IDENTIFYING THE BARRIERS OF IMPLEMENTING LEAN CONSTRUCTION PRINCIPALS IN DEVELOPING COUNTRIES

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ABSTRACT

IDENTIFYING THE BARRIERS OF IMPLEMENTING LEAN CONSTRUCTION PRINCIPALS IN DEVELOPING COUNTRIES

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The construction industry is congested with many types of project management systems to control and manage construction projects but none of them really look in-depth to maximize the efficiency of the work flow and minimizing waste. The implementation of the lean construction principles into the local construction scene can improve the problems. However, lean construction is complex and can be risky if not properly managed. Lean construction efforts in some other countries have not been successful due to the many hindrances to its successful execution. To implement lean construction principles and to increase the chances of success in eliminating waste, a thorough investigation of the barriers is essential.

The aim of this study was to first, understand the concept of Lean culture and its advantages in the industry. Furthermore, to identify the barriers of lean construction in construction industry of different countries. After conducting a literature survey to identify the common barriers of application of Lean principals in the construction industry, two cities both claimed to be active in construction industry were selected as a case study. A questionnaire was distributed among professionals, practitioners and academicians related to the domain of the construction industry. Face to face

interviews were also conducted. The data thus obtained was analyzed in order to see the readiness of organizations for transformation to Lean concepts and then to identify the barriers to implementing Lean construction principles in developing countries

It was concluded that, Lack of adequate Lean awareness and understanding, Culture and human attitudinal issues and, top management commitment, are the most significant barriers hindering the implementation of Lean construction in the developing countries. Furthermore, this study made professionals and practitioners aware of Lean construction.

Keywords: Lean construction, barriers to implementation, developing countries, Construction industry

ÖZ

GELIŞMEKTE OLAN ÜLKELERDE YALIN INŞAAT PRENSIPLERININ UYGULANMASINA KARŞI OLAN ENGELLERIN BELIRLENMESİ

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Yüksek Lisans, Yapi Bilimi, Mimarlik Bölümü

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İnşaat sektörü, inşaat projelerinin yönetimi ve kontrolü için çeşitli proje yönetim sistemleri ile doludur. fakat hiçbiri işin akışını verim açısından gerçek anlamında maksimize etmeye ve atığı minimize etmeye yeterli görünmüyor. Yalın inşaat ilkelerinin, yerel/bölgesel inşaat çerçevesi içinde uygulanması sorunları çözebilir. Ancak, yalın inşaat ilkeleri düzgün yötetilmezse durum karmaşık ve riskli olabilir. Yalın inşaat çalışmaları, diğer bazı ülkelerde, başarılı şekilde yürütülmesine birçok engel bulunduğu için ile muvaffak olmamıştır. Yalın inşaat kurallarının uygulanması ve atıkların ortadan kaldırılma şansının artırılması için engellerin kapsamlı şekilde incelemesi esastır.

Bu çalışmanın amacı öncelikle yalın kültür kavramı ve bunun sektördeki avantajlarını anlamaktır. Buna ek olarak, çeşitli ülkelerin inşaat sektöründe yalın inşaat prensibinin önündeki engellerini tespit etmektir.

İnşaat sektöründe yalın ilkelerin uygulanmasındaki ortak engelleri belirlemek amacı ile literatür taraması yapıldıktan sonra, inşaat sektöründe aktif olduğu iddia edilen iki şehir incelemeye alınmışlar. inşaat sektörü ile ilgili çalışan profesyoneller, uygulamacılar ve akademisyenler arasında bir anket dağıtılmıştır. Yüz yüze

görüşmeler de gerçekleştirilmiştir. Elde edilen bilgiler organizasyonların yalın kavramına dönüşmesi konusunda hazır olup olmadığını görmek ve, gelişmekte olan ülkelerde yalın inşaat ilkelerinin uygulanmasındaki engelleri belirlemek için~~,~~ analiz edilmiştir .

Sonuç olarak, yalın konusu ile ilgili farkındalık ve anlayış eksikliği, kültür ve insan~~ın~~ davranış~~sal~~ı sorunları, üst yönetimlerin taahhütlerini yerine getirmeme problemi, gelişmekte olan ülkelerdeki yalın inşaat uygulamasını engelleyen en önemli faktörlerdir. Ayrıca, bu çalışma inşaat uzmanları ve uygulamacılarının yalın yapının farkında olmasını sağlamıştır.

Anahtar Kelimeler: Yalın inşaat, uygulama engelleri, gelişmekte olan ülkeler, İnşaat sektörü

To My Family

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LIST OF ABBREVIATIONS

BPR(Business Process Re-engineering)

CE(Concurrent Engineering)

CI (construction industry)

CPP (Critical Path Planning)

JIT (JUST IN TIME)

LC (Lean Construction)

LPDS (Lean Project Delivery System)

LPS (Last Planner System)

LTCA (Long Term Contractual Agreement)

KPI (Key Performance Indicators)

NVA (Non-value Adding)

NW (Necessary Waste)

PDCA (Plan Do Check Act)

PMBOK (Project Management Body of Knowledge)

PMS (Proformance Measurement System)

SCM (Supply Chain Management)

TQM (Total Quality Management)

TPS (Toyota Production System)

VSM (Value Stream Mapping)

WIP (Work In Progress)

CHAPTER 1

INTRODUCTION

This study identifies the barriers to applying lean construction principles in developing countries and, in this chapter are presented the argument, primary objectives of the study and a brief overview of the methodology. The chapter finalize with a disposition of the material stated in the remaining chapters.

1.1 Argument

The Iranian construction industry is congested with many types of project management system to control and manage construction projects. However, most of the available statistical results of the conducted projects indicate a considerably prolonged process of project conduct or not being able to achieve the required capacity; but none of them look in-depth to maximize the efficiency of the workflow and minimizing waste of resources. There are also instances of the inaccurate execution of the project due to the lack of knowledge and the incorrect beliefs of some of the managers regarding the reduction of costs of the project. The reports of Plan and Budget Organization clearly state that these occasions

have led to about 90 percent increase in the time spent in the development of the construction projects.

According to statistics, Iran loses more than 100 billion dollars, each year, due to the prolonged development of the projects. In recent years, only 59 percent of the goals of the Power Ministry projects, 54 percent of the objectives of the projects of Oil Ministry, and 31 percent of the aims of the projects of Iran's Ministry of Industries and Mines have been achieved. Fifteen more years are needed for the completion of the 60 percent of the unfinished projects. Furthermore, according to a World Bank study, 30 to 40 percent of the projects in all countries are faced with this problem of the increasing costs.

Iran, as a developing country, invests the bulk of its annual income in the fulfillment and development of the civil and infrastructural projects. Accordingly, a large number of the projects are defined and implemented in the various sectors of the infrastructure, civil, industrial and services. To be able to have a successful implementation of such an extraordinary volume of the projects, the various sectors of investment, employers, engineering and also contractors are required to be informed of the necessary knowledge of contract management and project conduct.

Today the construction industry is facing the high demand of the market regarding project management expertise. Hence, knowledge and comprehension of the techniques of planning, control and implementation of projects are necessary and will have a significant impact on the construction industry’s performance. In addition to the experts and managers active in the sectors of consulting and contracting, practitioners and decision makers engaged in the administration and planning sections of the country are also required to be familiar with the methods of managing the construction projects at different levels.

The implementation of the lean construction principles into the local construction scene can help to deal with the problems. However, lean construction is risky and can be difficult to apply if not properly managed. Lean construction efforts in some other countries have not been successful due to the many barriers to its successful implementation. To implement lean construction principles and to increase the chances of success in eliminating waste, a thorough investigation of the barriers is essential.

1.2 Objectives

The main aim of this research was to understand the concept of lean culture and the transformation of lean manufacturing to lean construction. Hence, the main goals of this research can be listed as follows:

- Identifying the principles of lean construction
- Identify the common barriers of lean construction in the different regions of the world and especially in developing countries
- Identify the barriers of implementing lean construction culture in Iran

1.3. Procedure

The study was based on a survey that was conducted in the developing countries. The questionnaire used in this research was adapted from larger study by Sarhan and Fox (2011) and translated into Persian. This questionnaire was distributed among professionals, practitioners and academicians related to the domain of the construction industry. The data thus obtained was analyzed in order see the readiness of organizations for transformation to Lean concepts and then to identify the barriers to implementing Lean construction principles in developing countries.

1.4. Disposition

Chapter 1 introduces the subject of the study including its argument and objectives; together with a brief procedure of the study and disposition of the subject matter.

Chapter 2 includes the survey of literature and presents information on the construction industry and its characteristics, lean thinking and lean principles, lean construction tools and techniques and barriers to the application of lean construction principles.

In Chapter 3, the material and method of the study is presented.

Chapter 4, includes the results, evaluation and discussion of the data obtained from the questionnaire; and

Finally, Chapter 5 presents the conclusion derived from this study and recommendations for removing the barriers.

CHAPTER 2

LITERATURE REVIEW

In this chapter are presented a survey of literature about lean construction; their historical development, various definitions about them together with specific obstacles to applying lean construction.

2.1 The Construction Industry

The construction industry is set apart from traditional manufacturing by specific characteristics. Despite being important, these factors may be the reason for not executing production philosophy in construction (Koskela. 1992).

Four aspects of construction are listed by (Koskela, 1992) which are being mentioned as follows:

1. One-of-a-kind nature of projects
2. Site production
3. Temporary multi-organization
4. Regulatory intervention

Also, some other factors are classified by Koskela that are unique to this industry like costliness, durability, complexity, and uncertainty. Below, the factors identified by Koskela will be discussed.

Paez et al., (2005) define the typical construction production by building the final product on the site that it will stand. Each site is unique because of having its characteristics and in the result, site production leads to one of a kind production. The diversity of priorities and requirements that customer and designers also seek to affect the on of kind production (Warszawski, 1990). Nevertheless, the components, material, needed to complete the project are similar to each other. It is clear that from the perspective of practitioners the procedures are being considered as the same. These manners are not visible to outsiders but designers and contractors. (Koskela 1992). Fragmentation in the construction industry brings the third factor into the field. A construction project is based on fragmented efforts from different sectors (Koskela, 1992).

It is a fact that a provisional organization on a construction project consist of the variety of companies and also different people. Moreover, the probability of not having worked together before, for these firms and people, is high. Through various contractual adjustments, they may be attached to project. Manpower also may be increased by this provisional organization due to interacting or overlapping activities engaged by various contractors that make it challenging to keep on timetables (Paez, Salem, Solomon, & Genaidy, 2005).

(Koskela,1992) Regulatory intervention is the last factor classified by Koskela in the construction characteristics. Complexity of projects within risks involved in the site and projects need to be check ratified. This permanent checking and approval are executed by contractors and essentially by regulatory authorities to make sure the project satisfy regulations and standards.

2.1.1 Construction Industry in developing countries

There are two main sectors of construction industry in Iran; construction projects funded by the government and housing industry. In recent years, construction companies are growing rapidly because of the expansion in the investment, both nationally and internationally in way that they are counted as the biggest construction firms in the Middle East. According to data published by central bank of Iran, 70 percent of Iranian residents have their own houses and very huge amount of money found its way toward house brokering market. Moreover, demand growth rate for new houses is 750 thousand units per year mainly derived from the youngsters' requirements who get married and start their own lives in separate homes from their parents. Therefore, the current 2000 units which are built every day, is not enough and needs to be increase to 2740 units per day to meet the fast growing demand of the country. Iran's construction market value will be almost doubled to $154.4 billion by 2016 from the current level of 88.7 billion (2013).

For more than decade after the Islamic Revolution, land acquisition was one of the most important challenges the country faced. In this period, Tehran' area doubled in two years while Ahwaz became tripled in size from 23 to 75 square kilometers (9 to 29 sq mi), but only 10 percent of the development happened on the private land and the rest was acquired from the public areas. The Urban Land Organization and Housing Foundation was responsible to transfer the properties.

Two factors have changed Iran's urban geography over these years, privatization of public lands and lack of enforceable regulations. In three years from 1979 to 1982, 75 percent of the new construction in Tehran happened outside the defined city limits, transforming satellite villages to the extended suburbs. As per the Housing Ministry survey half of the whole residential buildings in the country were built after the Islamic revolution where by 1986, the urban housing capitalization were almost doubled. However, while the government was transferring the title of public lands to the private sector, its share in the housing construction investment was less than 2 percent from the whole investment occurred after the Islamic revolution and the 2.3 million new

units were built by the private sector. [9] After the sky rocketing growth in the Iranian real estate market started from 2004, the activity in the market decreased sharply in early 2008. In 2009, the construction investment in the country hit the record low in over 8 years. However, the market has experienced a moderate recovery from 2010.

Construction difficulties

Construction sector in Iran has experienced a few challenging years, not only because of the recession that hit the economy but also due to the increase in the construction cost. The unfair sanctions against the country from one side and the removal of the energy subsidies from the other side made the construction material more expensive and more difficult to find. Devaluation of Rial, largely affected the property market which is a very common investment area for the Iranians, significantly affected by. The unsuccessful social housing program also negatively affected the property market as the huge amount of money invested in the program could have been absorbed by more efficient housing investments.

However, over the past five years the construction portion in GDP remained the same at about 9 percent, where in 1392 (2013-14) the contribution was 863,908 billion Rilas, almost USD 35 billion. But this sector reduced in real terms as the GDP decreased. As per the World Bank report, by the decline in construction material importation and the investment reduction, construction productivity declined by 3.6 and 3.1 percent in 2012 and 2013 respectively.

Removal of the unjust sanctions, which will increase the revenues by releasing the frozen assets and increasing crude oil production, is good news for the construction. “Technology transfer and better financing terms are both easier to access after the removal of sanctions, so it is good news for the construction sector.” Said Dr. Khajepour. He, the Managing Director of Atieh International, a consulting firm based in Austria, has talked to me prior to the lifting of the sanctions. His firm has the

experience in advising Iranian Investors for more than 20 years. “When sanctions are removed, Iranian banks will enjoy a better access to the international banking systems and funds, and could provide Iranian construction firms with much better financing facilities” he added.

While the investment in public infrastructure is done mainly by the government, the small private companies dominating the real estate sector are expected to be more active.” At this point of time, we will see increasing investment activity in building new residential units as there is a common feeling that by lifting of the sanctions the access to construction material will be easier at lower prices which will ultimately cause demand growth. There will be non-residential Iranian going back home as well as international companies finding Iran as an investment opportunity.”

