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Exploring the Use of Lean Construction in Unusual Work Conditions: Iraq 2005-2017

Mohsin Al Taie[1], Diana J. Schwerha[2], Songsu Son[3], Gene Sullivan[4], and Matthew Ricks[5]

Abstract

Question: What are the benefits of using the Last Planner System (LPS®) in commercial construction projects in areas with high disruption, e.g., the Civil War in Iraq from 2005 to 2017?

Purpose: The purpose of this research is to explore the benefits of using the Last Planner System® concerning the critical project metrics of cost, safety, quality, and time performance in projects operating in highly disruptive environments. Very few qualitative studies have been done on LPS® in commercial construction, and none explicitly study its application in areas of high disruption.

Research Method: The study utilizes a qualitative methodology with input from focus groups and structured interviews. Twenty-one individuals practicing engineering professionals from the Middle East, mainly in Iraq, participated in this research.

Findings: Results indicated that the application of Lean Construction, particularly LPS®, in unusual work conditions led to four themes in its use: planning, quality, safety, and cost. Ninety-five percent of the participants agreed that using a lean approach helped reduce waste in construction projects, 75% reported that it had improved the planning and quality of work, and 65% said it extended safety in their construction work in Iraq.

Limitations: This study utilized professionals from the Middle East who were working on specific types of commercial construction projects. Results may be different for other construction sectors and areas.

Implications: Results indicate that the use of the LPS® can assist in improving the project metrics of cost, quality, safety, and planning over traditional project management methods.

Value for practitioners: This research demonstrates how the use of the LPS® can aid in the adaptability of project planning, allowing for successful management of safety, cost, and quality in conflict-ridden areas where stability for planning is not possible.

Keywords: Lean Construction, Last Planner System®, Commercial Construction, Middle

[1] ABM Industries, USA, Facilities Project Manager, PhD, PMP; mohsinaltaie1976@gmail.com
[2] Liberty University; Chair of Computer, Electrical, and Industrial and Systems Engineering; B.S., M.S., Ph.D.; dschwerha@liberty.edu
[3] Liberty University; Associate Professor of Civil Engineering; B.S., M.S., Ph.D., P.E.; sson7@liberty.edu
[4] Liberty University; Professor of Accounting/DBA, School of Business
[5] Georgia Southern University; Civil Engineering; Assistant Professor; Ph.D. P.E

East, Project Planning, Highly Disruptive Work Environments.
Paper type: Case Study

Introduction

Managing construction projects involves addressing cost, quality, safety, and time performance metrics. Necessary compromises between planning and operation processes often impact these project metrics. Ballard has argued that to manage construction projects better, a radical change in approach is needed(Ballard and Tommelein 2021). However, traditional work approaches in planning show some inconsistency in managing project tasks, which leads to increased productivity waste. One of the disadvantages of the conventional approach in planning is regarding risk and adaptability with work progress; without this in mind, the project will incur more significant costs and need more time (Van Wyngaard et al. 2012).

The Project Management Book of Knowledge Guide (PMBOK Guide) defines project management as applying knowledge, skills, tools, and techniques to meet project requirements (PMI 2018). According to Meredith and Mantel (2006), project management is defined as producing project outcomes within the three metrics of cost, schedule, and quality specifications(Meredith and Mantel 2006). To make Project Management theory more robust and aligned with new challenges, project planning needs to focus more on organizing work activities, actions, and applicable execution strategies (Abdelhamid et al. 2008).

One recommended approach for managing construction work and responding to a reduction in low construction productivity, errors, delays, cost overruns, and safety is the Lean Construction (LC) approach(Forbes et al. 2021). The definition of this approach has been widely discussed, with some saying that there is no universally accepted definition (Mossman 2018). The approach aims to generate the best value for clients by doing the right thing in all project phases and sharing a common understanding between project stakeholders (Abdelhamid and Copeland 2022). It has been referred to as a practical collection of theories, principles, strategies, techniques, and ways of thinking that together enhance project teams and individuals to improve work processes and produce better value (Mossman 2018).

Abdelhamid (2004), in his discussion about Boyd's theory of "Destruction and Creation", has pointed out that the transformation, flow, and value generation present in current theories may eventually result in different project-based production systems (Abdelhamid 2004). Tapase (2019), in the review of Mike Rother's Toyota Kata book, describes the essence of lean tools as continuous improvement and adaptation. The lean approach aligns with PMI's focus on project outcomes in terms of project metrics. In the lean approach, however, project work with specified elements takes distinct steps and actions to benchmark each aspect to stakeholders' needs and desires (Bergmann 2018).

Abdelhamid et al. (2008) demonstrated that lean is not just another specific approach to managing construction work but rather a challenge to the conventional understanding and practice of construction. The most crucial benefit is minimizing construction work waste (Koskela and Howell 2002). Mossman (2018) referred to lean as creating more value for customers with fewer resources. Although Lean Construction applications significantly reduce waste in construction work, their application has also

been found to improve quality, cost, safety, time performance, and reliable workflow (Ebbs et al. 2018).

Several studies have revealed the critical factors of using the Lean Construction method; studies also discussed the benefits of using the Lean Construction strategy to implement the work plan and control the timeline of a construction project. As philosophy is the core element of the lean system, this can empower employees to participate and create the right environments for their valued contribution (Watfa and Sawalha 2021).

