

GUIDELINE OF LEAN CRITICAL SUCCESS FACTORS IMPLEMENTATION
IN CONSTRUCTION PROJECT

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DEDICATION

I dedicate this thesis to the Almighty God who granted me the wisdom, favour, insight and enablement to embark upon and complete this PhD

To my Beloved Mother, who gave me endless love, support, trust, constant encouragement over the years, and for her patience and prayers

To my lovely family, my brother, sisters and nieces for their patience, support, love and prayers

And my late father

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ABSTRACT

Lean consists of a collection of principles and tools which aim to identify and eliminate waste. Lean practices aim to maximize value to the customer or client, while minimizing waste and deploying continuous improvement in manufacturing, construction or business industry. Construction projects are complex and require a rigorous application of project management embedded with Lean principles to reduce the waste in construction industry. Many researches have been done in construction but few have involved studies on implementation of Lean Critical Success Factors (CSFs) in case studies to measure the effectiveness of the Lean CSF. In this research, an investigation is carried out into the implementation of Lean CSF in Iran, to improve construction site performance, within Iranian construction industry. Unfortunately, in Iran there are few research projects on Lean in building construction but non on implementation of Lean CSFs in the construction industry. This research has three objectives; 1) To evaluate the current awareness and attitudes of the construction experts towards the existence of waste in construction projects and opportunity for implementing Lean principle in the construction site within the Iranian construction industry. 2) To evaluate and identify the Lean critical success factors in order to implement the Lean construction management principle in building construction site. 3) To propose a guideline for implementing the Lean critical success factors on construction project site and to evaluate the productivity of construction project site before and after the implementation of Lean. For achieving the first objective, questionnaire-survey based on Likert scale is used for collecting data and the data is analyzed by Ranking Indices of Importance (RII). The questionnaires are used to analyze the waste and Lean situation in the construction site, by seven main categories; waste, continuous improvement, material supplying (just-in-time), supplying collaboration, standardization, value flow and attitude. It is designed for two groups of top managers and senior engineers. The result showed that there is awareness of waste in construction industry. For the second objective, two CSFs are identified. The first one is 5S which is selected based on literature review, and for second CFS, a questionnaire-survey using Delphi, and Fuzzy AHP is employed. Based on the results Last Planner System (LPS) is selected. For the third objective, Function Analysis System Technique (FAST) diagram is used to develop guideline for implementing the LPS and 5S. After implementing FAST diagram, Pareto is then applied to analyze the outcomes of proposed guideline. After implementation of the guideline, another questionnaire is conducted among the top managers and senior engineers using T-square method to evaluate the effectiveness of implementing LPS and 5Ss on construction productivity. This is to validate the proposed guideline. The results have shown that Lean CSFs in particular, LPS and 5S can improve the productivity of construction.

