KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF ARCHITECTURE AND PLANNING
DEPARTMENT OF BUILDING TECHNOLOGY

IMPROVING CONSTRUCTION SUPPLY CHAIN MANAGEMENT IN GHANA: LEAN APPROACH

BY

EMMANUEL NSIAH ANKOMAH, B.Sc. (Hons)

A Thesis submitted to the Department of Building Technology,
Kwame Nkrumah University of Science and Technology
in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE
Faculty of Architecture and Building Technology
College of Architecture and Planning

MAY, 2013

DECLARATION AND CERTIFICATION

I hereby declare that this submission is my own work towards the M.Sc Construction Management and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

Emmanuel Nsiah Ankomah (ID: 20245761) ..... 28/10/2013.

(Student name and ID) Signature Date

Certified by

Dr B.K. Baiden 28/10/13

(Supervisor) Signature Date

Prof. Joshua Ayarkwa 30/10/13

(Head of Department) Signature Date

ABSTRACT

Various forms of waste and problems are associated with the construction supply chains which are seen as contributing largely to the incidence of high cost of construction, bad financial performance and decreased value of products delivered to customers. Lean systems strive to achieve "continuous flow," i.e., get raw materials to proceed through all production steps without undue inventory or other waste. The purpose of this study was to determine where the problems lie in terms of material delivery and site management for three (3) construction sites in Ghana and give recommendations for improvement based on lean construction methods. Using three (3) case studies and a qualitative research methodology to collect and analyze the data, results are drawn that provide pragmatic lean solutions for future projects. To unfold the meanings of peoples' responses, **themes** were identified and categorized based on the content of the interviews held with respondents on the cases selected. The themes identified were supplier relationship management, information management and internal operations management. Problems identified in the chain included but not limited to late deliveries, quantity and quality problems, excessive build up of inventory and double handling. Suppliers' inefficiencies, late placement of orders, shortage of materials, communication problems, and transportation amongst others were the causes of the problems. The implementation of kanban can help maintain a minimum and maximum inventory level. Other lean tools such as the last planner, 5S, Kaizen can bring improvements to the chain.

DEDICATION

I dedicate this work to my wife, Mrs Helen Yaa Asaa Ankomah

and

to my son: Kwaku Kusi Ankomah

ACKNOWLEDGEMENT

My first gratitude goes to the Almighty God for not only the opportunity, but also the guidance and wisdom to go through this programme.

I owe a great deal of appreciation to my supervisors, Dr B.K.Baiden and Mr Ofori Kuragu, for their precious contribution and guidance.

I am most grateful to my family, Mr Michael Kofi Nsiah, Mr and Mrs Akeampong, siblings, Benjamin Amoah Akyeampong Junior, as well as my beloved wife, Mrs Helen Yaa Asaa Ankomah who have gone a very long way to support me in diverse ways. I say God bless you all.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

5S	Separate, Sort, Sweep, Standardize, and Sustain
CII	Construction Industry Institute
EE	Electrical Engineers
GDP	Gross Domestic Product
GE	Geodetic Engineers
GhIA	Ghana Institution of Architects
GhIS	Ghana Institution of Surveyors
GREDA	Ghana Real Estate Developers Association
HBR	Harvard Business Review
IT	Information Technology
JIT	Just-In-Time
KPIs	Key Performance Indicators
LAP	Language Action Perspective
LC	Lean Construction
LCI	Lean Construction Institute
LSCM	Lean Supply Chain Management
OEMs	Original Equipment Manufacturers
QS	Quantity Surveyors
S&OP	Sales and Operations Planning
SC	Supply Chain

SCM	Supply Chain Management
SE	Services Engineers
SSNIT	Social Security and National Insurance Trust
St.E	Structural Engineers
TFV	Transformation-Flow-Value
TPS	Toyota Production System
TQM	Total Quality Management
VSM	Value Stream Mapping
WIP	Work-In-Process

CHAPTER 1: INTRODUCTION

1.1 Background

A supply chain can be viewed as a complex web of information systems, operational activities and management techniques that exist amongst entities that maintain relationships of varying strengths with one another (Bjork, 2002). The most common definition, as proposed by Houlihan (1985), Stevens (1989), Lee et al., (1993) and Lamming (1996) is a system of suppliers, manufacturers, distributors, retailers, and customers where materials flow downstream from suppliers to customers, and information flows in both directions. It is generally accepted in the literature that efficient Supply Chain Management (SCM) is an effective way to reduce cost. This can be achieved through building long term relationships with customers and suppliers to achieve benefits for each component of the supply chain (Chopra, 2002). An individual component (enterprise) needs to ensure information flow in the entire supply chain (SC) to achieve these benefits (Goldstein & Zack, 1989). However, in the construction industry, the information flow from building component manufacturers, suppliers, designers and architectures to the builders, land developers, quantity estimators, building trades and building owners is complex and often chaotic.

In recent years, there have been several efforts to best understand how to manage construction supply chains efficiently and effectively eg, Wegelius-Lehtonen, (1995); O'Brien, (1995); Wegelius-Lehtonen and Pahkala, (1998); Naim et. al., 1999; Vrijhoef

and Koskela, (2000); and Arbulu et. al. (2003). Achieving excellence in the management of construction supply chains represents a way of increasing competitive advantage in the market. The reality is that supply chain participants (i.e., owners, contractors, suppliers, etc) are still in exploration towards a better understanding of what supply chain management is, how they can increase their competitive advantage by applying it, and the dynamics it involves.

Construction is known to being ruled by schedules. It is not difficult to find management personnel arguing about working under so many pressures to achieve project milestones and not having the luxury of time to see the whole picture. This is, in part, a symptom from a construction industry dominated by extreme specialization. Everything is optimized to meet individual participant's performance objectives but far from optimal and from systems approach eg. Tommelein et. al., (1999); Bashford et. al.,(2002). Along with supply chain complexities and dynamics, today's construction projects are 'complex, uncertain and quick' (Shenhar and Laufer, 1995). They require the definition, design and implementation of temporary production systems that incorporate temporary flows of physical resources (eg. labour, materials, equipment,) and information for the on-time completion of milestones.

From previous researches, three main conclusions can be drawn according to the current status of construction supply chains (Vrijhoef & Koskela, 2000). First, the construction supply chain has a great deal of waste and problems. Secondly, most of waste and problems have a negative flow effect on other stages of the construction supply chain

than where it is recognized. Thirdly, waste and problems are because of the antiquated and short sighted control of the construction supply chain and also the independent control of each stage of the chain.

Lean systems strive to achieve "continuous flow," i.e., get raw materials to proceed through all production steps without undue inventory or other waste. A production system design is said to be "lean" when it is done in pursuit of Transformation-Flow-Value (TFV) goals (Ballard et al. 2002). Correspondingly, the lean approach to production system design is to first root out all unwanted variability, and then accommodate the remaining variability in its design.

The core concept behind lean production, according to Caldeira (1999), is to create a flow among value adding work steps while eliminating non-value steps. This has led to changes in production processes with some recurring themes: Broad-skilled, multi-disciplined teams replacing functionally-grouped specialists; Continuous workflow which ensures steady production rates that eliminate the chaos of fragmented stop-and-go production processes; a focus on fast cycle times to eliminate non-value-adding activities (Kpamma, 2009).

Extending lean manufacturing principles to the supply chain is non-trivial. However, the extension of lean concepts across a complex supply chain network of suppliers, customers and partners can result in dramatic financial improvements for all. Significant benefits in reduced cycle times, increased production yields and quality levels, decreased inventories, minimized waste, lowered costs and increased customer satisfaction are to

be expected, which in turn, drive increased revenue and improved operating margins. A lean supply chain is one that produces just what and how much is needed, when it is needed, and where it is needed.

1.2 Problem Statement

Various forms of waste and problems are associated with construction supply chains which are seen as contributing largely to the incidence of high cost of construction, bad financial performance and decreased value of products delivered to customers. Sobotka (2000) found in his study on construction material flows that in the delivering of the physical flow of materials between elements of the supply chain, only from 0.3% to 0.6% of the total time is value being added. Only for the interface between the main contractor and the supplier has an average cost reduction potential of 10% (of material costs) through improved logistical procedures been shown (Sobotka, 2000). The waste can be even higher when taking the whole supply chain into consideration. A significant proportion of time and effort is spent on waste activities. Over-production, defective products, waiting, multiple handling, inventory and over-processing are some of the common forms of waste in the production systems employed by Ghanaian firms. These non-value adding activities – or waste – must, therefore, be targeted for removal while value adding activities are identified and maintained to be improved upon (Kpamma, 2009).

It has been shown that the purchasing price is still the primary criterion for supplier selection, Wegelius et al. (1996). O' Brien (2000) found that subcontractors are nearly

always selected according to price. Roy and Gaze (2003) found that decision making on the improvement of supply chain is often limited by those solutions one has experience of. It is customary to use material inventories as buffers against disruption. Similarly, Marsh and Finch (1998) found that nearly all supply chain partners add a time buffer to their schedule to allow for lack of co-operation and an inefficient flow of information. Adding a buffer increases time and cost.

Many of the problems are caused directly and indirectly by insufficient coordination, communication, and these commitments lead to wrong information about schedule changes, late confirmation of deliveries, and lack of feedback procedures. Supply chain participants perceive uncertainty on what has to be done, who has to do it and when it has to be ready. From site coordination point of view, Dainty (2001) found that the specialists (contractors) are just thrown together and told to sort things out between themselves. These kinds of phenomena in the supply chain are the causes of misunderstanding. It shows a complete lack of coordination and structure in the communication and collaboration on site. It can therefore be said that supply chains are not defined and therefore not designed, they just happen!

From previous researches, it can be seen that waste and problems in construction supply chains are extensively present and persistent. As a result of interdependency, the occurrence of waste and problems are interrelated with causes in other stages of the supply chain (Ward, 2005). What is more, myopic control of the construction supply

chain enlarges waste and problems and makes things even worse (Vrijhoef & Koskela, 2000).

1.3 Purpose of Study

Laufer and Tucker (1987) argued that uncertainty and complexity cannot be eliminated from construction projects and that there is an increasing demand of speed. Hence, construction projects and their underlying processes have to be designed to cope with uncertainty, complexity, and speed (Laufer 1997).Various forms of waste and problems are associated with the construction supply chains which are seen as contributing largely to the incidence of high cost of construction, bad financial performance and decreased value of products delivered to customers. From previous researches construction supply chains has a great deal of waste and problems, which have a negative flow effect on other stages of the construction supply chain than where it is recognized.

A central concept in lean construction (LC) is that downstream players are involved in upstream decisions. This includes contractors as well as suppliers. Studies have shown that managing material supply in construction projects is of major importance because, in general, around half of the project cost comes from material and equipment (Tanhuanpää et al., 1999), and most project delays are due to the lack of material (CII 1988 p. 1). Processing that adds value to materials and information amounts to only a small percent of total time, Jarnbring(1994), Arbulu and Tommelein (2002), Arbulu

(2002). Most of the non-value-added tasks, (e.g., waiting), and problems, (e.g., poor information flow), are overlooked (Vrijhoef and Koskela 1999).

The study is intended to explore the actual opportunities that exist to improve the SC of Ghanaian construction firms, through lean production principles by identifying and eliminating non-value adding steps while value-adding steps are maintained and improved upon.

1.4 Research Aim

The aim of the research is to investigate into the opportunities for improving the management of supply chains, through the adoption of lean production principles.

1.4.1 Research Objectives

To achieve the aim of the study the following objectives were identified:

- To identify the current practices in the management of the Ghanaian construction supply chain.
- To identify problems inherent in the management of the supply chain on construction sites.
- To identify the causes of the problems in the management of the supply chain.
- To identify the opportunities for improving the management of the supply chain through the adoption of lean production principles.

1.5 Justification of Research Objectives

To be able to achieve the aim of identifying opportunities to improve the management of the supply chain, will require an appraisal of the current practices in use and identify problems in the delivery process.

There is the need to identify the causes of these problems, which will eventually help in tackling the problems inherent in the supply chain.

Having identified the problems, opportunities for the adoption of lean production principles into the SC would be established.

1.6 Research Scope and Focus

Jarnbring (1994) found in his study on material flows in Swedish construction that the value added time of those flows is only 0.3% to 0.6% of the total flow time. Various studies show a cost reduction potential varying from 10% to 17% of the material costs (i.e. purchasing price) by means of improved logistics e.g., Asplund and Danielson (1991), Jarnbring 1994, Wegelius-Lehtonen (1995). Limited studies in construction suggest that poor supply chain design regularly increases project cost by 10% (Bertelsen, 1993), and this estimate is probably conservative. Project duration may be similarly affected. Most researchers argue that chances for these cost savings would increase if contractors and suppliers would co-operate to identify joint opportunities to improve logistics. These findings support the fact that there is existence of considerable waste and problems in construction supply chains (i.e. the part of the chain involving

contractors and suppliers). The study is limited to that part of the chain involving main contractors and suppliers, with the focus being on the part coordinated by the main contractor. The study was limited to D1 contractors in the southern part of Ghana. Three construction sites were selected for a case study in the southern part of Ghana.

1.7 Research Methodology

In order to achieve the aim of the present study, the tools for data collection included literature survey, and structured interviews. The research methodology is assessed under each objective as follows:

- The objective of examining the current practices in use by Ghanaian construction industry was achieved by undertaking a careful appraisal of the industry. Data collection involved interviews, documentation, archival records and direct observation on site.
- Data on identifying problems inherent in the supply chain was obtained through personal observations as well as interviewing supply chain participants on site.
- Data collection on identifying the causes of problems in the supply chain was obtained through interviewing supply chain participants on site.
- The collection of data on identifying opportunities for improving the supply chain through the adoption of lean production principles for the benefit of the industry was undertaken by reviewing literature as well as interviewing supply chain participants.

1.7.1 Summary of the Research Process

This section describes the research process used in conducting the research. The section explains the step by step methodology used in order to help achieve the research aim. In the first step the aim of the study was determined; the second step consisted of formulating the objectives and scope of the study. Following the research aim, an appropriate research design was selected for this specific study. Then a literature review was performed in order to provide a theoretical background connected to the research topic. The two last steps consisted respectively of data collection and analysis and the discussions of results and recommendations.

1.7.2 Organisation of the study

The first chapter of the research contains the introduction. Sections within this chapter include problem statement, purpose of the study, aims and objectives of the study, research methodology, scope and focus of the study, as well as research process in carrying out the study.

The Second chapter gives an overview of Supply chain management and its related concepts. The chapter continues further to talk about the future of supply chain management and conceptual gaps in supply chain management research.

The Third chapter is divided into four sections. The first section introduces supply chain management and the Ghanaian construction industry. The second section discusses the waste and problems inherent in the construction chain and its causes. The concept of

Lean thinking, the main philosophy behind the study is scrutinized in the third section. Finally, in the last section the concept of LC and Lean supply chain management (LSCM) is discussed.

The research methodology is described in the fourth chapter of the work. Details like type of data to collect, data collection tools and data analysis tools have been discussed here.

Chapter five of the research contains data collected and findings from the data.

Discussion of the findings of the data collected is carried out in chapter six (6). Conclusions and recommendations on the research are also discussed in this chapter. Proposals for establishing opportunities to improve the supply chain of materials, through the adoption of lean production principles are discussed.

CHAPTER 2: OVERVIEW OF SUPPLY CHAIN MANAGEMENT

2.1 Concept of Supply Chain Management

A SC encompasses all the processes and phases a product goes through on its way to final customer delivery. It includes the flow of information, material, and services. Lee and Billington (1993) define supply chain as "*a network of facilities that performs the functions of product development, procurement of material, transformation of material to intermediate and finished product, distribution of finished products to customers and after-market support for sustainment.*" With this in mind, the members of the supply chain will include not only suppliers and manufacturers, but also warehouses, transporters, retailers and customers. Each is a stakeholder in the process.

The concept of supply chains have been considered from different points of view in different bodies of literature. Various definitions have been proposed and some common points can be identified. In this thesis, the definition from Lau, Huang and Mak (2004) was considered. It defined SCM as "coordination of independent enterprises in order to improve the performance of the whole supply chain by considering their individual needs". This definition of supply chain implicitly describes the supply chain as a group of companies working collaboratively to satisfy customer needs. One of the main functions of SCM, which is coordination, is also exhibited.

Every supply chain has different challenges. Each has different customer requirements, product types, organizational structures, schedules, etc. Business strategies vary.

However, there are still similarities in how supply chain leaders must approach their given situation. Hugos (2003) identifies three steps to aligning supply chain and business strategy: *understanding customer requirements, defining core competencies and the roles the company will play to serve customers, and develop supply chain capabilities to support the roles the company has chosen.*

These are three basic but critical steps that must be taken to stay afloat in competitive markets. Hugos (2003) goes further to explain how companies must "*make decisions individually and collectively regarding their actions in five areas: Production, Inventory, Location, Transformation, and Information.*" When evaluating these five business drivers, the goal is to find the best mix of responsiveness and efficiency for the market being served. Each supply chain will achieve this in its own unique way.

Another commonly heard term in this realm of operations is logistics. It is important to note, as experts support, that there is a difference between the concept of SCM and the traditional concept of logistics. Hugos (2003) also touches on this quoting, "*logistics typically refers to activities that occur within the boundaries of a single organization and supply chains refer to networks of companies that work together and coordinate their actions to deliver a product to market.*" SCM basically includes all traditional logistics, along with other activities. It takes a systems approach to coordinating all the entities within the business. Logistics will focus on optimization within a certain area of an organization, such as distribution.

Harrison and Van Hoek (2002) outline practices for coordination of value-adding activities between supply chain partners in order to help with improving performance in areas such as lead time. Harrison and Van Hoek (2002) go on to link supply chain coordination with the related terms of cooperation and collaboration in the supply chain partnerships. They characterize cooperation, coordination and collaboration as the supply chain relationship types, stating that increasing levels of commitment and trust as relationships move towards collaboration are linked to success. The broader supply chain literature also relates the term "coordination" to upstream and downstream information exchange (Frohlich and Westbrook, 2001).

Fawcett and Magnan (2002) identify the link between coordination and collaboration: "Early adopters of supply chain practice have discovered that real collaboration goes beyond information exchange, and are working diligently to establish other integrative mechanisms to enhance coordination with truly important first-tier suppliers and customers."In the supply chain context, according to Harrison and Van Hoek (2002) the term "coordination" is considered an important form of supply chain relationship as supply chain partners develop mutual commitment and trust and move from cooperative to fully collaborative partnerships.

In conclusion, SCM as a philosophy and concept has developed as business organisations realised that they need their suppliers to decrease costs and improve efficiency. Also, their customers need their cooperation as suppliers to further decrease costs and improve efficiency. It was therefore realised that by cooperating and managing

it as one process, the supply chain members could be more efficient together than separately (Hugo et al 2004). The word "coordination" implies a certain relationship between people or groups of people.

2.2 Supply Chain Management Current Literature

2.2.1 The scope of supply chain management research

In their seminal work on the automotive sector, Womack et al. (1990) encapsulate the importance of supply chain management and give a clear view of the huge challenges it presents to mangers. They state that complexity and lack of understanding present considerable challenges to the academic research community. Croom et al. (2000) agrees that supply chain management has received attention since the early 1980's, yet conceptually the management of supply chains is not particularly well understood"

The development of the idea of the supply chain owes much to the emergence from the 1950s onwards of systems theory and the associated notion of holism (i.e, that the whole is greater than the sum of parts) (Cavinato, 1992). This can be summarized by the observation that the behavior of a complex system cannot be completely understood by the segregated analysis of its constituent parts (New, 1997). Related to the philosophy of considering the whole supply chain rather than individual companies within it, one of the key themes is that companies should not seek to achieve cost reductions or profit improvement at the expense of their supply chain partners, but rather seek to make the supply chain as a whole more competitive. In short, the contention that supply chains,

rather than single firms, compete is emerging as a central tenet in the field of supply chain management (Christopher, 1992).

New (1995) contend that there is a confusing profusion of overlapping terminology and meanings within the supply chain management literature, with many labels referring to supply chain and to practices for supply chain management, including: integrated purchasing strategy, supplier integration , buyer-supplier partnership, supply base management, strategic supplier, supply chain synchronization, network supply chain, value –added chain, lean chain approach, supply pipeline management, supply network, and value stream. Harland et al. (1999) prefer the term "supply strategy".

Furthermore, Croom et al. (2000) state that "the lack of a universal definition of supply chain management is in part due to the way the concept of supply chain has developed. The concept of supply chain has been considered from different points of view in different bodies of literature". Hence they believe the absence of consistent terminology or universal definitions to be almost inevitable, given the multidisciplinary origin and evolution of the field. Croom et al. (2000) argue that what is considerably more concerning is the lack of robust conceptual frameworks for the development of theory in the field.