One such method within Lean Construction is the Last Planner System (LPS®) (Samad and Hamzeh 2017). It is considered a control system for project planning designed to work in a collaborative planning system for project management. It is one of the lean-based tools used to manage and control workflow (Abdelhamid et al. 2008). The system is designed to manage the project schedule and improve the implementation process by addressing the right task at the right time to the master schedule (Ahiakwo et al. 2013). (Cwik and Rosłon 2017) agree with this meaning of LPS® in managing project planning, arguing that a project control system must provide accurate information to the project team. Although It is a collaborative approach, it improves project stakeholders for continuous improvement(Warcup and Reeve 2014). So, they can identify and track problems that may arise to control project quality and cost.

Studies showed that the LPS® system can improve planning system with some challenges; organization culture, communication systems and other related factors can be addressed to enhance the effectiveness of using the LPS® system in projects (Warid and Hamani 2023), it utilizes pull planning. It allows project teams to share their notes and ideas. The approach produces a high level of psychological safety within a project team and is a crucial predictor of creative team performance that meets stakeholders' needs (Wilkinson et al. 2020). Performance measurements are helpful and critical for production management as a basis for improvement; collaborative and systematically shared understanding work must ensure the effectiveness of the LPS® and LC approach (Bygballe et al. 2022).

While many studies have been published on the use of Lean Construction, very little research has been completed on using a lean approach in managing projects in unusual work conditions, such as civil war, political upheaval, or other similar instances of external influence. Such situations are more extreme than normal disruptions in that they are unexpected, often have safety implications, and may include damage to the construction that has already been completed. The purpose of this study is to explore the use of Lean Construction and LPS® in managing construction projects in the unusual work conditions present in Iraq during the period 2005-2017. After the ISIS war, post-conflict contexts in Mosul created challenging work environments impacted by volatility, uncertainty, complexity, and ambiguity of unquantifiable risk (Khaleel and Al-Zubaidy 2018). The unexpected interruptions in these unusual work conditions made project planning a challenge.

Since little is known about the use of LPS® in unusual work conditions, a qualitative research methodology was used, employing a combination of focus groups and interviews with construction managers to gather in-depth information (Farr 2008). The research seeks to answer the question: *What are the benefits of using the Last Planner System (LPS®) in commercial construction projects in areas with high disruption, e.g., the Civil War in Iraq from 2005 to 2017?* Results from the study can help inform practitioners of techniques

beneficial to project management teams working through disruptive environments to meet their scheduling deadlines. Because of the disruptive environment, safety concerns are always paramount in meeting project deadlines.

Background

Lean thinking, and why should we care about using Lean Construction?

Seed (2015) demonstrated that in construction industry studies, 50% or more of the tasks done in projects to produce deliverables are non-value-added tasks that are considered waste in customers' eyes. Waste in construction projects can categorized in more varieties, like rework, unskilled workers, motion, etc. (Al-Aomar 2012). To minimize such waste, the LC method allows a new form of a production management system with a clear set of objectives for the delivery process to minimize waste in work performance and get stakeholder satisfaction (Howell 1999). Tezel and Aziz (2017) stated that lean thinking can be more effective with visual management tools to improve construction work. Reducing or eliminating non-value-added activities is the key part of lean project delivery process and can minimize waste accordingly by providing a new form of project implementation(Abdelhamid et al. 2008, Emuze and Saurin 2015). Unfortunately, the construction sector has been slow in adopting Lean Construction for more than one reason (Aziz and Hafez 2013).

While traditional project management can work in standardized environments, such approaches become more problematic in changing work conditions where workflow disruptions with variations undermine project performance and disrupt project timeline and planning, thus leading to detrimental impacts on the project's duration, cost, safety, and quality of work (Bajjou et al. 2017). In such environments, sharing collaborative work, early engagement, decision-making, and continuous improvement in a competitive environment(Tapase 2019). In addition, an improvement process becomes necessary to satisfy stakeholders and keep project criteria (quality, safety, cost, time) within the project budget (see Figure 1). Using new software programs and smartphones for construction management has recently enhanced lean methods applications and created a better environment adapted to lean strategies.