ABSTRAK

Lean terdiri daripada satu koleksi prinsip dan alat yang bertujuan mengenalpasti dan menghapuskan pembaziran. Amalan Lean bertujuan memaksimumkan nilai kepada pelanggan, sambil meminimumkan pembaziran dan menggunakan pembaikan berterusan dalam industri pembuatan, pembinaan dan perniagaan. Projek pembinaan adalah kompleks dan memerlukan pengurusan projek berteraskan Lean untuk mengurangkan sisa pembaziran dalam industri pembinaan. Banyak penyelidikan telah dijalankan dalam bidang pembinaan tetapi tidak banyak yang melibatkan kajian mengukur keberkesanan Faktor Kritikal Kejayaan Lean dalam kajian kes. Dalam kajian ini, pelaksanaan Faktor Kritikal Kejayaan Lean, untuk memperbaiki prestasi di tapak pembinaan dalam industri pembinaan Iran telah dilaksanakan. Malangnya, tidak banyak kajian telah dilakukan berkaitan Lean dalam projek pembinaan dan tiada kajian dibuat berkaitan pelaksanaan Lean melalui Faktor Kritikal Kejayaannya dalam industri pembinaan Iran. Kajian ini mempunyai tiga objektif; 1) Menilai kesedaran dan sikap semasa pakar pembinaan terhadap keujudan sisa pembaziran dalam projek-projek dan mengenalpasti peluang untuk mengimplementasi prinsip Lean di tapak pembinaan dalam industri pembinaan di Iran. 2) Menilai dan mengenalpasti Faktor Kritikal Kejayaan Lean yang membolehkan implementasi prinsip pengurusan pembinaan Lean di tapak pembinaan bangunan. 3) Mencadangkan garis panduan implementasi Faktor Kritikal Kejayaan Lean di tapak projek pembinaan dan menilai produktiviti tapak projek pembinaan sebelum dan selepas implementasi. Bagi mencapai objektif pertama, kajian soal selidik menggunakan skala Likert digunakan untuk mengumpul data dan data ini dianalisa menggunakan Ranking Indices of Importance (RII). Soalselidik ini digunakan untuk menganalisa situasi pembaziran dan Lean di tapak pembinaan melalui tujuh kategori utama, iaitu: pembaziran, pembaikan berterusan, pembekalan bahan, kerjasama pembekalan, piawai, aliran nilai dan sikap. Soalan soal selidik direkabentuk untuk pengurus atasan dan jurutera kanan. Hasilnya menunjukkan bahawa ada kesedaran tentang sisa dalam industri pembinaan. Untuk objektif kedua, dua Faktor Kritikal Kejayaan Lean akan dikenalpasti. Faktor pertama ialah 5S yang dipilih berdasarkan kajian literature manakala bagi faktor yang kedua, kajian soal selidik telah dibuat menggunakan Delphi dan Fuzzy AHP. Berdasarkan hasil kajian, Last Planner System (LPS) dipilih. Bagi objektif ketiga, rajah Function Analysis Technique (FAST) telah digunakan untuk membangunkan garis panduan implementasi LPS dan 5S. Selepas implementasi dilakukan menggunakan rajah FAST, Pareto digunakan untuk menganalisa hasilnya. Selepas implementasi, satu lagi soal selidik dilakukan dikalangan pengurus atasan dan jurutera kanan dan kaedah T-square digunakan untuk menilai keberkesanan implementasi LPS dan 5S kepada produktiviti pembinaan. Ini adalah untuk pengesahan garis panduan yang dicadangkan. Keputusan telah menunjukkan bahawa prinsip Lean terutamanya LPS dan 5S boleh memperbaiki produktiviti dan prestasi industri pembinaan.

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LIST OF ABBREVIATIONS

AHP	-	Fuzzy analytic hierarchy process
CSF	-	Critical Success Factor
FAST	-	Function Analysis System Technique
JIT	-	Just-It-Time
LPS	-	Last Planner System
PF	-	principle function
PPC	-	Plan-Percentage-Completed
RII	-	Ranking Indices of Importance
SFM	-	Shop Floor Management
TPS	-	Toyota production system
VSM	-	Value Stream Mapping
WBS	-	Work Breakdown Structure

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the recent decade, the subject of the need of increasing the projects productivity by using the Lean technique has caused the managers and project stakeholders to pay more attention to the Lean procedures. The domain of intervention in the development of the building industrial should include managerial, supporting and financial system, addition to the building details and elements. It is evident that exploiting new buildings technologies such as Radio Frequency Identification (RFID), Project Management Information System (PMIS), Online Analytical Processing (OLAP) systems, make achieving the goals more manageable than before. It also happened, that some techniques and methods such as Total Quality Management (TQM), International Standard Organization (ISO), and other productivity methods was merged with exiting company legacy systems for improving the organization. Recent researches on construction management have shown that the Lean could co-exist in other systems. The Lean techniques can be applied from the company perspectives and strategy to the operational level as a culture. This need diffusion tools to check on new attitude for achieving excellent improvement (Abbasian-Hosseini et al, 2014; Hosseini Anvari, 2008).

Lean method is not readily available on market in comparison with other systems and tools such as Management Information System (MIS), and Total Project Management (TPM). It is considered as a knowledge that is related to way of thinking which makes it distinguished from other systems (Hosseini Anvari, 2008).