2.2.2 The Historical Challenge of Coordinating the Supply Chain

Womack et al. (1990) stressed that the key to a competitive parts-supply system is the way the assembler works with its suppliers. One of the keys to successful supply chain

coordination for Japanese car manufacturers , specifically Toyota, was "managing the relationship" in a far more cooperative way so as to provide incentive for suppliers to "merge their learning curves" (i.e., share findings about how to make parts better, cheaper, faster and with less effort) with the customer and other suppliers.

Lamming (1993) built-upon the work of Womack et al. (1990), characterizing such cooperative supply relationships as "beyond partnership" Whilst Lamming (1996) indicates that many organizations in different sectors (e.g., high street retail and computer manufacture) have moved to adopt cooperative, lean supply type relations, he makes it clear that this not necessarily the norm. Lamming (1996) states that one of the goals in modern supply chain management is to exploit expertise wherever it lies in the chain and to recognize the impacts in one part of the chain, of decisions made in another.

2.3 Objectives of Supply Chain Management

Hugo et al (2004) acknowledge the fact that supply chain management is a philosophy that evolved in response to the transformations in the business environment, especially during the 1990s. The emphasis in defining supply chain management is that it is a management philosophy aimed at integrating all the linkages in the supply chain into a seamless unit. This is a difficult task because so many interests have to be taken into account. Clearly the goals of managing the supply chain should include the following two levels of interest:

- The goals of individual firms should be included in the supply chain. One such goal could be to balance customers' demands with the need for making a profit and attaining growth objectives.
- The second group of goals may be associated with the integrated supply chain. Examples of such goals could be to integrate all supply chain activities, processes and organisational entities; increase the rate of flow of products and services; reduce total cost of ownership for the ultimate customer; and decrease the total cycle time of the supply chain.

Simchi-Levi et al (2008) acknowledge that intensified competition in global markets, the introduction of products with shorter life cycles, growing customer expectations, ongoing developments in communications and transportation technologies have compelled businesses to invest in and direct attention to their supply chains. Consequently, in order to remain competitive, there is pressure on businesses to decrease costs and enhance customer service levels. Simchi-Levi et al (2008) define supply chain management "as a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores so that merchandise is produced and distributed at the right quantities, at the right locations, and at the right time, in order to minimise system-wide costs while satisfying service level requirements."

This definition conjures up several ideas. One of these is the goal of supply chain management, namely to be efficient and cost effective across the entire system in order

to minimise total system-wide costs. O'Marah (2007) also notes that SCM is not simply about reducing costs, but is the process of enhancing value for customers and investors.

2.4 Building Relationships in Supply Chains

Christopher (2005) adopted the following definition of supply chain management: "The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole".

When the Harvard Business Review (HBR) organised a team of leading academics in the discipline of supply chain management, technology was not the main topic of discussion – people and relationships were identified as the major themes. For example, the opportunities and challenges of globalisation and the continued pressure for speed and cost containment are requiring businesses to establish relationships with new types of suppliers (Beth et al 2006).

Traditionally, the majority of businesses were of the opinion that the way which they manage suppliers is insignificant in their overall performance. Buyers play off suppliers against each other and frequently replace them. This adversarial model was not ideal and the model transformed when international competitors demonstrated that joining forces with suppliers could lead to competitive market benefits (Monczka, Trend & Handfield 2005). Stevenson (2005) confirms that maintaining good relationships with suppliers is increasingly being recognised as a critical factor in sustaining a competitive advantage.

Nowadays, numerous businesses view their suppliers as partners – in other words, a

stable relationship with comparatively few suppliers who can make available high-quality supplies, sustain delivery schedules and remain flexible relative to changes in specifications and delivery schedules.

Liker and Choi (2006) acknowledge that businesses are largely relying on their suppliers to reduce costs, enhance quality and develop innovations faster than their competitors' suppliers can. One way of achieving this is to build networks of suppliers that learn, improve and grow. Hence supplier relationships and the trust element in particular, are crucial. Liker and Choi (2006) cite the following in this regard:

> "The Big Three (US automakers) set annual cost-reduction targets (for the parts they purchase). To realise those targets, they'll do anything. They've unleashed a reign of terror, it gets worse every year. You can't trust anyone (in those companies)" (Director, interior systems supplier to Ford, GM and Chrysler, October 1999).
>
> "In my opinion, (Ford) seems to send its people to "hate school" so that they learn how to hate suppliers. The company is extremely confrontational. After dealing with Ford, I decided not to buy its cars" (Senior Executive. Supplier to Ford, October 2002).

Burt et al (2010) acknowledge that buyer-supplier relationships have evolved from being transactional to collaborative to alliance based. For example, the automotive assemblers in South Africa hold a strong position in the automotive industry and because of this, in

the past, this strength led to adversarial relationships with component suppliers and sellers. However, as a result of the lifting of protection, relationships both up and down the supply chain have had to change, and today, partnerships are being created (Williams 2004). According to Saunders (1996) the outcome of an adversarial relationship is perceived in terms of "win-lose" results, whereas the outcome of a partnership relationship is perceived to result in a "win-win" situation – both sides winning at the same time through the implementation of a problem –solving approach.

Bowersox, Closs and Cooper (2007) identify two beliefs to facilitate a drive for supply chain efficiency improvement and increased competitiveness:

- Collaborative relationships will decrease risks and improve the efficiency of the whole supply chain process. In order to achieve this collaborative relationship, it is essential for supply chain players to share strategic information. Information sharing must not only be restricted to transaction data but also information relating to future plans so that participating businesses can jointly develop the best way to satisfy customer requirements. Collaborative information is vital for businesses to jointly do the right things more rapidly and efficiently.
- There is an opportunity to eliminate waste and non value added processes. For example, as a result of collaboration, substantial inventory held in a traditional channel can be eliminated. In addition, supply chain collaboration can also eliminate or reduce the risk associated with inventory speculation.

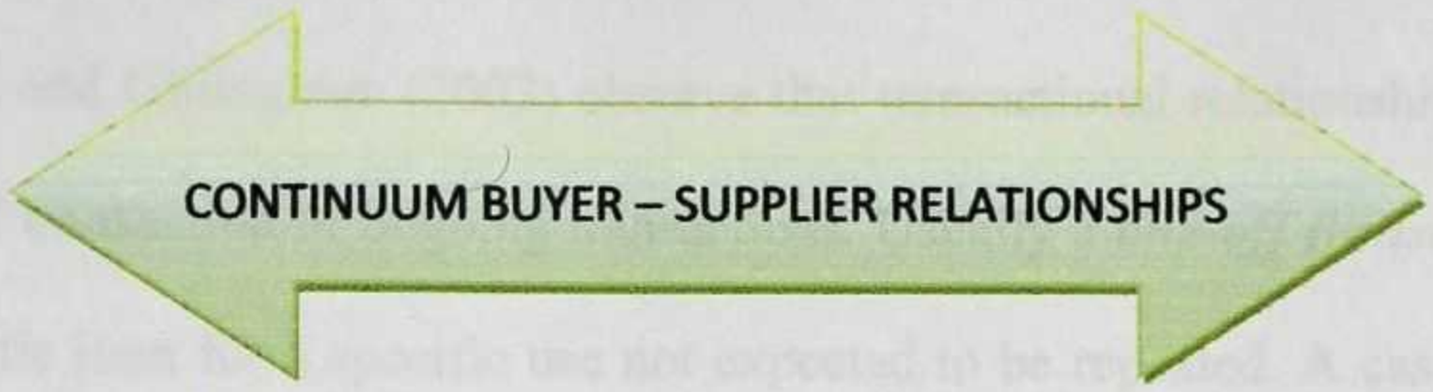
2.4.1 Types of Buyer-Supplier Relationships

Burt et al (2010) identify three principal classes of relationships and activities and attributes common to each. These are depicted in figure 2.1. In addition, Lysons and Gillingham (2003) recognise *power relationships*. The authors note that power relationships afford one company a negotiation advantage over the other. These relationships can develop from factors such as size, volume of business, environmental conditions and ownership by one party of some asset that is not on hand by the other.

On the whole, most types of relationships are transactional. Lysons and Gillingham (2003) define a transactional relationship as follows: "A straightforward relationship between buyer and seller whereby the two parties do not get closely involved with each other, but simply exchange goods or services for payment."

Burt *et* al (2010) confirm this by describing this kind of relationship as neither "good nor bad" – it is merely an arm's-length relationship in which neither party is particularly concerned with the other's interest.

A collaborative relationship is viewed as crucial. Both collaborative and alliance relationships are inclined to result in lower total costs compared to transactional relationships. The main distinction between these two relationships is the existence of institutional trust. With institutional trust, both parties have access to each other's strategic plans in the area of the interface. For example, cost information and forecasts are shared and risks and incentives dealt with openly (Burt et al 2010; Lysons and Gillingham 2003).



Activity/Attribute	Transactional→Collaborative→Alliance	
Communication	High Potential for Problems	Systematic approach to enhance communication
Competitive advantage	Low	High
Connectedness	Independence	Interdependence
Continuous Improvement	Little	A focus
Contributions to new product development	Few	Many – early supplier involvement
Difficulty of exit	Low	Difficult – high impact
Duration	Short	Long
Expiditing	Reactive	Proactive
Focus	Price	Total cost
Levels of Integration	Little or none	High or total
Level of Trust	Low	High
Number of suppliers	Many	Few
Open books	No	Yes
Quality	Incoming Inspection	Design quality into system
Relations	Inward looking	Concern with other's well being
Resources	Few – low skill	Professional
Service	Minimal	Greatly improved
Shared Forecasts	No	Yes
Supply disruptions	Possible	Unlikely
Technology inflows	No	Yes
Type of interaction	Tactical	Strategic synergy

Figure 2.1: Characteristics of three types of relationships

Source: (Burt et al, 2010)

2.4.1.1 Transactional relationships

Lysons and Gillingham (2003) observe that transactional relationships could either be a one-off transaction or ongoing transactions. Usually a ***one-off transaction*** would be for a specific item for a specific use not expected to be repeated. A case in point would be capital equipment. In this instance, long-term relationships are not always beneficial. ***Ongoing transactions*** are similar to Bensaou's "market exchange" category. In this instance, buyers who are satisfied with the products and services supplied by a supplier continue using that supplier so that a solid informal relationship results.

Burt et al (2010) note that transactional relationships have several characteristics as highlighted below.

- There is a lack of interest by both parties about the other party's well-being – "one party's gain is another one's loss".
- There is one of a series of independent deals – little or no basis exists for collaboration.
- Costs, data and forecasts are not shared.
- Price is the main focus of the relationship.
- Minimum purchasing time and energy are required to determine prices.

The disadvantages of transactional relationships (Burt et al 2010):

- Possible communication difficulties
- Substantial investment in expediting and checking incoming quality and timely delivery

- Inflexibility when flexibility may be required, particularly when changing technology and changing market conditions require flexibility in supplier/buyer relationships
- Delivery problems
- Minimum services provided by suppliers
- Supply disruptions
- Reluctance by the supplier to invest time and energy in the development of the potential buyer's products

2.4.1.2 Collaborative relationships

Monczka et al (2005) reports that most buyers and sellers recognise a need for co-operation with suppliers, in order to achieve cost, quality, delivery, and time improvements. During the 1980s and 1990s, progressive buyers eliminated poor or marginal suppliers from their supplier database. Today, the goal of many of these buyers is to build collaborative relationships or alliances with current suppliers.

Monczka et al (2005) define collaboration as follows: "Collaboration is defined as the process by which two or more parties adopt a high level of cooperation to maintain a trading relationship over time".

Burt et al (2010) hold that the basic difference between transactional and collaborative relationships is recognition of interdependency of and necessity for cooperation. Recognition of interdependency of and the need for cooperation results in many benefits

for both parties such as building trust, communicating, planning and promoting interdependency, which may result in achieving a competitive advantage. Collaborative relationships look out for their "friends" and not their opportunistic customers. Both customers and suppliers who see one another in terms of long-term relations and respect and would probably support one another in difficult times. However, Burt et al (2010) state that the main weakness of such relationships is the amount of human resources and time and energy needed to build and manage these types of relationships.

2.4.1.3 Alliance relationships

In industrial markets, buying and selling can be defined as a series of events in long-standing complex relationships between suppliers and purchasers which, when examined over an extensive period, are dynamic rather than stable (Dyer 2000). Burt et al (2010) acknowledge that the main distinction between these two relationships is the existence of institutional trust.

Burt et al (2010) observe that trust in alliance relationships is not at all "blind trust" but rather a "prudent trust", which is carefully designed, planned and mutually agreed upon. When alliance relationships are first formed, this trust is usually established interpersonally between the alliance champions and the executives who create this unit.

From this it is evident that building strong alliance relationships requires hard work and commitment by both purchasers and suppliers.

The discussion thus far in this section indicates that relationships in supply chain management are vital. In the current competitive environment, the trend is for companies to focus on their core competencies, which results in an ongoing increase in the level of outsourcing. Quesada, Syamil and Doll (2006) acknowledge that in industries such as the automotive industry, where value added by suppliers contributes significantly to the final product, the competitiveness of OEMs depends upon supplier performance in terms of cost, quality and on-time delivery. It is for this reason that businesses require their suppliers to deliver products, in "the right quality, the right quantity, at the right time, at the right place, from the right source at the right price." Consequently, "supply, sourcing and purchasing professionals in companies nationwide believe strongly that more and stronger supplier partnerships are critical to achieving competitive corporate performance" (Morgan 2001). In the light of this, companies are realising the importance of developing "win-win" long-term relationships with suppliers.

2.5 Supply Chain Integration

Kwon and Suh (2005) regard supply chain integration as a strategic tool aimed at reducing costs and thus increasing customer and shareholder value. Hence effective supply chain planning, built on shared information and trust among partners is a vital part of successful supply chain functioning. Monczka et al (2005) define integration as follows: "The process of incorporating or bringing together different groups, functions, or organisations, either formally or informally, physically or by information technology,

to work jointly and often concurrently on a common business-related assignment or purpose".

If supply chain management is well executed it efficiently integrates suppliers, manufacturers, warehouses and other intermediate value-adding partners so that production and distribution are synchronised with customer demand, thereby reducing overall system or pipeline costs and satisfying service level requirements (Hugo et al 2004). This is confirmed in Wisner et al (2005), who acknowledge that activities in the supply chain are well coordinated when members of the supply chain work together when making delivery, inventory, production and purchasing decisions that impact on the profits of the supply chain. In other words, if one activity fails or is badly performed, supply along the supply chain is interrupted, which puts the effectiveness of the whole supply chain at risk.

Hence successful supply chain integration happens when the players realise that supply chain management must become part of all the business' strategic planning processes, in which the objectives and policies are jointly determined based on the final customers' needs and what the supply chain as a whole does well. Ultimately, businesses act together to maximise total supply chain profits by determining optimal purchase quantities, product availabilities, service levels, lead times, production quantities and technical and product support at each level in the supply chain (Wisner et al 2005).

According to Blanchard (2007), the key to Campbell's sales and operations planning (S&OP) programme was being able to integrate all those different departments and

processes into one central plan. This strategy can be applied in any company in any industry. Blanchard (2007) defines S&OP as follows: "Sales and operations planning (S&OP) align all of a company's business plans (customers, sales and marketing, research and development, production, sourcing, and financial) into a single, integrated set of plans. The end goal is a plan that more accurately forecasts supply and demand".

Simchi-Levi et al (2008) report that in today's competitive markets, most businesses have no choice but to integrate their supply chains and engage in strategic partnering. These authors acknowledge the fact that integration can be achieved through information sharing and operational planning.

2.5.1 Information Sharing

At the Harvard Business Review Panel Lee (Beth et al 2006) revealed that nowadays, he still finds many large businesses in which the different functions are unaware what the others are doing. For example, one of these businesses may run a promotion or have a special deal in place which has not been communicated to staff in the supply chain division. Alternatively, a supply chain manager may determine inventory levels but fail to communicate this to the sales and marketing division. The most celebrated example of this lack of communication is Volvo, which manufactured many green cars in 1995. Volvo was unable to sell these cars. In response, the salespeople secretly offered huge discounts, rebates and special deals on these green cars. The supply chain people noticed an increased demand in green cars and doubled the production plan for green cars the following year. As a result, Volvo had many green cars at year-end.

Competitive forces and an increase in environmental turbulence have forced businesses to reconsider their form, structure, linkages and models. Traditional strategies and practices have proved to be unsuitable for solving the challenges of the new business paradigm. This new paradigm calls for collaboration, business focus and pipeline-wide access to information. The lack of supply chain-wide information led to the creation of waste, information and material flow barriers and consequently poor customer service (Hugo et al 2004). An example of these problems is illustrated by the so-called "bullwhip effect" (Simchi-Levi, et al 2003).

Simchi-Levi et al (2003) note that the implications of available information are enormous. Supply chain gurus like to use the phrase "In modern supply chains, information replaces inventory". Although this phrase is vague, information changes the way supply chains can and should be effectively managed and these changes may, inter alia, lead to lower inventory levels.

In recent years, suppliers and retailers have noticed that while customer demand for particular products does not fluctuate much, inventory and back-order levels vary significantly across their supply chain (Simchi-Levi et al 2003). The so-called "bullwhip" effect implies that inconsistency in demand increases as one moves up the supply chain. This increase in variability causes significant operational inefficiencies in that it forces every link in the chain to increase inventory significantly (Hugo et al 2004). By centralising demand information and integrating business processes across the supply chain (ie supply each stage of the supply chain with complete information on the

actual customer demand), the bullwhip effect can be counterbalanced (Hugo et al 2004 & Simchi-Levi et al 2003). It should be clear from this discussion that information is a critical building block and facilitator of supply chain integration.

2.6 Supply Chain Flows

According to Burt et al (2010), the supply chain extends from the ultimate customer back to mother earth. The chain is regarded as one unit rather than fragmented units, each performing its own task. Cash enters the supply chain only when the end customer purchases a product and/or service. Business deals in the supply chain merely distribute the end customer's money among the members of the chain. A business's supply system comprises all internal functions, including the external suppliers involved in the fulfillment of needs for materials, equipment and services in an optimised approach.

Burt et al (2010) acknowledges five kinds of movement flow in the supply system: (1) the physical movement of materials, usually in the direction of the end of the chain (which is the focal point of the supply chain); (2) the exchange of information; (3) the fund (money) flow; (4) the relationships flow; and (5) the flow back to mother earth, which would include recycling and the remanufacturing disposal of products.

2.6.1 Materials flow

Supply chain management incorporates product, information and cash flows between businesses, from the point of origin to the point of consumption with a view to of maximising customer satisfaction and minimising costs. As noted in section 3.9, the

supply chain stretches from the end customer back to mother earth (Burt et al 2010), and there are five flows in the supply chain of which materials flow is one.

Vogt, Pienaar and De Wit (2005) acknowledge that the flow of goods (raw materials, goods-in-process and finished goods), services and information between the point of origin and the point of consumption or application involves the following activities: demand management, facility site selection and design, materials handling, packaging, warehouse management, inventory management, procurement, logistics communications, transport reverse logistics (return goods handling and waste disposal), customer service. These activities make up the materials flows.

2.6.2 Information flow

According to Burt et al (2010), "networks are flexible virtual systems linked together by communication systems and alliances. They optimise the flow of materials and services, information and money". Strydom, Grové, Van Heerden, Nel, Van Scheers and Bothma (2005) state that information flows enhance supply chain relationships. In their opinion, one of the easiest ways to improve the entire system is to share demand data through sound two-way communication between suppliers and producers or retailers. For example, a retailer could share point-of-sale data and forecasts with suppliers.

2.6.3 Funds flow

According to Burt et al (2010), cash enters the supply chain once the end customer purchases a product and/or service.

Business deals in the supply chain merely distribute the end customer's money among the members of the chain.

Bowersox, Closs & Cooper (2007) acknowledge that few managers question the benefits of applying time-based strategies to supply chain operations. The financial benefits of timely response are simple. Fast delivery means less inventory and reduced need for distribution facilities.

2.6.4. "Cradle-to-Grave" Flow

The two goals of economic growth and environmental considerations are in direct conflict. Over time, manufacturing has evolved from mass production to TQM and time-based competition, and it has reached the latest and perhaps most significant driving force in society: environmental protection. Environmental protection emerged because of the rapid reduction of our worldwide stockpile of resources, the loss of clean, healthy air and increasing marine pollution. Environmental protection is a vital development that impacts on our quality of life (Burt et al 2003).

The main objective of environmental protection is not to promote recycling or reuse, but to focus on prevention of any kind of pollution – in other words, "zero pollution generation" (Burt et al 2003). Three main groups are the driving forces, namely environmentally friendly products, packaging and production processes. Hence, in the future, businesses will be required to purchase environmentally friendly products that

contain fewer toxic materials, minimise waste, contain recycle content, and contain plant-based materials.

