INVESTIGATION OF CONSTRUCTION MATERIAL SUPPLY CHAIN MANAGEMENT SYSTEM IN THE CONSTRUCTION INDUSTRY OF ADDIS ABABA GRADE ONE BUILDING CONTRACTORS.

FIKIRTE AMDETSION WEDAG

A THESIS SUMMITED TO THE DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN CONSTRUCTION ENGINEERING AND MANAGEMENT

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

NOVEMBER 2022

ADAMA, ETHIOPIA

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DECLARATION

I hereby declare that this Master Thesis entitled “Investigation of Construction Material Supply Chain Management System in the Construction Industry of Addis Ababa Grade One Building Contractors" is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

_____	_____	_____
Name of Student	Signature	Date

RECOMMENDATION OF ADVISOR

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled " Investigation of Construction Material Supply Chain Management System in the Construction Industry of Addis Ababa Grade One Building Contractors," prepared under my guidance by Fikirte Amdetsion Wedag, submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Construction Engineering and Management. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

_____	_____	_____
Advisor	Signature	Date

APPROVAL OF ADVISORS

I, the advisor of the thesis entitled “Investigation of Construction Material Supply Chain Management System in the Construction Industry of Addis Ababa Grade One Building Contractors " and developed by Fikirte Amdetsion Wedag, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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Advisor	Signature	Date

APPROVAL OF THE BOARD OF EXAMINERS

We, the undersigned, members of the Board of Examiners of the thesis by Fikirte Amdetsion Wedag have read and evaluated the thesis entitled “Investigation of Construction Material Supply Chain Management System in the Construction Industry of Addis Ababa Grade One Building Contractors” and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and Management.

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Finally, approval and acceptance of the thesis is contingent upon the submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department of Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of Post Graduate Studies Dean	Signature	Date

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LIST OF ACRONYMS

CII	Construction Industry Institute
CPDI	Construction Project Document Information
CSC	Construction Supply Chain
CSCM	Construction Supply Chain Management
EDI	Electro Data Interchange
EOQ	Economic Order Quantity
FIFO	First In First Out
FSN	Fast, slow and non-moving
GDP	Gross Domestic Product
HML	High cost, medium cost Low cost
JIT	Just in Time
LIFO	Last In First Out
MRP	Materials Requirements Planning
MSCM	Material Supply Chain Management
MSCP	Material Supply Chain Process
MSCP	Material Supply Chain Process
SC	Supply chain
SCM	Supply Chain Management
SPSS	Statistical Package for the Social Sciences
VED	Vital Essential Desirable

ABSTRACT

Construction supply chain management has become a potentially valuable element in the construction industry to improve operational efficiency and enhance organizational performance. Different studies are conducted in construction supply chain management. However, there is a lack of study on material supply chain management in the construction industry regarding the challenge and practice of material supply chain management from the perspectives of contractors. So, the current study aims to fill this research gap by developing a conceptual framework and ABC classification of inventory materials list that helps to distinguish the variables that play a role in material supply chain management coordination and to provide a way for a business to identify that valuable 20% of materials. To realize this objective, first, current practices of material supply management in the construction industry and the most critical challenges that contractors face during the material supply chain management of projects were identified from literature sources. Second, the identified current practices and challenges of material supply chain management were assessed using a questionnaire survey. The results obtained from the questionnaire survey showed that The right perception of material supply chain management ideas is retained by 50% of contractors, which is regarded as a moderate level that has to be addressed to raise awareness of the value of such concepts and 43.3% of contracting organizations do not have a material supply management department, and another 23.1 % have incomplete material supply management departments, indicating that material supply chain management adoption is not valued by a significant number of companies. Furthermore, some important inventory materials were identified and classified by using the ABC analysis method from questionnaire survey sources. Lastly, a conceptual framework that helps to distinguish the variables that play a role in material supply chain management coordination was prepared.

Keywords: supply chain management, material supply chain management, framework

CHAPTER ONE

INTRODUCTION

1.1 Background

Construction is one of the world's most important sectors, accounting for a significant amount of most countries' GDP. It creates the infrastructure that unites these facilities into an increasingly complicated network, as well as the facilities that house a wide range of human activities(Koçtaş & Tek, 2013).

To accommodate the growing complexity of the construction process, various management systems and methods have been developed in academic research and well applied in industry practices. Among those, supply chain management becomes increasingly popular, especially within the context of broader cooperation, vertical disintegration, and the viewpoint of a networked supply chain in the construction industry (Vrijhoef & Koskela, 2000).

Even though the construction sector has achieved significant technical and management advances throughout the world, these advancements have not resulted in the widespread adoption of Supply Chain Management systems (Koçtaş & Tek, 2013).

(Chen & Paulraj, 2004) found that the origin of the supply chain concept has its inspirations from the fields of quality revolution, materials management, integrated logistics, interest in industrial markets and networks, and the ideas of increased focus as well as influential industry-specific studies. The growing need to reduce costs, increase the quality of products, and improve the level of customer service in the 1980s, coupled with the intense global competition, gave rise to the emergence of the SCM concept.

Supply chain management (SCM) is a concept that started in the manufacturing industry and was developed there. The Just-in-Time (JIT) delivery system, which was part of the Toyota Production System, was the first obvious indicator of SCM (Shingo, 1988). This system was designed to ensure that supplies to Toyota manufacturing arrived at precisely the appropriate moment. The main objectives of this system were to substantially reduce inventories and properly regulate the interactions of suppliers with the production line.

The administration of materials and information resources across a network of companies participating in the design and production process is dealt with by Supply Chain Management (SCM). It recognizes the interconnectedness of materials and information resources both within and outside the organization's walls and strives to enhance the way these resources are organized and controlled in a methodical fashion (Tucker et al., 2001). The goal of supply chain management is to have the right products in the right quantities at the right location at the right time and at the lowest possible price.

According to (Shorafa & Rageb, 2009), the Construction Supply Chain (CSC) encompasses all aspects of the construction process, including client demands, conceptual design, construction, and maintenance, as well as organizations involved in the process, such as owners, designers, general contractors, subcontractors, suppliers, consultants, and others. CSC is a network of multiple organizations and relationships that includes the flow of information, the flow of material services or products, and the flow of funds between clients, designers, contractors, and suppliers.

In the construction industry, antagonistic relationships and fragmented processes have completely wrecked materials management practices. The absence of integration, coordination, and collaboration among the numerous stakeholders involved in the project life cycle causes this breakdown(X. Xue, Wang, Shen, & Yu, 2007). Furthermore, the construction industry's disintegration is aided by general contractors' reliance on third parties such as suppliers and subcontractors. All of them are critical elements that contribute to performance concerns such as material ordering and receiving delays, low productivity, cost and time overruns, and conflict and disputes(X. Xue et al., 2007).

Additionally, contractors face multiple obstacles at various levels of material supply chain management (MSCM). A contractor may decide to minimize costs at the bidding stage to win the contract; this decision will have an impact on the material supply chain management’s (MSCM) succeeding phases. Choosing a reliable supplier at the sourcing stage is critical for ensuring that materials are delivered in the required quantity and on schedule. Contractors must make various decisions during the procurement stage, including "when to organize materials," "when to purchase goods," and "how much to purchase." Contractors face the issue of determining the best location for material conveyance during the construction phase. Finally,

during the post-construction phase of a project, contractors should have the option of how to deal with excess material.

To date, many nations around the world (including China, Japan, Austria, Germany, the Netherlands, and the United States) have taken steps to promote the idea of the construction supply chain (CSC) and have already created some degree of supply chain management strategies (Mangla et al., 2018). However, in developing countries like Ethiopia, the construction industry's current supply chain management practices are traditional in that partners across the supply chain act independently in designing, developing, and executing strategies, with little effort made to align strategies with those doing business with them, particularly suppliers and distributors (DIBABA, 2015).

Construction materials supply chain management is the focus of this study since materials account for a major amount of the total cost of a construction project. Furthermore, supplies are necessary for a construction project's daily progress. One of the most common causes of job site productivity loss is a lack of materials when they are needed (Shorafa, 2009). As a result, to stay in business, contractors must effectively manage their materials to save expenses. They should choose reliable suppliers and track materials to determine when new materials are needed based on real material usage on site and the development of the project, as well as dealing with materials handling, storage, misplacement, and handling of materials surplus on-site.

Hence, this study investigates the current practice of material supply chain management employed by Addis Abeba building contractors, identifies the most critical challenges that contractors face during project supply chain management, and develops a conceptual framework for the construction material supply chain process based on contractor perspectives throughout the project stage.

1.2. Statement of the Problem

According to (Le, Elmughrabi, Dao, & Chaabane, 2020), Construction supply chains (CSCs) are extremely complex systems whose effectiveness is based on hundreds of decisions made by several separate companies. Clients, consultants, contractors, designers, subcontractors, and suppliers are major participants in construction networks, connected through interfaces that

encompass knowledge transfer, information sharing, financial, and contractual ties. Inefficient cooperation is still a feature of these networks. For example, construction management faces issues such as the separation of design and construction, the lack of integration and coordination across different functional disciplines, and inadequate communication(Behera, Mohanty, & Prakash, 2015). Stakeholders in the building sector are typically concerned with their advantages. As a result, a lack of collaboration leads to a slew of issues with communication and information exchange. They tend to push data and documents to other people on the network. The absence of information exchange in construction networks is a serious issue that leads to delays, inaccuracies, and duplications in construction project management (X. Xue, Li, Shen, & Wang, 2005). Stakeholders are uninterested in enhancing construction networks since it is unclear who would profit from improved network links (Vaidyanathan, 2009). The inefficient communication between supply chain actors is then discovered to be the source of time and material waste(R. B. N. E. L. Handfield, 1999).

Furthermore, as(Shorafa & Rageb, 2009) identified, the construction industry's disintegration is aided by general contractors' reliance on third parties such as suppliers and subcontractors. All of them are critical elements that contribute to performance concerns such as material ordering and receiving delays; low productivity; cost and time overruns; and conflict and disputes. Contractors also face multiple hurdles at various stages of the MSCM(2017 ,بدوي & بدوي). A contractor may opt to minimize costs at the bidding stage to win the contract; this decision will have an impact on the MSCM's succeeding phases. Choosing a reliable supplier at the sourcing stage is critical for ensuring that materials are delivered in the required quantity and on schedule. Contractors must make various decisions during the procurement stage, including "when to organize materials," "when to purchase goods," and "how much to purchase." Contractors face the issue of determining the best location for material conveyance during the construction stage. Finally, during the post-construction phase of a project, contractors should have the option of how to deal with surplus material.

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current practice of material supply chain management employed by Addis Abeba building contractors, identifies the most critical challenges that contractors face during project supply chain management, and develops a conceptual framework for the construction material supply chain process based on contractor perspectives throughout the project stage.

1.3. Objectives of the Study

1.3.1 General Objective

The general objective of this study is to investigate construction material supply chain management systems in the construction industry of Addis Ababa grade one building contractors.

1.3.2 Specific Objectives

- To investigate the current practices of material supply chain management employed by the construction industry of Addis Ababa grade one building contractors.
- To identify the most critical challenges that contractors face during the material supply chain management of projects.
- To develop a conceptual framework for the construction material supply chain process based on the perspectives of contractors throughout the project stage.
- To identify important inventory materials during supply chain management using ABC analyzing the model in the case of yot construction plc.

1.4 Research questions

- ✓ What are the current practices of material supply chain management in Ethiopia, the case of Addis Ababa?
- ✓ What are the most critical challenges that face contractors during the management of the material supply chain?
- ✓ How can we develop conceptual frameworks for contractors' supply chain management?
- ✓ How does ABC analytical model help to identify important inventory materials during supply chain management?

1.5 Scope and Limitation of the Study

1.5.1 Scope of Study

Construction Supply chain management involves a wide range of managerial activities. However, due to manageability issues, the study is limited to material supply chain management current practice; identification of important inventory material types, which plays an important role in the effectiveness of material supply chain management practice; and the most critical challenges that contractors face during material supply chain management from the perspective of building contractors who have a grade one license according to the regulation that is published by the ministry of urban development and construction, directive No. 19, which is found in Addis Ababa.

1.5.2 Limitations of the study

There was a limitation in finding properly organized and compiled data in the Addis Ababa city administration building permit and control office. Which made it difficult and time-consuming to find the population for the study and the research was intended to design a blueprint for a knowledge management system for the material supply chain and not the development of a computer application.

1.6 Significance of the Study

In a few aspects, the framework and ABC classification model of inventory materials are crucial. To begin, the framework recognizes and characterizes all stages of material supply chain management (MSCM), from offering, sourcing, and acquiring to construction, post-construction, and evaluation. The framework uses material supply chain management (MSCM) to report on issues that contractors are having and proposes solutions for the most important ones and, the framework distinguishes the variables that play a role in material supply chain management (MSCM) coordination. Second, the goal of the ABC classification model of inventory materials is to provide a way for a business to identify the valuable 20% of materials based on their quantity required and the costs of materials. So that material can be controlled most closely. Once the A's, B's, and C's have been identified, each category can be handled differently, with more attention being devoted to category A, less to B, and even less to C. As

result, this classification helps the material supply chain management practice effectiveness in the construction industry.

1.7 Structure of Study

Five chapters make to the organization of the research. The chapters from one to five are, in sequence, the introduction, literature review, methodology, results and discussion, and conclusion.

Chapter One: - Introduction

The introduction part includes: the background of the study; a statement of the problem; objectives of the study; the significance of the study; research questions; scope of the study; and limitations of the study.

Chapter Two: Literature Review

This chapter encompasses relevant related literature on the concept and overview of the current practice of material supply chain management; the challenges that contractors face during the material supply chain process; and inventory management techniques that are used to facilitate material supply chain management systems.

Chapter Three: Methodology

This chapter covers how the research is carried out and covers the research method, target population, instruments of data collection, data collection techniques, and procedures, and the data analysis method.

Chapter Four: Result and Discussion

This chapter presents the analysis of data that has been collected from the questionnaires and interviews. Presents detailed analysis of the RII and ABC classification calculation, and results from the analysis.

Chapter Five: Conclusion and Recommendations

Based on the study's findings, this chapter provides a conclusion and recommendations for contracting companies, construction professionals, and, finally, further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The construction industry contributes to the achievement of national socio-economic development goals by providing shelter, infrastructure, and employment. The construction industry has an impact on practically every aspect of the economy, and it is one of the primary drivers of economic growth in developing countries (Stasiak-Betlejewska, Potkány, & Finance, 2015). It is common to see construction projects fail to achieve their goal of constructing facilities within the specified time and cost (Cox, Ireland, & management, 2002). Few projects are completed on time and within budget because of factors such as construction complexity, the presence of various interest groups such as project owners, end users, consultants, contractors, financiers, materials, equipment, project funding, the climatic environment, the economic and political environment, and statutory regulations(TAGESSE, 2017).

A supply chain, according to Christopher (1998), is a network of multiple companies linked upstream and downstream in different types of activities and processes. The term "supply chain" refers to a series of interconnected activities, including process order and overlapping processes, as well as flows between them, all supported by infrastructure (people, equipment, buildings, software, and so on).

Supply chain management is the integration and management of supply chain organizations through building integrated organizational relationships, effective business processes, and high levels of information sharing to create high-performing value systems that provide actors in organizations with a sustainable competitive advantage(R. B. Handfield, Handfield, & Nichols Jr, 2002).

Supply chain management consists of a stable group of interacting partners with a mutual interest in improving product quality and process efficiency. SCM strategies, as they are adopted in the manufacturing industry, assume an ongoing process where the supplier and customer experience involve frequent transactions for the same or similar products (Hines, 1994).

2.2 Supply Chain Management

A supply chain, according to (Christopher, 1998), is a network of multiple companies linked upstream and downstream in different types of activities and processes. The term "supply chain" refers to a series of interconnected activities, including process order and overlapping processes, as well as flows between them, all supported by infrastructure (people, equipment, buildings, software, and so on).

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Four main SCM roles have been recognized (Albaloushi & Skitmore, 2008).To begin, consider the effects of the supply chain (SC) on-site operations. The objective is to cut the expenditures and length of time spent on the site. The major objective in this scenario is to ensure consistent material and labor flows to the site to minimize disruptions in operations. This may be accomplished by simply concentrating on the site's relationship with direct suppliers. The contractor, whose primary interest is in site activities, is best suited to take this stance. Second, the focus may be on the SC itself, to lower costs, particularly those associated with logistics, lead time, and inventory. Thirdly, operations from the site may be transferred to previous phases of the SC. This might be done merely to avoid poor on-site circumstances, or it could be done to achieve more coordination between operations, which may not be achievable in instances when the site development is plagued by technological issues. The objective is to lower overall cost and time, and the initiators might be suppliers or contractors. Fourth, integrated management and enhancement of the SC and site production may be prioritized. As a result, site production is included in SCM, with clients, suppliers, and contractors as potential initiators.

The ideas of supply chain management and conventional logistics are different from one another(Betelhem, 2017). The terms "logistics" and "supply chains" refer to networks of businesses that collaborate and coordinate their efforts to get a product to market, respectively. Typically, logistics refers to operations that take place inside the limits of a single company. Additionally, conventional logistics concentrates on tasks like inventory management, distribution, maintenance, and procurement(Shorafa & Rageb, 2009). Supply chain management recognises all aspects of conventional logistics and also incorporates tasks like marketing, developing new products, handling finances, and providing customer support (Vrijhoef, Koskela, & management, 2000).According to(Shorafa & Rageb, 2009), the transition from conventional supply chain management to supply chain management (SCM) contains several elements, as shown in Table 2.1

Table 2. 1: Characteristic differences between traditional ways of managing the supply chain and SCM

No	Elements	Traditional management	Supply chain management
1	Inventory management approach	Independent efforts	Joint reduction of channel Inventories
2	Total cost approach	Minimize firm costs	Channel-wide cost efficiencies
3	Time horizon	Short term	Long term
4	Amount of information sharing and monitoring	Limited to needs of the current transaction	As required for planning and monitoring processes
5	Amount of coordination of multiple levels in the channel	Single contact for the transaction between channel pairs	Multiple contacts between levels in firms and levels of channel
6	Joint planning	Transaction-based	Ongoing
7	Compatibility of corporate philosophies	Not relevant	Compatibility at least for key relationships
8	The breadth of the supplier base	Large to increase competition and spread risks	Small to increase coordination

9	Channel leadership	Not needed	Needed for coordination focus
10	Amount of sharing risks and rewards	Each on its own	Risks and rewards shared over the long term
11	Speed of operations, information, and inventory levels.	Warehouse" orientation (storage, safety stock) interrupted by barriers to flows; localized to channel pairs.	"Distribution center" orientation (Inventory velocity) interconnecting flows; JIT, quick response across the channel

2.2.1 Construction Supply Chain Management (CSCM)

The basic Supply Chain Management (SCM) techniques have been widely implemented in the manufacturing industry, but recently, these techniques have found their way into the construction industry as well, and they have been tried with varying degrees of success (Tiwari, Shepherd, Pandey, & Strategy, 2014).

The SCM approach to projects is a new field having tremendous scope for further research and experimentation. SCM techniques have been successfully implemented by various construction companies around the world. Some Indian companies have also applied the SCM technique in the construction of airport runways in some central Asian countries (Tiwari et al., 2014).

The construction supply chain is an operational and strategic cycle that includes labor, materials, equipment, subcontracting, and a finished project and profitability. The three aspects that connect all of the chain's components are technology, safety, and communication(Khutale, Kulkarni, & Engineering, 2013).

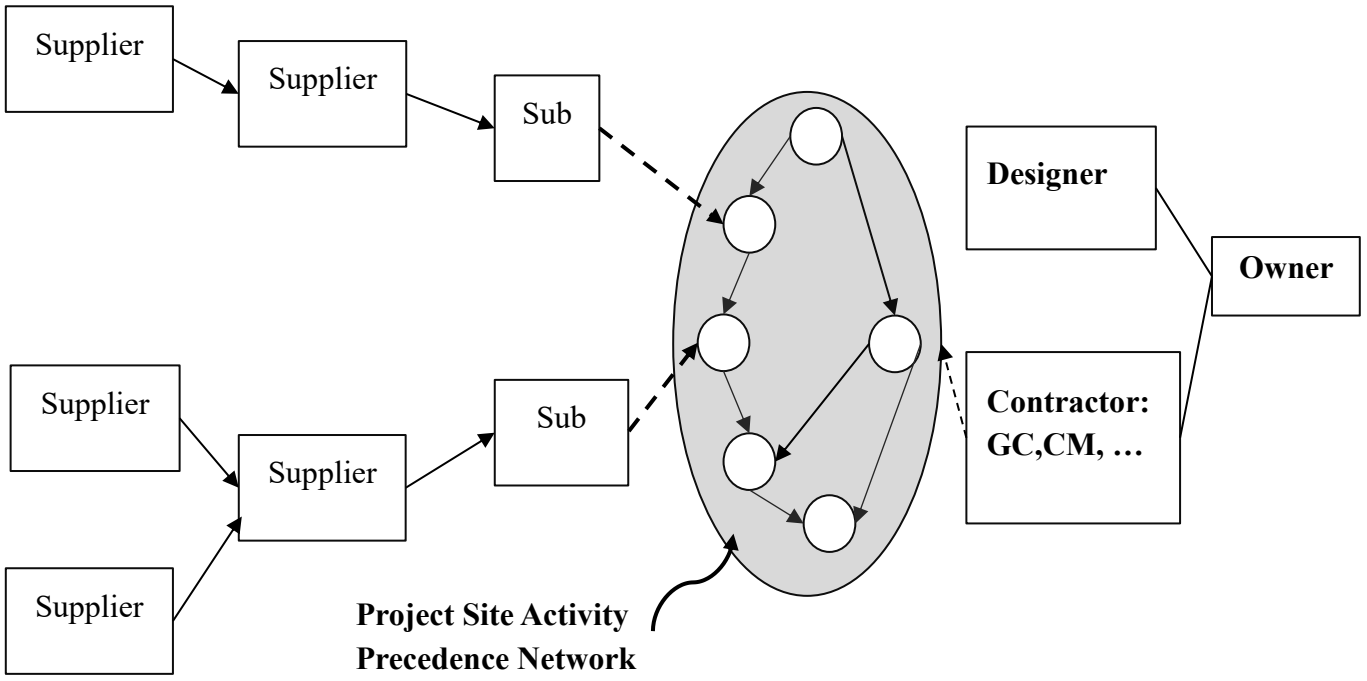

Figure 2. 1: Construction Supply Chain Process (X. Xue, Wang, Yaowu, Shen, Qiping & Li, Xiaodong, 2007)

Based on that, construction supply chain management can be defined as the integration of key construction business processes, from the demands of clients, design to construction, and key members of the construction supply chain, including client/owner, designer, contractor, subcontractor, and supplier, to achieve the objectives of reducing the cost of and increasing the reliability and speed of facility construction.

Limited studies in construction recommend that project costs may increase by 10% when applying poor supply chain management practices. The duration may also be similarly affected (O'Brien, 1999), as the subcontractor and supplier production comprises the largest value of project cost.

2.2.1.1 The role of construction supply chain management

According to (Al-Werikat, 2017), SCM was first used in the manufacturing industry to govern company operations in a defined and systematic manner to enhance quality, reduce time, and boost profit. SCM procedures in the construction business, on the other hand, are only partially adopted and disseminated.

SCM responsibilities in construction are critical and significant, according to (Vrijhoef et al., 2000). They suggested that there are four primary functions of SCM in a building. As shown in Figure 2.2, these responsibilities can be recognized depending on industry concerns, whether it's the whole supply chain, the building site, or both. They are:

- Role 1: The impact of the supply chain on-site operations may be the main focus. The objective is to shorten the time and expense of site activities. In this instance, ensuring consistent labor and material flows to the site is of the highest concern to prevent workflow disruption. Simply concentrating on the connection between the site and direct suppliers could accomplish this. The best person to adopt this approach is the contractor, whose primary interest is in site activities.
- Role 2: The supply chain itself may be the focus, with a concentration on lowering costs, particularly those associated with logistics, lead times, and inventory. This focus may be adopted by material and component suppliers as well.
- Role 3: The focus may be on moving operations from the site to the early supply chain stages. This justification may be as simple as avoiding the generally poor circumstances on-site or as an effort to accomplish a more concurrent activity, which is impossible with site building due to its numerous technological requirements. Reducing both the overall expenses and the length is the aim. Contractors or suppliers may start this focus.
- Role 4: The integrated management and enhancement of the supply chain and on-site manufacturing may be the main concerns. Site output is therefore incorporated into SCM. Contractors, suppliers, or clients may start this emphasis.

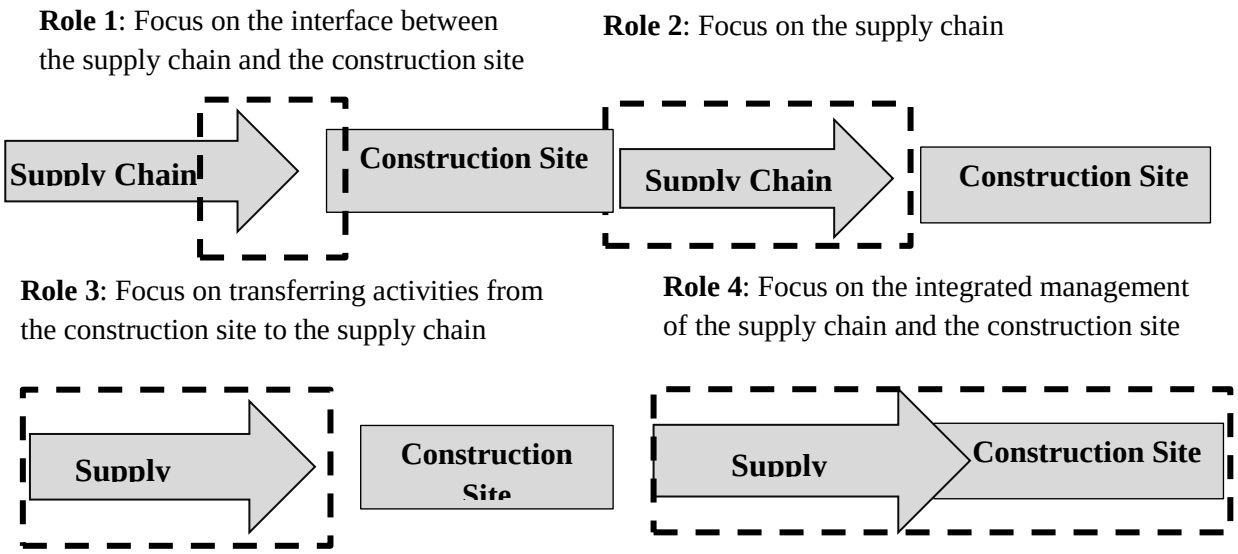

Figure 2. 2: Supply chain management role in construction (Vrijhoef et al., 2000)

2.2.1.2 Construction supply chain management characteristics

Construction supply chains (CSC) may be quite complicated, especially when working on major projects. The range of site materials and parties (suppliers and sub-contractors) necessary for a building project accounts for one of the primary features. As more individuals join engaged, the project may grow more complicated. For instance, first-tier, second-tier, and third-tier suppliers, as well as additional levels of subcontractors. Furthermore, there is a link between the breadth of a project and the complexity of the supply chain, since more labor, partners, and materials are required to complete the project. This necessitates extensive planning, organization, and communication among supply chain partners, which might add to the complexity. To complete a project, a large construction firm may engage with hundreds or thousands of suppliers and subcontractors each year.

(Vrijhoef et al., 2000) studied residential construction and found that CSCs are often convergent, made to order, fragmented, and transient, as indicated below:

Converging supply chain: In most construction projects, subcontractors and suppliers assemble and deliver operation capacity, documents, materials, and other items to the job site under the supervision of the primary contractor. Typically, the end user is a single person or a

small group of people. As a result, unlike the industrial supply chain, which is most likely to be diverging, the CSC is converging**.**

The supply chain for made-to-order items: Construction projects are driven by the needs of their clients. This might be due to the end user's custom of taking the initiative and initiating a building project. As a result, the end user is involved in the whole manufacturing process.

Fragmented supply chain: This is the industry's most distinguishing attribute. Contractors, suppliers, and other participants are involved in various phases of the project, and the allocation of responsibility and authority shifts as the project progresses**.**

Temporary supply chain: Upon conclusion of any construction project, all participants and firms engaged are often fired, which may be traced back to the project-based nature of construction. As a result, all project members must complete their tasks and responsibilities. This short-term cooperation with several members may result in performance and productivity changes.

On the other hand, (Muya, 1999) pointed out other CSC features as follows:
The primary supply chain: Distributes products such as sub-assemblies, components, raw materials, and electrical and mechanical equipment that are included in the final step of the building process.

The support chain: Scaffolding and excavation supports are examples of the knowledge and equipment provided by this chain to smooth and expedite the building process**.**

The human resource supply chain: This is in charge of supplying supervisory personnel and labor to the building process.

2.2.1.3 Difficulties of the Construction Supply Chains

Many studies and real-world case studies have concluded that building is ineffective and has numerous flaws. According to an analysis of these issues, a significant portion of them are supply chain issues arising at the interfaces of various parties or functions, including (Vrijhoef et al., 2000): Design/engineering interface: incorrect documents, design changes, extended wait

for architect's approval or design changes, Engineering/purchasing and preparation interface: inaccurate data, engineering drawings not fitting the use, engineering/purchasing and preparation interface: incorrect data, engineering drawings not fitting the use, engineering/purchasing and preparation interface: incorrect data, engineering drawings not fitting the use, engineering/purchasing and preparation interface: incorrect data, engineering drawings not fitting the use, engineering/purchasing and preparation interface: incorrect data, engineering Purchase and preparation for supplier interfaces, as well as purchase and preparation for subcontractor interfaces: faulty data, unmet information demands, hostile negotiating, and other modifications. Communication problems (either stated in terms of "data" or more broadly in terms of information handled during exchanges) are an essential aspect of the problems encountered in building supply chains, as can be seen from this list. Controlling the supply chain as an integrated value-generating flow, rather than a series of individual activities, is the modern practice of supply chain management. According to Vrijhoef et al., (2001), various problems in Construction Supply Chain were identified as shown in Figure 2.3.