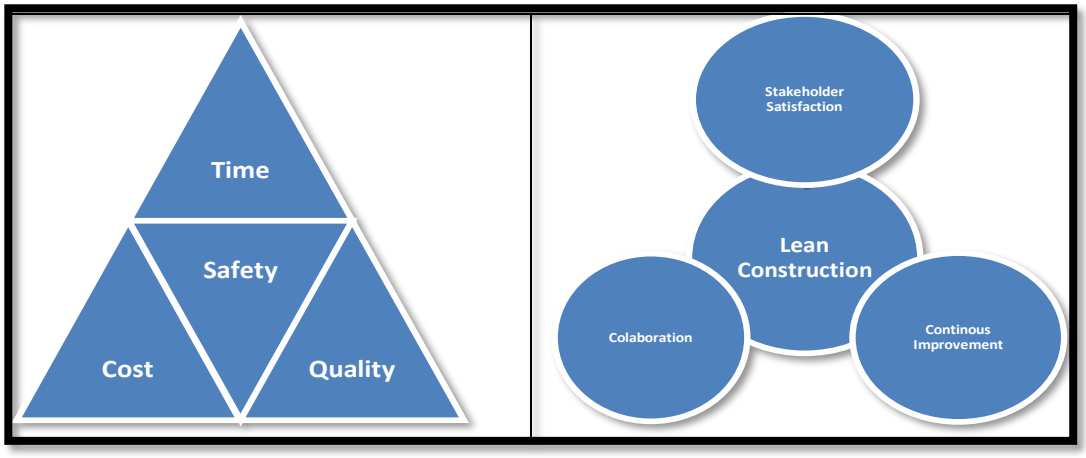

Figure 1: Lean Thinking Applied to Construction Projects

Lean Construction and benefits of the Last Planner System®

Lean thinking applied to construction improves outcomes and adapts to keep pace with the ever-growing complexity of the built environment. It can influence the total cost of the selected process of managing the work process of construction projects (Nowotarski et al. 2016). Lean Construction has increased competitiveness by improving planning, maximizing customer value, eliminating waste, and enhancing workflow reliability (Ballard and Tommelein 2016). In addition, fluctuating work conditions incentivize construction companies to adopt a Lean Construction approach for managing project schedules and reducing planning variability.

The Last Planner System® is a tool within the LC approach. Ansah and Sorooshian (2017), and many others found that the LPS® application reduces waste by improving workflow reliability in construction work(Ansah and Sorooshian 2017). It helps to set criteria for making quality assignments in the implementation process. It considers those quality criteria in advance of committing production units to do work to shield these units from uncertainty and variation (Ballard and Tommelein 2016 2021).

Cwik and Rosłon (2017) mentioned the LPS® applies common sense in planning and focuses on facilitating workflow to reduce variation in planning and consider dependencies between work activities. However, the LPS®'s lean approach faces barriers in some companies as each has a different environment in which to apply it (Merker 2018).

Research Methodology

Qualitative methods are particularly well suited to generating new understanding of phenomena or issues that are poorly understood. Grounded theory and data analysis refine data and get deep information about Lean Construction through interviews. Coding is the essential link between collecting, defining what is happening, developing an emergent theory in the data, and beginning to explain this data (Urquhart et al. 2010).

Although qualitative methods have been used to study lean approaches in other disciplines (Lerche et al. 2022), their use to study Lean Construction is relatively new. Marhani et al. (2018) showed that using Lean Construction (LC) tools in managing construction projects was particularly useful in showing how waste was controlled. Few other qualitative studies exist on the relationship between the use of Lean Construction and project metrics (cost, quality, safety, and time performance) or the use of Lean Construction in unusual work conditions.

To address the gap in literature related to the use of the LPS® in disruptive environments, our study of Lean Construction was conducted using focus groups and interviews with practitioners who have used LPS® on projects from 2005-2017. The Liberty University Human Subjects Review Board approved the study, and study subjects participated on an informed consent basis. Consent forms were completed before collecting the data.

The research question for this study was: *What are the benefits of using the Last Planner System (LPS®) in commercial construction projects in areas with high disruption, e.g., the Civil War in Iraq from 2005 to 2017* (supply chain disruptions, job security, political chaos, average time to complete projects)*?* We set out to inquire how using the Last Planner System—a Lean Construction tool—affects the project metrics of cost, safety,

quality, and time performance and how its use impacts these metrics under unusual conditions.

The primary researcher was particularly well-suited to carry out this study, given that he speaks fluent Arabic, grew up in and studied engineering in Iraq, and has previously used the lean Construction approach in construction projects in Iraq. He had access to a network of construction professionals who had used Lean Construction in Iraq and, importantly, was familiar with this study's general cultural and specific work environments.

The first step in this research was to conduct two focus groups, each with five to six individuals, to determine the questions for the structured interviews. The participants for these focus groups were project managers, engineers, general managers, and supervisors experienced in managing building projects with the Lean Construction approach (see Tables 1 and 2).

Table 1: Focus Groups Demographics and Work Experience

Job Function	Years of Experience	Company Size
Engineer	Less than 5 years	Less than 10 employees
Project Manager	5-10 years	10-25 employees
Supervisor	More than 10 years	More than 25 employees
Manager		
Other		

Following these focus groups, twenty-one practitioners experienced in Lean Construction who mainly were not included in the focus groups were recruited for the structured interview part of the research. From the information gained during the focus groups, a list of twenty-two open-ended and closed questions was developed and sent to the twenty-one individuals via a Google form. These individuals answered the questions and returned them to the researcher. Finally, the researcher contacted each of the individuals on TEAMS to review the answers. The participants could provide additional information or clarification. These interviews were approximately 30 minutes and were recorded and analyzed using the Delve system.

The interviews were designed to explore the lean practitioners' perceptions and experiences with using LPS® in Iraq, focusing on key project metrics and performance regarding quality, time, safety, and cost. Both focus groups and interviews enabled the researcher to explore the use of the Lean Construction tool LPS® system in Iraq during the civil war. Each participant answered the same questions (see Appendix A for the list of questions). No set definition of Lean Construction was provided by the researcher.

The interview transcripts were coded and then categorized under concepts important in Lean Construction. Several themes were generated, and these are presented in the results section. We used Delve (2022) to perform the qualitative data analysis. This software is designed to help researchers analyze and categorize transcript data from interviews and focus groups. The data collection strategy, therefore, used an iterative approach to qualitative data collection and analysis developed in the grounded theory approach (Staats et al. 2011), where the data are coded, the codes grouped into fewer categories (here linked to the theory about Lean Construction tools and the LPS®), and finally, several themes are generated (see Table 3 and Table 4). Closed-ended questions were summarized using basic statistical methods.

