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COLLEGE OF TECHNOLGY EDUCATION, KUMASI

DEVELOPMENT OF A DECISION-MAKING MATRIX FOR EFFECTIVE MATERIALS MANAGEMENT PRACTICES ON CONSTRUCTION PROJECTS IN GHANA USING ANALYTICAL HIERARCHY PROCESS (AHP)

FREDERICK NARTEY DUGBA

MAY 2022

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BY

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A Dissertation in the Department of CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in Partial fulfilment of the requirement for the award of Master of Philosophy (Construction) degree.

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DECLARATION

STUDENT'S DECLARATION

I, Frederick Nartey Dugba, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ....

Date: FEBRURARY 01, 2021

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of this thesis as laid down by the University of Education, Winneba.

Dr. Nongiba A. Kheni

Signature: ....

Date: February 01, 2023

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DEDICATION

This study is dedicated to Esther Abena Pomaah, my wife and children; Clara, Davina and Benjamin.

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With a heart full of praise, I would like to thank God Almighty for the wisdom, knowledge and provision which enabled me start and complete my research work successfully

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ABSTRACT

Construction materials constitute about 60% of the total cost of construction of most building projects. Significant reductions in the cost of projects can be achieved through effective materials management. The aim of the study was to develop a decision-making matrix for effective materials management practices on construction projects in Ghana using analytical hierarchy process (AHP). The specific objectives were to; assess the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana, determine factors that militate against effective decision making in relation to construction materials management in the Ghanaian construction industry, develop a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). The study adopted a cross sectional survey design. The target population of the study was site managers/engineers and supervisors employed by D1K1 and D2K2 construction firms. Systematic random sampling was used to select the construction firms whilst purposive sampling technique was used to select the survey respondents and interview participants. The findings of the study revealed that the construction materials management practices adopted by the D1K1 and D2K2 construction firms included; training people on how to reduce waste, daily recording of materials usage on the project, buying efficiently and wisely, obtaining by an ethical means the best value for every money spent, controlling over-ordering and purchasing and tracking materials ordered. In addition, the main factors that militate against effective decision making in relation to materials include; storage, procurement and personnel management issues/factor, inventory and quality control issues/factor, supplier and manufacturing default factor, and communication and system implementation factor. The findings of the study suggest AHP as a promising strategy for addressing challenges to materials management and ensuring significant waste reduction. However, construction firms need to have the requisite human resource and financial resources to bolster the adoption of analytical hierarchy process in materials management within the large-scale construction firms studied. The research recommends optimal training to people in prioritize decision making process and information support systems to effectively and efficiently support material management practices in terms of planning, procurement, storage, usage and waste management in the construction industry.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Material management practices in the construction industry are crucial in the effective running of every construction firm. A key factor that positively affects project performance is appropriate management of materials on the site of construction. The construction industry is very important to the economy of all nations including Ghana. For instance, according to Ghana Statistical Service (2022), GDP from Construction in Ghana increased to 3445.05 GHS Million in the second quarter of 2022 from 3301.52 GHS Million in the first quarter of 2022 %, whereas the UK and other developed economies record 8%–10%. In light of the significant progress made in many countries, including some African countries (taking South Africa as an example) it appears that Ghana is being left behind by developments in the effort to improve performance in the construction industry. A widespread culture of underperformance means that a majority of the major projects in Ghana are awarded to very few large firms, which are mostly foreign owned (Ofori-Kuragu et al., 2016). Most of the predicaments of the local contractors have emanated from poor strategies being adhered to when it comes to material management.

Materials management can be particularly problematic on projects where design and procurement decisions are not made concomitantly with construction activities (Harrison and Lock 2017). In order to achieve good materials management on building project, Lester (2006) has opined that special attention must be paid to training of management and other staff, inventory control of materials on site, and ensuring proper planning, monitoring and control. Similarly, Albert et al., (2018) also recommended management, supervision and administration of sites, provision of adequate storage of materials, proper usage of materials, materials schedule for the contract on

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hand, materials delivery, and attention to weather conditions as some of the effective management of building projects.

Over the years, several authors and scholars have defined material management differently but with similar ideologies. For instance, Ashika (2019) defined it to include planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution. Summarizing the above definitions, it can be pointed out that material management is concerned with the planning, identification, procuring, storage, receiving and distribution of materials as well how effective and efficient the materials enhance the economic viability of the project. The purpose of material management is therefore to ensure that the right materials are in the right place, and in the right quantities needed (Saka et al., 2019).

Whenever materials are well managed in the construction site, it leads to a lot of effectiveness since materials constitute a major cost component for construction industry (Semma 2021). According to Wachira and Ngari (2019) the cost for material in construction projects ranges from 30 – 80 % of the total construction cost, therefore, the control of materials becomes very important and vital subject for every company and should be handled effectively for the successful completion of projects. The proper procurement and handling of material represent a key role in the successful completion of the work (Ershadi et al., 2021).

In the past, several strategies have been used to improve material management in construction sites the world over. These strategies have hovered around training of both management and other staff, inventory control of materials on site, ensuring proper planning, monitoring and control, management, supervision and administration of sites which is the direction of people at work and management is the planning and control of the work process on construction site, supervision,

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management and administration of site are gradually spread over the world because it is a more efficient way of accomplishing work (Rathinakumar et al., 2018). Additionally, there should be the provision of adequate storage of materials, proper usage of materials, materials schedule for the contract on hand, provision and accessibility site layout, and attention to weather conditions among others (Oseghale et al., 2021).

In assessing the material management procedures used in most Ghanaian construction firms, it is glaring that performance in the Ghanaian construction industries is a major cause of concern amongst client groups and other stakeholders. In this wise, Ahadzie (2007) asserts that in many instances, contractors were blamed for poor performance and were criticized for having limited knowledge of the application of requisite management techniques. Similarly, Vulink (2004) pointed out that construction firms do not employ personnel with the technical know-how to guide their firms towards sustainable growth. Consequently, poor management of resources including labour, finance, materials, plant and equipment in Ghanaian construction sites does not promote growth (Akomah et al., 2010). In addition, the industry has been described as "having a highly unstable business environment in which inflation negatively affects the capital of contractors amongst other challenges which make it increasingly difficult to manage construction businesses" (Dansoh, 2005). The foregoing underlines serious problems associated with Managerial skills of personnel within the Ghanaian construction industry. These constraints are, however, symptomatic of a wider problem of the lack of a clearly defined agenda for the Ghanaian construction industry and the absence of appropriate platforms for organizing the proposal and delivery of industry-wide improvements towards material management in construction sites in general (Williams et al., 2019).

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1.2 Statement of the Problem

Management of materials has over the years been a great problem to most firms in the construction industry (Tembo et al., 2022). In construction project operations, there is always a tendency of mismanagement of materials by construction firms which include wastage, stealing, misapplication and effect of inclement weather (Kanyago et al., 2017).

Scores of studies have been conducted regarding the use of Analytical Hierarchy Process (AHP) on building projects in the construction industry (Darko et al., 2019; Putri and Nusraningrum 2022; Gunduz and Khan 2018; Razi et al., 2020; Waris et al., 2019; Gunduz and Mohammad 2020 and Oluleye et al., 2020). Darko et al., (2019) reviewed 77 AHP-based papers 7 published in eight selected peer-reviewed construction management journals from 2004 to 2014 to better define and delineate AHP application areas and typical decision-making problems solved within construction management. Their studies found out that AHP is flexible and can be used either as a stand-alone tool or used in conjunction with other tool to resolve decision-making problems; and is widely used throughout Asian higher education institutions (HEIs). Putri and Nusraningrum (2022) investigated the most important qualification criteria for selecting subcontractors in the construction supply chain. Their findings revealed that Quality, Health, Safety, and Environment (HSE) and Price were the highest priority criteria for subcontractor selection, with the most influential sub-criteria being quality work specifications, tender prices, and having an HSE supervisor on the project. Gunduz and Khan (2018) studied the effective framework for the change order management in the construction industry. They discovered that by using AHP, the top three causes of change orders with highest cumulative impact on project duration, cost and quality were, “Change in specifications by the owner”, “Change of plans or scope by the owner”, and “Poor project planning by the contractor. Razi et al., (2020) inquired into an AHP-based consultant

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selection model applied to develop and assist in decision making process to resolve the consultant selection problem in choosing the most favourable consultant's criteria combination. They found out that financial capability of the consultant prioritizes the decision of the selection while dominating the sub-criteria for selection is the profit made by the consultant within the last 3 years. Waris et al., (2019) established a comprehensive link by proposing an AHP-based assessment framework for developing sustainable procurement index for the procurement of earthmoving equipment. Their study discovered that life cycle cost is an important decision factor in the selection of sustainable earthmoving equipment and has a percentage weightage 38.5%. It had also the highest value of priority vector, which represented that decision-makers had considered it significantly more important. It was followed by other main criteria, i.e., performance (17.6%), system capability (16.5%), and operational convenience (12.8%). Gunduz and Mohammad (2020) outlined a complete assessment on change orders impacts factors on construction project performance using (AHP). They found out from their study that the most important change orders impact factors were increased project management efforts, increased project replanning, loss of efficiency due to work interruption, increased reworks/demolition works and delay of payments. Oluleye et al., (2020) probed into adopting the AHP survey in evaluating the Critical Success Factors (CSFs) that can enhance the delivery of sustainable housing and in turn meeting the nation sustainable housing needs. Their findings revealed that government funding towards sustainable housing, access to low-interest housing loan, mandating affordable housing development, ensuring community participation during housing delivery, the involvement of housing stakeholders, ensuring the security of life and properties, use of sustainable materials, adaptable housing design and befitting land use were the significant CSFs required for enhancing sustainable housing delivery.

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Arising from the preceding build-up on the application of use of Analytical Hierarchy Process (AHP) on building projects in the construction industry, most of the studies focused on using this process as a selection criterion, measure of performance and success rates and procurement in the construction management set up. Little or no priority was accorded to using this process to decide on the most effective materials management practice on construction projects in Ghana. There is therefore a paucity in knowledge that needs to be pursued. The study in this regard sought to develop a decision-making matrix for effective materials management practices on construction projects in Ghana using analytical hierarchy process (AHP).

1.3 Aim of the Study

The aim of the study is to develop a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP).

1.4 Specific Objectives

The study sought to achieve the following specific objectives:

1. to assess the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana;
2. to determine factors that militate against effective decision making in relation to construction materials management in the Ghanaian construction industry;
3. to develop a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP)

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1.5 Research Questions

The following research questions were used to drive the study;

1. What are the current material management practices of large-scale construction firms in Ghana?
2. What are the factors that militate against effective decision making in relation to construction materials management within large-scale construction firms in Ghana?
3. What decision-making matrix will be developed for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP)?

1.6 Significance of the Study

This research, among other things will be of immense benefit to the Ministry of housing in the sense that it will go a long way to augment the efforts that are being made in this housing sector to modulate the building industry which has informed the introduction of Ghana building code (GhBC) which was launched by Dr. Bawumia on 31st October 2018. This code is designed to regulate the building of any kind of structure in the country. The study would further add a lot of insight and literature to the already existing ones in the field of construction. This would go a long way to ensure that future researchers have enough literature to lay hands on. Besides, construction practitioners would have adequate information on how to effectively manage materials on large construction site. This will assist the avoidance of material waste and theft as well as safety for workers.

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1.6 Scope of the Study

Much as the researcher envisages that this phenomenon has a broad outlook, the study was delimited to cover medium and large works focusing on D1K1 and D2K2 constructors within metropolises and municipalities of Ashanti, Eastern and Greater Accra Regions in the country. This decision was informed based on the fact that these construction firms worked on large projects involving the use of voluminous quantities of materials. Here, material management plays a key role in keeping up with such firms making it imperative to consider in undertaking the study. The researcher resort to develop a decision-making matrix for effective materials management practices on construction projects in Ghana (D1K1 and D2K2) using Analytic Hierarchical Process (AHP) instead of other material management approaches being used like Just-In-Time (JIT) concepts to resolve the problems of space constraints, and the implementation of Information and Communication Technologies (ICT) such as bar-coding for automatic tracking of materials because it is an easier to adopt and more cost-effective approach if well utilized.

1.7 Limitations of the study

A number of constraints were encountered in the course of carrying out the study. However, steps were taken to ensure that these constraints do not affect the quality of the study. The number of construction firms selected for the study was limited to construction firms operating within the towns of Kumasi, Accra and Koforidua. Thus, any generalisations to drawn to the population of construction firms in Ghana must be done with caution. Additionally, a common constraint of using the questionnaire method for data collection is the difficulty in getting respondents to respond promptly and frankly to the questionnaire items. Also, the nature of the construction work necessitates that questionnaires are often left with the respondents to make time to answer them

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after which they will be collected later. This situation therefore made it difficult for the researcher to ensure that there was no consultation among the respondents during the process of answering the questions. If consultations were made between respondents, then the genuineness and fairness of the responses could be compromised hence, conclusions drawn may not be reliable. However, being aware of this possible constraint, the researcher triangulated the study by conducting a semi-structured interview in addition to the questionnaire

1.8 Organization of the Study

The study was organized in six chapters. The first chapter introduced the study. It focused on the background to the study, the statement of the problem, objectives, the research questions, significance of the study, delimitation, and organization of the study. The second chapter dealt with the review of related literature. The central theme of this chapter included overview and definitions of the key concepts in the field of building and construction. The third chapter presented the study methodology. It highlighted the key methods used in the study design and sources of data. Other items treated in this chapter included study population, sample size, sampling procedure and instrumentation, data collection procedure and analysis plan. The fourth chapter focused on data presentation and analysis of the results. The chapter presented the data analysis based on the research objectives. Chapter Five of the study looked at the discussions of the result and compared it to literature. Finally, Chapter Six was written to present the findings, conclusions and recommendations of the study.

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CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter gives an account and review on what has been published and those unpublished by accredited or recognized scholars or institution on Improving Materials Management Practices in Construction Projects through Analytical Hierarchy Process.

To attain project success, Gunduz and Almuajebh (2020) conceded that proper management of construction materials during construction should be made paramount to the project manager. Idowu et al. (2020) added that the acquisition of construction materials determines the cost and quality of the construction project, as it claims approximately 40-70% of the total working capital of the project. Conversely, the construction industry in its present state is barely focused on materials management efficiency and effectiveness improvement. Thus, in an effort to improve materials management efficiency during sustainable buildings construction, a rigorous review of the basic factors affecting materials management, and possible solutions to any problems, will be discussed later in this chapter.

2.2 Nature of Construction

The understanding of what is construction extrapolates its technical characteristics (Antunes & Gonzalez, 2015). In this research, construction is not restricted to civil engineering and architecture, but covers a broader understanding of building, putting up, setting up, establishing and assembling (Allen & Iano, 2019). Construction is the materialization of a concept through design, taking into account functional requirements and technical specifications for a project product utilizing specialized labour (Denard et al., 2020). In other words, it is the creation of a product that will fulfil a strategic goal, (Mandal, 2006). This study excludes prototyping as the

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final product; however, a project scope may include prototyping as a deliverable or stage, as, for example, in the design phase. Prototype objectives test a process or concept in real situations and then provide information about what works and what needs improvement before the final product (Antunes & Gonzalez, 2015). In contrast to prototypes, the project product is final and definitive. Project products, according to the design specifications, have usability in a first and unique building. Project products of building construction are, for instance, software, pipelines, roads, bridges, tunnels, house building and oil well construction (Jackson, 2020). In summary, project deliverables with different technical backlogs and fields of application are in accordance with the definition of construction stated in this study. Moreover, the existence of a technical backlog brings a dimension of repetitiveness. Because these projects require specialized labour, the project executive is likely to be involved in projects with a similar technical background, (Vidal et al., 2007). For instance, an offshore oil well construction company is more likely to have future endeavors in the same technical field rather than in a road building. In this case, the repetitiveness occurs horizontally across different projects with a similar scope. A project can also have repetitiveness within an endeavor: for instance, the construction of similar products, such as housing units, floors of a skyscraper or the installation of cases in an oil well (Amoah et al., 2021).

2.2.1 Construction Sector in Ghana

Williams et al. (2019) described the Ghanaian construction industry as a group of firms with closely related activities involved in the construction of real estates, and building private and public infrastructure. In Ghana generally the construction industry is grouped into two categories namely; General Building Construction and Engineered Construction (Owusu-Manu et al., 2020). In most instances a contractor or construction company chooses the category that will enhance its long-term sustainability (Kylili & Fokaides, 2017). The Ghanaian building construction firms are made

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up of large number of enterprises of various sizes and are registered and categorized by the Ministry of Water Resources, Works and Housing (MWH) into groups such as; D1K1, D2K2, D3K3 and D4K4 (Ofori et al., 2017). Criterion for the categorization is based on criteria such as; annual turnover, equipment holding, number of personnel. However, per the ministry categorization, the D1K1 class of contractors is termed as larger firms, whereas D2K2 construction firms are classified as medium size firms with the D3K3 and D4K4 being classified as small firms (Owusu-Manu et al., 2017). The larger firms, according to the Ghana Ministry of Works and Housing (MWH), the construction companies are classified as financial class 1 (D1K1), capable of undertaking projects of any value, class 2 (D2K2) on the other hand are capable of undertaking projects up to the financial value of US$500,000 or GH¢ 2,100,000 (per the current exchange rate of 1 USD = GH¢ 4.2000) whereas class 3 (D3K3) category of construction companies are also capable of undertaking projects up to US$200,000 or GH¢ 840,000 (per the current exchange rate of 1 USD = GH¢ 4.2000) or class 4 (D4K4) category capable of undertaking projects up to the magnitude of US$75,000 or GH¢315,000 (per the current exchange rate of 1 USD = GH¢ 4.2000) (Ofori et al., 2017).

According to Adjarko et al., (2016) nearly a little over 90 percent of Ghanaian construction companies consist of small enterprises whereas the remaining 10% are made up of the large and medium construction enterprises. They added that, this statistic is quite not surprising as it affirms previous anecdotal evidence often raised by various governmental agencies that local construction firms do not have the necessary capital and technology to successfully performed governmental projects. For example, most of the commercial roads in the country are being built by foreign contractors at the expense of local contractors. Additionally, Adjarko et al. (2016) in their work also found out that most of the SMEs in Ghana construction companies do not have the requisite

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technological abilities thus, plants, equipment and key personnel to handle most of the government projects.

Additionally, the construction sector is regulated by the government ministries and agencies responsible for public infrastructure development. For instance, The Ministry of Roads and Transport (MRT) are responsible for regulating all construction works related to roads infrastructures whereas the Ministry of Works and Housing (MWH) importantly spearhead all government projects not relating road and transportation projects in Ghana (Adjarko et al., 2016). Due to the large magnitude of projects The Ministry of Works and Housing controls it has additional responsibility in registering contractors and classifying them into forms such as; class D and class K. Importantly the class D category is for those contractors who are qualified to undertake building construction works and class K are equally for those that are qualified to undertake civil engineering construction works. Contractors registered in either class are further classified into subclasses 1, 2, 3, or 4. Contractors are free to register with either of the ministries and are also permitted to join either the Association of Road Contractor of Ghana (ASROC) or the Association of Building and Civil Engineering Contractors of Ghana (ABCECG).

2.3 Materials Management

Different researchers provide different definitions for material management, therefore different definitions can be found in different references. Basically, material management is concerned with the planning, identification, procuring, storage, receiving and distribution of materials (Kulkarni et al., 2017). The purpose of material management is to assure that the right materials are in the right place, in the right quantities when needed (Karoriya & Pandey, 2018). The responsibility of

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one department (i.e., material management department) for the flow of materials from the time the materials are ordered, received, and stored until they are used is the basis of material management.

- Ballot (2006) defined material management as the process of planning, acquiring, storing, moving, and controlling materials to effectively use facilities, personnel, resources and capital.
- Oluwaseyi et al (2017) defined material management as the process to provide the right materials at the right place at the right time in order to maintain a desired level of production at minimum cost. The purpose of material management is to control the flow of materials effectively.
- Phu and Cho (2014) stated that a material management structure should be organized in such a way that it allows for integral planning and coordination of the flow of materials, in order to use the resources in an optimal way and to minimize costs.
- Chandler (2001) stated that material management systems should be implemented to plan, order, check deliveries, warehousing, controlling the use of materials, and paying for materials. He adds that these activities should be interrelated.
- Ammer and Dean (2004) defined material management as the process in which a company acquires the materials that it needs to achieve their objectives. This process usually begins with the requisition of materials from the supplier until the material is used or incorporated into a product.
- Bailey and Farmer (2009) defined material management as a concept concerned with the management of materials until the materials have been used and converted into the final product. Activities include cooperation with designers, purchasing, receiving, storage, quality control, inventory control, and material control.