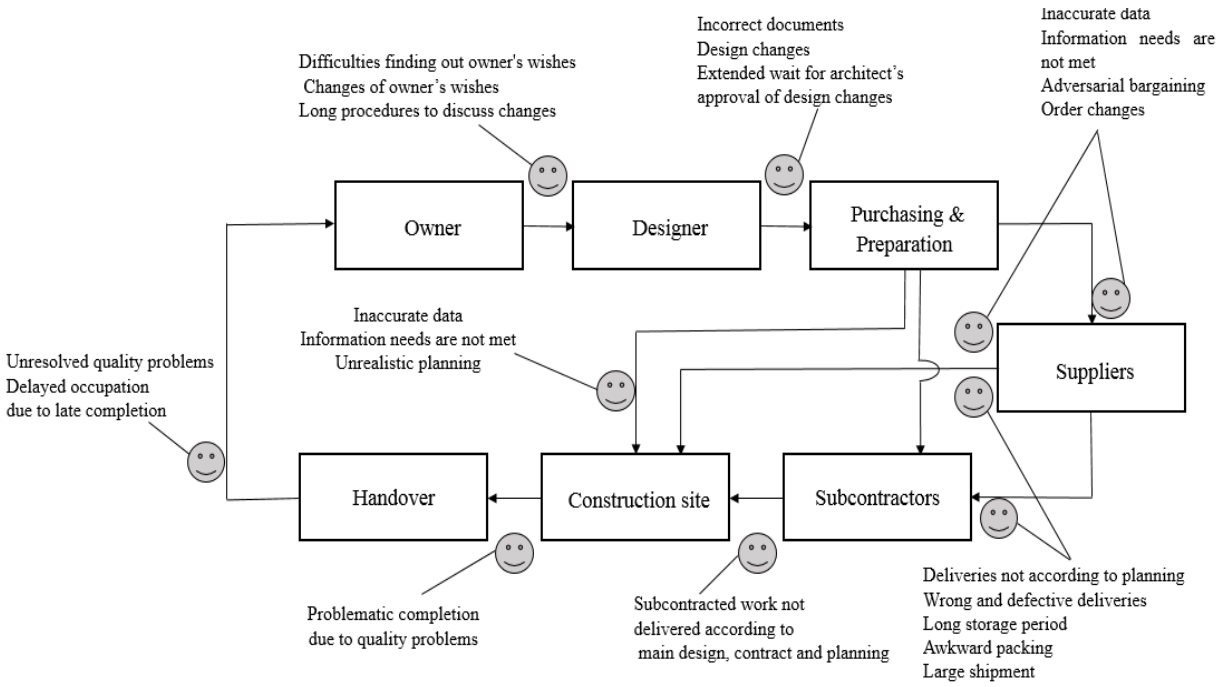

Figure 2. 3: Problems in Construction Supply Chain management

According to (Al-Werikat, 2017), the construction industry's problems originate from supply, demand, and common issues. Incorrect selection criteria, discontinuous and low demand difficulties, inappropriate risk distribution, and frequent specification changes are all examples of demand concerns.

Inappropriate selection criteria: In the construction business, this problem relates to the practice of giving a contract to the contractor that gave the lowest price, regardless of the worth of the offer. As a result, the chosen contractor may deliver inferior quality and service, resulting in issues such as a lack of confidence, resistance to design modifications, and demands for additional payments.

Discontinuous and low demand issues: The economic downturn and tough financial circumstances result in a drop in public investment, resulting in such issues.

Inappropriate risk allocation: This refers to the project's unequal risk distribution between the principal contractor and the customer**.**

Client-driven specification changes: This issue arises during the project and is caused by the client. This has major consequences for the strategy, the budget, and other considerations.

Supply issues contain poor public image, inefficient methods of construction, and poor quality:

Poor public image: The construction sector has a poor public image and has struggled to maintain and attract highly skilled and experienced workers. Furthermore, the sector is blamed for conditions such as being unhealthy, risky, unpredictable and having little work security.

Inefficient construction methods: This is a typical issue in the housing industry. The best way to solve this challenge is to integrate the design process with the building procedure to keep the project buildable.

Poor quality: According to: (M. Latham, 1994), poor quality is caused by the lack of and simplicity of guidelines for entering the building sector. This encouraged unskilled and new enterprises to enter the market, sullying its reputation and lowering the industry's overall quality.

On the other hand, the common issues contain fragmented industry structure, adversarial culture, inadequate investment, and poor management.

Fragmented industry structure: Fragmentation here refers to the size and number of construction companies, diversity of trends and professionals, and contractors who intend to use subcontractors, but subcontractors use other subcontractors to complete the work. Some subcontractors are untrained or lack the necessary experience to complete the project, resulting in a fragmented industrial structure.

Adversarial culture: This issue has been known for years and has the potential to negatively impact both the client and the contractor. Furthermore, this issue may fail to implement the new procurement procedure.

Inadequate training investment: The construction business has a noticeable lack of research and development, which might impair quality

Inadequate management: this can happen at the site or the company level, and it can lead to poor performance.

Furthermore, Dey (2001) noted that the common issues related to materials management are as follows(Kasim, Anumba, & Dainty, 2005): Receiving materials before they are needed increases inventory costs and increases the likelihood of quality deterioration. Not receiving materials on time causes productivity loss; incorrect materials takeoff from drawings and design documents; subsequent design changes; item damage or loss; contract type selection for specific material procurement; vendor evaluation criteria; and inventory accumulation, control, and management of surplus materials.

2.2.1.4 Supply chain management benefits in construction

The trend towards an integrated supply chain is reflected in modern approaches to procurement processes. This strategy ensures that all partners in the supply chain have the same goals by aligning their objectives, which adds value to the customer. Contracts were once the primary mode of communication between businesses and their customers, with specified pricing and conditions (Al-Werikat, 2017). Clients were not substantially involved, contractors were not

driven to work in the customer's best interests, and contracts with the client and designers were frequently split.

SCM may now be fully integrated as part of the march toward an integrated supply chain. The following are some of the advantages of integrated supply chains for businesses: Cost-cutting and waste-reduction are two goals that we have set for ourselves. With a more guaranteed end project cost, there is less risk. Client benefit, Allows for long-term planning. Repeat business or ongoing business (with the client).

Clients and end users benefit in the long run by being a part of an industry that caters to their demands. Projects are finished on schedule and budget, with faults kept to a minimum, resulting in customer satisfaction and increased trust in the construction sector. Furthermore, (Eriksson, 2010) stated that in the construction industry, an integrated supply chain provides better control and benefits in cost reduction.

2.2.2. Material Supply Management in Construction

Many studies have shown that effective management of construction materials plays a significant role in the performance of construction projects. Some studies conclude that materials account for around 50% – 60% of the project cost (Bernold, Treseler, & management, 1991).

(Scholman, 1997) mentioned that, according to statistics, more than 65% of a construction project budget is spent on the procurement of materials.

(Agapiou, Flanagan, Norman, Notman, & Economics, 1998) also stated that in the process of the flow of materials from suppliers to construction sites, the focus should be on coordination and communication between project participants. The process of construction materials management starts with design and engineering, follows at the manufacturers' workshop, and ends with a set of activities that starts in factories and ends at the construction site.

Planning of the supply chain needs a deep study for all stages that include purchasing, expediting, and inventory control of the construction process considering the time and cost to

achieve best practices and avoid material shortages, loss, and theft, which might result in loss of productivity and delay of activities.

Fawaz Badawibdo, (2017) identified the material supply chain procedure across the several project phase as shown Table 2.2.

Table 2. 2: The material supply chain procedure across the several project phases

Item No.	Material Supply Chain Process
	Phase 1: Bidding Phase (Estimate, preparation & Submission)
1.1	Once you have the project's designs and specifications, you may determine the materials required for each component.
1.2	Estimating the quantities of items required for each component (quantity take off)
1.3	Specifying any special requirements or materials to be used in the project.
1.4	Classifying the primary materials that must be prefabricated and the readily available materials
1.5	Identifying locally available or locally manufactured materials as well as items that should be imported.
1.6	preparing the estimate using software programs or computer programs like Microsoft Excel
1.7	A realistic estimate should be provided by including project managers and construction teams in the estimation process.
1.8	Developing a pricing database for the materials used in the previously completed projects so that it can be utilized to prepare estimates for the projects that will be undertaken in the future.
1.9	Determining the project estimate will depend on the costs of the manufacturers and suppliers.
1.10	Before submitting the offer, confirm the costs mentioned in the estimate.
1.11	When you win the bid, you should schedule a meeting with the project manager and the construction crew to reassess the project's quantities.

1.12	Preparing a preliminary material requisition schedule that includes the material types, quantities required, delivery dates, and any other clarification-needed details
	Phase 2: Sourcing (Vendor Selection)
2.1	Pre-qualify the manufacturers and suppliers, and maintain a list of reliable manufacturers and suppliers.
2.2	confirming that the supplier can supply the required materials in the required quantities and at the required times, i.e., on the dates stated,
2.3	Purchasing the materials from vendors you've already collaborated with on projects
2.4	Requesting quotations from many suppliers to obtain fair and competitive rates.
2.5	Selecting the supplier with the best pricing.
2.6	Consider suppliers that cost more but offer better services or who have a track record of delivering the required materials in the required quantities at the required times.
2.7	Directly negotiates pricing with suppliers.
	Phase 3: Material Procurement
3.1	Obtaining a copy of the site staff-prepared material requisition schedule that details the types of materials, the quantities required, the dates, and the deadlines for delivery (such a schedule prepared by the site staff for the construction phase)
3.2	Before requesting any materials from suppliers, make sure the needed materials are already in your stock.
3.3	Requesting a submittal (material sample) from the manufacturer or supplier and having the engineer approve it before the delivery of the materials
3.4	To manage the connection between the contractor and the supplier, a purchase order is sent to the successful provider (a contract is established).
3.5	Field personnel directly request materials.
3.6	Ordering all of the estimated item quantities at once.
3.7	Ordering estimated item quantities based on on-site work progress.

3.8	Specifying to suppliers the release dates for the material and the specific location of material delivery to avoid material re-handling
3.9	Monitoring the status of the requested materials to ensure that they are supplied on time, in the required quantities, and compliance with the requirements.
	Phase 4: Construction
4.1	Determining the necessary material amounts for each item.
4.2	Determining the availability dates for the materials for each item.
4.3	Determine the precise location of material delivery for each item.
4.4	Preparing a material request form that includes the material description, quantities required, delivery dates, and delivery locations.
4.5	Verify the quantity obtained versus the quantity ordered.
4.6	Inspecting supplied items to ensure they meet specifications
4.7	Mentioning any issues with the delivered materials
4.8	Keeping a record of the materials supplied, the remaining balance, and the materials installed
	Phase 5: Construction Supply Chain Management Assessment
5.1	Conducting a thorough examination of the material supply chain process through the aforementioned steps is necessary to avoid mistakes and enhance this process in future projects.

2.2.2.1. Supplier /Contractor Arrangements in Material Supply Chain Management

The unavailability of materials when they are needed can have a significant impact on labor productivity, generating delays in operations, raising project costs, and possibly delaying project completion.

There is no doubt that having the supplies you need when you need them is vital to the project's success. The contractor should make arrangements to guarantee that materials are available when they are needed (Leach, 2014).

The building sector has a history of adversarial interactions among the many players involved. Hard bidding has always been the most prevalent method of obtaining most of a contractor's

projects. The contractor must purchase supplies and subcontractor services at the lowest feasible cost due to the competitive nature of hard bidding. Contractors frequently request bids from suppliers and subcontractors to obtain the best possible costs for their services and products.

Suppliers or subcontractors will attempt to win the contract by providing the contractor with a relatively cheap price. The given price may not be low enough to win the contract, and the contractor may request a lower price. The contract may be granted to another company if the supplier or subcontractor does not drop the price. This bidding procedure may lead to hostile relationships since suppliers or subcontractors may be able to receive the task at a cheaper price than they anticipated, resulting in a lesser profit margin. Because of the financial loss, the supplier or subcontractor may not be fully committed to this contract, and complications may occur (Perdomo-Rivera, 2004).

The contractor-supplier connection is important to the effective execution of any construction project. The timely completion of operations and the productivity of the labor force are dependent on the availability of supplies. Several problems may develop if materials are not accessible when they are required.

(Leenders, Johnson, Flynn, & Fearon, 2005) propose a supplier categorization based on the quality of the service provided to the client. Unacceptable suppliers, acceptable suppliers, good suppliers, preferred suppliers, and extraordinary suppliers are the classifications they provide.

Following is a description of each category.

Unacceptable Suppliers: These suppliers are unable to satisfy the customer's operating demands and offer materials when they are required. Furthermore, they do not provide tools to meet their clients' strategic needs.

Acceptable Suppliers: These providers suit the customer's present operating demands, but their services are easily duplicated by any other source.

Good Suppliers: These suppliers are a step up from acceptable suppliers in that they can supply not just the products required, but also certain value-added services.

Preferred Suppliers: These companies provide an electronic system that integrates the purchasing and selling processes. This connection avoids redundancy and allows transactions to be processed more quickly. These vendors can satisfy the company's operational as well as strategic demands.

Exceptional Suppliers: These suppliers can detect and anticipate their customers' demands and can meet them. They are appreciated because of the value they bring to their clients. Because of their efficiency, they allow customers to experiment with various situations and techniques, resulting in a reduction in risk for their clients.

2.2.2.2 Materials supply Management Functions

(Caldas, Menches, Reyes, Navarro, & Vargas, 2015) identified the most important materials management functions and practices based on the results of the surveys and case studies analyzed, as well as interviews with many owners and contractors.

Materials Requirements Planning (MRP): Refers to the process of identifying, quantifying, and scheduling the procurement of project materials and equipment(Choudhary & Jadoun, 2016). This function is critical to the project's success. All project activities are influenced by the determination of required materials and equipment, as well as the acquisition of those materials and equipment(Choudhary & Jadoun, 2016). From the order of engineering processes to the scheduling of construction packages, lead periods related to the purchase of materials and equipment have an impact on the overall project timeline(TAGESSE, 2017). Owners, engineers, builders, fabricators, and suppliers are all part of the MRP process.

Project Acquisition Strategy: Identifying suppliers who can deliver the essential materials, equipment, and services is part of the project acquisition strategy(Giunipero, Handfield, & Eltantawy, 2006). It necessitates familiarity with the industry, corporate operations, goods to be purchased, and current providers of these commodities. This duty also includes site and shop visits to suppliers' sites to qualify, certify, and conduct background checks as necessary.

Purchasing: In capital project execution, the purchasing function is normally responsible for and in charge of authorizing the use of project money for materials and equipment(Kerzner,

2017). Purchasing acts as a link between the identification of a need and the ordering of products and services in materials management. Purchasing must find sources of supply that satisfy the need of providing a quality product at a competitive price while adhering to set delivery and reliability requirements in this capacity(Kerzner, 2017). Purchasing is also responsible for the maintenance of supplier relationships and the measurement of supplier performance(Van Weele, 2018).

Subcontracting: When it comes to contractor services and equipment, subcontracting is usually associated with the obligation and authority to commit project funds for contractor services and equipment. Assessing the overall project and company requirements, developing appropriate subcontracting strategies and plans to service those requirements, identifying and validating potential subcontractors, issuing requests for proposals, receiving bids, preparing commercial evaluations, negotiating in good faith, committing project funds for the supply of goods and services, and administering the contract are all subcontracting responsibilities (Caldas et al., 2015).

Expediting: The expediting process ensures that suppliers deliver goods, engineering submittals, technical data, and equipment to the project on time, following the purchase order's conditions and the project's needs and timetables. It's an important part of a well-thought-out project execution strategy. According to (Caldas et al., 2015), expediting should be a planned, orderly, and systematic process in which information is secured and distributed on time, detailed elements of supplier and contractor performance are planned and reviewed regularly, problems are avoided or detected proactively, deficiencies are corrected, and compliance is ensured.

Supplier Quality Management: The quality of construction materials, fabrication, and on-site services remain crucial in deciding a capital construction project's success. Poor quality expenses, as well as the resulting delays in the construction schedule, have had a direct impact on profitability, reputation, opportunities for repeat business, customer relationships, and, most critically, public and plant safety (AlMaian, Needy, Walsh, & Alves, 2015). Furthermore, the presence of quality faults in materials, as well as poor artisanship in service and construction, greatly increases the danger of future operational difficulties, which can drastically raise the

owner's maintenance and operations costs. In certain situations, injuries and deaths have resulted from the use of inferior materials, untested techniques, faulty design, and poor artisanship.

Transportation and Logistics: Transportation and logistics' major goal is to organize, control, and execute the flow of goods to the project site. This aim must be compatible with engineering, procurement, and construction schedule constraints, and it must be taken into account during the planning process. The cost of transportation frequently accounts for a significant portion of the material cost; however, the financial impact of timetable delays can be considerably bigger. A well-functioning transportation and logistics component is critical to the project's success.

Site Materials Management: Good material management on the job site may make a big difference in a project's success, therefore it's important to include it in your overall materials management plan. Site materials management is an extension of material management methods, procedures, and systems established early in the project's life cycle, and it is an essential component of such a program(Kulkarni, Sharma, Hote, & Civil, 2017)**.** Its primary goal is to ensure that the proper supplies and equipment, in the right amounts, are delivered to the project's construction crews at the right time. Material shortages may be discovered far in advance of when they are needed, and such problems can be remedied in time to support the demands of the construction forces and fulfill the project schedule, thanks to excellent planning and full system integration(Caldas et al., 2015).

2.2.2.3 Benefits of the Materials Management

An effective material management system can bring many benefits to 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% additional savings (Bernold and Treseler, 1991). Among these benefits are: Reduced overall costs of materials, better handling of materials, materials will be on-site when needed and in quantities required, improvement in labor productivity, improvement in the project schedule, better relation with suppliers, reduction of surplus materials, reduce storage of materials on site, labor savings, stock reduction.

2.2.3. Construction Supply Chain Integration /Collaboration

Because of the findings, there is a growing realization that integrating the many disciplines (participants) in a building project is critical; this includes features of integrating all supply chain members.

2.2.3.1. Partnering

To minimize the risk of not having materials when they are needed, companies are continuing to set up partnering agreements with suppliers. Project partnering is an approach used to enable the different parties involved in a project to work cooperatively. Project partnering is a synergy cooperative, collaborative management effort among contracting and related parties to complete projects in the most efficient, cost-effective method possible by setting common goals, keeping lines of communication open, and solving problems as they arise.

A partnering agreement is described as a commercial relationship that anticipates the mutual advantages of the parties involved (Perdomo-Rivera, 2004). A partnering agreement is not a legal partnership between the linked parties; rather, it is an informal working arrangement to keep cooperative partnerships going. In such cases, the decision-making process should be done in a way that benefits all parties involved.

By withholding information from third parties, no benefits should be gained. Trust, fairness, and dedication from all people involved are essential components of a successful partnership relationship. The importance of communication in a partnership cannot be overstated. It is impossible to overestimate the value of open and honest communication among team members.

(Leenders et al., 2005) differentiate between basic and extended partners. They emphasize the need of treating all suppliers as basic partners, with mutual respect, honesty, trust, open communication, and an awareness of the factors that drive their relationship. Only with important suppliers is an extended partnership formed. This form of agreement goes beyond simple collaboration and is focused on the supplier and customer's objectives. It's not unusual for a team made up of suppliers and customers to come up with ideas for mutual success and profit. The extended partnership has a long-term perspective, and the major goal should be to enhance both parties.

Some fundamental parts of a partnership agreement are defined by (Mistry, Gajera, Rathod, & ISSN, 2003). Here's a quick rundown of these components.

Commitment: All members of the team should pledge to interact with the other partners fairly and honestly.

Equity: When defining common goals and strategies for the company, stakeholders' interests must be considered. Stakeholders will not commit to the partnership agreement if there are components that they do not like or believe are useful.

Communication: It is vital to have open and honest communication. Trust is essential for problem-solving success. It is critical to share information without fear among partners.

System for Issue Resolution: There must be a fair method for resolving disputes that do not include pointing fingers. These problems must be treated immediately and fairly.

Evaluation: Meetings are required to assess the team's work. To evaluate if the partnership agreement is performing as planned, a review of work performed vs. work completed is required.

The elimination of adversarial relationships between contractors and suppliers is one of the most significant advantages of a partnership agreement. The parties' cooperative environment reduces the risk of materials not being available on the building site when they are needed. Furthermore, the contractor will ensure that invoices are paid according to the partnership agreement, allowing the supplier to have improved cash flow. Another major benefit is the exchange of information between companies, which may help one firm improve its competitive position by utilizing the knowledge and resources offered by the partner(Perdomo-Rivera, 2004).

2.2.3.2 Role of information in the supply chain

The administration of materials, information, and financial flows in a network of general contractors, subcontractors, suppliers, and distributors is known as supply chain management in construction. To operate a supply chain effectively, these flows must be coordinated and

integrated both inside and between enterprises. Information sharing is a vital component for tight integration to maximize chain-wide efficiency, and it has been made easier because of recent advancements in information technology ((Titus & Bröchner, 2005).

During a procurement process, the overall amount of data to manage is significant, and it is frequently buried behind a mountain of sedimentary layers of bureaucracy. Furthermore, the sheer number of actors in the building supply chain, as well as its complexity, make information exchange challenges. The difficulty in exchanging information stems from the nature of construction, where each project is unique, transient, and acts as a multi-organizational entity (Titus & Bröchner, 2005).

As a result, the organization of a building project generally comprises specially formed teams from many organizations working together to create a one-of-a-kind product. Setting up information channels to communicate data and expertise is tough, but vital because each team member has not necessarily worked together previously. Furthermore, the project members' diverse interests and objectives prevent information exchange.

The movement of material and information in construction is entangled across a supply chain, and each process segment is not closely connected(Titus & Bröchner, 2005). These phenomena increase the time it takes for information to reach its destination by halting the flow of information at specific locations along the supply chain. As the supply chain's structure gets more complex, it's doubtful that a single individual will be able to manage the complete information and material flow. Several strategies for adopting supply chain management have been offered in the literature. Maintaining long-term connections with supply chain participants (Buzzell & Ortmeyer, 1995), collaborating with fewer suppliers to lower inventory levels and cycle times across the whole supply chain (Davis, 1993), exchanging information with supply chain participants (Lee & Whang, 2000)and strong commitment at all levels of the company.

Even though these techniques appear to reflect diverse strategies, they all highlight the significance of communication and teamwork. Information sharing is a crucial method that underpins both communication and cooperation in this setting(Marinagi, Trivellas, & Reklitis, 2015). Existing manufacturing technologies are frequently designed to facilitate information

sharing among supply chain management. Large manufacturers and merchants with generally solid supply networks will benefit from such technologies.

Furthermore, their implementation and configuration are difficult and time-consuming. However, from a building standpoint, it is unclear if these applications are viable for use outside of the industrial business. The construction business features project-based transitory supply chains, which means that supply chains change from project to project in the majority of situations, and players can't afford to spend a lot of time setting up a system(Reyes, Raisinghani, & Singh, 2002). As a result, a solution for this market must be adaptable enough to handle project-based supply chains.

Although many engineers, construction managers, and contractors are unaware of the supply chain, they all engage with it regularly and make supply chain management decisions(Hong, Youn, & Nahm, 2008). As existing industry practice shows, having real-time information available always may reduce lead times while also increasing responsibility for tracking purposes(Lee & Whang, 2000). However, achieving real-time availability is difficult: information is difficult to obtain; it takes too long to obtain; and no single person can handle all of the information in a supply chain because there are thousands of products, numerous production requirements, and numerous types of interactions.

Myopic supply chain control, along with conventional trade and no cooperative relationships, exacerbates the issues and makes their resolution more difficult(Titus & Bröchner, 2005). In comparison to other sectors, the construction supply chain has a less linear design due to its multitier customers and suppliers. A manufacturing company's production technique cannot be readily applied to a building project.

Because of the project's nature, firms involved in a certain construction project are separated. Design Build initiatives aim to reintegrate traditionally segmented construction partners, allowing for more effective resource allocation and project completion. Such efforts encourage many businesses involved in a project to collaborate closely and early on (Titus & Bröchner, 2005).

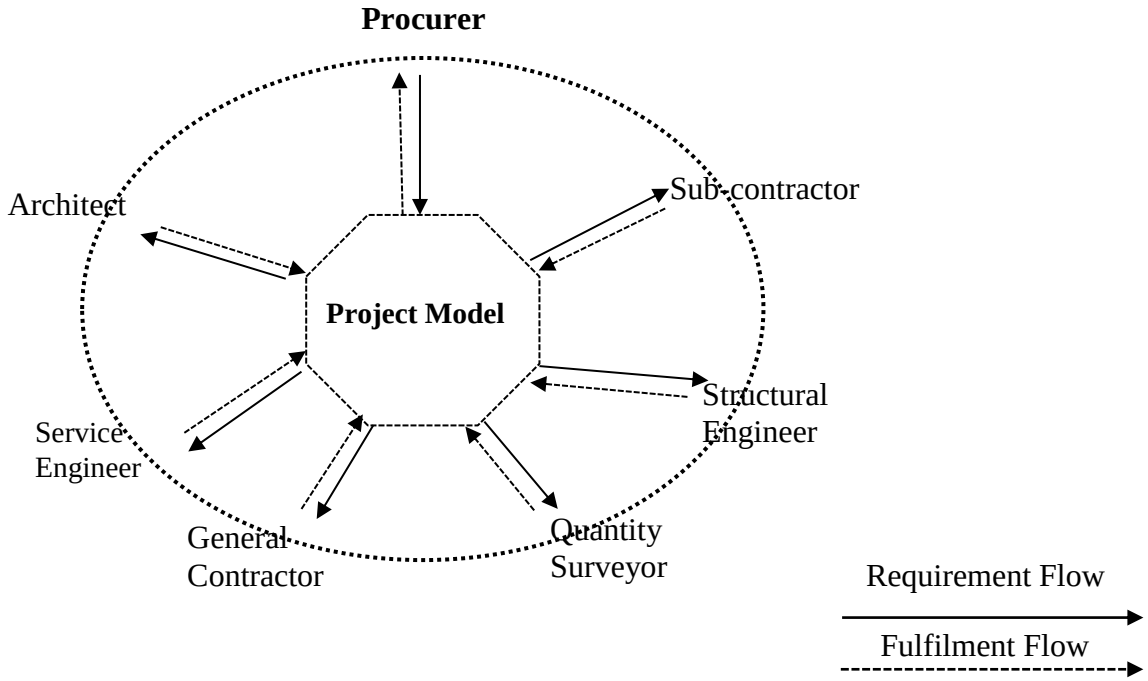

Figure 2.4: Project model depicting information flow in the construction supply chain

As seen in the model, this project-centered approach allows for increased cooperation and communication (Figure 2.4). The two arrows represent the bidirectional information flow: the required information received by a partner and the information released by the partner.

2.3 Supply chain Management Practices

SCM practices are described as a collection of actions carried out in an organization to achieve successful supply chain management (Donlon, 1996). In this literature study, many viewpoints on SCM practices have been examined. For example, (Donlon, 1996) explains the evolution of SCM techniques, which include supplier collaboration, outsourcing, cycle time compression, continuous process flow, and information technology share. Many techniques for SCM deployment were proposed by(Alvarado & Kotzab, 2001), including focusing on core competencies, employing inter-organizational technologies such as EDI, and minimizing surplus inventory levels.

Through factor analysis, (Tan, Lyman, & Wisner, 2002) discovered the following six features of SCM Practices: Integration of the supply chain, information exchange, supply chain

characteristics, customer service management, geographic closeness, and JIT capabilities are all factors to consider.

(Chen & Paulraj, 2004) tend to measure buyer-supplier interactions using supplier base reduction, long-term connections, communication, cross-functional teams, and supplier engagement. Wong and Kanji (1998) said that it is critical to incorporate overall quality management in construction SCM to properly expose significant industry concerns and that this will provide a clearer perspective of the project partnership, as underlined by Wong and Kanji (1998). (Talib, Rahman, & Qureshi, 2010). They suggested developing an effective communication strategy for successful relationship management to meet a general contractor's entire quality goal.

Strategic supplier partnership, customer connection, amount of information sharing, quality of information sharing, and delay are five separate dimensions given by (Li, Ragu-Nathan, Ragu-Nathan, & Rao, 2006) to quantify SCM processes. The five dimensions address the supply chain's upstream (strategic supplier partnerships) and downstream (customer relationships) sides, as well as information flow (amount and quality of information exchange) and internal supply chain processes (postponement). Despite this, other elements must be considered to ensure that SCM procedures are comprehensive. Geographic closeness, JIT/lean capabilities (Tan et al., 2002), cross-functional teams, logistical integration (Chen et al., 2004), shared vision and goals, and agreed supply chain leadership are all examples of these characteristics(Min & Mentzer, 2004).

2.3.1 Supply Management Practices in Different Countries of the World

2.3.1.1. Supply Chain Management practices in Malaysia

Malaysian building supply chain management involves overseeing all activities in the chain to provide the highest value to customers and maintain a competitive advantage. With the rise of competition and technology, many organizations can transform supply chain management into a core strategic competency that can help them gain a competitive advantage (Othman, Abd Rahman, & Property, 2010).

In practice, SCM is applied to prevent issues like abandoned projects and delays. This issue will cause the customer to lose the project and project management that is not consistent with plans made before the start of construction. A real plan is called a real plan only after the contractor gets the Letter of Acceptance. Besides that, by practicing SCM on a construction site, an integrated supply chain for building and facility standards can be achieved.