Housing shortage

Residential sector has experienced volatility in the past ten years and supply and demand are still not at equilibrium point where the residential units are estimated to be short of about 1.3 million units. President Ahmadinejad administration tried to address this problem by investing in Mehr social housing program. The program started in 2007 was aiming to build 2 million new residential units for the low income families over a period of five years, such a big plan that made the private investors to step away from investing for the low incomes. In this scheme the government gives the land to developers and a state bank specialized in housing investments, Bank Maskan, provides the developers with the required financing. Buyers must deposit 100 million Rials, and then Bank Maskan will pay the contractors to build the units. By completing the construction, property and debt are transferred to the buyer who has to pay back the loan as well as a monthly rental fee of the land lease to the government for a period of 99 years. Khajepour says “At the beginning, less fortunate people in need of housing started to invest in the program; some have invested all their savings. They expected the government to deliver it but gradually there were news that the units will be completed later than expectations if ever or the quality of the buildings is not good enough, so a lot of people stepped away”

This programme faced many financial obstacles. The required credit lines and other financings by Bank Maskan which were supposed to be provided by Central bank of Iran has almost tripled over a period of three years from 50 trillion Rilas (USD 5.1 Billion) in 2008 to 150 trillion Rials (USD 14.5 Billion) in 2010. The sharp increase continued to 450 trillion Rials (USD 36.6 billion) by 2012 as removing the electricity subsidies caused the construction costs to rise sharply. Based on IMF data, 40 percent of Iran's base money was absorbed by the housing bank.

Mehr scheme can provide many valuable lessons for future programs which must be developed to meet the residential demand. "Mass production was a necessary good idea" said Mohammad Mahdi Banaei , a specialist in system dynamics and public policy at the Isfahan University of Technology who has written several papers about this program. "In hurry, you may forget to consider all aspects deeply, as happened in Mehr Scheme" he added.

Future opportunity

While government struggles with housing programs for low income families, private sector will invest in the more attractive construction sector like high rise buildings, hotels and hospitality related developments. It is understood that international hotels are already exploring the investment opportunities in major cities.

such developments also notice larger development companies join the market, which has been controlled by smaller investors traditionally. Khajehpour mentions this is not related to the size of development but related to new energy efficiency requirements. "Since energy and fuel subsidies were partially lifted, there is a focus on energy efficiency. There are hundreds of new regulations on what materials you have to use, what windows you have to use, what kind of energy efficiency standards have to be observed in larger cities. Urban construction projects have become too complex for

the average small scale investor and that is why I see the necessity to move towards larger companies," he says.

2.2 Deficiencies in Traditional Project Management system

Special consideration is expressed by Koskela and Howell(2000) for their prior study to interduce new methods of construction management. They believed that their study is not feasible and needs to be improved to keep pace with the complexity and risk of the projects. In the next paragraph, explanation of traditional management procedure will be presented then, drawbacks of this strategy will be shown

"Project Management is the application of knowledge skills tools, and techniques to project activities to meet or exceed stakeholder needs and expectations from a project. Meeting or exceeding stakeholder needs and expectations invariably involves balancing competing demands among:

• Scope, time, cost and quality

• Stakeholders with differing needs and expectations

• Identified requirements (needs) and unidentified requirements (expectations)"

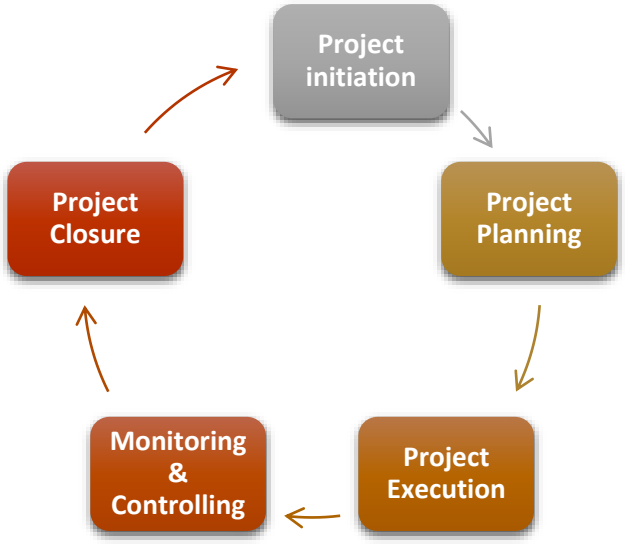


Figure 2.1: Project Management Life Cycle (Pmi, 2008)

The Project Management Body of Knowledge (PMBOK) supplies the required guidance for the typical project life cycle. The phases of the project life cycle as introduced in the PMBOK are as follows:

1) Initiation Process

2) Planning Process

3) Execution Process

4) Monitoring & Controlling Process

5) Closing process

It was described by Howell (2000) that insufficiencies are the result of false hypotheses and ideas in the current project management. The hypotheses include various inadequate understandings; e.g., the clear relationship between activities guaranteed results of managing activity criteria. Morris explained the principles of project management as a method of implementing the pattern of change in production applied earlier in manufacturing (Howell and Koskela, 2000).

General flaws are being mentioned briefly as follows: other features in production can make the outcome important, the efficiency of resource usage and customer requirements are satisfied in the safest way desirable (Howell,2000). It was discussed that the progress in the contemporary method of management is possible to be attained by implementing the production management method involving not only the transformation but the management of workflow and value creating method also. Therefore, lean philosophy and systems were arranged to be employed in construction (Howell, 2000).

According to Koskela and Howel (2002) believe that application of the theory of traditional construction management is antiqued therefore reformation of this theory is necessary. They addressed the defects occurred as the consequences of the traditional techniques defects such as:

The main purposes of project management have not been executed properly. Its techniques do not work in a satisfying fashion. A manageable and gradual projects that are small can resolve the theory- associated difficulties without extensive fines. Nevertheless in complicated, big, and fast projects, project management is clearly non-productive. This approach creates difficulties which severely threaten execution.“ (Howell, 2000).

2.3. The Concept of Waste

Wastes usually arise as a consequence of inadequately maintained operations and methods which cause extreme time and expense. Toyota classified important species of waste in production, Liker (2004) also decided to add an extra body of waste, the particularly unused creativity of the people who are engaged in the business. It might be assumed that a tiny loss is not necessary, however, those waste will be piled up in the and cause a substantial inefficiency. People often come to know lean with the

buzzword waste or muda. However, the exclusive focus on the elimination of waste can damage the creativity of people also.

Furthermore, the activities have to be classified when a process is being analyzed for the purpose of detecting and eliminating waste. Monden (1993) recognized three separate kinds of processes in a regional manufacturing context.

The actions are mentioned as follows:

1. Value Adding (VA)

2. Non-value Adding (NVA)

The level of waste, which is attached to inefficiencies of plan, mobilization, construction and preservation actions and is closely related to the building plans, was listed to be equal to 50 percent (O'Connor 2013).

Sacks (2010) describes the aim of lean construction as waste minimization. The difficulty in waste minimization directs the procedure of recognizing waste in projects which are related to the construction industry. Waste removal is about to initiate at the design platform. Types of wastes should be identified to discharge the waste in the building manner. Eight types of waste are commonly agreed upon (Terry & Smith, 2011):

- Transportation
- Inventory
- Motion
- Waiting
- Over-Production
- Over-Processing
- Defects

Different kinds of waste which have been noted before, can be minimized or defeated by some proper techniques. Examples of these tools include: 5S, and Just in time, however, transparency plays an important role to that the reduction of waste would happen and as visualization would help to minimize instabilities. The waste generation results from both the execution (material waste, productivity) and the flow of information and documentation, in the construction industry.

According to (Josephson& Saukkoriipi, 2005), many participants in the industry or those who are attached to the industry admit that it is possible to reduce construction costs. However, they oppose on which costs should be prioritized. It has not been many efforts to focus on construction processes nor to try to perform them more effective by diminishing waste. Sakorupi argue that industry is affected by waste that is evident in the industry

2.4. The Concept of Lean

the philosophy of lean was created in manufacturing environment. it was first introduced by Krafcik (1988) and later in 1990 Womack; Jones & Roos. Womack, Jones & Roos (1990) gave a detailed description of Lean Production as a method that mingles the advantages of craft production and mass production, such as avoiding the high costs of craft production and preventing the rigidity of mass production. The main idea of lean production was developed by Engineer Ohno for Toyota. Toyota is known as the establisher (TPS) (Shingo, 1989). Ohno was determined to eliminate waste The research team who were working on international auto production create the term lean to display both the waste minimization nature of the Toyota production system and to compare it with craft and mass forms of production. (Womck et al. 1991). He focused on entire production scheme rather than craft production on worker productivity and mass production on the machine. Henry Ford inspired him in the development of flow based production management. Perception of Ford was about demanding a standard product however Ohno wanted to build cars to customer order. “He produced a

manageable set of goals for the design of the production system: Produce the car to the demands of a particular customer, deliver it immediately, and keep no inventories or intermediate stores." Definition of waste is defined by the performances criteria for a production system. Failure to meet the unique requirements of the client is waste, as is time beyond instant and inventory standing idle (Howell, 1999). He realized that there was a waste in every line of the production system. He understood keeping each machine running at maximum production rate causes extensive intermediate waste. Japan does not have the ability to implement the principles of mass production. Therefore, they created a new method of production which was named as lean production.

Lean production is the third mutation in the production process which follows craft production and mass production. Main characteristic of lean production is using fewer resources (any resource) in comparison to mass production.

Lean as a theory was developed gradually exceeding Lean manufacturing and its development has not been stopped. Hence, the progress of lean has caused a confusion related to what constitutes and not constitutes lean. A model is presented by Hines, Holwe & Rich in 2004 which covers the whole lean concept and in which two levels are recognized: the strategic (Lean Thinking) and the operational (Lean Production). Every organization that provides customer value can utilize the customer-centered strategic thinking, but not the shop floor tools. To understand the whole concept of lean and to be able to implement the right agents and tactics to afford customer value, it is essential to know the distinction between these two levels.

Liker (2004) discovered 14 key principles while doing his research of the TPS, origins that push the methods and devices of the system and the supervision of Toyota. These beliefs include four different sectors that came to be called the four P's of the TPS: (1) Philosophy, (2) Process, (3) People and Partners, and (4) Problem Solving. The philosophy aspect focuses on making management decisions in a long-term perspective even at expenses of short-term financial goals. The Process section is about the elimination of waste and process creation on which the authors have emphasized.

The two last sections, related to personal and organizational development, apply teamwork thinking and put the effort in continuous education and improvements.

2.4.1 Lean Principles and Lean Thinking

According to Howell and Lichting (2008),it is necessary to reform the system of the work to improve the execution of the project is the goal of approaching projects as production systems (Howell and Lichtig 2008). Bu using lean concept optimization of processes are delivered through waste elimination, client satisfaction, and continuous improvement (Enache-Pommer et al. 2010). The efforts of lean construction are concentrated upon the defect prevention (O. Salem et al. 2006). The lean system is fully explained and generalized in the book named as (the machine that changed the world 1990) by Jim Womack and Don Junes. These two engineers then explained the main and substantial principles to fulfill lean thinking in a company.

it is explained by (Womack and Jones, 2003) that lean techniques for reducing waste in organizations. They recognized the absence of strategic structure in altering lean production into different industries and their practice. These five principles include; identifying value from customer aspect, map the value stream, flow in work procedures, and accomplish customer pull and, an attempt for perfection and continuous improvement. These principles are mentioned to as the mandatory path term _lean thinking.

2.4.1.1 Identifying Value

The value can be defined by client's perception. Therefore, it has subjective meaning Because of having a complex and different definitions. According to (Koskela, 2000) value can be described by both utility value and market value. Many researchers in

this sector verify this definition of value. According to Ballard (1998), value comes to exist throughout a procedure of consultation among customer's goals and demands. (Linfors, 2000) believes that value is concerned is service or product that boosts profit, reduce time and expense. Furthermore, it enhances quality for the company and produces the profit. Leinon and Huovila (2000) suggested three separate sets of value; exchange value, use value, and esteem value. Exchange and use values are related to market and business. However, esteem value has a deeper scope that is not only about product-customer perception.

(Womack and Jones,2003) in their book Lean Thinking describe value as an element that alludes to materials, components of a product which are feasible understood and defined. (Emmitt al. 2005) Classifies value in external value and internal value. Any project should meet client value that is defined as external value nevertheless internal value is created by members and participants in the project. (Emmitt al. 2005) Declared that value is the ultimate purpose in all of the construction projects. Moreover, hence, the review and arbitration of value characteristic are necessary to the success of enhanced productivity and client/user satisfaction.

2.4.1.2 Value Stream Mapping

Next principle in lean philosophy is mapping the value stream. Every stage to generate and deliver a product to the client is identified by value stream. (Womack and Jones 1996). It is crucial to map the current situation to understand this principle. Therefore, having a whole perception about this factor is required to apply lean philosophy. Furthermore, value stream map can be a framework of procedures which head to a worthy accomplishment of product and recognizes the variety of courses to increase performances in the construction process. Fewings (2013), explains that, value stream necessitates all the value-adding levels needed to design, build and provide the produce. Value stream mapping frequently applies standard symbols to describe items

and methods, consequently knowledge of these symbols is necessary to evaluate the production system obstacles accurately.

2.4.1.3 Flow

The fundamental process of performing activities perfect and adjust them to improve a product is flow. the definition of flow is reducing the passing period of time from raw material to completed products which results in the best quality, economical price, and quickest dispatch time. The truth lies in the fact that developed flow decreases the "water line", and so exposes the problems. The removal of these problems or wastes are necessary for the creation of flow. It is needed here to refer to the process mapping, which is employed to recognize waste.

Liker (2004) exclaims that it is not always possible to have a continuous flow, but it can be considered as a goal. The achievement of this aim is possible, and there is a great hope for the improvement of this process However, there are two wrong ways often taken by companies: (1) the implement of flow is mistakenly perceived by them while in reality, they set up fake flows, (2) if something goes wrong the attempt to implement flow is stopped with no delay, and they return to how things used to be done (Liker, 2004).

Koskela (1992) his idea on the new production philosophy. These steps indicate how the flow is achieved by minimizing or dismissing waste and obtaining the transformation. They incorporate waste minimization, customer focus, reduced variability, reduced cycle time, increased flexibility, simplification, increased process transparency and continuous improvements. The last step of benchmarking. Mixing strengths with those of the best external organizations can provide with superiority (Camp, 1989). However, benchmarking can also exist to set up goals for the organization. (Eriksson, 2010).

A proper method to estimate flow is to apply of the percentage plan completed (PPC), to understand the amount of the task is accomplished. In other words, to see the relationship of performed activities according to programmed actions, and so to be able to tests the workflow authenticity (Ballard, 1998).

2.4.1.4 Enabling Client to Pull

Pull scheduling plays an important role in lean strategy, as a proper production process. This factor is recognized as critical lean methods to enhance workflow in Construction projects (Thomas et al. 2003).

2.4.1.5 Pursuing perfection

This factor is the most important agent in lean approach since it represents the necessity for the way of working and organizing to address outcomes to enhance a style of life with an original culture. To achieve perfection implies continually considering what is being done, how it is being done and providing the expertise and awareness of all those included in the processes to improve and change it (Womack and Jones, 1996; Dulaimi and Tanamas, 2001). The principle of perfection involves producing precisely what the client wants concerning quality and quantity at the right time at a decent price and with least waste; the real target is zero waste (Bicheno, 2000). Perfection can be accomplished by a constant improvement in reducing all sorts of obstacles and non-value adding tasks along the flow process (Dulaimi and Tanamas 2001).