Table 2: Structured Interviews Participant's Demographics (Data to be used in GT)

Company	Department	size	Current Country	Position	Years of Experience	Practice in Lean Construction (well known, known, unrecognized, recognized but not used)
A	Mechanical engineering	Small	Iraq	Project manager	18	Well known
B	Technical Support Specialist	Small	Egypt	Project Manager	14	Known
C	construction manager	Large	Iraq	Engineer Manager	19	Well known
D	Civil engineering	Large	Iraq	Manager	20	Well known
E	Technical	Large	USA	Operation Manager	20	recognized but not used)
F	Accounting, construction	Medium	Kurdistan	Engineer Manager	18	recognized but not used)
G	Operations	Small	Iraq	CEO	18	Well known
H	Civil engineering	Small	Iraq	Project Manager	14	Well known
I	Civil engineering	Large	USA	Project manager	19	Well known
J	Structural	Small	Iraq	CEO	20	Known
K	Construction Environmental Engineering	Large	Kurdistan	Project manager	19	Well known
L	Information Technology	Medium	Kurdistan	Project Manager	18	Known
M	Human resource manager	Small	Iraq	Project manager	18	recognized but not used
N	Management	Small	Egypt	Engineer Manager	14	Well known
O	Construction Manager	Small	Iraq	CEO	19	Well known
P	Construction	Large	Iraq	Engineer Manager	20	Known
Q	Mechanical engineer	Large	USA	Engineer Manager	20	Known
R	Technical	Medium	Kurdistan	Supervisor	18	recognized but not used
S	construction manager	Small	Iraq	Professor	18	known
T	Civil engineer	Small	Iraq	Professor	14	Well known
U	Technical	Large	USA	IT Engineer	19	recognized but not used

Results

The interviews were transcribed, and the excerpts from the open-ended questions were coded. The key codes were then grouped together to form category codes from which the following themes were developed: planning, quality, cost, and safety. The Key Codes, Category Codes, and Themes are shown in Table 3.

Table 3: Themes Developed from the Structured Interview Questions

Key Codes	Category Codes	Themes
Timeline	Project planning Project plans	Main advantage of using the Lean Construction application: improved planning
Bar Chart		
Project plans		
Project schedule		
Job security	External environmental factors-work conditions	Lean Construction was found to improve safety
Safety		
Bad work conditions		
Quality of work	Work standards	Lean Construction application improves quality of work
Work standards		
Quality assurance		
Value		
Grade		
Classification		
Difficulties		
Work issues		
Problems		
Final cost	Cost	Lean Construction was found to improve cost
Cost of materials		
Budget		
Project expenses		
Men, hours waste		

Theme #1 - Main advantage of using the LC application and LPS® system: improved planning

The first theme is related to the ability of the LPS® to aid in planning. Most of the participants indicated that planning is a critical element in managing a construction project. They reported that using LPS® was helpful to this end. Not only was planning one of the significant themes from the qualitative analysis, but it was also the most frequently mentioned issue in the focus groups, as shown in Figure 2.

Similarly, most of the managers interviewed found that the main advantage of using a Lean Construction approach and the LPS® was improved planning. As can be seen below, improved planning was the reason most frequently given by participants for using LPS® in their projects (80% of participants). Regarding the importance of LPS®, participants' transcript responses showed that 85% of participants felt that LPS® improved planning variation.

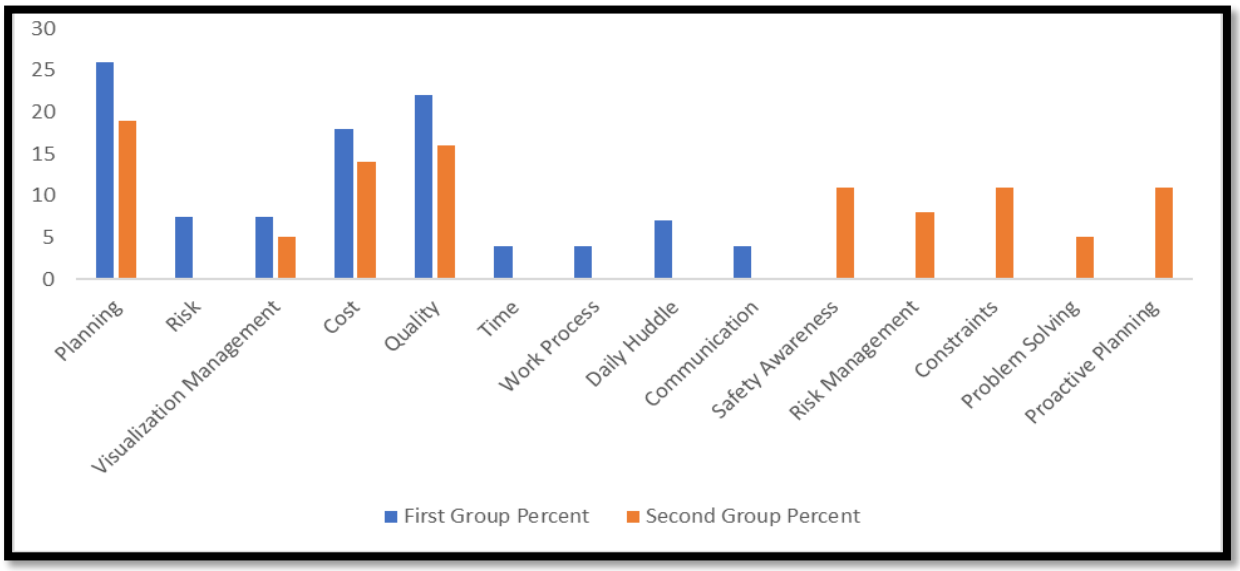

Figure 2: Percent of Total Coded Comments for Each Focus Group

Figure 3 shows that although planning was not one of the project constraints (cost, quality, safety, and time performance), many participants indicated that planning was crucial in better managing these factors; if they could better control planning, all the critical project metrics tended to improve.