In the building industry of a new construction method such as industrialized building, most of the construction stages will be done in factory concurrently and on site. Many variances can affect the decision-making in construction method and types

of structure for optimal choice, including the budget allocated for project, materials market price, equipment, and the soil samples of land. Moreover, customers play the main and key roles in all over the project construction cycle (Banki and Zavichi, 2014;2013).

There are more uncertainty factors in conventional construction, as compared to factory-based production process. In manufacturing industries, the uncertainty can be reduced by increasing the quality control of the production process. So, by making continuous improvement, it is possible to achieve better performance. However, in construction industry, there is uncertainty in the whole project life which can be unavoidable. Factors such as climatic conditions, ownership changes, design regulations defects, and overlapping activities are among these unpredictable events. In comparison with other industries, the building construction industry have been able to achieve only a minor increase in productivity in recent decades, while, the other industries have been able to achieve the improvements through the execution of new management methods (Asadi and Hassani, 2018; Hosseiny and Aghdashi, 2013).

Accordingly, construction projects which involve complex projects require rigorous applications of project management and renewing the management method and system. The speed, time, cost and quality in building industry are a primary attribute that are necessary for leading and managing projects, in addition of planning and instructing the works. It also requires determining and monitoring the rate of the operations towards organizational objectives. The most important factors that should be taken into account relates to reducing the cost and time and increasing the quality for building projects (Abbasian-Hosseini, et al., 2015; Hosseiny and Aghdashi, 2013; Naghash Tusi, Sebt, and Zavichi, 2008).

Lean manufacturing is a method in manufacturing that may be applied to construction management to provide the feasibility to produce products by using the least possible cost, human resources, equipment, time and space in productions. It also provides for high level value of customer requirement. Overall, it can be summarized that from the first stage of the work, this method can provide improvement of management in construction for managers. Moreover, the method provides the

possibility of control, provide managerial view and empower decision making at all project operational stages. Lean in the construction context is called Lean construction, which has a theoretical background related to Lean production and Lean thinking (Aziz and Hafez, 2013a).

This research is considering Lean for construction management in construction site in order to achieve on-scheduled planning in construction via identifying the wastes by using Lean techniques. It also, explores the scope, setting and opportunities for implementation of Lean construction throughout the whole construction process, and at the end, offering suggestion in the form of guideline for improving the on-going construction by Lean principles.

1.2 Problem Background

There are many problems and issues during project execution. These problems and issues will cause deviations from the planned construction. The issues are for example, lack of land problem resolution such as land ownership- (especially in road projects where projects involve to passing through a particular land), prolongation of the agreement or disagreement with the owners in some cases, the creation of the valuation problem and others. These issues impose delays and difficulties in the projects. In some cases, the issues like shortage and lack of on-time material supply due to the specific weather seasons can sometimes lead to closure of projects. Thus, some developers use appropriate weather seasons only for construction, causing stagnation or delay in the projects (Hosseiny and Aghdashi, 2013; Naghash Tusi et al., 2008).

Furthermore, the problems due to lack of efficient and appropriate method for recognizing the technical and financial qualification of contractors and consultants or failure to provide the procedures and regulations with high accuracy in order to recognize this financial qualification can be as a factor that caused the defect, reworking or delay in operations. In addition to the above issues that occur during project execution, the organization of President Deputy Strategic Planning and Control

of Iran (SPAC)¹, mentioned that it is the shortage of credibility that causes the project deviation. It is also due to other numerous factors such as budget shortage, the lack of accurate estimation of the amount and size of project activities, weakness in estimating the cost of activities and or weaknesses in project cost control system and alike (Hosseiny and Aghdashi, 2013).

According to Hosseiny et.al (2013) and Naghash Tusi et al. (2008) the project managers will try to speed up or reduce the deviation of the projects, but, even with detailed scheduling at the start of the project, the deviation average time and budget in construction projects is usually much more than the anticipated values. These deviations not only happened in building construction projects but according to statistics reported by organization of President Deputy Strategic Planning and Control (SPAC), time-weighted average of national projects that have been completed in 2004 in Iran, was more than a decade (nearly 11 years). However, similar situation during the implementation of national projects are 4 years in developed industrial countries, which means, more than two and a half times shorter than the situation reported in Iran. It should be known that the management practices have a considerable impact on construction projects conditions and the matters relating to their collection. Therefore, the modern methods and practices of management can be made efficient.

