T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

THE EFFECT OF LEAN CONSTRUCTION PRINCIPLES AND PRACTICES ON IMPROVING PROJECT MANAGEMENT IN IRAQ

MASTER'S THESIS

Jamal Subhi NAYYEF

Engineering Management Department

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LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

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DECLARATION

I, Jamal NAYYEF, do hereby declare that this thesis titled as "The Effect of Lean Construction Principles and Practices on Improving Project Management in Iraq" is original work done by me for the award of the masters degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (/ /2022)

Jamal Subhi NAYYEF

PREFACE

I dedicate the results of my research to all institutions and companies working in the field of construction and contracting that seek to develop their executive and administrative work through the application of the latest technologies in the world for the purpose of implementing and completing their projects and obtaining the economic value they seek.

I would like to extend my thanks and gratitude to my supervisors Dr. Radwan Ghasemlounia and Dr. Zeyad S. M. Khaled, for their support and valuable guidence and advice that helped me accomplish my research.

I also dedicate my research to my father, mother, wife and children, who provided me with the appropriate supportive atmosphere the whole period of my study.

I thank the Turkish Republic and Mr. President for providing study opportunities for Iraqi students to complete their studies in this beautiful country.

Finally and before all, praise to God for blessing me during the pursuit of my acadimic study.

June 2022 Jamal Subhi NAYYEF

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ABREVIATIONS

ANOVA : Analysis of Variance
BIM : Building Information Modelling
CEO : Chief Executive Officer
CO_2 : Carbon Dioxide
df : Degree of Freedom
F : Frequency
GMP : Guaranteed Maximum Price
H&S : Health and Safety
ICT : Information and communication technology
JIT : Just in Time
KSA : Kingdom of Saudi Arabia
LC : Lean Construction
LPDS : Lean Project Delivery System
LPS : Last Planner System
RII : Relative Importance Index
SBCE : Set-Based Concurrent Engineering
SD : Standard Deviation
Sig. : Significance
SPSS : Statistical Package for Social Sciences
TPS : Toyota Production System
TQM : Total Quality Managemen
TVD : Target Value Design
UAE : The United Arab Emirates
UIC : University-Consortium Collaboration
VSM : Value Stream Mapping

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THE EFFECT OF LEAN CONSTRUCTION PRINCIPLES AND PRACTICES ON IMPROVING PROJECT MANAGEMENT IN IRAQ

ABSTRACT

The main goals of successful construction projects is to be completed within the planned time, cost and quality, in addition to minimizing waste, polution and energy consumption. It is believed that adopting lean principles in the construction industry can help a lote in achieving those goals. This reseach aims at studying the benefits, obstacles, success factors and opportunities of adopting lean construction in the Iraqi construction industry and proposed actions. In order to meet these objectives, an exploratory method was followed including a questionnaire survey supported by direct interviews. The questionnaire was designed based on extensive review of relevant litterature. It was directed to (123) professionals of all types of the construction industry stakeholders including clients, consultants, contractors, suppliers, maufacturers and academics in both public and privet sectors in Iraq. The results were statistically analyzed and tested and found to be valid and reiable. Contradictions of very few aspects were then discussed and clarified through direct interviews with (10%) of the questionnaire respondents.

The research revieled that the most important benefits are; better quality assurance with greater reliability, cost saving with higher profitability, earlier completion time with greater certainty, higher productivity with less labour and inventory, controlled environment with lower hazards, and sustainability enhancement with less energy.

The most important exogenous obstacles are: lack of engineers' expertise and workers skills, lack of awareness and knowledge, lack of transparency and integrity, multiple parties in each project, lack of a long-term vision, absence of government support, inefficient transportation and logistics, hard to obtain technology and standardization, fragmented nature of the industry, improper environmental conditions, initial and additional costs, and weak stakeholders' intention.

The most important endogenous obstacles are: poor team work culture, multilayer subcontracting, lack of identification and control of waste, poor feedback, high turnover of workforce, stress and pressure in deadlines, lack of prefabrication, losing some jobs due to work changes, uncertainty in production process, lack of contractor/supplier involvement, and lack of long-term relationship with suppliers.

The most important proactive measures for success factors on national scale are: expertise and skills, information and communication technology, government strategy and commitment, coordination/collaboration between parties, design and process standardization, demand and market conditions, awareness and knowledge, research and development, and technology transfer.

The most important proactive measures for success factors on institutional scale are: design, manufacture and construction integration, constructability and life-cycle engineering, facilities and equipment, business and finance, planning and control, organization and leadership, cost and risk management, quality assurance and work environment, supply and storage management, transportation and logistics, and procurement and contracting strategy.

Finally the most important actions needed are: 1) Financial support including: non-delayed payment, business and marketing, tax exemption and levy reduction, affordable loans, and demand continuity and stability. 2) Productivity improvement including: training, mechanization, controlled environment, information and communication technology, and health and safety measures. 3) Management enhancement including: collaboration and coordination, organization and leadership, extensive planning and control, change strategy, and transportation, logistics and supply chain management. 4) Knowledge and skills leverage including: consultants' development programs, craftsmen training programs, academic education, manufacturers' and Contractors' development programs, and regulations, codes, standards and certification. and 5) Quality assurance including: design, manufacture and construction integration, design and processes standardization, causal analysis and technical solutions, product, process and people certification, and environmentally friendly life cycle engineering.

Keywords: *Lean construction, Iraqi construction industry, Improvement methods in the construction industry*

YALIN İNŞAAT İLKE VE UYGULAMALARININ IRAK'TA PROJE YÖNETİMİNİN İYİLEŞTİRİLMESİ ÜZERİNE ETKİSİ

ÖZET

Başarılı inşaat projelerinin ana hedefleri, atık, kirlilik ve enerji tüketimini en aza indirmenin yanı sıra planlanan süre, maliyet ve kalitede tamamlanmasıdır. İnşaat sektöründe yalın ilkelerin benimsenmesinin bu hedeflere ulaşmada çok yardımcı olabileceğine inanılmaktadır. Bu araştırma, Irak inşaat endüstrisinde yalın inşaatın benimsenmesinin yararlarını, engellerini, başarı faktörlerini ve fırsatlarını ve önerilen eylemleri incelemeyi amaçlamaktadır. Bu hedeflere ulaşmak için, doğrudan görüşmelerle desteklenen bir anket anketini içeren bir keşif yöntemi izlenmiştir. Anket, ilgili literatürün kapsamlı bir şekilde gözden geçirilmesine dayalı olarak tasarlanmıştır. Irak'ta hem kamu hem de özel sektördeki müşteriler, danışmanlar, müteahhitler, tedarikçiler, üreticiler ve akademisyenler dahil olmak üzere inşaat sektörü paydaşlarının her türden (123) profesyoneline yönlendirildi. Sonuçlar istatistiksel olarak analiz edildi ve test edildi ve geçerli ve güvenilir bulundu. Çok az sayıdaki çelişkiler daha sonra tartışıldı ve ankete katılanların (%10) ile doğrudan görüşmeler yoluyla açıklığa kavuşturuldu.

Araştırma, en önemli faydaların; daha yüksek güvenilirlikle daha iyi kalite güvencesi, daha yüksek kârlılıkla maliyet tasarrufu, daha kesin bir şekilde daha erken tamamlanma süresi, daha az iş gücü ve envanterle daha yüksek üretkenlik, daha düşük tehlikelerle kontrollü çevre ve daha az enerjiyle sürdürülebilirlik geliştirme.

En önemli dışsal engeller şunlardır: mühendislerin uzmanlık ve işçi becerileri eksikliği, farkındalık ve bilgi eksikliği, şeffaflık ve dürüstlük eksikliği, her projede birden fazla taraf, uzun vadeli bir vizyon eksikliği, hükümet desteğinin olmaması, verimsiz ulaşım ve lojistik, elde edilmesi zor teknoloji ve standardizasyon, endüstrinin parçalı yapısı, uygun olmayan çevre koşulları, başlangıç ve ek maliyetler ve zayıf paydaş niyetleri.

En önemli içsel engeller şunlardır: zayıf ekip çalışması kültürü, çok katmanlı taşeronluk, atıkların tanımlanmaması ve kontrol edilmemesi, yetersiz geri bildirim, yüksek işgücü devri, son teslim tarihlerinde stres ve baskı, prefabrikasyon eksikliği, iş değişiklikleri nedeniyle bazı işleri kaybetme, belirsizlik üretim sürecinde, yüklenici/tedarikçi katılımı eksikliği ve tedarikçilerle uzun vadeli ilişki eksikliği.

Ulusal ölçekte başarı faktörleri için en önemli proaktif önlemler şunlardır: uzmanlık ve beceriler, bilgi ve iletişim teknolojisi, hükümet stratejisi ve taahhüdü, taraflar arasında koordinasyon/işbirliği, tasarım ve süreç standardizasyonu, talep ve piyasa koşulları, farkındalık ve bilgi, araştırma ve geliştirme ve teknoloji transferi.

Kurumsal ölçekte başarı faktörleri için en önemli proaktif önlemler şunlardır: tasarım, üretim ve inşaat entegrasyonu, inşa edilebilirlik ve yaşam döngüsü mühendisliği, tesisler ve ekipman, iş ve finans, planlama ve kontrol, organizasyon ve liderlik, maliyet ve risk yönetimi, kalite güvencesi ve çalışma ortamı, tedarik ve depolama yönetimi, nakliye ve lojistik ve tedarik ve sözleşme stratejisi.

Son olarak ihtiyaç duyulan en önemli eylemler şunlardır: 1) Gecikmeyen ödeme, iş ve pazarlama, vergi muafiyeti ve vergi indirimi, uygun fiyatlı krediler ve talep sürekliliği ve istikrarı dahil olmak üzere mali destek. 2) Eğitim, mekanizasyon, kontrollü çevre, bilgi ve iletişim teknolojisi ve sağlık ve güvenlik önlemleri dahil olmak üzere üretkenlik geliştirme. 3) Aşağıdakileri içeren yönetim geliştirme: işbirliği ve koordinasyon, organizasyon ve liderlik, kapsamlı planlama ve kontrol, değişim stratejisi ve ulaşım, lojistik ve tedarik zinciri yönetimi. 4) Danışmanların geliştirme programları, zanaatkar eğitim programları, akademik eğitim, imalatçıların ve Yüklenicilerin geliştirme programları ve yönetmelikler, kurallar, standartlar ve sertifikasyon dahil olmak üzere bilgi ve becerilerden yararlanma. ve 5) Aşağıdakileri içeren kalite güvencesi: tasarım, üretim ve inşaat entegrasyonu, tasarım ve süreç standardizasyonu, nedensel analiz ve teknik çözümler, ürün, süreç ve insan belgelendirmesi ve çevre dostu yaşam döngüsü mühendisliği.

Anahtar Kelimeler: *Yalın inşaat, Irak inşaat sectorü, İnşaat sektöründe iyileştirme yöntemleri*

1. INTRODUCTION

1.1 Background

constructing industries deal with the creation, maintenance, rehabilitation and renovation of buildings and other types of permanent infrastructures like dams, bridges, highways, railways, airports, seeports, utility systems and alike. It is concerned with providing different types of facilities including; resedential, education, health, commercial, transportation, irrigation, watersupply, sewerage and industrial facilities. Construction works are performed through projects. Construction projects starts with planning, design, estimating (time, cost and other required physical resources), assignment and then execution and commissining of works which all need financing. Each construction project requires a unique team in each stage and as a whole (Abdul Lateef and Abdul-Aziz, 2015).

The construction industry faces many challenges like rising material and labor costs, skills and technology problems, increased competition with shrinking profit margins and the emergence of sustainbility and green building concepts. On the other hand, construction projects usually confronted performance problems like time and cost overrun, low productivty and quality defects (Muir, 2005).

Such huge and important industry, suffering such challenges and problems, had drivin its stakeholders to look for sollutions. One solution is to make use of lean thinking already addopted in the manufacturing industry. Lean represents a technique that designs producting systems to reduce any materials' waste, timing as well as efforts with the purpose of generating as much value as possible (Koskela et al., 2002).

Lean manufacturing focuses on decreasing wastes, including not only wastes of materlais but also labor and timing loss created by certain procedures. If all of such wastes have been eliminated from the systems, accordingly the systems may be considered fully optimal. Such necessitates ongoing efforts to decrease or remove wastes, beginning with the designing procedure and continuing through production, distribution, product support, and beyond. However, it is not just about decreasing trash; it is also about enhancing speed, efficiency, and quality in addition to waste removal. This necessitates a significant amount of effort to cultivate a Lean culture among the workforce, which, in turn, results in increased value for both the client and the firm (Blokdyk, 2019).

The Lean Constructing denotes to adaptating and applying the notions and techniques of lean production in the constructing industries in which a vast amount of waste is witnessed. The primary goals of lean constructing are to decrease wastes, increase productivity and increase values for customers throughout the project lifecycle while ensuring customer requirements are met without delays or defects. Yet, several obstacles exist which facing the application of lean constructing due to conventional management practices, undesirable organization cultures, and absence of the required technic expertises as well as knowledge (Koskela et al., 2002).

In this research, previous studies were reviewed to have a comprehensive idea on lean construction and its impact on improving construction projects performance, in addition to the expected challenges facing the application of this approach and then focusing on the opportunities of adopting this approach in the Iraqi construction industry. The latter is practicing major difficulties, including timing along with costs overrun and little production and quality, due to political and economic instability. Hence, the possibility of adopting lean construction is examined including benefits and challenges in order to find solutions and then recommendations to facilitate its application.

1.2 Problem Statement

Inspite of many performance defects witnessed by the Iraqi construction industry, for example time along with costs overrun, little quality and productivity, and high rates of wast, this important and vital industry is still hesitated to adopt lean construction and gain its benefits to mitigate these defects. A matter that necessitates studying the possibility of adopting lean construction in Iraq, its potential benefits, expected obstacles, readiness to alter, success factors and proposed actions.

1.3 Research Aims and Objectives

The current work aims at drawing a roadmape to the Iraqi constructing industry to facilitate adopting lean construction. The following objectives were set:

1. To find out the possible benfits that could be gained.
2. To find out what potential obstacles that could be confronted.
3. To determine the rediness success factors.
4. To reach some proposed actions to be taken

1.4 Research Questions

The roadmape to adopt lean construction in Iraq has to answer the next questions:

1. What is the role of construction projects planning and design in this sence?
2. What is the role of construction projects procurement in this sence?
3. What is the role of construction projects execution in this sence?
4. What is the role of the construction industry stakeholders in this sence?
5. What is the role of the government in this sence?
6. What is the role of markets in this sence?
7. What is the role of technology transfer in this sence?
8. What is the role of training and education in this sence?

1.5 Research Hypothesis

The Iraqi construction industry is not famelier with Lean Construction nor motiviated to addopt it. Meanwhile, it is possible to overcome the obstacles facing its application in construction projects in Iraq.

1.6 Research Justification

It has been noticed that traditional methods of managing any constructing project are unable to avoid the low perforemance of such constructing project in Iraq. A novative approach need to be adopted. Lean construction proved to be promissing in other countries.

1.7 Research Methodology

This research is an experimental work that tries to find out the challenges of adopting lean constructing in view of current practice and the actions needed. Quantitative and qualitative approaches were used. A wide range of related literature was reviewed and then a questionnaire survey was directed to Iraqi professionals including clients, contractors, manufacturers, suppliers, consultants and academics. The questionnaire was supported by personal interviews conducted with some executives among the aforementioned stakeholders in order to address critical issues. Special attention was paid to building projects for it comprises many activities, skills and types ofmaterials. Statistical analysis was carried out to verify the findings.

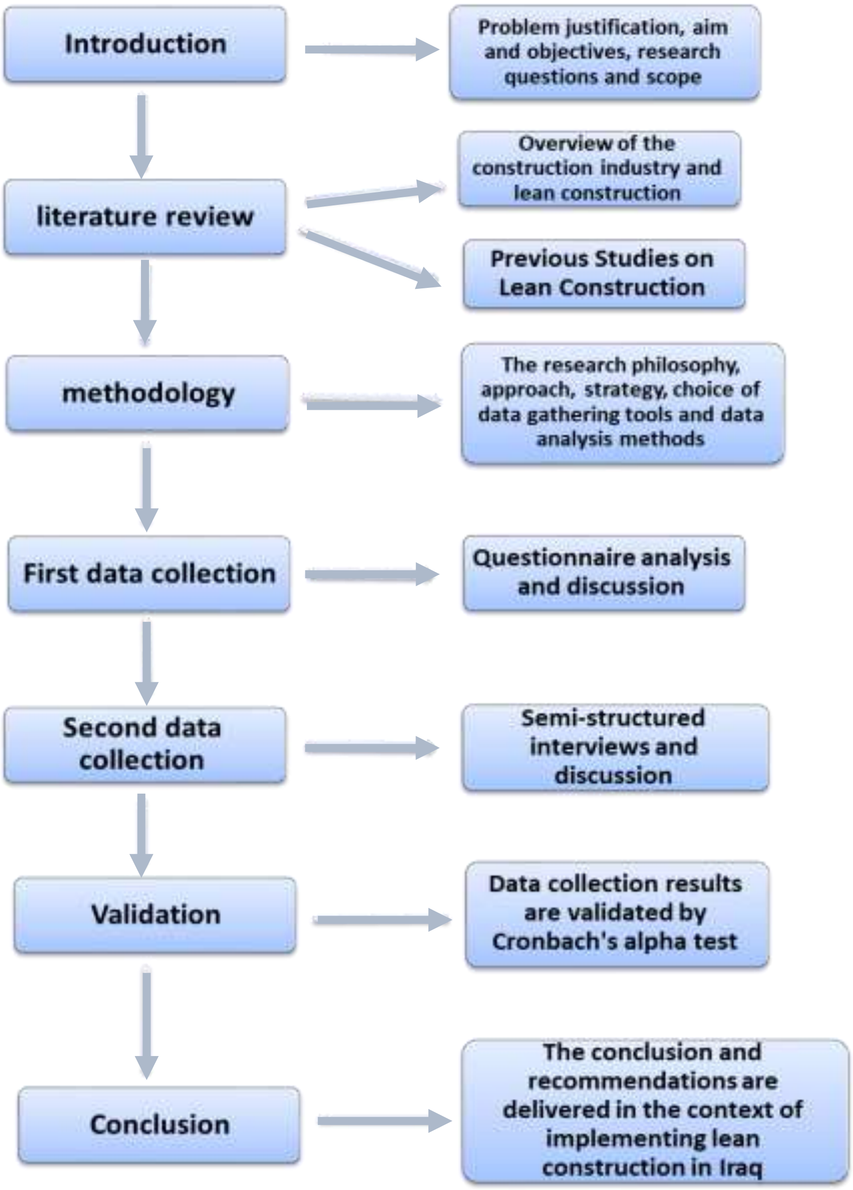

Figure 1.1: Flow of research work

1.8 Research Limitations

Due to scarcity of construction projects that clearly implement lean construction in Iraq, actual local casestudies on construction sites are not possible. Therfore, the study was forced to be based on conducting a questionnaire survey and personal interviews to a varity of Iraqi construction stakeholders. Building projects experts were especially adressed becouse building projects comprises a wide range of materials and skills and so involving different parties.

1.9 The layout of the thesis

The organization for the current work can be given as follows:

Chapter One: provides an introduction including; research background, problem, objectives, questions, hypothesis, justification, methodology and limitations.

Chapter Two: provides literature review related to constructing industries in general and then in Iraq, material waste and sustainability, processing waste and product value, lean production, lean construction advantages and barriers, lean construction in Iraq, factors to aid lean construction, construction project management and success factors, best practices for lean construction, and finally some related previous studies.

Chapter Three: explains the research methodology including its; framework, tools and jurisdiction, and then the questionnaire and the interviews and their study samples.

Chapter Four: demonstrates the results of the questionnaire survey including; all about the respondents' identification, construction projects success factors, lean construction adoptability in Iraq, potential benefits, expected obstacles, readiness to alter, proposed actions, actual practice, degree of acceptance to change and open suggestions. Furthermore, Interviews were conducted to (10%) of the respondents in order to clarify some few contradictions found to exist in their opinions. The questionnaire survey results were subjected to reliability and validity tests.

Chapter Five: provides discussion of the research findings classified into the role of; planning and design, procurement, execution, industry, government, markets, technology, training and education.

Chapter Six: provides conclusions, recommendations and suggested future studies.

2. LITERATURE REVIEW

2.1 Introduction

The present chapter makes a review related to construction industry issues, including the construction industry in Iraq, that is related to lean construction. The origin, history and main beliefs regarding lean constructing are overviewed, along with its benefits, the most important obstacles that hinder its application, the most in effect uses which got enhanced so far to impliment it and its relation to construction project management. Relevant previous studies in this sense are also summarized.

Like a new manufacturing philosophy for constructing sectors, lean construction involves applying as well as adapting lean production's underlying principles and methodologies. This manufacturing modelling has been adopted by the industry in order to increase its performance and minimize the amount of waste which exists in the building sector. (Antillón, 2010).

Lean producting can be known as “a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible value” (Koskela et al., 2002).

Lean Production emphasizes upon reducing waste , increasing customer value, and continual improvements. In the construction business, certain lean production principles along with procedures have been effectively adopted, and several useful tools, including the Last Planner Systems, were established within lean constructing (Antillón, 2010).

2.2 The Construction Industry

The constructing industry is defined as “comprising new construction work, general construction and demolition work, construction and repair of buildings, civil engineering, installation of fixtures and fittings and building completion work” (Druke and White, 1996).

Planning, regulating, designing, manufacturing, constructing, and maintaining buildings and other forms of structures are all part of the constructing industry's operations (Burtonshaw-Gunn, 2009).

The concept "construction" could refer to the erecting, maintenance, and destruction of a wide range of structures, including a house, workplace, store, reservoir, bridge, highway, home additions, chimney, enterprises, and airport. Several various companies perform specialized work related to specific technologies, but only a handful specialize in one style of constructing or a single technology. Due to the links between both the parts and the industry's boundaries are ambiguous, the industry and the challenges which impact constructing projects are hard to understand (Murdoch and Hughes, 2015).

The scope of the construction industry should further include designers, material suppliers and equipment providers (Barrie and Paulson, 1992).

2.2.1 Sustainability and construction material waste

Material waste production from different types of industries is attracting global concern for green environment and sustainabile concerns. The terms "sustainability" and "sustainable development" have been utilized indiscriminately. Sustainability refers to addressing the requirements of the current generation without jeopardizing future generations' capacity.The expanded definition of sustainability now includes economic, social, and environmental performing, as well as profits, people, as well as the planet (Porter and Kramer 2006).

Sustainability in all types of industries emphasizes upon creating totally recyclable productions; ecological and green manufacture procedures and totally dismantling produces when the operational lifespan for such produces comes to end. Waste disposal is clearly linked to environmental sustainability (EPA, 2009). As a result, eliminating garbage can benefit the environment. Transporting production materials efficiently, for example, reduces CO_2 emissions. Another example is that fewer faulty items save raw materials and energy used in rework and trash recycling. Waste collection contributes significantly to environmental conservation and enhancement, as well as the enjoyment of consumers and employees (Mostafa et al., 2013).

2.2.2 The construction industry in Iraq

The constructing industries use to play a prominent part within the economical as well as social country developing. They contribute to fulfill infrastructure needs according to the National Development Plan, such as transportation, irrigation, education, health, industrial, agricultural, and various governmental building projects. However, the Iraqi infrastructure has been exposed to destruction as a result of wars since 1980's and retardation due to the economic blockade since 1991. Furthermore, the governments fail to activate this industry after 2003 (Mohammed, and Jasim, 2018).

There is an enormous shortage nowadays in all types of public services. Moreover, there is a lack of means for quality assurance over all types of construction projects in addition to absence of qualified contractors within the non-public sector and qualified staff in the gogernmental sector (Mohammed, and Jasim, 2018).

Due to corruption, qualified local and international contractors are not willing to work in Iraq. Even state companies have no effective means for internal control over sub-contractors where most of them are not qualified enough. As a result many problems are confronted including time and cost overrun and low quality accompanied with high rates of waste (Mohammed, and Jasim, 2018).

2.2.3 Lean Production

Lean thinking has emerged since the move towards mass manufacture which had started soon after the Second World War. However, in (1988) Taiichi Ohno and Shigeo Shingo have set in place its main principles within the Toyota manufacture systems. In which it emphasizes upon removing times been wasted and materials from each stage of the manufacture procedure. Attention was shifted to the whole producing systems instead of the limited attention upon worker productivity of craft productions and machine productivity upon mass productions (Howell, 1999). As in early 1990s, the Toyota manufacturing systems were dubbed the Lean Producing Systems, such systems that improved the world and made the concepts and techniques of lean production more popularized and easily accessible (Womack et al., 1990). The term ‘lean’ became counterpoise to ‘mass’ production systems (Ballard, 2000).

Systems belong to the Toyota Production initially depended upon double ideas: 1) “Jidoka” i.e. “automation with a human touch”, which refers to the apparatus that is stopped instantly once a problem happens which prevents to produce any imperfect product, besides 2) "Just-in-Time" manufacturing is a method of manufacturing whereby any procedure produces just what is required for the following procedure within a constant flowing. "Jidoka" enables a single person to visually monitor and operate a large number of machines. Workers had to handle problems as they emerged, or the entire manufacturing line would come to a halt. Such can bring issues to be clearly seen and encourage the identification and resolution of issues at their source. The reason behind “Just-in-Time” is to “make only what is needed, when it is needed, and in the amount needed”. Based on both concepts, Toyota was able to create good quality productions in a cost-effective manner by removing defects. It is capable of producing high-quality items in a timely and effective manner that meet all client needs.

The Lean Enterprise Institute summarized the waste elimination steps based on lean principles as follows (Womack et al. 1990):

1. Specifing the value according to views of the last client for each production family (A product family comprises the production along with its variations that go through the same processing stages as well as mutual equipment before shipping to the client).

2. For every production family, identifying all of the phases in the value streaming and eliminate those that do not provide value wherever possible.

3. Ensuring that the value-making activities are carried out in a precise order so that the product may easily pass to the client.

4. Allowing clients to experience value from another upstream action like the flowing is stored.5. Restarting the procedure as the previous phases are presented, and keep going until you achieve a sense of perfection, where ideal value is generated without wastes, as shown in Figure. (2.1).

