A successful construction company meets the customer's needs effectively and in the process makes a profit. Owners are looking for construction companies that can deliver the project at low cost, with the required standards of quality and in a reasonable time. Similar to other industries, the cost of materials in construction accounts for a considerable part of the project cost. Some studies concluded that materials account for around 50-60% of the project cost \{(Stukhart, 2007), Bernold and Treseler (1991)\}. It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company (Damodara, 2008). In the late 1970's, construction companies experienced an increase in costs and a decrease in productivity. Owners of these companies thought that these increases in cost were due to inflation and economy problems. Further research concluded that these companies were not using their resources efficiently and that the decrease in productivity was also attributable to poor management (Stukhart et al. 1995). Materials management has been an issue of concern in the construction industry. In addition, 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification of materials and inadequate storage (Baldwin et al. 1994).
In any construction project the cost of materials can exceed half the cost of construction. Many researches have indicated that in a typical industrial facility 50% to 60% of the total cost is for equipment and materials. The proportion in terms of cost of materials has increased more than labor. Bernold and Treseler (1991) stated that cost of materials escalated twice the cost of labor between 1975 and 1980 and 60% of costs of projects were materials and equipment. They also pointed out that the construction industry spends 0.15% in material management systems.

Some studies have shown that an effective material management system can produce 6% improvement in labor productivity and a computerized system can produce additional 4-6% in savings (Stukhart, 2007). There is a growing awareness in the industrial construction industry that materials management needs to be addressed as a comprehensive integrated management activity. Researchers have acknowledged the importance of materials and the impact that these have in the total project cost, plans and operations. This chapter presents an overview of some of the aspects considered in previous and ongoing research in materials management in small scale manufacturing & construction industry.

3.1 MATERIALS MANAGEMENT AND PROJECT MANAGEMENT

Different authors define the concept of materials management in different ways. However, all the researchers point out that materials management is extremely important for a successful project completion. The basic idea behind materials management is that the materials and/or equipment needed, in the quantities needed, meeting the standards of quality specified, are obtained at a reasonable cost and are available when needed on the construction site. The process of materials management should integrate
purchasing, expediting, and inventory control. The benefits of implementing a materials management system have not been recognized by senior management. A well managed materials management system can contribute to the cost effectiveness of a project. In order for a company to implement a successful materials management system, top management support is required.

Damodara (2008) identifies seven stages in which the project management team must ensure a materials management focus. These seven stages are: Planning, Preliminary design, Final design, Procurement, Vendor control, Construction, and Closeout. A description on the tasks of managers in each stage follows. In the Planning stage the project management team develops the materials management team and the functional relationships among members of the team in order to develop a team that is united and working towards the same goal. In this stage the materials management focus should be defined and adapted to the mission, which is to complete the project at the lowest cost possible. In the Preliminary design phase the materials to be used in the project are defined. This definition of materials should minimize the cost of the design, but assuring that the materials and equipment selected meet the owner's requirements. Once materials are defined, the project team starts to inquire suppliers for information about the materials needed and possible delivery dates.

In the Final design stage the team should develop specifications for equipment and materials to be used in order to request and obtain competitive proposals. In the Procurement stage the team should consider to use standard materials that meet the specifications and requirements. In addition, the submittals should be kept to minimum levels. This might ensure more reliable delivery dates. The team should not buy materials
advance. Buying materials earlier than needed may require re-handling which will increase costs. When dealing with vendors, the team should review the drawings submitted by the vendor without delay, this will eliminate delays due to necessary changes. In addition, the team has to put in place a plan to expedite the orders so that the materials are delivered according to the schedule. In the Construction stage the team should account for all materials and equipment received. This practice will be useful to avoid duplicated orders. These materials and equipment should be available when needed on site to avoid delays. In the Closeout stage the project team should dispose any surplus materials. The disposal process can be simplified if the team uses standard materials. The team can identify any pitfalls in the materials management process and identify areas of improvement. The success of a project depends greatly in the effective implementation of materials management system.

