



**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**  
**SCHOOL OF ENGINEERING & ARCHITECTURE**  
**DEPARTMENT OF CIVIL ENGINEERING**

**Title: Materials supply chain management practice and its effects on water supply  
construction projects in Oromia**

**A Thesis submitted in partial fulfillment of the requirements for the Degree of  
Master of Science in Civil Engineering  
(Construction Management)**

**By  
Tesfaye Mamo**

September 2017  
Adama, Ethiopia

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**Approved by Board of Examiners**

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## **DECLARATION**

I hereby declare that this thesis entitled Title: Materials supply chain management practice and its effects on water supply construction projects in Oromia " is my original work. This thesis has not been submitted in candidature for a degree/diploma of this or any other university, references to other people's works, opinions and observations have been duly acknowledged.

Candidate: Tesfaye Mamo

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

Date: \_\_\_\_\_

## **ACKNOWLEDGMENT**

I would like to express my heartfelt thanks to Wubishet Jekale (Dr.-Ing), the advisor of this thesis, for his valuable comments, suggestions, advises and for all necessary guidance in all aspect to complete this thesis.

I would like also thank offices and bureaus in Oromia region such as Oromia water, mineral and Energy bureau, Oromia construction Bureau, from which I received invaluable information and data to produce this thesis. In addition, many thanks and gratitude goes to Contractors who assisted me by filling out the questionnaires for this study.

Last, but not least the support of my families and friends is invaluable in shaping me to the best of their capacity in a disciplined manner to develop self confidence, believe in my own ability and not to give up under difficult situations.

## Contents

|                                                                                  |     |
|----------------------------------------------------------------------------------|-----|
| DECLARATION .....                                                                | iv  |
| ACKNOWLEDGMENT .....                                                             | v   |
| ABSTRACT .....                                                                   | xiv |
| CHAPTER ONE .....                                                                | 1   |
| 1 INTRODUCTION .....                                                             | 1   |
| 1.1 Background .....                                                             | 1   |
| 1.2 Statement of the Problem .....                                               | 2   |
| 1.3 Research Objectives .....                                                    | 3   |
| 1.3.1 General Objectives .....                                                   | 3   |
| 1.3.2 Specific Objectives .....                                                  | 3   |
| 1.4 Research Questions.....                                                      | 3   |
| 1.5 Scope and limitation .....                                                   | 4   |
| 1.6 Significance of the Study .....                                              | 4   |
| 1.7 Thesis Content.....                                                          | 4   |
| CHAPTER TWO .....                                                                | 6   |
| 2 LITRETURE REVIEW .....                                                         | 6   |
| 2.1 Construction Industry .....                                                  | 6   |
| 2.2 Construction Material Management .....                                       | 7   |
| 2.3 Materials Management Benefits .....                                          | 7   |
| 2.4 Fundamentals of Supply Chain.....                                            | 8   |
| 2.5 Objectives of Supply Chain Management .....                                  | 8   |
| 2.6 Manufacture Supply Chain.....                                                | 8   |
| 2.6.1 Supply Chain Management Origin .....                                       | 8   |
| 2.6.2 Concept of Supply Chain Management.....                                    | 9   |
| 2.6.3 Construction Supply Chains Characteristics.....                            | 12  |
| 2.7 Construction Supply Chain Management .....                                   | 12  |
| 2.7.1 Roles and Areas of Focus, of Supply Chain Management in Construction ..... | 13  |
| 2.8 Process of Material Supply Chain.....                                        | 14  |
| 2.9 Construction Supply Chains Problems .....                                    | 16  |
| 2.10 Traditional Construction Supply Chain.....                                  | 17  |
| 2.11 Supplier/Contractor Arrangements .....                                      | 19  |

|                     |                                                                                                 |    |
|---------------------|-------------------------------------------------------------------------------------------------|----|
| 2.12                | Integration of Construction Supply Chain.....                                                   | 21 |
| 2.12.1              | Partnering.....                                                                                 | 21 |
| 2.12.2              | Communication System and Information .....                                                      | 23 |
| 2.13                | Barriers that Obstruct integration of Construction Supply Chain.....                            | 26 |
| 2.14                | Summary .....                                                                                   | 26 |
| CHAPTER THREE ..... |                                                                                                 | 28 |
| 3                   | METHODOLOGY .....                                                                               | 28 |
| 3.1                 | Research Design .....                                                                           | 28 |
| 3.2                 | Literature review .....                                                                         | 30 |
| 3.3                 | Questionnaire Design and Content .....                                                          | 30 |
| 3.4                 | Research Population and Sampling Technique.....                                                 | 32 |
| 3.5                 | Instrumentation .....                                                                           | 33 |
| 3.6                 | Data Collection and Analysis .....                                                              | 33 |
| 3.7                 | Validity of the Questionnaire .....                                                             | 34 |
| 3.7.1               | Content Validity of the Questionnaire .....                                                     | 34 |
| 3.7.2               | Statistical Validity of the Questionnaire .....                                                 | 35 |
| CHAPTER FOUR .....  |                                                                                                 | 36 |
| 4                   | DATA DISCUSSION AND ANALYSIS .....                                                              | 36 |
| 4.1                 | Introduction .....                                                                              | 36 |
| 4.2                 | General Background and Information .....                                                        | 36 |
| 4.2.1               | General Background and Information .....                                                        | 36 |
| 4.2.2               | Companies Classifications (grade) .....                                                         | 37 |
| 4.2.3               | The Person in Charge of Materials Procurement.....                                              | 37 |
| 4.3                 | Current Practices of Material Supply Chain Process and the Important Factors that Form it ..... | 38 |
| 4.3.1               | Bidding Phase .....                                                                             | 39 |
| 4.3.2               | Sourcing phase .....                                                                            | 44 |
| 4.3.3               | Material procurement phase .....                                                                | 47 |
| 4.3.4               | Construction Phase .....                                                                        | 51 |
| 4.3.5               | Post Construction Phase .....                                                                   | 54 |
| 4.4                 | Evaluation Phase .....                                                                          | 56 |
| 4.5                 | Contractor /Supplier Relationship .....                                                         | 57 |

|                   |                                                                                  |    |
|-------------------|----------------------------------------------------------------------------------|----|
| 4.5.1             | Criteria for selection the suppliers.....                                        | 58 |
| 4.5.2             | Action Taken Against late Deliveries and Not Complying With Specifications ..... | 60 |
| 4.6               | Problems Encountering Contractors in material Supply Chain Process .....         | 62 |
| 4.6.1             | Bidding Phase .....                                                              | 62 |
| 4.6.2             | Sourcing phase .....                                                             | 64 |
| 4.6.3             | Material Procurement phase .....                                                 | 65 |
| 4.6.4             | Construction Phase .....                                                         | 67 |
| 4.6.5             | Post-Construction Phase .....                                                    | 69 |
| 4.7               | Key Factors Contributing in Integrating Construction Supply Chain.....           | 71 |
| CHAPTER FIVE..... |                                                                                  | 76 |
| 5                 | MATERIALS SUPPLY CHAIN PROCESS FRAMEWORK .....                                   | 76 |
| 5.1               | Bidding Phase .....                                                              | 76 |
| 5.1.1             | Process .....                                                                    | 76 |
| 5.1.2             | Problems Encountered.....                                                        | 77 |
| 5.1.3             | Key Integrating Factors .....                                                    | 78 |
| 5.2               | Sourcing Phase .....                                                             | 78 |
| 5.2.1             | Process .....                                                                    | 78 |
| 5.2.2             | Problems Encountered.....                                                        | 79 |
| 5.2.3             | Key Integrating Factors .....                                                    | 79 |
| 5.2.4             | Decision Node .....                                                              | 80 |
| 5.3               | Procurement Phase.....                                                           | 80 |
| 5.3.1             | Process .....                                                                    | 80 |
| 5.3.2             | Problems Encountered.....                                                        | 81 |
| 5.3.3             | Key Integrating Factors .....                                                    | 82 |
| 5.3.4             | Decision Node .....                                                              | 82 |
| 5.4               | Construction Phase .....                                                         | 83 |
| 5.4.1             | Process .....                                                                    | 83 |
| 5.4.2             | Problems Encountered.....                                                        | 84 |
| 5.4.3             | Key Integrating Factors .....                                                    | 85 |
| 5.4.4             | Decision Node .....                                                              | 85 |
| 5.5               | Post-Construction Phase .....                                                    | 85 |
| 5.5.1             | Process .....                                                                    | 85 |

|                  |                                          |     |
|------------------|------------------------------------------|-----|
| 5.5.2            | 5Problems Encountered.....               | 86  |
| 5.5.3            | Key Integrating Factors .....            | 86  |
| 5.5.4            | Decision Node .....                      | 86  |
| 5.6              | Evaluation Phase .....                   | 87  |
| CHAPTER SIX..... |                                          | 96  |
| 6                | CONCLUSION AND RECOMMENDATIONS.....      | 96  |
| 6.1              | Conclusion .....                         | 96  |
| 6.2              | Recommendations .....                    | 98  |
| 6.3              | Recommendations for Further Studies..... | 99  |
| References ..... |                                          | 100 |
| 7                | Appendix 1 the Questionnaire .....       | 105 |

## LIST OF TABLES

| TABLES                                                                                   | PAGE |
|------------------------------------------------------------------------------------------|------|
| Table 2.1: Characteristic differences be .....                                           | 10   |
| Table 3.1: Classification of Sample Size-----                                            | 32   |
| Table 4.1: contracting companies establishment year .....                                | 36   |
| Table 4.2: Companies Classifications (grade).....                                        | 37   |
| Table 4.3: Person or Section in Charge of the Material Procurement .....                 | 37   |
| Table 4.4: Bidding Process Phase .....                                                   | 39   |
| Table 4.5: Sourcing phase .....                                                          | 44   |
| Table 4.6 Material procurement process .....                                             | 48   |
| Table 4.7 Construction phase .....                                                       | 51   |
| Table 4.8 Post Construction Phase .....                                                  | 55   |
| Table 4.9 Assessment Phase Result .....                                                  | 56   |
| Table 4.10 Ranking the methods of ordering materials from the suppliers .....            | 57   |
| Table 4.11 Ranking of the Methods of Ordering Materials from the Suppliers .....         | 58   |
| Table 4.12: Ranking the criteria to select the Supplier (Source: Pheng & Chuan,2001..... | 59   |
| Table 4.15: Problem Encountering Contractors during the Bidding Phase .....              | 63   |

|                                                                                                                          |    |
|--------------------------------------------------------------------------------------------------------------------------|----|
| Table 4.16: : Problems Encountering Contractors during the Sourcing (Vendor Selection) Phase .....                       | 64 |
| Table 4.17: Problems Encountering Contractors During Material Procurement Phase .....                                    | 65 |
| Table 4.18: : Problems Encountering Contractors during Construction Phase .....                                          | 68 |
| Table 4.19: Problems Encountering Contra 1.....                                                                          | 70 |
| Table 4.20: Factors which may Contribute to Successful Integration of the Construction Supply chain process Process..... | 71 |
| Table 5.1: : Problem Encountered During the Bidding Phase and Possible Solutions .....                                   | 77 |
| Table 5.2: Problem Encountered During the Sourcing Phase and Possible Solutions .....                                    | 79 |
| Table 5.3: Sourcing Phase Decision 1.....                                                                                | 80 |
| Table 5.4: Problem Encountered During the Procurement Phase and Possible Solutions .....                                 | 81 |
| Table 5.5: Procurement Phase Decisions .....                                                                             | 83 |
| Table 5.6: Problem Encountered During the Construction Phase and Possible Solutions .....                                | 84 |
| Table 5.7: Construction Phase Decisions 1 .....                                                                          | 85 |
| Table 5.8: Post-Construction Phase Decis .....                                                                           | 87 |

## LIST OF FIGURES

| FIGURE                                                                                                                      | PAGE |
|-----------------------------------------------------------------------------------------------------------------------------|------|
| Figure 2.1 Generic Configuration of a Supply Chain in Manufacturing -----                                                   | 9    |
| Figure 2.2 General Structure of construction supply chain -----                                                             | 11   |
| Figure 2.3 problems in CSC -----                                                                                            | 17   |
| Figure 3.1 Research Methodology Flowchart -----                                                                             | 29   |
| Figure 5.1.A: Material Supply Chain Process Framework (Bidding Phase) ---                                                   | 89   |
| Figure 5.1.B: Material Supply Chain Process Framework (Procurement and Sourcing<br>Phase) -----                             | 90   |
| Figure 5.1.C: Material Supply Chain Process Framework (Sourcing Phase)                                                      | 91   |
| Figure 5.1.D: Material Supply Chain Process Framework (Sourcing Phase)                                                      | 92   |
| Figure 5.1.E: Material Supply Chain Process Framework (Procurement and<br>Construction Phase)-----                          | 93   |
| Figure 5.1.F: Material Supply Chain Process Framework (Construction Phase)                                                  | 94   |
| Figure 5.1.G: Material Supply Chain Process Framework (Construction Phase, Post-<br>Construction and Evaluation Phase)----- | 95   |

## Abbreviations

- (CSC)..... Construction Supply Chain
- (SCM)..... supply Chain Management
- (PMBOK)..... Project management body of knowledge
- (CSCM)..... Construction Supply Chain Management
- (CII)..... Construction Industry Institute
- (MSCP)..... Material Supply Chain Process
- (SPSS).....Statistical Package for the Social Sciences
- (JIT).....Just-In-Time
- (BPR).....Business Process Redesign
- (TQM).....Total Quality Management
- (CII).....Construction Industry Institute

## ABSTRACT

The aim of this research is to assess the practice of materials supply chain management process of contractors in Oromia region working on Water supply construction projects. finally to develop a framework for the best practice of material supply chain process through the project phases that suits the local construction industry in order to help contractors to have the right materials in the right quantities at the right place, at the right moment at minimal cost. This will assist contractors to improve their productivity, minimize losses and increase competitiveness. Accordingly, thirty eight questionnaires were distributed to the contractors of grade, one, two, three and four. However, thirty questionnaires were received back and analyzed.

The important result of this study is developing Material Supply Chain process Framework. The framework consists of six phases which are: bidding phase, sourcing phase, procurement phase, construction phase, post construction phase and evaluation phase. The study reveals that contractor/supplier relationship is based on project by project basis. Most of the contractors do not form long term agreement or partnership with the suppliers. Competitive pricing is the most important criteria adopted for selection of the suppliers and it is primarily based on the lowest price. Finally The problems that may hamper the smooth application of the material supply chain process through project phases were identified and possible solutions for these problems were provided.

**Keywords** construction supply Chain Management, Supply chain management, Relationships integrating the project phases and the project participants.

# **CHAPTER ONE**

## **1 INTRODUCTION**

### **1.1 Background**

The current economic environment in Ethiopia has been providing opportunities for the private sector to participate actively in investment activities. Among this investment areas construction sector is the one.

Supply Chain Management (SCM) is a concept originating from the supply system by which Toyota was seen to coordinate its supplies and manages its suppliers. The basic concept of the SCM includes tools like Just-In-Time (JIT) and logistics management. The current concept of the SCM is somewhat broader but still largely dominated by logistics (Vrijhoef and Koskela, 1999).

SCM deals with the management of materials and information resources across a network of organizations that are involved in the design and the production process. It recognizes the inter-connection between materials and information resources within and across the organization boundaries and seeks systematic improvement in the way these resources are structured and controlled (Trucker and Mohammed, 2001). The objective of supply chain management is to be able to have the right products in the right quantities at the right place at the right moment at minimal cost.

Construction Supply Chain (CSC) is all the construction process, from the demands by the client, conceptual design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc. CSC is not a chain of construction business with business to business relationships but a network of multiple organizations and relationships, which includes the flow of information, the flow of material services or products, and the flow of funds between client, designer, contractor and supplier (Xue, et al., 2007).

The focus and attention in this research are given to the materials since it forms a large portion of the total cost of a construction project. In addition, materials are essential for the daily progress of a construction project. The absence of materials when needed is one of the main causes of loss of productivity in a jobsite. Therefore, contractors have to manage their materials efficiently to lower cost in order to remain in business. They should select reputable suppliers, tracking the materials to identify when materials need to be ordered based on the actual usage of materials on site and progress of the work, dealing on site with materials handling, storage misplacement and handling of materials surplus.

## **1.2 Statement of the Problem**

Construction companies are always under pressure from all sides to reduce costs and deliver excellent performance, while improving availability, reliability, safety and sustainability of its complex supply chain management is neglected.

Current materials management practices in the construction industry are performed on fragmented basis with unstructured communication and no clearly established responsibilities between the parties involved. The highly fragmentation is a result of the separation of design and construction, lack of coordination and integration between various functional disciplines, poor communication, etc. furthermore, dependency of the general contractors on other parties such as suppliers and subcontractors reinforces the construction industry fragmentation. All of these are the important factors causing performance-related problems such as delay in material ordering and receiving, low productivity, cost and time overrun, conflict and disputes.

This research investigates current material management practices and develops Material Supply Chain Process (MSCP) that suits the local construction industry. The investigation considered all the activities starting with the estimating process and ending up with surplus materials at the end of the project. The supplier/contractor relationship was studied. The problems encountering the contractors during MSCP were documented. Furthermore, the investigation included the factors that may contribute in integrating the MSCP.

Still, there are many challenges facing contractors during various phases of the MSCP. During the bidding stage, contractor may decide to reduce the cost in order to win the contract; such decision will affect the subsequent phases of the MSCP. During the sourcing phase, the selection of a reputable supplier is critical for ensuring that materials are delivered in quantities needed at the specified time. During the procurement phase, contractors face many decisions that related to “when to order materials”, “when to buy materials” and “how much to buy”. During the construction phase, contractors have the challenge to choose the best location for delivering the material. Finally, contractors have to decide how to deal with surplus material at the end of the project at the post-construction phase.

### **1.3 Research Objectives**

#### **1.3.1 General Objectives**

The primary objective of this research is to examine the existing practices and challenges of supply chain management used by the construction companies and. to develop a framework for the best practice of material supply chain process through the project phases that suits the local construction industry in order to help contractors to have the right materials in the right quantities (at the right place) at the right moment at minimal cost so they can improve their productivity, minimize losses and increase competitiveness.

#### **1.3.2 Specific Objectives**

The aim of this research was realized through the following objectives:

1. To investigate the current practices of the MSCP in the local construction industry
2. To determine the important activities that form the phases of MSCP
3. To study the contractor/supplier relationship
4. To identify the most frequently occurring problems facing contractors in MSCP through the project phases, to diagnose the root causes of them and to develop possible solutions for them
5. To study key factors that may contribute in integrating the phases of MSCP

### **1.4 Research Questions**

- What are the current practices of materials supply chain management process by contractors in Oromia region?

- What are the problems and challenges in the process of Materials supply chain management process?
- What are the key phases in materials supply chain process?
- How the contractors are working towards integrated internal Operation.

### **1.5 Scope and limitation**

The proposed research will be limited to the following assumptions:

- The research will focus on contracting companies grade as one ,two, three, four working in oromia water supply construction at bureau level.from 2005 to 2009
- The focus of this research is on the material supply chain process from the main contractor's perspective, as the questionnaire is addressed only to the construction contractors of water supply in the Oromia. Clients and suppliers are not included.

### **1.6 Significance of the Study**

This study is of significant to contractors in oromia water supply construction several ways. First, the framework identifies and describes all phases of the MSCP starting from bidding, sourcing, procurement, construction, post-construction and ending with evaluation. Second, the framework presents solution to the uncertainties and risk inherent in the MSCP. Third, the framework documents the problems encountering the contractors through the MSCP and providing possible solutions to the most occurred ones. Finally, the framework identifies the factors that contribute in integrate the MSCP.

### **1.7 Thesis Content**

This thesis is divided into six chapters: Background, Statement of the problem, Significance of the Study and Objectives of the Study are introduced and discussed in Chapter One. Literature related to the concept of supply chain management and construction supply chain management is reviewed in Chapter Two. Chapter Three describes the research methodology. Chapter Four shows the results and discussion of the survey. Results are presented in eight main parts:

- General Background Information

- Current practices of the materials supply chain process and important activities that forming it
- Contractor/supplier relationship
- Factors considered to mitigate uncertainties and risks inherent in the material supply chain process
- Most occurred problems encountering the contractors in the materials supply chain process
- Key factors that integrate the material supply chain process.

Chapter Five presents material supply chain process framework. Finally, Chapter Six contains the conclusion and recommendations.

## **CHAPTER TWO**

### **2 LITRETURE REVIEW**

#### **2.1 Construction Industry**

The construction industry in general is highly fragmented with significant negative impacts perceived low productivity, cost and time overruns, conflicts and disputes, and resulting claims and time-consuming litigation. These have been acknowledged as the major causes of performance-related problems facing the industry. The legacy of this high level of fragmentation is that the project delivery process is considered highly inefficient in comparison with other industry sectors (Trucker et al, 2001). The construction industry has numerous problems because of its complicated nature of operation. This industry is comprised of a multitude of occupations, professions and organizations (Milakovich, 1995). They are involved in the different phases of a construction project, which, according to Schultzel and Unruh (1996), include: feasibility, development, finance, concept development and review, estimate, detailed engineering, procurement, construction and start-up. The client, consultants, contractor and sub-contractors of a construction project all have a role to play in delivering a quality project. Failure of any of the parties will seriously affect the quality of the final project. Moreover, the parties have different objectives which keep them apart.

Rowlinson and Walker (1995) point out that the construction industry is also characterized by its non-standardization. Production processes are to some extent different from each other. Hence, no universal standard or specification can be applied to the product, which leads to difficulties in quality assurance. Moreover, excessive changes to the details of the design of a project are typical throughout the construction process. They may be the result of the lack of build ability of the design produced or variations by the contractors for the sake of speed and cost of production. Rowlinson and Walker (1995) further added, quality is often at risk because of the excessive changes. As a result of the changes, delays in completion of the construction project and claims by different parties to the project often occur. Hence, the relationship between the parties tends to be confrontational.

## **2.2 Construction Material Management**

Efficient management of materials plays a key role in the successful completion of a project. The control of materials is a very important and vital subject for every company and should be handled effectively for successful completion of a project. Materials account for a big part of project cost. Some studies concluded that materials account for around 50%-60% of the project cost (Bernold and Treseler, 1991).

Different authors define the concept of materials management in different ways. However, all the researchers point out that materials management is extremely important for a successful project completion. The basic idea behind materials management is that the materials and/or equipment needed, in the quantities needed, meeting the standards of quality specified, are obtained at a reasonable cost and are available when needed on the construction site. The process of materials management should integrate purchasing, expediting, and inventory control. A well managed materials management system can contribute to the cost effectiveness of a project (Perdomo, 2004).

## **2.3 Materials Management Benefits**

An effective material management system can bring many benefits for a company. Previous studies by the Construction Industry Institute (CII) concluded that labor productivity could be improved by six percent and can produce 4-6% additional savings (Bernold and Treseler, 1991). Among these benefits are:

- Reducing the 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 project schedule
- Better relation with suppliers
- Reduce of surplus materials
- Reduce storage of materials on site
- Labor savings

- Stock reduction

## **2.4 Fundamentals of Supply Chain**

There are many definitions for the supply chain (SC) and there seems to be a universal agreement on what a supply chain is (Teigen, 1997). Lee et al. (1995) define a SC to be a network of facilities that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. Swaminathan et al. (1996) has a similar definition: a network of autonomous or semi-autonomous business entities collectively responsible for procurement, manufacturing, and distribution activities associated with one or more families of related products. Geneshan et al. (1995) has yet another analogous definition: SC is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers.

## **2.5 Objectives of Supply Chain Management**

The objective of supply chain management (SCM) is to be able to have the right products in the right quantities (at the right place) at the right moment at minimal cost. More precisely, the objective can be translated in to more precise areas of concern, which are: flexibility, delivery reliability, delivery, time/lead time and inventory level. Delivery reliability and delivery times are both aspects of customer service, which is highly dependent on flexibility and on inventory (Teigen, 1997).

## **2.6 Manufacture Supply Chain**

The concept of the SC is addressed here as it was initially developed and used in manufacturing industries.