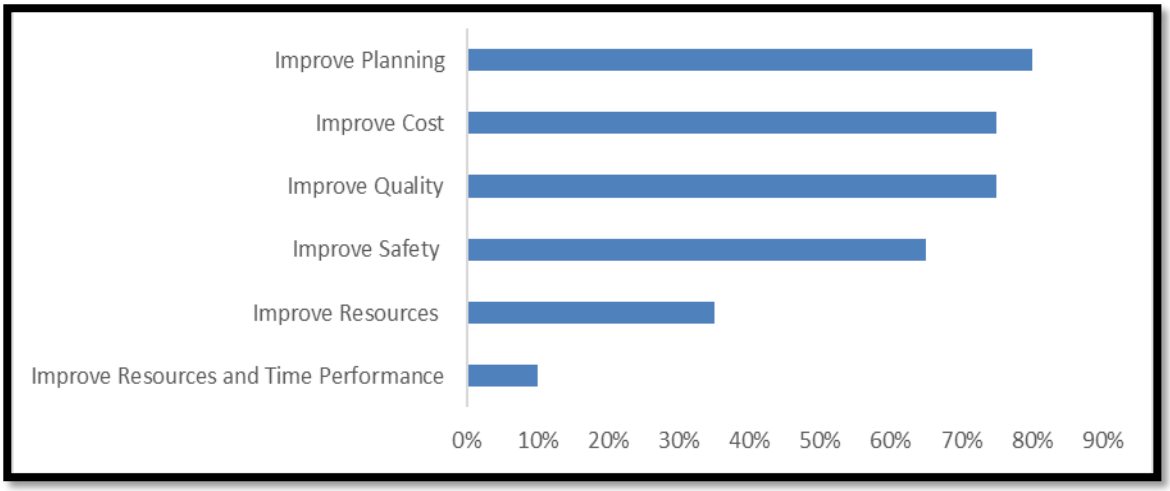

Figure 3: Reasons for Using Lean Application in Construction Projects – Structures Interviews Results

Participants noted that using different strategies in planning by using LPS® increased safety awareness. Planning with the LPS® system entails using a short cycle schedule that improves project team engagement as they share their input with respect to safety, cost, quality, efficiency, effectiveness, and flexibility. Their input using the LPS® helped project managers avoid any potential hazard or risk that might have arisen during the civil war. For example, the LPS® system allowed employees working in different areas within the same project to include all risk issues that could happen daily and let the project leader adjust planning accordingly to secure workers, resources, and materials. This allowed for more adaptability in the face of significant disruptions.

How did LPS® help with planning? Managers found that using LPS® allowed feedback from the whole project team to be brought into the planning process. One of the managers of a school project in Iraq mentioned how this aspect of LPS® created better planning for a project. He noted:

> *"Using the LPS® in construction helped the project team to use wise planning by sharing the feedback from the project team about the priorities of activities and activities requirements."*

Another project manager working on a school project also reported that the use of LPS® improved planning because it facilitated the sharing of information between all project stakeholders for any suggestions or comments, specifically the way to communicate work activities with all project stakeholders during the civil war. He stated:

> *"I did remember one of the problems that we had with some of the project team was how to facilitate the feedback loop when we have more changes in the project work. Using Lean Construction tools has helped us share the approved changes visually with project stakeholders."*

Participants also reported that using LPS® added value to the project timeline by reducing waste due to planning variation. One manager said:

> *"Variation in planning leads to increased timeline duration and waste in a project (budget overrun). In most construction projects, the most critical issue in planning is how to control delay and reduce the non-working hours due to a variance in task sequences."*

Project managers also found that a Lean Construction application was vital when the project had multiple stakeholders. It helped execute the owners' wishes, especially in a work environment such as Iraq during the civil war, by curbing losses from the planning variation during wartime.

Lean Construction was generally found to facilitate project execution in the sample we considered from Iraqi projects. Managers and team professionals who did projects in Iraq know how difficult it is to execute and maintain project activities during a civil war. Lean Construction and the LPS® enabled them to create better project implementation processes during that time.

