

**SCHOOL OF GRADUATE STUDIES  
DEPARTEMENT OF CONSTRUCTION TECHNOLOGY AND  
MANAGEMENT**

**CONSTRUCTION MATERIALS MANAGEMENT PRACTICE ON  
PUBLIC BUILDING CONSTRUCTION PROJECTS IN ADDIS  
ABABA: THE CASE OF ETHIOPIAN CONSTRUCTION WORKS  
CORORATION**

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A Thesis submitted to the school of graduate studies in Addis College in partial fulfillment for the Master's degree in Construction Technology and Management.

**AUGUST, 2023**

**ADDIS ABABA, ETHIOPIA.**

## DECLARATION

I declare that this thesis entitled “**Construction materials management practice on public building construction projects in Addis Ababa: the case of Ethiopian construction works corporation.**” is my original work and has not been presented for a master’s degree in any other university and that all sources of material used for the thesis have been properly acknowledged.

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## **ENDORSEMENT**

This is to certify that Biruk Chafie Abie has conducted this thesis work entitled “Construction Materials Management Practice on Public Building Construction Projects in Addis Ababa: the case of Ethiopian construction works corporation.” is under my supervision.

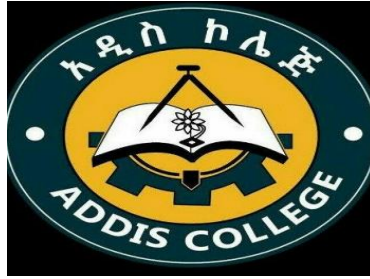
This thesis work is original and suitable for the submission in partial fulfilment of the requirement for the award of Masters of Science Degree in Construction Technology and Management.

Dagnachew Adugna (Ph.D.) \_\_\_\_\_

Advisor

Signature

Date



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## ABSTRACT

*Construction materials management is a procedure that contains planning, procurement, purchasing, delivery, handling, and Controlling of building materials, including waste and surplus materials management. The aim of material management is to ensure that the right material and right quantity are acquired at the right place and right time with the right quality. This research was conducted on the public building Materials management practice of Ethiopian Construction Works Corporation. The objective of the study was to investigate the practices of construction materials management in the Ethiopian construction works corporation. Both descriptive and explanatory types of research was conducted. Questionnaire, interview and observation were the methods of data collection. The data was analyzed by using Excel spreadsheet software, and the results were presented with tables and graphs. The findings of the study showed that some major practices of construction materials management practices include paper based exchange of information, computer-based materials management system integrated with computer aided design, scheduling, and accounting systems purchases from government suppliers. Moreover, the challenges associated with construction materials management includes delay in material supply to sites, Budget shortage to purchase construction materials, Excessive paperwork and Problems using Automation technologies. Finally, the study suggested some strategic tools to improve construction materials management such as Application of Emerged technologies like enterprise resource planning system software, radio frequency identification for automation, Application of lean thinking such as web-based tool designed based on the Last Planner System and process mapping, and Adequate construction materials procurement and materials delivery schedule.*

**KEY TERMS: Construction project, Materials management, Public building, management practice, Challenges, Strategic tools.**

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## **LIST OF ACRONYMS AND ABBREVIATION**

4D	Fourth-Dimensional
AACDACB	Addis Ababa City Design And Construction Bureau
AACDBCE	Addis Ababa City Design and Building Construction Engineers
AAD&CA	Addis Ababa design and Consulting Agency
AAHB	Addis Ababa Health Bureau
AATA	Addis Ababa Teachers association
AKPSDTP	Akaki public service depot construction project
BIM	Building Information Model
CGAAD&CWB	City Government of Addis Ababa Design & Construction Works Bureau
CLM	Construction Logistics Management
CMM	Construction Materials Management
COME	Construction Materials Exchange
DCDE	Defense Construction Design Enterprise
ECWC	Ethiopian Construction Works corporation
ECDSWCO	Ethiopian Construction Design Supervision Works Corporation
EKCA&E	Eyob kinfe consulting Architects & Engineers
FEDRE HoPR	Federal democratic republic of Ethiopia House of People Representative
EOQ	Economic Order Quantity
ESCAPE	Expert System Advisor for Concrete Placing
FDARA	Federal Documents Authentication and Registration Agency
GBM	Green Building Material
GDP	Grose Domestic Product
GIS	Geographical Information System

GSCM	Green Supply Chain management
ICT	Information Communication Technology
IoT	Internet of Things
JIT	Just In Time
KKSB	Kolfe Keranio sub city
MoR	Ministry of revenue
MHESA	Material Handling Equipment Selection Advisor
MLP	Multi-Layer Perceptron
LCA	Logistics Cycle Assessment
PMBOK	Project Management Body of Knowledge
PSTB	Public Service Transport Bureau
RFID	RadioFrequency Identification
RII	Relative Importance Index
SMEs	Small and medium enterprises
SMART	Specific, Measurable, Achievable, and Time bounded
UK	United Kingdom
USA/US	United States of America
WB-MPC	Web-Based Material Planning and Control
VED	Vital, Essential and D Desirable
VCMR	Virtual Construction Material Router
YACAE	Yohanis Abay Consulting Architects &Engineers
YPSDTP	Yeka Public service Depot construction project

# CHAPTER I: INTRODUCTION

## 1.1 Background of the study

According to (Ahmed et al., 2018), Construction Materials management is defined as a coordinating function responsible for planning and controlling materials flow. This means that, materials management is a planned procedure that comprises purchasing, delivery, handling, and minimization of waste, intending to ensure that requirements are met. Construction materials management is a practice for planning, executing and controlling field and office activities in construction. It is an essential function that improves productivity in construction projects.

Construction materials usually constitute a major portion of the total cost of a building construction project. An essential factor adversely affecting the performance of construction projects is the improper handling of materials during site activities (Tibebu, 2016).

A successful completion of projects requires all resources to be effectively managed and up to 70% of Ethiopia's need for construction materials is imported to accomplish the positive advance and infrastructure objectives of the country (Amare, 2016). Therefore, the effective use and good management of material practices have an important influence on a company's profit and can avoid delay in construction. So, it needs a well-organized use and administration of material have a significant impact on a project's profit and can avoid delay (Kanimozhi and Latha, 2014).

In developed countries, implementation of just in time, off site construction and ICT technologies such as RFID are currently using for construction materials management (Nwankwo, 2022).

In developing countries such as China construction materials management systems are using current emerged technologies. According to (Han et al., 2020), the implementation of GIS-BIM technology in material management helps to achieve more predictable project outcomes, reduce costs, improve productivity and quality, and provide a safer work environment.

Construction material management in the Ethiopian construction industry, especially in Public building construction projects in Addis Ababa, is usually done by skills familiarity and using traditional methods (Getnet, 2017).

The purpose of this study was a detail analysis of Construction material management practice in the Ethiopian Construction Works Corporation on public building projects and provides strategic

tools that can be suitable for the appropriate management of construction materials which can minimize the projects' total cost and increases quality.

The Ethiopian Construction Works Corporation (ECWC) is a newly established on December 18/2015 based on council of ministers regulation number 366/2015. The corporation is amended by council of ministers regulation number 390/2016, on September 28/2016. It is governed by the public enterprises proclamation number 25/1992. The corporation, as a contractor, has been engaged and to be engaged area of business in various large-scale projects such as construction of transport & water infrastructure, construction of buildings & industrial projects, undertaking project management service, dam & irrigation infrastructure administration, spare parts & construction materials production, assembling construction equipment & machineries, and leasing warehouse & construction machinery.

The study showed that ECWC has been managing materials manually and paper based which is exposed to human errors. Currently some of major construction materials management practices in ECWC includes paper-based Exchange of information and recording relating to material management, Computer-based materials management system integrated with CAD, scheduling, and accounting systems, materials purchases from government suppliers, application of long-lead materials identification, implementation of Ms. Excel and Ms. Word, and application of bulk Method of purchasing and forward buying system at least for one year were from major practices implemented in public building construction materials management.

## **1.2 Statement of the problem**

According to (Getnet, 2017), in the Ethiopian construction industry, construction material management, mainly in public building construction projects in Addis Ababa, is done by experience and using old-style techniques. Also, the absence of proper construction materials management methods contributes to high construction costs and poor quality of construction products in Ethiopia. And poor materials management is one of the major problems for delaying construction projects.

Construction materials management is becoming a serious problem, especially on public building construction projects in Addis Ababa and no attention is given to such basic subject. According to (Baldwin and Bordoli, 2014), cited by (Ermias, 2019), 40% of the time lost on the construction project site can be attributed to bad management, lack of materials when needed poor

identification of materials, and inadequate storage, Lack of formulating an effective materials management plan can have a negative impact on cost, quality and time, which affect the project delivery. And also Unavailability of materials when needed can affect the productivity and it may cause delay and difficulties to meet the project completion. Whereas having excessive materials on site also create problems to the managers handling the materials on site and affect the cash flow. Storage of materials can increase cost of production thus increasing the overall cost of the project.

As discussed by (Woyesa, 2017), the major impacts of poor construction materials management includes Delay in construction project delivery, disorganize the project and leads to onsite accidents, Excessive cost of construction, gives Poor image to the construction industry, Poor quality construction project, Promotes of corruption & robbery, Fragmentation of activities within the construction process.

The major problems which leads to study construction materials management practices in ECWC. Included delay of ready mix to deliver on time, there were no more attention given for the management of materials on site, daily recording of consumed materials were not continuously implemented, and sometimes received materials were not known where it consumed or used and Also the researcher had seen that auditors were difficult to audit due to improper recording of consumed materials.

Some identified major problems associated with construction materials management (CMM) in public buildings in Addis Ababa includes; Delay in material supply to sites or Late delivery of construction material to the project site, Budget shortage to purchase construction materials affects the material management system, Excessive paperwork, Problems using Automation technologies such as barcoding, RFID, and web-based technologies, There is a problem of implementing the current information communication technology, Price escalation on the material, Frequent changes in design affected the material management, Excessive quantity of work during construction which is not found on planning, and Materials required but not purchased or not Received.

These construction materials management had an implication on the public projects completion time or delay and increment on the total cost of the projects. To minimize these problems and improve construction materials management strategic tools needs to be applied.

### **1.3 Research objective**

#### **1.3.1 General objective**

The general objective of the study is to investigate the Practice of Construction Materials Management by Ethiopian construction Works Corporation.

#### **1.3.2 Specific objectives**

- To assess Construction Material Management Practices on public building Projects in Addis Ababa.
- To identify the challenges of Construction Materials Management on public Building Projects in Addis Ababa.
- To develop strategic tools to improve the management of Addis Ababa construction materials.

### **1.4 Research questions**

- What are the construction materials management practice on public of building projects in Addis Ababa.?
- What are the challenges affecting Construction Materials Management on public Building Projects in Addis Ababa.?
- What are strategic tools to improve the management of construction materials?

### **1.5 Scope of the study**

#### **1.5.1 Spatial scope**

This study was conducted in Addis Ababa only on fourteen purposively selected public Building construction projects that were constructed by the Ethiopian construction works corporation.

#### **1.5.2 Thematic scope**

This study covered only the Construction Materials Management on public Building projects. Materials Management practices for public building projects constructed by Ethiopian Construction Works Corporation including Materials planning, procurement, Transporting, site management, and waste and surplus controlling of materials on public building projects was studied, as also problems for the Materials Management processes identified and strategies appropriate for effective and efficient material management developed.

## **1.6 Significance of the study**

This study will be relevant:

### **To clients;**

- Helps to select suitable construction materials management to be used through the construction processes.
- Helps to know what problems of construction materials management found through construction process and to take care of it.
- It also helps to know the implication of improper construction materials management system on completion time and total cost of the project, and to be ready for proper solution for it.

### **To contractors;**

- Serves as a guide in implementing suitable material management practices.
- Help to look the problems ahead and managing materials properly.
- Helps to give more information about construction materials management systems.
- It helps to contractors to use technologies for construction materials management and reduce the impacts of improper construction materials management.

### **To professionals;**

- Helps to Know and read more about materials management and the encounters.
- Gives updated information on material management in construction projects to be used.

It can help us in the future research works on the materials management and project success.

## CHAPTER II: LITERATURE REVIEW

### 2.1 Definition of key terms

**Construction Project:** Project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end (PMBOK, 2017).

**Construction Materials management:** (Jusoh & Kasim, 2017), defined Construction Materials management as ‘the planning and controlling of all necessary efforts to ensure that the correct quality and quantity of materials and equipment are appropriately specified in a timely manner are obtained at a reasonable cost, and are available when needed’.

**Practices of Construction Materials Management:** is an activity methods, procedures, level of management strengths and others techniques done by the stakeholders of a construction project to gate the right materials, at right quantity and at right time (Carlos et al., 2015). It is a planned procedure that comprises purchasing, delivery, handling and minimization of waste with the aim of ensuring that requirements are met (Kanimozhi, 2014).

**Logistics management in construction:** it involves the strategic storage, handling, transportation and distribution of resources, as well as planning of a building site’s layout, and the active management of its evolution as necessary construction processes unfold (Whitlock et al., 2018).

**Public Procurement:** According to United Nations Development Programme, UNDP (2007) Cited on (Thai, 2017), public procurement is the “overall process of acquiring goods, civil works and services which includes all functions from the identification of needs, selection and solicitation of sources, preparation and award of contract, and all phases of contract administration through the end of a services’ contract or the useful life of an asset”.

**Demand Management:** “The demand management marks the beginning of public procurement processes. The focus is on the exact identification and specification of needs in terms of quantity and function-specific quality” (Rabin et al., 2009).

## **2.2 Public buildings**

According to [www.lawinsider.com](http://www.lawinsider.com), public building is a building or work, the construction, alteration, maintenance, or repair of which is carried on directly or indirectly by authority of, or with funds of, a federal agency to serve the interest of the general public regardless of whether little thereof is in a federal agency.

A Public body is, which is partly or wholly financed by the Federal Government Budget, higher education institutions, and public institutions of like nature which has the powers and duties to conclude a Contract for the supply of Works, as specified in the SCC PPA (2011).

According to (Rabin et al., 2009), “Public duties and responsibilities are derived from the public interest as far as variety and volume are concerned, which again is in a permanent change apparently manifesting itself in the results of elections, acclamations, and numerous public private negotiations. Public interest determines political objectives. For these political objectives politicians are willing to spend money, which ideally, also creates an additional social benefit. To perform these public duties derived from a political decision-making process, different value-adding activities are necessary”. It is the same in our country that most public buildings are constructed based on the above consideration we have observing it practically.

In Ethiopia, Public construction projects are parts of the country’s development initiative. since the construction industry is the highest beneficiary of government budget as portion of government development program, it takes considerable amount of the country’s scarce financial resources. From 58.2% to 60%, annual rate of government’s capital budget consume the public construction projects (Betelhem, 2017).

## **2.3 Construction materials management**

According to (CII, 2012), construction materials management is a complex and comprehensive process that consists of people, organizations, technology, and processes used to manage the definition, sourcing planning, quantification, supplier qualification, purchasing, supplier QA/QC, expediting, transportation, logistics, and controlling of materials and associated information across the lifecycle of a capital project.

(Kasim et al., 2008) said that Materials management is a significant duty in order to improve productivity in construction projects. It showed that Construction materials waste, in the USA

contributes approximately 29%. In the UK it contributes more than 50% and in Australia it contributes 20-30%. This means the practice of good material management can reduce material problems and improves the performance of project objectives. The study was on improvement of construction materials management on fast tracking construction projects in UK, and also identified the problems of construction materials management and practices implemented at that time.

Materials management is a process for planning, executing and controlling field and office activities in construction (Mahavidyalaya et al., 2011). Construction Materials management contains the logistics of the materials components of a supply chain which involves the process of planning, implementing and controlling of the movement and storage of materials, work-in-process inventory, and finished goods from point-of-origin to point-of consumption (Kasim et al., 2006). (Mahagaonkar & Kelkar, 2017), described the objective of construction materials management includes; Effective material planning, Low cost for procurement, Efficient storage and inventory control, Continuity in supply and circulation of materials, Quality assurance, Good supplier relations, Development of personnel, and Good information system.

(Mahavidyalaya et al., 2011), stated the components and functions of construction material management; which consist of; material estimation, budgeting, planning and programming, scheduling , purchasing and procurement, receiving and inspection, inventory control, storage and warehousing, material handling and transport, waste management. The major functions of the construction material management contains comprises; efficient materials planning, buying or purchasing, procuring and receiving, storing and inventory control, supply and distribution of materials, quality assurance, good supplier and customer relationship, improved departmental efficiency.

(Kasim, 2008) studied about improving materials management on construction projects; and stated “As projects grow in scale and complexity, materials management becomes more difficult, often requiring the use of appropriate tools and techniques to ensure, amongst other things, that materials are delivered on time, stock levels are well managed, the construction schedule is not compromised, and that wastage is minimized”. In complex construction projects Management of materials needs adequate consideration due to the various elements involved and the importance of the projects.

The consequences of poor material management might result in late delivery of materials or risk of purchasing at higher prices, thus resulting in delay and cost overrun. And also with upturn in the number of construction projects in a single location, the local market cannot meet the high level of demand for building materials. Thus, a contractor might face a shortage of construction materials on the market or an increase of the material prices, which results in cost overrun. For large and complex construction projects where special materials are required, the risk of importing delay is raised as the construction industry depends on the international market to provide such materials (Aljohani, 2017).