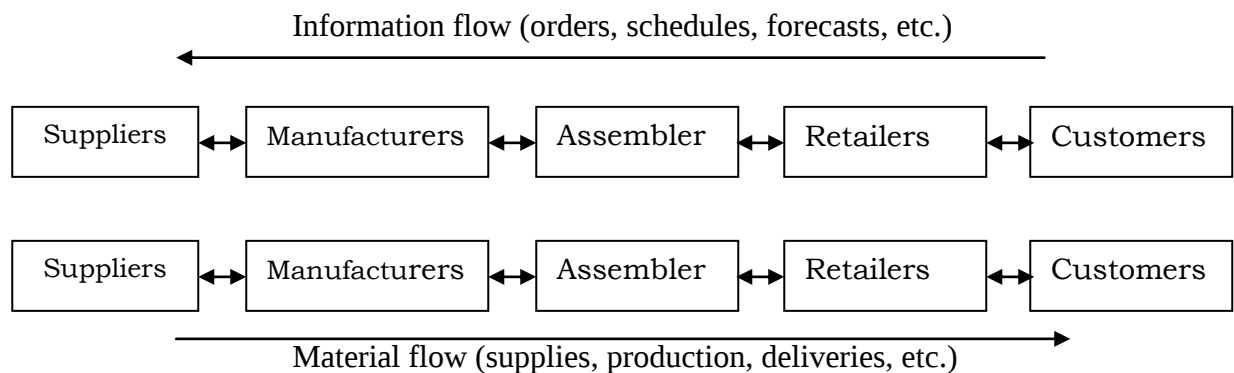
### **2.6.1 Supply Chain Management Origin**

SCM is a concept that has originated and flourished in the manufacturing industry. The first signs of SCM were perceptible in the JIT delivery system as part of the Toyota Production System (Shingo 1988). This system aimed to regulate supplies to the Toyota motor factory just in the right-small-amount, just on the right time. The main goal was to decrease inventory drastically, and to regulate the suppliers' interaction with the production line more effectively.

After its emergence in the Japanese automotive industry as part of a production system, the conceptual evolution of SCM has resulted in an autonomous status of the concept in industrial management theory, and a distinct subject of scientific research, as discussed in literature on SCM (Bechtel and Yayaram 1997, Cooper et al. 1997). Along with original SCM approaches, other management concepts (e.g, value chain, extended enterprise) have been influencing the conceptual evolution towards the present understanding of SCM. In a way, the concept of SCM represents a logical continuation of previous management developments (Van der Veen and Robben 1997). Although largely dominated by logistics, the contemporary concept of SCM encompasses more than just logistics (Cooper et al. 1997). Actually, SCM is combining particular features from concepts including Total Quality Management (TQM), Business Process Redesign (BPR) and JIT (Van der Veen and Robben 1997).

## 2.6.2 Concept of Supply Chain Management

The supply chain has been defined as ‘the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer’ (Christoph, 1992).



**Figure 2.1 Generic Configuration of a Supply Chain in Manufacturing (Christopher, 92).**

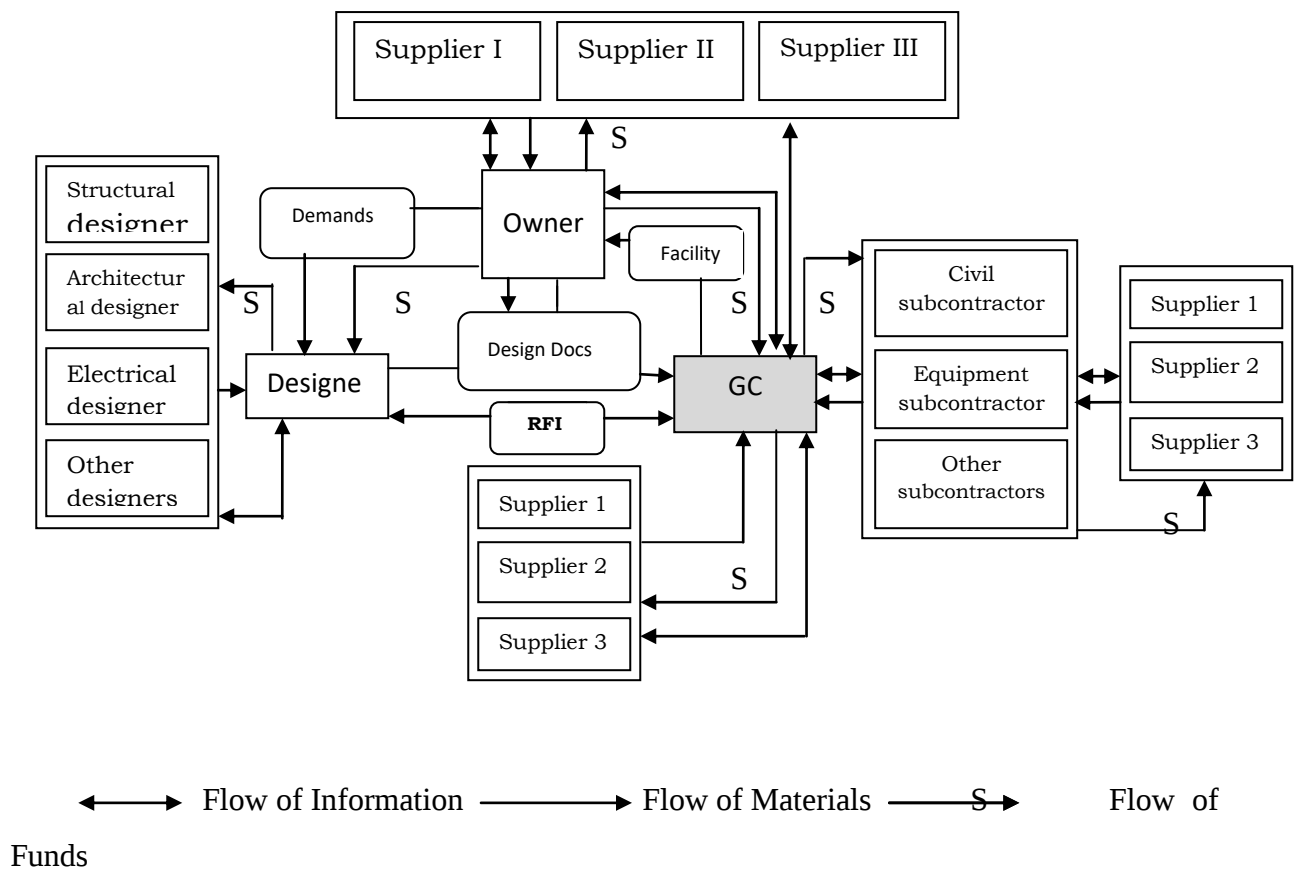
Figure 2.1 shows a generic configuration of supply chain in manufacturing, with information flows (such as orders, schedules, forecasts), circulating between customers, retailers, assemblers, manufacturers and suppliers. Material flows (as supplies, production, deliveries, and products of whatever kind) circulate from their manufacturing from raw materials or

components, through to their use within the manufactured product. SCM looks across the entire supply chain (Figure 2.1), rather than just at the next entity or level, and aims to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries (Cooper and Ellram 1993). According to Cooper and Ellram (1993), the shift from traditional ways of managing the supply chain towards SCM includes various elements (Table 2.1). the traditional way of managing (Table 2.1) is essentially based on a conversion (or transformation) view on production, whereas SCM is based on a flow view of production. The conversion view suggests that each stage of production is controlled independently, whereas the flow view focuses on the control of the total flow of production (Koskela 1992).

**Table 2.1: Characteristic differences between traditional ways of managing the supply chain and SCM, (Cooper et al., 1993) cited in (Vrijhoef et al., 1999).**

| Element                                                  | Traditional Management                                                                                      | Supply chain management                                                                                               |
|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Inventory management approach                            | Independent efforts                                                                                         | Joint reduction of channel Inventories                                                                                |
| Total cost approach                                      | Minimize firm costs                                                                                         | Channel-wide cost efficiencies                                                                                        |
| Time horizon                                             | Short term                                                                                                  | Long term                                                                                                             |
| Amount of information sharing and monitoring             | Limited to needs of current transaction                                                                     | As required for planning and monitoring processes                                                                     |
| 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                                                       |
| Joint planning                                           | Transaction-based                                                                                           | Ongoing                                                                                                               |
| Compatibility of corporate philosophies                  | Not relevant                                                                                                | Compatibility at least for key relationships                                                                          |
| Breadth of supplier base                                 | Large to increase completion and spread risks                                                               | Small to increase coordination                                                                                        |
| Channel leadership                                       | Not needed                                                                                                  | Needed for coordination focus                                                                                         |
| Amount of sharing risks and rewards                      | Each on its own                                                                                             | Risks and rewards shared over the long term                                                                           |
| 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. |

Construction is a multi-organization process, which involves owner, designer, contractor supplier, consultant, etc. it is also a multi-stage process, which includes conceptual, design, construction, maintenance, replacement. From this point of view, Construction Supply Chain (CSC) is all the construction process, from the demands by the client, conceptual, design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc. CSC is not a chain of construction business with business-to-business relationships but a network of multiple organizations and relationships, which includes the flow of information, the flow of materials services or products, and the flow of funds between client, designer, contractor and supplier, as shown in figure 2.2 (Xue, et al., 2007).



**Figure 2.2 General Structure of Construction Supply Chain (Xue, et al., 2007)**

### **2.6.3 Construction Supply Chains Characteristics**

Terms of structure and function, the CSC is characterized by the following elements (Vrijhoef et al., 2000):

- It is a converging supply chain directing all materials to the construction site where the object is assembled from incoming materials. The “construction factory” is set up around the single product, in contrast to manufacturing systems where multiple products pass through the factory, and are distributed to many customers.
- It is, apart from rare exceptions, a temporary supply chain producing one-of construction projects through repeated reconfiguration of project organizations. As a result, the construction supply chain is typified by instability, fragmentation, and especially by the separation between the design and the construction of the built object.
- It is a typical make-to-order supply chain, with every project creating a new product or prototype. There is little repletion, again with minor exceptions. The process can be very similar, however, for projects of a particular kind.

### **2.7 Construction Supply Chain Management**

Agapiou et al (1998) noted that no studies have defined what is SCM in the construction process. However, based on the understanding of SCM, Construction Supply Chain Management (CSCM) can be defined as: the integration of key construction business processes, from the demands of client, design to construction, and key members of construction supply chain, including client/owner, designer, contractor, subcontractor and supplier. CSCM focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency. CSCM emphasizes on long-term win-win, cooperative relationships between stakeholders in systemic perspective. Its ultimate goal is to improve construction performance and add client value at less cost (Xue, et al., 2007). Trucker et al. (2001) define the CSCM as the strategic management of information flow, tasks and process,

involving various networks of organizations and linkages (upstream and downstream), throughout a project life cycle. The upstream activities within construction in relation to the position of a main contractor, consists of the activities and tasks leading to the preparation of the production on site involving construction clients and design teams. The downstream consists of activities and tasks in the delivery of construction product involving construction suppliers, subcontractors, and specialist contractor interrelating with the main contractor.

### **2.7.1 Roles and Areas of Focus, of Supply Chain Management in Construction**

Vrijhoef & Koskela (2000) identified four major roles or level of implementation of SCM, dependent on whether the focus is on the supply chain, the construction site, or both. One or several SC participants could lead each level of implementation. The roles or level of implementation are not mutually exclusive, but are often used jointly.

1. The focus may be on the impacts of the supply chain on site activities. The goal is to reduce costs and duration of site activities. In this case, the primary consideration is to ensure dependable material and labor flows to the site to avoid disruption to the workflow. This may be achieved by simply focusing on the relationship between the site and direct suppliers. The contractor, whose main interest is in site activities, is in the best position to adopt this focus.
2. The focus may be on the supply chain itself, with the goal of reducing costs, especially those relating to logistics, lead-time and inventory. Material and component suppliers may also adopt this focus.
3. The focus may be on transferring activities from the site to earlier stages of the supply chain. This rationale may simply be to avoid the basically inferior conditions on site, or to achieve wider concurrency between activities, the goal is again to reduce the total costs and duration. Suppliers or contractors may initiate this focus.
4. The focus may be on the integrated management and improvement of the supply chain and the site production. Thus, site production is subsume into SCM. Clients, suppliers or contractors may initiate this focus. The focus here is on the supply chain of a main contractor.

## 2.8 Process of Material Supply Chain

Perdomo (2004) developed a conceptual framework for the Material Supply Chain Process (MSCP). The framework was based on various discussions and interviews with office and site personnel from the electrical contracting industry in Northern Virginia, Southwest Virginia, Tennessee, Maryland and Carolina. From the information acquired from the interviews, five distinct phases that comprise the MSCP were identified which are: 1-Bidding Phase, 2-Sourcing Phase, 3-Materials Procurement, 4-Construction Phase, 5-Post Construction Phase. The following subsections will briefly discuss the five phases.

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

**Sourcing Phase :** This phase includes the selection of reputable suppliers and manufacturers. The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified).

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

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

disruption and possible delays due to late deliveries, stock outs due to small quantities bought, material delivered to the wrong locations, material backordered and effects in overall costs. The requisition process for miscellaneous material starts in the construction phase and is focused on how much material to buy, when to buy this material, where to deliver this material, when to deliver, which supplier to buy from, where to store on site.

**Post-Construction Phase:** after installation of the materials on the structure, the contractor has to manage any surplus material. The surplus is handled differently depending on the type of material and also whether or not the contractor has a warehouse. If the company has a warehouse, the surplus material is stored in the warehouse for use in future projects. Other companies return surplus material to the supplier for reimbursement.

Furthermore, Abdul Rahman And Al-Dirisy (1993) developed a framework that shows the activities involved in the management of materials on construction site. The following is a description of the activities:

1. Preparation of material purchase- this involves the description, quantity and quality of the materials to be used, order and delivery dates and the location.
2. Order of materials- the preparation of a purchase order that describes the quantity, quality, dimensions and location of delivery.
3. Transportation- this covers the loading and transit, handling and off-loading of materials.
4. Delivery- site management should check the material delivery order against the purchase order. Damages during the transit have to be spotted upon the arrival of materials.
5. Site material management- a record of the performance of the material vendor, providing information on the materials needed and which manages the warehouse and distribution of the materials.
6. Comparison and evaluation- this activity involves comparing materials receipt against orders and records on materials usage.
7. Materials handling- the duty of the foreman to oversee workmanship, overall handling materials and protection of the completed structure.

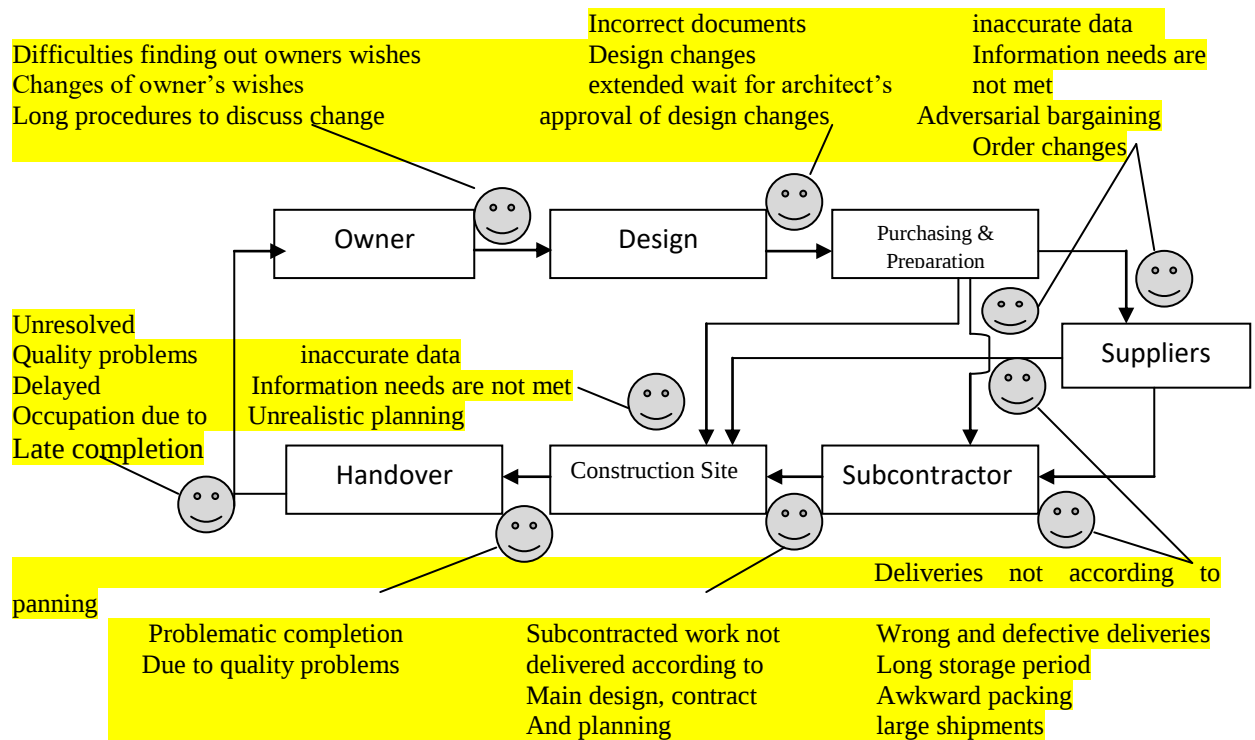
8. Work implementation and monitoring- this include supervision of the work, the use of proper instrument and check against wastage.
9. Work completed and acceptance- examination of the completed works, inspection and request for remedial work. Once a task is completed and satisfactorily accepted by the client, an evaluation should be made to assess wastage/surplus and stock.

## **2.9 Construction Supply Chains Problems**

Much research work and real test cases analyses have assessed that construction is ineffective and many problems can be observed. Analysis of these problems has shown that a major part of them are supply chain problems, originating at the interfaces of different parties or functions, as represented in Figure 2.3, among which (Vrijhoef et al., 2001):

- Client/design interface: difficulties in finding out client's wishes, changes of client's wishes, long procedures to discuss changes,
- 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,
- Purchasing and preparation/suppliers interface and purchase and preparation /subcontractors interface: inaccurate data, information needs not met, adversarial bargaining and other changes.

It can be noticed from this list that communication problems (either described in terms of “data”, or more generally in terms of information handled during the exchanges) form an important part of the problems faced in construction supply chains. The current practice of supply chain management rightly suggests controlling the supply chain as an integrated value-generating flow, rather than only as a series of individual activities.



**Figure 2.3 Problems in Construction Supply Chain (Vrijhoef et al., 2001)**

Furthermore, Dey (2001) noted that the common issues related to materials management are as follows (cited by Kasim et al, 2005):

- Receiving materials before they are required, causing more inventory cost and chances of deterioration in quality;
- Not receiving the materials at the time requirement, causing loss of productivity;
- Incorrect materials takeoff from drawings and design documents;
- Subsequent design changes;
- Damage/loss of items;
- Selection of type of contract for specific materials procurement;
- Vendor evaluation criteria;
- Piling up of inventory and controlling of the same; and
- Management of surplus materials

## 2.10 Traditional Construction Supply Chain

Traditionally, project management in construction follows an activity-centered approach that concentrates on monitoring project participants; activities against a construction schedule

(Howell 1999). Since the underlying motivation of this approach is to improve efficiency in value-adding activities where physical conversions occur (Koskela 1992), passive communications from downstream (customer side) to upstream (supplier side) have been prevailing in the industry. However, due to the long information lead-time and the lack of coordination, the initiated communication often fails to have the required information in a timely manner. To make matters even worse, the communication itself may not be initiated because of the large number of project participants in a construction project: it is an overwhelming task for project managers to cover numerous project members and their suppliers. These types of disturbances in information flows generate turbulences in material flows, which are one of the highly ranked causes of delay in a construction project. Furthermore, project information exchange between designers and contractors has mainly based on paper documents (Luiten et al, 1998). These documents come in the form of architectural and engineering drawings, specification and bills of quantities and materials. This practice is far from being satisfactory, which research showing that about two-thirds of the construction problems are caused by inadequate communication and exchange of information and data (Cornick, 1990).

The most significant characteristic of this process is the project organization which has been described as a “temporary multiple organization” (Cherns and Bryant, 1983). Such an organization is usually project-focused, with a short-term perspective, emphasizing competitive bidding as the main tool in contractors, subcontractors and supplier evaluation. Consequently, customer-supplier relationships in construction are generally of the arms length type rather than being partnerships. Cox and Thompson (1997) concluded that competitive tendering assures that sub-contracting is procured to the lowest-price supplier with little or no guarantee (or even incentive) to future work.

In Brazil, the construction of the projects is often managed in the traditional way. The construction phase often begins with only a part of the designs complete, and the rest of them are completed during the construction. In additions to this, designs are mostly limited to what build, there is a little information about how to build. Unfortunately, this erroneous way of thinking has resulted in many problems in the construction phase: rework, constructability

problems, delay caused by incomplete design or lack of congruency are daily problems on site (Villagarcia & Cardoso, 1999).

To overcome industry fragmentation, a number of integration approaches and strategies, and their successful applications in manufacturing and other industries have been recommended (Mohammed, 1997). These include design-and-construct, design-for-construction, concurrent engineering, lean construction, business process reengineering, and a variety of others. Unfortunately, these approaches have proved inadequate to cope with the increasing complexity of construction projects, without the support of information technology (Mokhtar and Bedard, 1995). Also, most of these approaches have tried to focus on elements linked to time, quality and/or cost, but research (Kagioglou et al, 1998) noted that 85% of commonly associated problems are process related, and not product related. Except for the most trivial projects, the delivery process for a constructed facility consists of several phases and a multitude of professionals from various disciplines working together to advance the project (Fischer et al, 1998).

## **2.11 Supplier/Contractor Arrangements**

Unavailability of materials when needed can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying the completion of the project. There is no doubt availability of materials when needed is critical for the successful completion of the project. The contractor should search for arrangements that will ensure availability of materials when they are needed.

The construction industry has been characterized by adversarial relationships between the parties involved. Traditionally, the most common way in which the contractor gets most of his projects is by hard bid. Because of the competitive nature of hard bidding, the contractor needs to obtain materials and subcontractor's services at the lowest cost possible. Usually, the contractors request bids from suppliers and subcontractors in order to get the lowest prices possible for their services and products. Suppliers or subcontractors will try to win the contract by offering a relative low price to the contractor. Sometimes the price offered might

not be low enough to win the contract and the contractor could request a lower price. If the supplier or subcontractor does not lower the price, the contract might be awarded to another party. This bidding process might create adversarial relationships because the suppliers or subcontractors could get the job at a lower amount than what they originally were expecting; therefore they are making less profit. Because of this loss in profit, the supplier or subcontractor might not be totally devoted to this particular contract and some problems might arise (Perdomo, 2004).

The relationship of a contractor with his suppliers is critical for the successful completion of any construction project. Availability of materials is essential for the timely completion of activities and for the productivity of activities and for the productivity of the labor force. If materials are not available when they are needed, a variety of problems might arise. Lenders et. Al. (2002) offer a classification of supplier based on the quality of the service that the supplier offers to the customer. The classifications that they present are unacceptable suppliers, acceptable suppliers, good suppliers, preferred suppliers, and exceptional suppliers. A description of each category follows.

- Unacceptable suppliers- these suppliers are not able to meet the operational needs of the customer and are not able to provide materials when they are needed. In addition, they don't offer means to satisfy the strategic needs of their customers.
- Acceptable suppliers- these suppliers meet the current operational needs of the customer, however, the services that they provide can easily be matched by any other supplier.
- Good suppliers- these suppliers are a step above acceptable suppliers in the fact that they can provide the materials needed, but in addition they can also provide some value added services.
- Preferred suppliers- these suppliers offer a system that integrates the buying/selling functions in an electronic format. This integration eliminates duplication and allows to process transactions faster. These suppliers meet both the operational needs of the company as well as their strategic needs.

- Exceptional suppliers- these suppliers are able to recognize and anticipate the needs of their customers and are able to satisfy those needs. Because of the value they provide to their customers, they are valued. They allow customers to experiment with different scenarios and approaches, because of their efficiency, which results in minimization of risk for their customers.

## **2.12 Integration of Construction Supply Chain**

In view of the above, there has a growing recognition that it is important to integrate the various disciplines/participants in a construction project; this includes aspects of integrating all the members of the supply chain.

### **2.12.1 Partnering**

To minimize the risk of not having materials when they are needed, companies are recurring 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- a cooperative, collaborative management effort among contracting and related parties to complete project in the most efficient, cost-effective method possible, by setting common goals, keeping lines of communication open and solving problems tighter as they arise. Perdomo (2004) defined partnering agreement as business relationship that looks forward to the benefits of the partners involved. A partnering agreement does not represent a legal partnership with the associated partners, instead it refers to an informal working agreement to maintain cooperative relationships. In such types of agreement, the decision process should be done in a win-win basis for all the parties involved. No benefits should be acquired by hiding information from other parties. A successful partnering relationship consists of trust, fairness and commitment from all the parties involved. Communication is a very important aspect in Partnering. Open and honest communication among team members is critical.