2.3.1.2. Supply Chain Management practices in Portugal

A framework was developed in Portugal to automate the tendering, ordering, delivery, invoicing, and payment processes of prefabricated house systems, equipment, and services in its supply chain, whose members have varying levels of information and communication technologies (Jardim-Gonçalves, Tavares, Grilo, & Steiger-Garcao, 2000). This framework, in combination with an EDI communication infrastructure based on an inter-organizational workflow system, allows for greater coordination among supply chain partners, from the client to the contractor and suppliers. The proposed solution organizes the flow of business and management information among participants at various phases of the prefabricated house construction process.

The construction sector is a major contributor to many countries economies. The current economic crisis has provided an opportunity for Portuguese construction companies to examine SCM methods more closely and evaluate them as a means of becoming more competitive. The survey is focused on larger companies that generally take on the role of contractors and are capable of influencing and organizing the CSC.

The findings show that: a large percentage of contractors have an SCM strategy in place, and, interestingly, all internationalized contractors have an SCM strategy in place; construction SCM awareness is low; overall perception of the construction SCM integration level is positive and increases with the size of the contractor, and performance assessment transparency increases with the size of the contractor.

2.3.1.3. Supply Chain Management practices in the UK Construction Industry

There is a growing interest among major clients and contractors in the UK construction industry in developing collaborative relationships. So far, these efforts have not been very successful, although the search for more collaborative relationships has become a contemporary theme in the industry (Cox, Thompson, & management, 1997). SCM is considered to have replaced partnering as the latest buzzword in the UK construction industry (Pearson, 1999). He says that SCM is used by a few key clients and contractors.

They are also involving suppliers in projects at an early stage and managing them more effectively, for example, by organizing structured development programs for them. As a result, contractors can lower project contingency budgets, and suppliers can respond to and adapt to the contractor's short- and long-term plans.

In a study, contractors' opinions were surveyed because of their pivotal role in the construction supply chain (Akintoye, McIntosh, Fitzgerald, & management, 2000). The study reveals that contractors are more oriented toward clients than product suppliers in the supply chain. Contractors seem to have more arrangements with clients than with suppliers, and a higher proportion of these relationships are contractual. Due to the aggressive business mentality of the industry and the non-trusting climate, contractors tend to pay more attention to clients who provide their workload (Akintoye et al., 2000). Finally, the survey highlights that problems in implementing successful SCM within the UK construction industry are at present associated with inappropriate traditional business culture and the unique individual features of the organizational structure.

Several problems within UK construction might arguably be addressed through the use of SCM (Morledge & Smith, 2013). These are fragmentation, adversarial relationships, project uniqueness, separation of design and manufacturing, and competitive tendering.

There is new, substantial literature that acknowledges that greater contractor involvement at an early stage in the choice to build is an important part of the formula for effective reform of the UK construction sector. Two government-sponsored papers in the United Kingdom urge fundamental reform in procurement processes in the United Kingdom, and the potential of

supply chain management (SCM) is particularly relevant at this time(CONTASFOR, EGAN, & WILLIAMS, 1998; M. J. J. R. o. P. Latham & Industry, 1994).

2.3.1.4. Supply Chain Management in the North America Construction Industry

Virtual Construction Group, Arup Computing, and Arup Project Management have been researching, analyzing, and developing innovative methods to improve the quality, quantity, and speed of project information required to complete construction tasks since 1999. (Hudgins & Chang, 2000)

To use as a communication and document-handling tool for their global operations, Ove Arup and Partners developed a Web-based Project Extranet Site (a website that allows controlled access to partners, vendors, and suppliers or an authorized set of customers:- normally to a subset of the information accessible from an organization's intranet). Through improved access, organization, and interchange of project information, the site streamlines the movement of information across all companies involved in the project, regardless of where they are located, increasing productivity and creating cost savings. The Arup Partnership's Project Extranet Site has been successfully adopted by over 20 distinct project sites (Hudgins & Chang, 2000).

A Web-based communications structure has been created in Canada to serve as a document information center for project participants (Hammad & Alkass, 2000). The Construction Project Document Information (CPDI) Center is a framework that includes a search function as well as additional services including document storage, retrieval, and general project information. It may be customized to fit any project organization or the delivery mechanism, and it can be used for both single-site and geographically dispersed projects.

2.3.1.5 Current Supply Chain Management practice in Ethiopia

Ethiopian construction industries' current supply chain management practices are traditional in the sense that partners involved across the supply chain act independently in designing, developing, and executing strategies, with little effort made to align strategies with the partners doing business with them, particularly suppliers and distributors (DIBABA, 2015). (Russell, 2011) suggests that the connection with suppliers and other partners be supported with an

adequate degree of collaborative information technology, information system, and Lean-agile principle as just a managing technique.

Several studies on supply chain management in the manufacturing and construction industries have been undertaken in Ethiopia. (Admaw, 2010) investigated the use of SCM in Ethiopian textile companies. SCM practices in Ethiopian textile firms are found to be inadequate, and they do not view SCM as a strategic instrument for competition. Textile top managers paid little attention to SCM ideas and practices. (Dereje, 2012) has looked into the impact of SCM methods on the performance of metal and engineering companies. The study's findings reveal that SCM implementation in this industry is weak. Furthermore, except for internal lean approaches, SCM procedures have no association with organizational performance.

Ethiopian Pharmaceuticals Manufacturing Sharing Company, (Wondimieneh, 2013) researched pharmaceutical manufacturing companies' supply chain management practices. His research discovered that most of the suppliers did not have long-term relationships with the company, that information was shared within departments but not with suppliers and distributors, and that most of the company's clients did not receive on-time and direct deliveries.

The case of Awash Tannery Plc, (Mustefa, 2014) looked at supply chain management methods and company performance. On the variables of strategic supplier partnership, customer relationship, amount of information sharing, level of information quality, and internal lean process, he focuses on the relationship between SCM practice and operational as well as organizational performance. He discovered that each variable had a strong link to operational and organizational performance.

(Moges, 2015) selected five companies from a total of twenty-three to study the practice and challenges of SCM on Ethiopian private grade one road construction companies. Each company had seven sample sizes. His research looked at the practice and issues of supply chain management, as well as the levels of collaboration among supply chain members. He discovered that performance was moderate in supplier and customer connections, internal operations, and information exchange, but low in the use of information technology and training practice. His research, on the other hand, did not aim to show a link between supply chain management practices and firm success.

(Betelhem, 2017) investigated supply chain management in public building construction projects in Addis Ababa, to identify supply chain management difficulties and the various supply chain management methodologies employed in these projects.

The instance of Yotake Construction Plc, (Temesgen, 2017) investigated supply chain management practice and its impact on firm performance.

Using the term "supply chain management" in the context of the current Ethiopian construction industry suggests that it is possible to adopt those practices that have proved to be successful elsewhere without significantly adapting them to reflect the particular nature of the industry and its culture (Mugher Cement Enterprise, 2010).

On the other hand, the number of construction companies is growing at an alarming rate, and some of the new entrants are international conglomerates with vast capital as well as extensive technical and managerial experience in the industry. The supply chain management practices categorized under different issues show that the level of the practices is at their lower level(Betelhem, 2017). The impacts of different variables on the competitive position of the construction industry are highly significant.

2.4. Challenges of Supply Chain management

Supply chain management (SCM) appears to be effective for managing building projects, according to(Albaloushi & Skitmore, 2008). In comparison to other industries, however, the implementation of SCM in construction is a relatively young issue, with just a few studies to date (Tiwari et al., 2014). Despite the numerous benefits of SCM, the construction sector has been slow to implement it. This might be due to obstacles to its implementation. As a result, obstacles to construction supply chain management (CSCM) implementation should be identified to encourage the growth of SCM in construction. Identifying the barriers can assist practitioners in determining which ones are the most important, allowing them to develop appropriate solutions and strategies to speed the adoption of SCM in construction. Furthermore, if barriers to implementation are not addressed, the potential benefits of CSCM adoption may not materialize. A thorough examination of the obstacles to CSCM deployment is required**.**

There are several barriers to the CSCM's coordination and integration(X. Xue, Wang, Yaowu, Shen, Qiping & Li, Xiaodong, 2007).

Attitude-related issues: such as narrow-minded "win-lose" attitude and short-term focus, arrogant attitude, exclusion of the subcontractors and suppliers from the early involvement phases, lack of praise for good performance, and lack of understanding of the subcontractors and suppliers' problems.

Information-related issues: such as poor information quality from general contractors and less transparency coupled with inadequate information exchanges and limited communications.

Financial/cost-related issues: these are related to competitive tendering based on price (with inadequate focus on life-cycle costs and ultimate value), which has developed into adversarial relationships among clients, general contractors, subcontractors, and suppliers that result in serious problems concerning payments.

Programming/time-related issues: such as false expectations on the part of the general contractor, and unrealistic and uncertain lead times of material.

Table 2. 3: List of identified Challenges of Material Supply Chain Management from the literature review.

No	Material Supply Chain management process	Challenges	(Perdomo,2003)	(Perdomo-Rivera, 2004)	(Shorafa, 2009)	(بدوي, 2017)
1	Phase1: Bidding Phase-Material	• Not a good definition of what is wanted from the owner and suppliers			√	√
		• Lack of communication between the parties involved	√	√	√	√
		• Incomplete drawings and details are missing	√	√	√	√

	Takeoff and Identification	• Using specifications different from those commonly used			√	√
		• Ambiguities between plans and specifications	√		√	√
2	Phase2: Sourcing (Vendor Selection)	• Having too many suppliers and do not have information about them	√	√	√	√
		• Incomplete proposals (Suppliers did not include all the documents with the proposal)			√	√
		• Time spent investigating non-qualified suppliers	√	√		
3	Phase3: Material Procurement	• Unavailability of required material	√	√	√	√
		• Late submittals by the contractor to be approved by the Supervisor Engineer (Submittals are not submitted as planned)			√	√
		• Incorrect submittals by the suppliers	√	√		√
		• Late approval of submittal by the Supervisor Engineer	√	√		
		• Poor communication between the parties involved	√	√	√	√
		• The contractor sets delivery dates that are impossible to meet by the suppliers)	√		√	
		• The contractor does not communicate exactly what is wanted to suppliers	√	√	√	

4	Phase4: Construction	• Late deliveries (Materials do not arrive as scheduled)	√	√	√	√
		• The delivered materials do not comply with the required specifications		√		√
		• Re-handling of materials- Materials must be moved from one place to another before being installed	√	√	√	
		• Storage of materials- storage area is limited or far away from the working area	√		√	√
		• Loss of materials	√	√		√
		• Theft		√	√	√
5	Phase 5: Post-Construction	• No storage for the surplus materials	√	√	√	√
		• No possibility that the surplus materials to be returned to the supplier	√	√	√	√
		• Charging penalties by the suppliers for the returned materials		√	√	√
		• Salvage losses for the surplus materials				√

2.5 Inventory Management

Inventory management refers to a collection of tools, processes, and tactics used to store, track, deliver, and order inventory. Inventory management strategies come into play because it is critical to regulate inventory to avoid losses and increase profits.

Inventory management systems are regarded to play a critical function in a company; about 40% to 60% of a project's budget is allocated to inventory (DP, 2019). The project's time and expense

will grow as a result of insufficient scheduling and control (Madhavarao, Mahindra, & Asadi, 2018). There is a need to do research into cost-cutting options focused on controlling and decreasing construction waste and enhancing management efficiency (Karoriya & Pandey, 2018).

A shortage of inventory can result in stock-outs, delaying production, while a large inventory, on the other hand, might result in higher production costs due to the high cost of carrying inventory (Nanaware & Saharkar, 2017). As a result, inventory optimization should guarantee that stockpiles are not too low or too high(Jaśkowski, Sobotka, & Czarnigowska, 2018).

In recent years, the notion of an inventory system has grown in significance in our country. Due to serious market competition, businesses have been pushed to find out efficient inventory control techniques to decrease inventory investment and, as a result, lower total costs(DP, 2019).

A well-planned materials management model is essential to maintain effective management, accomplish timely delivery of materials and equipment, and save project costs(Madhavarao et al., 2018). Construction is easier, but supply chain management is more complicated(Wibowo & Sholeh, 2015).

Inventory management's goal is to have a sufficient quantity of resources on hand to fulfill expected demand patterns for a given financial expenditure (RathinaKumar, Priya, Kumar.I, & Ravekumar, 2018). To keep the resources in excellent working order, proper inventory management is required.

2.5.1 Techniques in Inventory Management

An inventory control system is to be engineered to achieve the basic purpose for which the inventories are created. The fundamental objective of a good inventory control system is to be able to determine what to order when to order, How much to order, and How much to carry in stock to gain economy in purchasing, storing, manufacturing, and selling (Mohopadkar & Patil, 2017).

Selecting inventory management strategies for your business is not an easy task, but with the proper inventory management techniques, owners can minimize expenses, keep their businesses

profitable, analyze sales patterns and anticipate future sales, and prepare their businesses for the unexpected.

The approaches listed below are the most common and successful inventory management techniques that might help you enhance your inventory system.

ABC Analysis (Always Better Control: The ABC analysis is a systematic process upon which materials are managed, and it helps in the specifying of inventories and the determination of inventory check intervals. It's an analytical method for keeping track of various inventory items. Pareto's law argues that a tiny fraction of goods accounts for a high amount of value (RathinaKumar et al., 2018). All materials are divided into three groups using this technique: A, B, and C.

In ABC classification, the materials are classified as(DP, 2019):

- A class material – 20% of materials account for 70% of money value.
- B class materials – 30% of materials account for 25% of money value.
- C class materials – 50% of materials account for 5% of money value.

Materials are categorized as follows by (Madhavarao et al., 2018): "A"-class goods—5% to 10% of the total—represent 60% to 70% of their monetary value.15% to 20% of the things in the "B" class have a 15%–20% financial value. "C" class: 60% to 70% of the things have a value in money between 5% and 10%.

(Gupta, Gupta, Jain, & Garg, 2007) state that class items typically account for 10-20% of volume and 60–70% of the cost of materials, while B-class items typically account for 15–30% of volume and 15–30% of the cost of materials, A-class items typically account for 10–20% of volume and 60–70% of the cost of materials, and C-class items typically account for 50–60% of volume and 10-15% of the cost of materials.

The items in the inventory are classified based on factors such as investment, the value of the material used, and the nature of inventory items. Classifying inventory enables a company to have the right items in the proper amount at the right time. Understanding and categorizing different types of inventory enables a company to reduce expenses by not carrying too much inventory while increasing sales by decreasing stockouts.

VED Analysis(Vital, Essential, and Desirable): VED acronym stands for Vital Essential Desirable, VED can be combined with the A-B-C analysis to segregate the materials depending on their importance in the project and can be used when the demand pattern changes(DP, 2019). Vital items are the most important type of items without which the work will halt and have a great impact. Essential items are the one which does not affect the work but still has some impact on the project. Desirable items are the type of items that do not affect the work and does not have much impact.

HML Analysis (High, Medium, and Low): HML stands for the acronym High cost, medium cost Low cost. It is generally used by the procurement purchase department as the cost is the main focus while procuring the inventory(DP, 2019). High-cost items are the ones with high price value and more importance is given to them while purchasing. Medium-cost items are the one which has medium value and much less importance is given compared to high-cost item and low-cost items are the one that is given the least importance compared with High and Medium cost items.

FIFO and LIFO are methods for calculating the cost of inventories. The first item in the inventory is the first one to be taken, according to the first in, first out (FIFO) approach. FIFO is a wonderful approach to maintaining current inventories. The final item in stock is the first one to be withdrawn according to the LIFO, or first in, approach. LIFO helps in avoiding damaged inventory(Ching, Mutuc, & Jose, 2019).

Economic order quantity (EOQ): The amount of inventory that has to be ordered may be determined using this approach. It does this by taking into consideration both the product's price and demand. Costs associated with purchases, shipping, and inventory storage may be decreased with this technique(Senthilnathan, 2019).

Fast, slow, and non-moving (FSN) analysis: The FSN inventory approach involves categorizing materials based on their consumption rate, quantity, and rate of usage. Items are divided into three categories: fast-moving, slow-moving, and non-moving(Nerkar, 2021).

- Fast Moving (F): This category includes items with a high usage frequency.

- Slow Moving (S): This denotes items that are used infrequently.
- Non-Moving (N) items are those that are used for a specified duration only.

Making decisions about inventory management is helped by FSN analysis. Fast-moving items, for instance, may be put in an area that is simple to get to. Additionally, it may be used to identify which things are slow-moving and require special ordering arrangements as well as which items are non-moving and expensive to store.

2.5.2 Inventory Control Policy

Inventory control and management are one of the most complex issues within organizations. It is very common to hear logistics managers and analysts affirm that one of their main problems is the administration of inventories. The typical problem is the existence of excesses and shortages(López-Ramírez, Rojas-Trejos, & González-Velasco, 2017).

As for traditional models with probabilistic demand, several studies and authors have approached the subject of inventory control under uncertainty conditions, looking for a balance between the levels and quantities of inventories to be maintained (and the costs involved), and customer satisfaction and quality of services(López-Ramírez et al., 2017).

According to a study conducted by (Nallusamy, Balaji, & Sundar, 2017), the two most common inventory management policies are the Just-In-Time (JIT) method, in which companies plan to receive materials as they are needed rather than maintaining high inventory levels, and Materials Requirement Planning (MRP), which schedules material deliveries based on sales forecasts.

Just in time (JIT): Many companies employ the "just in time" (JIT) strategy to reduce the expense of overstocking. They use this method to order only what is required to fulfill immediate demand. The firm saves money on storage and insurance by not having excess goods on hand. When the old stock of inventory is nearing replenishment, the corporation orders more inventory. This is a dangerous strategy since even a minor delay in ordering new goods might result in a stock-out situation. As a result, this strategy necessitates careful preparation to accommodate new orders on time.

Materials Requirement Planning (MRP): Material requirement planning (MRP) is a process for determining what, when, and how many components and materials are needed to fulfill a long-term manufacturing plan for final products. The MRP system requires a large amount of information and procedures to function properly(Hassoon, 2007).

2.6. Research Gap

Many researchers have investigated supply chain management issues from various perspectives, including (Perdomo-Rivera, 2004) who developed a conceptual framework for the Material Supply Chain Process (MSCP) in the electrical contracting industry in Northern Virginia, Southwest Virginia, Tennessee, Maryland, and Carolina. The five unique stages that make up the MSCP were defined based on the information gathered from the interviews. These phases are the 1-bidding phase, 2-sourcing phase, 3-materials procurement phase, 4-construction phase, and 5-post construction phase.

Furthermore, Abdul Rahman and Al-Dirisy (1993) developed a framework that shows the activities involved in the management of materials on construction sites.

And also, several studies on supply chain management in the manufacturing and construction industries have been undertaken in Ethiopia. (Admaw, 2010) who investigated the use of SCM in Ethiopian textile companies. (Dereje, 2012) investigated the impact of SCM methods on the performance of metal and engineering companies; (Wondimieneh, 2013) researched pharmaceutical manufacturing companies' supply chain management practices; (Mustefa, 2014) investigated supply chain management methods and company performance; (Moges, 2015) investigated the practice and challenges of SCM on Ethiopian private grade one road construction companies; and (Betelhem, 2017) investigated supply chain management methods and company performance.

Construction supply chain management has become a potentially valuable element in the construction industry to improve operational efficiency and enhance organizational performance. However, the majority of previous studies conducted in Ethiopia were focused on supply chain management methods and issues and their overall implications for manufacturing projects and, to a lesser extent, the construction sector in general, which means there is a lack

of study on material supply chain management in the construction industry regarding the challenge and practice of material supply chain management from the perspectives of contractors. Materials make up a significant portion of the total cost of construction projects and are essential to their daily progress. As a result, they demand specific consideration during material supply management. So, the current study aims to fill this research gap by developing a conceptual framework and an ABC classification of inventory materials list that helps to distinguish the variables that play a role in material supply chain management coordination and provides a way for a business to identify those valuable materials.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter includes the methodology used in this research paperwork and provides information about the research approach, target population, sample size, research method, questionnaire design, questionnaire content, and tests of the consistency of the questionnaire and data analysis methods.

3.1 Description of the Study Area

The research area for this study is Addis Ababa, Ethiopia's capital city, which has 12 sub-cities. Construction is a key activity in Addis Ababa. The fast rise of the construction industry has increased the number of contractors entering the field. According to the Industry Development and Regulatory Bureau of the Ministry of Urban Development, Housing and Construction, there are 1068 BC/RC/GC registered contractors in Addis Ababa for the 2021/22 budget year. There are 330 BC1/RC1/GC1 contractors, 44 BC2/RC2/GC2 contractors, and 260 BC3/RC3/GC3 contractors up to level three. Only grade-one building contractors are studied in this study because they have a properly structured system, organized data set, and better experience. The details regarding the research area information are given in figure 3.1 below.

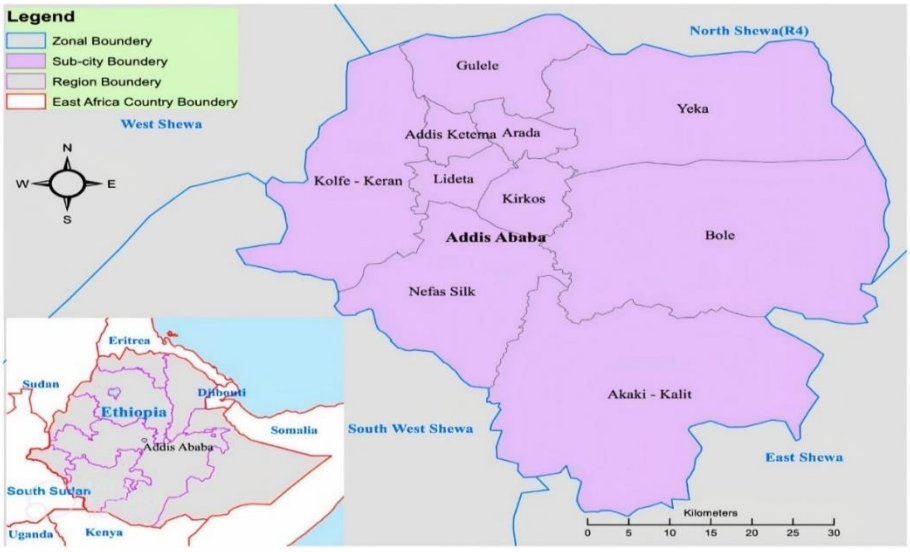

Figure 3. 1: Map of Addis Ababa city (Source Hassen et al., 2018)

3.2. Study Design

Research design is defined as the framework of procedures and strategies used by researchers to combine diverse components of research in a reasonably logical manner so that research problems are efficiently handled (Bhat, et, al 2019). It is a plan for performing the research that maximizes control over these factors that could skew the results' validity. Designing a study aids the researcher in planning and carrying out the study in such a way that the researcher can acquire the desired outcome, thereby increasing the possibility of receiving data that is relevant to the current world (Burns & Grove, 2005).

This study is both quantitative and qualitative with descriptive nature aiming to develop a conceptual framework and ABC analytical model for construction material supply chain management in Addis Ababa grade one building contractors. To fulfill the objectives of the study both primary and secondary data were used. For the collection of primary data, a questionnaire was designed to assess the current practice of material supply chain management, to identify critical challenges that contractors face as a result of material supply chain management, and to specify inventory material that the contracting company has. Statistical Package for the Social Sciences (SPSS) and MS-Excel was used for the computation of analysis.

For the data analysis, the relative importance index and ABC analytical model were used. Relative importance index (RII) was used to ordinals arrange variables in terms of importance and agreement. RII was chosen to be used as a tool for this study because of familiarity with the tool, and also because it is a strong yet simple tool. Also, the ABC analysis model was used to identify material items that have a high impact on overall inventory cost. In this method, materials are divided into three groups, A class, B class, and C class. This inventory control model was chosen because, it is best for a systematic process upon which materials are managed, and it helps in the specifying of inventories and the determination of inventory check intervals. It's an analytical method for keeping track of various inventory items. As a result, this model facilitates the overall material supply chain management system of the contracting companies. After the analysis has done, the material supply chain management framework was developed based on a literature study, questionnaire analysis, and the researcher's experience. The

framework was evaluated by specialists. The findings and suggestions were incorporated into the final.

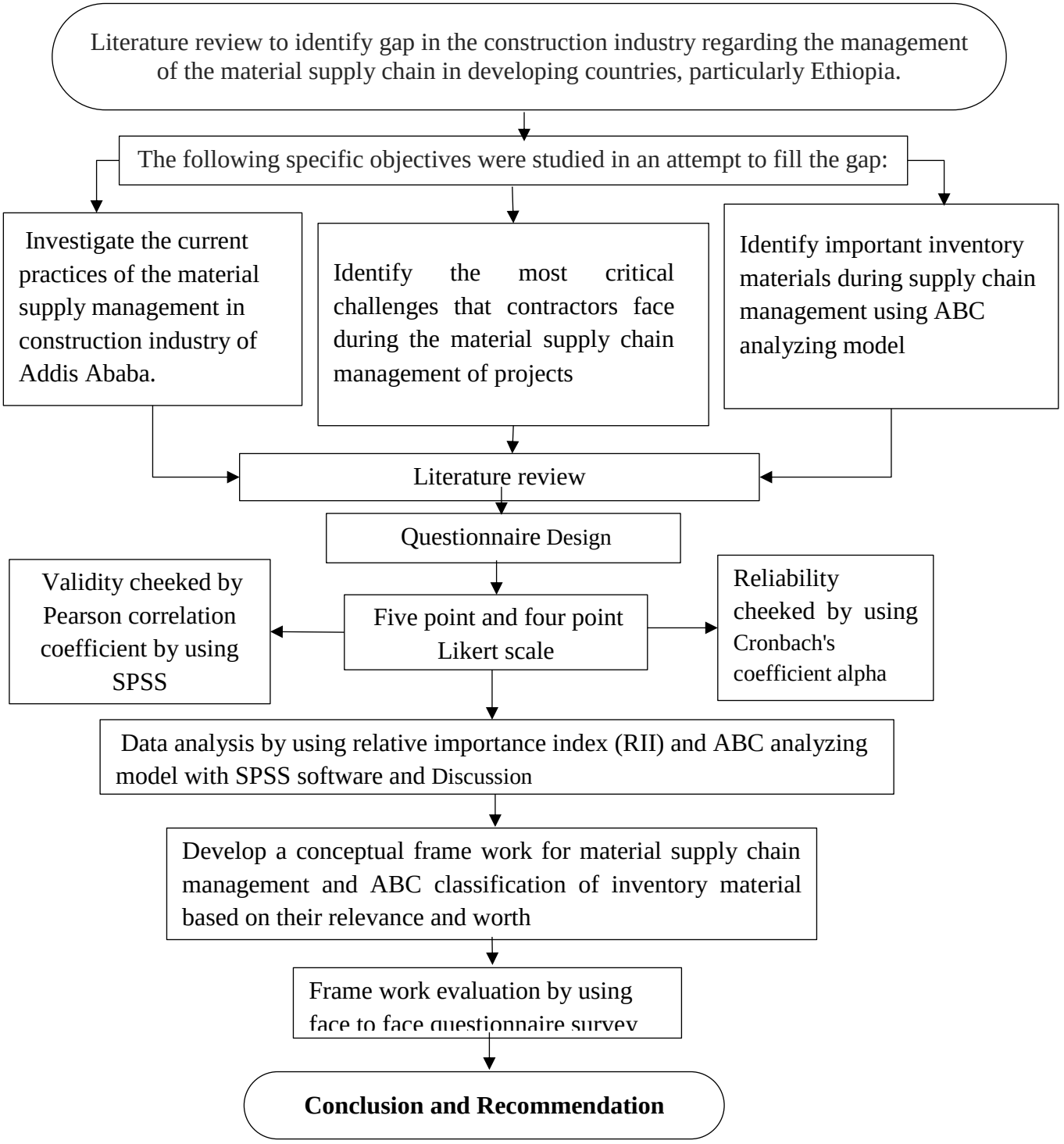

Figure 3. 2: Methodology flowchart of the research

3.3. Population and Sampling Technique

3.3.1 Target Population

The population of this study includes grade one building contractors in Addis Ababa because there are various building construction projects in Addis Ababa. The majority of higher building projects are constructed by grade one building contractors since grade one building contractors are the largest construction contractor classification in Ethiopia qualified to undertake building construction(FISSEHA, 2021). According to a field survey by the ministry of urban development and construction's directive No. 19, which is published as a regulation, currently, there are a total of 51 grade-one building contractors actively involved in the building construction sector in Addis Ababa city.

From those contracting companies' organizational structures, the general manager, purchasing managers, and supply chain managers were targeted for filling out the questionnaires. Because purchasing managers are responsible for sourcing, researching, and contracting with material or product suppliers, they work to find the highest quality, most cost-effective materials and negotiate to receive the best deal for their organization on products to use or resell. On the other hand, supply chain managers, also referred to as supply chain administrators, plan and oversee each component of the supply chain. They aim to decrease costs, monitor inventory, and keep the process moving efficiently. They try to anticipate and respond to issues in supplies, logistics, or budgeting. As a result, because they had prior knowledge of material supply chain management in their organization and were qualified to fill out the questionnaires, the target respondents were considered.

3.3.2 Sampling Technique

In a research investigation, sampling is the process of choosing representative units of a population for the study (Shorafa & Rageb, 2009). The goal of sampling is to provide a viable method for carrying out the data gathering and processing necessary for the research parts while verifying that the sample accurately represents the population. To get meaningful results, the analysis used the whole population of grade one contractors as a sample for this study because the study's participant population is somewhat small.

3.4 Source of Data

Both primary and secondary data are collected to meet the study's objectives. By employing a questionnaire as a data collection tool, primary data is obtained to acquire information and data from various companies. To analyze the current literature on material supply chain management, secondary data was collected from various published journal articles, conference proceedings, and books.

3.5 Data Collection Instruments

3.5.1 Desk Study

A thorough literature search was conducted to identify the activities that comprise the material supply chain process, the criteria that contractors use to select suppliers, the challenges that contractors face during the material supply chain process, and inventory management techniques that are used to facilitate the material supply chain.