2.7 Manufacturing Supply Chains and Lean Practice

Supply chains in manufacturing are also quite complicated, for example in the auto industry, but are generally more steady and consistent in its members. Due to the nature of the business, manufacturers typically keep a steady stream of work going with their primary suppliers. They develop multi-year agreements and establish relationships. Supplier quality is also monitored. Most manufacturing operations are continuous and not solely run on a project by project basis, as is its construction counterpart (Zimmer, 2006).

Manufacturing involves a production system where construction projects are more temporary productions systems. Manufacturing also involves shipping and distributing the product to the end customer. This is another significant difference verses that of construction, where the final product is in place at project completion and ready to handover. Manufacturing operations usually center on a single production facility and the supply chain includes first-tier suppliers, sub-tier suppliers, vendors, transporters, warehouses, retailers, and customers (Zimmer, 2006).

Lean thinking has transformed every aspect of the manufacturing industry. What started as an initiative of lean manufacturing has developed into the vision of lean enterprise. Companies have applied lean improvement efforts to nearly every aspect of their

business, especially in managing the entire supply chain. They have come to realize how taking a structured view in assessing the performance of their respective supply chains can reveal improvement opportunities. Wincel (2004) quotes, "SCM and lean manufacturing intersect most significantly in profitability objectives, customer satisfaction objectives, and quality objectives." These are three drivers behind the pursuit of a lean supply chain in the industry.

According to Zimmer, 2006, the technique of value stream mapping (VSM) is responsible for kicking off many lean efforts. This term "value stream" includes all activities that add value to the final product or service. For example, installing a door on an automobile adds value while double or triple handling materials from one place in the shop to another does not.

VSM involves mapping all the processes in a business operation and sorting value added steps or activities from waste. This exposes the waste and allows the organization to begin finding ways of removing or at least reducing this waste. In other words, consideration is given to how the process can be arranged to improve efficiency. The mapping from the original process is named the current state map and then after some suggestions and changes, a future map is created.

Manufacturers have found their supplier relations to be very important. They form close interweaving relationships with their suppliers. Resulting from this, efficiency of the transaction increases and the product or service is being produced at the lowest possible cost. In addition, major suppliers to manufacturers who practice lean also begin to

incorporate lean and continuous improvement into their organizations. For example, lean efforts in the shops of these suppliers may result in a reduced lead time for products. The manufacturer or customer of this supplier will then benefit from the responsiveness. Another example is seen when suppliers improve their quality. This keeps much burden off of manufacturers who would otherwise have to deal with any quality problems downstream during their part of the process.

Materials management also has become a science with manufacturers. Just-in-time delivery and visual control have shown great improvements by lowering inventory in the shop, eliminating multiple handlings of materials, decreasing search time for materials and tools, and improving safety, just to name a few. This term "just-in-time" means making and delivering only what is needed, only when it is needed, and only in the amount needed. This falls back on the previous discussion of working closely with suppliers (Zimmer, 2006).Visual control includes the practice of organizing any materials in the shop and utilizing the lean 5S process, which includes sorting, setting in order, shining ,standardizing, and sustaining. The implementation of the kanban tool has supported the central lean philosophy of having a "pull" production system. A pull system basically means that all work being done is to fulfill actual customer orders. Work is not being done or "pushed" just to create product with hope of selling it downstream. The kanban tool is basically a way of signaling for more raw materials to be drawn into the production process or for more raw materials to be made available. The two kinds of kanbans used in the Toyota Production System to serve these functions are production instruction kanbans (production kanbans) and withdrawal kanbans

(transport kanbans). The term kanban means 'card' or 'sign' and are usually some type of printed cards on each item or signal. When items have been used or transported, kanbans come off of the items and go back to the preceding processes as orders for more of the item. This helps maintain a minimum and maximum inventory level. It also allows quick response to changing customer demand (Zimmer, 2006)

CHAPTER 3: SUPPLY CHAIN MANAGEMENT AND THE GHANAIAN CONSTRUCTION INDUSTRY

3.1 Overview of the Ghanaian Construction

Typically, a construction industry of any country could be seen as having two main sets of features which make it unique from all others. The first one is the peculiarity of the construction industry which distinguishes it from other industries. The second being the peculiarities of each country's construction industry as defined by its socio-economic level, technological level, culture, institutional and legal frameworks (Gyadu-Asiedu, 2009).

3.1.1 The Industry Set-up

The key stakeholders in the Ghanaian construction industry are clients, professional consultants and contractors (Gyadu-Asiedu, 2009)

Clients

In Ghana four main clients are distinguishable: the Government (being the major client), Real Estate Developers, Investors and Owner occupiers. Between 2000 and 2008 the government of Ghana identified construction as a priority sector for foreign and private investment as part of its vision to promote the private sector as the engine of growth. According World Bank (2003) as provided by Anvuur and Kumaraswamy (2006), an approximate annual value of public procurement for goods, works and consultant

services amount to US$600 million. This represent about 10% of the country's GDP. This amount forms part of the bulk of the expenditure of all government agencies, namely, the Ministries, the Assemblies, Departments, Institutions and other agencies. Procurement of contracts must strictly follow the rules and regulation of the national procurement law as stipulated in the Procurement Act, 2003 (Act 663). The main procurement arrangement is the traditional competitive bidding. The government as a client is represented by the Ministry of Road and Transport (for road works) and the Ministry of Water Resources, Works and Housing in giving out projects .The Real Estate developers are also the other group of clients who undertake large investment in building. Usually, these take loans and undertake speculative buildings for sale. Their performance is usually influenced by the lending situations in the country.

An interview with the head of the Ghana real estate developers association (GREDA) in 2007 revealed that they expect extra assistance from the government to support them in their quest to contribute to solving the housing problem in the country. In particular, they expected the government to have involved their association in its on-going affordable housing programme. Investors are usually financial companies who decide to invest excess capital in building construction. The social security and national insurance trust (SSNIT) is one of the leading investor in housing in Ghana. Owner occupiers are individuals who decide to build their houses to live in. It has been the tradition of Ghanaians to buy lands from the chiefs (the chiefs are the custodians and owners of land in Ghana, not the government) and hire skilled workers to build their houses for them. This tradition has been entrenched mostly because successive governments failed to

meet the housing expectations of individuals. Some of these owner occupiers also rent out extra rooms in their houses for income. Therefore, some of these owner occupiers are able to progress to the level of being private investors. The owner occupiers, thus, constitute the largest number of clients in Ghana –almost every Ghanaian is a potential owner occupier. They, usually, do not engage professional consultants (Gyadu-Asiedu, 2009)

Professional Consultants

According to Gyadu, 2009, Professional consultants who are regularly engaged by the government and other clients are Architects, the Quantity Surveyors (QS), Geodetic Engineers (GE), Structural Engineers (St.E), Electrical Engineers (EE) and Services Engineers (SE). Geodetic Engineers are often called when it is about roads construction. All these professionals are regulated by their professional institution, namely, Ghana Institution of Architects (GhIA), Ghana Institution of Surveyors (GhIS) for the QS and GE and (GhIE) for the rest respectively.

Contractors

Contractors in Ghana are grouped into eight categories (A, B, C, S, D, K, E and G) according to the type of works they undertake. These are (i) Roads, Airports, and Related Structures (A); (ii) Bridges, Culverts and other Structures (B); (iii) Labour based road works (C); (iv) Steel bridges and structures: construction rehabilitation and maintenance (S); (v) General building works (D); (vi) General civil works (K); (vii) Electrical works (E); and (viii) Plumbing works (G). In each category, they are grouped

into 4, 3, 2 and 1 financial classes in increasing order (Vulink, 2004). In addition, Dansoh (2005) notes a combined category of AB for road contractors. According to Dansoh (2005) Class 4 contractors can tender for contracts up to $75,000; class 3 up to $200,000; class 2 up to $500,000. Class 1 takes contracts of all amounts. Vulink (2004) notes that because of the poor performance of Ghanaian local contractors most of the nation's major projects are usually awarded to foreign contractors. Assibey-Mensah (2008) attributes this to the "non-businesslike culture" with which indigenous firms operate in Ghana.

3.1.2 Construction Supply Chain Management

Supply chain management (hereinafter, SCM), originated and flourished in the manufacturing industry before spreading to other sectors. Its first visible signs were in the Just-in-Time (JIT) delivery system, which was a part of the Toyota Production System .The system is aimed to regulate supplies to the Toyota factory just in the right amount, the right quality, at the right place and at the right time.

The concept of supply chains have been considered from different points of view in different bodies of literature. Various definitions have been proposed and some common points can be identified. In this thesis, the definition from Lau, Huang and Mak (2004) will be considered. They defined SCM as "coordination of independent enterprises in order to improve the performance of the whole supply chain by considering their individual needs". This definition of supply chain implicitly describes the supply chain as a group of companies working collaboratively to satisfy customer needs. One of the

main functions of SCM, which is coordination, is also exhibited. This line of exploration is further continued by Vrijhoef, Koskela, and Voordijk (2003) who suggest that current practice of SCM considers the supply chain as an integrated value generating flow rather than only as set of independent activities. Cooperation and consultation among actors are regarded as paramount in supply chain management. Christopher (2000) goes further to say that trust, commitment, and willingness to share information among the supply chain participants are pre requisites for making efficient supply chains. However, the construction industry has been slower to employ the concept of supply chain management which has been embraced elsewhere (i.e. manufacturing) (Love 2000). The reasoning for the poor up-take of supply chain management in construction can be linked to two factors: the long-lasting supplier-contractor relation that are subject to vulnerability due to the temporary nature of construction projects and the one of kind nature of the product (Akintoye, McIntosh, and Fitzgerald 2000).

Previous researches have shown that in traditionally managed supply chains, there are considerable waste due to excessive variability and little control (Wegelius-Lethonen et al. 1996). Cooper and Ellram (1993) describe differences between the traditional way of managing the supply chain which is based upon conversions view of production and the SCM based on a flow view of production. The main differences between the traditional way and SCM are shown in the table below

As can be seen in the table below, SCM contrasts sharply with traditional methods of managing projects which focus on optimizing individual activities. Unlike the current

construction methods, supply-chain management aims to design, plan and manage construction projects in a more collaborative way. In addition, supply chain management is about integrating subcontractors and suppliers skills and competencies in order to achieve performance improvement, and to overcome barriers to implementing supply chain management arrangements with small to medium enterprises suggested by Dainty et al. 2001.

Table 3.1. Traditional and Supply chain management approaches compared.

Element	Traditional	Supply chain
Inventory management Approach	Independent efforts	Joint reduction in 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	On-going
Compatibility of corporate Philosophies	Not relevant	Compatibility at least key Relationship
Breath of supplier base	Large to include competition and spread risks	Small to increase coordination
Channel Leadership	Not needed	Needed for coordination focus
Amount of sharing of risks and Rewards	Each on its own	Risks and rewards shared
Speed of Operations, Information and inventory Flows	Warehouse" orientation (storage, safety stock), interrupted by barriers to flow	"Distribution Centre" orientation, Interconnecting flows; JIT, Quick response across the channel

(Source: Cooper and Ellram 1993)

In a nutshell, supply chain management can be seen as a set of practices aimed at managing and co-coordinating the whole supply chain from raw material suppliers to the end consumer (Fewings, 2005). However, Fernie and Thorpe (2007) suggest that underlying all these definitions of supply chain management is the assumption that developing and understanding relationships within and between organisations underpins the ability to optimise flow; breakdown process discontinuities; develop networks; make decisions about managing competencies, and optimise the use of power.

Supply chain management is therefore, closely associated with improvement programmes that have been broadened to include methods of reducing waste and adding value across the entire supply chain. The aim is to evolve greater collaboration and synergy throughout the whole network of suppliers through better integration of both upstream and downstream processes. This significant emphasis on coordination and integration is strongly dependent on the development of more effective and longer-term relationships between buyers and suppliers with increased trust and commitment. It is about adopting a more holistic approach in order to optimise the overall activities of companies working together to build greater mutual competitive advantage and greater customer satisfaction. Love et al., 2004 suggest that if the construction industry is to move from an adversarial environment to one that is founded on collaboration then it should openly embrace the concepts of supply chain management.

Often, construction projects are carried out by short-term teams of architects, contractors, subcontractors and suppliers who have been put together specifically for the

execution of the project, only to disperse once the contract reaches its terminal end. In fact, Fearne and Fowler (2006) note that the construction industry is arguably the least integrated of the all major industrial sectors, characterised by adversarial practices, disjointed supply relationships and a lack of trust between clients, contractors and subcontractors. In order to overcome this problem, the concept of longer-term contractual relationships was evolved. Informed thinking suggests that smaller, and more integrated supply chains are the remedy to prevalent cost and time overruns on projects. To this end most top rate contractors have changed the way business is done. Fewer and better supplier and subcontractors now work closely with main contractors and the client reaps the benefits of this new phenomenon. A reduction of the number of the supply chain members and signing long-term contracts with them precludes prolonged and expensive formalities, thus adding the much needed value to the supply chain.

Latham (1994) highlights some of the industry problems, and underlines the reliance of the construction sector on competitive tendering for subcontracted work. He also mentions the adversarial attitudes that commonly exist between main contractors and their suppliers. One-off contracts and a failure to develop longer-term relationships between main contractors and key suppliers is common place in the construction industry. Supply chain theory indicates that value must be added to the process faster than cost (Lamming, 1996 cited by Dainty et al., 2001). Industry reports suggest that this is probably often not the case for the construction industry, as cost overruns and low profits are both endemic in the industry. The implementation of supply chain

management principles in construction have started to address these issues. The current discourse of change proposes the need for a journey away from adversarial attitudes towards enlightened cooperative relations and appears to demonise adversarial opportunistic behaviours over cooperative and collaborative behaviour (Fernie and Thorpe, 2007).

Similarly, Khalfan et al. (2005) advocated the use of supply chain management philosophy as a means to effectively reduce overall construction costs. They proposed early involvement of subcontractors and suppliers in a manner similar to the early involvement of the contractor during the procurement process. According to them, this would give an opportunity to the supply chain members to offer their expertise which could result in significant cost savings and potentially improve collaboration and communication within the chain. The need to build inter-firm relationships based on mutual trust was also explained. According to them it is crucial to take away the deep-rooted barriers of traditional relationships and the adversarial culture, and instead, introduce a change management framework to facilitate the implementation of supply chain management at the operational level.

Dainty et al. (2001) (cited by Khalfan et al., 2005) suggest that structural changes are necessary to make supply chain integration effective. These changes include developing trust within the supply chain; ensuring fair payments; early involvement with projects; educating the construction workers; improving communication skills; knowing the operations of other parties in the supply chain; knowing the benefits of supply chain

integration and partnering; understanding new contractual documents; client and main contractor. In terms of the foregoing, the upstream activities within construction SCM in relation to the position of a main contractor, consists of the activities and tasks leading to preparation of the production on site involving construction clients and design teams. The downstream consists of activities and tasks in the delivery of the construction product involving construction suppliers, subcontractors, and specialist contractor interrelating with the main contractor. Downstream activities require substantial co-ordination among project partners. This feature should provide a breeding ground for unproved supply network improvements.

3.1.3 Challenges in Construction Supply chains

The status of construction supply chains does not seem to have changed much in the last few decades. Peansupap and Walker (2006) observed that: "… any lack of cohesion and co-ordination is less the result of ill-will or malignancy on the part of any groups or individuals, but more the result of forces beyond the control of any individual or group and which are affecting all".

From previous research, three main conclusions can be drawn as to the current status of construction supply chains (Vrijhoef & Koskela 2000). First of all, the construction supply chain has a great deal of waste and problems. Secondly, most of these waste and problems have a bad effect in other stages of the construction supply chain than where it is recognized. Last but not least, waste and problems are because of the antiquated and

short sight control of the construction supply chain and also the independent control of each stage of the chain.

- Waste and problems in construction supply chains: Sobotka (2000) found in his study on construction material flows that the value-added time of materials flow is only 0.3-0.6% of the total flow time. Only for the interface between the main contractor and the supplier has an average cost reduction potential of 10% (of material costs) through improved logistical procedures been shown (Sobotka, 2000). The waste can be even higher when taking the whole supply chain into consideration.
- Root causes of waste and problems in former stages of the construction supply chain: Sobotka (2000) found that "incomplete planning and information on the amount of necessary material are characteristic for materials purchasing in construction component manufacturing", Vrijhoef and Koskela (2000) found that the construction component orders are always made according to the incomplete and wrong design data. In another study on the supply of concrete façade component, Roy (2003) found that several of the problems in the factory were caused by external chain partners. The design documents are often insufficient and most of the issues are not described in detailed. Changes are caused by unavailable, late, wrong and incomplete information and are often not well communicated. On the other hand, the factory may bring problems for other chain partners as well. When trying to improve its activities it supplied elements

in a different order. The factory needed to have all drawings at the same time because of its own inadequate scheduling of its information needs.

- Myopic control of the construction supply chain: It was shown that the purchasing price is the primary criterion for supplier selection (DTI Internet, 2006). O' Brien (2002) found that subcontractors are always selected according to price. Roy (2003) found that decision making on the improvement of supply chain is often limited by those solutions one has experience of. It is customary to use material inventories as buffers against disruption. Similarly, Marsh and Finch (1998) found that nearly all supply chain partners add a time buffer to their schedule, and it will increase the time cost.

According to those previous researches, it can be seen that waste and problems in construction supply chains are extensively present and persistent. As a result of interdependency, the occurrence of waste and problems is interrelated with causes in other stages of the supply chain (Peansupap & Walker, 2006). What is more, myopic control of the construction supply chain enlarges waste and problems and makes things even worse. It is obviously that those uncontrollable forces and their organizational after effects hindered the development of construction supply chain. A part of the new model, such as open building system, sequential procedure, the new construction mode, design/build and partnering, have directly attacked this lack of cohesion and coordination. There are several other examples: generic initiatives, like re-engineering, time compression, quality and information technology (Ward, 2005). These have been recently implemented in construction. However, only few of them succeed.

What may be the reason for the failures? One possibility is pointed out by Peansupap and Walker (2006) who compared a time compression program in construction with a corresponding program in manufacturing. They conclude that for builders with their project culture it is easier to implant renewal efforts (Peansupap & Walker, 2006). However, at the same time this means that a fundamental mental change was hardly needed in implementing the construction time compression program, and thus its cultural and mental influence was limited.

In another research, it shows that communication perspective provide a useful conceptual basis for analyzing construction supply chains (Tsemg et al., 2005). In this study, the author showed primary evidence for the relevance of communication and the construction supply chain waste and problems.

In Vrijhoef and Koskela's study on design management, 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 it has to be ready. The actors in the design project organization have no common and clear understanding on what should be designed" (Vrijhoef & Koskela, 2000). They pointed out that conversations for action were either ineffective or missing in the coordination of design.

Vrijhoef and Koskela (2000) found that there are different supply chain management problems in different stages of the construction supply chain. Many of the problems are caused directly or indirectly by insufficient coordination, communication, and these

commitments lead to wrong inform about schedule changes, late confirmation of deliveries, and lack of feedback procedures.

From site coordination point of view, Dainty (2001) mentioned in his paper that "… the specialists [contractors] are just thrown together and told to sort things out between themselves". These kinds of phenomena which always happened in the supply chain are always the causes of misunderstanding. It shows a complete lack of coordination and structure in the communication and collaboration on site.

Naim and James (2001) study of quality defect costs in construction found 'that the majority of causes for defects are related to various forms of ambiguity, such as ambiguity about clients' (e.g. concerns, interests and requests), ambiguity about organizational structure and responsibilities (e.g. agreements and promises) and ambiguity in drawings (e.g descriptors of conditions and clients responsibilities)".

3.3 Lean Thinking

Lean thinking is a framework and a production philosophy originating from Japan. It is based on different elements derived from the Toyota Production System (TPS). These elements are discussed below.

3.3.1 Lean Production

Lean production (or the Toyota Production System) was developed after the Second World War by Toyota. Engineer Ohno, a smart person dedicated to eliminating waste

led the Toyota team. The term "lean" was coined by the research team working on an international auto production to reflect the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production (Womack et al, 1991).

Faced with the challenge of producing a variety of cars with Toyota's small capital base for a small market, Ohno shifted attention to the entire production system from the narrow focus of craft production on worker productivity and mass production on machine. He followed the work of Henry Ford and continued the development of flow based production management. However unlike Ford who had an almost unlimited desire for a standard product, Ohno wanted to build cars to meet customers' peculiar demand. Having been influenced by Total Quality Management (TQM) and as a result of efforts to reduce machine set up time Engineer Ohno developed a simple set of objectives for the design of the production system: Produce a car to the requirements of a specific customer, deliver it instantly, and maintain no inventories or intermediate stores (Howell, 1999).