Based on the evaluation of projects deviations studied by researchers in Iran, it can be recognizing that there are no considerable changes in the deviation percentage between project plan and actual project execution in recent years but the project cost keep increasing every year. One of the major factors which cause delay in construction projects is the planning nature of construction projects which has been given less attention. Most of the managers believed that during the project execution there are

¹ This deputy was established in 2007 after the dissolution of the Organization for Management and Planning and was part of its duties. It needs to be explained that, in accordance with the Supreme Administrative Council's decision, part of the rest of the duties of that organization was delegated to the Deputy Director for Development and Human Capital of the President.

different issues and problems which are the main reason of deviations from project plans (Banki and Zavichi, 2013; Kabirifar and Mojtahedi, 2019).

Little attention has been given to identify the most common factors that causes deviations in civil projects, however Banki and Zavichi (2013) stated that this is due to the weakness of the planning system in the projects. However, this issue cannot be directly linked to the executive managers. These problems are due to some reasons that have roots in the planning department. One of the reason for this weakness is that the planners arranged the plans with ideal views, but projects are is faced with the real world problems. If the real program can be adjusted in accordance with the planned program, then there is no reason for it to deviate from the plan. For example, the statistics of the performance of executive development at the level of national projects in 2006 shows that 57.4 percent of the projects which are financially weighing 57.9% (more expensive) are over-scheduled. Likewise, the results of supervision of civil projects in the second quarter in 2007 shows that the 55.5 percent of the visited national civil projects, were over-scheduled. These statistics indicate a lack of efficiency (Banki & Zavichi, 2013).

The organizations problem occur when managers face lack or surplus of financial resources, human resources, materials or facilities. Therefore, these resources should be coordinated by managers. However the lack of coordination between surpluses and shortages caused projects to be over budget or over scheduling. Managers should be able to exploit and coordinate these resources in order to realize the organizations objectives. Thereupon, failure to do this will incur a major cost to construction companies in the management of resources at the construction site. Researchers have shown that high production costs in a construction site are wastes (Mudas), thus failure to create value for customers. A significant portion of these wastes are activities associated with the internal handling of resources. Waste issue in construction industry has been considered as the subject for several research projects among researchers around the world in recent years. Researchers implemented different methods in order to reduce the waste in construction industries. One of effective methods implemented is applying the lean approach in construction

industries (Abbasian-hosseini, Nikakhtar, and Zavichi, 2015; Hosseiny and Aghdashi, 2013).

The wastes can be manifested in the form of stationary machines, waiting, material waste, theft, damage, disruptions to production, insurance, capital, controls and costs for early retirement and rehabilitation. These are examples of both hidden and visible costs that have been identified on construction sites. These costs can all be linked to the handling of materials at the construction site in one way or another. Reducing these costs is a step in the right direction for reducing time and cost, and increasing the quality in building industries. Hence, the biggest concern in construction projects, is the uncertainty of the work in accordance with scheduled plan and also time and cost increment in construction projects that most of them are caused by wastes in construction. So, solving these problems depends on using new or improved management tools and techniques (Hosseiny and Aghdashi, 2013).

1.3 Problem Statement

Iranmanesh (2011) believed that eliminating and reducing wastes in any industries, is an ideal aim for Lean. This is because waste incur huge costs whether hidden or visible. Lean manufacturing can fulfilled this goal and innovate the system by eliminating and reducing waste. Due to its unique characteristics in comparison to other industry, construction industry is inherent with a high level of waste that if it can be reduced a huge unnecessary amounts of capital expenditure may be avoided. In 1992, after entrancing the Lean manufacturing concept in construction area, the researchers such as Alarcon (2008) and Koskela (2013) tried to match the Lean concepts with building construction categories and they have reached good results.

In the last two decades Lean implementation is conducted for 42 case studied in 20 countries but so far in the field of wastes in construction of Iran, less research have been published and sanction made it more critical that is mentioned in chapter 2, Table 2.6 . A lean technique, can identifying the wastes and focuses on them, then solves or reduces them. A Lean system can help project managers to lead, organize,

executing in allocated time and specified financial credits and do projects control in project management and construction management better than before. It can create the maximum possible value for customer. In Iran the construction and building projects are consuming a huge funding are in needs of coherence Lean construction system (Iranmanesh, 2011). Thus, for this research Iran as a case study is selected.