2.5. Three steps of Lean

It was said by Green (2005) that, lean application attempts are being classified into three distinct stages, with a growing degree of perfection. According to these researchers that first step of lean is to concentrate on waste removal from the technical and operational aspect. Individual workers are nor responsible for obligations and focus. However, managers are tied to these elements. Green and may 2005 stated that step one contains four crucial parts that must be considered. These parts are: cutting out needless expenses, optimizing workflow removal of unnecessary actions and, sharing the benefits from improved performance. However, the most significant component of lean is to minimize waste (Ballard, 2003). Jorgensen and Emmitt (2008), and Mao and Zhang (2008) also declared that effective transportation and stock holding of material, often termed just-in-time (JIT) delivery, is necessary for waste minimization in lean construction. Another perspective of waste minimization is the offsite fabrication of elements and units (Green may 2005). Prefabrication has many benefits similar to manufacturing industries, such as decreasing material waste, decreasing building duration, enhancing work atmosphere. Hence, enhanced prefabrication makes lean construction more alike to lean production in manufacturing industries.

Green (2005) declared that phase 2 concentrates on reducing antagonistic connections plus improving collaborative connections and executing the task together between supply chain participants. The required elements are participation, solid accommodations, and etc. The workshops and coordinator function play an important role as to enhance the healthy connection between the project associates which improves combination and coordination in return (Fang, 2005). the continuous enhancement will also be the result of Information sharing and joint learning. Hence, the perception of lean theory by projects associates must be grown (Green, 2005). This can be promoted by appropriate education in educational environments where project partners engage regularly in communicating information and experience plus together propose thoughts for the most apparent difficulties in the workplace (Salem et al., 2006). Perspectives linked to the second phase, are restricted bid invitation, soft

parameters, long-term agreements, collaborative agents, and extensive partnering unit. phase two does not perform away from the idea of associating as this phase is about reducing waste obtained from sub-optimizations and adversarial relationships through increased integration and collaboration. Hence, enhanced prefabrication causes LC more alike to LP in manufacturing industries.

Stage 3, according to Green and May (2005), is the most complicated because it requires a fundamental revision in project governance. Its vital sectors are information technology, pre-fabrication, Last Planner, bottom-up activities and emphasis on individuals, a rethink of design and construction, decreased competitive forces, long-term contracts, training at all staff levels, and Systems Perspective of both processes and the product. Aspects related to lean Stage 3 are joint IT tools, pre-fabrication, Last planner, self-control, concurrent engineering, limited bid invitation, soft parameters, long-term contracts, special interest groups, training, suggestions from workers, logical procurement decisions, large-scale contracts, and correctly balanced goals. Only when striving to achieve Stage 3 is a revolutionary change from other kinds of project governance needed (Eriksson, 2010).

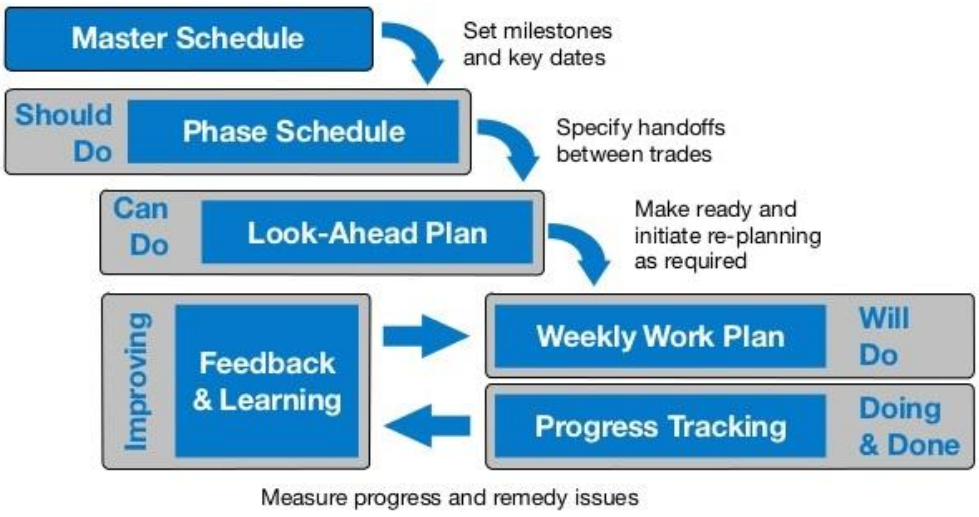
2.6. Lean Construction Tools and Techniques

Many methods can be found in a firm that are being able to be implemented inside a corporation. These agents and techniques involve 5S, visual management, value stream, constant development exercises. The lean strategy approval inside the business has possible importance regarding productivity, service delivery and quality that finally happens in important expense profits. (Salem et al. 2005) carried out a research to evaluate the performance of some lean methods. The following is a summary about some of the lean accessories and methods. Several techniques in Lean philosophy can be implemented to enhance the quality of the construction industry. Some of these techniques are being explained as follow:

2.6.1 Last Planner System

(LPS) is a method which creates workflow directs project variabilities in construction. LPS became control method which aims to highlight connections among scheduling and production control in order to enhance the stream of supplies. This system is responsible for developments in operational sectors and, tries to simplify increased workflow, and production unit control (Ballard 2000). the flows needed for the combination of the corporation to permit construction transformation to flow are information , materials, and safe operating atmosphere. LPA runs every issue by creating connections, producing communications, and also ensuring responsibilities to performance (Mossman 2008). Ballard and Howell (1994), explain the application of Lean-based accessories related to the Last Planner reduces setback rates.

according to Ballard (1997), the goal of last planner method is to enhance productivity by defeating obstacles to workflow. The most iportant advantge of this technique is to bring the realistic pllaning rather than idealistic planning



2.6.2 Visual Management

(O. Salem et al. 2006) believes that With the intention of evading any uncertainty in the information, visualization is important in the construction process. With the help of visualization, identifying the work flow on the construction site will be much easier. The lean approach is being able to be supported by this technique if it adapts in the construction process properly. This method involves pointing the practice achievement situation of the prior actions, the availability of elements, every modification in the plan and the positions of other supplies (Sacks, Treckmann and Rozenfeld 2009). These Figures display some visualization techniques.

Figure 2.2: Site information center for all participants to reach important project data (Swain 2013)

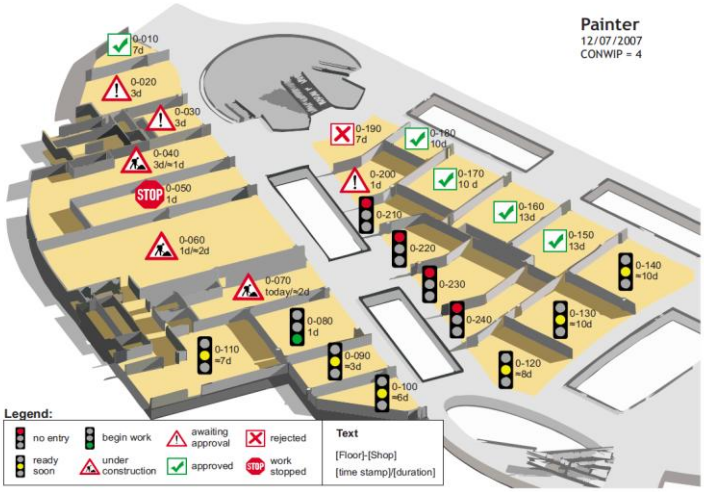


Figure 2.3: Proposed 3D visualization for past, present and future work status for a trade (Sacks, Treckmann and Rozenfeld 2009)

2.6.3 First Run Studies

First run studies is a technique that is to redesign significant tasks and involve fertility considerations and analysis operation processes by replanning and streamlining the various roles associated. According to (Abdelhamid and Salem, 2005) using photos, video files or graphics is accepted by first run studies because they can be helpful to show the procedure or explain the work instructions. The first run of a chosen task should be reviewed in detail, causing opinions and opinions to investigate alternative techniques for performing the task. A PDCA cycle (Plan, do, check, act) is proposed to improve the study (Forbes and Ahmed 2011).

Plan: this step points out to choose work mechanism to bring together.Team members, investigate process step, innovative ideas to how to reduce steps and control for quality and fertility

Do: refers to examine new ideas on the first run.

Check: includes explaining and measuring procedures.

Act: indicates to reassemble the crew, and demonstrate the enhanced practice and achievement as the standard to satisfy. This tool looks like to mixture of the lean manufacturing technique, graphic work guidances, and the conventional production method, time and movement research

2.6.4. Five S

this method was originally founded in factories to recognize housework in facilities. it means that any reference that does not offer to a good act will be considered as waste which will be taken out from the system. (O. Salem, et al., 2006). this technique consist of five phase: sort, straighten, standardize, shine, and sustain.in the sites which a construction project is being undertaken this technique helps to provide a clear environment and in result a better workflow

Figure 2.4: 5S approach (the left picture store before 5S & the left picture after 5S) (O'Connor and Swain 2013)

This mechanism is alike to the 5S housekeeping system from lean manufacturing (Salem 2005). The body layout is practiced for the hastening of 5S application the construction site. The advantages from the application of 5S involve enhanced safety, productivity, quality, and set-up-times enhancement, the creation of space, decreased lead times, cycle times, increased machine uptime, improved morale, teamwork, and constant growth (kaizen activities).

2.6.5 Concurrent Engineering

According to (Rolstadås, 1995) concurrent engineering is defined as the same accomplishment of different developing assignments in integrative teams with the purpose of achieving optimal results on functionality, quality, and productivity. This technique operates ahead graphs, tables, and algorithms. It requires an interdisciplinary team attempt where information sharing and communication are essential to recognize opinions (Kamara, 2003). (Gil et al., 2000) Believes that engagement of all participants in early design is the key factor for accomplishing lean product technique. Hence, connection with the client should not be neglected as the customer may simplify concurrent engineering purposes that decrease the project ‘s expense. Partnering with subcontractors and suppliers can also affect the result of concurrent engineering attempts.

2.6.6 Value Stream Mapping

Womack and Jones (1996)believe that value stream is the collection of particular activities, expected for producing a particular good within three essential control assignments of any industry. First one is a problem-solving task that is to operate from concept through specific design. The second one is engineering to production launch.

The last one is the information management task that is to proceed from raw elements and elements to a completed output in the customer's hand.

Paez listed the effective methods employed in lean construction into three levels. various stages are explained here, also organization is reviewed in Table 2.1.

1. Level One: Direct application of the techniques from lean manufacturing.

2. Level Two: Modification of the techniques taken from lean manufacturing.

3. Level Three: The all-in-all lean construction specific techniques.

Table 2.1: Three levels of lean construction

Levels	Lean Construction Technique	Related Lean Manufacturing Technique
Level One	- Material Kanban Cards	- Kanban System
Level Two	- Visual Inspection - Quality Management Tools - Concurrent Engineering	- Visual Inspection (Poka Yoke Devices) - Multifunctional Layout - T.Q.M - Standard Operations -Single Minute Exchange of Dies (S.M.E.D.)
Level Three	- Last Planner - Plan Conditions of Work Environment (P.C.W.E.) - Daily Huddle Meetings	- Kanban System - Production Leveling - Toyota Verification of Assembly Line (T.V.A.L.)

2.7. Advantages of lean construction

Implementation and penetration related to lean thinking within construction industry reform the approach of traditional construction management. Koskela (1992) proposed the foundation of how it is possible to apply lean building conditions with the goal of reaching the same advantages as obtained in the automotive industry in 1992. He studied and examined the principles of lean manufacturing concerning its fundamental components and its conceptual background. Koskela defines construction as a manufacturing process. Furthermore, he declares that difficulties that experts would have in approving the strategy is recognized. Koskela classifies courses of lean production as follows:

- A production system that performs efficient and could eliminate waste
- A general management philosophy
- A collection of devices to constantly enhance quality

construction production should be considered as process flow rather than transformation of activities. Elimination of Non- value adding activities such as waiting, examination of elements is some of the advantages of implementing process flow perspective. The conception of lean production is defined as; rearrangement of the workforce to promote and simplify new working procedures and fundamental cultural shifts that are needed inside the corporation and individuals for achieving lean production fundamental. Hence, it becomes crucial for a corporation to choose Lean theory to study how it can reach to the most proper organizational framework that this system can work on it. Likewise, it seems essential for a corporation to modify living methods for satisfying its unique conditions or from other tools and methods to sustain its new running and management structures. It should be noted that the instruments and techniques are evolved to help the remaining two factors as discussed beforehand. Some advantages of Lean techniques are being mentioned as follow.

- Construction supply chain
- On-Site Subcontractor Evaluation
- Finishing Trades in buildings
- Construction Submittals
- Improving labor workflow in construction
- Formwork Engineering:
- Construction projects (Structure and Finishes)
- Precast concrete fabrication
- Infrastructure projects

2.8 Differences between traditional project management and lean construction

Currently, the process of planning of construction Projects is carried out by breaking project stream to activities. Time, cost and resources are estimated then every one of

these items is allocated to each activity. Afterward with the use of CPM method, the Logical sequence of activities is determined various part of work thus will be handed out by outsourcing or the working group itself will do it internally.

By using scheduling programs, Project managers set the start time and with the use of pressure, they begin activities at the earliest start time. Activities are monitored and evaluated by project control. If any deviation is observed, Control unit comes to operate to correct it. This unit also identifies whether each activity matches to the two primary objectives (total estimated project cost and time scheduling) or not.

Why this approach that seems logical, often fails and the time and cost of projects rise beyond from initial anticipations?

From the perspective of Lean construction, the common practice in project management is based on the wrong model because the current project management tries to manage projects according to central scheduling program and control relies on the output criteria

In this type of management, workflow and value-adding for the customer have been ignored. In fact, activities that are non-adding-value" have been omitted during applying value- adding activities in the project, thus handling all related activities is impossible.

Nowadays, the process of construction projects is transforming into the variability, complexity and rapid progressing. The complexity and variability of projects are due to the needs of the client (employer), market and technology. Pressure to speed up the project will also increase the overhead expenses. In this dynamic environment, a chain of activities (assumed to critical path method) are linked together rarely. This type of scheduling program specifies the project by applying activities and ignores the workflow between activities. Reliable practice and transferring activities between working groups are also assumed and omitted.

In general Project control is about to monitor actual performance, compared to the schedule and identifying deviations from the plan for making the right decisions. (Banki 2007). In fact, by looking at the past, you decide for future (Orumchi 2009). The role of project control in leaning processes is to prepare activities for implementation into a systematic process that is carried out through a clear commitment by those who are responsible for the site. In traditional systems, the foundation is defined by performing an activity or a project whereas the definition of value, waste reduction, is ignored. From lean construction perspective, applying an activity is tracking its three goals that are execution (traditional), value stream (speeding up and reducing waste) and the following perfection.