Figure 2.1: Waste elimination steps based on Lean Enterprise Institute

Source: (Womack et al. 1990)

2.2.4 Product value and process waste

All industries are increased to sustain value-added activities that customers are prepared to pay for through continual development. Customers see value when an activity, process, or operation offers a product or service that meets their needs and exceeds their expectations. Value indicators, such as those provided in Table, can help identify the major drivers of customer value or end-user value of a product or service can be further identified using value indicators as listed in Table (2.1) (Naylor et al., 1999).

Table 2.1: Value indicators

Quality	Services level	Lead time	Cost
- Meet the customer needs. - Eliminating wastes. - Ongoing improvement. - Least variances.	- Customer support. - Product service. - Product support. - Flexibility to meet customer demands. - Flexibility to meet market change.	- Time to market. - Concept to delivery. - Order entry to delivery. - Response to market forces. - Lead time. - Materials inventory.	- Design and engineering conversion. - Quality assurance. - Distribution. - Administration. - Inventory. - Material.

Source: (Naylor et al., 1999)

Any action in a procedure which can add costs and/or time without adding value to products or services in the eyes of consumers is considered process waste. Three kinds of value-related production actions have usually been found. The first is value-added action within which the raw materials are processed into what customers want, the second is a necessary but not value-added action within which a waste action is unavoidable under current circumstances, and thelast represents Non-value-added action in which a waste action is clear and should be completely eliminated (Hines, and Rich, 1997).

It is obvious that any production system should consist of inputs, processes and outputs using proper tools. As a result, efficient waste elimination should extend non-value-added activities to a wider scope of waste elimination covering all the components of the production system. In this sense, nine types of waste in production systems are identified: 1) Overproduction, 2) waiting, 3) unnecessary transportation, 4) incorrect processing, 5) overstocking, 6) unnecessary, 7) defects 8) non-employee creativity and 9) environmental waste. The last type of wastes includes actions which causes hurt to humans and to health of the environment, for example unnecessary release of materials into the air, waters and/or lands. The Toyota producing systems were the first to identify the first seven kinds, while the eighth kind got recognized by (Womack and Jones, 2003) and the ninth type was identified by (Nizami et al., 2017).

2.3 Lean Construction

The construction sector was pushed to investigate and embrace new lean production concepts and practices as an alternative to the existing construction production systems. (Koskela, 1992). This was elaborated in the dissertation entitled "An exploration towards a production theory and its application to construction" (Koskela, 2000).

In order to make lean production easier to adopt in the construction sector, additional tools were created based on the principles of lean production. The last planner system, which is one of the most successful lean construction tools, establishes itself as a useful approach for improving workflow efficiency by stabilizing it and shielding it from upstream unpredictability (Antillón, 2010).

2.3.1 Advantages of lean construction

Despite the fact that the construction sector has faced several hurdles in implementing lean construction on a global basis, certain nations recognized the possibility to accept advances through lean implementation (Vilasini et al., 2011).

Numerous profits as well as privillages of adopting lean construction have been recognized by many researchers. These benefits can be summarized as: improving safety, lessening waste, eliminating costs, increasing production, shortening timetables, improving reliability, enhancing quality, satisfying client needs, increasing expectedness, and improve design to improve building ability (Mossman, 2009).

The most significant benefit of utilizing lean constructing is to reduce wastes (Luo et al., 2005). This can be achieved by encouraging the following (Akinradewo et al., 2018):

• Reduce the amount of time equipment and personnel are handled twice.

• Work as a team to balance and coordinate flows.

• Remove any limits imposed by materials.

• Keep input variance to a minimum.

• Reduce the number of changeovers and complicated setups.

• Lower interpersonal tensions.

It is also emphasized that The most significant advantage is to satisfy client needs. By Employing lean constructing police with client focus, Construction businesses can do the following: (Womack and Jones, 2010):

• Provide for the client's needs.

• Define value from the perspective of the project.

• Respond to opportunities and changing demands with flexible resources and adaptable planning.

• Make utilization of goal costs and value.

Construction site neatness and well-organization represent other profits as they constitute chances for improvements and bases of difficulties can frequently be hidden. For instance, cracking, losing parts or leakages in equipment can be more seen in a clean workingplace and this increases safetness at work along with reducing the accidents' opportunities to the minimum (Salem et al., 2005).

Lean construction also leads to the use of relevant tools, skillful workers, and high performance of adequate equipment. Behavior and skills are significant to reduce wastes and constant improving of production (Akinradewo et al., 2018).

Lean construction also helps in reducing inventory, making delivery as required, increasing the usage of workers having many skills and drawing the management attention on using assets in the most active activities. The gains are: to reduce a lead time, to reduce costs, to improve production, to decrease wastes, to enhance quality, to eliminate flaws and to decrease cycle timing (Modi and Thakkar, 2014).

Furthermore, there are labour-related benefits in lean construction that can be summarized as follows (Modi and Thakkar, 2014):

• Reduction in labor costs while preserving or growing production.

• Make the most of multi-skilled workers.

• Increase the effectiveness of stakeholder communication.

• Encourage people to work together.

• Promote lean thinking across all project participants.

2.3.2 Common barriers to lean construction

According to several studies carried out in many States, the barriers which confront a the six primary factors of effective lean constructing implementation are as following:

1. Management barriers: Most of those barriers mentioned in many studies had been discovered to be in relation with managerial aspects, for instance, delayed decision making, a bsence of managerial supporting and commitments, defining projects in poor way, delays in materials' delivery, a non - availability of equipment, materials' rareness, an insufficient time to innovation, an inappropriate organisational structure, poor administration, a bsence of logistics activities, weak communicating, the usage of non-standard constituents, a lack of consistent job involvement, Long implementation time, insufficient preplanning, bad procurement selection techniques, poor planning, insufficient resources, lack of client and supplier interaction, consumer focus, and lack of long-term planning (Common et al., 2000; Alarcon et al., 2002; Forbes et al., 2002; Olatunji, 2008;

and Alinaitwe, 2009). Though some appear to be easy addressed, the overcoming of these barriers is very critical to the implementation of lean construction. Top management holds the major role in ataining successful implementation of innovative strategies (Salem et al., 2006) Therefore, to assure a successful lean practice, the top management should be commited to develop as well as implement an effect plan and sufficiently provide any needed resource plus support.

2. Financial barriers: Innovative solutions such as lean construction need sufficient funding to encourage workers, supply necessary equipment, and hire lean specialists to assist both employers and employees in putting the concept into practice. Finance-related issues are one of the most prevalent roadblocks to lean implementation in enterprises around the globe. The nature of this barrier, however, differs per country. Corruption, insufficient financing, inflation, rising costs, low salaries, a lack of incentives, and risk are among the most typical roadblocks. (Common et al., 2000; Olatunji, 2008; Mossman, 2009).

3. Education barriers: Scholars, research scientists, professionals, and entities like the Lean Construction Institutes, Constructing Lean Implementation Program, Constructing Excellence, and the British Research Establishment have all made attempts in specific countries to raise awareness, provide instruction, and provide information about lean constructing. Nevertheless, only a few nations have these organizations. Regardless the enormous number of study articles, education has been identified as one of the most prevalent impediments to lean practices. Poor understanding, absence of technic skills, high-level illiteracy, inadequate training, absence of holistic execution, insufficient information, absence of project leadership skill, insufficient exposing to lean implementation prerequisites, absence of awareness programs, difficulties to understand concepts, as well as absence of information share all represent educational barriers . (Common et al., 2000; Alarcon et al., 2002; Olatunji, 2008; Jorgensen and Emmitt, 2008; Alinaitwe, 2009; Abdullah et al., 2009; and Mossman, 2009).

4. Governmental barriers: Despite the construction industry's enormous economic contribution in several nations, it confronts multiple issues that appear to be tied to government policy. According to various research, some restrictions evolved in some nations as a result of government views toward the building sector. An indepth examination of the research findings exposes roadblocks such as government bureaucracy, policy inconsistency, a lack of social amenities and infrastructure, material scarcity, and volatile pricing commodities. Furthermore, some financial obstacles, such as inflation, professional wages, and corruption practices, may be linked to government impedemnts. (Olatunji, 2008; and Alinaitwe, 2009).

5. Technical barriers: The technological components of lean construction have an impact on its implementation. Technical barriers are those that have a direct influence on the application of lean construction technologies including dependability, simplicity, adaptability, and benchmarking (Koskela, 1992). Complex, imprecise, and/or incomplete design, inadequate measurement tactics, lack of acceptable building methods, lack of prefabrication, supply chain unpredictability, and lack of design constructability were highlighted as some of these impediments (Ballard and Howell, 1998; Koskela, 1999; and Alinaitwe, 2009). In addition, the fragmented character of the sector was noted as an impediment to collaboration and teamwork (Mossman, 2009).
6. Human attitud barriers: One of the primary issues impacting the execution of lean construction is human mindset (Howell, 1999). Lack of transparency, cultural change, a lack of team spirit, a lack of self-criticism, a lack of cooperation, poor housekeeping, poor leadership, leadership conflict, a lack of understanding of the client's brief, misconceptions about lean practice, over enthusiasms, and fear of unfamiliar practices are all examples of human attitude barriers. (Common et al., 2000; Alarcon et al., 2002; Forbes and Ahmed, 2020; Alinaitwe, 2009; and Mossman, 2009).

2.3.3 Lean construction in Iraq

It can be noticed that most of the studies on lean construction, as a modern method for construction project management, were conducted in developed countries. This can be attributed to their stable political and economic conditions and the existence of qualified companies in different construction-related industries, a matter that does not exist in Iraq. Due to the war of the eighties, Iraq relied on governmental direct force approach in executing construction projects making use of foreign labour, meanwhile, even the foreign labour vanished due to the economic blockade in the nineties. This was the case until the invasion of Iraq in 2003 which was accompanied with a wide scale of alteration in all the policies of the government. This new circumstances opened the door widely for the private sector to take the lead, yet it was not qualified enough to handle this role. Unfortunately their performance was very poor concerning time, cost and quality. On the other hand the public sector wasn't capable to adopt modern techniques for it was subjected to damages and corruption. In addition to financial and administrative failure, the employers and employees were reluctant to move to modern techniques for they lack knowledge and awareness in lean construction. The opportunity to adopt lean construction needs to be investigated.

2.4 Factors to Aid in Lean Construction

2.4.1 Standardization

Traditional construction methods are far from assembly lines. Yet, Everybody understands what to do and the time to do it in case only a single way is available to accomplish things. As a result, minimalism may help construction sites run more smoothly and enable everybody to become even more creative.

A weakness point in traditional construction processes is the lack of standardization. Project managers use to keep the similar kinds of practice being utilized in earlier assignments, whether they fit with the new ones or not. This might also lead to considerable variation in the same company from one project to another by doing in different ways causing the entire organization to suffer poor performance (Ellis, 2020).

It's also more challenging for groups to interact when they're employing various equipment and applications, or depending on paper notes and memory to get things done. Such variation also makes the data of each team less reliable or useful to others. Bringing all information under one roof accelerates and simplifies procedures since it compels each team member to interact using the same format, language, and tools (Ellis, 2020).

When construction processes are repeatable, replicable and linear, works can be more effectively done. Procedures should also be set in a way that they can be measurable in order to assess how well the teams are performing and to prevent different judgments in different projects. Standardization of construction works, makes it simpler for the teams to be succeeded and make a workingflow which guarantees projects to go on the way it should be and finish on time (Ellis, 2020).

Furthermore, standardizing the technology used by a construction company in all of its projects reduces potential business disruption. Moreover, adopting modern standardized technology minimizes both inefficiencies and redundancies.

When considering the advantages of standardization, it can obviously be noticed how standardization can aid in adopting lean construction. The benefits of standardization can be summarized in this sense by: productivity increase, mistakes reduction, communication improvement, better information availability and accessibility, better opportunities for continuous improvement and scalability of organization growth (Ellis, 2020)

2.4.2 Prefabrication

In order to take the best advantage of standardization, prefabricated construction is desirable. Construction prefabricating denotes to an advanced constructing tools which includes manufacturing construction constituents within manufacturing works prior to assembling at construction sites(Baghchesaraei et al.,2015) . This can help achieve the desired outcomes of reduced cost and time, reduced health and safety concerns, reduced construction waste, reduced energy consumption, and reduced carbon emissions, as well as improved quality, predictability, sustainability, whole-life performance, and profitability. Prefabricated construction is regarded as an essential technique to achieving sustainable construction and building industrialisation because to its enormous socioeconomic and environmental benefits (Cheng, et al., 2020).

Lean construction contractors who choose prefabricated construction can appreciate a flexible, high quality, quicker, safer, profitable, and environmentally friendly constructing methods with reduced site disruption. This goes with value creation concept of lean construction. Prefabrication in this way frees up resources and opens up doors for incremental improvements in the value stream (Björnfot and Sardén 2006).

2.4.3 Technology innovation

Innovation in construction methods has created significant chances for performance improving according to cost saving, construction speed and higher quality and sustainability. Technology inventions similarly assist in mitigating the changing influence of any weather condition upon construction actions at site, and also improve planning and coordination of constructing actions and establish different marketplace opportunities by improving the attractiveness of constructing companies (van Egmond, 2012)

Construction processes perceived in numerous countries have evolved along with growing mechanization, rationalization, systematization, standardization and automation of construction. This means shifting most of the constructing actions as of the sites till the factories to produce building products, components and technologies (van Egmond, 2012)

In the construction business, it appears that a mix of new solutions based on cumulative technology and knowledge breakthroughs have been embraced in an attempt to shift away from craft-based building and toward a systematic construction process that may better utilize resources. Indeed, from the standpoint of building innovation, the confluence of technologies and knowledge from various fields and disciplines is visible. The reduction, reuse, and recycling of resources, as well as the elimination of harmful compounds, appear to be the major concepts employed to promote sustainability in building (Kibert, 2003).

The bulk of innovations are aimed at improving construction sustainability by introducing new goods that enhance energy efficiency and by replacing old materials and products with creative ones, such as eco-materials and products. Other fields of invention include design and engineering, transportation, and equipment's information and communication technology, robotics, and new business and procurement modelling (Rovers, 2007).

The construction technology innovations can be achieved incrementally via ‘innovation-by-addition in three stages: i) constructing materials and elements developing and producting, ii) building design and engineering development and production, and iii) construction process development and execution As a result, on-site building methods run in more or less parallel.

Another principle is ‘innovation-by-integration’, this principle implies that new goods and differnt building methods must be designed in a systematic way and integrated manner. Thus, innovation based on aforementioned principles could result in: I cost, time, and quality improvements in the construction process, ii) adaptable and lifespan-based structures that lower operations costs while preserving client value, and iii) reduced environmental impact.

The aforementioned advantages enable the lean construction approach in providing sustainable projects with reduced waste better manpower performance and more efficient workplace organization. Lean constructing also meaningfully impacts innovation via improving attractiveness as well as resource effectiveness within the constructing industry (Mostafaa and Dumrak 2015).

2.5 Construction Project Management

2.5.1 Contract management

Contract mangement varies according to the procurement methods and payment terms of each type of contracts. Procurement methods can vary among; design and build (or turnkey jobs), design-bid-build (by main contractor or by multi contractors), construction management, build-operate-transfer and partnership. Types of contracts can vary among; priced bill of quantities, lump sum, cost plus and target cost. The procurement method and the type of contract used for construction projects are recognized as an example of the main causes for bad performing (Maizon, 1996). The procurement method and the type of contract should both be carefully decided when implementing lean construction.

2.5.2 Time management

Time management includes project time plan process, observing and controlling. Project time planning depends on clear description of design, specifications, construction methods and proper estimating of resources required. The initial objective of time management is to prepare schedules (based on networks) and then update them while works are going on, taking proper actions to mitigate deviations in order to control time (Antillón, 2010).

In other words, time management is “the function required to maintain appropriate allocation of time to the overall conduct of the project through the successive stages of its natural life-cycle (i.e. concept, development, execution and finishing) by means of the processes of time planning, time estimating, time scheduling and schedule control” (Mackenzie, 1990).

Efficient time management can critically be significant for constructing projects. The process should succeed in controlling as well as managing time via the utilization of proper instruments in order to create a standard base for monitoring the flow of the project works. The most populer tools used for time management are: i) bar-chart, ii) partly connected network, iii) completely connected network, iv) time chainage diagram, v) line of balance diagram, vi) flowchart, vii) minutes of meetings and viii) correspondence (Maizon, 1996).

In lean construction, time management have to be more carefully adressed for the purpose of reducing the risks in the constructing project target duration (Issa, 2013).

2.5.3 Cost management

Cost represents a key consideration during the course of the construction project lifespan. Cost stands for a significant feature of a achievement when meeting a pre-specified cost. Cost might include expenses spent for permanent works, provisional works, materials, equipment, services, utilities as well as overheads (Memon et al., 2011).

The goal of cost management is to guarantee that the project meets the goals for the specified financial performance targets. It is the procedure by which one can determine, approve, and pay project costs being provided for any project. Managers, contractors, and designers are in charge of all parts of the project to guarantee that it is completed on time and on budget.Project cost management includes the following tasks; cost estimating, cash-flow forecasting, budgeting and cost control (PMBOK Guide7, 2021).

Among these tasks, the most difficult and demanding one is cost estimating, particularly in the primary stage of a project, whereby any document is still designed. It usually depends on records of previously finished projects. It is an attempt to know the expected cost of a constructing project prior to the commencement to work. this needs an overall perception of the constructing procedures and the labor costs, material and equipment along with enough practice, skills, far sightedness as well as sound judgment. For a good cost estimation, As long as no extraordinary or unforeseen conditions are there, the true cost of labor after fulfillment must not change by more than (5-10%) (Chitkara, 1998).

In lean construction, cost management of construction projects become more vital. This might be aided by creating a mutual platform for sharing cost information by all parties involved in the construction project.

2.5.4 Quality management

It should be noticed that A quality managing system is a set of all procedures, instruments, methods, and sub-systems that work together to ensure the efficiency and efficacy of a production system. Numerous individuals and bodies are concerned with formulating, planning and implementing them to assure that their requirements are met (Evans and Lindsay, 1996).

Quality managing in constructing projects, accordeing to the viewpoint of a construction firm, must imply maintaining the needed standard of constructing work in order to satisfy consumers, an issue which might ensure the company's long-term competitiveness and commercial survival. Quality management covers both design and construction phases. Effective quality management is a systematic way of guaranteeing that works are done exactly as should be (Tan and Abdul-Raman, 2005).

Quality managements are more challenging to accomplish in the constructing industry compared to differnt industries (Tam et al., 2000). Anyhow, construction firms are in need of adopting Total Quality Management (TQM) as all organizations do since the 1990’s. TQM is frequently characterized as a comprehensive management philosophy that pervades all aspects of a business and prioritizes quality as a strategic concern. It is performed via a concerted effort at all levels of a firm to improve existing performance and raise customer satisfaction (Biggar, 1990).

In view of the principle of continuous improvement in lean construction, higher quality requirements arise for self-awareness of all involved human resources. For instance, a quality control team should be able to push persons within a group to become accustomed to the novel quality control modelling as well as ask them to interact with others for the purpose of improving quality (Liu and Shi, 2017).

2.5.5 Resources management

Construction resources The process of planning and assigning resources necessary to fulfill project objectives and satisfy customer needs is known as management. Appropriate resource management keeps projects on track via guaranteeing that project resource demands are met and by maximizing resource use from project to project. Projects can fall behind schedule or become unprofitable if resources are not properly managed. The goal is to guarantee that resources are available in a timely and appropriate manner while also maximizing resource use among projects. Constructing resources could involve; i) productions plus material, ii) constructing plant, instruments plus equipment, iii) human resources, iv)place and services, v) sub-contractors as well as vi) financing (Karthick Raja and Murali, 2020).

In lean construction, the process of planning and distributing resources should properly portrayed, effectively contributing to smooth application and thus leads to timely delivery and lower costs.

2.5.6 Productivity management

Productivity represents a significant issue within the field of project management. Great productivity is so significan to accomplish superiority in relation to costs, timing in addition to quality. Construction firms who cannot maintain high productivity will face competing difficulties. So it is essential to have an assessment model for productive measurement of construction projects (Park et al., 2005).

Creating a proper model to measure productivity against optimal one and set future improvement efforts is essential. It can be used as a tool for assessment to define current situation also to provide the correct data on productivity. Furthermore, it provides a framework to line up activities to get dealth with and to define the policies for the purpose of improving upcoming productivity (Alinaitwe et al., 2007).

Numerous factors can influence the productivity of any constructing project, these factors can be classified into external and internal categories or industry, management, labor and project categories. Their influence use to change over time. At the national scale, any country's building sector does have its own application, construction techniques, and available resources and regulations (El-Gohary and Aziz, 2014).

Adopting the principles of lean construction can be very useful to deal with productivity problems in construction projects by complete method and via effective instruments. This can at the same time create a culture of a wide ranging of advantages for example, less wastes, lower inventory, better quality, more flexibile way, decreased variances and greater problems vision (Mao and Zhang, 2008).

Many studies have provided examples around the world that dramatically improve constructing productivity by increasing and decreasing problems via lean tools (Al-Sehaimi et al., 2009; Ikuma et al., 2010).

2.5.7 Risk management

The unique nature of the construction industry make it easily influenced by many factors that are able not just devastating projects but these factors could likewise cause permanent deviation. As a result, risk management has become a critical tool for dealing with a variety of hazards for example, the assessments and corrective actions which may be performed to avoid them in a specific project. The most common risks which a project manager faces while overseeing a construction project can be given as follows (Bahamid and Doh, 2017):

1. **Financial risks** in a project include fluctuating currency rates, material costs, market demand, incorrect estimation, inflation, payment delays, mismanaged cash flow, and financial ineptitude of the contractor.

2. **Socio-politic risks** which including changes in government rules and regulations, law and order, bribery, government payment failure, tax increases, and government change from this repertory.

3. **Environment risks** include adverse weather, natural catastrophes, accessibility to the location, pollution, and compliance with safety regulations.

4. **Constructing-related risks** include logistical failures, labor conflicts, design modifications, labor productivity, rush bidding, time gaps for revision of drawings, and bad work quality owing to time restrictions, among others.

In lean construction, adopting lean principles and tools can provide better opportunities to manage all aspects of the project's logistical, technical, managerial and financial risks. Commitment to using lean techniques is one of the best methods for reducing the impacts of project uncertainties.

2.5.8 Factors affecting construction projects success

The success factors of construction projects can be classified into the following seven groups, in which, the factors within each group are interrelated and can influence factors of other groups as well (Tang and Palaneeswaran, 2009):

1. **External factors:** These factors are attributed to the macro environment. They are beyond the control of the company. Yet, they can affect its performance and even its survival. External factors include; economic (e.g. taxes, credit, interest and inflation), social (e.g. demographics, ethnic hostility, religion as well as social values), cultural (e.g. values, behaviors plus behaving rules), lawful and politic (e.g. changes of laws, proprietorship and limits on importing), physical (e.g. natural disasters, weather, pollution and noise), nature and environmental (e.g. raw material and different resource) and technological factors (technological change and development). The influence of external factors might differ once in a while dependent on the changing in public concerns, market fluctuation, policy changing …and so on.
2. **Institutional factors:** they represent the amount of construction and building permit review is determined by construction rules, product and service certification, standards, and construction permits provided by state public bodies and financial institutions. These characteristics have a significant impact on the success of construction projects since they are based on internal factors that are under the company's control and represent the company's current state and project performance capabilities.
3. **Project-related factors:** The project's value, size, kind, complexity, goals, risk, and so on are all aspects to consider. Project characteristics are critical aspects that determine a project's success.
4. **Project team-related factors:** In addition to people difficulties, these factors include the team's expertise, experience, decision-making efficacy, motivation, and technological capabilities. Project success is also influenced by the proper selection of team members. In order for a project to succeed, all sides must work together well.
5. **Project manager-related factors:** The manager competences constitute a serious element that affects project plans and execution. The competences that relates to

the performing of the manager involves leadership, organizing and coordination abilities, involvement, authorization and belief.

6. **Contractor-related factors:** The experience and competence of contractors are critical to the successful completion of projects. Company characteristics, technical and professional capacity, experience, economic and financial state, quality concerns, health and safety measures, and working conditions are all part of this category.
7. **Client-related factors:** These factors are related to the client's organization features including; kind (private or public), sizing, experience, impact, capability to take timely decisions, ability to set obvious and accurate objectives, risk attitudes and aptitude to take part in different stages of construction projects.
8. **Stakeholders-related factors:** Stakeholders in a construction project are those that possess a vested interests in the project's success and the environment in which it works. Clients, initiators, planners, designers, contractors, project managers, and institutions are all involved in the development of building projects. Identifying those stakeholders who can have an impact on the project and managing their varied needs through excellent communication in the early phases of a project is a critical challenge for a project management team.

2.6 Best Practices and Techniques for Lean Construction

Lean construction endeavors to track the following practices (Le Gratiet, 2017):

1. **Setting clear objectives for the delivery process:** This process could be split down from the project levels to the sub-contractor levels, then to the suppliers levels, also within actions when distinct activities are performed.
2. **Maintaining maximum performance at the project level:** The entire process must be analyzed while any bad performance of any action must be deliberated, whether it can be compromised or consequently another activity performance will be affected at an advanced phase. There should be ongoing tracking on the general performance.
3. **Concurrent design of processes and products:** Coordinated design and workshop meetings are essential to highlight different potential clashes and so

improvements can be worked upon in early stages. Such will result in a proactive management approach rather than a reactive one, which might result in time and expense overruns.

4. **Applying production control all along the project life:** Any deviation from the design or unplanned incident must be closely tracked in order to improve the process and avoid a recurrence of divergence.

These practices mean that lean construction management performs on the project holistic scale rather than on individual activity scale. To do so, proper techniques is needed. The widely implemented lean construction techniques found in the relevant literature can be summarized in the following.

2.6.1 The last planner system (LPS)

LPS represents a lean constructing technology that creates weekly work plans to increase efficiency. It was created in line with lean building concepts by (Ballard, 2000). The weekly plan lists project-related tasks as well as the people who will be responsible for completing them. For all associated workers, LPS enables for immediate monitoring of work difficulties. It also creates an environment in which faults are readily apparent. When difficulties arise, prompt action may be done to avert project delays. The last planner is the person in charge of the tasks in question. This individual is generally in charge of quality control. A project engineer, department manager, or even foreman might be the last planner.The last planner system is shown in Fig. (2.2) (Ballard and Tommelein, 2016).