3.2 BENEFITS AND COSTS OF A MATERIALS MANAGEMENT SYSTEM

The Construction Industry Institute (CII) created a materials management task force in the middle 1980s. This task force was comprised by owners, contractor and people from the academy. The first research conducted was to examine the attributes of a materials management system. Bell and Stukhart (1986) presented the attributes of a materials management system that they identified as part of a research work. The attributes identified were: Planning and communications, Material takeoff and engineering interface, Vendor Inquiry and Evaluation, Purchasing, Expediting and Shipping, Warehousing, receiving, and material distribution, Material control, and Computer Systems.
Bell and Stukhart (1986) completed another study to identify the costs and benefits of a materials management system. They stated that the development of some materials management systems that combine takeoff, expediting, purchasing, and vendor evaluation, among other factors, can produce benefits in productivity, cash flow and reductions in inventory. The benefits identified by Bell and Stukhart are:

- Improved labor productivity
- Reduced Bulk Materials Surplus
- Reduced Materials Management Manpower
- Improved Vendor Performance
- Other benefits
  - Timely materials procurement results in reduced requirement for physical warehouse facilities
  - Other benefits are those associated with timely material purchases

Some of the factors that might impact the benefits of a materials management system were also identified. Among these factors, inadequate training, inadequate, insecure, or poorly designed warehouse and laydown areas are included.

Wong and Norman (2007) stated that benefits of implementing materials planning software packages in the manufacturing industry include labor savings, stock reduction, purchase savings and better cash flow management. They suggested implementing a construction materials planning system (CMPS) to determine what components are needed. In
addition, it should help to determine what to order, order quantity, ordering time, when to schedule delivery. They identified the major costs such as acquisition cost, start-up costs and annual operating costs. Benefits identified include labor savings, stock savings, cost control savings, purchase savings, earnings generated from extra contracts.

Tuffour (1987) performed some research in materials management for construction in developing countries. He identified the following as benefits of a materials management system and these include the following:-

Reduction in paper work, coordination or cooperation among departments, improvement in relations with suppliers, reduction in double handling of materials, assurance of materials availability, and increase in productivity at the job site.

In addition, Tuffour identified the following as costs associated with the development of a materials management system:

- Warehousing
- Personnel
- Computer system development and application

3.3 ROLE OF VENDOR/SUPPLIER AND FABRICATOR

The relationship between the contractor and suppliers is crucial for the success of a project and it is vital in determining whether or not a construction company stays in business. If the contractor has a good relationship with the suppliers, better prices and more reliable delivery dates can be expected. On the other hand, if the relationship with the supplier is not a good one, the contractor can expect higher prices and late deliveries.
Thomas and Sanvido (2004) stated that although fabricators are a critical component for material management process, their role has not been considered in previous research. Furthermore, they pointed out that they didn't find quantitative research studies that studied the impacts in a project due fabricator's performance. They analyzed three case studies to demonstrate the quantitative effect of the fabricator in labor productivity.

Agapiou, et al. (1998) investigated the role of merchants/suppliers in the supply process and discussed the changes in their roles. They stated that a supply chain can bring savings in the costs of materials and components and that the supply includes price, discounts, reliability and timing of deliveries, credit facilities for payment.

Bernold and Treseler (1991) stated that the performance of suppliers is related to the success of the material management system, thus selection of vendors is a very important aspect. They introduced the Concept of Best Buy. Best Buy assumes certain level of suitability, but considers cost and procurability, transportation and disposal. Best Buy not necessarily means best price, procurement and technical specifications should also be considered. In addition, other factors such as specifications, price, delivery time, etc. should be considered.

3.4 MODELS DEVELOPED AND STUDIES OF EFFECTIVENESS OF MATERIALS MANAGEMENT

The delivery of materials to a construction site is a critical aspect. The supply of building materials and components is filled with obstacles that can have a significant effect on levels of productivity if the materials are not available when needed. Therefore, the delivery of materials is an aspect which demands the introduction of a carefully developed system to monitor
and control the problems as early as possible. In addition, the conditions in which the materials are kept on site could lead to damage from weather and movement of people, plant and equipment. This aspect could also have an impact in productivity.

Agapiou, et al. (1998) studied the role of logistics in the materials flow process. They defined logistics as the art of moving, lodging and supplying troops and equipment. For the construction industry, logistics comprise planning, organization, coordination, and control of the materials flow from the extraction of raw materials to the incorporation into the finished building. Logistics spans the organization, from the management of raw materials through to the delivery of the final product. They concluded that the success of the model was based on an integrated approach and the roles adopted by the participants during design and construction phases. In addition, they concluded that the primary focus of logistics is to improve communication and coordination between participants during design and construction, particularly in the materials flow control. They stated that Partnering arrangements could lead to effective materials control through coordination and cooperation.

Proverbs, et. al. (2005) examined the materials management procedures and wastage levels of a medium sized building contractor during the recession in UK. Some comparisons are made with wastage levels prior to recession to evaluate improvements in materials control procedures. They prepared a structured questionnaire based on materials management practices and distributed to site managers. Actual site measurement of direct materials wastage was undertaken. The research team concluded that a materials manager could reduce wastage, improve materials control on site and lead to overall improvements in the competitiveness and efficiency of a company.
If the site management is motivated, the morale of employees will increase which will increase the percent of time spent doing productive work.