The constructor and project owner in Iran are expecting a productivity improvement to happen in building and construction project but instead decrements have been seen in some parts. This decrement is indicated by the lack of coordination among stakeholders, existence of wastes during project execution, the surpluses or shortages in resources and lack of coordination in planning and execution making project over budget or over scheduling. While in the other industries in developed countries, the application of Lean management has led to a significant process improvements but, these potentials remained unrealized in the construction industry especially in Iran (Hosseini Anvari, 2008; Iranmanesh et al., 2011; Kabirifar and Mojtahedi, 2019)

According to Womack and Jones (2010), the concepts of Lean management aimed to minimize continuously existing waste in production processes. Another point which is especially to be observed in the longer term is the shortage of resources. A shortage of resources will result in more expensive projects and therefore may cause waste of other resources as well. This will exert more pressure on companies to optimize their resources.

Unfortunately, in Iran there is few research on Lean in building construction and that it is not strategically implemented in the construction industry. This raises the question of which innovation is a real competitive advantage that can be realized. The main aim of Lean management is to increase the proportion of value added, and value should be the created at the product creation. Also the aim of Lean management is to optimize the conditions of value creation. For instance, through implementation of appropriate measures to ensure that those individuals who are directly involved in the value creation can “work” under optimum conditions. This “work” analyzed here is the step to transfer the ideas of Lean to the construction production system which is

the construction site and how this can be implemented (Banki and Zavichi, 2013). However, banki and zavichi (2013) did not study the effect of implementation of Lean in construction. They only discussed the gaps in Lean construction.

It is claimed that in today situation, the best way for achieving the project profitability is by reducing or eliminating variation from organization and project construction cycle that contribute to waste (Ballard, and Howell, 2010).

The aim of this thesis is to achieve Lean construction site by identifying the existence of waste in project site, and analyzing the Lean construction management critical success factors for improving the construction site. Therefore, based on previous researchers (Abbasian-hosseini et al., 2015; Aziz and Hafez, 2013b; G. Ballard, 2014; Banki and Zavichi, 2014; Hosseini Anvari, 2008; Kabirifar and Mojtahedi, 2019; Koskela, Ballard, Howell and Tommelein, 2002; Womack and Jones, 2010), it is believed that using Lean construction is a suitable way to assist project-based organizations to manage wastes and simultaneously reduce the costs.

Thus, there is a need to address the issue of wastes in the construction site. In this thesis, by implementing the Lean manufacturing techniques, the wastes in the construction site is evaluated and determined. Based on the three case study companies in Iran, Lean construction critical success factors are identified and classified. The important critical success factors in Lean construction projects is implemented in one construction site belonging to a case study company in Iran. In this thesis researcher focus on application of Lean critical success factor on construction management which can create the required coordination of elimination of waste.

This thesis aims to identify the Lean Critical Success Factors and implement them on a construction site. Although, most construction should be managed systematically but mostly are done conventionally in Iran, and have a tendency to generate wastes inherit in conventional construction method.

This research will allow provide a guideline for process improvement using Lean management methods in individual and small series of production in building

construction. This study is based on questionnaires and observations of real project construction data in Iran.

1.4 Research Objectives and Questions

There are large differences between different industrial sectors in terms of productivity development and optimization potentials. Particularly, in the development of the automobile industry and the building industry in Iran. However, within construction industry, the potential of industrial development through detailed production flow analysis and process improvement are not often considered. This may partly due to the individual character of construction players which are difficult to generalized (Tavasoly and Mortaheb, 2013).

The difficulty with production-oriented and project-oriented processes is that they require knowing the process details, relevant company value creation and their bottlenecks, through which the overall result can be positively influenced. This is related to indicators and measuring concepts that are not available in a form suitable for building construction. If limiting factors are recognized in the production, the question will arise on, which methods have the highest improvement benefits in relation to resource, and how the implementation should be done. Although the practice of construction logistic imputes an essential factor, the implementation of standardized logistic planning and control methods in the construction industry still is in its infancy stage (Tavasoly and Mortaheb, 2013a).