Lean Construction is a different strategy because it consists of precise collection of purposes, and is directed at maximizing achievement for the client at the project stages, designs all at once outcome and method, also affects production control during the life of the product from conception to offering (Howell, 1999). researchers assume that the most important goal of LC is to eliminate waste, described in non-value adding actions, and enhancing the effectiveness of value-adding actions.

Nevertheless, Koskela (1992), believes that this concept involves: practice of just in time (JIT), use of pull-driven scheduling, decrease of variability in labor productivity, advancement of flow reliability, elimination of waste, simplification of the operation, and implementation of benchmarking.

(Mossman, 2009) believes that Confirmation of the application of lean concept has proved that there are numerous advantages to be produced from implementing lean beliefs to construction. These advantages claimed include: increased productivity, enhanced reliability, increased quality, more customer comfort, enhanced predictability, reduced agendas, fewer waste, lessened expense, improved buildability advances to design, and increased safety

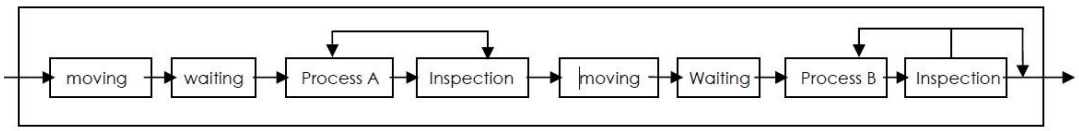


Figure2.5: Production as a Process: Simplistic Illustration (Koskela, 1992)

LC is also defined as a concept that incorporates several other concepts from the construction management industry such as Total Quality Management (TQM), Last Planner System (LPS), Business Process Re-engineering (BPR), Concurrent Engineering (CE), Product Circles (PCs) and Team and Value Based Management (Alinaitwe, 2009). Most of the above concepts illustrated in Figure 2.7 are interrelated, and all aim to improve performance while minimizing waste (Alinaitwe, 2009)

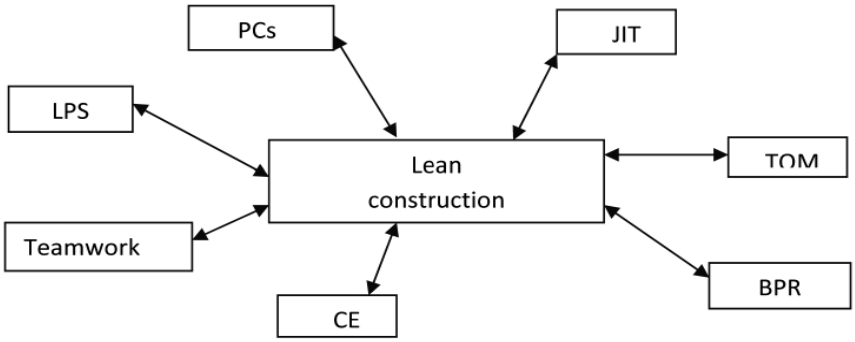


Figure 2.6: lean construction tools and techniques

Table 2.2: Differences between the traditional approach and the Lean approach (H. G. Ballard 2000, Sicat 2012, G. Ballard, 2000, Howell, 1999)

Activity	Traditional PM Approach	Lean Construction Approach
Control	Project control represented in monitoring the performance (schedule and cost) and take corrective actions after detecting negative variances (H. G. Ballard 2000).	The role of project control is to assure reliable workflow by measuring and improving the system Performance (Sicat 2012)
Performance	In the traditional approach, all the efforts of the management are concentrated on optimizing each activity separately, thus, reducing overall performance (Sicat 2012)	The main target is maximizing value with minimum waste at the project level to assure reliable workflow (Sicat 2012) (G. Ballard, Lean Project Delivery System 2000).
Value	Considering less cost as value. Also, the customer has to define all his requirements at the outset of the project regardless the change in markets and the new technologies (Sicat 2012).	The project is managed as a value generating process where the customer satisfaction is created and developed over the course of the project (G. A. Howell, What is Lean Construction 1999).
Work techniques	Push-driven schedules are used to release information and material (Sicat 2012). (e.g. material is ordered to a pre-determined schedule to arrive on site before the work is carried out. If the stock is not used, the supplier continues to deliver to schedule.)	Pull-driven schedules control the information and material flow (H. G. Ballard 2000). etc. The team works backwards (pulls) from the end date to the start of the phase to identify the activities necessary to reach the "end" target. (building only what is needed, when it is needed, with no waste in the process)
Centralization	Decision making is centralized through one manger in sometimes.	Decision making through transparency by getting project participants involved in the production control system and empowering them to take action (Sicat 2012) (H. G. Ballard 2000).
Under loading	PMI does not consider adjustments	Production unit capacity is adjusted as well as inventory to be able to absorb variation (H. G. Ballard 2000) .
Variations	Variation's mitigation and management is not considered	Attempts to mitigate variation in respect of end product quality and work rate (H. G. Ballard 2000)
Collaboration	Such policy is not applied in the traditional methods	LC gives continuing support to suppliers by developing new commercial contracts which gave the suppliers incentives for reliable work flow and for participating in the overall product improvement (G. A. Howell, What is Lean Construction 1999).
Transparency	Transparency methods are not considered in traditional management methods.	Increasing transparency between all the project's stakeholders to allow people make decisions reducing the need of central management (G. A. Howell, What is Lean Construction 1999).
Continuous Improvement	Traditional method does not consider continuous improvement so much.	LC considers continuous improvement in the process and workflow (G. A. Howell, What is Lean Construction 1999).
Interactions and dependencies		Managing the combined effect of dependence and variation on activities is important as it affects the time and cost of any project (G. A. Howell, What is Lean Construction 1999).

2.9 Barriers to implementation of lean construction

(Salem 2006) explains that Lean thinking theory was rejected by construction industry because people working in this sector believe that the construction projects are unique. according to Egan (1998) this industry involves many duplicated rules. Egan believes that considering the construction as unique process prevents learning new lessons or investigating new attempts. Moreover, according to (Koskela, 2000) hindrances are only provisional. They can decrease the dispersion however they cannot prevent it. Lean concept demonstrates that it is possible to recognize the wasteful actions in the manners and to earn grants for them. This leads to a satisfying perception of such processes and an improvement in the overall performance.

Several researches were executed around the globe to recognize the obstacles in application of the lean construction. few research's concentrated on examining obstacles which restrict the dissemination and application of lean construction (Abdullah 2009). However, others concentrated on recognizing obstacles which point when the accomplishment of lean construction methods. These obstacles have a negative influence on project performances furthermore could affect the application process of lean construction if not properly managed. if the agents that influence the successful application of LC, could not being understood, companies won't be able to understand what exercises should be made to improve the process

Thirty-one barriers were classified as obstacles to the successful implementation of lean construction by construction firms in Uganda by Alinaitwe (2009). The author notes ten obstacles which are supposed to be defeated comfortably. These restrictions can be named as: lack of keeping items in the right places, lacking buildable designs, lacking a participative management technique for the workforce, not having compatible management leadership, not using standard elements, lacking communication inside teams, lacking constant work commitment, no understanding of the needs of customers, lacking project team skill and not having a well-defined focus for the team. Alinaitwe (2009) emphasized that one of the main barriers under technical aspects is the lack of buildable designs. For sure, the production process and

provision of benchmarks were also contributed as the main barriers to implementation of LC.

On the other hand, Tindiwensi (2006) discovered that most of the architectural designs were deprived of constructability elements which were the result of the limited knowledge about construction practices. Moreover, the separation of design from construction opened the way to a breakdown of the production process during construction. This would influence the implementation of LC specifically to the workers' productivity. So, all stakeholders should take part in the process from the pre-construction stage and carefully consider the build ability and constructability of design and process. Such a conduct throughout the production process would prevent the disturbing transformations on designs during the construction stage.

Howell (1999) aso expressed that especially during the physical implementation phase, human approach is one of the primary aspects that slowed down the execution of LC in the industry. According to Kim and Park (2006), the success of implementing LC concept was actually very much affected by the sensitive factor of the stakeholders' reaction in relation to a construction project towards the LC concept. Abdullah et al. (2009) further described that a stakeholder's success in implementing LC totally depends on this reaction; in other words, the stakeholder should be endowed with a kind of tendency regarding the intent, commitment, and cooperation. Their performance of work and the productivity of a construction project is thus determinable through this sort of thinking.

Moreover, the dull application period of LC manner was considered as the difficulties in performing lean construction. Kim (2006), found out during their research that the implementation of LC in construction projects had caused so many meetings and information necessary for discussions. Also, these meetings could have been time wasting if poorly managed and also had to be held in a regular way. This takes place especially during the pre-construction stage, but a well-managed meeting will certainly generate profit and positive effects to the construction company itself especially on boost up their reputation.

According to (Forbes and Ahmed 2004) also these barriers refer to an attitude, roles, relationships, actions and communications among the respective parties involved in the construction industry such as the contractors, sub-contractors as well as the client/owner. Additionally, (Abdullah, 2009) classifies various hindrances that are cable of interfering with the implementation of lean concepts. These hindrances are mentioned as follow:

- Absence of attentiveness and responsibility from top management
- Challenges in realizing the theory of lean construction
- Lack of exposure to the need to use the lean construction concept
- Lack of proper education
- Weak connection between clients, consultants and contractors
- The tendency of construction firms to implement traditional management theories as opposed to productivity and quality management concepts.
- Attitude and ability to work in group (teamwork.)
- Extended implementation period of lean concept in construction processes.

(Sarhan, S., and Fox, 2013) Classifies barriers into ten different categories, based on previous literature reviews linking to obstacles to applying lean construction approach. this researchers work will explain these factors briefly.

2.9.1 Fragmentation and subcontracting

Participants of a project will feel less inclined to work and learn together to reach a common goal if there is fragmentation and subcontracting. Each of the participants will have their own background and approach, but share the goal of strongly finishing the project. Hence, establishment a clear path of communication between all of the

parties is essential. Weak connection causes a harmful influence on the entire project, preventing effective synergy in the application of LC concepts. (Abdullah 2009)

2.9.2 Procurement and contracts

Traditional acquisition methods and contracts may establish relationships between the players involved in the project that are not conducive to success, subverting the implementation of lean principles (Mossman, 2009) and adding unnecessary protocols and impeding progress. Antagonistic relationships result when contract forms enable one party to dominate another. Transaction costs established by these combative relationships are wasteful and in contrast to lean philosophy. (Abdullah 2009)

In addition, when the implementation framework delegates external design contactors to do the work, this prevents inclusive participation by all involved in the project and detaches the design phase from the construction method, thereby precluding the lean purpose of continuous cooperation and combination. In order to successfully advance LC, it is essential to create a cooperative environment emphasizing a direct link between the design process and construction. (Abdullah 2009)

2.9.3 Culture and human attitudinal issues

A creative, synergistic approach is essential to correctly apply lean thinking principles to the construction industry, removing ‘waste’, creating a ‘continuous flow’ and improving the value of the end product for the customer. A fundamental realignment of traditions and behavior is essential if a country wants to radically enhance and take advantage of lean construction benefits. Research performed by (Common 2000) Abdullah (2009) and Mossman (2009), identified ambivalence, lack of teamwork, absence of self-evaluation, a secretive attitude and anemic lines of communication

among parties involved in the construction process. They found cultural biases hampered the ability adopt a comprehensive framework in choosing competent subcontractors and workers. These many potent biases included reticence to take risks, mistaken attitudes regarding advancing positive realignment, neglecting continuous monitoring, an uncooperative, adversarial attitude between professionals, overenthusiastic zealots, excessive dependency, lack of incentives and inducement, lack of allegiance, contractual quarrels and a fear of failure.

2.9.4 Adherence to traditional management concepts

The preference of construction firms to rely on traditional, non-progressive thinking regarding productivity and management should be considered as one of the main obstacles in successfully implementing LC principles. (Abdullah et al., 2009) Common 2000 reveals that production issues are often only revamped when there is a disaster. For this reason, (Mossman 2000) warns organizations not to wait until there is a crisis before reacting because then it may be too late to learn new approaches and ways of thinking. Abdullah (2000) emphasizes that construction endeavors inclination to remain glued to their current management ideas when they are unaware of better ways to accomplish their intended objectives, will make them disinclined toward change, in spite of the fact these differences will assist increase their bottom line also enhance quality and output standards.

2.9.5 Financial issues

Effective application of lean construction demands sufficient funding to acquire the necessary infrastructure, adequate professional salaries, promotion of reasons and award schemes and investment in training and development programs. Employing a lean specialist to instruct both companies and workers through fundamental revamping

of the entire process will help ensure success. (Bashir et al., 2010) Mossman (2009) has uncovered endemic financial obstacles that must be dealt with carefully: inflation, insufficient project funding, a volatile construction environment, a lack of fundamental social infrastructure to expedite lean adherence, a lack of ownership and inducement, low salaries and a reluctance of some companies to train and adequately equip their employees beyond what is absolutely required.

2.9.6 Lack of top management commitment and support

Senior management plays a crucial role in taking advantage of lean construction and implementing a coherent strategy for success. Higher management should bring to bear adequate time and resources to produce an effective strategy to modernize management and implement new LC concepts. However, studies conducted by (Abdullah, 2009) and (Alinaitwe, 2009) have uncovered top management reluctance to provide real leadership as a fundamental obstacle in promoting lean construction ideals. In contrast, (Mossman, 2009) reported the most serious blockade resides with middle-management, rather than the top echelons of companies. The benefits of LC are not as obvious to middle-management as they are to top management. Besides this, their level of experience and training is often not adequate to enable them make fundamental changes in the way things have traditionally been done. On the other hand, the benefits of implementing lean construction concepts should be abundantly clear to top management. They envision increased productivity, faster delivery and a reduction of potential challenges. (Mossman, 2009) In conclusion, a number of studies have uncovered numerous management linked problems such as inadequate devising, a shortage of employee ownership and regulation which promotes a higher level of workflow, not recognizing the full needs of the customer, a lack of inclusive participation within the workforce, logistic challenges, the absence of visionary planning and weak coordination.