3.5.2 Questionnaire

Based on a review of the literature on building supply chain management and the researcher's expertise, all information that may aid in accomplishing the study objectives was gathered, examined, and formalized for use in the study survey. A questionnaire with closed questions was designed after several stages of brainstorming, consulting, modifying, and evaluating by the researcher with the supervisor (refer to Appendix A).

To unfold the meanings of people's responses appropriately and more understandably, themes are identified and categorized based on the objectives of the thesis. The following themes are used:

Demographic or general information: This part contains general information about the construction companies like educational qualifications, the position of participants, years of experience, and the person or section in charge of material procurement.

Current practices of material supply management: in this part, the objective is to examine the applicability of material supply management practices in construction projects, the methods for ordering materials, the criteria used to choose suppliers, and the course of action taken by

the contractors in the event of late material delivery. Under this section 14 questions are prepared.

Identification of the challenges that face the contractors through the Material Supply Chain management process: in this section questions from five phases (bidding, vendor selection, material procurement, construction, and post-construction) are answered to identify the most critical problems that face contractors while material supplying, and 27 items of challenges are identified (refer to Appendix A section III).

Each part consists of many questions designed based on a Likert scale, question in the Likert scale is grouped and analyzed in each part. This system for evaluation was used because Likert Scale-based questionnaires are quick and easy for data collection, making them an excellent choice for surveys, and the responses provide reliable data based on their personal experience (Assafi, Hoque, & Hossain, 2022).

The study employs four and five Likert - scale ordinal measures as shown in the following sections.

The usage degree of the items of the MSCM through the project's phases by scores 1 to 5, where "1" represents never and "5" represents Always.

The importance degree of the items of the MSCM through the project's phases by scores 1 to 5, where "1" represents little importance and "5" represents very importance.

The most critical challenges through the project’s phases of the MSCM by scores of 1 to 4, where "1" represents not at all a problem and "4" represents a serious problem.

Investigating important inventory material during supply chain management: in this part, the objective is to categorize the materials based on their relevance and worth by using ABC analyzing model, so that the elements that account for most of the cost may be controlled with special care. To obtain the required list of inventory material, the contractors are asked to fill the list inventory table by using face to face questionary survey which contains the types of inventors available at the current time, the rate of each material, and its quantity available.

The questionnaires are prepared in such a way that detailed information can be gathered in a systematically prepared matrix table and multiple-choice form. The final draft of the questionnaire was distributed to contracting construction companies in Addis Ababa. It took about seven weeks for the questionnaire to be distributed, collected, and returned to the researchers. The respondent number of questionnaires was 115 questionnaires, 75 were hard copies and 40 were gathered via the internet. No questionnaire has been excluded.

3.5.2.1 Face-to-Face Questionnaire

The purpose of this assessment was to validate the material supply chain process framework that has been developed. To attain this goal, a face-to-face questionnaire survey was done to maximize responses. A sample of 15 contractors with relevant experience was visited, and the researcher described the Material Supply Chain Process Framework to them. Then they were given a questionnaire and asked to score their agreement on each issue on a 5-point Likert Scale, with 1 very weakly agreeing, 2 being weakly agreeing, 3 somewhat agreeing, 4 being agreeing, and 5 being strongly agree. The survey results are shown in chapter four table 4.29.

3.5.3. Case study

A case study is used to validate the framework of this research. The case study project is used as an example to demonstrate the implementation of the conceptual framework in a real-life context. To show how it may assist a decision maker in selecting the appropriate material supply chain management process based on its project criteria.

A purposive sampling technique was used to select the case study project in this research. In purposive sampling, the researcher determines what information is necessary and then searches for those who can and are willing to supply it due to their expertise or experience (Etikan et al., 2016). The criteria used to select the case study project are experience, a project that has a similar approach to the theoretical background of the study, and because of its convenience to data collection, in which it is difficult to collect data from inactive sites.

According to the data that was gathered from the questionnaire survey 12.20% of the sample study had experienced more than 15 years. The researcher chose a case study project that has a similar approach to the theoretical background of the study (Starman, 2013). Consequently, the

researcher selected three building projects located in Addis Ababa which are currently under construction. The first project is taken from Yot construction plc, which is a 2B+G+12 mixed-use building located in Addis Ababa around Figa. Then, the second project is taken from Sunshine Construction plc which is the five-star apartment Hotel (to be called Marriott Executive Apartment) located around Flamingo and the third project is taken from united construction plc, which is a B+G+10 mixed-use building located in Addis Ababa Megenagna.

3.6 Data Analysis and Techniques

The descriptive statistics method was used to analyze the responses in numbers. Percentages and frequencies are easier to interpret, and, in this analysis, they are implemented to express the findings as a proportion of the whole. The findings are presented in the form of tables and charts to understand easily. The study used the relative importance index (RII) and ABC analyzing method.

3.6.1 Relative Important Index

The relative importance index RII is a statistical method to determine the ranking of different factors (Hossen et al. 2015).

The relative importance index is the sum of all the responses divided by the number of responses and the maximum number of Likert scale i.e., the Weighted average of all the responses received. According to (Dixit, Mandal, Thanikal, & Saurabh, 2019), the RII method is one of the most utilized and has a good reliable value while ranking the attributes/factors using a structured questionnaire survey. This method was used to investigate the relative importance of numerous challenges that influence contractors during material supply chain management and the importance and usage degree of material supply chain management practice on building contractors. SPSS software was used to do the data analysis. The frequency (fi) of the response category index for current practice and challenges of material supply chain management was calculated using SPSS. Using the frequency data for each answer category provided by SPSS, the relative importance index (RII) for each element was determined.

Relative importance index (RII) was used to ordinals arrange variables in terms of importance and agreement and it is calculated as follows (Aibinu & Jagboro, 2002).

$$\boldsymbol{RII} = \frac{\sum_{i=1}^{N} \boldsymbol{fi} * \boldsymbol{wi}}{\mathbf{N} * \mathbf{A}} \text{.....Equation 3.1}$$

Where: N = Total number of respondents, wi = the variable expressing the frequency of the i^{th} response, f_i = frequency or count of variables, and A = the maximum scale. The relative importance index ranges from 0 to 1 (Tam & Le, 2006).

Based on the ranks obtained from the analysis, the capability was categorized as very high level, high level, medium level, or low level.

RII values Importance level (Assafi et al., 2022).

- Low level (RII < 0.5),
- Medium level (0.5 < RII < 0.7),
- High level (0.7 < RII < 0.9) and
- Very high level (RII > 0.9)

3.6.2 ABC Analysis Method

ABC analysis and S curve analysis are frequently employed for material management in various literature studies, despite ABC analysis being the most significant in most circumstances (Madhavarao et al., 2018).

In this study, the ABC classification is used to identify the materials based on their relevance and worth, so that the items that account for most of the cost may be tightly monitored. Because ABC classification permits the planning of more efficient collaborative relationships among the companies in the supply chain.

As a case study, primary and secondary data were collected and evaluated from Yot's Construction PLC's project of ten stored and under-construction residential building warehouses in Addis Abeba's Bole sub-city. The case study project was chosen using the following criteria:

The project is active and under construction, with a well-organized warehouse, good records, and up-to-date information regarding the project's material list, as well as updated material cost and quantity data. From such storage facilities, 56 inventory items were identified. The data was also analyzed using Excel.

The ABC analysis was performed to determine material items with a significant influence on overall inventory cost. This approach divides items into three groups. A, B, and C classes are available. “A” Class materials demand the most attention, “B” Class materials require moderate consideration, and “C” Class materials require the least consideration, requiring the control mechanism to be focused on a certain class of materials(Madhavarao et al., 2018).

According to a (DP, 2019) study, A-class items typically account for 10-20% of volume and 60 -70 % of materials cost, while B-class items account for 15-30% of volume and 15-30% of materials cost. A-class items typically account for 10-20% of volume and 60-70 percent of materials cost, while C-class items account for 50-60% of volume and 10-15% of materials cost.

The following procedure is adopted to perform ABC classification (RathinaKumar et al., 2018):

1. Different materials required for the construction project are identified and their estimated quantities are worked out,
2. The unit rates of materials are estimated,
3. The usage values for each of the materials are obtained by multiplying by the estimated quantities and their unit rates,
4. These values are converted into a percentage of total annual usage or total project cost, and
5. The percentage usage cost for each of the materials is arranged in descending order of their ranking, starting with the first rank, i.e., highest to lowest usage value.

In general, the findings of questionnaires were analyzed using MS Excel 2016 and SPSS version 26, and the analysis and results are given in the form of graphs and tables in Chapter 4. The findings are being prepared to offer information regarding the sample size, response rate, and features of contracting companies in Ethiopia, particularly in Addis Ababa. It also covers a collection of material items with a large influence on overall inventory cost, existing practices

and challenges in MSCM based on their relative mean rankings, and solutions to supply chain network challenges.

3.7 Decision Nodes

Decision nodes are junctures in the material management process when a material decision must be taken, such as supplier selection, material procurement (who to buy from, how much to buy, when to buy), delivery options, and storage possibilities(Perdomo-Rivera, 2004). As a result, the decision nodes in the material supply chain for the building contractor were more precisely defined, as illustrated in table 3.1 below.

The inputs are defined by the factors (or parameters) and alternatives. The output is defined by performance measures. Alternatives reflect the many possibilities accessible for a given decision node. Parameters are "values" that might limit the decision-making process. Performance metrics are used to assess the system's effectiveness when alternatives and parameters are provided as inputs.

Table 3. 1: The procurement decisions that need to be made, the alternatives and factors that will affect them, as well as the performance measures related to each option.

Decision	**Alternative**	**Factors**	**Performance Measures**
What is the procurement method?	➢ Competitive Bidding ➢ Negotiation	➢ Materials availability ➢ Number of suppliers ➢ Uncertainty in a project schedule ➢ Criticality of the materials ➢ Costs ➢ Location of the project ➢ Location of supplier ➢ Past supplier performance	➢ Projected shortages ➢ Quality ➢ Quantity ➢ Costs ➢ Long term commitment

When to order materials?	**For local materials in normal conditions** ➢ 1 to 2 days in advance ➢ 3 to 5 days in advance ➢ 1 week in advance ➢ 2 weeks in advance **For local materials in unstable conditions** ➢ 1 week in advance ➢ 2 weeks in advance ➢ 3 weeks in advance ➢ 1 month in advance	➢ Type of materials ➢ Project schedule ➢ Storage capacity ➢ Location of the supplier ➢ Criticality of materials ➢ Location of the project ➢ Location of supplier	➢ Projected shortages ➢ Inventory ➢ Direct costs ➢ Indirect costs
How much to buy?	➢ As estimated ➢ Less than estimated ➢ More than estimated	➢ Project schedule ➢ Storage capacity ➢ Location of the supplier ➢ Installation rate and usage ➢ Location of the project ➢ Procurement cost rates ➢ Imported materials vs. locally available materials ➢ Stable conditions vs. unstable conditions	➢ Projected shortages ➢ Inventory ➢ Direct costs ➢ Indirect costs
Where to deliver?	➢ Jobsite ➢ Warehouse	➢ Project schedule ➢ Uncertainty in a project schedule ➢ Storage capacity	➢ Projected shortages ➢ Quality ➢ Quantity

		➢ Immediate installation ➢ Costs ➢ Location of the project ➢ Location of the warehouse	➢ Costs
What to do with the surplus materials?	➢ Storing the surplus materials to be used in the future projects ➢ Returning the surplus materials to the suppliers without penalty ➢ Returning then suppliers with a penalty	➢ Space availability in the warehouse ➢ Expected need for the materials in the future projects ➢ The actual need for the material in an existing project	➢ Inventory costs ➢ Damage ➢ Penalty costs ➢ Opportunity costs

Once the decision nodes were discovered, mind mapping and knowledge management concepts were used to create an integrated, effective system of decision-support tools (conceptual framework) for construction contractors' material supply chain management system. The design calls for a knowledge database and procedures that enable a contractor to run what-if scenarios on various procurement decisions to identify better alternatives.

Mind mapping is a spatial way of breaking down complex topics into actionable and digestible parts and it does create meaningful engagement because researchers actively engaged in the process of brainstorming, generating ideas, and connecting concepts together while reviewing and developing mind maps.

3.8. Validity of the Questionnaire

The degree to which an instrument measures what it is intended to measure is known as its validity (Heale & Twycross, 2015). There are two techniques to measure instrument validity: content validity and statistical validity, which include constructing validity.

3.8.1. Content Validity of the Questionnaire

Two expert groups were consulted to conduct the content validity test. The first task was to examine and identify if the questions agreed with the scope of the items and how well these items reflected the idea of the research topic. The other was asked to assess if the instrument employed was statistically valid and whether the questionnaire was well-designed enough to give relationships and tests between variables. With slight modifications, the two expert teams agreed that the questionnaire was valid and appropriate for measuring the idea of interest.

3.8.2. Statistical Validity of the Questionnaire

Statistical tests should be employed to assess the validity of the questionnaire. The structural validity test (Pearson test) is a statistical test that evaluates the validity of each field as well as the overall validity of a questionnaire structure. It computes the correlation coefficient between one field and all other fields on the questionnaire at the same scale level. The correlation result must meet the following conditions to be a valid questionnaire.

Step 1: The Significance (2-tailed) value should be less than 0.05 it should be checked for every question.

Step 2: Obtained a value greater than the critical value in table 3.2 by using the Pearson's Correlation Coefficient formula as shown below in equation 3.2.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad \text{..... Equation 3.2}$$

Where, r = Pearson Coefficient, n= number of the pairs of the stock, $\sum xy$ = sum of products of the paired stocks, $\sum x$ = sum of the x scores, $\sum y$= sum of the y scores, $\sum x^2$ = sum of the squared x scores, and $\sum y^2$ = sum of the squared y scores.

Critical values for Pearson's *r* (Zhou et al., 2016).

Table 3. 2: Critical values for Pearson's r coefficient table

	Level of significance for a one-tailed test			
Degree of freedom (Df) = N-2	0.05	0.25	0.01	0.05
	Level of significance for a two-tailed test			
	0.10	0.05	0.02	0.01
1	0.988	0.997	0.9995	0.9999
2	0.900	0.950	0.980	0.990
3	0.805	0.878	0.934	0.959
4	0.729	0.811	0.882	0.917
5	0.6690	0.754	0.833	0.874
6	0.622	0.707	0.789	0.834
7	0.582	0.666	0.750	0.798
8	0.549	0.632	0.716	0.765
9	0.521	0.602	0.685	0.735
10	0.497	0.576	0.658	0.708
20	0.360	0.423	0.492	0.537
30	0.296	0.349	0.409	0.449
40	0.257	0.304	0.358	0.393
50	0.231	0.273	0.322	0.354
60	0.211	0.250	0.295	0.325
70	0.195	0.232	0.274	0.302
80	0.183	0.217	0.256	0.284
90	0.173	0.205	0.242	0.267
100	0.164	0.195	0.230	0.254
∞	0.073	0.087	0.103	0.114

As shown in Appendix (C1.1), all fields' significance values are less than 0.05 or 0.01, meaning that all fields' correlation coefficients are significant at = 0.01 or = 0.05. Consequently, the fields are valid for assessing what they were intended to measure to satisfy the primary aims of the research.

3.9. Reliability of the Research

The degree of consistency with which an instrument measures the property it is designed to assess is defined as its reliability. The lower the fluctuation produced by an instrument in repeated measurements of an attribute, the better its reliability. A measuring tool's reliability might be defined as its stability, consistency, or dependability. The test is given to the same group of people repeatedly, and the results are compared by computing a reliability coefficient. Due to the varying work conditions for this sample, it is impossible to return the same sample of the questionnaire that is used to test the validity of the questionnaire to the same respondents. As a result, Cronbach's coefficient alpha test may be used on the scouting sample to evaluate the consistency of the questionnaire.

3.9.1. Cronbach’s Coefficient Alpha

This approach is used to determine the consistency of the questionnaire between each field and the mean of all fields. Cronbach's coefficient alpha values typically vary between 0.0 and +1.0, with higher values indicating greater internal consistency(Adamson & Prion, 2013).

Cronbach’s alpha Internal consistency(Assafi et al., 2022)**.**

- $\boldsymbol{\alpha} \geq 0.9$ Excellent
- $0.8 \leq \boldsymbol{\alpha} < 0.9$ Good
- $0.7 \leq \boldsymbol{\alpha} < 0.8$ Acceptable
- $0.6 \leq \boldsymbol{\alpha} < 0.7$ Questionable
- $0.5 \leq \boldsymbol{\alpha} < 0.6$ Poor
- $\boldsymbol{\alpha} < 0.5$ Unacceptable

The Cronbach's coefficient alpha was determined for the first field of existing material supply chain management practices and the second field of identifying the important difficulties that contractors face via material supply chain management, as shown in Table 3.3. The values ranged from 0.767 to 0.869. This range is regarded as high; the result confirms the questionnaire's reliability.

Table 3. 3: Cronbach’s Coefficient Alpha value for every section of the questionnaire.

No.	**Section**	**No. of items**	**Cronbach’s coefficient alpha**
1	Current practices of construction material supply chain management	37	0.797
2	Identification of the critical challenges that encountering the contractors through the material supply chain management	28	0.879
	All sections	**65**	**0.838**

As a result, the research finding shows that the questionnaire was valid, trustworthy, and appropriate for distribution to the population sample.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The main objectives of this research were to provide a conceptual framework and an ABC analytical model for the application of building material supply chain management. The results of the questionnaire and the interview were discussed in this chapter. The data analysis and interpretation process is divided into two stages. The first phase displays the respondents' demographics, and the second phase gives the findings and discussion from the questionnaire's survey. Based on the findings, a conceptual framework for building material supply chain management was developed, and key categories of materials were classified using ABC analysis techniques.

A total of 115 questionnaires were distributed individually to respondents, and all 115 survey papers were returned. Out of the 115 survey papers, 110 were valid, with four having incomplete responses and one having an invalid response. According to Flincharm (2018), a response rate of 70% or more can help in the creation of an excellent analysis. The present study response rate is 95.65%, which suggests that there is enough data to form a very solid conclusion. The information provided by respondents is detailed in table 4.1 below.

Table 4. 1: A response rate of the questionnaires survey

	Total no of questionnaires distributed	Successfully responded	Incomplete response	Invalid response
General managers	51	50	1	0
Purchasing manager	51	49	1	1
Supply chain manager	13	11	2	0
Total	115	110	4	1
Percentage	100%	95.65%	3.47%	0.88%

4.2 Respondent Profile

Based on data given by the Ministry of Housing and Urban Development, the prepared questionnaire was delivered to construction professionals in grade one building contractors. General Managers 44.35% of survey respondents, Purchasing managers 44.35% and Supply chain managers make up 13.30%. This means that practically all responders are identified as the right people to know about the company's material supply chain management system. The details regarding the respondent's organizational position are given in figure 4.1 below.

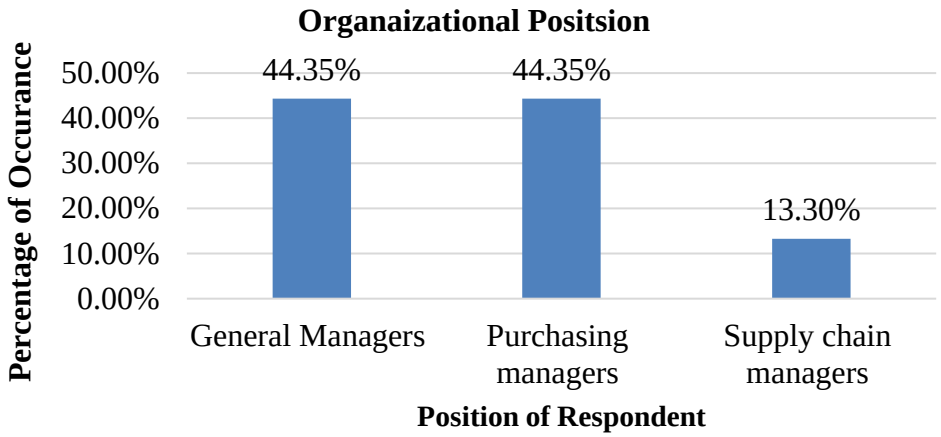

Figure 4. 1: Organizational position of respondents

The respondent's educational background, this study targets construction professionals with a first degree and above, accordingly 73.5% of the respondents have a first degree, and 26.5% have a second degree.

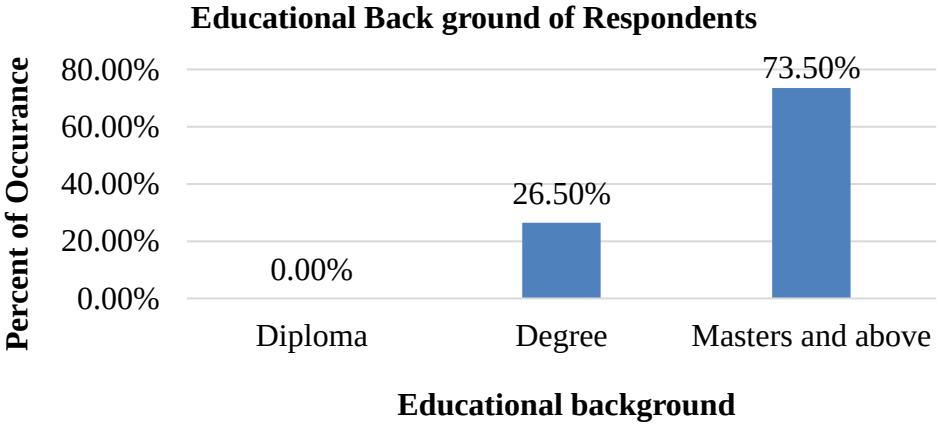

Figure 4. 2: Educational background of the respondents

Another aspect is respondents' construction sector experience: 18.4 % have 1–5 years of experience, 51.0 % have 5–10 years of experience, 18.4 % have 10–15 years of experience, and the remaining 12.2 % have more than 15 years of experience. This means that more than half of the respondents have 5 years or more of experience in material supply management and are considered to be knowledgeable about the company's supply chain management system.

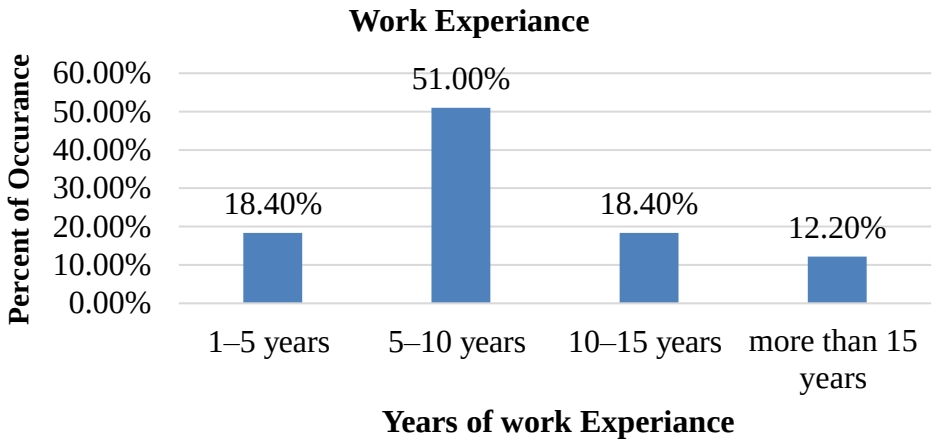

Figure 4. 3: Work experience of respondents

The project manager 46.9%, the site engineer 2.0%, and the owner 6.1% are the people in control of the firms' materials procurement, as shown in Figure 4.4. In 44.9 percent of contracting organizations, procurement divisions handle material procurement. The findings show that the majority of contracting organizations are minor and that one employee does many duties at once.

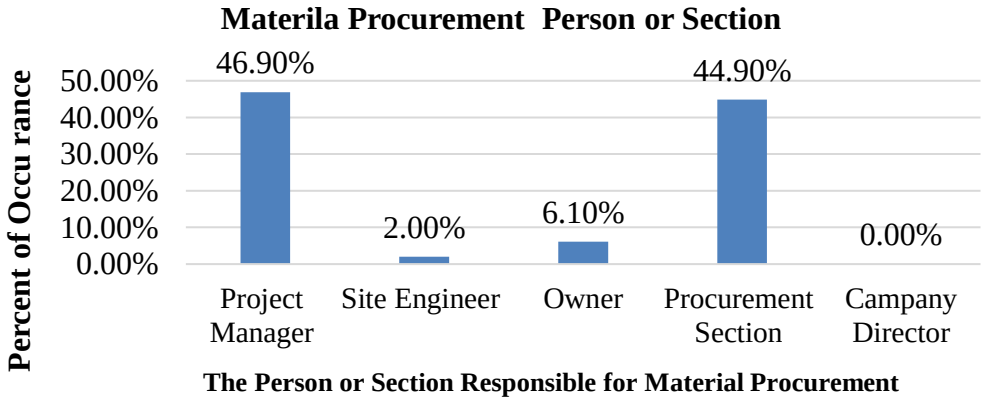

Figure 4. 4: Material procurement persons or section

4.3 Current Material Supply Chain Management Practices

4.3.1 Construction Supply Chain Management Practices Information

The key objectives of this section are to examine existing building material supply chain management practices in Addis Ababa building contractors. The questions in this area revolve around the phrase "material supply chain management," as well as larger material supply management practices.

According to Table 4.2, 50% have the right material supply chain management (MSCM) perspective, indicating a moderate level with opportunity for growth. According to statistics, 42.3% do not have a material supply chain management department, which has a negative influence on the material supply process. This shows a management flaw, and senior executives are unaware of the significance of this management flaw for construction projects.

When it comes to inventories, 32.7% have their inventories, which looks to be a very low level with room for improvement because a well-managed inventory may be critical to profitability because delayed, misplaced, or lost goods might incur unnecessary delays and excessive costs. A well-thought-out project schedule, as well as a detailed inventory of the required materials, labor, and equipment, are critical components of project planning.

Material management forms are used by 44.2% of contracting companies, whereas they are not used by 49.0%. This suggests that 46.2% of contracting companies do not have a good communication system in place with the other parties involved. The forms are a valuable tool for expressing and distributing project information, and they are an important part of integrating the various phases of the material supply chain.

51.9% of contractors have a partnership agreement with suppliers, while the remaining 38.5% do not. This implies that most contractual parties do not see the advantage of having a supplier partnership agreement and that it has to be improved. Supplier relationship management is vital because it provides for the open flow of feedback and ideas between contractual parties and their suppliers. Over time, this will result in a more streamlined, efficient supply chain, which will save costs and improve customer service.

A contractual partnership exists in 36.5% of cases, but not in 51.9% of cases. This means that a partnership agreement isn't a formal legal partnership between the parties involved; rather, it's an informal working arrangement to keep cooperative collaborations going. In these situations, the decision-making process should be carried out in a way that benefits all parties concerned.

Table 4. 2: Distribution of study Sample for the implementation of MSM**.**

Variable	Categories	Frequency	Percentage %
1. What are your thoughts on material supply chain management? It is...	Material procurement	35	30.8
	purchasing raw materials	8	1.9
	Suppliers relationships	16	13.5
	A Tool to control inventories	18	15.4
	Project management	27	23.1
	Customer Satisfaction	11	9.6
	All of the above	58	50
2. Is there a material supply chain management department in your company?	Yes	33	28.8
	No	49	42.3
	Partially Existing	27	23.1
3. Do you have any inventory (stoke material) in your company?	Yes	39	32.7
	No	28	23.1
	Partially Existing	47	38.5
4. Have there been any incidents of late material delivery?	Yes	106	92.3
	No		
	Don’t know	9	1.92
5. Does your organization have detailed information about your suppliers?	Yes	71	61.5
	No	20	17.3
	Don't Know	18	15.4
	Yes	51	44.2
	No	53	46.2

6. Do you use any particular forms for material management?	Don't Know	11	3.8
7. Do any of your suppliers have a partnership arrangement with you?	Yes	60	51.9
	No	44	38.5
	Don’t Know	11	3.8
8. Are there any contractual agreements in place as part of these partnerships?	Yes	42	36.5
	No	60	51.9
	Don’t know	13	5.8
9. How do you value partnership with your suppliers?	Important	77	67.3
	Unimportant	27	23.1
	Normal	11	3.8
	Total	**115**	**100.0**

Table (4.3) indicates that the most important tool that the contractors adopt to order the materials from the suppliers is the telephone (79.6%) for dealing with approved suppliers. The other method that came after this method could be personal meetings (75.5%), as this method can provide contractors with more accurate information about the suppliers and material status.

The results also reveal that the least preferred tool is e-mail (12.2%). This may refer to the fact that direct speech is more effective and offers more persuasion, and this is agreed with Arnold's study (The Persuasive Style of Debates in Direct Speech in Thucydides, 1992).

Table 4. 3: Methods used to make material orders

No	Methods used to make material orders	Responses		Percent of Cases
		No. of response	Percent	
1	Telephone	39	32.5%	79.6%
2	Personal meeting	37	30.8%	75.5%
3	Internet	21	17.5%	42.9%
4	Letter	17	14.2%	34.7%
5	E-mail	6	5.0%	12.2%
	Total	**120**	**100.0%**	**244.9%**

A long-term relationship with the suppliers is one of the fundamental concepts of construction supply chain management. Such relations should be built on cooperation, trust, fairness, and commitment, and done on a win-win basis for all the parties involved. In this subsection, the respondents were given eight criteria and they were requested to choose them following their concerns to select the suppliers.

Table 4.4 indicates that the combination of availability (75.5%), good quality (87.8%), and competitive pricing cost was the most generally used criteria for supplier selection (73.5%). Such criteria are regarded as the primary characteristics of building supply chain management and are crucial in the selection of suppliers. Contractors also value personal relationships (32.7%), mutual interest (32.7%), relative delivery (28.56%), and flexibility in addressing contractors' demands (28.56%). The least utilized criterion by contractors is to enter into a partnership of 14.3 percent. This demonstrates that the contractor/supplier relationship is mostly established on a project-by-project basis.