The tasks should be classified to double categories; ‘as required’ tasks plus ‘weekly’ tasks. The ‘as required’ type involves ‘should’ tasks which includes works needs completion to fulfill the defined milestones depending upon the project plan. Whereas weekly tasks include ‘can’, ‘will’ and ‘did’ tasks which are created based on different information for example, client requirements, project objectives, and previous planner experience. The ‘can’ tasks reflect the work that can be executed with respect to the constraints of the project, as the required materials and labor are ready. The ‘will’ tasks ensure the work to be completed after all constraints are assessed, where the previous project stage is completed and the required materials and labor are ready. The ‘did’ tasks refer to completed work (Gao and Low, 2014).

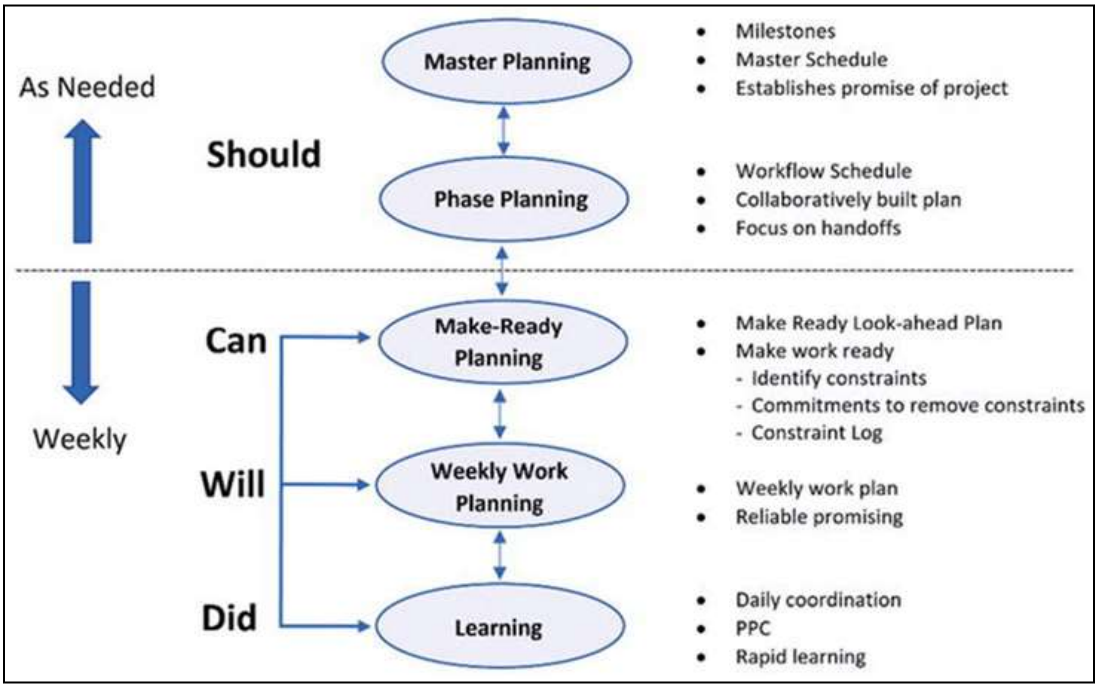

Figure 2.2: Last planner system

Source: (Ballard and Tommelein, 2016)

2.6.2 Just-in-time (JIT)

JIT Technique represents a method of inventory management that entails close collaboration with suppliers to ensure that raw materials arrive when manufacturing is scheduled to begin, not before or after. An agile management process is another name for it. The idea is to have a small amount of inventory on hand to fulfill demand, reduce waste, and improve operational efficiency. This method necessitates long-term agreements with dependable vendors. People, like all other components of a product or service system, are interrelated. They teach one another and are mutually reliant on reaching positive outcomes.

This method is based on the Japanese phrase 'Kaizen,' which means 'change for the better.' Kaizen is a company concept that seeks to continuously improve operations by incorporating all employees, from assembly line workers to the CEO. In addition to reducing waste, the objective is to increase quality. The specifics of how organizations deploy JIT in different environments may vary, but the essential stages remain the same. The continuous improvement cycle in JIT inventory management is depicted in Figure (2.3) (Enshassi et al., 2020).

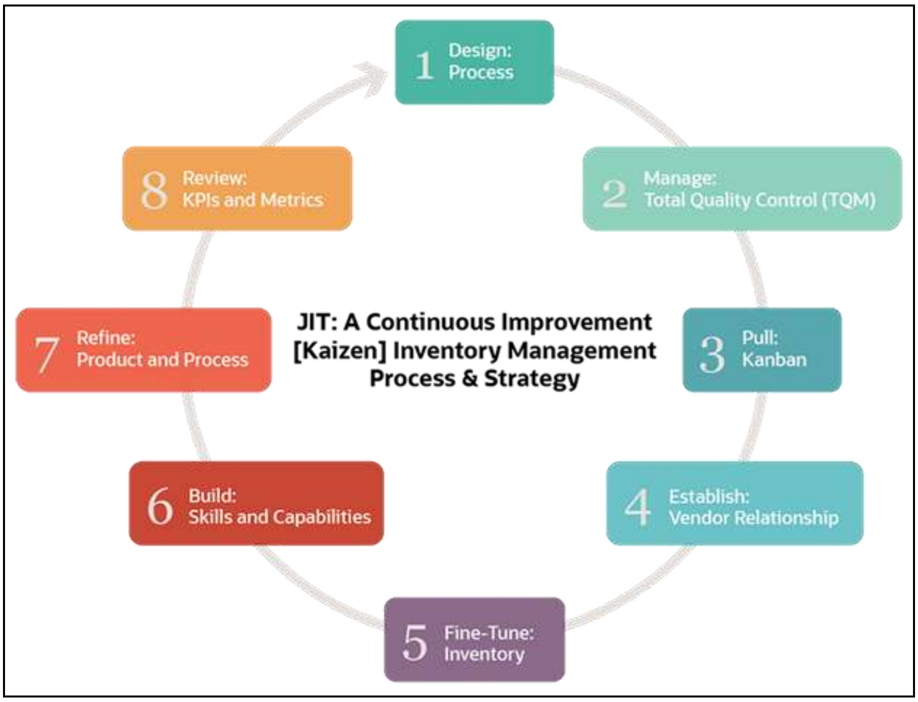

Figure 2.3: Steps of the JIT Process

Source: (Enshassi et al., 2020)

The steps of the cycle of continuous improvement for JIT inventory can be summarized as follows:

1. **Design:** It is the initial step in the JIT process of assessing the key production building pieces, such as product design, process design, people, and manufacturing planning. Plans are being put in place to minimize interruption, waste, and create a flexible system.

2. **Manage:** To achieve continual improvement throughout the process, a Total Quality Management (TQM) review should be done. A management review establishes the roles and duties of employees, establishes and assesses statistical quality control, stabilizes schedules, and verifies load and capacity schedules and levels.

3. **Pull:** It is the step of educating the team on production and withdrawal methods using signaling methods like ‘Kanban’. Review your lot size policies and try to decrease them.

4. **Establish vendor partnerships**: Establishing vendor relationships is critical to JIT's success. It will need to look through vendor lists, choose preferred suppliers, negotiate contracts, and talk about lead times, delivery expectations, and usage metrics and benchmarks.

5. **Fine-tune:** This is the process of determining inventory requirements, regulations, and controls, as well as reducing inventory movement.

6. **Build:** Building the skills and capabilities of the work team starts with informing them about what is needed to finish the works and then conducting team educating as well as empowerment meetings.

7. **Refine:** In this step, the number of the production components and steps are reduced by refine, standardization and review the whole procedure.

8. **Review:** To enhance every area of JIT, it is necessary to design and implement quality measurements and metrics, undertake a root cause analysis of any problems, and emphasize improvements and track trends..

2.6.3 The 5S method

The Japanese 5S method aims at organize the workplace within a clean, effective, and harmless way in order to make a productive working setting. The name 5S represents the first letters of (5) different Japanese words namely: Seiri (i.e. Sort), Seiton (i.e. Set in order), Seiso (i.e. Shine), Seiketsu (i.e. Standardize) and Shitsuke (i.e. Sustain self-discipline). These wards present the five steps shown in Fig. (2.4). The 5S represents an opening mark to every construction firm that aims to be acknowledged as a liable and dependable producing entity (Demirkesen, 2021).

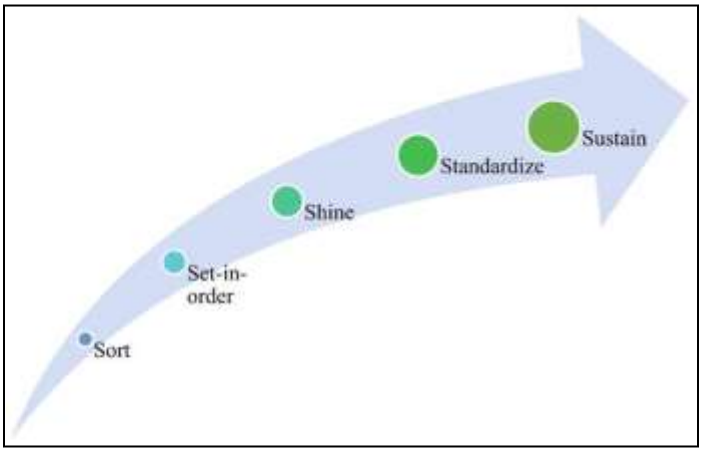

Figure 2.4: The 5S method stages

Source: (Demirkesen, 2021)

1. **Sort:** this refers to the procedure of categorizing material and equipment based on how urgent they are needed.

2. **Set in order:** It is the process of making all needed equipment and materials easy accessible and prepared and facilitated for use in production.
3. **Shine:** It is the process of cleaning and maintaining polluted equipment and work area.
4. **Standardize:** It is the process of arrangement standardizing in order to fully meet requirements by constantly checking the environment, detecting deficiencies and eliminating the root cause of problems.
5. **Sustain self-discipline:** All phases are included in this procedure. Checking the current system, educating the personnel, developing effective communication, and rewarding the employees are all part of the process.

2.6.4 Mistake-proofing (Poka-yoke in Japanese)

Mistake-proofing is broadly implemented in lean production. It is the application of any automated device or procedure that either prevents a mistake from occurring or makes the problem instantly visible once it has occurred. Mistake-proofing is a quality-control approach that helps to eliminate human error, which can lead to errors or defects. General quality control inspection procedures include judgment inspection, informative inspection, and source inspection. Informed inspection is used to minimize defect rates by regulating the process and preventing problems, whereas judgment inspection is used to find defects. Rather, source inspection looks for the conditions that may lead to an error-free operation (Shingo, 1986).

Mistake-proofing is expressed in three functions; shutdown, control and warning. Proper devices are used to make sure of diverse significant parameters to discover if there is an incorrect action in the procedure. The shutdown function is a crucial step in preventing faults by removing the risk of human mistake. The control function, which acts as a redactor, is embedded into the manufacturing equipment. When the gadget detects an undesirable state during the manufacturing process, it alerts production to prevent defects. When a mistake occurs, the warning function alerts the operator with either visual symbols or auditory messages. The warning function is based on human factors, and it is not always possible to eliminate faults in the manufacturing process. (Tommelein and Demirkesen, 2018).

Elimination, prevention, replacement, facilitation, detection, and mitigation are the six concepts of mistake-proofing. The first four principles are aimed at preventing human error, while the final two are aimed at minimizing the impact of human mistake after it has occurred. The duties within each of these six principles are depicted in Figure (2.5) (Demirkesen, 2021).

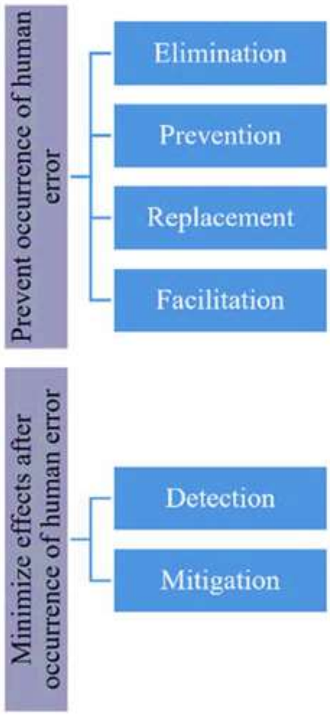

Figure 2.5: Mistake proofing principles

Source: (Demirkesen, 2021)

The usage of error-proofing equipment has a number of advantages in relation with workplace safeness. With the use of such equipment and gadgets, it is feasible to develop fail-safe production methods. Given the high accident rates in the construction sector, mistake-proofing devices are seen as an efficient way to improve safeness performances and eliminate human mistakes that contribute to working related mishaps (Saurin et al., 2008).

2.6.5 Visual management

Visual management is widely used in lean manufacturing. By displaying information through visual signals, this strategy aids in making information apparent to everybody (Singh and Kumar, 2020). Employees may now better grasp their position and contribution in relation to company values and customer demands thanks to the usage of visual management. Despite this, the construction sector has a poor understanding of the vital function of visual management. However, some visual tools, including 3D modeling and visual planning, are used in constructing design (Tjell and Bosch-Sijtsema, 2015). Increased communications, integrity, and stakeholder capacities are all aided by visual management (Liker, 2004; Tezel et al., 2010). Visual management approaches may help construction organizations offer a better working environment for their employees while also increasing efficiency and output.

2.6.6 Target value design (TVD)

This process can be basically known as "a management practice that steers the design and construction of the project to the customer's constraints while maximizing the value delivered within those constraints". TVD also facilitates cost predictability during design, construction, and delivery. It was based on the Target-Cost production process (Cooper and Kaplan, 1999). The building sector stands to gain from this technology in a number of ways. In terms of lowering building costs, it is a successful collaborative lean strategy (Zimina et al., 2012). It was also said that the systematic deployment of TVD resulted in a considerable improvement in the performance of construction projects(Khah et al., 2019). The TVD process in relation to a building project is depicted in Figure (2.6).

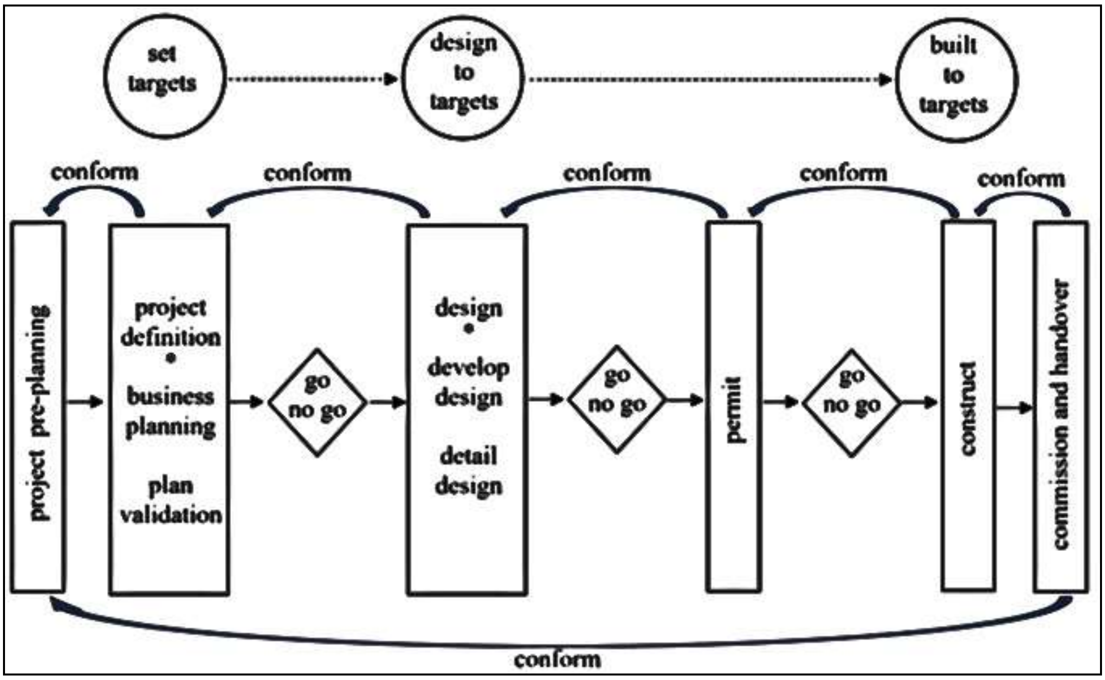

Figure 2.6: TVD process scheme

Source: (Zimina et al., 2012)

2.6.7 Value stream mapping (VSM)

This process represents a critical tool for identifying and comprehending the productive stream, with a focus on identifying waste sources such as waiting for products and inventories, rework, lost information, and non-value-adding activities, as well as identifying opportunities for improvement. Through the use of VSM, it is feasible to enhance the information stream in the design process by including various control approaches. This establishes a foundation for future activities and incentives to generate value. VSM aids in the visualization of the entire process rather than isolated elements of it, as well as the monitoring of goods, papers, as well as data. It also enables for the simultaneous observation of material and information streams, as well as the visualization of indicators such as throughput time, value aggregation %, lot size, and cycle time for the performance of operations (Womack, 2006).

VSM consists of various processes, including mapping activities for a family of goods, establishing the current state map of the value stream, and building the future value stream map, where improvement occurs based on accurate problem identification (Rother and Shook, 1999; Womack, 2006;Freire and Alarcón, 2002). The VSM procedures are depicted in Figure (2.7).

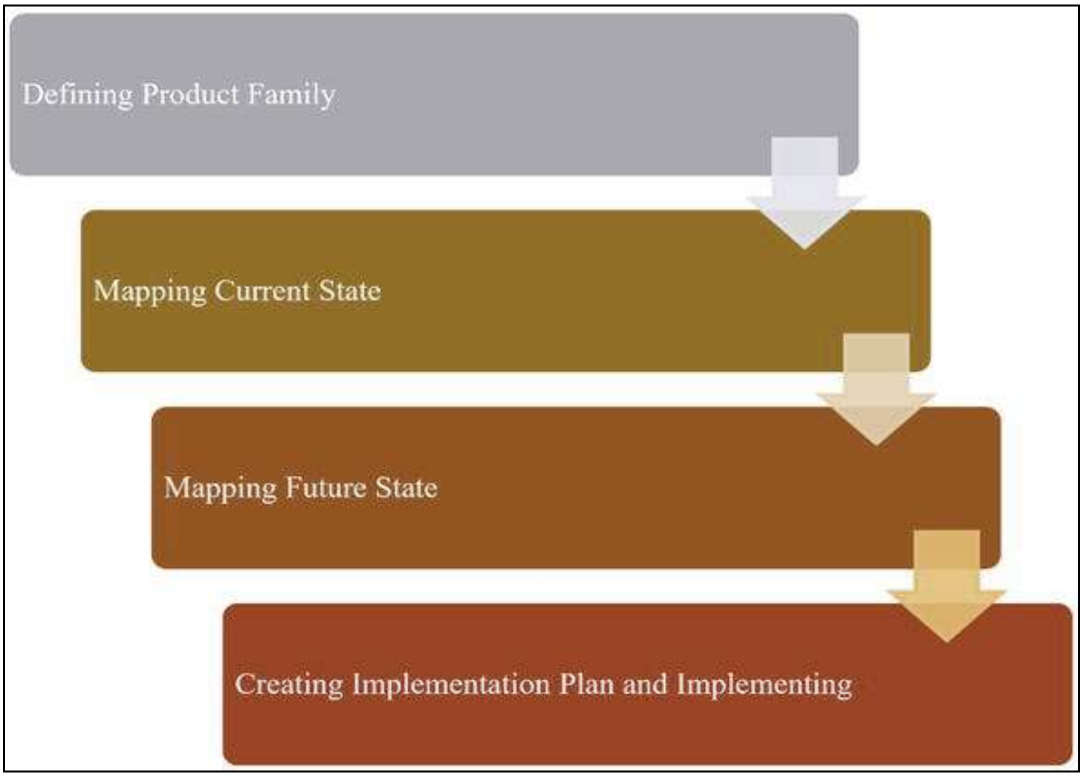

Figure 2.7: The VSM processes

Source: (Demirkesen, 2021)

2.6.8 The 5 whys for root cause analysis

The 5 Whys denotes a quality managing instrument to solve problems which aims at finding the base reason of an incident (Ansah et al., 2016). It directs the attention to ask (why) five times repeatedly, as shown in Fig. (2.8), to identify the cause of each (why) with the intention of reach the the problem base reason. This procedure aims to eliminate and prevent recurrence of the root cause (Tsao et al., 2004).

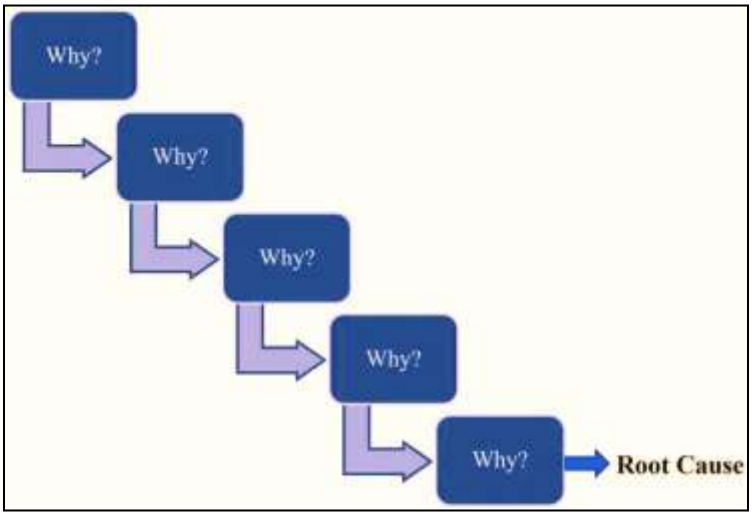

Figure 2.8: Whys analysis procedure

Source: (Ansah et al., 2016)

Given the hazardous nature of building projects, it is critical to identify the core cause of issues that lead to unfavorable outcomes. As a result, this technique of analysis is critical for preventing issues from arising or repeating.

2.6.9 Gemba walks

It is a Japanese term that means "real location" (Imai, 2007). Employees must be able to manufacture with less waste, less obstacles, less overload, and less overproduction in order to add value to the firm. Gemba walks are required at this time to assess the existing situation and determine the root cause of the problem. Walking in the context of lean construction implies "go see, ask why, and show respect" (Womack, 2013). Gemba walks assist in making problems apparent and generating improvement suggestions while taking into account the core cause. It also enables for the collection of data on the fundamental cause of issues. Gemba walks are clearly crucial in the construction sector, since the majority of building processes are in need of modification and require the appropriate identification of the underlying cause of issues.

2.6.10 Daily huddle meetings

Every day, there are huddle meetings where team members may share what they've accomplished and what they're working on. In addition to reviewing the work to be done that day, a huddle meeting can be conducted as a weekly work plan meeting, stressing the completion of assignments for the following week (Zhang and Chen, 2016). Employee work satisfaction is improved as a result of the huddle sessions, which also improve two-way communication within the team (Ogunbiyi et al., 2013). Employees can participate in conversations and express the positive and bad aspects of their jobs during daily huddle sessions. During those sessions, the personnel also find time to work together to solve difficulties. These gatherings also aid in the detection of accident causes, which are linked to a lack of communicating as well as coordinating. (Enshassi et al., 2019).

2.7 Previous Studies on Lean Construction

Sarhan et al. in (2017) studied the obstacles to implement lean construction practices in the KSA constructing industries. A questionnaire survey method got used to gather information to identify obstacles and rank them in order of priority. The sample included suppliers, contractors, engineers and clients. The highest-ranking obstacles found are: persistence of outdated practices, disapproving organization culture, absence of relevant technic skills as well as nonexistence of knowing lean principles.

Small et al. in (2017) examined the chances for integrating the lean concepts in the constructing industry of Dubai. A questionnaire survey was addressed to Emirati professionals including; contractors, consultants and owners. The study recognized the obstacles to implementing lean constructing principles and their reasons. The study also investigated the suitability of the techniques previously proposed by (Kanafani, 2015) to overcome the barriers.

Dede in (2018) investigated the sources of waste and their consequences for the Turkish construction sector. To limit the consequences of waste reasons, a waste management method based on Lean and BIM was presented. Five construction companies were interviewed to learn about the most common wasting reasons. The interview questions were prepared in accordance with “Taiichi Ohno’s” waste approach. The outcomes showed that waste causes might initiate at designing, procurement and project operation stages. The main waste reasons found were "inefficient planning and programming" and "lack of organization skills". These may be avoided by employing Lean and BIM techniques such as the Last Planner System, Computer Aided Design, Value Stream Mapping, and Partnering, among others..

Mustonen in (2018) studied the implimentation of lean constructing instruments with their contributions to location management activities. The implementation of Takt schedule was studied along planning and executing. depending upon interviews and site monitor, Takt scheduling implementing outcumes were reported. It was found that a Takt scheduling shortened the lead timing as well as provided obvious frameworking for the project. Takt scheduling requires to be complemantary in the project primary phasess. Planning, procurements and contracting play very important role in project success by ensuring anticipated executing and better constructing ability, unifying objectives and providing assistance for contracted resolution. It is not easy to affect such factors during execution. The contract is the most significant interface with other parties.

Yusof, I. H. M. in (2018) dveloped a lean design process for building projects. A questionnaire survey was conducted to obtain opinions of construction practitioners on current practices of mitigating a list of design-related types of waste. It was found that: i) the importance of innovation in the building design process was expressed by some academics, yet, an absence of research is there. ii) the Set-Based Concurrent Engineering (SBCE) principles gave empowerment for adopting the principles of lean thinking in the architectural design process. iii) integrating problem solving technique with (SBCE) principles supported the development of design activities. iv) the waste related to the construction process cannot be adopted in the design process, hence, a list of wastes should be previously developed. v) There were seven knowledge areas identified from the literature review supporting design process innovation in the construction industry.

Albanna in (2019) developed an istrument to measure and develop workers' comprehension of lean ideas in the constructing industry of Lebanon using a quesionaire survey. the respondent answered on a Likert scale from (1 to 7) and the coming outcomes had been achieved: i) Construction labors suffer from misunderstanding; waste-related concepts and waste types, lean pull production practices and knowledge, site organization and standardization concepts. They do not show responsibility for the jobs they are doing. ii) Construction workers are not strong believers of these concepts. They may support them but they don’t understand the importance of applying them. These areas are somehow as well related to the overall company’s concepts and practices regarding lean construction. iii) The planning and control of construction operations, as well as the construction site, are not performed by construction personnel. They don't provide feedback on how their task is progressing. Traditional building methods, which are still used on many construction sites, clearly demonstrate this.