Lenders et. Al. (2002) describes two different types of partners, basic and extended partners. They point out that all suppliers should be treated as basic partners with respect among

parties, honesty, trust, open communication, and understanding of the aspects that drive their relationship. An extended partnership is only established with key suppliers. This type of agreement goes beyond basic partnering and is oriented on the goals of the supplier and customer. It is not uncommon to have a team, comprised from supplier/customer employees, to create plans for mutual success and profitability. Extended partnering has a long term view and improvement of both parties should be the main objective. Anderson(1994) defines some key elements of a Partnering agreement. A brief description of these elements follows.

- Commitment- All members of the team should commit to good faith and fair dealings with the other partners
- Equity- When developing mutual goals and plans for the companies, the interest of the stakeholders must be considered. If there are aspects that stakeholders don't appreciate or think that are valuable, they won't commit to the partnership agreement.
- Communication- Open and honest communication is critical. Trust is critical for resolution of issues. Information sharing among partners without fear is essential. Issue Resolution System- There must be a fair process for dispute resolution without finger pointing. These issues should be solved quickly and in a fair way.
- Evaluation- Meetings are needed to evaluate the work being performed by the team. An assessment of work performed vs. work accomplished is essential to identify if the partnership agreement is working as expected.

One of the biggest benefits of a Partnering agreement is the elimination of adversarial relationships between contractors and suppliers. The cooperative environment between the parties minimizes the risk of unavailability of materials on the construction site when they are needed. In addition, the contractor will ensure that bills are paid as stated in the partnership agreement, which provides a better cash flow for the supplier. Another main benefit is the information sharing between parties, which can lead to the enhancement of one company's competitive position by using the information and resources provided by the partner company (Perdomo, 2004).

### **2.12.2 Communication System and Information**

There is a growing awareness of the value of information and communications technology to bring together the major parties in the construction process and share project as well as industry information in a meaningful way (Tucker et al, 2001). Thus, the coordination of information flows is a key component in achieving tight integration in order to optimize the chain-wide performance. As a way of coordinating information flows, the idea of real-time information sharing has been studied extensively in the manufacturing industry. It specifically emphasizes instantaneous multilateral information sharing within a supply chain in order to reduce uncertainties associated with operations and demand forecast (Cooper et al. 1997).

The concept of the a Web-Based information system is to utilize the internet and the technologies associated with the World Wide Web (as a publishing media) for global distribution of information using widely available technologies. With the Web-based information system, time requirement for transferring and checking information are expected to be decreased. The application of a Web-based system to construction project enhances the general process of collecting, gathering and reporting different types of data information. The availability of the current and valid information decrease the response time required to handle any unforeseen situation that may arise (Trucker al, 2001).

As a part of the PhD graduation project, Pinho et al. (2007) designed a Web-based system, like a web portal, to allow users to access the information from the outside the company. The portal is designed in order to introduce information, such as requests of materials and equipment, fuel consumption, etc. related to the construction sites and to generate reports based on that information. Its primary function is to eliminate the papers that were being used to inform center of the company. With this on-line information, managers are able to request something and get much of the information they need, in real time. All the information used is stored in the main data base of the company, which provides all the users with the same information, without any errors or misinterpretation, since the information introduced and visualized in the portal is the same information used by the main program used in the company intranet. The main characteristics of the portal are being developed in order to correspond to the needs of the intervenient of the company's supply chain so that the

information could be available at anytime and anywhere. The principle features offered by the portal are:

- Ability to launch request of materials: the portal connects to the main database and order processing system of the company, which immediately returns all relevant information about stocks and expedition details related to requests;
- Ability to launch requests for equipments: the user selects the equipment based on the characteristics needed:
- Ability to launch requests of transportation equipment: the user selects the vehicle, based on the characteristics needed:
- Ability to display the status of fuel consumption: the user can then manage the stock of the fuel stored on the tanks in the construction sites;
- Allows to perform project management, with the association of the resources (materials, equipment, work force) to the activities executed on-site;
- Ability to display the status of requests;
- Ability to validate documents and generate official documents for transportation;
- Ability to evaluate suppliers
- Possibility to consult the stock available on-site;
- Possibility to consult information about external suppliers, e.g., information about their products (lead times, technical reports, technical drawings, etc.).

Coordination is managing the dependencies between activities. If it defined as mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals. It also refers to the integration of different parts of an organization or different organizations in the supply chain to accomplish a collective set of tasks and to achieve mutual benefits. It involves more formal relationships, objectives and actions which are mutual, compatible and common, not necessary a centralized authority (Xue, et al., 2005).

Many researchers emphasized the importance of communication and information exchange between project participants in the material flow control process (Agapiou et al. 1998; Vrijhoef and Koskela 1999). In this context, numerous researchers have focused on sharing information in construction supply chain management. Nicolini et al. (2001) pointed out the

inefficiency of centralized coordination system in managing interdependencies within a construction supply chain. In order to facilitate information sharing, they suggested a cluster, which is a temporary organization consisting of designers and suppliers, to support intensive collaboration between different disciplines. Clustering design helps minimize interfaces, which in turn, facilitates communication transparency (Nicolini et al. 2001). In terms of this type of collaborative design, Bogus et al. (2000) claimed that design team should be expanded such that it includes contractors, subcontractors, and material suppliers. They described that traditional constructability concepts have contributed to improve the flow of construction process but they should not be limited only to designers and contractors. However, they expected that communication will be the most difficult part but recent advances in information technology could make it easier for them to communicate (Bogus et al. 2000).

In a thoroughly study on the design department (Vrijhoef et al., 2001), the central problems found were defined as follows “the involved persons perceive uncertainty on what has to be done, who has to do it and when has to be ready”. The actors of the design project organization have no common and clear understanding on what should be designed. In other words, this indicates that the conversation for action were either in effective or missing altogether in the coordination of the design.

In addition to the information sharing in the design phase, Chua et al. (1999) extensively discussed the planning and the scheduling perspective of information sharing. In the distributed Integrated Production Scheduler (IPS) model, all the members of a project are responsible for executing schedules and providing relevant information so that all the process is clearly visible to the others (Chua et al. 1999). Choo and Tommelein (2000) emphasized the importance of well-structured communication and coordination in a dynamic and complex project. They developed a database program called Work Move Plan in order to automatically create look-ahead plans and weekly work plans (Choo and Tommelein 2000). Both of the approaches allow project participants to share the latest schedule information and to propagate conflicts if there is any. Vrijhoef et al., (2001) found various logistics problems, in various stages of the construction supply chain. Many of the problems referred directly and indirectly to insufficient coordination, communication and thus commitment, such as failures to inform about schedule change, late confirmation of deliverers and lack of feedback procedures.

### **2.13 Barriers that Obstruct integration of Construction Supply Chain**

There are several barriers that obstruct coordination and integration of the CSC process (Xue, et al., 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 of good performance and lack of understanding of the subcontractors and suppliers problems
- Quality of information-related issues: such as poor information quality from general contractor 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 adversarial relationships among clients, general contractors, subcontractors and suppliers that result in serious problems with regards to payments.
- Programming/time related issues: such as false expectation on part of the general contractor, unrealistic and uncertain lead time of materials.

### **2.14 Summary**

Current materials management practices in the construction industry are performed on fragmented basis with unstructured communication and no clearly responsibilities between the parties involved. The fragmentation leads to low productivity, cost and time overruns, conflicts and disputes. Efficient material management plays an important role in the successful completion of project since the cost of material forms large portion of the project total cost. The material supply chain process comprises five phases which are: bidding phase, sourcing phase, procurement phase, construction phase and post-construction phase. Each phase consists of a set of activities. Traditionally, the management of these activities follows an activity-centered approach that concentrates on monitoring project participants’ activities against construction schedule. Also, the exchange of information within the five phases often fails to be transferred on timely manner among the project participants. Such disturbance in

information flow leads to turbulences in material flow which cause delay to the project completion. Furthermore, the contractor/supplier relationship is usually project-focused with a short-term perspective, emphasizing competitive bidding as the main tool in contractors, subcontractors and supplier evaluation. Consequently, customer-supplier relationships in construction are generally of the arms length type rather than being partnerships. The construction supply chain management seeks to integrate the project phases starting with the client demands and ending up with the construction and the key members of the construction supply chain, including client, designer, contractor, subcontractor and supplier. Such integration aims at enabling contractors to have the right products in the right quantities (at the right place) at the right moment at minimal cost. Partnering is one of the fundamental concepts of the construction supply chain process. Project partnering is an approach used to enable the different parties involved in a project to work cooperatively in order to complete project in the most efficient, cost-effective method possible, by setting common goals, keeping lines of communication open and solving problems tighter as they arise. Also, the coordination of information is a key component in achieving tight integration. Web-based information system is utilized for distribution, collecting and reporting different types of data among the project participants.

Reviewing the literature that related to the construction supply chain management the following have been achieved: identifying the activities that form the material supply chain process, exploring the contractor supplier relationship, identifying two concepts that help in mitigating the risks inherent in the construction setting, identifying the problems encountering the contractors during the project phase of the material supply chain process and finally determining the key factors that contribute in integrating the project phases as well as the key members of the project participants.

## **CHAPTER THREE**

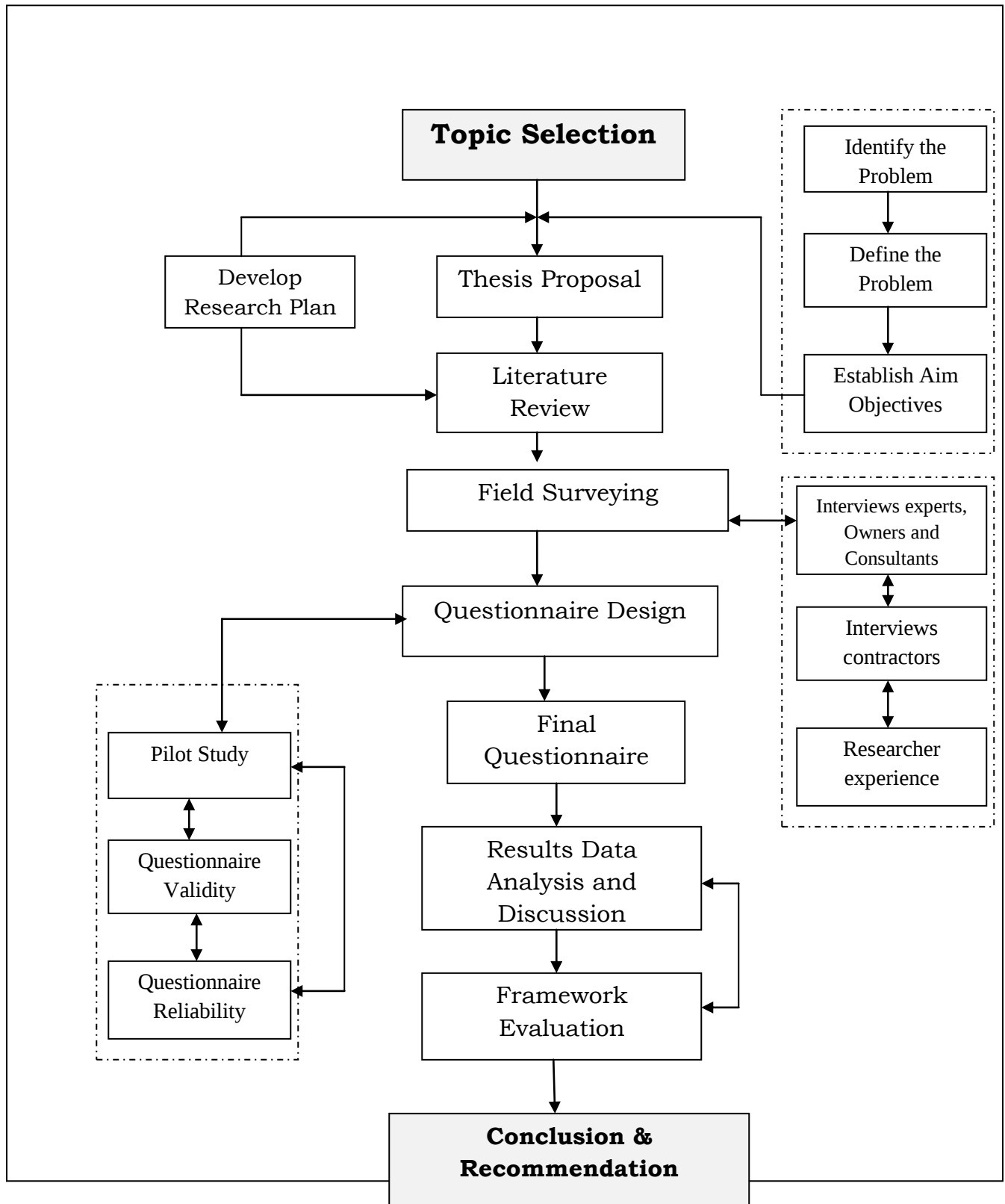
### **3 METHODOLOGY**

This chapter describes the methodology that was used in this research. The adopted methodology to accomplish this study uses the following techniques: review of literature related to construction supply chain management, information about the research design, questionnaire design, pilot study, research population, research sample size, content validity, instrument reliability and statistical data analysis, formulation of narrative and graphical representation of the material supply chain process, evaluation of the material supply chain process, conclusion and recommendations.

#### **3.1 Research Design**

The first phase of the research thesis proposal included identifying and defining the problems, establishing the objectives of the study and developing the research plan. The second phase included a summary of the comprehensive literature review. The third phase included a field survey which was conducted from the viewpoint of contracting companies. The fourth phase focused on the modification of the questionnaire design (pilot study), through distributing the questionnaire to experts. The purpose of the pilot study was to test and prove that the questionnaire questions are clear to be answered in a way that help to achieve the aim of the study. In addition, it was important to ensure that all information received from contracting companies would be useful in achieving the research objectives. The questionnaire was modified based on the results of the pilot study. The fifth phase was distributing the questionnaire. Thirty eight questionnaires were distributed to the research population but only thirty three (86.8%) were received back. The sixth phase was data analysis and discussion. Statistical Package for the Social Sciences (SPSS) was used to perform the required analysis. The seventh phase was developing the material supply chain process framework based on literature review, questionnaire analysis and the researcher experience. The eighth phase included evaluation of the framework by ten experts. The final phase included the conclusion

and recommendations .Figure 3.1 shows the methodology flowchart, which leads to achieve the research objectives.



### **3.2 Literature review**

A comprehensive literature search was conducted to identify the activities that form the material supply chain process, the criteria that contractors consider to select and suppliers, the factors that could help in mitigating the risks and uncertainties inherent in the material supply chain process, the problems encountering the contractors through the material supply chain process and the factors that may contribute in integrating the phases of the material supply chain process.

### **3.3 Questionnaire Design and Content**

Based on the review of the literature related to the construction supply chain management, interview experts who have experience with the subject at different levels and the researcher experience, all the information that could help in achieving the study objectives were collected, reviewed and formalized to be suitable for the study survey and after many stages of brain storming, consulting, amending, and reviewing executed by the researcher with the supervisor, a questionnaire was developed with closed questions.

The questionnaire design composed of five sections to accomplish the aim of the research, as follows:

1. The first section contained information about Companies Profiles.
2. The second section contained Current Practices of construction Material Supply Chain Process and the important activities that form it.
3. The third section was about the Contractor/Supplier Relationship.
4. The forth section was about the Identification of the Most Occurred Problems Encountering the Contractors through the Material Supply Chain Process.
5. The fifth section was about the Key Factors Contributing in Integrating the Material Supply Chain Process.

The first section contains eight questions aiming at providing general information about the contracting companies like, company establishment year, company class, respondent position, the person or section in charge of material procurement.

The second section contains the phases that form the material supply chain process and each phase contains set of activities. The aim of this section is to study the current practices of the material supply chain process and identifying the main activities that form it through using two rating scales. The first rating scale is the usage degree and the second one is the importance degree.

The third section contains two subsections aiming at studying the contractor/supplier relationship. The first subsection contains nine criteria aiming at studying the concerns of the contractors in selecting the suppliers. The second subsection contains five courses of actions aims at studying the likely course of action that contractors will adopt in case suppliers do not deliver materials on time and/or deliver materials do not comply with the project specifications.

The forth section contains the problems that may encounter the contractors during the application of the material supply chain process. This section aims at determining the most occurred problems facing the contractors through each phase of the material supply chain process in order to address solutions to these problems.

The fifth phase contains twelve questions that aiming at determining the key factors that may contribute in integrating the project phases of the material supply chain process as well as the key project participants in order to achieve smooth application of the material supply chain process.

The questionnaire

Attached also in Appendix:1.unnecessary personal data, complex and duplicated questions were avoided. The questionnaire was provided with a covering letter which explained the

purpose of the study, the way of responding, the aim of the research and the confidentiality of the information in order to encourage high response.

### 3.4 Research Population and Sampling Technique

Sampling is the selection of study units from a defined population of interest, so that by studying the sample we can fairly generalize our results back to the population from which they were chosen (William, 2006). In this research, the population size of contractors in water supply projects commenced and undertaken in 2005 up to 2009 EC at regional level. The lists of the projects have been taken from Oromia water mineral and Energy bureau. Therefore, here the sample size is equal to the population. Consequently, respective contractors undertaken the selected projects were identified as respondents. Therefore; the total number of contractors participated in the research become thirty eight (38) which is equal to the number of selected projects for which questionnaire paper were distributed. The percent of valid respondents to No. of distributed questionnaires is shown in Table 3.1.

**Table 3.1: Classification of Sample Size 1**

| <b>Number of<br/>(Population)</b> | <b>Number of<br/>Sample</b> | <b>Number of<br/>distributed<br/>questionnaire</b> | <b>Number of<br/>respondents</b> | <b>Percent of<br/>respondents to<br/>distributed<br/>questionnaires</b> | <b>Number of<br/>valid<br/>respondents</b> | <b>% of valid<br/>respondents to<br/>distributed<br/>questionnaires</b> |
|-----------------------------------|-----------------------------|----------------------------------------------------|----------------------------------|-------------------------------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------|
| 38                                | 38                          | 38                                                 | 33                               | 86.8                                                                    | 30                                         | 78.9                                                                    |

### **3.5 Instrumentation**

The research instrument employed under this study was self administered questionnaire. It was designed according to the objectives and the research questions by reviewing literature dealing related with the subject matter. The approach enabled participants to provide the essential data at their convenience. The types of Research instrument were questionnaires. Data collection was based on questionnaires. The questionnaires were used to collect relevant data on existing practices and challenges of supply chain management system variables..

### **3.6 Data Collection and Analysis**

The data collection approach adopted for conducting this research includes both primary and secondary sources. Questionnaire is the major primary data for this thesis while the secondary data sources include previous academic research papers, journals, internet sources, as well as reviewing related archival documents.

In this research both descriptive and inferential statistical method has been used for analysis of data collected from various sources. For summarizing of the collected data and to determine the number of responses belonging to each category, frequency tables by SPSS have been used together with Excel or spread sheet frequency analysis. In addition to this For assessing the questionnaire factors, the respondents were required to rate these factors on a 5-point Likert scale as follows:

The usage degree of the items of the MSCP 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 MSCP through the project's phases by scores 1 to 5, where "1" represents the Little Importance and "5" represents the Very Important.

The most occurred problems through the projects phases of the MSCP by scores 1 to 5, where "1" represents the Never and "5" represents the Always.

The key factors that contribute in integrating the project's phases of the MSCP through by scores 1 to 5, where "1" represents the Little Importance and "5" represents the Very Important.

To determine the relative ranking of the factors, these scores were then transformed to importance indices based on the following formula:

$$\text{Relative Importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where w is the weighting given to each factor by the respondent, ranging from 1 to 5. For example, n1 = number of respondents for Little Important, n2 = number of respondents for Some Important, n3 = number of respondents for Quite Important, n4 = number of respondents for Important, n5 = number of respondents for Very Important). A is the highest weight (i.e. 5 in the study) and N is the total number of respondents. The relative importance index ranges from 0 to 1 (Tam and Le, 2006).

### 3.7 Validity of the Questionnaire

Validity refers to the degree to which an instrument measures what it is supposed to be measuring. Validity has a number of different aspects and assessment approaches. There are two ways to evaluate instrument validity: content validity and statistical validity, which include criterion-related validity and construct validity.

#### 3.7.1 Content Validity of the Questionnaire

Content validity test was conducted by consulting two groups of experts. The first was requested to evaluate and identify whether the questions agreed with the scope of the items and the extent to which these items reflect the concept of the research problem. The other was requested to evaluate that the instrument used is valid statistically and that the questionnaire was designed well enough to provide relations and tests between variables. The two groups of

experts did agree that the questionnaire was valid and suitable enough to measure the concept of interest with some amendments

### **3.7.2 Statistical Validity of the Questionnaire**

To insure the validity of the questionnaire, two statistical tests applied. The first test is Criterion-related validity test (Pearson test) which measures the correlation coefficient between each paragraph in one field and the whole field. The second test is structure validity test (Pearson test) that is used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. It measures the correlation coefficient between one field and all the fields of the questionnaire that have the same level of similar scale.

## CHAPTER FOUR

### 4 DATA DISCUSSION AND ANALYSIS

#### 4.1 Introduction

In this chapter, the results of the questionnaires are presented and discussed. The chapter illustrates and discusses the characteristics of the study population, current construction materials supply chain management, the important factors that form the MSCP that are appropriate for the Oromia water supply construction, contractor-supplier relationship, some concepts that mitigate the uncertainties and risks in the construction industry, the most occurred problems facing contractors through the MSCP and the factors that may contribute to integrate the phases of the MSCP.

#### 4.2 General Background and Information

This section presents the general background information of the respondents. It includes company establishment year, classification of contractors, respondent position in the company and the person in charge of material procurement in the contracting companies.

##### 4.2.1 General Background and Information

Table 4.1 shows that (40%) of the contracting companies have been established before or on 2000, (27%) of the companies have been established between 2001-2005 and (33%) of them were established after 2006.

**Table 4.1:** Contracting Companies Establishment Year

| Company Establishment year | Frequency | Percentage   |
|----------------------------|-----------|--------------|
| 2000 or before             | 12        | 40           |
| 2001-2005                  | 8         | 27           |
| After 2006                 | 10        | 33           |
| <b>Total</b>               | <b>30</b> | <b>100.0</b> |

**Table 4.1: Contracting Companies Establish 1**

#### 4.2.2 Companies Classifications (grade)

Table 4.2 illustrates that (16%) of the contracting companies are classified as the grade one and (30.0%) are classified as the grade two in and only (40%) classified as the grade three. (13%) of the contracting companies are classified grade four.

**Table 4.2: Companies Classifications (grade)**

| Grade        | Grade 1 | Grade 2 | Grade 3 | Grade 4 |
|--------------|---------|---------|---------|---------|
| Frequency    | 5       | 9       | 12      | 4       |
| Percentage % | 16      | 30      | 40      | 13      |

.

#### 4.2.3 The Person in Charge of Materials Procurement

Table 4.3 shows that the company director is the person in charge of the materials procurement in (16%) of the contracting companies while the project manager is in (30%) of the companies.

Site engineer (40%) and (13%) of the contracting companies have procurement sections responsible for the materials procurement. The results reveal that most of the contracting companies are small and one person performs many tasks at the same time.

**Table 4.3: Person or Section in Charge of the Material Procurement**

| The person or section in charge of the material procurement is | Frequency | Percent      |
|----------------------------------------------------------------|-----------|--------------|
| General Manager                                                | 9         | 16           |
| Project Manager                                                | 12        | 30           |
| Site Engineer                                                  | 4         | 40           |
| Procurement Section                                            | 5         | 13           |
| <b>Total</b>                                                   | <b>30</b> | <b>100.0</b> |

### **4.3 Current Practices of Material Supply Chain Process and the Important Factors that Form it**

The main objectives of this section are to study the current practices of the construction material supply chain practices in the Oromia region water supply Construction as well as the important factors that are appropriate for the same industry. This section contains six phases of the materials supply chain process which are: the bidding phase, the sourcing phase, the procurement phase, the construction phase, the post construction phase and the assessment and evaluation phase. The respondents were given a group of questions in each phase to achieve the said two objectives. The rating of these questions consists of two main scales. The first one is the usage degree that aims at studying the current practices of the material supply chain in the water supply construction and the second one is the importance degree which aims at paving the ground for developing the construction materials supply chain process. The respondents were asked to mark each question as always, often, sometimes, seldom and never for the usage degree scale and very important, important, quite important, some important and little important for the importance degree scale.