In other industries such as manufacturing, successful planning methods and control methods has established themselves which have led to a clear increase in efficiency. The majority of these industries have introduced in its development central planning instruments which explain the tasks of the quantity, date and capacity planning, as well as sequential and continual process control. In construction however, the problems arose because the link between steering and execution level in most cases is not clear. Only in rare cases the centrally planned and controlled circumstances coincide with reality. This results from the fact that central planning and control

methods always start from a liable model. In practice, this has led to the development of distributed scheduling and control method to overcome the disadvantages of the centralized planning procedure (Mortazavi, 2013).

Construction projects have a unique character and therefore require a special planning and control methods. In the realization of a building project, different disciplines need to work together in different fields. The unique character and the different composition of the project participants contradict at a purely centralized planning and control. Although the focus of this work is on the construction site, the accumulated knowledge can also be transferred to other areas of construction (Hosseini Anvari, 2008).

1.4.1 Research Objectives

This research aims to improve construction site management through Lean critical success factors and evaluating the effectiveness of implementing these factors in construction project in Iran. In order to realize this aim, the following objectives have been identified.

The objectives of the thesis are:

- (a) To evaluate the current awareness and attitudes of the construction experts towards the existence of waste in construction projects and identify opportunity for implementing Lean principle in the construction site within the Iranian construction industry.
- (b) To evaluate and identify the Lean critical success factors in order to implement these factors in a case study building construction site.
- (c) To propose the guideline for implementing the Lean critical success factors on construction project site and evaluating the productivity of construction project site before and after the implementation.

1.4.2 Research Questions and Hypotheses

The work is based on three main research questions:

- (a) What is the waste and Lean awareness among the project experts and Lean implementing opportunity in construction site in Iran?
- (b) Which Lean factors could become the critical success factor in building construction site based on Lean construction principle in Iran?
- (c) Can Lean principle improve the productivity in construction site management?

This study is based three hypotheses of:

- (a) There is awareness of existence of waste in construction site.
- (b) The Lean critical success factors can be implemented in building construction site.
- (c) There is a direct relevance between Lean principle and productivity improvement in building construction site by implementing the Lean construction critical success factors and reducing waste.

1.5 Significance of the Research

The construction industry can only continue to exist if, besides the development of appropriate technological processes, that process must be more efficient to give an advantages of proximity to the market. Given the opportunity they could perform more reliably and operate more flexibly. Comparing the developments in the developed countries with industry of construction, it is evident that they have strong logistics concepts to personalize their processes more efficiently (Ahiakwo, 2014).

The developing countries are regarded as the countries where the average of incomes is much lower than other advanced industrial countries that referred as developed countries (Akinwunmi et al, 2008)

In construction industry in developed countries, the application of Lean management has led to significant process improvements, these potentials have remained virtually unrealized in Iran. However the concepts of Lean management have a goal to minimize the existing waste continuously in production processes and it can be beneficial to the construction industry (Kabirifar and Mojtahedi, 2019).

In comparison with the traditional construction, Lean Construction promotes cooperative production planning while underscoring on the workflows reliability, promoting improved communication system and the pull-based culture (Ballard, 2008; Mossman, 2013). Likewise, it promotes the transparency and trust through the aim of increasing customer value, and improve the construction industry performance (AlSehaimi et al 2014; Ballard, 2008; Ballard and Howell, 2003; Jefferson, 2006). In most countries the training of Lean Construction has recorded the project performance improvement and the complete construction process (Alarcon et al., 2005; Gonzalez et al., 2010; Thomas et al., 2003).

In many countries, Lean principles have been successfully implemented and they are known to improve productivity, planning and control, collaboration and learning, project performances, and communication, (Mossman, 2012; Ballard et al., 2009, Gonzalez et al., 2010; Fiallo and Revelo, 2002; Alarcon, 1997; Tommelein and Ballard, 1997).