The desire of Toyota to achieve zero waste and perfection, according to Howell and Ballard (1999), shifted the improvement focus from the activity to the delivery system. Ohno and other Japanese engineers got exposed to the mass production of cars from their plant visits in the United States and where US managers saw efficiency, Ohno saw waste at every turn. He realised that the pressure to keep each machine running at

maximum production led to a lot of intermediate inventories he called “the waste of over production.”

Ohno also observed defects built into cars because of the pressure to keep the assembly line moving. Production at all costs implied that defects were left in cars as they moved down the line. "These defects disrupted downstream work and left completed cars riddled with embedded defects. Where the US approach aimed to keep the machines running and the line moving to minimize the cost of each part and car, Ohno’s system design criteria set a multi-dimensioned standard of perfection that prevented sub-optimization and promoted continuous improvement" (Howell and Ballard, 1999).

According to Howell, zero time delivery of a car that meets customer needs with nothing in inventory called for stiff coordination between the progress of each car down the line and the arrival of parts from supply chains. The incidence of rework arising from errors could not be tolerated as it reduced throughput (that is the time to make a car from beginning to end) and caused unreliable workflow.

Engineer Ohno, reports Howell (1999), in trying to eliminate the incidence of rework arising from errors went as far as calling for workers to stop the line on receipt of a defective part or product from upstream unlike in US plants where only the plant manager could stop the line. Requiring workers to stop the line led to the decentralization of decision making. The decentralization process was carried further when he replaced centralized control of inventory with a simple system of cards or bins which signaled the upstream station of downstream demand. "In effect, an inventory

control strategy was developed which replaced central push with distributed pull". Howell (1999) also observed Ohno´s decentralization of shop floor management by making visible production system information to everyone involved with production. "Transparency" allowed people to make decisions in support of production system objectives and reduced the need for more senior and central management.

The Toyota production team after understanding the demands of low waste production in manufacturing, moved back into the design process and out along supply chains. In an effort to cut down the time to design and deliver a new model, the design of the production process was carefully considered along with the design of the car. The responsibility of ensuring that engineering components meet design and production criteria was then shifted to the suppliers (Howell, 1999).

Lean production, according to Howell (1999), is evolving but the basic outline has become clear: Design a production system that will deliver a custom product instantly on order but maintain no intermediate inventories. The concepts include:

- Identify and deliver value to the customer: eliminate anything that does not add value.
- Organize production as a continuous flow.
- Perfect the product and create reliable flow through stopping the line, pulling inventory, and distributing information and decision making.
- Pursue perfection: Deliver on order a product meeting customer requirements with nothing in inventory.

"Lean production can now be understood as a new way to design and make things differentiated from mass and craft forms of production by the objectives and techniques applied on the shop floor, in design and along supply chains. Lean production aims to optimize performance of the production system against a standard of perfection to meet unique customer requirements" (Howell, 1999).

3.3.2 Eight Lean "Wastes"

Lean philosophy is a common sense approach that strives for the systematic elimination of waste in the production process. Womack and Jones (2003) define waste as any human activity which absorbs resources but do not create value. Taiichi Ohno (1988) cited by Dao et al (2009) defines waste into seven categories that are apparent in every manufacturing facility in the world:

(1) *Overproduction*; (2) *Waiting*; (3) *Unnecessary Transport*; (4) *Inappropriate Processing*; (5) *Unnecessary Inventory*; (6) *Unnecessary Motion*; (7) *Defects*. An eighth waste was added by Jeffrey Liker (2004) which is (8) *Unused Employee Creativity*. They are described below.

Overproduction

This waste is considered as the most serious one as it discourages smooth flow of goods and services and is likely to inhibit quality and productivity. Producing items for which there are no orders generates wastes such as overstaffing, storage and transportation costs. Such overproduction also tends to result in excessive lead and storage times. As a

result, defects may not be detected early, products may deteriorate and artificial pressure on work rate may be generated.

Waiting

This waste is concerned with the ineffective use of time. Waiting occur whenever goods are not moving not being processed. In manufacturing, this waste occurs whenever workers are waiting for equipment, plans or instructions on how to proceed. This waste affects both goods and workers, each spending time waiting. The best use of waiting time would for instance be to train workers.

Unnecessary Transport

The third waste involves goods being moved around. Carrying Work In Process (WIP) long distances, creating inefficient transport, or moving materials, parts, or finished goods into or out of storage or between processes. Taken to an extreme, any movement in the factory could be viewed as waste. In addition, double handling and excessive movements are likely to cause damage and deterioration of material.

Inappropriate Processing

This waste is about taking unnecessary steps to process the parts. Inappropriate processing can for instance be depicted as using expensive highly advanced equipment where simple tools would be sufficient to do the work. The over complexity generally discourages ownership and encourages the employees to overproduce so that the large investment in the complex machines can be recovered.

Unnecessary Inventory

This can be related to material stored on site too far in advance of when it is needed. Unnecessary inventory tends to increase lead time, obsolescence, damaged goods, transportation, storage costs, and delays. The long lead time prevents rapid identification of problems and discourages communication. By achieving flow between the work stations, inventory can be reduced.

Unnecessary Motion

Any wasted motion employees have to perform during the course of their work such as stretching or bending. Taken to an extreme, walking can be considered as waste. Such waste is tiring for the employees and is likely to lead to poor productivity and often, to quality problems.

Defects (rework)

This is considered as the bottom-line waste because defects are direct costs. Production of defective parts or correction is typically a wasteful spending. Repair or rework, scrap, and inspection mean wasteful handling, time and effort.

Unused Employee Creativity

This is about losing time, ideas, skills, improvement and learning opportunities by not engaging or listening to employees (Liker 2004).

3.3.3 Lean Principles

In their war against '*muda*' (the Japanese word for waste), Womack and Jones (2003) describe Lean thinking as a cycle of five guiding principles where the implementation of the first four lead to achieving the fifth. The ultimate goal is the elimination of waste. The principles are described below:

Specify Value

Value is specified from the standpoint of the end customer. Only what the customer considers as value should be taken into consideration, "*nothing more, and nothing less*".

Identify the Value Stream

When the value is specified, the value stream that creates this value must be identified. This is about identifying all the steps in the value stream in order to determine activities that do not add value and seek for their elimination.

Make Value Flow without Interruption

In Lean thinking, flow is considered to be the tool used for waste elimination. Value should be created in a flow of activities and processes. This is done by minimizing delays, inventories, defects and downtime.

Use Pull Logistics

Produce only in response to a signal from a customer, not based on forecast.

Pursue Perfection

Lean is about continuous improvement. The organisation should continuously strive for improvement. The ultimate goal is to achieve perfection. The figure below shows the five Lean principles cycle. It shows that "muda" is removed from one step to another and all the steps aim to achieve perfection as discussed above.

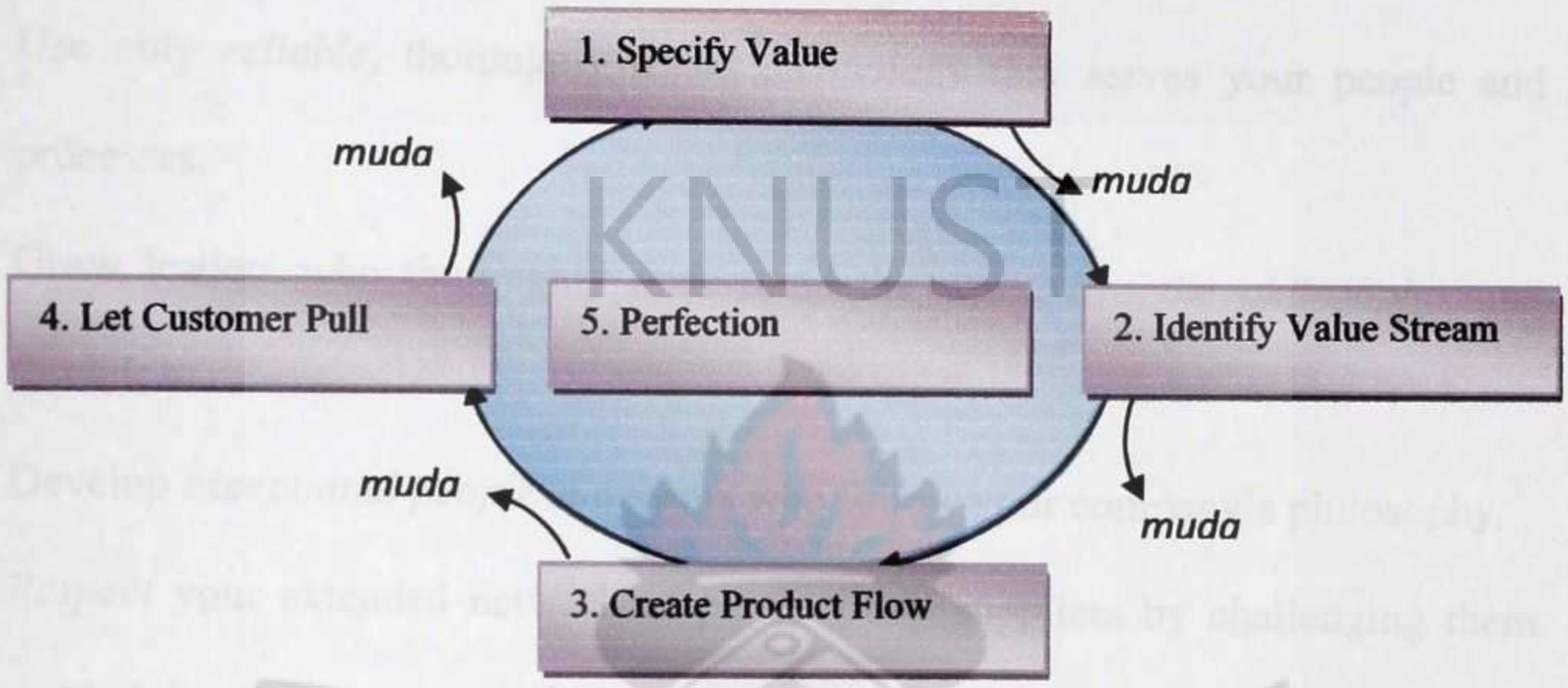


Figure 3.1. Lean Principles (Source: Womack and Jones 2003)

These five principles of the Lean philosophy have been widely used over the past decades by companies seeking to implement Lean in their production process. Jeffrey Liker (2004) describes a much broader way of implementing Lean through the 14 principles of the Toyota way:

1. Base your management decisions on a *long term philosophy*, even at the expense of short term financial goals.
2. Create *continuous process flow* to bring problems to the surface.
3. Use *"Pull" systems* to avoid overproduction.

4. *Level out* the workload.
5. Build a *culture of stopping the production to fix problems*, to get *quality right* the first time.
6. *Standardized tasks* are the foundation for *continuous improvement* and employee empowerment.
7. Use *visual control* so no problem is hidden.
8. Use only *reliable*, thoroughly tested *technology* that serves your people and processes.
9. Grow leaders who thoroughly understand the work, *live the philosophy*, and teach it to others.
10. Develop *exceptional people* and teams who follow your company's philosophy.
11. *Respect* your extended network of partners and suppliers by challenging them and helping them improve.
12. Go and see for yourself to thoroughly *understand the situation*
13. Make decisions slowly by *consensus*, thoroughly *considering all options*; *implement decisions rapidly.*
14. Become a *learning organisation* through relentless reflection and *continuous improvement.*

However, Liker (2004) insists on the fact that the equation might be different depending on the organisation. He insists that Lean philosophy is not about imitating the tools used by Toyota in the particular manufacturing process but about customizing the principles and carefully practicing them to best fit your own organisation.

3.4 Lean Supply Chain Management in Construction

In a typical construction project, it can be found several organisations working together to achieve a common goal. Members of this chain include manufacturers, suppliers, distributors and transporters. A high degree of cooperation between those entities is critical for the success of a construction project. The strategy involving the integration and coordination among these different members of the supply chain is called supply chain management. In term of Lean production, supply chain management is closely related to Lean supply (Lamming 1996).

Since its introduction, Lean thinking has been applied to many aspect of the manufacturing industry. Companies around the world have applied the concept to nearly every aspects of their business, including their supply chain. According to Wincel (2004), SCM and the concept of Lean intersects most significantly in "*profitability objectives, customer satisfaction and quality objectives*".

The primary goal of Lean supply chain management is to accomplish supply management with the minimum possible waste in construction. Lean supply chain management emphasizes and focuses on improving relationships among project participants. It focuses on the cooperation between all actors involved in a typical construction project for improving the total flow of material.

3.4.1 Lean Construction

Lean construction as defined by the Lean construction institute is "*a production management-based project delivery system emphasizing the reliable and speedy delivery of value. The ultimate goal is carry on the project while maximizing value, minimizing waste and pursuing perfection – for the benefit of all project stakeholders.*" (LCI, 2002).

Kim (2002) agrees with this definition and adds that Lean construction challenges the general concept of trade-off between time, cost and quality employed in traditional construction. Howell (1999) claimed that managing construction under Lean philosophy is different from typical construction contemporary practice because it:

- Has a clear set of objectives for the delivery process
- Is aimed at maximizing performance for the customer at the project level.
- Applies production control throughout the life of the project

In his attempt to make the construction leaner, Koskela (1992) joined the debate by developing eleven heuristics principles which are applicable to construction:

1. Reduce the share of non value-adding activities
2. Increase output value through systematic consideration of customer requirements
3. Reduce variability
4. Reduce the cycle time
5. Simplify by minimizing the number of steps, parts and linkages
6. Increase output flexibility
7. Increase process transparency

8. Focus control on the complete process
9. Build continuous improvement into the process
10. Balance flow improvement with conversion improvement
11. Benchmark

Construction is considered to be one of the most change resistant industries in the world. Koskela (1992) claimed that the most general concept seems to be understanding construction as a simple process of transforming an input to an output. This conception is actually shared by both old and newer methods in construction.

The traditional system of construction project focuses more on keeping track of time and cost. Time control is about looking at the progress in the production line, while cost control is primarily concerned with the budget. Cost control tracks if the project is under or over budget. Kim (2002) suggests that in traditional construction, control consists on monitoring against schedule and budget estimates; while in Lean construction control is defined as causing events to conform to plan. Kim (2002) continues on to say that traditional construction focuses more on individual activities. In traditional construction, control begins with tracking cost and schedule, and therefore any effort to improve productivity lead to unreliable work flow due to sub-optimization. As a result, project performance is considerably reduced.

In Lean philosophy, the focus is on how one activity affects the next activity, as all activities are part of the whole system. Ballard and Howell (1998) claimed that the goal in Lean construction is to improve the performance of the whole system. They put

forward that where current project management manages projects as more or less independent activities, Lean philosophy works first to assure the reliable flow of work between the tasks. In that perspective Koskela (2000) depicts construction as a continuous flow of materials and/or information instead of just conversion activities (from input to output). Koskela (1992) states that production concepts used in various industries are of three main types:

1. Transformation view – concept of transforming inputs to outputs.
2. Flow view – materials and information flow in a production process.
3. Value generation view – process where the value for customer is created through fulfillment of his/her requirements.

However, construction has for a long time been managed according to the transformation or conversion concept, thus focusing more on transforming an input to an output. Principles related to the flow and value generation concepts were largely neglected resulting in inefficiency. Koskela (2000) states that it is crucial that the peculiarities of construction are understood and taken into consideration in construction management both from the point of view of Transformation-Flow and Value concept. For Koskela (2000), this tripartite view of construction will foster tremendous improvement in construction.

The table below describes the nature of construction, its main principles, the methods and practices and its practical contribution from the standpoint of each element of the

TFV theory. Table 3.2 is summarized from the **practical contribution viewpoint** depicted at the bottom of the table.

Table 3.2. Transformation/Flow/Value

	Transformation View	**Flow View**	**Value Generation**
Nature of Construction	A series of activities which convert inputs to outputs	The flows of information & resources, which release work: composed of conversion, inspection, moving & waiting.	A value creating process which defines and meets customer requirements
Main Principles	Hierarchical decomposition of activities; control and optimization by activity	Decomposition at joints. Elimination of waste (unnecessary activities), time reduction	Elimination of value loss the gap between achieved and possible value
Methods & Activities	Work breakdown structure Critical path method Planning concerned with timing start and responsibility for activities through contracting or assigning.	Team approach, rapid reduction of uncertainty, shielding, balancing, decoupling. Planning concerned with timing, quality and release of work	Development and testing of ends against means to determine requirements. Planning concerned with work structure, process and participation.
Practical Contribution	Taking care to do necessary things	Taking care that the unnecessary is as little as possible.	Taking care that the customer's requirements are met in the possible best manner.

(Source: Ballard 2000)

"Taking care to do necessary things" in the Transformation aspect can be linked to effectiveness and "taking care that the unnecessary is done as little as possible" in the Flow aspect can be linked to efficiency. By combining these two aspects, value can be obtained which mean "taking care that customer requirements are met in the best possible manner" (Koskela, 2000).

3.4.2 Pulling to Site Demand and Just-in-Time

The idea of creating "pull" systems in a production environment is central in implementing Lean principles (Zimmer 2006). Just-in-Time is the most common term used in pull systems. Just-in-Time is described as "*the state in which value can be said to flow through the process with minimum interruptions and waste*" (Kocakülâh, Brown, and Thomson 2008). This definition is supported by Thomas et al. (2002) who assert that any interruptions to the normal flow of materials will result in having bad performance and poor labour productivity at the workface. Once more the flow concept is pinpointed.

One of the main objectives of Just-in-Time is to decrease inventories and to develop an effective cooperation with the supplier. To achieve Just-in-Time, the delivery rate from suppliers must be compatible with the installation rate in the field of operations. In construction, this aspect of Just-in-Time involves delivering only materials that are ready for installation, in the amount needed, and at the time needed. The use of Pull systems is deemed to be necessary in the situation where there is little storage capacity for the construction project to be successful. The challenge would be to guarantee material availability without building up unnecessary inventory.

Many researchers in Lean construction give the example of concrete as a typical material that has to be delivered Just-in-Time. When a contractor calls for concrete delivery, he needs to be ready to place that concrete once it arrives. The initiative now is to apply the same system to all kind of materials and equipment going into the workface. It would

not be appropriate to talk about Just-in-Time without mentioning the concept of Kanban. Kanban is a Lean approach that has been developed by Toyota to pull materials and parts throughout the value stream on a Just-in-Time basis. Kanban means 'card' or 'sign' in Japanese and is the name given to the inventory control card used in a pull system. Two types of Kanban exist: *Transport Kanban* which is used to signal the need to replenish materials from suppliers and *Productions Kanban* which is used to initiate production (PPDT 2002).

3.4.3 Information Sharing and Collaboration

The performance of a supply chain depends to a great extent on how its members coordinate their actions. However, it seems hard to imagine coordination without information sharing (Chen 2003). Communication and coordination are major factors that support Lean implementation because if all people involved in the project openly share information, it can lead to a better site coordination and substantially reduce inefficiencies in the project, two objectives sought by Lean philosophy. Therefore finding ways to communicate more effectively with all participants in the project is an important aspect of implementing Lean principles.

According to Pinho, Telhada, and Carvalho (2007), the large number of organizations working together in a construction project necessitate that the information which flows between them must be reliable and in real time. An information system that can aggregate information related to the needs of materials, equipment is necessary to achieve a better supply chain. Furthermore, improving coordination and communication

between the participants in the supply chain is absolutely paramount to achieve a synchronized flow.

Koskela (2000) proposes the use of communication and Information Technology (IT) in the construction industry to support the delivery process of the building. Koskela (2000) states that the use of IT can help improve communication in the construction industry. Zimmer (2006) asserts that IT provides visibility throughout the supply chain. Nowadays, software systems and online capability have been extensively developed and provide organisations with numerous ways to share information in real time. All parties involved in a construction project can collaborate more efficiently through the effective use of IT. By using IT systems, information is shared in the same format and therefore standardized. According to Zimmer (2006), by using IT, cooperation between site manager and suppliers off-site will be improved because real time communication is established. Owners can also keep themselves informed on construction job completion through IT. Subsequently, paperwork and lead times will be reduced and most importantly visibility about the progress of work will improve.

3.4.4 Supply Chain Coordination through the Management of Commitment

Considering the fact that every construction project involves different parties, a high level of commitment is required from all members for achieving a satisfactory level of performance. According to Azambuja et al. (2006), most causes of inefficiency in construction supply chains are greatly related to the poor management of commitments among their members. As for site coordination, Bennett and Ferry (1990) depict the

situation by saying that contractors are "*just thrown together*" on the construction site and have to find ways to sort things out between themselves. This, in turn creates a lot of misunderstanding fostered by a complete lack of both coordination and communication, which plausibly can be assumed to cause a lack of commitment.