Theme#2 – Lean Construction application and LPS® system were found to improve the quality of work

The application of Lean Construction in managing construction projects was found to enhance the quality of the work. One of the ways that participants explained that using Lean Construction improved quality was by facilitating the execution of project work activities according to customer needs. One participant noted:

> *"Also, the use of LPS® and lean approach enabled our project team to understand the job requirements better and meet the client's needs to complete the project."*

Another way that helped enhance the quality of work done was by setting all job requirements in the planning system, as this manager remarked:

> *"When we use a Lean Construction approach in managing construction work for one of the projects in Iraq, the approach helps us to reduce the errors in the steel works and in the electrical works, some of which can generate more errors and reduce the quality of produced work."*

When participants were asked quantitative questions about the project metrics they consider in their work, they indicated that the most important metrics were quality and safety, and the least important was time performance. The reasons behind their answers were related to their priority of ensuring quality and safety in their work in Iraq during unusual work conditions. When professionals and project teams felt secure in their jobs, they performed their jobs more efficiently and produced high-quality results. When work conditions are not normal, as mentioned above, using the LPS® improved planning and made jobs more secure for project team members, thus reducing the risks of mistakes and rework.

Main takeaway: Quality of work can be improved by using LC application in unusual work conditions.

Theme#3 - Lean Construction application and LPS® system were found to improve cost

Cost is associated with every task in project work. Improved cost was expected to be stated as one of the main benefits of implementing Lean Construction by most participants. As expected, this was true for 75% of interview participants (see Figure 3), and cost was also one of the most frequently mentioned issues in the focus groups. One participant said:

> *"The cost of projects can be reduced by using Lean Construction in implementation processes."*

When asked, "How did the lean approach reduce waste in your construction projects?" one of the interviewees replied:

> *"Lean Construction is an amazingly effective approach to reducing the time of work and materials wasted on the project. In school projects, we found that Lean Construction helped the project team focus on all kinds of waste in the construction work, some visible, like from materials or billed extra time hours, and some non-visible, like from having an unskilled employee."*

Using Lean Construction, specifically the LPS®, in the implementation processes for the construction projects was also found to facilitate work and enhance labor productivity by improving collaboration and coordination in teamwork. One manager noted:

> *"Something in my mind I did remember regarding the benefit of a lean and agile approach is how to increase the collaborative learning and feedback sharing to prevent any type of waste like delay in some work process, email, or any clarification confusion."*

Another way of using a lean approach helped improve costs was by reducing the need for rework as one of the engineers explains below:

> *"I did notice that using lean in some electrical projects ensured standards of work and reduced the rework and errors in project work."*

Participants found that the lean approach was a helpful tool to increase the project team's productivity in situations where the work environment was interrupted because of the civil war. A participant stated:

> *"As I remember, the use of this approach has improved the project team to track any extra activity in the workflow when we did the foundation of the school building by removing all unnecessary time for workers that do not produce quality work and add something valuable to the project need."*

In unusual work conditions, using a lean approach has improved waste metrics. It reduced the associated costs of project work activities. Participants indicated that using a lean strategy in planning increased collaborative feedback and shared the positive processes of updating work plans and completing project teamwork activities in less time than planned. See Table 4 for benefits associated with different aspects of work.

Table 4: Main Disruptive Work Conditions

Aspect of Work	Benefit	Projects
Safety	Planning, cost, quality	Telecommunication, school building
Job security	Cost, planning	Government projects
Supply Chain	Cost, planning	All types of projects

Main takeaway: Using LC applications in unusual work conditions improves the cost associated with a project.

Theme #4 - LC application and LPS® system were found to improve safety

Improved safety was cited by 65% of the interviewed managers as one of the reasons behind using LPS® in their construction projects (see Figure 8). Using LPS® allowed the managers to account for all the OSHA requirements, security, job safety, and any other requirements related to human safety in the planning process. One project manager explained how this improved safety in the projects:

> *"Safety is one of the tasks associated with monitoring project work and planning for all safety requirements in risk management plans. Applying LPS® in the project plans and executing the work with a lean management strategy enhanced safety awareness by supporting the project team and work activities with all safety requirements to prevent damage or injuries."*

Safety was one of the most critical issues managers faced in their projects during the Civil War period. The analysis, however, revealed that most of the safety issues and job security issues in previous projects done in Iraq were not included in the planning phases;

all these issues were caused by unusual work conditions and interrupted project plans regarding the safety of all project employees. A participant recalled:

> *"One situation I did remember in Iraq because when we use lean application-specific in the telecommunication projects, and there is shooting near the site, project team inputs had helped our work plan process to reduce the chances of injuries or damage to our team and equipment."*

The reasons that LPS® was found to improve safety and job sequencing in these unusual conditions were related to how LPS® involves setting job requirements in the planning process and including all aspects of risk management in the planning process. As one of the project managers who practiced the lean approach in United Nations projects in Iraq during this period stated:

> *"Using Lean Construction helps the project team to predict the plans for work process before starting the project where the area is not secured and not safe."*

They used the LPS® system to measure safety awareness for their team and how the project team can reduce the problems and high-risk areas in terms of faltering project implementation. A project manager of a plant energy unit reported that using a lean approach in unsafe conditions in Iraq improves safety surrounding inventory:

> *"One of the important uses of lean is that it helps us to manage stores and the direction guide for the inventory plans, which assists in preventing damage or risk associated with unwise inventory management."*

The lean approach was also valuable in improving safety in construction projects in areas impacted by bombing. As one of the project engineers who had worked in such areas recalled:

> *"When an unexpected bombing occurs, lean tools can facilitate the work process because project stakeholders can put in place safety procedures which can prevent damage or injuries to workers if the bombing happens again near the project area."*

Main takeaway: LC application can improve work safety during unusual work conditions.