Amunzu in (2020) conducted a qualitative case investigation of constructing managers’ comprehension of lean rational. A qualitative approach was used to identify an insight study. The partecepants consisted of construction managers from highway construction projects in the Northeast United States. The study explored their comprehension of lean thought within the material selecting, quality, and finishing period. The results were found to be aligned with the Toyota Production System (TPS) lean concepts in three key aspects; i) continuous improvement, ii) 5S and iii) visual management. The results also highlighted the strengths of the TPS lean thinking framework in the construction industry.

Yuan et al. in (2020) conducted cause analyzing of delaying at site lean constructing for manufactured constructions in China. The study also covered the evaluation of corresponding organizational capability. Data collecting approaches included; literature analyzing, field survey, semi-structured interviews, online consultations, questionnaire surveys, and constructing company surveys. Five influential barriers have been identified namely; “Inadequate professional management capacity of managers”, “Insufficient standardization”, “lack of consciousness thinking”, “Professional skills of employees” and “lack of adequate technology tools”. Six barriers were also identified namely; “management-related barriers”, “skills and knowledge-related barriers”, “the construction industry itself”, “objective building conditions re-gardening barriers”, “rail barriers in relation to materials and leaders” and “barriers relating to the proportion of prefabrication”.

Gupta et al. in (2020) carried out a review on the obstacles of lean constructing implementing in India. A survey of previous studies was conducted. The following barriers have been identified:

1. Civil engineers identified lack of training and awareness, lack of technical skills, lack of government assistance, inability to alter corporate culture, and lack of teamwork as the top hurdles.
2. Architects selected lack of experience and information sharing, lack of training and awareness, lack of technical skills, openness, and leadership as the top impediments.
3. Academics identified logistical issues, a lack of understanding and expertise of lean concepts, working circumstances, a lack of training and awareness, and the expense of lean consultancy as the top hurdles.
4. Other stakeholders cited the complexity of lean construction, the danger of top management support, government bureaucracy and instability, the long implementation period, and a lack of transparency as the top impediments.

Koohestani et al. in (2020) conducted a questionnaire survey as well as a set of recognized elements aiming to find a way to implement lean construction in Iran. It was found that Organizational and project-related factors were shown to have a greater impact on the effectiveness of lean construction adoption than external factors. A critical first step is to increase understanding and awareness of the advantages of lean construction.

Demirkesen and Bayhan in (2020) developed a model for lean implementation in the constructing industries in Turkey. A questionnaire survey got carried out using Delphi method. The model was employed for weighting the effects of (27) elements associated with lean victory, grouped under seven categories; finance, administration, technic, workingforce, cultures, governments, and communications. The developed model showed that lean train, accessibility of lean apparatuses and methods were the chief elements that have effects upon the success of lean implementing. Moreover, it was found that the market share and strong comprehension of the technic demands are the next important factors of the success.

Aslam et al. in (2020) explored the factors of implementing lean construction for rapid initial successes in Pakistan through a self-structured questionnaire. A literature review was carried out to determine the prevailing barriers and factors associated with the successful implementation of lean construction. The results indicated that organizations should start lean construction with a clear goal of improving results and processes through commitment and collaboration by all project participants. The companies must select the right tools and techniques that are compatible with construction processes and implement them using a collaborative project delivery system to achieve successes.

Al-Balkhy et al. in (2021) evaluated the challenges to lean construction adoption, categorizing them as endogenous, input-related, and exogenous constraints. From the views of owners, contractors, and consultants, a questionnaire survey was undertaken to determine the most influencing impediments. The findings revealed that these groups have similar perspectives on the obstacles to lean adoption in Jordan. The most important barrier to lean adoption was the “lack of support from top management”, “inadequate training of workers”, “lack of adequate lean awareness and understanding”, “insufficient management of necessary information to generate a learning cycle and take corrective actions” and “lack of participation and transparency among stakeholders”. Other vital barriers include “lack of long-term philosophy and planning”, “managing resistance to change”, “lack of incentives and motivation, and poor professionalism”, “wages”, “limited use of design and construction purchases”, and “inaccurate and incomplete designs and poor applying of the concept of structural design”.

Watfa and Sawalha in (2021) carried out an empiric research in the UAE on the critical success factors for lean construction. A survey was conducted by means of a questionnaire and the sample consisted of professionals and senior managers working within the area of lean constructing implementations. The components were then grouped into four key constructs, which form the proposed conceptual framework's pillars. The study discovered that lean construction principles are not extensively adopted in the UAE, with just 28% of the enterprises assessed knowing about or employing lean techniques. This study identified thirteen characteristics that were deemed crucial to the success of lean construction adoption, including: Management commitments plus involvements, Organization culture, Employee participation and motivating, Contractor Takt control involvements, Strategy and planning, Management leaderships, Takt control Suppliers' quality, Contracts, Training and knowledge, Skills and expertise, Communicating and collaborating Takt controlling, Suppliers' and customers' relationships, Process documentating and Standardizing.

Zhang in (2019) investigated the impact of combining lean construction and BIM as a new paradigm for improving construction quality in China. The research was based on the findings of case studies and the literature. The following is a summary of the research contribution to the industry: By outlining the methodologies of lean construction and BIM to improve construction quality from the perspective of construction businesses, it adds to existing information on quality-based lean construction and quality-based BIM. Such would aid the construction sector and government in determining future development paths for quality-based lean construction and quality-based BIM. The study also revealed a number of relationships between lean construction, BIM, and construction quality. Each contact provides a way for construction businesses to use lean construction and BIM to improve the quality of their own projects.

3. METHODOLGY

3.1 Chapter Introduction

In the present chapter, the methodological framework as well as tools are clarified. The way the questionnaire and the interview sheet were designed are also explained. The sample size has also been put into consideration along with the necessary statistical measures needed. Literature on how to prepare for a secessfull well-structured questionnaire survey and predesigned interviews were reviewed in advance. Furthermore, literature on how to choose the relevent population, representative samples, data collection and analysis were also reviewed in advance in addition to selecting proper software.

3.2 Methodology Framework

The methodology framework of the present work contained the following stages:

1. A questionnaire was used as a quantitative method to reach Iraqi experts opinions. The core questions that can address the research problem were set based on extensive literature review about the role of using lean construction concepts, methods challenges, and success factors.
2. The questions were classified into parts and sections in order to get usefull responses that can be compiled and analysed. Therefore a proper quesionaire were designed. A specific part concentrated on investigating and ranking successful factors which donate to the completion of any constructing project. Another specific part concentrated on the possibility to apply lean construction in Iraq by investigating and ranking the benefits, obstacles and readiness success factors which pave the way to carry out lean constructing, as well as the actions needed. A further specific part concentrated on investigating the actual practice of the participants firmsin terms of completed projects and the most appropriate projects to apply lean construction. The last specific part concentrated on investigating the level of institutional acceptance to move to lean construction and withdrawing particiants suggestions in this sense.

3. Tregeted respondants were decided including professionals in all the aspects of the construction industry and its stakeholders. A group of Iraqi experts with different specializations, academic degrees, experiences and jobs in diverse contracting firms, trading companies, supervisory engineers, design centers and academics were adressed. Diversity helps to collect and rank all types of factors that affect the overall success of implementing lean construction.
4. After collecting and analysing the quesionaire results, the emerging qestions for further elaboration were set using an interview sheet.
5. All quesionaire results were subjected to statistical analysis to test reliability and validity.

3.3 Research Tools

A quesionaire survey were conducted for data collectiong. The quesionaire, shown in Appendix A, were designed according to Likert's five degrees scale and directed to (160) of the Iraqi construction industry stakeholders. Sixty of the quesionaire copies were disterudted using internet by means of Google Form, while (100) paper copies were directly handeled. The number of electronic copies collected was (54), while the number of paper copies collected was (69). The interviews were held face-to-face with discussion being conducted. The results of both quesionaire survey and interviews were statistically anlysed using SPSS-V24. The questionnaire survey is a common technique that broadly employed in social sciences studies (Oppenheim, 2000).

The SPSS (Statistical Package) V.24 was used for statistical anlysis and presentation of the results. It is a very useful and widely used statistical program for statistical analysis in scientific researches. It performs all necessary statistical tests and results presentation forms needed.

The participants' rating of each specific factor in each section of the questionnaire was measured using Likert scale of five points specified according to prescribed level of agreement or disagreement categories, table (3.1) shows that. The five Likert scale choices appeared to be less threatening to participants (Hair et al., 2009).

An additional tool, included direct interviews with (10%) of the respondents, were used to discuss and clarify specific aspects which seem to have some contradictions between the respondents' opinions. A structured interview sheet was designed and used as shown in Appendix B.

Table 3.1: Likret's scale used for rating

Ranking	1	2	3	4	5
Effect	Very low	Low	Medium	High	Very high

3.4 Research Jurisdiction

This research was conducted in the Republic of Iraq covering construction industry stakeholders from the whole (18) provinces. Professionals from Public and Private Sectors were adressed including governmental adminstrations, contracting companies, consultancy bureaus, laboratory centers, material manufacturers and suppliers, equipment providers and Unversities' academcs. This gives the research credibility in terms of representing the jurisdiction of application all over Iraq.

3.5 Setting the Questionnaire

In order to obtain useful results, the questionnaire was divided into five parts as follows:

3.5.1 Part-A of the questionnaire

Part-A was dedicated for general information about the participants and their organizations. The participants were asked to state their organizations' name, work sector (public/ private), type of business (client, consultant, contractor, manufacturers, suppliers or others), field of practice (buildings, highways and bridges, water supply and sewerage, irrigation, industrial, electrical, communication or others) and classification rank (only for contractors). Furthermore, they were asked to state their job position, academic degree, specialization, years of construction expertise and years of lean expertise if any. Table (3.2) shows this part. It can be noticed that all relevant types of construction firms and respondents qualifications are covered. The years of experience in general started with (6) years at least to ensure addressing fair experienced staff. In contrast, the years of experience in lean constructing started from zero in order to cover all expected cases.

3.5.2 Part-B of the questionnaire

Part-B was dedicated to examine the success factors relevance in the Iraqi constructing industry in general. The factors were classified according to each of the construction project parties; clients, consultants, contractors, suppliers and manufacturers (together), in addition to external factors. Table (3.3) shows this part.

It can be noticed in parts B, C and D, that Likert scale is used for ranking accompanied with a column for justification in order to be sure that the respondent is aware and serious.

Table 3.2: Part A - general information about the respondents

A1. Organization name				
A2. Organization work sector	Public	Private		
A3. Organization type of business	Client	Consultant	Contractor	
	Manufacturer	Supplier	Others	
A4. Organization field of practice	Buildings	Highways & Bridges	Water Supply & Sewerage	Irrigation
	Industrial Facilities	Electrical Works	Communications Networks	Others
A5. Classification rank (only for contractors)	Civil ( )	Mechanical / Electrical / Chemical ( )		
A6. Respondent position	Top Management	Middle Management	Site Management	Supportive Management
A7. Respondent academic degree	PhD	MSc	BSc	Others
A8. Respondent specialization	Civil Engineer	Architect	Mechanical	Electrical
	Communications	Highways	Chemical	Others
A9. Respondent years of experience in the construction industry	(6 – 10)	(11 – 15)	(16 – 20)	(> 20)
A10. Respondent years of experience in Lean Construction	(< 3)	(4 – 6)	(7 – 9)	(> 9)

Table 3.3: Part B - Construction projects success factors

Factors per party		Importance					Justification
		1	2	3	4	5	
O	**Client/Owner**						
O1	Type of contract and procurement method.						
O2	Timely payment to the contractor.						
O3	Timely approval of change orders/added time.						
O4	Timely resolution of admin. and financial issues.						
O5	Experienced and efficient supervision team.						
O6	Effective coordination with the authorities.						
O7	Others/ to be stated please.						
D	**Consultant/Designer**						
D1	Accurate, adequate and simple design & specific.						
D2	Accurate bill of quantities.						
D3	Accurate planned time table.						
D4	Timely resolution of execution issues.						
D5	Professional in resolving changes/added time.						
D6	Timely approval of submittals and tests results.						
D7	Others/ to be stated please.						
B	**Contractor/Builder**						
B1	Timely supply of all needed resources.						
B2	Timely providing of all required facilities.						
B3	Ensure all health and safety requirements.						
B4	Confirm to quality assurance procedures.						
B5	Adhere to schedule and deadlines.						
B6	Timely payment to suppliers and alike.						
B7	Others/ to be stated please.						
S	**Supplier/Manufacturer**						
S1	Timely providing of the required type/quantity.						
S2	Ability to import the required items in time.						
S3	Assure the required quantity.						
S4	Providing good and suitable warehouses.						
S5	Others/ to be stated please.						
E	**External**						
E1	Legislations and governmental laws.						
E2	Political and economic situation of the country.						
E3	Market fluctuations in supply/demand & prices.						
E4	Restrictions on working hours, holidays/events.						
E5	Others/ to be stated please.						

3.5.3 Part-C of the questionnaire

Part-C was dedicated to investigate the possibility of adopting lean construction in Iraq, classified in three sections for benefits, general and specific obstacles and readiness success factors (opportunities on national scale and on company scale separately), in addition to a fourth section dedicated for suggested actions classified to knowledge and skills leverage, financial support, quality assurance, productivity improvement and management enhancement. Tables (3.4) to (3.7) show the sections of this part.

Table 3.4: Part C - section CI - Lean construction obstacles benefits

Benefits		Importance					Justification
		1	2	3	4	5	
1	Earlier completion time with greater certainty.						
2	Cost saving with higher profitability.						
3	Better quality assurance with greater reliability.						
4	Higher productivity with less labour & inventory.						
5	Controlled environment with lower hazards.						
6	Sustainability enhancement with less energy.						
7	Others/ to be stated please.						

Table 3.5: Part C - section CII - Lean construction obstacles

Obstacles		Importance					Justification
		1	2	3	4	5	
General Obstacles							
1	Absence of government support.						
2	Lack of awareness and knowledge.						
3	Lack of a long-term vision.						
4	Fragmented nature of the industry.						
5	Many parties joined the project.						
6	Inefficient Transportation and logistics.						
7	Hard to bring technology and standardization.						
8	Initial and additional costs.						
9	Weak stakeholders' intention.						
10	Lack of engineers expertise and workers skills.						
11	Lack of transparency and integrity.						
12	Improper environmental conditions.						
13	Others/ to be stated please.						
Specific Obstacles							
1	Lack of contractor/supplier involvement.						
2	Lack of prefabrication.						
3	Uncertainty in production process.						
4	Lack of identification and control of waste.						
5	High turnover of workforce.						
6	Lack of long-term relationship with suppliers.						
7	Multilayer subcontracting.						
8	Stress and pressure in deadlines.						
9	Poor team work culture.						
10	Absence of feedback.						
11	Losing some jobs due to work changes.						
12	Others/ to be stated please.						

Table 3.6: Part C - section CIII - Readiness success factors

Success Factors		Importance					Justification
		1	2	3	4	5	
On national scale							
1	Government strategy and commitment.						
2	Demand and market conditions.						
3	Technology transfer.						
4	Awareness and knowledge						
5	Expertise and skills.						
6	Design and process standardization						
7	Information and communication technology.						
8	Research and development.						
9	Coordination and collaboration between parties.						
10	Others/ to be stated please.						

On company scale							
1	Business and finance.						
2	Facilities and equipment.						
3	Design, manufacture & construction integration.						
4	Constructability and life cycle engineering						
5	Organization and leadership.						
6	Planning and control.						
7	Procurement and contracting strategy.						
8	Supply and storage management.						
9	Cost and risk management.						
10	Transportation and logistics.						
11	Quality assurance and work environment.						
12	Others/ to be stated please.						

Table 3.7: Part C - section CIV - Actions to be taken

Actions		Importance					Justification
		1	2	3	4	5	
K	**Knowledge and skills leverage**						
K1	Academic education.						
K2	Consultants' development programs.						
K3	Manufacturers' & Contractors' dev. programs.						
K4	Labour training programs.						
K5	Regulations, codes, standards and certification.						
K6	Others/ to be stated please.						
F	**Financial support**						
F1	Demand continuity and stability.						
F2	Affordable loans.						
F3	Tax exemption and levy reduction.						
F4	Business and marketing.						
F5	Non-delayed payment.						
F6	Others/ to be stated please.						

3.5.4 Part-D of the questionnaire

Part-D was dedicated to investigate the actual practice the respondent's organization within the past 5 years by stating the number of completed lean construction projects and the percentage to all projects including conventional projects. The same was also stated for on-going projects. Furthermore, A question was directed to participants about ranking the type of projects in terms of suitability for lean construction implementation among; residential, offices, health, educational, industrial, tourism, commercial and utilities. Table (3.8) shows this part.

Table 3.8: Part D - Construction projects success factors

<table>
<tr><td colspan="14">D1- Completed Lean Construction Projects:</td></tr>
<tr><td colspan="3">Total number:</td><td colspan="11">Percentage to all projects including conventional: %</td></tr>
<tr><td colspan="14">D2- On-going Lean Construction Projects:</td></tr>
<tr><td colspan="3">Current number:</td><td colspan="11">Percentage to all projects including conventional: %</td></tr>
<tr><td colspan="14">D3- The type of projects suitable for Lean Construction:</td></tr>
<tr><th rowspan="2">Project Function</th><th colspan="5">Suitability</th><th rowspan="2">Notes</th><th rowspan="2">Project Function</th><th colspan="5">Suitability</th><th rowspan="2">Notes</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Residential</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Industrial</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Offices</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Tourism</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Health</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Commercial</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Educational</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Utilities</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

3.5.5 Part-E of the questionnaire

Part-E is an open field that was dedicated to withdraw the respondents' suggestions to overcome the barriers and further comments.

The questions were set in clear and simple Arabic accompanied with the English version.

3.6 Sample Size Determination for the Questionnaire

For the purpose of obtaining a statically representative specimen according to the Normal Distribution principles, (120) respondents should be maintained at least. Further statistical tests should also be conducted when the results are collected. Therefore, (160) survey targets were approached covering all relevant stakeholders; clients, consultants, contractors, suppliers and manufacturers as well as academics. The actual number collected responses was (123) including (69) respondents approached using paper copies of the questionnaire and (54) via Google Form. Both are more than (50) which is the minimum acceptable sample size for questionnaires statistical tests (Hair et al., 1995).

3.7 Setting the Interview Sheet

In order to obtain useful results, a structured interview sheet was designed to cover all aspects of contradicted questionnaire results including the following:

Table 3.9: The content of the interview sheet

General information about the interviewee:	
Organization information	Personal information
Specific questions to clarify:	
Q1: already practicing lean construction vs. severe cost and time overrun	
Q2: all proposed actions received almost the same level of attention	
Q3: Non-delayed payments vs. Procurement and contracting strategy	
Q4: Relationship with suppliers vs. Business and marketing	
Q5: Lack of a long-term vision vs. Change strategy	
Q6: Mechanization vs. Technology transfer	
Q7: Absence of feedback vs. ICT	
Q8: Lack of waste control vs. Constructability and life-cycle engineering	
Q9: all project phases and parties received almost the same level of attention	

3.8 Sample Size Determination for the Interviews

It was decided to interview a random sample of (10%) of the respondents at first, i.e. (12) out of (123) respondents, and see whether it is enough to be confident with results based on their consistency. It was planned that the sample should include (3) clients, (3) consultants, (3) contractors and (3) suppliers/manufacturers.

3.9 Statististcal Tools

In this thesis, the researcher use statistical tools that fit with aim of research. that table below explain these tools:

Table 3.10: The content of statistical tools

Name	Symbol	Fourmla	Defention
Mean	M	$M=\frac{\sum x}{n}$	Is the sum of a collection of numbers divided by the count of numbers in the collection
Standard deviation	σ	$\sigma(r) = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - r)^2}.$	A measure of the amount of variation or dispersion of a set of values
Dgree of freedom	df	Df= N-1	Is the number of values in the final calculation of a statistic that are free to vary
Sum of squares	S.S	$SS = \sum_{i=1}^{n}(y_i - f(x_i))^2$	is the sum of the squares of residuals (deviations predicted from actual empirical values of data). It is a measure of the discrepancy between the data and an estimation model,
Sigifcant	Sig.	P- value	is the probability of obtaining test results at least as extreme as the result actually observed, under the assumption that the null hypothesis is correct
F-test	F	$F = \frac{\text{between-group variability}}{\text{within-group variability}}.$	it is most often used when comparing statistical models that have been fitted to a data set,
Mean square Error	MSE	$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2.$	An unobserved quantity) measures the average of the squares of the errors—that is, the average squared difference between the estimated values and the
Cronbach's alpha or	Pt	$\rho_T = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_X^2}\right)$	Is a reliability coefficient that provides a method of measuring internal consistency of tests

4. RESULTS AND ANALYSIS

4.1 Chapter Introduction

The findings of the questionnaire survey are displayed and examined in this chapter, together with any applicable statistical testing results. The answers of (123) respondents out of (160) targeted ones were collected and then analyzed. The gathered answers included descriptive overall kinds of information concerning the participants and their organizations, their ratings of various factors are classified as needed for proper analysis, and another descriptive information about the participants' arguments.

There are also descriptive statistical measurements, ranking in accordance with the relative relevance of factors, and statistical test measures.

4.2 Respondents' General Information

With the questionnaire, part-A, overall data about the participants along with their organizations is gathered in order to identify; the organization name, work sector, type of business, field of practice and classification rank (only for contractors) for each respondent, as well as the respondents job position, academic degree, specialization field, experience in construction and finally experience in lean construction.

4.2.1 Respondents' organizations

Section-A1 of part-A was designated to disclose the respondents' organizations. Appendix (C) lists the names of the respondents' organizations.

4.2.2 Respondents' organizations work sector

In section-A2 of part-A, the respondent's organization work sector weather Pubilc or Private one was investigated. The results are shown in Table (4.1) and Fig. (4.1) in which it can be noticed that (108) of the respondents' organizations were from the Public Setor and the rest (15) were Private ones. This is due to the limited opportunities available to private construction firms for novel types of project due to the absence of funds allocated by the government to this sector. On the other hand, public construction firms keep going just because they are subsidized by the government which gives them the largest share of new projects especially major projects. Furthermore, most of the private construction firms didn't respond to the questionnaire. Anyway, public construction firms have highly experienced engineering staff.

Table 4.1: Respondents organizations work sector

Sector	Frequency	Percentage
Public	108	87.8%
Private	15	12.2%
Total	123	100.0%

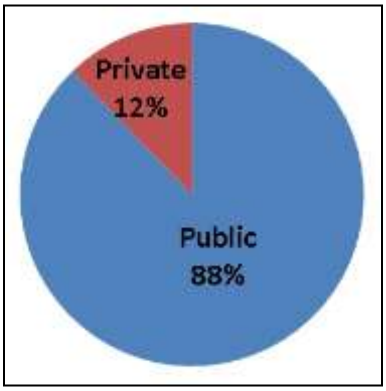

Figure 4.1: Respondents organizations work sector (Pie diagram**)**

4.2.3 Respondents' organizations type of business

In section-A3 of part-A, the respondents' organizations type of business was investigated. The results are shown in Table (4.2) and Fig. (4.2) in which it can be noticed that there were (35) clients, (41) consultatnts, (24) contractors, (2) manufacturers, (13) suppliers and finally (8) other stackeholders like academics. The number of manufacturers was low because most of the materials, fixtures and fittings used in the Iraqi construction industry are exported from abraod. This didn't affect the survey results for it has already cover all the parties ivolved in the construction industry.

Table 4.2: Respondents organizations type of business

Role	Frequency	Percentage
Client	35	28.5%
Consultant	41	33.3%
Contractor	24	19.5%
Manufacturer	2	1.6%
Supplier	13	2.4%
Others	8	14.6%
Total	123	100.0%

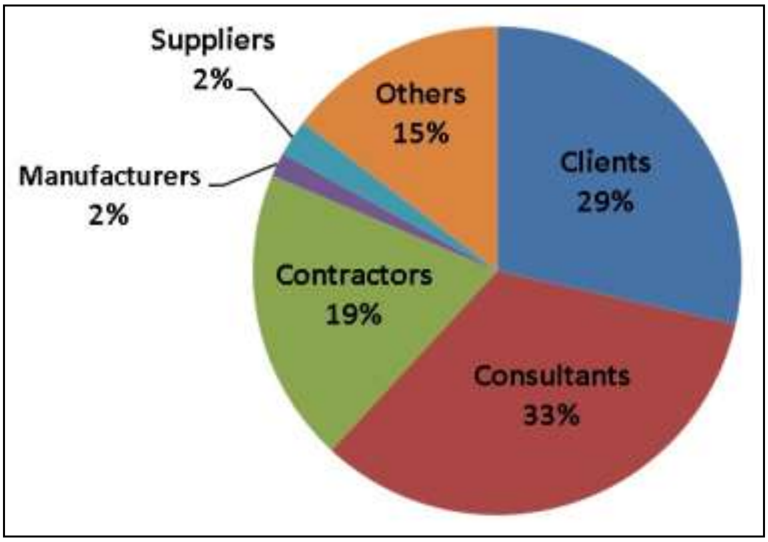

Figure 4.2: Respondents organizations type of business (Pie diagram**)**

4.2.4 Respondents' organizations field of practice

In section-A4 of part-A, the respondents' organizations field of practice was investigated. Table (4.3) plus Fig. (4.3) show the outcomes, in which it can be noticed that the respondents' organizations fields of practice were (78) in buildings, (9) in highways and bridges, (4) in water supply & sewerage, (1) in irrigation, (7) in industrial facilities, (16) in electrical plants, (2) in communications networks and finally (6) in other fields of practice like Engineers Syndicate and some organizations. Although the study has mainly focused on building projects, it is valid for the construction industry as a whole because building projects require a variety of materials, skills and equipment.