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

The items of the materials supply chain process used in this study are derived mainly from the material supply chain process that developed by Perdomo (2004) based on various discussions and interviews with the office and site personnel. This is due to the fact that the researcher after extensive review to the related literature did not find many researches about the subject under this study. Hence, the findings of each phase of this thesis will be compared to that of developed by Perdomo (2004). It is worth mentioning that the material supply chain process contains five phases which are: the bidding phase, the sourcing phase, the

procurement phase, the construction phase and post construction phase. A new phase has been developed by the researcher which is assessment and evaluation phase.

#### 4.3.1 Bidding Phase

This section contains 12 items that form bidding phase of the MSCP. The respondents were asked about their usage degree for these items and the importance degree from their point of view. Table 4.4 presents the results.

**Table 4.4: Bidding Process Phase 1**

| I/No. | Material Supply Chain Process                                                                                | Usage       |              |    | Importance   |              |    |
|-------|--------------------------------------------------------------------------------------------------------------|-------------|--------------|----|--------------|--------------|----|
|       |                                                                                                              |             |              |    |              |              |    |
| 1.1   | Identifying materials for each item once receive drawings and specifications                                 | 4.89        | 0.978        | 2  | 4.89         | 0.982        | 2  |
| 1.2   | Estimating the quantity of materials per each item                                                           | 4.4         | 0.910        | 4  | 4.63         | 0.931        | 4  |
| 1.3   | Defining any special requirements materials to be used                                                       | 4.10        | 0.820        | 8  | 4.16         | 0.832        | 8  |
| 1.4   | Classifying the materials that are off-the-shelf and to be prefabricated                                     | 3.90        | 0.780        | 10 | 4.10         | 0.820        | 9  |
| 1.5   | Identifying the local available and to be imported                                                           | 4.28        | 0.856        | 7  | 3.95         | 0.810        | 11 |
| 1.6   | Using computer applications for preparing the estimate                                                       | 4.69        | 0.938        | 3  | 4.75         | 0.946        | 3  |
| 1.7   | Involving the project construction team in the estimation                                                    | 3.80        | 0.755        | 11 | 4.09         | 0.813        | 10 |
| 1.8   | Establishing prices database for the materials from the previous projects to be used for the future projects | 3.52        | 0.704        | 12 | 3.56         | 0.712        | 12 |
| 1.9   | Depending on price of suppliers on preparing the project estimate                                            | 4.30        | 0.859        | 6  | 4.55         | 0.912        | 5  |
| 1.10  | Verifying the prices used in the estimate prior to the bid                                                   | 4.96        | 0.995        | 1  | 4.94         | 0.991        | 1  |
| 1.11  | Scheduling a meeting that includes contraction team to re-estimate the project quantities after win the bid  | 4.08        | 0.816        | 9  | 4.40         | 0.880        | 7  |
| 1.12  | Generating a preliminary materials requisition schedule, for material types, quantity needed, dates,         | 4.34        | 0.870        | 5  | 4.48         | 0.896        | 6  |
|       | <b>Total</b>                                                                                                 | <b>4.28</b> | <b>0.857</b> |    | <b>4.38.</b> | <b>0.877</b> |    |

As shown in Table 4.4, the responses on item 1.1 “Identifying the needed material if for each item once you receive the project’s drawings and specifications” show that the relative importance index is very high (0.978) for Usage with rank equals (2) and the relative importance index is very high (0.982) for Importance Degree with rank equals (2). The respondents gave this item very high degree for both the usage and importance. This means that they are fully aware of the importance of identifying the needed material of each item of the Bill of Quantities (BOQ). BOQ is prepared in a way that places all the risks on the contractor; one item of it includes many materials. For example, the item of “supplying and installing the bathroom cabinet” usually includes PVC pipes, excavation, manholes and all the necessary accessories and fittings. Therefore, contractors have to identify exactly the needed materials per each item of the BOQ and take the prices of such materials into account when preparing the estimate.

The relative importance index for item 1.2 “Estimating the quantity of the needed materials per each item (quantity take off)” is very high (0.910) for Usage Degree with rank equals (4) and very high (0.931) for Importance Degree with rank equals (4). The contractors gave this item very high degree for the usage and importance. It is common practice that the consulting offices increase the quantity of each item of the BOQ than what is originally estimated from the project’s drawings by certain percent. In addition, some items of BOQ may contain mistakes in the estimated quantities that affect the estimate. Therefore, it is very important for the contractors to estimate the quantity of the needed materials from the projects drawings and to compare it with the ones shown in the BOQ.

The relative importance index for item 1.3 “Defining any special requirements and/or special materials to be used in the project” is high (0.832) for Usage Degree with rank equals (8) and high (0.820) for Importance Degree with rank equals (8). The respondents gave high degree for the usage and the importance. Many contracts require special materials or material with high quality to be used in the project and usually the cost of these materials is expensive. If a contractor does not study the project’s specifications carefully, he will prepare bad estimate and will suffer loss at the end of the project.

The relative importance index for item 1.4 “Classifying the materials that are off-the-shelf and the major materials that need to be prefabricated” is medium (0.78) for Usage Degree with rank equals (10) and high (0.820) for the importance degree with rank equals (9). There is a slight difference between the usage degree and the importance degree. Contractors sometimes contain materials that are not off-the shelf and need to be manufactured only for a specific project. The manufacturing of these materials are usually costly and take time. Therefore, contractors should take into account these factors when preparing the estimate.

The relative importance index for item 1.5 “Identifying the local available materials or locally manufactured materials and the materials that are need to be imported” is high (0.856) for Usage Degree with rank equals (7) and high (0.810) for Importance Degree with rank equal (11). The contractors gave this item high degree for both the usage and the importance. Such result reveals that the contractors know that there are always additional costs associated with importing materials from outside Ethiopia such as freight cost, insurance cost, bank commissions and others that should be taken in to account while preparing the project estimate.

The relative importance index for item 1.6 “Using software packages or computer applications such as Microsoft Excel for preparing the estimate” is very high (0.938) for Usage Degree in with rank equals (3) and very high (0.946) for the Importance Degree with rank equals (3). As it is expected, most of the respondents use Microsoft excel for preparing the estimate because it makes the estimation process more accurate, easier and faster. Still the contractors can develop other programs that suit their needs.

The relative importance index for item 1.7 “Involving the project manager or construction team in the estimation process in order to prepare a realistic estimate” is medium (0.755) for Usage Degree with rank equals (11) and high (0.813) for the Importance Degree with rank equals (10). There is a slight difference between the usage degree and the importance degree. The project estimate should not be prepared only by the company owner or manager but the project manager and the field personnel should be involved in preparing the estimate; this will

lead to preparation of more realistic and good estimate due to their knowledge and experience in the construction works.

The relative importance index for item 1.8 “Establishing prices database for the materials from the previous implemented projects in order to be used for preparing the estimate for the future projects” is medium (0.704) for Usage Degree with rank equals (12) and medium (0.712) for Importance Degree with rank equals (12). The result reveals that despite that the prices of the construction materials fluctuated, many contractors still use the prices database of materials from the previous project to prepare the estimate. This may be due to the fact that using the prices database makes the estimation process faster and easier.

The relative importance index for item 1.9 “Depending on the prices of suppliers and manufacturers on preparing the project estimate” is high (0.859) for Usage Degree with rank equals (6) and very high (0.912) for the Importance Degree with rank equals (5). The results indicate that the respondents favor depending on the prices of the suppliers and manufacturers on preparing the estimate over using the material prices database of the previous implemented project. The researcher believes that contractors should mitigate the risk of the material prices fluctuation by depending on the prices of the suppliers and manufactures at the time of preparing the estimate.

The relative importance index for item 1.10 “Verifying the prices used in the estimate prior to submitting the bid” is very high (0.995) for Usage Degree with rank equals (1) and very high (0.991) for the Importance Degree with rank equals (1). As it is expected, all the respondents verify the prices used in the estimate prior to submitting the bid. Any mistake in the estimate will either make the contractor to lose the contract or win it with high loss.

The relative importance index for item 1.11 “Scheduling a meeting that includes the project manager and the construction team to re-estimate the project quantities once you win the bid” is high (0.816) for Usage Degree with ranks equals (9) and high (0.880) for Importance Degree with rank equals (7). The respondents gave high degree for the usage and importance. The re-estimate of the project quantities is important especially when the project drawings are

not clear and there is a high possibility for changes due to design deficiency. Moreover, and as it is mentioned earlier, it is common practice that consultants increase the quantities of the BOQ than what are estimated from the project drawings by certain percent. Therefore, if a contractor does not re-estimate the project quantity, he will end up with either materials shortage that hinder the work progress on site or surplus materials at the end of the project.

The relative importance index for item 1.12 “Generating a preliminary material requisition schedule, specifying material types, quantity needed, dates, when the material should be delivered and any additional information needed for clarification” is high (0.870) for Usage Degree with rank equals (5) and high (0.896) for Importance Degree with rank equals (6). The respondents gave high degree for the usage and high degree for the importance. The project team and procurement section or the person in charge of procurement should cooperate to generate a preliminary material requisition schedule in which the material types, quantity needed, dates when the material should be delivered and any other information are specified. This schedule will be considered the baseline by which the actual progress will be measured accordingly. Such schedule has to be distributed to the construction team so that all the project staff can share the project information.

The results show that bidding phase of the material supply chain process adopted in the local construction industry agrees with Perdomo study (2004). Perdomo pointed out that materials takeoff and identification process is the first step in the Bidding Phase that involves identifying the materials needed as well as any special requirement or special materials to be used in the project. Materials can be classified into two categories which are off the shelf items and the materials need to be manufactured. He indicated that most of the companies use computer applications such as Excel for preparing the estimate because this will make the estimating process easier and faster and the contracting companies verified the estimates several times prior to submitting the bid. He further added that the project managers are involved in the estimating phase because this could lead to the preparation of more realistic estimate due to the project’s manager’s experience. After successfully winning the bid for a particular project, companies schedule a kick-off meeting that includes the superintendent, the project manager and all the foremen in which they generate a material requisition schedule

specifying materials types, quantity needed, dates when the materials should be delivered and any additional information needed for clarifications.

### 4.3.2 Sourcing phase

This section contains 7 items that form the sourcing phase of the MSCP. The respondents were asked about their usage degree for these items and the importance degree from their point of view. Table 4.5 presents the results.

**Table 4.5: Sourcing phase**

| <b>Items No.</b> | <b>Material Supply Chain Process</b>                                                                    | <b>Usage Degree</b> |              |   | <b>Importance Degree</b> |             |   |
|------------------|---------------------------------------------------------------------------------------------------------|---------------------|--------------|---|--------------------------|-------------|---|
| 2.1              | Pre-qualify and list of reputable suppliers and manufacturers                                           | 4.22                | 0.858        | 5 | 4.22                     | 0.839       | 5 |
| 2.2              | Verifying that the suppliers delivering the right materials and right time                              | 4.83                | 0.962        | 1 | 4.82                     | 0.961       | 1 |
| 2.3              | Purchasing materials from suppliers you worked with on previous projects                                | 4.60                | 0.919        | 4 | 4.58                     | 0.932       | 4 |
| 2.4              | Requesting different suppliers in order to get good prices                                              | 4.74                | 0.934        | 2 | 4.80                     | 0.958       | 2 |
| 2.5              | Selecting the winner supplier based on lowest prices                                                    | 3.26                | 0.652        | 7 | 4.15                     | 0.812       | 6 |
| 2.6              | Considering suppliers with higher prices provide better services right materials at the times specified | 3.90                | 0.780        | 6 | 3.98                     | 0.796       | 7 |
| 2.7              | Negotiating the prices with the suppliers                                                               | 4.65                | 0.929        | 3 | 4.69                     | 0.938       | 3 |
|                  |                                                                                                         | <b>4.31</b>         | <b>0.862</b> |   | <b>4.463</b>             | <b>0.89</b> |   |

As shown in Table 4.5, the responses on item 2.1 “Prequalify the suppliers and manufacturer and keeping a list of reputable ones in order to obtain quotations from them” show that the relative importance index is high (0.858) for Usage Degree with rank equals (5) and high (0.839) for the Importance Degree with rank equals (5). The respondents gave this item high degree for both the usage and importance. The result indicates that the contractors realize the importance of awarding contracts to reputable suppliers. Contractors have to pre-qualify the

suppliers and to keep a list of the reputable suppliers so they can obtain quotations from these suppliers to prepare the estimate. Therefore, if a bid is awarded to any one of these suppliers, contractors can guarantee to certain degree that right materials will be delivered on the right quantities and in the right time.

The relative importance index for item 2.2 “Verifying that the supplier is capable of delivering the right materials (type, quality and quantity) when needed (i.e. at dates specified)” is very high (0.962) for Usage Degree with rank equals (1) and very high (0.961) for Importance Degree with rank equals (1). As it is expected, the respondents gave this item very high degree for both the usage and importance. The results indicate that contractors are fully aware that unavailability of materials when needed or/and delay deliveries of materials can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying of the completion of the project. Contractors should make sure that the selected suppliers or manufactures are capable of delivering the right materials in the right time prior to awarding the contract.

The relative importance index for item 2.3 “purchasing the materials from suppliers that you worked with on previous projects” is very high (0.919)for Usage Degree with rank equals (4) and very high (.932)for importance Degree with rank equals(4).The respondents gave high degree from both the usage and importance. When a contractor purchasing materials from suppliers whom he worked with on previous projects a good relationship might be established between the contractor and suppliers and in turn all the project parties get benefit from such relationship. The contractor may be offered good prices and the suppliers get the jobs from this contractor on a continuous basis. This will enhance the integration concept between the contractor and. the suppliers.

The relative importance index for item 2.4 “requesting quotations from different suppliers in order to get reasonable good prices” is very high (0.934) for usage Degree with rank equals (2) and very high(0.958)for importance Degree with rank equals(2) The results indicate that the most common way in which the contractors select suppliers is by competitive bidding and the respondents consider it the most important tool for the same. The researcher believes that because of the competitive nature of the bidding, the contractor needs to obtain materials at the lowest cost possible, usually, the contractors Request bids from suppliers to get the lowest prices possible for their products. Suppliers will try to win the contract by offering low relative price to the contractor. If a supplier does not lower the price, the contract may be

awarded to another party. Awarding the contract to the lowest price may create adversarial relation with the suppliers during the course of project implementation.

The relative importance index for item 2.5 “selecting the winner supplier based on lowest prices is (0.652) for Usage Degree with rank equals (7) and high (0.812) for Importance Degree with rank equals (6). The results indicate that many respondents select the suppliers based on the lowest prices and consider it important method for selecting the suppliers. As stated in the previous item selecting suppliers based on Lowest prices may create adversarial relationships the suppliers get the job at a Lower price than what they originally were expecting, therefore they are making less Profit. Because of this loss in profit, the suppliers might not be totally devoted to this particular contract and some problems might be arising.

The relative importance index for item 2.6 “considering suppliers with higher prices but that will provide better services or that have a record to supply the right materials in the quantities needed at the times specified” is medium (0.780) for Usage Degree with rank equals (6) and medium (0.796) for importance Degree with rank equals (7). The results show that the respondents gave higher degree for the importance than that of the usage. This means that although many contractors award the contract to the lowest prices, they believe that it is important to consider suppliers with higher prices who provide better services or that have a record to supply the right materials in the quantities needed at the times specified. The researcher believes that contractors should not consider only the cost of the materials to select suppliers but should also consider other factors also such as quality, delivery time and availability of the materials. In other words contractors should consider the cost overrun which associated with not supplying the right materials within the time specified.

The relative importance index for item 2.7 “Negotiating the prices directly with the suppliers” is very high (0.929) for the Usage degree with rank equals (3) and very high (0.938) for the importance Degree with rank equals (3). The result show that the second common used method and also the second important method for selecting suppliers is by negotiation. This may be due to the fact that construction material suppliers for each type of material are limited and the contractors know the suppliers who offer best prices.

In general, the results show that the most common usage and most important method for selecting the suppliers is requesting quotations from different suppliers. Negotiation is the third used and third important technique used from selecting the suppliers and finally contractors select suppliers whom they worked with in previous project. Contractors decision which method to use depend on many criteria such as cost, availability of the materials, and capability of the suppliers to deliver the right materials in the right time.

Permedo (2004) stated the first stage in the sourcing phase is the selection of reputable suppliers and manufactures. Most of contractors prefer to buy materials from suppliers that they worked with on previous projects and the contractor needs to verify that these suppliers

are capable of delivering the right materials (type, quality and quantity) when needed (i.e at dates specified).He added, in order to get reasonably good prices for the materials, they request quotations from different suppliers, Suppliers are usually selected based on the lowest prices, however, contractors may consider suppliers with higher prices but that will provide better services or that have a record to supply the right materials in the quantities needed at the times specified . He further added, for major materials contractor often negotiates prices directly with the suppliers.

### **4.3.3 Material procurement phase**

This section contains 9 items that form the procurement phase of the MSCP. The

Respondents were asked about their usage degree for these items and the importance Degree from their point of view. Table 4.6 presents the results.

Table 4.6 Material procurement process

| Item No | Material Supply Chain process                                                                                                  | Usage Degree |       |   | Importance Degree |       |   |
|---------|--------------------------------------------------------------------------------------------------------------------------------|--------------|-------|---|-------------------|-------|---|
| 3.1     | Obtaining a copy the material requisition schedule, specifying material types, quality, dates, that prepared by site personnel | 4.26         | 0.852 | 5 | 4.60              | 0.925 | 6 |
| 3.2     | Verifying availability of requested materials in stocks before requesting suppliers                                            | 4.20         | 0.841 | 6 | 4.58              | 0.816 | 7 |
| 3.3     | Requesting a submittal from supplier and approving it by the engineer prior to delivery                                        | 4.50         | 0.900 | 3 | 4.78              | 0.956 | 3 |
| 3.4     | Issuing purchase order to the winner supplier (setting an agreement)                                                           | 4.81         | 0.958 | 1 | 4.88              | 0.975 | 2 |
| 3.5     | Requesting materials directly by the field personnel                                                                           | 2.42         | 0.584 | 8 | 2.44              | 0.488 | 9 |
| 3.6     | Order 100% of items quantities at once                                                                                         | 2.46         | 0.792 | 7 | 3.00              | 0.610 | 8 |
| 3.7     | Ordering item quantities as per the work progress on site                                                                      | 4.44         | 0.886 | 4 | 4.77              | 0.948 | 4 |
| 3.8     | Specifying to the suppliers the release dates and the location of materials delivery                                           | 4.50         | 0.400 | 9 | 4.70              | 0.930 | 5 |
| 3.9     | Following up ordered materials delivered materials comply with the specifications                                              | 4.76         | 0.951 | 2 | 4.96              | 0.992 | 1 |
|         | Total                                                                                                                          | 4.04         | 0.796 |   | 3.78              | 0.849 |   |

As shown in Table 4.6 the responses on item 3.1” obtaining a copy the material requisition schedule, specifying material types, quantity needed, dates, when the material should be delivered that prepared by site personnel (such schedule prepared by the site staff on the construction phase)” show that the relative importance index is high (0.852) for Usage Degree with rank equals (5) and the relative importance index for Importance Degree is very high (0.925) with rank equals (6).The respondents gave high degree for the usage and very high degree for the importance. The objective of obtaining a copy of the requisition schedule is organizing the purchasing process of materials and issuing delivery schedules to the suppliers. Such schedule should classify the long lead items, local available materials, off the shelf materials and the materials that need to be manufactured. Failure in the purchasing process could result in either over-ordering materials which in turn causing wastage process could result in either over-ordering materials which in turn causing wastage problems or shortage in materials that could lead to delay in project completion .The site staff should

always keep the procurement section or the person in charge in the procurement with updated copy of the material requisition schedule.

The relative importance index for item 3.2 “Verifying the availability of requested materials in you stocks before requesting any materials from suppliers” is high (0.841) for Usage Degree with rank equals (6) and high (0.816) for importance Degree with rank equals (7). The respondents gave high degree for the usage and very high degree for the importance. The procurement section or the person in charge of procurement should check with the person in charge of the warehouse the availability of the requested materials before procuring them to avoid wastage and stock problems.

The relative importance index for item 3.3 “Requesting a submittal (material sample) from the supplier or manufacturer and approving it by the Engineer prior to materials delivery” is high (0.900) for Usage Degree with rank equals (3) and very high (0.956) for importance Degree with rank equals (3).The result shows that the majority of The contractors requesting material sample and/or specifications to be approved by the Engineer prior to the material delivery .This indicates that are fully aware of the Importance of this step. If a supplier, for example, deliver materials do not comply with the project’s specifications, the work will be disrupted and project completion may be delayed.

The relative importance index for time 3.4 “issuing purchase order to the winner supplier (setting an agreement) in order to organize the relationship between the contractor and The supplier” is very high (0.958) for Usage Degree with rank equals (1) and very high (0.975) for importance Degree with rank equals (2). The respondents gave very high Degree for both the usage and importance. The results reveal that the contractors realize the importance of the purchase order. The researcher believes that the purchase order represents the contract between the contractor and the supplier .It shows the quantity to be Delivered, the specifications, and the time to be on the site and other conditions. Such purchase order is used as a reference for any dispute that many arise between the Contractor and the supplier.

The relative importance index for item 3.5 “requesting materials directly by the field Personnel” is very low (0.584) for Usage Degree with rank equals (8) and very low (0.488)For importance Degree with rank equals (9).The respondents gave low degree for the usage And importance. The result indicates that few number of contractors purchase materials

directly by the field staff. However, the researcher believes that field personnel can buy minor materials directly if such materials are necessary for work progress on site.

The relative importance index for item 3.6 “ordering 100% of the estimated items quantities at once” is medium (0.792) for Usage Degree with rank equals (7) and low (0.610) for Importance Degree with rank equals (8). The result shows that only few number of contractors purchase the estimated quantities at once. Purchasing all the project materials at once will lead to stockpiling the materials on the project site or the warehouse, theft, losses and tie down the capital. However and as stated in the literature there are many advantages of purchasing 100% of the estimated quantities at once such as insuring against delay in delivery, allow for possible increase in demand, price discount, insuring against scarcity

The relative importance index for item 3.7 “ordering the estimated item quantities as per the work progress on the site” is high (0.886) the sample for Usage Degree with rank equals (4) and very high (0.948) for importance Degree with rank equals (4) The result demonstrates that the contractors prefer to order the required quantities as per the work progress to avoid stockpiling the materials on the project site or the warehouse.

The relative importance index for item 3.8 “specifying to the suppliers the release dates at which the material is needed and the exact location of materials delivery to avoid materials re-handling” is very low (0.400) for Usage Degree with rank equals (9) and very high (0.930) for importance Degree with rank equals (5). The respondents gave high degree for in the charge of the procurement should specify to the suppliers the exact date that the materials should be on the site. If the materials are delivered earlier than what is planned for, it will be stockpiled on the site and if the materials are delivered later than what is planned for the works on the site will be sprouted and the project completion will be delayed. Furthermore, the procurement department should specify the location on which the materials should be delivered at in order to avoid materials re-handling and the associated cost and time overrun.

The relative importance index for item 3.9 “following up the status of the ordered materials to make sure that the delivered materials comply with the specifications, in the quantities needed and within the timeframe specified” is very high (0.951) for Usage Degree with rank equals (2) and very high (0.992) for importance Degree with rank equals (1). Contractors gave this

item very high degree for both the usage and the importance .The procurement section or the person in charge of procurement should coordinate with the construction team on the site and the suppliers to make sure that the right materials are delivered to the site within the time specified.

Perdomo (2004) stated that the procurement process starts with the generation of material requisition schedule that usually starts by the site staff and then is sent to the purchasing department for material request from the suppliers under contract. In smaller jobs, materials may be requisitioned directly by the field personnel. The material requisition schedule specifying material types, quantity needed, dates, when the material should be delivered. In companies that have warehouse, the purchasing department first verifies the availability of the materials in the warehouse before ordering the materials from the suppliers. He further added, once a release form is generated, suppliers are contracted for procuring the material needed .The type of material needed, quantities and the time when the material is needed is specified to the supplier.

#### 4.3.4 Construction Phase

This section contains 8 items that form the construction phase of the MSCO. The respondents were asked about their usage degree for these items and the importance degree from their point of view. Table 4.7 presents the results.