Formoso and Revelo (1996) developed a method for improving the materials supply system in small sized building firms using total quality management (TQM). The main problems detected while performing the study were: problems related to design such as delays, incompleteness, lack of details and inconsistencies, lack of planning and organization of transportation and delivery of materials, materials ordered on short notice or verbally, incomplete or inconsistent materials specification, lack of estimation of the amount of materials needed, delays in price surveys and in ordering materials, delays in checking stocks. The improvements were mostly related to supply planning, design phase management, qualification of suppliers and designers, and changes in the process flow. They concluded that although quality concepts and techniques seem easy to understand, their application in complex processes, such as materials supply management, tend to be rather difficult and time consuming.

Dos at al. (1996) devised a method of intervention in the flow of materials on building sites, based on the concepts of the new production philosophy. The principles of the method of intervention as described by them are:-

- **Short term benefits**- quality and productivity improvement programs, scale improvements in the flow of materials can bring short term results, which can be easily noticed on site, and contribute for creating an improvement culture, leading to a major change in the company production philosophy

- **Low cost improvements**- development of the operations function role in construction companies is usually internally and externally neutral
(reactive) to the needs of the company, may lead to the rejection of any kind of improvement that implies in high investment

- **Without the need of significant technological changes**—Without a corresponding improvement in operations management, radical changes in technology often leads deterioration in the flow activities.

They stated that it was verified after the research that the intervention contributed to changing the role of that professional, by providing a structured source of ideas. Images proved that the method proved to be the most powerful instrument of communication. Level of the flow of materials the researchers found positive effects both in terms of quantitative and qualitative parameters. The intervention can also be used as an audit process for a current strategy, assessing the existing practices in the diagnosis, analyzing those practices against benchmarks, and making confrontation with the perception of the managers.

Plemmons and Bell (1995) studied the key effectiveness measures of the industrial construction materials and which mechanism can be used for benchmarking. The objectives of the research were the following:

- Determine current effectiveness measures use in construction industry.
- Generate generic diagrams of flow of materials management
- Do a survey to determine which measures best communicate effectiveness.
- Propose a mechanism for benchmarking the effectiveness of materials management systems.
Abdul-Malak, et al. (2000) investigated policies that could ensure that costs associated with materials purchasing are kept to a minimum. The research investigated the parameters used in characterizing construction materials, the contractor's purchasing policies and costs associated with purchasing of and holding materials, and the owner's payment policies for purchased materials. They identified three major cost categories associated with procurement and purchasing: purchase cost, holding costs and shortage costs. They identified payment policies from the contractor to supplier and from the owner to the contractor. After finishing the research they concluded that the owners should carefully check procurement policies by contractors. Owners should require a procurement schedule of all major materials against to partial payments apply. The contractor should be paid for materials purchased according to the schedule, so as to avoid paying for materials that are prematurely delivered to site. Control should be exercised over the contractor's ordering policies and payments to contractors should be scheduled properly to reduce overall costs of acquiring materials for construction.

Tuffour (1987) developed a materials management model to be used as a guide for contractor in developing countries, especially Ghana. The materials management was divided into three main parts. These parts are the materials management organization, purchasing procedures and relations with suppliers, and material utilization. The materials management organization presented a role and responsibility matrix that showed the responsibilities of several people from different departments.

Elzarka et al. (1995) developed a prototype object oriented computer model for piping systems. They wanted to examine and determine potential expert
systems applications to materials management. They stated that model is capable of executing automatic takeoff. Also, the program can generate purchase orders daily and allows for reduction in paperwork. The object oriented model was integrated with the design and the schedule. This integration allows updating the material takeoff automatically. In addition, changes in materials are updated automatically. They concluded that expert systems could improve the efficiency of material management systems.

The objective of the research effort by Jiang et. al. (2003) is to identify performance measure attributes for continuous process improvement in business process reengineering. They propose the multi-level decomposition process modeling with performance attributes (PMPA), which is a hierarchical structure. The PMPA was used to model an "as-is" organization and it is ideal to diagnose the non-value added activities. They present a case study of the measurement of performance for a residential builder.

3.5 USE OF TECHNOLOGY FOR MATERIALS MANAGEMENT

The tools used in the construction industry change constantly with the continuous changes of technology. Researchers are finding ways to apply those changes in technology to construction in order to improve production and lower the cost of the operations.

