

IMPLEMENTATION OF LEAN TOOLS ON SAFETY IN CONSTRUCTION PROJECTS IN PALESTINE

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ABSTRACT

Lean construction approach is a set of tools that improve project performance by increasing project value and minimizing waste. The purpose of this paper is to investigate the implementation of lean tools in construction project and its impact on safety conditions in the Gaza Strip. The applicability of last planner, increased visualization and 5s process were investigated. A questionnaire survey was undertaken with contractors and clients in order to elicit their attitudes concerning the implementation of lean tools in construction projects. The results of this study indicated that most construction organizations are not interested in using new management techniques although they are interested in minimizing waste and maximizing projects value. The majority of the respondents indicated that there is a significant influence of implementing lean tools on safety in construction sites. The study indicated that there is a strong relationship between occurring accidents and bad visualization in the construction sites. It was found that there is a significant weakness in the learning environment in construction projects and there is very limited amount of knowledge about lean construction tools and other new safety techniques. Training will be a key aspect of implementation and success of the lean construction techniques to increase safety conditions at the site. This training may result in an increased burden in early stages of implementation but over the long haul, it will serve to increase the efficiency and safety level of construction companies. Lack of budget for training and lack of interest in safety training were some of the barriers in using lean construction tools.

KEYWORDS

Lean construction, safety, last planner, 5s process, training.

INTRODUCTION

Improving productivity in construction is a great challenge facing the construction industry (Abdelhamid 2004). Achieving smooth work flow with minimal waste requires not only appropriate construction planning, but also effective production management (Sack et al., 2010). Improving safety in construction remains a priority in almost every country around the world, because the construction industry stands out among all other industries as the main contributor to severe and fatal accidents (Ahmed et al., 2000). Increasing safety is critical in the context of improving

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productivity and efficiency in construction industry. However improving occupational safety in the construction industry is essential, not only because enlightened clients demand excellent safety performance from contractors, but also due to continuous search for more economic benefit and increased productivity (Ghosh and Young-Corbett 2009).

Lean thinking is a new way to manage construction. It aimed to redefine performance against three dimensions of perfection: (1) a uniquely custom product, (2) delivered instantly, with (3) nothing in stores. This is an ideal which maximizes value and minimizes waste (Ballard1999). Minimizing waste in a production system is one of the cornerstones of lean construction. Howell et al. (2002) indicated that the relationship between lean and safety is clear where incidents that disrupt the flow of work or lead to injury are waste. Improved safety performance, such as reduced injury and fatality rates, is an example of waste reduction. Accidents result in reduced efficiency of a process, resulting in non-value-adding events in a production system.

Since lean principles aim at reducing waste, it would be prudent to assume that the reduction of occupational hazards is a naturally occurring outcome of the implementation of lean construction principles (Eric et al., 2010). The creation of a lean environment in a workplace requires employee motivation and good management. All the different levels of an organization need to put forth their best efforts on a day-to-day basis and work together toward achieving improved performance and reducing waste, thus productivity, quality and safety will be improved effectively (Anvari et al., 2011).

The objective of this paper is to investigate the implementation of lean tools and its impact on reducing accidents in construction projects. The following tools were evaluated: last planner, increased visualization and 5s process. The first part of this paper reviews lean construction techniques and its relationship with safety and the second part presents a study of lean tools implementation and its impact on safety conditions in construction projects in Gaza Strip. Then, the paper presents the possibility and barriers of implementing lean construction tools.

LITERATURE REVIEW

THEORETICAL BACKGROUND

Lean Construction is starting from the early 1990s, and in fact the term "Lean Construction" was coined by the International Group for Lean Construction in its first meeting in 1993 (Abdelhamid 2004). Lean construction is concerned with the holistic pursuit of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, activation, maintenance, salvaging, and recycling (Abdelhamid 2007). This approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs (Koskela et al., 2002). Being "lean" basically means endeavoring to minimize waste and maintaining continuous flow in a production plant (Abdelhamid 2007). Using lean tools, reducing waste and increasing efficiency, often result in a reduction of process steps, materials used, and motions required. These reductions in turn will reduce the probability of incurring an accident or coming in contact with hazardous materials (Nahmens and Ikuma 2009).