## **2.4 Practices of construction materials management in developed countries**

### **2.4.1 USA**

According to (Spillane, et al., 2010), studied on the material management on confine building project, a well-known practices used for material management in USA is the application of Just-In-Time delivery which is used as an important technique for congested building project sites. As the study identified the Application of this JIT management of building materials is an important for environmentally confined sites, Pre-fabrication and pre- assembly is currently being utilized Practice in USA more vastly. According to (Dallasega, 2019), Industry 4.0 is used to combine the internet, information and communication technologies (ICT) and with classical industrial processes; and it similarly described that a transformation comes with Industry 4.0 is the shift from a centralized to a decentralized control to reach a highly flexible production of customized products and services.

USA and European countries are applying industry 4.0 for logistics management for the manufacturing and construction sites. (Golkhoo, 2018), Stated that planning of material be able to optimize the cost of construction materials by implementing generic algorism (GA) with Multi-Layer Perceptron (MLP). The other most practice used in USA is offsite construction which have many advantages on construction project. According to (Razkenari et al., 2020), offsite construction practices can give an advantages such as saving material wastage, reinforcement, concrete use, site manpower, and even from the complete elimination of the use of external scaffolding.

### 2.4.2 Germany

In Germany Public procurement is one of the major function of construction materials management. According to (Rabin et al., 2009), a book on international public procurement stated the public procurement implemented in Germany; Accordingly a function of public procurement is to ensure government acquire required goods and services that enable public performance in all areas of public duties and responsibilities. The book stated the public procurement process in Germany as follows;

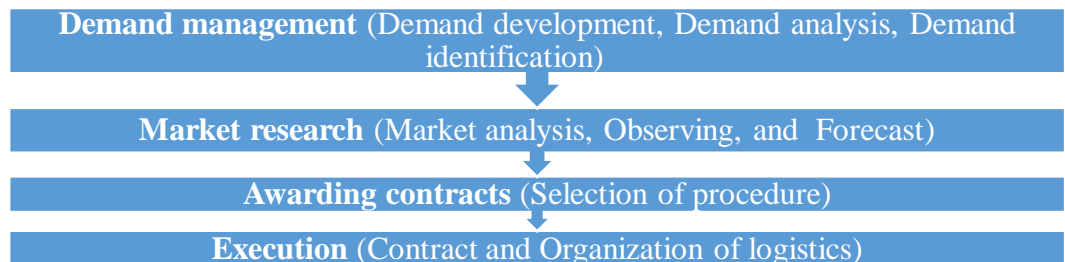


Figure 2.1: public procurement process in Germany

### 2.4.3 Australia

(Fauzan and Sunindijo, 2021), identified four lean construction materials management tools which were adequately practicing in Australia, namely, Just in Time (JIT), Last Planner System (LPS), Six Sigma and 5S Management. This tools have advantages such as productivity, waste reduction, and on-time delivery of works, quality, and client satisfaction. Gurmu (2018) studied the material management practice in Australia to improve Labour productivity. It described implementation of innovative technology and change in materials management practices could improve productivity. The study identified six (6) major construction material management practices that can improve the productivity of the construction project including from top to bottom; Long-Lead materials identification, Procurement plans for materials, Materials delivery schedule, Material inspection process, Materials status database, and Materials inspection team which improves the productivity.

In Australian Application of of-site construction or prefabrication practices for construction industry is also increasing, Off-site manufacture In Australia and other developed countries like the US and the UK, and is accepted as a diesel for the processes of efficient improvements in construction industries (Blismas & Wakefield, 2008). Radio frequency identification Aided

Tracking System is used to improve work efficiency. In Australia, a studied by (Moon et al., 2018), confirmed that using RFID-Aided Tracking System can increase work performance. It stated that productivity could be improved by 10% compared to the conventional method.

#### **2.4.4 United Kingdom (UK)**

In UK the current practice of material management is using implementation of ICT technology such as RFID and bar-coding (tagging technologies) that are less paper based methods were used, and also Just-In-Time (JIT) techniques to the proper supply chain of materials to the site is using to minimize the stock at site (Nwankwo, 2022). From (Whitlock et al., 2021) study; the study observed that many major projects in UK were using 4D BIM Construction material management. It stated that BIM-based CLM on current construction sites was established. In UK using Green Supply Chain management GSCM practice was believed as material management, environmental integration of supply chain management with consumer end-of-life management such as green purchasing, green manufacturing, green design, reverse logistics and green distribution/marketing were considered.

#### **2.4.5 Spain**

(Gangolells et al., 2014), in Spain studied on the implementation of effective waste management practices in construction projects and sites; the study divided the waste management practices into three (Design phase, planning phase and Construction phase) stated as follows:

**Design phase:** Coordination has been established among the stakeholders of the project (client, developer, architect, engineer, on-site workers) during the project's design phase to minimize construction and demolition waste, Standardization and dimensional coordination of construction materials and elements were considered during the project's design phase, Reusable elements from earlier buildings were introduced in the project during the design phase, provided that this was technically and economically feasible, and Future dismantling and reuse or recycling of the construction elements and materials were considered during the project's design phase.

**Planning phase:** All the stakeholders were involved in the coordination of the waste management plan, a coordinator of the waste management plan is designated and is responsible for ensuring that the plan is followed on site. All personnel working on-site know the waste management plan and contribute to meeting the requirements stated in it. Types and quantities

of construction and demolition waste were estimated for each phase of the work. An individualized drawing illustrates the size and location of stockpiles, waste storage areas and traffic pathways. Each construction site has the free space and the resources required to ensure compliance with the waste management plan. Movement of generated waste is tracked from the moment it is generated right up to its final destination, and new opportunities for waste minimization was periodically considered. The nearest authorized managers are prioritized. And the budget includes detailed cost data on the waste management strategies.

**Construction phase:** The waste management plan is applied and compliance is ensured. Construction staff should properly trained in on-site waste management. Selective dismantling or disassembly is prioritized over massive demolition. The construction site is kept clean and well organized. Materials should properly store in a protected area to prevent premature damage. On-site waste sorting is done at the time waste is generated.

## **2.5 Practices of construction materials management in developing countries**

### **2.5.1 China**

The current practice of construction materials management in china is using BIM technologies with prefabricated buildings. (Wu, 2020) described the method of BIM technology and prefabricated material management to reduce the construction material management problems. And stated that based on the BIM construction material dynamic management practice, For the on-site construction management, control of progress and cost is effectively improved, materials were produced on demand, order delay is avoided, delivery efficiency is improved, visual dynamic management is realized, construction plan is optimized, and fine construction management of the project is promoted. GIS and BIM were other technological practices used in china for the management of construction materials. According to (Han et al., 2020) The implementation of GIS-BIM technology in material management helps to achieve more predictable project outcomes, reduce costs, improve productivity and quality, and provide a safer work environment.

The other commonly used construction materials management technique in China is using a green building material (GBM). As described by (Science, 2018), the practice of using green building material have the following advantages compared to the traditional building materials

Reduce energy consumption, Sustainability, Qualified materials can be used again after being produced and recycled for many times, Health and harmless. Good material properties, Most of the GBM have the characteristics of high strength, high water resistance, and light weight, which can reduce the cost of material handling and improve the quality of buildings.

### **2.5.2 Pakistan**

(Ali et al., 2020), studied on Materials Management on Construction Sites Using RFID Technique in Pakistan. The study implemented a data collection techniques including reviewing previous studies, field survey and interviews to assess the construction materials management on construction sites. From the result of the study there was no an application of modern technology such as RFID techniques for management of materials on construction sites in Pakistan. And finally the study recommended the use of RFID for construction materials management practices to prevent problems that could affect the management process. As observed from the study in Pakistan, modern materials management is using for large construction companies but not for small and medium. Which means Conventional practices of material management were implemented in small and medium construction projects. The study suggested all companies to implement the modern technologies like RFID.

### **2.5.3 Kenya**

The construction materials management practices used in Kenya includes EOQ analysis, ABC analysis and FSN analysis as described by (Sila, 2021). Which is an inventory management techniques. (Joseph, 2018) studied the practice of inventory management in Nairobi Kenya and found that construction companies used vendor managed inventory to collaborate with suppliers, as well as suppliers used it to track inventory level of the construction companies. And also they uses software to monitor their inventory level. The study assured that construction companies were used EOQ anytime when the inventory level is goes down which is a good practice in material management. Just in time ordering technique also used properly, construction companies keep inventory level minimum which minimizes cost inventory. Material requirement planning is using by the construction companies in Nairobi.

#### **2.5.4 India**

(Gulghane & Khandve, 2015), described the practices of construction materials management in India that includes New emerging technologies such as wireless communication system, bar-coding readers and Radio Frequency Identification (RFID) were adequately used on site to overcome human error and are well integrated with project management systems on construction projects to make the tracking and management of construction materials easier and faster. The study identified that there is poor handling of construction materials in India which affects the overall performance of construction projects in terms of cost, time, quality, and productivity.

#### **2.5.5 South Africa**

According to (Maleka, 2016), the most implemented public construction materials management practice is demand management, followed by acquisition management, and the least implemented practices were logistics, disposal, and risk and performance management. (Odubiyi et al., 2019), stated that the practice of construction materials management using the new technology in South Africa is very slow.

### **2.6 Practices of construction materials management in Ethiopia**

(Ahmad, 2018) studied the practice of materials management in developing countries and identified that the traditional methods and manual control procedures were applied, which makes it unsatisfactory. The construction materials management practice in Ethiopian contractors is also a non-computerized form (Tibebu, 2016). (Ajahunegn, 2021), found the current material management systems used in Ethiopia on the public project have weak practices. Paper-based reports are problematic, error-prone, and inefficient, it is mostly used to record and exchange information related to the materials component within a material management (Binti, 2008). (Tibebu, 2016), also studied that the construction materials management practice in Ethiopian contractors is non computerized forms and, Shortage of suitable construction materials management software is considered the main difficulty to computerize materials management processes. The other most issue is absence of experienced persons using computerized construction materials management packages.

(Ajahunegn, 2021), found that the application of material management systems on the public project in Addis Ababa has weak practice. And also identified the benefits of the material

management levels including very high degree levels to reduce the costs of project materials, and High degree beneficial for timely available of Materials on site with the right quantity, Better relationships with suppliers Better handling of materials, Complying with a schedule, Complying with the improvement of quality control Waste reduction, and Reducing duplication of materials orders. It also showed that Weak materials management have the impact levels with Very high degree Shortage of material and a High degree of Cost overrun, Conflicts between parties, Wastage of material and mid degree on Delay of the project compilation. Majority of Contractors in public building projects in Addis Ababa were not using software to manage construction materials (Ermias, 2019).

(Ermias, 2019) stated that Majority of the public building projects in Addis Ababa were using multiple suppliers than single supplier for most important construction materials because of price variation, the material quality variation, supply shortage, and risk reduction. Most public building construction projects in Addis Ababa have both performance inefficiency on the project cost and completion time.

(Meberatie & Bahiru, 2023), studied on the Assessment of Materials Management Practice on Public Building Construction Project; and The study was assessed the material management practice, problems related to materials management, and the mitigation measures for materials management, on selected public building construction projects in Debre Markos Town. The study used both quantitative and qualitative research methods and also used both secondary and primary data collection methods. Finally it was found that in public building, materials management practices includes; construction material testing, materials planning, material transportation, material handling systems, Economic order quantity of materials.

## **2.7 Challenges of construction materials management in developed Countries**

### **2.7.1 USA**

According to (Caldas, 2015), cited by (Rodríguez et al., 2022), the identified challenges of construction materials management in USA includes construction industry does not sufficiently invest to rely on satisfactory material management and control.

The major challenges of construction materials management in USA identified by (Spillane, et al., 2023) includes Lack of adequate storage space, over-crowded of Workplace, inadequate room

for effective handling of materials, materials transport difficulty from place to place in site, problems on available space on-site to facilitate the effective storage and removal of material waste from site, difficulty in receiving large material deliveries onto site, Damage of materials due to confined space, insufficient storage space for materials on-site, poor quality of materials, security risks due to the lack of adequate space to safely facilitate the storage of materials, Lack of adequate room to account for materials. the identified challenges by (Spillane, et al., 2023), study is considering only confined project site. It also not considered public projects, it stated generally construction material management in confined project sites.

### **2.7.2 Australia**

According to (Zhang & Tan, 2022), in Australia building materials management challenges related to prefabrication includes Cost inefficiency, Lack of standardization, Increased transportation and logistics considerations/restrictions, inter module connection design, Inflexible for design change, Production planning, Long design time, Site access.

(Wu, 2021), stated the major challenges on building material management in Australia, the use of sustainable materials were related to cost and profit considerations, unwillingness of the key stakeholders to incorporate materials into building projects, lack of incentives and government policies to use sustainable materials. The other challenge on building material management is problems on reduction of material waste, problems on reuse of materials and recycle; this problems were caused by Lack of knowledge about what can be recycled or recycling opportunities, Contamination of recyclables due to lack of separation or lack of space for separation, Lack of markets/lack of demand for the recycled materials, Technological barriers in terms of conversion of waste materials to useful end, Cost of recycling processes making products more expensive than that from virgin material, Design for deconstruction has not yet been incorporated into the building process, Alternatives to recycling were less costly landfill gate prices were too low, Government policy is not driving recycling, Lack of confidence in recycled materials (Zou & Yang, 2015).

### **2.7.3 United Kingdom (UK)**

In the UK construction industry, construction materials management has difficulties such as material supply delays, shortages, price fluctuations, wastage and damage, and insufficient storage space (Nwankwo, 2022). The other Main challenges of many construction firms were

purchasing of materials from quality source, timely delivery and at the best price. According to The study, transporting materials from one location/supplier to another location/project is also a major challenge for large and complex construction projects.

The other challenges of construction materials management in UK stated on (Kasim, 2011) as cited by (Nwankwo, 2022), includes; Incurring more inventory cost and tendency for quality of material to deteriorate when materials are received before they are required, There was loss in productivity when materials were not received on time, Untimely commencement of projects from design documents and drawings, Subsequent changes to design, Loss/damage of items, Choosing contract type for individual materials procurement, Criteria for supplier evaluation, Stacking up and controlling of inventory, and Surplus materials management.

## **2.8 Challenges of construction materials management in developing countries**

### **2.8.1 China**

(Science, 2018), identified some construction materials management challenges. From these there is a large amount of waste in China each year and comprehensive recycling of resources is not realized, and the overall rate of utilization is quite low. The technological input and raw material costs in the production of GBM were relatively high, and they are unfavorable to the cost control of products. There were few supporting policies as well as market forces, and the government fails to keep jump with market propaganda.

(Hasan & Zhang, 2017), identified the challenges for the implementation of green building material practice in china including, Additional costs caused by green construction, Incremental time caused by green construction, Reduction of structure aesthetics, Uncertainty in the performance of green materials and equipment's, Imperfect green technological specifications, Misunderstanding of green technological operations, Restrictions of new green productions and technologies. Awareness, Regional ambiguities in the green concept. Conflicts in benefits with competitors, Dependence on promotion by government. Management, Construction Management Lack of support from senior management, Lack of knowledge on green technologies and materials. Limited availability of green suppliers and information. Lack of quantitative evaluation tools for green performance, and Contract management Additional responsibility for construction maintenance.

### **2.8.2 Pakistan**

According to (Ahmed, 2017) and (Sardroud, 2012) cited on (Ali et al., 2020), major problems and challenges of material management on construction sites in Pakistan includes Materials required but not purchased, Materials purchased but haven't been received yet, Materials received with wrong quality, Materials received at the wrong time, Material specifications that do not correspond to those in the purchase order, Absence of information about the status of orders, Shortage in updated information regarding the arrival of materials on site, Deficiency in up-to-date information regarding site stock, Lack or excess of materials, The dimensions of storage areas being not satisfactory to contain materials, Searching for materials and material tracking being time-consuming, Project delays due to lack of timely availability of materials, which, in turn, impede project productivity, Penalties imposed on contractors in contracts in cases of delay in delivery. Increase in project costs as a result of payment of workers' wages during the interruptions in the work. The problems related to agreed payments by clients due to non-conforming with the planned time schedule as a result of lack of materials on site.

### **2.8.3 Kenya**

In Kenya the major challenges identified by (Sila, 2021) includes poor storage facilities, poor initial planning and also inadequate purchasing procedures. The challenges were showed in projects to material shortages, surplus materials on site, inadequate storage space for materials, uncontrolled wastage of materials, damaged materials on site and wrongful purchase of materials and also poor material handling is a challenge for the construction materials management and mismanagement.

(Sila, 2021), identified three most series challenges of construction material management in Kenya, lack adequate planning of the material, Transport problem, storage problem, problems of using computer software.

### **2.8.4 India**

According to (Kebede, 2018), the major factors affecting material management in India includes; Top most factors for unsuccessful material management between organization and client, Rework due to errors occurred during construction, Improper handling during construction, change orders due to enhancement required by clients, Inaccurate data, engineering drawings not

fitting the use, Design/engineering interface - incorrect documents, design changes, extended delay for architects approval or design changes, Material price escalation, Poor planning, controlling and monitoring of material, Difficulties in finding out clients desires, changes of clients requirements, long procedures to discuss changes, Cash flow problems due to late and reduced payments, Late delivery of construction material, excessive quantity during construction, Deliveries not in conformance with planning, wrong and defective deliveries, long storage period, awkward packing, large shipments

According to (Madhavi & Varghese Mathew, 2013) cited by (Rodríguez et al., 2022), Problems of construction materials management in India were stated as inadequately obtained and stored and a lack of inventory control is perceived, Material cost fluctuation, Delayed delivery of materials, Procurement of materials that does not fulfill the specified quality, and Risk management problems regarding the materials and the inventory (Vipin & Shabeen, 2019). Organizational structure: problems such as no communication between the parties involved, non-conformity with the requirements, incomplete executive project Procurement, availability problems, delayed delivery, limitation and bad location of the storage areas and lack of communication between the persons involved, Storage space, and Security problems. Gradual stealing. Material availability in the market (Raibole & Waghmare, 2019). Problems related to the management and minimization of material waste, caused by the lack of competent planning and management (Karoriya & Pandey, 2018). And Storage remains the most important problem with regard to the construction material management (Desai & Patel, 2019).