Table 4.3: Respondents organizations field of practice

Field	Frequency	Percentage
Buildings	78	63.4%
Highways and Bridges	9	7.3%
Water Supply & Sewerage	4	3.3%
Irrigation	1	0.8%
Industrial Facilities	7	5.7%
Electrical Plants	16	13.0%
Communications Networks	2	1.6%
Other	6	4.9%
Total	123	100.0%

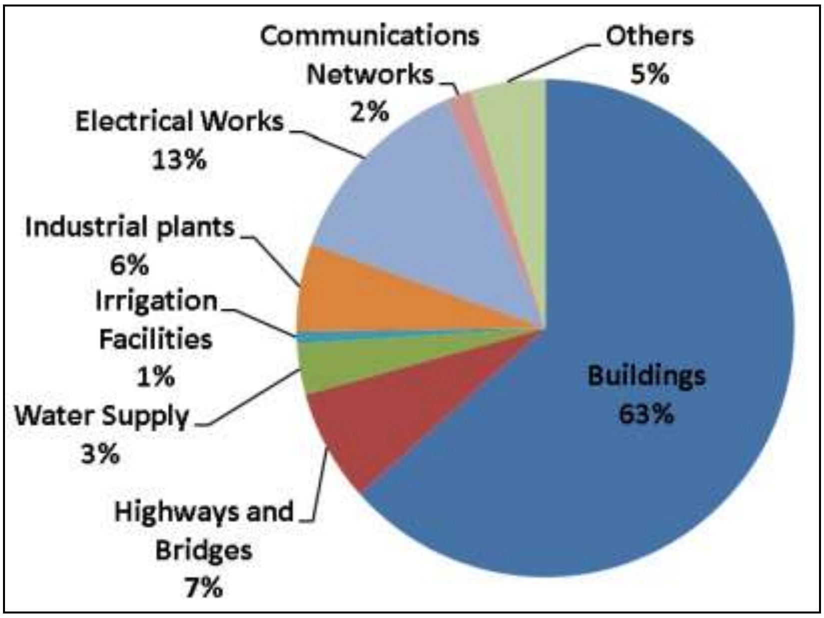

Figure 4.3: Respondents organizations field of practice (Pie diagram**)**

4.2.5 Classification rank for contractors

The Ministry of Planning in Iraq classifies the Iraqi contractors in two main categories; Civil Engineering Works Contractors (including mechanical, electrical and plumbing engineering) and Mechanical, Electrical & Chemical Works Contractors. Each includes eleven classes descending from Excellent, First to Tenth. In section-A5 of part-A of the questionnaire, the classification rank was investigated only for contractors among the respondents. The results are shown in Table (4.4) and Fig. (4.4) in which it can be noticed that (14) of them were specialized in civil engineering works holding excellent and first classes, while (5) were specialized only in mechanical, electrical or chemical engineering works holding excellent and first classes.

Table 4.4: Contractors classification rank

Excellent and First Class	Frequency	Percentage
Civil	14	73.5%
Mechanical, Electrical & Chemical	5	26.5%
Total	19	100.0%

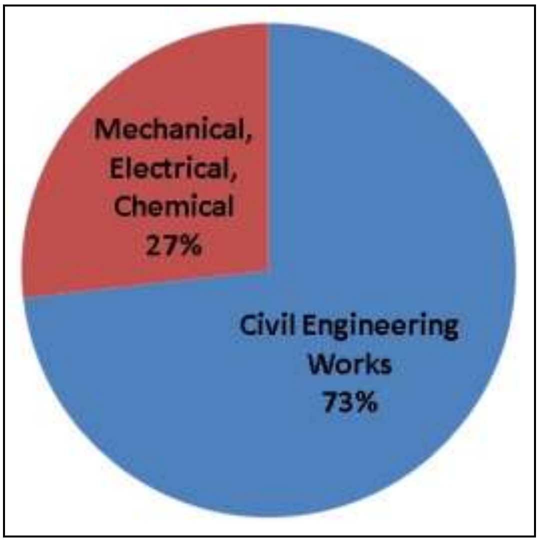

Figure 4.4: Contractors classification rank (Pie diagram**)**

4.2.6 Respondents' job position

In section-A6 of part-A, the respondents' job position was investigated. The results are shown in Table (4.5) and Fig. (4.5) in which it can be noticed that the respondents' job positions were (34) within top management, (44) within middle management, (27) within site management and finally (18) within supportive management. This indicated that all relevant managerial levels were sufficiently covered.

Table 4.5: Respondents job position

Position	Frequency	Percentage
Top Management	34	27.6%
Middle Management	44	35.8%
Site Management	27	22.0%
Supportive Management	18	14.6%
Total	123	100.0%

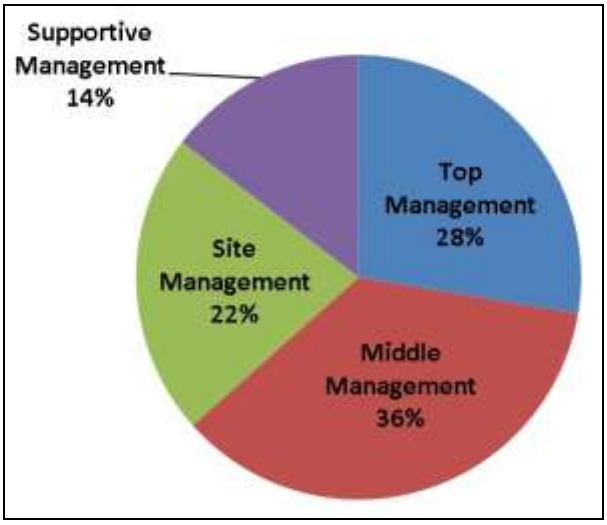

Figure 4.5: Respondents job position (Pie diagram**)**

4.2.7 Respondents' academic degree

In section-A7 of part-A, the respondents' academic degree was investigated. The results are shown in Table (4.6) and Fig. (4.6) in which it can be noticed that (27) of the respondents hold PhD dergree, (17) hold MSc dergree, (76) hold BSc dergree and the rest (3) respondents hold lower dergrees. These results can be considered very rational for most of the construction firms' engineering staff hold BSc degrees.

Table 4.6: Respondents education degree

Degree	Frequency	Percentage
PhD	27	22.0%
MSc	17	13.8%
BSc	76	61.8%
Others	3	2.4%
Total	123	100.0%

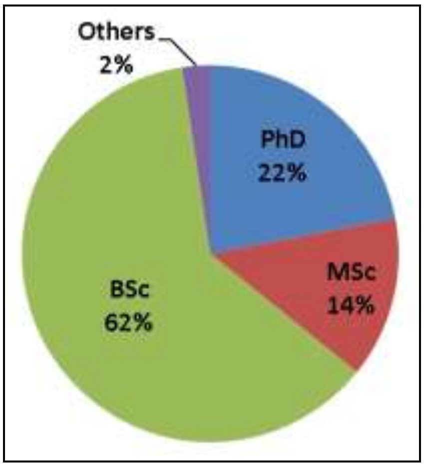

Figure 4.6: Respondents educational degree (Pie diagram**)**

4.2.8 Respondents' specialization

In section-A8 of part-A, the respondents' specialization was investigated. The results are shown in Table (4.7) and Fig. (4.7) in which it can be noticed that (68) of the respondents were civil engineers, (11) architects, (18) mechanical engineers, (20) electrical engineers, (1) communication engineers, (1) highway engineer, (4) not engineers and no chemical engineers were among them. This variation was expected because most of the respondents firms were building companies.

Table 4.7: Respondents specialization field

Specialization	Frequency	Percentage
Civil Engineers	68	55.3%
Architects	11	8.9%
Mechanical Engineers	18	14.6%
Electrical Engineers	20	16.3%
Communication Engineers	1	0.8%
Highway Engineers	1	0.8%
Chemical Engineers	0	0.0%
Others	4	3.3%
Total	123	100.0%

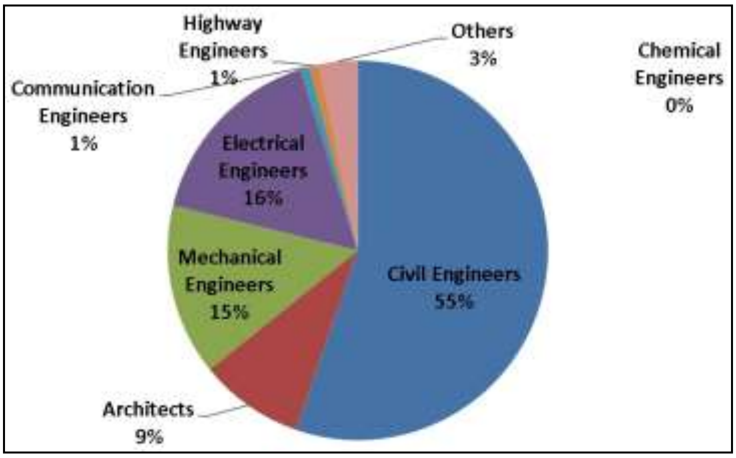

Figure 4.7: Respondents specialization (Pie diagram**)**

4.2.9 Respondents' expertise within the construction sector

In section-A9 of part-A, years of general experience within the construction sector were investigated for the respondents. The results are shown in Table (4.8) and Fig. (4.8) in which it can be noticed that (22) of the respondents have (6-10) years, (29) have (11-15) years, (39) have (16-20) year while (33) have over (20) years of expertise. These results indicated that the respondents are qualified enough to answer the questionnaire.

Table 4.8: Respondents experience in the construction industry

Years	Frequency	Percentage
(6-10)	22	17.9%
(11-15)	29	23.6%
(16-20)	39	31.7%
(> 20)	33	26.8%
Total	123	100.0%

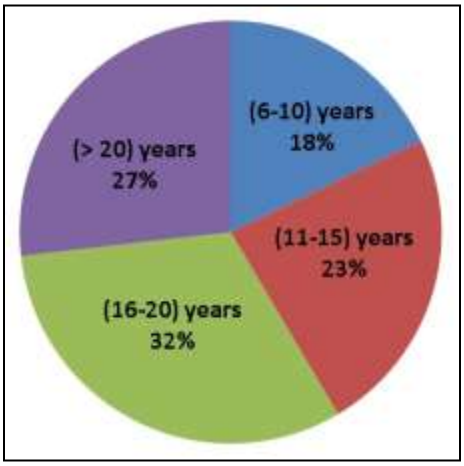

Figure 4.8: Respondents' experience within the construction sector (Pie diagram**)**

4.2.10 Respondents' expertise within lean construction

In section-A10 of part-A, the respondents' experience, specifically in lean construction, was investigated in years. The results are shown in Table (4.9) and Fig. (4.9) in which it can be noticed that (44) of the respondents have (0-3) years, (18) have (4-6) years, (23) have (7-9) years and (38) get over (9) years of practicing expertise within lean construction. These results are surprisingly unrealistic, which may be attributed to non-understanding of lean construction. This necessitated supporting the questionnaire with direct interviews for the purpose of finding out the truth.

Table 4.9: Respondents experience in lean construction

Years	Frequency	Percentage
(< 3)	44	35.8%
(4-6)	18	14.6%
(7-9)	23	18.7%
(> 9)	38	30.9%
Total	123	100.0%

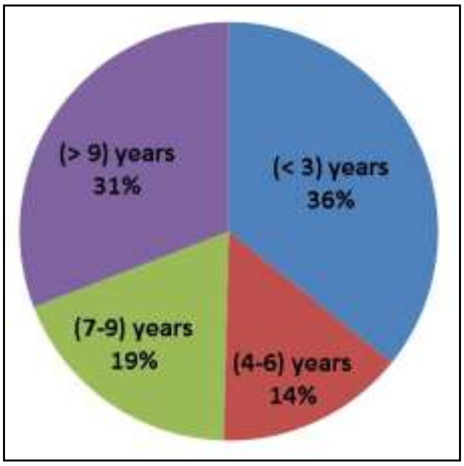

Figure 4.9: Respondents experience in lean construction (Pie diagram)

4.3 Success Factors for Constructing Projects

Within the questionnaire's part-B, the opinions of the construction industry stakeholders including the construction project parties on the success factors of any construction project, compiled from extensive literature review, were investigated. Based on these entities the success factors were classified into five sections; section-O for owners and clients, section-D for designers and consultants, section-B for Builders and contractors, section-S for suppliers and manufacturers and section-E for external entities. Table (4.10) shows the success factors related to each party and their ranking of importance according to the respondents' opinions.

It can be noticed that the respondents allocated almost the same influential role in construction projects success to all parties. The influential role of designers and consultants was found to be a bit higher with relative importance index of (72.412%), followed by owners and clients with relative importance index of (70.624%), Builders and contractors with relative importance index of (70.542%), external entities with relative importance index of (70.204%) and then suppliers and manufacturers with relative importance index of (69.512%). This can be attributed to the crucial role of professionalism in setting proper, practical, flexible, just as needed project design, bill of quantities, time plan and cost model by the designers and consultants based on deep feasibility study, thorough investigation of all surrounding circumstances, proper topographical and geotechnical investigation, … etc. Furthermore, their professionalism in solving execution problems is essential. It has been found that the accuracy of the bill of quantities, for instance, is the most influential factor with relative importance index of (75.122%).

Table 4.10: Ranking of the success factors of construction projects

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Client/Owner							**3.5312**	**0.79712**	**70.624**	**2**
Type of contract and procurement method	F	4	14	58	30	17	3.3415	0.96521	66.83	6
	%	3.3	11.4	47.2	24.4	13.8				
Timely payment to the contractor	F	2	11	51	34	25	3.561	0.9679	71.22	3
	%	1.6	8.9	41.5	27.6	20.3				
Timely approval of change orders/added	F	5	11	61	24	22	3.3821	1.01238	67.642	5
	%	4.1	8.9	49.6	19.5	17.9				
Timely resolution of admin. and financial issues time	F	6	8	47	33	29	3.5772	1.0713	71.544	2
	%	4.9	6.5	38.2	26.8	23.6				
Experienced and efficient supervision team	F	3	9	43	21	47	3.813	1.10401	76.26	1
	%	2.4	7.3	35	17.1	38.2				
Effective coordination with the authorities	F	2	11	61	20	29	3.5122	1.00299	70.244	4
	%	1.6	8.9	49.6	16.3	23.6				
Consultant/Designer:							**3.6206**	**0.84292**	**72.412**	**1**
Accurate, adequate & simple design & specifications	F	6	6	47	31	33	3.6423	1.07985	72.846	3
	%	4.9	4.9	38.2	25.2	26.8				
Accurate bill of quantities	F	6	8	37	31	41	3.7561	1.13326	75.122	1
	%	4.9	6.5	30.1	25.2	33.3				
Accurate planned time table	F	6	7	54	27	29	3.5366	1.06581	70.732	5
	%	4.9	5.7	43.9	22	23.6				
Timely resolution of execution issues	F	3	8	47	28	37	3.7154	1.04427	74.308	2
	%	2.4	6.5	38.2	22.8	30.1				
Professional in resolving changes/added time	F	1	10	55	32	25	3.5691	0.93284	71.382	4
	%	0.8	8.1	44.7	26	20.3				
Timely approval of submittals and tests results	F	3	10	55	32	23	3.5041	0.96982	70.082	6
	%	2.4	8.1	44.7	26	18.7				
Contractor/Builder							**3.5271**	**0.85475**	**70.542**	**3**

Table 4.10: (Cont.) Ranking of the success factors of construction projects

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Client/Owner							**3.5312**	**0.79712**	**70.624**	**2**
Timely supply of all needed resources	F	6	10	44	24	39	3.6504	1.15222	73.008	2
	%	4.9	8.1	35.8	19.5	31.7				
Timely providing of all required facilities	F	3	6	59	32	23	3.5366	0.93469	70.732	4
	%	2.4	4.9	48	26	18.7				
Ensure all health and safety requirements	F	5	17	62	21	18	3.2439	1.00279	64.878	6
	%	4.1	13.8	50.4	17.1	14.6				
Confirm to quality assurance procedures	F	4	12	57	32	18	3.3902	0.96355	67.804	5
	%	3.3	9.8	46.3	26	14.6				
Adhere to schedule and deadlines	F	5	8	41	33	36	3.7073	1.0844	74.146	1
	%	4.1	6.5	33.3	26.8	29.3				
Timely payment to suppliers and alike	F	7	5	46	33	32	3.6341	1.08845	72.682	3
	%	5.7	4.1	37.4	26.8	26				
Supplier/Manufacturer							**3.4756**	**0.86863**	**69.512**	**5**
Timely providing of the required type/quantity	F	10	2	44	36	31	3.6179	1.12731	72.358	1
	%	8.1	1.6	35.8	29.3	25.2				
Ability to import the required items in time	F	3	10	55	30	25	3.5203	0.98638	70.406	2
	%	2.4	8.1	44.7	24.4	20.3				
Assure the required quantity.	F	5	9	54	29	26	3.5041	1.03523	70.082	3
	%	4.1	7.3	43.9	23.6	21.1				
Providing good and suitable warehouses.	F	7	10	65	26	15	3.2602	0.97373	65.204	4
	%	5.7	8.1	52.8	21.1	12.2				
External Entities							**3.5102**	**0.85854**	**70.204**	**4**
Legislations and governmental laws	F	8	4	53	33	25	3.5122	1.05866	70.244	3
	%	6.5	3.3	43.1	26.8	20.3				
Political and economic situation of the country	F	6	7	48	22	40	3.6748	1.13438	73.496	1
	%	4.9	5.7	39	17.9	32.5				
Market fluctuations in supply/demand & prices	F	5	7	57	24	30	3.5447	1.05	70.894	2
	%	4.1	5.7	46.3	19.5	24.4				
Restrictions on working hours, holidays/events	F	5	13	58	33	14	3.3089	0.95067	66.178	4
	%	4.1	10.6	47.2	26.8	11.4				

* RII: is the Relative Importance Index.

The owners' and clients' role was straight next because the degree of the project complexity is highly dependent weather their requirements are rational. The success of construction projects is highly influenced by positive attitude of the owner and his clients (supervision team) and their quick response to solve work problems. The experienced and efficiency of the supervision team, for instance, have the highest importance ranking of (76.26%) among the whole success factors.

At nearly the same importance of the role of owners, the role of contractors was next. It is obvious that the performance of contractors has an influence on the project's success.

External factors stood in rank four including the effect of legislations, economy, markets and alike.

The role of suppliers and manufacturers had the last rank including quantity, quality, and timely supplies with proper warehouses. This might be an encouraging factor to move to lean construction.

4.4 Lean Construction Adoptability

In part-C of the questionnaire, the respondents' opinions on lean construction aspects were investigated. The aspects included; potential benefits in section-C1, adoption obstacles in section-C2, readiness success factors in section-C3 and proposed actions in section-C4.

4.4.1 Potential benefits

In section-C1, the respondents' opinions about the possible advantages of lean construction got investigated. It can be noticed in Table (4.11), that the respondents allocated almost the same importance for all potential benefits. This can be attributed to the principles of lean construction which mainly aim at faster production, less waste, and higher value. The higher ranked potential benefit was ‘better quality assurance with greater reliability’, it gets (68.78%) of relative significance index, followed by ‘cost saving with higher profitability’ that gets (67.642%) of relative significance index, ‘earlier completion time with greater certainty’ having the same relative importance index of (67.642%) but with slightly higher standard deviation, ‘higher productivity with less labour & inventory’ having a relative importance index of (67.154%), ‘controlled environment with lower hazards’ that gets (66.992%) of relative significance index, finally, ‘sustainability enhancement with less energy’ that gets (65.528%) of relative significance index.

Table 4.11: Ranking of the potential benefits of lean construction

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Benefits							3.3645	0.81324		
Earlier completion time with greater certainty	F	8	6	59	31	19	3.3821	1.02045	67.642	3
	%	6.5	4.9	48	25.2	15.4				
Cost saving with higher profitability	F	7	7	60	30	19	3.3821	1.00426	67.642	2
	%	5.7	5.7	48.8	24.4	15.4				
Better quality assurance with greater reliability	F	4	13	56	25	25	3.439	1.03343	68.78	1
	%	3.3	10.6	45.5	20.3	20.3				
Higher productivity with less labour & inventory	F	5	10	60	32	16	3.3577	0.95067	67.154	4
	%	4.1	8.1	48.8	26	13				
Controlled environment with lower hazards	F	4	13	62	24	20	3.3496	0.98333	66.992	5
	%	3.3	10.6	50.4	19.5	16.3				
Sustainability enhancement with less energy	F	8	15	56	23	21	3.2764	1.0887	65.528	6
	%	6.5	12.2	45.5	18.7	17.1				
* RII: is the Relative Importance Index.										

Value maximization as a major objective of lean construction stands for ranking the potential benefit of ‘better quality assurance with greater reliability’ at first. Using standardization, prefabrication and modern construction techniques in lean construction is another reason for that.

Time and cost saving and west mitigation are obvious basic drivers of lean construction. Productivity is also expected to be higher because Communicating, collaborating, and a secure and effective work environment are all emphasized in lean construction. Lean construction lowers downtime by removing inefficiencies in the process of obtaining supplies, equipment, and information..

Furthermore, lean construction is expected to reduce risks and enhance safety because of better monitoring and control of activities. Lean planning techniques assists in reducing any risk via enabling teamworks to observe progressing and classify and mitigate any possible risk in quick possible manner. At the front line, those who make decisions are enlisted to promptly resolve such issues and not wait till they get a long-term impact on the project.

4.4.2 Adoption obstacles

In section-C2, the respondents' opinions on the obstacles against lean construction adoption were classified into exogenous and endogenous obstacles and then investigated. Exogenous obstacles are those that are out of the institution control, while endogenous ones are within its intention. It can be noticed in Table (4.12), that the influence of the exogenous obstacles were higher than the endogenous ones with relative importance index of (71.07%) and (65.692%) respectively.

Table 4.12: Ranking of the obstacles against lean construction addoption

Factors	**Respondents' Ranking**						**Mean**	**SD**	**Total Ranking**	
	F/%	**1**	**2**	**3**	**4**	**5**			**RII%***	**1, 2, 3**
Over all							3.419	0.67396		
Exogenous Obstacles							**3.5535**	**0.76474**	**71.07**	**1**
Absence of government support	F	2	10	60	22	29	3.5366	0.99419	70.732	6
	%	1.6	8.1	48.8	17.9	23.6				
Lack of awareness and knowledge	F	4	9	43	30	37	3.7073	1.07682	74.146	2
	%	3.3	7.3	35	24.4	30.1				
Lack of a long-term vision.	F	4	6	52	31	30	3.626	1.0114	72.52	5
	%	3.3	4.9	42.3	25.2	24.4				
Fragmented nature of the industry	F	1	16	54	30	22	3.4553	0.96029	69.106	9
	%	0.8	13	43.9	24.4	17.9				
Many parties joined the project	F	2	10	49	32	30	3.6341	0.99398	72.682	4
	%	1.6	8.1	39.8	26	24.4				
Inefficient transportation and logistics	F	2	14	51	32	24	3.5041	0.98658	70.082	7
	%	1.6	11.4	41.5	26	19.5				
Hard to obtain technology and standardization	F	2	14	57	24	26	3.4715	1.00266	69.43	8
	%	1.6	11.4	46.3	19.5	21.1				
Initial and additional costs	F	2	13	60	28	20	3.4146	0.94024	68.292	11
	%	1.6	10.6	48.8	22.8	16.3				
Weak stakeholders' intention	F	8	11	59	21	24	3.3415	1.09267	66.83	12
	%	6.5	8.9	48	17.1	19.5				
Lack of engineers expertise and workers skills	F	3	10	40	25	45	3.8049	1.09887	76.098	1
	%	2.4	8.1	32.5	20.3	36.6				
Lack of transparency and integrity	F	6	11	41	22	43	3.6911	1.18134	73.822	3
	%	4.9	8.9	33.3	17.9	35				
Improper environmental conditions	F	5	17	45	29	27	3.4553	1.10329	69.106	10
	%	4.1	13.8	36.6	23.6	22				

Table 4.12: (Cont.) Ranking of the obstacles against lean construction addoption

Factors	**Respondents' Ranking**						**Mean**	**SD**	**Total Ranking**	
	F/%	**1**	**2**	**3**	**4**	**5**			**RII%***	**1, 2, 3**
Over all							3.419	0.67396		
Endogenous Obstacles							**3.2846**	**0.74029**	**65.692**	**2**
Lack of contractor/supplier involvement	F	11	12	59	26	15	3.1789	1.0638	63.578	10
	%	8.9	9.8	48	21.1	12.2				
Lack of prefabrication	F	1	20	67	20	15	3.2276	0.89455	64.552	7
	%	0.8	16.3	54.5	16.3	12.2				
Uncertainty in production process	F	3	18	69	17	16	3.2033	0.93177	64.066	9
	%	2.4	14.6	56.1	13.8	13				
Lack of identification and control of waste	F	1	21	58	25	18	3.3089	0.95067	66.178	3
	%	0.8	17.1	47.2	20.3	14.6				
High turnover of workforce	F	4	14	64	24	17	3.2927	0.95584	65.854	5
	%	3.3	11.4	52	19.5	13.8				
Lack of long-term relationship with suppliers	F	3	21	71	16	12	3.1057	0.88534	62.114	11
	%	2.4	17.1	57.7	13	9.8				
Multilayer subcontracting	F	6	10	66	17	24	3.3496	1.04005	66.992	2
	%	4.9	8.1	53.7	13.8	19.5				
Stress and pressure in deadlines	F	6	14	61	25	17	3.2683	1.0006	65.366	6
	%	4.9	11.4	49.6	20.3	13.8				
Poor team work culture	F	5	7	49	24	38	3.6748	1.09766	73.496	1
	%	4.1	5.7	39.8	19.5	30.9				
Absence of feedback	F	5	15	61	22	20	3.3008	1.01574	66.016	4
	%	4.1	12.2	49.6	17.9	16.3				
Losing some jobs due to work changes	F	3	21	62	20	17	3.2195	0.9712	64.39	8
	%	2.4	17.1	50.4	16.3	13.8				

* RII: is the Relative Importance Index.

Among the exogenous obstacles, it can be noticed that the ‘lack of engineers expertise and workers skills’ had the highest influence with relative importance index of (76.098%), followed by ‘lack of awareness and knowledge’ with relative importance index of (74.146%), ‘lack of transparency and integrity’ with relative importance index of (73.822%), ‘many parties joined the project’ with relative importance index of (72.682%), ‘lack of a long-term vision’ with relative importance index of (72.52%), ‘absence of government support’ with relative importance index of (70.732%), ‘inefficient transportation and logistics’ with relative importance index of (70.082%), ‘hard to obtain technology and standardization’ with (69.43%) of relative significance index, ‘fragmented nature of the industry’ with (69.106%) of relative significance index, ‘improper environmental conditions’ with relative importance index of (69.106%), ‘initial and additional costs’ with relative importance index of (68.292%), and finally ‘weak stakeholders' intention’ with relative importance index of (66.83%).

These ratings of exogenous factors look realistic because the adoption of any new technology or method requires first of all appropriate experience and skills supported by adequate knowledge and awareness. On the other hand, corruption, bureaucracy, inflation and prices fluctuation are out of the construction parties' control.