Safety at work is a complex phenomenon, and the subject of safety attitudes and safety performance in the construction industry is even more so (Sawacha et al., 1999). According to Davis et al., (1990) the risk of a fatality in the construction industry is five times more likely than in a manufacturing based industry, whilst the risk of a major injury is two and a half times higher. This rate of injury is of ongoing concern for the industry, insurers, the community and government. This rate of injury is of ongoing concern for the industry, insurers, the community and government. Every effort needs to be made to ensure the safety of workplaces for all concerned. Not only do work related deaths and injuries have a dramatic impact on the quality of life of individuals and their families, they also Adverse effect on construction industry economic performance (Bhattacharjee and Ghosh, 2011). Occupational accidents are wasteful and non-value-adding events in any form of production system. Since lean principles aim to reduce non-value-adding elements of work processes, it follows that safeguarding construction workers from occupational hazards would be a natural outcome of the lean construction ideal of waste elimination (Ghosh and Young-Corbett 2009). The loss or injury of workers, and the resulting disruption to progress of work represent waste in the performance of construction. Lean advocates minimizing waste and continuously improving. Incidents that disrupt the flow of work or lead to injury are waste, so the relationship between lean and safety is clear (Howell et al., 2002). Nahmens and Ikuma (2009) showed that lean strategies encourage less material in the work area, an orderly and clean workplace, and systematic workflow. Therefore, it could be expected that standardizing, systematizing and regularizing production leads to better safety. Poor safety is considered a form of waste because, from a lean perspective, incidents that disrupt the flow of work or lead to injuries are waste (Howell et al., 2002).

Typical production planning decisions, which determine what will be done, when, how and by whom, are the basis to establish preventive measures (Ghosh and Young-Corbett 2009). Making work flow more reliable seems an obvious way to reduce the unexpected events that lead to incidents. (Howell et al. 2002). Nahmens and Ikuma (2009) indicated that poor safety is a form of waste. Injuries are costly not only in terms of human suffering but also in terms of worker compensation costs, lost time, lost productivity, and higher employee turnover. Therefore, it is imperative to incorporate safety into process and production plans, in order to achieve projected goals of improved worker health, reduced costs, and increased value. Using lean tools may be used to support safety programs in industrialized housing manufacturers by increasing safe behavior and reducing injury rates, by increasing the efficiency of communication through the project level (Bashir et al. 2011).

LEAN CONSTRUCTION TOOLS

Salem et al. (2006) sorted the techniques employed in lean construction by their utilization goals; this classification is shown in table 1. Although these techniques can be applied separately, their complementary nature proposes that a combined utilization of techniques will increase leanness of a construction organization.

Table 1: Classification of Lean Construction Tools

Goal	Flow Variability	Process Variability	Transparency	Continuous Improvement
Lean Const. Technique	Last Planner	Fail Safe for Quality	- 5S - Increased Visualization	- Huddle Meetings - First Run Studies

(Source: Salem et al., 2006)

LAST PLANNER SYSTEM

Last Planner System (LPS) is a technique that shapes workflow and addresses project variability in construction (Ballard 2000). The important role of the last planner tool is to replace optimistic planning with realistic planning by evaluating the performance of workers based on their ability to reliably achieve their commitments. The goals of last planner are to pull activities by reverse phase scheduling through team planning and optimize resources in the long-term (Salem et al., 2005). Han et al. (2012) indicated that workers' unsafe actions are likely to result in injuries and are regarded as precursors of incidents. Behavior measurement can thus be used to evaluate safety performance and prevent serious accidents.

Good safety performance is not attained only with the implementation of an isolated safety practice or a large number of practices in any order or combination. Razuri et al. (2007) indicated that orientation and specialized training for management; project planning; orientation and specialized training for workers; safety committee; and safety incentives program are good practices with production management using the LPS. Several of the strategies implemented by LPS can be easily extended to safety planning, thus directly affecting the effectiveness of safety programs. One of the main goals of the look ahead process is to shape the work flow sequence and rate. In terms of pre-project planning for safety, this allows to establish more reliable project-specific safety resources for a given time period during a project and thus staff for safety accordingly (Eric et al., 2010). Safety culture in LPS is supported toward increased empowerment of the employees, which give a push to increased gang self-governance (Forman 2010).

