based Computers'. *Journal of Construction Engineering and Management, Vol.119*(Issue 2). *Media Research*. (2013). India: Sikkim Manipal University.
- Mengesha, W. J. (2004). Performance for Public Construction Projects in Developing Countries. Doctorial Thesis at NTNU.
- (n.d.). *Mitigation Assesment Team Report :Performance of Mid-and High-Rise Buildings*. New Jersey: Hurricane Sandy.
- Mohammed, A.-K. (2004). Measuring Effectiveness of Material Management for Industrial Projects. *Journal of Management in Engineering, 20*(3), 82-87.
- Naief, H. (2002). A Comparative Evaluation of Construction and Manufacturing Materials Management. *International Journal of Project Management, Vol.20*(Issue 4), pp.263-270.
- Navon R. and Berkovich O. (2004). Development and on Site Evaluation of an Automated Material management and Control Model. *Journal of Construction Engineering and Management*.
- Navon, R. and Berkovich, O. (2006). An Automated Model for Materials Management and Control. *Construction Management and Economics, Vol. 24*(6), pp 635-646.
- Navon, R. and Berkovich, O.,. (2005). Automated Materials Management and Control Model. *Proceeding of the Construction Research Congress, ASCE*, 146-150.
- Neunam, W. (2006). *Social Research Methods: Qualitative and Quantitative Approaches* (6th ed.). Boston: Pearson Education.

- Nevile, A. (1985). *Properties of Concrete*. Longman Scientific and Technical.
- O.S. Ademeso and A.O. Windapo. (2008). Relationship between Material Management Approach and Scheduled Project Completion Time. *Construction and Building Research of the Royal Institution of Chartered Surveyors Conference*. Dublin Institute of Technology.
- Opfer, N. (1998). Just-In-Time Construction Materials Management. *AACE International*.
- Patel, K. V. (2011). Construction Materials Management on Project Sites. *National Conference on Recent Trends in Engineering & Technology*. India.
- Peters, J. and Howard, K. (2001). *Looking for Good Research in Management- A publisher's Case Study* (Vol. 7).
- Plemmons, James K., and Bell, Lansford C. (1995). Measuring Effectiveness of Materials Management Systems. *Journal of Management in Engineering, Vol.11*.
- Poon, C.S., Yu, A.T.W., Wong, S.W., & Cheung, E. (2004). Management of construction waste in public housing projects in Hong Kong. *22(7)*, 675-689.
- Poppendieck, M. (2000). The Impact of Logistics Innovations on Project Management. *Proceedings of Project Management Institute Seminars & Symposium*.
- Remington, K. and Pollack, J. (2007). *Tools for Complex Projects*. Gower Publishing Limited.
- Richard J. Tersine and John Campbell. (2004). *Modern Material Management*.
- Rong, Ying, Z.J., Max Shen and Candace Arai Yano. (2012). Cheaper by the Pallet? Multi Item Procurement with Standard Batch Sizes. *Featured in Industrial Engineer Magazine*, 405-418.
- Sadiwala, R. C. (2006). *Materials and Financial Management*. New age International Publishers. pp 15-30
- Spilliane, J. P. (2010). Material Management within Confined Construction Sites. *COBRA (The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors)*.
- Stukhart, G. (1995). *Construction Materials Management*. New York: Marcel Dekker Inc.
- Stukhart, G. (2007). *Materials Management Approach for Small Scale Sector* (2nd ed.). New York: Marcel Dekker Inc.
- Stukhart, G. and Bell, L.C. (1987). Costs and Benefits of Materials Management Systems. *ASCE Journal of Construction Engineering and Management, Vol. 113*, 222-234.
- Sultan, B. and Kajewski, S. (2006). Requirements for Economic Sustainability in the Yemen Construction Industry. *International Symposium on Construction in Developing Economies*. Santiago, Chile.
- Sun, M. and Howard, R. (2004). *Understanding I.T. in Construction*. London: Spoon Press.
- Thabet, W. (2001). A Framework for an Integrated Materials Management System. Research Proposal Submitted to the Electrical Contracting Foundation, Inc.
- Thessaloniki (2006). *Kaizen Definition & Principles in Brief: A concept & Tool for Employees Involvement*
- Thomas, H.R, Riley, D.R., & Messner, J.I. (2005). Fundamental Principles of Site Material Management. *Journal of Construction Engineering and Management, 131(7)*, 808-815.
- Thomas, H.R. and Riley, D.R. (2006). Fundamental Principle for Avoiding Congested Work Areas- A Case Study. *Practice Periodical on Structural Design and onstruction, 115(No.3)*, 370-384.
- V. Prabu and M. Baker. (1986). *Materials Management*. UK: McGraw-Hill.

- (UNIDO), U. N. (2009). *Breaking in and moving up: New industrial challenges for the bottom billion and middle-income countries*. Vienna: UNIDO: UNIDO Industrial Development Report.
- Wideman, R. (1990). *Total Project Management of Complex Projects Improving Performance with Modern Techniques*. New Delhi, India: Presentation to the Construction Industry in the Cities of Bangalore, Bombay, Calcutta, Madras and New Delhi on behalf of the Consultancy Development Centre.
- Willis, E. (2008). *Scheduling Construction Projects* (2nd ed.). John Wiley and Sons.
- Winch, G.M. and North, S. (2006). Critical Space Analysis. *Journal of Construction Engineering and Management*, 132(No. 5), 473-481.
- Wong, E.T.T and Norman, G. (1997). Economic Evaluation of Materials Planning Systems for Construction. *Construction Management and Economics*, Vol. 15.
- Yeung, N.S.Y., Chan, A.P.C. and Chan, D.W.M. (2005). Application of Prefabrication in Construction – A New Research Agenda for Reform by CII-HK. *Proceedings of the Conference on Precast Concrete Building Systems*.
- Z. Ren, C.J. Anumba and J.Tah. (2011). RFID-Facilitated Construction Materials Management-A Case Study of Water-Supply Project. *Advanced Engineering Informatics*, 25, 198-207.
- Zakeri,M,Olomolaiye,P,Holt, GD and Harris, F C. (1996). A Survey of Constraints of Iranian Construction Operatives' Productivity. *Construction Management and Economics*.