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- Abd Karim et al. (2018) indicated that a material management system should have standard procedures for planning, expediting, transportation, receipt, and storage to ensure and efficient system for materials control.
- Ibegbulem and Okorie (2015) stated that material management involves the control of the flow of goods in a firm. It is the combination of purchasing with production, distribution, marketing and finance.
- Nurprihatin et al. (2021) stated that material management is a function responsible for planning and controlling of materials flow. He adds that a materials manager should maximize the use of resources of the company.
- Alumbugu et al. (2022) defined material management as the activities involved to plan, control, purchase, expedite, transport, storage, and issue in order to achieve an efficient flow of materials and that the required materials are bought in the required quantities, at the required time, with the required quality and at an acceptable price.
- Ahmed (2017) defined material management as the plan and control of all activities to ensure the correct quality and quantity of materials and equipment to be installed are specified in timely manner, obtained at reasonable cost and are available when needed.
- Arijeloye and Akinradewo (2016) stated that material management is designed to improve the activities related to the flow of materials. They add that material management should coordinate purchasing, inventory control, receiving, warehousing, materials handling, planning, and transportation.

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The role that a materials manager plays in an organization is strictly economical since the materials manager should keep the total cost of materials as low as possible (JerutoKeitany and Richu, 2014). The person in charge of handling materials should keep in mind the goals of the company and ensure that the company is not paying extra money for materials (Ahmed, 2017). The goal of every company is to make a profit (Sucuahi & Cambarihan, 2016). This is the basis for company's survival, costs should not exceed income, but keeping in mind customer's expectations.

According to Abd Karim et al. (2018), Alumbugu et al. (2022) and Arijeloye and Akinradewo (2016) typical tasks associated with a material management system include the following:

- Procurement and purchasing
- Expediting
- Materials planning
- Materials handling
- Distribution
- Cost control
- Inventory management / Receiving/ Warehousing
- Transportation

Purchasing and procurement deals with the acquisition of materials to be used in the operations. The primary function of purchasing and procurement is to get the materials at the lowest cost possible, but keeping in mind quality requirements (Manana et al., 2012). Expediting is the continuous monitoring of suppliers to ensure on time deliveries of materials purchased. The purpose of materials planning is to procure the materials for the dates when they are needed, storage facilities, and handling requirements (Govender & Watermeyer, 2000). The primary function of materials handling is to manage the flow of materials in the organization (Gulghane &

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Khandve, 2015). The manager has to assure that the costs associated with handling materials are kept to a minimum. In cost control, the manager has to ensure that the costs to buy materials are kept to a minimum (Arijeloye & Akinradewo, 2016). In other words, the manager has to ensure that he is buying the products at the lowest possible price. The inventory management deals with the availability of materials (Manana et al., 2012). Transportation involves using the safest most economical means to transport the materials to the site where they are needed.

Figure 2.1 depicts the different phases of the material management process including the relationship and interdependency between the different activities in each phase. From this figure it can be seen that decisions taken at each phase in the system, directly affect the activities of the phases that follow:

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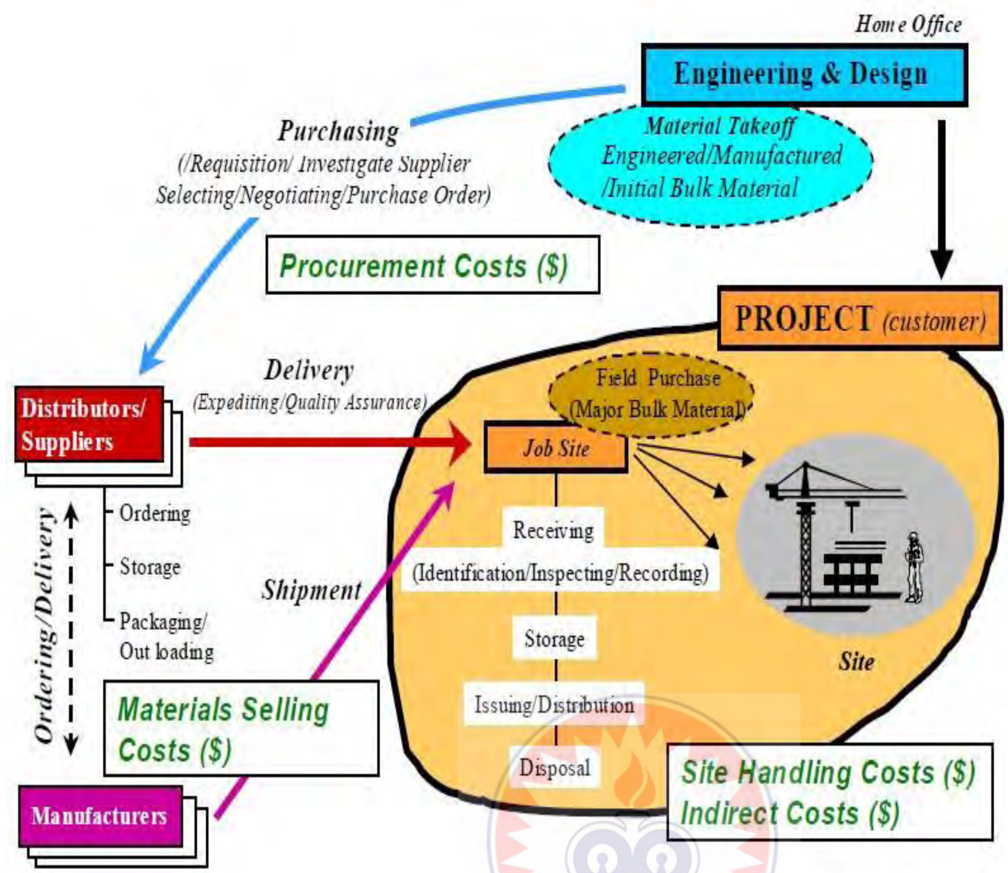

Figure 2.1: Typical Material Management in Construction. Source: Thabet (2001)

As a result, a successful implementation of a material management system needs to consider the different decisions made at various phases of the supply chain.

2.3.1 Material management in Construction Project

Construction material is recognized to be a major component in the construction project cost. Depending on different project it is assumed that the material cost can represent from 30% to 70% of the total project (Donyavi & Flanagan, 2009). Construction materials consist of various raw materials extracted from different markets. Sadly, the prices and availability of these materials are

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highly vulnerable to the turbulences of the varying market conditions (Christopher, 2011). Thereby making the construction materials a highly uncertain component in the construction project.

The range and variety of construction material are accelerating with the advancement of technology (Sasaki et al., 2016). This has resulted the construction industry to shift away from localized use of materials to centralized worldwide production. Gradually the simple materials are being replaced by the introduction of engineered composites and mixed assemblies. Moreover, chemical additives have enhanced the materials producing a wider array of properties (Calkins, 2012). The ample options of materials with varying properties have been considered as an accomplishment to the construction industry however the availability of too many options have caused complications in making the right choice (Zainal et al., 2019). Experts and specialists are required to select the most compatible construction material to compliment the project (Gudeta, 2021). The material choice will determine the machinery and workmanship required and making the right choice from initiation can pave the path for a smoother delivery (Zainal et al., 2019).

After the selection of material till the final product is erected, it involves a series of processes, which is referred as material management. This involves storage, identification, retrieval, transport and construction methods (Pellicer, et al., 2013). Material management is the system of planning and controlling to ensure the right quality and quantity of materials and equipment are specified in a timely manner (Donyavi & Flanagan, 2009). All these processes possess high uncertainty, as they are interlinked with other series of activities with unknown variables. Therefore, according to many authors effective materials management is the key to the success to construction project (Gulghane & Khandve, 2015). More researches even elaborate that effective material management can improve the productivity of the project and thus can lead to success (Pande & Sabihuddin, 2015).

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2.3.1.1 Classification of Materials Management in Construction Industry

Burt and Dobler (2003) classify materials into five categories. These categories are:

- Raw materials**-** materials that the company converts into processed parts. This might include parts specifically produced for the company and parts bought directly off the shelf (i.e., bolts, nuts).
- Purchased parts**-** parts that the company buys from outside sources (i.e., rubber parts, plastic parts).
- Manufactured parts**-** parts built by the company (i.e., tower case for a computer).
- Work in process**-** these are semi-finished products found at various stages in the production process (i.e., assembled motherboard).
- MRO supplies**-** maintenance, repairing, and operating supplies used in the manufacturing process but are not part of the final products (i.e., soap, lubricating oil). Chandler (2001) states that construction materials can be classified into different categories depending on their fabrication and in the way that they can be handled on site. He classifies the materials into five categories (Table 2.1). These categories are
- Bulk materials- these are materials that are delivered in mass and are deposited in a container.
- Bagged materials- these are materials delivered in bags for ease of handling and controlled use.
- Palleted materials- these are bagged materials that are placed in pallets for delivery.
- Packaged materials- these are materials that are packaged together to prevent damage during transportation and deterioration when they are stored.

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- Loose materials- these are materials that are partially fabricated and that should be handled individually.

Table 2.1 presents some examples of commonly used materials in construction and their classification.

Table 2.1: Classification of Materials

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

(Adopted from Chandler, 2001)

Tanubrata and Gunawan (2018) stated that the main categories of materials encountered in a construction project are engineered materials, bulk materials, and fabricated materials.

- Bulk materials- these are materials manufactured to standards and are purchased in quantity. They are bought in standard length or lot quantities. Examples of such materials include pipes, wiring, and cables. They are more difficult to plan because of uncertainty in quantities needed.
- Engineered materials- these materials are specifically fabricated for a particular project or are manufactured to an industry specification in a shop away from the site. These materials

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are used for a particular purpose. This includes materials that require detailed engineering data.

- Fabricated materials- these are materials that are assembled together to form a finished part or a more complicated part. Examples of such materials include steel beams with holes and beam seats.

2.3.2 Importance of Materials for a Project

Problems related to managing the flow of materials can be found in every organization (Ibegbulem & Okorie, 2015). The efficient management of materials plays a key role in the successful completion of a project (Hasaballah, 2018). The control of materials is a very important and vital subject for every company and should be handled effectively for the successful completion of a project (Shah 2016). Materials account for a big part of products and project costs (Stasiak-Betlejewska & Potkány, 2015). The cost represented by materials fluctuates and may comprise between 20-50% of the total project cost and sometimes more. Materials are critical in the operations in every industry since unavailability of materials can stop production (Abdel-Wahab et al., 2018). In addition, unavailability of materials when needed can affect productivity, cause delays and possible suspension of activities until the required material is available. It is important for a company to consider that even for standard materials, there may be significant difference in the date that the material was requested or date when the purchase order was made, and the time in which the material will be delivered (Segerstedt, 2017). These delays can occur if the quantities needed are large and the supplier is not able to produce those materials at that time or by any other factors beyond the control of the company (Griffin et al., 2019). The company should always consider that purchase of materials is a potential cause for delay (Chen and Lee, 2017). Unavailability of materials is not the only aspect that can cause problems. Excessive quantities of

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materials could also create serious problems to managers (Abdel-Wahab et al., 2018). Storage of materials can increase the costs of production and the total cost of any project (Bertram et al., 2019). When there are limited areas available for storage, the managers have to find other alternatives to store the materials until they are needed. Some of these alternatives might require re-handling of materials, which will increase the costs associated with them. Provisions should be taken to handle and store the materials adequately when they are received (Arijeloye & Akinradewo, 2016). Special attention should be given to the flow of materials once they are procured from suppliers.

It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company (Schmuch et al., 2018). In the late 1970's, construction companies experienced an increase in costs and a decrease in productivity. Owners of these companies thought that these increases in cost were due to inflation and economic problems. Further research concluded that these companies were not using their resources efficiently and that the decrease in productivity was also attributable to poor management (Bell & Stukhart, 2007). Material Management has been an issue of concern in the construction industry. 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification of materials and inadequate storage (Mehr & Omran, 2013).

The need for an effective material planning system becomes mandatory. Some companies have increased the efficiency of their activities in order to remain competitive and secure future work (Sodiq et al., 2019). Many other firms have reduced overheads and undertaken productivity improvement strategies. Considerable improvement and cost savings would seem possible through enhanced materials management (Capodaglio & Olsson, 2019). Timely availability of materials,

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systems, and assemblies are vital to successful construction. Materials management functions are often performed on a fragmented basis with minimal communication and no clearly established responsibilities assigned to the owner, engineer or contractor (Isaac 2015). Better material management practices could increase efficiency in operations and reduce overall cost (Essel, 2021). Top management is paying more attention to material management because of material shortages, high interest rates, rising prices of materials, and competition (Allwood et al., 2011). There is a growing awareness in the construction industry that material management needs to be addressed as a comprehensive integrated management activity (Kar & Jha, 2021).

2.4 Concept of Materials Management and Related Concepts

2.4.1 Material

Knop (2021) defined material as the physical components that are purchased and used to produce the final product and does not suggest that materials are the final product. In other words, materials are the parts used to produce the final product. Arijeloye and Akinradewo, (2016) defined materials as the goods purchased from sources out of the organization that are used to produce finished products. Dosumu (2015) defined materials as the items that are used to produce a product and which include raw materials, parts, supplies and equipment items.

2.4.2 Construction Materials

Construction materials are a collection of materials incorporated into buildings or structures at any stage or phase of construction (Samarasinghe et al., 2012). In attaining project success and stakeholders' satisfaction, it has been argued by some researchers that the construction workforce is most relevant in reinforcing sustainability in the construction industry (Fien & Winfree, 2014). However, Solanke and Fapohunda (2016) noted that for reduced construction cost; increased

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productivity; quality and timely project delivery, materials management efficiency must be a top priority. In affirmation, Teseama et al., (2021) stated that adequate use of the construction materials determines the strength, functionality and quality of the building, regardless of the expertise involved in the building construction process. Thus, construction materials play a vital role in workforce and machinery productivity (Aiyetan & Das, 2022). Hence, the importance of construction materials in sustainable building production cannot be underestimated.

2.4.3 Materials Procurement

Materials procurement (MP) is the primary objective of materials management in a project management system (Patel & Vyas, 2011). Materials procurement MP is the process of purchasing materials from external sources to support the operations of the construction company (Solanke, 2015). Furthermore, Hadikusumo et al., (2005) and Mehr and Omran (2013) described MP as a fundamental function of acquiring goods and services based on established terms and conditions mutually acceptable by buyers and sellers to enhance work efficiency.

2.5 Objectives and Functions of Materials Management

According to Mishra et al., (2007), Materials Management has three main objectives that could be expressed as:

- ❖ Maintaining continuity of supply: Previously, the stable flow of materials and goods for operations was supported by having high stock levels in the inventory and through the implementation of multiple sourcing procedures. Today, when the technological part of operations has gone through a deeper analysis, it is more likely embodied with help of purchasing portfolios, scrupulous selection of suppliers and development of supplier relationship.

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- Contributing to the reduction of costs. This objective is important to study from two perspectives: the first one is the size of the purchase share in the acquired materials, and the second one is the total cost of the ownership perspective or the effect on the bottom line. These could be achieved by using many methods, such as value engineering, purchasing tools, life cycle cost analysis and inventory control models.
- Innovation into product or process: Through a better understanding of procurement's capabilities, innovation might be achieved through the involvement of the supplier at the early stage of product development.

Many experts view the function of Materials Management from different perspectives and divide them hierarchically in various subdivisions (Iden & Eikebrokk, 2013). However, generally speaking, we can state the three primary functions of Materials Management:

i. Material Requirement Planning (MRP).

This function includes each activity that relates to capacity and resource planning. MRP is tightly concerned with all manufacturing or production activities, and it determines how much/many raw materials or semi-finished parts are required for operations, how to purchase them when it is sensible for the company and how to make these operations cost effective (Sri, 2021). For years, MRP disciplines have been developing and obtained a great deal of different methods that could be used for answering these essential questions (Silfiani et al., 2021). One of these methods is using various inventory models, which are aimed at minimizing the total costs of operations. The models could be chosen according to the industry and type of organization (Mishra et al., 2007).

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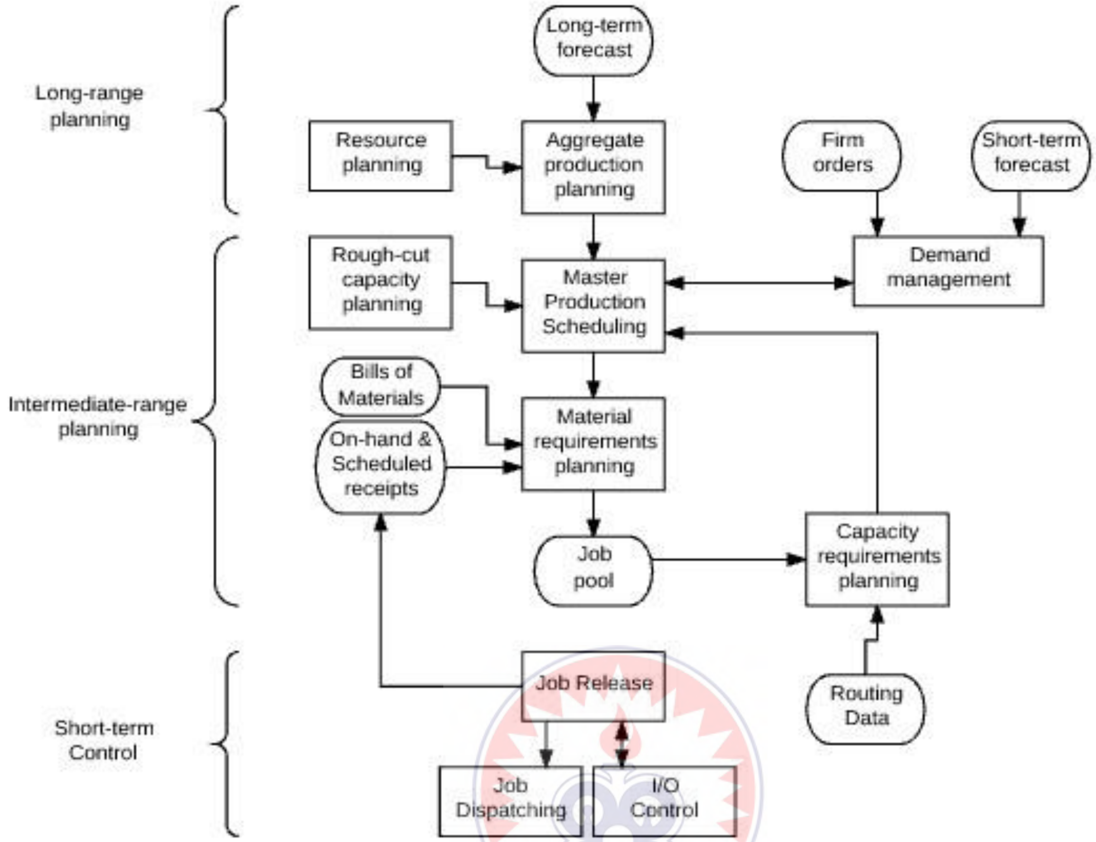

Figure 2.2: MMRP II Hierarchy example obtained from (Hopp and Spearman, 2008)

ii. Procurement.

Procurement, also called industrial buying, is the bottom function of Materials Management (Schiele 2019). Its Procurement's primary aim is to support the manufacturing activities of an enterprise by the acquisition of resources that the enterprise is not capable of producing in their premises due to a diversity of the industries or other technical issues (Chofreh et al., 2020). For example, a manufacturer of a mechatronic hydraulic motor system could only produce the components of the hydraulic motor, while the electric components and software are purchased from outer sources. Industrial buying differs greatly from traditional buying in many ways, since materials planning, logistics operations (warehousing and transportation) and cost analysis are

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much more complicated in this case, and its proper utilization has a serious impact on the operations and performance of an enterprise (Mishra et al., 2007).

iii. Warehousing and Transportation

The final function is mostly related to physical activities and the flow of materials. This property defines such details as which transportation mode to use or which warehousing solution would be appropriate for a particular company case (Koo & Choo, 2022). The selection of the appropriate option in these two factors plays a crucial role in an enterprise's activities as well. For instance, if the selected transportation option is too expensive for the particular type of product, it might have negative effect on the bottom line, and the overall costs on the annual basis may lead to extra expenses and, hence, financial instability of the company (Lamperti et al., 2019). The same could be stated about warehousing or material handling solutions. Since these factors have considerable influence on the overall cost, their management has to be seriously considered (Mishra et al., 2007).