**Table 4.7 Construction phase**

| Item No | Material Supply Chain Process                                                             | Usage Degree |       |   | Importance Degree |       |   |
|---------|-------------------------------------------------------------------------------------------|--------------|-------|---|-------------------|-------|---|
|         |                                                                                           |              |       |   |                   |       |   |
| 4.1     | Determining the quantities of needed materials each item                                  | 4.08         | 0.816 | 7 | 4.58              | 0.918 | 4 |
| 4.2     | Determining dates materials per each item are needed                                      | 4.22         | 0.840 | 5 | 4.48              | 0.896 | 5 |
| 4.3     | Determine materials delivery location each item                                           | 4.26         | 0.852 | 4 | 4.40              | 0.880 | 6 |
| 4.4     | \generating materials requisition form which description, quantities, dates and locations | 4.14         | 0.828 | 6 | 4.38              | 0.876 | 7 |
| 4.5     | Verifying the material received against the                                               |              |       |   |                   |       |   |

|     |                                                                                 |      |       |   |      |       |   |
|-----|---------------------------------------------------------------------------------|------|-------|---|------|-------|---|
|     | quantity ordered.                                                               | 4.74 | 0.958 | 2 | 4.78 | 0.966 | 2 |
| 4.6 | Inspecting delivered materials that it meets specifications.                    | 4.91 | 0.979 | 1 | 4.92 | 0.985 | 1 |
| 4.7 | Recording any problems in the delivered materials                               | 4.66 | 0.932 | 3 | 4.78 | 0.956 | 3 |
| 4.8 | Keeping track record of supplied ,remaining balance and the installed materials | 3.84 | 0.768 | 8 | 4.36 | 0.872 | 8 |
|     | Total                                                                           | 4.38 | 0.87  |   | 4.59 | 0.9   |   |

As shown in Table 4.7, the responses on item 4.1 “Determining the quantities of the needed materials per each item “show that relative importance index is high (0.816)for Usage Degree with rank equals (7) and very high (0.918) for importance Degree with rank equals(4).The result shows that the relative importance index for usage degree and the importance degree are almost the same and high. Once the works start, the construction team on site can determine the needed materials per each item more accurately. Therefore, this item will help the contractor to avoid the shortage of material delivery which leads to work disruption and project delay or to avoid materials surplus which may be subject to damage, theft ,loss and more importantly tying down the contractor capital that could be utilized for more critical purposes.

The relative importance index for item 4.2 “Determining dates in which materials per each item are needed to be available” is high (0.84) for Usage Degree with rank equals (5) and high(0.896)for importance Degree with rank equals(5).The contractors gave this item high degree for the usage and importance. The construction team should determine the optimum date that the materials should be available on the site. Ordering the materials earlier than what planned from will lead to materials overstock while ordering materials later what are planned for will lead to delay of the project completion and cost overrun.

The relative importance index for item 4.3 “Determining the exact materials delivery location per each item” is high(0.852)for Usage Degree with rank equals (4) and high (0.880)for Importance Degree with rank equals (6).The contractors gave this item high degree for both the usage and importance and almost the same. The contractors realize that specifying the

exact location for materials delivery will avoid materials re-handling which in turn saving time and cost.

The relative importance index for item 4.4 “Generating a material requisition form in which the material description, quantities needed, dates when the materials are needed and the delivery locations” is high (0.828) for Usage Degree with rank equals (6) and high (0.876) for importance Degree with rank equals(7).The contractors gave this item high degree for the usage and importance and almost the same .Once a contractor finished the above mentioned item, he generates a material requisition form. Such form may contain materials description, the local materials, the materials needed to imported, the off-shelf materials and the materials needed to be fabricated, the quantities needed, the dates that should be available on the site and delivery location. Having prepared the said form, a copy of the same is sent to the procurement section or the person in charge for procurement implementation.

The relative importance index for item 4.5”Verifying the material received against the quantity ordered” is very high (0.958) for Usage Degree with rank equals(2) and very high (0.966) for Importance Degree with rank equals(2).The contractors gave this item very high degree for both the usage and importance The construction team should make a comparison between the ordered quantities and the received quantities. If there is a deviation, the construction team or the one who responsible for receipting the materials should inform the procurement section or the person in charge of procurement to follow up with the suppliers.

The relative importance index for item 4.6 “Inspecting the delivered materials to make sure that it meets the specification” is very high (0.979) for Usage Degree with rank equals (1) and very high (0.985) for Importance with rank equals (1).The contractors gave this item very high degree for the usage and the importance .The results indicate that the contractors are fully aware of the importance of inspecting the quality of the delivered materials against the required specifications. If the supplied materials have been installed and it has been detected later on that it does not comply with the project’s specification, the contractor may be instructed by the supervisor Engineer to remove the installed materials and to replace it by

new materials that meet the project's specifications. Consequently, the work progress will be hindered and the project as a whole may be delayed.

The relative importance index for item 4.7 "Recording any problems in the delivered materials" is very high (0.932) for Usage Degree with equals (3) and very high (0.956) for Importance with rank equals (3). The respondents gave very high degree from the usage and very high degree for the importance. The construction team should inspect the materials delivered and to record any problem if any. For example, the damaged during the transit have to be recorded upon the material arrival.

The relative importance index for item 4.8 "keeping a track record of the supplied materials, remaining balance and the installed materials" is medium (0.768) for Usage Degree with rank equals (8) and high (.872) for Importance Degree with equals (8). The respondents gave higher degree for the importance than the usage. This item will help contractors to make control over the supplied materials, installed and the remaining balance. The contractors, therefore, can know exactly how much material to order in case there is a shortage.

Perdomo (2004) illustrated that whenever materials are needed at the construction site, a material requisition process is initiated by site personnel (foreman or the project manager). This process involves generating a material requisition form in which the material description, quantities needed, dates when the materials are needed and the delivery locations are specified. In the case that the material is delivered to the job site, the designated site personnel verify the material received against the requisition form. Actual quantities received are recorded. If there are Discrepancies in the material quantities, damages to the material or items not delivered, the foreman fills a problem sheet form and forwards a copy of this form to the purchasing department for follow up with the concerned supplier.

#### **4.3.5 Post Construction Phase**

Reducing the surplus materials to the minimum is one of the fundamental concepts of the supply chain management in the construction industry that related to the quantity attribute. This section contains five scenarios for dealing with surplus materials at the end of the

project. The respondents were asked to select the scenario/s that they encountered and the percentage of occurrence. Table 4.8 presents the results.

**Table 4.8 Post Construction Phase**

| tem No | Material Supply Chain process                                 | %of Occurrence | Ranks |
|--------|---------------------------------------------------------------|----------------|-------|
| 6.1    | Storing the surplus materials to be used future projects      | 40.8           | 2     |
| 6.2    | Returning back surplus materials to suppliers without penalty | 42.8           | 1     |
| 6.3    | Returning back surplus materials to suppliers with penalty    | 3.68           | 5     |
| 6.4    | Selling surplus materials to other contractors                | 8.88           | 3     |
| 6.5    | Scraping surplus materials                                    | 3.84           | 4     |
|        | Total                                                         | 100%           |       |

Table 4.8 shows that (42.8%) of the surplus materials are returned to the suppliers without penalty at the end of the project ,(3.68%) of the surplus materials are returned to the suppliers with penalty .These results indicate that the suppliers are very flexible and the contractors may keep some kind of good relationships with them. Keeping good relationships with the suppliers is very important for achieving integration between them .The result also shows that (40.8%) of the surplus materials are stored on the contractors' warehouses. Such materials may be subject to deterioration, damage, loss, theft and more importantly it will tie down the capital of the contractors. Thus, Contractors should prepare good materials take off in order to avoid the material surplus.

The study which conducted on Malaysia construction industry by Abdul Rahman and Al-Dirisy (1994) showed that the frequency of surplus materials being on site the end of the construction project was as follows: very often (1.59%), often (3.13%),sometimes (38.06%),seldom (45.88%) and never (11.34%).The same study showed also that the quantity percentage of the surplus materials experienced by the contractors at the end of construction

projects were as follows: (1.8%) of the respondents experienced more than 10.0%,(9.40%) experienced more than 1-3% and finally (25.34%) experienced a maximum of 1%

The results of this research along with the study conducted by Abdul Rahman and Al- Dirisy (1994) show that there are surplus materials at the end of the construction project and the contractors need to develop a plan for managing it in proper way.

#### 4.4 Evaluation Phase

The respondents were asked about their usage and importance degree for conducting a comprehensive assessment for the material supply chain process through the project phases. Table 4.9 presents the results.

**Table 4.9 Assessment Phase Result**

| Item No | Material Supply Chain process                                                            | Usage Degree |       |  | Importance Degree |       |  |
|---------|------------------------------------------------------------------------------------------|--------------|-------|--|-------------------|-------|--|
|         |                                                                                          |              |       |  |                   |       |  |
| 5.1     | Conducting assessment for the material supply chain process through the mentioned phases | 4.42         | 0.664 |  | 5.44              | 0.878 |  |

Table 4.9 shows that the relative importance index for usage degree is low (0.664) and the relative importance index for the importance degree is high (0.878).The result indicates that although many contractors do not evaluate materials supply chain process through the mentioned five phases at the end of the project, they believe that such evaluation is a very important step to improve the material supply chain process in the future projects. As a matter of fact, there are many decisions emerged out of the five mentioned phases of the materials supply chain process that contractors should take. After completing the project, contractors have to measure the performance of their decisions they took during the supply chain phases. For example, the decision of “how much materials to buy” that may be raised during the procurement phase involves four scenarios which are 100% of the estimated quantities, less than the estimated quantities, more than the performance of their decision in terms of schedule (time), direct and indirect cost, surplus materials .Therefore, such evaluation will

create knowledge for the contractors that could be used to improve their decisions making in the future projects.

#### **Table 4.10 Methods Used for Ordering Materials form the suppliers**

This subsection contains five methods that contractor may use to order the materials form the suppliers. The respondents were asked to rank these methods as per their use. Table 4.10 presents the results

**Table 4.10 Ranking the methods of ordering materials from the suppliers**

| Method           | Percentages | Ranks |
|------------------|-------------|-------|
| Personal meeting | 75          | 1     |
| Telephone        | 55.4        | 2     |
| Fax              | 40          | 3     |
| E-mail           | 28.2        | 4     |
| Internet         | 3.8         | 5     |

Table 4.10 indicates that the most important tool that the contractors adopt to order the materials from the suppliers is the personal meeting. This may be due to fact they can negotiate the prices of materials directly with the suppliers and get better prices.

The results reveal that the least preferable tool is the internet or website. The researcher believe that website provides a good tool for sharing information such as text, full color graphics and photos, audio and video between the project participants and make them to act as one team which in turn achieving the principle of the integration through the supply chain process.

#### **4.5 Contractor /Supplier Relationship**

The relationship of a contractor with his suppliers is critical for the successful of any construction project .This section aims at studying the contractor/supplier relationships. It is divided into two subsections. The first subsection shows the criteria that the contractors adopt to select the suppliers. The second subsection shows the likely or preferred course of action

that contractors use when the supplier deliver materials late or deliver materials do not meet the required specifications.

#### 4.5.1 Criteria for selection the suppliers

A long-term relationship with suppliers is one of the fundamental concepts of the construction supply chain management. Such relation should be built on cooperation, trust, fairness, commitment and done in win-win basis for all the parties involved. In this subsection the respondents were give nine criteria and they were requested to rank it in accordance with their concerns to select the suppliers. Table 4.11 presents the results

**Table 4.11 Criteria for selection the suppliers**

| Criteria                                                  | Percentages | Rank |
|-----------------------------------------------------------|-------------|------|
| Competitive pricing-Cost                                  | 72.40       | 1    |
| Reliable delivery                                         | 50.58       | 4    |
| Good Quality                                              | 63.33       | 2    |
| Availability                                              | 60.2        | 3    |
| Flexibility in accommodating contractor's changes/request | 30.46       | 7    |
| Financial facilities                                      | 36.60       | 5    |
| Sign long term agreement/enter into partnership           | 33.79       | 6    |
| Personal relationship                                     | 16.42       | 9    |
| Mutual interests                                          | 23.28       | 8    |

Table4:11 show that competitive pricing is the most important criteria to select suppliers. This is may be due to the fact that the contractors believe that they can get lowest prices by competitive bidding. However, using competitive bidding to select the suppliers will make the suppliers to reduce their profit to the minimum in order to win the contract. This in turn may

create adversarial relationships between them during the course of project implementation and consequently affect the project's success. Furthermore, reliable delivery, good quality and availability of the materials when needed will not be guaranteed in a relationship based on a competitive bidding. Most of the contractors believe that the good quality and availability and reliable delivery are very important criteria for selecting the suppliers as these criteria was ranked second, third and fourth respectively. Such criteria are considered the main attributes of the construction supply chain management.

Sign long term agreement/enter into partnership agreement were ranked sixth. This reveals that the contractor/ supplier relationship are based mainly on project by project basis.

The results also show that the contractors do not depend on the personal relation and mutual interest in selecting the suppliers as these two criteria was ranked ninth and eighth respectively.

As part of the study that has been conducted by Pheng & Chuan (2001) to determine the relationship between client and supplier, 31 contractors were asked to rank the criteria for selecting of precasters and other suppliers. From the survey, it was found that competitive pricing is the most important criteria for the selection of the precasters or other suppliers. Twenty-five respondents or (78%) rank this criterion as the most important. "Reliability in delivery" was ranked the second and "good quality" was ranked the third. Contractors have also ranked the "signing of long-term agreement and going into partnership" as the least important consideration for striking a contract.

Table 4.12 shows the criteria selection for the precasters and the other suppliers.

**Table 4.12: Ranking the criteria to select the Supplier (Source: Pheng & Chuan, 2001)**

| Criteria                                                   | Rank |
|------------------------------------------------------------|------|
| Competitive pricing                                        | 1    |
| Reliable delivery                                          | 2    |
| Reliable production                                        | 3    |
| Flexibility in accommodating contractor's changes/requests | 4    |
| Sign long-term agreement/enter into partnerships           | 5    |

#### 4.5.2 Action Taken Against late Deliveries and Not Complying With Specifications

The basic principle behind the material supply chain management is to have the right products in the right quantities at the right place at the right moment at minimal cost. If a supplier does not deliver materials needed on time or deliver materials that do not meet the quality specified, then the work progress on site will be disrupted and the project completion may be delayed. What will be the behavior of the contractors or the most likely course of actions that they will take against the suppliers who deliver the materials late or not comply with the quality specified? In this sub-section, the respondents were provided five likely courses of actions that they may take in case a supplier is in default and they are requested to rank these actions in accordance to their use and preferences. Table 4.13 presents the results.

**Table 4.13:** Preferred Course of Action Taken Against Late Deliveries and not Complying with Specifications

**Table 4.13: Preferred Course of Action**

| Likely Course of Action                               | Percentages | Rank |
|-------------------------------------------------------|-------------|------|
| Send a letter of complaint to the supplier            | 55.21       | 1    |
| Simply “give-and-take” to avoid any sour relationship | 48.00       | 2    |
| Learn from the lesson and take preventive measures    | 42.10       | 3    |
| Impose penalty charges on the supplier                | 25.00       | 4    |
| Reprimand the supplier and then let the matter rest   | 20.15       | 5    |

Table 4.13 reveals that “sending a letter of a complaint to the suppliers” is the first likely course of action that the respondents will take against late deliveries or delivering materials not complying with the required specifications. An official letter that will be a good document to such problem and puts the contractor in a better bargaining position if there will be a need for dispute resolution at a later stage.

“Simply give and take to avoid any sour relationship’ is the second likely course of action that the respondents will take against the supplier who defaults. Defaulted suppliers may not fully realize the impact of late deliveries or delivering materials do not meet the quality specified on the project success and on the future relationship with the contractors as well. Therefore some contractors may prefer to discuss the problem with the supplier first hoping that the defaulted actions not to be repeated and to keep good relationship with the suppliers.

Learn from the lesson and take preventive measures was ranked third. Contractors adopt preventive measures in relation to late deliveries. Some contractors take into account in the material delivery schedule the possibility of such delayed activities in order to mitigate their impact on the project activities. The materials are then requested for earlier than required.

Imposing penalty charges on the defaulted suppliers was ranked fourth. This course of action depends on the terms and agreement of the contract between the two parties. If the terms and conditions of the contract give the contractor the right to withhold payments against later deliveries or delivering materials don’t meet the specification then the contractor will not hesitate to exercise this right. Hitting the suppliers in their pockets will make them to avoid any defaults in the supplier in order to organize the relationship between the two parties and to show the responsibilities and duties of each party. such an agreement with the supplier who defaults.

Table 4.14 shows the results of the study that had been conducted Pheng Chuan (2001) to determine the most likely course of action that contractors would be adopted in case suppliers make late deliveries. **Table 4.14:** preferred course of Action Taken against Late Deliveries (Source: Pheng & Chuan, 2001)

Table 4.14: preferred course of Action

| Likely Course of Action                               | Rank |
|-------------------------------------------------------|------|
| Send a letter of complaint to the supplier            | 1    |
| Simply “give-and-take” to avoid any sour relationship | 5    |
| Learn from the lesson and take preventive measures    | 2    |
| Impose penalty charges on the supplier                | 3    |
| Reprimand the supplier and then let the matter rest   | 4    |

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#### **4.6 Problems Encountering Contractors in material Supply Chain Process**

Understanding the existing problems is an absolute necessity for resolving the effectively. Many problems may be encountering the contractors during the phases of the materials supply chain process that hamper achieving the main objectives of the supply chain management. This section aims to determine the most occurred problems encountering the contractors during the materials supply chain process through the five phases which are: the bidding phase, the sourcing phase, the procurement phase, the construction phase, the post construction phase. The section also aims at studying the root causes of these problems and then developing possible solutions for them in order to make the application of MSCP goes smoothly without interruption.

##### **4.6.1 Bidding Phase**

The respondents were given 5 problems that may face contractors in the bidding phase and they were asked to mark each question as always, often, sometimes, seldom and never. Table 4.15 presents the results

**Table 4.15: Problems Encountering Contractors during the Bidding Phase**

| No   | Problems                                                             | Mean        | Relative index | Rank |
|------|----------------------------------------------------------------------|-------------|----------------|------|
| 1.1. | Not a good definition of what is wanted from the owner and suppliers | 3.0         | 0.610          | 4    |
| 1.2  | Lack of communication between parties involved                       | 3.38        | 0.686          | 2    |
| 1.3  | Incomplete drawings and details are missing                          | 3.24        | 0.638          | 3    |
| 1.4  | Using specifications different from those commonly used              | 2.36        | 0.482          | 5    |
| 1.5  | Ambiguities between plans and specifications                         | 3.78        | 0.754          | 1    |
|      | <b>Total</b>                                                         | <b>3.15</b> | <b>0.634</b>   |      |

Table 4.15 shows “Ambiguities and differences between plans and specifications” and “incomplete drawings and details are missing” were marked the first and third with relative important indices (0.757) and (0.638) respectively. The results indicate that tender documents are not well prepared by the consultants. Ambiguities in the tender documents and incomplete drawings and disputes between the involved parties during the construction phase which may consequently lead to disruption of project activities on site.

To solve these problems, the researcher believes that consultants should give more focus and attention when preparing the tender documents in order to be clear. In addition, during the bidding phase contractors have to study the tender documents carefully and request more information and clarifications from the consultants in case there are ambiguities between plans and specifications. Ambiguities should be solved in advance otherwise it will interrupt the works during construction phase.

“Lack of communication between the parties involved” was ranked the second with relative importance index (0.686). During the bidding phase contractors may need more information and/or clarifications from the parties involved in order to prepare reasonable and good

estimate. For example, contractors may need from the owner more information about the materials type and clarifications about discrepancies that may be found in the contract documents. They may need from the suppliers information about the prices of the construction materials and means and methods of installation. Contractors may also need from the subcontractors information about the difficulty, cost and time required from the installation. Therefore, if contractors have not good communications with these parties involved, they may not be able to prepare good estimate. The main reason for this problem could be due to the absence of effective communication system and information sharing among the parties involved. Accordingly, contractors should develop their capabilities in the involved parties in the estimation process and enabling them to have an access to project data and to share project information.

#### 4.6.2 Sourcing phase

The respondents were given 3 problems that may face contractors in the sourcing phase and they were asked to mark each question as always, often, sometimes, seldom and never. Table 4.16 presents the results.

**Table 4.16: Problems Encountering Contractors during the Sourcing Phase**

| No  | Problems                                                      | Mean        | Relative index | Rank |
|-----|---------------------------------------------------------------|-------------|----------------|------|
| 2.1 | Having many suppliers and do not have information about them  | 3.1         | 0.630          | 2    |
| 2.2 | suppliers did not include all the documents with the proposal | 3.20        | 0.64           | 1    |
| 2.3 | Time spent investigating non-qualified suppliers              | 2.5         | 0.50           | 3    |
|     | <b>Total</b>                                                  | <b>2.93</b> | <b>0.59</b>    |      |

Table 4.16 shows that “suppliers did not include all the documents with the proposal)” were ranked first with relative importance index (0.640). This item may be applied more for electrical and mechanical materials. The researcher believe that evaluation of the suppliers’ offers should not be on the financial basis only, but the technical offers and other factors should be considered also therefore, enclosing specifications, brochures and/ or technical data

of the materials with suppliers' offers will help contractors to evaluate them properly. If a contractor award the contract only on the financial basis, there will be a high possibility that the winner supplier will deliver materials do not meet the required specifications. Such problem will hinder the work progress on the site during the construction phase, especially if the materials are imported from the outside Ethiopia.

The root cause behind incomplete proposal by suppliers may be due to the bad communication represented in incomplete or bad formulation of the "invitation to bid" documents that prepared by the contracting companies. From instance, the invitation to bid documents may not request from the suppliers to enclose technical data and specifications of required materials. To solve this problem, contractors have to improve their communication with the suppliers. Invitation to bid documents, from example, should 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, his offer will be rejected.

#### **4.6.3 Material Procurement phase**

The respondents were given 7 problems that may face contractors in the procurement phase and they were asked to mark each question as always, often, sometimes, seldom and never. Table 4.17 presents the results.

**Table 4.17: Problems Encountering Contractors during material Procurements Phase**

| No  | Problems                                                                        | Degree of Occurrence |                |      |
|-----|---------------------------------------------------------------------------------|----------------------|----------------|------|
|     |                                                                                 | Mean                 | Relative index | Rank |
| 3.1 | Unavailability of required construction material                                | 3.70                 | 0.760          | 1    |
| 3.2 | submittals are not submitted as planned                                         | 2.78                 | 0.576          | 6    |
| 3.3 | Incorrect of submittals by the suppliers                                        | 3.22                 | 0.654          | 3    |
| 3.4 | Late approval of submittal by Engineer                                          | 2.46                 | 0.503          | 7    |
| 3.5 | Poor communication between the parties involved                                 | 3.29                 | 0.678          | 2    |
| 3.6 | The contractor sets delivery dates that are impossible to meet by the suppliers | 3.08                 | 0.606          | 5    |
| 3.7 | The contractor not communicate exactly what is wanted                           | 3.18                 | 0.646          | 4    |

|              |              |             |               |  |
|--------------|--------------|-------------|---------------|--|
|              | to suppliers |             |               |  |
| <b>Total</b> |              | <b>3.10</b> | <b>0..632</b> |  |

Table 4.17 shows that

“Unavailability of required material” was ranked the first with relative importance index (0.760). Unavailability of the materials when needed can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying the completion of the project. This problem could be detected in the construction phase whilst the origin of it could be happened in the sourcing phase as the contractors may select the supplier based on the lowest price only without considering other factors. Table 4.16 of this study shows that, competitive pricing was the most important criteria for selecting suppliers by contractors. To avoid this problem contractors should not rely only on lowest price to award the contract during the sourcing phase but should also consider other factors such as availability of the materials.

“Poor communication between the parties involved” was ranked the second with relative importance index (0.678). Unavailability of the materials when needed can greatly affect the productivity of the workforce, thus causing delays to activities, increasing the cost of the project and possibly delaying the completion of the project. This problem could be detected in the construction phase whilst the origin of it could be happened in the sourcing phase as the contractors may select supplier based on the lowest prices only without considering other factors. Table 4.16 of this study shows that, competitive pricing was the most important criteria for selecting suppliers by contractors. To avoid these problem contractors should not rely only on lowest price to award the contract during the sourcing phase but should also consider other factors such as availability of the materials.