Table 4. 4: Criteria that are used to select suppliers

No	Criteria used to choose the suppliers	Responses		Percent of Cases
		No of response	Percent	
1	Good quality	43	23.5%	87.8%
2	Availability	37	20.2%	75.5%
3	Competitive pricing cost	36	19.7%	73.5%
4	Personal relationship	16	8.7%	32.7%
5	Mutual interest	16	8.7%	32.7%
6	Relative delivery	14	7.7%	28.6%
7	Flexibility in accommodating contractor's request	14	7.7%	28.6%
8	Enter into partnership	7	3.8%	14.3%
	Total	**183**	**100.0%**	**373.5%**

The fundamental concept of material supply chain management is to have the appropriate items in the right amounts at the right place at the right time and the lowest possible cost. If a supplier fails to provide supplies on schedule or delivers items that are of poor quality, work progress on-site may be disrupted, and project completion may be delayed. What will be the contractors' reaction or the most likely course of action against suppliers that deliver items late or do not meet the quality specifications? Respondents were given five possible courses of action that they may take if a supplier went out of business, and they were asked to rate these options based on their usefulness and priorities. The findings are shown in table 4.5.

Table 4. 5: Rank the most likely course of action in the event of late material delivery.

No.	In the event of late material delivery, the following are the most likely course of action	Rank
1	If there is a need for dispute resolution, send a letter of complaint to the supplier to strengthen the contractor's negotiating position	1
2	Learn from the experience and implement the appropriate measures and processes in the future.	2
3	Simply "give and take" to prevent a difficult relationship	3
4	Reprimand the supplier and then put the subject to rest.	4
5	Penalty charges should be imposed on the supplier.	5

According to table 4.5, the first likely course of action that respondents will follow in the event of late delivery or supplies that do not meet the specified requirements is "sending a letter of protest to the suppliers." An official letter will be a good document for such an issue and will put the contractor in a stronger bargaining position if a dispute settlement is required later on.

The second was to learn from the lesson and take precautionary steps. Contractors make preventative efforts to avoid late delivery. Some contractors include the likelihood of such delayed operations in the material supply schedule to offset their influence on project activities. The resources are then sought sooner than necessary.

The third likely course of action that respondents will take against the defaulting provider is "just give and take to avoid any bad relationship." Defaulted suppliers may not fully understand the implications of late deliveries or supplies that do not satisfy the quality specifications on project success and future relationships with contractors. As a result, some contractors may choose to resolve the issue with the supplier first, in the hope that the same acts will not be repeated and those good relationships will be maintained with the suppliers.

The fourth likely line of action that the response will take against the delayed supplier is to reprimand the supplier and then let the matter rest. A reprimand is a formal warning issued by a contractor to a supplier in an attempt to rectify undesirable conduct. A manager may penalize a supplier for poor work performance, repeated delays, or other undesirable workplace

behaviors. Imposing penalty costs on delayed suppliers came in fifth place. This course of action is determined by the terms and consent of the two parties' contract. If the contract terms and conditions provide the contractor the ability to withhold payments for late deliveries or items that do not match specifications, the contractor will not hesitate to enforce this power. Hitting the suppliers in the pocket will force them to prevent future defaults. As a result, there should be a contractual agreement between the contractor and the supplier to arrange the connection and demonstrate the obligations and duties of each party. Such a contract with the supplier provides the contractor with a significant tool for controlling and acting against any defaulting supplier.

As a part of the research, Shorafa & Rageb conducted (2009), 31 contractors were asked to rate the most likely course of action that contractors will do in the case of late delivery or supplies that do not match the required specifications to establish the most likely course of action that contractors will take. According to the survey, the first likely course of action is "sending a letter of protest to the suppliers." 25 respondents, or 78%, think that this anticipated course of action is most crucial. Simple "give-and-take" was placed second to prevent any sour relationships, and "Learn from the lesson and take preventive actions" was ranked third. Table 4.6 shows the results of the study that had been conducted by (Shorafa & Rageb, 2009) to determine the most likely course of action that contractors would be adopted in case suppliers make late deliveries.

Table 4. 6: Preferred Action against Late Deliveries and/or Failure to Meet Required Specifications (Shorafa & Rageb, 2009)

No.	**Likely Course of Action**	**Percentages**	**Rank**
1	Send a letter of complaint to the supplier	53.20	1
2	Simply "give-and-take" to avoid any sour relationship	50.00	2
3	Learn from the lesson and take preventive measures	48.80	3
4	Impose penalty charges on the supplier	28.00	4
5	Reprimand the supplier and then let the matter rest	17.20	5

4.3.2 Current Material Supply Chain Process Practices

This section comprises six steps of the materials supply chain process: bidding, sourcing, procurement, construction, post-construction, and assessment and evaluation. In each step, respondents were given a set of questions to answer to meet the two objectives mentioned above. These questions are evaluated using two different scales. The first is the usage degree, which tries to determine present material supply chain practices in construction companies, and the second is the importance degree, which aims to provide the basis for improving the building materials supply chain process.

The materials supply chain process elements utilized in this study are mostly drawn from Perdomo's (2004) material supply chain process, which was built based on different conversations and interviews with office and site people from the electrical contracting business in the United States. This is because the researcher discovered little research on the subject of this study after conducting a detailed evaluation of the related studies.

4.3.2.1 Bidding Phase (Estimating, Preparation, Submission, and Winning)

This section includes 12 items that comprise the MSCP's bidding process. The participants were asked how often they used these goods and how significant they believed they were. The findings are shown in table 4.7.

Table 4. 7: Bidding process phase (estimating, preparation, submission, and winning)

Item No.	Material Supply Chain Process	Usage degree		Importance degree	
		Relative index	Rank	Relative index	Rank
1.6	preparing the estimate using software programs or computer programs like Microsoft Excel	0.996	1	0.992	1

1.1	Once you have the project's designs and specifications, you may determine the materials required for each component.	0.980	2	0.984	2
1.2	Estimating the quantities of items required for each component (quantity take off)	0.940	3	0.956	3
1.10	Before submitting the offer, confirm the costs mentioned in the estimate.	0.912	4	0.932	4
1.9	Determining the project estimate will depend on the costs of the manufacturers and suppliers.	0.872	5	0.896	6
1.12	Preparing a preliminary material requisition schedule that includes the material types, quantities required, delivery dates, and any other clarification-needed details.	0.861	6	0.914	5
1.5	Identifying locally available or locally manufactured materials as well as items that should be imported.	0.856	7	0.896	6
1.11	When you win the bid, you should schedule a meeting with the project manager and the construction crew to reassess the project's quantities.	0.820	8	0.832	8
1.3	Specifying any special requirements or materials to be used in the project.	0.816	9	0.880	7
1.7	A realistic estimate should be provided by including project managers and construction teams in the estimation process.	0.780	10	0.820	9
1.4	Classifying the primary materials that must be prefabricated and the readily available materials	0.760	11	0.820	10
1.8	Developing a pricing database for the materials used in the previously completed projects so that it can be utilized to prepare estimates for the projects that will be undertaken in the future.	0.704	12	0.712	11
	Total	**0.858**		**0.886**	

The relative importance index for item 1.6 "Using software packages or computer programs such as Microsoft Excel for creating the estimate" is very high (0.996) for Usage Degree with rank equals (1) and very high (0.992) for Importance Degree with rank equals (1), as shown in table 4.7. As expected, the majority of respondents utilize Microsoft Excel to prepare estimates since it makes the process more accurate, simpler, and faster. However, the contractors might create various programs to meet their needs.

The relative importance index for item 1.1 "Identifying the materials needed for each item after you obtain the project's designs and specifications" is very high (0.980) for usage degree with rank equals (2) and very high (0.984) for importance degree with rank equals (2). This item was rated extremely highly by respondents in terms of usage and importance. This implies they understand the significance of specifying the required material for each item in the Bill of Quantities (BOQ).

The relative importance index for item 1.2 "Estimating the number of materials required per item (quantity take off)" is very high (0.940) for Usage Degree with rank equals (3) and very high (0.956) for Importance Degree with rank equals (3). This item was given a high level of usage and priority by the contractors. It is typical practice for consulting firms to raise the amount of each item in the BOQ by a specific percentage beyond what was initially projected from the project's drawings. Furthermore, some BOQ items may have inaccuracies in estimated amounts that impact the estimate. As a result, contractors must estimate the number of required materials from the project designs and compare them to the ones listed in the BOQ. The relative importance index for item 1.10 "Verifying the prices used in the estimate before submitting the bid" is very high (0.912) for usage with rank equals (4) and very high (0.932) for importance with rank equals (4). As expected, all respondents double-checked the pricing in the estimate before submitting their bid. Any errors in the estimate may cause the contractor to either lose the contract or win it with a significant loss.

The findings indicate that the bidding phase of the material supply chain approach used in the Addis Ababa construction sector is compatible with the Perdomo research (2004). According to Perdomo, the materials takeoff and identification procedure is the first stage in the bidding phase, and it entails identifying the materials required as well as any specific needs or unusual

materials to be utilized in the project. Materials are divided into two categories: off-the-shelf materials and materials that must be manufactured. He stated that the majority of organizations prepare estimates using computer tools such as Excel since it makes the estimating process quicker and faster, and the contracting companies verify the numbers numerous times before submitting the bid. He further said that including project managers in the estimating phase might result in the development of a more realistic estimate due to the project manager's experience. After winning a bid for a specific project, companies hold a kick-off meeting with the superintendent, project manager, and all foremen to generate a material requisition schedule that specifies material types, quantity needed, dates when the materials should be delivered, and any additional information required for clarification.

4.3.2.2 Sourcing (Vendor Selection) Phase

This section includes seven items that constitute the MSCP's sourcing phase. The participants were asked how often they used these items and how important they considered they were. The findings are shown in table 4.8.

Table 4. 8: Sourcing (Vendor Selection) Process

Item No	Material Supply Chain Process	Usage degree		Importance degree	
		Relative index	Rank	Relative index	Rank
2.4	Requesting quotations from many suppliers to obtain fair and competitive rates.	0.973	1	0.965	1
2.5	Selecting the supplier with the best pricing.	0.953	2	0.964	2
2.2	confirming that the supplier can supply the required materials in the required quantities and at the required times, i.e., on the dates stated,	0.931	3	0.949	3
2.7	Directly negotiates pricing with suppliers.	0.926	4	0.938	4
2.3	Purchasing the materials from suppliers you've already collaborated with on projects	0.847	5	0.847	5

2.1	Pre-qualify the manufacturers and suppliers, and maintain a list of reliable manufacturers and suppliers	0.782	6	0.798	7
2.6	Consider suppliers that cost more but offer better services or who have a track record of delivering the required materials in the required quantities at the required times.	0.655	7	0.836	6
	Total	**0.876**		**0.898**	

The relative importance index for item 2.4, "Requesting quotations from various suppliers to get reasonable and good rates," as shown in Table 4.8, is very high (0.972) for Usage Degree with rank equals (1) and very high (0.964) for Importance Degree with rank equals (1). According to the findings, competitive bidding is the most prevalent method by which contractors choose suppliers, and respondents regard it as the most crucial tool for doing so. Because of the competitive nature of the bidding, the researcher argues that the contractor must purchase items at the lowest feasible cost. Typically, contractors receive bids from suppliers to obtain the lowest feasible price for their products. Suppliers will aim to win the contract by providing the contractor with a low relative price. If a supplier does not reduce his or her price, the contract may be offered to another company. Giving the contract to the lowest bidder may result in an uneasy relationship with the suppliers throughout project implementation.

The relative relevance index for item 2.5 is very high (0.9530) for usage degree with a rank equal to (2) and (0.964) for importance degree with a rank equal to (2). According to the findings, many respondents choose suppliers based on the lowest pricing and consider this to be a key factor in supplier selection. As indicated in the preceding paragraph, choosing suppliers based on the lowest price may result in antagonistic relationships since the suppliers receive the task at a lower price than they expected, resulting in a reduced profit. Because of the revenue loss, the suppliers may be less loyal to this particular contract, and difficulties may arise.

The relative importance index for item 2.2 "Verifying that the supplier can supply the necessary materials (kind, quality, and quantity) when needed" (i.e., at the dates specified") is quite high (0.931) for usage degree with equal rank (3) and extremely high (0.949) for importance degree with equals rank (3). As predicted, respondents rated this item as very useful and important. The

findings reveal that contractors are well aware that a lack of materials when needed or a delayed supply of materials can have a significant impact on labor productivity, generating delays in operations, raising project costs, and possibly postponing project completion. Before awarding the contract, contractors should ensure that the selected suppliers or manufacturers are capable of providing the required materials on time.

The relative importance index for item 2.7 "Directly negotiating pricing with suppliers" is very high (0.926) for the Usage Degree with a rank equal to (4) and very high (0.938) for the Importance Degree with a rank equal to (4). According to the findings, negotiation is the second most widely utilized and crucial approach for selecting suppliers. This might be because building material suppliers for each type of material are limited, and contractors know which vendors give the best prices.

According to Permedo (2004), the initial stage of the sourcing phase is the identification of trustworthy suppliers and manufacturers. Most contractors prefer to purchase materials from suppliers with whom they have previously worked on past projects, and the contractor must ensure that these suppliers are capable of supplying the appropriate products (type, quality, and quantity) when required (i.e., at the dates specified). He further said that to get reasonable costs for the materials, they get quotations from many vendors. Suppliers are often chosen based on the lowest price. Contractors, on the other hand, may choose suppliers with higher pricing but better services, or those with a track record of providing the proper products in the quantities required at the times stated. He even said that large material contractors frequently negotiate costs directly with suppliers.

4.3.2.2. Material Procurement Phase

This section includes nine items that comprise the MSCP's procurement phase. The respondents were asked how often they used these items and how important they believed they were. The findings are shown in table 4.9.

Table 4. 9: Material Procurement Process

Item No	Material Supply Chain Process	Usage degree		Importance degree	
		Relative index	Rank	Relative index	Rank
3.1	Obtaining a copy of the site staff-prepared material requisition schedule that details the types of materials, the quantities required, the dates, and the deadlines for delivery (such a schedule prepared by the site staff for the construction phase)	0.972	1	0.978	2
3.2	Before requesting any materials from suppliers, make sure the needed materials are already in your stock.	0.952	2	0.981	1
3.4	To manage the connection between the contractor and the supplier, a purchase order is sent to the successful provider (a contract is established).	0.901	3	0.957	3
3.7	Ordering estimated item quantities based on on-site work progress.	0.901	3	0.978	2
3.9	Monitoring the status of the requested materials to ensure that they are supplied on time, in the required quantities, and compliance with the requirements.	0.889	4	0.951	4
3.8	Specifying to suppliers the release dates for the material and the specific location of material delivery to avoid material re-handling	0.853	5	0.922	5
3.3	Requesting a submittal (material sample) from the manufacturer or supplier and having the engineer approve it before the delivery of the materials	0.844	6	0.918	6
3.6	Ordering all of the estimated item quantities at once.	0.495	7	0.612	7

3.5	Field personnel directly request materials.	0.486	8	0.489	8
	Total	**0.810**		**0.860**	

According to Table 4.9, the responses to item 3.1 "Obtaining a copy of the material requisition schedule, specifying material types, quantity needed, dates, and when the material should be delivered that is prepared by site personnel (such as the schedule prepared by site staff during the construction phase")" show that the relative importance index is very high (0.972) for Usage Degree with rank equals (1) and Importance Degree with rank equals (1). The purpose of acquiring a copy of the requisition schedule is to coordinate the material purchase process and offer delivery schedules to suppliers. A schedule such as this should categorize long-lead products into locally available materials, off-the-shelf materials, and materials that should be manufactured. Failure in the purchasing process might result in either over-ordering of materials, resulting in waste issues, or a scarcity of materials, resulting in a delay in project completion. The site personnel should always have an updated copy of the material requisition schedule on hand for the procurement division or the person in charge of procurement.

The relative importance index for item 3.2 "Verifying the availability of requested materials in your stocks before requesting any materials from suppliers" is high (0.952) for usage degree with rank equals (2) and extremely high (0.981) for importance degree with rank equals (2). Respondents indicated a high level of usage and a very high level of relevance. To minimize wastage and stock difficulties, the procurement department, or the person in charge of procurement should verify with the person in charge of the warehouse the availability of the desired items before purchasing them.

The relative importance index for item 3.4 "Issuing purchase orders to the winner supplier (Setting an agreement) to organize the contractor-supplier relationship" is very high (0.901) for Usage Degree with rank equals (3) and very high (0.957) for Importance Degree with rank equals (3). Both usage and importance got very high marks from respondents. The findings show that the contractors understand the significance of the purchase order. According to the researcher, the purchase order reflects the contract between the contractor and the supplier. It displays, among other things, the amount to be supplied, the requirements, and the time to be on

site. A purchase order of such a kind is used as a reference in the event of a disagreement between the contractor and the supplier.

The relative importance index for item 3.7 "Ordering estimated item quantities based on-site work progress" is very high (0.901) for the sample for Usage Degree with rank equals (3) and very high (0.978) for Importance Degree with rank equals (3). Both usage and importance got very high ratings from respondents. The results show that contractors prefer to order the necessary quantities as the work progresses to avoid stockpiling items on the job site or in the warehouse.

The relative importance index for item 3.9, "Following up on the status of the ordered materials to ensure that the delivered materials comply with the specifications, in the quantities required, and within the timeframe specified," is very high (0.889) for usage with rank equals (4) and very high (0.951) for importance with rank equals (4). Contractors rated this item highly for its use and significance. The procurement division or the person in charge of procurement should work with the construction team on the job site and the suppliers to ensure that the proper products arrive on schedule.

According to Perdomo (2004), the procurement process begins with the creation of a material requisition schedule, which is often initiated by site staff and then forwarded to the purchasing department for material requests from contract suppliers. Materials may be requisitioned directly by field employees on smaller operations. The material requisition schedule specifies the material type and amount required, as well as the dates when the material shall be supplied.

Before ordering materials from suppliers, the purchasing department at a company with a warehouse first confirms the availability of the items in the warehouse. He further said that after a release form is prepared, vendors are contracted to obtain the necessary materials. The supplier is notified about the type of material required, the quantities required, and the time frame in which the supply is needed.

4.3.2.3. Construction Phase

This section includes eight items that comprise the MSCP's building phase. The respondents were asked how frequently they used these goods and how important they thought they were. The findings are shown in table 4.10

Table 4. 10: Construction Process Phase

Item No	Material Supply Chain Process	Usage degree		Importance degree	
		Relative index	Rank	Relative index	Rank
4.5	Verify the quantity obtained versus the quantity ordered.	0.980	1	0.988	1
4.6	Inspecting supplied items to ensure they meet specifications	0.964	2	0.988	1
4.1	Determining the necessary material amounts for each item.	0.932	3	0.956	2
4.3	Determine the precise location of material delivery for each item.	0.852	4	0.880	5
4.4	Preparing a material request form that includes the material description, quantities required, delivery dates, and delivery locations.	0.844	5	0.896	4
4.2	Determining the availability dates for the materials for each item.	0.828	6	0.876	6
4.7	Mentioning any issues with the delivered materials	0.816	7	0.920	3
4.8	Keeping a record of the materials supplied, the remaining balance, and the materials installed	0.768	8	0.872	7
	Total	**0.873**		**0.922**	

The relative importance index for item 4.5 "Verifying the material received against the quantity ordered" is very high (0.980) for Usage Degree with a rank equal to (1) and very high (0.988) for Importance Degree with a rank equal to (1), as shown in table 4.10. The contractors rated this item as really useful and important. The construction team should verify the ordered amounts with the received quantities. If there is a variance, the construction team or the person in charge of receiving materials should notify the procurement department or the person in charge of procurement so that the suppliers may be accompanied.

For item 4.6, "Inspecting the delivered materials to ensure that they fulfill the specifications," the relative importance index is very high (0.964) for usage degree with a rank equal to (2) and very high (0.988) for importance with a rank equal to (2). The results show that the contractors understand the significance of verifying the quality of the provided materials against the specified requirements. If the provided materials are installed and it is later discovered that they do not satisfy the project's criteria, the Supervisor Engineer may order the contractor to remove the installed materials and replace them with new materials that meet the project's specifications. As a result, work progress will be delayed, and the project as a whole may be delayed.

The relative importance index for item 4.1 "Determining the quantities of materials needed per item" reveals that the relative importance index is extremely high (0.932) for usage degree with rank equals (3) and very high (0.956) for importance degree with rank equals (3). The outcome indicates that the relative importance index for the usage degree and the importance degree is almost identical and extremely high. Once the work begins, the construction team on-site can more precisely determine the resources required for each item. As a result, this item will assist the contractor in avoiding material delivery shortages, which cause work disruption and project delays; or in avoiding material surpluses, which may be subject to damage, theft, and loss; and, more importantly, tie down the contractor's capital that could be used for more critical purposes.

For item 4.3, "Determining the exact materials delivery location for each item," the relative importance index is high (0.852) for usage degree with a rank equal to (4) and high (0.880) for an important degree with a rank equal to (4). The contractors gave this item a high rating for both its usage and its importance, which were almost equal. The contractors understand that determining the precise location for material delivery eliminates material re-handling, saving time and money.

Perdomo (2004) revealed that anytime materials are required on the construction site, site staff initiate a material request procedure (Forman or the project manager). This process involves creating a material request form in which the material description, quantities required, delivery dates, and delivery locations are provided. If the item is delivered to the job site, the designated site staff will check the material against the request form. The actual quantities received are documented. If there are variations in the material quantities, material damage, or missing items,

the foreman fills out a complaint sheet form and sends a copy to the purchasing department for follow-up with the concerned supplier.

4.3.2.4. Post-Construction Phase (Surplus Materials)

One of the key ideas of supply chain management in the construction industry that is connected to the quantity attribute is reducing surplus materials to a minimum. This section offers five situations for dealing with project surplus materials. The respondents were asked to choose the scenarios (s) they encountered and the percentage of the time they encountered them. The findings are shown in table 4.11.

Table 4. 11: Post-Construction Phase (Surplus Materials)

Item No	Material Supply Chain Process	Percent Occurrence	Ranks
6.1	Keeping surplus materials for use in future projects	87.4	1
6.4	Selling surplus supplies to other contractors	8.28	2
6.2	Returning surplus materials to suppliers with no penalty	2.68	3
6.3	Penalty-laden returns of surplus materials to suppliers.	1.64	4
	Total	**100%**	

Table 4.11 indicates that the majority of surplus materials (87.4 %) are stored in the contractors' warehouses. Such items may deteriorate, be damaged, lost, or stolen, and, more significantly, they will tie up the contractors' cash. To minimize material surpluses, contractors should establish a comprehensive materials takeoff. Table 4.11 further shows that at the end of the project, (2.68%) of the surplus materials are returned to the suppliers without penalty, and (1.64%) of the surplus materials are returned to the suppliers with a penalty. These findings suggest that suppliers are ridged, and contractors may not have class backgrounds with them.

4.3.2.5. Evaluation Phase

The respondents were asked about their usage and the importance of doing a comprehensive investigation of the material supply chain process throughout the project phases. The findings are shown in table 4.12.

Table 4. 12: Assessment phase result

Item No	Material Supply Chain Process	Usage degree		Importance degree	
		Relative index	Rank	Relative index	Rank
5.1	Conducting a thorough examination of the material supply chain process through the aforementioned steps is necessary to avoid mistakes and enhance this process in future projects.	0.684		0.889	

According to table 4.12, the relative importance index for usage degree is medium (0.684), whereas the relative importance index for importance degree is high (0.889). Although many contractors do not analyze the material supply chain process through the five stages at the end of the project, they believe that such evaluation is a critical step in improving the material supply chain process in future projects. There are several decisions that contractors should make as a result of the five described steps of the materials supply chain process.

4.4 Contractor's Challenges during the Material Supply Chain Process

4.4.1. Bidding Phase: Material Takeoff and Identification

Respondents were given four challenges that contractors could experience during the bidding process and asked to rate each one as not at all a challenge, minor challenge, moderate challenge, or serious challenge.

Table 4. 13: Challenges with Contractors during the bidding process

Item No	Challenges	Degree of challenges	
		Relative index	**Rank**
1.2	There is a communication gap between the parties involved.	0.821	1
1.3	There is missing information and incomplete drawings.	0.806	2
1.1	There is no clear definition of what the owner and suppliers are looking for.	0.796	3
1.5	Ambiguities between plans and specifications.	0.755	4
1.4	Using different specifications than those that are typically employed.	0.602	5
	Total	**0.756**	

According to table 4.13, the "lack of communication between the parties concerned" was placed at the top in terms of the relative relevance index (0.821). Contractors may want more information and/or clarification from the parties involved during the bidding phase to generate a fair and good estimate. Contractors, for example, may want further information regarding the materials from the owner, as well as explanations of any contradictions identified in the contract agreements. They may want information from suppliers on the cost of building materials as well as the means and techniques of installation. Contractors may also collect information from subcontractors on the difficulty, cost, and time necessary for installation. As a result, if contractors do not maintain open lines of communication with these parties, they may be unable to provide an accurate estimate. As a result, contractors should improve their communication skills and build positive relationships with owners, suppliers, and subcontractors. Furthermore, an internet-based communication system will integrate all parties participating in the estimating process, allowing them to access project data and communicate project information.

"Incomplete drawings and details are lacking" and "Ambiguities between plans and specifications" were ranked second and fourth, respectively, with relative important indexes of

(0.806) and (0.755). The findings imply that the consultants' tender documents are not adequately written. Ambiguities in the bidding documentation, as well as missing drawings and information, may make it difficult for contractors to create accurate estimates. Furthermore, inconsistencies between plans and specifications may cause numerous issues and arguments among the interested parties throughout the building phase, potentially disrupting project operations on site.

The researcher argues that consultants should pay more attention and effort while drafting tender documents to be clear. Furthermore, during the bidding phase, contractors must carefully review the tender documents and request further information and explanations from consultants if there are any discrepancies between plans and specifications. Ambiguities should be resolved in advance; otherwise, the building process will be disrupted.

4.4.2. Sourcing (Vendor Selection) Phase

Respondents were given three challenges that contractors could experience during the sourcing process and asked to grade each question as not at all a challenge, minor challenge, moderate challenge, or serious challenge. The findings are shown in table 4.14.

Table 4. 14: Contractor Challenges during the Sourcing (Vendor Selection) Phase

Item No	**Challenges**	**Degree of challenges**	
		Relative index	**Rank**
2.2	Incomplete proposals (Suppliers did not include all the documents with the proposal.)	0.729	1
2.1	Having too many suppliers and not having information about them	0.668	2
2.3	Investigating non-qualified suppliers takes time.	0.653	3
	Total	**0.683**	

According to table 4.14, "Incomplete bids by suppliers (suppliers did not submit all of the papers with the proposal)" was placed first in terms of relative relevance index (0.729). The researcher believes that the examination of suppliers' proposals should take into account not only financial offers but also technical offers and other elements. As a result, sending specifications, brochures, and/or technical data on the materials with supplier offers will assist contractors in appropriately evaluating them. If a contractor awards the contract only on budgetary grounds, there is a good chance that the winning supplier may provide materials that do not satisfy the specified criteria. Such a difficulty will delay construction progress on the site, particularly if supplies are imported from outside Addis Ababa. To address these issues, contractors must strengthen their contact with suppliers. Invitation to bid paperwork, for example, should require suppliers to provide brochures and/or technical data on the items they intend to deliver with their bids, and any supplier who fails to do so will have his bid rejected.

4.4.3. Material Procurement

Respondents were given six challenges that contractors may experience throughout the procurement phase and asked to evaluate each question as not at all a challenge, minor challenge, moderate challenge, or serious challenge. The findings are shown in table 4.15.

Table 4. 15: Challenges Encountering Contractors during Material Procurement Phase.

Item No.	**Challenges**	**Degree of challenges**	
		Relative index	Rank
3.1	Unavailability of required material	0.872	1
3.2	Late submittals by the contractor to be approved by the Supervisor Engineer (Submittals are not submitted as planned)	0.796	2
3.3	Suppliers' submissions were incorrect.	0.735	3
3.5	Poor communication between the parties	0.735	3
3.4	The Supervisor Engineer's late approval of a submission	0.704	4
3.6	The contractor fails to make clear to suppliers what is required.	0.699	5
	Total	**0.757**	

According to table 4.15, the "unavailability of needed materials" was placed first in terms of relative importance index (0.872). Unavailability of materials when needed can have a significant impact on labor productivity, generating delays in operations, raising project costs, and perhaps delaying project completion. This problem may be recognized during the building phase, but its origin may occur during the sourcing process, since contractors may choose suppliers based only on availability and good quality without considering other considerations.

According to table 4.4 of this survey, the most essential factors for contractors when selecting suppliers were availability and good quality. To overcome this problem, contractors should award contracts based on more than just availability and good quality during the sourcing process, such as the cost of materials at a competitive price. Furthermore, contractors might employ a time buffer for ordering goods throughout the building phase to protect against uncertainty.

The relative importance index placed "poor communication between the parties concerned" third (0.734). For example, the procurement division or the person in charge of procurement must verify that the necessary materials are ordered in the exact quantities. This individual must also know the expected dates for the materials and inform the supplier of the delivery location. Poor communication, according to the study, might be caused by a lack of appropriate tools and channels for exchanging information among the people concerned. To accomplish his job, the procurement department or the person in charge of procurement should have access to contract data, project scheduling, and a method of communicating delivery instructions to the workers on site. Developing an internet-based communication system will also allow the procurement department or the person in charge of procurement to place orders and track the progress of the requested products to ensure that they arrive at the project site in the quantities and on the dates stated. To address this issue, contractors should pre-qualify suppliers, obtain estimates from trustworthy suppliers, and submit a letter of complaint to suppliers who are in default, according to Table 4.5's findings. Such an official letter will be a useful document in such a situation, and it will place the contractor in a stronger bargaining position if a conflict arises later.