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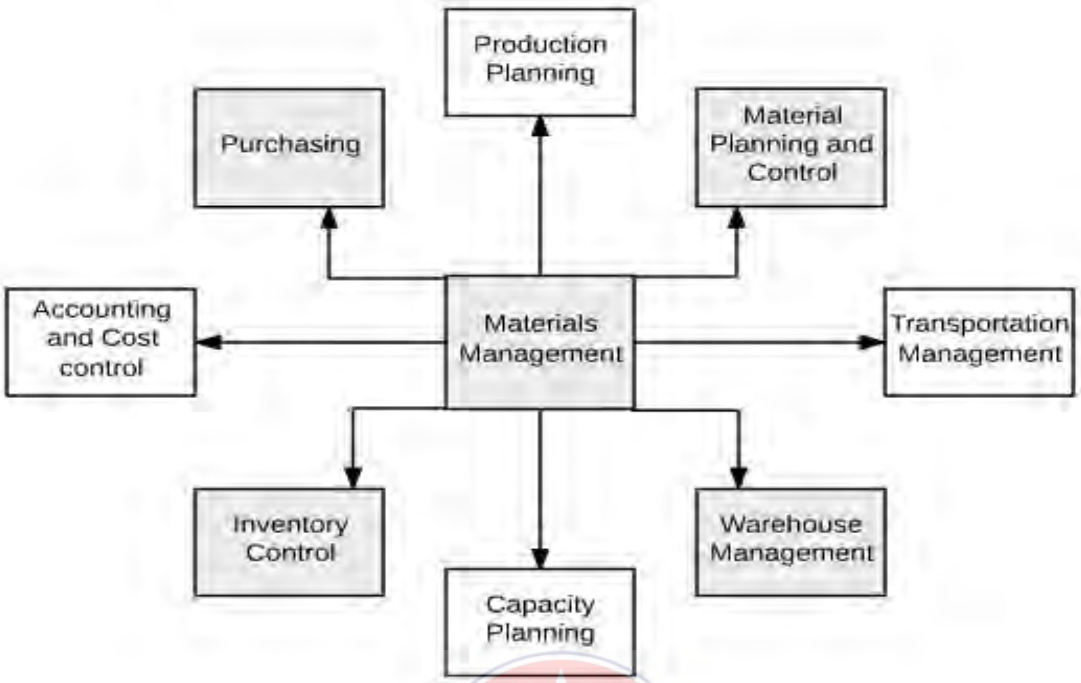

Figure 2.3: Scope of Materials Management. Source: (Mishra et al., 2007)

2.6 Material Management Practices

Materials management practices on building project are categorized practices to five processes, planning, purchasing, transportation, handling and waste control (Gulghane & Khandve, 2015). Ocheoha (2013) also identify practices such as just in time, Economic order quantity, warehousing management as part of materials management practices that should be taken seriously and these practices are described in the next section.

Materials Planning Method: Patel (2011) informed that the most commonly used basis for planning things out for the project is the Bill of Quantity prepared by the client. Companies may have two major levels in planning that is micro and macro level (Marsaoli & Kusumasari, 2022). Time, cost, material and labor are the four major types of planning undertaken on sites (Arijeloye &

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Akinradewo, 2016). The planning should be revised as frequently as possible in order to monitor whether work is progressing as planned. During the planning prices, detailing the project in terms of its outcome, team members' roles and responsibilities, schedules, resources, scope and costs are needed (Kerzner, 2022). At the end of this phase, a project management plan is produced, which is a document that details how your project will be executed, monitored and controlled, and closed (Aartsengel & Kurtoglu, 2013).

Burt (2003) observed that planning and programming of work should include strategies, tactics, and tools for managing the design and construction delivery processes and for controlling key factor to ensure the client receives a facility that matches their expectations and function as it is intended to function. Materials requirement planning is technique used to determine the quantity and timing requirements of dependent demand "materials used in the construction operation"

Purchasing of Materials: The purchasing function is central to material management (Arijeloye & Akinradewo, 2016). Purchasing has the responsibility and the authority to commit project funds for materials, equipment, and services (Fan et al., 2020). This activity may be accomplished by the home office, the field, or a combination of both depending on the size and the scope of the project. The home office must maintain planning, procedural, and policy direction over the field operations in order to ensure consistent purchasing practices, (Bell & Stukhart, 2007). The term procurement encompasses a wide range of activities that includes purchasing of equipment, materials, labour and services required for construction and implementation of a project (Pahinggis & Sucita, 2022). The objective of procurement in materials management is to provide quality materials at the right time and place, and at an agreed budget (Vrat, 2014). Procurement is also about organizing the purchasing of materials and issuing delivery schedules to suppliers and following-up, to make sure that suppliers deliver on time (Albert et al., 2018).

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Transportation of Materials: The movement of equipment, materials, and personnel to the job site represents a unique and specialization element of materials management (Hardin & McCool, 2015). Experienced traffic personnel can have a positive impact on the execution of the project while minimizing transportation cost (Oguntona et al., 2018). Good logistics involved the use of minimum of materials on site awaiting assembly, as well as being good for cash flow, this makes it easier to keep the site clean and tidy and reduces opportunities for slips trips and falls, an effective logistics team will also pay attention to the maintenance of plant and equipment (Kulkarni et al., 2017). Transportation or traffic expertise aids the materials management team in handling numerous types of special loads from delicate electronics to massive modules (Aasonaa, 2022). Knowledge of requirements, source and availability of this equipment may be critical to successful execution of the work, transport permitting requirements also must be considered early in the project, (Bailey & Farmer, 2002).

Materials Handling: Satoglu and Türkekul (2021) defined effective material handling as using the right method, amount, material, place, time, sequence, position, condition, and cost. This involves handling, storing, and controlling of the construction materials. Handling of materials is the flow component that provides for their movement and placement (Arijeloye & Akinradewo, 2016). The importance of appropriate handling of materials is highlighted by the fact that they are expensive and engage critical decisions (Ahmed, 2017). Due to the frequency of handling materials, there are quality considerations when designing a materials handling system. Material handling equipment selection is an important function as it can enhance the production process, provide effective utilization of manpower, increase production and improve system flexibility, (Chan 2002). Maauf (2021) affirmed the following improvement of materials handling system which are: Motion which implies that materials movement from one place to another should be handled efficiently to

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eliminate avoidable movements so as to minimize cost (Albert et al., 2021). Time which indicates that materials handling officer must ensure materials get to, or remove from production unit at the right time (Telek & Koštál, 2022). Place that materials should be at the right place at the right time to enhance smooth operations, Quantity: which means that materials supply to, or remove from the right place should be according to operating unit (Watts, 2011). Demands and Space: which means efficient storage space is paramount to achieving the objectives of materials handling system and overall organization goals.

Material Waste Control: Stock control is classified as a technique devised to cover and ensure all items are available when required (Panchal, 2013). Stock control can include raw materials, processed materials, and components for assembly, consumable stores, general stores, maintenance materials and spares, work in progress and finished products, (Murthy & Sukumar, 2017). It is of great importance that the bulk of construction materials delivery requires proper management of stock control (Ahmadian et al., 2014). Meanwhile, construction activities can generate an enormous amount of waste (Teo & Loosemore, 2001). It has been recognized as a major problem in the construction industry, (Formoso et al., 2002). However, tighter materials planning can reduce waste and can directly contribute to profit-improvement and productivity (Kasim, 2011). Reduction of waste can be done by practicing attitude towards Zero wastage, proper decisions at design stage, site management, proper standardization of construction materials, and codification of the same construction waste can also be reduced by using waste management system on project (Park & Tucker, 2017). The project activities are to be planned at every stage by every construction personnel, who are involved, in minimizing the overall waste generation at project (Thomas & Savido, 2000).

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Just-In-Time Method (JIT): The acronym JIT has been highly visible since late 1980 have, as manufacturing attempted to meet competitive challenges by adopting newly emerging management theories and techniques, referred to as Lean production, (Akintoye, 2005). Javadian et al. (2013) stated that Just in Time (JIT) manufacturing is described as a system that helps in making appropriate order of materials available to each operating unit at the right time in the right quantity. JIT is a systematic concept consisting of JIT purchasing, JIT transportation and JIT production. These three elements combine to create a material handling system that avoids waste and minimizes inventory investment. The technique has changed employees' belief, attitude, work habits and awareness of quality assurance (Kumar, 2010). It Just-In-Time Method is an operating management philosophy of continuous improvement in which non-value-adding activities (or wastes) are identified and removed for the purposes of reducing cost (Dange et al., 2014).

Ocheoha (2013) affirmed the objectives of JIT which is to reduce processing time, elimination of waste, have respect for people and cost minimization and these can be achieved if firms hold zero inventory; a system known as lean supply chain. The summary of the objectives of lean supply chain-oriented organizations is to improve productivity by minimizing the cost of the quality product (Qi et al., 2017). The following factors can be considered for the required improvements: process and product design, using state-of-the art equipment and technology, holding zero inventory, reducing lead-time of supply of materials, reducing batch size, using pull production system, simplifying factory layout (Arijeloye & Akinradewo, 2016).

Economic Order Quantity of Materials (EOQ): This determines the number of orders that minimizes total variable costs required to order and hold inventory (Riza et al., 2018). The economic order quantity (EOQ) refers to the order size that will result in the lowest total of ordering and carrying costs for an item of inventory (Sebatjane & Adetunji, 2019). If a firm place

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unnecessary orders it will incur unneeded order costs. If a firm places too few orders, it must maintain large stocks of goods and will have excessive carrying cost (Patil & Pataskar, 2013).

Adedayo et al., (2006) recommended the following assumptions of economic Order Quantity which are : deal with only one material whose demand is assumed to be and completely predetermined, demand remains constant over a period of time; Holding and ordering related costs per unit remain constant during the period of one year irrespective of the order quantity, No stock out is allowed and ordered materials arrive instantaneously and The lead time which is the time between ordering and receiving goods is instantaneous and is equal to 0, and all materials ordered are delivered.

Recovering and Recycling of Materials: Recycling is the process of collecting materials that are often considered trash and remanufactured tin to new products that can be resold or used again, construction recycling as the separation and recycling of recoverable waste materials generated during construction (Arijeloye & Akinradewo, 2016). Recovering simply refers to the process of retrieving the disposed or about to be disposed materials and make it ready for recycling. That is, removal of materials from the solid waste stream for sale, use, or reuse as raw materials, (Paul et al., 2019).

Warehousing Management: Arijeloye & Akinradewo (2016) opined that warehousing can be defined as materials management that houses and stores materials (raw materials, parts, components, work-in-process and finished goods) temporarily or for sufficient period between the point of origin and place of consumption and provision of necessary managerial information about the conditions of stored materials. All organizations have a minimum level of inventory they keep for future operation whether they operate Just-In-Time Method (JIT) or traditional delivery system (Bortolotti et al., 2013). Where inventory is kept is typically referred to as warehouse. Although,

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in many logistical arrangements the role of warehouse is more properly viewed as a switching facility as contrasted to a storage facility, i.e., effective distribution systems should be designed not to hold inventory for an excessive length of time but there are times when inventory storage is economical (Tien et al., 2019). In the same vein, warehouse management means effective and efficient storage and provision of required materials to ensure smooth operations (Varma & Khan, 2014). Paul et al. (2019) opined that a centralized warehousing is a situation where all materials (raw materials, parts, components, and finished goods) are stored in a specific location where materials are received and delivered to required operating places. This method is most suitable for small organizations because one store can be sufficient for their operations.

Decentralized warehousing permits materials to be stored in different right places to facilitate production operations and provide quality customer services (Westerkamp et al., 2020). Decentralization of warehouse is a common practice of large organizations that have different plants and product lines scattered over the country (Ben-Ner & Siemsen, 2017). Leenders (2002) identified the importance of warehousing to includes: reduction in transportation cost; warehousing and the associated inventory are added expenses, but they may be traded off with lower cost realized if JIT transportation is adopted; achieving smooth production-warehousing to some levels of inventories make materials available at all time for production process, hence, it helps to avoid stock-out of materials; coordination of supply and demand- firms that experience highly seasonal production and sales most times have problem in coordinating supply with demand of materials, warehouse helps them to even out supply and demand of materials over a given period; enjoy quantity purchase discounts- availability of warehouse encourages bulk purchases at discounted prices and maintaining a reliable source of supply - companies that have where to store materials always purchase materials and have regular supplier(s).

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2.7 Goals and Benefits of Material Management

As was mentioned previously, the role of the materials manager is strictly economical within an organization (Soni et al., 2016). This section will describe some of the aspects that the materials manager should keep in mind to handle all activities related to materials appropriately. Roy et al., (2013) stated that the objectives of a material management system should include lowest final cost, optimum quality, assurance of supply, and lowest administrative costs. The materials manager should obtain the materials needed at the lowest cost possible (Chavan, 2013). By buying products at the lowest possible costs, operating costs can be reduced and profits can be increased. Proper handling and storage of materials can reduce the total cost of materials; therefore, the materials manager should ensure that materials are handled properly and stored in the most adequate places (Arijeloye & Akinradewo, 2016). Quality is a very important aspect that the materials manager has to keep in mind (Zuo et al., 2012). When specifications require a high-quality product, quality could become the most important objective. Suppliers play an important role in any organization. Many companies rely greatly in outside suppliers for the materials needed for production. Good relations with suppliers might be decisive for a company to be in business (Macaulay, 2018). Companies that have good relations with suppliers could be more successful in attracting customers than companies that have bad relations with suppliers (Urbaniak, 2019). When a company has good relations with its suppliers it could benefit from cost reductions, cooperative environment from the employees of the supplier, and willingness to help with materials ordered and orders pending (Mehr & Omran, 2013). When a company has bad relation with their suppliers it might be possible that it experiences late deliveries or wrong materials delivered (Roy et al., 2013). This will have an impact in the total cost of the product, possibly increasing the total costs, and delaying the completion of the final product. Materials acquisition from the procurement time

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until it is received in the field can have a significant impact on the schedule of a construction project (Ogunde et al., 2017). Based on the studies presented, it is clear that effective management of materials can minimize the impact that lack of materials or improper management of materials could have in the overall schedule and cost of the project (Gulghane & Khandve, 2015).

The materials manager should assure that effective and economical transportation are used to transport materials to the site (Liu et al., 2020).

2.7.1 Benefits of Material Management

An effective material management system can bring many benefits for a company. Previous studies by the Construction Industry Institute (CII) concluded that labor productivity could be improved by six percent and can produce 4-6% in additional savings (Shehata & El-Gohary, 2011). Among these benefits are:

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

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- Stock reduction
- Purchase savings
- Better cash flow management

2.7.2 Material Management Processes and Techniques

Material management consist of a series of processes that need to be integrated, coordinated and synchronized well to ensure that material is available at their point of use when needed (Arezki et al., 2019). Material management process begins from need generated from site followed by this information conveyed to store department and material is ordered in the store, indent is generated (Fig. 2.4). Usually, vender selection is to be carried out for the least value and best items. Materials are received at store departments and inspection is carried out.

Figure 2.4: Material Management Processes. Source: (From Patil and Pataskar, 2013)

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2.7.2.1 Planning

Material planning is the initial process that needs to be carried out accurately in order to provide guide to all the subsequent activities. According to (Gulghane & Khandve, 2015) material planning includes quantifying, ordering and scheduling. The materials planning process covers the set-up maintenance of records and determines the target levels and delivery frequency. Adopting a good material management plan can increase productivity and profit. Hence, it can help to increase the success of project delivery, (Kasim, et al., 2005).

2.7.2.2 Testing

Quality is a prime factor to measure the performance of a project (Doloi et al., 2011). Quality assurance of building materials is vital in order to create strong durable and cost-effective structures (Berardi, 2012). Each construction project has a different set of specification and requirements. The contractors are required to select and procure suitable construction materials so that they can meet the contract specification. Unless a specific brand and model number is stated, it is advisable to conduct thorough study and analysis of the different material properties to check for its compatibility in the different zones of the building (Sanni & Eyiah, 2022). The materials are only ordered after receiving approval (Low and Ong 2014). Proper assessment of the various materials is important to ensure quality and durability of the final product (Sanni & Eyiah, 2022).

2.7.2.3 Procurement

Procurement is not only about appointing contractors and about preparing contract, but is also very much a starting point in the process of delivery (Mead & Gruneberg, 2013).

Activities included in the procurement process range from purchasing of equipment, materials, labour and services required for construction and implementation of a project (Kasim, et al., 2005). Another author has defined procurement is defined as identifying and analyzing user requirements

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and type of purchase, selecting suppliers, negotiating contracts, acting as liaison between the supplier and the user, and evaluating and forging strategic alliances with suppliers (Lechler et al., 2019). For many organizations, materials and components purchased from outside vendors represent a substantial portion of the cost of the end product, and hence effective procurement can significantly enhance the competitive advantage of a project (Morris & Pinto, 2007). Many authors have suggested that choosing best option of procurement can help to reduce the impact of uncertainties such as late deliveries, substandard raw material qualities, resource constraints and so on (Morris & Pinto, 2007). Therefore, to successfully deliver a project it is not about adopting a procurement system with best practice tactic to fix all problems, but to embrace an approach that has the best-fit tactic that gets the job done most efficiently (Keith, et al., 2016).

2.7.2.4 Logistics

Logistic is defined as concept that includes movement and it may encompass planning implementing and controlling flow and storage of all goods from raw materials to the finished product to meet customer requirements (Kasim, et al., 2005). For smoothly handling the materials, space need to be carefully allocated for material handling equipment, access roads, warehouses, workshop, and laydown materials in the construction site (Pellicer, et al., 2013). Planning these tasks accurately can help to formulate an efficient construction site layout that can provide easy access and routing of materials within the construction site (Lechler et al., 2019). Moreover, introducing slopes in the construction site can ease the circulation of materials because of the gravity effect. To control access and to increase the security of the site, setup wall or fence can be considered as a requirement for the construction site. Optimum forecasting for material movement, Mahdjoubi and Yang (2001) and planning of access and routing of materials within construction site.

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2.7.2.5 Handling

Various materials posses' different features and properties, that makes the handling of materials critical. Effective material handling involves handling, storing and controlling of construction material (Kasim et al., 2005). Proper protection during storage is often ignored, and this can result poor material quality or material deterioration (Ahzahar, et al., 2011). Moreover, it is also advised that transportation, loading and unloading of material should not be conducted in the rain. It is also recommended that the storage area needs to be enclosed, clean and dry with good air circulation and for some materials need to be stacked on pallets, not more than a certain safe height to prevent dampness and so on (Low & Ong, 2014). By adopting proper material handling and storage will help to keep the material intact and in good quality. And also, will reduce loss of profit due to theft, damage and wastage as well as running out of stock (Kasim, et al., 2005).

2.7.2.6 Stock and waste control

Material waste is a significant factor in construction cost. Calkins (2012) stated material waste is 9% by weight in the Dutch construction industry and 20-30% of purchased materials in the Brazilian construction industry. Material wastes are caused by several sources such as design, procurement, material handling, and operation and so on. Shen et al. (2003) defined building material wastages as the difference between the value of materials delivered and accepted on site. Moreover, material waste has been recognized as a major problem in the construction industry and it can also implicate inefficiency in project delivery. Adopting a proper stock control will help to increase the productivity and also can be one of the ways to improve waste control in the construction site. By introducing minimizing strategies to reuse materials in both design and construction phase can be a mean to reduce waste (Dainty & Brooke, 2004).

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Some authors simplify these stages into distinctive phases. As a matter of fact, one of the research projects done by Manteau (2007) on the material management practices in Ghana explains that the current material management phases in Ghanaian construction industry are bidding phase, sourcing phase, material procurement phase, construction phase and post construction phase. A study conducted in India by Patel and Vyas (2011) has summarized the material management processes into 8 main parts. They were planning, benchmarking, purchasing, receiving, inspection, storage, issuing material and inventory control.

Therefore, it is very evident that in various countries these processes are carried out in different ways. There can be many factors that might influence these processes such as culture, work environment, belief and so on. Moreover, different groups have learnt to deal with uncertainty in different ways, often because they find themselves faced with different levels of uncertainty.

2.8 Root Causes of Ineffective Material Management in Construction Sector

During the past years, various academics researchers have conducted studies investigating to find out the issues causing ineffective materials management in construction projects. Among these studies were:

A study carried out by Oguntona et al. (2018) suggested that transport difficulties, waste, improper handling on site, misuse of specification, lack of proper work plan, inappropriate materials delivery and excessive paperwork all have an immense effect on materials management. Another researcher Dey (2001) emphasized that the common issues regarding material management are as follows:

- Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality;

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- Not receiving materials during the time of requirement causing to decrease motivation as well as productivity.
- Incorrect materials take-off from design and drawing documents;
- Constant design changes
- Theft or loss of item
- Choice of type of contract for specific material procurement
- Vendor evaluation criteria
- Piling up of inventory and controlling of the same
- Management of surplus material.

In another study conducted by Donyavi and Flanagan (2009) stated the common problems in material management are as follows:

- Failure to order on time which may cause delay in the projects;
- Delivery at the wrong time which may interrupt the work schedule;
- Over ordering;
- Wrong materials or wrong in direction of materials requiring re-work;
- Theft of materials from delivery into production;
- Double handling of materials because of inadequate material

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Moreover, a study conducted Kasim (2008) highlighted those problems could emerge due to human error, especially because some construction firms still rely on manual methods for material management which involves paper-based techniques. In addition, she states that problematic use of paper-based reports for exchanging information relating to materials component with supply chain can result misunderstanding and poor coordination.