“Incorrect of submittals by the suppliers” was ranked the third with relative importance index (0.654). Despite that this problem may be detected on the procurement phase, the base of this problem occurred in the sourcing phase. Section 4.4.51 table 4.11 showed that contractors top concern criteria to select suppliers was the cost.

To overcome this problem contractors should pre-qualify the suppliers, obtain quotations from reputable suppliers and whom they worked with on previous projects as per the conclusion that have been drawn out of this research, section 4.3.3, Table 4.6. Also contractors could send a letter of a complaint to the suppliers who are in default as per the finding of section 4.5.2 Table 4.13. Such an official letter that will be good documents to such problem and puts the contractor in a better bargaining position if there will be a need for dispute resolution at later stage.

“The contractor does not communicate exactly what is wanted to suppliers” was ranked the fourth with relative Importance index (0.646). Although this problem may be discovered in the procurement phase, its origin may be at earlier phase. The main cause of such problem may be the absence of clause

or agreement between the owner and the contractors on the approval period of the submittal. To solve this problem, once a contractor sign a contract, he should, among other issues, make an agreement with the owner on the approval period for submittal if there no related clause in the project general conditions. During the construction phase contractor has to follow up the status of material submittal approval. In case there is a late approval by the Engineer, he should send a letter of a complaint to the owner. Such an official letter will be a good document to such problem and puts the contractor in a better bargaining position if there will be a need for dispute Resolution at later stage. Furthermore, contractors can take in to account in the material delivery schedule the possibility of such late approval in order to mitigate their impact on the project activities. The material are then submitted for approval earlier than what are planned for.

#### **4.6.4 Construction Phase**

The respondents were given 9 problems that may face contractors in the construction phase and they were asked to mark each question as always, often, sometimes, seldom and never.

#### 4.5.4: Problems Encountering Contractors during construction Phase

**Table 4.18: Problems Encountering Contractors during construction Phase**

| No           | Problems                                                                    | Mean        | Relative index | Rank |
|--------------|-----------------------------------------------------------------------------|-------------|----------------|------|
| 4.1          | Late Deliveries                                                             | 3.12        | 0.644          | 2    |
| 4.2          | The delivered materials do not comply specifications                        | 4.12        | 0.824          | 1    |
| 4.8          | Poor communication between the parties involved                             | 2.52        | 0.504          | 5    |
| 4.7          | - Materials are damaged while handling                                      | 2.53        | 0.527          | 4    |
| 4.3          | materials have to be moved from one place to another before being installed | 3.02        | 0.624          | 3    |
| 4.4          | storage area are limited or far away from the working area                  | 2.38        | 0.486          | 6    |
| 4.9          | Receive, handling and storage of the unused materials                       | 2.16        | 0.432          | 8    |
| 4.5          | Loss of materials                                                           | 2.30        | 0.470          | 7    |
| 4.6          | Theft of materials                                                          | 2.08        | 0.426          | 9    |
| <b>Total</b> |                                                                             | <b>2.69</b> | <b>0.55</b>    |      |

Table 4.18 shows that “Late deliveries (Materials do not arrive as scheduled)” was ranked the second with relative importance index (0.644) and “The delivered materials do not comply with the required specifications” was ranked the first with relative important index (0.824). Although these problems uncovered in the construction phase of the supply chain but their base may be in the sourcing phase. For example, in sourcing phase the contractor may use bidding for selecting the supplier. Because of the competitive nature of the bidding the supplier may offer low price to the contractor in order to get the job. Because of the low price, the supplier might not totally devote to the project. Furthermore, contractors may do not pre-qualify the suppliers and did not make sure that the supplier is capable to deliver the required quantities in the right time. No contract between the supplier and the contractor in procurement phase is another cause that may make late deliveries and delivering materials

that do not comply with the project specifications. Bad planning by contractors during the construction phase may also cause late deliveries. To solve the problems of late deliveries and delivering materials do not comply with the required specifications, the contractors have to do the following: In the sourcing phase, they should pre-qualify the suppliers and should make sure that they are capable of delivering the right material in the right quantities in the time specified. They should not select the supplier based on the lowest prices but should consider the supplier with higher prices but who provide better services in accordance with the finding section 4.3.2 table 4.5 of this study.

In the procurement phase, contractors have to set out agreement with the suppliers showing the duties and responsibilities of each party. There should be a clause of penalty charges in case the supplier make late deliveries or deliver materials that do not meet the required specifications. Table 4.13 shows the preferred course of actions taken by the contractors in case a supplier is in default.

“Poor communication between the parties involved” was ranked the fifth with relative importance index (0.504). The main cause of this problem may be the absence of effective tools and mechanisms of sharing information between the involved parties. To overcome this problem, there should be a system for exchanging information and sharing data among the project participants. Such system allows a contractor to identify what material is available, materials not delivered as ordered or if the order is delayed and where the materials are stored on site.

#### **4.6.5 Post-Construction Phase**

The respondents were given 4 problems that may face contractors in the post construction phase and they were asked to mark each question as always, often, sometimes, seldom and never. Table 4.19 presents the results.

**Table 4.19: Problems Encountering Contractors during Post-Construction Phase**

| No. | Problems                                                       | Degree of Occurrence |                |      |
|-----|----------------------------------------------------------------|----------------------|----------------|------|
|     |                                                                | Mean                 | Relative index | Rank |
| 5.1 | No storage for the surplus materials                           | 2.50                 | 0.490          | 1    |
| 5.2 | No possibility surplus materials to be returned to supplier    | 2.28                 | 0.466          | 2    |
| 5.3 | Charging penalties by the suppliers for the returned materials | 1.70                 | 0.360          | 4    |
| 5.4 | Salvage losses for the surplus materials                       | 2.06                 | 0.422          | 3    |
|     | <b>Total</b>                                                   | <b>2.14</b>          | <b>0.44</b>    |      |

Table 4.19 shows that relative importance indices for the problems are low. The results reveal that most of the contractors can return the surplus materials to the suppliers without charging penalties. Also the contractors have warehouses where they can store the surplus materials.

Two conclusions could be drawn out of this section. First, poor communication among the parties involved is the common problem occurred in each phase of the MSCP.

Therefore, there should be a system such as web-based system to manage the information properly among the concerned parties. Mohammed and Trucker (2001) stated that “visualizing SCM as two parallel tracks: physical (products, materials and even funds) flow and the corresponding information flow that manages it. Products, materials, equipment and funds move in response to signal from the information flow. However in the construction project these flows take place in the context of linkages between separate organizations. SCM crosses organizational boundaries, organizing information and process flows, sending signal to operations and evaluating results. There is a heavy reliance in information management to coordinate the chain. As a result, information management becomes the heart of CSCM”. Second, most problems are caused in another (i.e. earlier) stage other than where they are found. This conclusion agrees with one of the findings of the three case studies conducted by Vrijhoef and Koskela (1999) which was the root causes of the problems were rarely found in the activity where they are encountered, but rather in a previous activity executed by a prior actor.

#### 4.7 Key Factors Contributing in Integrating Construction Supply Chain

Integration among the key members of the project participants: owner, main contractor, subcontractors and suppliers and also integration of the project phases will contribute in making the MSCP through the project phases described in section 4.3 goes smoothly. The aim of this section is to study the key factors that could contribute in integrating the project phase of the MSCP. The respondents were asked to mark each factor as very important, important, quite important, some important and little important. Table 4.20 presents the results.

**Table 4.20: Factors which may contribute to Successful Integration of the Construction Supply Chain Process**

| No.  | Factors                                                                                             | Mean        | R.index      | rank |
|------|-----------------------------------------------------------------------------------------------------|-------------|--------------|------|
| 6.1  | The design team includes contractors, subcontractors and materials suppliers                        | 2.85        | 0.565        | 11   |
| 6.2  | Using design contract arrangement between the contractor and the client                             | 2.44        | 0.522        | 12   |
| 6.3  | Entering a partnership relationship with suppliers and subcontractors based on extended time period | 4.22        | 0.854        | 4    |
| 6.4  | Understanding the client needs and objectives by the contractor, subcontractors and suppliers       | 4.37        | 0.938        | 2    |
| 6.5  | Executing the projects activities by the contractors own sources                                    | 3.26        | 0.652        | 9    |
| 6.6  | Negotiating contracts with the suppliers rather than tendering                                      | 3.36        | 0.682        | 8    |
| 6.7  | The participation of the designers continues during construction phase                              | 4.02        | 0.806        | 6    |
| 6.8  | Establishing a protocol for dealing effectively with disputes and problems                          | 4.92        | 0.973        | 1    |
| 6.9  | Conducting workshop for suppliers and subcontractors to discuss the quality, innovation,            | 3.14        | 0.630        | 10   |
| 6.10 | Aligning the system and procedures of your own company with client, suppliers and subcontractors    | 4.20        | 0.842        | 5    |
| 6.11 | Establishing a system for communication and share information in timely and accurate manner         | 4.28        | 0.922        | 3    |
| 6.12 | Using Web Based system for information access                                                       | 3.80        | 0.766        | 7    |
|      | <b>Total</b>                                                                                        | <b>3.74</b> | <b>0.763</b> |      |

Table 4.20 shows that The relative importance index for item 6.8 “Establishing a protocol for dealing effectively with disputes and problems that may arise between the project participant during the course of project implementation “ is very high (0.973) and rank equals (1). One of the findings of the case studies conducted by Briscoe and Dainty (2005) to determine the important factors for successful integration of the construction supply chain was that establishing a protocol for dealing effectively disputes and problems was essential factor underpinning the performance of the projects performed and rapid action is required to minimize supply chain problems at an early stage

The relative importance index for item 6.4 “Understanding the client needs and objectives by the contractors, subcontractors and suppliers and committing for these needs and objectives” is very high (0.938) with rank equals (2). It is not expected by the researcher that this factor to obtain the highest relative importance index. This factor is related to the prevailing culture among contractors, suppliers and subcontractors which is that all of them want to get the maximum benefit from the project regardless the other parties’ benefits. As a matter of fact, any project is always initiated by owners to achieve specific objectives and needs; therefore, other project parties should work toward achieving these objectives and needs.

The relative importance index for item 6.11 “Establishing a system between the project participants for communication and share project information in timely and accurate manner” is very high 0.922” and with rank equals (3). Communication and information sharing are key components in achieving tight integration between the project participants and project phases. MSCP depends mainly on accurate and timely generation and transfer of information.. Trucker and Mohammed (1996) stated that “there is growing awareness of the value of the information and communication technology to bring together the major parties in the construction process and share project information in a meaningful way”.

The relative importance index for item 6.3 “Entering a partnership relationship with suppliers and subcontractors based on commitment over extended time period, mutual information sharing, trust, openness, dedication to common goals” is medium (0.854) and with rank equal (4). The result shows that the contractors do not fully aware of the importance of the

partnership in integrating the project participants. Also the finding of section 4.5.1 table 4.11 indicated that partnership ranked 6 out of 9 criteria provided to the respondents to rank them in order of their importance. This may refer to fact that partnership is a new concept in the local construction industry and many contractors even do not hear about it. The results also indicate the relationship between the contractors, suppliers and subcontractors is project-focused with short term perspective.

The relative importance index for item 6.10 "Aligning the system and procedures of your own company with that of the client, suppliers and subcontractors" is high (0.842) with ranks equal (5). The respondents gave high degree for this factor. Existence of the unified, clear and understandable system for communication and sharing project information will reduce the uncertainties and will enhance the integration between the project parties. For example, there should unified forms that all the involved parties agreed upon for testing and approving materials, ordering materials from suppliers, documenting any damage in the delivered materials and the like. One of the findings of the case studies conducted by Briscoe and Dainty (2005) pointed out it is very important for an efficient supply chain that owners, contractors, subcontractors and suppliers to have an alignment systems and procedures.

The relative importance index for item 6.7 "The participation of the designers should not end at the design phase but continues during construction phase" is high (0.806) with rank equals (6). The respondents gave this factor high degree since this factor integrates the design phase with the construction phase. During the project implementation many problems may arise because of ambiguities in the project documents. The finding of this study section 4.6.1 Table 4.15 indicated that one of problems encountering contractors during the bidding phase is ambiguities between plans and specifications. Despite that such problem existed in bidding phase; it is always detected in the construction phase. If the problem is not solved immediately once it is uncovered, the works on the site will be stopped and the project will be delayed accordingly. Therefore the participation of the designers in the construction phase will contribute in solving many of problems that could arise during the project implementation. Villagarcia and Cardoso (1999) indicated that the participation of designers

do not end at design phase but should continue during the construction phase; there is not a break between these phases, they support each other till the end of the project.

The relative importance index for item 6.12 “Using Web Based system for information access and exchange between the project participants that include memos, request for information, transmittal, site instruction, etc” is medium (0.766) and with rank equal (7). The result shows that some of the contractors still don’t aware of the importance of using the web-site system for information sharing among the project participants. Trucker et al. (2001) pointed out that a web-based system can be used to instantly share, visualize, and communicate project information between any project participants including staff, clients, consultants, subcontractors and suppliers. The internet fosters the integration of construction process across the construction supply chain by facilitating the information flows necessary for coordinating construction activities.

The relative importance index for item 6.6 “Negotiating contracts with the supplier and subcontractors rather than using competitive tendering” is high (0.682) and with rank equals (8). The top concern criteria for suppliers and subcontractors selection is price as shown in section 4.5.1 Table 4.11. However, many contractors believe that negotiation contracts with suppliers and subcontractors are important for achieving integration between the project participants.

The relative importance index for item 6.5 “Executing the projects activities by the contractors own sources (Not sourcing the entire project to subcontractors)” is medium (0.652) and with rank equals (9). The contractors gave medium importance for executing the project activities by their own sources. Briscoe and Dainty (2005) pointed out a continued reliance on a fragmented and largely subcontracted works has arguably of the supply chain and delimited opportunities for process integration.. The result reveals that some contractors are not fully aware of the importance of executing the project by their own resources. As stated in the problem statement of this thesis, dependency of the main contractors on the sub contractors increases the project fragmentation and uncertainties.

The relative importance index for item 6.2 “Using design construct arrangement between the contractor and the client” is low (0.522) and with rank equal (12). The respondents gave this factor little importance. This may be due to the fact that contractors are not familiar with design construct arrangement. One of the advantages of the design construct arrangement is integrating the design phase with the construction phase and minimizing the adversarial relationship inherent in the traditional arrangement. As indicated in the literature of this research that design-construct arrangement is one of the integration approaches and strategies used to overcome the construction industry fragmentation.

## **CHAPTER FIVE**

### **5 MATERIALS SUPPLY CHAIN PROCESS FRAMEWORK**

The main aim of this framework is to enable contractors to deliver the right materials, in the right quality, in the right time with minimal cost through controlling the material supply chain through the project phases as an integrated process-oriented approach rather than a series of individual activities or activity-centered approach.

The framework is developed based on the study by Perdomo (2004) and other literature review and the findings of the questionnaire. The framework is designed to include all the project's phases which are: bidding phase, sourcing phase, procurement phase, construction phase, post-construction phase and finally the evaluation phase. Each phase contains the process or the step that contractors should consider, most occurred problems that encounter contractors and the possible solutions for them, the integrating factors of material supply chain process and finally the decision nodes that may raised in any phase. A graphical representation for the material supply chain process (MSCP) is shown in.

#### **5.1 Bidding Phase**

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

##### **5.1.1 Process**

1. Identifying the needed materials for each item once the project's drawings and specifications are received
2. Estimating the quantity of the needed materials per each item (quantity take off)
3. Defining any special requirements and/or special materials to be used in the project
4. Classifying the materials that are off-the-shelf and the major materials that need to be prefabricated

5. Identifying the local available materials or locally manufactured materials and the materials that are needed to be imported
6. Using software packages or computer applications such as Microsoft Excel for preparing the estimate
7. Involving the project manager or construction team in the estimation process in order to prepare a realistic estimate
8. Estimating the project cost using the prices of suppliers or manufacturers
9. Verifying the prices used in the estimate prior to submitting the bid
10. Scheduling a meeting that includes the project manager and the construction team to re-estimate the project quantities once you win the bid
11. Generating a preliminary material requisition schedule, specifying material types, quantity needed, dates, when the material should be delivered and any additional information needed for clarification

### 5.1.2 Problems Encountered

Table 5.1 shows the most frequently occurring problems encountering contractors during the bidding phase and the possible solutions for them.

**Table 5.1: Problems Encountered During the Bidding Phase and Possible Solutions**

| Encountered Problems                                                                     | Possible Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lack of communication between the parties involved                                       | <u>Contractors Should</u> <ul style="list-style-type: none"> <li>- Establish internet-based communication system to integrate the involved parties in the estimation process and enabling them to have an access to project data and to share project information.</li> <li>- Using special forms for data sharing and communication</li> <li>- Build good relationship with the owners, suppliers and subcontractors based on trust and exchange of information.</li> </ul> |
| Ambiguities between plans and specifications and Incomplete drawings and missing details | <u>Consultants Should</u> <ul style="list-style-type: none"> <li>- Give more focus and attention when preparing the tender documents in order to be clear and understandable.</li> </ul> <u>Contractors Should</u> <ul style="list-style-type: none"> <li>- Study the tender documents carefully</li> <li>- Request more information and clarifications from</li> </ul>                                                                                                      |

|  |                                                                                                                                                                                                                                                       |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>the client in case there are ambiguities between plans and specifications.</p> <ul style="list-style-type: none"> <li>- Solve ambiguities in advance as they arise otherwise it will interrupt the works during the construction phase.</li> </ul> |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### 5.1.3 Key Integrating Factors

1. The design team should be expanded such that to include contractors, subcontractors and suppliers. This could be done after winning the contract.
2. Entering a partnership relationship with clients based on mutual information sharing, trust, openness, and dedication to common goals.
3. Understanding the client needs and objectives
4. Establishing a protocol with the owner for dealing effectively with disputes and problems.
5. Establishing a system with the owner for communication and share project information in timely and accurate manner.

## 5.2 Sourcing Phase

### 5.2.1 Process

1. Pre-qualifying the suppliers and keep lists of the reputable suppliers
2. Verifying that the supplier is capable of delivering the right materials (type, quality and quantity) when needed (i.e. at dates specified)
3. If materials are provided by specified suppliers; these materials need to be acquired from those suppliers by negotiation
4. If there is 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 with on previous projects.

6. Selecting the winner supplier based on 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.

### 5.2.2 Problems Encountered

Table 5.2 shows the most frequently occurring problems encountering the contractors during the sourcing phase and the possible solutions for them.

**Table 5.2: Problems Encountered During the Sourcing Phase and Possible Solutions**

| Encountered Problems                                                                | Possible Solution                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Incomplete proposal (Suppliers did not include all the documents with the proposal) | <u>Contractors Should</u> <ul style="list-style-type: none"><li>- Improve their communication with the suppliers via using special forms</li><li>- Use website information system for transferring the information</li><li>- 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, his offer will be rejected.</li></ul> |

### 5.2.3 Key Integrating Factors

1. Entering a partnership relationship with suppliers and subcontractors based on commitment over extended time period, mutual information sharing, trust, openness and dedication to common goals.
2. Negotiating contracts with the suppliers and subcontractors rather than using competitive tendering.

#### 5.2.4 Decision Node

Out of the sourcing phase there is a decision related to “what is the procurement method to use?” that a contractor should take. Table 5.3 shows the alternatives for this decision, parameters and the performance measures.

Table 5.3: Sourcing Phase Decision

| Decision                        | Alternative                                                                                 | Parameters                                                                                                                                                                                                                                                                                                   | Performance Measures                                                                                                                                      |
|---------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| What is the procurement method? | <ul style="list-style-type: none"><li>- Competitive Bidding</li><li>- Negotiation</li></ul> | <ul style="list-style-type: none"><li>- Materials availability</li><li>- Number of suppliers</li><li>- Uncertainty in project schedule</li><li>- Criticality of the materials</li><li>- Costs</li><li>- Location of the project</li><li>- Location of supplier</li><li>- Past supplier performance</li></ul> | <ul style="list-style-type: none"><li>- Projected shortages</li><li>- Quality</li><li>- Quantity</li><li>- Costs</li><li>- Long term commitment</li></ul> |

### 5.3 Procurement Phase

#### 5.3.1 Process

1. Obtaining a copy of the material requisition schedule, specifying material types, quantity needed, dates and when the material should be delivered that was prepared by site personnel.
2. Verifying the availability of requested materials stocks before requesting additional materials from the suppliers.
3. Requesting a submittal (material sample) from the supplier or manufacturer and approving it by the Engineer prior to materials delivery
4. Issuing purchase order to the winner supplier (setting an agreement) in order to organize the relationship between the contractor and the supplier
5. Ordering 100% of the estimated items 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 the suppliers the release dates at which the material is needed and the exact location of materials delivery to avoid materials re-handling

7. Following up the status of the ordered materials to make sure that the delivered materials comply with the specifications, in the quantities needed and within the time frame specified.

### 5.3.2 Problems Encountered

Table 5.4 shows the most frequently occurring problems encountering contractors during the procurement phase and the possible solutions for them. Although some of the problems may be detected in the procurement phase, the root causes of this problem may lie in the previous phases (sourcing phase) by other actors. Thus, the solutions for these problems will be provided where they are detected and where they may lie.

**Table 5.4: Problems Encountered**

| Encountered Problems                            | Possible Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Poor communication between the parties involved | <u>Contractor should</u> <ul style="list-style-type: none"> <li>- Have an access to contract data, project scheduling as well as means to communicate delivery instruction to the personnel on site in order to perform tasks</li> <li>- Develop internet-based communication system to place orders</li> <li>- Follow up the status of the ordered materials in order to make sure that the materials arrive to the job site in the quantities and date specified.</li> </ul> |
| Unavailability of required material             | <u>Contractor should</u> <ul style="list-style-type: none"> <li>- Not rely only on lowest price to award the contract during the sourcing phase but should also consider other factors such as availability of the materials.</li> <li>- Use buffer time for ordering the materials to safeguard against uncertainties during the construction phase.</li> </ul>                                                                                                               |
| Incorrect submittals by the suppliers`          | <u>Contractor should</u> <ul style="list-style-type: none"> <li>- Pre-qualify the suppliers</li> <li>- Obtain quotations from reputable suppliers and whom they worked with on previous projects</li> <li>- Send a letter of a complaint to the defaulted suppliers. Such an official letter will be a good document to such problem and puts the contractor in a better bargaining position if there will be a need for dispute resolution at later stage.</li> </ul>         |

| Encountered Problems                                  | Possible Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Late approval of submittal by the Supervisor Engineer | <u>Contractor should</u> <ul style="list-style-type: none"> <li>- Specify with the owner the approval period for submittal if there are no related clauses in the project general conditions.</li> <li>- Follow up the status of material submittal approval during the construction phase</li> <li>- Send a letter of a complaint to the owner in case there is a late approval by the engineer</li> <li>- 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 for.</li> </ul> |

### 5.3.3 Key Integrating Factors

1. Aligning the system and procedures of your own company with that of the suppliers
2. Establishing a contract agreement with the suppliers and subcontractors for dealing effectively with disputes and problems that may arise during the course of project implementation
3. Establishing a system with the suppliers and subcontractors for communication and share project information in timely and accurate manner

### 5.3.4 Decision Node

Out of the procurement phase there are three decisions related to “when to order materials?”, “how much to buy?” and “what is the minimum buffer stocks needed?” that a contractor should make. Table 5.5 shows the alternatives for these three decisions, parameters and the performance measures.