Denning and Medina-Mora (1995) see every organisation as a network of commitment. Their view are based on the work of Winograd and Flores (1986) who approached construction supply chains from a theoretical point of view called the *Language Action Perspective* (LAP). According to Vrijhoef, Koskela, and Voordijk (2003), a basic tenet of the LAP is that by improving communication in an organisation, the organisation itself can be improved.

Azambuja et al. (2006) assert that LAP offers a comprehensive approach to understand and coordinate the work among people and organisations which Denning and Medina-Mora (1995) depict as a "*map of interconnected commitment loops*". According to them, "*the basic element of a coordination process is a closed loop that connects two parties*". The loop entails a performer who promises to satisfy a request from the other party, the customer. Figure 3.2 on the next page illustrates the commitment loop. It seems evident that when everyone reliably meets their commitments, the overall project proceeds more smoothly. Figure 3.2 can be described as follow: let's consider the customer as a contractor and the performer as the material supplier. At the start of the loop, conversation is initiated by a request for material from the customer; negotiation occurs in term of both time of delivery and amount of material.

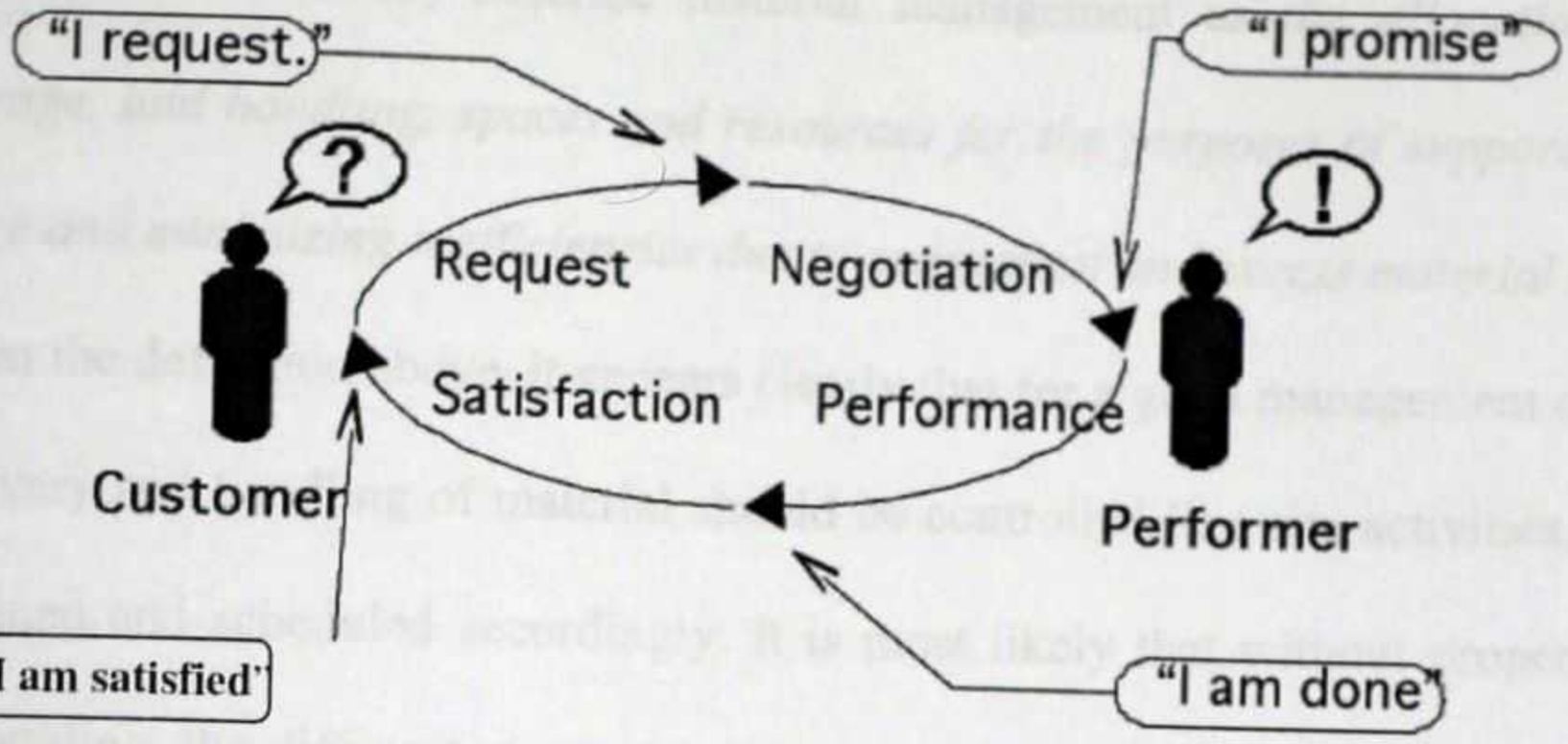


Figure 3.2. The commitment loop (Source: Denning and Medina-Mora 1995)

The declaration from the requestor that the action is satisfactory closes the loop. This methodology stresses the importance of the completion of commitment loops in order to achieve effective coordination of work as well as Just-in-Time delivery.

3.4.5 Planning Delivery and Material Management

Several studies, for instances CII (1988) and Thomas et al. (2002) have demonstrated that poor material management practice can result in large cost during construction projects. The lack of material on site when required, lack of the "right" materials on site and unnecessary inventory are some types of waste stemmed from bad material management. It is also suggested by Thomas, Riley, and Messner (2005) that site layout and the way materials are managed are closely linked, especially for small construction sites.

Thomas *et al.* (2005) describe material management as *the allocation of delivery, storage, and handling, spaces and resources for the purposes of supporting the labour force and minimizing inefficiencies due to congestion and excess material movement.* From the definition above, it appears clearly that for a good management of material, the delivery and handling of material should be controlled like site activities, and therefore planned and scheduled accordingly. It is most likely that without proper planning and scheduling, the different contractors involved in a construction project will face chaotic material deliveries such as out-of-sequence deliveries of similar or different materials on the job site, peaks in arrival of materials creating congestion, parallel unloading and poor site organisation. These situations are sources of wastes.

Efficient material planning is a key to high productivity on site. Material planning embraces quantifying, ordering and scheduling. Productivity will suffer if the material planning process is not executed properly (Kaming et al. 1997). Furthermore, Ballard and Howell (1994) emphasized that planning must be extended downward to foremen, sub-crews and individual craftsmen until work has been executed. They developed a new method called the "*Last planner*" which is a tool aimed for better planning and controlling the production process. Making sure that job sites are in perfect conditions to receive the material to be delivered is also fundamental for Just-in-Time.

3.4.6. Lean Tools

Several tools have been developed along with lean philosophy including, Kaizen, 5S, the Last planner system, and Value stream mapping.

3.4.6.1 5S

In Lean philosophy, the concept of 5S aims at managing the production site in a best possible way. The 5S designation can be translated from Japanese into "*separate, sort, sweep, standardize,* and *sustain*" which is a philosophy and a procedure of organizing and managing the workspace in order to increase efficiency. This concept was originally developed by Toyota to describe the proper method of maintaining cleanliness and order at the workplace referred to also as *housekeeping*. A 6th S for *safety* is added by some companies implementing lean (Kocakülâh, Brown, and Thomson 2008).

The first step, *separate* consists of evaluating and removing anything which is not necessary to perform a task in a specific area. The next step, *sort*, consists of finding a specific place to keep the remaining items that are required to perform the task in that specific area. The third step *sweep,* talks for itself; everything must be kept clean, free of debris and tools must be placed back in place after use. The fourth step, *standardize,* means keeping things consistent from one place to another. Multiple workstations for the same process have to be set up in the same way. This will support flexibility for employees across all workstations. In the final step, *sustain,* the focus is on maintaining the discipline to keep the area of work clean and in order at the start as well as the end of the day. This is about changing the culture in the way thing works (Kocakülâh, Brown, and Thomson 2008). The fifth S, *sustain,* is the hardest to implement because it takes time to change the culture of people in an organisation. Sustaining the culture will keep the first four S's going. It can be achieved by emphasizing the necessary education, training and rewards needed to encourage workers to properly maintain and

continuously improve operating procedures and the workplace environment. According to them (Kocakülâh, Brown, and Thomson 2008), 5S is the first Lean perspective on making operations flow and layout of the workplace. The ultimate goal of 6S is to sustain a tidy working place, make things visual and maintain a safe working environment.

3.4.6.2 Kaizen

Kaizen is a Japanese word for improvement. This Lean construction tool involves looking at some task in the field and finding out how to do it better, more efficiently, safer and quicker. Liker and Meier (2006) suggested that an important part of Kaizen is that processes are repeatable so they can be measured. Key performance indicators (KPIs) should be determined for this purpose. Standardization of processes is a requirement before starting on Kaizen activities. Three different aspects of standard work have been discussed in the literature.

1. Standard work is not static but updated each time a better solution is found.
2. Standard work supports stability and reduces variation.
3. It is essential for continuous improvement.

Furthermore, management standards should exist for meetings, communication, budget and many other activities (Bicheno 2004; Liker 2004).

3.4.6.3 The Last Planner System

The Last planner system is a planning method considered to be one of the most important tools in Lean construction. In the literature, its application in construction projects around the world has been mostly production oriented, for example, (Ballard 2000), has studied its interpretation in the construction industry. However it can also be applied to the management of material delivery. In their article '*Material delivery problems in construction projects: A possible solution'* Ala -Risku and Kärkkäinen (2004) propose a solution for the delivery of material without a build-up of unnecessary inventory on site based on the Last planner system.

Ala-Risku and Kärkkäinen (2004) state that the Last planner is a tool that uses the overall project plan as the general framework, but suggests that the day to day activities of the production should be managed by a more flexible approach with regard to the actual progress of the project. Concept such as pulling production, reducing variability and increasing flow reliability are integrated in the Last planner system (Sterzi et. al. 2007). Basically, the idea behind the Last planner system is to replace optimistic planning with realistic planning by allowing the last person in the process to plan and decide the assignment to be done. Assignments are likely to get done when they are clearly defined, in the right sequence, with the right amount of resources and within the capacity of the crew supposed to do the work (Kim 2002)

Concerning this issue, Koskela (2000) describes seven preconditions for the execution of a construction task which are: (1) *construction design,* (2) *components and materials,* (3)

workers, (4) *equipment,* (5) *Space,* (6) *connecting works,* (7) *external conditions*. The figure on the next page shows that for a construction task to be performed, the design (drawings) need to be ready, the right amount of materials as well as equipment should be at hand, the right number of workers in place, the space should be free of clutter and available for the work. In addition, *connecting works* which means the work preceding the task needs to be finished before the work can begin and finally external conditions (for example, weather and holiday.) need to be favourable. "*A reliable assignment determines what "Will" be done after considering what "Should" and "Can" get done based on the situation at hand*" (Kim 2002, p. 28). Figure 3.3 presents the diagram of Last planner.

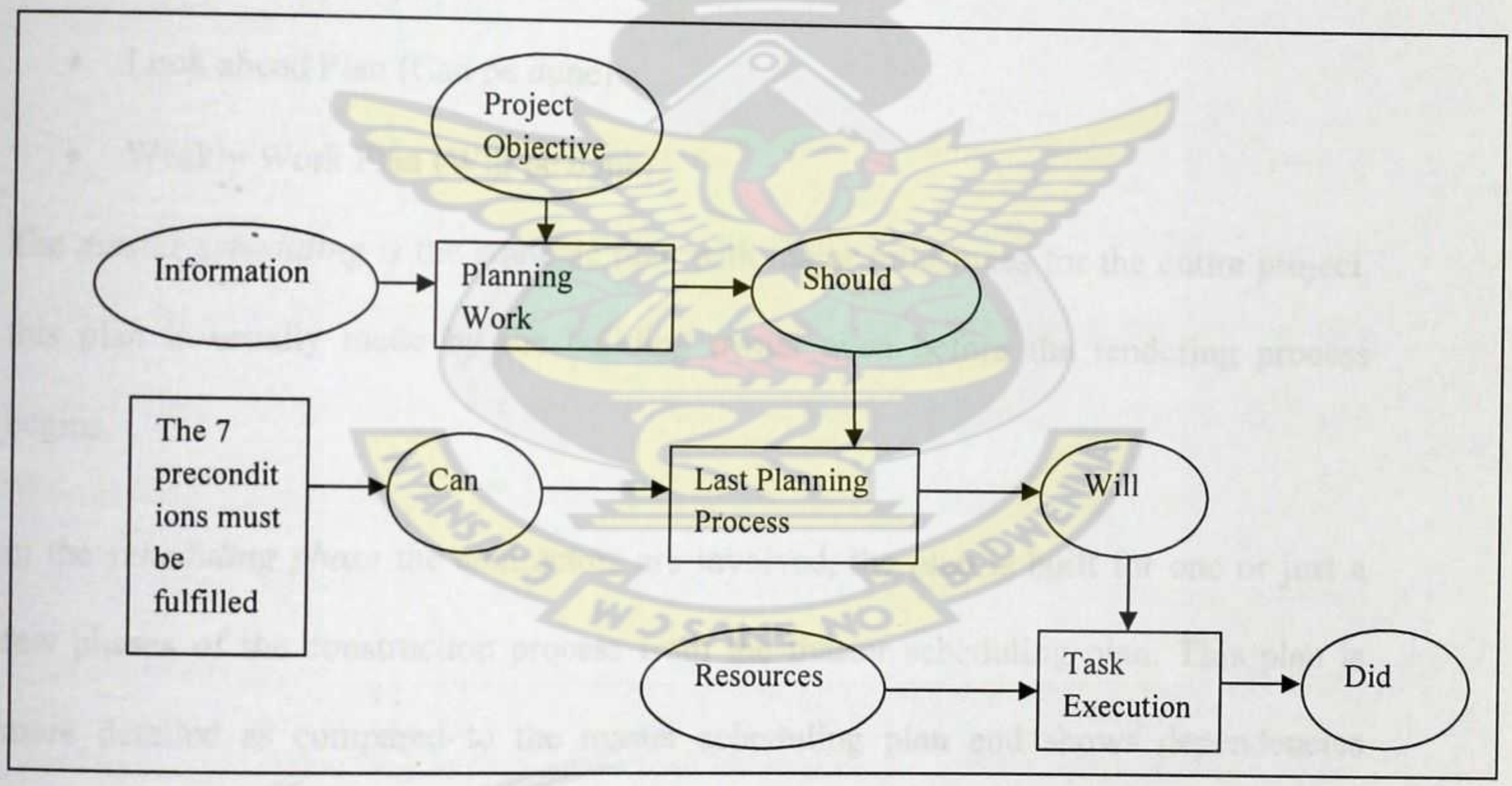


Figure 3.3. The Last Planner System (Adapted from: Ballard and Howell 1998)

The figure on the previous page can be described as follow, the project start with an objective, and then based on the information received from different sources such as suppliers for instance; the work that 'Should' be done is planned. After considering what should be done, only task that have all their prerequisites ready 'Can' expected to be done. Then come the Last planner who decides what 'Will' be done based on its assessment of the situation. Resources are therefore allocated and the work is done according to the last planning. Kim (2002) considers 'should' as "hopefully", 'Can' as "Probably" and 'Will' as "absolutely".

Ballard (2000) suggests four levels of planning with the Last Planner System.

- Master Scheduling (Needs to be done)
- Phase Scheduling (Should be done)
- Look ahead Plan (Can be done)
- Weekly Work Plan (Will be done)

The *master schèduling* is the strategic plan with major milestones for the entire project, this plan is usually made by the building owner even before the tendering process begins.

In the *scheduling phase* the contractors are involved, the plan is built for one or just a few phases of the construction process from the master scheduling plan. This plan is more detailed as compared to the master scheduling plan and shows dependencies between activities. The coordination phase of activities is taken into account in the scheduling phase. After the seven preconditions are checked, the *lookahead plan* is

made. This plan serves as a basis for the logistical plan. The look ahead plan may use a rolling basis of 3-6 weeks, which needs to be updated once a week.

The *Weekly Work Plan* is the plan where the Last planner makes commitment to what will be done in the coming week based on the fulfilment of the seven preconditions (Ballard, 2000).

3.4.7 Variability and Reliability Issues in Construction Supply Chains

Waste removal can be associated with reduction of variability. In the construction industry, sources of variability include late delivery of material and equipment, design errors, change orders, equipment breakdowns, accidents, and physical demands of work (Abdelhamid and Everett 2002).

According to Arbulu et al. (2005), the achievement of Just-in-Time in construction depends on the ability of project teams to control supply and accurately forecast demand. As in every production system, demand and supply are very dependent on each other and any type of variability will influence the effective management of project and subsequently impact on the total production system performance increasing cost and time and reducing quality and safety (Arbulu and Ballard 2004). This situation appears to be common in construction supply chains where complexity and uncertainty are high. As a result significant variations in plans and material delivery may occur at every stage.

Variability plagues construction supply chains and manifests itself mainly in the form of poor workflow reliability between production processes. As an example, if the production system is not reliable, it will be difficult for suppliers to effectively plan the delivery of material on site. According to Arbulu, Koerckel and Espana (2005) workflow reliability in the industry has been repeatedly measured at levels ranging from below 30% to 60%. These figures show that variability can rise up to 70% during the course of a single project. "*In Lean thinking, reliability is emphasized to reduce workflow variability. It can improve total system performance, make project outcomes more predictable, simplify coordination, and reveal new opportunities for improvement*" (Kim and Park 2006, p. 382). In other words improving workflow reliability equals reducing variability and therefore decreasing the volume of non value adding activities.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

Chapter Two reviewed literature on supply chain management in general. The chapter concluded with supply chain flows and lean practice in manufacturing supply chains. Chapter Three then explored construction supply chains and its problems. The chapter highlighted that the performance of construction supply chains can be improved through lean supply chain management.

This chapter discusses the approach and process followed in this research. The availability and selection of appropriate research design and method that would address the key questions raised are also presented in the chapter. This includes the selection and justification for the choice of exploratory interviews, case study approach. Methods and techniques used in data collection, analyses, and interpretation are also presented.

4.2 Research Strategy

The strategy proposed is of an exploratory nature. The research objectives, research question and proposition of this study are revisited in this section with the intention that they will give direction to the selection of the overall research design for this study.

4.2.1 Research Objectives

The study explored the actual opportunities that exist to improve the supply chain of Ghanaian construction firms, through lean production principles by identifying and eliminating non-value adding steps while value-adding steps are maintained and improved upon. This research seeks to describe and explain the construction supply chain phenomenon by examining real world situations.

The research objectives include:

- To identify the current management practices in the supply chain in the Ghanaian construction industry.
- Identify problems inherent in the management of the Ghanaian construction supply chain.
- Identify the causes of the problems in the management of the supply chain in the Ghanaian construction industry.
- To identify opportunities for improving the management of the construction supply chain through the adoption of lean production principles.

4.2.2 Research questions

The research questions posed are:

- What are the current management practices of the Ghanaian construction supply chain?
- What are problems inherent in the management of the construction supply chain on construction sites in Ghana?

- What are the causes of these problems in the supply chain?
- What opportunities exist for improving the management of the construction supply chain through the adoption of lean production principles?

4.2.3 Quantitative Research

Quantitative research follows a deductive approach in relation to theory and is concerned with the design measurement and sampling. The strategy employs the use of mathematical and statistical techniques to identify facts and causal relationships. It follows the practices and norms of natural scientific model and particularly, positivism; and viewing social reality as an external, objective reality. Quantitative research is, therefore, objective in nature and based on testing a hypothesis or theory composed of variables (Fitzgerald and Howcroft 1998; Naoum 2002).

Frechtling and Sharp (1997) characterised the common data collection techniques used in quantitative research as questionnaires, tests and existing databases. Hard and reliable data are often collected in quantitative research and, therefore, emphasises on quantification. The samples collected are often large and representative. This means that quantitative research results can be generalised to a larger population within acceptable error limits. Quantitative or "hard" measures are also required for evaluation and can be replicated using sophiscated statistical techniques (Bryman 2004; Fitzgerald and Howcroft 1998). The validity of results depends on the careful choice of measuring instrument and how accurately it measures targets (Patton 2002).

Bryman (2004) outlined the main steps in quantitative research but emphasised that they represents an ideal account of how research should progress. He, however, argued that, though research is rarely linear, it provides a good indication of the interconnections between the main steps in quantitative research.

Naoum (2002) concluded that quantitative research strategy is selected for:

- Finding facts about a concept, a question or an attribute; and
- Collecting factual evidence and study the relationships between the facts in order to test a particular theory or hypothesis.

4.2.4 Qualitative Research

Qualitative research follows an inductive approach in relation to theory. It emphasises words rather than quantification in the collection and analysis of data. Qualitative research is subjective in nature and is exploratory and attitudinal (Frechtling and Sharp 1997). Qualitative researchers often rely on interpretive or critical social science and follow a non linear research path. The language of the strategy is, therefore, cases and contexts (Neuman 2003). Small number of, usually, non-representative cases are used and respondents are selected to fill a given requirement (Sherif 2002).