In another research done by Gulghane and Khandve (2015), they state that problematic management of material are due to overstock materials because of improper planning, damaged materials due to logistics, handling or in application, loss of materials because of improper supervision, waiting of the materials to arrive in location due to improper tracking system, frequent movement of materials due to improper site layout, inflation, material changes in buying or purchasing situation starting from the prepared cost estimation, bulk construction material, the shortage and changes of construction materials quantity required, material inefficient on site, stealing and loss of construction material, material shipment, work repairing, delay in updating or posting storage system on site, in accurate estimation of shipment quantity of materials, uneconomical order quantity of materials poor shipping time, increasing transport cost of materials, material over usage in location of project, choosing the wrong materials for construction, the increasing storage cost of materials, the poor buying ability of managers, delay of payment for materials.

A study done by Kasim et al. (2005) investigates the problems in material management by conducting research on 6 case studies. Case study A and B are two small projects from two different construction companies, while the other 4 case studies are larger or more complex studies. The interviewees under study were experience constructional professionals ranging from 8- 32 years' experience. Moreover, the cost of the projects ranged from £ 1.78 million to £ 4.2 billion.

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17 possible issues causing ineffective material management were revealed. The major problems that were discovered are material management activities related to constraints site storage, site logistics with regards to material handling and distribution and also ordering and delivery of materials to the construction site. The following are the identified 17 causes:

- Late delivery
- Site storage problems
- Logistics problems
- Incorrect delivery
- Inadequate loading area
- Site access problem
- Regulation consideration
- Congestion time
- Others: Incomplete delivery
- Constraint's storage compound
- Material damages
- Lack of materials
- Improper handling
- Tower crane distribution problem
- Supply chain challenge
- Project size challenge
- Project location challenge

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A study done by Patel and Vyas (2011) had an interesting approach to identify the problems occurring in the material management process. They have used 3 projects from Hyderabad, India to reveal the problems in the material management. Initially they divided material management process into 4 main phases, which are material identification, Vendor selection, Procurement and Construction phase. Next the problems associated with each phase were clearly identified, disclosing the usual problems occurring in these phases, this is shown in the below Table 2.2 (Patel & Vyas, 2011).

Table 2.2: Problems Occurring in the Materials Management Process.

A		**Material Identification**
	A1	Undefined scope
	A2	Lack of communication
	A3	Incomplete drawings
	A4	Lack of conformance to requirements
	A5	Nonstandard specification
	A6	Incomplete/ ineffective meeting
	A7	Difference between plans and specification
	A8	Not determining what and when materials needed
B		**Vendor selection**
	B1	Uncontrollable bid list
	B2	Incomplete proposal
	B3	Time spent in investigating non-qualified suppliers
C		**Procurement Problem**
	C1	Availability of material
	C2	Availability of quality
	C3	Matching price to competitors' price
	C4	Late deliveries
	C5	Late or incorrect submittals

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	C6	Poor communication
	C7	Lack of conformance to requirements
	C8	Unrealistic delivery date
	C9	Vague stated requirements
	C10	Re handling of material
	C11	Storage of materials
	C12	Theft
	C13	Damage of material
D		**Construction Phase**
	D1	Incorrect type of material delivery
	D2	Incorrect sizes delivered
	D3	Incorrect quantity delivered
	D4	Keeping track of material
	D5	Re-handling of material
	D6	Storage of material
	D7	Loss of material
	D8	Damage of material
	D9	No supplier quality assurance
	D10	Poor communication
	D11	Receiving handling and storage of unused materials

Source: (Patel and Vyas, 2011)

Even though we understand all these issues are usual problems in material management in construction industry, we need to further identify the threats and the vulnerabilities associated in the construction industry related to material management (Kar & Jha, 2021). It has been identified that in construction problems such as limited skilled professionals, lack of labours and unavailability of local constructional materials are major issues faced by the construction industry (Chan et al., 2018). However, the relationship between these issues and ineffective material management are not recognized. Therefore, to improve the construction project delivery, further

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research needs to be conducted to find the major root causes of ineffective material management at each phase (Vatsal & Pitroda, 2017).

2.8.1 Consequences of Ineffective Material Management on Project Delivery

A success of a construction project lies in the ability of all the stakeholders to plan effectively, as well as properly manage the resources (Morris, 2013). Furthermore, this grand plan encompasses of sub plans, which helps to determine, sequence, strategize how to allocate the resources effectively. Construction projects are well known for being complex and are subjected to high uncertainty and variability (Ali et al., 2018). Construction materials are involved throughout the construction project and variability and uncertainty can be traced back to construction material (Sanni & Eyiah 2022). Therefore, formulating a good material management plan is highly mandatory to support the grand plan (Gudeta, 2021).

Unavailability of materials when needed can affect the productivity and it may cause delay and difficulties to meet the schedule (Muhwezi et al., 2014). On the other hand, having excessive materials on site will also create problems to the managers. Storage of materials can increase cost of production thus increasing the overall cost of the project (Olabi et al., 2021). Furthermore, if the site lacks space to store all the materials may burden the managers to rent alternative storage areas which will cause more trouble and cost, (AlHaddad, 2006).

In most contracts, the cost and time requires to complete the specified scope of works are defined in project documents (Gransberg et al., 2013). Control of quality of materials and workmanship is achieved through proper quality control plan and its implementation through a preset level of quality control and inspection of various activities and materials (Mohamed & Tran, 2022). Budget control is done through monitoring progress payments and variation costs. The schedule is monitored by ensuring timely approval of materials, shop drawings, timely procurement of

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materials and execution of works as planned (Sanni & Eyiah, 2022). Quality control and safety are achieved through inspection of works during the construction process, ensuring the use of approved materials and workmanship (Rumane, 2017).

It is a fact that those construction projects that are unable to use their resources efficiently will reduce their productivity reflecting their poor management skills. According to a study done by Baldwin and Bordoli (2014) stated that 40% of the time lost on the site can be attributed to bad management, lack of materials when needed poor identification of materials and inadequate storage. By formulating an ineffective materials management plan can have a negative impact on cost, quality and time, which will affect the project delivery (Gudeta, 2021).

There have been various studies conducted in different countries to identify the factors causing cost overrun, delay and quality issues in construction projects (Shah, 2016). Surprisingly, the factors are more or less very similar in various cases, but the ranking of the factors were different. The fact that cannot be ignored is that factors related to construction material appeared in most of these lists of factors causing cost overrun, delay and quality issues.

In a study conducted by Wanjari and Dobariya (2016), the highest factor causing cost overrun in India construction industry was identified as price escalation of raw material. In another study done by Cheng (2014) about an exploration into cost influencing factors on construction projects revealed that material shortage or supply delay is a prominent project risk that will influence the project cost. Similarly, study conducted to identify the delay factors in construction projects of Turkey found out that material is a significant factor causing project delay, (Gunduz et al., 2013). Furthermore, it was explained that problems such as late delivery of materials, poor procurement of construction material and shortage of construction materials are prime factors causing project delay (Amri & Marey-Pérez, 2020).

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Unlike cost and time, quality is more subjective. The factors affecting the quality of a project are perceived differently by the contractor, consultant and client (Alinaitwe et al., 2013).

2.9 Materials Utilization and Wastages in Construction Projects

Materials procurement management is being recognized academically and industrially as an integral section of construction. According to Song et al. (2006), materials procurement management in construction projects, especially large and complex project, guarantees proper management of available funds and materials (at the right place, time and quantity). As a result, materials wastages due to excessive purchase of materials, long materials storages and unclear design specifications will be drastically minimized (Chalmers et al., 2014). In addition, the implementation of this management strategy also ensures timely project delivery, environmental protection and proper utilization of materials towards sustainable construction, (Donyavi & Flanagan, 2009).

2.9.1 Unavoidable waste (or natural waste)

This type of material wastage in which the investment necessary to its reduction is higher than the economy produced (Formoso et al., 2002). The percentage of unavoidable waste in each process depends on the company and on the particular site, since it is related to the level of technological development (Meghani et al., 2011).

2.9.2 Avoidable waste

This happens when the cost of waste is significantly higher than the cost to prevent it (Thyberg & Tonjes, 2016). That is to say the cost of the material is much higher than the cost which is required to minimize the waste.

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Waste can also be classified according to its origin, i.e., the stage that the main root cause is related to. Although waste is usually identified during the production stage, it can be originated by processes that precede production, such as materials manufacturing, training of human resources, design, materials supply, and planning (Khanh & Kim, 2014).

2.9.3.3 Transportation

Concerned with the internal movement of materials on site, excessive handling, the use of inadequate equipment or bad conditions of pathways can cause this kind of waste (Oguntona et al., 2018). It is usually related to poor layout, and the lack of planning of material flows. Its main consequences are; waste of man hours, waste of energy, waste of space on site, and the possibility of material waste during transportation.

2.9.3.4 Processing

Related to the nature of the processing (conversion) activity is which could only be avoided by changing the construction technology. For instance, a percentage of mortar is usually wasted when a ceiling is being plastered (Ugochukwu et al., 2017).

2.9.3.5 Inventories

Related to excessive or unnecessary inventories which is lead to material waste (by deterioration, losses due to inadequate stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up to inventory wastage (Hasmori et al., 2020). It might be a result of lack of resource planning or uncertainty on the estimation of quantities.

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2.9.3.6 Movement

Movement is Concerned with unnecessary or inefficient movements made by workers during their job this might be caused by inadequate equipment, ineffective work methods, or poor arrangement of the working place (Ayalew et al., 2018).

2.9.3.7 Production of defective materials

It occurs when the final or intermediate product does not fit the quality specifications (Aziz & Hafez, 2013).

This may lead to rework or to the incorporation of unnecessary materials to the building (indirect waste), such as the excessive thickness of plastering. It Production of defective materials can be caused by a wide range of reasons: poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc. (Liu et al., 2020).

2.10 Theoretical framework

The theoretical framework of a research study refers to the system of concepts, assumptions, expectations, beliefs, ideologies and theories that lend support and inform the research themes identified as well as their relationship (Creswell, 2009, Robson, 2002; Maxwell, 2004). It thus forms a critical part of any research design (Creswell, 2009, Maxwell, 2004). In establishing a decision to solve complicated, unstructured decision problems, Saaty (2008), presents a model with explains how such decision-making process is undertaken in any management system. As my overarching research question is: What is the best decision on the most effective practices to improve material management in the Ghanaian construction industry? This model (Fig. 2.5) appears to provide a perfect fit for developing the theoretical framework suitable to use to analyze data in this study.

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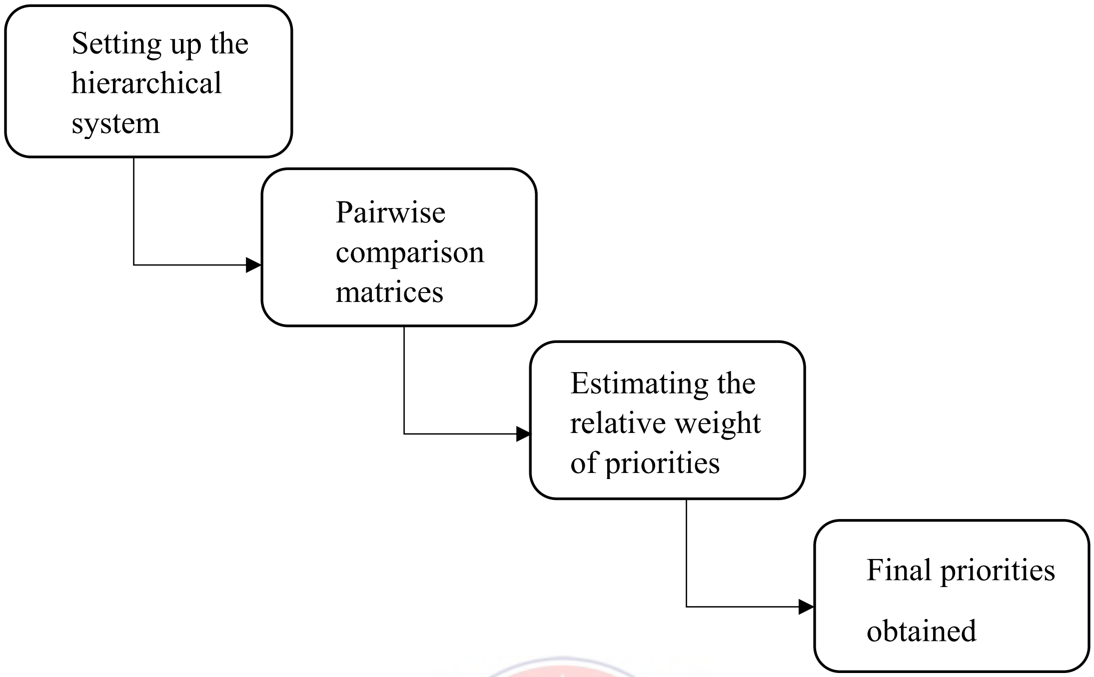

Figure 2.5: Representative Model of Saaty's Analytical Hierarchy Process. Source: (Author's Construct, 2021)

As illustrated in Figure 1, Saaty (2008) proposes an Analytical Hierarchy Process (AHP) to make a decision in an organized way in four main steps. In order of operation, the first phase constituted setting up the hierarchical system by decomposing the problem into a hierarchy of interrelated elements/criteria. Here, the decision hierarchy is structured from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives) (Fig. 2.6). Next, a set of pairwise matrices is constructed. Each element in an upper level is used to compare the elements in the level immediately below with respect to it. Comparing the comparative weight between the attributes of the decision elements informs the reciprocal matrix. To make such comparisons, Saaty (2008) recommended a scale of numbers that indicated how

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many times more important or dominant one element was over another element with respect to the criterion or property with respect to which they are compared (Table 2. 3).

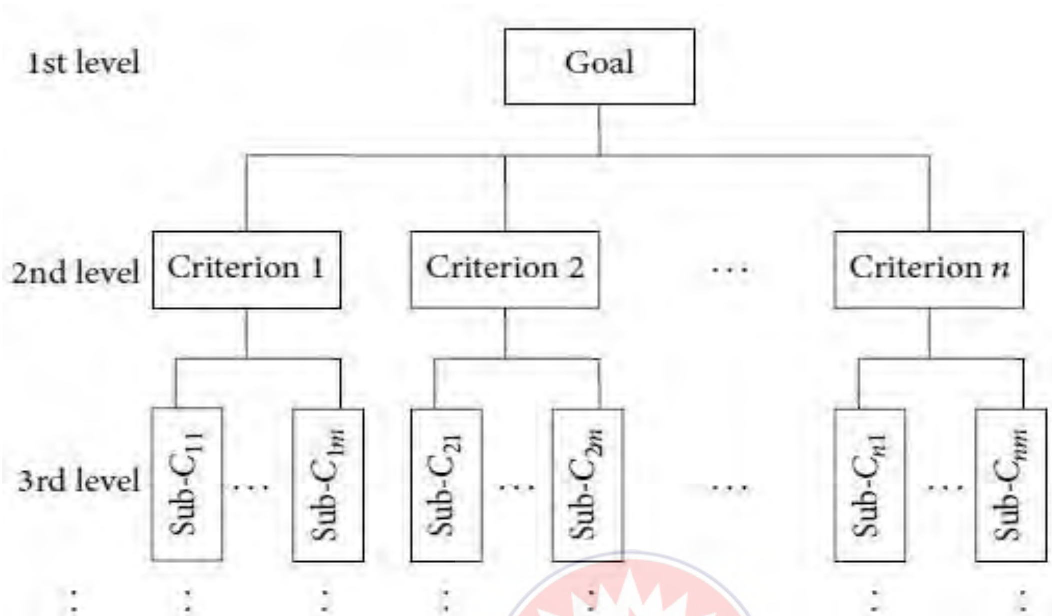

Figure 2.6: The Hierarchy Structure of AHP. Source: (Liu et al., 2015)

After, the individual subjective judgments are synthesized and the relative weights estimated. In this regard, the priorities obtained from the comparisons are used to weigh the priorities in the level immediately below. This is done for every element. Finally, for each element in the level below, its weighed values are added to obtain its overall or global priority. This process of weighing is continued and added until the final priorities of the alternatives in the bottom most level are obtained.

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Table 2.3: Scale of Relative Importance for Pairwise Comparison

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equally to the object
3	Moderate importance	Slightly favors one over another
5	Essential or strong importance	Strongly favors one over another
7	Very strong importance	Dominance of the demonstrated importance in practice
9	Extreme importance	Evidence favoring one over another of highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed
½,1/4, 1/6,1/8	Inverse values	Reverse importance of comparison

Source: T.L. Saaty (1980), The Analytic Hierarchy Process

More importantly, Saaty (1980) established a consistency ratio as a checking criterion to validate the effectiveness of the decision made. This ratio tells the decision-maker how consistent he has been when making the pair-wise comparisons (Yin, 2013). Such detail is imperative to care for the inconsistencies that may apply due to random judgements from decision makers. The consistency index (CI) is calculated according to the following equation;

$$C.I = \frac{\lambda_{\max} - n}{n-1} \qquad (1)$$

Where, is $\lambda_{\max}$ the largest eigen value of matrix M and n is the number row or columns. The values of consistency index have been determined for matrix with different dimensions and presented as random consistency index. Through using this index and index obtained from above equation, the rate of consistency index can be determined as follows:

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$$CR = \frac{CI}{RCI} \qquad \rule{4cm}{0.4pt}$$

Where; ***CR*** is the Consistency Ratio; ***CI*** is the consistent Index and ***RCI*** (Table 2.4) denoting the Random Consistency index (the consistency index of randomly generated pairwise matrix).

Table 2.4: Values of Random Consistency Index (RCI)

N	1	2	3	4	5	6	7	8	9	10
RC	0	0	0.5247	0.8816	1.1086	1.2479	1.3417	1.41	1.4057	1.4854

Source: *Introduction to the Analytic Hierarchy Process* (Brunelli, 2015).

As a caveat, If CR is less or equal to 0.1, the rate of consistency in the matrix is acceptable; otherwise, there is inconsistency in the matrix.

This model has been used by many authorities regarding decision-making phenomena (Yin, 2013; Cheung et. al.,2001; Atthirawong and MacCarthy, 2002; Palcic and Lalic, 2009 and Schmidt et al., 2016).

2.10.1 Application of Analytic Hierarchy Process in Materials Management

Analytic Hierarchy Process (AHP) is a simple decision-making tool to deal with complex, unstructured and multi-attribute problems. Most of the early works of AHP has been developed primarily by Saaty (1980). AHP has been applied in numerous fields such as Geographic Information System (GIS) (Bouroumine et al., 2020; Das et al., 2020), genetic algorithms (İnce et al., 2020) and Small and medium-sized enterprises (SMEs) (Azzahra et al., 2021). The strength of AHP is its applicability to the measurement of intangible criteria along with tangible ones through relative importance of different influencing factors and to structure a complex multi-attribute system. AHP consists of four steps as listed below:

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- Structuring the hierarchy of criteria and alternatives for each criterion.
- Assessing the decision-makers 'evaluations by pairwise comparisons.
- Using the eigenvector method to yield priorities for criteria and for alternatives by criteria.
- Synthesizing the priorities of the alternatives by criteria into composite measures to arrive at a set of ratings for the alternatives.

The top level of hierarchy is known as the overall focus or goal. The elements that affect the decision are called attributes or criteria and are included in the subsequent levels, each of which may have several elements. Attributes are mutually exclusive ad their priority does not depend on the elements positioned below them in the hierarchy. The lowest level in the hierarchy is known as the alternative (decision options). Once complete the problem decomposition and hierarchy construction, pairwise comparison is carried out. The pairwise comparison feature is one of the major strengths of AHP, whereby it derives accurate ratio scale priorities by comparing the relative importance, preference or likelihood of two elements with respect to another element (the goal) in the level above as opposed to traditional approaches of assigning weights which can be difficult to justify. The quantification level of comparison can be carried out using verbal method such as naming the quantification levels from equally important to absolutely more important in a nine-point scale or using preferential numbers, Saaty (1980). After the comparison stage has completed, mathematical process will then commence to evaluate the priority weights for each matrix. The consistency ratio (CR) is being determined, whereby if the value is larger than 0.10, which is the acceptable upper limit for CR, Saaty (1980); it implies that non consistency in decision making has occurred and the comparison must be reviewed. Subsequent mathematical process will then integrate the assigned weights to develop an overall evaluation process. Mu et al., (2020) had

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reported that the use of expert system has made the mathematical process in Analytic Hierarchy Process AHP simple and accurate to apply.

In order to determine the optimal management system for the operating environments, a four-level hierarchical model is devised. The first level, focus, sets the main objective, here referred to as the optimal inventory management system. The focus is divided into four main attributes or characteristics, which are value of parts (cost), specificity, criticality and demand pattern. The third level of hierarchy includes sub-attributes for the four abovementioned objectives as follows:

- Value of parts: High, Low
- Specificity: Standard parts, User specific parts
- Criticality: Low, High
- Demand: Predictable, Volatile the fourth or the last level consists of four alternatives: no stock (outsource control to supplier), time guaranteed supply with cooperative stock pooling, decentralized safety stock policy and optimal safety stock policy with supplier partnership.