**Table 5.5: Procurement Phase Decisions**

| Decision                 | Alternative                                                                                                                                                                                                                                                                                                                                                                                                                               | Parameters                                                                                                                                                                                                                                                                                                                                                          | Performance Measures                                                                                                                           |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| When to order materials? | <b>for local materials in normal conditions</b> <ul style="list-style-type: none"> <li>- 1 to 2 days in advance</li> <li>- 3 to 5 days in advance</li> <li>- 1 week in advance</li> <li>- 2 weeks in advance</li> </ul> <b>For local materials in unstable conditions</b> <ul style="list-style-type: none"> <li>- 1 week in advance</li> <li>- 2 weeks in advance</li> <li>- 3 weeks in advance</li> <li>- 1 month in advance</li> </ul> | <ul style="list-style-type: none"> <li>- Type of materials</li> <li>- Project schedule</li> <li>- Storage capacity</li> <li>- Location of the supplier</li> <li>- Criticality of materials</li> <li>- Location of the project</li> <li>- Location of supplier</li> </ul>                                                                                            | <ul style="list-style-type: none"> <li>- Projected shortages</li> <li>- Inventory</li> <li>- Direct costs</li> <li>- Indirect costs</li> </ul> |
| How much to buy?         | <ul style="list-style-type: none"> <li>- As estimated</li> <li>- Less than estimated</li> <li>- More than estimated</li> </ul>                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>- Project schedule</li> <li>- Storage capacity</li> <li>- Location of the supplier</li> <li>- Installation rate and usage</li> <li>- Location of the project</li> <li>- Procurement cost rates</li> <li>- Imported materials vs. locally available materials</li> <li>- Stable conditions vs. unstable conditions</li> </ul> | <ul style="list-style-type: none"> <li>- Projected shortages</li> <li>- Inventory</li> <li>- Direct costs</li> <li>- Indirect costs</li> </ul> |

## 5.4 Construction Phase

### 5.4.1 Process

1. Determining the quantities of the needed materials per each item
2. Determining dates in which the materials per each item are needed to be available
3. Determine the exact materials delivery location per each item
4. Generating a material requisition form in which the material description, quantities needed, dates when the materials are needed and the delivery locations

5. Verifying the material received against the quantity ordered
6. Inspecting the delivered materials to make sure that it meets the specifications
7. Recording any problem in the delivered materials
8. Keeping a track record of the supplied materials, remaining balance and the installed materials

#### 5.4.2 Problems Encountered

Table 5.6 shows the most frequently occurring problems encountering contractors during the construction phase and the possible solutions for them. Although some of the problems may be detected in the construction phase, the root causes of this problem may lie in the previous phases (sourcing phase and procurement phase) by other actors. Thus, the solutions for these problems will be provided where they are detected and where they may lie.

**Table 5.6: Problems Encountered During**

| Encountered Problems                                                                                                              | Possible Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Late deliveries (Materials do not arrive as scheduled) and The delivered materials do not comply with the required specifications | <p><u>Contractors should</u></p> <p><u>In the Sourcing Phase</u></p> <ul style="list-style-type: none"> <li>- Pre-qualify the suppliers</li> <li>- Make sure that they are capable of delivering the right material in the right quantities and in the time specified.</li> <li>- Consider the suppliers with higher prices but who provide better services and not to select the suppliers based on the lowest prices.</li> </ul> <p><u>In the Procurement Phase</u></p> <ul style="list-style-type: none"> <li>- Set out agreement with the suppliers showing the duties and responsibilities of each party.</li> <li>- Impose penalty charges in case the supplier make late deliveries or deliver materials that do not meet the required specifications.</li> </ul> <p><u>In the construction phase</u></p> <ul style="list-style-type: none"> <li>- Keep buffer stocks on site enough for an operation for certain days to safeguard against the uncertainties inherent in the construction industry.</li> <li>- Order materials in advance by certain days prior starting</li> </ul> |

|                                                 |                                                                                                                               |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
|                                                 | the activity to safeguard against late deliveries.                                                                            |
| Poor communication between the parties involved | <u>Contractors should</u><br>- Establish a system for exchanging information and sharing data among the project participants. |

### 5.4.3 Key Integrating Factors

1. The participation of the designers should not end at the design phase but continues during construction phase
2. Establishing a system between the project participants for communication and share project information in timely and accurate manner

### 5.4.4 Decision Node

Out of the construction phase there is a decisions related to “where to deliver the materials?” that a contractor should make. Table 5.7 shows the alternatives for this decision, parameters and the performance measures.

**Table 5.7: Construction Phase Decisions**

| Decision          | Alternative              | Parameters                                                                                                                                                                       | Performance Measures                                        |
|-------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Where to deliver? | - Jobsite<br>- Warehouse | - Project schedule<br>- Uncertainty in project schedule<br>- Storage capacity<br>- Immediate installation<br>- Costs<br>- Location of the project<br>- Location of the warehouse | - Projected shortages<br>- Quality<br>- Quantity<br>- Costs |

## 5.5 Post-Construction Phase

### 5.5.1 Process

After completing the project, contractors have to manage the surplus materials.

- Storing the surplus materials to be used in the future projects if there is a warehouse for the contractor
- Returning back the surplus materials to the suppliers without penalty

- Returning back the surplus materials to the suppliers with penalty
- Selling the surplus materials to the other contractors

### **5.5.2 Problems Encountered**

As per the findings of the questionnaire section 4.6.5, almost there is no problem facing contractors during the post-construction phase.

### **5.5.3 Key Integrating Factors**

Entering a partnership relationship with suppliers can secure returning back the surplus materials without charging penalties.

### **5.5.4 Decision Node**

Out of the post construction phase there is a decision related to “what to do with the surplus materials” that a contractor should make. Table 5.8 shows the alternatives for this decision, parameters and the performance measures.

**Table 5.8: Post-Construction Phase Decis**

| <b>Decision</b>                        | <b>Alternative</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>Parameters</b>                                                                                                                                                                                                    | <b>Performance Measures</b>                                                                                                                                                |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| What to do with the surplus materials? | <ul style="list-style-type: none"> <li>- Storing the surplus materials to be used in the future projects</li> <li>- Returning back the surplus materials to the suppliers without penalty</li> <li>- Returning back the surplus materials to the suppliers with penalty</li> <li>- Selling the surplus materials to the other contractors</li> <li>- Scraping the surplus materials</li> </ul> | <ul style="list-style-type: none"> <li>- Space availability In warehouse</li> <li>- Expected need for the materials in the future projects</li> <li>- Actual need for the material in an existing project</li> </ul> | <ul style="list-style-type: none"> <li>- Projected shortages</li> <li>- Inventory costs</li> <li>- Damage</li> <li>- Penalty costs</li> <li>- Opportunity costs</li> </ul> |

## 5.6 Evaluation Phase

Contractors have to measure the performance of their decisions they took during the MSCP. For example, the decision of “how much materials to buy” that may be raised during the procurement phase involves four scenarios which are: 100% of the estimated quantities, less than the estimated quantities, more than the estimated quantities and quantities in accordance with the work progress on the site. Contractors have to measure the performance of the decision they chose in terms of schedule (time) direct and indirect cost and surplus materials. Such evaluation will create knowledge for the contractors that could be used to improve their decisions making in the future projects.

### 5.7. Graphical Representation of the Material Supply Chain Process

This section presents a graphical representation for the Material Supply Chain Process.

The steps presented on the above narrative description, are described in the in Figure 5.

The description is based on the sub-section numbers assigned to the narrative description

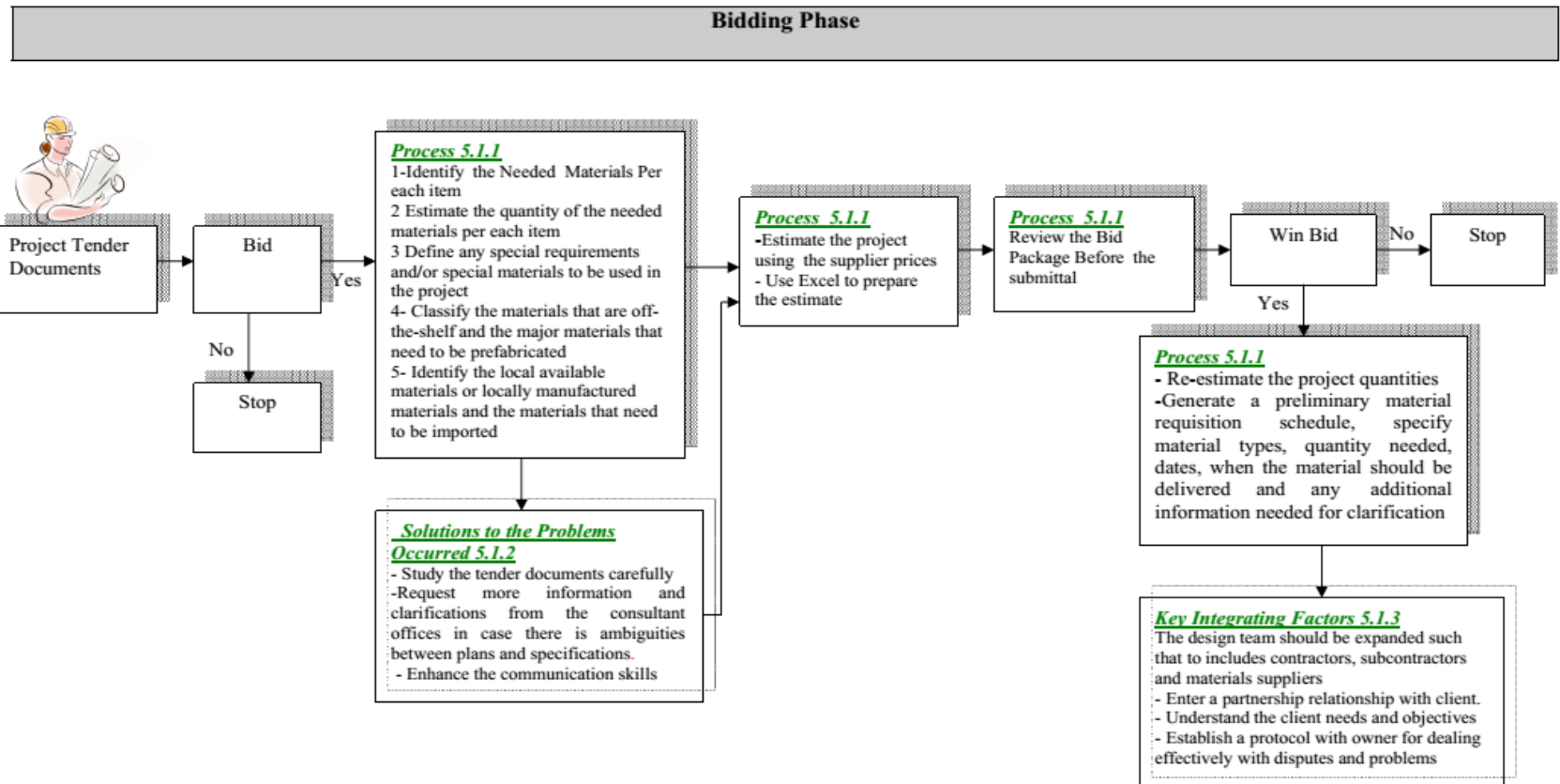


Figure 5.1.A: Material Supply Chain Process Framework (Bidding Phase)

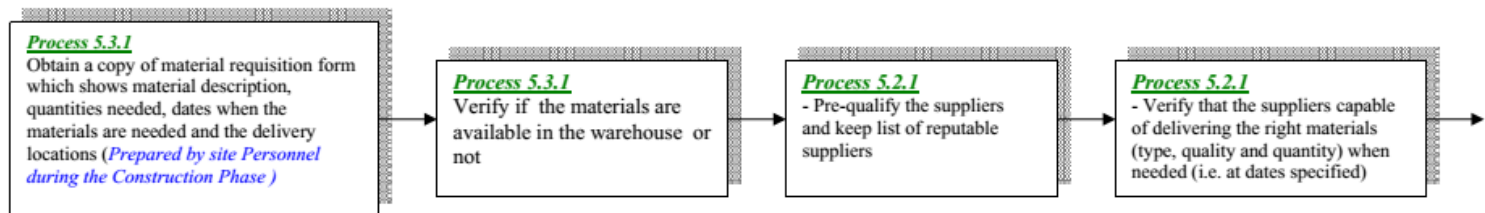


Figure 5.1.B: Material Supply Chain Process Framework (Procurement and Sourcing Phase)

## Sourcing Phase

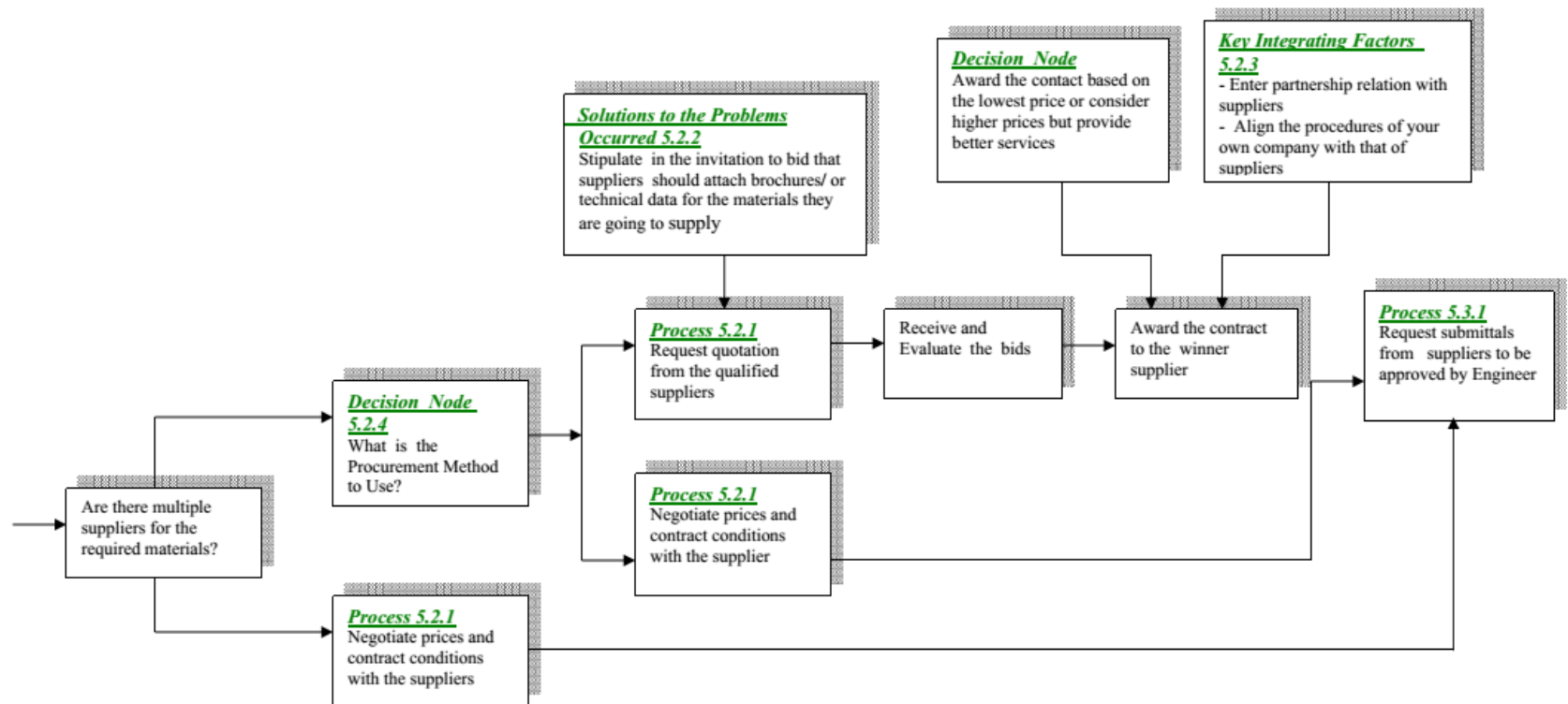


Figure 5.1.C: Material Supply Chain Process Framework (Sourcing Phase)

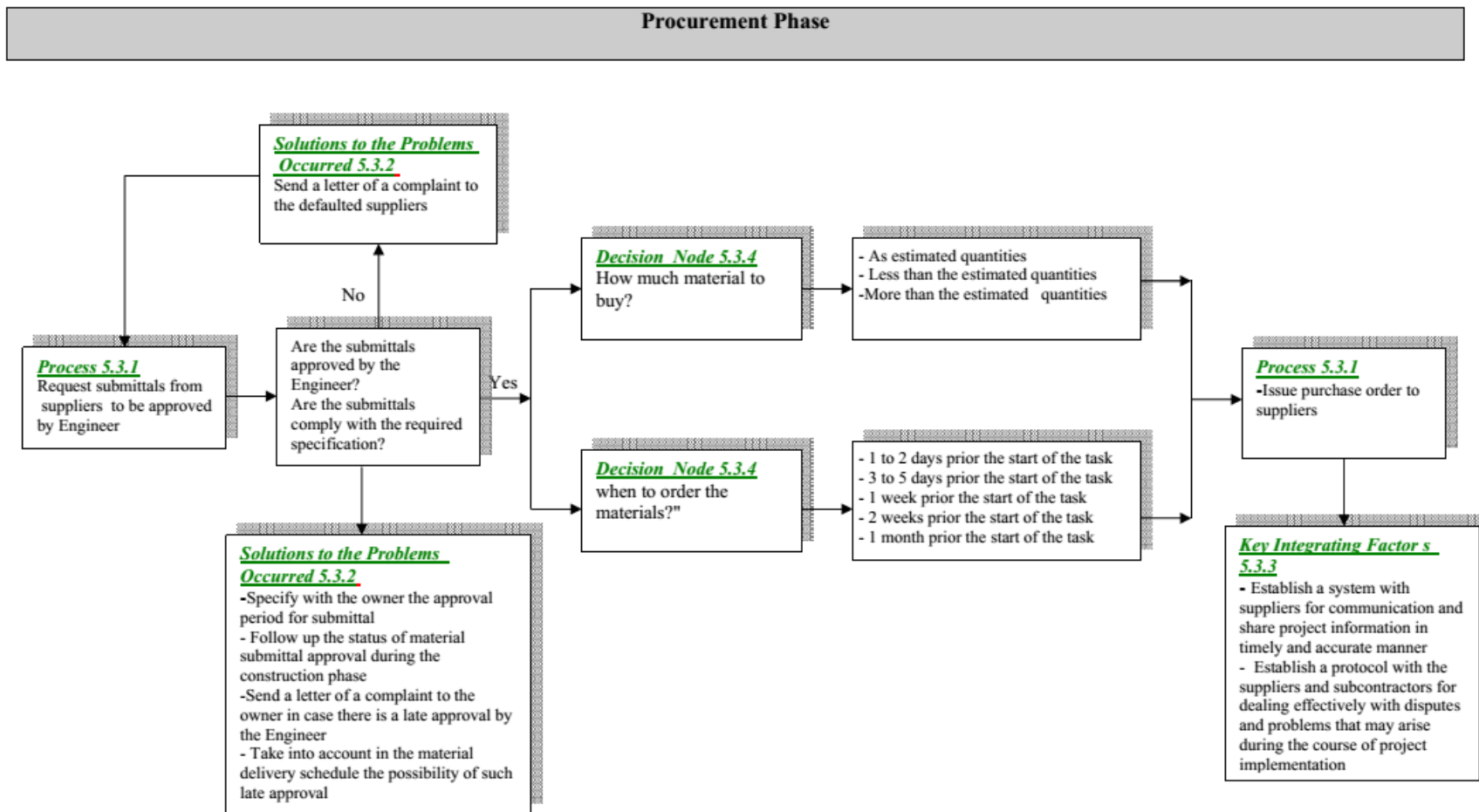
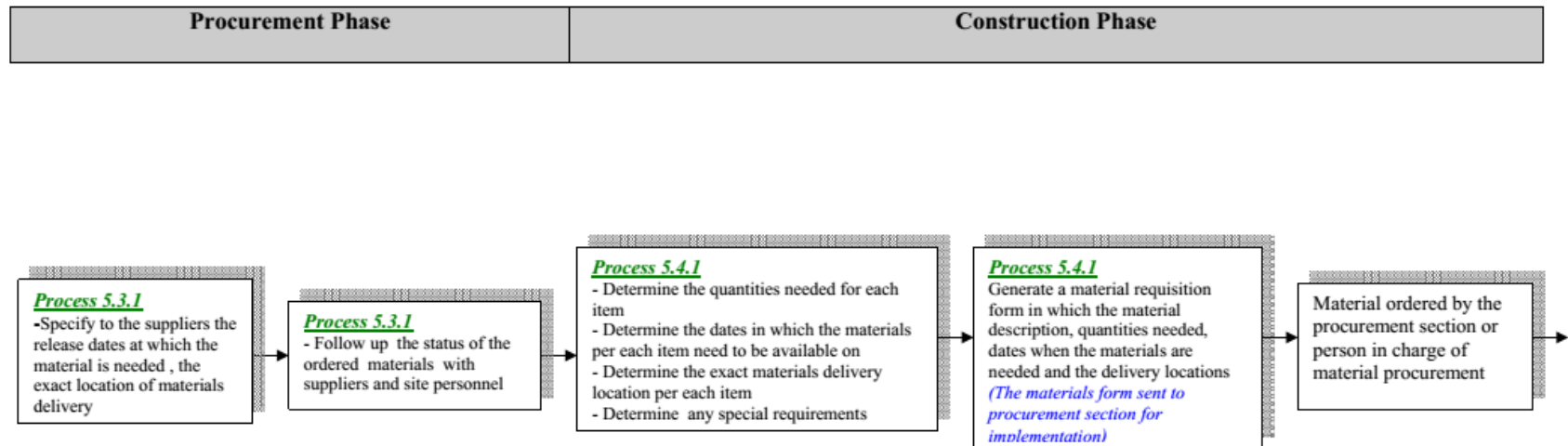
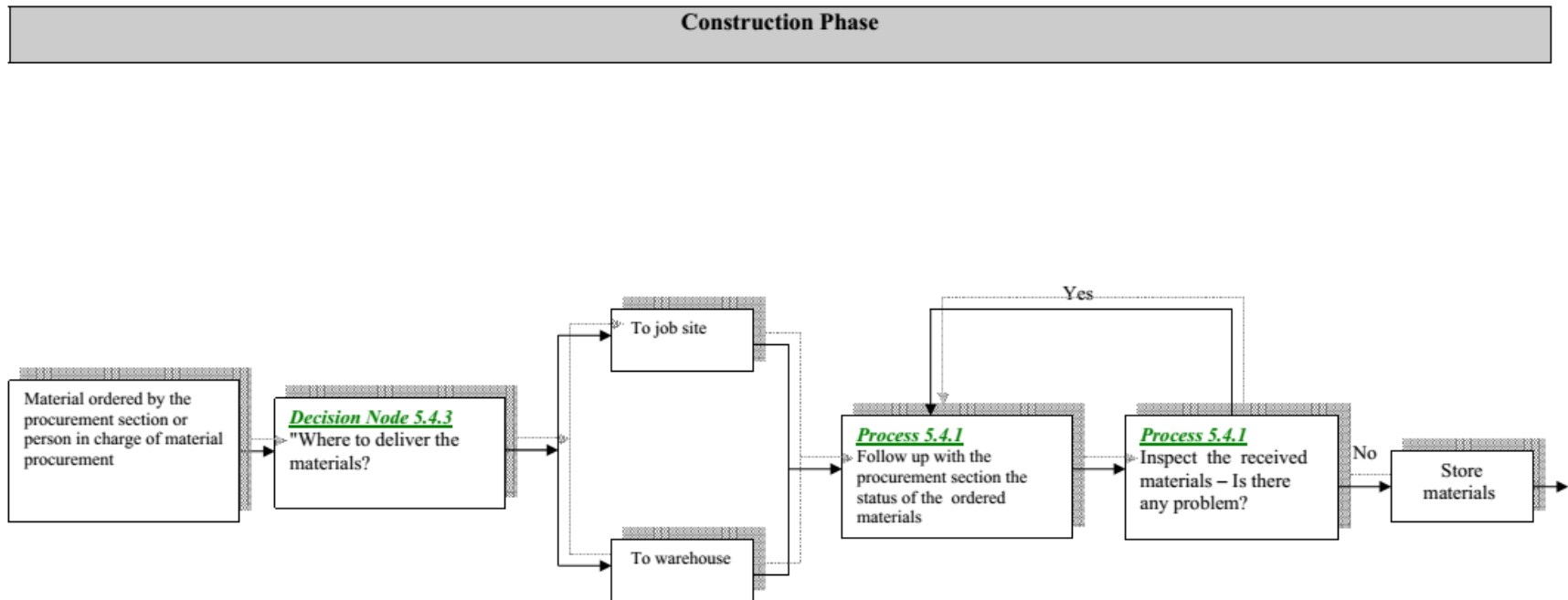