INCREASED VISUALIZATION

Visualization in general, and particularly in construction projects, is a convenient and intuitive way of conveying project information among various project parties (AlNimr and mohammed 2010). One of the major causes of accidents is unsafe site conditions, which basically is due to inadequate supervision with poor visualization (Shrestha et al., 2011). The increased visualization lean tool is about communicating key information effectively to the workforce through posting various signs and labels around the construction site.

Workers can remember elements such as workflow, performance targets, and specific required actions. This includes signs related to safety, schedule, and quality. This tool is similar to the lean manufacturing tool, visual controls, which is a continuous improvement activity that relates to the process control (Salem et al., 2005). Visual management can be extended for safety purposes using things such as

safety signs and boards displaying current accident rates allowing all workers to identify issues, thus providing an opportunity to be trained, the boundaries for safe performance and compare the expected safety performance (Eric et al., 2010). It was demonstrated that effective visual workplace vision lead to effective work conditions (Anvari et al., 2011).

THE FIVE S'S (5S) PROCESS

Abedhameed (2007) indicated that the Five S's (5S) are some rules for workplace organization and in housekeeping which aim to organize each worker's work area for maximum efficiency and to reduce waste associated with the workplace organization to create a working environment of which people are proud. It is believed that people who are proud of their workplace can produce high quality products easier. U.S. Environmental Protection Agency (2011) classified the Five S's as the following:

- Seiri (Sort): Sort frequently needed things and lesser needed things so that frequently needed things are available nearby and as easy to find as possible. Relocate or get rid of unnecessary things.
- Seiton (Set in order): Arrange essential things as accessible as possible to reduce the waste related to a worker's motion in locating or acquiring a needed thing.
- Seiso (Shine): Keep work areas and machines clean in order to reduce the waste related to uncleanness and increase workers' satisfaction.
- Seiketsu (Standardize): Standardize and diffuse the first 3 S's throughout the working place by means of clear procedures.
- Shitsuke (Sustain): Try to integrate the 5 S's in the organization's culture by means of training, promotions and control.

5S is one of the most effective tools of lean manufacturing because it is the basis for an effective lean implementation. Recently 5S was changed to 6S (5S+Safety) which is a method used to create and maintain a clean, orderly and safe work environment (Anvari et al., 2011). Lean implementation in the construction industry show this integration by adding a sixth S, to the lean tool 5S, for safety by conducting a process improvement event in the continuous improvement process dedicated to safety (Nahmens and Ikuma 2009).

FAIL SAFE FOR QUALITY AND SAFETY

Fail safe for quality is about being constantly focused on quality and safety issues from the beginning till the end. Potential quality and safety improvement practices are constantly investigated. Quality is sought to be reached at the source of any failure before a mistake's taking place (Salem et al., 2005).

FIRST RUN STUDIES

First run studies include productivity studies and review work methods by redesigning and streamlining the different functions involved. Using video files, photos or illustrations to show the process or illustrate the work instruction. First Run Studies are used to redesign critical assignments and it is one part of continuous

improvement effort; and includes productivity studies and review work methods by redesigning and streamlining the different functions involved (Salem et al., 2005).

METHODOLOGY

This research was undertaken as an exploratory study. A questionnaire survey targeting site engineers and project managers who were working with clients and contractors was conducted in this study. The questionnaire was provided with a covering letter explaining the purpose of the study, the way of responding, the aim of the research and the security of the information in order to encourage a high response. The questionnaire included multiple choice questions: which used widely in the questionnaire. The variety in these questions aims first to meet the research objectives, and to collect all the necessary data that can support the discussion, results and recommendations in the research.

The questionnaire was divided into four parts:

Section I: This section contains a series of questions related to personal features of individuals of the sample.

Section II: This section contains a series of yes and no questions to measure the extent of knowledge and use of safety conditions and lean construction techniques.

Section III: This section contains a series of questions to measure the benefits from using lean construction techniques and its influence on safety conditions.

Section IV: This section contains questions to discuss the possibility to implement lean construction techniques in construction projects and challenges and barriers for this implementation.

The sample for this study was selected from a population of contractors and clients in the construction industry. Forty questionnaires were distributed randomly to the research sample and 31 completed questionnaires were received which yielding a response rate of 77.7%. The respondents were qualified personnel with experience more than 10 years. The collected data were analyzed using SPSS for Windows 17.0 software package.

RESULTS AND DISCUSSION

TYPE OF ORGANIZATION

Table 2 show that, 29 % from the sample were from owner party, and 71% were from the sample from Contractor party.