Discussion

This study sought to explore the understudied issue of how the use of LC, specifically the LPS®, affects the critical project metrics of quality, cost, safety, and time performance in the unusual conditions (supply chain disruptions, job security, political chaos, average time to complete projects) present in the Iraqi civil war during the period 2005-2017.

The study results demonstrate that, like the findings of existing studies on using a lean approach in construction, the use of LPS® in Iraq during this period was associated

with improvements compared to a traditional project management approach. As previously indicated, 95% of the participants claimed that using a lean approach helped reduce waste in construction projects, 75% reported that it had improved planning and quality of work, and 65% said that it extended safety in their construction work in Iraq.

These improvements resulted primarily from the proactive and iterative planning practices associated with using lean applications, which help ensure job requirements are met, and the customers' needs for the project are completed.

Most participants indicated that planning is the most essential task in the work process and the most crucial task to control to ensure completed deliverables, particularly in the unusual conditions of the civil war they were working under in Iraq. A lean approach was reported to enable the project team to set work activities in a way that allowed the project work to be completed with less cost while reducing delays. Participants claimed that the improvements in the planning process resulted in improved key project metrics (quality, cost, safety, and time performance).

While most participants agreed that using Lean Construction in managing construction work was beneficial, there was almost unanimity among the participants that the issue of planning and tracking project work requirements is a key issue, as any planning error may lead to the loss of the project or to the project being permanently suspended if the stakeholders' needs are not met. Unusual work conditions include job insecurity, uncertain project completion dates, securing project employees, disrupted supply chain processes with other territories, the safety of all project teams, the area around the worksite with volatile security due to sectarian and political problems, and so on. Such issues created an especially challenging situation for construction work in Iraq during the study period.

While the results demonstrated many improvements in planning and project metrics in the conditions present in Iraq, they also revealed some challenges. The use of LPS® was highly effective, but this depended on the ability of the project team or the company to adopt a lean culture. Some participants indicated that they had to spend considerable time training the group in critical concepts and the LPS® system before starting work to ensure that LPS® could be implemented on the projects.

The findings also revealed some of the crucial ways that using the LPS® system helped construction managers deal with some of the unique safety issues in the unusual and often dangerous civil war conditions and the unique cultural environment in Iraq. Risk management and job security planning must be done in the planning stage. The application of LPS® in the planning process showed great benefit in supporting safety awareness and job security design, both in general and in the uncertain and continually changing conditions at job sites in Iraq. Using a lean application, emphasizing short, iterative planning cycles and collaboration in the planning process, helped identify many risks that could happen in the project and plan for them accordingly.

Managing risk in unusual work conditions also necessitates revising planning processes on an ongoing basis to maximize safety awareness when completing tasks as conditions change (work conditions like job security, project completion date, securing project employees, supply chain process with other territories, and the safety of the project team and the surrounding areas with volatility because of sectarian and political problems). The use of LPS® in construction in Iraq during the civil war was found to have assisted project

managers in completing project work while also better addressing safety, not just in general, but in terms of issues explicitly arising from unpredictable changes and often unsafe working environments during the civil war, because it allows for continual adjustments in iterative planning cycles made in consultation with the whole project team.

Highly Disruptive Work Environments

Risk can be defined as any uncertain event or condition that, if it does occur, has a positive or negative effect on one or more project objectives (PMI 2004). Using the LPS® in planning enhances project performance and mitigates risk by providing a flexible and reliable work schedule for project stakeholders to proceed with work. Unusual conditions present in the Iraqi civil war during the period 2005-2017 included but were not limited to job security, supply chain disruptions, political chaos, and the average time to complete projects. Work conditions include job security, project completion date, securing project employees, supply chain process with other territories, the safety of all project teams, and ensuring the safety of volatile areas plagues by sectarian and political problems

Conclusion

This study explored the use of LPS® specifically and Lean Construction as a management approach in managing project performance in construction in unusual work conditions, namely during the civil war in Iraq from 2005-2017. Like the findings of existing studies, the main results of this study show that using lean approaches in construction were perceived by practitioners to have considerable benefits compared to the traditional project management approaches in improving planning, safety, and reducing waste in projects.

The participants found that using LPS® as their planning strategy improved the critical project metrics of quality, cost, and safety. The short, iterative planning cycles, which allow continuous adjustments involving the whole project team throughout the project, were found not only to improve the quality, cost, and safety but also to help address the safety and planning issues arising in a specific cultural environment and in the uncertain, changing, and often dangerous work conditions in projects during that period in Iraq.

By closely examining the use of Lean Construction approaches and project performance in construction projects in Iraq during the civil war, this study contributed to an improved understanding of implementation in the understudied area of unusual work conditions.

Future Work and Limitations

As a follow-up to our research, we would like to outline four areas with potential for future inquiry: 1) Research participation could be increased by including more samples from different sectors of construction projects like mechanical engineering and manufacturing engineering; 2) More use of the qualitative approach given the study shows it is an excellent way to discover human behaviors in previous projects and how they faced the phenomena in their real work environment; and 3) Other work environments could be considered to provide additional results about the impact of using LPS® on managing

alternative kinds of projects; 4) Unreliability could be researched in a different work environment and technology solution could reduce uncertainty as conditions shift. Most of the work cases were in Iraq, where the safety of the work environment was paramount, and it is different compared to other countries with different standard work systems and regular work schedules. With different types of cultures, lean procedures may be possible solutions to extend safety and reduce the risk of injuries. Limitations of this study included the small sample size and the focus on one type of construction.