2.9.7 Design/ construction dichotomy

Design and planning are recognized as leading contributors in lean construction strategy. Disregarding the value of these concepts may lead to a considerable loss of time and significant loss of revenue. (Common 2000) Design and its application are often unlinked and treated separately because of traditional ways of doing things. (Banki 2009) This creates friction among two points which leads to deficient or incorrect designs, unnecessary overhaul in design and construction, lack of efficient constructible designs, a significant disconnect between the conceptual design and its implementation and work schedule delays due to late adjustments performed by designers. (Seymour and Rooke,2000) found production considerations were often not considered by the designers whose designs required implementation. There are additional challenges which need to be addressed such as how sustained quality can be guaranteed. While some consider reaching the goal to be good relationships and coordination, others focus on strict adherence to specifications and codes. (Shammas – Toma et al., 1998)

2.9.8 Lack of adequate lean awareness/ understanding

"Manufacturing lean thinking concepts are being adapted to the construction industry. (Eriksson, 2009) Hence, numerous Lean construction opinions are related directly to lean manufacturing. There is disagreement about how lean techniques should be applied to Lean construction. (Green, 1999)) Some lean production models need to be altered and adapted because they may not be equally applicable in construction. (Eriksson, 2009) Abdullah et al,. (2009) recommends that lean manufacturing concepts need to be fully understood first, in order to have a broad overview of the philosophy behind LC. The Built & Human Environment Review, Volume 6, 20138. Moreover, many studies highlighted the absence of introduction to the necessity of adopting LC and the difficulties in identifying its framework of concepts as significant obstacles to successfully implementing lean construction. it maybe because the lack of a

comprehensive shared and accepted interpretation of lean concepts. (Abdullah et al., 2002) believed interpretation and comprehension would best be developed by evaluating its core elements, such as partnering, as an example of innovative management practices. Additionally, LC established the application of new tools for the construction industry that has clear differences in comparison to those used in traditional practices. As Abdullah et al. (2009) noted, these differences must be considered in order to optimally take advantage of these tools. Several researchers currently believe that lean is more important than tools or techniques; instead, requiring an alternation of thinking, cooperation, flexibility, commitment, discipline, and a broad system-wide refocus (Rooke et al., 2007; Mossman, 2009; Terry & Smith, 2011)". Lean implementation should stretch across the business and value chain in order to be able to fully realize the promised consequences; any segregated attempts might even cause additional waste (HA, 2009). It should be noted, the study carried out by Common et al. (2000) reveals that UK construction companies do not have an appreciable understanding of the main concepts and application of lean. For example, a large number of respondents have concerns, lean concepts are insufficient for the construction industry due to the high demand for quicker and cheaper projects by clients.

2.9.9 Educational issues

Despite some attempts were made to present knowledge and instruction about lean construction by researchers, academics, practitioners and professional bodies in different countries, it seems that educational obstacles can still threaten the application of LC. Some of those barriers include lack of technical skills, rejecting innovative human resource management and development, insufficient training, poor comprehension and awareness, poor teamwork skills, illiteracy and computer illiteracy (Abdullah 2009, Mossman, 2009).

2.9.10 Lack of customer-focused and process-based performance measurement systems

Despite the inclination to only measure industry performance, a small number of investigations have focused on customer comfort (Forbes 2002). These traditional performance litmus tests (cost and schedule) do not promote sustainable improvement since they cannot qualify the basic quality and productivity losses effectively.

conventional performance measurement systems (PMSs) are based on financial measures. They are not measured until the project is finished, and thus, the information obtained is realized too late in the process in order to take corrective action. As a result, PMSs cannot be used to recognize the obstacles or difficulties embedded during the implementation of the production process. With regard to (Abdullah 2009), traditional control systems concentrate on conversion activities and refuse flow activities. In this way, almost all non-value-adding activities become invisible. In contrast, it is strongly advised to apply measures up front with the aim of giving early warnings, identifying obstacles and potential problems and emphasizing the guidelines for future investigation.

CHAPTER 3

MATERIAL AND METHOD

In this chapter the material used in the research and the method of research are presented. Under the material section information related to questionnaire and participants are given.

3.1 Materials of the Study

This research focuses on the challenges to implement lean construction (LC) concepts. The research applied a different methods procedure involving a questionnaire survey and interviews to gather quantitative and qualitative data. This research is based on findings of face to face interviews and a questionnaire survey which included 34 questions.

The questionnaire which is given in Appendix A consisted of 34 questions. The first 5 questions were about background details and information about respondents and the next 4 questions were about information about the organization in which they work. Thereafter (questions 10 – 16) were asked to measure the awareness of the participants about LC alongside with any attempts to implement lean culture within construction organization in Iranian construction industry.

Question 15 was **"To what extent do you agree/disagree with the following sentences?"** And the respondents were asked to measure on a scale of strongly agree to strongly disagree about consciousness of lean culture. Data on their awareness is shown in Table 4.

Question 17 – 27 were asked about tools and techniques in LC and questions 17 – 27 were asked about advantages of lean construction. These questions cover 7 corner stones of the conceptual framework, namely: Procurement; Management concepts; Planning and control; Design, Installation of design, Supply, and Performance measurement and evaluation.

Question 27 was **"Please score out of 10 each of the following 'Non - Financial' performance measures, according to their importance (10 being the most important and 1 being the least important)"** and respondents were asked to measure each aspect on a scale of 10. Data on their answers is shown in Figure 4.12.

Question 28 - 32 were about outcomes of successful implementation of LC

Question 33 and 34 were about Challenges to the successful implementation of LC

Question 33 was "**To what extent do you agree that the following issues are considered barriers to the successful implementation of Lean Construction?"** and participants in the questionnaire were asked to measure each of the 8 aspects on a scale of strongly agree to strongly disagree about barriers of lean construction

The questionnaire was filled by professionals and academicians. The largest proportion of these participants were civil engineers (34%). In addition, many of the respondents (41%) were practitioners holding managerial positions and with more than 10 years of experience in the industry.

3.2 Method of the Study

Methodology was to first identify a framework which is the result and summary of issues cited in literature survey. An comprehensive literature review was carried out to learn the principles of LC and possible barriers to its implementation. One of the studies conducted by Sarhan and Fox (2012) regarding barriers to the successful implementation of LC in the UK was found to be useful as a methodology that could be adopted for research in Iran. Hence, the questionnaire that was used by these authors was adapted according to the case study area requirements and realities for this research. The original questionnaire had 36 question, but two of these were omitted since they were not relevant to the Iranian construction industry.

Then an invitation to complete the questionnaire was sent to 58 professional practitioners in the Iranian construction industry as well as a small sample of academicians. Participants were selected randomly from some professional groups (consultants and contractors) that represent many of the professional organizations involved in the Iranian construction industry. Total of 30 responses were received. This represents a response rate of 51%. The results acquired indicated that the research was able to capture a well-distributed mixture of professionals and organizations

The cities where the questionnaire was distributed were Tehran and Tabriz. Tehran is the capital city of Iran which has 226 construction companies including contractors and consultants in the city. Tabriz also has 170 active companies participating in the construction industry.

Quantitative and qualitative data were collected through these questionnaires from different sectors in the construction industry, including contractors and consultants. These data were evaluated and the most important barriers of LC were determined statistically, to improve recommendations about future decisions.

CHAPTER 4

RESULTS AND DISCUSSION

Questions 1 to 10 were asked to gather detailed information on the background of the participants and their organizations; and the data collected from there is summarized in Tables 4.1 and 4.2 below.

Table 4.1: Background information about the construction companies

AAT in thousand dollars				Size of organizations		Major Client		
<40	400-400	400-4000	4000<	<500 employees	>500 employees	Private	Public	Both
20%	11%	18%	51%	70%	30%	22%	12%	64%

Table 4.2: Background information regarding the respondents

Years of experience			Current role (Managerial level)				Level of education		
0-10	10-20	20+	Graduate /Junior	Middle management	Senior management	Other	Practical qualification	Bachelor's degree	Master's Degree & above
32%	17%	51%	60%	36%	16%	5%	3%	36%	61%

In order to reveal trends in the development of lean culture within the organizations question 10 to 13 were designed to gather pertinent information. The following section is a summary of these questions

To consider the readiness of construction organizations for progressing along the lean journey, participants were asked to evaluate the following aspects:

- the amount of efforts to provide lean training, in their organization
- the performance of leaders regarding motivation of personnel;
- the level of concentration devoted by team leaders to improve processes that are not processing significant problems (Lean Responsibility);
- the level of lean knowledge of leadership teams achieved by formal training/induction.

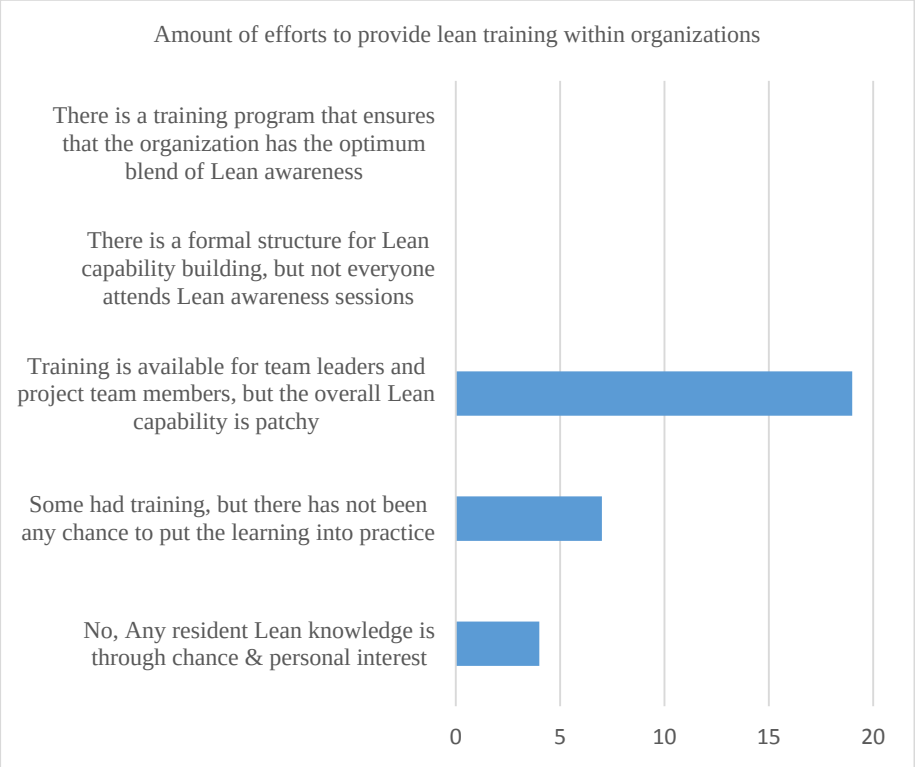


Figure 4.1: Amount of efforts to provide lean training within organizations

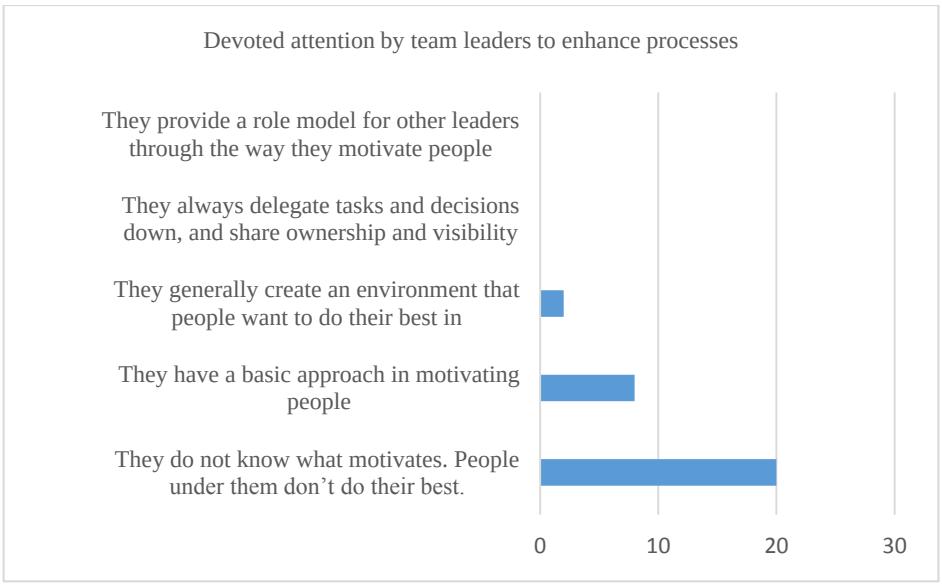


Figure 4.2: Evaluation the performance of leaders within organization, in terms of motivating people

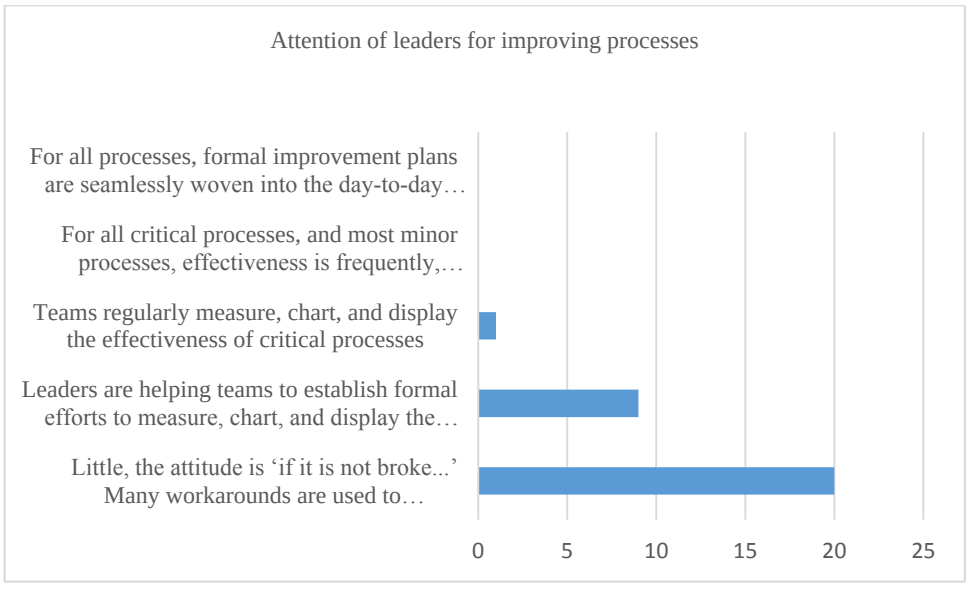


Figure 4.3: Team leader's attention to improve processes that are not big problems