Qualitative researchers tend to collect three kinds of data; in-depth and open-ended interviews; direct observations and written documents. These yield quotations, descriptions and excerpts which are either unstructured or semi-structured (Patton 2002). The data are soft, rich and deep and determine what things exist rather than how many

there are. Consequently, the qualitative research strategy is more responsive to needs and nature of research situation (Fitzgerald and Howcroft 1998). The credibility of qualitative research depends on the skill, competence and the rigor of the researcher (Patton 2002). The main steps involved in qualitative research are non-linear and the research questions are driven by theoretical issues which in turn drive the data collection and analysis (Bryman 2004).

The main steps involved in qualitative research are non-linear and the research questions are:

- There is no existing research data on the topic and the most appropriate unit of measurement is not certain; and
- The concepts to be researched are assessed on a nominal scale, with no clear demarcation and involve exploring behaviour or attitudes.

4.2.4 Strategy Adopted in this Research

A qualitative strategy was adopted in this research for reasons outlined below.

- The research is exploratory and was aimed at providing a holistic approach to improve the Ghanaian construction supply chain through the study of existing practice. The study did not involve any creation and subsequent testing of a theory or hypothesis, which are associated with quantitative research as identified by Bryman (2004).
- The research explored the problems which affects the construction supply chain. The study also covered issues in depth and involved detailed rather than

numerous descriptions. The approach was necessary to gain insights needed to appreciate and understand the problems and issues involved in the Ghanaian construction supply chain.

- The data available in the research quotations were from interviews and activities observed. They were soft, descriptive and less structured data and had to be collected using techniques such as interviews, observations, archival records and documentation. The data were analysed using non-statistical techniques and involved the creation of typologies as suggested by Fellow and Liu (2003).

4.3 Research Design

The previous Section, 4.2., discussed the research strategy to give a broad orientation to the research and to distinguish between quantitative and qualitative approaches. Having adopted a qualitative strategy for the conduct of the research, this section of the thesis outlines the various frameworks available for data collection and analysis.

Research design is the structure that guides the execution of the technique for collecting and subsequently, analysing data. It is, therefore, the framework within which the research method is employed. It enables the researcher to connect empirical data to its conclusions, in a logical sequence to the initial research question of the study (Bryman 2004; Yin 2003). Fellow and Liu (2003) and Yin (2003) concluded that options available to construction management and organisational research are largely unstructured, variable and unformulated. Blismas (2001) identified four research designs that are consistently recommended by researchers as viable options in addressing

questions posed in both social science and construction management research. He further pointed out that an assessment is required to help decide on an appropriate choice. The main options are: Experiment, Survey, Action Research and Case Study.

4.3.1 Case Study as a Research Design

The strategy of inquiry for this research involves using different methods of collecting and analysing empirical material. This section in particular describes the case study approach, which will be employed for this study as the strategy of inquiry. The section begins by describing the justification for why the strategy was selected and is then followed by a description of the specific processes undertaken.

Robson (1993) defines case study research as 'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence'. The methodology used in this case study and presented followed the recommendation of

Yin (1994) and has four stages:

1. Design the case study,
2. Conduct the case study,
3. Analyze the case study evidence, and
4. Develop the conclusions, recommendations and implications.

Case study is an ideal methodology when a qualitative, in-depth investigation is needed (Feagin, Orum, & Sjoberg, 1991). The selection of case study research is one that is

motivated by the 'what' or the phenomenon that is to be studied. It is therefore not a methodological choice but rather one that is focused on studying a case or a number of cases in detail in its natural setting to develop as complete an understanding of the case(s) as possible while at the same time recognising its complexity and context (Stake, 2005; Punch, 2005).

The case study strategy is considered an appropriate choice for this study due to the following reasons: Firstly, case study research is focused on studying a setting or contemporary phenomenon embedded in its real-life context (Yin, 1994; Groat and Wang, 2004) and encourages in-depth investigation "into the thick of what is going on" (Stake, 2005). Secondly, case study research investigates a research problem through interpretation with a focus on the 'how' and 'why' questions (Yin, 1994). Therefore the case study research is appropriate to investigate the Ghanaian construction supply chain phenomenon to describe 'how' and 'why' of material delivery and management on site. Finally, case study research allows for the selection of cases, which are exemplars of the phenomenon under exploration (Stake, 2005). This research aims to investigate specific examples that are representative of the Ghanaian construction supply chain phenomenon.

4.3.1.1 Types of Case Study

Stake (2005) identified three main types of cases, namely, the intrinsic, instrumental and multiple or collective case study. The *intrinsic* case study is undertaken to achieve a better understanding of a particular case, not because the case "represents other cases or

because it illustrates a particular trait or problem, but instead because, in all its particularity and ordinariness, this case itself is of interest" (Stake, 2005). On the other hand, the *instrumental* case study is undertaken when a particular case is investigated to provide insight into a specific issue, to redraw generalisation (Stake, 2005) or to refine a theory (Punch, 2005).

According to Stake (2005), the instrumental case which is investigated in-depth supports our understanding of something else. The *multiple* or *collective* case study is undertaken when a number of cases are investigated jointly to learn more about a phenomenon, population or general condition (Stake, 2005). The cases selected for study may or may not be known to demonstrate common characteristics but are chosen because it is believed that understanding the cases will "lead to better understanding, and perhaps better theorizing, about a still larger collection of cases" (Stake, 2005).

The multiple or collective case study approach was conducted for this study through an investigation of three live projects. All the participants in the projects are potential key informants. However, to ensure sufficient data collected for the analysis, a purposive sampling was used in this study (Ghauri and Grønhaug 2005). In the purposive sampling also known as judgmental sampling, the author can use his own judgment in selecting the sample. Therefore only project participants directly involved with the supply chain were interviewed. The basis for selecting the sample is that it can yield considerable data that is specific for the research topic.

4.3.1.2 Case Selection & Data Sources

Case selection is one of the most important aspects of conducting case study research as the appropriate selection of the case(s) can determine the extent to which we can understand the phenomenon under study (Stake, 2005). Cases involved with intrinsic case study are typically pre-identified whereas instrumental and collective case studies require cases to be selected (Stake, 2005). The case(s) selected should be in some way representative of some population of the cases (Ryan and Bernard, 2000).

Although it is important that case selection represents typicality it is also important to select cases, which offer the opportunity to learn. This could mean selecting the case that is most accessible or the one that the researcher can spend the most time with.

Case study literature does not indicate any precise guides to the number of cases to be included in the research (Patton, 1990). Some advocate a minimum of two, but the widest accepted range falls between two to four as a minimum and ten to fifteen as a maximum. The number of cases included is however only one aspect as the depth and richness of the cases is also another critical component of case study research. Three cases will be selected for the purpose of this study. There are two key ways of investigating case studies; within-case and cross-case analysis. The multiple case study is focused on both within and cross-case.

4.3.2 Data Collection

The primary data consisted of in-depth interviews, direct observations, documentations and archival records. The in-depth interviews were administered to project participants on three (3) different case studies in Accra and Kumasi. To make the analysis more comprehensive, a total of twenty (20) project professionals were interviewed using a purposive sampling technique. In the purposive sampling also known as judgmental sampling, the author can use his own judgment in selecting the sample. Therefore only project participants directly involved with the supply chain were interviewed. The basis for selecting the sample is that it can yield considerable data that is specific for the research topic. The cases are as follows:

CASE 1: 20 Unit Apartment Block for Knight Court at Cantoments, Accra. Nine (9) project professionals were interviewed. The project was about 30% complete at the time of the interviews.

CASE 2: Construction of 9 No Semi-Detached Houses and Administrative Blocks at Switch-Back Road, Accra. Four (4) project professionals were interviewed. The project was about 70% complete at the time of the interviews.

CASE 3: Construction of District Education Office Block at Nsuta, Ashanti Region. Seven (7) project professionals were interviewed. The project was about 70% complete at the time of the interviews.

The main sources used for the secondary data consist of articles, books, and master thesis and PhD dissertations.

4.4 Data Analysis

Yin (1994), suggests that data analysis consists of examining, categorizing or recombining the evidence to address the initial proposition of a study. Furthermore, Patton (1990,) stated: "*data interpretation and analysis involves making sense out of what people have said, looking for patterns, putting together what is said in one place with what is said in another place, and integrating what different people have said*".

Several authors (de Vos 2002; Neuman 1997) recommend a data analysis procedure based on the following steps:

Step 1: Data collection

Step 2: Managing and organizing data into categories with regard to patterns

Step 3: Reading and summarizing data

Step 4: Describing and classifying data and the interpretation thereof, and

Step 5: Presenting data in the form of research report

For these case studies, a combination of the different procedures proposed above was more or less followed.

CHAPTER 5: FINDINGS FROM THE CASE STUDIES

5.1 Introduction

The purpose of this chapter is to present the findings of the case studies. The evidences presented in this chapter are derived from interviews with the project members. It focuses on how the respondents experience supply chain related issues in their daily jobs.

In- depth interviews were designed and administered to investigate into the opportunities for improving the supply chain, through the adoption of lean production principles. For this purpose a qualitative case study approach was adopted. The in-depth interviews were administered to project participants on three (3) different case studies in Accra and Kumasi. To make the analysis more comprehensive, a total of twenty (20) project professionals were interviewed. The cases are as follows:

CASE 1: 20 Unit Apartment Block for Knight Court at Cantoments, Accra.

CASE 2: Construction of 9 No Semi-Detached Houses and Administrative Blocks at Switch-Back Road, Accra

CASE 3: Construction of District Education Office Block at Nsuta, Ashanti Region.

5.1.1 Profile of Interviewees

The respondents interviewed were three (3) project managers, a works superintendent, four (4) Quantity Surveyors, four (4) site supervisors, three (3) stores managers, a logistics manager, a site engineer and three (3) General foremen as can be seen from

figure 5.1 below. The respondents were of varied qualifications ranging from Construction Technician Course II (CTC 11) to Masters Degree holders. Majority of the respondents representing 50% held a Bachelor's Degree.

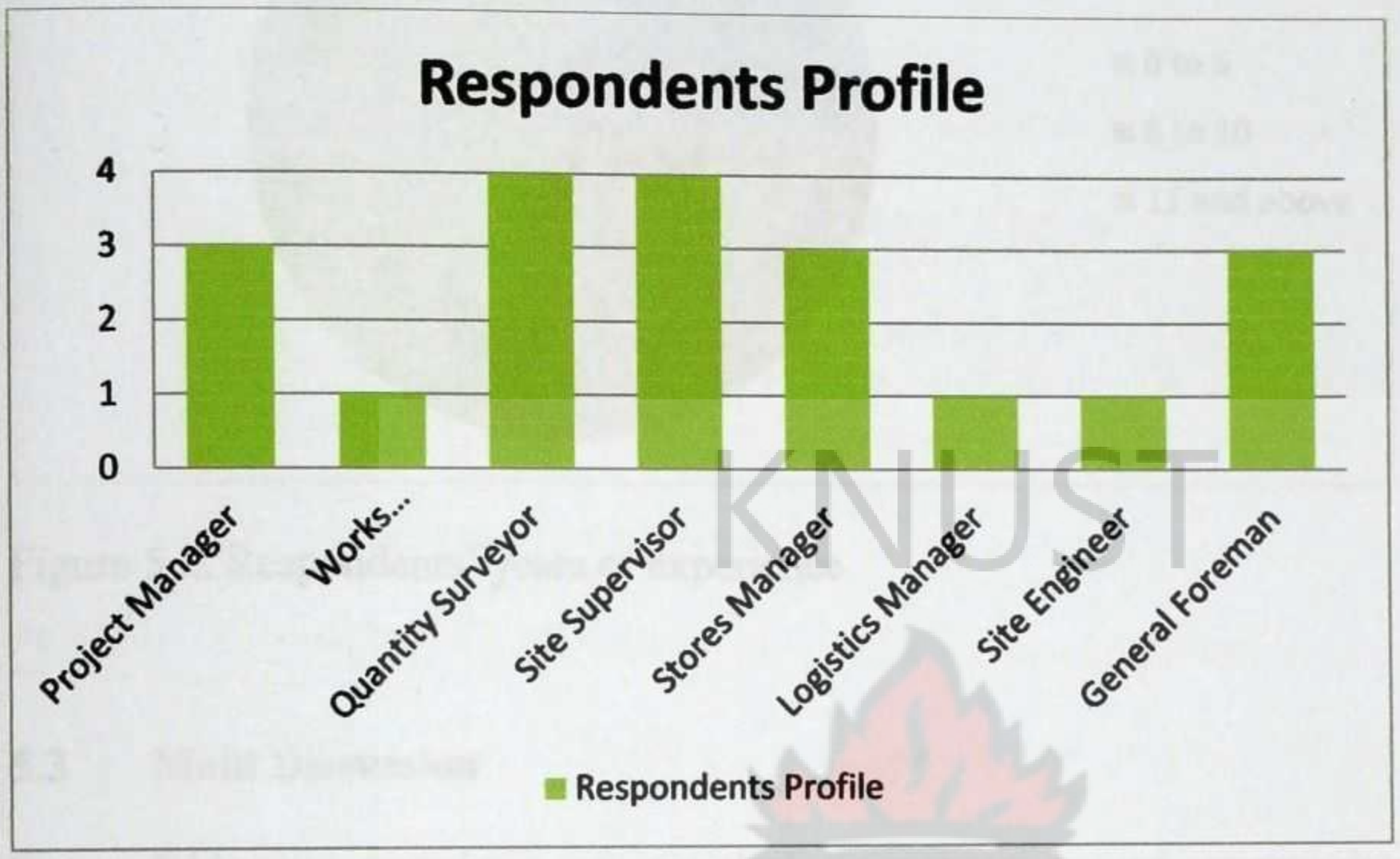


Figure 5.1. Respondents Profile

5.1.2 Industrial Experience

From the data collected industrial experience of respondents was also taken into account. In referring to figure 5.2 majorities of the respondents representing 45% had industrial experience from 11 years and above, 30% between 6-10 years, whilst 25% had less than 6 years of industrial experience.

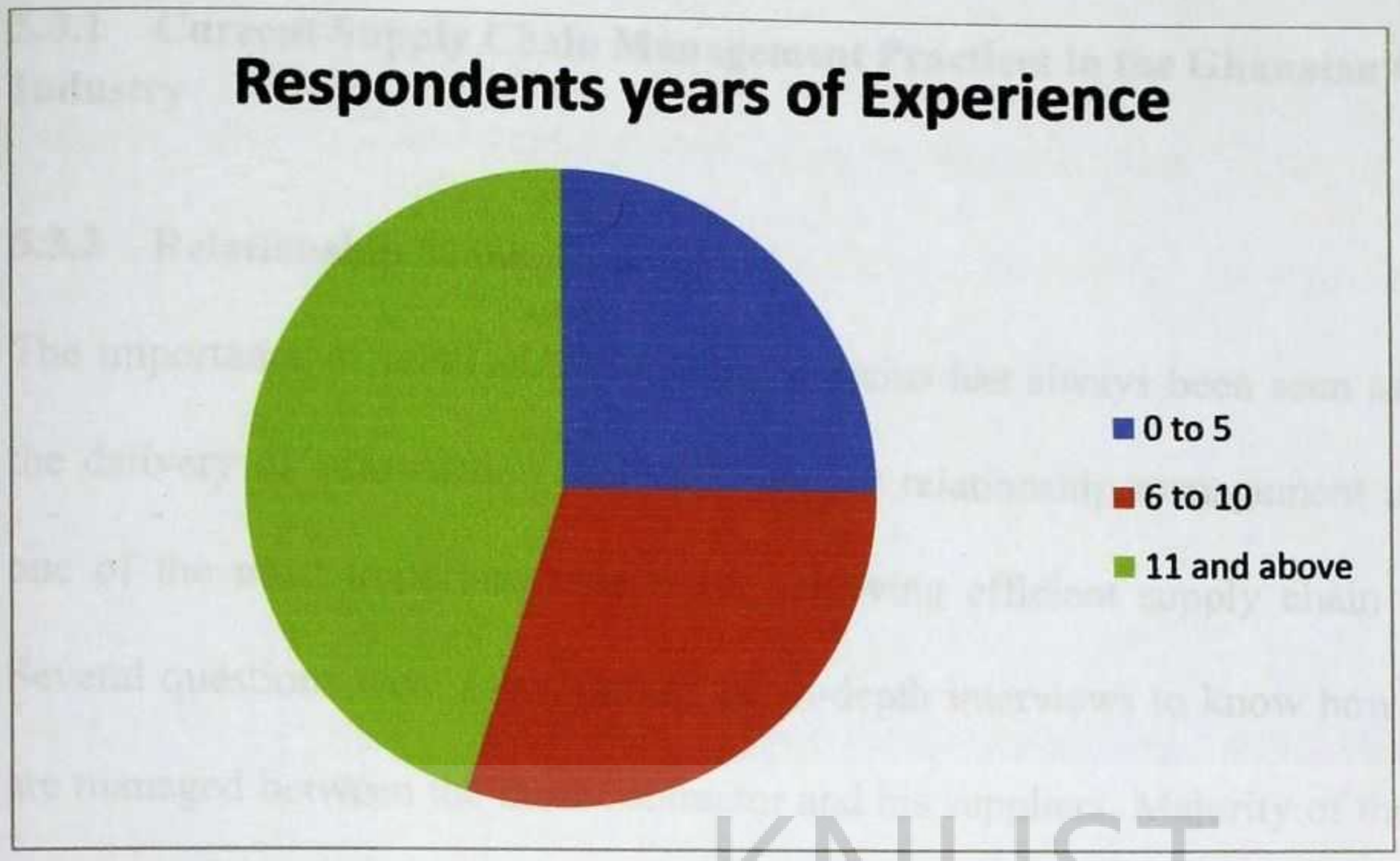


Figure 5.2. Respondents' years of experience

5.3 Main Discussion

To unfold the meanings of peoples' responses in an appropriate and more understandable way, **themes** were identified and categorized based on the content of the interviews. The following themes were derived in the management of the supply chains:

- Supplier Relationship Management
- Internal operations Management
- Information Management

5.3.1 Current Supply Chain Management Practices in the Ghanaian Construction Industry

5.3.2 Relationship Management

The importance of relationships in supply chains has always been seen as essential for the delivery of construction projects. Supplier relationship management is regarded as one of the most important aspects for achieving efficient supply chain management. Several questions were asked during the in-depth interviews to know how relationships are managed between the main contractor and his suppliers. Majority of the respondents indicated that there is some form of collaboration between the main contractor and the suppliers. This form of collaboration was mainly based on the needs of the current project. Respondents recognized the need for cooperation with the suppliers in order to cut down cost, achieve quality delivery and time improvements. Furthermore, all the respondents indicated that the way suppliers are managed is significant in their overall performance and on the project performance.

On whether price is the main focus of the relationship, most of the respondents argued in the negative and stressed that other factors such as ability to deliver on time, availability of credit facilities, quality of product or service and ability to deliver the needed quantity at a given point in time among others all come into play to form the bases of the relationship.

5.3.3 Information Management

Information available to supply chain partners has the potential to radically reduce production time, reduce errors, and enhance customer service. As a result, a core issue in SCM is the effective management of information. Majority of the respondents indicated that the amount of information sharing with suppliers is limited to the needs of the current project.

Most of the respondents stated that suppliers are only involved in the chain during the construction stage when their services are needed. It was also clear from the interviews held with the respondents that suppliers are usually not informed on the progress of work. The mode of communicating with suppliers is via phone calls, e-mails and occasionally meeting with suppliers. Most of the respondents indicated that information is accurately transmitted with a few saying otherwise.

5.3.4 Internal Operations Management

SCM emphasizes the importance of both effectiveness and efficiency of firm's internal operations on its performance. In this research internal operation refers to inventory management, systems for checking incoming supplies, systems for rating suppliers performance, storage and handling of materials.

When the respondents were asked about the procedure being used for the delivery of materials, two different alternatives were proposed: building up inventory or Just-in-Time delivery. Both ways seems to be utilized at the construction sites. However, most

of the respondents' preferred the build-up of inventory. According to most of these respondents, saving in transportation cost, avoiding shortage of materials leading to work being brought to a halt, and increasing your bargaining power for discounts were some of the reasons for ordering material in large amount (bulk). Materials were also delivered to the site and kept in project stores.

Furthermore, on what systems are in place for checking incoming supplies, the respondents indicated that visual inspection and testing were used to ensure that the right quality and quantity of materials were delivered, before they are received into stores. One interviewee said sometimes you might order for example 6 inches blocks only for 5 inches blocks to turn up on site. To avoid the situation of having to reload and send them back, there is always a professional to check and recheck before it is offloaded on site.