(Mahavidyalaya et al., 2011), identified the major challenges of each material management functions of materials Identification, vendor Selection, and procurement, Construction Phase as follows:

### **2.8.5 South Africa**

The challengers for public construction materials management in South Africa includes a lack of training for SCM staff, lack of proper capacity, poor planning, and ineffective black economic empowerment (Maleka, 2016). And others the following listed problems include; there was no uniform procedure for tender publications; some provinces advertised only in the major newspapers, not in the state tender bulletin, Suppliers were not paid within 30 days, which made doing business with government more expensive, Some tender committees had to deal with

political influence and conflict of interest, which made the process unfair and not transparent, Poor estimates of requirements were made in centrally managed supplies contracts.

According to (Odubiyi et al., 2019), identified the major challenges of construction materials management in South Africa and includes; The scale of construction projects Cultural barriers, Work environment challenges Financial challenges, Behaviors of people in key positions, Lack of attention by procurement officers, Shortage of skills towards operating complex technologies, Late payments from clients, Lack of time to implement new technologies, Incomplete information about materials needed, on construction sites from site managers, Lack of information security, Organizational cultures, and Delays in materials that have been ordered.

## **2.9 Challenges of construction materials management in Ethiopia**

(Adamu, 2021), identified the challenges on the public construction management in Ethiopia including unable to an understanding of the construction materials management method, shortage of qualified persons in using a construction materials management method, inability implementation of material management methods, shortage of user-friendly construction materials management method, the thinking that implementing the system wastes the time of project supervisors, the value of a construction materials management method, and the simplicity of manual managing a construction material.

(Yusuf & Tarekegn, 2020), Described the major challenges for material management using centralized procurement in Ethiopia due to lack of effective procurement process; lack of skills of procurement staffs, lack of well-integrated procurement plans, poor procurement planning and management of the procurement process, many public projects were delayed. Whereas Asmare (2016) stated major problems of construction materials management in the building construction projects sites were Weather conditions, management of surplus materials, slow response from the company to the site about submittals, Project delay due to slow delivery of materials and Material Shortage during construction, and Design changes were the most highly identified problems for construction materials wastage.

As stated by (Abraham, 2020), the major challenges of material management in Ethiopian public procurement performances includes Lack of experienced management and procurement staffs, lack of clearly defined key mistake, absence of transparency, and newness of procurement

process with known international or organizational procedure. And also By using centralized procurement, in Ethiopia due to lack of effective procurement process; lack of skills of procurement staffs, lack of well integrated procurement plans, poor procurement planning and management of the procurement process, many public projects were delayed including. (Anshebo, 2017), also identified that material price escalation is the first leveled problem for the cost factor of building public projects in Addis Ababa. (Damte, 2016) Found that the range of material wastage in building construction to be 6.86 % with respect to the project cost. The major Reasons for construction material wastage were Design, Procurement, and Material handling, and also operational, residual and subcontracting can be other causes. Challenges of material identification, planning, vendor selection, procurement and construction phase were root causes for ineffective construction material management in Addis Ababa public building construction projects (Ermias, 2019). (Betelhem, 2017) also stated that in most public building construction projects in Addis Ababa, there were challenges affected supply chain management that led to time and cost overrun; public authorities procure and deliver materials to the project site. (Abdurezak and Neway, 2019), identified Shortage of availability of imported construction materials and goods on market is a challenge on public building; and recommend that preparation materials procurement plan and state the lead time ahead for imported construction materials to minimize the delay caused from shortage of the imported resource.

According to (Adamu, 2021), public construction project has weak practice of material management methods. public building construction projects in Addis Ababa, materials management is suitable a serious problem especially on and no attention is given to such basic subject (Ermias, 2019).

(Meberatie & Bahiru, 2023), stated major challenges of management public building construction projects identified the following lack of coordination among crews, lack of adequate storage space for materials, misuse of specifications.

## **2.10 Strategic tools to improve construction materials management in public building by public construction companies**

Traditional management methods take additional time, make available errors, and demand labor (Ibrahim et al., 2020). The Sevier challenges faced by traditional material management methods

include Time consumption, Shortage of information, Intensive labor resulting in more errors, Paper-based usage, and Undelivered materials.

A study by (Spillane, et al., 2023), in UK labelled the strategic tools of construction materials management and techniques for confined project site including Space scheduling, Just-In-Time delivery techniques, Pre-fabrication and pre-assembly, providing adequate storage, and Effective design site layout.

According to (Meberatie and Bahiru, 2023), the following activities and procedures stated for Effective Material management of public building projects.

**Fast response from the consultant engineer to the project inquiries avoiding:** Avoiding the consultant team's slow response to the contractor's inquiries, Strong transport system, Present details according to quality, quantity, and specifications, and the consultant team should adept inspections and testing, early purchase order, monitoring of materials distribution systems.

**Effective Procurement process:** Early and complete deliveries Responsibility to procure materials, Using procurement policies and guild lines, Availability of storage space for procurement documents and Reducing the characters of corruption (document manipulation), usage of updated information regarding material procurement, purchases with checking the specification of materials, and selecting the best option of procurement methods.

**Prepare good communication and coordination among crews:** Establish harmony and good coordination between all the employees of the material management department, Good coordination and communication with crews, and clients on the basic construction process, Better coordination among purchase and finance department.

**Adequate storage space of materials:** Coding and cataloging of materials/ stores classification, veranda, and everywhere, Arranged based on KAIZEN principles Use the clear set of material return technique, Not be store in the walkways, , stacked as per the specification of the vendor or manufacturer.

**Related construction materials with requested materials (use of standard specification):** Provides better control of the site and more protection for work during the early stages of the contract, having accurate and good specifications for materials, Minimizing design changes, and complete contract documents at commencement of project.

Strategic tools for the effective construction materials management described by (Albert et al., 2017) includes such as Receiving and inspecting materials on site, Storage and issuing of materials to construction location, Complete quality records of materials, Established material management system to be used, Documentation, Construction activities and schedule of Materials, Proper materials handling, Determine the daily allocation of materials on site, Record receipt of goods upon delivery, Monitoring of materials distributed, Timely Placing of orders for materials, Ensure quality assurance/control processes are in place, Logistics for tracking & transportation of materials to site, Assigning of material codes, Education/training/enlightenment of staff in charge of materials management, Make the store safe from theft and Vandalism, Materials return to be submitted weekly, Special security agents and Usage of qualified construction professionals.

(Spillane, et al., 2010), suggested strategic tools to the confined site including 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 utilization of space scheduling so as to maximize the usage of the available space, The utilization of pre-fabrication and pre-assembly of materials prior to reaching site, Providing adequate storage of materials on-site, The effective design site layout so as to aid in the management of materials on-site, The use of Just-In-Time delivery techniques to Minimise the volume of materials on-site, The installation of tower cranes on-site to aid in the movement of materials, Executing a traffic management plan to aid in the movement of materials on-site, The effective management of material waste on-site, and The installation of material hoists on-site to aid in the movement of materials.

### **2.10.1 Material requirement planning strategies**

According to (Arnold, 2008), Material requirements planning (MRP) is the system used to avoid missing parts from must materials to be available in the right quantities and at the right time to meet the requirements of the project. Material requirement plan is establishes a schedule (priority plan) displaying the components required at each level of the assembly and, based on lead times, calculates the time when these components will be needed. The two objectives of Material requirements planning are to determine requirements and keep priorities current. Determining requirements objective is to answer questions what to order, how much to order, when to order,

when to schedule delivery, and keeping priority current is that the demand for, and supply of, components changes daily; it must be able to add and delete, expedite, delay, and change orders. The activities to be done by a material requirement planner includes; Launch (release) orders to purchasing, Reschedule due dates of open (existing) orders as required, Reconcile errors and try to find their cause, Solve critical material shortages by expediting or re-planning, and Coordinate with other planners, master schedulers, material management activity control, and purchasing to resolve problems.

(Nwankwo, 2022), studied in UK Suggested the strategic tools for Construction materials management includes Information and Communication Technology (ICT) systems (such as barcoding and RFID), proper logistics planning of materials and Just-In-Time (JIT) techniques.

According to (Rabin et al., 2009), Government agencies cannot spend until the budget is appropriated by the legislature and apportioned by the central budget office. As Procurement is a long and time-consuming process, contract planning should begin as soon as the agency need is identified, preferably well in advance of the fiscal year in which contract award is necessary by; Consulting requirements and logistics personnel who determine type, quality, quantity, and delivery requirements. Forming a team consisting of all those who will be responsible for significant aspects of the procurement, such as contracting, fiscal, legal, and technical personnel. Establishing standard acquisition plan formats, if desired, suitable to agency needs. Coordinating with and securing the concurrence of user departments in all planning.

Proper material requirement planning is the properly following and applying the construction project activities such as Quantifying, ordering, and scheduling, adopting a good materials requirement planning, and should be progressively updated (Meberatie and Bahiru, 2023). according to (Sogaxa & Email, 2022), studied on efficient material management strategies for enhancing the performance of SMEs in the South African construction industry. And identified the best strategies to the effective materials management includes Adherence to specifications for materials for construction project, effectively utilization of construction materials, Effective material recording strategy, and Adequate scheduling of construction materials Availability. According to (Gurmu, 2018), long-lead materials identification, procurement plans for materials and materials delivery schedule were the three most significant materials management practices

and others includes Material inspection process, Materials status database and Materials inspection team.

### 2.10.2 Material procurement strategies

Material ordered and delivered on time, Sustainable procurement system, Effective processes for purchasing material, and Worker awareness of budgeted material against available material are strategic tools to improve material management (Sogaxa & Email, 2022). Another major objective of procurement in materials management is to purchase quality materials available at the appropriate place and time, and appropriate budget (Nwankwo, 2022). The study stated that a project managers should to control the procedure and must make sure the standard requirement, quality and timeliness were followed in the purchasing of materials.

**Preparing and processing procurement requests:** it is required to be responsible for the procurement professional with the information and approvals necessary for initiating procurement. Preparing the PR, user departments should consult with the procurement staff. The more the user department consults with procurement professionals, the more precise the document will be. A deficient PR might result including, Need to cancel a solicitation because of improper approvals or lack of funds, Failure to order an economic quantity, Failure to include price-related evaluation factors in the solicitation (Rabin et al., 2009).

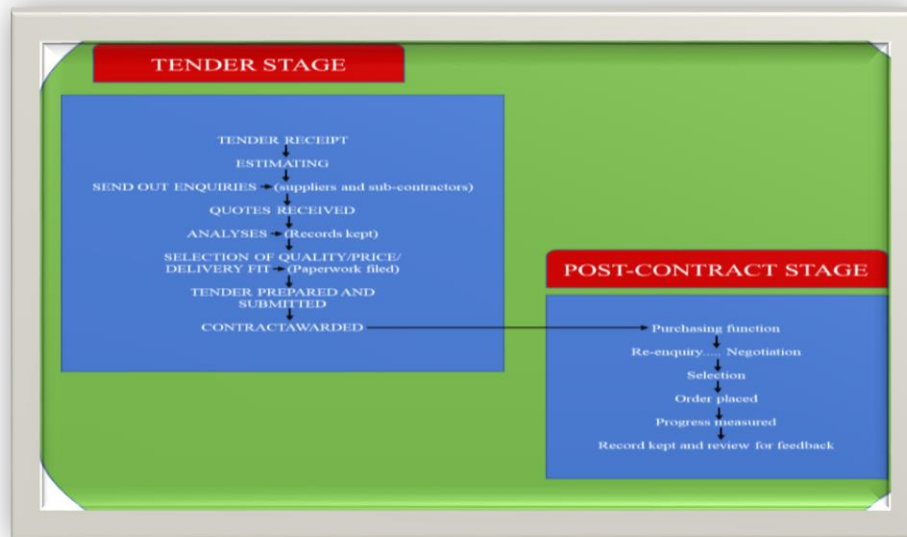


Figure 2.2: typical purchasing procedures. (Nwankwo, 2022).

### **Conducting market research**

The central procurement office researches markets even before developing new requirements documents for an acquisition by user agencies, before soliciting offers for acquisitions with an estimated value in excess of the simplified acquisition threshold, and before soliciting offers for acquisitions with an estimated value less than the simplified acquisition threshold when adequate information is not available and the circumstances justify its cost. The extent of market research and analysis will vary depending on the urgency, value, and complexity of the proposed acquisition (Rabin et al., 2009).

### **Developing and reviewing requirements documents**

(Rabin et al., 2009), also stated that in preparing the requirements documents, agencies may select from existing requirements documents, modify or combine existing requirements documents, or create new requirements documents to meet agency needs. To demonstrate that an item has achieved commercial market acceptance, the criteria in the solicitation should reflect the minimum need of the agency; relate to an item's performance and intended use, not an offeror's capability; and include consideration of items supplied satisfactorily under recent or current contracts for the same or similar items such as specification.

(Rabin et al., 2009), stated that a good specification contains elements such as; it identifies the test methods to be used to verify compliance with the requirement, It contributes to obtaining best value at the lowest possible cost using a fair, equitable, and transparent (easy for the public to see and understand) contract award process, It identifies a minimum requirement and It allows for maximum competition (competitive bids).

A specification can include Material and Method of Manufacture Specifications, Engineering Drawings, performance Specifications, Brand Name Specifications, Brand Name or Equivalent Specifications, and Design Specifications.

**Planning for evaluation:** The goal of the procurement is to achieve the "best value" for the user agency in terms of performance, delivery time, and cost while ensuring that all firms submitting offers should be treated in a fair and equitable manner. The procedures are much simpler in sealed bidding, where there is a public bid opening, determination of lowest responsive, responsible bidder, and award on that basis (Rabin et al., 2009).

### **Appointing an evaluation team:**

The evaluation team for public procurement normally consists of professional staff within the government entity. Occasionally, an elected official or a representative from the community can be appointed to the committee, but it is important that the committee include a representative from the central procurement office and the user agency

### **2.10.3 Material storage and inventory control strategies**

Factors for effective material storage includes Coding and cataloging of materials/ stores classification, Use the clear set of material return technique, Not be store in the walkways, veranda, and everywhere, Arranged based on KAIZEN principles, stacked as per the specification of the vendor or manufacturer (Meberatie and Bahiru, 2023). According to (Nwankwo, 2022 ), Materials inventory should be well managed to Reduced ordering cost, Quantity discounts, Price protection, Unreliability of materials supply, Fluctuation in market demand, and Predictability. After the materials safely delivered, they should be added to the stock and recorded to the store. Adequate information about the stored materials need to be recorded by the store keeper to enable easy identification of the material, their quantities, ease of retrieval for use when required materials need to be kept in a safe condition until they are needed in the project operations after they delivered.

Tools like Integrated material management approach among the team on site, effective material recording strategy, and effective management of materials by the use of requisitions are an important strategic tools to improve material management at construction project site (Sogaxa & Email, 2022).

According to (Meding and Management, 2023), the following strategic tools can improve storage and inventory management of material management.

**Adequate storage of materials on-site:** Inadequate storage leads to congested workspaces, where space is a limited factor, resulting in significantly reduced productivity. Providing sufficient storage arrangements coincide directly with the design site layout, which invariably occurs prior to commencing on-site.

**Space scheduling:** it supports in the management of materials and the available space on-site, and it optimizes the site layout by giving particular attention to the inter relationship of the other

facilities on-site. Effective space scheduling and materials management will acquire an initial cost but inevitable result in greater direct cost and time savings over the duration of a project.

**Just-In-Time delivery techniques:** it is the technique that ensure materials only arrive to site just as they are needed. This technique, just-in-time materials management are an important; especially where the space needed for the materials is greater than the space available on-site.

**ABC analysis:** it is an inventory control technique which is very suitable for the construction industry. classification of all materials used in the construction into materials which need highest attention, materials which require medium attention and materials which require the least attention such that the control mechanism be based on selective class of materials is called selective inventory control (Kebede, 2018). According to (Rathinakumar et al., 2018), studied on Construction Material Management through Inventory Control Techniques, applying proper material management can increases the overall efficiency of a project. It suggested ABC analysis and EOQ tools for materials management which used to improve effective materials management.

According to (Mahagaonkar & Kelkar, 2017), ABC analysis have its own procedure to be applied.

**A-items:** have “the highest annual consumption value” of goods i.e. 70%-80% of the annual consumption value of the company. Ironically, it accounts only 10%-20% of the total inventory items. They require stringent inventory control, more protected storage areas and improved sales forecasts, re-orders should be frequent, with weekly or even daily reorder; avoiding stock-outs on A-items is a priority.

**B-items:** are the interclass items, having medium consumption value i.e. 15%-25% of annual consumption value. It consumes around 30% of the total inventory items.

**C-items:** have the “lowest annual consumption value” of goods i.e. 10%-15% of the annual consumption value. On the contrary, it accounts for 50% of the total inventory items.

In the steps of ABC analysis, the unit cost and the demand of each item is obtained over a given period, multiply the unit cost by the calculated annual usage to obtain the net cost, All the items should listed out and arranged in a descending annual cost, Sum up the cost and add up the number of items then, compute percentage on the total inventory of total cost and for total number

of items consumed, Draw a graph of percentage items vs. percentage cost, It safeguards control over expensive items in which a hefty amount is invested, Clerical costs are substantially reduced and stock is retained at optimum level, and Mark from the curve the rational limits of A, B and C categories.

**Economic order quantity (EOQ) analysis:** The EOQ analysis is better technique for avoiding the extra cost of the materials by good management of the ordering construction materials. The EOQ techniques provide right number of order at the right time and the right quantity of the construction materials at the right places, which can reduce or avoids overrun of cost due to materials (Karoriya & Pandey, 2018).