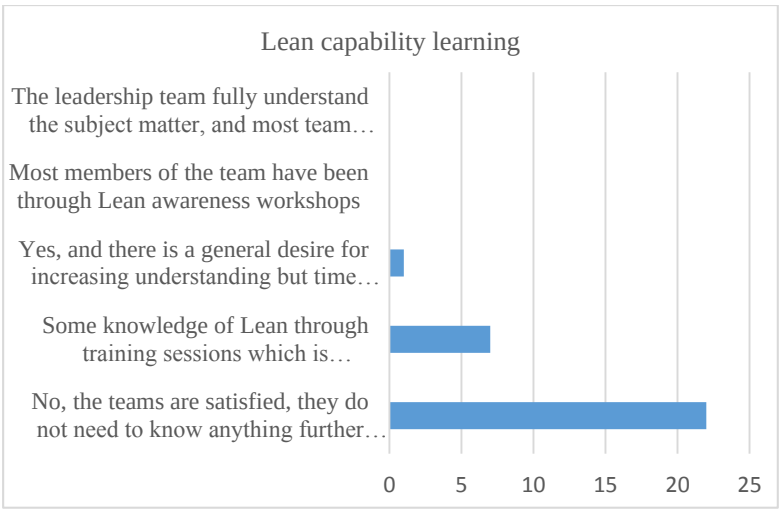
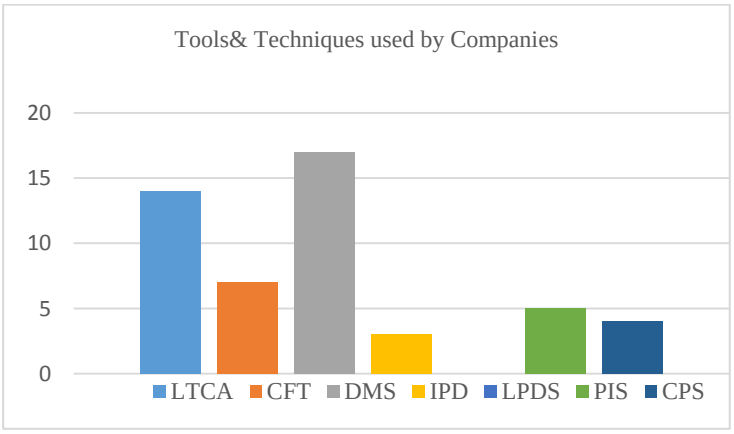


Figure 4.4: Any efforts to present formal lean training throughout their organizations (Lean capability learning)

Question 14 was about the techniques/tools used by the organization to facilitate internal/external collaborative relationships and as seen from the chart below DMS stands out as being the most preferred and IPS as the least used



LTCA= Long term contractual agreement; CFT= Cross-functional teams; DMS= Document management System
IPD= integrated project delivery; LPDS= Lean project delivery System; PIS= Project information systems;
CPS= Collaborative Planning Schedules

Figure 4.5 Data on the Tools and Techniques employed by the Construction: Companies

Question 15 was based on 11 concepts of LC; while the answers were ranging from strongly disagree to strongly agree on a 5 point Likert scale. In some cases, a lower scale could mean that a respondents was supporting the concept, while in another case a higher point might mean that the respondents was actually opposing the concept. Hence, answers to the questions are given below in Table 3 where the last column clarifies whether the majority of the responders were positive or not regarding that particular concept.

Table 4.3: Attitude of responders towards the concept of Lean Construction (Qs.15)

ID	Answer Scale* (5= Strongly Agree and 1= Strongly Disagree)					Answer to Qs		Attitude of majority towards LC concept
						Supporting (5+4)	Opposing (1+2+3)	
	5	4	3	2	1			
Lean concept is not suitable for the construction industry because of the demands from clients for quicker and cheaper projects	0	6	3	19	2	30% N	70% P	Positive
There is no need to improve processes that are not presenting major problems	0	2	10	14	4	6.3%	93.7% P	Positive
Contract forms that allow one party to impose power over another, create adversarial relations. These adversarial relations create transaction costs, which are considered waste	7	18	3	2	0	83% P	17% N	Positive
Lean has to be implemented across the business and value chain to deliver the promised results; any isolated efforts may even cause waste	9	18	3	0	0	90% P	1 0% N	Positive
Using performance measurement for self-defense or evidence for claims and counter-claims is recommended	10	8	4	8	0	60% P	40% N	Positive
The use of bills of quantity (BoQ) based on the civil engineering standard method of measurement (CESMM), could lead to price variations and delivery difficulties	0	7	3	19	1	33% N	67% P	Positive
Traditional performance preferences measured in projects, specifically costs and schedule, are not appropriate for continuous improvement	3	19	6	2	0	73% P	27% N	Positive

All activities of the organization/site should be continuously improved	7	23	0	0	0	100% P	0% N	Positive
Quality should be first priority, not profit	5	3	11	11	0	P	N	Positive
Any procurement form that tends to delegate design work to external designers, separates the design from the construction process; and therefore misses the lean aim of collaboration and integration	0	3	2	21	4	26.6% P	73.4% N	Negative
Lean is more than tools or techniques; it requires a transformation in thinking, collaboration, flexibility, commitment, discipline, and a broad system-wide focus	13	17	0	0	0	100% P	0% N	Positive

Question 16 was about using the tasks which can be helpful for organizations to establish Lean approach. As shown in the Figure4.6, 66% of participant are willing to use workplace organization to provide a safe and good workplace environment to establish the job while 33% consider that visual management is the proper tool for Lean approach.

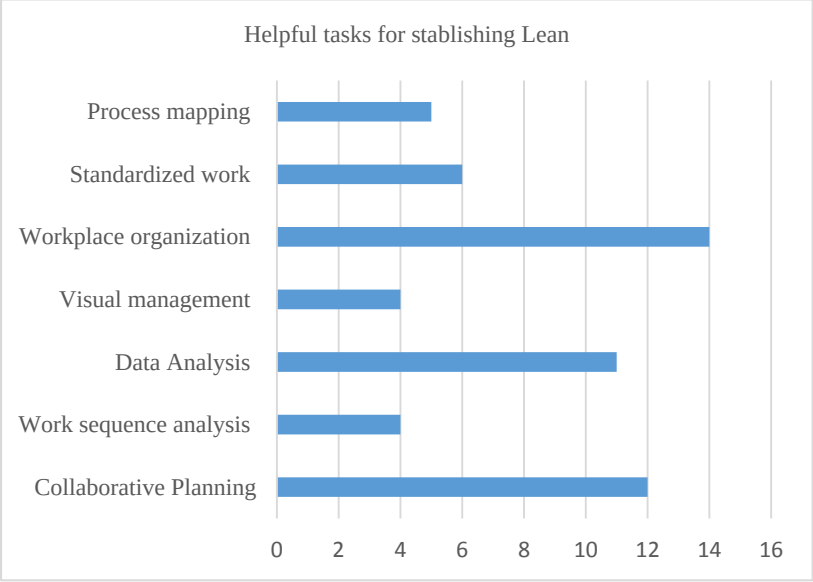


Figure 4.6: Data on tasks being helpful for companies to achieve Lean approach

Question 17 was about planning and control techniques that are used within participant's organizations. Most of respondents use critical path method in their

organization which is an algorithm for scheduling a set of project activities. (Figure 4.7)

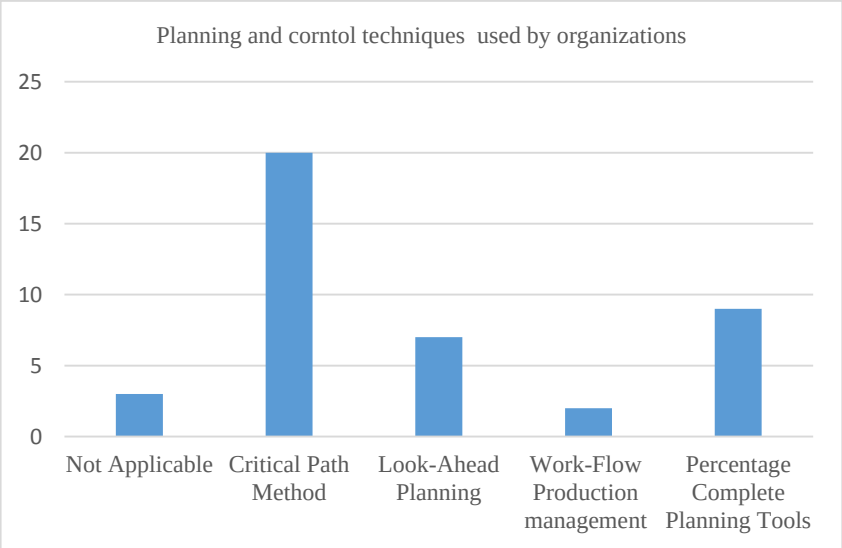
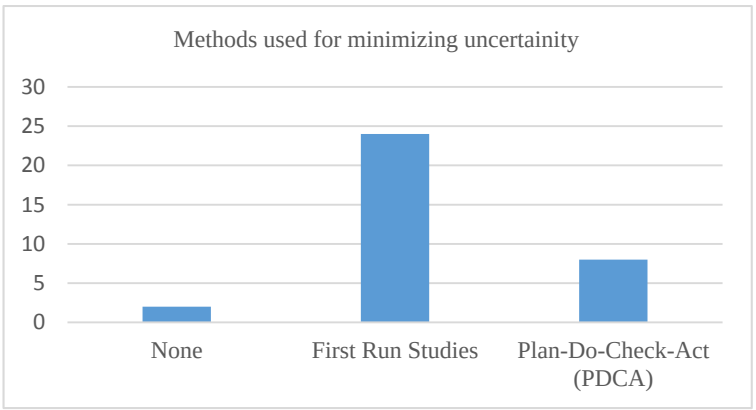


Figure 4.7: Data on planning and techniques applied by organizations

Question 18 was about the techniques that are being used in organization for minimizing uncertainty in production process. As revealed in Figure 4.8 first run studies are the main tools for organizations to reduce uncertainty.



PDCA; Plan-Do-Check-Act

Figure 4.8: The techniques used by organization to reduce uncertainty

Question 21 was about the techniques and tools which are being used by suppliers for provision of materials to construction site. According to the Figure 4.9, 53% of respondents believe that these techniques are not applicable in their organization furthermore 30% of them are not aware of the potential of these tools.

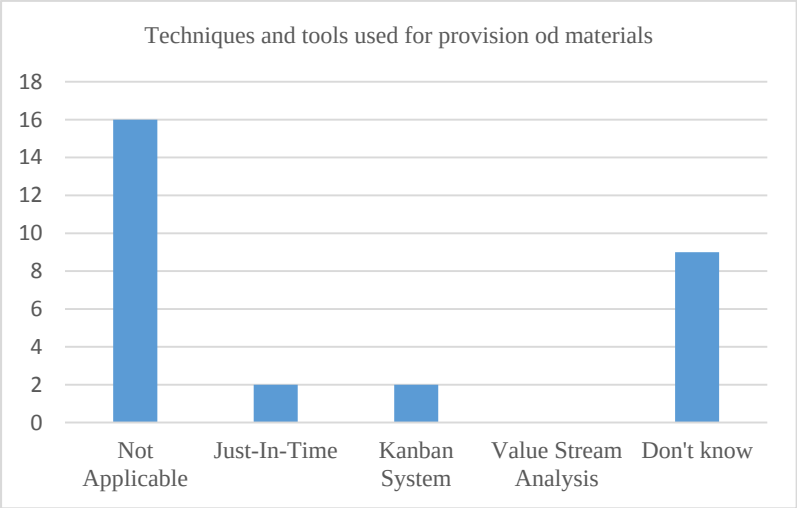


Figure 4.9: Techniques and tools which are used by supplier for provision of materials

In question 22 participants were asked to reveal which technique/tool is being used in their organizations to simulate flow by enhancing coordination and information procedures. Majority of respondents answered the question by implying that lean techniques are not applicable in their organizations or their organization does not use any techniques at all.

Question 23 was about the techniques/tools used by the organization to prevent value loss by reducing inconsistent decision making. As shown in (Figure 4.10) 70% of the organizations do not use any tools or techniques to prevent value loss.

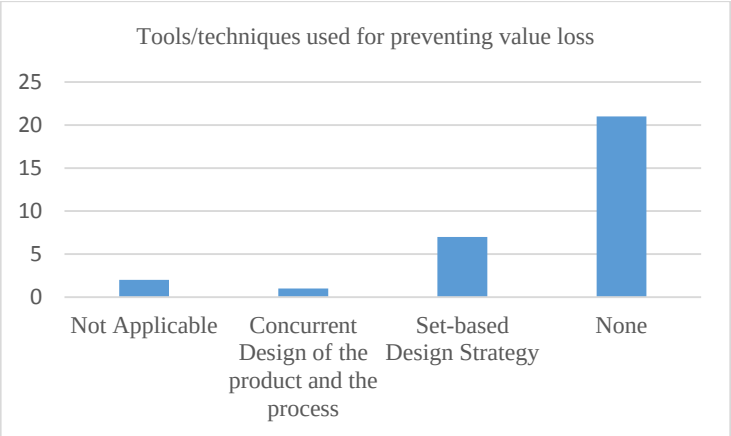
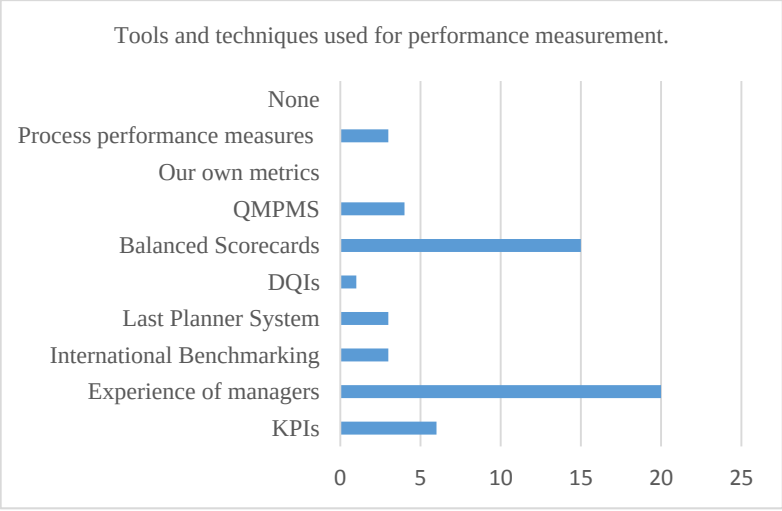


Figure 4.10: Techniques and tools used to prevent value loss

Question 24 was about using Last Planner System in organization. However, 76% of participants responded to this question as not applicable.

Question 26 was about techniques that organization use for performance measurement. As seen in the Figure. 4.11 experience of managers stands out as the most important factor for performance measurements, followed by balanced scorecards.



QMPMS= Quantative Models for Performance Measurement Systems; KPI= Key Performance Indicators

Figure 4.11: Tools and techniques used for performance measurement.

In question 27 respondents were asked to score seven Non-financial performance measures according to their importance. It seems that Quality is most significant performance measure followed by Client/ Customer satisfaction and, functionality. Quality was rated as a highly important by respondents followed by client/customer satisfaction and functionality. It seems that quality of a produced work or product affects organizations reputation and amount of business they receive.