With the relative importance index, "late approval of submission by the Supervisor Engineer" was rated fourth (0.704). If there is no relevant language in the project's general conditions, after a contractor signs a contract, he shall, among other things, negotiate an agreement with the owner on the approval period for submittal. The contractor must monitor the status of material submission approval during the building process. If the engineer approves the project late, he should write the owner a note of complaint. Such an official letter will be a useful document in such a situation, and it will place the contractor in a stronger bargaining position if a conflict arises later. Furthermore, contractors can account for the potential for such late approval in the material supply schedule to reduce the impact on project operations. The content is then submitted for approval earlier than planned.

4.4.4. Construction Phase

The respondents were given nine challenges that contractors could experience during the building phase and asked to evaluate each one as not at all a challenge, a minor challenge, a moderate challenge, or a serious challenge. The findings are shown in table 4.16.

Table 4. 16: Challenges Encountering Contractors during Construction Phase

Item No.	**Challenges**	**Degree of challenges**	
		Relative index	Rank
4.2	The delivered materials do not comply with the required specifications.	0.974	1
4.1	Delivery delays (Materials come later than expected.)	0.881	2
4.7	Material damage occurs as a result of handling or other factors.	0.745	3
4.5	Loss of materials	0.714	4

4.8	Poor communication and coordination between the parties involved	0.704	5
4.4	Storage of materials: There is a limitation of storage space, or it is located far from the working area.	0.663	6
4.9	Receiving, handling, and storage of the unused materials	0.647	7
4.6	Theft of materials	0.592	8
4.3	Re-handling of materials: Before installation, materials must be transported from one location to another.	0.413	9
	Total	**0.705**	

According to table 4.16, "The supplied materials do not comply with the required specifications" was ranked first with a relative importance index of 0.974, and "Late delivery (materials do not arrive as planned")" was ranked second with a relative importance index of 0.887. Although these issues were discovered during the supply chain's construction phase, their origins may have been discovered during the sourcing phase. For example, during the sourcing process, the contractor may identify the supplier through bidding. Because of the competitive nature of the bidding, the supplier may give the contractor a cheap price to win the business. Because of the cheap price, the supplier may not be able to fully contribute to the project. Furthermore, contractors may fail to pre-qualify suppliers and may fail to ensure that the supplier is capable of delivering the required quantities on time. Another reason for late delivery and materials that do not meet project standards is a lack of a contract between the supplier and the contractor during the procurement process. Contractors' poor planning during the construction phase may also result in late delivery.

To deal with the issues of late delivery and materials that do not meet the specified specifications, contractors must undertake the following:

During the sourcing phase, they should pre-qualify the suppliers and ensure that they can provide the correct material in the proper amounts on time. They should not choose the supplier with the lowest prices, but rather the supplier with higher prices but better services.

During the procurement phase, contractors must establish agreements with suppliers defining each party's roles and responsibilities. There should be a penalty fee provision in place if the supplier fails to deliver on time or delivers products that do not satisfy the specified requirements. Table 4.5 indicates the suggested course of action for contractors in the event of supplier default.

Contractors may maintain buffer inventories on-site for particular days throughout the construction phase to protect against the risks inherent in the construction industry.

4.4.5. Post-Construction Phase

The respondents were asked to rate each challenge as not at all a challenge, minor challenge, moderate challenge, or serious challenge. Table 4.17 shows the results.

Table 4. 17: Contractor Challenges during the Post-Construction Phase

Item No.	**Challenges**	**Degree of challenges**	
		Relative index	Rank
5.2	There is no way for the surplus materials to be returned to the supplier.	0.765	1
5.1	There is no storage for surplus materials.	0.714	2
5.4	Salvage losses for the surplus materials	0.699	3
5.3	The suppliers charge penalties for the returned materials.	0.602	4
	Total	**0.695**	

According to table 4.17, the majority of contractors are unable to return surplus goods to suppliers and do not have a warehouse in which to keep extra products.

This section might lead to two conclusions. First, inadequate communication among the parties involved is a constant issue in all phases of the MSCP. As a result, a system, such as a web-based system, should be in place to appropriately handle information among the parties involved. (Tucker et al., 2001) stated: "Visualize SCM as two parallel tracks: physical (products, materials, and even finances) flow and information flow that manages it." Products, materials, equipment, and finances move in response to information flow signals. However, in the context of a building project, these flows occur from the perspective of relations between different companies. SCM covers organizational barriers, organizing information and process flows, providing signals to activities, and analyzing outcomes. The coordination of the chain is dependent on information management. As a result, information management is elevated to the core of CSCM. Second, the material procurement stage is the most critical in dealing with material supply problems.

4.5 ABC Analysis of the Collected Inventory Data

Based on the capital investment of the item, A-B-C analysis operates on Pareto's "vital few and trivial many" concept (Flores & Whybark, 1987). It is an analytical approach for classifying materials into three categories based on their needs. The A-class items have the most preferences, the B-class items have a medium preference, and the C-class items have the least preferences.

A-class items typically account for 10-20% of total volume and 60-70% of total material cost, whereas B-class items account for 15-30% of total volume and 15-30% of total material cost. A-class items typically account for 10-20% of total volume and 60-70 percent of total material cost, whereas C-class items account for 50-60% of total volume and 10-15% of the total material cost(DP, 2019).

Table 4. 18: ABC Percentage Classification

A class Item	10-20% volume	60-70% cost
B class Item	15-30% Volume	15-30% cost
C class Item	50-60 % volume	10-15% cost

Table 4. 19: ABC classification of Inventory Material

S. N	Name of Inventory Materials	Unit	Unit Rate	No. of Stokes	Total Cost	No. of Stokes Percentage	Cost Percentage	Cumulative Percentage	Classification
1	Cement (OPC Mugger)	bag	650	15300	9945000	7.662%	21.833%	21.833%	A
2	Cement (PPC Mugger)	bag	520	18500	9620000	9.264%	21.120%	42.953%	A
3	RHS (rectangular hollow section)80cm*80cm*1.5mm*6mm	pcs	3500	830	2905000	0.416%	6.378%	49.330%	A
4	Rein. Bar dia. 24 mm Grade 70	kg	65	22700	1475500	11.368%	3.239%	52.569%	A
5	Rein. Bar dia. 12 mm Grade 70	kg	65	21500	1397500	10.767%	3.068%	55.637%	A
6	Rein. Bar dia. 10 mm Grade 70	kg	65	21460	1394900	10.747%	3.062%	58.700%	A
7	Rein. Bar dia. 14 mm Grade 70	kg	65	21300	1384500	10.667%	3.039%	61.739%	A
8	Stone	m3	1000	1120	1120000	0.561%	2.459%	64.198%	A
9	Sand	m3	1200	920	1104000	0.461%	2.424%	66.622%	A
10	Gravel 02	m3	900	1200	1080000	0.601%	2.371%	68.993%	A
11	Rein. Bar dia. 8 mm Grade 70	kg	52	20600	1071200	10.316%	2.352%	71.344%	B
12	3cm thick white marble	m2	4500	230	1035000	0.115%	2.272%	73.617%	B
13	Timber Imported	m3	32919.3	30	987579	0.015%	2.168%	75.785%	B
14	10 mm thick Porcelain tiles (imported)	m2	1249	760	949240	0.381%	2.084%	77.869%	B
15	30mm thick Granite	m2	5900	158	932200	0.079%	2.047%	79.915%	B
16	Timber Local	m3	20807.5	42	873915	0.021%	1.919%	81.834%	B

17	power cable 0.6/1kv3x2.5mm2	m	75	11650	873750	5.834%	1.918%	83.752%	B
18	The aluminum frame of different sections (L, T, Z, Circular, etc.)	Kg	585.83	1300	761579	0.651%	1.672%	85.424%	B
19	Plywood	m2	300	2500	750000	1.252%	1.647%	87.070%	B
20	RHS / SHS Different sizes	kg	130	5760	748800	2.884%	1.644%	88.714%	B
21	Granite 3cm	m2	5500	130	715000	0.065%	1.570%	90.284%	B
22	6 mm thick Ceramic tiles (local)	m2	265.217	2300	609999.1	1.152%	1.339%	91.623%	B
23	20mm thick Marble	m2	4000	140	560000	0.070%	1.229%	92.853%	B
24	Ø 75 mm uPVC pipe	ml	210	2570	539700	1.287%	1.185%	94.038%	B
25	2mm thick PVC floor tiles	m2	201	1570	315570	0.786%	0.693%	94.730%	B
26	PVC skirting	m	100	3100	310000	1.552%	0.681%	95.411%	B
27	Automatic circuit breaker	pcs	850	270	229500	0.135%	0.504%	95.915%	B
28	Black wire	Kg	80	2600	208000	1.302%	0.457%	96.371%	C
29	Hand wash basin	pcs	9000	23	207000	0.012%	0.454%	96.826%	C
30	Eucalyptus diameter 8 cm	pcs	45	3350	150750	1.678%	0.331%	97.157%	C
31	Water closet low flash	pcs	18000	7	126000	0.004%	0.277%	97.433%	C
32	Eucalyptus diameter 10-12 cm	pcs	50	2250	112500	1.127%	0.247%	97.680%	C
33	Junction box	pcs	150	675	101250	0.338%	0.222%	97.903%	C
34	Tile adhesive	Kg	150	670	100500	0.336%	0.221%	98.123%	C
35	Shower tray plate with head (cast iron)	pcs	3900	25	97500	0.013%	0.214%	98.337%	C
36	Turkish WC	pcs	2730	35	95550	0.018%	0.210%	98.547%	C
37	circuit breakers 10-32A/1P ACB ICU= 6KA	pcs	160	590	94400	0.295%	0.207%	98.754%	C

38	10 mm thick Ceramic tiles (local)	m2	395.652	210	83086.92	0.105%	0.182%	98.937%	C
39	Ceramic tile 30cm*30cm-7mm thick	m2	422	190	80180	0.095%	0.176%	99.113%	C
40	Ceramic skirting (imported)	ml	139.13	520	72347.6	0.260%	0.159%	99.272%	C
41	HCB 15 cm thick	pcs	15	3900	58500	1.953%	0.128%	99.400%	C
42	HCB, 20 cm thick Class B	pcs	17	2826	48042	1.415%	0.105%	99.505%	C
43	Quartz paint	Gal	780	50	39000	0.025%	0.086%	99.591%	C
44	HCB 10 cm thick	pcs	15	2294	34410	1.149%	0.076%	99.667%	C
45	Double socket outlet	pcs	320	90	28800	0.045%	0.063%	99.730%	C
46	Synthetic paint	Gal	504.348	50	25217.4	0.025%	0.055%	99.785%	C
47	Conduit	pcs	60	410	24600	0.205%	0.054%	99.839%	C
48	Varnish paint	Gal	600	25	15000	0.013%	0.033%	99.872%	C
49	Triple socket	pcs	220	65	14300	0.033%	0.031%	99.904%	C
50	Benzene (Regular)	Lit	30	350	10500	0.175%	0.023%	99.927%	C
51	Diesel	Lit	27	350	9450	0.175%	0.021%	99.947%	C
52	PVC insulated conductors1X1.5MM2 H97V-U 300/500V	pcs	175	45	7875	0.023%	0.017%	99.965%	C
53	Nail 12	kg	110	50	5500	0.025%	0.012%	99.977%	C
54	Nail 10	Kg	110	50	5500	0.025%	0.012%	99.989%	C
55	Nail 9	Kg	110	30	3300	0.015%	0.007%	99.996%	C
56	Nail 6	Kg	90	20	1800	0.010%	0.004%	100.000%	C

Table 4.19 indicates the classification of stored inventory materials from the project's grade one building contractor stocks.

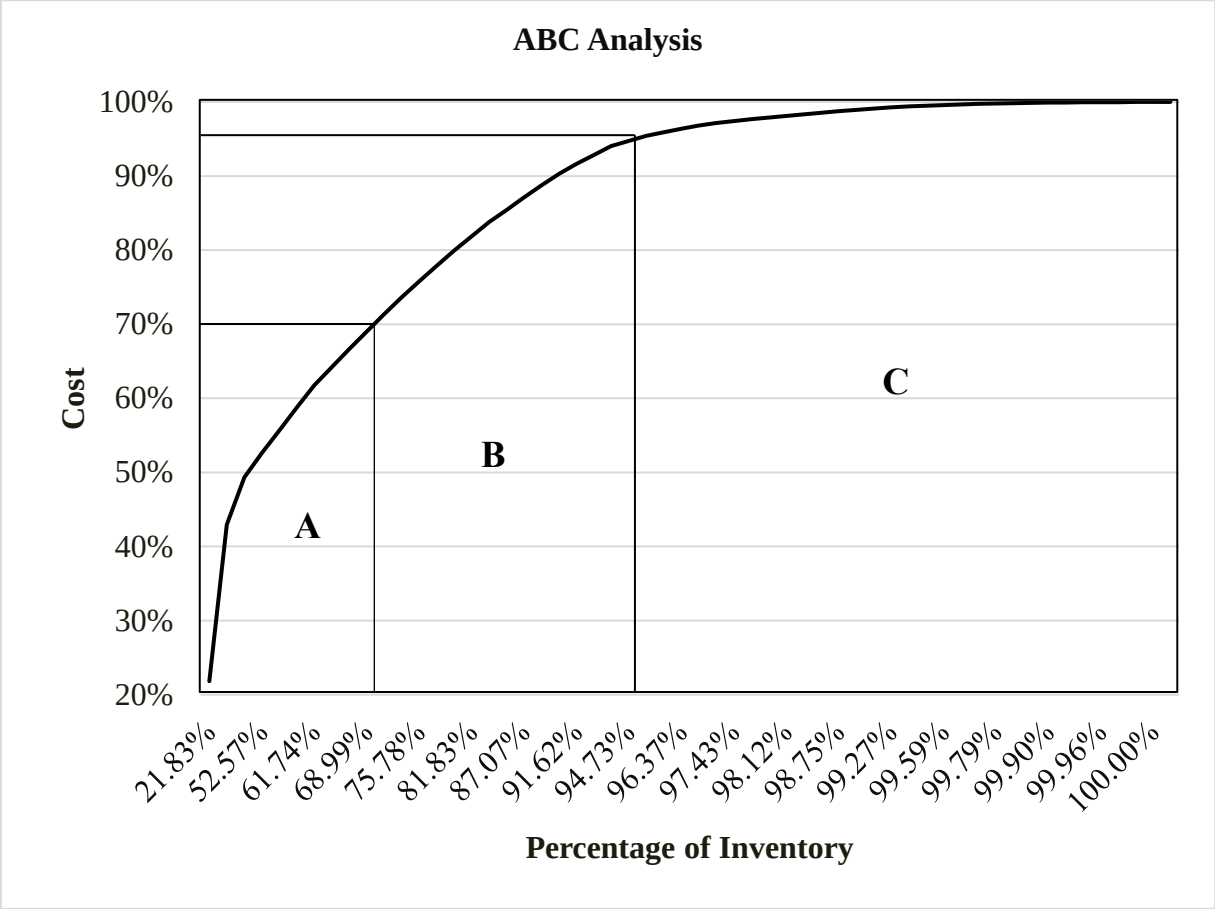

Figure 4. 5*:* ABC classification of Inventory Material

According to (Nallusamy et al., 2017), the objective of categorizing materials into three categories is to provide appropriate degrees of control over each item and to make its usage easy to understand.

For class item A, precise quantity forecasting is essential, as is senior-level purchasing involvement; ordering on a need-to-know basis; procurement inquiries should be issued to a large number of suppliers; tight control is required; ideally, weekly monitoring; and little safety stock is required.

For class item B, an estimated prediction of quantities is required. Purchases necessitate the involvement of the intermediate level. Orders are placed on an economic order quantity (EOQ)

basis. Procurement inquiries should be directed to 3-5 trustworthy vendors. A moderate level of control is necessary, preferably every month, as well as a modest level of safety stock.

There is no requirement for forecasting for class item C; even an approximate quantity estimate will be sufficient. Junior-level employees are empowered to order purchases; bulk purchasing is desired; bids from as few as three trusted suppliers are acceptable. A reasonably relaxed level of management is sufficient, and quarterly monitoring is possible. A sufficient safety supply can be kept on hand.

In general, we suggest a reorder point in a constantly monitoring method for “B” items and a two-bin regulating system for “C” items based on (Wanitwattanakosol, Attakomal, & Suriwan, 2015) and other research results. “A” items are only ordered when they are necessary.

4.6 Construction Material Supply Chain Management Conceptual Framework

The development of a conceptual framework begins with a deductive assumption that a problem exists, and the application of processes, procedures, functional approaches, models, and other tools is used for problem resolution (Zackoff et al., 2019).

A conceptual framework is constructed based on the research objective by using relationships between the particular factors in the research (Regoniel, 2015).

The primary goal of this framework is to enable contractors to deliver the right materials, in the right quantity, at the right time, and at the right cost by controlling the material supply chain as an integrated process-oriented approach rather than a series of individual activities or an activity-centered approach through the project phases. The framework was developed using Perdomo's (2004) study, as well as additional literature studies and questionnaire results. The framework is intended to incorporate all phases of the project, including the bidding phase, sourcing phase, procurement phase, construction phase, post-construction phase, and assessment phase. Each phase provides the process or actions that contractors should consider, critical challenges that contractors may face and potential solutions for them, and ultimately, decision nodes that may be raised in any phase.

4.6.1 Bidding Phase

This phase includes bid estimation, preparation, submission, and winning.

4.6.1.1. Process

1. Once you have the project's designs and specifications, you may determine the materials required for each component.
2. Estimating the quantities of items required for each component (quantity take off)
3. Specifying any special requirements or materials to be used in the project.
4. Classifying the primary materials that must be prefabricated and the readily available materials
5. Identifying locally available or locally manufactured materials as well as items that should be imported.
6. preparing the estimate using software programs or computer programs like Microsoft Excel
7. A realistic estimate should be provided by including project managers and construction teams in the estimation process.
8. Determining the project estimate will depend on the costs of the manufacturers and suppliers.
9. Before submitting the offer, confirm the costs mentioned in the estimate.
10. When you win the bid, you should schedule a meeting with the project manager and the construction crew to reassess the project's quantities.
11. Preparing a preliminary material requisition schedule that includes the material types, quantities required, delivery dates, and any other clarification-needed details.

4.6.1.2. Challenges Encountered

Table 4.20 shows the critical challenges encountered by contractors during the bidding phase and their possible solutions.

Table 4. 20*:* Challenges Encountered during the Bidding Phase and Possible Solutions

Encountered challenges	Possible Solution
There is a communication gap between the parties involved.	Contractors should establish an internet-based communication system to integrate the involved parties in the estimation process and enable them to have access to project data and share project
Ambiguities between plans and specifications and Incomplete drawings and missing details.	▪ Consultants Should -Give more focus and attention when preparing the tender documents to be clear and understandable. ▪ Contractors Should - Study the tender documents carefully ▪ Request more information and clarifications from the client in case there are ambiguities between plans and specifications. ▪ Solve ambiguities in advance as they arise otherwise it will interrupt the works during the construction phase.

4.6.2 Phase of Sourcing

4.6.2.2. Process

1. Pre-qualify the manufacturers and suppliers and maintain a list of reliable manufacturers and suppliers.
2. Confirming that the supplier can supply the required materials in the required quantities and at the required times, i.e., on the dates stated,
3. If materials are provided by specified suppliers; these materials need to be acquired from those suppliers through negotiation

4. If there are multiple suppliers, contractors can select the supplier either through bidding or negotiating the prices directly with the supplier
5. In case a contractor chooses the bidding process, then quotations should be requested from the pre-qualified suppliers and from suppliers who worked on previous projects
6. Selecting the winning supplier based on the lowest price or considering suppliers with higher prices but who will provide better services or who have a record to supply the right materials in the quantities needed at the times specified**.**

4.6.2.2. Challenges Encountered

Table 4.21 shows the critical challenges encountered by the contractors during the sourcing phase and the possible solutions for them.

Table 4. 21: Challenges Encountered during the Sourcing Phase and Possible Solutions

Encountered challenges	**Possible Solution**
Incomplete proposals (Suppliers did not include all the documents with the proposal).	➢ Contractors should improve their communication with the suppliers by using special forms. ➢ Use a website information system for transferring the information. ➢ Stipulate that suppliers have to attach with their offers brochures and/or technical data for the materials that they are going to deliver and anyone who does not adhere to this condition, the offer will be rejected.

4.6.2.4. Decision Node

Following the sourcing process, a contractor should decide on "what procurement method to use." Table 4.22 displays the decision possibilities, parameters, and performance metrics.

Table 4. 22: Sourcing Phase Decision

Decision	Alternative	Parameters	Performance Measures
What is the procurement method?	➢ Competitive Bidding ➢ Negotiation	➢ Materials availability ➢ Number of suppliers ➢ Uncertainty in a project schedule ➢ Criticality of the materials ➢ Costs ➢ Location of the project ➢ Location of supplier ➢ Past supplier performance	➢ Projected shortages ➢ Quality ➢ Quantity ➢ Costs ➢ Long term commitment

4.6.3 Phase of Procurement

4.6.3.1. Process

1. Obtaining a copy of the site staff-prepared material requisition schedule that details the types of materials, the quantities required, the dates, and the deadlines for delivery (such a schedule prepared by the site staff for the construction phase).

2. Before requesting any materials from suppliers, make sure the needed materials are already in your stock.
3. Requesting a submittal (material sample) from the manufacturer or supplier and having the engineer approve it before the delivery of the materials.
4. To manage the connection between the contractor and the supplier, a purchase order is sent to the successful provider (a contract is established).
5. Ordering all of the estimated item quantities at once or ordering the estimated item quantities as per the work progress on the site. The decisions should be taken by a contractor.
6. Specifying to suppliers the release dates for the material and the specific location of material delivery to avoid material re-handling.
7. Monitoring the status of the requested materials to ensure that they are supplied on time, in the required quantities, and compliance with the requirements.

4.6.3.2. Challenges Encountered

Table 4.23 outlines the major issues that contractors face throughout the procurement phase, as well as potential solutions. Although certain difficulties may be found during the procurement phase, the main causes of these challenges may be discovered during the prior phases (sourcing phase) by other players. As a result, solutions to these challenges will be supplied where they are discovered and may lie.

Table 4. 23: Challenges Encountered during the Procurement Phase and Possible Solutions

Encountered challenges	Possible Solution
Poor communication between the parties.	➢ Contractors should have access to contract data, and project scheduling as well as means to communicate delivery instructions to the personnel on-site to perform tasks.

	➢ Develop an internet-based communication system to place orders
Unavailability of required material.	➢ Contractors should not rely only on the lowest price to award the contract during the sourcing phase but should also consider other factors such as the availability of the materials. ➢ Use buffer time for ordering the materials to safeguard against uncertainties during the construction phase.
Suppliers' submissions were incorrect.	➢ Contractors should pre-qualify the suppliers ➢ Obtain quotations from reputable suppliers whom they worked with on previous projects ➢ Send a letter of complaint to the defaulted suppliers. Such an official letter will be a good document for such a problem and puts the contractor in a better bargaining position if there will be a need for dispute resolution at a later stage.
	➢ Contractors should specify with the owner the approval period for

The Supervisor Engineer's late approval of a submission.	submittal if there are no related clauses in the project's general conditions. ➢ Follow up on the status of material submittal approval during the construction phase. - Send a letter of complaint to the owner in case there is late approval by the Engineer. ➢ Take into account in the material delivery schedule the possibility of such late approval. Hence, the material samples should be submitted for approval earlier than what is planned.

4.6.3.3. Decision Node

A contractor must make two decisions during the procurement phase: "when to order materials?" and "how much to buy?" Table 4.24 displays the options for these three selections, as well as the parameters and performance measurements.

Table 4. 24: Procurement Phase Decisions

Decision	Alternative	Parameters	Performance Measures
	For local materials in normal conditions ➢ 1 to 2 days in advance ➢ 3 to 5 days in advance	➢ Type of materials ➢ Project schedule ➢ Storage capacity ➢ Location of the supplier	➢ Projected shortages ➢ Inventory ➢ Direct costs ➢ Indirect costs

When to order materials?	➢ 1 week in advance ➢ 2 weeks in advance **For local materials in unstable conditions** ➢ 1 week in advance ➢ 2 weeks in advance ➢ 3 weeks in advance ➢ 1 month in advance	➢ Criticality of materials ➢ Location of the project ➢ Location of supplier	
How much to buy?	➢ As estimated ➢ Less than estimated ➢ More than estimated	➢ Project schedule ➢ Storage capacity ➢ Location of the supplier ➢ Installation rate and usage ➢ Location of the project ➢ Procurement cost rates ➢ Imported materials vs. locally available materials ➢ Stable conditions vs. unstable conditions	➢ Projected shortages ➢ Inventory ➢ Direct costs ➢ Indirect costs

4.6.4 Phase of Construction

4.6.4.1. Process

1. Determining the necessary material amounts for each item.
2. Determining the availability dates for the materials for each item.
3. Determine the precise location of material delivery for each item.
4. Preparing a material request form that includes the material description, quantities required, delivery dates, and delivery locations.
5. Verify the quantity obtained versus the quantity ordered.
6. Inspecting supplied items to ensure they meet specifications.
7. Mentioning (recording) any issues with the delivered materials.
8. Keeping a record of the materials supplied, the remaining balance, and the materials installed.

4.6.4.2. Challenges Encountered

Table 4.25 shows major challenges encountered by contractors during the construction period, as well as potential solutions. Although certain difficulties may be discovered during the construction phase, the main causes of these challenges may be discovered during the prior stages (sourcing and procurement) by other players. As a result, solutions to these challenges will be supplied where they are discovered and may lie.

Table 4. 25: Challenges Encountered during the Construction Phase and Possible Solutions

Encountered Problems	**Possible Solution**
	In the Sourcing Phase ➢ Contractors should Pre-qualify the suppliers ➢ Make sure that they are capable of delivering the right material in the right quantities and in the time specified. ➢ Consider the suppliers with higher prices but who provide better services and not select the suppliers based on the lowest prices.

Delivery delays (Materials come later than expected) and the delivered materials do not comply with the required specifications.	**In the Procurement Phase** ➢ Set out an agreement with the suppliers showing the duties and responsibilities of each party. ➢ Impose penalty charges in case the supplier makes late deliveries or delivers materials that do not meet the required specifications. **In the construction phase** ➢ Keep buffer stocks on site enough for an operation for certain days to safeguard against the uncertainties inherent in the construction industry. ➢ Order materials in advance by certain days before starting the activity to safeguard against late deliveries.
Poor communication and coordination between the parties involved.	➢ Contractors should establish a system for exchanging information and sharing data among the project participants.

4.6.4.3. Decision Node

A contractor should decide on "where to deliver the materials?" during the construction phase. Table 4.26 displays the choice possibilities, their parameters, and the performance measures.

Table 4. 26: Construction Phase Decisions

Decision	Alternative	Parameters	Performance Measures
Where to deliver?	➢ Jobsite ➢ Warehouse	➢ Project schedule ➢ Uncertainty in a project schedule ➢ Storage capacity ➢ Immediate installation	➢ Projected shortages ➢ Quality ➢ Quantity Costs

		➢ Costs ➢ Location of the project ➢ Location of the warehouse	

4.6.5. Phase of Post-Construction

4.6.5.1. Process

1. After completing the project, contractors have to manage the surplus materials.
2. Keeping surplus materials for use in future projects
3. Returning surplus materials to suppliers with no penalty
4. Penalty-laden returns of surplus materials to suppliers.
5. Selling surplus supplies to other contractors

4.6.5.2. Challenges Encountered

Table 4. 27: Challenges Encountered during the post Construction Phase and Possible Solutions.

Encountered challenges	Possible Solution
There is no storage for surplus materials.	The contractor should make a good partnership agreement with the suppliers to return the surplus materials

4.6.5.3. Decision Node

A contractor should decide on "what to do with the extra materials" during the post-construction phase. Table 4.28 displays the choice alternatives, their parameters, and the performance measures.

Table 4. 28: Post- Construction Phase Decision

Decision	Alternative	Parameters	Performance Measures
What to do with the surplus materials?	➢ Storing the surplus materials to be used in future projects. ➢ Returning the surplus materials to the suppliers without a penalty. ➢ Returning the surplus materials to the suppliers with a penalty.	➢ Space availability in the warehouse. ➢ Expected need for the materials in future projects. ➢ The actual need for the material in an existing project.	➢ Inventory costs ➢ Damage ➢ Penalty costs ➢ Opportunity costs

4.6.5 Evaluation Phase

A contractor should decide on "what to do with the extra materials" during the post-construction phase. Table 4.28 displays the choice alternatives, their parameters, and the performance measures.