It is the order size that will result in the lowest total of ordering and carrying costs for an item of inventory (Arijeloye & Akinradewo, 2016).

Patil & Pataskar (2021), indicated for Economic Order Quantity can be calculated by following formula;

$$Q = \frac{\sqrt{2 * Co * S}}{Cu * I}$$
, where, Co = Ordering Cost, S = Total Consumption, Cu = Cost of Item, I = Inventory carrying Cost.

Using EOQ has many advantages, cost of a construction project could be reduced with the EOQ analysis Castillo Rodríguez et al., 2022). Joint application of ABC and EOQ analysis techniques on a construction project produces cost savings and prevents material waste.

According to (Umrani & Konnur, 2021) other than ABC analysis, the following inventory techniques can be used.

**HML analysis:** In this analysis, the classification of existing inventory is based on unit price of the items. They are classified as high price, medium price and low cost items (Mitra et.al, 2013).

**VED analysis:** In this analysis, the classification of existing inventory is based on criticality of the items. According to (Chaudhari & Mata, 2016) the items are classified into V (Vital), E (Essential) and D (Desirable) categories. Vital items are the most critical having extremely high opportunity cost of shortage and must be available in stock when demanded. Essential items are quite critical with substantial cost associated with shortage and should be available in stock by

and large. Desirable group of items do not have very serious consequences if not available when demanded but can be stocked items.

**S-curve:** S curve analysis should be done to check the deviations in the planned process to avoid the delay of the project. S curve analysis used to compare planned and actual material consumption. The deviations curve in the S shaped graph produced by the increasing expenditure of certain parameters against time was the representation of project path (Ezhilmathi et al., 2016).

#### **2.10.4 Material handling and wastage management**

According to (Ifeanyi et al., 2022), The strategic tools to improve material management includes Ordering materials on time, ensuring effective quality assurance and control, using the right logistics to track and deliver materials to the job site, and receiving and checking materials once they arrive; storing and distributing goods to the construction site; complete materials quality records; establishing a framework for managing materials; Construction activities and timetable of materials; materials documentation; record receipt of delivered products; monitoring of disseminated materials; assignment of material codes; proper handling of materials; secured storage from theft and vandalism; submission of returned materials every week; deciding how often things will be distributed and retrieved on the property; Utilizing qualified construction professionals, special security measures, and training the people responsible for managing the materials.

(Joy, 2008), divided Materials handling at construction site in to two categories. The first one includes unloading from Lorries, and stacking in the storage yard, transport from the yard to the site, the unloading at the site, shifting hoisting of heavy contract materials. This handling requires hoisting and transport machinery and facilities like tracks, loading unloading attachments, cranes and tractors.

Handling of light and medium stores. This handling type requires well barrow, trolleys and fork-lift tracks.

**Codification:** Codification helps easy identification, description and accounting, both manually and by computer. Codification may be done alphabetically or alphanumerically, or numerically the classification shall done on the basis of category of materials, end use, and type.

**Standardization:** it was the effort in the direction of variety reduction in materials and tools. By the standardization fewer items of stock, and interchangeably, transferability and reduction in working capital.

**Record keeping and accounting:** important of store records includes: purchase order copies, seller's delivery challans or packaging lists, copies of inspection notes and test certification.

**Reuse, Reduce, Recycle:** According to (Hore, Kehoe, McMillan and Penton, 2010) cited on (Gitau, 2018), for every 100 houses built there is enough waste material to build another 10 houses.

(Sogaxa & Email, 2022), also stated the strategic tools which have an important advantage to improve material management including Integrated material management approach among the team on site, Effective leadership on-site to avoid material wastage, Materials stored in safe areas, Effective management of materials by the use of requisitions, Building relationship with construction material suppliers.

**Lean thinking:** (Ballard, 2004), stated the lean principle as using the following techniques;

Use of a web-based tool designed based on the Last Planner System (LPS) to control production on site on a daily basis increasing workflow reliability, therefore reducing demand variability. Using planning tools such as process mapping and scheduling are required to properly manage workflow.

Link the web-based tools with material management process. The other implementation of logistic center. The technique using logistic center where materials from different supply systems are assembled in packages before they are delivered to project sites.

Deliver assembly packages based on pull from site. The use of a web-based production control tool will provide the mechanisms and signals to trigger deliveries from LCs to site. This way the assembly packages will not be pushed to site without explicit request from site based on daily production plans. Materials waste in the system will be reduced and the use of space can be better controlled. Define, design, and implement standardization and pre-assembly strategies. Pre-assembly can be performed at LCs or at suppliers' facilities as appropriate. And Minimize material lead times and inventories not needed to absorb variability.

**Green supply chain management:** In the world, buildings account for approximately 40% of CO<sub>2</sub> emissions, 40% of natural resource consumption, and approximately 40% of waste generation, which was disposed to the environment. A study in Australia (Lassio et al., 2016), recommended green supply chains management and life cycles to assist in making environmental decisions. The sustainability concept includes the choice of materials, the construction methods, and the use, operation, and demolition of buildings. Sustainability can be done through the Life cycle assessment and LCA methodology. (Kasim et al., 2005), stated the benefits of using materials management based on fast-track projects applying bar coding construction; which includes Extra space for the site compound, Maintain good vertical site access, Keep the site compound well surfaced, well organized, clean and tidy, Good access for material, Delivery of bulk materials in large.

#### **2.10.5 Application of information communication technology and current emerged advanced technology**

(Kasim, 2008), assess all the material management processes with problems and practice; and recommended implementation of ICT that can help the management of construction activities to become more effective and faster. ICT Increased with new software related to the construction industry and can support the effective management of materials practices. The emergence of ICT methods could transform conventional methods and improve materials management.

According to (Kasim, et al. 2008), the application of information technology practices such as database is an important to improve material management on construction site. Application of the following strategic tools used to improve material management on construction projects includes; Construction Materials Planning System (CMPS) - for planning of construction materials to achieved the right materials in quantities, time and meet the work programs; Material Handling Equipment Selection Advisor (MHESA) for material handling equipment selection; Construction Materials Exchange (COME) E-Commerce system for material procurement; and Bar-code system for material storage application. As stated on the study strategic tools to construction materials management that were identified for fast tracking projects compressed of Extra space for the site compound, Maintain good vertical site access, Keep the site compound well surfaced, well organized, clean and tidy, Good access for material/plant deliveries, Delivery of bulk materials in large. From the findings, I observed that implementation of IT are a good

strategic tools to improve materials management on construction projects. The study was consider only for fast tracking project types, while it is an important tool for this study of public building construction projects material management improvement.

Information and Communication Technology (ICT) is a wide-ranging term that includes all technologies for the manipulation and communication of information including more sophisticated solutions of ICT based technologies are emerging such as wireless communication, bar-coding and radio frequency identification (RFID) for tagging technologies. Thus, an appropriate implementation of ICT could (Kasim & Ern, 2011).

In Malaysia the main tools that were implemented in the materials management processes are the Microsoft Offices and handheld devices. In Malaysia, the applications of Microsoft Offices, walkie-talkie and mobile phone were widespread in the construction industry. Microsoft Excel and Microsoft Project are the most common ICT tools in the current industry's practice. They were perceived as the less costly ICT tools that contractors could afford investing in. However, bar-coding and RFID were tools under the category of sophisticated ICT tools to improve the materials management (Kasim, 2011).

(Nwankwo, 2022), described the implementation of Information and Communication Technologies (ICT) that can aid the construction activities management to be more effective and quicker. It showed that the conventional methods could be transformed, and materials management improved through the advent of Information and Communication Technologies (ICT) systems. ICT-enabled solution could overcome the challenges of material management.

**Pre-fabrication and pre-assembly:** The leading strategy highlighted in the effective materials management on confined construction sites is pre-fabrication and pre-assembly. The leading advantage is ‘‘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 (Meding and Management, 2023).

**GIS and BIM technology and the internet of things (IOT):** The Internet of things is a network of interconnected things. It was used for the collection, analysis and management of multi-source information, automated monitoring and early warning. GIS and BIM+IOT technology can carry out real-time monitoring, positioning and data analysis of the construction site, such as equipment

monitoring, material testing, climate and environment monitoring, noise monitoring, dust monitoring and personnel distribution (Han et al., 2020).

**Radiofrequency identification (RFID):** According to (Hannan et al., 2011), RFID was designed to enable readers to capture data from tags and transmit it to a computer system without any physical connection at a range of radio frequency. An RFID system consists of three components: an antenna, a tag, and a reader. The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna. It was more used to solve the management process problems fronting material management construction sites and facilitate tasks for project managers (Ibrahim, 2020). RFID-aided tracking system can use to Improve Work Efficiency. In Australia, a study (Moon et al., 2018), confirmed that using RFID-Aided Tracking System can increase work performance. It stated that productivity could be improved by 10% compared to the conventional method. RFID has the potential to facilitate materials management processes for large scale projects, particularly with regard to the capability to store a large amount of data compared to bar-coding (N. Kasim et al., 2006).

**Web-based material planning and control (WB-MPC):** The purpose of the web-based material planning and control (WB-MPC) model is to have an inter- active web-based interface which allows construction professionals to be able to estimate and store building material quantities, while planning and controlling the usage of building materials per time. Web-based material planning and control (WB-MPC) model have an interactive interface which allows construction professionals to be able to estimate and store building material quantities, while planning and controlling the usage of building materials per time Afolabi et al. (2017). The study recommended the use of web-based technologies in the construction industry in order to engender administrative efficiency, transparency, openness and accountability. Web-Based Material Planning and Control (WB-MPC), whose purpose is to rely on an interactive interface that allows constructors to calculate and store materials and, at the same time, to plan and control their use (Rodríguez et al., 2022).

**Enterprise resource planning (ERP) system:** Enterprise resource planning (ERP) systems provide the transactional tracking and global visibility of information from within a company and across its supply chain. This real-time information helps a supply chain improve the quality of its operational decisions. ERP system keep the track of the information, whereas the Internet

provides one method with which to view this information (Chopra, 2013). The adoption of enterprise resource planning (ERP) systems as standardized systems that encompass the activities of an entire enterprise has become an important factor for today's construction. The demand for ERP applications has increased for several reasons, including competitive pressure to become Low-cost producers, expectations of revenue growth, and the desire to re-engineer businesses to respond to market challenges. A properly selected and implemented ERP system offers several benefits, such as considerable reductions in inventory costs, raw material costs, lead time for customers, production time, and production costs (Leyh & Thomschke, 2015).

**BIM technology material management:** Building information modeling BIM, is based on the relevant information data of construction projects to establish the building model. Through digital information simulation, it can simulate the real information of the building, collect the information of the construction process and manage the whole life cycle of the building. It has eight characteristics (Kuppusamy & Chew, 2021). BIM Technology in the whole process of implementation, and the material management under BIM Technology studied by Wu (2020) found that based on the BIM construction material dynamic management practice can improve the on-site construction management, materials can produced on demand, order delay is avoided, delivery efficiency is improved, visual dynamic management is realized, construction plan is optimized, control of progress and cost is effectively improved, and fine construction management of the project is promoted. Technology to manage green building materials can strictly control every link involving the use, purchase, inventory management and later maintenance of green building materials, so as to maximize the utilization rate of green building materials and reduce the maintenance and management costs of green building materials (Kuppusamy & Chew, 2021). According to (Nwankwo, 2022), the other technologies used for construction management were described such as; Expert System Advisor for Concrete Placing (ESCAPE) which aids in planning and controlling concrete-placing operations without assistance of experienced personnel in charge; Industry 4.0 described the growing trend towards automation and data exchange in technology and processes within the manufacturing industry; Construction Materials Planning System (CMPS) applied in planning for the use of construction materials to attain the right materials in terms of meeting the work programs in time and quantities, Construction Materials Exchange (COME) for improving effectiveness and efficiency of materials procurement process in construction; and virtual Construction Material Router

(VCMR) - for supporting planners and site managers during complex construction on the site and to enable decision support system for material movement.

### **2.11 Gap of research**

The study have been reviewed literatures from developed countries, developing countries and local practices of construction materials management, challenges for the effective implementation of construction materials management and different strategic tools to improve construction materials management. it has been understood that the developed countries such as USA, UK and Australia were practiced a very well construction materials management techniques especially emerging technology applications and automated systems for management of construction materials at construction sites. Developing countries like china and India also more better exercising the current technologies and other systems to improve the construction materials management. On the other hand in Ethiopia the construction materials implementing traditional and paper work construction materials management especially on public building constructions, the purpose of the research is so to narrow the gap of that the construction materials management system and improve the materials management system in construction projects. So that this study was assessed the practices and Challenges of the public building construction materials management in Ethiopian construction works corporation.

Most studies in Ethiopia showed that technologies not used without Ms. Excel and Ms. Word; this study is different from those studies which assured that CCTV camera was implemented for construction materials management that indicates current technologies are started to be used.

The other factor which make this study to be unique from other research studied was that it was conducted only public building projects constructed by one single contractor ECWC. There was no any study conducted on construction materials management at the company. It is also unique by using practices from developed countries, developing countries and local practice as references and experiences.

## CHAPTER III: RESEARCH METHODOLOGY

### 3.1 Study area

The study area was Addis Ababa which is a capital city of Ethiopia. It is found in the central part of the country. The study area, Addis Ababa, has 14,788.78 square kilometers, and the geographical coordinates located between 9°1'48"N 38°44'24"E longitude and an elevation of 2,355 meters (7,726 ft.) above mean sea level. It is found on the highland which has an average temperature of 20°C.

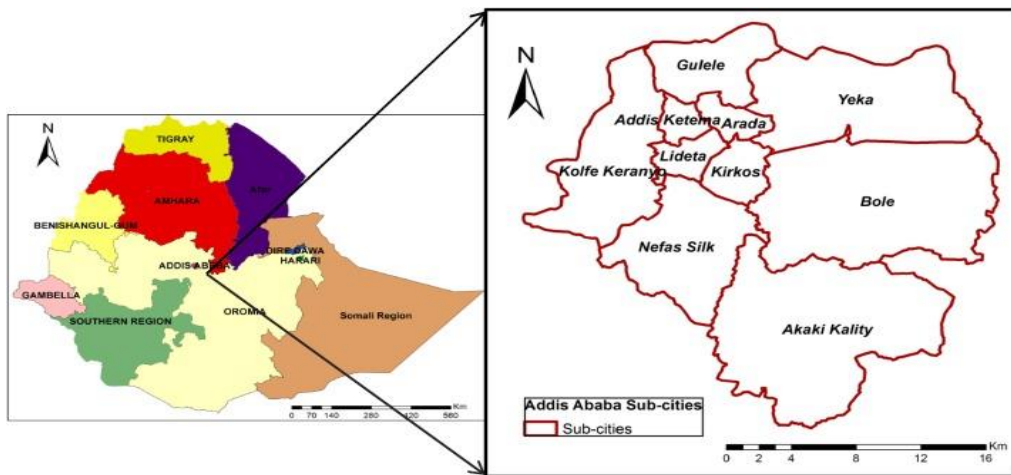


Figure 3.1: location map of the study area. (Science direct.com)

### 3.2 Research design

This research was started from observing the construction projects delay due to Materials delivery problems and followed reading a literature review about construction material management in global concepts and practices in detail up to the current technology used for material Management, including general concepts of construction material management, the practices of construction material management and the challenges to the effective construction material management.

This research was conducted both descriptive and explanatory research types as it was describe what construction materials management practices are applying; and what challenges of construction material management found to the application of public building construction projects; and after the data systematically recorded and analyzed further implication was conducted in detail.

### 3.3 Source of data

Both quantitative and qualitative data was taken from both primary and secondary sources of data to gather the necessary information.

### 3.4 Sampling design

#### 3.4.1 Sample population

The research population was drawn from the building construction sector of Ethiopian Construction Works Corporation employed in an engineering department and procurement team members that is working at the project site was included as a population.

#### 3.4.2 Sample size determination

The sample size was calculated by using a formula obtained from (Kebede, 2018).

$$n = \frac{m}{1+[m-1]/N} \quad \text{eq. 1}$$

Where  $n$ ,  $m$ , and  $N$  = the sample size of the limited, unlimited, and available population, respectively, and  $m$  estimated by eq. 2

$$m = \frac{Z^2 * p * (1-p)}{e^2} \quad \text{eq. 2 where } Z \text{ is the static confidence level, i.e., 2.575, 1.96, 1.645, for 99\%,}$$

95%, and 90% confidence levels, respectively,  $p$  is the value of the population proportion that was estimated,  $e$  is the sampling error of the point estimate; Sincich et al. (2013), cited on (Kebede, 2018), propose a conservative value of 0.50 used so that a sample size that is at least as large as required by obtained. By using 90% confidence level, i.e., 8% significance level, the unlimited sample size of the population,  $m$ , is approximated as follows:

$$m = \frac{1.645^2 * 0.5 * (1-0.5)}{0.08^2} = 105.70 \text{ and}$$

$$n = \frac{106}{1+[106-1]/400} \approx 63$$

70 questionnaire was distributed to take the sample size of 63.

#### 3.4.3 Sampling technique

Generally, purposive sampling technique was used to select a representative sample from the population. The sample was purposively selected from the project staff members of the

engineering department that are working on public building projects which were assumed to had the materials management problem. From those the sample was taken from 14 public building projects constructed by the corporation in Addis Ababa.