Bell (1986) studied the application of computer systems for materials management systems. He stated that computer systems were used to track and control engineered equipment and major fabricated items as well as small bulk materials items. In addition, he pointed out that a properly designed computer system tracks materials requisitions from the takeoff or
requisition generation, through purchasing, expediting, and warehousing functions to final material issue and installation.

He classifies the materials management computer systems into two general categories: Database Systems and Comprehensive, integrated systems. A description of each system follows:-

- **Database systems**- commonly used by owners, track status of engineered equipment and major critical materials items. The requisitions and purchases can be tracked and sorted according to data file parameters among other capabilities

- **Comprehensive, integrated systems**- commonly used by contractors, track status of bulk materials as well as engineered equipment. The requisitions and purchases can be tracked and sorted according to data file parameters. These systems are capable of interacting with the contractor's estimating, scheduling and accounting systems. Other capabilities include: system can interact with CAD drawings, computer takeoff assistance, analysis of vendor quotations, generation of purchase orders, trial allocation, generation of inventory reports among other capabilities

Bell stated that the computer system is only a single component of a properly designed and executed materials management system. In addition, he said that it is difficult to isolate the benefits that can be derived by simply developing and implementing a computer system. However, the materials management systems do result in improved labor productivity, reduced bulk materials surplus, reduced materials management manpower on site, and improved vendor performance. The most significant of the benefits appears
to be the improved craft labor productivity. Materials systems can be used by craft labor to plan their work according to material availability.

Stone et al. (2000) performed some research to develop a web based system for rapid tracking, identifying, and locating manufactured components on the construction jobsite. Their approach includes the use of bar codes, RFID, 3D long range coordinate measurement systems technologies, portable/wearable computers, wireless communications, high speed networking, temporal object databases, web-based data analysis, and 3D user interfaces. The research addressed the problem of identifying, locating, and tracking discrete construction components and sub-assemblies in a construction site. The primary objectives of the study were: to develop means for real-time tracking of sub-assemblies and components, to develop standards for component identification and tracking that the construction industry will adopt, to develop standard means to wirelessly transmit that information to a construction project database, to demonstrate the utility of these techniques on full scale construction sites. According to the researchers, the procedures and techniques were implemented in actual hardware and software and demonstrated live. The field data system is being integrated into a rugged hand held computer that will handle different coordinate measurement sensors including both laser and GPS.

Mascari Development Inc. developed a web based software tool which allows for materials management functionality. This tool defines the policies and procedures to order, process, receive and deliver materials. The main features of the software are: supply ordering, form ordering, money limit ordering, work orders among others.
Proctor and Gamble Company developed a web based construction purchasing system. The main objectives of this system are:-

Work process simplification, achieve cost savings and to make purchasing more responsive/timely, allow real time access to purchase data, standardize purchasing systems among others.

They stated that the system produce a more efficient time from requisition to delivery, rework is avoided because electronic data minimizes paper shuffling, accuracy of data is improved, and the ability to place emergency order among others.

ProcureIT™ is an enterprise-wide electronic procurement and MRO solution that automates the entire purchasing and materials management process that was developed by Verian technologies. This web-based Intranet application is deployed directly to individual user desktops and gives you complete control over all of your purchasing activity. The program has an easy-to-use interface and is designed for organizations that want to lower resource costs, decrease cycle time, increase end-user satisfaction, and improve control in their procurement and materials management processes.

QMS Materials Management System was developed by QA Software. The purpose of QMS in regard to materials management include: management of changes to the bill of materials, automatic generation of inquiries and purchase orders for materials, management of the impact of a changing bill of materials on material orders, management of expediting of materials, control of material deliveries, management of material shortages both on fabrication and construction, control of material issues and movements, inventory/stock control management, management of material traceability,
progress monitoring. The program offers a variety of modules to keep track of changes to the bill of materials, summarize bill of materials in minutes, with automatic documentation generation for both bid packages and/or purchase orders, keep a complete history of all changes to purchase orders, recording the receipt of materials simple with typing only of the quantities received, analyze what can be fabricated or installed, automatic generation of issue slips/dockets and/or movement dockets to save time and improves accuracy. At all times the exact quantities of material at any location is known.

3.5.1 Bar Codes Applications to Material Management

Bar code applications in construction are mostly intended to provide accuracy in data collection, to improve productivity and to save time in the data collection process. Typically, bar codes are used for materials and inventory management. The scope of bar codes extends beyond materials management. Bar codes provide the advantage of relatively error free data collection, which improves productivity and avoid errors. Some construction firms that use bar codes claim that it saves time, money and labor while improving the accuracy of inventory.