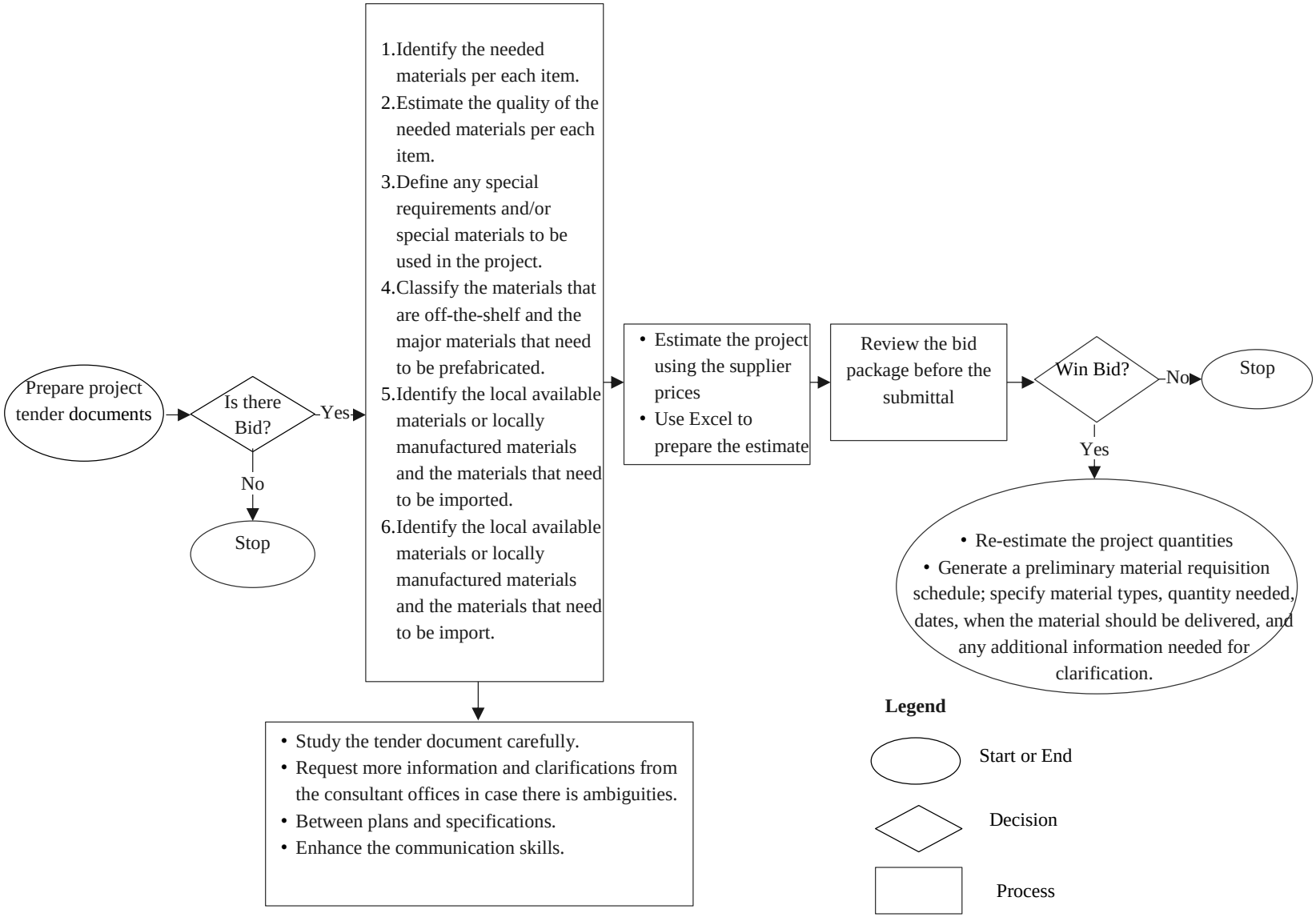

Figure 4. 6: Material Supply Chain Process Framework (Bidding Phase)

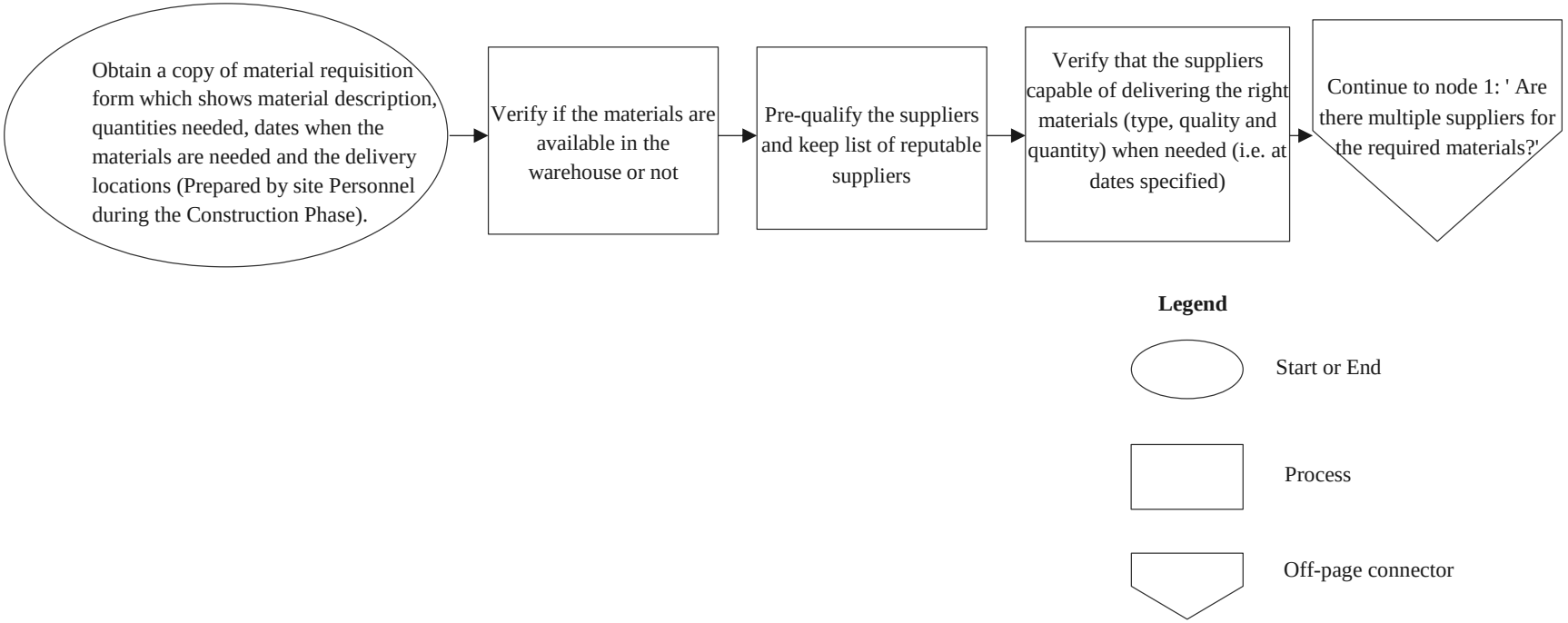

Figure 4. 7: Material Supply Chain Process Framework (Procurement and Sourcing Phase)

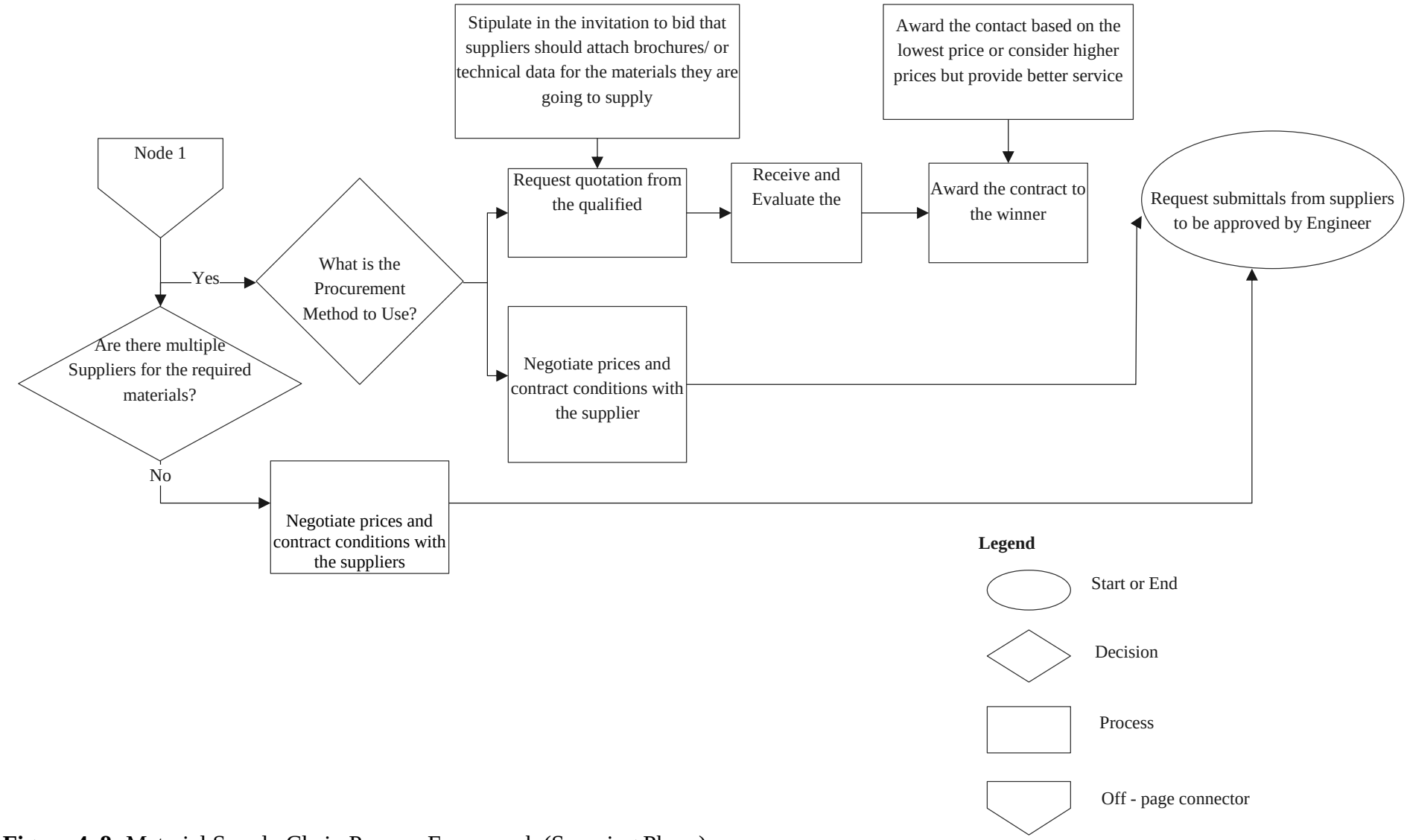

Figure 4. 8: Material Supply Chain Process Framework (Sourcing Phase)

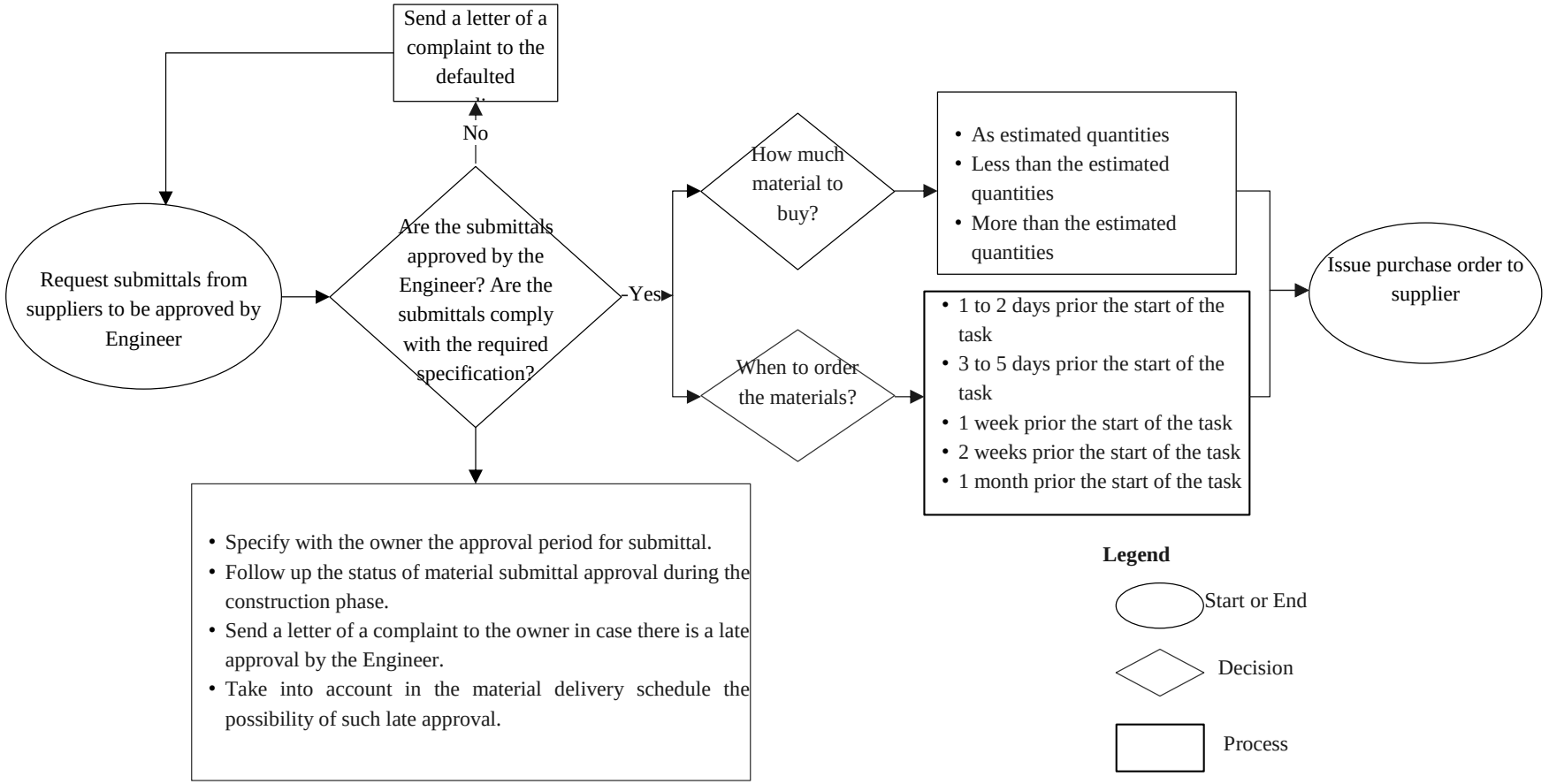

Figure 4. 9: Material Supply Chain Process Framework (Sourcing Phase)

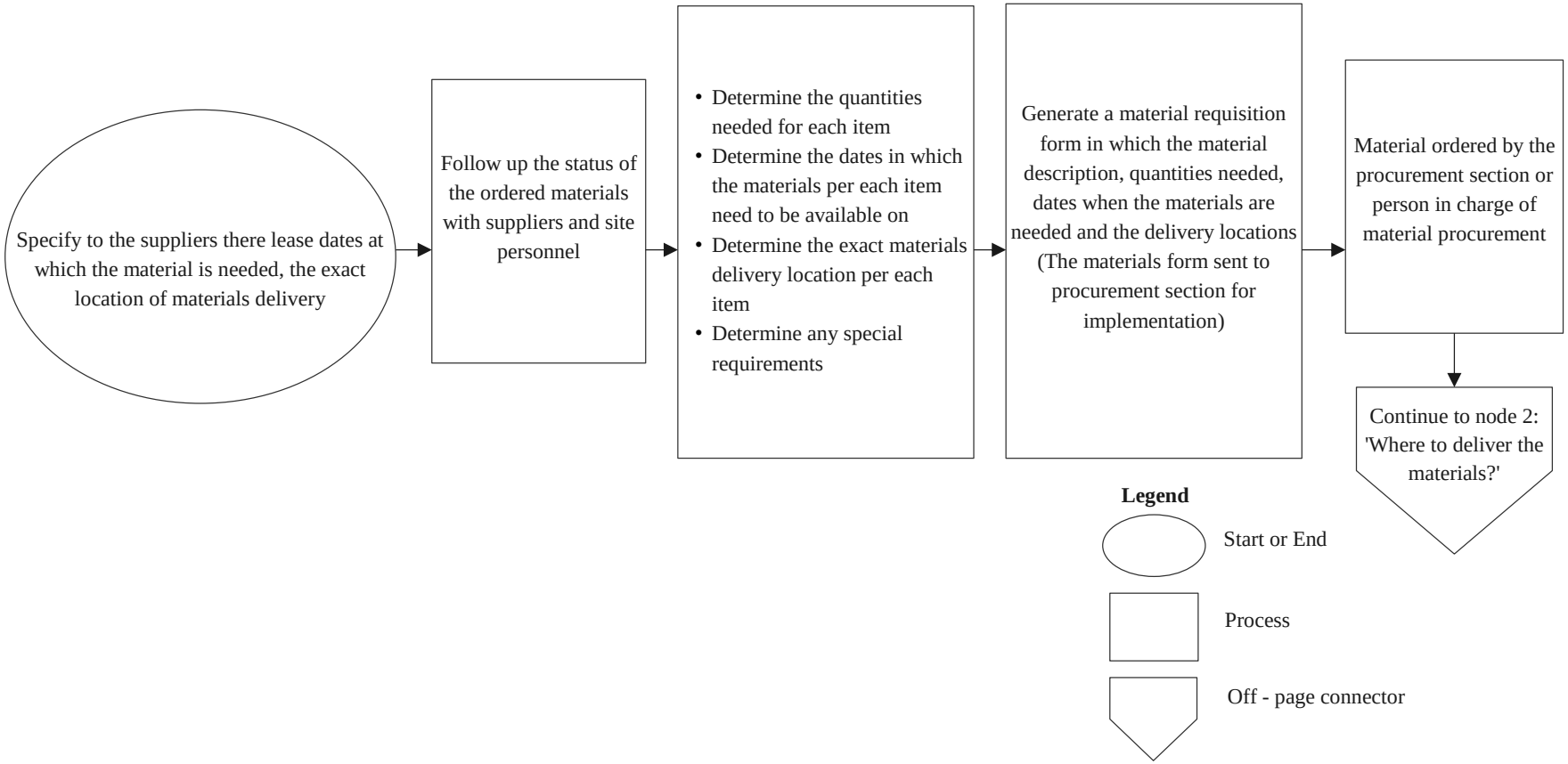

Figure 4. 10: Material Supply Chain Process Framework (Procurement and Construction Phase)

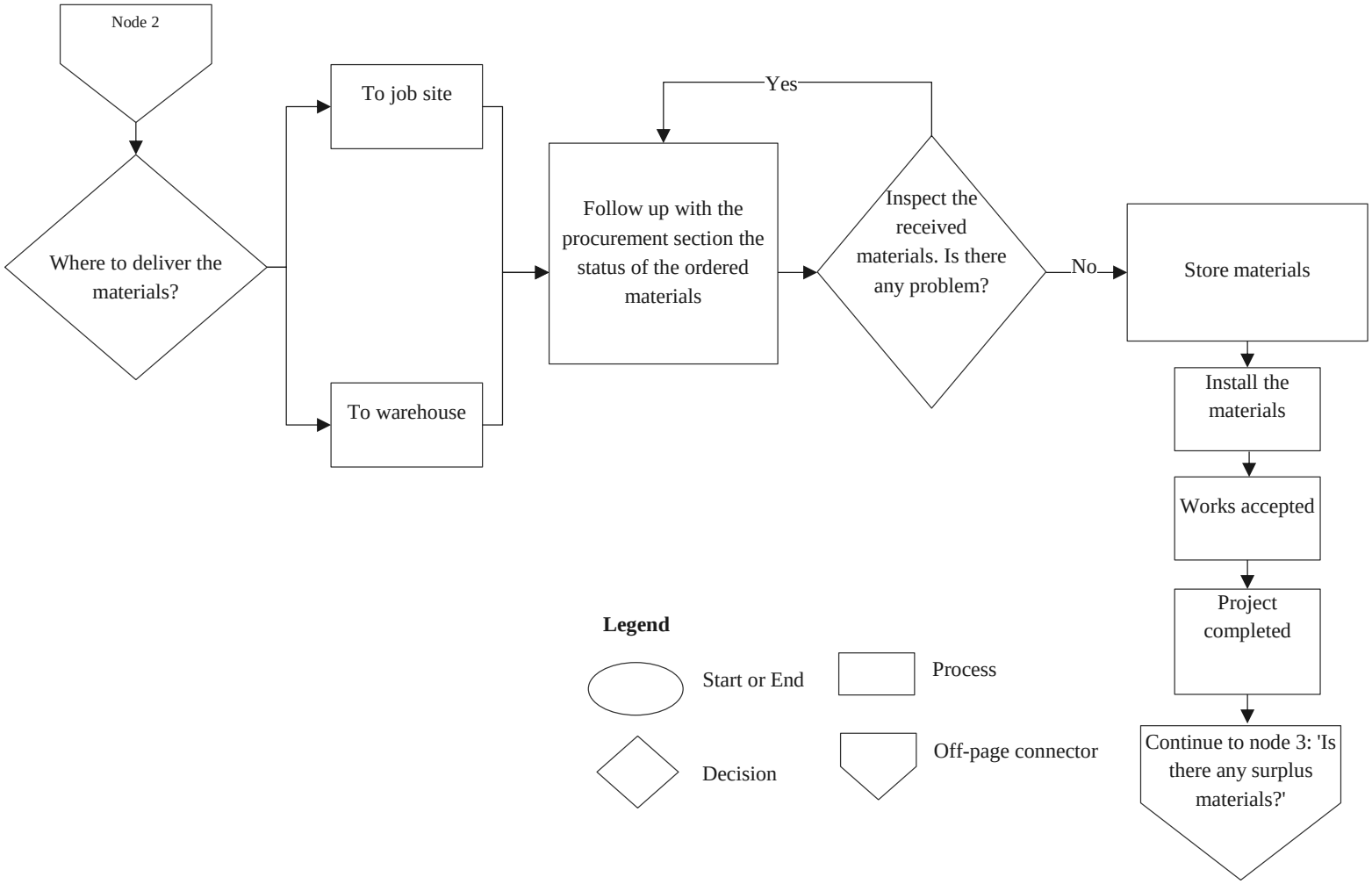

Figure 4. 11: Material Supply Chain Process Framework (Construction Phase)

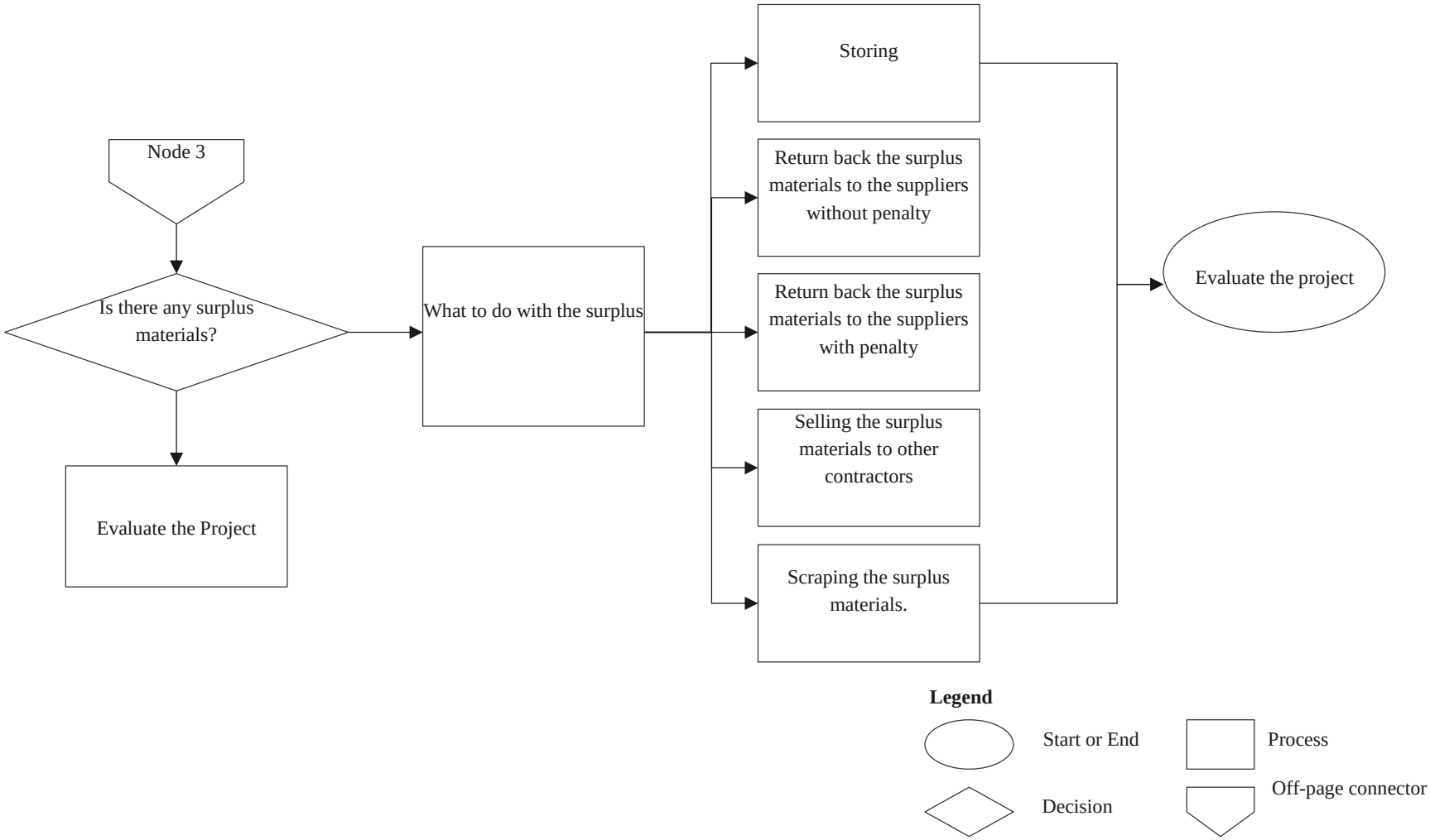

Figure 4. 12: Material Supply Chain Process Framework (Construction Phase, Post- Construction and Evaluation Phase

4.6.8. Evaluation of Material Supply Chain Process Conceptual Framework

According to table 4.29, the majority of respondents strongly agree that the activities that comprise the material supply chain process Framework will allow contractors to have the right materials in the right quantity at the right place at the right time and the lowest possible cost.

Table 4. 29: Evaluation of the Material Supply Chain Process Framework

No.	Issues	Strongly agree	Agree	Quite agree	Weakly agree	Very weakly agree
1	Encourage project completion following the required quality.	13	2			
2	Contribute to project implementation at the lowest possible cost.	12	3			
3	Contribute to completing the project within the allotted period.	13	2			
4	This will facilitate the integration of project control stages.	14	1			
5	Encourage the mindset of looking out for the other project members' best interests.	15	0			
6	Encourage collaboration among the project participants.	15	0			
7	Encourage project participants to exchange data and information.	13	2			
8	Encourage people to resolve problems before they arise; if they do,	12	3			
9	Reduce project disagreements and claims.	12	3			
10	To promote keeping and updating project documents.	13	2			

11	Promoting project activity tracking and follow-up	13	2			
12	Improving the standard of documentation quality	12	3			
13	Encourage cooperation between internal and external parties.	12	3			
14	Encouragement of communication skills development	14	1			
15	Encourage consideration of the root causes of the challenges.	14	1			
16	Encourage critical thinking in decision-making.	13	2			
17	Encourage the participants in the project to reconsider their conventional perspective on their interaction with one another.	12	3			

Additionally, the respondents were asked to score the subsequent concerns on a scale from 0 to 100%; the average responses are shown below.

- The framework activities' sufficiency rate was 96% out of 100%.
- The framework activities' clarity scored 93% out of 100%.
- The framework activities' practicality score was 93% out of 100%.
- On a scale of 1 to 100%, the researcher gave the framework a 94% total satisfaction rating.

The results also imply that the activities of the framework are sufficient, clear, and concise. The responses received prove the viability of the material supply chain process framework.

The case study project was used as an example to validate the application of the material supply chain management process framework in a real-life scenario. The validation process provides clues on how the framework helps a decision maker to apply a suitable material supply chain process at each construction stage of the project.

Case Study Project 1: 2B+G+12 Mixed-Use Building.

The first case study project is a 2B+G+12 mixed-use building located in Addis Ababa around Figa. Which is constructed by yot construction plc with 45 million birrs. According to Yonas Mulugeta, manager and owner of YOT Construction, the biggest issue during the construction phase was a continual increase in the price of construction materials.

The steps to follow for the Material supply chain proses by using the framework are as follows:

1. Is there a bid? yes
2. Are there multiple suppliers for the required materials? Yes.
3. Are the suppliers capable of delivering the right materials (type, quality, and quantity) when needed (i.e. at dates specified)? Yes.
4. What is the Procurement Method to Use? Negotiating prices and contract conditions with the supplier is selected.
5. Are the submittals approved by the Engineer? Are the submittals comply with the required specification? Yes
6. How much material to buy? As estimated quantities is selected
7. When to order the materials? 1 to 2 days before the start of the task is selected
8. 'Where to deliver the materials? To job site is selected
9. Is there any problem with the materials? No
10. Are there any surplus materials? Yes
11. What to do with the surplus materials? storing for future use is selected

Case Study Project 2: Marriott Executive Apartment

The second case study project is the five-star apartment Hotel (to be called Marriott Executive Apartment) which is constructed by sunshine construction plc and located in Addis Ababa flamingo. The apartment hotel is estimated to cost around 260 million birrs.

The steps to follow for the Material supply chain proses by using the framework are as follows:

1. Is there a bid? yes
2. Are there multiple suppliers for the required materials? Yes.

3. Are the suppliers capable of delivering the right materials (type, quality, and quantity) when needed (i.e. at dates specified)? Yes.
4. What is the Procurement Method to Use? Request quotation from the qualified supplier is selected.
5. Are the submittals approved by the Engineer? And, Are the submittals comply with the required specification? Yes
6. How much material to buy? More than estimated quantities is selected
7. When to order the materials? 1 week before the start of the task is selected
8. 'Where to deliver the materials? 'To warehouse is selected
9. Is there any problem with the materials? No
10. Are there any surplus materials? Yes
11. What to do with the surplus materials? Returning the surplus material to the supplier without penalty is selected

Case Study Project 3: B+G+10 mixed-use building

The third case study project is a B+G+10 mixed-use building which is constructed by united construction plc and located in Addis Ababa Megenagna.

The steps to follow for the Material supply chain proses by using the framework are as follows:

1. Is there a bid? yes
2. Are there multiple suppliers for the required materials? Yes.
3. Are the suppliers capable of delivering the right materials (type, quality, and quantity) when needed (i.e. at dates specified)? Yes.
4. What is the Procurement Method to Use? Negotiating prices and contract conditions with the supplier is selected.
5. Are the submittals comply with the required specification? Yes
6. How much material to buy? Less than quantities is selected
7. When to order the materials? 2 weeks before the start of the task is selected
8. 'Where to deliver the materials? 'To warehouse is selected
9. Are there any surplus materials? No

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Objective one: To investigate the current practices of material supply chain management employed by the construction industry of Addis Ababa grade one building contractors.