Table 2: Type of Organization

Type of Organization	Frequency	Percentages
Owner	9	29
Contractor	22	71
Total	31	100

POST OF THE RESPONDENT

Figure 1 showed that 38.7% of the sample was site/office engineer, and 29% of the sample was project engineer, and 32.3% of the sample was project manager.

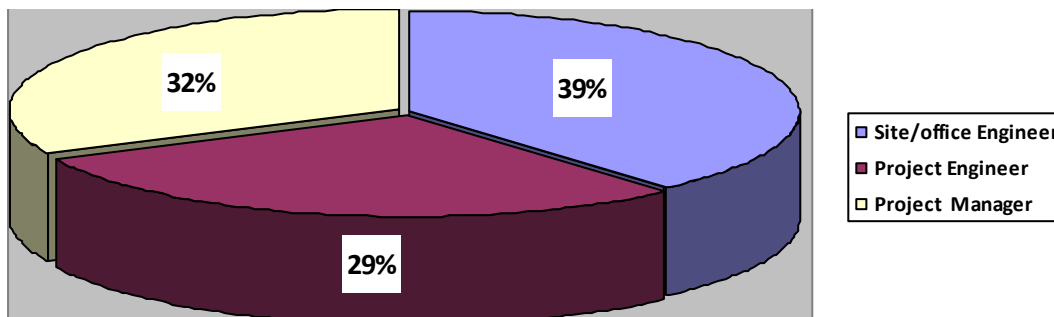


Figure 1: Post of the Respondent

SAFETY CONDITION

Table 3 showed the respondents answers regarding safety-related. The results show that in general most of construction organizations in Gaza Strip don't have a safety program for its projects, although most of them gave occupational safety priority at company policies. Although training is not a priority by the respondents organizations, the respondents considered safety as very important.

Table 3: Safety Condition Issues

Question	No		Yes	
	N	%	N	%
Does the employer have a safety program?	26	84	5	16
Is occupational safety forms part of company policies?	6	19.4	25	80.6
Does the company provide project employees safety training?	21	67.7	10	32.3
Do you give safety issues a priority in your projects?	3	9.7	28	90.3

Table 4: Safety and Lean Techniques

Safety and lean techniques question	No		Yes	
	N	%	N	%
Does the company interest in use new managing techniques?	21	68%	10	32%
Does the company interest in minimizing waste and maximizing value in its projects?	7	23%	24	77%
Do you know about lean construction techniques in construction work?	20	65%	11	35%
Do you know about last planner technique in construction work?	19	61%	12	39%
Do you have a realistic plan to evaluate the performance of workers based on their ability to reliably achieve their commitments?	11	35%	20	65%
Are you increasing empowerment of your employees, which give a push to increased gang self-governance?	22	71%	9	29%
Does the company have behavior measurement to evaluate safety performance in its projects?	20	65%	11	35%
Do you know about Increased Visualization technique in construction work?	18	58%	13	42%
Does the company use signs and labels around the construction site? This includes signs related to safety, schedule, quality, and work performance?	8	25%	23	75%
Do you know about 5S process technique in construction work?	18	58%	13	42%
Are there any rules for workplace organization and housekeeping to organize each worker's work area?	15	48%	16	52%
Is it an interesting issue to keep your project site clean, tidy and orderly?	9	29%	19	71%

SAFETY AND LEAN CONSTRUCTION

Table 4 shows the answers of the respondents who have been targeted by the questionnaire on lean construction techniques. The results showed that in general most of construction organizations in Gaza Strip were not interest in using new managing techniques, although most of them were interested in minimizing waste and maximizing value in its projects. The majority of the respondents didn't know about lean construction techniques as new managing technique in construction management.

THE INFLUENCE OF IMPLEMENTATION LEAN TOOLS ON SAFETY IN CONSTRUCTION PROJECTS

The majority of the respondents indicated that there is a significant influence of implementation lean tools on safety in construction projects. Table 5 shows the answers of the respondents who have been targeted by the questionnaire to investigate the influence of implementation lean management on safety in construction projects.

There is a consensus among the participants that the impact of the use of lean management enhances the safety condition in construction projects. As lean construction aims to minimize waste and maximize the value, it put safety conditions in the top of project objectives.