2.11 Summary of the Chapter

The chapter reviewed related literatures by different scholars on the area under study of Materials Management in the construction industry. This chapter outlined some key terms which were defined and any other associated information's that was essential to the research work and it also looked at the theoretical framework of the study.

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CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology describes the principles and procedures of logical thoughts captured in research (Fellows & Liu, 2015). In this context, this chapter unveils a detailed description of how the entire study was carried out with a spot light highlighted on the research paradigm, study design, study population, study areas, sample and sampling techniques, data collection instruments, validity, reliability and data analysis techniques embraced eventually.

3.2 Research Paradigm

Inclined to the research process, it serves a great significance to consider the philosophical assumptions that underlie this study. Ditsa (2004) defined paradigm is a set of beliefs, values and techniques which is shared by members of a scientific community, and which acts as a guide or map, dictating the kinds of problems scientists should address and the types of explanations that are acceptable to them. In the world of research, there are a number of paradigms and even new paradigms have continued to evolve over time. Ditsa (2004) asserts that the dominant paradigms widely accepted in research are the positivist, interpretive/constructivist, pragmatic and critical paradigms. Relative to the various types of research paradigms, Boateng (2014) believes that the choice of a particular research paradigm can arguably be based on: a researcher's philosophical beliefs/views of the world, the research topic of interest, the level of existing knowledge pertaining to the topic, and the range of skills the researcher may have in methodological approaches. The different approaches of research allow researchers to understand different phenomena and for different reasons. Similarly, Migiro and Magangi (2011) agrees that, research approaches are

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determined by the researcher's philosophical perspective (whether postpositivist, constructivist, or pragmatist), the type of information sought (such as objective, factual, or subjective information, and personal experiences) and the methods and strategies employed to obtain this knowledge (surveys and experiments versus open-ended interviews and observations, or both). Thus, the choice of a research paradigm and its related methodologies may depend on the questions being asked rather than a commitment to a particular paradigm. The best paradigm is determined by the researcher and the research problem not by the method (Migiro & Magangi, 2011). Marked by mixed methods in the design, the study therefore adopted a pragmatic (quantitative and qualitative) stance primarily because of the complex nature of the research phenomenon being investigated and the research questions posed for the study. Teddlie and Tashakkori (2009) believe that pragmatism is the best philosophical basis of mixed methods research. For many mixed method researchers, pragmatism has become the answer to the question of what is the best paradigm for mixed methods research as it allows both methods to be used in a single study (Migiro & Magangi, 2011). Pragmatism refers to an approach to issues that is centered on practical needs, rather than what might be perceived as objectively or absolutely true (Morgan, 2014). Early pragmatists eschew the idea that social inquiry utilizing a single scientific methodology could reveal truths regarding the state of the world (Kaushik & Walsh, 2019, Maxcy, 2003). Pragmatists view the world in terms of "what works" rather than what is objectively "true" or "real."

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3.3 Research design

Asenahabi (2019) defined research design as a process that sets the procedure on the required data, the methods to be applied to collect and analyze this data, and how all of this is going to answer the research question. Cross-sectional survey therefore was employed for the research design. The reason for this choice was based on the fact that, it permitted all the measurements for a sample member to be obtained at a single point in time (Sedgwick, 2014). More importantly, this design generally was quick, easy, and cheap to perform especially comparing to the time frame attached to complete the study. Akin often to questionnaire survey, this design also ensured that there was no loss to follow-ups because the participants were interviewed only once (Sedgwick, 2014). In effect, this design was used to assess the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana, determine factors that militate against effective decision making in relation to construction materials management in the Ghanaian construction industry, develop a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP), and make recommendations for adoption of hierarchical decision-making process in construction materials management within large-scale construction firms in Ghana

This survey design was paramount as it compared many different variables and assembled a pool of opinions and practices at the same time which in turn allowed the researcher to obtain a detailed perspective towards improving material management practices in construction projects in the Ghanaian construction industry (Zuberbier et al., 2010). As a two-staged design, the study employed both qualitative and quantitative methods (mixed method). Using both methods compensated the weakness of the other and improved the quality of the study subsequently (Malhotra, 2007). The qualitative approach through the use of interview aided to collect data in

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establishing a decision on the most effective practices to improve material management in the Ghanaian construction industry. According to Polgar and Thomas, (2011) qualitative research is an interpretative approach which attempts to gain insight into the specific meanings and behaviors experienced in a certain social phenomenon through the subjective experiences of the participants. With the goal of understanding the phenomenon from the viewpoint of the participants (Cohen et al., 2002), this method was imperative. Similarly, quantitative approach was adapted in assessing the current material management practices applied in large construction projects as well as in determining the factors that militate against effective material management in the Ghanaian construction industry. This approach allowed the data to be quantified and analyzed to obtain the needed results (Apuke, 2017). Williams, (2011) defined quantitative research as the collection of data in order that information can be quantified and subjected to statistical treatment in order to support or refute alternative claims of knowledge. Saunders et al. (2007) buttressed further that, combining these methods improves the quality of any research.

3.4 Population

The study population comprised site supervisors namely; site managers/engineers, project managers, general foremen, and works superintendent employed by D1K1 and D2K2 construction firms in Greater Accra Region, Ashanti Region and Eastern Region. These regions were selected because of the large volumes of construction projects and the prevalence of D1K1 and D2K2 construction firms. All these contractors' personnel are responsible for managing materials on construction sites. In order to access these personnel, the contractors registered with the Association of Building and Civil Engineering Contractors, Ghana (ABCEG) in the three selected regions were selected. The number of D1K1 and D2K2 construction firms registered with ABCEG in the selected regions as at February 2020 in the selected regions is given in Table 3.1. The region,

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Ashanti and Greater Accra were considered because they have many and important ongoing projects compared to other regions of Ghana. Eastern was also considered because it is a fast-growing town encompassed with fast growing operatives as well as managers in the construction industry. The target population for the study therefore constituted workers and management in the construction industry in the towns of Accra, Kumasi and Koforidua respectively.

Table 3.1: Number of Contractors Registered with ABCEG

Town	Contractors registered with ABCEG
Kumasi	40
Accra	61
Koforidua	20
Total	**121**

Source: Association of Building and Civil Engineering Contractors, Ghana (ABCEG) (2020).

3.5 Sampling Technique and Sample size

Sampling technique describes the process whereby a researcher chooses his sample (Trochim, 2004). In this regard, two sampling techniques were employed to access both the construction firms (sites) and also reach the respondents: systematic and purposive sampling techniques. Systematic random sampling was adopted in the selection from a sampling frame the construction firms registered with the Association of Building and Civil Engineering Contractors, Ghana (ABCEG) in the three towns of study (Accra, Kumasi, and Koforidua). In using this technique and as a rule of thumb, the researcher must assume an appropriate sample size with respect to the nature of the study. Here, an ideal and desirable sample size of 7 was reached owing to the resources (money and time) and workload involved in carrying out the study. The firms in the sampling frame were all arranged in a classified sequence. The interval for the sample was then determined using the formulae;

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$$k = \frac{N}{n},$$

Where k denotes the interval of the sample, N, the population size and n, the sample size. This interval served as the standard distance between each selected number.

After, a starting point (number) was randomly selected between 1 and the sampling interval. Devoid of any element of bias, a random number generator was engaged to obtain this number. The sample interval (k) was then added to this random number (r) to add the next member to the sample and the process was repeated to add the remaining members of the sample, thus, r, r+k r+2k, etc. became the elements of the sample. This procedure was used to get the sample for all the three firms (Table 3.1). According to Thompson, (2012), Systematic sampling is a symmetrical process where the researcher chooses the samples after a specifically defined interval. Sampling like this leaves the researcher no room for bias regarding choosing the sample. Purposive sampling technique was used to selected respondents who had achieved a minimum of five years of experience in supervising construction projects undertaken by their respective firms.

After having had the136 respondents through purposive sampling technique, the researcher used purposively sampling to select 10 of them (Table 3.1) for semi-structured interview since the questionnaire could not delve deeper into many of the issues raised in the literature. Under this premise, the researcher unrelentingly run a background check on all these participants especially owing to the complex nature of the study. Per their experience, exposure, knowledge, size and number of construction projects undertaken by them, these ten participants deemed a level ahead of the others hence informing their selection. Invariably, these ten respondents stood privileged to respond both to the questionnaire and to be interviewed as well. This technique was based on the reason that participants were deemed experts with much experience and exposure in their

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respective fields (Saunders et al, 2012). Purposive sampling is a sampling technique in which the researcher relies on his or her own judgment when choosing members of population to participate in a study (Black, 2010).

Table 3.1: Sample Representation of Respondents.

Towns	Number of Construction sites visited	Number of Respondents Selected for Questionnaire	Number of Respondents Selected for Interview
Kumasi	7	48	3
Accra	7	52	5
Koforidua	6	36	2
Total	**20**	**136**	**10**

Source: Author's field study (2021).

Owing to the intensive construction projects populating the towns of Kumasi and Accra, more of the construction sites were selected than those in Koforidua. Conclusively, 136 respondents were selected from the towns; Kumasi, Accra and Koforidua and used for the study eventually

3.6 Data collection

The study was dependent on both secondary and primary sources of data. Primary data was collected using structured questionnaires and semi-structured interview guide developed in tandem with the study objectives. Data gotten through thorough review of literature of authorities on material management in the construction industry constituted the secondary data. A blend of these two sources resulted in realizing the objectives of the study.

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3.6.1 Questionnaire

In addressing the objectives of this study, the use of a questionnaire was eminent to obtain the needed data. The questionnaire was used to collect data from the respondents in assessing the current material management practices and also to determine the factors militating against effective material management in the Ghanaian construction industry. Through the support of literature, the questionnaire was formulated. In its design structure, the first section made up the demographic characteristics of respondents. The second section comprised assessing the current material management practices applied in the Ghanaian construction industry. The third section centered on determining the factors militating against effective material management in the Ghanaian construction industry. The questions were closed-ended items and subsequently self-administered to ensure they are easily filled by respondents' performances. A questionnaire was used because it enabled the researcher to efficiently collect a large amount of data required to develop relationships through statistical (Fellows & Liu, 2015). Moreover, this instrument was chosen because it sustained the respondents on the subject, provided the easiest means of reaching them and also obtained the desired information in the limited time available. For easy response by participants, the items were subjected to five-point Likert scale rating. In assessing the current material management practices applied in the Ghanaian construction industry, respondents were allowed to rate the responses with the scale; not important (1), less important (2), neutral (3), important (4) and very important (5). Again, in determining the factors militating against effective material management in the Ghanaian construction industry, respondents had the option to rank with the scale; strongly disagree (1), disagree (2), neutral (3), agree (4), disagree (2) and strongly agree (5). Concerned with knowing respondents' preference in terms of their level of agreement,

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this scale equally provided the means to understand the opinions/perceptions of respondents related with a single 'latent' variable (phenomenon of interest) (Joshi et al, 2015).

3.6.2 Interview

In proposing a decision on the most effective material management practice in the Ghanaian construction industry, respondents were interviewed in this quest. This approach offered the opportunity to gain insight into the specific meanings and behaviors experienced in material management through their subjective experiences and aimed at understanding a variance of phenomena from the viewpoint (Cohen et al., 2002). The interview was conducted on site supervisors who had practiced for ten or more years. This decision was influenced by the fact that these supervisors stood experienced in their field of work as project managers and could better provide the relevant and requisite information. The interview questions focused on identifying the best current material management practices. This was aided by a specially designed pairwise comparison matrix sheet to easily sum up their responses. Per the sheet, respondents were made to compare their preference on a scale of relative importance proposed by Saaty, (2008) that rated preferences or priorities with given values. This scale was used to determine the level of preference of one decision over another (Saaty, 2008). Here, the intensity of any designated number (1 = Equal importance, 3 = Moderate importance, 5 = Strong importance, 7 = Very strong importance, 9 = Extreme importance) selected indicated the degree of preference of one criterion over another in any given circumstance. More essentially, the value in a pairwise matrix depended on the decision maker (Alonso and Lamata, 2006). Accordingly, when a criterion was compared to itself, 1 was selected to signify that they both are of equal importance. When a criterion was of equal importance to moderate importance, 2 was scripted to indicate that choice. Further, the selection of 3 made this criterion of moderate importance to the other criteria compared to. Choosing 4

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placed a criterion of equal moderate importance to strong importance to the other been equated. This pattern continued till the whole matrix was estimated guided by the scale. Notably, the matrix of the criteria was always entered in rows and columns. As a rule of thumb, the criterion in the row is always preferred to the criterion in the column (Saaty,2008). However, inverse values are entered for the previously entered values of preference for each criterion when these same criteria are compared in a reverse form (Table 4.11). This process provided a foundation for carrying out matrix operations (Wang et al., 2007). In responding to these, the alternatives to each of the factors/ criteria provided a solid basis to their decisions established. 10 respondents provided the response to this effect. This was partly due to the outbreak of the Covid 19 pandemic with its associated restrictions as well as access and the tight schedules of these respondents. On safety grounds, the respondents decided how they wanted the interview to be conducted which in turn was carried out successfully. Each interview took an average of 25 minutes.

3.6.3 Validation of instrument

In ensuring the accuracy of the information collected by the instruments, they were validated consequently. Validity explains the extent to which an instrument accurately measures what is supposed to measure (Frisby et al., 2014). To ensure the accuracy and comprehensiveness of information, the content of the questionnaire and the interview guide were subjected to content validity analysis. The items were given to eight people to rate according to a scale of "been essential", "important but not Essent" and "not necessary" significant at 0.05 (Lawshe, 1975). These included my supervisor and seven experts in the construction field whose recommendations upon review of the items were used to formulate the instruments. This method was used to establish the content validity of the items by computing for the Content Validity Ratio (CVR) using the formular;

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$$CVR = \frac{n_e - \left(\frac{N}{2}\right)}{\frac{N}{2}}$$ Where;

CVR = Content Validity ratio, n_e = number of judges indicating the essence of the items, N = the total number of judges. Obtaining a CVR value of 0.93 validated the instruments to be used to collect the data. As opined by Taherdoost (2016), content validity involves evaluation of survey instruments in order to ensure it includes all the items that are essential as it eliminates undesirable items to a particular construct domain.

3.6.4 Reliability of the Test Items

To confirm the reliability of the items used, the questionnaire was pre-tested on twelve selected respondents who shared the same characteristics as the actual group. This was done to ensure consistency and dependency of the research instrument and its ability to tap data that will answer the objectives of the study. Next, the Likert scales used by the respondents to rate the items were checked for their internal consistency as the instruments were subjected to reliability analysis from which the Cronbach's coefficient alpha was computed.

3.7 Data collection procedure

An introductory letter was obtained from the Department of Construction and Wood Technology Education, Faculty of Technical Education, University of Education, Winneba-Kumasi. After, permission was sought from the appropriate quarters from the study areas to collect data from the respective respondents. The questionnaire was self-administered to the respondents anonymously.

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3.8 Data Analysis Procedure

The quantitative data collected from the field survey through the use of structured closed ended items was analysed on Statistical Package for Social Sciences (SPSS) and Microsoft Excel software's. The qualitative aspect similarly used Expert Choice software to analyse data regarding Analytic Hierarchy Process (AHP). The validity and reliability of the questionnaire used in the survey was determined using content validity ratio in the case of the former and Cronbach's Coefficient Alpha for the latter.

3.8.1 Research Question one: What are the current material management practices of large-scale construction firms in Ghana?

Data for this objective was collected using a questionnaire. The items on the questionnaire were rated on a five-point Likert scale from; not important (1), less important (2), neutral (3), important (4) to very important (5). This was further analysed using Relative Importance Index (RII) and the corresponding conclusions drawn.

3.8.2 Research Question two: What are the factors that militate against effective decision making in relation to construction materials management within large-scale construction firms in Ghana?

A questionnaire again with the items rated on a five-point Likert scale scheme was utilized under this objective. The rating scale extended from strongly disagree (1), disagree (2), neutral (3), agree (4), disagree (2) and strongly agree (5). Factor analysis was then employed in the analysis process in achieving the appropriate justifications subsequently. Kendall's Coefficient of Concordance was

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consequently used to establish a degree of agreement among respondents on the independent variables that emerged from the objective.

3.8.3 Research Question three: What decision-making matrix will be developed for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP)?

Pairwise Comparison matrix was used to streamline and summarise the interview data regarding the preference of the respondents on the principal component factors extracted in the second objective. Analytic Hierarchy Process (AHP) was then used to analyse these preferences to better conclude this objective.

3.9 Ethical Consideration

Permission was sought from the management of the construction firms regarding the content of the study. Each participant was previewed on the content of the research which included the research objectives - the current construction materials management practices, factors that militate against effective decision making, and a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). It was vividly communicated to the targeted population that; any decision from the participate in the research was completely voluntary and not compulsory. Again, any consented nurse or midwife who wished to opt out of the research could do so at any time without any repercussion or form of intimidation. Further, strict confidentiality was assured as such no names were requested and information obtained shall be restricted to the purposes of the said study. More

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so, there were no monetary or any other form of tangible benefits for the study units who partook in the research. Importantly, no invasive procedure was carried out on any of the participants.

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CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents an aggregate of the constituent parts of data sourced from participants in relation to the objectives of the study. In essence, its order and plan recognized the position of each component as outlined in the study. Coming first was analysis of participants' demographic characteristics. This was followed by assessment of the current material management practices applied in large construction projects in Ghana. Third in line with the proceedings focused on determining the factors that militate against the effective material management in the Ghanaian construction industry. The fourth and final part developed a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). Extending to about six months in its administration, 125 valid questionnaires were received eventually from 136 questionnaires self-administered in the three regions of Greater Accra, Ashanti and Eastern respectively. This data which represented a response rate of almost 92% was subsequently used for the study (Table 4.1). According to Mugenda and Mugenda (2003) in Ayettey and Danso (2018), data exceeding the 50% mark is deemed adequate to be accepted.

Table 4.1: Statistical Data of Questionnaires Sent and Received

Questionnaire	Accra	Kumasi	Koforidua	Total	Percentage (%)
Number sent	52	48	36	136	100%
Number received	49	45	35	129	94.8%
Number unreceived	3	3	1	7	5.1%
Valid responses	**47**	**44**	**34**	**125**	**91.9%**
Invalid responses	2	1	1	4	2.9%

Source: Author's field study (2021).

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In effect, nearly 8% of the questionnaires were either unrecovered or tagged invalid. In the case of the latter, this was due to participants answering the questionnaire wrongly, halfway or not responding at all. In addition, to assume strong alternatives to each of the factors/ criteria provided a solid basis for the AHP decisions established, 10 respondents were interviewed at 100% response rate to this effect.

Assuming both quantitative and qualitative status, descriptive analysis, factor analysis, Relative Importance Index (RII), Spearman's correlation, regression analysis and Analytical Hierarchy Process (AHP) were used to analysis the data accordingly.

4.2 Demographic Characteristics

The characteristics of respondents and their relation to their respective fields of work in aspects such as gender, profession, academic qualification, work experience, position in the industry and others similar is established in this subdivision (Table 4.2).

Table 4.2: Demographic Characteristics of Respondents

Characteristics	**Category/Option**	**Frequency**	**Percentage (%)**
Gender	Male	101	80.8
	Female	24	19.2
	Total	125	100.0
Highest academic qualification	Diploma	66	52.8
	Undergraduate	41	32.8
	Master's Degree	13	10.4
	PhD	4	3.2
	Others	1	0.8
	Total	125	100.0
Work experience	0-5 years or less	30	24.0
	6-10 years	45	36.0
	11-15 years	32	25.6

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	Above 15 years	18	14.4
	Total	125	100.0
Position in the industry	Project manager	34	27.2
	Site manager/engineer	36	28.8
	General foremen	28	22.4
	Works superintendent	27	21.6
	Total	125	100.0
Class of construction firm	D1K1	52	41.6
	D2K2	48	38.4
	D3K3	23	18.4
	D4K4	2	1.6
	Total	125	100.0
Scale of current/previous project	Small scaled projects (less than 50,000 Ghana Cedis or less	42	33.6
	Medium scaled projects (between 50,000 to 1.5 million Ghana Cedis	58	46.4
	Large scaled projects (Above 1.5 million Ghana	25	20.0
	Total	125	100.0

Source: Author's field study (2021).

Table 4.2 displays an overview of the general characteristics of participants indulged in the study. Gender coming first recorded a high male dominance (80.0%) as against the females involved (19.2%). In terms of their highest academic qualification, more than half of the participants were diploma holders (52.8%). Sequentially, undergraduates (32.8%), Master's Degree honors (10.4%), PhD holders (3.2%) and other related qualifications (0.8%) followed. On participants work experience, the majority had spent between 6-10 years (36.0%) in their respective fields of practice. This was closely followed by those within the bracket (11-15) years (25.6%), 0-5 years or less (24.0%) and above 15 years (14.4%). Relative to their position in their area of expertise, the participants represented as Site manager/engineer (28.8%), project managers (27.2%), General foremen (22.4%) and Works superintendent (21.6%). Further, in considering the class of

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construction firm, participants belonged to D1K1 (41.6%), D2K2 (38.4%), D3K3 (18.4%) and D4K4 (1.6%) concurrently. Interestingly, on participants' scale of current/previous project, Large scaled projects (Above 1.5 million Ghana) having attained 33.6% registered the lowest. Small scaled projects (less than 50,000 Ghana Cedis or less) came next with 46.4% as Medium scaled projects (between 50,000 to 1.5 million Ghana Cedis) took the first spot with 20.0%.