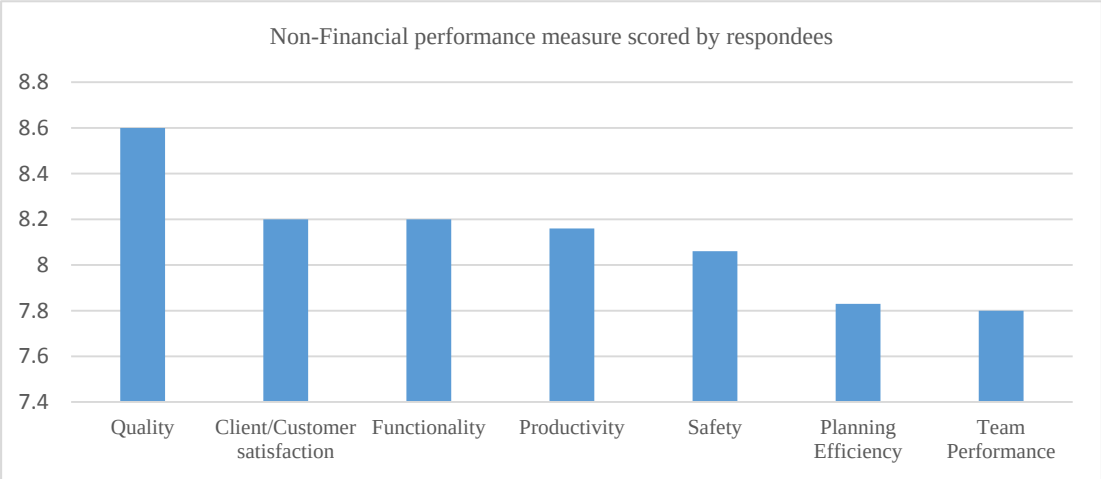


Figure 4.12: Non-financial performance measures

Question 28 was about possible advantages of lean construction if applied in construction sector. According to the data, improved productivity stands out as the most important benefit of Lean construction from the respondent's point of view.

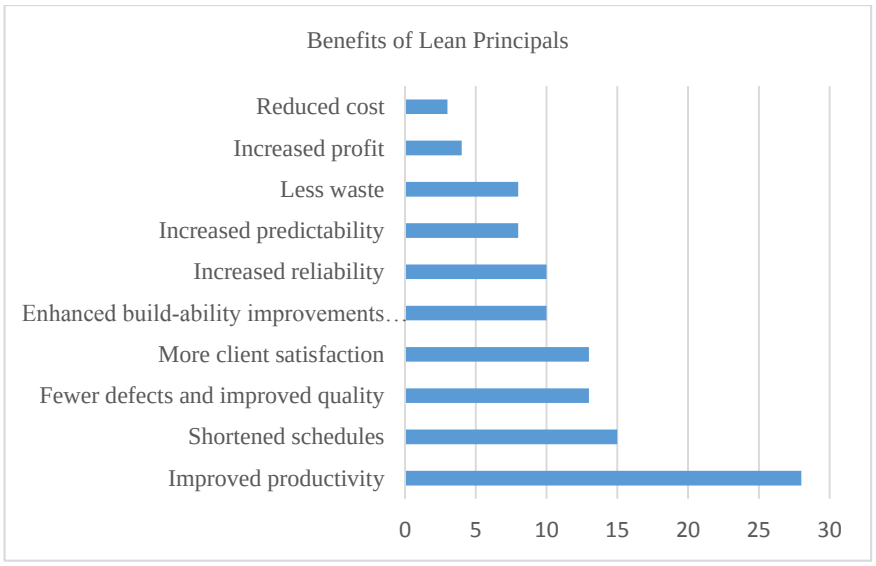


Figure 4.13: Possible advantages of Lean concept if being applied in construction industry

Question 29 was about concepts which draw on economic success in organizations. As shown in Figure 4.14, Cost and value management as the most important method for achieving economic success followed by risk management and mitigation.

Figure 4.14: Concepts for achieving economical success

According to the data collected from question 30, environmental considerations, are achieved by International standards and accreditations like, ISO 14001which is the most important method among other ones. As shown in the Figure 4.15 Lean construction is not considered as an option by anyone.

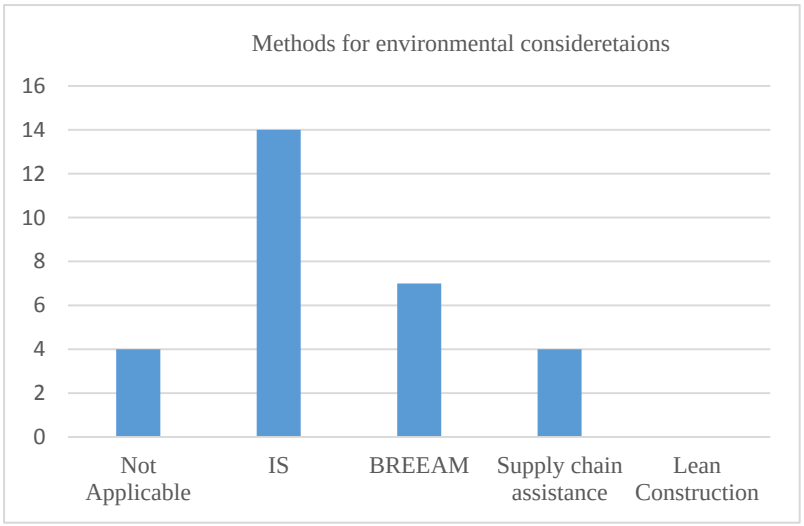


Figure 4.15: Environmental considerations

According to the Figure 4.16 most of the organizations achieve social considerations based on Job knowledge and skill scheme (data on question number 31).

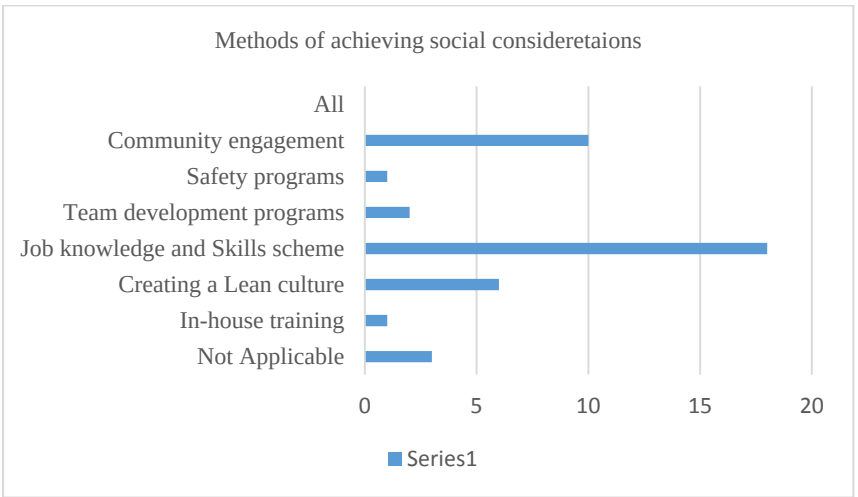


Figure 4.16: Methods of achieving social considerations

Question 32 was about reasons that make organizations Go Lean. As illustrated in the **Figure 4.17**, improving quality is the most important factor which makes them go Lean.

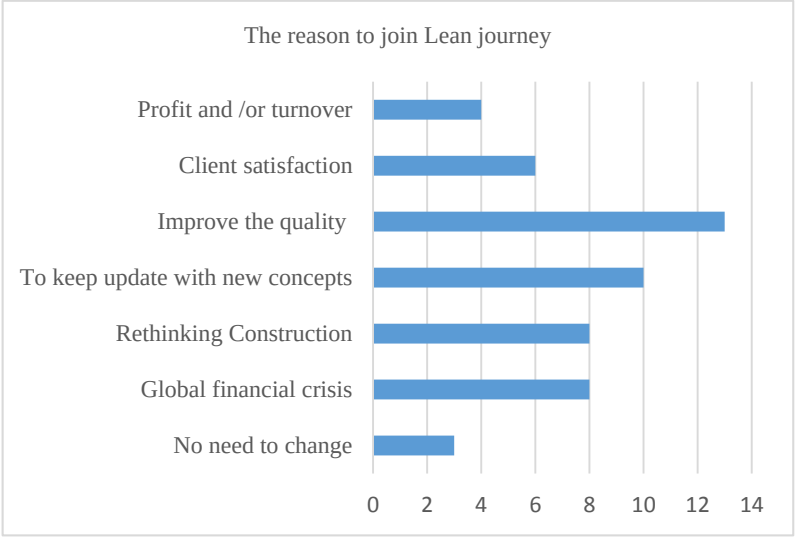


Figure 4.17: Reasons which would make organizations start lean journey

Question 33 was about the issues of successful implementation of Lean construction and respondents were asked to rate the barriers on a five-point Likert scale as an indication of their attitude, ranging from “5” equal to strongly agree to “1” equal to strongly disagree.

As can be seen from Figure 4.18, the attitude percentage of three barriers, namely B3, B4 & B10 were considered as the significant barriers to the successful implementation of LC.

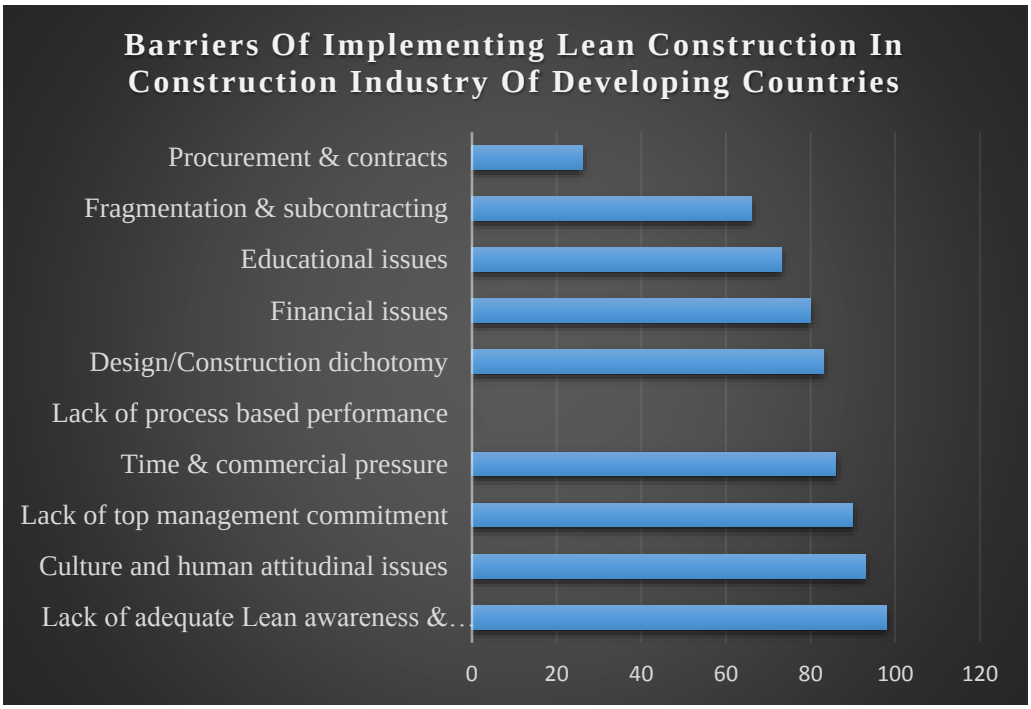


Figure 4.18: A summary of the barriers of implementing LC principals in the developing countries

Table 4.4: The significant barriers to the successful implementation of LC

ID	List of the key barriers identified	Answer Scale* (5= Strongly Agree and 1=Strongly Disagree)					Attitude	
		1	2	3	4	5	Agreement (4+5)	Disagreement (1+2+3)
B1	Fragmentation & subcontracting	1	3	6	17	3	66.6%	33.3%
B2	Procurement & contracts	0	12	10	6	2	26%	84%
B3	Lack of adequate Lean awareness & understanding	0	0	2	10	18	98%	2%
B4	Culture and human attitudinal issues	0	0	2	14	14	93%	7%
B5	Time & commercial pressure	0	0	4	19	7	26 86.6%	4 13.4%
B6	Financial issues	0	2	4	14	10	24 80%	6 20%
B7	Lack of top management commitment	0	1	2	11	16	27 90%	3 10%
B8	Design/Construction dichotomy	0	2	3	10	15	25 83.3%	5 16.7%
B9	Educational issues	0	2	6	13	9	22 73.3%	8 26.7%
B10	Lack of process based performance Measurement systems	0	0	4	10	16	26 86.6%	4 13.4%

*Scale 3 is considered neutral and is categorized within the disagreement group.

CHAPTER 5

CONCLUSION

Efforts to implement Lean Construction (LC) principles can be highly satisfying for the construction industry in developing countries and, many countries worldwide attained great success by using the lean concepts. Although construction sector suffers from fundamental problems frequently and the industry calls for Lean approach to revolutionize this area, it seems that some attitudinal, organizational, financial, technical and cultural barriers are preventing the progress of construction organizations towards achieving the lean strategy.

Several studies have been carried out in different countries worldwide to identify the restrictions in implementing the LC approach. These obstacles could affect the adoption process of LC and hinder the project performance, if not properly eliminated or avoided. Despite a necessity for transformation in the construction industry by Lean concept, there has not been enough research in this field. " By not understanding the factors that affect the successful implementation of LC, organizations will not be able to know what improvement efforts need to be made, where these efforts should be focused, or which efforts could obtain the best results."

For this reason, this study was conducted to understand the possible barriers to the successful implementation of LC. In the context of the research, an extensive literature review was conducted, and a questionnaire was distributed to professionals, practitioners, and academicians who work in this domain. Outcome of this questionnaire demonstrates the attitude of the respondents about lean principles and

their readiness for transformation and identification of hindrances in implementing lean principals

From the data collected, it was found that training is available for team leaders and project team members in the majority of organizations. A few leadership teams have some knowledge of lean concept which they do not consider to be adequate for the involvement of lean principles. Moreover, according to their answers, the overall lean capability within their organizations is patchy. There is no formal lean training throughout the majority of organizations. Furthermore, the obstacle is that the majority of them are resistant to any changes even though these changes may be able to enhance the performance and improve the quality & productivity standards of their organization. Almost all of respondents agree upon the fact that Lean demands a transformation in thinking collaboration and discipline. Furthermore, the necessity of implementation of Lean philosophy in the construction industry is evident.

According to collected data, organizations have been resistant to new tools and techniques offered by Lean philosophy. It seems that they are either not aware of Lean construction principals or, methods of lean construction are not applicable in their firms. Also, there is no attention paid by the majority of these firms to prevent value loss. Furthermore, the experience of managers is used to measure performance in these organizations Meanwhile, some of the organizations use some Lean methods whiteout realizing that those tools are lean techniques.

This study evaluated some obstacles to the successful implementation of LC, and three of them were classified as significant, according to the respondents' viewpoint, these are:

1. Lack of adequate lean awareness and understanding;
2. Culture and human attitudinal issues
3. Top management commitment

The result of this study could be used to assist researchers, professionals, and companies in the construction industry to concentrate their efforts and resources on the critical issues needed to support the implementation of LC concepts.

One remarkable impact of this research was that the distribution of the questionnaire among different professionals in the construction industry made them aware of Lean principles and its vast benefits.