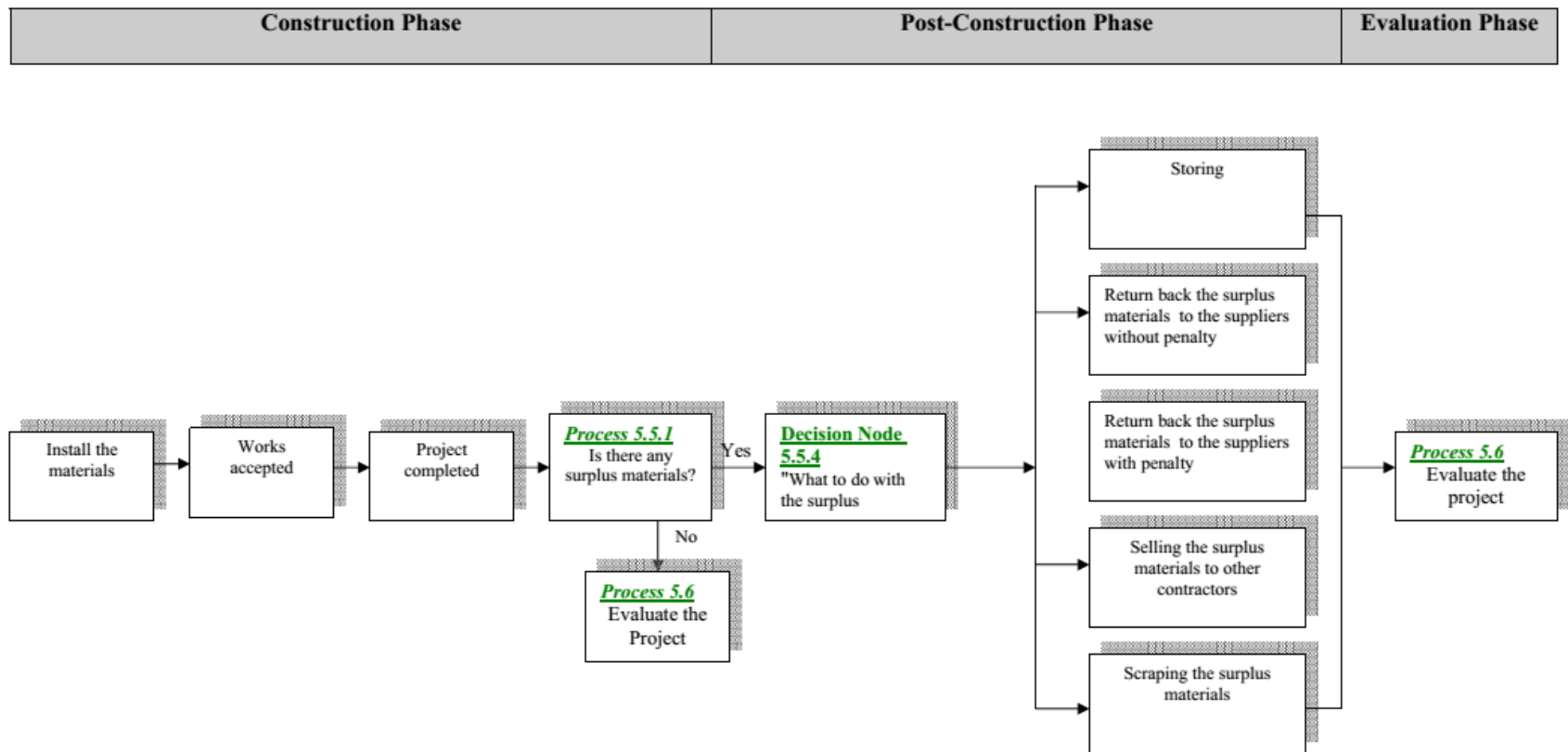
Figure 5.1.D: Material Supply Chain Process Framework (Sourcing Phase)



**Figure 5.1.E: Material Supply Chain Process Framework (Procurement and Construction Phase)**



**Figure 5.1.F: Material Supply Chain Process Framework (Construction Phase)**



**Figure 5.1.G: Material Supply Chain Process Framework (Construction Phase, Post- Construction and Evaluation Phase )**

## **CHAPTER SIX**

### **6 CONCLUSION AND RECOMMENDATIONS**

#### **6.1 Conclusion**

Construction industry has been characterized with fragmentation and poor communication and coordination among the project participants. There are many inter-organizational problems, such as late deliveries of materials, wrong deliveries and inaccurate information transfer in materials supply chain process, which result in miss performance. 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 primary aim of this research was to develop a material supply chain process framework that enables contractors to have the materials needed, in the right quantities, with the quality and time required .this was accomplished through achieving the following objectives:

- Studying the current practices of the MSCP and the important factors that constitute it. It has been concluded that MSCP comprises six phases which are bidding phase, sourcing phase, procurement phase, construction phase, post construction and evaluation phase. Each phase contains a set of activities that should be viewed as integrated activities rather than only a series of individual activities.
- Studying contractor/supplier relationship. It has been found that the contractor supplier relationship is based on project by project basis. Most of the contractors do not form long term agreement or partnership with the suppliers. Competitive pricing is the most important criteria adopted for selection of the suppliers and it is primarily based on the lowest price. Contractors are obscured by price and have generally overlooked the bigger picture of the total costs. Selection of supplier based on long term agreement or relationship is one of the fundamentals of MSCP concept. Furthermore, contractors prefer to send a letter of complaint in case suppliers deliver

wrong materials or make late deliveries, and they do not prefer imposing penalty charges.

- Identifying the most frequently occurring problems facing contractors through the MSCP, diagnosing the root cause of these problems and developing possible solutions for them. It has been found the most occurred problems encountering the contractors were:

#### **Bidding phase**

- Lack of the communication between the parties involved
- Ambiguities between plans and specifications
- Incomplete drawings and details are missing

#### **Sourcing phase**

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

#### **Procurement phase**

- Poor communication between the parties involved
- Unavailability of required material
- Incorrect of submittals by the suppliers
- Late approval of submittal by the supervisor Engineer

#### **Construction phase**

- Late deliveries (materials do not arrive as schedules)
- The delivered materials do not comply with the required specifications
- Poor communication between the parties involved

It has been found that most of the problems are caused in another (i.e. earlier) stage of the MSCP other than where they are detected. The root causes of the most occurred problems are found in previous activity executed by a prior actor.

- Determining the key factors that may contribute in integrating the project phases of MSCP. It has been found that the most factors that contribute in integrating the project phases of the MSCP are:
  - Understanding the client needs and objectives by the contractor, subcontractors and suppliers and committing for these needs and objectives
  - Establishing a protocol for dealing effectively with disputes and problems that may arise between the project participants during the course of project implementation
  - Establishing a system between the project participants for communication and share project information in timely and accurate manner
  - Negotiating contracts with the suppliers and subcontractors rather than using competitive tendering
  - The participation of the designers should not end at the design phase but continues during construction phase.

## **6.2 Recommendations**

The following recommendations are based on the conclusions drawn from the survey results and the literature outcomes.

- Project participants are encouraged to deal with the activities that form the material supply chain process as integrated ones rather than a series of separated activities. Each participant should consider the impact of his activities and behaviors on the other activities in the chain.
- Contracting companies are recommended to adopt new techniques for selecting the suppliers other than the competitive bidding that usually creates adversarial relationship. They are urged to set up partnership agreement with the suppliers based on a win-win relationship.
- Internal coordination is an important prerequisite for successful MSCP. Internal integration involves achieving seamless integration of organizational functions (logistics, operation, etc) facilitated by reorganizing the organizational structure around key business processes

- All project participants include owner, contractor, supplier and subcontractor are recommended to work in a cooperative environment and should commit to good faith and fair dealings with other partners
- Contracting companies are recommended to develop web based information technology system for information sharing among the project participants.
- The Universities, the Engineering Syndicate recommended through conducting training courses and workshops to:
  - Increase the awareness of the value of information and communication technology to bring together the major parties in the construction process
  - Increase the awareness of mutual benefits of applying the supply chain management among the project participants
- Contracting firms are encouraged to change their cultural issues that resist change and are invited to adopt new strategic management/planning.

### **6.3 Recommendations for Further Studies**

This research establishes the knowledge and bases for reengineering the current practices for the material supply chain process for the construction oromia water supply construction projects

The research provides a framework for the material supply chain. The implementation of framework will help contractors to have the materials needed, in the quantities needed, with the quality required and the time that they are needed. This framework did not consider all the issues related to the MSCP; however, it serves as the basis for the future researches in the same field. Following are suggested research:

- Research to study possible procurement methods, other than awarding the contract to the lowest bidder.
- Research to study the impact of information technology on the construction industry
- Research to study the factors that hinder the application of the SCM
- Research to develop the website as an integrated tool for project planning
- Research to study the supply chain management from the client perspective
- Research to study management of inventories
- Research to develop decision models for procurement

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## **7 Appendix 1 the Questionnaire**

**Dear Contractors**

**Reference: Dissertation-MSc Construction Management**

I am currently undertaking a Master of Science Degree in construction management at the Adama Science and Technology University. In fulfillment of this dissertation I am required to research a topic area and produce a dissertation. The topic I have chosen is construction supply chain management in the water supply construction projects in oromia Materials process Framework.

Through this questionnaire, I am investigating the following:

1. Company Profile
2. The current practices of material supply chain process through the project phases in the local construction industry
3. The contractors/supplier relationship
4. The most serious problems encountered the contractors through the project phase in order to find possible solution for them later on
5. The key factors that are considered necessary for successful integration of the construction supply chain through the project phases as well as the project main players the information provided will be used only for the above mentioned objectives, and will be treated with strict confidence and individual firms will not be identified. The results of the study will be provided to you for the benefit.

**Researcher**

**Tesfaye Mamo**

**Supervisor**

**Dr. EngWubishetJekale**

### Section one-Company Profile

Please respond to the following questions by either ticking the appropriate box or by writing your answer in the space provided.

1.1 Company Establishment year:\_\_\_\_\_

1.2 Company classification (Grade)

☐\_\_\_\_\_

1.3 Respondent position in the company

☐ Project Manager

☐ Site Engineer

☐ Other, Please

Specify\_\_\_\_\_

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

☐ Company Director

☐ Project Manager

☐ Site Engineer

☐ Procurment

Section

☐ Other, Please Specify\_\_\_\_\_

## Section Two- Current practices of material supply chain process

2.1 Below is material supply chain process through the various phase of project. Please choose your practice to each statement and then express your opinion on how important each one on the material supply chain process. Please tick the appropriate all.

| Item No. | Material supply chain process                                                                                | Usage  |       |      |        |       |      | Importance |       |      |        |           |
|----------|--------------------------------------------------------------------------------------------------------------|--------|-------|------|--------|-------|------|------------|-------|------|--------|-----------|
|          |                                                                                                              | Always | Often | Some | Seldom | Never | Very | Important  | Quite | Semi | Little | Important |
| no       | <b>Phase 1: Bidding phase (Estimate, preparation &amp; Submission</b>                                        |        |       |      |        |       |      |            |       |      |        |           |
| 1.1      | Identifying materials for each item once receive drawings and specifications                                 |        |       |      |        |       |      |            |       |      |        |           |
| 1.2      | Estimating the quality of materials per each item                                                            |        |       |      |        |       |      |            |       |      |        |           |
| 1.3      | Defining any special requirements materials to be used                                                       |        |       |      |        |       |      |            |       |      |        |           |
| 1.4      | Classifying the materials that are off-the-shelf and to be prefabricated                                     |        |       |      |        |       |      |            |       |      |        |           |
| 1.5      | Identifying the local available and to be imported                                                           |        |       |      |        |       |      |            |       |      |        |           |
| 1.6      | Using computer applications for preparing the estimate                                                       |        |       |      |        |       |      |            |       |      |        |           |
| 1.7      | Involving the project construction team in the estimation                                                    |        |       |      |        |       |      |            |       |      |        |           |
| 1.8      | Establishing prices database for the materials from the previous projects to be used for the future projects |        |       |      |        |       |      |            |       |      |        |           |
| 1.9      | Depending on price of suppliers on preparing the project estimate                                            |        |       |      |        |       |      |            |       |      |        |           |
| 1.10     | Verifying the prices used in the estimate prior to the bid                                                   |        |       |      |        |       |      |            |       |      |        |           |
| 1.11     | Scheduling a meeting that includes contraction team to re-estimate the project quantities after win the bid  |        |       |      |        |       |      |            |       |      |        |           |
| 1.12     | Generating a preliminary materials requisition schedule, for material types, quantity needed, dates,         |        |       |      |        |       |      |            |       |      |        |           |

| Item No. | Material supply chain process                                                                                                  | Usage  |       |            |        |       |                | Importance |                 |                |                  |
|----------|--------------------------------------------------------------------------------------------------------------------------------|--------|-------|------------|--------|-------|----------------|------------|-----------------|----------------|------------------|
|          |                                                                                                                                | Always | Often | Some times | Seldom | Never | Very Important | Important  | Quite Important | Semi Important | Little Important |
|          | <b>Phase 2: Sourcing (Vendor selection)</b>                                                                                    |        |       |            |        |       |                |            |                 |                |                  |
| 2.1      | Pre-qualify and list of reputable suppliers and manufacturers                                                                  |        |       |            |        |       |                |            |                 |                |                  |
| 2.2      | Verifying that the suppliers delivering the right materials and right time                                                     |        |       |            |        |       |                |            |                 |                |                  |
| 2.3      | Purchasing materials from supplierst you worked with on previous projects                                                      |        |       |            |        |       |                |            |                 |                |                  |
| 2.4      | Requesting different suppliers in order to get good prices                                                                     |        |       |            |        |       |                |            |                 |                |                  |
| 2.5      | Selecting the winner supplier based on lowest prices                                                                           |        |       |            |        |       |                |            |                 |                |                  |
| 2.6      | Considering suppliers with higher prices provide better services right materials at the times specified                        |        |       |            |        |       |                |            |                 |                |                  |
| 2.7      | Negotiating the prices with the suppliers                                                                                      |        |       |            |        |       |                |            |                 |                |                  |
|          | <b>Phase 3: Material Procurement</b>                                                                                           |        |       |            |        |       |                |            |                 |                |                  |
| 3.1      | Obtaining a copy the material requisition schedule, specifying material types, quality, dates, that prepared by site personnel |        |       |            |        |       |                |            |                 |                |                  |
| 3.2      | Verifying availability of requested materials in stocks before requesting suppliers                                            |        |       |            |        |       |                |            |                 |                |                  |
| 3.3      | Requesting a submittal from supplier and approving it by the engineer prior to delivery                                        |        |       |            |        |       |                |            |                 |                |                  |
| 3.4      | Issuing purchase order to the winner supplier (setting an agreement)                                                           |        |       |            |        |       |                |            |                 |                |                  |
| 3.5      | Requesting materials directly by the field personnel                                                                           |        |       |            |        |       |                |            |                 |                |                  |
| 3.6      | Order 100% of items quantities at once                                                                                         |        |       |            |        |       |                |            |                 |                |                  |
| 3.7      | Ordering item quantities as per the work progress on site                                                                      |        |       |            |        |       |                |            |                 |                |                  |
| 3.8      | Specifying to the suppliers the release dates and the location of materials delivery                                           |        |       |            |        |       |                |            |                 |                |                  |
| 3.9      | Following up ordered materials delivered materials comply with the specifications                                              |        |       |            |        |       |                |            |                 |                |                  |

| Item No. | Material supply chain process                                                                                                     | Usage  |       |            |        |       | Importance     |           |                 |                |                   |
|----------|-----------------------------------------------------------------------------------------------------------------------------------|--------|-------|------------|--------|-------|----------------|-----------|-----------------|----------------|-------------------|
|          |                                                                                                                                   | Always | Often | Some times | Seldom | Never | Very Important | Important | Quite Important | Semi Important | Little Importance |
|          | <b>Phase 4: Construction works phase</b>                                                                                          |        |       |            |        |       |                |           |                 |                |                   |
| 4.1      | Determining the quantities of needed materials each item                                                                          |        |       |            |        |       |                |           |                 |                |                   |
| 4.2      | Determining dates materials per each item are needed                                                                              |        |       |            |        |       |                |           |                 |                |                   |
| 4.3      | Determine materials delivery location each item                                                                                   |        |       |            |        |       |                |           |                 |                |                   |
| 4.4      | \generating materials requisition form which description, quantities, dates and locations                                         |        |       |            |        |       |                |           |                 |                |                   |
| 4.5      | Verifying the material received against the quantity ordered                                                                      |        |       |            |        |       |                |           |                 |                |                   |
| 4.6      | Inspecting the delivered materials that it meets the specifications                                                               |        |       |            |        |       |                |           |                 |                |                   |
| 4.7      | Recording any problems in the delivered materials                                                                                 |        |       |            |        |       |                |           |                 |                |                   |
| 4.8      | Keeping a track record of the supplied remaining balance and the installed materials                                              |        |       |            |        |       |                |           |                 |                |                   |
|          | <b>Phase 5: Construction supply chain management assessment</b>                                                                   |        |       |            |        |       |                |           |                 |                |                   |
| 5.1      | Conducting assessment for the material supply chain process to avoid the mistakes and develop this process in the future projects |        |       |            |        |       |                |           |                 |                |                   |

2.2 Following are five scenarios for dealing with surplus materials. Please select the scenarios/s that you encountered during project implementation and then write the % of occurrence.

| Item No. | Material supply chain process                                 | Selected Scenario/s | % of Occurrence |
|----------|---------------------------------------------------------------|---------------------|-----------------|
|          | <b>Phase 6: Post Construction works</b>                       |                     |                 |
| 6.1      | Storing the surplus materials to be used future projects      |                     |                 |
| 6.2      | Returning back surplus materials to suppliers without penalty |                     |                 |
| 6.3      | Returning back surplus materials to suppliers with penalty    |                     |                 |
| 6.4      | Selling surplus materials to other contractors                |                     |                 |
| 6.5      | Scraping surplus materials                                    |                     |                 |
|          | <b>Total</b>                                                  |                     | <b>100%</b>     |

2.4 Would you please indicate, in priority order, which of the following method you choose to place your material orders. Please indicate which method is first, which Method is second, which method is third and so forth.

8

| No. | Method           | Rank |
|-----|------------------|------|
| 1   | Internet         |      |
| 2   | E-mail           |      |
| 3   | Fax              |      |
| 4   | Telephone        |      |
| 5   | Personal meeting |      |
| 6   | Others           |      |

### Section three- Contractor/Supplier Relationship

3.1 Please choose your practice to each statement usage and then express your opinion on how important each one on the material supply chain process. Please tick the appropriate all.

| No | Criteria                                                  | Rank |
|----|-----------------------------------------------------------|------|
| 1  | Availability                                              |      |
| 2  | Good quality                                              |      |
| 3  | Competitive pricing cost                                  |      |
| 4  | Reliable delivery                                         |      |
| 5  | Flexibility in accommodating contractor's changes/request |      |
| 6  | Sign long term agreement/enter into partnership           |      |
| 7  | Personal relationship                                     |      |
| 8  | Mutual interest                                           |      |

3.2 would you please indicate, in priority order, which of the following course of action you will take in case the supplier make late delivery to the materials or not comply with the requested specifications. Please indicate which course of action is taken first, which is second, which is third and so forth

| no | Likely Course of Action                                                      | Rank |
|----|------------------------------------------------------------------------------|------|
| 1  | Learn from the lesson & taking the necessary actions & procedures next times |      |
| 2  | Send a letter of complaint to the supplier to improve                        |      |
| 3  | Reprimand the supplier and then let the matter rest                          |      |
| 4  | Simply ‘‘ give-and-take’’ to avoid any sour relationship                     |      |
| 5  | Impose penalty charges on the suppliers                                      |      |

## Section Four-Identification of the most Occurred problems encountering the contractors through the material supply chain process

Use your experience to determine the degree of occurrence of the following problems by ticking the appropriate cell.

| No. | Problems                                                                    | Degree of Occurrence |       |          |        |       |
|-----|-----------------------------------------------------------------------------|----------------------|-------|----------|--------|-------|
|     |                                                                             | Always               | Often | Sometime | Seldom | Never |
|     | <b>Phase 1: Bidding phase-Materials take off and Identification</b>         |                      |       |          |        |       |
| 1.1 | Not good definition of what is wanted from owner and suppliers              |                      |       |          |        |       |
| 1.2 | Lack of communication between parties involved                              |                      |       |          |        |       |
| 1.3 | Incomplete drawings and details are missing                                 |                      |       |          |        |       |
| 1.4 | Using specifications Different from commonly used                           |                      |       |          |        |       |
| 1.5 | Ambiguities between plans and specifications                                |                      |       |          |        |       |
|     | <b>Phase 2: Sourcing (Vendor Selection)</b>                                 |                      |       |          |        |       |
| 2.1 | Having many suppliers and not have information about them                   |                      |       |          |        |       |
| 2.2 | suppliers did not include all the documents with the proposal               |                      |       |          |        |       |
| 2.3 | Time spent investigation non-qualified suppliers                            |                      |       |          |        |       |
|     | <b>Phase 3: Material procurement</b>                                        |                      |       |          |        |       |
| 3.1 | Unavailability of required materials                                        |                      |       |          |        |       |
| 3.2 | submittals are not submitted as planned                                     |                      |       |          |        |       |
| 3.3 | Incorrect of submittals by the suppliers                                    |                      |       |          |        |       |
| 3.4 | Late approval of submittal by Engineer                                      |                      |       |          |        |       |
| 3.5 | Poor Communication between the parties involved                             |                      |       |          |        |       |
| 3.6 | contractor sets delivery dates that are impossible to meet by the suppliers |                      |       |          |        |       |
| 3.7 | contractors not communicate exactly what is wanted to suppliers             |                      |       |          |        |       |

| No. | Problems                                                                    | Degree of Occurrence |       |          |        |       |
|-----|-----------------------------------------------------------------------------|----------------------|-------|----------|--------|-------|
|     |                                                                             | Always               | Often | Sometime | Seldom | Never |
|     | <b>Phase 4: Construction</b>                                                |                      |       |          |        |       |
| 4.1 | Late Deliveries                                                             |                      |       |          |        |       |
| 4.2 | The delivered materials do not comply specifications                        |                      |       |          |        |       |
| 4.3 | materials have to be moved from one place to another before being installed |                      |       |          |        |       |
| 4.4 | storage area are limited or far away from the working area                  |                      |       |          |        |       |
| 4.5 | Loss of materials                                                           |                      |       |          |        |       |
| 4.6 | Theft                                                                       |                      |       |          |        |       |
| 4.7 | - Materials are damaged while handling                                      |                      |       |          |        |       |
| 4.8 | Poor Communication between the parties involved                             |                      |       |          |        |       |
| 4.9 | Receive, handling and storage of the unused materials                       |                      |       |          |        |       |
|     | <b>Phase 5: Post - Construction</b>                                         |                      |       |          |        |       |
| 5.1 | No storage for the surplus materials                                        |                      |       |          |        |       |
| 5.2 | No possibility surplus materials to be returned to supplier                 |                      |       |          |        |       |
| 5.3 | Charging penalties by suppliers for returned materials                      |                      |       |          |        |       |
| 5.4 | Salvage losses for the surplus materials                                    |                      |       |          |        |       |

### Section five- Key factors Contributing Supply Chain Integration

Below are numbers of factors which can have an impact on successful integration of the construction supply chain. From your experience, please express your opinion on how important each factor can be on construction supply chain integration.

| No   | Factors                                                                                             | Little Importance | Sami Importance | Quite Important | Important | Very Important |
|------|-----------------------------------------------------------------------------------------------------|-------------------|-----------------|-----------------|-----------|----------------|
| 6.1  | The design team includes contractors, subcontractors and materials suppliers                        |                   |                 |                 |           |                |
| 6.2  | Using design contract arrangement between the contractor and the client                             |                   |                 |                 |           |                |
| 6.3  | Entering a partnership relationship with suppliers and subcontractors based on extended time period |                   |                 |                 |           |                |
| 6.4  | Understanding the client needs and objectives by the contractor, subcontractors and suppliers and   |                   |                 |                 |           |                |
| 6.5  | Executing the projects activities by the contractors own sources                                    |                   |                 |                 |           |                |
| 6.6  | Negotiating contracts with the suppliers rather than tendering                                      |                   |                 |                 |           |                |
| 6.7  | The participation of the designers continues during construction phase                              |                   |                 |                 |           |                |
| 6.8  | Establishing a protocol for dealing effectively with disputes and problems                          |                   |                 |                 |           |                |
| 6.9  | Conducting workshop for suppliers and subcontractors to discuss the quality, innovation,            |                   |                 |                 |           |                |
| 6.10 | Aligning the system and procedures of your own company with client, suppliers and subcontractors    |                   |                 |                 |           |                |
| 6.11 | Establishing a system for communication and share information in timely and accurate manner         |                   |                 |                 |           |                |
| 6.12 | Using Web Based system for information access                                                       |                   |                 |                 |           |                |