4.3. Reliability of the Test

Table 4.3 shows the reliability analysis of the test items used for the study. The total value given by the Cronbach's alpha in assessing the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana was 0.978. Also, the factors that militate against effective decision making in relation to construction materials management in the Ghanaian construction industry gave an alpha value of 0.965. Convincingly, these alpha values attested to the fact that all the Cronbach's coefficient values exceeded the threshold of 0.7 (Hair et al., 2010). Here, all the questionnaire items used assumed a sense of internal consistency.

Table 4.3: Reliability Analysis

Objective	Cronbach's Alpha	No. of variables
Assessment of the current material management practices applied in large construction projects in Ghana.	0.978	24
Factors militating against effective material management in the Ghanaian construction industry.	0.965	27

Source: Author's Field survey

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4.3 Assessing the Current Construction Materials Management Practices of Large-Scale Construction Firms (D1K1 And D2K2) In Selected Regions in Ghana.

Aimed at assessing the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in Ghana, respondents' opinions were analyzed through the use of Relative Importance index (RII) and ranked accordingly. As a prerequisite, corresponding descriptors were ascribed to the key material management practices identified by the participants as applied in large construction projects in Ghana. Respectively, respondents were given the option to rank the practices on a scale from 1 – 5 where 1 = Not important, 2 = Less Important, 3 = Neutral, 4 = Important, 5 = Very important (Table 4.4). According to Akadiri (2011), a 5 – point Likert scale for computing RII is associated with five important levels of critically. This, he defined as; High (H) ($0.8 \leq RI \leq 1$), High Medium (H–M) ($0.6 \leq RI \leq 0.8$), Medium (M) ($0.4 \leq RI \leq 0.6$), Medium-Low (M-L) ($0.2 \leq RI \leq 0.4$) and Low (L) ($0 \leq RI \leq 0.2$).

Comprehensively, he indicated that in establishing the RII of each variable from the data accrued from respondents, estimation can be done using the formula;

$$RII = \sum \frac{W}{AN}$$

Where ***RII*** (Relative index) is used for ranking indicators (degree of importance), ***W*** is the weight given to each item by respondents on a scale of one to five with one implying the least and five the highest, ***A*** is the highest weight (5 in our case) and ***N*** is the number of respondents.

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Table 4.4: Current Material Management Practices Applied in Large Construction Projects in Ghana

Key Approaches	RESPONSES (RANKING)					TOTAL	∑W	MEAN	RII	RANK	IMPORTANCE LEVEL
	1	2	3	4	5						
Training people on how to reduce waste	1	1	20	41	62	125	537	4.30	0.86	1	High
Daily recording of using materials in the project	0	6	19	42	58	125	527	4.22	0.84	2	High
Buy efficiently and wisely, obtaining by ethical means the best value for all money spent.	1	1	29	42	52	125	518	4.14	0.83	3	High
Controlling over-ordering and purchasing	0	4	31	41	49	125	510	4.08	0.82	4	High
Define the system to be used to track purchase orders and update need date.	3	4	28	45	45	125	500	4.00	0.80	5	High
Manage inventory so as to give the best possible service to users at lowest cost.	4	8	30	34	49	125	491	3.93	0.79	6	High – Medium
Develop staff, policies, procedures, and organization to ensure the achievement of the foregoing objectives.	4	9	32	30	50	125	488	3.90	0.78	7	High – Medium
Maintain sound co-operative relationships with other departments, providing information and advice as necessary to ensure the effective operation of the organization as a whole.	2	11	34	36	42	125	480	3.84	0.77	8	High – Medium
Supply the organization with a steady flow of materials and services to meet its needs.	10	8	26	31	50	125	478	3.82	0.76	9	High – Medium

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Forecasting materials price in market	8	12	18	45	42	125	476	3.81	0.76	10	High – Medium
Using suitable, safe and secure storage	3	14	36	33	39	125	466	3.73	0.75	11	High – Medium
Co-create construction schedule together with contractors.	4	21	25	34	41	125	462	3.70	0.74	12	High – Medium
Make the schedule available to materials management team.	11	13	28	32	41	125	454	3.63	0.73	13	High – Medium
Reporting the problems; for examples (wastage and loss-storage in delivery)	12	9	32	34	38	125	452	3.62	0.72	14	High – Medium
Reporting the situation of materials in the project's store	14	8	24	48	31	125	449	3.59	0.72	15	High – Medium
Employment of store keeper and security personnel	14	17	22	31	41	125	443	3.54	0.71	16	High – Medium
Define storing, receiving and inspection responsibility and details.	15	12	31	28	39	125	439	3.51	0.70	17	High – Medium
Consideration of efficient mechanical systems and machinery for moving materials	16	19	22	31	37	125	429	3.43	0.69	18	High – Medium
Define policy on materials left-over.	14	31	8	34	38	125	426	3.41	0.68	19	High – Medium
Have a planning session with contractor, client and project organization.	12	19	35	25	34	125	425	3.40	0.68	20	High – Medium
Considering required communication methods for material management	12	24	28	30	31	125	419	3.35	0.67	21	High – Medium
Locating sources of materials for procurement	11	25	28	37	24	125	413	3.30	0.66	22	High – Medium

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Following up the prices in the market and recording the variations of prices.	18	19	33	21	34	125	409	3.27	0.65	23	High – Medium
Planning and monitoring construction activities.	14	28	23	33	27	125	406	3.25	0.65	24	High – Medium

High (H) ($0.8 \leq RI \leq 1$), High Medium (H–M) ($0.6 \leq RI \leq 0.8$), Medium (M) ($0.4 \leq RI \leq 0.6$), Medium-Low (M-L) ($0.2 \leq RI \leq 0.4$) and Low (L) ($0 \leq RI \leq 0.2$).
Source: Author's field study (2021).

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Table 4.4 presents the Relative Importance Index (RII) analysis and ratings of respondent's judgement in assessing assess the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana. As stipulated by Akadiri (2011) in describing the measure of importance of RII, five main practices surfaced as highly important. These included, Training people on how to reduce waste (RII = 0.86), Daily recording of using materials in the project (RII = 0.84), Buying efficiently and wisely, obtaining by an ethical means the best value for every money spent (RII = 0.83), Controlling over-ordering and purchasing (RII = 0.82) and defining a system to be used to track purchase orders and update need date (RII = 0.80).

However, practices such as Managing inventory so as to give the best possible service to users at lowest cost (RII = 0.79), Maintaining sound co-operative relationships with other departments (RII = 0.78), providing information and advice as necessary to ensure the effective operation of the organization as a whole (RII = 0.078) and the like, although contributed to current material management practices in Ghana, they were not recognized as highly important. Planning and monitoring construction activities was the least ranked with RII = 0.65.

4.4 Determining the Factors That Militate Against Effective Decision Making in Relation to Construction Materials Management in The Ghanaian Construction Industry.

In determining the factors that militate against effective decision making in relation to construction materials management in the Ghanaian construction industry, respondents' thoughts and perceptions were analyzed statistically using factor analysis.

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4.4.1 Initial considerations

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and a Bartlett's Test of Sphericity which establishes the suitability of using factor analysis were performed. As a requirement, a KMO value of 0.5 or higher justifies the need to proceed with factor analysis. In this regard, obtaining (Chi-square = 14932.886, df = 351, $p < 0.000$) signifies that it is worth continuing with factor analysis as there exist a relationship to probe (Table 4.5).

Table 4.5: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.818
Bartlett's Test of Sphericity	Approx. Chi-Square	14932.886
	Df	351
	Sig.	0.000

Source: Author's field study (2021).

4.4.2 Determination of components

Characterized by its defining assumptions in employing this analytical tool, four main factors were obtained. Here, the eigenvalue of one or greater indicated four factors although the scree plot by inspection pointed to five factors (Fig 4.1). Again, only four factors met the 5% of the variance explained threshold accounting for about 73% in their accumulation. Theoretically, these factors were further considered as they stood interpretable. Conversely, three of these factors were rejected owing to their inability to meet the prescribed criteria. Essentially, the percentages of variance explained by these factors were; 52.516%, 9.641%, 5.411% and 5.002%. in order, they were

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assigned as component one, component two, component three and component four respectively (Table 4.6).

Table 4.6: Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.179	52.516	52.516	6.111	22.633	22.633
2	2.603	9.641	62.157	5.057	18.729	41.362
3	1.461	5.411	67.567	4.219	15.628	56.990
4	1.351	5.002	72.569	2.816	10.428	67.418

Extraction Method: Principal Component Analysis

Source: Author's field survey (2021).

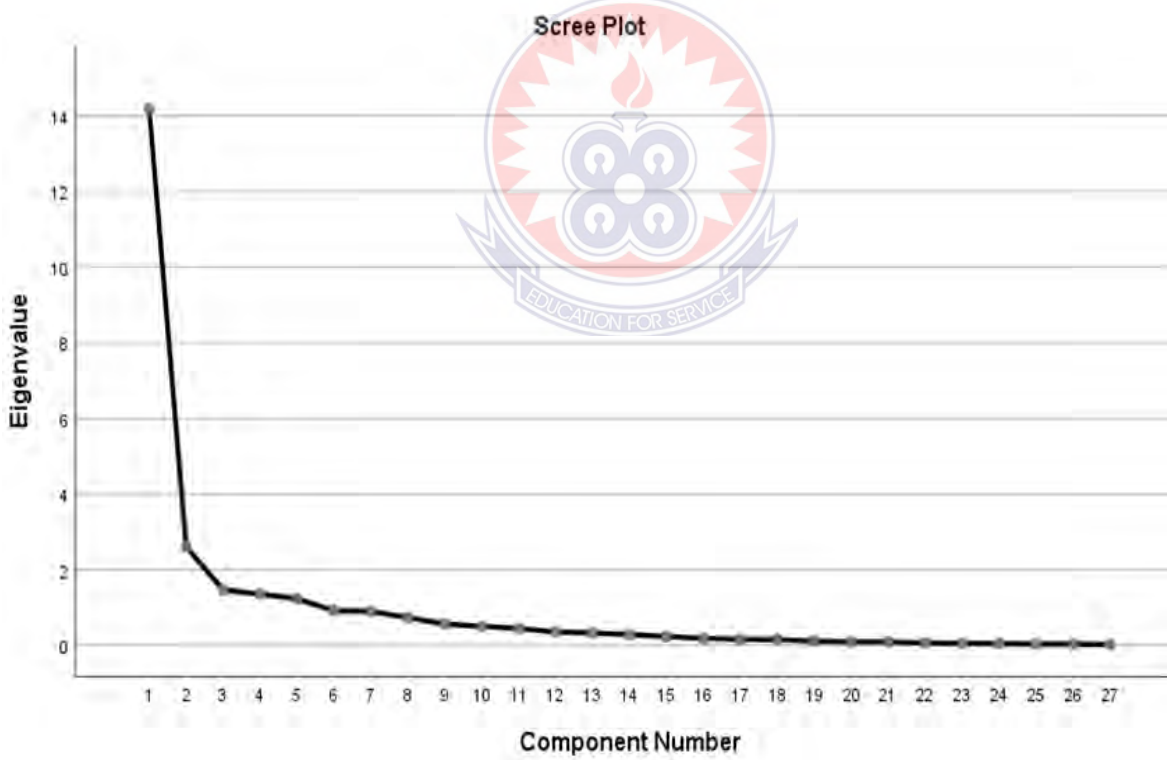

Figure 4.1: Scree Plot

Source: Author's field study (2021).

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Adopting varimax method of rotation, the factor loadings generated in our pursuit to determine the key challenges to effective materials management by the construction companies in Ghana is presented in Table 4.7.

Table 4.7: Factors That Militate Against Effective Decision Making in Relation to Construction Materials Management in the Ghanaian Construction Industry

Challenges	Component			
	1	**2**	**3**	**4**
Disturbance due to poor materials storage.	**0.799**			
The high cost of a construction materials management system	**0.780**			
Shortage of qualified persons in using a construction material management system.	**0.713**			
Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality.	**0.704**			
Damage due to weather.	**0.693**			
Non- realization of importance of construction materials	**0.664**			
Improper selection of type of contract for material procurement	**0.662**			
Incorrect material takeoff from drawing and design	**0.626**			
Wrong materials or wrong in direction of materials requiring re-work.	**0.612**			
Insufficient places for material storage.		**0.805**		
Inadequate supervision in usage of materials.		**0.786**		
Delay in material inspection and testing		**0.778**		
Lack of supervision and proper control during storage.		**0.755**		
Theft of materials from delivery to production site		**0.709**		
Absence of understanding of construction materials management system		**0.560**		
Shortage of materials			**0.789**	
Poor quality of materials			**0.737**	
High cost in material transportation.			**0.694**	
Suddenly alteration in price of materials.			**0.671**	
Materials unavailable in required quantity			**0.545**	
The thinking that implementing the system wastes the time of project supervisors.			**0.529**	
Lack of proper work planning and scheduling.			**0.473**	
Inappropriate coordination of Teamwork in site				**0.798**
Inability of system implementation.				**0.737**

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Failure to order on time which may cause delay in the projects.	**0.635**
Wrong methods and regulations in materials usage.	**0.470**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Source: Author's field study (2021).

Per Table 4.7, component one secured the highest loadings with nine factors loading onto it. Component three likewise succeeded with seven factor loadings. Component two came next with six factors loading onto it as component four had the least with four factor loadings. Loading under component one were the factors; Disturbance due to poor materials storage (0.799), The high cost of a construction materials management (0.780), Shortage of qualified persons in using a construction materials management system (0.713), Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality (0.704), Damage due to weather (0.693), Non- realization of importance of construction materials management system by the contractor (0.664), Improper selection of type of contract for material procurement (0.662), Incorrect material takeoff from drawing and design (0.626) and Wrong materials or wrong in direction of materials requiring re-work (0.612). Comprehensively, this was named **Storage, procurement and personnel management factor**. Component two equally was loaded with the following factors; Insufficient places for material storage (0.805), Inadequate supervision in usage of materials (0.786), Delay in material inspection and testing (0.778), Lack of supervision and proper control during storage (0.755), Theft of materials from delivery into production (0.709) and Absence of understanding of construction materials management system (0.560). **Inventory and quality control factor** was given to this component. With seven factors, the following factors were loading onto component three; Shortage of materials (0.789), Poor quality of materials (0.737), High cost in material transportation (0.694), sudden alteration in price of materials (0.671), Unavailable required quantity (0.545), the thinking that implementing the

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system wastes the time of project supervisors (0.529) and Lack of proper work planning and scheduling (0.473). This was equally labelled as **supplier and manufacturing default factor**. Eventually, four factors were loaded onto component four which included; Inappropriate coordination of Teamwork on site (0.798), Inability of system implementation (0.737), Failure to order on time which may cause delay in the projects (0.635) and Wrong methods and regulations in materials usage (0.470). **Communication and system implementation factor** was the name given to this component.

4.4.3 Degree of Agreement among Respondents in Determining the Factors Militating against Effective Material Management in the Ghanaian Construction Industry.

Kendall's Coefficient of Concordance (*W*) was invoked on the four main factors identified as militating against effective material management in the Ghanaian construction industry. This was necessitated in determining the significant degree of agreement among the participants in rating the four key effects independently (Shaibu et al., 2018). In its operation, respondents are represented as judges or raters and each variable served as an item being judged (Nyangwara and Datche 2015). Kendall's *W*, ranges between zero (no agreement) and one (complete agreement) (Engur et al., 2015). As a measure of agreement among the raters, the Kendall's Coefficient of Concordance (*W*) is computed using the formula;

$$W = \frac{12\sum D^2}{m^2(n)(n^2-1)} \qquad \text{———} \qquad (1)$$

Where;

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W represents the coefficient of concordance, ***D*** is the difference between the individual sum of ranks of the raters or judges and the average of the sum of ranks of the items, $\sum D^2$ denotes the sum of the squares of the difference, ***m*** is the number of judges/respondents and ***n*** symbolizing the number of items/variables being rated (Legendre, 2010).

Interesting, Kendall's W only gives the degree of agreement between participants, less it's significance to either accept or reject the hypothesis raised regarding the level of agreement. In establishing the significance in this regard, Fisher's test of hypothesis and significance are calculated from the formula;

$$F = \frac{(m-1)W}{(1-W)} \qquad \text{———} \qquad (2)$$

Where;

F means Fisher's test – statistic, ***m*** is the number of judges/respondents and ***W***, Kendall's Coefficient of Concordance (Legendre 2010). The hypotheses tested were;

Null hypothesis (H_0): There is no significant degree of agreement among participants.

Alternate hypothesis (H_a): There is significant degree of agreement among participants.

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Table 4.5: Degree of Agreement of Factors that Militate against Effective Materials Management in the Ghanaian Construction Industry

Factors	*W*	Chi-square	Df.	Sig.	Decision
Storage, procurement and personnel	0.037	124.707	8	0.000	Reject H_0
Inventory and quality control factor	0.047	144.383	9	0.013	Reject H_0
supplier and manufacturing default	0.055	138.912	6	0.000	Reject H_0
Communication and system implementation factor	0.024	118.277	7	0.012	Reject H_0
All factors	0.035	390.287	26	0.000	Reject H_0

Source: Author's field study (2021).

As presented Table 4.8, Storage, procurement and personnel management factor (0.037), Inventory and quality control factor (0.047), supplier and manufacturing default factor (0.055), Communication and system implementation factor (0.024) and all the factors (0.035) passed the level of significance pegged at 0.05. Clearly, there is a proof of evidence enough to reject the null hypothesis and accept the alternate hypothesis conversely. Conveniently, it was concluded that there stood a significant degree of agreement among participants regarding the four main factors identified as militating against effective material management in the Ghanaian construction industry.

4.5 Developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP).

Analytic Hierarchy Process (AHP) was explored in developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). In its application, six principal component factors extracted using

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varimax method of rotation from factor analysis under the second objective (Table 4.8) - determining the key challenges to effective materials management by the construction companies in Ghana. This was used to develop an AHP model (Fig.4.2) adapted from Dey (2002). These factors constituted; Storage factor, procurement and personnel management factor, Inventory and quality control factor, supplier and manufacturing default factor, Organization Risk factor, Act of God factor and Communication and system implementation factor. Here, information drawn from the pairwise comparing sheet given to the respondents through their interview to sum their opinions were coded and tabulated.

Table 4.6: Pairwise Comparative Matrix on most Effective Management Practice in the Ghanaian Construction Industry

Criteria	Communication and System implementation	Storage, Procurement and Personal Management	Inventory and Quality Control	Organization Risk	Supplier and Manufacturing Default	Act of God
Communication and System implementation	1	2	2	5	2	3
Storage, Procurement and Personal Management	½	1	5	9	3	3
Inventory and Quality Control	½	1/5	1	5	3	2
Organization Risk	1/5	1/9	1/5	1	2	2
Supplier and Manufacturing Default	1/3	1/3	1/3	½	1	3
Act of God	1/5	1/3	1/2	½	1/3	1

Source: Author's field study (2021).

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Per Table 4.9, the level of preference of respondents on the most effective material management practice in the Ghanaian construction industry is clearly evident. As indicated on the table, values illustrated relative to the rated scale profess the degree to which each respondent perceives the importance of a criterion over the other.

Table 4.7: Normalized Pairwise Comparison Matrix on most Effective Material Management Practice in the Ghanaian Construction Industry

	Factors	1	2	3	4	5	6	Sum	Criteria Weight	Weight (%)	Decision Priorities
1	Communication and System implementation	0.37	0.50	0.22	0.24	0.18	0.21	1.72	0.29	29	2
2	Storage, Procurement Personal Management	0.18	0.25	0.55	0.43	0.26	0.21	1.89	0.32	32	1
3	Inventory and Quality Control	0.18	0.05	0.11	0.24	0.26	0.14	0.99	0.16	16	3
4	Organization Risk	0.07	0.03	0.02	0.05	0.18	0.14	0.49	0.08	8	5
5	Supplier and Manufacturing Default	0.12	0.08	0.04	0.02	0.09	0.21	0.57	0.09	9	4
6	Act of God	0.07	0.08	0.06	0.02	0.03	0.07	0.34	0.06	6	6
Consistency Ratio = 0.025											

Source: Author's field study (2021).

Table 4.10 presents the normalization pairwise matrix deduced from the pairwise comparison matrix to decide on the most effective material management practice in the Ghanaian construction industry. Demonstrating the final step in AHP after the pairwise comparison matrix, the decisions indicative of their importance was realized eventually.