Also, on factors for rating the performance of suppliers, respondents were of the view that suppliers' performance were measured basically on their ability to deliver on time, right place and to the right specifications. More so, the credit facilities being offered by the supplier is also considered in rating suppliers' performance. These factors have an effect on the continuous relationship between the contractor and the supplier. In addition, respondents stated that time buffers are added to avoid disruptions in the supply of materials.

5.4 Problems in the Management of Construction Supply Chain

The following **themes** were derived for the problems inherent in the management of the supply chains:

- Supply and Delivery
- Materials management on site (Inventory management, storage and materials handling on site).

5.4.1 Supply and Delivery Problems

It was revealed from the interviews that contractors occasionally experience late deliveries on site. Materials ordered from suppliers sometimes do not arrive on site as expected. Most of the respondents indicated that this problem results from inefficiencies from the suppliers' outfit, late placement of orders on the contractors' part and breakdown of trucks in transit.

Majority of the respondents indicated that they experienced problems with the quantity and quality of supplies. Visual inspection, counting, comparison of supplies with specifications and sometimes testing of the supplies are the systems in place for checking quality and quantity of materials delivered. Materials are rejected and asked to be replaced when it fails to meet the required specifications.

Furthermore, respondents indicated that they occasionally experienced bad sequence of supplies. Suppliers' mostly do not conform to the sequence of orders. Sometimes materials tend to sit on site for a long time waiting for other installations and supplies to

arrive before it can be used. Quite often there are changes in designs and product specifications, which lead to bad sequence of orders and timely delivery of supplies.

5.4.2 Materials Management Problems on Site (Inventory, Storage and Handling)

Most of the respondents' indicated that there is excessive build up of inventory on site. According to most of these respondents, saving in transportation cost was one of the reasons for ordering material in large amount (bulk). Variations occur quite often on the supplier side as stated by the respondents; contractors need to be prepared to deal with this situation. In their bid to avoid shortage of materials and for continuous flow of work, they tend to build unnecessary inventory on site..

The respondents indicated that if the supplies are in the wrong order, this will require double handing. Since they spend a lot of time moving the materials, it means less time doing the actual work; as a result the project may incur delays. This seems even more important for a small construction site with limited storage capacity. An assessment of the construction sites visited showed that the site was quite well managed.

5.5 Causes of the Problems in the Management of Construction Supply Chain

Respondents indicated that the problems of delays in deliveries are mostly due to inefficiencies on the part of suppliers. Late deliveries are experienced when suppliers are not as organized as they should be. Few of the respondents also indicated that sometimes these delays are due to shortages of materials on the market and

transportation problems on the suppliers' side. Late placement of orders from contractors due to inadequate planning of procurement also leads to delay in the supply.

Quantity problems are mostly due to shortages of the materials, and sometimes communication problems especially when there are changes in design and product specifications. Few of the respondents indicated that suppliers are sometimes in a haste to make money and therefore rush in making deliveries not conforming to the right specifications. On the other hand others also argued that some quality problems are due to transportation of the materials to site.

Most of the respondents stated that since suppliers are not usually informed of the progress of work that could be a contributory factor to the bad sequence of orders. Few of the respondents indicated that changing client brief and design are also causes of bad sequence of orders.

Excessive build up of inventory on site is mainly due to variability in the chain as indicated by majority of the respondents. Respondents mainly blame the suppliers for creating such variability. Savings in transportation is also a cause of excessive build up of inventory on site. Respondents argued that bad sequence of orders, lack of space and good stores location system are the main causes of double handling of materials on site

5.6 Concept of Lean Supply Chain Management

Majority of the respondents were familiar with the concept but had not been involved with its application on any project. Respondents agreed that the application of this concept can bring improvements in the management of their supply chains.

CHAPTER 6: DISCUSSIONS AND RECOMMENDATIONS

6.1 Introduction

The purpose of the case studies was to investigate the different challenges related to material delivery and site management and suggest ways of improving it through a lean supply chain management.

The chapter presents a discussion of the research findings focusing on the concept of flow. As discussed earlier flow is considered to be the driving force for value generation Discussions and recommendations will be conducted under the themes identified thus: supplier relationship management, information management and internal operations management. However the key factors identified in the data analysis as affecting the efficient delivery of materials and its management is also considered.

6.2 Supplier Relationship Management

From the in-depth interviews conducted it was realized that the contractor- supplier relationship has moved from being transactional to collaborative. This stems from the fact that each see the other as a partner in business. The outcome of an adversarial or transactional relationship is perceived in terms of "win-lose" results, whereas the outcome of a partnership relationship is perceived as "win-win" situation – both sides winning at the same time through the implementation of problem-solving approach. A transactional relationship is a straight forward relationship between buyer and seller

whereby the two parties do not get closely involved with each other, but simply exchange goods or services for payment.

The basic difference between transactional and collaborative relationships is recognition of interdependency of and necessity for cooperation. Recognition of interdependency of and the need for cooperation results in many benefits for both parties such as building trust, communicating, planning and promoting interdependency, which may result in achieving a competitive advantage.

As indicated in the literature, buyer-supplier relationships have evolved from being transactional to collaborative to alliance based. The main difference between a collaborative and alliance relationship is the existence of institutional trust. The trust in alliance relationships is not at all "blind trust" but rather a "prudent trust", which is carefully designed, planned and mutually agreed upon.

It is recommended that contractors should form alliance with their suppliers through a carefully designed and planned institutional trust. This can be done by ensuring early and fair payments to suppliers.

6.3 Information Management

According to the interviews conducted for this research, there was a consensus on communication and information flow as well as coordination as an essential element for completing the project on time.

From the interviews the main medium for communicating with suppliers is via phone calls and e-mails. Most of the respondents indicated that information is accurately transmitted with a few saying otherwise. Concerning this issue, an important point noticed in the findings was that a large percentage of respondents agreed that information was accurately transmitted between themselves and the supplier off site. However, at the same time they face challenges related to material deliveries such as quality, quantity and bad sequence of deliveries. This situation shows that there are communication problems. It was also clear from the interviews held with the respondents that suppliers are not informed on the progress of work.

The concept of Kaizen which promote standardization of procedures should be applied at this level. Information should be transmitted in the same format through the same channel to assure its accuracy, consistency and also improve its readability. An integrated information system for all participants of the project is required to achieve standardization as suggested by the theory.

Through this common information system, new plans and information about material delivery can flow immediately to the parties involved and quicker and more efficient document transfer can be obtained.

In 1998, the Web technology was utilised in an attempt to provide a way for contractors and suppliers to work collaboratively, from different locations, on the Sashiki Bridge construction project, located in the Kyusyu region, Japan. A computer system was developed to improve communication accessibility between project participants through

the Internet. The developed system allows users to access project databases faster, delivering precise project information. Throughout the project, system users enjoyed the luxury of checking project development and daily activities via the system's electronic Bulletin Board.

Shared project information in construction is a best practice being carried out by NCC Puolimatka, a leading Finnish construction company. This best practice is gaining wide acceptance especially in the realm of construction project information management. The basic idea behind shared project information is to gather all relevant information in a central location to allow project participants to access the same information. This, in turn, helps speed up the decision-making process, reduces data and information redundancy, and hence contributes to cost reduction

6.4 Internal Operations Management

As discussed in the theory, much of the waste in the construction industry is related to ineffective planning and particularly to ineffective integration of all parties in the planning system. From the discussion above we can conclude that the integration of all parties in the planning will improve the planning and therefore increase coordination and information sharing. This in turn will facilitate the material delivery process

From the Lean perspective, subcontractors should provide a workable plan first to the general contractor and the general contractor will in turn combine them and develop the most workable plan for everyone. The Last planner system can be used to assure a more

reliable plan. It is a project execution system that uses the overall project plan as the general frame, but suggests that the day-to-day activities of the actual production should be managed by a more flexible approach accounting for the actual progress of the project. The main philosophy is to ensure that all the prerequisites needed for performing a distinct task are in place, before it is assigned to a work group. This is the task of the "last planner" in the chain of plans of increasing detail in a project. Therefore, Last Planner has been used to mean both the system and the person responsible for the final arrangement of tasks.

However since variations occur quite often on the supplier side as stated by the respondents, contractors need to be prepared to deal with this situation. The Last planner system has found a solution dealing with variation without the build-up of unnecessary inventory. It includes in the weekly work some activities that are not critical for the progress plan but have their seven preconditions ready (design, materials, workers, equipment, space, connecting works, external conditions). The working crew can therefore shift to these "workable backlogs" if delays occur in material delivery for instance in order to assure continuity of flow.

The implementation of the kanban tool has supported the central lean philosophy of having a "pull" production system. A pull system basically means that all work being done is to fulfill actual customer orders. The kanban tool is basically a way of signaling for more raw materials to be drawn into the production process or for more raw materials to be made available. The two kinds of kanbans used in the Toyota Production

System to serve these functions are production instruction kanbans (production kanbans) and withdrawal kanbans (transport kanbans). The term kanban means 'card' or 'sign' and are usually some type of printed cards on each item or signal. When items have been used or transported, kanbans come off of the items and go back to the preceding processes as orders for more of the item. This helps maintain a minimum and maximum inventory level. It also allows quick response to changing customer demand.

The deliveries should be properly sequenced to be consistent with the work plan. In addition, the contractor should make sure the delivery rate from the supplier is compatible with the installation rate of the workers on site. By using *Transport Kanban* to signal the need for more material, Just-in-Time delivery can be achieved. One of the rationales behind ordering material in bulk is the savings in transportation cost. From literature it has been realised that in some situations the costs saved in transportation can be offset by the labour cost of double handling

To avoid the construction site to become cluttered and therefore hamper productivity and delay the project, continuous care should be taken. Written procedures to handle these issues are important. Lean theory suggests the 5S methodology to keep the construction site clean and tidy. By using the 5S procedures, the construction site will be free of clutter. Again, it is important that the material is being delivered directly at the area of work to avoid double handling, by doing so, a significant amount of labour cost and schedule time can be saved for the contractors.

Kaizen is the Japanese word for improvement. This lean construction tool involves looking at some task in the field and finding out how to do it better, more efficiently, safer, and quicker. For example, this task could be the handling of materials on site to avoid double handling.

6.5 Conclusions and Recommendations

6.5.1 Conclusion

In this thesis, the researcher studied the challenges related to material delivery management and site management for some construction sites in Ghana. In order to answer the research questions, a qualitative, interview based case study research design was used for this study. The findings derived from the data collected suggested room for improvement. During the data collection, an interesting finding was that the respondents knew where their problems lay but did not have a systematic tool to solve them. Based on the theory, and the findings derived from the data collected, the researcher believes that the implementation of lean methods into the supply chain can improve efficiency and better project management. Furthermore, it is important to say that Lean construction is a comprehensive process that should involve every party in the construction project to achieve better performance.

The following conclusions can be drawn from the study:

- There is some form of collaboration between the main contractor and his suppliers' off site. The relationship has moved from transactional to

collaborative. This collaboration is mainly based on the needs of the current project. This stems from the fact that each sees the other as a partner in business.

- Respondents indicated that information is accurately transmitted between the contractor and his suppliers'. However, at the same time they face challenges related to material deliveries such as quality, quantity and bad sequence of deliveries. This situation shows that there are communication problems.
- Build-up of inventory as well as JIT deliveries are both used on the construction sites.
- Contractors usually experience supply and delivery problems such as late deliveries, problems with quantity and quality of supplies, and bad sequence of orders.

6.5.2 Summary of Recommendations

Based on the findings of the study and the discussions above, a summary of some general recommendations are offered to support the construction industry. These are listed below:

- It is recommended that research be conducted to find the advantages of an alliance relationship between contractors and their suppliers.
- Information should be transmitted in the same format through the same channel to assure its accuracy, consistency and also improve its readability.

An integrated information system for all participants of the project is

required. This information system could for instance provide real-time feedback regarding material status on site to the supplier off site and will keep everyone aware of the actual situation on site. It is recommended that research be conducted to see the impact of an integrated information system in the management of the construction supply chain.

- Lean theory suggests that the suppliers must know and monitor each step of work-in-process; this can be achieved by using information technology as pinpointed earlier. The Last planner system can be used to assure a more reliable plan. The implementation of the kanban tool can help maintain a minimum and maximum inventory level. By using *Transport Kanban* to signal the need for more material, Just-in-Time delivery can be achieved. Lean theory suggests the 5S methodology to keep the construction site clean and tidy. By using the 5S procedures, the construction site will be free of clutter. Kaizen is the Japanese word for improvement. It should be used to improve the processes and task involved in the management of the supply chain.

- Professional bodies such as Ghana Institution of Surveyors (GhIS), the Ghana Institute of Architects (GIA), the and the Ghana Institution of Engineers (GhIE) should expose their members to the concept of lean supply chain management through some form of continuing professional

development programmes. This will address the problem of low familiarity of members with the concept of lean thinking.

6.6 Future Research

This study has pursued to obtain knowledge concerning the problems related to supply chain management on a very limited scale. There is a lot of room for further explorations and research.

It is recommended that a comparative study can be undertaken between a contractor implementing lean supply chain management and a contractor who does not. The same situation can apply for suppliers.

Further research may explore the influence and contribution of subcontractors on the supply chain.

REFERENCES

Abdelhamid , T. S., & Everett, G. J. (2002). Physical demands of construction work: A source of workflow unreliability. *10th Conference of the International Group for Lean Construction (IGLC-10),.* Gramado, Brazil.

Akintoye, Akintola, George McIntosh, & Eamon, F. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European Journal of Purchasing & Supply Management 6 (3-4)*, 159-168.

Ala-Risku, T., & Kärkkäinen, M. (2004). Material delivery problems in construction projects: A possible solution. *International Journal of Production Economics 104 (1)*, 19-29.

Anvuur, A., & Kumaraswamy, M. (2006). Taking Forward Public Procurement Reforms in. *CIBW107 Construction in Developing Economies International Symposium.* Santiago, Chile.

Arbulu, R. J. (2002). *Improving Construction Supply Chain Performance: Pipe Hangers and System Interfaces.* U.C. Berkeley, Berkeley, CA: Master of Engineering Thesis, Constr.

Arbulu, R. J., & Ballard, H. G. (2004). Lean supply systems in construction. *The 12th Annual Conference of the International Group for Lean Construction (IGLC-12).* Copenhagen, Denmark.

Arbulu, R., Koerckel, A., & Espana, F. (2005). Linking production-level workflow with materials supply. *IGLC.* Sydney, Australia.

Asplund, E., & Danielson, U. (1991). *Straightening the Building Roundabout.* Stockholm, Sweden.

Assibey-Mensah, G. O. (2008). Ghana□s Construction Industry and Global Competition. *A research Note, Journal of Black Studies*.

Azambuja, B. M., Isatto, L. E., Marder, T. S., & Formoso, C. (2006.). The importance of Commitment Management to the Integration of Make to Order Supply Chains in Construction Industry. *IGLC.* Santiago, Chile.

Ballard, G. (2000). *The Last Planner System of production control, School of Civil Engineering, Faculty of Engineering, The University of Birmingham.*

Ballard, G., & Greg , H. (1998). What kind of production is construction? *Sixth Annual Conference of the International Group for Lean Construction.* Guarujá, Brazil.

Ballard, G., Tommelein, I., Koskela, L., & Howel, G. (2002). Lean construction tools. (R. Best, & G. de Valence, Eds.) *Design and Construction: Building in Value*, 227–255.

Bashford, H. H., Sahwney, A., Walsh, K. D., & Kot, K. (2002). Implications of Even-Flow Production Methodology for the US Housing Industry. *J of Constr. Engrg. and Mgmt., ASCE.*

Bennett, J., & Ferry, D. (1990). Specialist contractors: A review of issues raised by their new role in building. *Construction Management and Economics 8*, 259-283.

Bertelsen, S. (1993). *Building logistics -Material Management in the Building Process.* Denmark.

Beth, S., Burt, D. N., Copacino, W., Gopa, C., Lee, H. L., Lynch, R. P., & Morris S. (2006). *Supply chain challenges: building relationships; Harvard Business Review on Supply Chain Management.* Boston: Harvard Business School Press.

Bicheno, J. (2004). *The new lean toolbox : towards fast, flexible flow. [3rd ed.].* Buckingham: PICSIE Books.

Bjork, B. (2002). A formalized model of the information and materials handling activities in the construction process. *Construction Innovation*, 133-149.

Blanchard, D. (2007). *Supply chain management: best practices.* Englewood Cliff, NJ: Wiley.

Blismas, N. G. (2001). *Multi-project environments of construction clients, PhD Thesis.* Loughborough University.

Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2007). *Supply chain logistics management. 2nd edition.* Boston: McGraw-Hill.

Briscoe, Geoffrey, Andrew , R. J., Dainty, & Sarah , M. (2001). Construction supply chain partnerships: skills, knowledge and attitudinal requirements . *European Journal of Purchasing & Supply Management 7 (4)*, 243-255.

Bryman, A. (2004). *Social research methods, 2nd edition.* Oxford: Oxford University Press.

Burt, D. N., Dobler, D. W., & Starling, S. L. (2003). *World-class supply management: the key to supply management. 7th edition.* Boston: Irwin McGraw-Hill.

Burt, D. N., Petcavage, S., & Pinkerton, R. (2010). *Supply management. 8th edition. Boston.* Boston: Irwin McGraw-Hill.

Caldeira, E. (1999). *Learn Construction*. Retrieved September 15, 2012, from http://www.housingzone.com/info/CA379761.html: www.housingzone.com

Cavinato, J. L. (1992). A Total Cost/ Value Model for Supply Chain Competitiveness. *Journal of Business Logistics V13, No. 2*, 285-301.

Chen, F. (2003). Information Sharing and Supply Chain Coordination. *Operations Research and Management Sciences, Elsevier Science*.

Chopra, S. (2002). Supply Chain Management: Strategy, Planning and Operation. *IIE Transactions 34(2)*, 221-222.

Christopher, M. (1992). *Logistcis and Supply Chain Management.* London: Pitman Publishing.

Christopher, M. (2000). The agile supply chain; Competing in volatile markets. *Industrial Marketing Management 29 (1):7.*

Christopher, M. (2005). *Logistics and Supply Chain management: creating value-adding networks. 3rd edition.* Harlow: FT Prentice Hall.

Construction Industry Institute. (1988). *Project Materials Management Primer.* Austin, TX,.

Cooper, Martha , C., Lisa, M., & Ellram. (1993). Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy. *The International Journal of Logistics Management 4 (2)*, 13 - 24.

Croom, S., Romano, P., & Giannakis, M. (2000). Supply chain management: An analytical framework for critical review. *European Journal of Purchasing and Supply Management V6*, 67-83.

Dainty, R. J., Briscoe, G. H., & Millett, S. J. (2001). Subcontractor perspectives on supply chain alliances. *Construction Management & Economics, V19*, 841-848.

Dansoh, A. (2005). Strategic Planning for Construction Firms in Ghana. *Construction Management and Economics, Vol. 23, No.2*, 163-168.

Daouda , D., & Bernt , H. F. (2009). *Efficient material delivery and site management; A lean construction perspective. Case study at Statsbygg.A masters degree thesis molde university college.*

de Vos, A. S. (2002). *Research at Grassroots.* Pretoria: J.L Van Schaik publishers.

Denning, P. J., & Medina-Mora, R. (1995). *Completing the loops.*

DTI Internet. (n.d.). *How supply chain management works*. Retrieved October 15, 2012, from http://www.dti.gov.uk/energy/eid/study.pdf.

Dyer, J. H. (2000). *Collaborative advantage.* New York: Oxford University Press.

Fawcett, S. E., & Magnan, G. M. (2002). The Rhetoric and Reality of Supply Chain Integration. *International Journal of Physical Distribution and Logistics Management, V32 No 5*, 339-361.

Feagin, J., Orum, A., & Sjoberg, G. (1991). *A case for case study.* Chapel Hill, NC: University of North Carolina Press.

Fearne, A., & Fowler, N. (2006). Efficiency versus effectiveness in construction supply chains: the dangers of lean thinking in isolation. *Supply chain management: An international journal, 11(4)*, 283-287.

Fellows, R., & Liu, A. M. (2003). *Research methods in construction, 2nd edn. Oxford.* Blackwell Science Ltd.

Fernie, S., & Thorpe, A. (2007). Exploring change in construction: supply chain management Engineering. *Construction and Architectural Management, 14(4)*, 319-333.

Fewings, P. (2005). *Construction Project Management: An Integrated Approach.* London: Taylor & Francis.

Fitzgerald, B., & Howcroft, D. (1998). Towards dissolution of the IS research debates: from polarisation to polarity. *Journal of Information Technology, vol. 13(4)*, 313-326.

Frechtling, J., & Sharp, L. (1997). *Introducing the handbook.* Washington DC: Westat, Inc.