Table 3.1: Selected project sites

<b>No.</b>	<b>Project name</b>	<b>Project location</b>	<b>Client</b>	<b>Consultant</b>	<b>Contract Amount ETB.</b>
1	KKGGH lot-2	KK W/10	AACDA CB	ECDSWC, BUDSWS	467,479,494.94 (revised)
2	G+4 Apartment Buildings Construction Project	Nifas Silk Lafto Sub-city W/02	AACDA CB	ECDSWC, BUDSWS	103,500,000.00
3	FDARA 4B+G+21 Head Quarter Office Building	Mexico	FDARA	YACAE	1,434,323,142.4 9 (original)
4	Construction of Cattle Market (Rehabilitation) lot-1	Bole W/10	AACDA CB	EKCA&E	705,812,099.94
5	Kolfe G+5 Urban Health Center	KKSB W/02	AAHB	AAD&CA	173,253,376.38 (rev.)
6	FEDRE HoPR Renovation Work	4-Killo	FDRE HoPR	ECDSWC, BUDSWS	133,908,247.94
7	Nifas Silk Lafto Hospital building project lot-1	Nifas silk sub city	CGAAD & CWB	ECDSWC, BUDSWS	947,936,784.39
8	Livestock and related shades works phase two	Bole W/10	AADCB	DCDE	788,751,557.15 (rev.)

9	KKGH lot- 1	KK W/10	AACDA CB	ECDSWC	2,432,186,949.7 2 (revised)
10	Ministry of revenue renovation project	Bole sub-city (megenagna)	FDRE MoR	ECDSWC	711,018,482.42
11	YPSDTP	Yeka sub city	PSTB	YACAE	275,451,050.52
12	AATA 2B+G+9 & B+G+7 HOSPITAL Building project	Yeka sub city (kebena)	AATA	AACDBC E	443,210,572.83
13	Jemo public Service Depot project	NSLSC	PSTB	YACAE	239,049,835.10
14	AKPSDTP	Kality sub city	>>	>>	239,049,835.10

#### 3.4.4 Method of data collection

The primary data was collected through a method of questionnaire and field survey. During field survey informal interview was used as a support to get clear information on the material management practices which were observed during site survey. Questionnaire containing four sections was distributed to 14 purposively selected public building project staffs and the data was collected. Field observation informal interview on the management of material on the public building construction projects was conducted parallel to the questionnaire distribution. The secondary data was collected through literature review; which provided knowledge on how the concept of the material management practices. Also procurement manuals and recorded report documents were seen to get information which was supported the study.

#### 3.5 Method of data analysis

After both the primary and secondary data was collected, Likert scales was used, which involve ranking or rating data that uses integers in ascending or descending order. Numbers (1, 2, 3, 4, 5) assigned ranks from strongly disagree to strongly agree are Responses obtained from the

questionnaires. These ranked numbers was collected and entered into a software Excel spreadsheet and the data was categorized based on their similarity for simplicity. An analysis of all answers was undertaken with the results with relative importance index (RII), and interpreted in detail. According to (Kebede, 2018), and (Ayegba, 2013), RII can be calculated;

$RII = \frac{\sum W}{A * N}$  Where, the limits of definition of RII were:  $0 < RII < 0.25 =$  Strongly Disagree,  $0.25 < RII < 0.50 =$  Disagree,  $0.5 < RII < 0.75 =$  Agree and  $0.75 < RII < 1 =$  Strongly Agree;

W the weight given by the respondents to each factor, it ranges from 1 to 5

A the highest weight (5 in this case)

N the number of respondents in total

### 3.6 Method of data presentation

The analyzed data are presented using tables and charts.

### 3.7 Validation

Research questionnaire was reviewed by the advisor of the study and two public building managers, two site engineers and two office engineers from the company requested to check the suitability of the questions, and language (style of expression), and Questionnaire was distributed after taking comments and suggestions from the pilot test.

### 3.8 Reliability

A Standardized formula of Cronbach's alpha was used to check the reliability of data. (Keith S.Taber, 2017), cited on (Kalkidan, 2021), If the Cronbach's alpha result is below 0.5, it indicate that the items are inappropriate; while if Cronbach alpha's resut is greater 0.5 it is acceptable.

Cronbach alpha's formula;

$$\bar{\alpha} = \frac{N * \bar{c}}{\bar{v} + (N - 1) * \bar{c}}$$

Where N is equal to the number of items,

$\bar{c}$  Is the average inter-item covariance among the items; and

$\bar{v}$  Equals the average variance.

Table 3.2: Reliability on Material management practices

<b>Material management challenges</b>	<b>Number of Items</b>	<b>Cronbach's Alpha value</b>
Practices on materials requirement planning	9	0.902
Practices on procurement	16	0.731
Practices on delivery and Transporting	4	0.812
Practice on storage and inventory management	8	0.781
Practices on material handling and waste control	11	0.814
Practices on Implementation of Information Communication Technology (ICT) and current emerged technologies	9	0.710

Table 3.3: Reliability on Material management challenges

<b>Material management practices</b>	<b>Number of Items</b>	<b>Cronbach's Alpha value</b>
challenges on material planning	8	0.813
Challenges on procurement	11	0.839
Challenges on material storage and inventor control	5	0.851
Problems on material handling and wastage management stage	14	0.773
Challenges on the application of current emerged technologies	10	0.880

Challenges on Implementation of Information Communication Technology (ICT) and current emerged technologies	9	0.710
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Table 3.4: Reliability Strategic tools on construction material management

<b>Strategic tools to improve public building construction material management</b>	<b>Number of Items</b>	<b>Cronbach's Alpha value</b>
Public building Strategic tools	14	0.756

## CHAPTER IV: DATA ANALYSIS AND DISCUSSION

### 4.1 Response rate and general background of respondents

#### 4.1.1 Response rate

For of 14 sites a total of 70 questionnaire, 5 for each project were distributed. Accordingly 67 questionnaire were answered in which 96% of the questionnaires were replied.

#### Questionnaire’s response rate

Table 4.1: Percentage of questionnaire respondents

Questionnaire	Frequency			Percentage %
	Male	Female	Total	Total
Number of distributed	50	20	70	100%
Accepted responses	49	18	67	96%

Source: Field survey (2023)

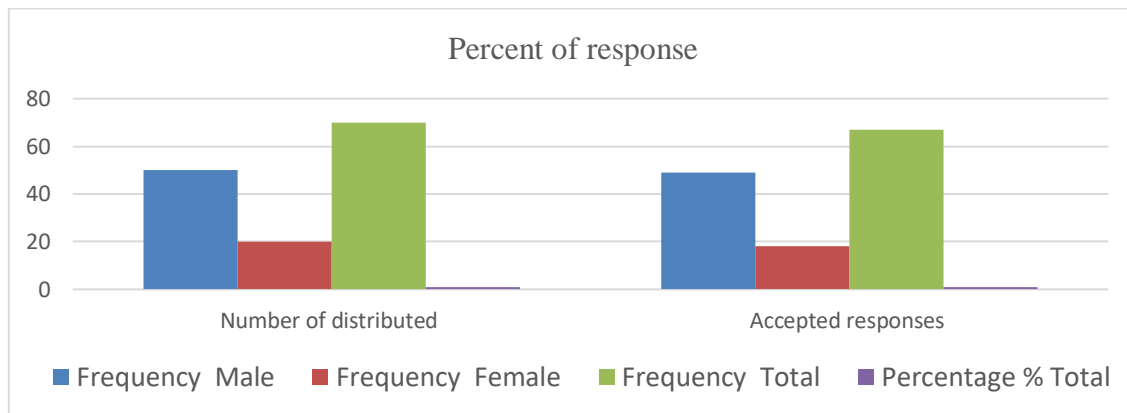


Figure 4.1: Chart to show distributed vs. responded. Questionnaire survey (2023)

#### 4.1.2 Background profile of respondents

The respondent’s gender, age, education qualification, experience, and project name, project size and type of contract implemented are presented in sections below:

## Respondent's gender

Table 4.2: Respondent's Gender and position of work

Respondents	No. /Frequency			% from Total
	Male	Female	Total	
Project Manager	6	1	5	7%
Procurement management leader	5	1	6	9%
Engineering service team leader	5	4	9	13%
Work execution team leader	7	2	9	13%
Site Engineer	17	4	21	31%
Office Engineer	9	8	17	25%
<b>Total</b>	<b>49</b>	<b>20</b>	<b>67</b>	<b>100%</b>

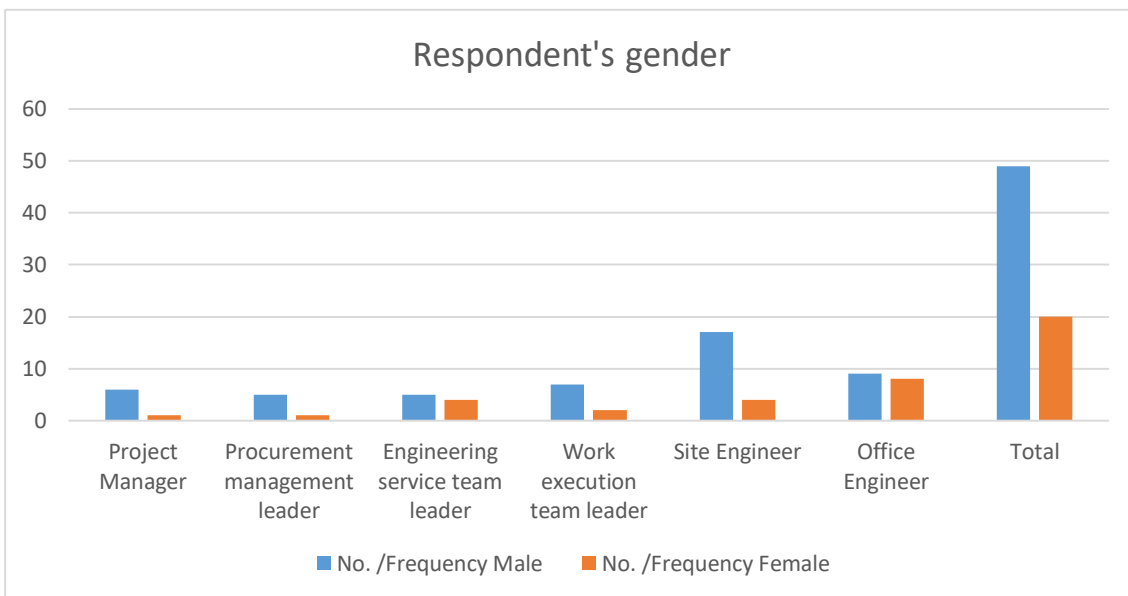


Figure 4.2: Respondent's Gender and position of work

From the respondents 27% are female and 73% male as shown on the figure 4.2 above.

### Respondent's work experience

Table 4.3: respondent's Work experience

Respondent's years of experience	No. /Frequency			% from Total
	Male	Female	Total	
0– 5Yrs,	23	16	39	58%
6 – 10Yrs,	16	3	19	28%
11 – 15Yrs,	5	1	6	9%
16 – 20yrs,	2	0	2	3%
Over 20yrs	1	0	1	1%
<b>Total</b>	<b>47</b>	<b>20</b>	<b>67</b>	<b>100%</b>

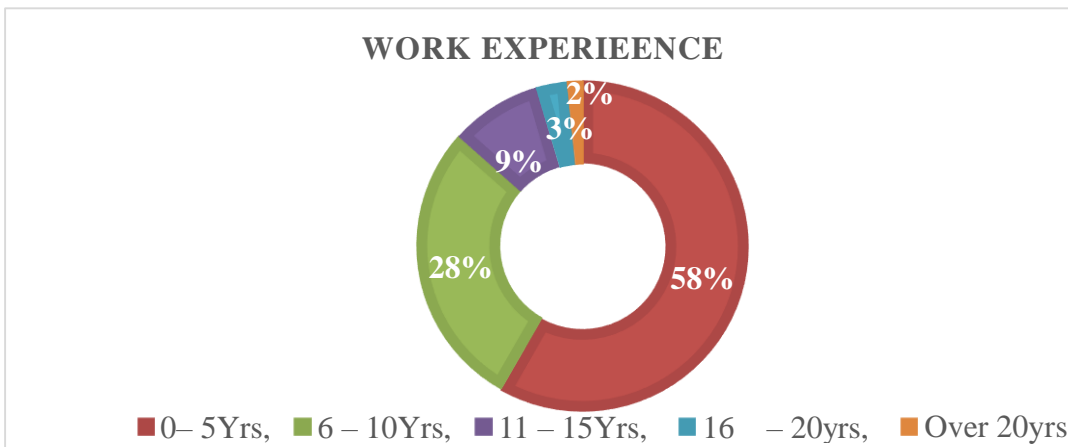


Figure 4.3: Respondent's work experience

As shown on the figure 4.3 site engineers and office engineers are the highest and second highest responses with 31% and 25% respectively.

### Respondent's qualifications

Table 4.4: Respondent's qualifications

Respondent's qualifications	No. /Frequency			% from Total
	Male	Female	Total	
Below diploma	0	0	0	0%

Diploma	0	0	0	0%
Bachelor Degree	36	15	51	76%
Master Degree	11	5	16	24%
Doctoral	0	0	0	0%
Degree and above			0	0%
<b>Total</b>	<b>47</b>	<b>20</b>	<b>67</b>	<b>100%</b>

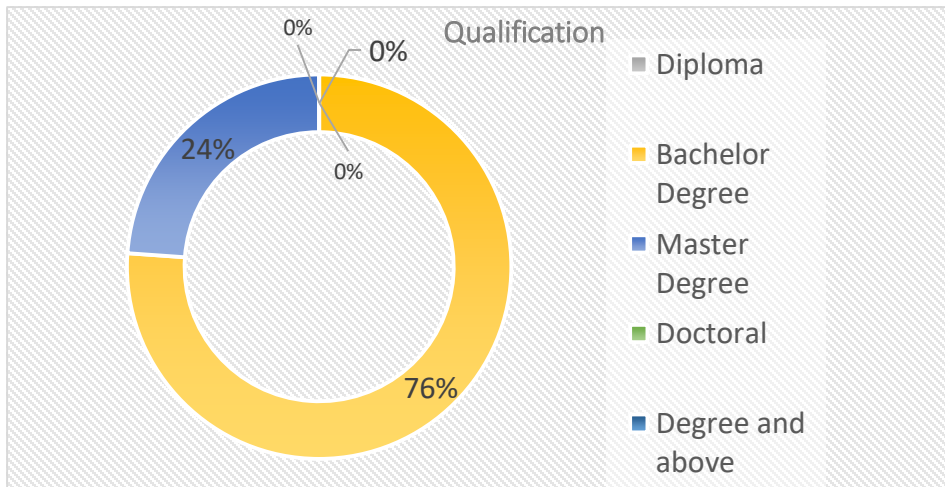


Figure 4.4: Respondent’s qualifications

The high percentage from respondents are bachelor degree with 76% and master’s degree with 24% no other qualification found below diploma, diploma, and doctoral degree and above.

### Respondent’s Age

Table 4.5: Respondent’s Age

Respondent’s Age	No. /Frequency			% from Total
	Male	Female	Total	
18-25yrs	24	16	40	60%
26-35yrs,	15	3	18	27%
36-45yrs	5	1	6	9%
Above 46	3	0	3	4%
<b>Total</b>	<b>47</b>	<b>20</b>	<b>67</b>	<b>100%</b>

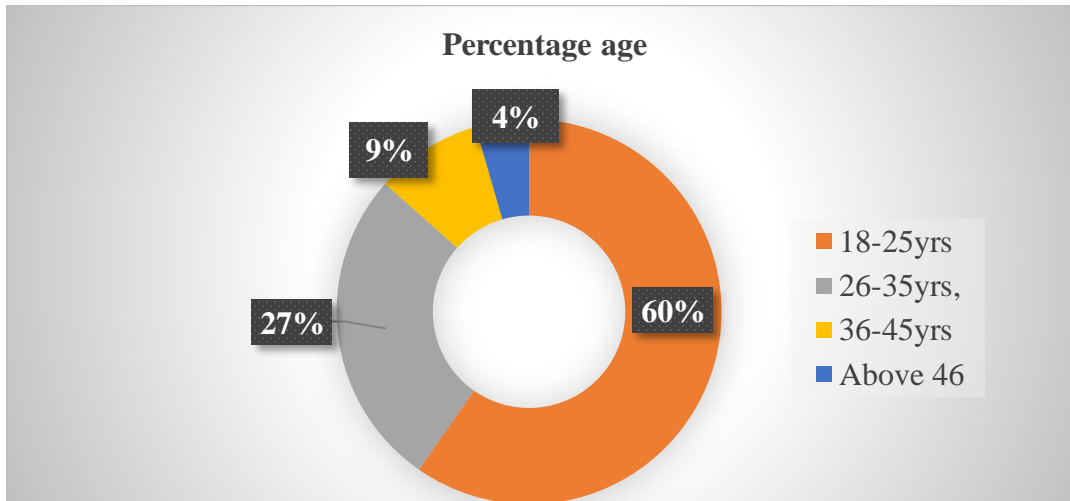


Figure 4.5: Respondent's Age

60% of the respondents are young with 18-25 years old; followed by 27% 26-35, 9% 36-45% and 4% 46 and above as shown on the chart clearly.