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Imperative to this process was the value of the consistency ratio which ascertains whether the computed values are correct and reasonable consistent ($p < 0.10$) to continue with decision making with AHP (Wang et al., 2007). To them, if this ratio is met, the decision and analysis can be made according to the results of the weight vector of the total order. Otherwise, it is necessary to reconsider the hierarchical model or to re-adjust the comparison matrices. This ratio was derived from the formular proposed by Saaty (1988) in Brunelli (2015) as; supposing there is an (n × n) matrix M, then the consistency index can be

$$C.I = \frac{\lambda_{\max} - n}{n - 1} \qquad (1)$$

Where, is $\lambda_{\max}$ the largest Eigen value of matrix M and n is the number row or columns. The values of consistency index have been determined for matrix with different dimensions and presented as random consistency index. Through using this index and index obtained from above equation, the rate of consistency index can be determined as follows:

$$CR = \frac{CI}{RCI} \qquad (2)$$

Where; ***CR*** is the Consistency Ratio; ***CI*** is the consistent Index and ***RCI*** (Table 4.11) denoting the Random Consistency index (the consistency index of randomly generated pairwise matrix).

Table 4.8: Values of Random Consistency Index (RCI)

N	1	2	3	4	5	6	7	8	9	10
RC	0	0	0.5247	0.8816	1.1086	1.2479	1.3417	1.41	1.4057	1.4854

Source: Introduction to the Analytic Hierarchy Process (Brunelli, 2015).

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As a caveat, If CR is less or equal to 0.1, the rate of consistency in the matrix is acceptable; otherwise, there is inconsistency in the matrix.

Obtaining a value of 0.025 and as a requirement, esteems the matrix to be statistically significant ($p < 0.10$) thus permitting decisions to be made on the weighted criteria. Under this circumstance, Storage, Procurement and Personal Management (32%) emerged as the highest weighted criteria and therefore the first decision to consider as the most effective material management practice in the Ghanaian construction industry. Communication and System implementation (29%), Inventory and Quality Control (16%), Supplier and Manufacturing Default (9%), Organization Risk (8%) and Act of God (6%) followed in order (Table 4.12).

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Figure 4.2: AHP Model for the most Effective Materials Management Practice in the Ghanaian Construction Industry.

Source: AHP Model for Determining Riskiness of Project Adapted from Dey (2002).

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CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Introduction

Enshrined in this chapter is a composition of detailed discussions, theoretical exploration and the perspectives of experts in the field relevant to the study. Grounded on the objectives propelling this study, detailed and insightful explanations are further given to concepts and ideas raised in the process to unravel key elements significant to bringing a conclusion to this discourse. Apparently, literature was invoked to substantiate and affirm the dynamism of these narratives to better bring meaning to the entire project.

5.2 Assessing the current construction materials management practices of large-scale construction firms (D1K1 and D2K2) in selected regions in Ghana.

Tailored at assessing the current material management practices applied in large construction projects in Ghana, respondents' opinions were analyzed through the use of Relative Importance index (RII) and ranked accordingly. Relative importance index RII is a statistical method used to determine the ranking of different factors (Hossen et al. 2015). This tool was expedient as this objective sought to arrange the variables in terms of importance, agreement and severity (Holt 2014). In this respect, five main practices deemed highly important material management practices applied in the Ghanaian industry were identified. These included, training people on how to reduce waste, daily recording of materials used in the project, buying efficiently and wisely, obtaining by an ethical means the best value for every money spent, controlling over-ordering and purchasing and defining a system to be used to track purchase orders and update need date.

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5.2.1 Training People on How to Reduce Waste

Categorized highly as important, training people on how to reduce waste remained imperative as a current material management practice applied in large construction projects in Ghana. Admittedly, Teo and Loosemore, (2001) pointed out that construction activities generate an enormous amount of waste. In this regard however, Zakeri et al. (1996) suggested that waste, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect materials management. The respondents equally believed that when people are exposed to the needed waste management practices, it leaves an indelible positive repercussion on reducing waste in the construction industry. Lean construction methods as postulated by Mahamid (2020) when introduced to operators can effectively decrease material waste and have a positive impact on project costs. Interestingly, a big percentage of construction site waste is generated simply by inefficient purchasing (Lu et al., 2018). In remedying this assertion, he proposed that, operators should be enlightened on the need to avoid "template buying" practices and instead take time to purchase specifically what is needed for each individual project. Waste can be reduced through the careful consideration of minimization strategies and through better reuse of materials in both the design and construction phases (Dainty and Brooke 2004).

5.2.2 Daily Recording of Using Materials in the Project

Increasingly, daily recording of materials used in the project significantly stood out as a key current material management practice applied in large construction projects in Ghana. According to Dawood (1994), it is a prerequisite for companies to check their materials daily. This he explained that, the majority of firms do operate a quality assurance scheme which lays down guidelines for the checking of materials. Daniel, (2019) pointed out that one key aspect of receipt of materials is to check the source of goods supplied and to make sure they conform to the specification as contained in the purchasing order. Expressing his concern, UK Essays (2018), indicated that, the stages of materials receiving, checking and payment should be critical in terms of records. These activities and actions provide an important means for controlling the waste of material, and make the right supplier so as eliminating the addition cost paid. In support, Hare (2002) suggested that, it is important that the standard of records kept is high, or they may not provide the expected information when they are actually required. Particularly, records should be dated (including incoming records) and where appropriate, signed, and a document management system should be in place to allow efficient storage and retrieval.

5.2.3 Buy Efficiently and Wisely, Obtaining by Ethical Means the Best Value for All Money Spent.

Dominantly, this component emerged as an important element contributing to the current material management practice applied in large construction projects in Ghana. Reasonably, Donyavi and Flanagan (2009) were of the view that material management system in any project should ensure that the right quality of material and quantity of materials are appropriately selected, effectively purchased, properly delivered and safely handled on site in a timely manner and at a proper reasonable cost. Larsen et al (2015) suggested that improving budgeting and planning is hugely important for the material management process. This he indicated that materials make up a huge percentage of projects, so accurately scrutinizing these materials costs throughout the project ensures that the project is kept on track. Confidently, Kashid and Kolhe (2018) recommended that, the buying manager should be aware of potential suppliers by reviewing trade journals, technical publications and directives. He should also endeavor to attend trade fairs and keep in contact with

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professional colleagues. Also, for effective material management, he should keep personal contact and touch with key figures on the supply companies, he elaborated.

5.2.4 Controlling Over-Ordering and Purchasing

Controlling over-ordering and purchasing correspondently had a positive influence on current material management practice applied in large construction projects in Ghana. A failure in the purchasing process or in overseeing and organizing the buying functions as listed by Canter (1993) could result in over-ordering of materials (wastage) and over-payments for materials. Bragg and Hahn (1989) relating this to material managers indicated that material managers should maintain reports such as ordering materials between two dates, material assignments, waste management when purchasing building materials, managing materials up to the location and purchasing orders. To Andersen et al (2020), planning can dramatically reduce material control, over-ordering as well as purchasing. He explained further regarding this claim that by allowing time between ordering, purchase and delivery means you can shop around for the best prices on a day for the required list.

5.2.5 Defining a System to be used to Track Purchase Orders and Update Need Date.

Evidently, defining a system to be used to track purchase orders and update need date likewise came up as a prime constituent of the current material management practice applied in large construction projects in Ghana. Convincingly, Nasir (2013), Caldas et al. (2014) attested that the implementation of materials tracking technology has been confirmed as one of the best practices that enhance productivity in infrastructure and industrial projects. Buttressing this assertion, Ammar et al (2021) opined that improved material related to management using modern technologies available today such as mobile phones and laptops or other appropriate and affordable technologies such as the internet, RFID (Radio Frequency Identification), GIS (GPS Information

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System), GPS (Global Positioning System), tracking technologies available should be used to assist in better material handling as well as the ability to detect materials. As suggested by Kashid and Kolhe (2018), the implementation of construction purchase order software and a good material management strategy gives contractors access to important historical material prices. This data gives companies the ability to analyze material costs as they arrive to ensure the agreed rate is being charged. From the perspective of Jagatap and Phatak (2018), a tracking system, whether paper based or software should be able to record damaged materials as they appear on.

5.3 Determining the Factors that Militate against the Effective Materials Management by the Construction Companies in Ghana.

In determining the factors that militate against the effective materials management by the construction companies in Ghana, respondents' thoughts and perceptions were analyzed statistically using expository factor analysis. In the case of exploratory factor analysis, the researcher generally may not have a clear idea regarding the number and nature of the factors or constructs underlying observed variables (Kline, 2013). They added that, this technique allows the researcher to explore the relationships among measured variables and determine whether the relationships can be summarized in a few latent constructs. Contextually, this method was ideal in evaluating these challenges. Under this premise, four principal component factors posing as a challenge to effective material management in the construction industry were conceived especially after going through the criteria necessary to use this statistical tool. These factors were; Storage, procurement and personnel management factor, Inventory and quality control factor, supplier and manufacturing default factor and Communication and system implementation factor.

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5.3.1 Component One: Storage, Procurement and Personnel Management Factor

The principal component explained 52.516% of the total variance with nine factors loading unto it. These included; Disturbance due to poor materials storage, The high cost of a construction materials management system, Shortage of qualified persons in using a construction materials management system, Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality, Damage due to weather, Non-realization of importance of construction materials management system by the contractor, Improper selection of type of contract for material procurement, Incorrect material takeoff from drawing and design and Wrong materials or wrong in direction of materials requiring re-work. Evidently, the result of improper handling and managing materials on site during a construction process will influence the total project cost, time and the quality. Che Wan Putra et al. (1999); Canter (1993) are obsessed with the fact that problems always arise during materials supply because of improper storage and protection facilities. Donyavi and Flanagan (2009) in Aibinu et al., (2011) opined that waste, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect materials management. Again, in a two-way opinion, Waters, (2011) affirmed that receiving materials before they are required causes more inventory cost and chances of deterioration in quality and not receiving materials at the time of requirement, causes loss of productivity. To Mead and Gruneberg (2013), procurement is not only about appointing contractors and preparing contracts, but is also very much a starting point in the process of delivery. In confirming this claim, Kasim (2010) reiterates that the acquisition of construction materials determines the cost and quality of the construction project, as it claims approximately 40-70% of the total working capital of the project. Comprehensively, Safa et al. (2014) recommended that

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material management should involve an integrated coordination of all material related functions. Adding that, these functions can be carried out efficiently only when sufficient emphasis is placed on early project planning, use of qualified personnel, adequate personnel training and proper communication amongst those involved in the process.

5.3.2 Component Two: Inventory and Quality Control Factor

Accruing six factors, this component explained 9.641% of the total variance. Making up the factors were; Insufficient places for material storage, Inadequate supervision in usage of materials, Delay in material inspection and testing, Lack of supervision and proper control during storage, Theft of materials from delivery into production and Absence of understanding of construction materials management system. According to Zwikael, (2009), the success of a project invariably depends on the level of supervision of the project or the managerial skills of the project manager or the site supervisor. Buttressing this fact, Thomas and Zavrski (1999) advocate that when the contractor or consultant is not well versed in an area on the construction process, decisions may be taken that will lead to wrong works being executed and thereby poor supervision. Detailing further, Agapiou et al. (1998) revealed that previous studies have identified that building materials often require a large storage capacity which is rarely available on site. In salvaging this phenomenon, Gurmu, (2020) suggested that careful inspection of construction materials could be one of the potential areas where productivity can be gained in the construction projects.

5.3.3 Component Three: Supplier and Manufacturing Default Factor

Supplier and manufacturing default factor explained 5.411% of the total variance with seven factor loadings. Loaded under this component were the factors; Shortage of materials, Poor quality of materials, High cost in material transportation, sudden alteration in price of materials,

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Unavailability of required quantity, the thinking that implementing the system wastes the time of project supervisors and Lack of proper work planning and scheduling. Lange and Schilling, (2015) advocate that the typical problems of construction logistics are as follows: missing or delayed deliveries, no direct unloading of transporters, ineffective management of storage space, installation of wrong and damaged material, and no or insufficient separation of emerging waste. Zakeri et al. (1996) believed that generally, the problems have included that of scarcity and high cost of imported building materials or those with foreign components. Adversely, Arditi and Chotibhongs (2005) were empathetic asserting that material standardization and checking the product availability by the designer are identified factors which have positive impacts on construction projects productivity. Similarly, Abdul Kadir et al. (2005) recommended that, to enhance productivity the project management team should plan ahead to ensure that the critical materials are identified, procured and available on site every time.

5.3.4 Component Four: Communication and System Implementation Factor

The principal component explained 5.002% of the total variance imbibed with four factor loadings. These included; Inappropriate coordination of Teamwork in site, Inability of system implementation, Failure to order on time which may cause delay in the projects and Wrong methods and regulations in materials usage. The expectancy for Loss of benefits is always prevalent if there is lack of skilled negotiating (Canter, 1993). Kasim et al., (2005) on the other hand contends that incorrect materials takeoff from drawing and design documents results in subsequent design changes. However, Caldas et al., (2015) established that, material management should involve an integrated coordination of all material related functions. In their explanation, they came very clear that these functions can be carried out efficiently only when sufficient emphasis is placed on early project planning, use of qualified personnel, adequate personnel

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training and proper communication amongst those involved in the process. To this effect, Ng et al. (2009) professed that, to accomplish substantial productivity through effective supervision, every member of a crew requires adequate space to perform tasks without being affected with/by the other crew members.

5.4 Developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP).

In pursuance to determine the key challenges to effective materials management by the construction companies in Ghana, Analytical Hierarchy Process (AHP) was adapted in this sense. According to Anderson et al., (2008), AHP is a process used to calibrate priorities. Expanding further, he explained that, if one is uncertain of how he/she prefers a certain criterion over another, this approach stands the most expedient in such situations. Similarly, de FSM Russo and Camanho (2015) described this process as measurement through pairwise comparisons which relies on the judgments of experts to derive priority scales. Here, six principal component factors extracted using varimax method of rotation from factor analysis under the second objective (Table 4.5) - determining the key challenges to effective materials management by the construction companies in Ghana were used in an AHP model (Fig.5). These factors constituted; Storage, procurement and personnel management factor, Inventory and quality control factor, supplier and manufacturing default factor and Communication and system implementation.

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The selection of this objective was bent on the conviction that, by reaching a decision on the challenges to effective material management, there will be a subsequent improvement in their efficacy when these shortfalls are addressed accordingly. Mitigating, better yet having the appropriate solutions to these challenges consciously will merit in effective material management practice in the construction industry in Ghana.

Consistent with the use of this analytical process, a model from Dey (2002) was adapted. Two of his constructs yielding a positive influence relevant to this objective were equally used subsequently. In effect, Storage, Procurement and Personal Management came up as the most effective material management practice in the Ghanaian construction industry ahead of Communication and System implementation, Inventory and Quality Control, Supplier and Manufacturing Default, Organization Risk and Act of God respectively accordingly.

5.4.1 Storage, Procurement and Personal Management

The experts approached regarding the most effective material management practice in the Ghanaian construction industry were convinced that by addressing all the issues raised under this subject, positive outcomes will be borne out if implemented appropriately. Admittedly, they stipulated that improving material storage, curbing the incidence of high cost of construction materials, enlisting qualified persons in using construction material management system, providing the needed inventory and ordering schedules, offering interventions to mitigate material damage to weather, realization of importance of construction materials management system by the contractor, proper selection of type of contract for material procurement, correct material takeoff from drawing and design as well as recommended materials will place this factor the most expedient in terms of material management.

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5.4.2 Communication and System implementation

Communication and system implementation was esteemed the next most effective material management practice in the Ghanaian construction industry. In their dispensation, the experts this field of operation again upon an encounter on this need suggested that, solutions to the challenges, thus, ensuring appropriate coordination of teamwork in site, enabling the implementation of systems, ordering on time to prevent delays in projects and correct application of methods and regulations in materials usage, on this factor will drastically add to material.

5.4.3 Inventory and Quality Control

Bestowed under this criterion follows Communication and system implementation as the most effective material management practice in the Ghanaian construction industry. Similarly, resolutions to the issues confined under segment, that is; providing sufficient places for material storage, adequate supervision in use of materials, prompt material inspection and testing, required supervision and proper control during storage, security against theft of materials from delivery into production and availability of understanding of construction materials management system will in turn produce the necessary effectiveness in material management practice in the Ghanaian construction industry.

5.4.4 Supplier and Manufacturing Default

Supplier and Manufacturing Default, equally emerging as effective material management practice in the Ghanaian construction industry were recorded from the experts. They concluded that, by finding remedies to the underlying situations comprising this factor, effective material management practice will be invoked in the Ghanaian construction industry. Solutions such as; preventing shortage of materials, ensuring quality of materials, avoiding high cost in material transportation, consistency in price of materials, available required quantity of materials, erasing

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the perception that implementing the system wastes the time of project supervisors and proper work planning and scheduling all cluster to assure effective material management practice will be invoked in the Ghanaian construction industry.

5.4.5 Act of God

Act of God also from Ahadzie and Amoa-Mensah, (2010) remained the least most effective material management practice in the Ghanaian construction industry. Although serves as an important element in material management, experts believe this act hardly occurs regardless its dire consequences.

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CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

Bringing together the key findings, requisite conclusions and corresponding recommendations pertaining to material management in Ghana, this chapter discusses developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). The fundamental buildup of the entire study was dependent on clearly defined objectives. These constituted; assessing the current material management practices applied in large construction projects in Ghana, determining the factors that militate against effective material management in the Ghanaian construction industry and developing decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP).

6.1 Summary of Findings

Extensively, the data used for the study obtained through the process of field survey was appropriately received from 125 participants from a total of 136 questionnaires self-administered. These were selected from a population of site managers/engineers, project managers, general foremen, and works superintendent in the towns of Accra, Kumasi and Koforidua respectively.

Significantly, the summary of the pertinent findings obtained for the study from each specific objective in conjunction with the review of the hypothesis are outlined below;

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6.1.1 Assessing the Current Material Management Practices Applied in Large Construction Projects in Ghana.

Respectively, five main practices surfaced as the current material management practices applied in large construction projects in Ghana. This was made manifest through the use of Relative Importance index (RII). These included; (1) Training people on how to reduce waste which explained that, practices such as; improper handling of materials on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect material management. People, specifically workers ought to be exposed to the needed waste management practices. (2) Daily recording of using materials in the project as a current management practice revealed that records should be dated (including incoming records) and where appropriate, signed, and a document management system should be in place to allow efficient storage and retrieval. (3) Buying efficiently and wisely, obtaining by an ethical means the best value for all money spent also attributed to the current material management practices. To this, material management system in any project should ensure that the right quality of material and quantity of materials are appropriately selected, effectively purchased, properly delivered and safely handled on site in a timely manner and at a proper reasonable cost. (4), Controlling over-ordering and purchasing similarly explained this practice in terms of planning which can dramatically reduce material control, over-ordering as well as purchasing (5) defining a system to be used to track purchase orders and update need date equally uncovered that using modern technologies available today such as mobile phones and laptops or other appropriate and affordable technologies such as the internet, RFID (Radio Frequency Identification), GIS (GPS Information System), GPS (Global Positioning System), tracking technologies available can assist in better material handling as well as the ability to detect materials.

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6.1.2 Assessing the Factors that Militate against Effective Decision Making in Relation to Materials Management in the Ghanaian Construction Industry.

In determining the factors that militate against effective material management in the Ghanaian construction industry, the findings disclosed that the factors obtained were; (1) Storage, procurement and personnel management factor. Here, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect materials management. (2) Inventory and quality control factor remained a contributor in this direction in the sense that lack of supervision and proper control during storage, theft of materials from delivery into production and absence of understanding of construction materials management system posed a threat to effective material management. (3) Supplier and manufacturing default factor summed this factor in terms of high cost in material transportation, sudden alteration in price of materials, unavailability of required quantity, the thinking that implementing the system wastes the time of project supervisors and lack of proper work planning and scheduling. (4) Communication and system implementation factor which invariably explained this factor in terms of inappropriate coordination of teamwork in site, inability of system implementation, failure to order on time which may cause delay in the projects and wrong methods and regulations in materials usage. This achievement was evident through the use of factor analysis which streamlined all the independent variables into underlying dimensions.