Frohlich, M. T., & Westbrook, R. (2001). Arcs of integration: An international study on supply chain strategies. *Journal of operations management V 19 No 2*, 185-200.

Ghauri, P. N., & Kjell , G. (2005). *Research methods in business studies : a practical guide. 3rd ed.* Harlow : Financial Times Prentice Hall.

Goldstein , D. K., & Zack, H. M. (1989). The Impact of Marketing Information Supply on Product Managers. *An Organizational Information Processing Perspective, Office." Technology and People, vol. 4 (4)*, 313-336.

Groat, L., & Wang, D. (2002). *Architectural Research Methods.* New York: John Wiley.

Gyadu-Asiedu, W. (2009). *Assessing construction project performance in Ghana. Modelling. A Thesis Submitted to the Technology University of Eindhoven.* Eindohoven, Netherlands.

Harland, C. M., Lamming, R. C., & Cousins, P. D. (1999). Developing the Concept of Supply Strategy. *International Journal of Operations & Production Management, V 19, No 7*, 650-666.

Harrison, A., & Van Hoek, R. (2002). *Logistics Management and Strategy.* Harlow, England: Prentice Hall.

Houlihan , J. B. (1985.). International Supply Chain Management. *International Journal of Physical Distribution & Materials Management 15.*

How supply chain management works. (n.d.). Retrieved September 15, 2012, from DTI Internet: http://www.dti.gov.uk/energy/eid/study.pdf.

Howell, G. (1999). *Managing Construction: The Lean Perspective.* Ketchum: Lean Construction Institute, .

Howell, G., & Ballard, G. (1999). What is Lean Construction. *Conference of the International Group for Lean Construction*, (pp. 1-3).

Hugo, WMJ, Badenhorst-Weiss, Van, B., & Van, B. E. (2004). *Supply chain management: logistics in perspective.* Pretoria: Van Schaik.

Hugos, M. (2003). *Essentials of supply chain management.* New Jersey: John Wiley & Sons, Hoboken.

Jarnbring, J. (1994). *Material Flow Costs on the Building Site.* Lund, Sweden.

Kaming, P. F., Paul , O. O., Gary, D. H., & Frank, C. H. (1997). Factors Influencing Construction Time and Cost Overruns on High-Rise Projects in Indonesia. *Construction Management and Economics 15 (1):*, 83-94.

Khalfan, M., Asad, S., & McDermott, P. (2005). Towards demand and supply management in construction industry. *13th annual Conference of the International Group for Lean Construction proceedings* (pp. 109-116). Sydney: IGLC.

Kim, D. (2002). *Exploratory study of lean construction: Assessment of lean implementation.* The University of Texas at Austin.

Kocakülâh, M. C., Jason , F. B., & Joshua, W. T. (2008). Lean manufacturing principles and their application. *Cost Management 22 (3)*, 16-27.

Koskela, L. (1992). *Application of the new production philosophy to construction.* Stanford University. Centre for Integrated Facility Engineering.

Koskela, L. (2000). *An Exploration towards a Production Theory and its Application to Construction.* Espoo, Finland: Helsinki University of Technology,.

Kpamma, Z. E. (2009). *The practice of lean thinking at the pre-contract stage of building construction projects by selected Ghanaian firms. A thesis submitted to the Department of Building Technology at the Kwame Nkrumah University of Science and Technology.* Kumasi.

Kwon, I. G., & Suh, T. (2005). Trust, commitment and relationships in supply chain management: a path analysis. *Supply Chain Management: An International Journal 10(1).*

Lamming, R. C. (1996). Squaring Lean Supply with Supply Chain Management. *International Journal of Operations & Production Management 16(2).*

Lamming, R. C. (1993). *Beyond Partnership: Strategies for Innovation and Lean Supply.* Hemel Hempstead: Prentice-Hall .

Latham, M. (1994). *Constructing the Team.* London: HMSO.

Lau, J. S., Huang, G. Q., & Mak, K. L. (2004). Impact of information sharing on inventory replenishment in divergent supply chains. *International Journal of Production Research 42 (5)*, 919-941.

Laufer, A. (1997). *Simultaneous Management: Managing Projects in a Dynamic Environment.* New York, NY: Amacom.

Laufer, A., & Tucker, R. L. (1987). Is Construction Project Planning Really Doing Its Job? A Critical Examination of Focus, Roles, and Process. *Construction Management and Economics, V5.*, 243-266.

LCI. (n.d.). *Lean Construction Institute (LCI) 2002*. Retrieved October 20, 2012, from http://www.leanconstruction.org/about.htm

Lee, H., & Billington , C. (1993). *Operations Research :Materials management in decentralized supply chain.*

Liker, J. K., & Choi, T. Y. (2006). *Building deep supplier relationships ; Harvard Business Review on Supply Chain Management.* Boston: Harvard Business School Press.

Liker, J. K., & David , M. (2006.). *The Toyota way fieldbook: a practical guide for implementing Toyota's 4Ps.* London: McGraw-Hill.

Liker, J. K., & Jeffrey , K. (2004). *The Toyota way : 14 management principles from the world's greatest manufacturer.* New York: London: McGraw-Hill.

Love, P. (2000). Construction supply chains. *European Journal of Purchasing and Supply Management 6 (3-4):*, 145-147.

Love, P., Irani, Z., & Edwards, D. J. (2004). A seamless supply chain management model for construction. *Supply chain management: an international journal, 9(1)*, 43-56.

Lysons, K., & Gillingham, M. (2003). *Purchasing and supply chain management. 6th edition.* Harlow: Prentice Hall Financial Times.

Marsh, L., & Finch, E. (1998). Attitudes towards auto-ID technologies within the UK construction industry. *Construction Management & Economics, V16*, 383-388.

Millet, S. J., Dainty, A., Briscoe, G. H., & Neale, R. H. (2001). The Relationship between Client□s Primary Business Functions and the Implementation of Supply Chain Management in Construction. *CIB World Building Congress* (pp. 1-10). Wellington: CIB.

Monczka, R., Trent, R., & Handfield, R. (2005). *Purchasing and supply chain management. 3rd edition.* Australia: Thomson South Western.

Morgan, J. (2001). *New survey finds big gap between rhetoric and reality. Purchasing.* Retrieved 2012 12, October, from http://www.manufacturing/net/pur.

Naim, M., & James Barlow, J. (2001). An innovative supply chain strategy for customized housing. *Construction Management & Economics, V21*, 593-602.

Naim, M., Naylor, J., & Barlow, J. (1999). Developing Lean and Agile Supply Chains in the UK House Building Industry. *Proceedings of the Seventh Annual Conference, International Group for Lean Construction.* Berkeley, CA.

Naoum, S. G. (2002). *Dissertation research and writing for construction students, Oxford.* Butterworth-Heinemann.

Neuman, W. L. (1997). *Social research methods : qualitative and quantitative approaches. 3rd ed.* London: Allyn and B.

Neuman, W. L. (2003). *Social research methods: qualitative and quantitative approaches.* Boston: Pearson Education, Inc.

New, S. J. (1995). Supply Chain Integration: Results From a Mixed Mehod Pilot Study. *In Fourth International IPSERA Conference.* Birmingham.

New, S. J. (1997). The Scope of Supply Chain Management Research. *Supply Chain Mnanagement, V 2 No 1*, 15-22.

O' Brien, W.J., London, K., & Vrijhoef, R. (2002). *Construction supply chain modeling: a research review and interdisciplinary research agenda*. Retrieved September 18, 2012, from http://www.cpgec.ufrgs.br/norie/iglc10/papers/62-O'BrienEtAl.pdf.

O'Brien, W. J. (1995). Construction Supply – chains: Case Study and Integrated Cost and Performance Analysis. *Proceedings of the 3rd Annual Conference, International Group for Lean Construction.* Albuquerque, New Mexico.

O'Brien, W. J. (2000). Construction Supply-Chain Management: A Vision for Advanced Coordination, Costing, and Control. *Construction Engineering and Management Workshop.*

O'Marah, K. (2007). *The Top 25 supply chains: Supply Chain Management Review.* Retrieved October 12, 2012, from www.scmr.com

Ohno, T. (1988). *Toyota production system : beyond large-scale production.* New York: Productivity Press.

Patton, M. (1990). *Qualitative Evaluation and Research Methods.* Newbury Park, CA.

Patton, M. Q. (2002). *Qualitative research and evaluation methods.* Thousand Oaks, California: Sage Publications, Inc.

Peansupap, V., & Walker, D. (2006). Innovation diffusion at the implementation stage of a construction project: a case study of information communication technology. *Construction Management & Economics, V24,*, 321-332.

Pinho, T., Telhada, J., & Carvalho, S. M. (2007). Definition of supply chain management model in construction- case study. *IGLC.* Michigan, USA.

PPDT. (2002). *Kanban for the shopfloor.* Portland: Productivity Press Development Team.

Punch, K. (2005). *Introduction to social research: quantitative and qualitative approaches.* London: Sage publications.

Quesada, G., Syamil, A., & Doll, W. J. (2006). OEM new product development practices: the case of the automotive industry. *The Journal of Supply Chain Management 42(3)*, 40-41.

Robson, C. (1993). *Real world research. A resource for social scientists and practitioner–researchers.* Oxford: Blackwell.

Roy, R., Brown, J., & Gaze, C. (2003). Re-engineering the construction process in the speculative house-building sector. *Construction Management and Economics, Vol21*, 209-218.

Ryan, G., & Bernard, H. (2000). *Handbook of Qualitative Research, second edition, London.* Sage Publications.

Saunders, M. (1996). *Strategic purchasing and supply chain management. 2nd edition.* London: Pitman (Financial Times).

Shenhar, A. J., & Laufer, A. (1995). Integrating Product and Project Management – A new Synergistic Approach. *Engineering Mnanagement Journal 7(3)*, 11-15.

Sherif, M. A. (2002). *A framework for improving pre-project planning, PhD Thesis.* Loughborough University.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). *Designing and managing the supply chain concepts, strategies and case studies. 3rd edition.* Boston: Irwin McGraw-Hill.

Sobotka, A. (2000). Simulation modeling for logistics re-engineering in the construction company. *Construction Management & Economics, V18*, 183-195.

Stake, R. (2005). *The Sage Handbook of Qualitative Research, Third edition.* US: Sage publications.

Sterzi, M. P., Isatto, L., & Formoso, C. (2007). Integrating strategic project supply chain members in Production planning and control. *IGLC-15.* Michigan,USA.

Stevens, G. C. (1989). Integrating the Supply Chain. *International Journal of Physical Distribution & Materials, V19.*

Stevenson, W. (2005). *Operations Management. 8th edition. International Edition.* Boston: McGraw-Hill.

Strydom, J. W., Grové, T., Van Heerden, C. H., Nel, D., van Scheers, L., & Bothma, C. (2005). *Distribution management. 2nd edition.* Claremont: Sumani.

Tanhuanpää, V. P., Koskela, L., & Lahdenperä, P. (1999). [Improving the Performance in Construction Projects: Means and Possibilities in Different Project Phases. *VTT Building Technology, Espoo.*

Thomas, H. R., Horman, M. D., Souza, U., & Zavrs, I. (2002). Benchmarking of labor intensive construction activities: Lean construction and fundamental principles of workforce management. *International Council for Research and Innovation in Building and Construction.*

Thomas, H. R., Riley, D. R., & Messner, J. I. (2005). Fundamental principles of site material management. *Journal of Construction Engineering and Management-ASCE 131(7)*, 808-815.

Tommelein, I. D., Riley, D., & Howell, G. A. (1999). Parade Game: Impact of Work Flow Variability on Trade Performance. *J. of Constr. Engrg. and Mgmt ASCE*, 304-310.

Tsemg, H. P., Dzeng, R. J., Lin, Y. C., & Lin, S. T. (2005). *Computer-Aided Civil and Infrastructure Engineering. V20 (4).*

Vogt, J. J., Pienaar, W. J., & de Wit, P. (2005). *Business logistics management: theory and practice. 2nd edition.* Cape Town: Oxford Press.

Vrijhoef, R. L., Koskela, L., & Voordijk, H. (2003). Understanding construction supply chains: a multiple theoretical approach to inter-organizational relationships in construction. *11th International Group of Lean Construction Annual Conference (IGLC-11).*

Vrijhoef, R., & Koskela, L. (n.d.). Roles of Supply Chain Management in Construction. *7th Annual Conf. Int'l. Group Lean Constr. IGLC-7*, (pp. 26-28).

Vrijhoef, R., & Koskela, L. (2000). The Four Roles of Supply Chain Management in construction. *European J. of purchasing & Supply Chain Management, V6.*, 169-178.

Vrijhoef, R., Koskela, L., & Voordijk, H. (2003). Understanding construction supply chains: a multiple theoretical approach to inter-organizational relationships in construction. *11th International Group of Lean Construction Annual Conference (IGLC-11).* Blacksburg, USA.

Vulink, M. (2004). *Technology Transfer in the Construction Industry of Ghana: Human Resource Development through International Collaboration between Foreign and Local Contractors in the Greater Accra Region.*

Ward, P. (2005). *Towards a synthesis of supply chain management and partnering strategies within the construction industry.* Retrieved November 20, 2012, from http://aut.lconz.ac.nz/cgi-

Wegelius-Lehtonen, T. (1995). Measuring and Re-engineering Logistic Chains in the Construction industry. *International Federation for information Processing Working Conference on Re-engineering the Enterprise.* Galway, Ireland.

Wegelius-Lehtonen, T., & Pahkala, S. (1998). Developing Material Delivery Processes in Cooperation: An Application Example of the construction Industry. *International Journal of Production Economics*, 56-57,689-698.

Wegelius-Lehtonen, T., Pahkala, S., Nyman, H., Vuolio, H., & Tanskanen, K. (1996). *Guidelines for Construction Logistics.* Helsinki, Finland.

Wegelius-Lethonen, Tutu, Samuli , P., Hannu , N., Hannu, V., & Kari, T. (1996). *Guidelines for logistics of construction.* Helsinki, Finland.

Williams, C. (2004). *National association of automotive component and allied manufacturers*. Retrieved September 20, 2012, from http://www.naacam.co.za/sami.htm.

Wincel, J. (2004). *Lean supply chain management: a handbook for strategic procurement Vol. 15.* New York: Productivity Press.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design.* Boston: Addison -Wesley.

Wisner, J. D., Keong, G., & Tan, K. C. (2005). *Principles of supply chain management: a balanced approach.* Australia: Thomson South-Western.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine that Changed the World.* New York: Rawson Associates.

Womack, J. P., Jones, D. T., & Roos, D. (1991). *The Machine That Changed The World: The Story of Lean Production.* New York. 1st Harper Perennial Ed.

Womack, James, P., & Daniel , T. J. (2003). *Lean thinking : banish waste and create wealth in your corporation.* New York:: Free Press.

Yin, R. (1994a). *Case Study Research – Design and Methods, Applied Social Research Method Series 5 2nd edition.* Newbury Park, CA: Sage Publications.

Yin, R. (1994b). Case study research. Design and methods. *Applied Social Research Methods Series, Vol. 5.* California: Sage Publications.

Yin, R. K. (2003). *Case study research: design and methods, 3rd edn.* Thousand Oaks, California: Sage Publications, Inc.

Zimmer, E. R. (2006). *Improving Lean Supply Chain Management in the Construction Industry. A Thesis submitted to Department of Civil and Environment Engineering College of Engineering, University of Cincinnati.*

APPENDIX A: Interview Guide for Contractors

1. Which of these stakeholders does your company belong to?

a) Contractor [ ]

b) Sub Contractor [ ]

2. Please provide a brief background about yourself?

.....

.....

.....

.....

CURRENT PRACTICES IN THE MANAGEMENT OF THE GHANAIAN CONSTRUCTION SUPPLY CHAIN

3. How critical does your organisation view supply chain management for project success?

.....

.....

.....

4. How do you keep suppliers informed about changes in design, product specifications, sequence of orders and time delivery?

.....

.....

.....

.....

5. How do you handle nonconformance by suppliers (eg quality, meeting specs and delivery deadlines)?

.....

.....

.....

.....

6. Tick as appropriate to the current practices in the management of your supply chains

Suppliers are at par with employees whose services are easily dispensable	
There is a lack of interest by both parties about the other party's well-being – "one party's gain is another one's loss".	
There is one of a series of independent deals – little or no basis exists for collaboration.	
Costs, data and forecasts are not shared	
Price is the main focus of the relationship.	
Substantial investment in expediting and checking incoming quality and timely delivery	
Inflexibility when flexibility may be required, particularly when changing technology and changing market conditions require flexibility in supplier/buyer relationships	
Minimum services provided by suppliers	
Time buffers are added to avoid disruptions in supply of material	
Approach to inventory management is independent effort	
Total cost approach is independent effort	
Transactions are short term to the needs of current project	
Amount of information sharing limited to the needs of current project	
Breath of supplier base is large to include competition and spread risk	
Risk sharing is independent efforts	
Too much materials are stored to avoid shortages	
The way suppliers are managed is insignificant in their overall performance and on the project performance.	

7. When are suppliers involved in the supply chain?

.....
.....
.....
.....

8. What systems are in place for rating suppliers' performance on quality, time and price?

.....
.....
.....
.....

9. How do you replenish materials?

.....
.....
.....
.....
.....

10. Where are materials delivered?

.....
.....
.....
.....

PROBLEMS AND ITS CAUSES IN THE MANAGEMENT OF THE GHANAIAN CONSTRUCTION SUPPLY CHAIN

11. How often do changes occur in designs, product specifications, sequence of orders and time delivery?

.....
.....
.....
.....

12. What are the causes of these changes?. Please tick as appropriate

Change Causes	
Inappropriate designs	
Incomplete technical drawings and specifications	
Contractual arrangements	
Poor coordination	
Bad communication	
Unavailable, late, wrong and incomplete information	

13. How do these changes affect the management of the supply chain?

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

14. Tick as appropriate to the problems in the management of your supply chains

Information is not accurately transmitted among contractors and suppliers	
Suppliers are not informed of the progress of work so they can be prepared for future deliveries	
Too much materials are stored on site	
Late deliveries	
Delivery problems with quality and quantity	
Shortage of materials	
Poor communication between actors	
There is seemingly bad relationship between contractor and suppliers	
Bad handling leads materials waste	
There is no much trust between contractor and suppliers	
Materials need to be moved around to make space for new incoming materials or to give access to other actors.	
Bad sequence of orders	
High inventory levels	
Transportation Problems	
Unnecessary processing of materials	
Unnecessary movement of people	
Unnecessary transport of goods	
So much time waste in the delivery and management of materials	

15. What are the causes of these problems?

.....

.....

.....

.....

16. What will you suggest for improvements?

.....

.....

.....

CONCEPT OF LEAN SUPPLY CHAIN MANAGEMENT

The primary goal of Lean supply chain management is to accomplish supply management with the minimum possible waste in construction. Lean supply chain management emphasizes and focuses on improving relationships among project participants. It focuses on the cooperation between all actors involved in a typical construction project for improving the total flow of material.

17. How familiar are you with the concept of lean supply chain management?

.....

.....

.....

18. Tick as appropriate if you are familiar with the following lean tools.

LEAN TOOLS	
Kanban	
Kaizen	
Last planner	
Visual Control (5S)	

19. To what extent do you think these lean tools are applied in the management of your supply chain?

.....

.....

20. If these tools and any other lean tools have been used what benefits or improvements has it brought to the company?

.....

.....

21. A lean supply aims to gain improvements in quality, cost and delivery of materials as well as an improved relationship with suppliers. Do you think application of lean supply chain management can bring an improvement to your supply chain and to your company?

a) Strongly Agree [ ]
b) Agree [ ]
c) Neutral [ ]
d) Disagree [ ]
e) Strongly disagree [ ]

22. Below are lists of possible measures to bridge the knowledge gaps on the concept of lean supply chain management in the construction industry. Please tick as appropriate.

MEASURES	
Training of employees at all levels on lean supply chain management	
Engagement of competent and skilled site operatives	
Promotion of the concept to firms, professional bodies and major stakeholders	
The construction industry should fund workshops and research conferences to promote transfer of knowledge on lean supply chain management	
Working on improving performance when carrying out projects	
Construction managers should be committed to changes	
Firms should change organizational culture that does not promote lean supply chain	

23. Structural changes are needed to make the management of the supply chain effective

a) Strongly Agree [ ]
b) Agree [ ]
c) Neutral [ ]
d) Disagree [ ]
e) Strongly disagree [ ]

24. Please tick as appropriate

STRUCTURAL CHANGES	
Trust must be developed within the supply chain	
Ensuring fair payments	
Early involvement of suppliers with projects	
Educating the construction workers	
Improving communication skills	
Knowing the operations of other parties in the supply chain	
Knowing the benefits of supply chain integration and partnering	
Understanding new contractual documents	