Among the endogenous obstacles, it can be noticed that ‘poor team work culture’ had the highest influence with relative importance index of (73.496%), followed by ‘multilayer subcontracting’ with relative importance index of (66.992%), ‘lack of identification and control of waste’ with relative importance index of (66.178%), ‘absence of feedback’ with relative importance index of (66.016%), ‘high turnover of workforce’ with relative importance index of (65.854%), ‘stress and pressure in deadlines’ with relative importance index of (65.366%), ‘lack of prefabrication’ with relative importance index of (64.552%), ‘losing some jobs due to work changes’ with (64.39%) of relative significance index, ‘uncertainty in production process’ with (64.066%) of relative significance index, ‘lack of contractor/supplier involvement’ with relative importance index of (63.578%), and finally ‘lack of long-term relationship with suppliers’ with relative importance index of (62.114%).

These ratings of endogenous factors also look realistic because team work by all parties involved is the backbone of lean construction for which multilayer subcontracting makes it more influential. Feedback including waste identification and other factors related to feedback such as meeting deadlines seem to have the same importance. Factors related to construction techniques like prefabrication and job changes seem also to have the same effect. In general, all endogenous factors seem to have very close effects.

4.4.3 Readiness success factors

In section-C3, the respondents' opinions on the readiness of the country (on national scale) and the readiness of organizations (on company scale) to successfuly addopt lean construction were investigated. It can be noticed in Table (4.13), that the influence of the readiness success factors on national scale were higher than the readiness success factors on company scale with relative importance index of (69.738%) and (68.678%) respectively. This indicates that the major role in shifting to lean construction rests with the government and the construction sector leaders.

Table 4.13: Ranking of the readiness success factors

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Over all							3.4604	0.7923		
On national scale							3.4869	0.83215	69.738	1
Government strategy and commitment	F	5	11	50	22	35	3.5772	1.11626	71.544	3
	%	4.1	8.9	40.7	17.9	28.5				
Demand and market conditions	F	0	19	54	23	27	3.4715	1.00266	69.43	6
	%	0	15.4	43.9	18.7	22				
Technology transfer	F	4	17	58	26	18	3.3008	0.99123	66.016	9
	%	3.3	13.8	47.2	21.1	14.6				
Awareness and knowledge	F	6	16	54	23	24	3.3496	1.08631	66.992	7
	%	4.9	13	43.9	18.7	19.5				
Expertise and skills	F	5	7	53	20	38	3.6423	1.10238	72.846	1
	%	4.1	5.7	43.1	16.3	30.9				
Design and process standardization	F	3	11	57	27	25	3.4878	0.99479	69.756	5
	%	2.4	8.9	46.3	22	20.3				
Information and communication technology	F	3	10	50	30	30	3.6016	1.02221	72.032	2
	%	2.4	8.1	40.7	24.4	24.4				
Research and development	F	2	14	62	19	26	3.4309	1.00067	68.618	8
	%	1.6	11.4	50.4	15.4	21.1				
Coordination/collaboration between parties	F	1	12	55	32	23	3.5203	0.93519	70.406	4
	%	0.8	9.8	44.7	26	18.7				
On company scale							3.4339	0.81093	68.678	2
Business and finance	F	6	11	51	26	29	3.4959	1.09675	69.918	4
	%	4.9	8.9	41.5	21.1	23.6				
Facilities and equipment	F	3	10	61	20	29	3.5041	1.01927	70.082	3
	%	2.4	8.1	49.6	16.3	23.6				
Design, manufacture & construction integration	F	3	11	48	27	34	3.6341	1.0579	72.682	1
	%	2.4	8.9	39	22	27.6				
Constructability and life-cycle engineering	F	0	12	56	25	30	3.5935	0.96528	71.87	2
	%	0	9.8	45.5	20.3	24.4				
Organization and leadership	F	1	19	53	22	28	3.4634	1.03459	69.268	6
	%	0.8	15.4	43.1	17.9	22.8				
Planning and control	F	3	13	56	26	25	3.4634	1.01054	69.268	5
	%	2.4	10.6	45.5	21.1	20.3				
Procurement and contracting strategy	F	4	16	66	19	18	3.252	0.97168	65.04	11
	%	3.3	13	53.7	15.4	14.6				
Supply and storage management	F	1	21	62	21	18	3.2764	0.94349	65.528	9
	%	0.8	17.1	50.4	17.1	14.6				

Table 4.13: (Cont.) Ranking of the readiness success factors

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Over all							3.4604	0.7923		
Cost and risk management	F	0	18	59	23	23	3.4146	0.95751	68.292	7
	%	0	14.6	48	18.7	18.7				
Transportation and logistics	F	4	17	64	19	19	3.2602	0.99042	65.204	10
	%	3.3	13.8	52	15.4	15.4				
Quality assurance and work environment	F	4	15	56	22	26	3.4146	1.05525	68.292	8
	%	3.3	12.2	45.5	17.9	21.1				
* RII: is the Relative Importance Index.										

Among the readiness elements of success on national scale, one can notice that ‘expertise and skills’ were confirmed to have the highest influence with relative importance index of (72.846%), followed by ‘information and communication technology’ with relative importance index of (72.032%), ‘government strategy and commitment’ with relative importance index of (71.544%), ‘coordination and collaboration between parties’ with relative importance index of (70.406%), ‘design and process standardization’ with relative importance index of (69.756%), ‘demand and market conditions’ with relative importance index of (69.43%), ‘awareness and knowledge’ with relative importance index of (66.992%), ‘research and development’ with relative importance index of (68.618%) and finally ‘technology transfer’ with relative importance index of (66.016%).

It can be clearly noticed that the rankings of readiness success factors on the national scale conform with the rankings of obstacles to be treated.

Among the readiness success factors on company scale, it can be noticed that the ‘integration of design, manufacture and construction activities’ had the highest influence with relative importance index of (72.682%), followed by ‘constructability and life-cycle engineering’ with relative importance index of (71.87%), ‘facilities and equipment’ with relative importance index of (70.087%), ‘business and finance’ with relative importance index of (69.918%), ‘planning and control’ with relative importance index of (69.268%), ‘organization and leadership’ with the same relative importance index of (69.268%) but higher standard deviation, ‘cost and risk management’ with relative importance index of (68.292%), ‘quality assurance and work environment’ with the same relative importance index of (68.292%) but higher standard deviation, ‘supply and storage management’ with relative importance index of (65.528%), ‘transportation and logistics’ with relative importance index of (65.204%), ‘procurement and contracting strategy’ with relative importance index of (65.04%).

It can be noticed that more emphasis was made to engineering-related factors like design, constructability and equipment. Management-related factors like business, planning, organization, cost and quality came next. Logistics-related factors like storage, transportation and procurement came last.

4.4.4 Proposed actions

In section-C4, the respondents' opinions on the proposed actions needed to adopt lean construction were classified into: knowledge and skills aspects, financial aspects, quality aspects, productivity aspects and management aspects and then investigated. It can be noticed in Table (4.14), that the influence of ‘financial support’ was the highest with relative importance index of (71.968%), followed by ‘productivity improvement’ with relative importance index of (70.048%), ‘management enhancement’ with relative importance index of (69.788%), ‘knowledge and skills leverage’ with relative importance index of (68.878%) and finally ‘quality assurance’ with relative importance index of (68.032%).

Table 4.14: Ranking of the proposed sections

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Over all							3.4872	0.74693		
Knowledge/skills leverage:							**3.4439**	**0.87798**	**68.878**	**4**
Academic education	F	4	14	55	28	22	3.4065	1.01495	68.13	3
	%	3.3	11.4	44.7	22.8	17.9				
Consultants' development programs	F	5	12	47	29	30	3.5447	1.08833	70.894	1
	%	4.1	9.8	38.2	23.6	24.4				
Manufacturers' & Contractors' dev. programs	F	6	14	53	28	22	3.374	1.05891	67.48	4
	%	4.9	11.4	43.1	22.8	17.9				
Labour training programs	F	1	12	56	28	26	3.5366	0.96064	70.732	2
	%	0.8	9.8	45.5	22.8	21.1				
Regulations, codes, standards and certification	F	4	15	58	25	21	3.3577	1.00922	67.154	5
	%	3.3	12.2	47.2	20.3	17.1				

Table 4.14: (Cont.) Ranking of the proposed sections

Factors	F/%	1	2	3	4	5	Mean	SD	RII%*	Total Ranking 1, 2, 3
Over all							3.4872	0.74693		
Financial support:							**3.5984**	**0.79403**	**71.968**	**1**
Demand continuity and stability	F	5	13	56	21	28	3.439	1.07997	68.78	5
	%	4.1	10.6	45.5	17.1	22.8				
Affordable loans	F	1	21	39	39	23	3.5041	1.0112	70.082	4
	%	0.8	17.1	31.7	31.7	18.7				
Tax exemption and levy reduction	F	5	14	46	27	31	3.5285	1.11123	70.57	3
	%	4.1	11.4	37.4	22	25.2				
Business and marketing	F	2	5	53	39	24	3.6341	0.89871	72.682	2
	%	1.6	4.1	43.1	31.7	19.5				
Non-delayed payment	F	3	5	41	28	46	3.8862	1.04178	77.724	1
	%	2.4	4.1	33.3	22.8	37.4				
Quality assurance:							**3.4016**	**0.8394**	**68.032**	**5**
Product, process and people certification	F	2	14	64	22	21	3.374	0.95298	67.48	4
	%	1.6	11.4	52	17.9	17.1				
Design, manufacture & construction integration	F	4	12	51	20	36	3.5854	1.10829	71.708	1
	%	3.3	9.8	41.5	16.3	29.3				
Design and processes standardization	F	3	15	54	30	21	3.4146	0.99116	68.292	2
	%	2.4	12.2	43.9	24.4	17.1				
Causal analysis and technical solutions	F	5	12	52	37	17	3.3984	0.9813	67.968	3
	%	4.1	9.8	42.3	30.1	13.8				
Environmentally friendly life cycle engineering	F	5	17	60	26	15	3.2358	0.97578	64.716	5
	%	4.1	13.8	48.8	21.1	12.2				
Productivity improvement:							**3.5024**	**0.86966**	**70.048**	**2**
Mechanization	F	9	4	49	26	35	3.6016	1.15048	72.032	2
	%	7.3	3.3	39.8	21.1	28.5				
Training	F	0	15	50	23	35	3.6341	1.02644	72.682	1
	%	0	12.2	40.7	18.7	28.5				
Controlled environment	F	2	12	60	28	21	3.439	0.94215	68.78	3
	%	1.6	9.8	48.8	22.8	17.1				
Health and safety measures	F	1	19	59	23	21	3.3577	0.96776	67.154	5
	%	0.8	15.4	48	18.7	17.1				
Information and communication technology	F	5	7	58	30	23	3.4797	0.99465	69.594	4
	%	4.1	5.7	47.2	24.4	18.7				

Table 4.14: (Cont.) Ranking of the proposed sections

Factors	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Over all							3.4872	0.74693		
Management enhancement:							**3.4894**	**0.8945**	**69.788**	**3**
Change strategy	F	8	12	50	29	24	3.3984	1.10691	67.968	4
	%	6.5	9.8	40.7	23.6	19.5				
Extensive planning and control	F	2	15	56	24	26	3.4634	1.01054	69.268	3
	%	1.6	12.2	45.5	19.5	21.1				
Organization and leadership	F	7	9	51	23	33	3.5366	1.13291	70.732	2
	%	5.7	7.3	41.5	18.7	26.8				
Collaboration and coordination	F	0	13	48	28	34	3.6748	0.99586	73.496	1
	%	0	10.6	39	22.8	27.6				
Transportation, logistics & supply chain mgmt.	F	4	10	63	28	18	3.374	0.94434	67.48	5
	%	3.3	8.1	51.2	22.8	14.6				

* RII: is the Relative Importance Index.

Because all actions need to be financed, it can be noticed that more emphasis was made to financial aspects like timely payment, marketing, tax reduction, affording loans and demand stability. All other factors received almost the same level of attention. This fact also necessitated supporting the questionnaire with direct interviews for the purpose of obtaining more precise results.

Concerning productivity aspects, training and mechanization received slightly higher attention than work environment, communication and safety, a matter that emphasis the importance of skills and technology as stressed earlier in the readiness success factors.

Regarding management aspects, collaboration received higher attention than organization, planning, strategy and transportation, this conform to the need of team work emphasized earlier in the readiness success factors.

The knowledge and skills aspects received lower ranking than expected including; development programs for each party, education, training and codes. This may be attributed to that each party blames the other parties.

Finally quality assurance aspects received the lowest ranking including; integration, standardization, causal analysis, certification and life-cycle engineering. This might be due to considering quality assurance aspects are based on fulfilling the other aspects of finance, productivity, management and knowledge.

4.5 Respondents' Organizations Actual Practice

Part-D was designated to gather information about the actual practice of the respondents' organizations in lean construction within the last 5 years. This part consisted three sections: D1 for completed lean construction projects, D2 for on-going lean construction projects and D3 for the respondents' opinions on the types of projects that are more suitable for lean construction application based on their organizations actual practice. It can be concluded from Table (4.15), that lean construction is adopted in Iraq in the last five years in not more than one third of all construction projects including conventional. This result seem to be exagerated, a matter that also necessitated supporting the questionnaire with direct interviews for the purpose of finding out the truth.

Table 4.15: The respondents' organizations actual practice within past 5 years

Project Status	F/%	Percentage of lean construction projects to all projects including conventional ones				
		20%	40%	60%	80%	100%
Completed projects	F	84	13	13	10	3
	%	68.3	10.6	10.6	8.1	2.4
On-going projects	F	81	13	17	9	3
	%	65.9	10.6	13.8	7.3	2.4

According to Table (4.16), the most suitable kind of constructing projects for lean implementation are residential projects based on the respondents' opinions with (71.708%) of relative significance index, next are industrial projects with (70.406%) of relative significance index, utilities projects with relative importance index of (70.244%), both educational and commercial projects with relative importance index of (66.992%) each, both health and tourism projects with relative importance index of (65.528%) each and finally offices projects with relative importance index of (61.952%).

Table 4.16: The suitable type of projects for lean construction

Type of projects	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Residential	F	13	7	41	19	43	3.5854	1.30527	71.708	1
	%	10.6	5.7	33.3	15.4	35				
Offices	F	7	19	64	21	12	3.0976	0.97017	61.952	8
	%	5.7	15.4	52	17.1	9.8				
Health	F	7	13	61	23	19	3.2764	1.03465	65.528	6
	%	5.7	10.6	49.6	18.7	15.4				

Table 4.16: (Cont.) The suitable type of projects for lean construction

Type of projects	Respondents' Ranking						Mean	SD	Total Ranking	
	F/%	1	2	3	4	5			RII%*	1, 2, 3
Educational	F	6	15	58	18	26	3.3496	1.09383	66.992	4
	%	4.9	12.2	47.2	14.6	21.1				
Industrial	F	5	14	49	22	33	3.5203	1.12607	70.406	2
	%	4.1	11.4	39.8	17.9	26.8				
Tourism	F	10	15	52	23	23	3.2764	1.14735	65.528	7
	%	8.1	12.2	42.3	18.7	18.7				
Commercial	F	5	13	65	14	26	3.3496	1.05569	66.992	5
	%	4.1	10.6	52.8	11.4	21.1				
Utilities	F	4	15	49	24	31	3.5122	1.09669	70.244	3
	%	3.3	12.2	39.8	19.5	25.2				
* RII: is the Relative Importance Index.										

This might be attributed to that residential projects are less sophisticated than other types of projects. On the other hand industrial projects are specialized ones.

4.6 Respondents' Suggestions to Overcome Obstacles

In Part-E of the questionnaire, the respondents' suggestions to overcome the expected problems were investigated through an open space. The respondents' suggestions to overcome encountered problems are summarized in the followings:

1. Eliminate corruption.
2. Maintain security.
3. Place the right man in the right place.
4. Providing government support to the private sector.
5. Assure finance and pay contractors dues in time.
6. Study the successful practices of other countries in lean construction and technology transfer.
7. Enhance the technical level of the supervision team to the required skills and knowledge.
8. Conduct continuous education and training courses for engineers, technicians and workers.
9. Conduct symposiums and webinars for contractors, suppliers and manufacturers in lean construction
10. Adopt modern techniques and software for design, estimation and execution.
11. Produce accurate, feasible and complete design, bids and procurement methods.
12. Maintain proper scheduling with continual updating.

13. Offer more work opportunities to local labour and self-sufficiency.
14. Prepare the required resources before inception.
15. Provide the required infrastructure before inception.
16. Standardize work procedures.
17. Take sustainability and green building aspects into consideration.

4.7 Reliability and Validity of the Questionnaire

For the purpose of finding the interior consistency of the questionnaire results and to know how well they represent the variables under study, the Cronbach's alpha test was conducted as an after distribution quantitative test. The results are shown in Table (4.17) in which it can be noticed that the internal consistency of the factors in each section of the questionnaire is in between (82.8% - 94.5%) and the internal consistency of all factors as a whole is (98.5%) which means a high degree of consistency.

Table 4.17: Reliability test results of the respondents evaluation of factors

Sections	Number of factors	Cronbach's Alpha
Client/Owner	6	0.871
Consultant/Designer	6	0.896
Contractor/Builder	6	0.904
Supplier/Manufacturer	4	0.862
External Entities	4	0.834
LC Benefits	6	0.889
General Obstacles	12	0.923
Specific Obstacles	11	0.923
Readiness on national scale	9	0.934
Readiness on company scale	11	0.945
Knowledge and skills leverage	5	0.908
Financial support	5	0.828
Quality assurance	5	0.893
Productivity improvement	5	0.907
Management enhancement	5	0.912
Type of projects suitable for LC	8	0.871
All	107	0.985

Furthermore, ANOVA (one-way variation analyzing) was executed for the questionnaire results means, between and within groups (sections of the questionnaire) to define any significant variances amongst the views of different respondents regarding the significance of the various elements. In this regard, the respondents were classified according to the general information of Part-A of the questionnaire. The mean values, F statistics, and P-values (the point where the hypothesis of equal mean values across dissimilar groups might be discarded) got measured. Tables (4.18) to (4.26) show the ANOVA tests results for the perceptions of different respondents. It can be noticed that the P-value (Sig.) is higher than (5%) for all factors in all cases except very few ones, which means there are no differences between answers in the vast majority of the results.

The only exceptions were in the 'benefits', 'quality assurance' and 'management enhancement' in Table (4.18), the 'consultant/designer' and 'exogenous obstacles'' in Table (4.19), the 'consultant/designer' in Table (4.22), and finally the 'endogenous obstacles' in Table (4.26). These exceptions represent less than (5%) of the results.

The reason of this is the conflict of interest between the constructing industry stakeholders (including different construction project parties). Each evaluated the factors based on his own point of interest.

Table 4.18: ANOVA test for respondents' organization work sector

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	.346	1	.346	.542	.463
	Within Groups	77.174	121	.638		
	Total	77.519	122			
Consultant/ Designer	Between Groups	2.562	1	2.562	3.685	.057
	Within Groups	84.121	121	.695		
	Total	86.683	122			
Contractor/ Builder	Between Groups	1.706	1	1.706	2.361	.127
	Within Groups	87.426	121	.723		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	2.201	1	2.201	2.964	.088
	Within Groups	89.851	121	.743		
	Total	92.052	122			
External Entities	Between Groups	1.309	1	1.309	1.788	.184
	Within Groups	88.616	121	.732		
	Total	89.925	122			
LC Benefits	Between Groups	6.568	1	6.568	10.722	.001
	Within Groups	74.118	121	.613		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	.141	1	.141	.240	.625
	Within Groups	71.208	121	.588		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	.090	1	.090	.162	.688
	Within Groups	66.769	121	.552		
	Total	66.859	122			
Readiness on national scale	Between Groups	.621	1	.621	.896	.346
	Within Groups	83.861	121	.693		
	Total	84.482	122			

Table 4.18: (Cont.) ANOVA test for respondents' organization work sector

		Sum of Squares	df	Mean Square	F	Sig.
Readiness on company scale	Between Groups	.099	1	.099	.150	.699
	Within Groups	80.129	121	.662		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	.908	1	.908	1.180	.280
	Within Groups	93.135	121	.770		
	Total	94.043	122			
Financial support	Between Groups	.359	1	.359	.568	.453
	Within Groups	76.560	121	.633		
	Total	76.920	122			
Quality assurance	Between Groups	2.942	1	2.942	4.287	.041
	Within Groups	83.018	121	.686		
	Total	85.960	122			
Productivity improvement	Between Groups	1.703	1	1.703	2.276	.134
	Within Groups	90.566	121	.748		
	Total	92.269	122			
Management enhancement	Between Groups	5.283	1	5.283	6.923	.010
	Within Groups	92.333	121	.763		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	1.947	1	1.947	3.073	.082
	Within Groups	76.676	121	.634		
	Total	78.623	122			

Table 4.19: ANOVA test for respondents' organization type of business

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	6.522	5	1.304	2.150	.064
	Within Groups	70.998	117	.607		
	Total	77.519	122			
Consultant/ Designer	Between Groups	9.026	5	1.805	2.720	.023
	Within Groups	77.657	117	.664		
	Total	86.683	122			
Contractor/ Builder	Between Groups	4.067	5	.813	1.119	.354
	Within Groups	85.065	117	.727		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	8.013	5	1.603	2.231	.056
	Within Groups	84.039	117	.718		
	Total	92.052	122			
External Entities	Between Groups	3.298	5	.660	.891	.490
	Within Groups	86.627	117	.740		
	Total	89.925	122			
LC Benefits	Between Groups	4.336	5	.867	1.329	.257
	Within Groups	76.351	117	.653		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	6.509	5	1.302	2.349	.045
	Within Groups	64.840	117	.554		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	1.059	5	.212	.376	.864
	Within Groups	65.800	117	.562		
	Total	66.859	122			
Readiness on national scale	Between Groups	3.931	5	.786	1.142	.342
	Within Groups	80.551	117	.688		
	Total	84.482	122			
Readiness on company scale	Between Groups	2.659	5	.532	.802	.550
	Within Groups	77.570	117	.663		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	5.827	5	1.165	1.546	.181
	Within Groups	88.216	117	.754		
	Total	94.043	122			
Financial support	Between Groups	1.702	5	.340	.529	.754
	Within Groups	75.218	117	.643		
	Total	76.920	122			
Quality assurance	Between Groups	5.691	5	1.138	1.659	.150
	Within Groups	80.269	117	.686		
	Total	85.960	122			
Productivity improvement	Between Groups	6.892	5	1.378	1.889	.101
	Within Groups	85.377	117	.730		
	Total	92.269	122			
Management enhancement	Between Groups	6.118	5	1.224	1.565	.175
	Within Groups	91.499	117	.782		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	2.710	5	.542	.836	.527
	Within Groups	75.912	117	.649		
	Total	78.623	122			

Table 4.20: ANOVA test for respondents' organization field of practice

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	1.381	7	.197	.298	.953
	Within Groups	76.138	115	.662		
	Total	77.519	122			
Consultant/ Designer	Between Groups	3.617	7	.517	.715	.659
	Within Groups	83.066	115	.722		
	Total	86.683	122			
Contractor/ Builder	Between Groups	2.163	7	.309	.409	.895
	Within Groups	86.969	115	.756		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	3.617	7	.517	.672	.695
	Within Groups	88.435	115	.769		
	Total	92.052	122			
External Entities	Between Groups	1.843	7	.263	.344	.932
	Within Groups	88.082	115	.766		
	Total	89.925	122			
LC Benefits	Between Groups	3.581	7	.512	.763	.619
	Within Groups	77.105	115	.670		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	1.452	7	.207	.341	.933
	Within Groups	69.897	115	.608		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	2.514	7	.359	.642	.720
	Within Groups	64.345	115	.560		
	Total	66.859	122			
Readiness on national scale	Between Groups	4.849	7	.693	1.000	.435
	Within Groups	79.633	115	.692		
	Total	84.482	122			
Readiness on company scale	Between Groups	3.610	7	.516	.774	.610
	Within Groups	76.618	115	.666		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	4.771	7	.682	.878	.526
	Within Groups	89.272	115	.776		
	Total	94.043	122			
Financial support	Between Groups	4.363	7	.623	.988	.444
	Within Groups	72.557	115	.631		
	Total	76.920	122			
Quality assurance	Between Groups	4.919	7	.703	.997	.437
	Within Groups	81.041	115	.705		
	Total	85.960	122			
Productivity improvement	Between Groups	4.320	7	.617	.807	.583
	Within Groups	87.949	115	.765		
	Total	92.269	122			
Management enhancement	Between Groups	4.091	7	.584	.719	.656
	Within Groups	93.525	115	.813		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	1.914	7	.273	.410	.895
	Within Groups	76.709	115	.667		
	Total	78.623	122			

Table 4.21: ANOVA test for respondents' company classification rank

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	1.047	1	1.047	1.657	.200
	Within Groups	76.472	17	.632		
	Total	77.519	18			
Consultant/ Designer	Between Groups	.501	1	.501	.704	.403
	Within Groups	86.182	17	.712		
	Total	86.683	18			
Contractor/ Builder	Between Groups	.130	1	.130	.177	.675
	Within Groups	89.002	17	.736		
	Total	89.132	18			
Supplier/ Manufacturer	Between Groups	.135	1	.135	.178	.674
	Within Groups	91.917	17	.760		
	Total	92.052	18			
External Entities	Between Groups	.277	1	.277	.374	.542
	Within Groups	89.648	17	.741		
	Total	89.925	18			
LC Benefits	Between Groups	.231	1	.231	.347	.557
	Within Groups	80.455	17	.665		
	Total	80.686	18			
Exogenous Obstacles	Between Groups	.150	1	.150	.254	.615
	Within Groups	71.199	17	.588		
	Total	71.349	18			
Endogenous Obstacles	Between Groups	.366	1	.366	.666	.416
	Within Groups	66.493	17	.550		
	Total	66.859	18			
Readiness on national scale	Between Groups	.256	1	.256	.368	.545
	Within Groups	84.226	17	.696		
	Total	84.482	18			
Readiness on company scale	Between Groups	.144	1	.144	.218	.642
	Within Groups	80.084	17	.662		
	Total	80.228	18			
Knowledge and skills leverage	Between Groups	.087	1	.087	.112	.739
	Within Groups	93.956	17	.776		
	Total	94.043	18			
Financial support	Between Groups	.360	1	.360	.568	.452
	Within Groups	76.560	17	.633		
	Total	76.920	18			
Quality assurance	Between Groups	.003	1	.003	.004	.951
	Within Groups	85.957	121	.710		
	Total	85.960	122			
Productivity improvement	Between Groups	.016	1	.016	.021	.885
	Within Groups	92.253	121	.762		
	Total	92.269	122			
Management enhancement	Between Groups	.411	1	.411	.512	.476
	Within Groups	97.205	121	.803		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	.017	1	.017	.026	.873
	Within Groups	78.606	121	.650		
	Total	78.623	122			