Recommendations

In view of the above barriers following are specific recommendations to overcome them.

Without basic understanding of the mechanism of lean construction, it is not possible for organizations to apply Lean construction principals in their system. Hence introduction of an awareness program is strongly recommended for start. Workshops and trainings should be given to deliver the key principals, to explain applications and, provide guidance on learning. By preparing learning programs, team members also start to realize how they fit into the process as a whole and how their actions affect the up and down stream portions of the process.

Lean philosophy leads to the proper management behavior and responsibility. The management requires being completely engaged to this concept also to meet the difficulties that encounter as chances and convert every difficulty to an educational adventure. Implementing reliable methods has to be everyone's obligation. Managers can receive the complete advantage of lean techniques and significantly enhance their results if they implement these ideas collectively. What is needed most is that managers should essentially change their philosophy of management. Organizational transformation is never easy and basically, the philosophies need to be changed, roles, responsibilities should be changed too. The process needs a real dedication from the

top. Top managers should be satisfied that lean is the proper organizational growth also the leaders, should constantly urge and assign the values of responsibility to everybody in the organization. Organizational culture should be created and shared values of the goals should be spread throughout the firm. A fresh approach in thinking is crucial for applying Lean concepts in the construction industry. culture and human attitudes are recognized as a critical aspect of the implementation of Lean philosophy. Therefore, organizations should evaluate their working culture before applying lean system. It is verified by different studies that organizations cannot succeed in lean unless they have healthy culture.

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APPENDIX

Questionnaire used in the survey

1. What is your profession?

- o Academic
- o Technician
- o Civil Engineer
- o Quantity Surveyor
- o Architect
- o Designer
- o Consultant
- o Construction Manager
- o Project Manager
- o If other, please specify

_____

2. Where are you based?

- o Tehran
- o Tabriz
- o If other, please specify

_____

3. Current role?

- o Academic/Researcher
- o Graduate Engineer
- o Junior Engineer
- o Team Leader
- o Site Manager
- o Project Manager
- o Regional Manager
- o Department Manager
- o Managing Director
- o If other, please specify

_____

4. Highest level of qualification?

- NVQ
- HNC or HND
- Degree
- Master's Degree
- Doctorate
- If other, please specify

_____

5. Years of experience?

- 0-5
- 5-10
- 10-20
- 20+

6. How many employees do work in your organization?

_____

7. Areas of operations of your organization? (Multiple choice)

- Higher education
- Residential and/or Commercial buildings
- Highways and Transportation
- Railways and Tunnel works
- Design and Consultancy
- Dams
- Airports
- Infrastructural facilities

8. Average Annual Turnover (in Millions, Iranian Rial)?

- 100 – 1000
- 1000 – 10000
- 10000 – 100000
- 100000+

9. Major Clients/Customers?

- Public Organizations
- Private Individuals and Organizations
- Both

The five principles of Lean:

1. Specify value from the customer's perspective;

2. Identify and integrate the processes that deliver value (value stream). This is the sequence of processes from raw materials to product (the supply chain). To achieve this, you need to (i) map the value chain and (ii) eliminate waste;

3. Make value flow by eliminating bottlenecks and disruption. Never stop a value adding step by a non-value adding step;

4. Let the customer pull the product through the manufacturing process. Produce only what is wanted when it is wanted;

5. Pursue perfection through continuous improvement. This is not just restricted to quality; it is extended to include producing exactly what the customer wants when it is wanted at a fair price with zero waste.

10. Have there been any attempts to provide formal Lean training throughout your organization?

- No, Any resident Lean knowledge is through chance & personal interest
- Some had training, but there has not been any chance to put the learning into practice
- Training is available for team leaders and project team members, but the overall Lean capability is patchy
- There is a formal structure for Lean capability building, but not everyone attends Lean awareness sessions
- There is a training program that ensures that the organization has the optimum blend of Lean awareness

11. How would you evaluate the performance of leaders within your organisation, in terms of motivating people?

- They do not know what motivates. People under them don't do their best.
- They have a basic approach in motivating people
- They generally create an environment that people want to do their best in
- They always delegate tasks and decisions down, and share ownership and visibility
- They provide a role model for other leaders through the way they motivate people. They are currently invincible.

12. Is there any attention devoted by team leaders to improving processes that are not presenting major problems?

- Little, the attitude is 'if it is not broke...' Many workarounds are used to accommodate long standing process constraints
- Leaders are helping teams to establish formal efforts to measure, chart, and display the performance of critical processes

- Teams regularly measure, chart, and display the effectiveness of critical processes
- For all critical processes, and most minor processes, effectiveness is frequently, measured, charted and displayed
- For all processes, formal improvement plans are seamlessly woven into the day-to-day activities of the team

13. Has your organization's leadership team been through any formal training/induction into Lean Thinking/methodology?

- No, the teams are satisfied, they do not need to know anything further on the subject
- Some knowledge of Lean through training sessions which is adequate for involvement in Lean
- Yes, and there is a general desire for increasing understanding but time pressure makes this difficult
- Most members of the team have been through Lean awareness workshops
- The leadership team fully understand the subject matter, and most team members have at least a basic understanding

14. Which of the following techniques/tools does your organization use to facilitate internal/external collaborative relationships? (Multiple choice)

- Long-Term Contractual Agreements (e.g. Frameworks & Partnering)
- Cross-Functional Teams
- Document Management Systems
- Integrated Project Delievery
- Lean Project Delivery System
- Project Information Systems
- Collaborative Planning Schedules (e.g. with subcontractors or suppliers)
- All
- If other, please specify

_____

15. To what extent do you agree/disagree with the following sentences?

	STRONGLY AGREE	**AGREE**	**NOT SURE**	**DISAGREE**	**STRONGLY DISAGREE**

LEAN CONCEPT IS NOT SUITABLE FOR THE CONSTRUCTION INDUSTRY BECAUSE OF THE DEMANDS FROM CLIENTS FOR QUICKER AND CHEAPER PROJECTS	○	○	○	○	○
THERE IS NO NEED TO IMPROVE PROCESSES THAT ARE NOT PRESENTING MAJOR PROBLEMS	○	○	○	○	○
CONTRACT FORMS THAT ALLOW ONE PARTY TO IMPOSE POWER OVER ANOTHER, CREATE ADVERSARIAL RELATIONS. THESE ADVERSARIAL RELATIONS CREATE TRANSACTION COSTS, WHICH ARE CONSIDERED WASTE	○	○	○	○	○
LEAN HAS TO BE IMPLEMENTED ACROSS THE BUSINESS AND VALUE CHAIN TO DELIVER THE PROMISED RESULTS; ANY ISOLATED EFFORTS MAY EVEN CAUSE WASTE	○	○	○	○	○
USING PERFORMANCE MEASUREMENT FOR SELF-DEFENSE OR EVIDENCE FOR CLAIMS AND COUNTER-CLAIMS IS RECOMMENDED	○	○	○	○	○

THE USE OF BILLS OF QUANTITY (BOQ) BASED ON THE CIVIL ENGINEERING STANDARD METHOD OF MEASUREMENT (CESMM), COULD LEAD TO PRICE VARIATIONS AND DELIVERY DIFFICULTIES	○	○	○	○	○
TRADITIONAL PERFORMANCE PREFERENCES MEASURED IN PROJECTS, SPECIFICALLY COSTS AND SCHEDULE, ARE NOT APPROPRIATE FOR CONTINUOUS IMPROVEMENT	○	○	○	○	○
ALL ACTIVITIES OF THE ORGANIZATION/SITE SHOULD BE CONTINUOUSLY IMPROVED	○	○	○	○	○
QUALITY SHOULD BE FIRST PRIORITY, NOT PROFIT	○	○	○	○	○
ANY PROCUREMENT FORM THAT TENDS TO DELEGATE DESIGN WORK TO EXTERNAL DESIGNERS, SEPARATES THE DESIGN FROM THE CONSTRUCTION PROCESS; AND THEREFORE MISSES THE LEAN AIM OF COLLABORATION AND INTEGRATION	○	○	○	○	○
LEAN IS MORE THAN TOOLS OR TECHNIQUES; IT REQUIRES A	○	○	○	○	○

TRANSFORMATION IN THINKING, COLLABORATION, FLEXIBILITY, COMMITMENT, DISCIPLINE, AND A BROAD SYSTEM-WIDE FOCUS	

16. Which of the following tasks are set in place to help your organization achieve the Lean approach? (Multiple-choice)

- o Collaborative Planning
- o Work sequence analysis - identify wastes and risks, and consider logistics
- o Data Analysis - Set targets, monitor and improve
- o Visual management - clear process-oriented performance information - identify problems before they occur
- o Workplace organization - creaste a safe and good workplace environment to complete the job
- o Standardized work - identify best method to achieve quality, cost and time, safely and consistently
- o Process mapping - identify who does what, when, why and how
- o Problem solving - identify root-causes of problems
- o None
- o All
- o If other, please specify

_____

17. Which Planning & Control tools/techniques are used by your organisation? (multiple choice)

Not Applicable

Critical Path Method

Look-Ahead Planning

Work-Flow Production management as a construction scheduling tool

Percentage Complete Planning Tools

Last Planner System

Constraint Analysis

Reverse-Phase Scheduling

If other, please specify

_____

18. What techniques does your organization use for minimizing uncertainty in production processes? (Multiple choice)

- None
- First Run Studies
- Plan-Do-Check-Act (PDCA)
- Pre-Fabrication Strategies
- If other, please specify

_____

19. What techniques does your organization use for planning and organizing the movement of work crews and materials, as well as the production processes itself? (Multiple choice)

- Not Applicable
- Continuous flow processing (CFP)
- Visual Management
- Last Planner System (LPS)
- The use of a transportation support system integrating horizontal and vertical movements (e.g. Crane)
- If other, please specify

_____

20. Does your organization have 'successful' experience with any of the following management concepts: Supply Chain Management (SCM), Concurrent Engineering (CE), Total Quality Management (TQM)?

- No
- If yes, please identify which?

_____

21. Which of these techniques do your suppliers use for the provision of materials to your construction sites? (multiple choice)

- Not Applicable
- Just-In-Time
- Kanban System
- Value Stream Analysis

- Don't know
- If other, please specify

_____

22. Which of the following tools/techniques does your organization use to simulate flow by enhancing coordination and information procedures? (Multiple choice)

- Not Applicable
- Design Structure Matrix
- Virtual Design Studios
- Virtual Reality Tools
- Building Information Modeling (BIM)
- None of above
- If other, please specify

_____

23. What tools/techniques does your organization use to prevent value loss by reducing inconsistent decision making? (Multiple choice)

- Not Applicable
- Concurrent Design of the product and the process
- Set-based Design Strategy
- None
- If other, please specify

_____

24. Last Planner System is used in your organization for:

- Not Applicable
- Planning as an activity scheduling tool
- Production Control
- Tuning Logistics Operations during Production
- Performance measurement & organizational learning
- Management Control
- If other, please specify

_____

_____

25. In Last Planner, the Percentage Plan Complete (PPC) value:

- measures the level of utilization of a work flow (efficiency).
- measures production planning effectiveness and workflow reliability
- Both of above
- Not Applicable

26. Which of the following techniques does your organization use for performance measurement? (Multiple choice)

- Results oriented Key Performance Indicators (KPIs), such as cost and time indicators
- Experience of managers
- International Benchmarking
- Last Planner System
- Design Quality Indicators (DQIs)
- Balanced Scorecards
- Quantative Models for Performance Measurement Systems (QMPMS)
- Our own metrics which consists of leading indicators aiming to give early warnings. It is also consistent with our
- business strategy
- Process performance measures (e.g. cycle time, Rework, waste, etc)
- None
- If other, please specify

_____

27. Please score out of 10 each of the following 'Non - Financial' performance measures, according to their importance (10 being the most important and 1 being the least important).

	Score out of 10 according to importance
Quality	----------
Safety	----------
Client/Customer satisfaction	----------
Functionality	----------
Planning Efficiency	----------

Team Performance	----------
Productivity	----------

28. Which of the following benefits could be achieved from applying lean principles to construction? (Please choose Up to 5 benefits only)

- o improved productivity
- o increased reliability
- o fewer defects and improved quality
- o more client satisfaction
- o increased predictability
- o shortened schedules
- o less waste
- o reduced cost
- o enhanced build-ability improvements to design
- o increased profit
- o improved safety and health conditions
- o If other, please specify

_____

29. Economic success is achieved in your organization through:

- o Risk management and mitigation
- o Lean Construction
- o Supply-chain assistance
- o Cost and Value Management
- o All
- o If other, please specify

_____

30. Environmental considerations are achieved in your organization through:

- o Not Applicable
- o International standards and accreditation, such as the ISO 14001
- o BRE Environmental Assessment Model (BREEAM)
- o Supply chain assistance

- ○ Lean Construction as a primary tool for reducing physical waste
- ○ All
- ○ If other, please specify

_____

31. Social Considerations are achieved in your organization through:

- ○ Not Applicable
- ○ In-house training
- ○ Creating a Lean culture
- ○ Job knowledge and Skills scheme
- ○ Team development programs
- ○ Safety programs
- ○ Community engagement
- ○ All
- ○ If other, please specify

_____

32. Why did or would your organization decide to go on the Lean journey? (Multiple choice)

- ○ We are satisfied with achieving our intended objectives. No need to change
- ○ When a major problem occurs/occurred (e.g. global financial crisis)
- ○ As a respond to the Egan's report (Rethinking Construction)
- ○ To keep up-to-date with any new emerging management concepts
- ○ To improve the quality of our outputs
- ○ To improve our rate of client satisfaction
- ○ To increase our profit and /or turnover
- ○ If other, please specify

_____

33. To what extent do you agree that the following issues are considered barriers to the successful implementation of Lean Construction?

	STRONGLY AGREE	**AGREE**	**DISAGREE**	**DISAGREE**	**STRONGLY DISAGREE**
FRAGMENTATION & SUBCONTRACTING	○	○	○	○	○

PROCUREMENT & CONTRACTS	○	○	○	○	○
LACK OF ADEQUATE LEAN AWARENESS & UNDERSTANDING	○	○	○	○	○
CULTURE & HUMAN ATTITUDINAL ISSUES	○	○	○	○	○
TIME & COMMERCIAL PRESSURE	○	○	○	○	○
FINANCIAL ISSUES	○	○	○	○	○
LACK OF TOP MANAGEMENT COMMITTMENT	○	○	○	○	○
DESIGN/CONSTRUCTION DICHOTOMY	○	○	○	○	○
EDUCATIONAL ISSUES	○	○	○	○	○
LACK OF PROCESS BASED PERFORMANCE MEASUREMENT SYSTEMS	○	○	○	○	○

34. Are there any other barriers that you strongly believe that could affect the successful implementation of Lean Construction?

- ○ No
- ○ Not Sure
- ○ If yes, could you please mention them?