Table 5: The Influence of Implementation Lean Management on Safety in Construction Projects

Influence statements	No important		Some important		Great important		Mean	STD	RW
	N	%	N	%	N	%			
Improving the productivity in construction projects.	0	0.0	16	51.6	15	48.39	2.5	0.51	0.83
Increasing value by minimizing waste and continues improvement in construction projects.	6	19.4	9	29.0	16	51.61	2.3	0.79	0.77
Occupational accidents are wasteful and non-value-adding events.	6	19.4	12	38.7	13	41.94	2.2	0.76	0.74
Incidents that disrupt the flow of work or lead to injury are waste.	15	48.4	3	9.7	13	41.94	1.9	0.96	0.65
less material in the work area, an orderly and clean workplace, and systematic workflow.	0	0.0	16	51.6	15	48.39	2.5	0.51	0.83

LAST PLANNER SYSTEM

Table 6 shows the answers of the respondents who have been targeted by the questionnaire to investigate the influence of last planner implementation system on safety in construction projects. Most of the respondents' indicated that they had a realistic plan to evaluate the performance of workers based on their ability to reliably achieve their commitments, but on the other side they indicated that they rarely increased empowerment of their workers, which give a push to increased gang self-governance. The updating operations on a schedule and plan are rarely amended and developed during the project, especially in small and medium enterprises.

The measurement of the completion rate for workers and staff is depended on the observation and measurement of work done without reference to prior written plan. Project managers focused more on verifying that the durations of the activities would meet the schedule and that those resources were available. All projects did not have any separate safety plan but safety conditions were mentioned in the master plan. Therefore it is very important to integrated safety planning and control model, and enabling workers to identify risks and make suggestions to control them by using last planner system.

Table 6: The Influence of Implementation Last planner System on Safety in Construction Projects

Influence statements	No important		Some important		Great important		Mean	STD	RW
	N	%	N	%	N	%			
Orientation and specialized training for management.	3	9.7	16	51.6	12	38.71	2.3	0.64	0.76
Training for workers; safety committee; and safety incentives program	6	19.4	6	19.4	19	61.29	2.4	0.81	0.81
Increased empowerment of the employees in the projects.	12	38.7	7	22.6	12	38.71	2.0	0.89	0.67
Involve all people in project levels in planning process.	15	48.4	13	41.9	3	9.68	1.6	0.67	0.54
Behavior measurement and continuous improving.	6	19.4	16	51.6	9	29.03	2.1	0.70	0.70

INCREASED VISUALIZATION

Table 7 shows the answers of the respondents who have been targeted by the questionnaire to investigate the influence of increased visualization implementation on safety in construction projects. Most of the respondents indicated that their companies used signs and labels around the construction site such as signs related to safety, schedule, quality, and work performance. Most of construction projects use safety signs, schedule and visual tools to define the project, project name, owner, contractor, duration, donor and other information. Regarding using visual tools for communicating between workforces in the project site which is the main objective of increased visualization tools was found very limited. The study indicated that there is a strong relationship between occurring accidents and bad visualization in the construction sites.

THE 5S PROCESS

Table 8 shows the answers of the respondents who have been targeted by the questionnaire to investigate the influence of implementation the 5s Process on safety in construction projects.

Table 7: The Influence of Implementation Increased Visualization on Safety in Construction Projects

Influence statements	No important		Some important		Great important		Mean	STD	RW
	N	%	N	%	N	%			
Increased Visualization in the project site.	9	29.0	9	29.0	13	41.94	2.1	0.85	0.71
Safety signs, boards displaying (working methods, instructions and current accident rates).	0	0.0	12	38.7	19	61.29	2.6	0.50	0.87
Efficient communication system.	15	48.4	10	32.3	6	19.35	1.7	0.78	0.57

Most of the respondents stated that they were interested in keeping their projects site clean, tidy and orderly that mean they are interesting to use 5S tool although about 50% indicated that they did not use this tool in their projects now. Throughout the projects, sort, straighten, and standardize are the winners in this category mainly due to management eagerly making efforts. Conversely, the traditional working behavior became an obstacle for the enforcement of shine (clean up) and sustain. Workers are used to being messy and throwing garbage on the ground, and they think that they were hired to do physical construction work, but not to clean up. The respondents stressed on importance of this technique and mentioned that many accidents and injuries resulted because of wastes and chaos in the site.