- The construction sector has been characterized by fragmentation as well as inadequate communication and coordination among project participants.
- Traditional project management concepts are insufficient for project success since they do not take into account all participants in building projects. Due to the problems that have appeared in the material supply process, the need has arisen for implementing new trends in management, such as applying material supply chain management.
- An efficient material supply chain process is crucial for the success of any construction project and can be the deciding factor between a successful project and a project full of delays and claims.
- The right perception of material supply chain management (MSCM) ideas is retained by 50% of contractors, which is regarded as a moderate level that has to be addressed to raise awareness of the value of such concepts.
- 43.3% of contracting organizations do not have a material supply management department, and another 23.1 % have incomplete material supply management departments, indicating that MSCM adoption is not valued by a significant number of companies. This also refers to a lack of perception of MSCM.

Objective two: To identify the most critical challenges that contractors face during the material supply chain management of projects.

- Contractors in Addis Ababa encounter many challenges which result in poor performance. such as :
- **At Bidding Phase:**
    - There is a communication gap between the parties involved.
    - There is missing information and incomplete drawings.
    - There is no clear definition of what the owner and suppliers are looking for.
- **Sourcing Phase:**

- Incomplete proposals (Suppliers did not include all the documents with the proposal.)

- **Procurement Phase**:
  - Unavailability of required material
  - Late submittals by the contractor to be approved by the Supervisor Engineer (Submittals are not submitted as planned)
  - Suppliers' submissions were incorrect.
- **Construction Phase:**
  - The delivered materials do not comply with the required specifications.
  - Delivery delays (Materials come later than expected).
  - Material damage occurs as a result of handling or other factors.
- **Post-construction phase:**
  - There is no way for the surplus materials to be returned to the supplier.
- Poor communication between the parties involved is a typical issue that happens throughout the material supply chain process.

Objective three: To develop a conceptual framework for the construction material supply chain process based on the perspectives of contractors throughout the project stage.

- Contracting firms in Addis Ababa urgently need to use a material supply chain management process framework to improve their performance. Materials account for more than 70% of the cost of a building project. Every material saved without loss increases profit at the same time.

Objective four: To identify important inventory materials during supply chain management using ABC analyzing the model in the case of yot construction plc.

- Some important materials from the warehouses of grade-one contractors have been identified by using the ABC analysis technique. This classification can be used to determine where to allocate inventory system operating costs and where care should be taken to minimize costs.
- The A-B-C analysis provides a clear image of the materials that should be purchased, as well as the total cost of the items and their relevance. The project manager may organize the timeline and reduce extra costs and waste by using the A-B-C grouping.

5.2. Recommendation

Recommendation for Contracting Companies

- ✓ Contracting company Create communication lines among suppliers, contractors, consultants, owners, and other construction project participants.
- ✓ The contracting firm strengthens and develops long-term connections with suppliers.
- ✓ Contracting company Conduct training classes to improve employees' material supply chain management abilities, knowledge, and perspectives.
- ✓ The firm creates awareness of the need of employing technology for inventory management and material control by organizing training for managers.
- ✓ To coordinate activities between functional disciplines and stages, the contracting organization encourages managers to adopt a "team management" approach.
- ✓ Contracting businesses' use of the conducted material supply management framework.

Recommendation for construction professional

- ✓ According to construction professionals, the production of construction materials consumes a significant quantity of natural resources. As a result, they must be used correctly, and construction professionals should follow up with modern inventory management and material control technologies.
- ✓ By properly analyzing and applying the ideas and strategy of supply chain management in their company, construction professionals may minimize the challenges faced by contracting organizations as a result of the delivery of materials.

Recommendations for further study

- ✓ Study warehouse management and how it affects the material supply chain.
- ✓ Other studies might look into the role of logistics management in the construction industry and how it affects MSCM.
- ✓ In CSCM, define and investigate the relevance of horizontal and vertical integrations.
- ✓ Develop MSCM research from the viewpoint of the owner.
- ✓ Investigate alternative procurement procedures to award the contract to the lowest bidder.

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APPENDICES

Appendix A: Questionnaire

Letter No: _____

Date: _____

Dear Sir/Madam,

Re: Questionnaire for an MSc thesis on the investigation of Addis Ababa's building material supply chain management system.

My name is Fikirte Amdetsion, and I am a student at **ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY** doing an MSc in Civil Engineering - Construction Technology and Management.

For the fulfillment of graduation, I have chosen a research topic entitled **"INVESTIGATION OF CONSTRUCTION MATERIAL SUPPLY CHAIN MANAGEMENT SYSTEM IN ADDIS ABABA."**

According to the Global Supply Chain Forum, Material Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, material supply chain management integrates supply and demand management within and across companies.

As a result, I would like to request that you volunteer some of your important time to aid my research study by completing the enclosed questionnaire. The questionnaire is designed to elicit information from grade one building contractors. The study findings will be used to fulfill a portion of the MSc in construction engineering and management requirements. The study's goal is to develop a theoretical framework for building material supply chain management. Your response is highly valuable and contributes to the outcome of the research. In the meanwhile, please know that any replies you provide will be kept strictly confidential and anonymous. If you are interested in obtaining a copy of the executive summary of this research, please include

a note on your return questionnaire so that I may send it to you. If you have any questions or concerns concerning the study, please send them to the addresses listed below.

Thank you! With my best regards,

Fikirte Amdetsion is a postgraduate student specializing in construction engineering management.

Adana Science and Technology University

Tel: +251921309864

Email: kibebeyene2012@gmail.com

Addis Ababa, Ethiopia

General Instructions

There is no need of writing your name

Answer the following questions by ticking (√) in the appropriate box.

Section I- General Information

1.1. Educational qualification:

1. Certificate Diploma ☐ 2. First Degree ☐ 3. Masters Above ☐

1.2. Respondent Years of Experience:

1. 1-5yrs ☐ 2. 5-10yrs ☐ 3. 10-15yrs ☐ 4. More than15yrs ☐

1.3. Respondent's Position in the company

1. Project Manager ☐ 3. Supply chain manager ☐
2. Purchasing manager ☐ 4. Other: _____

1.4. The person or section in charge of the material procurement is:

1. Company Director ☐ 4. Procurement Section ☐
2. Site Engineer ☐ 5. Owner ☐
3. Project Manager ☐ 6. Other,

Section Two – Current Practices of Material Supply Chain management

2.1. Assess the current state of material supply chain management in the construction sector of Addis Ababa's building contractors.

2.1.1. What are your thoughts on material supply chain management? It is….

1. Material procurement ☐ 5. Purchasing raw materials ☐
2. Supplier's relationships ☐ 6. A Tool to control inventories ☐
3. Project management ☐ 7. All of the above ☐
4. Customer Satisfaction ☐

2.1.2. Is there a material supply chain management department in your company?

1. Yes ☐ 2. No ☐ 3. Partially Existing ☐

2.1.3. Do you have any inventory (stoke material) in your company?

Yes ☐ 2. No ☐ 3. Partially Existing ☐

2.1.4. Have there been any incidents of late material delivery?

1. Yes ☐ 2. No ☐ 3. Don't know ☐

2.1.5. Does your organization have detailed information about your suppliers?

1. Yes ☐ 2. No ☐ 3. Don't Know ☐

2.1.6. Do you use any particular forms for material management?

Yes ☐ 2. No ☐ 3. Don't Know ☐

2.1.7. Do any of your suppliers have a partnership arrangement with you?

1. Yes ☐ 2. No ☐ 3. Don't Know ☐

2.1.8. Are there any contractual agreements in place as part of these partnerships?

1. Yes ☐ 2. No ☐ 3. Don't Know ☐

2.1.9. How do you value partnership with your suppliers?

Important ☐ 2. Unimportant ☐ 3. Normal ☐

2.1.10. Please select the method(s) you used to make your material order.

Internet ☐ 3. Telephone ☐

Personal meeting ☐ 4. E-mail ☐ 5. Other,

2.1.11. Which of the following criteria will you use to choose a supplier?

1. Availability ☐ 2. Competitive pricing cost ☐ 3. Relative delivery ☐

4. Good quality ☐ 5. Enter into partnership ☐ 6. Personal relationship ☐

7. Flexibility in accommodating contractor's request ☐ 8.mutual interest ☐

9. Other, _____

2. 2. Could you kindly specify, in priority order, which of the following actions you will take if the supplier fails to deliver the materials on time or fails to meet the necessary specifications? Please state which option is chosen first, second, third, and so on.

No	**In the event of late material delivery, the following is the most likely course of action:**	**Rank (1-5)**
1	Learn from the experience and implement the appropriate measures and processes in the future.	
2	If there is a need for dispute resolution, send a letter of complaint to the supplier to strengthen the contractor's negotiating position.	
3	Reprimand the supplier and then put the subject to rest.	

4	Simply "give and take" to prevent a difficult relationship.	
5	Penalty charges should be imposed on the supplier.	

2.3. The material supply chain procedure across the several project phases is shown below. Select your response to each statement, and then let us know how significant you believe it to be for the material supply chain process. Please choose the relevant cell.

Item No	Material Supply Chain Process	Usage Degree					Importance Degree				
		Always	Often	Sometimes	Seldom	Never	Very important	Important	Quite important	Some important	Little important
	Phase 1: Bidding Phase (Estimate, preparation & Submission)										
1.1	Once you have the project's designs and specifications, you may determine the materials required for each component.										
1.2	Estimating the quantities of items required for each component (quantity take off)										
1.3	Specifying any special requirements or materials to be used in the project.										
1.4	Classifying the primary materials that must be prefabricated and the readily available materials										
1.5	Identifying locally available or locally manufactured materials as well as items that should be imported.										

1.6	preparing the estimate using software programs or computer programs like Microsoft Excel										
1.7	A realistic estimate should be provided by including project managers and construction teams in the estimation process.										
1.8	Developing a pricing database for the materials used in the previously completed projects so that it can be utilized to prepare estimates for the projects that will be undertaken in the future.										
1.9	Determining the project estimate will depend on the costs of the manufacturers and suppliers.										
1.10	Before submitting the offer, confirm the costs mentioned in the estimate.										
1.11	When you win the bid, you should schedule a meeting with the project manager and the construction crew to reassess the project's quantities.										
1.12	Preparing a preliminary material requisition schedule that includes the material types, quantities required, delivery dates, and any other clarification-needed details										
	Phase 2: Sourcing (Vendor Selection)										

2.1	Pre-qualify the manufacturers and suppliers and maintain a list of reliable manufacturers and suppliers.										
2.2	confirming that the supplier can supply the required materials in the required quantities and at the required times, i.e., on the dates stated,										
2.3	Purchasing the materials from vendors you've already collaborated with on projects										
2.4	Requesting quotations from many suppliers to obtain fair and competitive rates.										
2.5	Selecting the supplier with the best pricing.										
2.6	Consider suppliers that cost more but offer better services or who have a track record of delivering the required materials in the required quantities at the required times.										
2.7	Directly negotiates pricing with suppliers.										
	Phase 3: Material Procurement										
3.1	Obtaining a copy of the site staff-prepared material requisition schedule that details the types of materials, the quantities required, the dates, and the deadlines for delivery (such a schedule prepared by the site staff for the construction phase)										

3.2	Before requesting any materials from suppliers, make sure the needed materials are already in your stock.										
3.3	Requesting a submittal (material sample) from the manufacturer or supplier and having the engineer approve it before the delivery of the materials										
3.4	To manage the connection between the contractor and the supplier, a purchase order is sent to the successful provider (a contract is established).										
3.5	Field personnel directly request materials.										
3.6	Ordering all of the estimated item quantities at once.										
3.7	Ordering estimated item quantities based on on-site work progress.										
3.8	Specifying to suppliers the release dates for the material and the specific location of material delivery to avoid material re-handling										
3.9	Monitoring the status of the requested materials to ensure that they are supplied on time, in the required quantities, and compliance with the requirements.										

Item No	Material Supply Chain Process	Usage Degree					Importance Degree				
		Always	Often	Sometimes	Seldom	Never	Very important	Important	Quite important	Some important	Little important
	Phase 4: Construction										
4.1	Determining the necessary material amounts for each item.										
4.2	Determining the availability dates for the materials for each item.										
4.3	Determine the precise location of material delivery for each item.										
4.4	Preparing a material request form that includes the material description, quantities required, delivery dates, and delivery locations.										
4.5	Verify the quantity obtained versus the quantity ordered.										
4.6	Inspecting supplied items to ensure they meet specifications										
4.7	Mentioning any issues with the delivered materials										
4.8	Keeping a record of the materials supplied, the remaining balance, and the materials installed										
	Phase 5: Construction Supply Chain Management Assessment										
5.1	Conducting a thorough examination of the material supply chain process										

	through the steps is necessary to avoid mistakes and enhance this process in future projects.										

2.3.1The five possibilities for handling extra materials are listed below.

Please select the scenario(s) you encountered while carrying out the project and indicate the percentage of the occurrence.

Item No	**Material Supply Chain Process**	**Selected Scenario/s**	**Percent of Occurrence**
	Phase 6: Post Construction		
6.1	Keeping surplus materials for use in future projects		
6.2	Returning surplus materials to suppliers with no penalty		
6.3	Penalty-laden returns of surplus materials to suppliers.		
6.4	Selling surplus supplies to other contractors		
	Total		**100%**

Section three: Identifies critical challenges that Contractors face as a result of Material Supply Chain Management**.**

3.1. By selecting the relevant cell, you may determine the degree of impact of the following challenges based on your experience.

No	Challenges	Degree of challenges			
		Not at all a challenge	Minor challenge	Moderate challenge	Serious challenge
	Phase 1: Bidding Phase - Material Takeoff and Identification				

1.1	There is no clear definition of what the owner and suppliers are looking for.				
1.2	There is a communication gap between the parties involved.				
1.3	There is missing information and incomplete drawings.				
1.4	Using different specifications than those that are typically employed.				
1.5	Ambiguities between plans and specifications.				
	Phase 2: Sourcing (Vendor Selection)				
2.1	Having too many suppliers and not having information about them				
2.2	Incomplete proposals (Suppliers did not include all the documents with the proposal.)				
2.3	Investigating non-qualified suppliers takes time.				
	Phase 3: Material Procurement				
3.1	Unavailability of required material				
3.2	Late submittals by the contractor to be approved by the Supervisor Engineer (Submittals are not submitted as planned)				
3.3	Suppliers' submissions were incorrect.				
3.4	The Supervisor Engineer's late approval of a submission				
3.5	Poor communication between the parties				
3.6					

3.7	The contractor fails to make clear to suppliers what is required.				
	Phase 4: Construction				
4.1	Delivery delays (Materials come later than expected.)				
4.2	The delivered materials do not comply with the required specifications.				
4.3	Re-handling of materials: Before installation, materials must be transported from one location to another.				
4.4	Storage of materials: There is a limitation of storage space, or it is located far from the working area.				
4.5	Loss of materials				
4.6	Theft				
4.7	Material damage occurs as a result of handling or other factors.				
4.8	Poor communication and coordination between the parties involved				
4.9	Receiving, handling, and storage of the unused materials				
	Phase 5: Post-Construction				
5.1	There is no storage for surplus materials.				
5.2	There is no way for the surplus materials to be returned to the supplier.				
5.3	The suppliers charge penalties for the returned materials.				
5.4	Salvage losses for the surplus materials				

Section Four: Please specify the essential inventory materials that your organization uses to construct buildings in the table below.

SI No	**Inventory materials**	**Units**	**Rate/ Unit**	**Average annual consumption (No.)**
1				
2				
3				

Appendix B: Result of Cronbach's Alpha

- Reliability test results were obtained by using SPSS software for the current practice of material supply chain management.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
.797	.773	61

- Reliability test results were obtained by using SPSS software for critical challenges that contractors face as a result of material supply chain management.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
.879	.880	27

- Reliability test results were obtained by using SPSS software for all sections of the questionnaires.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
.773	.863	62

Appendix C: Result of the Pearson Correlation coefficients

Correlation coefficients for criterion-related validity and structure validity of the questionnaire.

Table C1.1 shows the correlation coefficients between each paragraph's field of study and the overall field as it relates to the current practice of material supply chain management.

Item No	Material Supply Chain Process	Pearson correlation	P-Value	Significant level
	Phase 1: Bidding Phase (Estimate, preparation & Submission)			
1.1	Once you have the project's designs and specifications, you may determine the materials required for each component.	0.720	0.000	**
1.2	Estimating the quantities of items required for each component (quantity take off)	0.726	0.000	**
1.3	Specifying any special requirements or materials to be used in the project.	0.812	0.000	**
1.4	Classifying the primary materials that must be prefabricated and the readily available materials	0.718	0.000	**
1.5	Identifying locally available or locally manufactured materials as well as items that should be imported.	0.765	0.000	**
1.6	preparing the estimate using software programs or computer programs like Microsoft Excel	0.686	0.000	**
1.7	A realistic estimate should be provided by including project managers and construction teams in the estimation process.	0.432	0.018	*
1.8	Developing a pricing database for the materials used in the previously completed	0.519	0.005	**

	projects so that it can be utilized to prepare estimates for the projects that will be undertaken in the future.			
1.9	Determining the project estimate will depend on the costs of the manufacturers and suppliers.	0.570	0.001	**
1.10	Before submitting the offer, confirm the costs mentioned in the estimate.	0.435	0.018	*
1.11	When you win the bid, you should schedule a meeting with the project manager and the construction crew to reassess the project's quantities.	0.705	0.000	**
1.12	Preparing a preliminary material requisition schedule that includes the material types, quantities required, delivery dates, and any other clarification-needed details	0.477	0.009	**
	Phase 2: Sourcing (Vendor Selection)			
2.1	Pre-qualify the manufacturers and suppliers and maintain a list of reliable manufacturers and suppliers.	0.391	0.031	*
2.2	confirming that the supplier can supply the required materials in the required quantities and at the required times, i.e., on the dates stated,	0.653	0.000	**
2.3	Purchasing the materials from vendors you've already collaborated with on projects	0.495	0.005	**
2.4	Requesting quotations from many suppliers to obtain fair and competitive rates.	0.499	0.006	**

2.5	Selecting the supplier with the best pricing.	0.668	0.000	**
2.6	Consider suppliers that cost more but offer better services or who have a track record of delivering the required materials in the required quantities at the required times.	0.528	0.003	**
2.7	Directly negotiates pricing with suppliers.	0.602	0.000	**
	Phase 3: Material Procurement			
3.1	Obtaining a copy of the site staff-prepared material requisition schedule that details the types of materials, the quantities required, the dates, and the deadlines for delivery (such a schedule prepared by the site staff for the construction phase)	0.528	0.003	**
3.2	Before requesting any materials from suppliers, make sure the needed materials are already in your stock.	0.602	0.000	**
3.3	Requesting a submittal (material sample) from the manufacturer or supplier and having the engineer approve it before the delivery of the materials	0.558	0.001	**
3.4	To manage the connection between the contractor and the supplier, a purchase order is sent to the successful provider (a contract is established).	0.447	0.015	*
3.5	Field personnel directly request materials.	0.480	0.008	**
3.6	Ordering all of the estimated item quantities at once.	0.656	0.000	**
3.7	Ordering estimated item quantities based on on-site work progress.	0.705	0.000	**
3.8	Specifying to suppliers the release dates for the material and the specific location of	0.712	0.000	**

	material delivery to avoid material re-handling			
3.9	Monitoring the status of the requested materials to ensure that they are supplied on time, in the required quantities, and compliance with the requirements.	0.668	0.000	**
	Phase 4: Construction			
4.1	Determining the necessary material amounts for each item.	0.365	0.047	*
4.2	Determining the availability dates for the materials for each item.	0.686	0.000	**
4.3	Determine the precise location of material delivery for each item.	0.833	0.000	**
4.4	Preparing a material request form that includes the material description, quantities required, delivery dates, and delivery locations.	0.720	0.000	**
4.5	Verify the quantity obtained versus the quantity ordered.	0.620	0.000	**
4.6	Inspecting supplied items to ensure they meet specifications	0.675	0.000	**
4.7	Mentioning any issues with the delivered materials	0.683	0.000	**
4.8	Keeping a record of the materials supplied, the remaining balance, and the materials installed	0.828	0.000	**
	Phase 5: Construction Supply Chain Management Assessment			
5.1	Conducting a thorough examination of the material supply chain process through the steps is necessary to avoid mistakes and enhance this process in future projects.	0.365	0.045	**

* Correlation coefficient is significant at the $\alpha = 0.05$
** Correlation coefficient is significant at the $\alpha = 0.01$

Table C1.2: There are correlation coefficients between each paragraph in the section devoted to identifying the major challenges that contractors face in the overall field of material supply chain management.

No	Challenges	Pearson Correlation	P-Value	Significant level
	Phase 1: Bidding Phase - Material Takeoff and Identification			
1.1	There is no clear definition of what the owner and suppliers are looking for.	0.635	0.000	**
1.2	There is a communication gap between the parties involved.	0.687	0.000	**
1.3	There is missing information and incomplete drawings.	0.692	0.000	**
1.4	Using different specifications than those that are typically employed.	0.524	0.000	**
1.5	Ambiguities between plans and specifications.	0.781	0.000	**
	Phase 2: Sourcing (Vendor Selection)			
2.1	Having too many suppliers and not having information about them	0.513	0.000	**
2.2	Incomplete proposals (Suppliers did not include all the documents with the proposal.)	0.680	0.000	**
2.3	Investigating non-qualified suppliers takes time.	0.555	0.000	**

	Phase 3: Material Procurement			
3.1	Unavailability of required material	0.707	0.000	**
3.2	Late submittals by the contractor to be approved by the Supervisor Engineer (Submittals are not submitted as planned)	0.329	0.000	*
3.3	Suppliers' submissions were incorrect.	0.472	0.001	**
3.4	The Supervisor Engineer's late approval of a submission	0.345	0.015	*
3.5	Poor communication between the parties	0.496	0.019	**
3.6	The contractor establishes delivery deadlines that the suppliers cannot satisfy.	0.528	0.000	**
3.7	The contractor fails to make clear to suppliers what is required.	0.321	0.025	*
	Phase 4: Construction			
4.1	Delivery delays (Materials come later than expected.)	0.560	0.005	**
4.2	The delivered materials do not comply with the required specifications.	0.303	0.035	*
4.3	Re-handling of materials: Before installation, materials must be transported from one location to another.	0.319	0.025	*
4.4	Storage of materials: There is a limitation of storage space, or it is located far from the working area.	0.571	0.014	**

4.5	Loss of materials	0.411	0.003	**
4.6	Theft	0.689	0.000	**
4.7	Material damage occurs as a result of handling or other factors.	0.599	0.000	**
4.8	Poor communication and coordination between the parties involved	0.483	0.000	**
4.9	Receiving, handling, and storage of the unused materials	0.483	0.000	**
	Phase 5: Post-Construction			
5.1	There is no storage for surplus materials.	0.483	0.000	**
5.2	There is no way for the surplus materials to be returned to the supplier.	0.381	0.007	**
5.3	The suppliers charge penalties for the returned materials.	0.371	0.009	**
5.4	Salvage losses for the surplus materials	0.378	0.007	**

* Correlation coefficient is significant at the $\alpha = 0.05$
** Correlation coefficient is significant at the $\alpha = 0.01$

Table C1.3: Correlation Coefficients between each paragraph in a field related to the whole questionnaire.

No.	section	Correlation	P-value	Significant level
1	The current practice of the material supply chain process	0.727	0.000	**
2	Identification of the critical challenges encountered by the Contractors Through the Material Supply Chain management	0.533	0.002	**

* Correlation coefficient is significant at the $\alpha = 0.05$

** Correlation coefficient is significant at the $\alpha = 0.01$

Appendix D: List of grades one building contractors which are found in Addis Ababa

No.	Organization Name	Category	Town	Date of Registration	Remark Type
1	YESHICOLOSSEUM CONSTRUCTION PLC	BC-1	ADDIS ABABA	06/05/2014	RENEWAL
2	ETHIOPIAN CONSTRUCTION WORKS CORPORATION	BC-1	ADDIS ABABA	02/05/2014	RENEWAL
3	SINOHYDRO CORP.LIM ETHIOPIAN BRANCH	BC-1	ADDIS ABABA	18/12/2013	RENEWAL
4	ASER CONSTRUCTION PLC	BC-1	ADDIS ABABA	22/04/2014	RENEWAL
5	MAT GENERAL CONSTRUCTION PLC	BC-1	ADDIS ABABA	02/02/2014	RENEWAL
6	MAVEN CONSTRUCTION	BC-1	ADDIS ABABA	15/03/2014	RENEWAL
7	PYRAMID CONSTRUCTION & TRADE PLC	BC-1	ADDIS ABABA	03/01/2014	RENEWAL
8	FUFA LEGISSA JEKA	BC-1	ADDIS ABABA	06/05/2014	RENEWAL
9	SEYEF WONDIE ADENEW	BC-1	ADDIS ABABA	23/05/2014	RENEWAL
10	KORACON CONSTRUCTION	BC-1	ADDIS ABABA	26/02/2014	RENEWAL
11	UNITED CONSTRUCTION PLC	BC-1	ADDIS ABABA	06/01/2014	RENEWAL
12	YOT CONSTRUCTION PLC	BC-1	ADDIS ABABA	16/07/2014	RENEWAL

13	GASHAW MELESE FEREW	BC-1	ADDIS ABABA	26/12/2013	RENEWAL
14	KASSAHUN MILLION CONSTRUCTION	BC-1	ADDIS ABABA	19/02/2014	RENEWAL
15	YETWINS CONSTRUCTION PLC	BC-1	ADDIS ABABA	14/04/2014	RENEWAL
16	TNT CONSTRUCTION & TRADING	BC-1	ADDIS ABABA	14/04/2014	RENEWAL
17	SAMCON ENGINEERING	BC-1	ADDIS ABABA	13/04/2014	RENEWAL
18	GEMESHU BEYENE CONSTRUCTION PLC	BC-1	ADDIS ABABA	18/12/2013	RENEWAL
19	MOHAMMED ABAS BILAE	BC-1	ADDIS ABABA	24/06/2014	RENEWAL
20	JUSTICE BUILDING CONSTRACTOR PLC	BC-1	ADDIS ABABA	22/04/2014	RENEWAL
21	AYNALEM GASHAW ARAGE	BC-1	ADDIS ABABA	25/05/2014	RENEWAL
22	YOHANNES HAILE SIRANO	BC-1	ADDIS ABABA	09/02/2014	RENEWAL
23	BENCON CONSTRUCTION	BC-1	ADDIS ABABA	27/04/2014	RENEWAL
24	FEKADU MULATU JELEBO	BC-1	ADDIS ABABA	27/04/2014	RENEWAL
25	DEFENCE CONSTRUCTION ENTERPRISE	BC-1	ADDIS ABABA	28/07/2014	RENEWAL
26	BIYANKO BUI/CON. PLC	BC-1	ADDIS ABABA	16/11/2013	RENEWAL
27	SUN SHINE CONSTRUCTION PLC	BC-1	ADDIS ABABA	08/06/2014	RENEWAL

28	GYG GENERAL CONTRACTOR	BC-1	ADDIS ABABA	26/05/2014	RENEWAL
29	SOF OMAR TRADING & CONSTRUCTION PLC	BC-1	ADDIS ABABA	19/04/2014	RENEWAL
30	TAMIRAT TEMESGEN H/WOLDE	BC-1	ADDIS ABABA	18/05/2014	RENEWAL
31	CAPSTONE ENGINEERING	BC-1	ADDIS ABABA	06/05/2014	RENEWAL
32	DAWIT EMERU BUILDING CONTRACTOR	BC-1	ADDIS ABABA	11/12/2013	RENEWAL
33	GETACHEW ASSEFA MEKONNEN	BC-1	ADDIS ABABA	10/06/2014	RENEWAL
34	UNITY ENGINEERING PLC	BC-1	ADDIS ABABA	03/06/2014	RENEWAL
35	WORKINEH GUDAY TESHALE	BC-1	ADDIS ABABA	06/03/2014	RENEWAL
36	ETHIO CANADIAN BUSINESS GROUP PLC	BC-1	ADDIS ABABA	08/07/2014	RENEWAL
37	GEOM LUIGI VARNERO	BC-1	ADDIS ABABA	18/04/2014	RENEWAL
38	EWUKET HAILU GURMU	BC-1	ADDIS ABABA	22/02/2014	RENEWAL
39	ASMELASH AND SONS CONSTRUCTION PLC	BC-1	ADDIS ABABA	24/06/2014	RENEWAL
40	GENALE CONSTRUCTION & TRADING PLC	BC-1	ADDIS ABABA	22/04/2014	RENEWAL
41	N.K.H CONSTRUCTION PLC	BC-1	ADDIS ABABA	30/06/2014	RENEWAL

42	LIKE BUILDING CONSTRUCTION	BC-1	ADDIS ABABA	15/02/2014	RENEWAL
43	GETENET TESFAYE WUBE	BC-1	ADDIS ABABA	15/04/2014	RENEWAL
44	JINGLIAN INTERNATIONAL ENGINEERING CO LTD ETHIO. BRANCH	BC-1	ADDIS ABABA	22/11/2013	RENEWAL
45	SINOMA INTERNATIONAL ENG/CON/LI	BC-1	ADDIS ABABA	19/04/2014	RENEWAL
46	ELNAF ENGINEERING TRADING PLC	BC-1	ADDIS ABABA	16/07/2014	RENEWAL
47	SERJA CONSTRUCTION AND GENERAL TRADING PLC	BC-1	ADDIS ABABA	12/02/2014	RENEWAL
48	BANTIWALU TESSEMA YITNA	BC-1	ADDIS ABABA	28/12/2013	RENEWAL
49	TESFAYE TSEGAYE DIDAMO	BC-1	ADDIS ABABA	28/04/2014	RENEWAL
50	BEIJING URBAN CONSTRUCTION GROUP COMP.LIM.ETH.BRANCH	BC-1	ADDIS ABABA	19/01/2014	RENEWAL
51	HEBEI CONSTRUCTION GE/ET/PLC	BC-1	ADDIS ABABA	11/12/2013	NEW