### Project size

Table 4.6: Project size

Project Size	Frequency	% from Total
Small-size project (contract amount between 0 and 150 Million)	2	14%
Medium size project (contract amount between 150.01Million and 300 Million)	4	29%
Large project (contract amount above 300 Million)	8	57%
<b>Total</b>	<b>14</b>	<b>100%</b>

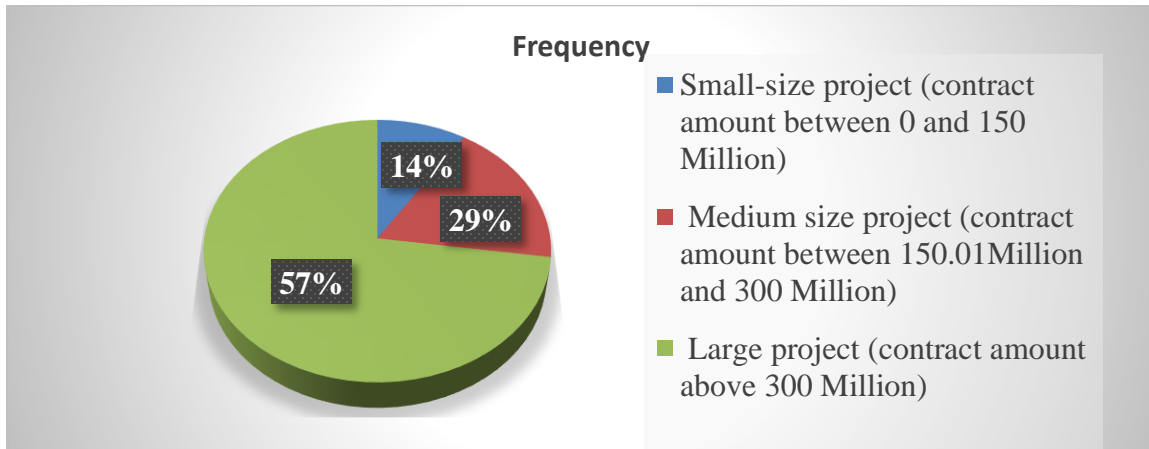


Figure 4.6: Project size

Most projects are large size which is more than 300 million contract amount with 57% and followed by 36% and 7% respectively medium and small project sizes.

#### 4.2 Practices of public building construction materials management in the study area

The summary of the practices of construction materials management in public buildings is shown in Table 4.7.

Table 4.7: Public building construction materials management practice

No	Material management practices	RII	Rank
1.	Paper-based Exchange of information and recording relating to material management procurement	0.944	1
2.	Computer-based materials management system integrated with CAD, scheduling, and accounting systems	0.818	2
3.	The project purchases from government suppliers	0.788	3
4.	Application of Long-Lead Materials Identification	0.786	4
5.	Implementation of Ms. Excel and Ms. Word	0.755	5
6.	Application of bulk Method of purchasing and forward buying system at least for one year	0.723	6

7.	The project has an appropriate transportation facility for material logistics	0.723	6
8.	The project has a good relationship with material suppliers	0.692	8
9.	Implementation of Ms. Project	0.692	8
10.	Following up on material prices in the market	0.661	10
11.	Application of CCTV camera	0.639	11
12.	Implementation of KAIZEN principle	0.629	12
13.	Application of the competitive weighted average method of Procurement, consistent with quality at the lowest possible cost	0.629	12
14.	Daily recording of consumed materials in the project	0.629	12
15.	Implementation of off-site construction system	0.629	12
16.	The project has to implement a training and communication plan	0.598	16
17.	Proper storage System, Proper planning, controlling, and monitoring of material	0.598	16
18.	The project has to plan for material receipt and storage	0.594	18
19.	There is a regular internal and external auditing system for materials	0.586	19
20.	The project has a proper Waste management system and Wastage minimization techniques	0.566	20
21.	Application Bulk materials planning	0.566	20
22.	The project has to implement procedures to manage suppliers and apply a formal supplier evaluation system	0.566	20

23.	Application of proper material procurement system	0.535	23
24.	A separate procurement plan and schedule for long-lead materials	0.535	23
25.	The project has to plan the logistics of material at site mobilization and Construction time	0.535	23
26.	The project has good material handling system and management of surplus materials	0.535	23
27.	Implementation of site materials production (pre-cast)	0.518	27
28.	The project has a good Material estimation, budgeting, planning, and programming systems	0.516	28
29.	Reuse, Reduce, Recycle Practices	0.515	29
30.	Adequate supervision in the usage of materials	0.503	30

As shown in table 4.7 above the survey on construction materials management practices, 30 major items were significantly applied that is ranked based on Relative importance index. From the 30 significant practices the top 20 practices are detail explained by adding information taken from informal interview during field survey.

The first ranked practice is Paper-based Exchange of information and recording relating to material management and procurement with RII=0.944 which showed that the communication among all stakeholders is manual and paper based; the second practice implementing is Computer-based materials management system integrated with CAD, scheduling, accounting systems with RII=0.818 which means, the application of computer to quantify with Cad interface, plan, schedule and for accounting systems. Project purchases from government suppliers is the fourth practice currently implementing with RII=0.788. the researcher have taken information by informal interview during project field survey and major construction materials such as reinforcement bar, ready mix concrete are purchasing mostly from government supplies. The purchasing manual of the corporation also gives priority to purchase first from government suppliers. The other practice is Application of Long-Lead Materials Identification with RII=0.786 ranked as fifth. Materials with high price are such as cement, reinforcement bar,

Concrete, and finished materials are known in common practice. Such identified high unit price construction materials are requested from projects and purchased by head office. Implementation of Ms. Excel and Ms. Word is the sixth ranked practice having RII= 0.755. Ms. Excel and Ms. Word are implementing to record materials and prepare schedules and write letters to formally communicate with stakeholders. Application of bulk Method of purchasing and forward buying system at least for one year is seven ranked construction materials practice currently implementing to all public projects of the corporation which have RII=0.723. All projects required to request major construction materials such as reinforcement bar, cement, finishing materials. for one year ahead, and head office planned budget for the requested materials and purchase with open bidding with minimized price in bulk. Especially finishing materials are purchasing in bulk even not only one project, but collecting same materials requirement from different projects. Having an appropriate transportation facility for material logistics is also ranked seventh with RII= 0.723. Transportation for materials logistics has a department which is facilitating for all material purchased to the site. The corporation has its own equipment and vehicles department to facilitate the materials logistics. Ninth ranked construction materials management practice contains Good relationship with material suppliers and Implementation of Ms. Project. Both items have a relative importance index RII=0.692. Mater schedule is prepared with Ms. Project. Other schedules, daily, weekly, and monthly are prepared mostly with Ms. Excel. All most all projects have good relation to the materials suppliers and sub-contractors so that the suppliers supplied materials by debit that will pay a least for three months and above after the materials are received and consumed. Following up on material prices in the market is the eleventh ranked practice, RII= 0.661; a market survey implemented regular monthly from head office and send to all projects to be used. The twelfth and thirteen ranked practices were Application of CCTV camera and Implementation of KAIZEN principle at project site with 0.639 and 0.629 respectively. CCTV camera is implemented for large size projects to follow up the materials on stock and also following up the project progress from head office.

Application of the competitive weighted average method of Procurement, consistent with quality at the lowest possible cost, an Daily recording of consumed materials in the project were ranked fourteen with RII=value of 0.629. All the three items have same RII value and ranked fourteen, but it was believed that these items should more practiced. Implementation of a training and communication plan and Proper storage System, Proper planning, controlling, and monitoring of

material are the eighteenth ranked construction materials management having a value of RII= 0.598. And the twentieth ranked construction practice implementing was to plan for material receipt and storage. Figure 4.7 showed the major public building materials management practices and their ranks.

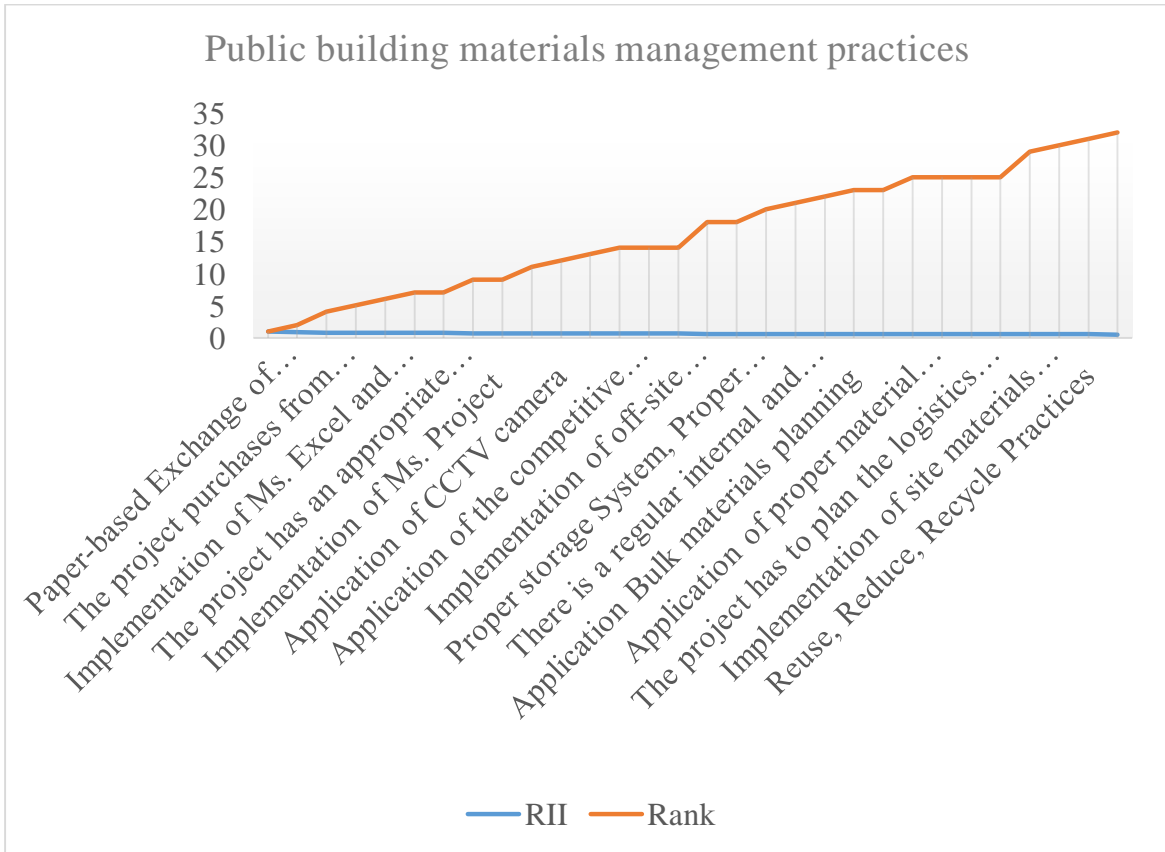


Figure 4.7: Chart to show public building construction materials management. (Own survey, 2023)

#### 4.2.1 Interpretation on findings from questionnaire of construction materials management practices

##### 4.2.1.1 Materials requirement planning practice

From items found on material requirement practice computer-based materials management system integrated with CAD, scheduling, and accounting systems is a good practice which is the second highest practice implementing on the project sites. Scheduling is prepared based on computer software such as Ms. Project and Ms. Excel and quantities taken from AUTO CAD software which is common practice for all projects. The other good practice identified for

material requirement planning is long lead materials identification, high costly with to be highly consumed materials such as cement, reinforcement bar and other finishing materials identified before one year and purchasing process started early Material estimation, budgeting, planning, and programming systems is ranked fourteenth practiced.

#### ***4.2.1.2 Materials procurement practice***

Paper-based Exchange of information and recording relating to material management and procurement is a construction materials management practice without application of current technologies used to manage materials during requesting to purchase, purchasing process, delivery, and issuing at construction project site. This paper based materials management information exchanges and procurement needs to be changed to automated and advanced technology systems. The practice of purchases from government suppliers, following up on material prices in the market, the project has a good relationship with material suppliers and Application of bulk Method of purchasing and forward buying system at least for one year said to be good practices to reduce the materials cost and total cost of project. methods of testing construction materials and a material inspection team and an experienced material inspector and application of the competitive weighted average method of Procurement, consistent with quality at the lowest possible cost identified as poor practiced. These poor practiced materials management needs to develop to purchase quality materials and construct quality good project.

#### ***4.2.1.3 Practices on delivery and Transporting***

Transportation facility for material logistics is appropriate and said to be a good practice for all projects. Other practices of material delivery such as Materials delivered to site based on the indent generated from the site after checking the availability from local suppliers shop, minimizes project costs through the efficient utilization of material transport, and Materials delivered to the site by the selected vendor according to the project schedule given in bill of material (BoM) all are said to be poorly practiced from the analysis of the questionnaire.

#### ***4.2.1.4 Practice on storage and inventory management***

Storage System, planning, controlling, and monitoring of material and plan for material receipt and storage identified as good practiced but not all the system to be satisfactory. Preparation of adequate stacking, and storage of materials, Application of Just in time (JIT), and Controlling

inventory using ABC analysis for inventory control are poorly practiced or not used as a construction materials management system.

***4.2.1.5 Practices on material handling and waste control***

Daily recording of consumed materials and implementation of off-site construction system is a hardly to say good practice. It needs improvement to the practice of daily recording of materials used. Offsite construction was started exercising at head office found at kality. Good material handling system and management of surplus materials and to plan the logistics of material at site was also practiced but not satisfactorily. Implementation of site materials production (pre-cast), Reuse, Reduce, Recycle Practices and Adequate supervision in the usage of materials are somewhat practiced but it also needs improvement more. While Recycled materials are being incorporated into building designs is poorly practiced.

***4.2.1.6 Practices on implementation of information communication technology (ICT) and current emerged technologies***

The current emerged digital technologies for construction materials management such as Using Industry 4.0 for construction materials management (using BIM for material management), Web-Based Material Planning and Control (WB-MPC), automated data collection such as Barcode, Radio Frequency Identification Devices (RFID), and Global Positioning Systems (GPS), Implementation of ERP system for material management and e-purchase for materials all are poorly practiced. Only implementation of Ms. Excel, Ms. Word, Ms., project and Auto CAD interface to generate materials requirements are good practiced from the technology parts.

**4.3 Challenges of public building construction materials management**

On public building construction projects many challenges were found managing construction materials through the construction process. Table 4.8 shows the responses obtained from the respondents.

Table 4.8: Challenges of public building construction material management

No.	Challenges on public building construction material management	RII	Rank
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1	Delay in material supply to sites or Late delivery of construction material to the project site	0.958	1
2	Budget shortage to purchase construction materials affects the material management system	0.95	2
3	Excessive paperwork	0.94	3
4	Problems using Automation technologies such as barcoding, RFID, and web-based technologies	0.91	4
5	There is a problem of implementing the current information communication technology	0.90	5
6	Price escalation on the material	0.83	6
7	Frequent changes in design affected the material management	0.82	7
8	Excessive quantity of work during construction which is not found on planning	0.80	8
9	Materials required but not purchased or not Received	0.78	9
10	Lack of awareness of current technology used for material management	0.78	9
11	Materials arriving at the site with wrong quality and at wrong time	0.77	11
12	Barriers to using ERP system for material management	0.77	11
13	Inappropriate delivery of materials	0.77	13
14	The management staff of the work site does not much more attention to material management	0.77	13
15	Difficulties to use e-procurement	0.76	15

16	Barriers to the application of BIM technology or material management	0.76	16
17	Purchases without checking the specification of materials	0.76	17
18	Change orders due to enhancement required by clients affected material management of the contractor	0.75	18
19	Improper implementation of procurement policies and guidelines	0.73	19
20	Unavailable materials in the market	0.73	20
21	Lack of proper work planning and scheduling for materials	0.73	21
22	Lack of training staff for supply chain management (SCM)	0.72	22
23	Rework due to workers' mistakes is a problem of material wastage on the construction project sites	0.69	23
24	Lack of adequate storage space for materials on the construction project sites	0.69	24
25	Poor internal auditing system	0.69	24
26	There is material wastage due to imperfect planning on the construction project site	0.68	26
27	There is a problem with an inventory control system	0.68	27
28	There is material wastage due to a slow response from the consultant	0.67	28
29	Poor quality inspection and control system, Poor quality of materials	0.66	29
30	Poor Material Handling on the construction project site	0.65	30

31	Public procurement procedures have a negative impact on the material management system and the Ineffective public procurement process	0.64	31
32	Lack of coordination among crews on the construction project sites	0.64	31
33	Deliveries not in conformance with planning, wrong and defective deliveries, long storage periods, difficult packing, large shipments	0.64	33
34	Lack of standardization	0.61	34
35	Reporting problems, for example (wastage and breakage-thief and loss shortage in delivery)	0.60	35
36	There is a problem of theft and vandalism at the project site	0.60	36
37	Improper inventory control system	0.59	37
38	Materials arriving at a site whose specifications do not match the purchase order	0.59	38
39	Problems with the Management of surplus materials	0.57	39
40	There is material wastage due to lack of supervision and delay of Inspections on the construction project sites	0.56	40

Table 4.8 showed that the major challenges associated with construction materials management in public building construction projects. Table 4.8 presents the challenges with the rank of the challenges. Delay in material supply to sites or late delivery of construction material to the project site is the first ranked challenge with a RII value of 0.958.

The second ranked challenge of construction materials management is Budget shortage to purchase construction materials that affecting the material management system with RII= 0.946. Excessive paperwork ranked the third challenge with RII= 0.943 and a Problem of using Automation technologies such as barcoding, RFID, and web-based technologies followed as the

forth ranked challenge with RII= 0.907. There is a problem of implementing the current information communication technology is also the fifth ranked challenge with RII= 0.899, which showed that implementation of automation technological tools and current digital technology such as application of internet of things problems are found at project sites. The problems with application of current emerged technologies are not only for our country; many literatures showed in most developing countries have a problem with the application of technological tools on construction project. The sixth ranked major challenge on current public building construction materials management is price escalation on the material. As shown on the table its RII value is 0.830.

Frequent design changes with RII=0.820 and Excessive quantity of work during construction which is not found on planning with RII=0.80 are the seventh and eighth ranked public building construction materials management challenges respectively. The researcher also observed interview during field survey and found that most projects quantity of during design phase and that of construction phase are different. The construction phase have excessive quantity because of many design amendments and additional work orders.