However, this has not been the case in Iran. Notwithstanding, the application of various techniques, tools and theories, the construction industries are still suffering from inefficiency in poor quality, cost overruns and time. This issue threatens the whole projects life and lead to wastes, disputes, delays, and losses. Construction industry in Iran is also involved with inefficiencies due to several factors which finally effect on cost, scope and time of the projects. Unfortunately, there are lack of comprehensive research in exploring the factors which cause poor performance in

whole phases of construction projects in Iran. Meanwhile, the prioritizing these factors and also their interaction with performance of project have also not been studied (Kabirifar and Mojtahedi, 2019). Therefore, the aims of this research is identifying and prioritizing the Lean critical success factors which effect on construction project site.

In view of the benefits of Lean critical success factors and the problems associated with the construction industry in Iran, the researcher aims to verify the effect of implementing Lean on effectiveness in construction projects site in Iran.

1.6 Scope of the Study

This research's scope is limited to the construction management and planning of construction site in Iran. Specifically, the thesis target is on the planning scheduling workflow in supporting the Lean critical success factor. The domain of construction management and planning encompasses technical solutions in the form of Lean that can be applicable to the whole process of construction and operations. Also, the research considers the construction site and planning while proposing the technical solutions, through literature review, questionnaire survey, developing and implementation of guideline to evaluate the effectiveness of guideline during construction stage of the project.

Due to the limitation of resources and time and difficulty to find related projects in Iran it is not possible to develop all construction management systems areas within this thesis. Therefore, the research will focuses on the planning schedule workflow on the construction site management in alignment with use of Lean critical success factors to site-based construction. Lastly, as the research took place in the Iran, the construction processes and other work are related to this region.

The case study project for implementation of Lean CSF is a project to build a manufacturing factory for extracting ethanol from planet seeds. The main owner of case study is Milad Khorasan Company. This project is located in a city named Semnan city in north of Iran which is explained in chapter 3.

As summary, the research scope is limited to the following:

- (a) Focusing on planning, and management of the construction project.
- (b) Implementing the Lean critical success factor in a case study project construction site.
- (c) To evaluate the effectiveness of Lean critical success factor in construction site efficiency.

1.7 Research Limitation

This research was done in Iran construction sites and using the construction experts and project managers in the construction industry as source of information for analysis. Unfortunately, the Lean construction is not yet applied in construction sites in Iran completely. Therefore, there were limited construction project which is managing based on Lean principles and knowledge on lean construction. Therefore, the procedure for data collection have been limited to case study sites only. And also, people was involved in training conducted and also the execution of lean projects. Also, there were not enough references about Lean in construction in Iran because of shortage of research about this issue. Also it was limitation to access to the experts and top managers who be interested to participate in the research. Accordingly, the research had to be limited to the case study only.

As the sanction condition creates many problems for companies in Iran such as limited trading situation and more difficult competitive condition. Most company did not permit the Author to access most documents related to their strategy. The researcher had limited access the any information needed for the thesis, and were only able to collect data based on 3 participating companies.

1.8 Research Structure

This thesis consists of 7 chapters as can be seen in Figure 1.1. Chapter 1 gives an introduction about research, by highlighting the research background, research problem and gap. Furthermore, in this chapter, the research aims and objectives along with research questions are outlined. The scope and significance of research is identified followed by the limitations of research. Finally, the structure of the research has been presented. The chapter 2 consists of literature review. In this chapter the Lean principles and techniques, Lean construction, construction site, critical success factors base on Lean construction and the construction situation in Iran are discussed. Chapter 3, consists of research methodology. It presents the method and tools of data collection and analysis and introduces the case study.

Chapter 4 is evaluating the situation of waste and Lean activities in construction site and whether the Lean Management methods and principles can be applicable and acceptable in construction site area or otherwise. For next step in this chapter, researcher aims to identify the critical success factors and prioritizing them by another questionnaire among the construction project experts who are in two parts as top managers and site engineers in Iran who are participated in survey, of implementing the lean management in construction in order to achieve a Lean construction site.