The Commerce department of USA funded a research project in 1987 to study potential applications of the bar code technology in the construction industry. Bell and McCullouch (1988) and Stukhart et al. (1990) presented the results of these studies. Bernhold (1990) provided a background on the technical details, suitability of bar codes for construction and field testing of bar codes in the construction site environment. Blakey (1990) demonstrated the use of bar codes in parts inventory and scheduling maintenance for military facilities. Stukhart et al. (1990) discussed the approaches used by
other industries to develop bar code standards and how these approaches could be used to develop a bar code standard for the construction industry. Rasdorf and Herbert (1990) presented the applicability of bar codes for the development of a construction information management system for the control of information. McCullough and Lueprasert (1994) studied the applicability of 2D bar codes for the construction industry.

The major applications of bar code to material management identified in previous research can be identified as follow:

- **Field material control**: Bar codes have different applications for field control of bulk and engineered materials. This technology can be used to control receiving, inspection, storage and issue of consumables, parts, equipment, and all the items that could be controlled with bar codes. A report can be kept when materials are taken from the storage. These materials can be scanned and the report of issuance of materials can be completed.

- **Warehouse maintenance and control**: When materials are received and stored, the assigned location can be entered into the computer system by scanning the bar code of the particular material. Bar codes allow performing inventory by scanning the bar codes of the materials. As the project progresses and materials are used, a better overall picture of available materials is accessible for forecasting and scheduling purposes.

- **Inventory control applications and tool and consumable material issue**: Consumable materials, such as rain coats, gloves, safety glasses, are subject to abuse and misuse. Although some time might be spent entering bar code data into the computer system, it might
eliminate misuse of consumables. The inventory can be kept up to date as the materials and resources are consumed.

- **Purchasing and accounting**: Forms used for purchasing or other functions related to cost control can be printed with bar codes. Shipping forms from vendors can include bar codes to facilitate the receiving process.

### 3.5.2 Radio Frequency Identification (RFID) Applications to Material Management

Similar to bar code, RFID applications in construction are mostly intended to provide accuracy in data collection, to improve productivity and to save time in the data collection process. A Radio Frequency Identification (RFID) system is an automated data collection system similar to bar code. The tag used in RFID can be compared to the bar code and the wand used to scan bar codes can be compared to the receiver used in RFID. The principal difference between bar code systems and RFID is that in RFID the data collection process is done autonomous. No line of sight is needed for data collection. In the case of the bar code system, the bar code has to be scanned with a wand. In addition, in RFID systems data is carried in the tags. RFID can be viewed as a wireless link used to identify objects individually. This technology is primarily used in places where the bar codes can't be used. Some of the applications in which RFID tags could be used and in which bar code could be inappropriate include situations in which there is no sunlight or place in which the tags get covered with grease or dirt.

Many researchers have used RFID in previous studies to apply them to construction. RFID systems could be used in the same way in which bar codes are used. However, the cost is a major factor. There are other
applications in which RFID systems work better than bar code systems.

RFID had been used for material tracking and material receipt in the construction industry.

- RFID allow tracking materials as the move in the jobsite since direct contact is not required for data collection. This can avoid theft and lost since managers can notice when materials are not where they are supposed to be.

- **Materials Receipt:** Materials can be easily verified as they arrive to the site. The type of materials received can be known easily and verify if the right quantities were received.

### 3.5.3 Handheld Devices for Material Management

Recent advances in technology have proven to be very useful to the construction industry. Portable computers, wireless data transmission, among others, have been used for asset tracking, data collection and transmission. This data collection and transmission has been used to monitor performance with the ultimate goal of improving productivity and lower costs. Personal digital assistants (PDAs) have been used in the construction industry for different purposes. These devices have been used to develop applications in scheduling (Updater), tools tracking and control (ToolTrac), and tracking of personnel (TimeTrac). Presently, different types of software are available that easily allow building customize applications to be used in portable devices. The available software allows building and editing applications in Pocket PCs. The availability of these resources makes possible the development of applications for material management and inventory control. In addition, bar code readers could be used in conjunction
with Pocket PCs for automating the inventory process. Technology changes constantly, therefore the Pocket PC hardware and software are constantly evolving with these changes in technology. There are continuous efforts to develop new systems and/or improve the current devices. Some of these improvements include the ability to install more powerful processors, to use storage devices of small size in conjunction with the Pocket PC. These improvements allow these devices to be used as standalone systems. The compact size and light weight of the Pocket PCs make them suitable to be easily carried around and used at the construction site to perform various tasks.