A challenge of Materials required but not purchased or not Received is ranked ninth with RII= 0.78. And a problem of lack of awareness of current technology used for material management and materials arriving at the site with wrong quality and at wrong time having a value of 0.780 RII value. Materials arriving at the site with wrong quality and at wrong time and Barriers to use ERP system for material management, it is related with current technology awareness problems; are eleventh ranked challenges on public building construction materials management with RII=0.77. And also inappropriate delivery of materials and management staff does not much more attention to material management to the site work are thirteenth ranked challenges on public building construction materials management which have RII=0.771. Difficulties to use e-procurement, Barriers to the application of BIM technology or material management, Purchases without checking the specification of materials, Change orders due to enhancement required by clients affected material management of the contractor, Improper implementation of procurement policies and guidelines, and Unavailable materials in the market are the challenges found on the public building construction materials management with RII value of 0.761, 0.76, 0.759, 0.750,

0.730, and 0.729 ranked fifteen to twenty respectively. Figure 4.8 below showed the challenges on public building construction materials management.

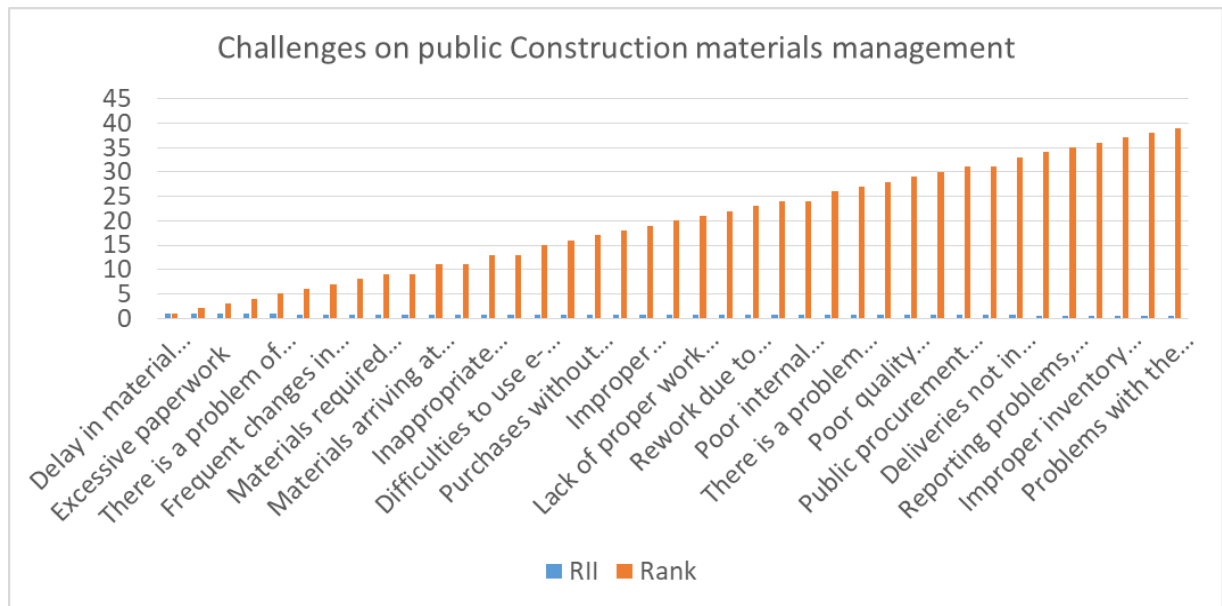


Figure 4.8: Challenges on public building construction materials management. (Own survey, 2023)

### 4.3.1 Interpretation on findings from questionnaire of construction materials management challenges

#### 4.3.1.1 Interpretation findings on problems of planning stage

From the findings of the questionnaire on challenges of construction materials management the study found that major challenges on planning stage interpreted as follows; Excessive quantity of work during construction which is not found on planning, excessive quantity of work requires more construction materials which were not found on the scheduled materials and affected the management of the construction materials.

Frequent changes in design also a major challenge the study found which affected the material management due to the change of design also changed the schedule of material requirement and required materials quantity.

Change orders due to enhancement required by clients also a major challenge found which was affected material management of the contractor. Client’s interest changed frequently time to time

and wanted to improve the design, materials type to be used, and to minimize the cost of the project.

Improper implementation of procurement policies and guidelines was founded as a major challenge which means that even though good policies and guidelines of materials procurement established, well application of the policies and guidelines not occurred due to personnel understandings and interests during the implementation.

Challenges on lack of proper work planning and scheduling for materials requirement also founded. Improper work planning and scheduling of works affected the planning for construction materials to deliver on required time and quality. And also there was a problems of construction material wastage due to imperfect planning on the construction project site.

Lack of training staff for supply chain management (SCM) was founded as a challenge to properly management of construction materials. Training to how construction materials supply chain can improves the construction materials management system.

#### ***4.3.1.2 Interpretation on problems founded on procurement management stage***

Findings from questionnaire on challenges of construction materials management interpreted as follows;

Delay in material supply to sites or late delivery of construction material to the project site was founded the most major challenge on construction materials management. Supply of materials on required time is an important management for construction materials to achieve project success. Achieving on time supply of construction materials was challenged due to different reasons such as budget shortage to purchase materials.

Budget shortage to purchase construction materials and price escalation on the construction material were also founded as a major challenges to construction materials management. Since public buildings are constructed with assigned budget from government, Sufficient Budget is required to purchase materials to achieve construction project success and the price escalation should assumed to reasonable.

Materials required but not purchased, Materials arriving at the site with wrong quality and at wrong time, inappropriate delivery of materials were other major challenges of construction materials management. These construction materials challenges affected the construction

project's cost and completion time. To achieve the construction projects objectives construction materials should be delivered or supplied with right quantity, right quality at right location and at right time.

Difficulties to use e-procurement was also a challenge at construction projects, this is to say that the awareness to the application of technologies on procurement is a problem in construction projects.

Purchases without checking the specification of materials was a problem of construction materials management. Purchasing without checking the materials specification will be affected the quality of work and also more costly due to reworks and repurchase. Unavailable materials in the market occurred as a challenge to purchase and deliver construction materials which was affected supply of the materials on required time.

#### ***4.3.1.3 Problems on material handling and wastage management stage***

The management staff of the work site does not much more attention to material management, management teams have not been giving serious consideration for materials management, for example not daily recording consumed materials, not properly quantify supplied materials, not checking the supplied materials quality said be the factors that the management staffs does not give attention to the materials management.

Problems with the Management of surplus materials; if issued and consumed materials were not properly recorded and materials on site not known, proper management of surplus materials will be difficult.

Other challenges that the study was found consists of Rework due to workers' mistakes during construction leads to material wastage, and Lack of adequate storage space for materials at the construction site is a problem to work activities with the scheduled time because of materials not to deliver with the required time, and Poor internal auditing system was also one of the problems of construction materials management; if the construction projects implement proper and regularly auditing, the management teams will give attention to the management and control of materials at the construction.

#### 4.3.1.4 Problems on the application of current emerged technologies

Problems using Automation technologies such as barcoding, RFID, and web-based technologies and problems with current advanced technologies such as ERP system and BIM based construction materials management occurred which have to be implemented to improve the construction materials management there was Lack of awareness of those current technology used for material management.

#### 4.1 Strategic tools to improve public building construction materials management

The study tried to identify key strategic tools from different literatures and professionals working at public building projects for better construction materials management at construction sites. The following Table 4.9 presents the strategic tools which is important to improve the construction materials management on public building projects.

Table 4.9: Strategic tools to improve public building construction material management

No.	Strategic tools to improve public building construction material management	RII	Rank
1	Application of Emerged technologies like Enterprise resource planning (ERP) system software and Implementation of GIS, BIM technology and the internet of things (IOT)	0.97	1
2	Application of lean thinking such as web-based tool designed based on the Last Planner System (LPS) and process mapping and scheduling	0.95	2
3	Adequate construction materials procurement and materials delivery schedule	0.95	3
4	Application of Just-In-Time delivery techniques	0.94	4
5	Effective material recording strategy	0.93	5

6	Establishment of Materials inspection team and Materials status database	0.93	6
7	Construction Materials Planning System (CMPS)	0.92	7
8	Construction Materials Exchange (COME), E-Commerce system for material procurement	0.87	8
9	Application of Database systems such as Radiofrequency identification (RFID) and Web-based material planning and control (WB-MPC)	0.87	9
10	Implementation of ABC analysis and Economic Order Quantity EOQ methods of inventory	0.86	10
11	Long-lead materials identification	0.85	11
12	Appointing an evaluation team and Planning for evaluation	0.85	11
13	Codification, standardization, Pre-fabrication and pre-assembly strategies	0.84	13
14	Arranged based on KAIZEN principles And Providing sufficient storage arrangements coincide directly with the design site layout	0.81	14

As shown from Table 4.9 above all fourteen listed strategic tools are significant to improve materials management system on public building construction projects having RII value greater than 0.5 to all. As illustrated in the table that application of the current emerged technologies are the most important strategic tools to improve the material management. Application of Emerged technologies like Enterprise resource planning (ERP) system software and Implementation of GIS, BIM technology and the internet of things (IOT) are the first ranked strategic tool with RII= 0.97. During field survey the researcher interviewed engineers what materials management technologies are applied on the projects sites, as a result CCTV camera installed for some large size projects, but other automated wireless devises are no applying. Implementation of ERP

digital system can avoid paper work and human errors which can improve all project management practices not only materials management. Application of lean thinking such as web-based tool designed based on the Last Planner (LPS) and process mapping and scheduling also important Strategic tools to improve building construction materials management. It ranked the second strategic tool with RII=0.95. A strategic tool, adequate construction materials procurement and materials delivery schedule is also the second ranked with RII=0.95. This strategic tools are implemented in developed countries and some developing countries construction materials production and construction sites, so that it is a very important for the improvement of construction project sites especially public building construction. Application of Just-In-Time delivery techniques and Effective material recording strategy are the third ranked strategic tools having a RII value of 0.94. JIT technique is a more important strategic tool which is applied in most countries in the world and many researches recommended. Establishment of Materials inspection team and Materials status database ranked the fourth with RII=0.93 and Construction Materials Planning System (CMPS), Construction Materials Exchange (COME), E-Commerce system for material procurement, and Application of Database systems such as Radiofrequency identification (RFID) and Web-based material planning and control (WB-MPC) are the fifth ranked strategic tools with RII=0.86. The sixth ranked strategic tools consists of Implementation of ABC analysis and Economic Order Quantity EOQ methods of inventory, Long-lead materials identification and Appointing an evaluation team and Planning for evaluation with RII=0.85. Finally Codification, standardization, Pre-fabrication and pre-assembly strategies Arranged based on KAIZEN principles and providing sufficient storage arrangements coincide directly with the design site layout are significant strategic tools for improvement of public construction materials management. Figure 4.9 below showed the strategic tools to improve public building construction material management.



Figure 4.9: Strategic tools to improve public building construction material management

## 4.2 Findings from field survey

### 4.2.1 Practices from field survey with informal interview as support

The projects were surveyed and the construction materials management practices have been tried to be seen including the major challenges which have been affected the construction materials management. From the field survey with the support of informal interview the construction materials management practices were stated as follows.

The study tried to know whether the projects were applied digital technologies for the construction materials management and interview field engineers as well and the study observed the project environment whether digital devices were implemented or not as a result only CCTV camera was installed for three projects and observed from interviewed engineers that it will be applied for large construction projects. Other current digital technologies were not implemented, even there was not awareness at project sites about the current technology usage on construction materials management.

Figure 4.10 below showed CCTV camera installed at proper locations to show all the site activities.



Figure 4.10: CCTV camera at project site. (Own field survey, 2023)

Some projects but not all arranged materials using the principle of KAIZEN as observe from sites.

The other practices shown from the field observation was that the communication among stockholders and suppliers was paper based.

Computers have been applied for the preparation of takeoff sheet, bill of quality by using Ms. Excel and using CAD software for view of drawings. There was no any other advanced software used for construction materials management.

The study also tried to identify the purchasing process, as a result from the fourteen projects all projects were given that the first chance to purchase from government projects, if not found from the government, open bid for private organization will be used with reasonable price. Application of Ms. Word and Ms. Excel were majorly applying for scheduling and for preparation of material requirement planning as well as for payment certificate preparation for material suppliers and sub-contractors. Others materials management practices observed from the field survey included, implementation of KAIZEN principle, following up of market price, good relationship with materials suppliers were the major identified construction materials management practices.

Construction material management was one of the reform project management body of knowledge presented on the reform policy. Figure 4.11 below showed the sixteen project management body of knowledge to be implemented. In practice the study found that it was not implemented as stated.



Figure 4.11: Construction project management knowledge area reform. (Own survey, 2023)

#### 4.2.2 Challenges from field survey with informal interview as support

From the field survey the study observed different challenges of construction materials management. Here bellow interpreted the findings of construction materials management problems from field survey;

During field survey, the study observed that there were project waiting ready mix more than 4 months. All reinforcement bar and formworks are prepared before four months and still waiting requested ready mix concrete for slab and columns. The formworks and reinforcement bars needs to rework due deteriorating through long time. Figure 4.12 shows prepared formwork and Reinforcement bar waiting for concrete. The other main problems that the study observed during field survey was that use of excessive wood formworks and eucalyptus which were used maximum three times. Replacing it with steel scaffoldings and modular steel plate forms can minimize the cost of these wood and eucalyptus



Columns waiting for ready mix Concrete

Slabs waiting for ready mix Concrete

Slabs waiting for ready mix Concrete

Wood and eucalyptus

Figure 4.12: projects waiting for ready mix concrete. (Own field survey, 2023)

According to the study it was observed that from informal interview of project site during the field survey and from the review of documents, every formal and accepted communication is paper work; only for information and reporting works are exchanged with in telegram groups. Every process from material requesting through purchasing up to delivery of materials are with paper in work.

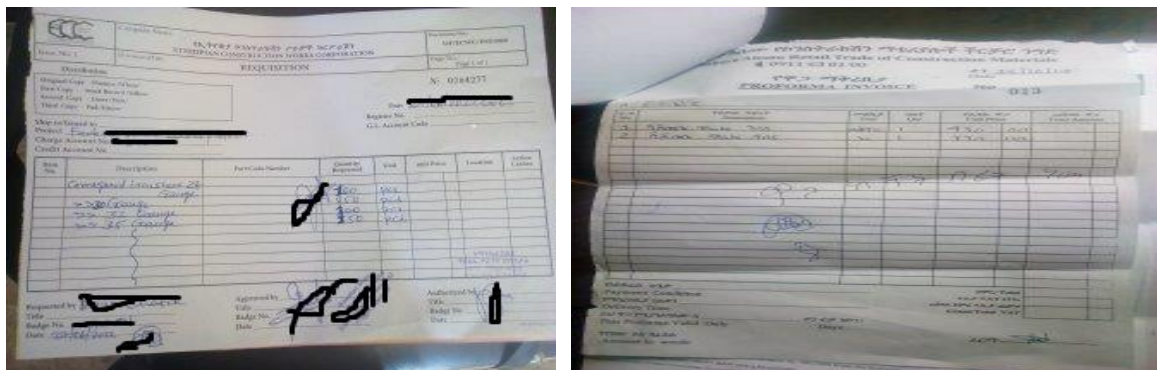


Figure 4.13: Material Request and proforma used for purchasing of materials. (Own field survey, 2023)

The study also observe the materials purchased price from report documents during field survey that the materials purchased last year 2022 and this year's materials purchased prices; as a result the material prices escalates with more than an average of 150% per year. The following table showed the escalation of some construction materials price that is taken from the report document reviewed during field survey.

Table 4.10: Price escalation of construction materials for one year 2022/2023

<b>No.</b>	<b>Material type</b>	<b>Unit</b>	<b>Unit Price ETB/2022</b>	<b>Unit Price ETB /2023</b>	<b>Difference</b>	<b>Percent increased</b>
1	Benzene	Ltr.	35.43	47.83	12.40	35%
2	Gasoil	Ltr.	28.94	67.85	38.91	134%
3	Power Cable 2.5*3	Rol.	8,850.00	22,146.96	13,296.96	150%
4	Timber	Pcs.	95.65	739.13	643.48	673%
5	Aggregate 02	M3	900.00	1,600.00	700.00	78%
6	Sand	M3	920.00	2,090.80	1,170.80	127%
7	Masonry Stone	M3	526.00	1,600.00	1,074.00	204%
8	Re-bar Ø8	Kg.	37.34	108.42	71.08	190%
9	Re-bar Ø10	Kg.	37.34	63.14	25.80	69%
10	Re-bar Ø12	Kg.	37.34	116.50	79.16	212%
11	Re-bar Ø14	Kg.	37.34	117.90	80.56	216%
12	Re-bar Ø16	Kg.	37.34	117.50	80.16	215%
13	Re-bar Ø20	Kg.	37.34	108.42	71.08	190%

14	Re-bar Ø24	Kg.	37.34	108.42	71.08	190%
15	Eucalyptus Ø12	Pcs.	112.00	170.00	58.00	52%
16	Eucalyptus Ø10	Pcs.	95.00	140.00	45.00	47%
17	Eucalyptus Ø8	Pcs.	75.00	130.00	55.00	73%
18	Ready mix concrete C-40	M3	5,346.35	10,096.00	4,749.65	89%
19	Ready mix concrete C-30	M3	5,077.28	9,492.64	4,415.36	87%
20	PPC cement	Qtl.	384.70	692.12	307.42	80%
21	OPC cement	Qtl.	463.11	692.12	229.01	49%
22	Nails #6	Kg.	135.00	147.83	12.83	10%
23	Nails #7	Kg.	135.00	147.83	12.83	10%
24	Nails #8	Kg.	135.00	147.83	12.83	10%
25	Nails #9	Kg.	135.00	147.83	12.83	10%
26	Nails #10	Kg.	135.00	180.00	45.00	33%
27	Nails #12	Kg.	135.00	147.83	12.83	10%
28	Roofing Nail	Kg.	156.67	300.00	143.33	91%
29	Black wire Ø2.5(3)	Kg.	35.24	220.00	184.76	524%
30	Black wire Ø1.5	Kg.	23.71	210.00	186.29	786%
31	Plywood	Pcs.	800.00	1,869.57	1,069.57	134%

Source from report document reviewed from project site, 2023

Construction materials waste management was also a problem observation from as field survey. There were storage problems and waste materials not appropriately placed. Reuse and recycling applications are not properly applied at site. Figure 4.14 showed the way of storage system and waste management at project sites.