Thereupon, in Chapter 5, the study discusses about data collected in construction site by the methods which is explained in Chapter 3. For the next step, the data will be analyzed as qualitative analysis. This step will take place in Chapter 6. Consequently, in Chapter 6, the research presents the results from analysis of the principles, methods and critical success factors of Lean construction in construction site. Subsequently, for proving the third hypothesis and validate the proposed guideline, at the end on this study, researcher employs another survey-questionnaire, which is distributed among the project managers and top engineers in construction site to validate the guideline.

Finally, in Chapter 7, the limitations, which is included case study limitations and research limitations, conclusion and recommendation will be presented as the closing of the research.

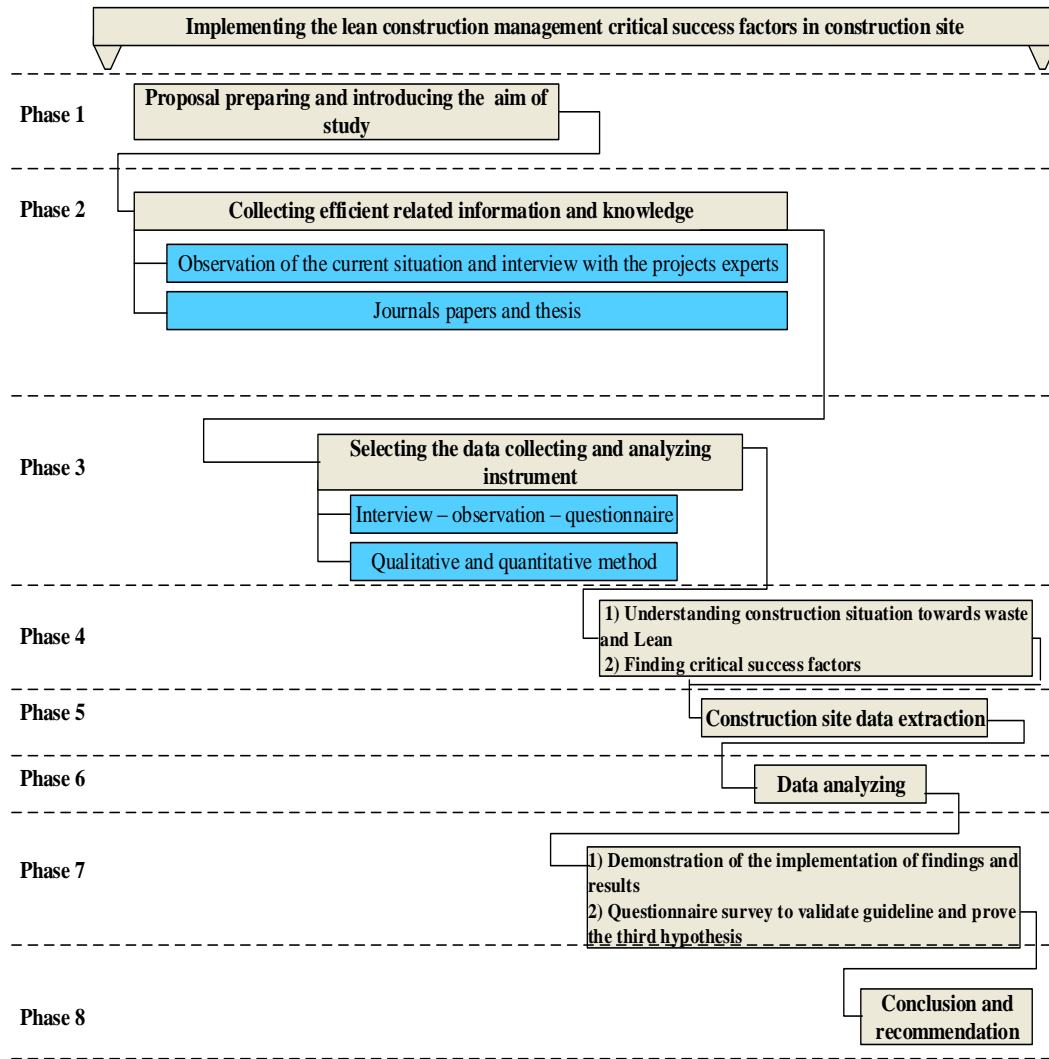


Figure 1.1 Research Structure

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