3.6 CULTURAL CHANGE IN SMALL SCALE INDUSTRY

Cultural behavior and its resistance to change have been extensively investigated and documented in all industries from manufacturing, corporate business to construction. The small scale industry is very resistant to change. The "if it is not broken, don't fix it" attitude is typical in construction. Implementation of new innovative methods might be difficult in such environment, therefore a study of the culture encountered in Small scale industry is essential for this study. Gossom, (1999) states that every Company has its own culture, therefore there is no ideal culture to guarantee success and every Company has to be investigated separately. Riley and Clarke-Brown (2001) investigated and compare the culture found in a Construction Company with the culture found in manufacturing companies. They wanted to investigate how suitable it would be to incorporate manufacturing techniques into the construction industry due to the resisting culture found in the construction industry. Davis and Songer (2003) investigated the resistance to adopt technological changes in the A/E/C
industries. Koivu et al. (2003) investigated how the different cultures within a company affect project performance and the adoption of technology. Beliveau (2003) investigated the cultural issues of implementation an advanced web based information technology system for construction.

3.7 OVERVIEW OF SUPPLY CHAIN MANAGEMENT

The structure of supply chain is going through rapid transformation. Customer pressures for lower prices and higher quality of products/services are forcing suppliers to achieve greater cost-efficiencies, improve lead time, and improve supply chain efficiency. Manufacturers, distributors, and Retailers are increasingly looking across the supply chain for more innovative and cost effective means to create a seamless flow of goods and information.

Today, Supply Chain Management application is increasing rapidly. Advantages in costs, flexibility, customer satisfaction, speed and economy of time, which are provided by this system, are among the reasons of why it becomes widespread. Besides, integration of more than one enterprise and flow of information, money and goods also make the system agile.

The pressures of the global competition and the need for the extensive inter-organizational, collaboration is forcing industries to streamline their supply chains to make them agile, flexible and responsive. The old way of delivering product was to develop relatively inaccurate projections of demand, then manufacture the product and fill up warehouses with finished goods. Aided by electronic data exchange and worldwide communications, inter-relationships among warehousing, transportation, manufacturing, procurement, and order management functions were discovered. The implemented SCM systems and techniques have substantially increased
overall productivity, improved inventory and shipping accuracy rates, improved inventory reduction, improved forecasting accuracy, and reduced lead time and non-value-added activities.

According to the Global Supply Chain Forum (Lambert and Cooper 2000), supply chain management is defined as: “Overall integration of key business processes from end-user through original suppliers who provide product, services, and information that add value for customers and other stakeholders.” There are physical flows in the form of raw materials, work-in-progress inventories, and finished products/services between supply chain echelons. (Sabbaghi et al. 2004) says we can only talk about supply chain management, if there is a proactive relationship between a buyer and supplier and the integration is across the whole supply chain, not just first tier suppliers. (Grossman, 2004) states that the supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows. (Chapman et al. 2005) says supply chain management (SCM) is the integration of all business and process activities through improved supply chain relationships, to achieve a sustainable competitive advantage. For Companies, it has become clear that a supply chain that flows information and material best can be a significant differentiator, the competitive winner. Supply chain includes the movement of information and money, and the procedures that support the movement of a product/service. Managing these physical, informational, and transactional flows effectively and efficiently requires an integration approach that promotes organizational relationship and fosters the sharing of strategic and technological efforts.
The Internet is dramatically affecting the way products are bought and distributed. In Internet business, companies have to solve a major supply chain problem - how to efficiently incorporate, integrate, and utilize the rich inflows of information provided by multiple suppliers. Agents are now being regarded as an important technology to assist in helping to solve the problems of information overload and management. Collaborative information agents will play a major role in the supply chain management. Following six characteristics define current supply chain management philosophy:

- Shared Information
- Organizational Relationships
- Inventory Management
- Total Pipeline Coordination
- Readiness to adopt Flexibility
- Costing Issues

The trend, however, is to consolidate these disparate functions into a comprehensive SCM suite. A well structured supply chain management system possesses the following set of characteristics:

Integrated, customer-centric, distributed; having interoperability, scalability; with open and flexible infrastructure; autonomous, capable of self-organization and reconfiguration, coordination and negotiation, with optimization and learning mechanism so evolve in and adapt to the dynamic marketplaces, synchronized and agile (to handle rapid change), involving production planning and scheduling, capable of making forecasts accurately, both active and proactive, compatible with globalized manufacturing, seamlessly Integratable with E-commerce & M-commerce and proper performance-measurements. These characteristics are interrelated.
The competitiveness between suppliers and customers in the supply chain partly relies on how effective and efficient the information about various elements of demand and supply are being handled between the parties in the supply chain and how efficiently various demands are fulfilled. Customer pressures for lower prices and higher quality of product/services are forcing retailers, manufacturers, and distributors to achieve greater cost efficiency and improve lead-time, thus making supply chain efficiency a key factor in gaining competitive advantage. Companies can improve their strategic positions within the supply chain by providing quality products/services to customers and strive to add value to meet the needs of the entire supply chain network.