Table 8: The Influence of Implementation 5s Process on Safety in Construction projects

Influence statements	No important		Some important		Great important		Mean	STD	RW
	N	%	N	%	N	%			
Reduce waste associated with the workplace.	0	0.0	19	61.3	12	38.71	2.4	0.50	0.80
Storing materials into the project site just when it is needed.	13	41.9	15	48.4	3	9.68	1.7	0.65	0.56
Keeping materials and equipment just in place where it is needed.	10	32.3	18	58.1	3	9.68	1.8	0.62	0.59
Keeping work areas and machines clean in order to reduce the waste related to uncleaness and increase workers' satisfaction.	9	29.0	13	41.9	9	29.03	2.0	0.77	0.67
Create and maintain a clean, orderly and safe work environment.	9	29.0	16	51.6	6	19.35	1.9	0.70	0.63
Grand Average							2.1	0.71	

The respondents stressed on a safe, clean, organized workplace where there is a specific location for everything that is required, and eliminates anything that is not required for an area. The study indicated that there are great relationship between 5S and safety, where 5S (sort, set in order, shine, standardize and sustain) leads to safe working environment. It was found that there is a significant weakness in the learning environment in construction projects thus there is limited amount of knowledge about lean construction tools. Lean construction is not implemented in Gaza strip yet and its concepts are unfamiliar for both contractors and clients' respondents.

POSSIBILITY AND BARRIERS OF IMPLEMENTING LEAN CONSTRUCTION

Figure 2 show that 70% from the respondents believed that using lean construction techniques are possible.

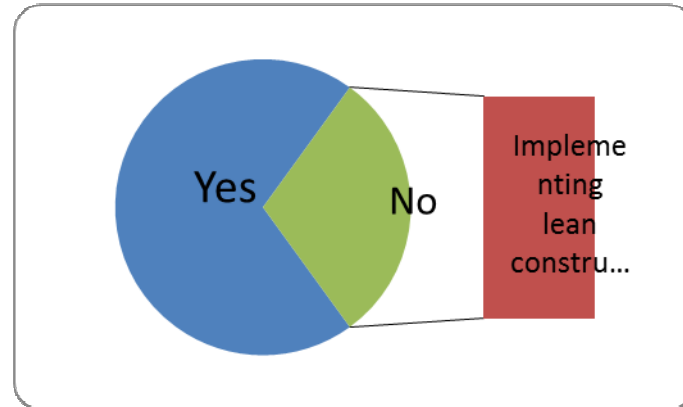


Figure 2: Possibility and Barriers of Implementing Lean Tools

Most of the respondents indicated that they are interesting to use lean construction techniques but they listed many barriers which decrease the opportunity of using lean construction techniques and employing it in safety issues such as:

- Weakness in the learning environment in construction projects.
- Lack interest in safety training in construction companies.
- Lack budget for training.
- Lack of interest and control by official bodies such as the government and contractors union about new managing techniques.

CONCLUSIONS AND RECOMMENDATION

This paper investigated the extent of use of different lean construction tools (last planner- increased visualization and the five S's process) in construction industry and its impact on safety conditions in construction projects in Gaza Strip.

As lean construction aims to minimize waste and maximize the value, it put safety conditions in the top of project objectives. All participants agree with implementing lean tools enhance safety conditions in construction projects.

Lean construction is not implemented in Gaza Strip construction industry yet, and lean construction concepts are unfamiliar for both contractors and consultant engineers. But on the other hand all of the respondents expressed their admiration for lean thinking. All of them stress that it is very important to find ways to achieve the purpose of the project in the most effective and efficient way in the most economic manner by minimizing waste and increasing the value in most safety level. Using lean construction tools, reducing waste and increasing efficiency, often reduce the probability of incurring an accident or coming in contact with hazardous materials. The analysis and discussion presented in this paper provides theoretical and empirical reasoning for the link between using lean tools and safety outcomes.

It was found that there is a significant weakness in the learning environment in construction projects thus there is limited amount of knowledge about lean construction tools. Lean construction is not implemented in Gaza Strip construction industry yet and its concepts are unfamiliar for both contractors and consultant engineer. Training will be a key aspect of implementation and success of the lean construction techniques at the site. The staff and workers will need to be trained to use this tool effectively. It will be so useful if an action research done on implementing lean construction tools in one of construction project to measure the effectiveness of these techniques and its influence on safety.

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