6.1.3 Developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP)

Here, Analytical Hierarchy Process (AHP) was adapted to develop a decision on the most effective practices to improve material management in the Ghanaian construction industry. By order of merit, it was revealed that (1) Storage, Procurement and Personal Management should be first in

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the decision-making process under this goal. This feat stood able as a result of improving material storage, curbing the incidence of high cost of construction materials, enlisting qualified persons in using construction material management system, providing the needed inventory and ordering schedules. (2) Communication and System implementation also came up as the next option taken which was explained by the experts in terms of ensuring appropriate coordination of teamwork in site, enabling the implementation of systems, ordering on time to prevent delays in projects and correct application of methods and regulations in materials usage. (3) Inventory and Quality Control in order, followed subsequently. The experts stated clearly that when there are resolutions to the issues confined under this segment, that is; providing sufficient places for material storage, adequate supervision in use of materials, prompt material inspection and testing, required supervision and proper control during storage, security against theft of materials from delivery into production, effective material management will be enforced. (4) Supplier and Manufacturing Default similarly served as a pertinent decision made. Under this circumstance, solutions such as; preventing shortage of materials, ensuring quality of materials, avoiding high cost in material transportation and consistency in price of materials ensured effective material management. Organization Risk surfaced as another key decision made by the experts. This they said greatly affected effective material management. Investing in human resources and current technology in material management are risks bored by the institution. Many a time, the outcomes of these investments are not guaranteed but yet have to be done. Such decisions become inevitable if an effective practice is needed to improve material management stands the focus in the Ghanaian construction industry. Act of God came last in the decision-making process regarding this objective. They simply attributed this claim to putting measures to make up for unforeseen and unexpected eventualities such as accidents, flooding and others alike.

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6.2 Conclusion

In the construction industry, effective material management practices make the construction project successful. This is seen by putting in place effective practices in material management. The study in this direction sought to look at developing a decision-making matrix for effective materials management practices on construction projects in Ghana using Analytical Hierarchy Process (AHP). Per the methodology, results and discussions from the preceding chapters accordingly, the study confirmed that, there exists an effective material management practice in the Ghanaian construction industry using Analytical Hierarchy Process (AHP) if the factors militating against its effectiveness are closely and carefully looked at. This revelation was made evident from the responses of the professionals engaged in the process as they agreed that, effective material management practices can be achieved through finding solutions to the challenges that hinder its effectiveness. Providing sufficient places for material storage, adequate supervision in use of materials, prompt material inspection and testing, required supervision and proper control during storage, security against theft of materials from delivery were some of their recommendations to effective material management practice in the Ghanaian construction industry. In this regard, the researcher made the following conclusions outlined below;

In the first place, workers ought to be exposed to the needed waste management practices, using a document management system to ensure that records of materials received and dispatched or used are up to date and using modern technologies available today such as mobile phones and laptops or other appropriate and affordable technologies such as the internet, RFID (Radio Frequency Identification), GIS (GPS Information System), GPS (Global Positioning System), tracking technologies available can assist in better material handling as well as the ability to detect

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materials which summarizes the current material management practices applied in large construction projects in Ghana.

Further, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affected materials management, high cost in material transportation, suddenly alternation price of materials, inappropriate coordination of teamwork in site, inability of system implementation, failure to order on time which may cause delay in the projects and wrong methods and regulations in materials usage were recorded as the factors that militated against effective material management in the Ghanaian construction industry.

Again, ordering on time to prevent delays in projects, correct application of methods and regulations in materials usage, enforcing effective material management systems, providing sufficient places for material storage and adequate supervision in use of materials proved to be the effective practices to improve material management in the Ghanaian construction industry.

The study thus concluded that, exposing workers to the needed waste management practices, using modern technologies available today, adequate supervision in use of materials, providing adequate security against theft of materials from delivery into production, providing sufficient places for material storage, properly testing of materials before use, adequate supervision in use of materials, ensuring quality of materials, enlisting qualified persons in using construction material management system, are all decisions that can be taken into consideration for an effective material management in the construction industry.

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6.3 Recommendations

In view of the findings discussed and the conclusion given, the researcher outlined the following recommendations;

6.3.1 Using Modern Technologies Available.

Confronted with the dynamic nature of the construction industry, material management processes are becoming more complex and hence the adoption of modern technologies and equipment's for better monitoring. In this regard, experts in the construction industry must endeavor to abreast themselves modern technology such as mobile phones and laptops or other appropriate and affordable technologies such as the internet, RFID (Radio Frequency Identification), GIS (GPS Information System), GPS (Global Positioning System) and tracking technologies.

6.3.2 Exposing Workers to the Needed Waste Management Practices

Workers must be educated on the need to manage materials effectively in their line of work. This way, they tend to appreciate the consequence of such actions on the overall performance on the entire project. Aware of these practices prompts workers on the requisite quantity and quality needed in a particular project execution.

6.3.3 Adequate Supervision in Use of Materials

Effective and proper use of materials and supervision systems must be put in place. For instance, if workers are marked relative to the materials they use on a project, some form of check is enacted. Regular and consistent checks on workers build a sense of caution in them, which eventually leads to proper material management.

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6.3.4 Providing Adequate Security against Theft of Materials from Delivery into Usage

There is the need install appropriate security aids at every process in the cycle of the material use to prevent theft at any stage of the entire material movement process.

6.3.5 Providing Sufficient Places for Material Storage

This to a large extent prevents the incidence of theft in the industry. When appropriate and sufficient places are made available for safe keeping of materials, monitoring and record keeping as well as in flows and out flows of materials are constantly checked. Security equally is instituted in this attempt. Sufficiency used here indicates that the capacity of the materials must correspond with the size of the storage facility.

6.3.6 Ensuring Quality of Materials

The quality of materials directly influences its effectiveness. Compromised materials will mean, more cost in rework, high risk and danger in using facility, less durable product, losing status in the industry and others similar. Effective material management shouldn't only look at tracking and monitoring of materials but also on how the materials involved are of required specified quality.

6.4. Recommendations for Future Research Studies.

The research has opened perspectives on further study on how to:

- Develop material management framework system in order to ensure effective material management in the Ghanaian construction industry.
- Establish the impact of effective material management on the quality of performance in project delivery in the Ghanaian construction industry.

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APPENDIX I

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLGY EDUCATION, KUMASI

DEPARTMENT OF CONSTRUCTION AND WOOD TECHNOLOGY

DISSERTATION

ASSESSING MATERIALS MANAGEMENT PRACTICES IN CONSTRUCTION PROJECTS IN GHANA THROUGH ANALYTICAL HIERARCHY PROCESS (DECISION-MAKING MATRIX MODEL)

INTRODUCTION TO QUESTIONNAIRE

Dear Respondents, this questionnaire seeks to gather information on the current practices of Materials Management in Ghana. It is part of a dissertation, which aims to **Improve Materials Management Practices in Construction Projects in Ghana through Analytical Hierarchy Process (Decision-Making Matrix Model)** in partial fulfilment of the award of a Post-Graduate degree (MPhil Construction Technology) in the Department of Construction and Wood Technology Education of the University of Education, Winneba.

Your participation, though voluntary, is very important to the success of this research and the development of the Industry under consideration. The information provided will be considered highly confidential and strictly for academic purposes.

I implore you to spare 30 — 45 minutes to complete this questionnaire.

Thank you.

Frederick Nartey Dugba (0243775611)

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Section A: Demographic Characteristics of Respondents

Please answer this section to help in the analysis of the data provided. (Please tick (√) as appropriate.

1. What is your gender?

[ ] Male [ ] Female

2. What is your highest academic qualification?

[ ] Diploma [ ] Undergraduate [ ] Master's Degree [ ] PhD Other (please specify)……………..

3. Number of years in the profession (work experience)?

5 years or less [ ] 6 – 10 years [ ] 11 – 15 years [ ] Above 15 years [ ]

4. What is your position/profession in the construction firm?

[ ] Construction project manager [ ] Construction manager [ ] Quantity surveyor

[ ] Architect [ ] Civil and/or structural engineer [ ] Electrical and/or mechanical engineer

Other (please specify) ………………………………………………………………

5. Which class does your construction firm belong to?

D1K1 [ ] D2K2 [ ] D3K3 [ ] D4K4 [ ]

6. Which region is your construction firm located in Ghana?

Greater Accra [ ] Ashanti [ ] Ahafo [ ] Bono [ ] Bono East [ ] Central [ ]

Eastern [ ] Northern [ ] Norther East [ ] Oti [ ] Savannah [ ] Upper East [ ] Upper West [ ]

Volta [ ] Western [ ] West North [ ]

7. What is the scale of your current/previous projects?

[ ] Small scaled projects (less than 50,000 Ghana Cedis or less)

[ ] Medium scaled projects (between 50,000 to 1.5 million Ghana Cedis)

[ ] Large scaled projects (Above 1.5 million Ghana Cedis)

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Section B: Assessment of Current Material Management Practices in Construction Firms in Ghana.

8. What are the current material management decision practices applied in large construction projects in Ghana? Rank on Likert scale of 1 to 5.

Please tick (√) your level of importance by ranking each option.

1 = Not important **2** = Less Important **3** = Neutral **4** = Important **5** = Very important

S/N	PRACTICES	Please Tick [√]				
		1	2	3	4	5
1	Have a planning session with contractor, client and project organization.					
2	Define storing, receiving and inspection responsibility and details.					
3	Make the schedule available to materials management team.					
4	Manage inventory so as to give the best possible service to users at lowest cost.					
5	Supply the organization with a steady flow of materials and services to meet its needs.					
6	Buy efficiently and wisely, obtaining by an ethical means the best value for every money spent.					
7	Co-create construction schedule together with contractors.					
8	Define the system to be used to track purchase orders and update need date.					
9	Maintain sound co-operative relationships with other departments, providing information and advice as necessary to ensure the effective operation of the organization as a whole.					
10	Develop staff, policies, procedures, and organization to ensure the achievement of the foregoing objectives.					
11	Define policy on materials left-over.					
12	Reporting the problems for examples (wastage and loss-storage in delivery)					
13	Controlling over-ordering and purchasing					
14	Considering required communication methods for material management					
15	Planning and monitoring construction activities.					
16	Employment of store keeper and security personnel					
17	Training people on how to reduce waste					
18	Using suitable, safe and secure storage					
19	Daily recording of using materials in the project					
20	Locating sources of materials for procurement					
21	Forecasting materials price in market					
22	Reporting the situation of materials in the project's store					

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23	Following up the prices in the market and recording the variations of prices.					
24	Consideration efficient mechanical systems and machinery for moving materials					

Section C: Factors that mitigate against effective material management in the Ghanaian Construction industry.

9. What are the key challenges of effective material management by construction firms in Ghana?

Please tick (√) your level of agreement by ranking each option.

1 = Strongly Disagree **2** = Disagree **3** = Neutral **4** =Agree **5** = Strongly Agree

S/N	CHALLENGES	Please Tick [√]				
		1	**2**	**3**	**4**	**5**
1	Lack of proper work planning and scheduling.					
2	Inadequate supervision in usage of materials.					
3	Wrong methods and regulations in materials usage.					
4	Lack of supervision and proper control during storage.					
5	Theft of materials from delivery into production					
6	Failure to order on time which may cause delay in the projects.					
7	Wrong materials or wrong in direction of materials requiring re-work.					
8	Incorrect material takeoff from drawing and design					
9	Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in					
10	High cost in material transportation.					
11	Disturbance due to poor materials storage.					
12	Improper selection of type of contract for material procurement					
13	Absence of understanding of construction materials management					
14	Shortage of qualified persons in using a construction materials management system.					
15	Non- realization of importance of construction materials management system by the contractor.					
16	The high cost of a construction materials management					
17	The thinking that implementing the system wastes the time of project supervisors.					
18	Inability of system implementation.					
19	Lack of material and time waste management plan.					

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20	Damage due to weather.					
21	Suddenly alternation price of materials.					
22	Insufficient places for material storage.					
23	Delay in material inspection and testing					
24	Inappropriate coordination of Teamwork in site					
25	Unavailable required quantity					
26	Poor quality of materials					
27	Shortage of materials					

Thank you!

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APPENDIX II

ESTABLISHING A DECISION ON THE MOST EFFECTIVE MATERIAL MANAGEMENT PRACTICE IN THE GHANAIAN CONSTRUCTION INDUSTRY USING A PAIR WISE COMPARISON MATRIX.

What is the most effective material management practice in the Ghanaian construction industry? Rank on a relative importance scale of 1 to 9.

Please tick (√) your level of importance by ranking each option.

1 = Equal importance **2,4,6,8** = of equal to moderate importance **3** = Moderate importance **5 =** Strong importance **7** = Very strong importance **9**= Extreme importance ½,**1/3,** ¼,**1/5,1/6,1/7,1/8, 1/9** = Inverse importance

FACTORS/CRITERIA	Level of importance									Inverse importance								FACTORS/CRITERIA
	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	
Organization Risk																		Act of God
																		Inventory and Quality Control
																		Communication and System implementation
																		Supplier and Manufacturing Default
																		Storage, Procurement and Personal Management
Act of God																		Inventory and Quality Control
																		Communication and System implementation

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																		Supplier and Manufacturing Default
																		Storage, Procurement and Personal Management
Inventory and Quality Control																		Communication and System implementation
																		Supplier and Manufacturing Default
																		Storage, Procurement and Personal Management
Communication and System implementation																		Supplier and Manufacturing Default
																		Storage, Procurement and Personal Management
Supplier and Manufacturing Default																		Storage, Procurement and Personal Management

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APPENDIX III

UNIVERSITY OF EDUCATION, WINNEBA
COLLEGE OF TECHNOLOGY EDUCATION, KUMASI
FACULTY OF TECHNICAL EDUCATION
DEPARTMENT OF CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION
P. O. Box 1277, Kumasi, Ghana
constwoodtech.coltek@uew.edu.gh
+233 (020) 3111934

UEW/KC/CW/19 June 13, 2020

The Manager

…………………………

Kumasi

Dear Sir/Madam,

LETTER OF INTRODUCTION

I write to introduce Mr. Fredrick Nartey Dugba, a final year student with index No.8171760007 Pursuing Master of Philosophy Construction Technology Programme at the College of Technology Education, Kumasi Campus of the University of Education, Winneba.

Mr. Fredrick Nartey Dugba, is undertaking a research project and wishes to collect some data in your Company. His Research Project is titled 'Assessing Material Management practices in Construction Projects in Ghana through analytical hierarchy process (Decision -Making Matrix Model),' I therefore confirm that, he is a student of the Department of Construction and Wood Technology Education.

Please kindlv offer him the needed assistance.

Thank you.

Yours sincerely,

MICHAEL K. TSORGALI (Engr.)

AG. HEAD OF DEPARTMENT

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APPENDIX IV

LIST OF ASHANTI REGION MEMBERS

NO	COMPANY NAME	CONTACT NUMBER
1	KRISTACON LTD	0244543267/0208113673
2	DE-CAPOL LTD	0208138000
3	GASCON LTD	0244372197/0267221381
4	NANA J.E. NSIAH LTD	0208111327
5	ATENA CONST. LTD	0243428370
6	FINE CONST. LTD	0277884331
7	SAK-COMP LTD	0243473585
8	LAKAYANA LTD	0244939132
9	G&A LTD	05129277
10	AGYEI CONST LTD	0244462433
11	JAMK CO LTD	0248257015
12	DUAKUMA CON WKS	0203701147
13	MABO CONST & ENG LTD	0244612416
14	S.K. ADJEI & SON LTD	0244664595
15	SAMFORI CONST LTD	0244859582
16	ANIGLO CONST WKS	0277889379
17	MAKODOMA CONST WKS	0277858769
18	BERGYA CONST ENT	0277428298
19	BOAKYE BA SAKA LTD	0206547425
20	KUMBOMACO ENT LTD	0206547425
21	F.O. AHINKRO WKS	0243249046
22	NAKWATEX CONST LTD	0244945178
23	EKUO BA C/WKS	0243461747
24	DAMPO ENT	0246935205
25	FRAN OSBON ENT	0274822192
26	AGGIE OFORI LTD	0277434502
27	GYANGICO LTD	0244038010

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28	JANMEL CONST WKS	0277830990
29	ADUUS CONST WKS	0277531100
30	PROFCON LTD	0244285190
31	INTERCITY CONST LTD	0244946947
32	REKFAS LTD	0208125431/0243813560
33	NO JESUS NO LIFE C/WKS	0271324537
34	SUMMER OAK LTD	0204823460
35	BOAKYE BRONI LTD	0207779442
36	MIRIKISI – BOAFO CO LTD	0244710063
37	GUY-ANA-FI ENT	0285321851
38	ADWOA AFRAKUMA ENT	0276179753
39	MICHAEL NYANFUL ENT	0246359223
40	CIVIL MASTERS CO LTD	0244376391
41	NABUK CONST	0242371728
42	RICH HOUSE CONST	0243681968
43	ABESUA ENT	0244461703
44	NANA KWAKU GYAME ENT	0244650164
45	KUSAP VENTURES	0244613471/0208790585
46	MELIS ENT	0246359223
47	EKOO AGYEIWAA	0242069185
48	K.D. E KAIZER CO. LTD	0273970719

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APPENDIX V

LIST OF CONTRACTORS -GREATER ACCRA – D1K1, D2K2

	COMPANY NAME	CLASS	CONTACT
1.	PROKO (GH) LTD	D1,K1	0244-803663
2.			
3.	M.O.Y. LTD	D1, K1	0244-730647
4.	KWAHU MODERN SUPPLY	D1, K1	0244-297146
5.	LIGHT SHINE INVESTMENT. LTD	D1, K1	0243-140208
6.	BIYIRA CO. LTD		0208168905
7.	LAVER TECHNOLOGY (GH) LTD	D1,K1	0246281679
8.	PRESCON LTD	D1,K1	0209-459045
9.	LORIS TRADING & CONST. CO.LTD	D1,K1	0302-258442
10.	ADANKO CONTRACTORS LTD	D1,K1	0244-279543
11.	WILKADO CONST. WKS. LTD	D1,K1	0243-348700
12.	DAKPEMA CO. LTD	D1,K1	0244-412171
13.	IVAL LTD	D1,K1	021-779117 - 0244225806
14.	BESSMONDS LTD		0244106764
15.	OKU FALLS ENT. LTD	D1,K1	0244-11817
16.	SEG MAHCEN CO.(GH) LTD	D1,K1	0244-507094

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17.	WAMYARK CO. LTD	D1,K1	020-8127339
18.	GASCON LTD		0244372197
19.	MAPP- H LTD	D1, K1	020-8112951
20.	ROEL CONST. LTD	D1,K1	0277-555440
21.	FRIDOUG LTD	D1,K1	021-762768
22.	CHAANOH ENT. LTD	D1,K1	0244-366719
23.	TALLMAN HOUSE LTD	D1,K1	021-923413
24.	TONYNAN CO. LTD	D1,K1	0243-101125
25.	GLOBAL- TEN LTD	D1,K1	0243-825586/0274-143668
26.	ADVANCE CONST. & DEV'T LTD	D1,K1	0244-76-71-76
27.	TSIK COMPANY LTD		0244809464
28.	LEMET CONST. LTD	D1, K1	ACHIMOTA MILE 7
29.	DIGICAST PROPERTIES	D1, K1	TESANO
30.	DOVETEKT	D1, K1	ACCRA
31.	GYESAN ENTERPRISE		0242344957
32.	UKIYA VENTURES		0243379973

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33.	P.W.GHANA LTD	D1, K1	EAST LEGON
34.	HARDANS ENT.		0244568904
35.	CONSAR LTD	D1, K1	SPINTEX
36.	M. BARBISOTTI & SONS LTD	D1, K1	TEMA COMM 4
37.	IBMAS		0244946823
38.	MICHELETTI & CO LTD	D1, K1	PANTANG
39.	TAYSEC CONST. LTD	D1, K1	NEW ACHIMOTA
40.	KRAMBA ENT. LTD		0244830944

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APPENDIX VI

MEMBERS OF ABCECG E/R

NO.	COMPANY NAME	CONTACT
1.	A. NAGGESTEN LTD	0208113584 0243257280
2.	A. S. K. ENT	0208173782
3.	BOMARF VENTURES	0549877030 0208206030
4.	DANMAWUS ENT.	0243181059
5.	DARAGY CO. LTD	0244542204
6.	DEFACTO LTD	0243334471
7.	DELTRACO SOL. VENTURES	0244820796
8.	EKOMAGE VENTURES	0557192221
9.	GYAASE COMPLEX LTD	0244214224
10.	HODOR CO. LTD	0246955279
11.	J. F. B. CONST.	0243270013
12.	JIAGUU ENT. LTD	0208139613
13.	JOSAMS CO. LTD	0504687546
14.	KASMO COMPANY LTD	0243165591 0208123255
15.	KOFDA ENT.	0274943006
16.	KWALITY CONST.	0208123447 0240336232

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17.	LOVE AFRIYIE ENT.	0244667098
18.	MADRICO ELECTRICALS	0244790892 0200787860
19.	MALKNA ENT. LTD	0244891603 0242009770
20.	MALTEO LTD	0546803048
21.	MANYEYO ENT.	0243952522
22.	MARK DZATAH CONST	0243129592
23.	NANA YAMOAH LTD	0246824436
24.	OGYEATUO ENT.	0244568357
25.	S & M VENTURES	0208208204
26.	T. K. AMOH CONST. WKS	0249692706 0277788579
27	STEVICENT ENT	0208737453
28.	TISK CO. LTD	0244809464
29.	UNCLE KINGFUL ENT.	0205803169
30.	UWACO GHANA LTD	0244150932 0209799009
31.	VICTAGOE LTD	0547775519
32.	VITAKINGS LTD	0244694542
33.	AKOFEX VENTURES	0244590564