Figure 4.14: Storage and waste management system. (Own field survey, 2023)

As shown at figure 4.14 'A' cement and purlins are stored near each other; it is difficult to load and to stock if additional cement delivered to site. At figure 4.14 'B' large amount of reinforcement bare wasted without form, it is difficult to measure and load it. And at figure 4.14 'C' it is improper waste management, wastes from reinforcement and eucalyptus are placed together.

## **CHAPTER V: CONCLUSION AND RECOMMENDATION**

### **5.1 Conclusion**

#### **5.1.1 Conclusion on construction materials management practices**

The major current practices on public building construction materials management includes

- Paper based and manual exchange of information communication system during procurement,
- Application of Computer on materials management system integrated with CAD, scheduling,
- Purchases are doing from government suppliers,
- Application of Long-Lead Materials Identification,
- Implementation of Ms. Excel and Ms. Word,
- Application of bulk Method of purchasing and forward buying system at least for one year,
- Applying appropriate transportation facility for material logistics,
- Good relationship with material suppliers, Following up on material prices in the market,
- Application of CCTV camera and others.

#### **5.1.2 Conclusion on challenges of construction materials management**

The study found out that the major challenges associated with construction material management system includes;

- Excessive paper work and exposed to human error through materials management processes. From identified challenges majors are incudes
- Delay in material supply to sites or late delivery of construction material to the project site,
- Budget shortage to purchase construction materials affects the material management system,
- Problems to the Automation technologies such as barcoding, RFID, and web-based technologies,
- Price escalation on the material,

- Frequent changes in design affected the material management
- Excessive quantity of work during construction which is not found on planning,
- Materials required but not purchased or not received,
- Lack of awareness of current technology used for material management,
- Inappropriate delivery of materials,
- Difficulties to use e-procurement,
- Change orders due to enhancement required by clients affected material management of the contractor,
- Materials arriving at the site with wrong quality and at wrong time, Barriers to using ERP system for material management,
- The management staff of the work site does not much more attention to material management, Barriers to the application of BIM technology or material management.

### **5.1.3 Conclusion on strategic tools to improve construction materials management**

To improve the management of construction materials in public building projects the study proposed that strategic tools including;

- application of Emerged technologies like Enterprise resource planning (ERP) system software and Implementation of GIS,
- BIM technology and the internet of things (IOT) to public projects,
- Application of lean thinking such as web-based tool designed based on the Last Planner System (LPS) and process mapping and scheduling,
- Adequate construction materials procurement and materials delivery schedule,
- Application of Just-In-Time delivery techniques,
- Effective material recording strategy, Establishment of Materials inspection team and Materials status database, Construction Materials Planning System (CMPS),
- Construction Materials Exchange (COME),
- E-Commerce system for material procurement,
- Application of Database systems such as Radiofrequency identification (RFID) and Web-based material planning and control (WB-MPC),

- Implementation of ABC analysis and Economic Order, Quantity EOQ methods of inventory. Especially the application of current technology for can improve the material management on project site.

The above strategic tools can improve the construction materials management and also it can minimize the challenges we identified in this study.

## **5.2 Recommendations**

- It is recommended that the application of wireless technologies such as RFID should be considered at project site to minimize human errors,
- Implementation of ERP system is also recommended to avoid traditional material management systems and to minimize the problem of excessive paper work through materials management system.
- The study recommended that Implementation of BIM construction material management practice which improves the on-site construction management, materials can produced on demand, order delay is avoided, delivery efficiency is improved, visual dynamic management is realized, construction plan is optimized, control of progress and cost is effectively improved, and fine construction management of the project is promoted.
- Using web-based material planning and control (WB-MPC) which allows construction professionals to be able to estimate and store building material quantities, while planning and controlling the usage of building materials per time.
- Application of lean principles on construction material management system recommended to reduce construction materials waste at construction site,
- The study also recommended that Implementation with Just in time delivery techniques to reduce the delay of construction materials supply to congested project sites,
- Using proper inventory control systems such as ABC analysis and EOQ techniques also a very important construction materials management to reduce materials inventory cost,
- The other recommended strategic tool to improve public building construction materials management is implementation of modular steel scaffolding and formworks which can use multiple times and reduce cost of wood forms and eucalyptus.

- Training professionals for digitalization on construction materials management is recommended especially for large projects, it can improve the communication among project teams and reduce the time to deliver construction materials on required time,
- The study recommended project team members to give more attention on construction materials management because, construction materials management has a large implication on the total cost of a project and also completion time of the construction projects.
- Properly allocation of budget for materials purchase and proper cash flow management is recommended to minimize challenges caused by budget shortage to purchase construction materials.
- Proper material requirement planning and detail quantification of required materials before construction is recommended for proper management of construction materials.
- Material ordered and delivered on time, Sustainable procurement system, Effective processes for purchasing material, and Worker awareness of budgeted material against available material are suggested to improve material management on construction project sites.
- For confined construction sites the study recommended to implement prefabrication and offsite construction which can reduce the challenges that will come due the limited space to store materials and access machineries to transport in project site.
- The other main recommendation the study has given to the stockholders of construction projects is that assigning proper construction materials management system starting from design through construction up to the end of the project completion will reduce the total cost of construction project.

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## **APPENDIX 1**

### **Questionnaire**

**Dear participant,**

I am a Student of Masters of Construction Technology and Management, (CoTM), at Addis College. As partial fulfillment of the program, I am undertaking research entitled “*construction materials management practice on public building construction projects in Addis Ababa: the Case of Ethiopian Construction Works Corporation*”. The research will enable the candidate to assess the construction materials management practice on public building construction project sites. It is believed that your contribution to this research will give in achieving the objectives of the research.

I wish to assure you that the information so provided will be treated with strict confidence and use it for academic purposes only. Interested participants of this study will be given feedback on the overall research results after the completion of the research work. If you would like any clarification on questions, please contact me by;

- Cell Phone: 09 21 33 12 92
- E-mail: [biruk1chafie@gmail.com](mailto:biruk1chafie@gmail.com)

Thank you for your time and consideration!

## Section-1: General Information

Note: Please Tick (✓) sign in the given box In front of or behind the asked question.

### 1.1. Respondents Information

- ii. Sex of respondent:  
Male  Female
  
- iii. Age of respondent:  
 18-25yrs  
 26-35yrs,  
 36-45yrs  
 Above 46
  
- iv. Respondent's qualifications;  
 Below diploma  
 Diploma  
 Bachelor Degree  
 Master Degree  
 Doctoral Degree and above
  
- v. Respondent's years of experience:  
 0– 5Yrs,  
 6 – 10Yrs,  
 11 – 15Yrs,  
 16 – 20yrs,  
 Over 20yrs
  
- vi. Please your current position of work:  
 Project Manager  
 Procurement management leader  
 Engineering service team leader  
 Work execution team leader  
 Office Engineer  
 Site Engineer

### 1.2. Project information

- i. Project size and type:
  - Small-size project (contract amount between 0 and 150 Million)
  - Medium size project (contract amount between 150.01Million and 300 Million)
  - Large project (contract amount above 300 Million)
- ii. Type of contract:
  - Design Bid Build
  - Design and Build
  - Build Operate and Transfer (BOT)
  - Others (Please specify).....

**Section 2-Practice of public building Material Management**

Please give the level of material management Practice implementation on your project/organization.

Please make (√) sign to the appropriate level of implementing material management practice.

*Use 1- for strongly disagree, 2- for disagree, 3- for Neutral, 4- for agree, and 5- for strongly agree*

**Table 2.1. To what extent is the material management practice to be applying?**

No	Material management practices	1	2	3	4	5
<b>1</b>	<b>practice on planning stage</b>					
1.1	The project has a good Material estimation, budgeting, planning, and programming systems					
1.2	Computer-based materials management system integrated with CAD, scheduling, and accounting systems					
1.3	The project has to implement a training and communication plan					
1.4	Training for particular requirements of Material management					
1.5	Application of long-term planning and actions					

1.6	Application Bulk materials planning					
1.7	Application of Long-Lead Materials Identification					
1.8	Continuously review planning					
<b>2</b>	<b>Practices on procurement</b>					
2.1	Application of proper material procurement system					
2.2	Construction materials are purchased and delivered to the site at the right time, in quality, and quantity.					
2.3	A separate procurement plan and schedule for long-lead materials					
2.4	Application of the competitive weighted average method of Procurement, consistent with quality at the lowest possible cost					
2.5	Paper-based Exchange of information and recording relating to material management and procurement					
2.6	The project has to implement procedures to manage suppliers and apply a formal supplier evaluation system					
2.7	The project has a good relationship with material suppliers					
2.8	Application of bulk Method of purchasing and forward buying system at least for one year					
2.9	The project purchases from government suppliers					
2.10	Following up on material prices in the market					
2.11	The project has Good methods of testing construction materials and a material inspection team and an experienced material inspector					
<b>3</b>	<b>Practices on delivery and Transporting</b>					
3.1	The project minimizes project costs through the efficient utilization of material transport					

3.2	Materials delivered to the site by the selected vendor according to the project schedule given in the bill of material (BoM)					
3.3	The project has an appropriate transportation facility for material logistics					
3.4	Materials delivered to site based on the indent generated from the site after checking the availability from local suppliers shop					
<b>4</b>	<b>Practice on storage and inventory management</b>					
4.1	Proper storage System, Proper planning, controlling, and monitoring of material					
4.2	Implementation of KAIZEN principle					
4.3	The project has to plan for material receipt and storage					
4.4	Preparation of adequate stacking, and storage of materials					
4.5	Application of Perpetual inventory control system					
4.6	Using economic order quantity (EOQ) for inventory management					
4.7	Controlling inventory using ABC analysis for inventory control					
4.8	Application of Just in time (JIT)					
<b>5</b>	<b>Practices on material handling and waste control</b>					
5.1	The project has a proper Waste management system and Wastage minimization techniques					
5.2	The project has to plan the logistics of material at site mobilization and Construction time					
5.3	Daily recording of consumed materials in the project					
5.4	The project has good material handling system and management of surplus materials					

5.5	Adequate supervision in the usage of materials					
5.6	There is a regular internal and external auditing system for materials					
5.7	Implementation of off-site construction system					
5.8	Using a Lean thinking material management system					
5.9	Recycled materials are being incorporated into building designs					
5.10	Implementation of site materials production (pre-cast)					
5.11	Reuse, Reduce, Recycle Practices					
<b>6</b>	<b>Practices on Implementation of Information Communication Technology (ICT) and current emerged technologies</b>					
6.1	CAD interface to generate material requirements					
6.2	Implementation of Ms. Project					
6.3	Implementation of Ms. Excel and Ms. Word					
6.4	Web-Based Material Planning and Control (WB-MPC)					
6.5	Using Industry 4.0 for construction materials management (using BIM for material management)					
6.6	Implementation of ERP system for material management					
6.7	Automated data collection such as Barcode, Radio Frequency Identification Devices (RFID), and Global Positioning Systems (GPS)					
6.8	Implementation of e-purchase for materials					
6.9	Application of CCTV camera					

### **Section 3-Factors affecting effective public building material management**

Please give the level of Factors affecting the implementation of effective building material management on your project.

Make (√) sign to the appropriate level of factors affecting your project material management.

*Use 1 for strongly disagree, 2 for disagree, 3 for Neutral, 4 for agree, and 5 for strongly agree*

**Table 3.1. To what extent are the factors affecting effective material management**

No.	Factors affecting building material management	1	2	3	4	5
<b>1</b>	<b>Problems on planning stage</b>					
1.1	Lack of proper work planning and scheduling for materials					
1.2	Misuse of the specification					
1.3	Incorrect materials takeoff from drawing and design documents					
1.4	Frequent changes in design affected the material management					
1.5	Poor qualification of the technical staff and Lack of training for Supply chain management (SCM) Staff					
1.6	Excessive quantity of work during construction which is not found on planning					
1.7	Materials Sourcing and requisition are affecting the material management system					
1.8	Reporting problems, for example (wastage and breakage-theft and loss shortage in delivery)					
1.9	change orders due to enhancement required by clients affected material management of the contractor					
<b>2</b>	<b>Problems on procurement management stage</b>					
2.1	Public procurement procedures have a negative impact on the material management system and the Ineffective public procurement process					
2.2	Excessive paperwork					
2.3	Improper implementation of procurement policies and guidelines					
2.4	purchases without checking the specification of materials					

2.5	unavailability of storage space for procurement documents and exposes to corruption					
2.6	Inappropriate delivery of materials					
2.7	Transport difficulties					
2.8	Price escalation on the material					
2.9	Problems with material quality during procurement and No quality assurance from the supplier					
2.10	Problems with vendor evaluation criteria					
2.11	Unavailable materials in the market					
2.12	Delay in material supply to sites or Late delivery of construction material to the project site					
2.13	Budget shortage to purchase construction materials affects the material management system					
2.14	Materials required but not purchased or not Received					
2.15	Poor quality inspection and control system, Poor quality of materials					
2.16	Deliveries not in conformance with planning, wrong and defective deliveries, long storage periods, difficult packing, large shipments					
<b>3</b>	<b>Problems on material storage and inventor control</b>					
3.1	Improper inventory control system					
3.2	Excess inventory construction materials					
3.3	There is a problem with an inventory control system					
3.4	Lack of adequate storage space for materials on the construction project sites					
3.5	Lack of training staff for supply chain management (SCM)					
<b>4</b>	<b>Problems on material handling and wastage management stage</b>					
4.1	Poor Material Handling on the construction project site					
4.2	Problems with the Management of surplus materials					

4.3	Lack of coordination among crews on the construction project sites					
4.4	There is material wastage due to over-ordering or under-ordering due to mistakes in quantity					
4.5	The management staff of the work site does not much more attention to material management					
4.6	Materials arriving at the site with wrong quality and at wrong time					
4.7	Materials arriving at a site whose specifications do not match the purchase order					
4.8	There is material wastage due to imperfect planning on the construction project site					
4.9	There is material wastage due to a slow response from the consultant					
4.10	There is material wastage due to lack of supervision and delay of Inspections on the construction project sites					
4.11	There is material wastage due to stocking and pilfering at the construction project sites					
4.12	Rework due to workers' mistakes is a problem of material wastage on the construction project sites					
4.13	There is a problem of theft and vandalism at the project site					
4.14	Poor internal auditing system					
<b>5</b>	<b>Problems on the application of current emerged technologies</b>					
5.1	Lack of awareness of current technology used for material management					
5.2	There is a problem of implementing the current information communication technology					
5.3	Lack of standardization					
5.4	Improper application of offsite construction					

5.5	Technological barriers in terms of conversion of waste materials to a useful end					
5.6	Problems using Automation technologies such as barcoding, RFID, and web-based technologies					
5.7	Barriers to using ERP system for material management					
5.8	Barriers to the application of BIM technology or material management					
5.9	Difficulties to use e-procurement					

Please write any material management problems if any other than listed above:

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**Section 4-Strategic tools to improve public building construction material management**

Make (√) sign to the appropriate level of Strategic tools you recommend for Public Building Construction material management.

*Use 1 for strongly disagree, 2 for disagree, 3 for Neutral, 4 for agree, and 5 for strongly agree*

**Table 4.1. To what extent are the strategic tools to improve public building construction material management?**

No.	Strategic tools to improve public building construction material management	1	2	3	4	5
1	Adequate construction materials procurement and materials delivery schedule					
2	Construction Materials Planning System (CMPS)					
3	Long-lead materials identification					
4	Appointing an evaluation team and Planning for evaluation					
5	Effective material recording strategy					

6	Establishment of Materials inspection team and Materials status database					
7	Arranged based on KAIZEN principles And Providing sufficient storage arrangements coincide directly with the design site layout					
8	Application of Just-In-Time delivery techniques					
9	Application of lean thinking such as web-based tool designed based on the Last Planner System (LPS) and process mapping and scheduling					
10	Implementation of ABC analysis and Economic Order Quantity EOQ methods of inventory					
11	Codification, standardization, Pre-fabrication and pre-assembly strategies					
12	Application of Database systems such as Radiofrequency identification (RFID) and Web-based material planning and control (WB-MPC)					
13	Application of Emerged technologies like Enterprise resource planning (ERP) system software and Implementation of GIS, BIM technology and the internet of things (IOT)					
14	Construction Materials Exchange (COME), E-Commerce system for material procurement					

Please write any strategic tool you suggested to improve public building construction material management, if any other than listed above:

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## **APPENDIX 2**

### **Questions to be seen during field observation**

1. What type of technologies implemented at construction projects?
2. Is there any automation devices implemented on the construction materials management?
3. Is the communication among stakeholders on construction materials management internet technology based or paper based?
4. Is computer used for advanced technology for construction materials management rather than Ms. Excel and Ms. Word?
5. What type of construction materials management strategic tools used at project site?
6. What systems used to reduce the cost of construction materials management during purchasing process?
7. What challenges/problems found on construction materials management?
8. What challenges found to use technologies for construction materials management?