Table 4.22: ANOVA test for respondents' job position

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	3.744	3	1.248	2.013	.116
	Within Groups	73.776	119	.620		
	Total	77.519	122			
Consultant/ Designer	Between Groups	6.622	3	2.207	3.281	.023
	Within Groups	80.062	119	.673		
	Total	86.683	122			
Contractor/ Builder	Between Groups	5.179	3	1.726	2.447	.067
	Within Groups	83.952	119	.705		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	1.355	3	.452	.593	.621
	Within Groups	90.697	119	.762		
	Total	92.052	122			
External Entities	Between Groups	4.956	3	1.652	2.314	.079
	Within Groups	84.969	119	.714		
	Total	89.925	122			
LC Benefits	Between Groups	2.047	3	.682	1.033	.381
	Within Groups	78.639	119	.661		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	1.038	3	.346	.586	.626
	Within Groups	70.311	119	.591		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	1.027	3	.342	.619	.604
	Within Groups	65.832	119	.553		
	Total	66.859	122			
Readiness on national scale	Between Groups	.051	3	.017	.024	.995
	Within Groups	84.431	119	.710		
	Total	84.482	122			
Readiness on company scale	Between Groups	.828	3	.276	.414	.744
	Within Groups	79.401	119	.667		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	.684	3	.228	.291	.832
	Within Groups	93.359	119	.785		
	Total	94.043	122			
Financial support	Between Groups	.526	3	.175	.273	.845
	Within Groups	76.394	119	.642		
	Total	76.920	122			
Quality assurance	Between Groups	.832	3	.277	.388	.762
	Within Groups	85.127	119	.715		
	Total	85.960	122			
Productivity improvement	Between Groups	1.382	3	.461	.603	.614
	Within Groups	90.887	119	.764		
	Total	92.269	122			
Management enhancement	Between Groups	2.839	3	.946	1.188	.317
	Within Groups	94.777	119	.796		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	1.610	3	.537	.829	.480
	Within Groups	77.013	119	.647		
	Total	78.623	122			

Table 4.23: ANOVA test for respondents' education degree

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	1.163	3	.388	.604	.614
	Within Groups	76.357	119	.642		
	Total	77.519	122			
Consultant/ Designer	Between Groups	4.069	3	1.356	1.954	.125
	Within Groups	82.614	119	.694		
	Total	86.683	122			
Contractor/ Builder	Between Groups	2.041	3	.680	.930	.429
	Within Groups	87.091	119	.732		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	1.219	3	.406	.532	.661
	Within Groups	90.833	119	.763		
	Total	92.052	122			
External Entities	Between Groups	.540	3	.180	.240	.869
	Within Groups	89.385	119	.751		
	Total	89.925	122			
LC Benefits	Between Groups	4.928	3	1.643	2.580	.057
	Within Groups	75.758	119	.637		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	1.973	3	.658	1.128	.341
	Within Groups	69.376	119	.583		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	1.151	3	.384	.695	.557
	Within Groups	65.708	119	.552		
	Total	66.859	122			
Readiness on national scale	Between Groups	4.748	3	1.583	2.362	.075
	Within Groups	79.734	119	.670		
	Total	84.482	122			
Readiness on company scale	Between Groups	1.539	3	.513	.776	.510
	Within Groups	78.690	119	.661		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	1.720	3	.573	.739	.531
	Within Groups	92.323	119	.776		
	Total	94.043	122			
Financial support	Between Groups	.252	3	.084	.130	.942
	Within Groups	76.668	119	.644		
	Total	76.920	122			
Quality assurance	Between Groups	2.459	3	.820	1.168	.325
	Within Groups	83.501	119	.702		
	Total	85.960	122			
Productivity improvement	Between Groups	3.662	3	1.221	1.639	.184
	Within Groups	88.608	119	.745		
	Total	92.269	122			
Management enhancement	Between Groups	3.168	3	1.056	1.331	.268
	Within Groups	94.448	119	.794		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	.879	3	.293	.448	.719
	Within Groups	77.744	119	.653		
	Total	78.623	122			

Table 4.24: ANOVA test for respondents' specialization

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	2.907	6	.485	.753	.608
	Within Groups	74.612	116	.643		
	Total	77.519	122			
Consultant/ Designer	Between Groups	2.467	6	.411	.566	.756
	Within Groups	84.216	116	.726		
	Total	86.683	122			
Contractor/ Builder	Between Groups	4.667	6	.778	1.068	.386
	Within Groups	84.465	116	.728		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	4.947	6	.825	1.098	.368
	Within Groups	87.104	116	.751		
	Total	92.052	122			
External Entities	Between Groups	2.512	6	.419	.556	.765
	Within Groups	87.413	116	.754		
	Total	89.925	122			
LC Benefits	Between Groups	1.435	6	.239	.350	.909
	Within Groups	79.251	116	.683		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	1.579	6	.263	.438	.852
	Within Groups	69.770	116	.601		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	.130	6	.022	.038	1.00
	Within Groups	66.729	116	.575		
	Total	66.859	122			
Readiness on national scale	Between Groups	4.185	6	.698	1.008	.424
	Within Groups	80.297	116	.692		
	Total	84.482	122			
Readiness on company scale	Between Groups	2.771	6	.462	.692	.657
	Within Groups	77.458	116	.668		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	2.971	6	.495	.631	.705
	Within Groups	91.071	116	.785		
	Total	94.043	122			
Financial support	Between Groups	3.302	6	.550	.867	.521
	Within Groups	73.618	116	.635		
	Total	76.920	122			
Quality assurance	Between Groups	.888	6	.148	.202	.976
	Within Groups	85.072	116	.733		
	Total	85.960	122			
Productivity improvement	Between Groups	.659	6	.110	.139	.991
	Within Groups	91.611	116	.790		
	Total	92.269	122			
Management enhancement	Between Groups	4.554	6	.759	.946	.465
	Within Groups	93.062	116	.802		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	1.910	6	.318	.481	.821
	Within Groups	76.713	116	.661		
	Total	78.623	122			

Table 4.25: ANOVA test for respondents' years of experience in construction

		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	2.263	3	.754	1.193	.316
	Within Groups	75.257	119	.632		
	Total	77.519	122			
Consultant/ Designer	Between Groups	2.309	3	.770	1.086	.358
	Within Groups	84.374	119	.709		
	Total	86.683	122			
Contractor/ Builder	Between Groups	2.651	3	.884	1.216	.307
	Within Groups	86.481	119	.727		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	.943	3	.314	.411	.746
	Within Groups	91.108	119	.766		
	Total	92.052	122			
External Entities	Between Groups	2.987	3	.996	1.363	.258
	Within Groups	86.938	119	.731		
	Total	89.925	122			
LC Benefits	Between Groups	1.739	3	.580	.874	.457
	Within Groups	78.947	119	.663		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	.870	3	.290	.489	.690
	Within Groups	70.479	119	.592		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	1.316	3	.439	.797	.498
	Within Groups	65.542	119	.551		
	Total	66.859	122			
Readiness on national scale	Between Groups	1.117	3	.372	.532	.662
	Within Groups	83.365	119	.701		
	Total	84.482	122			
Readiness on company scale	Between Groups	.679	3	.226	.339	.797
	Within Groups	79.549	119	.668		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	.564	3	.188	.239	.869
	Within Groups	93.479	119	.786		
	Total	94.043	122			
Financial support	Between Groups	1.829	3	.610	.966	.411
	Within Groups	75.090	119	.631		
	Total	76.920	122			
Quality assurance	Between Groups	2.173	3	.724	1.029	.383
	Within Groups	83.787	119	.704		
	Total	85.960	122			
Productivity improvement	Between Groups	.373	3	.124	.161	.922
	Within Groups	91.896	119	.772		
	Total	92.269	122			
Management enhancement	Between Groups	2.117	3	.706	.879	.454
	Within Groups	95.500	119	.803		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	2.006	3	.669	1.039	.378
	Within Groups	76.617	119	.644		
	Total	78.623	122			

Table 4.26: ANOVA test for respondents' years of experience in Lean Construction

Questionnaire Sections		Sum of Squares	df	Mean Square	F	Sig.
Client/Owner	Between Groups	3.023	3	1.008	1.610	.191
	Within Groups	74.496	119	.626		
	Total	77.519	122			
Consultant/ Designer	Between Groups	1.699	3	.566	.793	.500
	Within Groups	84.984	119	.714		
	Total	86.683	122			
Contractor/ Builder	Between Groups	3.238	3	1.079	1.495	.219
	Within Groups	85.894	119	.722		
	Total	89.132	122			
Supplier/ Manufacturer	Between Groups	1.593	3	.531	.698	.555
	Within Groups	90.459	119	.760		
	Total	92.052	122			
External Entities	Between Groups	.556	3	.185	.247	.864
	Within Groups	89.369	119	.751		
	Total	89.925	122			
LC Benefits	Between Groups	3.874	3	1.291	2.000	.118
	Within Groups	76.812	119	.645		
	Total	80.686	122			
Exogenous Obstacles	Between Groups	3.795	3	1.265	2.228	.088
	Within Groups	67.554	119	.568		
	Total	71.349	122			
Endogenous Obstacles	Between Groups	5.781	3	1.927	3.755	.013
	Within Groups	61.078	119	.513		
	Total	66.859	122			
Readiness on national scale	Between Groups	3.774	3	1.258	1.855	.141
	Within Groups	80.708	119	.678		
	Total	84.482	122			
Readiness on company scale	Between Groups	3.772	3	1.257	1.957	.124
	Within Groups	76.457	119	.642		
	Total	80.228	122			
Knowledge and skills leverage	Between Groups	3.015	3	1.005	1.314	.273
	Within Groups	91.028	119	.765		
	Total	94.043	122			
Financial support	Between Groups	1.746	3	.582	.922	.433
	Within Groups	75.173	119	.632		
	Total	76.920	122			
Quality assurance	Between Groups	3.639	3	1.213	1.754	.160
	Within Groups	82.320	119	.692		
	Total	85.960	122			
Productivity improvement	Between Groups	3.642	3	1.214	1.630	.186
	Within Groups	88.627	119	.745		
	Total	92.269	122			
Management enhancement	Between Groups	2.399	3	.800	.999	.396
	Within Groups	95.217	119	.800		
	Total	97.616	122			
Type of projects suitable for LC	Between Groups	1.938	3	.646	1.002	.394
	Within Groups	76.685	119	.644		
	Total	78.623	122			

Furthermore, normality test was carried out using Kolmogorov-Smirnov and Shapiro-Wilk measures of normality. It can be noticed from Table (4.27) that the significance value is higher than (5%) in most of the cases which means that all results are normally distributed except in one case in Kolmogorov-Smirnov test (readiness on national scale) and some cases in Shapiro-Wilk test (endogenous obstacles, readiness on national scale, readiness on company scale, knowledge and skills leverage, financial support, quality assurance, productivity improvement, management enhancement and type of projects).

The reason of this is the conflict of interest between the constructing industry stakeholders (including different construction project parties). Each evaluated the factors based on his own point of interest.

Table 4.27: Normality tests results

Questionnaire Sections	Kolmogorov-Smirnov*		
	Statistic	df	Sig.
Client/Owner	.012	123	.081
Consultant/Designer	.029	123	.140
Contractor/Builder	.031	123	.130
Supplier/Manufacturer	.029	123	.180
External Entities	.030	123	.100
LC Benefits	.012	123	.071
Exogenous Obstacles	.012	123	.069
Endogenous Obstacles	.030	123	.054
Readiness on national scale	.029	123	.017
Readiness on company scale	.035	123	.140
Knowledge and skills leverage	.032	123	.130
Financial support	.008	123	.071
Quality assurance	.031	123	.120
Productivity improvement	.011	123	.101
Management enhancement	.013	123	.081
Type of projects suitable for LC	.019	123	.090
* Lilliefors Significance Correction.			

4.8 The Interviews Results

The interviews were conducted with (12) out of (123) questionnaire respondents and found to be consistant and eough. They included (3) clients, (3) consultants, (3) contractors, (2) suppliers and (1) manufacturer. Tables (4.28) to (4.37) show the results of the interviews. These results had important impact when discusing the research results in the comming Chapter Five.

Table 4.28: General information about the interviewees

General information about the interviewees					
Affiliation					
No.	Name	Work Sector	Type of Business	Field of Practice	Class Rank
1	Public Authority for Building	Public	Supervision	Building*	NA***
2	Public Authority for Housing	Public	Supervision	Building*	NA***
3	Ministry of Higher Education	Public	Academic	Electrical	NA***
4	National Consultancy Center	Public	Consultancy	Building*	NA***
5	Baghdad Mayoralty	Public	Construction	Highways	NA***
6	University of Baghdad	Public	Academic	Civil	NA***
7	Al-Rasheed Contracting Co.	Public	Contractor	Building*	Excellent**
8	Al-Faw Contracting Co.	Public	Contractor	Building*	Excellent**
9	Rahman Trading & Contracting Co.	Privet	Contractor	Building*	First rank
10	Civil Techniques Co.	Privet	Supplier	Construction	First rank
11	Al-Miamar Palace Co.	Privet	Supplier	Construction	First rank
12	Glory Pillars Co.	Privet	Manufacturer	Construction	First rank
* Building includes civil, mechanical, electrical and plumbing engineering. ** Higher than the first rank. *** Not Applicable					

Table 4.28: (Cont.) General information about the interviewees

Interviewee				
No.	Position	Education	Specialization	Experience (years)
1	Top Management	BSc	Civil Eng.	25
2	Middle Management	BSc	Civil Eng.	18
3	NA*	MSc	Electrical Eng.	11
4	Top Management	PhD	Civil Eng.	20
5	Middle Management	MSc	Civil Eng.	16
6	NA*	PhD	Civil Eng.	12
7	Top Management	BSc	Civil Eng.	23
8	Middle Management	BSc	Electrical Eng.	17
9	Site Management	MSc	Civil Eng.	13
10	Site Management	MSc	Civil Eng.	10
11	Middle Management	PhD	Civil Eng.	16
12	Middle Management	BSc	Civil Eng.	18
* Not Applicable				

Table 4.29: Factual practice of lean construction in Iraq

Q1: already practicing lean construction vs. severe cost and time overrun	
Reasons of contradiction	Score
a) Unrealistic research hypothesis	0
b) Lack of proper understanding of lean construction.	12
c) Others.	0

Table 4.30: Sorting proposed action needed to adopt lean construction

Q2: all proposed actions received almost the same level of attention	
Sort	**Main area of proposed actions**
1	Knowledge and skills
2	Financial support
3	Quality assurance
4	Management enhancement
5	Productivity improvement

Table 4.31: Factual role of Procurement and contracting strategy

Q3: Non-delayed payments vs. Procurement and contracting strategy	
Reasons of contradiction	**Score**
a) Misunderstanding	0
b) Imperfect governmental regulations.	12
c) Others.	0

Table 4.32: Factual role of Business and marketing

Q4: Relationship with suppliers vs. Business and marketing	
Reasons of contradiction	**Score**
a) Misunderstanding	0
b) Already maintained relations.	12
c) Others.	0

Table 4.33: Factual role of strategy change

Q5: Lack of a long-term vision vs. Change strategy	
Reasons of contradiction	**Score**
a) Misunderstanding	9
b) Desperateness.	3
c) Others.	0

Table 4.34: Factual role of Technology transfer

Q6: Mechanization vs. Technology transfer	
Reasons of contradiction	**Score**
a) Misunderstanding	0
b) Lack of knowledge of modern technologies	3
c) Others (Lack of governmental support).	9

Table 4.35: Factual role of Information and communication technology

Q7: Absence of feedback vs. ICT	
Reasons of contradiction	**Score**
a) Misunderstanding	0
b) Lack of knowledge of modern ICT	9
c) Others.	3

Table 4.36: Factual role of Constructability and life-cycle engineering

Q8: Lack of waste control vs. Constructability and life-cycle engineering	
Reasons of contradiction	**Score**
a) Misunderstanding	0
b) Lack of knowledge of sustainability aspects	12
c) Others.	0

Table 4.37: Sorting the influence of construction project phases and parties

Q9: all project phases and parties received almost the same level of attention	
Sort	**Construction project phases and parties**
1	Government support.
2	Industry stakeholders' intentions.
3	Training and education programs.
4	Planning and design phase.
5	Procurement phase.
6	Execution phase.
7	Markets stability.
8	Technology transfer opportunities.

5. DISCUSSING THE RESEARCH FINDINGS

5.1 Chapter Introduction

In this chapter, the results and findings of the study are examined and discussed to pave the way to withdraw conclusions that serve the aim and objectives of the research. The results of the questionnaire survey supported by the interviews results were utilized in this discussion. An effective way to deal with the collected information explained in chapter four is to answer the research questions stated in chapter one which included:

1. What is the role of construction projects planning and design in this sense?
2. What is the role of construction projects procurement in this sense?
3. What is the role of construction projects execution in this sense?
4. What is the role of the construction industry stakeholders in this sense?
5. What is the role of the government in this sense?
6. What is the role of markets in this sense?
7. What is the role of technology transfer in this sense?
8. What is the role of training and education in this sense?

5.2 The Role of Planning and Design

The most influential stage in the construction project lifespan which has an influence on the project successfulness is the phase of planning and design. This stage has a vital role in deciding the project scope as well as proper methods of construction, which particularly are the bases of cost estimating, time scheduling, cash-flow forecasting, resources allocation (including materials, equipment, labour, and the project management team) and feasibility study. As much as planning and design are precise, the project success opportunities are higher in meeting time, cost and quality targets. For instance, how simple, clear, complete, practical, flexible, economic and eco-friendly is the design, in addition to the bill of quantities and plans. Modern techniques like building information modeling (BIM) can be of great aid in this sense. Performing precise planning and design is crucial to implement lean construction, for it needs much more scrutinizing of all activities than other approaches. Therefore, enough care should be taken in assigning the consultancy and design team. Another concept that became a worldwide humanity issue is sustainability, green building and mitigating greenhouse emissions, which necessitates to taken into consideration the effects upon people well-being as well as the natural environments via effectively use of energies, waters as well as different resources, in addition to decreasing wastes, pollution and environment degrading. It also includes protecting the health of the facility users and improves employee productivity **(Macomber, 2004).**

The most critical aspects to be accomblished in the phase of planning and design are:

1. Preparing the technical and economic feasibility study of the project.
2. Choosing a suitable site in a proper location.
3. Ensuring finance sources for the project.
4. Adherence to the target cost during design and specifications laydown.
5. Assignment of well-experienced staff for design and supervision.
6. Providing a favorable work environment aided by time schedules.
7. Maintaining team-work spirit through periodical meetings with involved teams.
8. Maintaining complete, constructible, flexible design according to the client needs.
9. Adopting modern design techniques and software like BIM.
10. Preparing precise list of amounts, time scheduling and diffferent tender papers.

In this sense, it should be noted that, Integrating multiple levels of planning must be possible with a lean schedule system. The information should flow smoothly from the short- and medium-term schedule to the long-term plans.To put it another way, managers must have ability to swiftly determine the strategic consequences of operational issues, and there must be a stronger mechanism to assess the master plan implications of decisions made throughout the schedule phase.Such matter could be more simply proven in complicated projects, where larger amounts of workflows and inter - dependencies can make analyzing and identifying the optimum schedule strategy for the project as a whole complex and time-consuming.

Depending upon the results of the current research, few aspects were stressed for successful adoption of lean construction. Maintaining timely payments comes first, which necessitates assuring finance sources since the planning phase. The second aspect is provide for high productivity by planning for using modern construction technology, modern ICT, health and safety precautions, environmental issues and solid performance monitoring. The third aspect is the integration between design and construction which necessitates planning for effective cooperation between parties, mobilization and logistics, quality assurance and supply chain management. These aspects imply that engineers and other relevant staff and labour should be subjected to suitable training.

5.3 The Role of Procurement

The procurement phase in lean construction is much more important than in traditional construction because of the higher number of deals need to be timely accomplished in lean construction. When there are some mistakes in estimating the time and requirements of any deal, all other related deals will be affected. Therefore, enough time and care should be paid to the procurement process in order to minimize the risk. Care should also be taken in deciding on the type of contract and terms of payment. Construction contracts use to have five main different types according to the procurement method, organization strategy and roles of the main parties. These five types are the traditional method of “General Contractor”, “Design and Build or Turnkey job”, “Project Management through Few Prime Contractors”, “Construction Management through Multiple Prime Contractors” and “Direct In-house Force”. Construction contracts also differ according to the payment strategy. The main types of contracts in this sense are “Firm Fixed Price” contracts including “Lump Sum”, “Unit Pricing” and “Schedule of Rates”, and “Fixed Price with Escalation”, “Fixed Price with Incentive or Guaranteed Maximum”, “Cost - Plus Fee”, “Cost - Plus Percentage of cost” and “Time and Material”.

The Guaranteed Maximum Price (GMP) contracts are considered one of the best contracts because they set a ceiling for the contract value. The land owner can not surpass the stipulated price with this form of constructing contract. Any material and/or labor expenses exceeding this amount must be covered by the contractors, which speeds up the job. Obtaining the ultimate contract price expedites the bidding process and makes project financing easier because lenders are aware of the project's maximum cost early on. GMP contracts encourage cost-cutting. Contractors are motivated to save expenses and complete ahead of time when they have a set general price. Landlords and contractors frequently agree to sharing any cost saving, and this type of contract fits the application of lean construction techniques and aims to reduce time and cost.

5.4 The Role of Execution

The executing stage of any construction project represents the real challenge of implementation in which success or failure will be faced. Therefore, adopting lean construction need to provide well-prepared staff with enough knowledge and skills to apply suitable techniques and methods. This is done either by introducing them to training courses using this technique or by seeking the assistance of experts in this field. Standardization, off-site manufacturing, prefabrication, modern technology, team spirit, and waste prevention of all kinds are vital. An effective monitoring and follow-up technique is required. The last scheme system is considered as a system of collaborative work management of the program coordination and product delivery by enhancing coordination between related parties. It is depending upon the "should, can, and will" method (Ballard, 2000). Latest Planner is another system that has proven to be a very useful tool for continuous monitoring and planning updating (Mosman, 2005). A technique called "Last Planner" became widely used when lean construction is employed. It is a weekly updating system showing all types of waste and what to do to save time, efforts and materials. A software program called Lean Project Delivery System (LPDS) can be of a great aid in this sense. It is a set of interrelated functions, decision-making rules, and implementing procedures. The LPDS is depicted as a five-stage model, with each stage consisting of three units (Ballard, 2000). To explain the delivery of supplies to a building location, for example, it is proposed that the items be carried to their ultimate installation location and placed at once when arrive, with no delay caused by storing in a temporary location or region.The system divides waste into six groups based on its sources including design (lack of information in design documents), procurement (ordering of unfit materials), material handling (imperfect methods), operation (imperfect methods), construction residual (uneconomical dimensions), and others (lack of on-site materials control and waste management plans) .

Here again, maintaining timely payments, using modern construction technology, modern ICT, H&S precautions, environmental issues and solid performance monitoring, cooperation between parties, mobilization and logistics, quality assurance and supply chain management were also stresses by the research results in addition to employing qualified site managers and well-trained staff.

5.5 The Role of Industry

The constructing industry represents a significant industry that contributes to the development of countries. For the success of this industry, stakeholders must perform their duties accurately and efficiently with the purpose of contributing to the success and improvement of this important industry. The word “stakeholders” includes clients, consultants, contractors, manufacturers, suppliers, importers, equipment and labour brokers, sponsors, professional organizations and related governmental agencies.

Clients must provide enough administrative and financial support to assure the project success in meeting specified time, quality and cost. They should choose the appropriate type of contract, provide financial liquidity, choose qualified supervisory team, coordinate actively with parties and authorities and prompit response to resolve work issues.

The consulting engineers must take into consideration the ease and accuracy of designs, bills of quantities, time schedule and other contract documents. They should maintain speed in resolving work problems, change orders, selection of materials and laboratory testing and alike.

The contractors must timely and suffeiciently provide all the resources needed, including human resources, equipment, and materials. Providing suitable machinery to increas productivity and speed up completion, suitable stores, energy, water sources and other logistics. Subcontractors and suppliers dues shoul be timely met.

Suppliers and manufacturers must abide by delivery dates of materials and manufactured supplies, ensure quality and secure suitable storage places.

Sponsers should provide soft loans, market stability and continuity of demand.

Proffesional organizations and unions should provide support to the industry stakeholders by organizing continual education and training courses and seminars for all levels on modern methods and techniques. Academic institutions might have a role too. Education and training, including courses for consultants, constructors and labour, enhancing the culture of lean construction, technology transfer, design and manufacturingstandardization, causal analysis, sustainability and life cycle analysis.

5.6 The Role of Government

The government has a crucial role in adopting new stratagems within the constructing industry to avoid any problem of time and cost overrun in addition to quality assurance. It has the power and tools to reorganize, in an effective ballanced way, the construction industry affaires such as market policies, human resources development and instsutional and financial support. It is resposible for relevant legislations and infrastructure management. According to the results of this research, the financial aspect comes first in affording for lean construction. The government can help a lot in this sense by adopting encouraging policies for tax exemption, banking facilities, bonds and loans, ensuring the continuity of supply and demand and market stability. It also plays a pivotal role in education and training needed to shift to lean construction, technology transfer, integration of design, manufacting and construction, quality assurance through institutional and personal certification, simplifying contract conditions and bidding procedures.

5.7 The Role of Markets

The market represents a vital factor affecting the successfulness of lean constructing implementation. Consistent with the findings of this research, some sort of market control need to be maintained to ensure material availability and flow, stable prices and balanced supply and demand. Manufacturers need to be continually supplied by raw materials, electrical power and fuel to operate their facilities. Importers need to be supported by facilitating letters of credits, rates of exchange, customs tariffs and taxes. At the same time a solid quality control system should be applied on materials and products. Transportation and storage should also be facilitated.