Today, virtually all industries including small scale sector are facing a more dynamic environment— that is, greater uncertainty of demand, shorter product life cycles, greater demand for mass customization, more significant seasonality, higher competitive intensity, Greater lead time, huge mismatch in supply & demand, fewer warehouses, more third-party service, new cost/service balance, globalization, channel integration, and so on. In order to overcome these shortcomings, supply chain management is a very effective tool which offers solutions to many of the issues in a very logical manner resulting into optimization and integration of overall infrastructure and facilities.

Small and Medium Enterprises (SME) have played a significant role in the landscape of global business competition. According to Australian Bureau of Statistics in Australia, SME represent 75 percent of all businesses and generating 49 percent of employment in private sector business. As reported by the US Small Business Administration (USSBA, 2009), SME are an integral part of the renewal process that pervades and defines markets and economies.
3.7.1 Small Medium Enterprises Characteristics and Challenges

In order to better understand the strategic roles of SME in the global business, it is important to recognize their inherent characteristics. SME are often independently owned and operated. They are closely controlled by the principal investors and decision makers with entrepreneurial spirit. The attitude, cultural values, and norms of owners can play a significant role in the adoption of new technology and strategy development (Stansfield, 2003). The decision maker formulates attitudes based on perception of their environment. The entrepreneur’s attitudes influence his/her own behavior and decisions. Their behavior and decisions have a direct impact on the SME’s capability. They also influence employee’s attitudes and behaviors and thus affect the internal environment through the organizational culture and norm, which in turn indirectly affect the SME’s capability further.

As per Ghobadian, Gallear (1996), Small and Medium Scale Enterprises are also often characterized by lack of standardization and formal working relationships, having a flat organizational structure. They have a more organic organizational structure when compared to a more bureaucratic structure in large firms. These characteristics make SME more flexible to environmental changes as well as incurring lower overhead expenses. Consequently, they have the potential of playing a significant role in global competition.

The characteristics of SME can determine strategic opportunities and challenges available to them in their supply chain. The entrepreneurial behavior of SME differentiates them from larger companies in the supply chain particularly in a cross-cultural dimension and global market. While SME’s managers are more sales oriented, they do not have a well-developed overall strategic plan. According to Dodge and Robbins (1992), 64% of
SME that failed did not have a business plan. SME managers tend to rely on their tacit knowledge rather than systematic techniques in supply chain management planning activities, such as vendor selection.

(Park and Krishnan, 2001) says Small to medium suppliers are less resourceful and often play niche roles within the supply chain as commodity supplier, collaboration specialist, technology specialist and problem-solving supplier. (Kaufman et al. 2000) The supplier topology divides along two dimensions: technology and collaboration. By dividing these dimensions into high and low categories, creates four distinct supplier strategies. The top left quadrant defines suppliers who use standard technologies and relate to customers through standard market contracts. These suppliers compete on the basis of low cost. These suppliers can be replaced since switching costs are low. These commodity suppliers design and sell parts to their customers as specified by their customers. The top right quadrant describes collaboration specialists. These suppliers use standard technologies, which meet customer specifications and delivery schedules. However, these firms develop enhanced collaborative techniques to fulfill current and to anticipate future customer needs. These suppliers use vendor managed inventory (VMI) strategy. The collaboration essentially requires accurate and timely information. They reduce the customers’ internal monitoring or administrative costs.

3.7.2 Relationship between Small Medium Enterprises & Supply Chain Management

SCM requires a serious integration from planning process to order and sales. In order to be successful in supply chains management, enterprises should share their stock, production and Promotion estimations and plans with
customers and suppliers, which form the other rings of the chain. However, most of the enterprises still avoid sharing since they fear that their rivals will obtain this information. Reservation of information and avoiding use of technology by some enterprises reduce pace and effectiveness of supply chains. Also, lack of technical knowledge in SMEs limits use of technology in supply chains. Besides, big enterprises, which take place in the same chain with SMEs still experience some problems in supply chains applications although they support the system with technologies. The reasons of these problems are that SMEs in the chain have limited resources of, they want to protect themselves from the competitive advantages of big enterprises and they do not want their control over their assets to be restricted. Other problems experienced in implementation of SCM in SMEs are: lack of supplier management skills, high level of competition in supply chain, lack of cooperation in supply chain, lack of customer management knowledge, distance with the customers, distance with the suppliers, requirement of investments on information technologies by partners.