**ANNEX**

## Interview Questions

### Part 1: General Information

- 1.1 Name of the organization you are currently working (optional)
- 1.2 Years since establishment
- 1.3 Your work experience in construction projects
- 1.4 Total project cost
- 1.5 Respondents designation
- 1.6 Date of Interview
- 1.7 Number of storey of the building under construction

### Part 2: Basic information about the materials management practice:

#### Questions

1. In your company, is there a material management department?
2. If yes, what are the duties of the material management department?
3. Who is the person in charge of managing construction materials in construction projects?

### Part 3: Materials management tasks:

#### Material requirement planning:

1. Do you identify the needed materials for each item once you receive the project's drawings and specification?
2. How do you plan for materials in terms of delivery date, storage area and equipment needed?
3. Who is involved in the estimation of materials needed?
4. Do you consider the master schedule when planning for materials?

#### Procurement:

1. How do you select your suppliers (e.g. capabilities, price, prior experience, geographical location etc)?
2. How do you conduct the purchase order (e.g. phone, fax, e-mail)?
3. Who is in charge of issuing purchase order?

**Handling:**

1. How do you manage material handling in terms of equipment needed and storage space?

**Inventory control:**

1. How do you undertake inventory management in terms of storage and site space?
2. Do you verify the material received against the quantity order and with the specification required?
3. Do you have a specific approach for Inventory control (e.g. the supplied materials, the remaining balance and installed materials)?

**Surplus material:**

1. How do you manage the surplus materials (e.g. storing for future projects, returning the surplus, selling the surplus)?

**Quality Control:**

1. Are the aggregates delivered to the site from various sources?
2. If yes, do you do quality checking for each delivery?
3. Do you have a covered storage space for Cement?
4. Do you store the steel reinforcement for a long period of time exposed to weather?

**Part 4: Problems of implementation of construction materials management on building sites**

1. What problems do you face during material identification?
  - Not a good definition of what is wanted from the owner and suppliers
  - Incomplete drawings and details are missing
  - Difference between plans and specification
  - No proper schedule of materials
2. What problems do you face while procuring?
  - Unavailability of required material and required quantity
  - Poor communication between the parties involved
  - What is wanted is not what is prepared
3. What problems do you face during construction?

- Late deliveries (Materials do not arrive as scheduled)
  - The delivered materials do not comply with the required
  - Not knowing where materials are at a certain period time
  - Re-handling of materials- Materials have to be moved
  - Limited storage area
  - Loss and damage of materials
  - No assurance of quality from suppliers
4. What problems do face during the closeout of the construction?
- No storage for the surplus materials
  - No possibility that the surplus materials to be returned to the supplier

#### **Part 5: Strategies for effective construction material management on building sites**

1. What are the strategies that can be used for effectively managing construction material on building sites?
  - The utilization of pre-fabrication and pre-assembly of materials prior to reaching site
  - Providing adequate storage of materials on-site
  - The utilization of space scheduling so as to maximize the usage of the available space
  - The use of Just-In-Time delivery techniques to minimize the volume of materials on-site
  - The effective design site layout so as to aid in the management of materials on-site
  - Implementation of a materials management program to assist in the movement/storage of materials on-site
  - Implement a traffic management program to aid in the overall management of the construction process
  - The use of Ready mixed concrete

#### **Part 6: Congestion of sites due to in proper placement of materials**

1. What are the causes/reasons for congestion of building sites?
2. What are the effects of having a congested site?
3. What solutions do you recommend to avoid the congestion of sites?

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**Part 7: Use of ICT in material management**

1. What technologies do you use to facilitate material management on your sites?
2. Do you use emerging technologies (such as wireless technologies, bar-coding, radio frequency identification (RFID), etc) in your material management? (If NO, answer Q3 and If YES, answer Q4)

**IF NO:**

3. What factors hinder the introduction of such ICT in materials management process in your organization?

**IF YES:**

4. What benefits has your organization experienced from the implementation of such ICT tools?

### Summary of the Project Sites

No.	Sub-City	No. of Storey	Respondents Designation	Experience in Construction Projects (Yrs.)	Cost of Projects (Birr)
1.	Gulele	G+8	Project Manager	34	322 million
2.	Arada	2+B+G+7	Site Engineer	8	72 million
3.	Lideta	G+M+8	Project Manager	11	202 million
4.	Nefas Silk	B+G+4	Project Manager	19	288 million
5.	Addis Ketema	G+9	Project Manager	22	357 million
6.	Cherkos	G+7	Site Engineer	10	195 million
7.	Yeka	G+5	Site Engineer	9	175 million
8.	Bole	G+8	Project Manager	35	312 million
9.	Akaki Kaliti	G+5	Site Engineer	12	111 million
10.	Kolfe Keranio	G+5	Project Manager	26	150 million