5.8 The Role of Technology

Its obviuous that modern technology facilitates construction works, while the challenge is how to transfer modern technology and adopt it the local industry. Using contemporary materials, equipment and techniques in lean construction, especially prefabrication, can provide for better quality and productivity, less health and safety hazards, more sustainable and eco-friendly products using renewable energy, and less energy consumption.

Using modern hardware or software can aid a lote too, such as:

1. A system called "pype" which utilizes AI "artificial intelligence" as well as "Machine Learning" to facilitate the procedures of lean construction by simplifying and speeding up the construction processes, keep pace with the current development, provide standardization across companies, increase productivity and enhance quality assurance.
2. A system called "Raken" which is an incentive to change The attitude and conduct of constructing firms when it comes to adopting different agile approaches. It's mostly about efficacy when it comes to constructing. In terms of field management, a lot of redundant components are availbe in the process, a lot of paperwork, and a lot of time wasted managing it all. Lean construction revolves around an efficiency mentality at the project level and Raken is the simple solution. Raken can provide a help for this as it simplifies everyday report-making, timing card as well as numerous site management workflow, automatic generation of whole and standard reports and it assigns as well as manages job site jobs via a cell phone.
3. A system called "Smartvideo" which allows any contractor to harness the influence of artificial intelligence by reducing risks in any project. Similar to a "virtual safety inspector", Smartvideo's security monitor solution connects current sources of images, videos and data projecting, it senses safety risks on constructing worksites by an automatic manner. With Smartvideo, project groups are able of taking correcting steps to eliminate identified risks. Company employees are objectively able of measuring trends within safety activities through their projects' folder and making better choices about assigning resources for any risky project. By utilizing pre-built connectors for current systems, all project photos can be collected. Safety threats, for example personnel

protecting equipment, fall protecting ,and housekeeping alerts are automatically detected. Safetyness managers and project team members should be notified so that remedial action may be taken.T the extent to which critical safety regulations being followed should objectively measured to expect and prevent mishaps.

4. A system called “StructionSite” is a photo documentation system used to clarify project's features, it can have an influence upon the landlord's view of the state of his project. It can also have a significant influence on field work coordination, enabling groups to better manage change when on the move. Firms may establish better design/location logistic planning for any project by employing a 360-degree picture documentation solution like StructionSite. Automation of 360 video location capture enables near-total location coverage while boosting the value of an activity currently performed by at least one person on-site: going onto the job site. For all project stakeholders, a site created by a team member becomes a comprehensive digital replica of the work site. Designers can see the location, subscribers could witness the current status of the businesses, while the landlord will have more insight into the job's status. Using data acquired from 360 videos, resources for planning sessions on a weekly basis and better collaborating within the area can be created. Reduce rework by using static picture and video evidence to catch mistakes in advance and saving time and money.

5.9 The Role of Training and Education

Continuous training has a significant role in order to succeed in lean construction implementation. This has been confirmed in this reseach and by many others like (Shrimali and Soni, 2017; Netland, 2016; Yamchello et al., 2014).

Learning and training for lean thinking could be split to double distinct fields of science and application. The learners are subjected to lean principles, concepts, and tools within the area of commercial governance. The other area should describe how to effectively apply learned principles and concepts in lean construction. In such cases, the education can be applied mostly inside offices as well as academic institutions. In this sense a university-consortium collaborating (UIC) could be an effective stage. According to (Ankrah and Al-Tabbaa, 2015) UIC can be classified to: research support, collaborative research, knowledge transfer and technology transfer. Within the setting of the UIC, simple education could be offered in class, so transferring knowledge in both directions can provide fresh knowledge from such cooperation. It looks very attractive in the business area. Companies in which students undergo their graduation projects can get benefits via different ideas and novel techniques by considering the difficulties while they actively improve simple capabilities within actual identification.

On the other hand, labour training is the responsibilty of vocational centers, manufacturers, contractors and labour unions. Within previous works, lean training was regularly mentioned as having a significant part to play in the success of lean implementation as well as continual improving programs. According to (Shrimali and Soni, 2017) poor training was one of the barriers witnessed in succeeding lean adoption within small and medium enterprises (Netland, 2016; Yamchello et al., 2014) found that training and education are the most regularly stated important success factors in the improvement program literature, behind management commitment and engagement.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Chapter Introduction

The findings of this research can be utilized to draw a roadmap for the Iraqi construction industry to facilitate the adoption of lean construction. In this chapter, conclusions and recommendations are provided based on the results of a questionnaire survey directed to relevant Iraqi stakeholders supported by personal interviews.

6.2 Conclusions

The study confirmed that using lean principles and techniques are useful to fulfill construction projects objectives namely time, cost and quality. The benefits, obstacles, success factors and actions needed to adopt lean construction in Iraq were identified. The roles of the main phases of construction projects and the main stakeholders of the construction industry were also explored.

It was found that there is quite a lack of knowledge and awareness in lean construction concepts and techniques among the Iraqi construction industry constituencies, a matter that need a comprehensive strategy for cultural change, education and training programs to be adopted by the government, academy and the industry itself. For instance, integration of design, manufacture and construction should be put in place by consultants, manufacturers and contractors through fruitful coordination and team work. Clients should consider different types of contracts and procurement methods in order to select the most suitable one for lean construction. All industry stakeholders should be aware of the benefits of lean construction in eliminating all types of materials and processes wastes, lowering costs, providing more reliable quality assurance and maintaining more certain timely delivery of works.

The benefits of lean construction confirmed in this study can be summarized as follows:

1. Better quality assurance with greater reliability.
2. Cost saving with higher profitability.
3. Earlier completion time with greater certainty.
4. Higher productivity with less labour and inventory.
5. Controlled environment with lower hazards.
6. Sustainability enhancement with less energy.

Nevertheless, the study identified some exogenous obstacles such as the absence of governmental support, corruption, fragmented nature of the industry, and multiple parties involved in each project, in addition to some endogenous obstacles such as lack of stakeholders' interest, poor feasibility studies, absence of proper planning and funding programs, multi-layered sub-contracting, poor coordination between the parties and the absence of team work spirit.

The obstacles against adopting lean construction confirmed in this study can be summarized as follows:

A. Exogenous Obstacles:

1. Lack of engineers expertise and workers skills.
2. Lack of awareness and knowledge.
3. Lack of transparency and integrity.
4. Multiple parties in each project.
5. Lack of a long-term vision.
6. Absence of government support.
7. Inefficient transportation and logistics.
8. Hard to obtain technology and standardization.
9. Fragmented nature of the industry.
10. Improper environmental conditions.
11. Initial and additional costs.
12. Weak stakeholders' intention.

B. Endogenous Obstacles:

1. Poor team work culture.
2. Multilayer subcontracting.
3. Lack of identification and control of waste.
4. Poor feedback.
5. High turnover of workforce.
6. Stress and pressure in deadlines.
7. Lack of prefabrication.
8. Losing some jobs due to work changes.
9. Uncertainty in production process.
10. Lack of contractor/supplier involvement.
11. Lack of long-term relationship with suppliers.

On the other hand, some proactive measures for success that should be available on the national scale were identified including political and economic stability, providing suitable standards, technology transfer strategy and adoption of modern information and communication technology. While on the institutional scale, other success factors were identified including the adoption of life-cycle analysis in engineering and acquiring modern construction facilities and software.

The proactive measures for success that should be available, as confirmed in this study can be summarized as follows:

A. On national scale:

1. Expertise and skills.
2. Information and communication technology.
3. Government strategy and commitment.
4. Coordination/collaboration between parties.
5. Design and process standardization.
6. Demand and market conditions.
7. Awareness and knowledge.
8. Research and development.
9. Technology transfer.

B. On institutional scale:

1. Design, manufacture and construction integration.
2. Constructability and life-cycle engineering.
3. Facilities and equipment.
4. Business and finance.
5. Planning and control.
6. Organization and leadership.
7. Cost and risk management.
8. Quality assurance and work environment.
9. Supply and storage management.
10. Transportation and logistics.
11. Procurement and contracting strategy.

The actions needed for successful implementation of lean construction were also identified including financial support, education and training, integration of design, manufacture and construction with sustainability being taken into consideration, suitable contract award methods and coordination between parties.

The actions needed for successful implementation of lean construction confirmed in this study can be summarized as follows:

1. Financial support including: non-delayed payment, business and marketing, tax exemption and levy reduction, affordable loans, and demand continuity and stability.

2. Productivity improvement including: training, mechanization, controlled environment, information and communication technology, and health and safety measures.

3. Management enhancement including: collaboration and coordination, organization and leadership, extensive planning and control, change strategy, and transportation, logistics and supply chain management.

4. Knowledge and skills leverage including: consultants' development programs, craftsmen training programs, academic education, manufacturers' and Contractors' development programs, and regulations, codes, standards and certification.

5. Quality assurance including: design, manufacture and construction integration, design and processes standardization, causal analysis and technical solutions,

product, process and people certification, and environmentally friendly life cycle engineering.

6.3 Contribution to Knowledge

The study confirmed the benefits of lean construction, found out; obstacles that challenge the adoption of lean construction in Iraq, the success factors that should be maintained, the readiness of the industry stakeholders to alter to this new approach and finally what actions should be taken and by whom.

6.4 Recommendations

Based on the aforementioned conclusions, the following recommendations can be offered:

1. The relevant governmental authorities should review the construction industry-related legislations, set standards and certifications, facilitate affordable loans, tax and customs exemptions, and facilitate technology transfer.
2. The industry stakeholders should pay attention to develop continual training programs for technicians and other construction projects-related crafts. It should be noted that:
   a. At the planning and design phase of construction projects, care should be taken of the feasibility study, design standards, design integration, and choosing the proper team to maintain the success factors as mentioned hereafter.
   b. At the procurement phase of construction projects, care should be taken of the procurement method, type of contract, priced bill of quantities, and contractors' qualification to maintain the success factors as mentioned hereafter.
   c. At the execution phase of construction projects, care should be taken of intensive monitoring and supervision, timely resolution of work problems, and choosing the proper team to maintain the success factors as mentioned hereafter.
3. The academy should pay attention to develop continual education programs for engineers and other construction projects-related professions in addition to the inclusion of lean principles and practices in the academic curriculum. Research

should be encouraged to tackle with the aspects needed to provide proper environment to move to lean construction.

4. The markets should introduce modern materials and technology and maintaining supplier/manufacturer-related success factors and external ones as mentioned hereafter.

Furthermore, the success factors that should be maintained are:

- Client-related success factors including: experienced and efficient supervision team, timely resolution of administrative and financial issues time, timely payment to the contractor, effective coordination with the authorities, timely approval of change orders and added time, and type of contract and procurement method.
- Consultant-related success factors including: accurate bill of quantities, timely resolution of execution issues, accurate, adequate and simple design and specifications, professional resolving of changes and added time, accurate scheduling, and timely approval of submittals and tests results.
- Contractor-related success factors including: adhere to schedule and deadlines, timely supply of all needed resources, timely payment to suppliers and alike, timely providing of all required facilities, Compliance with quality assurance procedures, and ensure all health and safety requirements.
- Supplier/Manufacturer-related success factors including: timely providing of the required type/quantity, ability to import the required items in time, assuring the required quantity, and providing good and suitable warehouses.
- External success factors including: political and economic situation of the country, market fluctuations in supply/demand and prices, legislations and governmental laws, and restrictions on working hours, holidays/events.

6.5 Future Studies

In order to go deeper for further investigation, the following empirical studies are suggested:

1. To conduct prototype case studies on real-life small construction projects to build a representative model promoted by the government and supported by academy using lean construction in detail.

2. To conduct pilot case studies on real-life major construction projects using some sort of public and privet sectors partnership to share the risks while using lean construction through a consortium of lenders, consultants, suppliers, manufacturers and contractors.

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APPENDICES

Appendix A: Questionnaire

QUESTIONNAIRE

This questionnaire is directed to professional engineers only. It is part of a scientific research entitled "The Effects of Lean Construction Principles and Practices on Improving Project Management in Iraq", and will be treated with confidentiality according to ethics and solely used for this purpose. Kindly fill in the questionnaire according to your experience and point of view.

Thank you for your prompt response. [Jamal Subhi Al-Rawi]

The Questionnaire consists of four parts:

Part A: General information about the respondent.

Part B: Success Factors for construction projects.

Part C: Lean Construction adoptability.

- **Section CI:** Potential Benefits.
- **Section CII:** Adoption Obstacles.
- **Section CIII:** Readiness Success Factors.
- **Section CV:** Proposed Actions.

Part D: Organization Actual Practice.

Part E: Acceptance Level and Suggestions

Note1: Read at first, about lean construction at the end of this form please.

Note2: The ranking system is as follows:

Ranking	1	2	3	4	5
Effect	Very low	Low	Medium	High	Very high

Part A: General Information:

A1. Organization name:

A2. Organization work sector:

Public	Private

A3. Organization type of business:

Client	Consultant	Contractor
Manufacturer	Supplier	Others/ to be stated pleas

A4. Organization field of practice:

Buildings	Highways & Bridges	Water Supply & Sewerage	Irrigation
Industrial Facilities	Electrical Works	Communications Networks	Others/ to be stated pleas

A5. Classification rank (only for contractors):

Civil ( ) Mechanical / Electrical / Chemical ( )

A6. Respondent position:

Top Management	Middle Management
Site Management	Supportive Management

A7. Respondent education degree:

PhD	MSc	BSc	Others/ to be stated pleas

A8. Respondent specialization:

Civil Engineer	Architect	Mechanical Engineer	Electrical Engineer
Communications Engineer	Highways Engineer	Chemical Engineer	Others/ to be stated pleas

A9. Respondent years of experience in the construction industry:

(6 – 10)	(11 – 15)	(16 – 20)	(> 20)

A10. Respondent years of experience in Lean Construction:

(< 3)	(4 – 6)	(7 – 9)	(> 9)

Part B: Success Factors for construction projects (in general)

Factors per party		Importance					Justification
		1	2	3	4	5	
O	Client/Owner						
O1	Type of contract and procurement method.						
O2	Timely payment to the contractor.						
O3	Timely approval of change orders/added time.						
O4	Timely resolution of admin. and financial issues.						
O5	Experienced and efficient supervision team.						
O6	Effective coordination with the authorities.						
O7	Others/ to be stated please.						
D	Consultant/Designer						
D1	Accurate, adequate and simple design & specific.						
D2	Accurate bill of quantities.						
D3	Accurate planned time table.						
D4	Timely resolution of execution issues.						
D5	Professional in resolving changes/added time.						
D6	Timely approval of submittals and tests results.						
D7	Others/ to be stated please.						
B	Contractor/Builder						
B1	Timely supply of all needed resources.						
B2	Timely providing of all required facilities.						
B3	Ensure all health and safety requirements.						
B4	Confirm to quality assurance procedures.						
B5	Adhere to schedule and deadlines.						
B6	Timely payment to suppliers and alike.						
B7	Others/ to be stated please.						
S	Supplier/Manufacturer						
S1	Timely providing of the required type/quantity.						
S2	Ability to import the required items in time.						
S3	Assure the required quantity.						
S4	Providing good and suitable warehouses.						
S5	Others/ to be stated please.						
E	External						
E1	Legislations and governmental laws.						
E2	Political and economic situation of the country.						
E3	Market fluctuations in supply/demand & prices.						
E4	Restrictions on working hours, holidays/events.						
E5	Others/ to be stated please.						

Part C: Lean Construction Adoptability

Section CI: Potential Benefits

Benefits		Importance					Justification
		1	2	3	4	5	
1	Earlier completion time with greater certainty.						
2	Cost saving with higher profitability.						
3	Better quality assurance with greater reliability.						
4	Higher productivity with less labour & inventory.						
5	Controlled environment with lower hazards.						
6	Sustainability enhancement with less energy.						
7	Others/ to be stated please.						

Section CII: Adoption Obstacles

Obstacles		Importance					Justification
		1	2	3	4	5	
General Obstacles							
1	Absence of government support.						
2	Lack of awareness and knowledge.						
3	Lack of a long-term vision.						
4	Fragmented nature of the industry.						
5	Many parties joined the project.						
6	Inefficient Transportation and logistics.						
7	Hard to bring technology and standardization.						
8	Initial and additional costs.						
9	Weak stakeholders' intention.						
10	Lack of engineers expertise and workers skills.						
11	Lack of transparency and integrity.						
12	Improper environmental conditions.						
13	Others/ to be stated please.						
Specific Obstacles							
1	Lack of contractor/supplier involvement.						
2	Lack of prefabrication.						
3	Uncertainty in production process.						
4	Lack of identification and control of waste.						
5	High turnover of workforce.						
6	Lack of long-term relationship with suppliers.						
7	Multilayer subcontracting.						
8	Stress and pressure in deadlines.						
9	Poor team work culture.						
10	Absence of feedback.						
11	Losing some jobs due to work changes.						
12	Others/ to be stated please.						

Section CIII: Readiness Success Factors

Success Factors		Importance					Justification
		1	2	3	4	5	
On national scale							
1	Government strategy and commitment.						
2	Demand and market conditions.						
3	Technology transfer.						
4	Awareness and knowledge						
5	Expertise and skills.						
6	Design and process standardization						
7	Information and communication technology.						
8	Research and development.						
9	Coordination and collaboration between parties.						
10	Others/ to be stated please.						
On company scale							
1	Business and finance.						
2	Facilities and equipment.						
3	Design, manufacture & construction integration.						
4	Constructability and life cycle engineering						
5	Organization and leadership.						
6	Planning and control.						
7	Procurement and contracting strategy.						
8	Supply and storage management.						
9	Cost and risk management.						
10	Transportation and logistics.						
11	Quality assurance and work environment.						
12	Others/ to be stated please.						

Section CIV: Proposed Actions

Actions		Importance					Justification
		1	2	3	4	5	
K	Knowledge and skills leverage						
K1	Academic education.						
K2	Consultants' development programs.						
K3	Manufacturers' & Contractors' dev. programs.						
K4	Labour training programs.						
K5	Regulations, codes, standards and certification.						
K6	Others/ to be stated please.						
F	Financial support						
F1	Demand continuity and stability.						
F2	Affordable loans.						
F3	Tax exemption and levy reduction.						
F4	Business and marketing.						
F5	Non-delayed payment.						
F6	Others/ to be stated please.						

Q	Quality assurance						
Q1	Product, process and people certification**.**						
Q2	Design, manufacture & construction integration**.**						
Q3	Design and processes standardization**.**						
Q4	Causal analysis and technical solutions.						
Q5	Environmentally friendly life cycle engineering.						
Q6	Others/ to be stated please.						
P	Productivity improvement						
P1	Mechanization**.**						
P2	Training**.**						
P3	Controlled environment.						
P4	Health and safety measures**.**						
P5	Information and communication technology.						
P6	Others/ to be stated please.						
M	Management enhancement						
M1	Change strategy**.**						
M2	Extensive planning and control**.**						
M3	Organization and leadership**.**						
M4	Collaboration and coordination.						
M5	Transportation, logistics & supply chain mgmt.						
M6	Others/ to be stated please.						

Part D: Organization Actual Practice within the Past 5 Years.

D1- Completed Lean Construction Projects:

Total number: **Percentage to all projects including conventional:** **%**

D2- On-going Lean Construction Projects:

Current number: **Percentage to all projects including conventional: %**

D3- The type of projects suitable for Lean Construction:

Project Function	**Suitability**					**Notes**	**Project Function**	**Suitability**					**Notes**
	0	**1**	**2**	**3**	**4**			**1**	**2**	**3**	**4**	**5**	
Residential							Industrial						
Offices							Tourism						
Health							Commercial						
Educational							Utilities						

Part E: Suggestions to overcome encountered problems.

About Lean Construction:

Lean thinking is the philosophy that focuses on elimination of waste in all activities to reduce the process cycle and to create value. It is a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. The term waste includes overproduction, over-processing, delay, excess inventory and motions, failure, and defects.

The lean principles which promote elimination of such waste are: value identification for all stakeholders; value stream mapping for all activities and tasks; value stream flow through a series of processes; achieving customer pull on the basis of current needs; and continuous improvement to eliminate new waste.

The main requirements to adopt lean construction are: standard methods for each procedure, team mentality over all processes, Just-in-time method, scheduling system for inventory control, leveling demand and production capacity.

Lean construction aimed at enhancing project management by eliminating waste, improving planning efficiency and reliability, improving productivity and maximizing value.

Appendix B: Interview Sheet

Interview Sheet

Based on the results of the questionnaire survey that was directed to (123) Iraqi professional engineers, as a part of a scientific research entitled "The Effects of Lean Construction Principles and Practices on Improving Project Management in Iraq", this interview is conducted to (10%) of the respondents to clarify specific aspects. It will be treated with confidentiality according to ethics and solely used for this purpose.

Thank you for your cooperation. [Jamal Subhi Al-Rawi]

General information about the interviewee:

1. Organization name:
2. Organization work sector:
3. Organization type of business:
4. Organization field of practice:
5. Classification rank (only for contractors):
6. Interviewee position:
7. Interviewee education degree:
8. Interviewee specialization:
9. Interviewee years of experience in the construction industry:
10. Interviewee years of experience in Lean Construction:

Aspects to be clarified:

Q1: Many studies had proved that the Iraqi construction industry suffers from severe cost and time overrun in most of the construction projects, how come that many respondents to the questionnaire stated that they already practice lean construction?

a) Unrealistic research hypothesis.
b) Lack of accurate understanding of lean construction.
c) Others.

Q2: It can be noticed in the questionnaire results, that all main areas of proposed actions received almost the same level of attention. Discuss these results for further justification.

a) Financial support (Non-delayed payment, Business and marketing, Tax exemption and levy reduction, Affordable loans, and Demand continuity and stability).
b) Productivity improvement (Continuous Training, Mechanization, Controlled environment, Information and communication technology, and Health and safety measures).
c) Management enhancement (Collaboration and coordination, Organization and leadership, Extensive planning and control, Change strategy, and Transportation, logistics and supply chain management).
d) Knowledge/skills leverage (Consultants' development, Labour training, Academic education, Manufacturers' & Contractors' development, and Regulations, codes, standards and certification).
e) Quality assurance (Design, manufacture & construction integration, Design and processes standardization, Causal analysis and technical solutions, Product, process and people certification, and Environmentally friendly life cycle engineering).

Q3: It can be noticed in the questionnaire results, that “Non-delayed payment received” received the highest level of attention, how come that “Procurement and contracting strategy” received low attention?

a) Misunderstanding.
b) Imperfect governmental regulations.
c) Others.

Q4: It can be noticed in the questionnaire results, that “Business and marketing” received a high level of attention, how come that “Relationship with suppliers” received low attention?

a) Misunderstanding.
b) Already maintained relations.
c) Others.

Q5: It can be noticed in the questionnaire results, that “Lack of a long-term vision” received a high level of attention, how come that “Change strategy” received lower attention?

a) Misunderstanding.
b) Desperateness.
c) Others.

Q6: It can be noticed in the questionnaire results, that “Mechanization” received a high level of attention, how come that “Technology transfer” received lower attention?

a) Misunderstanding.
b) Lack of knowledge of modern technologies.
c) Others.

Q7: It can be noticed in the questionnaire results, that “Information & communication technology” received a high level of attention, how come that “Absence of feedback” received lower attention?

a) Misunderstanding.
b) Lack of knowledge of modern software.
c) Others.

Q8: It can be noticed in the questionnaire results, that “Constructability and life-cycle engineering” received a high level of attention, how come that “Lack of waste control” received lower attention?

a) Misunderstanding.
b) Lack of knowledge of sustainability aspects.
c) Others.

Q9: Based on the questionnaire results, the role of the following aspects has been enlightened. Discuss and sort by importance.

a) The role of construction projects planning and design.
b) The role of construction projects procurement.
c) The role of construction projects execution.
d) The role of the construction industry stakeholders.
e) The role of the government.
f) The role of markets.
g) The role of technology transfer.
h) The role of training and education.

Appendix C: List of Companies Subject to Review

1-Telecom contracting company.

2- North Oil Company.

3-Fath Al Rahman Contracting Group.

4-General Company for Pharmaceutical Industries.

5-Projects of private pharmaceutical companies (mechanics).

6-Civil Technologies Co.

7- General Company for North Electricity Distribution.

8-Al-Rafidain State Company for the implementation of dams.

9-Qasr Al Mimar Contracting.

10-Ritaj Engineering Office (Refrigeration Mechanics).

11-FAO General Company.

12-Al Rasheed Contracting Company.

13-Al Moatasem Contracting Company.

14- Al-Ansam Contracting Company.

15-Albilad Contracting Company.

16-Green Land Contracting Company.

17-Sarh Al Sham Contracting Company (electrical and mechanical works).

18-White Sea Contracting Company.

19- Hammurabi Contracting Company.

20-University of Baghdad College of Engineering

21-University of Baghdad, Department of Construction and Projects

22-Ministry of Construction and Housing Public Authority for Buildings

23-Ministry of Construction and Housing Public Authority for Housing

24-Ministry of Construction and Housing National Consulting Center India Siya

25-Al-Nahrain University, Department of Construction and Projects

26-Al-Nahrain University College of Engineering

27-Engineers Syndicate, Civil Engineering Department

28-Ministry of Finance Department of Engineering Affairs

29-Ministry of Higher Education, Department of Construction and Projects

30-Ministry of Science and Technology Engineering Department

RESUME

PERSONAL INFORMATİON:

Jamal Subhi Nayef AL-RAWİ

Scientific Rank: Chief Engineers professional civil engineer

Nationality: Iraqi

Languages Spoken: Arabic (Mother language) and English

QUALİFİCATİON:

- BSc degree from the Department of Civil Engineering, University of Technology, Baghdad, Iraq, in 1992.

ADMİNİSTRATİVE POSİTİONS:

- Head of the Construction Materials Processing Division in the Ministry of Defense 1992
- Resident Engineer at Mic 1997
- Resident Engineer, Iraqi Ministry of Faa 1999
- Resident Engineer Al-Rasheed Military Hospital, Iraqi Ministry of Defense 2001
- Supervisor of the asphalt processing plant, Hammurabi Contracting Company, Ministry of Housing and Construction 2003
- Director of Maintenance Department at Al-Nahrain University 2006
- Resident Engineer, Central Library at Al-Nahrain University 2008
- Resident Engineer, University Presidency Building, Student Club and Internal Department Buildings 2014
- Responsible for the direct implementation committees for the university infrastructure 2016
- Director of Project Implementation Division at Al-Nahrain University 2018-2022