According to (Hvolby, Trienekens, 2002) SCM’s benefits for suppliers include shorter transformation process, low stocking costs, less labor costs, increasing effectiveness and fast distribution.

The competitiveness between suppliers and customers in the supply chain partly relies on how effective and efficient the information about various elements of demand and supply are being handled between the parties in the supply chain and how efficiently various demands are fulfilled. Customer pressures for lower prices and higher quality of product/services are forcing retailers, manufacturers, and distributors to achieve greater cost efficiency and improve lead-time, thus making supply chain efficiency a key factor in gaining competitive advantage. Companies can improve their strategic
positions within the supply chain by providing quality products/services to customers and strive to add value to meet the needs of the entire supply chain network.

3.8 SUPPLY CHAIN MANAGEMENT FOR MANUFACTURING INDUSTRY

Similar to construction, for manufacturing, material management is a critical activity. The smooth flow of operations depends highly on the availability, control and handling of materials. In addition, in order to minimize overall costs of the final products, minimization of the costs related to material handling, ordering and storage is essential. This is the reason why improvement of the supply chain management for manufacturing has been a target of numerous research efforts.

Among the published efforts in supply chain and material management for manufacturing are the works performed by Ballot, Robert (2006), Dag (1974), Tersine and Campbell (2004), Beekman-Love (1998), Ammer (1999), Bailey and Farmer (2009), Gossom (1999), Cavinato (1994), Arnold (2001), and Dobler et al. (2009), Simchi-Levi et al. (2000), and Leenders et al. (2002). Some of the work of these researchers was used in the introduction to material management in Chapter 2.

Dong (2001) developed a modular modeling and analyzing approach, based on object-oriented Petri nets, to facilitate the modeling and verification analysis of supply chain workflows. In addition, he developed a network of inventory-queue models for the performance analysis and optimization of an integrated supply network with inventory control at all sites. He also developed simulation models for understanding decision-making issues of the supply chain network configuration in an integrated environment.
3.9 KNOWLEDGE MANAGEMENT

The task of managing knowledge comprises many disciplines. Liebowitz, (1999) states that knowledge management has been linked to organizational performance and strategy in areas such as evolutionary economics, the economics of innovation, and technology management. He points out that knowledge management is characterized by terminology, approaches, methods and organization that are separated from the organization that is served by the km concept. Moreover, he states that the km concept is a theoretical concept that has not been tied to strategy and performance in practice and had yet to enter the business world.

Liebowitz, (1999) states that the field of knowledge management is just a little over 10 years old. He states that Karl Wiig is one of the pioneers of the field and could probably be its founder. He points out that several authors have been concerned with creating a framework and methodology for knowledge management. He states that the interest for knowledge management discipline boomed after 1996.

Barclay and Murray (1997) state that a number of management theorists have contributed to the evolution of knowledge management. Among these they mention Peter Drucker, Paul Stresemann, and Peter Senge. They point out that work done in the late 1970s at Stanford by Everett Rogers and the work at MIT by Thomas Allen in information and technology transfer, have contributed on how knowledge is produced, used and distributed among organizations. They argue that in the 1980s the development of systems for managing knowledge emerged and term knowledge management emerged. In 1989, knowledge management related articles started to appear in journals and the first books on the subject were published. In the mid 1990s,
the internet was used as a tool for knowledge management and share initiatives. Conferences and seminars on the subject started to appear. In 1994 the results of a knowledge management survey conducted among European firms were published, and the European Community began offering funding for KM-related projects through the ESPRIT program in 1995.

Gamble et al.(2001) suggest that the ideas behind knowledge management go back as far as the 1950s with the use of quantitative management techniques and structured management approaches. They state that the approach to knowledge management has evolved from corporate organization in the 1960s to creating enterprise integration through knowledge sharing culture in the 2000s. Messner (2003) presents the development of detailed information architecture for structuring the knowledge and information for the A/E/C industry.

All the above-mentioned research certainly contributed to the research effort presented in this document. Most of the research work investigated the activities that comprise the materials management independently with no integration of the process. The integration of the departments that deal with materials related activities is essential. By using and building upon some beneficial features from some of these research works, it is expected that this research will be able to improve the materials management system for the small scale electrical contracting industry. The next chapter will present an overview of electrical industry and current material management practices in this industry.