Acknowledgment

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Appendix 1

Questions	Answers
Section 1-Participant experience and background	
1. **What is your experience and background?**	Short paragraph
2. **What is your job function in most construction projects you work before?**	Multiple Choice: Engineer, project manager, manager, supervisor, other
Key codes from the focus group sessions	
Section 2-LPS® practice in construction works	
1. **How can a lean approach reduce waste in construction projects?**	Contextual-short paragraph
2. **Describe the reasons behind using lean applications in construction projects?**	Explanatory-more than one
3. **How can the LPS® improve job safety and communication in construction projects?**	Contextual-short paragraph
4. **What is the need to use Lean Construction to fix planning issues in construction projects?**	Evaluative- short paragraph
Section 3- LPS® with Project Metrics (cost, time, quality, safety, and time performance)	
1. **How are you satisfied with Lean Construction tools? 1-5**	Likert Scale (1-5)
2. **How are you satisfied with lean approach in unusual work conditions in construction projects? 1-5**	Likert Scale (1-5)
3. **How are you satisfied with the Last Planner System (LPS®) application? 1-5**	Likert Scale (1-5)
4. **Does the Lean Construction strategy a good fit when having multiple stakeholders?**	Multiple Choice: Yes/No
5. **Does the LPS® reduce the planning variability for the planning project work?**	Multiple Choice: Yes/No (if yes describe in short paragraph)
6. **Does the LPS® extend safety in construction works?**	Multiple Choice: Yes/No (if yes describe in short paragraph)
7. **Does the lean application improve the supply chain process for construction works?**	Multiple Choice: Yes/No
8. **What is the relationship between LPS® and time performance?**	Multiple Choice: linear/non-linear
9. **What is the relationship between LPS® and Safety?**	Multiple Choice: linear/non-linear
10. **What is the relationship between LPS® and quality?**	Multiple Choice: linear/non-linear

11. Do you think lean thinking is a good approach to managing construction projects?	Multiple Choice: Yes/No
12. Do you think the LPS® can reduce waste in construction projects?	Multiple Choice: Yes/No (if yes, explain)
13. Do you think the application of LPS® can improve time performance for the construction crew on the project site?	Multiple Choice: Yes/No (if yes, explain)
14. Does project constraints (quality, cost, time, safety) affected by LPS®?	Multiple Choice: Yes/No
15. Which project management strategy do you prefer to reduce waste in construction works? And why?	Multiple Choice: (Agile, waterfall, lean, others)
16. What is the most critical factor you consider in project constraints (quality, cost, safety, and time performance)	Multiple Choice: (quality, cost, safety, and time performance)

Consent From

Consent Form for Focus Groups

Title of the Project: Integrating Lean Construction Tools in Building Maintenance Projects
Principal Investigator: Mohsin Al Taie. PhD Student at Liberty University

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be 18 -65 years of age, and have worked on construction projects as a (project manager, project engineer, site engineer, construction manager, or another manager.
Taking part in this research project is voluntary.
Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to understand lean construction tools in construction projects, specifically the Last Planner System (LPS) and find out the relationship between the LPS and the project metrics (quality, cost, safety, and time performance. How can the application of LPS improve construction work in the implementation process? The independent variable is LPS, and the dependent variables are quality, cost, safety, and time performance.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following things:

1. Participate in the focus group with other participants that will be conducted on Team. The focus group will be audio and video recorded. The focus group should take about 30 minutes. Participants also have the option to respond to the focus group questions by writing out their responses and emailing them to the researcher, instead of scheduling a virtual focus group.

How could you or others benefit from this study?

Participants should not expect to not receive direct benefits from taking part in this study, Benefits to society include sharing the benefits of lean construction tools, like the Last Planner System application, in managing construction work and how construction companies can improve quality, reduce cost, extend safety, and improve time performance in construction projects by using lean application.

What risks might you experience from being in this study?

The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential using security codes

- Data will be stored on a password-locked computer and may be used in future presentations. Hard copy data will be stored in a locked desk. After three years all electronic records will be deleted, and any hard copy data will be shredded.
- Interviews will be recorded and transcribed. Recordings will be stored on a password-locked computer for three years and then erased. Only the researcher will have access to these recordings.
- Confidentiality cannot be guaranteed in focus group settings. While discouraged, other members of the focus group may share what was discussed with persons outside of the group.

How will you be compensated for being part of the study?

Participants will not be compensated for participating in this study.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please contact the researcher Mohsin Al Taie at the email address/phone number included in the next paragraph. Should you choose to withdraw. Focus group data will not be destroyed, but your contributions to the focus group will not be included in the study

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Mohsin Al Taie. You may ask any questions you have now. If you have questions later, you are encouraged to contact him at [5158220020 and email address: Maltaei@liberty.edu
You can also contact the researcher's faculty sponsor, Dr. Diana Schwerha, at dschwerha@liberty.edu.

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, you are encouraged to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

Before agreeing to be part of the research, please be sure that you understand what the study is about. You will be given a copy of this document for your records. If you have any questions about the study later, you can contact Mohsin Al Taie using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

☒ The researcher has my permission to audio-record me as part of my participation in this study
Printed Subject Name

[redacted] 7/18/2022

Signature & Date